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Poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija

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Sadržaj

O poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija

Doktorski studij *Tekstilna znanost i tehnologija* (https://www.ttf.unizg.hr/tekstilna-znanost-i-tehnologija/226) je jedini doktorski studij u području tekstilne znanosti i tehnologije u Republici Hrvatskoj te najznačajniji u regiji. Osnovni cilj studija je osposobljavanje doktoranada za samostalni znanstvenoistraživački rad, poticanje inovativnosti i transfer rezultata znanstvenih istraživanja na unaprjeđenje suvremenih proizvodnih procesa u tekstilnoj i odjevnoj industriji. Svjetski napredak u području tehničkih znanosti posebno potencira istraživanje materijala i njihovih karakteristika, s naglaskom na primjenu biotehnologije i nanotehnologije. Visoki domet u tome predstavljaju kompozitni materijali, pametni tekstil, funkcionalna zaštitna i inteligentna odjeća. Međunarodni savjet akademija tehničkih znanosti (CAETS) svrstao je istraživanje materijala, pa tako i tekstilnih, na listu prioriteta. Europska se tekstilna industrija usmjerava na razvoj naprednih tehnologija i materijala te na proizvodnju specijaliziranih proizvoda visoke kakvoće i funkcionalnosti, uz postizanje visokih ekoloških standarda. U sklopu ovoga modernoga studijskoga programa u Hrvatskoj se obrazuju doktorandi za rad na sveučilištu, u istraživačkim i razvojnim institucijama te gospodarstvu i privatnom sektoru. Visoki stupanj znanja iz područja tekstilne tehnologije doktorandima omogućuje uključivanje u razvojne projekte inovativnih i visokosofisticiranih tehnologija koje su temelj održivom razvoju i povećanju konkurentnosti gospodarstva. Nužno je uspjeh u tim procesima temeljiti na visokom stupnju inovacija, vlastitih istraživanja te razvoja novih mjernih metoda i instrumenata koristeći veliki laboratorijski potencijal Fakulteta, koji se ogleda u izvrsnoj opremljenosti suvremenom laboratorijskom opremom.

Voditeljica doktorskog studija

prof. dr. sc. Snježana Firšt Rogale

Dekanica Tekstilno-tehnološkog fakulteta

izv. prof. dr. sc. Anica Hursa Šajatović

Predgovor

Razorni potres koji je oštetio i objekte Tekstilno-tehnološkog fakulteta te globalna pandemija COVID-19, uvelike su utjecali na svakodnevni život, ali i na znanstveno-istraživački rad svih nastavnika i istraživača, pa tako i naših doktoranada. Tim više veseli činjenica da je ove godine, za Dan doktoranada poslijediplomskog sveučilišnog studija Tekstilna znanost i tehnologija, pristigao veliki broj prijava.

U Zborniku radova Dana doktoranada 2022. godine objavljeno je 40 proširenih sažetaka doktoranada sa poslijediplomskog sveučilišnog studija Tekstilna znanost i tehnologija te jednog doktoranda, zaposlenika našeg Fakulteta, koji će uskoro obraniti doktorat na Sveučilištu u Zagrebu Prirodoslovno-matematičkom fakultetu. Uz proširene sažetke doktoranada, objavljeni su cjeloviti radovi četiri doktora znanosti koji su, od prethodnog Dana doktoranada, doktorirali na Tekstilno-tehnološkom fakultetu te jedna naša zaposlenica koja je doktorirala na Sveučilištu u Zagrebu Filozofskom fakultetu.

Zbornik radova pruža uvid u raznolikost i kvalitetu znanstveno-istraživačkih tema te uključenost naših doktoranada u razvoj novih, inovativnih metoda, materijala i tehnologija kroz primjenu novih ideja i inženjerskih rješenja.

Voditeljica doktorskog studija

prof. dr. sc. Snježana Firšt Rogale

Ivona Jerković

Životopis

Ivona Jerković rođena je u Zagrebu 1982. godine. Diplomirala je 2006. godine na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu te završila Međunarodni europski master studij naprednog tekstilnog inženjerstva (E-TEAM) 2009. godine na Sveučilištu u Ghentu (Belgija). U Hrvatskoj je radila u odjevnoj industriji; TKT Zlatna igla (2007.), Naftalina (2010.); Marketingu, A.O.R. (2011.-2012.) te na Tekstilno-tehnološkom fakultetu na FP7 projektu MAPICC 3D (2012.-2015.). U okviru FP7 projekta 2015. godine boravila je na Ecole Nationale Supérieure des Arts et Industrie Textiles, Roubaix, Francuska. Od 2017. godine radi u Hrvatskoj agenciji za malo gospodarstvo, inovacije i investicije u Zagrebu na praćenju provedbe Strategije pametne specijalizacije za razdoblje 2016.-2020. te analizi podataka neposrednih rezultata i ishoda projekata istraživanja, razvoja i inovacija na nacionalnoj razini.

Naslov doktorskog rada

Novi tekstilni senzori za in situ praćenje stanja strukture tekstilom ojačanih termoplastičnih kompozita temeljenih na vodljivom polimernom kompleksu poli[3,4-(etilendioksi)tiofen]-compl-poli(4vinil-benzensulfonska kiselina)

Mentori

prof. emerita dr. sc. Ana Marija Grancarić
prof. dr. sc. Vladan Končar

Datum obrane doktorskog rada

26. 8. 2021.

UTJECAJ PEDOT-COMPL-PSS FILMOVA NA RAZVOJ NOVIH TEKSTILNIH SENZORA I TEKSTILOM OJAČANIH KOMPOZITA

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Sažetak: *Pametni tekstil ima važnu ulogu u znanosti i različitim tehnologijama zbog komercijalne održivosti. U radu je prikazan utjecaj tankih filmova vodljivog polimernog kompleksa na razvoj novih tekstilnih senzora i kompozita.*

1. Uvod

Pametni tekstil ima važnu ulogu u znanosti i različitim tehnologijama, prvenstveno zbog komercijalne održivosti i značajnog javnog interesa [1]. Ova vrsta tekstila združuje saznanja različitih znanstvenih disciplina sa specifičnim zahtjevima koji se nameću tekstilu [2]. Istraživanja u ovom području kontinuirano rastu posljednjih nekoliko godina [3]. Različite vrste senzora mogu se koristiti za pametni tekstil te primijeniti i u kompozitnoj tehnologiji koja zauzima značajno mjesto u automobilskoj, željezničkoj i srodnim industrijama [1, 3]. U ovom radu prikazan je utjecaj tankih filmova vodljivog polimernog kompleksa poli[3,4-(etilendioksi)tiofen]-compl-poli(4-vinil-benzensulfonska kiselina) (PEDOT-compl-PSS) na razvoj novih tekstilnih senzora i tekstilom ojačanih 2D termoplastičnih kompozita.

2. Eksperimentalni dio

Vodena vodljiva disperzija PEDOT-compl-PSS CLEVIOS P FORM. CPP105D (A, Heraeus, Leverkusen, Njemačka),) ili CLEVIOS F ET (B, Heraeus, Leverkusen, Njemačka), i vodena disperzija akrilnih estera, Latex Appretan 96100 (C, Clariant, Pariz, Francuska), miješane su pod određenim uvjetima za izradu tankih vodljivih filmova te naslojavanje vodljive disperzije na filamentnu pređu [3]. Vodena disperzija kopolimera akrilnih estera korištena je i kao zaštitni sloj za povezivanje filamenata pređe te zaštitu senzor pređe od abrazije [4].

Vodena disperzija (formulacija A/C ili B/C) miješana je na magnetnoj miješalici (IKA Werke GmbH & Co. KG, Staufen, Njemačka) pri temperaturi od 50 °C do 40 % isparavanja otapala (A/C) ili 50 °C do 25 % isparavanja otapala (B/C). Brzina miješanja disperzije iznosila je 550 rpm prvih 30 min i potom 1100 rpm u vremenu od 4 h.

Tanki filmovi polimernog kompleksa PEDOT-compl-PSS pripremljeni su nanošenjem 500 µL ove vodljive disperzije s mikropipetom unutar pripremljenih okvira na bazi celuloznog acetata (dimenzija 100 mm x 10 mm) na pleksiglas površinu. Nakon 48 h isparavanja otapala pri standardnim uvjetima, 20 °C i 65 % relativne vlažnosti, debljina suhih filmova određena je optičkim profilometrom, Altisurf 500 (Altimet SAS, Thonon-les-Bains, Francuska), prosjek vrijednosti 10 profila mjerenih duž svakog filma. Konačna debljina za svaku pripremljenu vodljivu formulaciju izračunata je kao prosjek od tri filma. Prag perkolacije polimernog kompleksa PEDOT-compl-PSS određen je po završetku mjerenja električnog otpora PEDOT-compl-PSS filmova standardnim Ommetrom u razdoblju od 75 dana.

E-stakleno/polipropilenska (GF/PP) pređa, E-stakleno/poli(N,N'- heksametilen-adipamid)na (GF/PA66) pređa i E-staklena (GF) pređa proizvođača PD Fiberglass (Glasseiden GmbH, Oschatz, Njemačka) su korištene za izradu novih tekstilnih senzora [4].

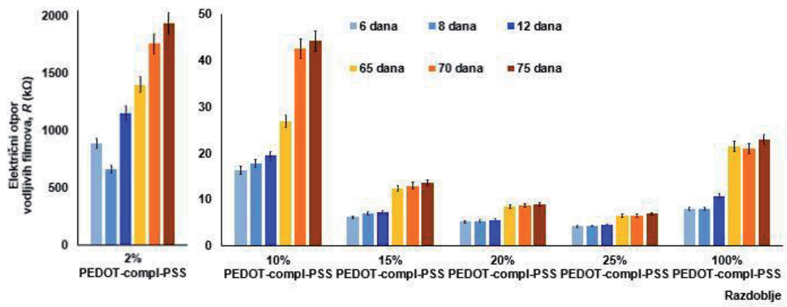
Novi laboratorijski uređaj s aluminijskim valjcima i pleksiglas komorom je razvijen za izradu novih tekstilnih senzora. Brzina naslojavanja iznosi 0,2 m/min radi kasnijeg sušenja periodično naslojene pređe pri temperaturi od 170 °C (za GF/PP pređu) ili 220 °C (za GF/PA66 i GF pređu) s uređajem HG 2310 LCD programmable intellitemp™ (Steinel Professional, Herzebrock-Clarhol, Njemačka).

Tekstilni senzori su izrađeni sa samo dva vodljiva nanosa polimernog kompleksa PEDOT-compl-PSS nanesena prema definiranom protokolu između dva zaštitna nanosa kopolimera akrilnog estera te su integrirani tijekom tkanja (ARM, Biglen, Švicarska) 2D tkanine, u smjeru potke. 2D tekstilni predoblici (tri sloja) s integriranim tekstilnim senzorima su konsolidirani pod određenim uvjetima u vrućoj preši (Dolouets, Soustons, Francuska) u kompozite kako bi se izvršilo in situ praćenje stanja kompozitnih uzoraka tijekom vlačnog opterećenja (Instron, Norwood, MA, USA) u stvarnom vremenu.

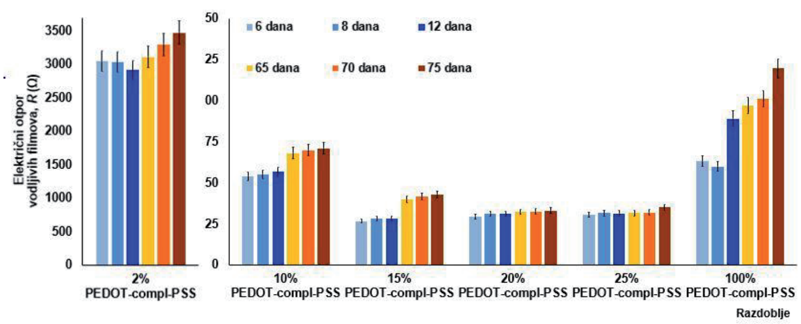
Analiza morfologije izrađenih filmova, tekstilnih senzora i kompozita izvršena je skenirajućim elektronskim mikroskopom (SEM), MIRA\\LMU (Tescan, Brno, Češka), pri 3,6 kV ili 5 kV uz različite razine povećanja, te tomografijom, uređajem Easy Tom (RX Solution, Chavanod, Francuska), pri rezoluciji 10-15 µm.

3. Rezultati i rasprava

Prva skupina suhih filmova vodljivog polimernog kompleksa PEDOT-compl-PSS (formulacija A/C) je izrađena s rasponom debljine od 7 µm do 166 µm, a druga skupina (formulacija B/C) s rasponom od 21 µm do 169 µm. Izmjerene su vrijednosti električnog otpora ovih filmova standardnim Ommetrom tijekom 75 dana na udaljenosti od 5 cm između nanesenih kapljica srebra na površini filmova, sl.1.



a.



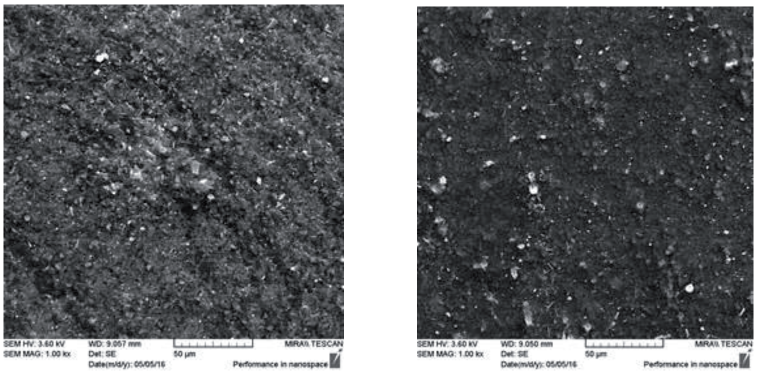
b.

Slika 1: Električni otpor PEDOT-compl-PSS filmova pripremljenih iz vodene disperzije: a. A/C; b. B/C

Općenito, električni otpor filmova se smanjuje sa smanjenjem njihove debljine. Manje promjene električnog otpora svih filmova uočene su nakon 8 i 12 dana praćenja, dok su značajne promjene primijećene nakon 65 dana. Prva skupina razvijenih filmova bila je manje stabilna u pogledu vrijednosti električnog otpora tijekom promatranog razdoblja od 75 dana u usporedbi s drugom skupinom filmova.

U okviru studije praga perkolacije [5], izračunat je logaritam vrijednosti električne otpornosti filmova vodljivog polimernog kompleksa PEDOT-compl-PSS kako bi se identificirao prag ovog kompleksa u zoni perkolacije. Rezultati su pokazali da odgovarajući omjer prve formulacije (A/C) odgovara 15 % PEDOT-compl-PSS (miješanjem A, 20 g, i C, 1,47 g). Omjer druge formulacije odgovara 8 % PEDOT-compl-PSS (miješanjem B, 20 g i C, 7,13 g).

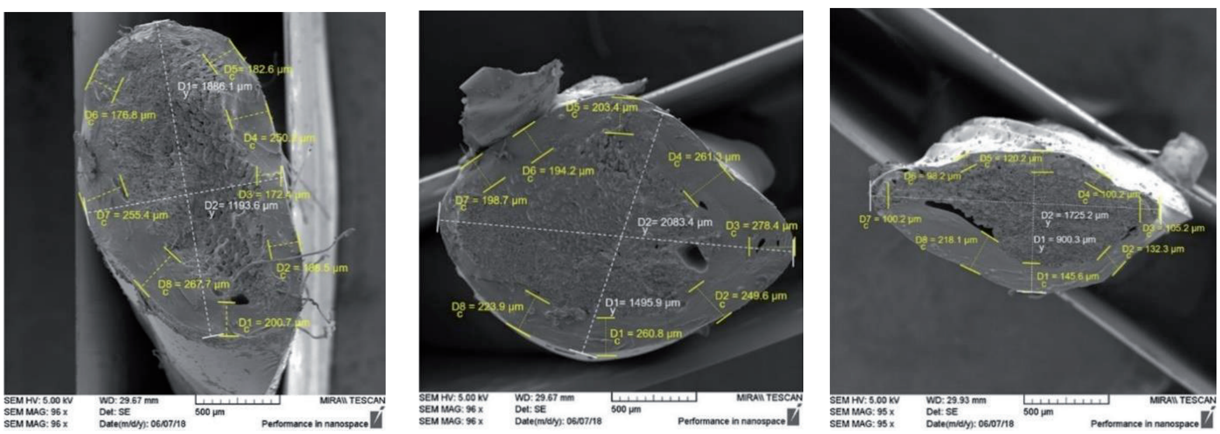
Prema SEM analizi, sl. 2, film druge formulacije (B/C, debljine 135,67 mm ± 31 mm) ima homogeniju površinu u odnosu na film prve formulacije (A/C, debljine 30,60 mm ± 0,97 mm) zbog manjeg udjela vodljivog polimernog kompleksa PEDOT-compl-PSS i veće prisutnosti kopolimera akrilnog estera u svom sastavu.



a. b.

Slika 2: SEM mikrosnimke PEDOT-compl-PSS filmova: a. 15 % PEDOT-compl-PSS film (A/C); b. 8 % PEDOT-compl-PSS film (B/C)

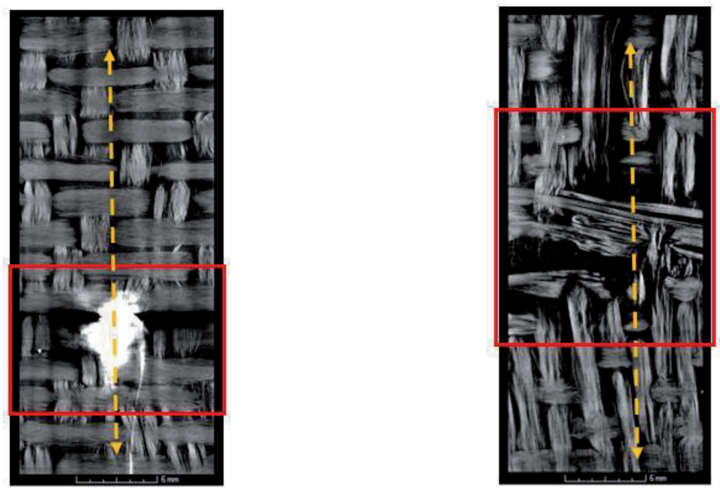
Dodatno, postupak izrade tekstilnih senzora utječe na poprečni presjek pređe, sl. 3. Debljina nanosa ovisi o masenom udjelu komponenata. Što je udio staklene komponente veći, debljina nanosa je manja: 212 ± 39 mm za GF/PP senzor pređu, 234 μm ± 33 μm za GF/PA66 senzor pređu, 128 ± 40 mm za GF senzor pređu. Rezultati su u korelaciji s međupovršinskim pojavama tekstilnih senzora. Na pojedinim mjestima unutar tekstilnih senzora prisutne su i šupljine u području vodljivog nanosa, zbog postupka naslojavanja, što ukazuje na neophodnu opsežniju studiju njihovih međufaznih svojstava.



a. b. c.

Slika 3: SEM mikrosnimke: a. GF/PP senzor pređa; b. GF/PA66 senzor pređ; c. GF senzor pređa

Prema tomografijskoj analizi, otkriveno je oštećeno područje uokolo bakrene žice omotane oko GF/PP senzor pređe uz dodatak srebrnih kapljica (tekstilni senzor) unutar GF/PP tekstilom ojačanog 2D termoplastičnog kompozita prije elektromehaničkog ispitivanja, sl. 4a. Glavni razlozi ovog oštećenja su primijenjena temperatura i tlak tijekom konsolidacije GF/PP 2D tekstilnog predoblika u kompozitni uzorak [6]. Nakon elektromehaničkog ispitivanja, sl. 4b, GF filamenti kao dio GF/PP senzor pređe nisu u potpunosti oštećeni te su uočene pukotine matrice i lom vlakana unutar kompozita uslijed elektromehaničkog ispitivanja.



a. b.

Slika 4: Tomografijska analiza - GF/PP kompozit s integriranom GF/PP senzor pređom: a. prije; b. nakon elektromehaničkog ispitivanja

4. Zaključak

Vodljivi filmovi imaju zrnastu morfologiju i homogenu površinu. Električni otpor filmova se smanjuje sa smanjenjem njihove debljine a značajne promjene primijećene su nakon 65 dana. Postupak izrade tekstilnih senzora utječe na poprečni presjek pređe a debljina nanosa ovisi o masenom udjelu komponenata. Rezultati su u korelaciji s međupovršinskim pojavama tekstilnih senzora. Tomografijska analiza kompozita ukazuje na manje pukotine, lom vlakana i oštećenja senzor pređe.

Zahvala

Istraživanje je izrađeno u okviru aktivnosti na FP7 istraživačkom projektu MAPICC 3D pod nazivom: One-shot Manufacturing on large scale of 3D up graded panels and stiffeners for lightweight thermoplastic textile composite structures u sklopu poziva NMP-FP7-2010-3.4-1, broj 263159, financiranog od Europske komisije.

Literatura

[1] Grancarić, A. M. et al: Conductive polymers for smart textile applications, *Journal of Industrial Textiles*, **48** (2018) 3, 612-642, ISSN 1530-8057

[2] Van Langenhove, L.; Rambausek, M. L.: The future of smart textiles according to Systex, *Book of Proceedings of the 12th AUTEX World Textile Conference*, Mijović, B. et al (eds.) 61-68, ISBN 978-953-7105-47-1, Zadar, June 2012, University of Zagreb Faculty of Textile Technology (2012)

[3] Syduzzaman, M. et al: Smart textiles and nano-technology: A general overview, *Journal of Textile Science & Engineering,* **5** (2015) 5, 1-7, ISSN 2165-8064

[4] Jerković I., Grancarić A. M., Končar, V.: The electrical properties of poly(3,4- ethylenedioxythiophene)-poly(styrenesulfonate) films and its effect onto sensor yarn coating, *Journal of Industrial Textiles*, May 2020, ISSN 1530-8057

[5] Jerković, I., Končar, V., Grancarić A. M.: New textile sensors for in situ structural health monitoring of textile reinforced thermoplastic composites based on the conductive poly (3, 4-ethylenedioxythiophene)-poly(styrene sulfonate) polymer complex, *Sensors*, **17** (2017) 10, 1-21, ISSN 1424-8220

[6] Jerković I., Grancarić A. M., Končar, V.: Textile sensors validation to perform in situ structural health monitorıng of textile reinforced thermoplastic composites, *Journal of Fashion Technology and Textile Engineering* **6** (2018), 1-5, ISSN 2329-9568

Snježana Kirin

Životopis	Snježana Kirin rođena je 1969. godine. Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 1994. godine stječe zvanje diplomirani inženjer, a 2007. godine magistre tehničkih znanosti. 2020. godine je doktorirala u području tehničkih znanosti. Radila je kao tehnički direktor tijekom dužeg vremenskog razdoblja u odjevnoj industriji. Na Veleučilište u Karlovcu zapošljava se u stalni radni odnos 2001. godine. Od rujna 2021. godine radi na mjestu profesora visoke škole. Od 2006. do 2014. godine obavlja dužnost pročelnice Tekstilnog odjela, a od 2014. godine pročelnice Odjela sigurnosti i zaštite. Do sada je objavila 13 znanstvenih radova i 3 stručna rada u časopisima, 22 znanstvena rada i 20 stručnih radova na međunarodnim skupovima, 4 stručna rada na domaćim skupovima. Objavila je dvije knjige i jedan priručnik.
Naslov doktorskog rada	Oblikovanje radnih metoda u tehnološkom procesu šivanja
Mentor	izv. prof. dr. sc. Anica Hursa Šajatović
Datum obrane doktorskog rada	21. 12. 2020.

DEFINIRANJE STANDARDNIH SKLOPOVA POKRETA U TEHNOLOŠKOM PROCESU ŠIVANJA PRIMJENOM MTM SUSTAVA

Snježana KIRIN
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Sažetak: *Prema strukturi izvođenja tehnološka operacija šivanja se sastoji od pomoćno-ručnih zahvata: uzimanje, međusobno postavljanje, pozicioniranje, zahvata tijekom prekida šivanja i odlaganje, te tehnološkog strojno-ručnog zahvata šivanja. Svaki tehnološki zahvat s obzirom na vrstu odjeće, položaj i funkciju šava u odjevnom predmetu, te obliku i duljini kontura šavova ima različitu mogućnost izvođenja. U radu je dan pregled mogućnosti izvođenja pojedinih zahvata sadržanih u tehnološkoj operaciji šivanja, te postavke izvođenja tehnološkog zahvata uzimanja. Unutar zahvata uzimanja prikazani su načini izvođenja koji ovisi o tome da li se izvode s jednom ili obje ruke, s jednog, dva ili tri svežnja, te o veličini izratka i duljini pokreta kojim se izradak prenosi, čime je utvrđeno deset načina izvođenja. Sustavnim istraživanjem mogućih metoda rada, njihovom standardizacijom i razradom do razine osnovnih pokreta pomoću MTM sustava, eng. Method Time Measurement, postavljeni su standardni logički sklopovi osnovnih pokreta pomoću kojih se može odrediti optimalna metoda rada što omogućava utvrđivanje stvarnih normativa, te smanjenje opterećenja radnika.*

1. Uvod

U tehnološkom procesu šivanja odjeće ovisno o vrsti odjevnog predmeta izvodi se razmjerno velik broj tehnoloških operacija na radnim mjestima. Prema organizaciji tehnološki proces šivanja pripada montažnom (komadnom) tipu radnog procesa s linijskim načinom ugradnje radnih mjesta, a pojedine tehnološke operacije šivanja pripadaju tzv. stabilnim radnim mjestima zatvorenog tipa s ustaljenim izvođenjem gdje radnik izvodi tehnološke operacije sličnih karakteristika. Takvo radno mjesto omogućuje viši stupanj iskorištenja radnih strojeva i uređaja, bolji međufazni transport predmeta izrade kroz proizvodnu liniju, smanjenje ciklusa proizvodnje i povećanje proizvodnih kapaciteta svakog radnog mjesta, proizvodnih linija i sustava [1].

Tehnološke operacije šivanja izvode se u sjedećem položaju na šivaćim strojevima koji imaju strojno-ručna obilježja u kojima postoji uzajamni odnos radnika i stroja, što predstavlja zatvoreni ciklus potrebnih reakcija pri izvođenju u kojima radnik ima ključnu ulogu u vođenju procesa šivanja i/ili donošenju potrebnih odluka [2].

Takav radni sustav zahtjeva visok stupanj točnosti izvođenja i koordinaciju pokreta s potrebnom vidnom usredotočenosti pogleda u središnjem vidnom polju uz istovremeno vođenje procesa šivanja kontroliranim pokretom stopala, čime se regulira ubodna brzina šivanja te istovremeno kontrolira udaljenost linije šava od ruba izratka, međusobna usklađenost rubova izratka, te duljina spoja do kraja šava [3].

Na izbor metoda rada za određenu tehnološku operaciju šivanja utječe oblik konture šava (polumjer zakrivljenosti), duljina konture šava, a značajnu ulogu ima vrsta i uzorak tkanina, zahtijevana kvaliteta i položaj šava. Nadalje, odabir pogodne metoda rada povezan je s oblikovanjem radnog mjesta (raspored svežnjeva, veličina i visina radne površine, usklađenost radnog mjesta antropometrijskom izmjeru radnika), vrstom i stupnjem tehnološke opremljenosti šivaćeg stroja, te sustavom ugradnje radnih mjesta [4, 5].

MTM sustav omogućava jasan opis metoda rada s potrebnim normalnim vremenima izvođenja pojedinih pokreta, te određuje zakonitosti na osnovu kojih radnik normalnih psihičkih i fizičkih sposobnosti izvodi pokrete po određenom redoslijedu. MTM sustav sastoji se od devet osnovnih pokreta prstiju, šake i ruke, dva pokreta očiju, deset pokreta tijela, nogu i stopala s oko 400 normalnih vremena izvođenja osnovnih pokreta, pri čemu je simbol pokreta izveden iz osnovnog engleskog nazivlja. Prema mogućim varijablama izvođenja (duljina pokreta, tip, slučaj, stupanj točnosti i dr.), osnovni pokreti s pripadajućim normalnim vremenima (t_n) tablično su prikazani u literaturi. Primjenom MTM sustava može se odrediti i mogućnost koordiniranog izvođenja kombiniranih i istovremenih pokreta. Vremenska jedinica MTM sustava je TMU, eng. Time Measurement Unit, koja iznosi 10-5h (3,6x10^{-2} s) [6, 7].

2. Eksperimentalni dio

U okviru eksperimentalnog dijela rada primjenom MTM-1 sustava napravljena je sustavna razrada i postavljeni su standardni sklopovi ručnih zahvata tehnoloških operacija šivanja. Pojedini zahvati u strukturi tehnološke operacije mogu se izvesti na više načina ovisno o veličini i broju izradaka, rasporedu slojeva izratka, stupnju tehničke opremljenosti šivaćih strojeva, veličini i obliku radne površine, potrebnim radnim zonama i vidnim poljima, te s obzirom na uvježbanost radnika. U tab. 1. prikazane su moguće metode izvođenja zahvata tehnoloških operacija šivanja.

Zahvati tehnološke operacije šivanja raščlanjeni su do razine osnovnih pokreta, te su određene pripadajuće varijable prema duljini pokreta, točnosti i dinamici izvođenja, potrebnoj vizualnoj i muskulaturnoj kontroli te mogućnosti izvođenja korištenjem kombiniranih i istovremenih pokreta. Na taj način dobiveni su standardni sklopovi zahvata tehnološke operacije šivanja kojima je moguće opisati pogodne metode rada.

Tablica 1: Zahvati tehnoloških operacija šivanja i metode njihovog izvođenja

Zahvat	Metode izvođenja zahvata
uzimanje	uzimanje jednog izratka iz jednog svežnja uzimanje dva izratka iz jednog svežnja uzimanje dva izratka iz dva svežnja uzimanje tri izratka iz tri svežnja
međusobno postavljanje	međusobno postavljanje rubova kontura postavljanje na označeno mjesto
pozicioniranje	pozicioniranje pod pritisnu nožicu pozicioniranje izratka pod iglu vođen pokretom stopala pozicioniranje do ispred igle
šivanje	zajedničko vođenje osnovno vođenje pojedinačno vođenje metoda vođenja nabiranjem učvršćivanje šava polugom mehanizma za učvršćivanje učvršćivanje šava tipkom za učvršćivanje programirano (automatsko) učvršćivanje šava vođenje izratka upotrebom graničnika podavijanje porubljivačem podavijanje podavijačem odsijecanje konca škarama odsijecanje konca napravom za odsijecanje odsijecanje mehanizmom za automatsko odsijecanje konca
zahvat tijekom prekida šivanja	poravnavanje rubova kontura zakretanje izratka oko igle
odlaganje	jednom rukom s dvije ruke

U nastavku prikazane su načini izvođenja tehnološkog zahvata uzimanja s obzirom na dimenzije izratka, potrebne veličine i oblike radnih površina, te mogućnost izvođenja prema razredima sklopova pokreta, a u okviru ergonomski pogodnih metoda. Na ergonomski oblikovanom radnom mjestu uvježbani radnik pojedine zahvate izvodi određenim slijedom pokreta čime je moguće uspostaviti skupine logičkih pokreta koji predstavljaju standardni sklop pokreta koji ima točno određeno vrijeme izvođenja.

3. Rezultati i rasprava

Tehnološki zahvat uzimanja se s obzirom na veličinu izratka, zakrivljenost i duljinu šava, te raspored slojeva izratka moguće je izvesti u četiri skupine uzimanja: jednog dijela s jednog svežnja (A01, A02, A03, A04), dva dijela s jednog svežnja (A05, A06, A07), dva dijela s dva svežnja s obje ruke (A08, A09), tri dijela s tri svežnja (A10), tab.2.

Tablica 2: Metode izvođenja zahvata uzimanja izratka iz svežnja

Broj izradaka / broj svežnjeva	Metoda izvođenja	Veličina izratka	Razred sklopa pokreta		
			30	50	80
Jedan izradak iz jednog svežnja	bez podizanja **(A01)**	mali	x	x	
	s podizanjem **(A02)**	mali	x	x	
		srednji		x	x
	s obje ruke **(A03)**	veliki		x	x
		vrlo veliki		x	x
	s okretanjem **(A04)**	srednji		x	x
		veliki		x	x
Dva izratka iz jednog svežnja	bez podizanja (**A05**)	mali	x	x	
	s podizanjem **(A06)**	mali	x	x	
		srednji		x	x
	s obje ruke **(A07)**	veliki		x	x
		vrlo veliki		x	x
Dva izratka iz dva svežnja s obje ruke	istovremeno s obje ruke **(A08)**	mali	x	x	
		srednji		x	x
	s obje ruke iz jednog, a zatim iz drugog svežnja **(A09)**	veliki		x	x
		vrlo veliki		x	x
Tri izratka iz tri svežnja s obje ruke	istovremeno s obje ruke **(A10)**	mali	x	x	
		srednji		x	x

Osnovi pokreti uzimanja izvode se u okviru normalnog ili maksimalnog dosega logičkim slijedom pokreta: posezanje (R) – hvatanje (G) – prenošenje (M) čime se izradak prenosi u središnju radnu zonu. Za određivanje duljine pokreta ruke pri posezanju i prenošenju prilikom definiranja modelnih sklopova određena je putanja ruke 25 cm (razred 30), 45 cm (razred 50), koji se izvode pokretom III razine, čime je određena zona normalnog dosega, dok putanja ruke duljine 70 cm (razred 80) izvodi se IV razinom u okviru zone maksimalnog dosega. S obzirom na dimenzije krojni dijelovi mogu biti: malih dimenzija (džepovi, džepne vrećice, orukvice, letvice), srednjih dimenzija (stražnji dio suknje, prednji bočni dio muškog sakoa, ovratnik, donji i gornji dio rukava i oplećnica muške košulje), velikih (prednji dio suknje, prednji i stražnji dio te rukav muškog sakoa, prednji dio muške košulje) i vrlo velikih dimenzija (pojasnica suknje, prednji i stražnji hlača i ogrtača).U tab. 3 i na sl. 1 prikazan je tehnološki zahvat uzimanja jednog izratka iz jednog svežnja jednom rukom bez podizanja za razred 30 i 50.

Tablica 3: Standardni sklop pokreta uzimanja jednog izratka iz jednog svežnja jednom rukom bez podizanja za razred 30 i 50

Red. broj	Opis pokreta	Simbol	Razred pokreta/Oznaka	
			30/ A01a30A	50/A01a50A
1.	posezanje do svežnja	mRB	8,5	14,2
2.	hvatanje izratka	G5/G2	5,6	5,6
3.	prenošenje izratka u središnju radnu zonu	MB	12,1	16,8
4.	ispuštanje izratka	RL1	2,0	2,0
		∑TMU (s)	28,2 (1,02)	38,6 (1,39)

Slika 1: Prikaz slijeda pokreta uzimanja jednog izratka iz jednog svežnja jednom rukom bez podizanja

Ovi zahvati zahtijevaju visok stupanj uvježbanosti radnika, dobre motoričke sposobnosti radnika i dobru koordinaciju izvođenja pokreta. Raspored svežnjeva kod ovog načina uzimanja treba biti takav da omogućava lako istovremeno izvođenje pokreta posezanje – hvatanje – prenošenje koje se izvodi u okviru normalnog dosega i središnjeg vidnog polja na radnoj površini.

4. Zaključak

Za modelni sustav postavljanja radnih metoda analitički su razrađeni standardni sklopovi ručnih zahvata temeljenih na logičkom slijedu potrebnih pokreta ovisno o duljini, slučaju, tipu i dinamici izvođenja te potrebnoj vizualnoj i muskulaturnoj kontroli uz mogućnost izvođenja istovremenih i kombiniranih pokreta. Tehnološki zahvat uzimanja, kao prvi tehnološki zahvat u strukturi tehnološke operacije ovisi o tome da li se izvodi s jednom, ili obje ruke, te jednog, dva ili tri svežnja, te ovisi o veličini izratka i dužini pokreta kojim se izvodi i može se izvoditi na deset načina. Određenim slijedom pokreta u tehnološkom zahvatu uzimanja određene su grupe logičkih pokreta koji predstavljaju standardni sklop pokreta. Kombinacijom tako definiranih standardnih sklopova može se odrediti optimalna radna metoda s pripadajućim normalnim vremenima izvođenja već u postupku projektiranja proizvodnog procesa te bitno utjecati na strukturu tehnološke operacije u smislu optimalizacije tehnoloških zahvata čime se postiže kraće vrijeme izrade, povoljniji stupanj iskorištenja stroja, te manje psihofizičko opterećenje radnika.

Literatura

[1] Kirin, S., Dragčević, Z., Firšt Rogale, S: Workplace redesign in the computer-aided technological sewing process, *Tekstil*, **63** (2014), 1-2,14-26, ISSN 0492-5882

[2] Dragčević, Z. Firšt Rogale, S.: Metode određivanja vremena strojno-ručnih tehnoloških zahvata šivanja, *Tekstil*, **51** (2000) 2, 51-63, ISSN 0492-5882

[3] Dragčević, Z.; Kirin, S.; Šaravanja, B.: A Method of Workplace Design for Sewing Operations, *Books of Proceedings 22nd International DAAAM Symposium „Intelligent Manufacturing & Automation: Power of Knowledge and Creativity“,* Katalinić B. (ed.), 0379-0380, ISSN 726-9679, Vienna, November, (2011)

[4] Kirin, S.: *Oblikovanje radnih metoda u tehnološkom procesu šivanja*, Doktorski rad, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb (2020)

[5] Kirin, S.; Hursa Šajatović, A.: Determination of Working Methods and Normal Times of Technological Sewing Operation using MTM System, *Tekstilec*, **63** (2020) 3, 203-215, ISSN 0351 3386

[6] Dragčević, Z., Kirin, S., Hursa Šajatović, A.: Systems of standard sets of motions in technological sewing operation, *Book of Proceedings of the 7th International Textile, Clothing & Desing Conference-Magic World of Textiles*, Dragčević, Z.; Hursa Šajatović, A.; Vujasinović, E. (ed.), 277-282, ISSN 1847-7275, Dubrovnik, October 2014, University of Zagreb, Faculty of Textile Technology, Zagreb, (2014)

[7] Aft, S.L.: Measurement of Work, Chapter 5.1. *In Maynard`s Industrial Engineering Handbook*, 5th Edition Kjell B. Zandin (ed.), McGraw-Hill, New York, USA, ISBN 0-007-041102-6 (2001) 5.3-5.22

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Životopis

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Naslov doktorskog rada

Utjecaj parametara 3D ispisa postupkom taložnog očvršćivanja i geometrije šupljikavih struktura na svojstva 3D ispisanih proizvoda od akrilonitril/butadien/stirena

Mentori

prof. dr. sc. Ana Sutlović
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Datum obrane doktorskog rada

6. 5. 2021.

UTJECAJ PARAMETARA 3D ISPISA NA SVOJSTVA TVOREVINA OD AKRILONITRIL/BUTADIEN/STIRENA

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Sažetak: *U doktorskom radu je istražen utjecaj parametara i geometrije 3D ispisa na mehanička svojstva 3D ispisanih ispitnih tijela postupkom taložnog očvršćivanja (e. Fused Deposition Modeling – FDM) iz akrilonitril/butadien/stirena (ABS). Ispitana je mogućnost naknadnog bojenja 3D ispisanih ABS tvorevina disperznim bojilima postupkom iscrpljenja te otpornost na habanje. Primjenom utvrđenih optimalnih parametra 3D ispisa izrađeni su prototipovi potpetica iz ABS-a.*

1. Uvod

Dizajn proizvoda značajan je segment u okviru kojeg napredne znanosti i tehnologije omogućuju povećanje broja inovacija u industrijskom procesu, pa tako i u području proizvodnje obuće. Jedan od postupaka aditivne proizvodnje (e. Additive Manufacturing – AM) koja omogućava brzu izradu prototipova ili malih serija je postupak taložnog očvršćivanja (e. Fused Deposition Modeling – FDM) [1, 2]. Iako postoji veći broj različitih materijala dostupnih za preradu postupkom FDM, akrilonitril/butadien/stiren (ABS) jedan je od najčešće primjenjivih zbog dimenzijske stabilnosti i niske temperature staklastog prijelaza [2]. U posljednjih desetak godina postignut je značajan napredak u razvoju opreme i materijala, no određivanje mehaničkih svojstava tvorevina i utjecaja parametra 3D ispisa ovisno o primjeni još je uvijek u fazi istraživanja i razvoja [1, 3]. Uvidom znanstvene literature evidentno je da je malen broj studija o utjecaju parametara 3D ispisa na pritisnu čvrstoću, a što je od velikog značaja, jer mnoštvo primjenjivih tvorevina izrađenih postupkom FDM izloženo je baš pritisnim opterećenjem [3], u skladu s ciljem istraživanja u ovom radu [4]. Jedno od ograničenja 3D ispisa ABS-a postupkom FDM na stolnim 3D pisačima je ispis jednobojnih ili dvobojnih tvorevina, što otežava ispunjavanje zahtjeva visoke kvalitete reprodukcije, stoga se istražuju moguća poboljšanja 3D ispisa u boji [5, 6]. Iz pregleda znanstvenih radova proizlazi da ne postoji primjer studije o mogućnosti bojanja 3D tvorevina ispisanih FDM tehnologijom iz ABS a. U radu je ispitana mogućnost naknadnog bojanja 3D ispisanih tvorevina iz ABS-a disperznim bojama postupkom iscrpljivanja. Kako bi se dobili proizvodi s dodanom vrijednošću u području vizualnih efekata, dodatno je istražena i mogućnost postizanja ombre efekata. Postupci AM dovode do značajnih promjena u mnogim područjima, uključujući modnu industriju, a time i primjenu 3D ispisa u sektoru obućarstva [2, 4]. Istraživanja u radu provedena su s ciljem primjene na konačan proizvod, konstruiranje prototipa dijelova donjišta obuće, odnosno visokih potpetica ženskih cipela.

2. Eksperimentalni dio

Istražen je utjecaj parametara 3D ispisa (gustoća ispune, debljina sloja ispisa, temperatura ispisa) i geometrije ispune (ispuna saća i linearna pod kutom 45°) na mehanička svojstva (pritisna, savojna i žilavost) 3D ispisanih ispitnih tijela iz ABS-a. Ispitivanje mehaničkih svojstava provedeno je prema centralno kompozitnim planu pokusa s tri podesiva parametra prerade i dva različita geometrijska parametra. Određivanje pritisnih i savojnih svojstava izvršeno je na uređaju za ispitivanje mehaničkih svojstava Shimadzu AGS-x, maksimalne sile do 10 kN, a mjerenje žilavosti instrumentom za mjerenje energije udara s tzv. Charpyjevim batom. S pomoću računalnog programa Design Expert provedeno je optimiranje podesivih parametara prerade na temelju tzv. funkcije poželjnosti [4]. Ispitivanja savojnih i pritisnih svojstava i žilavosti ostvarena su propisanim normama: HRN EN ISO 178: 2011 Plastika - Određivanje savojnih svojstava, HRN EN ISO 604: 2003 Plastika-Određivanje pritisnih svojstava i HRN EN ISO 179-1: 2010 Plastika-Određivanje svojstava žilavosti po Charpyju.

Ispitana je mogućnosti bojenja 3D ispisanih ABS ispitnih tijela disperznim bojilima postupkom iscrpljenja s ciljem dobivanja jednoličnog obojenja dobre postojanosti te postizanja višebojnih efekata. S obzirom na kemijsku strukturu ABS-a ispitna tijela bojena su disperznim bojilima primarnih tonova (C.I. Disperse Yellow 3, C.I. Disperse Red 15 i C.I. Disperse Blue 27). Proces bojenja izveden je u uređaju za mokre obrade tekstila, tvrtke Mathis AG model Polycolor, a određivanje kolorističkih parametra remisijskim spektrofotometrom Spectraflash SF 600 plus + CV UV. Bojenje je sprovedeno uz omjer kupelji OK 1 : 30, pH 4 podešen je dodatkom 20 % octene kiseline, pri temperaturi 95 °C u vremenu od 60 minuta [4, 6].

Otpornost na habanje, ABS ispitnih tijela bojenih u masi i ispitnih tijela naknadno bojenih, ispitana je na habalici prema Martindaleu za ispitivanje otpornosti na habanje i sklonosti pilingu sukladno normi HRN EN ISO 12947-3: 2008. Prema ciljanoj namjeni konačnog proizvoda odabrane su i habajuće podloge na kojima su provedena ispitivanja, podloge za unutrašnje površine (linoleum i tepisoni od polipropilenskih i vunenih vlakana) te podloge različite finoće kojima se simuliraju vanjske površine [4].

Temeljem geometrije i dimenzija skeniranih CAD modela (kalup ženske cipele broj 37 i pripadajuća potpetica visine 75 mm) u računalnom programu Rhinoceros 5 konstruirani su CAD modeli prototipova potpetica, od jednostavnijih i prošupljenih do složenijih geometrijskih oblika. Provedbom utvrđenih optimalnih parametra 3D ispisa izrađeni su prototipovi potpetica [4]. Ispitna tijela i prototipovi potpetica izrađeni su postupkom FDM od ABS-a na stolnom 3D pisaču MakerBot Replicator 2X.

3. Rezultati i rasprava

Primjenom centralnog kompozitnog plana pokusa načinjena je analiza utjecaja tri podesiva parametra prerade 3D ispisa (debljina sloja ispisa, gustoća ispune i temperatura ispisa) i dva geometrijska parametra linearna ispuna pod kutom °45 (L45) i ispuna saća (S) na mehanička svojstva; savojna čvrstoća, modul savitljivosti, pritisna čvrstoća, modul pritisnosti i savojna žilavost. U tab. 1 prikazani su rezultati statističke obrade podataka analize mehaničkih svojstava. Tablica sažeto prikazuje utjecaj i trend utjecaja pojedinog podesivog parametra 3D ispisa na promatrana mehanička svojstva ispitnih tijela L45 i S.

Tablica 1: Utjecaj podesivih parametra 3D ispisa na promatrana mehanička svojstva

Parametar	**Savojna čvrstoća** σ_{fm} [N/mm²]		**Modul savitljivosti** E_f [N/mm²]		**Pritisna čvrstoća** σ_x [N/mm²]		**Modul pritisnosti** E_c [N/mm²]		**Savojna žilavost** a_{CN} [kJ/m²]	
	L45	**S**	**L45**	**S**	**L45**	**S**	**L45**	**S**	**L45**	**S**
Debljina sloja	↓	X	↑	↑↓	↓	↓	↓	↓	↑	↓↑
Gustoća ispune	↑	↑	↑	↑↓	↑	↑	↑	↑	↑	↓↑
Temperatura	↓	X	X	X	X	↑	X	↑	X	↓↑

↑/↓ - najznačajniji pozitivan/negativan utjecaj
↑/↓ - značajan pozitivan/negativan utjecaj
↑/↓ - najmanje značajan pozitivan/negativan utjecaj
X - nema utjecaja

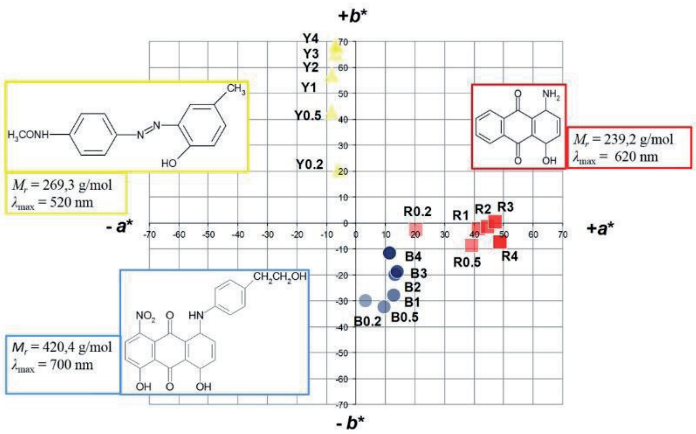
Iz tablice je vidljivo da je najutjecajniji faktor gustoća ispune. S porastom gustoće ispune rastu sva mehanička svojstva jer se povećava aktivni presjek koji na sebe preuzima opterećenja kojima su bila izložena ispitna tijela tijekom ispitivanja. Debljina sloja je sljedeći parametar po utjecajnosti, no njegov utjecaj na promatrana mehanička svojstva ispitnih tijela nije jednoznačan kao pri gustoći ispune. U pravilu, povećanje debljine sloja uzrokuje (blagi) pad promatranih mehaničkih svojstava, osim u slučaju modula savitljivosti L45 i savojne žilavosti kod ispuna saća, gdje je utjecaj suprotan. Najmanje utjecajni parametar 3D ispisa na promatrana mehanička svojstva je temperatura ispisa. Utjecaj temperature ispisa, na svojstva gdje je ona signifikantna, prikazuje složenu međuovisnost s ostalim parametrima ispisa. Rezultati bojenja ispitnih tijela iz ABS-a postupkom iscrpljenja, disperznim bojilima; Cibacet Yellow 2GC (Y), Cibacet Red 3B (R) i Foron Blue RD GLF (B) u gradijentu koncentracije bojila 0,2; 0,5; 1; 2; 3 i 4 % s obzirom na masu ispitnog tijela prikazani su u tab. 2.

Tablica 2: Ispitna tijela obojena bojilima Disperse Yellow 3, Disperse Red 15 i Disperse Blue 27

Koncentracija bojila s obzirom na masu ispitnog tijela (B_c, %)																	
0,2	0,5	1	2	3	4	0,2	0,5	1	2	3	4	0,2	0,5	1	2	3	4

Provedeno je objektivno vrednovanje obojenja ispitnih tijela prema CIEL*a*b* sustavu s ciljem određivanja kolorističkih parametara (*L**, *a**, *b**, *C**, *h*°).

Rezultati spektrofotometrijske analize uzoraka prikazani su kolorističkim parametrima prema CIE sustavu, remisijskim i K/S spektralnim krivuljama. Na sl. 1 prikazana je usporedna analiza ispitnih tijela žutog, crvenog i plavog tona u a*/b* prostoru boje.



Slika 1: a*/b* prostor boje ispitnih tijela žutog, crvenog i plavog tona

Na temelju dobivenih parametara boje, vrijednosti remisije i koeficijenta Kubelka-Munk, izvedene su mješavine bojila i ombre efekt kako bi se dobili šareni uzorci u željenim nijansama. Rotacijom 3D ispisanih ABS ispitnih tijela, odnosno promjenom smjera i vrste boje, ostvareni su različiti višebojni efekti, sl. 2.

Slika 2: Ombre efekti ispitnih tijela obojenih kombinacijom primarnih disperznih bojila

S gledišta umjetničke analize, budući da je konačna primjena dizajn obuće, može se reći da efekti pokazuju visok stupanj harmonične ravnoteže, a kombinacije boja u pozitivnom su kontrastu. Rezultati ispitivanja otpornosti na habanje ocijenjeni su određivanjem promjene mase nakon postupka habanja. Gubitak mase određen je na temelju razlike u masi nakon i prije habanja prema početnoj masi. Na temelju rezultata dobivenih s unutarnjim podnim oblogama, može se primijetiti da uzorci za ispitivanje imaju izvrsnu otpornost na trošenje te je njihova moguća primjena za izradu potpetica opravdana. S druge strane, rezultati ispitivanja otpornosti na habanje u vanjskim uvjetima pokazuju da su vanjski slojevi ispitnih uzoraka istrošeni sa značajno manjim brojem ciklusa (750), što je za očekivati s obzirom na hrapavost takvih čvrstih podloga. Rezultati pokazuju da su ispitna tijela obojena u masi (originalni ABS u boji) u prosjeku oko 10 % otpornija na habanje u usporedbi s uzorcima koji su naknadno obojeni disperznim bojama. Na temelju provedenog ispitivanja optimalnih parametara te uvidom u rezultate kompleksnog optimiranja oba tipa ispune, za 3D ispis potpetica iz ABS-a odabrana je linearna ispuna L45, debljina sloja 0,15 mm, gustoća ispune 40 % i temperaturi ispisa 205 °C. Izrađeni prototipovi potpetica su u suradnji s razvojnim timom Tvornice obuće *Ivančica d. d.* Ivanec ugrađeni u funkcionalne i nosive modele ženskih cipelasl. 3.

a. b. c. d.

Slika 3: Realizirani prototipovi ženskih cipela: a. prototip 1; b. prototip 2; c. prototip 3; d. prototip 4

Realizirani prototipovi potpetica od ABS-a kombinirani su klasičnim metodama industrijske proizvodnje u funkcionalan prototip ženske cipele, čime je dan znanstveni doprinos primjenom naprednih tehnologija u konstruiranju i izradi manjih serija 3D prototipova dijelova obuće ili personaliziranih modela cipela u okviru industrijske proizvodnje obuće.

4. Zaključak

Rezultatima ispitivanja je dokazano da geometrija ispune i parametri 3D ispisa ispitnih tijela iz ABS-a signifikantno utječu na pritisna i savojna svojstva te žilavost. Linearna ispuna rezultirala je u pravilu nešto višim svojstvima u usporedbi s ispunom saća, no razlike su vrlo male i moguće je zaključiti kako obje vrste ispuna rezultiraju zadovoljavajućim svojstvima. Dobivenim rezultatima bojenja 3D ispitnih tijela od ABS-a dokazano je da se ABS tvorevine mogu uspješno bojiti disperznim bojilima što potvrđuju visoke vrijednosti dubine bojenja za korištenih 4 % bojila. Utvrđeno je da se analizom objektivnih kolorističkih i spektralnih parametara boje mogu pratiti mehanizmi samog procesa bojenja čime se doprinosi postupku optimiranja procesnih parametara bojenja, optimiranja izbora bojila te razumijevanju mehanizama iscrpljenja i vezivanja bojila. Rezultati pokazuju da se 3D ABS proizvodi mogu proizvesti u jednoj ili više željenih nijansi sa zadovoljavajućom otpornošću na habanje. To nedvojbeno predstavlja dodatnu vrijednost 3D ABS materijala i proširuje njihovu primjenu, u doktorskom radu u području dizajna obuće.

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5. Literatura

[1] Calzado, M.; Romero, L.; Domínguez i sur.: Additive Manufacturing Technologies: An Overview about 3D Printing Methods and Future Prospects, *Complexity (*2019), 1-3, ISSN 1076-2787

[2] Gibson, I.; Rosen, D.; Stucker, B.: *Rapid Prototyping and Direct Digital Manufacturing*, Springer, ISBN 978-1-4939-2113-3, New York, (2015)

[3] Bakır, A. A.; Atik, R.; Özerinç, S.: Mechanical properties of thermoplastic parts produced by fused deposition modeling:a review, *Rapid Prototyping Journal,* **27** (2021) 3, 537-561, ISSN 1355-2546

[4] Kutnjak-Mravlinčić S.: *Utjecaj parametara 3D ispisa postupkom taložnog očvršćivanja i geometrije šupljikavih struktura na svojstva 3D ispisanih proizvoda od akrilonitril/butadien/stirena*, Doktorska disertacija, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb, Hrvatska, 2021.

[5] Chen, G. et al.: Color 3D Printing*, Color 3D Printing: Theory, Method, and Application, New Trends in 3D Printing*, InTechOpen, ISBN 978-953-51-2480-1, London, (2016), 25–51

[6] Kutnjak-Mravlinčić, S. et al: Innovative Development of Batch Dyed 3D Printed Acrylonitrile/Butadiene/ Styrene Objects, *Molecules,* **26** (2021), 21, 1-14, ISSN 1420-3049

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Naslov doktorskog rada

Analiza metalnih niti u povijesnom hrvatskom tekstilu od 17. do 20. st. - udio metala, sastav i struktura pređe

Mentori

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Datum obrane doktorskog rada

29. 10. 2020.

ANALIZA METALNIH NITI U POVIJESNOM HRVATSKOM TEKSTILU

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Sažetak: *Primjenom fizikalno-kemijskih metoda SEM-EDX (pretražna elektronska mikroskopija s energijsko disperzivnim detektorom X-zraka), XRF (rendgenska fluorescencija) i PIXE (inducirana emisija rendgenskog zračenja) provedena je analiza sastava i udjela metala u nitima. Analizirane su samostalne metalne niti žice i lamele te kombinirane, metalne niti omotane oko nemetalne tekstilne pređe, srme. Sastav i struktura nemetalne tekstilne pređe srma određeni su svjetlosnim mikroskopom. Cilj rada je utvrditi koje su vrste i sastavi metalnih niti korišteni u različitim regijama Hrvatske što može poslužiti kao baza podataka pri restauraciji i konzervaciji vrijednog povijesnog tekstila. Također, po sastavu metalnih niti mogu se odrediti tehnologija izrade niti i približno vremenska i prostorna datacija tekstilnih predmeta. Usporedbom metoda utvrđeno je kako je SEM-EDX najpogodnija za analizu povijesnog tekstila ukoliko se radi i analiza poprečnog presjeka kojom se utvrđuje da li su metalne niti homogene, pozlaćene ili posrebrene.*

1. Uvod

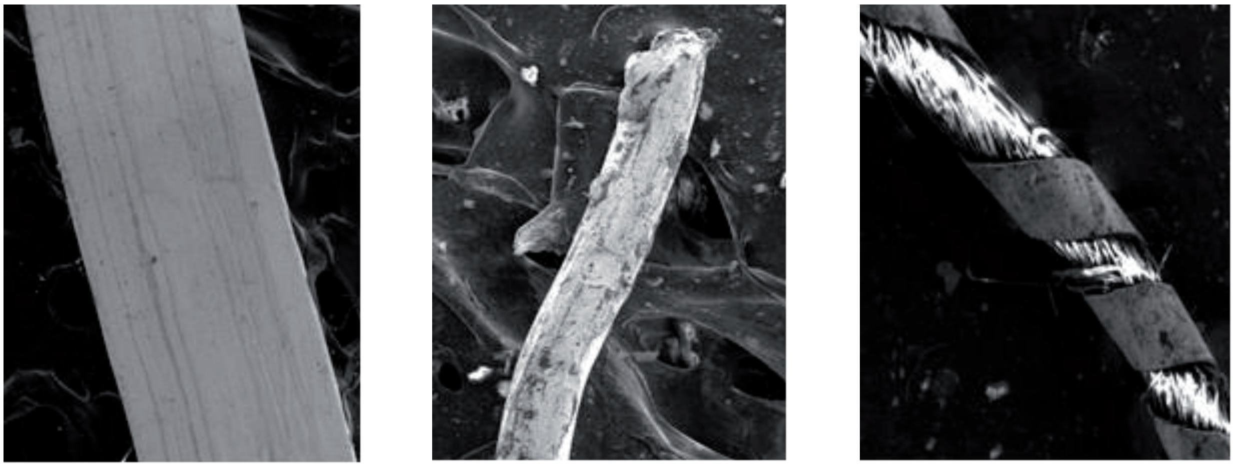
Dragocjeni metali koriste se za dekoraciju tekstila od antičkog doba kako bi se stvorili luksuzni predmeti za svjetovne potrebe i religijsku elitu. Metalne se niti pojavljuju u dva oblika, kao samostalne ili omotane oko nemetalne tekstilne pređe, kod nas je općepoznata pod nazivom srma. Tekstilno-metalna pređa (srma) dobiva se tako da se metalna nit spiralno omata oko nemetalne tekstilne pređe koja čini jezgru, srž ili “dušu”. Nemetalna tekstilna pređa može biti od celuloznih vlakana (lan, pamuk, konoplja) ili proteinskih (svila, vuna). U drugoj polovici 20. st. javljaju se i sintetička vlakna najčešće u mješavini s prirodnim. Metalna nit sastoji se od zlata, srebra ili bakra te od njihovih legura. Aluminij se počinje koristiti u drugoj polovici 20. st., njegov srebreni sjaj u potpunosti može imitirati srebro, a posebnim postupkom može dobiti zlatnu boju [1-5]. Svrha metalnih niti u tekstilu od početka pojavljivanja bila je pokazivanje moći, bogatstva i časti. U svečanim narodnim nošnjama označivale su društvenu ulogu i pokazivale su radi li se o svečanoj, obrednoj ili nekoj drugoj prigodi. Vrijedni liturgijski tekstil ukrašen sjajnim metalnim nitima služi kako bi se izrazila slava Božja. U novije vrijeme metalne niti imaju i neke nove uloge poput ojačavanja materijala ili zaštite od statičkog elektriciteta ili elektromagnetskog zračenja [1]. Analiza je provedena na hrvatskom povijesnom tekstilu iz više relevantnih hrvatskih muzeja i riznica. Uz posebno dopuštenje konzervatora-restauratora njihov nadzor i suradnju izdvojene su, bez narušavanja cjelovitosti predmeta, potrebne niti za istraživanje. Analizirano je 156 uzoraka s tri fizikalno-kemijske metode (SEM-EDX, XRF i PIXE) kako bi se s većom pouzdanošću, što točnije, moglo utvrditi u kojem su postotku pojedini metali zastupljeni u uzorcima. Provedena je detaljna analiza prikupljenih uzoraka metalnih niti i srma s povijesnog tekstila (narodne nošnje i liturgijsko ruho) iz područja cijele Hrvatske. Na taj način stvorena je referentna baza podataka i poboljšana analitička metoda za određivanje ove vrste uzoraka. Sadržaj metala u metalnim nitima određuje njihova svojstva, svrhu i podrijetlo, stoga je fizikalno kemijska analiza vrlo važan korak pri njihovoj karakterizaciji. Analiza metalnih niti u povijesnom tekstilu omogućuje također i pravilan odabir metoda čišćenja, konzervacije i restauracije starih, povijesno vrlo vrijednih tekstilnih materijala.

2. Eksperimentalni dio

Prva faza istraživanja, prikupljanje uzoraka, zahtijevala je detaljno planiranje posjeta muzejima i crkvenim riznicama diljem Hrvatske. Svrha posjeta raznim ustanovama u Hrvatskoj bila je pregledavanje povijesnog tekstila, narodnih nošnji i liturgijskog ruha i po mogućnosti izdvajanje uzoraka metalnih niti. Uzorci su dobiveni s predmeta gdje je bilo moguće uzorkovanje bez oštećenja vrijednog povijesnog tekstila. Nakon prikupljanja uzoraka slijedila je njihova detaljna obrada, vizualni pregled i analiza metalnog te nemetalnog dijela (srži) kod srma. Metalne niti analizirane su SEM-EDX uređajem, a jedan dio uzoraka metalnih niti analiziran je i XRF te PIXE metodama prvenstveno zbog razrade i izbora analitičke metode ispitivanja. Površina i poprečni presjeci analizirani su SEM-EDX uređajem kako bi se ustanovilo kakva je vrsta metalnih niti, homogena ili slojevita. Srž srma analizirana je svjetlosnim mikroskopom, te je utvrđeno od kojih je vlakana napravljena.

Materijali korišteni u ovom radu povijesni su tekstili, tj. različiti predmeti liturgijskog ruha i narodnih nošnji, iz kojih su izdvojeni uzorci metalnih niti i srma za analizu. Predmeti liturgijskog ruha dobiveni su iz Riznice zagrebačke katedrale (14 uzoraka), Gradskog muzeja Varaždin (18), Zavičajnog muzeja iz Prilišća (16), Zavičajnog muzeja iz Novigrada kod Zadra (16) i Muzeja Slavonije Osijek (9). Predmeti narodnih nošnji dobiveni su iz Etnografskog muzeja Zagreb (26 uzoraka), Sinjske alke iz Sinja (8), Etnografskog muzeja Split

(16), Etnografskog muzeja Dubrovnik (18) i Muzeja Slavonije Osijek (15). Pažljivim uzorkovanjem samo visećih niti dobili su se relativno mali uzorci samostalnih metalnih niti (lamela i žica) te srma, sl. 1.



a. b. c.

Slika 1: Tri različite metalne niti analizirane SEM-EDX-om: a. lamela; b. žica; c. srma

SEM-EDX analiza provedena je koristeći Tescan MIRA FE-SEM uređaj, s radnim naponom od 20 kV i radnom udaljenosti od 25 mm. Tip EDX detektora je SDD (Silicon Drift Detector) tj. silicijski detektor koji vrši detekciju u vakuumu od bora do urana. XRF analiza je rađena na uređaju tipa Artax, proizvođača Bruker, opremljen Rh anodnom rendgenskom cijevi, korišteni napon bio je 50 kV, a jačina struje elektronskog snopa 0,7 mA. SDD detektor od XRF-a provodi analizu metala na zraku čime su moguća onečišćenja iz zraka, a može detektirati elemente od kalija do urana. Karakteristično rendgensko zračenje iz PIXE uređaja pobuđeno je protonima od 2 MeV. Korišteni su protoni iz Tandetron akceleratora od 1 MV te su fokusirani pomoću sustava magnetskih leća koji se nalaze na ionskoj mikro probi akceleratorskog centra. Mjerenja su napravljena u vakuumu koristeći detektor rendgenskoga zračenja PGT Si(Li). Također je korišten svjetlosni, uspravan i transmisijski mikroskop Olympus cx22 koji je pogodan za analizu sirovinskog sastava nemetalnih tekstilnih pređa kod srma. Analiza se vršila pod povećanjem 10 x okulara, 10 x objektiva te je ukupno povećanje 100 x.

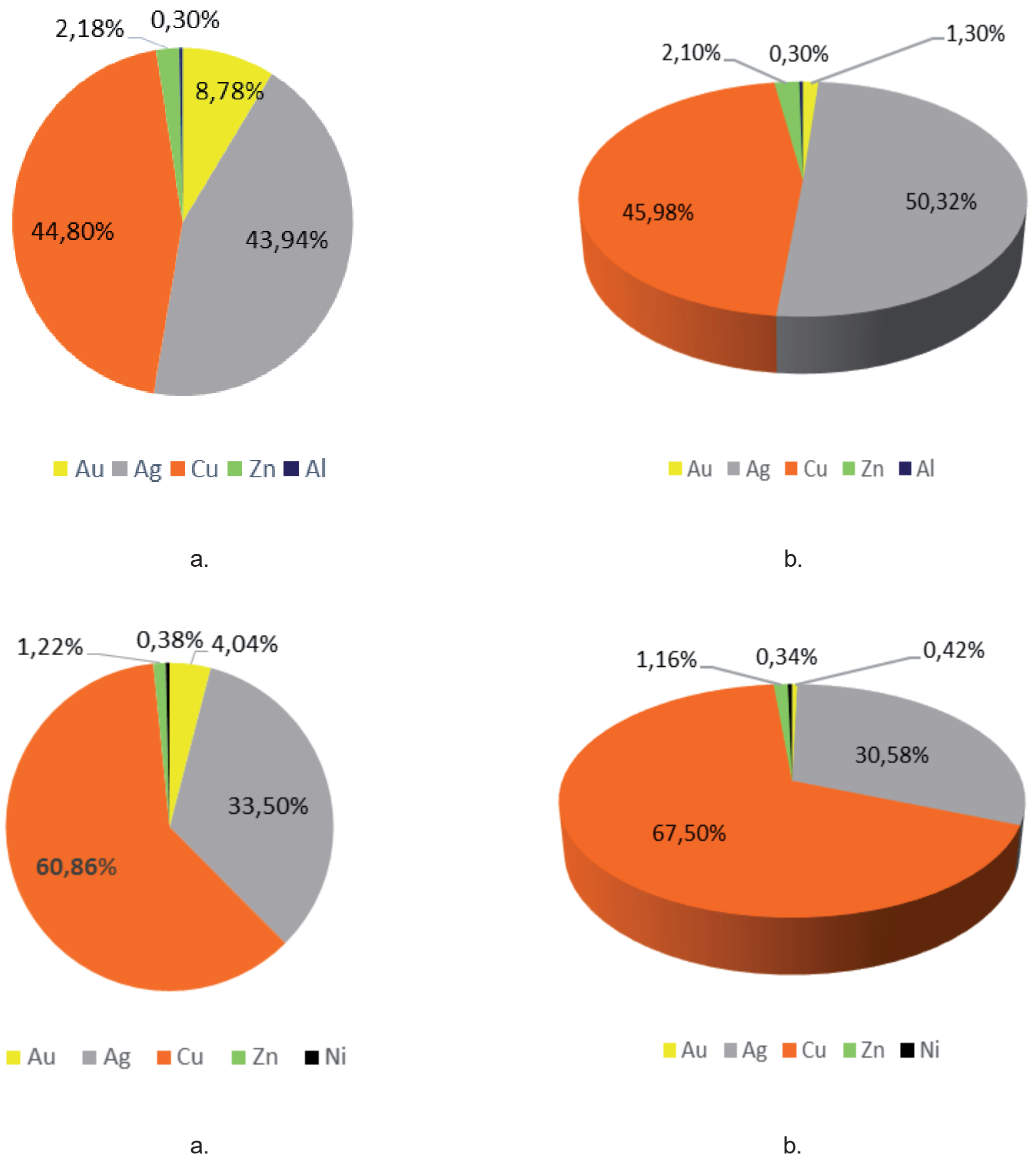
3. Rezultati i rasprava

Analizom srma utvrđeno je kako su svila i pamuk sastavni dio srži srma s narodnih nošnji, dok se lan, uz svilu i pamuk nađen je samo kod srma s liturgijskog ruha i to iz Varaždina i iz Novigrada. Kod srma iz Riznice zagrebačke katedrale nađena je isključivo svila. Tablica 1 pokazuje vrste metalnih niti po mjestu pronalaska za liturgijsko ruho i narodne nošnje, uočava se kako prevladavaju srme dok žica ima najmanje. Glavna razlika između kemijskog sastava metalnih niti s narodnih nošnji i onih s liturgijskog ruha što se kod nekih niti s narodnih nošnji pojavljuje nikal, a kod nekih niti s liturgijskog ruha aluminij. Međutim, ti su elementi minimalno zastupljeni u uzorcima legura s manje od 0,50 %. Primjećuje se kako zlata i srebra ima više na nitima liturgijskog ruha i na površini i u poprečnom presjeku, u skladu s tim bakra ima manje. Bakar i srebro su najzastupljeniji elementi na metalnim nitima. Cink se pronalazi samo na nekim nitima, zastupljenost se kreće od 1 do 3 % i ima ga više na metalnim nitima s liturgijskog ruha, sl.1 i 2. Uzorci iz Riznice zagrebačke katedrale su najvrjedniji, to su čiste srebrene niti ili niti od pozlaćenog srebra, ujedno su i najstarije niti, datiraju iz razdoblja od 17. do 18. st. Uzorci iz Muzeja Slavonije Osijek su najslabije kvalitete, prevladava bakar kao metal, a zlata i srebra ima najmanje i to samo na površini, to su najstarije niti iz 20. st.

Tablica 1: Vrste metalnih niti po gradovima za liturgijsko ruho i narodne nošnje

	Liturgijsko ruho					Narodne nošnje				
Metalne niti	Zagreb	Varaždin	Prilišće	Novigrad	Osijek	Zagreb	Sinj	Split	Dubro-vnik	Osijek
Lamele	3	7	3	4	1	-	2	5	-	1
Žice	-	1	2	-	2	6	-	3	-	2
Srme	11	10	11	12	6	20	6	8	18	12
Ukupno	14	18	16	16	9	26	8	16	18	15

Slike 2 i 3 prikazuju sastav metalnih niti iz liturgijskog ruha i narodnih nošnji i to njihovu površinu i poprečni presjek.



Slika 3: Sastav metalnih niti iz narodnih nošnji: a. površina; b. poprečni presjek

4. Zaključak

Među analiziranim uzorcima najmanji broj niti je napravljen od čistog srebra ili bakra s obzirom na to da s vremenom potamne i gube sjaj. Nešto više ima legura, a to su većinom legure bakra i cinka, jer su otpornije na koroziju. Najviše je niti koje su dvoslojne, tj. imaju neku vrstu pozlate. Najčešći i osnovni metali su srebro ili bakar presvučen plemenitijim metalom zlatom ili srebrom. Pamuk prevladava kod srži srma, dok se svila koristi kod srma s vrjednijom metalnom niti te se pronalazi kod svih uzoraka iz Riznice zagrebačke katedrale. Sastav metalnih niti mijenjao se vremenom, tako postoje dvije skupine uzoraka; jedna iz 17. i 18. st., a druga iz 19. i 20. st. Uzorci iz 17. i 18. st. bogatiji su zlatom i srebrom, te imaju nešto i bakra. Noviji uzorci metalnih niti iz 19. do 20. st. većinom su bakreni ili od njegove legure s cinkom te rjeđe niklom.

Usporedba korištenih metoda upućuje da je kod metode SEM-EDX, potrebno napraviti analizu površine i poprečnog presjeka jer elektroni ne prodiru dublje od 1 µm u uzorak. Prednost je mogućnost slike uzorka. Kod PIXE metode, protoni prodiru do 20 µm u uzorak te se dobije preciznija kvantitativna analiza uzorka, ali se ne može dobiti slika uzorka. Kod metode XRF, RTG zrake prolaze kroz cijeli uzorak (100 - 200 µm) nije ih moguće fokusirati kao elektrone od SEM-EDX i protone od PIXE. Precizna kvantifikacija je problem jer nema odgovarajućih standarda, te je korisno kombinirati metode SEM-EDX i PIXE jer se dobije najviše informacija o uzorku, dok se XRF može koristiti za brzu selekciju većeg broja uzoraka.

Literatura

[1] Šimić, K.; Soljačić, I.; Pušić, T.: Primjena srme u Hrvatskoj od 11. do 20. stoljeća, *Tekstil*, **62** (2013) 3-4, 101-111, ISSN 0492-5882

[2] Raffaelli, D.; Čunko, R.; Dragičević, M.: Istraživanja srme s tla Dalmacije u razmaku od tisuću godina, *Tekstil*, **31** (1982) 12, 827-838, ISSN 0492-5882

[3] Rezić, I.; Ćurković, L.; Ujević, M.: Simple methods for characterization of metals in historical textile threads, *Talanta*, **82** (2010) 1, 237-244, ISSN 0039-9140

[4] Soljačić, I.; Čunko, R.: Hrvatski tekstil kroz povijest, *Tekstil*, **43** (1994) 11, 584-602, ISSN 0492-5882

[5] Járó, M.; Tamás, G. & Tóth, A.: The characterization and deterioration of modern metallic threads, *Studies in Conservation*, **45** (2000) 1, 95-105, ISSN 2047-0584

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SUVREMENA MODA KAO DOGAĐAJ – NOVI MEDIJI I PREOBRAZBE TIJELA

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Sažetak: *U doktorskoj disertaciji 'Suvremena moda kao događaj – Novi mediji i preobrazbe tijela', uspostavio se nužan interdisciplinaran odnos između područja i pojma suvremene mode koja se pojavljuje nakon 1980-ih godina 20. stoljeća, novih medija kao nove mogućnosti razvoja modnog procesa i događaja te njihova značajna utjecaja na razumijevanje mode i teorija mode nakon postmoderne kao nove vizualne semiotike. Ova disertacija u istraživačkom i znanstvenom smislu, razvila je tezu kako suvremena moda ne opstaje bez utjecaja medija na tijelo i odjevni objekt te istovremeno mijenja logiku djelovanja u virtualnom svijetu na način da se moda slika pojavljuje na zaslonu medijskih ekrana kao nova slika, ali i u performativnom obliku kao moda-tijelo. Rad je također pokazao mogućnosti suvremene mode i načine reprezentacije tijela u modi kroz ulogu novih medija i izvedbenih umjetnosti. Suvremena moda se pojavljuje medijski kao reinterpretacija i reizvedba događaja.*

1. Uvod

U okviru teorija mode, suvremena moda predstavlja značajno područje u okviru interdisciplinarnih društveno-humanističkih znanosti. Osim što daje uvide u procese nastanka novih identiteta, nudi i precizan opis stanja mode, u teorijskom i praktičnom smislu, od 1980-ih godina do danas. U ovom doktorskom radu razmatra se utjecaj teorija izvedbe (*performance studies*) i teorija novih medija (*new media studies*), s obzirom na složenost i specifičnost onoga što nazivamo suvremenom modom u analogiji sa suvremenom umjetnošću. Razlika između teorija mode koje se bave vlastitim predmetom (kao što je to suvremena moda), u odnosu na teorije izvedbe i nove medije proizlazi iz sinkretičke naravi područja koje ima svoju uvjetnu autonomiju, a ona se izvodi iz razumijevanja biti suvremene mode kao transformacije ljudskog tijela u društvu, kulturi, politici i umjetnosti. Zato se teorije mode ne mogu više smatrati primijenjenim diskurzivnim analizama sociologije, antropologije, povijesti umjetnosti, psihologije. Isto vrijedi i za procvat već spomenutih teorija izvedbe i medijskih studija, u smislu interdisciplinarnih pristupa tijelu, u procesu nastanka njegova sveobuhvatnoga značenja za ljudsku egzistenciju u suvremenom svijetu. Razlog sve veće teorijske težnje za uvidom u događaj kojim se odijevanje i moda pojavljuju pokazateljem novog identiteta čovjeka u suvremenosti proizlazi iz sklopa globalizirane ekonomije, politike i kulture kao uvjeta mogućnosti priznanja dosad nepriznatih svjetskih kultura, ali isto tako i težnje za prelaskom granica u shvaćanju tijela u njegova tri načina pojavljivanja – fizičkom, simboličkom i vizualnom. Suvremena moda je autonomna, jer u potpunosti oslobađa tijelo, a to su joj omogućili novi mediji i nova konstrukcija modne izvedbe. Njezina autonomnost rezultat je pada društvenih i kulturalnih zakona i zabrana, dok je teorija mode istodobno ne-autonomna zato što "modu nije moguće razumjeti samo iz jedne znanstvene paradigme" [1]. Stoga je glavni cilj ovog rada bio razviti dvije osnovne teze koje su izvedene u dva dijela:

(1) Moda proizlazi iz nasljeđa semiotike i strukturalizma francuskog teoretičara Rolanda Barthesa i njegova organiziranog sustava jezika mode. Pritom se u interpretaciji više ne inzistira na vladavini jezičnih označitelja, već se obrat zbiva u analizi područja mode - slike. Korak prema konceptu suvremene mode, kao izvedbenog događaja, proizlazi iz promjene koja se odigrava u dekonstrukciji samoga sustava mode početkom 1990-ih godina. U svim aspektima odnosa između novih medija i mode na djelu je interaktivnost, prelazak u metamorfna stanja u kojima se pomiče granica između živog tijela i estetskog objekta mode i, posljednje, ali ne manje važno, stvaranje novih formi tjelesnosti kao hibridnih tvorbi nastalih invencijom tehnoznanosti i kreativnosti suvremene umjetnosti. Područje semiotike mode ključno je za razumijevanje nastanka mode kao pismovnog i stvarnog odjevnog objekta. U razdoblju između 1957. i 1969. godine Roland Barthes razvio je teorijski sustav koji se bavi područjem modnih kodova u korelaciji s jezikom. Njegovo ključno djelo iz 1967. godine pružilo je iscrpnu metodu čitanja modnih fotografija, ali i razvoja pojma intencionalnosti reklamne slike. U reklami se dolazi do istraživanja slike i njezinog značenja. Retorika slike, za Barthesa, ima prevlast nad slikom kao ikoničkim znakom. Kompleksan jezik tijela koji Barthes naziva *vêtement* postaje modna sintaksa.

Odnos između slike i jezika, međutim, ne znači i prevlast jezika nad slikom, već je riječ o međusobnom djelovanju u kojem upravo slika upućuje na nove granice značenja i označivanja. Barthesova semiologija, koja se u konačnici bavi odnosom slike i jezika, važna je za istraživanje novijih teorija mode u sklopu suvremene mode, kao diskursa revitalizacije i neohistoricizma u postupku stvaranja novoga, jer se istražuje značenje slike koja u vizualnom kodu postaje istodobno lingvistička, ikonička i simbolička forma, a ne više samo puka poruka u linearnom nizu od pošiljatelja do primatelja.

(2) U referenciji na područje modne fotografije kao novog vizualnog eseja [2], kojoj će biti posvećeno zasebno poglavlje, želi se plastično pokazati i dokazati zašto vladavina slikovnog u tjelesnom događanju ideje suvremene mode, kao eksperimenta s egzistencijalnim činom slobode individuuma, označuje ujedno i spektakularno polje fascinacije promatrača i učinak posvemašnje derealizacije modnog objekta. Modna fotografija, također, ne služi samo kao vizualizacija modnog arhiva, već se veže uz uočavanje nove vrste potrošnje [3]. Novu klasifikaciju potrošnje postavio je i John Berger, govoreći upravo o odijelu i fotografiji u svom eseju *The Suit and the Photograph* (1979). Berger je, promatrajući fotografije Augusta Sandera (1876-1964), uočio jasnu razliku između mode i njezinih protagonista. Moda se pojavljuje kao distinkcija između onih koji imaju kupovnu moć i onih koji je nemaju, kako su klasno-socijalne teorije mode i tvrdile. Ipak, modna fotografija, kao hibridni žanr između umjetničke fotografije i reklamne slike, u doba najznačajnijih modnih fotografa (primjerice, poput Helmuta Newtona), jasno je ukazivala na glavni fenomen onoga što modno tijelo i danas u digitalnom okružju izaziva i konstruira. Naravno, posrijedi je fetišizam objekta koji psihoanaliza Sigmunda Freuda i Jacquesa Lacana pronalaze u jazu između prirode i kulture, odnosno imaginarnog i simboličkoga. Približiti se tajni modne fotografije i njezinom začaravajućem utjecaju na poklonike i ljubitelje mode, nesumnjivo znači otvoriti problem sveze između suvremene mode i fetišizma, s obzirom na mogućnosti koje podaruje digitalna slika; poznato je da je Baudrillard, još u ranoj fazi svoga mišljenja, taj odnos nastojao promisliti s pomoću pojmova opscenosti, slike, žudnje za objektom i hiperrealnošću događaja. Ono što suvremenu modu čini atraktivnom i ujedno simuliranim događajem fascinacije slikom, zacijelo, više nije socijalno-kritička analiza kapitalizma potrošnje na najvišoj razini u povijesti ikad. Umjesto toga, potrebno je krenuti od onoga što žele gotovo svi modni editorijali. A to, očito, može biti samo ono što spaja sliku kao informaciju sa slikom kao komunikacijom - želja za stapanjem s objektom žudnje na način ekstatičnog doživljaja užitka, koji Lacan smješta u skopičko polje viđenja [4].

2. Eksperimentalni dio

Suvremena moda radikalni je ikonoklazam koji razara logičku strukturu vremena zahvaljujući medijima. Ona prethodi aktualitetu, ali ga i uključuje. Usprkos velikom utjecaju raznolikih društvenih formi na modu nakon 1990-ih godina, razaznajemo samostalno razvijen sustav jezika i slike kao nove mode. To nikako ne znači da prijašnja razdoblja u izučavanju povijesti mode i njezinih teorija nisu relevantna, već da se moda sada ostvaruje kao primat slike nad jezikom medijskom konstrukcijom stvarnosti. Bit suvremene mode pokazuje se težnji za estetizacijom ljudskoga tijela. Taj je proces započeo s postmodernom modom i tezom o kraju mode u djelu francuskog filozofa i sociologa Jeana Baudrillarda (1976.). Od 1960-ih godina do početka 1990-ih u društveno-humanističkim znanostima svjedočimo o pokušaju da se novim pojmovima dekonstrukcije, razlike, drugosti, diseminacije, konteksta, simulakruma opiše ulazak u novo razdoblje svijeta koji više ne počiva na kontinuitetu razvitka, nego na diskontinuitetu i rezovima, na nemogućnosti fiksnoga identiteta pojedinaca i skupina. Postmoderne teorije zasigurno su pomogle u razumijevanju mode kao strukturiranog vizualnog jezika, zahvaljujući prije svega francuskim teoretičarima Gillesu Lipovetskom (1987.) i Jeanu Baudrillardu (1967.). Oni su istodobno pridonijeli razvoju ovog interdisciplinarnog humanističkog područja inovativnim pristupom modi u cjelini drukčijeg shvaćanja kulture i medija. Stoga u ovom istraživanju, jednim dijelom, preuzimamo njihove epistemologijske pristupe - u kontekstu postmodernih teorija mode, ali isto tako i Rolanda Barthesa u okviru semiotike mode i organizacije modnog jezika u sustavu, ali još više u istraživanju reklamne slike u slučaju modne fotografije. Barthes je nesumnjivo najzaslužniji za stvaranje pojma modnog jezika i onoga što se naziva odjevni kod. Da bismo razumjeli kako se stvara odjevno značenje koristimo izraz odjevni kod. Ono što je Lipovetsky, pak, teorijski inovativno postavio odnosi se na jasne strukture koje naglašavaju disperziju i dislokaciju mode, upravo ono što određuje suvremenu modu u globalnom poretku neoliberalnog kapitalizma, ali uz sociološki predznak postmoderne mode. Drugo je, pak, gubitak i mode, i njezina identiteta, unutar novonastalih društvenih struktura. No, pitanja o modi upućuju na pokušaj očuvanja samoga modnog fenomena unutar modernog društva. Lipovetsky jasno naznačuje kako forma dovršene mode nema više epicentra i djeluje u različitim područjima na različitim razinama kolektivnog života. Novi mediji ukidaju epicentar mode, jer je logika njihova djelovanja mreža bez dubine i granice. Nedvojbeno je da je za ulazak u razdoblje, ili paradigmu, postmoderne mode potreban pronalazak novih pojmova primjerenih sve većoj potrošnji, slobodi u stiliziranju života pojedinca u liberalno-demokratskoj kulturi Zapada (SAD-a i Europe posebno). Ono što Lipovetsky naziva otvorenom modom, ili dovršenom formom mode, odnosi se na prestanak važenja čitave strukture modernog načina artikulacije društvenih odnosa.

3. Rezultati i rasprava

Suvremenu modu u analogiji s konceptualnom i performativnom umjetnošću kraja 20. stoljeća određuje tjelesnost u svim aspektima pojavljivanja. Tijelo se više ne može razumjeti tek kao funkcija, ili struktura, neposrednog djelovanja čovjeka u unaprijed postavljenom svijetu, nego kao autonomno događanje u mreži slikovne reprezentacije. Moda otuda označuje vizualnu konstrukciju tijela kao događaja i time se pokazuje nesvodivim fenomenom životnoga stila (*lifestyle*) u društvima spektakla današnjice. Suvremena moda može biti jedino medijski konstruirana, no time nastaju neke negativne posljedice za modu i njezino tijelo. Kako je precizno odredio Baudrillard, tijelo postaje metastazirano, ono koje ima mogućnosti beskonačne mijene, ali izraz je izvorno vezan uz nastanak smrtonosne bolesti, što unaprijed svodi bit tijela na nužnost stvaranja obrambene mreže protiv zloćudnih utjecaja iz okoline [5]. Moda se stoga u doba novih medija zbiva u ciklusima koji se vrtoglavo izmjenjuju. Potrebno je naglasiti kako su se ciklusi u modi izmjenjivali već početkom 20-ih godina u prikazivanju kolekcija. Ono što je Baudrillard uočio već krajem 1970-ih godina jest da se radi o svojevrsnoj promjeni paradigme cjelokupnog društva. Teza o kraju mode kao kraju društva u kojemu nestaju proturječja i binarne opreke rada i kapitala dovela je do radikalno drugačijeg razumijevanja pojma mode. *Kraj mode* označuje, dakle, kraj dotadašnjeg razumijevanja mode i modnog sustava 19. i 20. stoljeća, iako se i dalje vodimo temeljnim pojmovima koje je postavio Baudrillard. Moderna moda, nasuprot suvremenoj, pojavljuje se kao *ready-made*, dok se suvremena moda iskazuje u performativnom aktu kao estetizirani događaj [1]. U tom smislu nužno je pokazati zašto se moda sada objašnjava polazeći od pojma razvitka tehnološke osnove novih medija, a ne od nesvodive biti suvremene umjetnosti. Dakle, *ready-to-wear* postaje *ready-to-work,* jer se polazi od tehnologije i njezina utjecaja na odjevni objekt i tijelo.

4. Zaključak

Ovaj doktorski rad imao je za nakanu povezati pojam izvedbe u kontekstu modnog tijela i njezina događaja unutar medijskog prostora. Istraživanje mode veoma je važno za izvedbene studije (*performance studies*), jer predstavlja svojevrsno stjecište svih vrsta umjetnosti. Spaja pritom glumu, ples, akrobaciju i predstavlja svojevrsni fizičko-umjetnički teatar, posebno u neohistoricističkim izvedbama modnog dizajnera Johna Galliana i njegovim kolekcijama nastalim 1997. godine, u kojima je vidljivo spajanje elemenata brikolaža i pastiša. Ovaj doktorski rad imao je zadaću raščlaniti pojam modnog tijela, objekta i procesa u području teorija izvedbe, kao i pojam modnog događaja koji zamjenjuje reprezentaciju mode kao modne kolekcije. Nije to tek puka promjena mjesta označivanja, govoreći semiotički. Modna kolekcija uvijek nešto/nekoga predstavlja, ima jasno određenu namjeru, upravo onu o kojoj govori Barthes u ogledu Retorika slike, kada kaže da je namjena reklamne slike intencionalna, što znači da komercijalnost proizvoda određuje u konačnici značenje slikovnog sadržaja. Moda kao izvedbeni događaj upućuje na složenost performativnih praksi koje su se razvile od 1990-ih godina do danas. Ovdje, svakako, treba istaknuti da je premještanje težišta s reprezentacije na konstrukciju/dekonstrukciju samog događaja, kao primjerice u kritici društva spektakla i narcizma u McQueenovoj reviji *Voss* (2001.), neizbježan put promišljanja o daljnjim mogućnostima ove dematerijalizirajuće mode koja ulazi u život suvremenog čovjeka poput "sablasti" i čini ga estetski profiliranim korisnikom-potrošačem svih iluzija i blagodati društva hiperpotrošnje, kako to u svojim analizama pokazuje jedan od najznačajnijih teoretičara mode Gilles Lipovetsky. Naposljetku, ovaj je rad nastojao sagledati uvjete pod kojima nastaje suvremena moda, kao i u kojem se kontekstu odigrava njezin razvitak. To je izvedeno u preuzimanju pojmova iz druga dva ključna područja (teorije medija i teorije izvedbe), uz jasno isticanje autonomije teorija mode. Interdisciplinarnim pristupom, dospjeli smo do sinteze fotografije i filma s modom, što se pokazalo ključnim za razumijevanje vizualnosti i medijalnosti mode. S druge strane, izvedbenost modnog diskursa pokazuje se prekretnicom za razumijevanje biti suvremene modne prakse. Razlika između mode i prakse unutar sklopa suvremenosti proizlazi iz drukčijeg poretka ili ranga pojmova. Sada, naime, slika prethodi jeziku, što u semiotičkom smislu označuje novi poredak značenja. Simboličko značenje mode danas jest ponajprije u tome što se ona ne odnosi više na referencijalni okvir modernog društva i postmoderne kulture. U prvom slučaju moda je još uvijek bila ovisna o izvanjskim čimbenicima integracije u zadani društveni okvir patrijarhalnog poretka vrijednosti; u drugom, pak, sve je usmjereno ideji jednakosti i slobodi nepokorenog tijela pojedinca (demokratizacija mode kao antimode i prevlast marginalne diferencijacije). Ono što je autonomna značajka suvremene mode pokazuje se u događaju izvedbe tijela kao zbivanja onog traumatskog i opscenog, estetski zavodljivog i narcistički konstruiranog sebstva koje uranja u svijet mode kao u svoje ‘prirodno’ okružje, jer sve je u izvedbi, a ništa u reprezentaciji, odavno nestalih društvenih figura ranog kapitalizma. Suvremena moda označuje konačnu sintezu vizualnosti i događajnosti. Sve što vidimo istodobno se događa u virtualnoj aktualizaciji, a ona određuje stvarnost kao vizualnu konstrukciju mode. Stoga moda koju gledamo ne mora nužno biti moda koju nosimo, no zasigurno će biti moda koju strasno želimo gledati, ako nam već nije dano da njome ukrašavamo vlastito tijelo. Najznačajnija ostvarenja suvremenih modnih dizajnera poput McQueena, Galliana, Chalayana, Owensa i van Herpen, neprestano nas podsjećaju da se čarolija i moć mode ostvaruju u spektakularnoj izvedbi tijela u događaju. Od mode, kao i od svijeta, na kraju ostaje katalog fascinantnih slika, čista vizualizacija života kao estetskog užitka.

Literatura

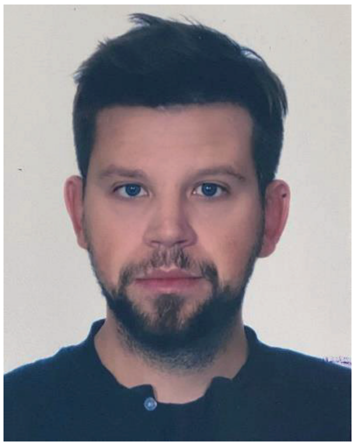
[1] Paić, Ž.: *Vrtoglavica u modi: prema vizualnoj semiotici tijela*, Altagama, ISBN 978-953-6934-30-0, Zagreb (2007)

[2] Shinkle, E.: *Fashion As Photograph: Viewing and Reviewing the Images of Fashion*, I. B. Tauris&Co Ltd, ISBN: 9780755696420 0755696425, London (2008)

[3] Radner, H.: *Fashion Cultures, Theories, Explorations and Analysis*, Routledge, ISBN 1136295445, 9781136295447, London (2000)

[4] Lacan, J: *Četiri temeljna pojma psihoanalize*, Naprijed, ISBN 9788634900255, Zagreb (1986)

[5] Baudrillard, J.: *Simulacija i zbilja,* Jesenski i Turk, ISBN 978-953-222-654-6, Zagreb (2001)



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Ivan Beritić rođen je 1989. godine. Završio je diplomski studij Tekstilna tehnologija i inženjerstvo, smjer Industrijski dizajn tekstila na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 2019. godine. Tijekom studija radio je kao industrijski dizajner, audio inženjer, te obavljao kustoske aktivnosti u galeriji ULUPUH. Trenutno je zaposlen kao asistent na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu u Zavodu za tekstilnu kemiju i ekologiju, gdje drži vježbe iz predmeta Osnove teorije boje, Osnove metrike boje, Specijalne metode tiska, Bojadisanja i tiska i Tekstilnog tiska.

Naslov doktorskog rada

Studijski savjetnik prof. dr. sc. Martinia Ira Glogar

Datum obrane teme doktorskog rada

KONTINUIRANI SLIKOTVORNI TISAK NA PREĐU

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Sažetak: *Predstavlja se ideja kontinuiranog tiska pređe s novitetom raščlanjivanja slike na integralne dijelove te pozicioniranja i otiskivanja svakog najmanjeg dijela slike na pređu, tako da se kasnijim uvođenjem pređe u sustav redova i nizova tj. pletivo, kreira cjelovita slika. Svaka od navedenih faza - raščlanjivanje slike, tisak, pletenje - mora biti računalno vođena i precizno programirana kako ne bi došlo do pogreške u realizaciji slike u kasnijoj fazi pletenja. Cilj je razviti princip prstenastog otiskivanja pređe, te ispitati određene aspekte primjene sublimacijskih bojila u digitalnom tisku. Primjenom metoda objektivizacije boje i ispitivanja kvalitete otiska, analizirat će se razlika između ovako kreirane slike otisnute u međufazi proizvodnje tekstilnog plošnog proizvoda i slike konvencionalno otisnute na gotovom tekstilnom plošnom proizvodu.*

1. Uvod

Kontinuirani slikotvorni tisak (S.T.N.P.) zamišljen je kao tisak pređe po principu raščlanjivanja slike na integralne dijelove (pixele) te računalnim pozicioniranjem i otiskivanjem točno određenih integralnih dijelova slike na pređu. Uvođenjem tako otisnute pređe u sustav nizova i redova, dobila bi se cjelovita slika. Pređa bi se otiskivala sa svih strana "prstenasto" koristeći CMYK sustav miješanja boja. Tisak će se provoditi sublimacijskim bojilima, primjenom digitalno kontroliranih mlaznica putem kojih će se ostvariti kružni transfer na pređu vidljiv sa svih strana [1, 2]. Ovakav princip tiska pređe je zamišljen kao pred faza WholeGarment® uređajima za 3D pletiva. Takvi uređaji imaju mogućnost proizvodnje gotovih pletenih proizvoda u konfekcijskom broju po želji, bez potrebe za daljnjim fazama obrade ili šivanja [3]. Prednost ovakvih uređaja je mogućnost primjene na širokoj paleti proizvoda, pri čemu se jednostavnom promjenom bojila omogućuje primjena na pređama različitih sirovinskih sastava. Kontinuirani slikotvorni tisak na pređu donosi dodatnu fleksibilnost već i onako fleksibilnom WholeGarment® sustavu.

2. Eksperimentalni dio

Eksperimentalni rad provoditi će se u tri faze; u prvoj fazi provest će se optimiranje sastava i reoloških svojstava tiskarske paste, odnosno tiskarske boje. Optimiranje sastava podrazumijeva izbor i ispitivanje reoloških svojstava ugušćivača, prvenstveno viskoziteta kao ključnog parametra u digitalnom tisku. U kontekstu sastava tiskarske paste provest će se optimiranje udjela bojila, ugušćivača i pomoćnih sredstava te će se ispitati njihovo zajedničko djelovanje na reološka svojstva gotove tiskarske paste. U drugoj fazi provest će se tisak te će se ispitati kvaliteta otiska „proof of concept" prototipa, kao i kvaliteta reprodukcije boje. Ispitivanje kvalitete reprodukcije boje provodi se temeljem objektivizacije boje, odnosno spektrofotometrijskog mjerenja. Spektorofotometrijsko mjerenje boje otisaka provest će se pomoću remisijskog spektrofotometra DataColor 850 uz definirane parametre mjernog otvora, standardnog svjetla D65 i geometrije mjerenja d/8°. Ispitivanje kvalitete otiska podrazumijeva ispitivanje postojanosti na pranje, svjetlo i trenje. Ispitivanja će se provoditi prema ISO normama HRN EN ISO 105-C06:2010: Tekstil - Ispitivanje postojanosti obojenja - Dio C06: Postojanost obojenja pri pranju u kućanstvu i komercijalnom pranju, HR EN ISO 105-X12:2016: Tekstil - Ispitivanje postojanosti obojenja - Dio X12: Postojanost obojenja na trljanje i HR EN ISO 105-B02:2013: Tekstil - Ispitivanje postojanosti obojenja - Dio B02: Postojanost obojenja na umjetno svjetlo: ispitivanje na blijeđenje Xenon lampom. Provest će se ispitivanje opipnih svojstava otisnutog tekstilnog proizvoda instrumentom za ispitivanje opipa - FTT (Fabric Touch Tester, SDL-Atlas). Dobiveni rezultati primijeniti će se u fazi unapređenja sustava tiska, kao i kemizma samih bojila s ciljem realizacije poboljšanoga „alfa" prototipa. U trećoj fazi provest će se analiza tržišta s ciljem postavljanja plana komercijalizacije predloženog sustava tiska te će se, također, predstaviti i plan znanstvene suradnje.

3. Rezultati i rasprava

Kao rezultat istraživanja, osim realizacije funkcionalnoga prototipa "proof of concept, cilj je potvrditi ekološku održivost i ekonomsku isplativost sustava. Realizacija prototipa ostvarit će se suradnjom s informatičkim i tehničkim zavodima kao i s proizvođačima samih uređaja za izradu 3D pletiva kao što je "Shima-Seki", te integracijom sustava u program za modeliranje odjevnih predmeta [4]. Također će se rješavati problematika mehaničkih parametara vezanih uz napetost pređe pri uvođenju, te razvijanja digitalnoga sustava za navođenje mlaznica i pravilno pozicioniranje slike na gotovom proizvodu. Rezultatima objektivizacije boje, iskazanim prema CIE sustavu analizirati će se međudjelovanje boje i podloge te će se ti rezultati koristiti za procjenu međudjelovanja bojila i vlakna s ciljem što šire uporabe sastava pređe, kao i ekologijom te ekonomičnosti samog procesa. Cilj je razvoj "alfa" prototipa, koji bi bio spreman za prva tržišna ispitivanja i suradnju, a istraživanje će se usredotočiti na usporedbu predobrade i tiska pređe spram predobrade i tiska na gotovi, ispleteni proizvod, s premisom da je tisak na pređu ekonomičnija i dugoročno ekološki prihvatljivija opcija tiska za rastući " WholeGarment®" sektor. Istraživanjem mogućnosti sustava koje bi proizašle iz same institucijske i tržišne suradnje, istražit će se mogućnost primjene S.T.N.P. sustava u svrhu preobrade i oplemenjivanja u kontinuiranoj pred-fazi, gdje bi se primjenom drugih mlaznica i postavki na uređaju mogle provoditi predobrade.

4. Zaključak

Kontinuirani slikotvorni tisak na pređu omogućuje veoma preciznu uporabu bojila, dok 3D pletaći strojevi omogućuju veoma brzi odaziv na tržištu. Povezivanjem, te usavršavanjem ovih dviju tehnologija tekstilna industrija je korak bliže lokalnoj proizvodnji prema potrebi nalik na J.I.T. sustav (Just In Time sustav) Ovakvim pristupom, omogućio bi se razvoj lokalne proizvodnje bojila, pređa i artikala točno prema potrebi, s globalno navođenim dizajnom bez skladištenja i transporta [5].

Literatura

[1] Silva, M.C. et al: Digital Sublimation Printing on Knitted Polyamide 6.6 Fabric Treated with Non-Thermal Plasma, *Polymers,* **13** (2021) 12, 1-15, ISSN 2073-4360

[2] Stojanović, S; Geršak, J.; Trajković, D.: Compression Properties Of Knitted Fabrics Printed By Sublimation Transfer Printing Technique, *Advanced Technologies*, **10** (2021) 1, 46-53, ISSN 2406-2979

[3] Peng, J. et al: Development of whole garment formed on four-bed computerized flat knitting machine, *International Journal of Clothing Science and Technology*, **30** (2018) 3, 320-331, ISSN 09556222

[4] Peter, J.: Hack 1 Knit 2 - Making Whole - Garment Knitting More Open, Oslo School of Architecture and Design requirements for Master of Design, (2019)

[5] Rahman, Md. M.: Applications of the digital technologies in textile and fashion manufacturing industry, *Bangladesh Technium*, **3** (2020) 1, 114-127, ISSN: 2668-778X

Martina Bobovčan Marcelić

Životopis	Martina Bobovčan Marcelić rođena je 1979. godine u Koprivnici. U veljači 2008. godine diplomirala je na Tekstilno-tehnološkom fakultetu, Sveučilišta u Zagrebu. Od 2006. godine bila je zaposlena u tvrtci Galko d.o.o., a od 2011. do 2021. godine bila je zaposlena na radnom mjestu asistenta na Tekstilno-tehnološkom fakultetu u Zavodu za odjevnu tehnologiju. Doktorski rad izrađuje pod mentorstvom prof. dr. sc. Dubravka Rogalea, u području spajanja termoplastičnih polimernih materijala, procesnih parametara visokotehnoloških metoda spajanja i utjecaja procesnih parametara spajanja na svojstva i kvalitetu spojeva.
Naslov doktorskog rada	Procesni parametri visokotehnoloških metoda spajanja i svojstva spojeva na zaštitnoj i inteligentnoj odjeći
Mentor	prof. dr. sc. Dubravko Rogale
Datum obrane teme doktorskog rada	30. 2. 2014.

ZNAČAJ ISTRAŽIVANJA UTJECAJA PROCESNIH PARAMETARA NAPREDNIH TEHNIKA SPAJANJA NA SVOJSTVA SPOJEVA NA ZAŠTITNOJ I INTELIGENTNOJ ODJEĆI

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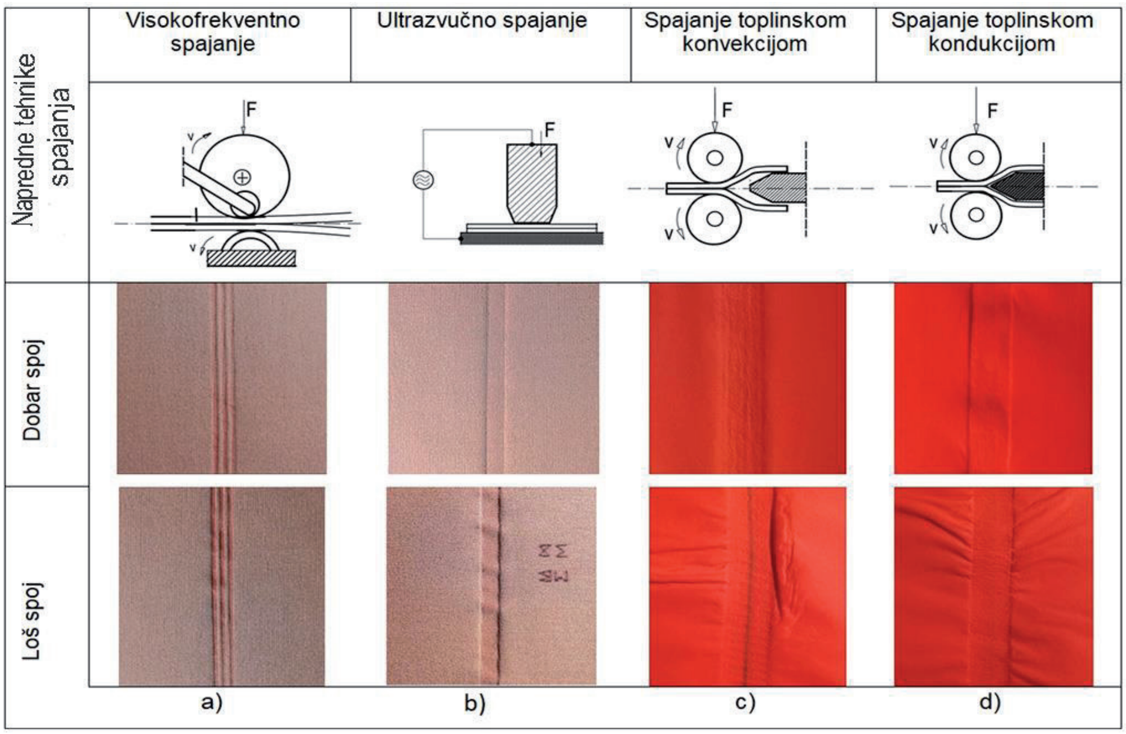
Sažetak: *U ovom radu bit će istražen utjecaj procesnih parametara primijenjenih naprednih tehnika spajanja na svojstva spojeva. Spojevi koji će se ispitivati nastali su spajanjem dijelova odjevnog predmeta upotrebom tehnike ultrazvučnog spajanja, visokofrekventnog spajanja (VF), spajanja toplinskom konvekcijom i kondukcijom. Ove tehnike spajanja se najčešće koriste pri izradi zaštitne i inteligentne odjeće gdje spojevi moraju zadovoljavati određena svojstva (zrakonepropusnost, vodonepropusnost, elastičnost, čvrstoću i dr.).*

1. Uvod

Neki dijelovi inteligentne odjeće mogu se izvoditi konvencionalnom tehnikom, šivanjem, ali se nužno moraju koristiti i napredne tehnike za spajanje materijala i elemenata budući da se konvencionalnom tehnikom, šivanjem, ne mogu polučiti zadovoljavajući tehnički i tehnološki uvjeti [1]. Tehnike spajanja koje su korištene za izradu spojeva razlikuju se s aspekta dovođenja i/ili iniciranja topline na mjestu spoja [2]. Istraživanjem se utvrdilo da upotreba optimalnih vrijednosti parametara spajanja ima značajan utjecaj ne samo na kvalitetu spoja već i na ostala svojstva koja su vrlo bitna kako bi određeni odjevni predmet zadovoljio sve zahtjeve koji su definirani prema njegovoj namjeni [3].

2. Eksperimentalni dio

Uzorak termoplastičnog materijala (nasloj 47% PU i pletivo 53% PES) spajan je primjenom četiri navedene tehnike spajanja, pri različitim parametrima spajanja, prema kojima su ostvareni dobri i loši spojevi, sl. 1.



Slika 1: Napredne tehnike spajanja i spojevi (dobar i loš spoj): a) VF spajanje, b) ultrazvučno spajanje, c) spajanje toplinskom konvekcijom, d) spajanje toplinskom kondukcijom

Pozitivno ocijenjen, dobar spoj, nema naglašene istisnute rubove, nema oštećenja materijala, pa takvi spojevi imaju dobru čvrstoću i elastičnost, te mogu biti zrakonepropusni i vodonepropusni. Iz sl. 1 vidljivo je da loši spojevi imaju vrlo naglašene rubove, oštećenja i nabiranja materijala u zoni spajanja, pa su ti spojevi neupotrebljivi za primjenu. Kod ultrazvučnog spajanja mijenjani su parametri snage ultrazvučnog generatora i brzine spajanja. Kod VF spajanja mijenjani su parametri jakosti anodne struje i vremena spajanja. Kod spajanja toplinskom konvekcijom i kondukcijom mijenjani su brzine spajanja i temperature spajanja.

3. Rezultati i rasprava

Parametri ultrazvučnog spajanja kojima je postignut dobar spoj su brzina spajanja od 5 m/min i snaga ultrazvučnog generatora, 332 W, pri tim parametrima spajanja spoj ostvaruje prekidnu silu, F_{max}=54 N, te je zrakonepropustan i vodonepropustan. Loš spoj, spajan je pri nižoj brzini spajanja, što odgovara duljem vremenu izlaganja materijala snazi ultrazvučnog generatora od 372 W, ima vidljiva oštećenja na materijalu, ali je spoj zrakopropustan i vodopropustan, a izmjerena prekidna sila je F_{max} =22 N. Spajanjem VF tehnikom, dobar spoj postignut je pri vremenu spajanja od 7 s i jakosti anodne struje od 220 mA. Pri tim parametrima postignut je spoj koji ima prekidnu silu, F_{max} =90 N, te je spoj zrakonepropustan i vodonepropustan. Loš spoj postignut je spajanjem pri vremenu od 7 s i jakosti anodne struje 300 mA, ima izrazito naglašene istisnute rubove, nema oštećenja materijala u zoni spajanja, prekidna sila spoja je F_{max}=72 N, a spoj je zrakonepropustan i vodonepropustan. Kod spajanja toplinskom konvekcijom dobar spoj postignut je spajanjem pri brzini od 5 m/min i temperaturi od 400 °C, izmjerena prekidna sila je F_{max}=62 N. Loš spoj, s naborima i oštećenjima u zoni spajanja, postignut je pri brzini spajanja od 4 m/min i temperaturi od 350 °C, a prekidna sila je F_{max}=51 N. Kod spajanja toplinskom kondukcijom dobar spoj postignut je pri brzini od 5 m/min i temperaturi od 350 °C, a prekidna sila je F_{max}=46 N. Loš spoj spajan je pri brzini od 5 m/min i temperaturi od 350 °C, izmjerena prekidna sila je F_{max}=34 N.

4. Zaključak

Primjena optimalnih vrijednosti parametara spajanja i njihova kombinacija, značajno utječu na kvalitetu i svojstva spoja. Upotreba jedne kombinacije parametara npr. kod tehnike VF spajanja, kraće vrijeme spajanja i veće vrijednosti jakosti anodne struje ili duže vrijeme spajanja i niže vrijednosti jakosti anodne struje, povoljno utječu na vizualni izgled, ali im se razlikuju ostale vrijednosti izmjerenih svojstava (prekidna sila, zrakonepropusnost, vodonepropusnost i dr.). Analizom rezultata svih spomenutih tehnika spajanja može se zaključiti da spojevi nastali spajanjem datog uzorka materijala najpovoljnija svojstva spojeva postižu spajanjem VF tehnikom.

Zahvala

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Literatura

[1] Rogale, D.; Bobovčan, M.; Firšt Rogale, S.: Suvremene tehnike spajanja elemenata na inteligentnoj odjeći, *Zbornik radova 4. međunarodno znanstveno-stručnog savjetovanja Tekstilna znanost i gospodarstvo*, Penava, Ž.; Ujević, D. (ur.), 167-172, ISSN 1847-2877, Zagreb, siječanj 2011., Tekstilno-tehnološki fakultet (2011).

[2] Grewell, D.; Benatar, A.; Park, J.: *Ultrasonic Welding in: Plastics and Composites Welding Handbook*, Hanser, ISBN 1-56990-313-1, München (2003) 142-188.

[3] Jakubčioniene, Ž. et al: Investigation of the strenght of textile bonded seams, *Journal of Materials Science*, **18** (2012) 2, 172-176, ISSN 0022-2461.

Iva Brlek

Životopis

Iva Brlek je rođena u Zagrebu 1988. godine. Preddiplomski studij upisala je 2007. godine, a završila 2010. godine na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Diplomski studij upisala je 2010. godine, a završila 2013. godine na Tekstilno-tehnološkom fakultetu. Poslijediplomski studij upisala 2014. godine na Tekstilno-tehnološkom fakultetu.
U periodu od 2015. do 2017. godine je bila zaposlena kao stručni suradnik u sustavu znanosti i visokog obrazovanja u području tehničkih znanosti, polje tekstilna tehnologija, grana tekstilna kemija - rad na projektu Hrvatske zaklade za znanost. Od 2017. godine radi kao asistent na Tekstilno-tehnološki fakultet u području bojadisanja tekstila, tiska te metrike boje.

Naslov doktorskog rada

Kozmeto-tekstilije kao prijenosnici aktivnih tvari prirodnog porijekla na kožu

Mentor

prof. dr.sc. Sandra Bischof

Datum obrane teme doktorskog rada

21. 6. 2016.

SPEKTROFOTOMETRIJSKA ANALIZA MIKROKAPSULA KOJE SADRŽE ETERIČNO ULJE SMILJA

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***Sažetak**: Mikrokapsule s eteričnim uljem smilja su sintetizirane za potencijalnu primjenu na tekstilu (kozmeto-tekstil, wellness tekstil). Karakterizacija ulja je važna za identifikaciju mikrokapsula. U radu je analizirano eterično ulje smilja, etil celulozne mikrokapsule koje sadrže ulje smilja te mikrokapsula koje ulje ne sadrže koristeći metodu UV spektrofotometrije. Analize su provedene na UV apsorpcijskom spektrofotometru Cary 50 Solascreen (Varian Inc, USA). Kvalitativnom spektrofotometrijskom analizom eteričnog ulja smilja, a nakon toga i mikrokapsula koje ga sadrže, potvrđen je apsorpcijski pik pri valnoj duljini 265 nm, a koji je karakterističan za pinene. Analizom mikrokapsula koje ne sadrže ulje smilja nije potvrđen pik na karakterističnoj valnoj duljini. Morfologija mikrokapsula utvrđena pomoću skenirajućeg elektronskog mikroskopa (FE - SEM) upućuje na pravilan sferni oblik i veličinu sintetiziranih mikrokapsula.*

1. Uvod

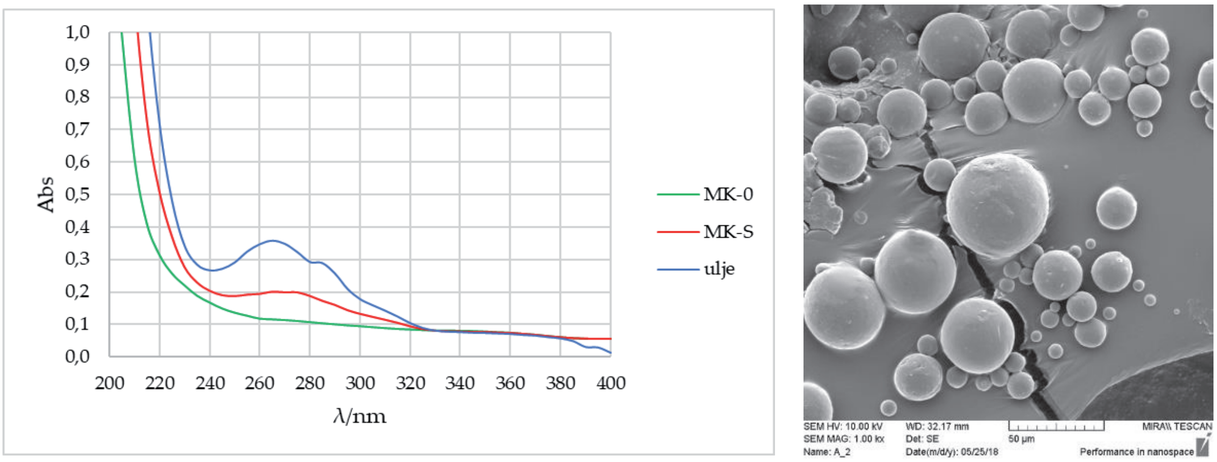
Mikrokapsule se dobivaju postupkom mikroenkapsulacije, mikrometarske su veličine (1 μm) i sastoje se od dva dijela: jezgra i ovojnica [1,2]. Mikrokapsule mogu imati široku primjenu, ovisno o prirodi tvari koja se u njima nalazi, kao i o svojstvima otpuštanja, što je kontrolirano materijalom za formiranje ovojnice [3]. Smilje (od lat. *Helichrysum italicum*) je aromatična biljka mediteranskog područja, a njegova ljekovita svojstva poznata su još od antičkog doba [4,5]. Potrebna su medicinska ispitivanja kako bi se ti podaci dodatno potvrdili i promovirali smilje kao važno sredstvo u liječenju određenih bolesti [5]. Mediteranska eterična ulja se sastoje od visokog udjela α -pinena (22 %) te značajne količine γ -kurkumena (10 %), β -selinena (6%), neril acetata (6%) i β -kariofilena (5 %) [1,2]. Prema literaturi pineni pokazuju pik na 265 nm stoga je cilj ovog istraživanja potvrditi ovaj apsorpcijski pik eteričnog ulja smilja koristeći UV spektrofotometriju [6]. Potrebno je isto istražiti i za sintetizirane etil celulozne mikrokapsule koje sadrže eterično ulje smilja.

2. Eksperimentalni dio

Cilj ovog istraživanja je karakterizacija eteričnog ulja smilja, Irex aroma d.o.o., Hrvatska i sintetiziranih etil celuloznih mikrokapsula koje to ulje sadrže (MK-S) te mikrokapsula koje ne sadrže ulje, odnosno praznih mikrokapsula (MK-0) [7]. Prije analize je provedena metoda ekstrakcije svih uzoraka heksanom. Karakterizacija ulja i mikrokapsula je provedena na UV apsorpcijskom spektrofotometru Cary 50 Solascreen (Varian Inc, SAD) pri raznim valnim duljinama (200 - 400 nm). Karakterizacija površine sintetiziranih mikrokapsula provedena je pomoću skenirajućeg elektronskog mikroskopa (MIRA\FE-SEM, Tescan, Češka Republika).

3. Rezultati i rasprava

Spektrofotometrijskim mjerenjem eteričnog ulja smilja te etil celuloznih mikrokapsula koje sadrže ulje (MK-S) dobiveni su spektri na kojima je prisutan pik na 265 nm što potvrđuje navode iz literature [6]. Na sl. 1a su prikazani spektri eteričnog ulja smilja (ulje), etil celuloznih mikrokapsula koje sadrže eterično ulje smilja (MK- S) te etil celuloznih mikrokapsula koje ne sadrže ulje (MK-0). SEM slika uz povećanje 1000x, sl. 1b, potvrđuje kvalitetu sintetiziranih mikrokapsula sa smiljem (MK-S), koje su karakterizirane pravilnim sfernim oblikom, veličine 10-50 μm s prosječnim promjerom 30 μm.



a. b.

Slika 1: Rezultati: a. UV spektri eteričnog ulja smilja (ulje), etil celuloznih mikrokapsula sa smiljem (MK-S) i etil celuloznih mikrokapsule koje ne sadrže eterično ulje smilja (MK-0); b. SEM slika mikrokapsula (MK-S)

4. Zaključak

Na temelju rezultata može se zaključiti da je metoda UV-spektrofotometrije prikladna za kvalitativnu analizu eteričnog ulja smilja i eteričnog ulja smilja u mikrokapsulama. Dobiveni rezultati upućuju da se ova metoda kao relevantne može primijeniti za kvantifikaciju mikrokapsuliranog ulja smilja na tekstilnim materijalima i njihovu karakterizaciju. SEM analiza potvrdila je kvalitetu sintetiziranih mikrokapsula etil celuloze, koje odlikuje pravilan sferni oblik.

Zahvala

Istraživanja/doktorski rad izrađen je u sklopu aktivnosti na istraživačkom projektu HRZZ-IP-2013-11-9967 - ADVANCETEX, voditeljice prof. dr. sc. Sandre Bischof.

Literatura

[1] Carvalho, I. T.; Estevinho, B. N.; Santos, L.: Application of microencapsulated essential oils in cosmetic and personal healthcare products – a review, *International Journal of Cosmetic Science*, **38** (2016) 2, 109–119, ISSN 14682494

[2] Lam, P.L.; Gambari, R.: Advanced progress of microencapsulation technologies: In vivo and in vitro models for studying oral and transdermal drug deliveries – a review, *Journal of Controlled Release*, **178** (2014) 1, 25-45, ISSN 01683659

[3] Jaâfar, F. et al: Impregnation of Ethylcellulose Microcapsules Containing Jojoba Oil onto Compressive Knits Developed for High Burns, *Fibers and Polymers*, **13** (2012) 3, 346-351, ISSN: 12299197

[4] Bakry, A.M. et al: Microencapsulation of Oils: A Comprehensive Review of Benefits, Techniques, and Applications, *Comprehensive Reviews in Food Science and Food Safety*, **15** (2016) 1, 143-182, ISSN 15414337

[5] Bezerra, F.M. et al: Controlled release of microencapsulated citronella essential oil on cotton and polyester matrices, *Cellulose*, **23** (2016) 2, 1459–1470, ISSN 1572882X

[6] Moore, R.N.; Fisher, G.S.: The Effect of Strained Rings on Ultraviolet Absorption Spectra, *Contribution from the Naval Stores Research section*, **78** (1956) 17, 4362-4364, ISSN 15205126

[7] Brlek, I.; Ludaš, A.; Sutlović, A.: Synthesis and Spectrophotometric Analysis of Microcapsules Containing Immortelle Essential Oil, *Molecules*, **26** (2021) 8, 1-9, ISSN 1420-3049

Darinka Cvetković

Životopis	Darinka Cvetković je rođena u Zagrebu 1962. godine. 1981. godine zapošljava se u Radio industriji Zagreb u IETA (istraživanje u elektrotehnici i telekomunikaciji) u laboratoriju na poslovima snimanja i izrade tehničkih filmova administrativnim poslovima. 1984. godine upisuje Fakultet kemijskog inženjerstva uz rad. 1990. godine nakon stečaja IETA ostaje bez zaposlenja. 1991. godine upisuje Kemijsko-tehnološki fakultet, smjer obuća na kojem diplomira. 2009. godine upisuje razlikovni studij na Tekstilno-tehnološkom fakultetu, a 2011. godine na istom upisuje diplomski studij, smjer tekstilna kemija, materijali i ekologija. Poslijediplomski specijalistički studij upisuje 2017. godine na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu, s ciljem unapređenja istraživačkih kompetencija kao potrebne osnove pri samozapošljavanju. Školu pčelarenja završava u akad. god. 2019./2020.
Naslov doktorskog rada	
Studijski savjetnik	izv. prof. dr. sc. Maja Somogyi Škoc
Datum obrane teme doktorskog rada	

ISTRAŽIVANJE I RAZVOJ OPTIMALNE FORMULACIJE PČELINJEG PROIZVODA NA TEKSTILNOM NOSAČU ZA OBNOVU TKIVA

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Sažetak: *Oštećenja kože, tj. rane definirane su kao prekid u kontinuitetu kože. Prema trajanju i prirodi procesa cijeljenja rana, one se dijele na akutne i kronične. Akutne rane nastaju uslijed oštećenja ili nezgode i zacjeljuju u nekom predvidivom roku dok kronične rane ne zacjeljuju kroz normalni proces cijeljenja rana. Ranama koje ne mogu zacijeliti najčešći uzrok su bakterije koje tvore biofilm. Biofilm se sastoji od skupina bakterija koje su okružene polimernom matricom, koja štiti bakterije, odnosno sprječava djelovanje antibiotika. Iz tog razloga kroz primjenu pčelinjih proizvoda i pomoćnih aktivnih tvari na tekstilnom nosaču nastoji se naći optimalna formulacija koja bi spriječila stvaranje biofilma ili mu otvorila trodimenzionalnu strukturu i time omogućila zacjeljivanje rane.*

1. Uvod

Kod ljudi ima nekoliko tipova tkiva koji mogu zacijeliti ili se regenerirati kao što je koža i crijevna sluznica, te se ta tkiva oporavljaju pomoću matičnih stanica koje se mogu razmnožavati i dijeliti u niz tipova stanica [1]. Jedini ljudski organ u kojem se mogu razmnožavati i dijeliti stanice su jetra, u drugim organima nakon što se stanice diferenciraju prestaju se dijeliti i razmnožavati [2]. Koža ima zaštitnu funkciju u odnosu na okolinu, te ima regenerativna svojstva u procesu zacjeljivanja rana koja uključuje staničnu proliferaciju (stvaranje novih stanica), migraciju i preoblikovanje tkiva. Teškoće pri zacjeljivanja rana uzrokuju bakterije koje tvore biofilm, a koji stvara kronične upale i infekcije koje je vrlo teško liječiti [3], odnosno, najveća prepreka zacjeljivanju kroničnih rana je virulentnost i patogenost biofilma. Za identifikaciju i heterogenost biofilma razvijeni su višekanalni senzori na bazi nanočestica zlata koji otkrivaju fizikalno kemijska svojstva biofilma nakon čega se on liječi antimikrobnim oblogama [3, 4]. Suvremene obloge za liječenje i njegu rana sadrže razne gelove, alginatna vlakna, hidrokoloide, srebro, ugljen, med, PHMB (poliheksametilen biguanid hidroklorid), srebrov sulfadiazin i sl. [5, 6]. Za liječenje kroničnih rana koristi se i med, gdje za manuka meda postoje radovi u kojima je prikazano učinkovito djelovanje meda protiv biofilma. Obloge s medom, mrežica impregnirana s medom, gel ili alginat s medicinskim medom, alginati s medom samo su neke od kombinacija[6]. Med penetrira kroz biofilm te ubija sesilne stanice zarobljene u medu [7]. Mehanizam antibakterijskog djelovanja meda ima četverostruko djelovanje. Med zbog svoje higroskopnosti apsorbira vodu iz okoline te na taj način dehidrira bakterije. Kiselost meda zaustavlja rast mikroorganizama. Visoki sadržaj šećera također sprječava rast mikroorganizama, a vodikov peroksid je najvažnija antibakterijska komponenta [9].

2. Eksperimentalni dio

Provedene su preliminarne obrade s ciljem stjecanja uvida u ponašanje i mogućnosti koje pruža sol-gel postupak za modifikaciju tekstila primjenom meda, propolisa i matične mliječi. Variranjem vrste i koncentracije pčelinjeg proizvoda i pomoćnih sredstava, uvjeta, načina i postupaka obrade plošnih tekstilija odabranim modifikatorima uz varijaciju procesnih parametara, istražuju se i utvrđuju optimalni uvjeti obrada za koje se očekuje da bi rezultirali zaštitnim svojstvima - spriječili stvaranje biofilma.

GLYMO + katalizator	→	Med, propolis Matična mliječ…	→	Uranjanje plošnih uzoraka u homogeniziranu otopinu pri definiranoj brzini	→	Umrezavanje Dodatno učvršćivanje	→	Instrumentalne tehnike Ispitivanje antimikrobne učinkovitosti

Slika 1: Shematski tijek ispitivanja

3. Rezultati i rasprava

Primjena pčelinjih proizvoda (med, propolis, matična mliječ) i ekstrakata biljaka (maslačak, kadulja i dr.) uz modifikaciju tekstila sol-gel postupkom omogućava dobivanje željenih svojstava gotovog uzorka (antibakterijsko, antivirusno i antifungalno) uz zadržavanje tekstilnog karaktera (opipa). Sol-gel postupak se pokazao prikladnim jer se reakcije odvijaju pri sobnoj temperaturi, a što je vrlo važno budući neke od korištenih biljaka ne podnose visoke temperature, jer time gube svoja važna ljekovita svojstva.

4. Zaključak

Na temelju saznanja dobivenih pregledom znanstveno-stručne literature pokazalo se da je istraživanje mogućnosti primjene pčelinjih proizvoda u borbi protiv stvaranja biofilma aktualno. Provedene preliminarne obrade djeluju obećavajuće, za med je poznato da je vrlo bogat izvor vitamina i minerala, uz visoki udio šećera i niski udio vode, a što mu omogućuje visoku osmotsku aktivnost, koja stvara nepovoljno okruženje za razvoj mikroorganizama. Prevencija adhezije biofilma pčelinjim proizvodima na tekstilnom nosaču čini se kao puno bolje rješenje nego liječenje raznim sistemskim antibiotskim terapijama, gdje se povećava rizik od razvoja rezistencije. Primjenom pčelinjih proizvoda i biljnih pripravaka te odabirom povoljnih spojeva za rane smatra se kako se mogu napraviti interesantne proizvode s raznim tekstilnim nosačima. Izvedeni Zaključak i istraživanja odnose se samo na preliminarne rezultate, a zbog množine utjecajnih čimbenika i dosta izraženih specifičnosti, potrebno je nastaviti istraživanja obuhvaćanjem većeg broja varijacija procesnih parametara i metoda karakterizacije u sinergiji prirodnih i tehničkih znanosti s biomedicinom i zdravstvom.

Zahvala

Istraživanje se odvija u okviru istraživačkog projekta HRZZ IP-2019-04-1381 "Antibakterijska prevlaka za biorazgradive medicinske materijale" - ABBAMEDICA, voditeljice izv. prof. dr. dr. sc. Iva Rezić financiranom od strane Hrvatske zaklade za znanosti.

Literatura

[1] Žlender, V.: Apoptoza - programirana smrt stanice, *Arhiv za higijenu rada i toksikologiju*, **54** (2003) 4, 267-274, ISSN 0004-1254
[2] Friar, G.: Stem Cells Evolution + Development Protein form and function. The science of self-repair: regeneration research at Whitehead Institute, *Dostupan na:* https://wi.mit.edu/news/science-self-repair-regeneration-research-whitehead-institute, *Pristupljeno:* 2.12.2021.
[3] Škrlin, J.: Utjecaj biofilma na cijeljenje rane i postupak za identifikaciju biofilma u rani, *Acta Med Croatica*, **70** (2016) 1, 29-32, ISSN 1330-0164
[4] Xiaoning, L.; Hao, K.; Rubul, M, Saha K.; Moyano F.M., et. al.: Rapid Identification of Bacterial Biofilms and Biofilm Wound Models Using a Multichannel Nanosensor, *ACS Nano*, **8** (2014) 12, 12014-12019, ISSN 1936-0851
[5] Mihelič, M.; Planinšek Ručigaj, T.: The role of therapeutic dressings with silver in chronic wound therapy, *Acta Med Croatica*, **69** (2015) supl. 1, 73-75, ISSN 1330-0164
[6] Štilet, P.; Ručigaj Planinšek, T.: Obloge za liječenje kroničnih rana, *Acta Med Croatica*, **70** (2016), supl. 1, 69-77, ISSN 1330-0164
[7] Triller, C.; Huljev, D.; Planišek Ričugaj, T.: Suvremena pokrivala za rane, *Acta Med Croatica*, **67** (2013) supl. 1, 81-87, ISSN 1330-0164
[8] Kučišec-Tepeš, N.: Uloga antiseptika i strategija uklanjanja biofilma kronične rane, *Acta Med Croatica*, **70** (2016) 1, 33-42, ISSN 1330-0164
[9] Eteraf-Oskouei ,T., Najafi, M.: Traditional and Modern Uses of Natural Honey in Human *Diseases,* Iranian *Journal of Basic Medical Sciences,* **16** (2013) 6, 731-742, ISSN 2008-3866

Daniel Časar Veličan

Životopis

Daniel Časar Veličan rođen je u Zagrebu, gdje je završio osnovnu i srednju školu. 2016. godine na Tekstilno-tehnološkom fakultetu u Zagrebu završio preddiplomski studij Tekstilna tehnologija i inženjerstvo, a 2019. godine diplomski studij. Od travnja 2019. godine zaposlen je kao asistent u okviru Istraživačkog projekta financiranog od Hrvatske zaklade za znanost, IP-2018-01-6363 Razvoj i toplinska svojstva inteligentne odjeće voditelja prof. dr. sc. D. Rogalea, a sukladno odobrenom radnom planu projekta razvoja karijera mladih istraživača - izobrazba novih doktora znanosti HRZZ-DOK-2018-09-7933.

Naslov doktorskog rada

Istraživanja procesnih parametara tehnike spajanja termoplastičnih polimernih materijala tehnikom visokofrekventnog elektromagnetskog polja

Studijski savjetnik

prof. dr. sc. Dubravko Rogale

Datum obrane teme doktorskog rada

ISTRAŽIVANJA PROCESNIH PARAMETARA TEHNIKE SPAJANJA TERMOPLASTIČNIH POLIMERNIH MATERIJALA TEHNIKOM VISOKOFREKVENTNOG ELEKTROMAGNETSKOG POLJA

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Sažetak: *U doktorskom radu će biti istraženi procesni parametri tehnike spajanja termoplastičnih polimernih materijala primjenom visokofrekventnog elektromagnetskog polja. Težište istraživanja bit će na, do sada, manje istraživanim procesnim parametrima poput električnog kapaciteta spoja, faznog kuta između struje i napona i kuta dielektričnih gubitaka.*

1. Uvod

Inteligentna odjeća s adaptivnim termoizolacijskim svojstvima temelji se na primjeni segmentiranih termoizolacijskih komora [1]. U komore se upuhuje stlačeni zrak, a o stupnju aktivacije pojedinih komora ovisi termička zaštita odjevnog predmeta kontroliranom kondukcijom i konvekcijom topline ljudskog tijela. Konvencionalne metode spajanje tekstilija metode šivanja se mogu koristiti za izradu vanjske školjke inteligentne odjeće, njegove podstave i samo ponekih ugradbenih elemenata. U nekim je slučajevima spajanje šivanjem potpuno nepraktična i nedopustiva metoda. Iz tog razloga, za izradu inteligentne odjeće, ali i zahtjevne zaštitne odjeće potrebno je primijeniti nove suvremene metode spajanja dijelova.

Suvremene visokotehnološke metode spajanja koje se koriste u tehničkom znanstvenom području pokazale su se izvrsnima za spomenute namjene. To se osobito odnosi na spajanje termoplastičnih polimernih materijala ultrazvučnom tehnikom, toplinskim tehnikama uz primjenu efekta kondukcije i konvekcije te primjenom tehnike primjenom visokofrekventnog elektromagnetskog polja [2,3].

2. Eksperimentalni dio

U sklopu doktorskog rada izvodit će se određivanje naponskih amplituda i oblika na spojnim elektrodama, strujnih amplituda i oblika na spojnim elektrodama, faznih kutova između napona i struje pri spajanju, jakost struje, snage spajanja, frekvencije spajanja, vremena spajanja, tlakova pri spajanju te ispitivanje čvrstoće spojeva pri variranju procesnih parametara. Konstruirat će se, patentirati i izraditi laboratorijski uređaj za određivanje kapaciteta spojnih elektroda pri spajanju primjenom visokofrekventnog elektromagnetskog polja, dielektričke konstante i kuta gubitaka polimernih spojnih sustava.

Također će se pristupiti konstruiranju, patentiranju i izradi laboratorijskog uređaja za određivanje procesnih parametara pri spajanju termoplastičnih polimernih materijala primjenom visokofrekvencijskih elektromagnetskih polja na jediničnoj površini s mogućnošću variranja visokofrekventnog napona, struje, snage i frekvencije, trajanja spajanja tlaka pri spajanju. Uspostavit će se mjeriteljski sustav i mjerna metoda za određivanje procesnih parametara spajanja primjenom tehnike visokofrekventnog elektromagnetskog polja. Istražit će se i iznaći matematičke međuovisnosti procesnih parametara spajanja polimernih materijala dijelova inteligentne odjeće, ali i konvencionalne, posebice zaštitne odjeće.

3. Rezultati i rasprava

Ispitat će se svi procesni parametri karakteristični za tehniku spajanja termoplastičnih polimernih materijala primjenom visokofrekventnog elektromagnetskog polja. Spajanje termoplastičnih polimernih materijala izvodit će se na stroju tvrtke Zemat oznake Depta, sl. 1. Snaga stroja je 4 kW, sa mogućnošću vrlo precizne regulacije procesnih parametara u cijelom području, a posebno precizna regulacija snage oko vrijednosti od 1 kW.

Posebnu pozornost i istraživanje utjecaja na karakteristike spoja bit će posvećene procesnim parametrima koji se do sada nisu istraživali ili su nedovoljno istražena.

Slika 1: Stroj za visokofrekventno spajanje termoplastičnih polimernih materijala tvrtke Zemat oznake Depta

Ukoliko će rezultati istraživanja biti dostatni za konstrukciju vlastite mjerne opreme za utvrđivanje vrijednosti navedenih procesnih parametara, pristupit će se realizaciji i patentnoj zaštiti spomenutog mjernog uređaja.

4. Zaključak

Primjenom najsuvremenijeg stroja za spajanja termoplastičnih polimernih materijala izvest će se istraživanja svih relevantnih procesnih parametara spajanja termoplastičnih polimernih materijala primjenom visokofrekventnog elektromagnetskog polja, s težištem na neistražene procesne parametre. Ovisno o kvaliteti dobivenih rezultata, konstruirat će se mjerni uređaj te će se utemeljiti nova mjerna metoda.

Zahvala

Istraživanja se izvode u sklopu istraživačkog projekta Razvoj i toplinska svojstva inteligentne odjeće (IP-2018-01-6363) financiranog od Hrvatske zaklade za znanost te u sklopu Projekta razvoja karijera mladih istraživača-izobrazba novih doktora znanosti DOK-09-2018-7373.

Literatura

[1] Firšt Rogale, S. i sur.: *Inteligentna odjeća*, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, ISBN 978-953-7105-52-5, Zagreb, (2014.)

[2] Mitelea, Ion et al: The High Frequency Welding Aptitude of Thermoplastic Polymers, *Materiale Plastice*, 46 (2009)1,101-107, ISSN 2668-8220

[3] Qiu, J.: Thermal Welding by the Third Phase Between Polymers: A Review for Ultrasonic Weld Technology Developments, *Polymers* **12** (2020), 1-26, ISSN 2073-4360

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Životopis

Rođena je u Slavonskom Brodu 1992. godine. Diplomirala je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 2015. godine. Od 2019. godine je zaposlena na Tekstilno-tehnološkom fakultetu kao asistent na Projektu razvoja karijera mladih istraživača – izobrazba novih doktora znanosti HRZZ-DOK-2018-09-4254 Bio-inovirani poliesterski materijal za ciljanu primjenu u bolničkom okruženju. Radno iskustvo stekla je na poslu stručnjaka za kvalitetu u Boxmark Leather d.o.o. Suradnica je na bilateralnom znanstveno-istraživačkom projektu i uspostavnom projektu HRZZ UIP-05-2019-8780 Bolničke zaštitne tekstilije. Nagrađena je za izvrsnost na poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija u ak. god. 2019./2020. te nagradu Znanstveno-istraživačkog centra za tekstil. Znanstveni interes veže se uz metode modificiranja poliesterskih tkanina i razvoj antimikrobnih tekstilija. U koautorstvu je objavila 2 znanstvena i 1 stručni rad u časopisu, 5 cjelovitih radova u zbornicima te 2 sažetka.

Naslov doktorskog rada

Studijski savjetnik izv. prof. dr. sc. Anita Tarbuk

Datum obrane teme doktorskog rada

BIO-INOVIRANI POLIESTERSKI MATERIJAL ZA CILJANU PRIMJENU U BOLNIČKOM OKRUŽENJU

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Sažetak: *Istraživanja u okviru doktorskog rada obuhvatit će razvoj bio-inoviranih poliesterskih materijala za ciljanu primjenu u bolničkom okruženju u tri faze. Prva faza je aktivacija površine poliesterske tkanine hidrolizom s naglaskom na održivost procesa. Druga faza obuhvaća pripremu sub-mikron čestica kitozana u homogeni polimer te implementaciju na površinu aktivirane tkanine. U trećoj fazi ispitat će se antimikrobna učinkovitost uz postojanost obrade na proces održavanja.*

1. Uvod

Poli(etilen-tereftalat), PET, je sintetsko vlakno najšire primjene radi izvrsnih mehaničkih svojstava. Međutim, radi visoke kristaliničnosti PET-a, vlakna su slabe hidrofilnosti, sklona nabijanju statičkim elektricitetom, pilingu, i drugo, što rezultira problemima u mokroj doradi te neudobnosti tkanina pri nošenju. Hidrofilnost se tradicionalno poboljšavala postupkom alkalne hidrolize i aminolize, međutim navedeni procesi nisu ekološki povoljni zbog uporabe jakih lužina i visokih temperatura koje dovode ne samo do onečišćenja okoliša nego i do ireverzibilnog oštećenja materijala. Posljednjih godina se, kao alternativa kemijskoj obradi lužinama i aminima, istražuju enzimi. Za enzimatsku hidrolizu PET-a najčešće se koriste enzimi lipaze, esteraze i kutinaze koji su istraženi pretežito na filmovima i folijama, a vrlo malo i na tekstilu [1-3].

Nakon celuloze, hitin je drugi najzastupljeniji polisaharid u prirodnom okruženju. Hitin je strukturni polimer školjki morskih beskralježnjaka, staničnih stijenki gljiva i kostura kukaca. Hitin je linearni polisaharid koji se većinom sastoji od ostataka 2-acetamido-2-deoksi-β-D-glukopiranoze i djelomično od 2-amino-2-deoksi-β-D-glukopiranoze međusobno povezanih β-(1→4) glikozidnim vezama. Njegova kemijska struktura otežava topljivost u vodi i većini organskih otapala te se zbog toga provode brojna istraživanja kemijske modifikacije hitina koja dovode do topljivog oblika u lako dostupnim otapalima. Kitozan je prirodni biopolimer dobiven enzimatskom ili kemijskom deacetilacijom hitina i smatra se njegovim najpoznatijim derivatom. Široko je dostupan u raznim oblicima poput gelova, membrana, nanovlakana, mikro- i nanočestica. Zbog svojih fizikalno-kemijskih svojstava može se koristiti za proizvodnju pametnih materijala za primjenu u bolničke svrhe. Otapa se u vodenim otopinama kiselina poput octene, limunske, mravlje, klorovodične i mliječne kiseline. Veliki interes za ovaj polimer proizlazi iz svojstava polimera: biokompatibilnost, biorazgradivost, netoksičnost, antimikrobna i hidratantna svojstva koja pozitivno utječu na proces cijeljenja rana [4].

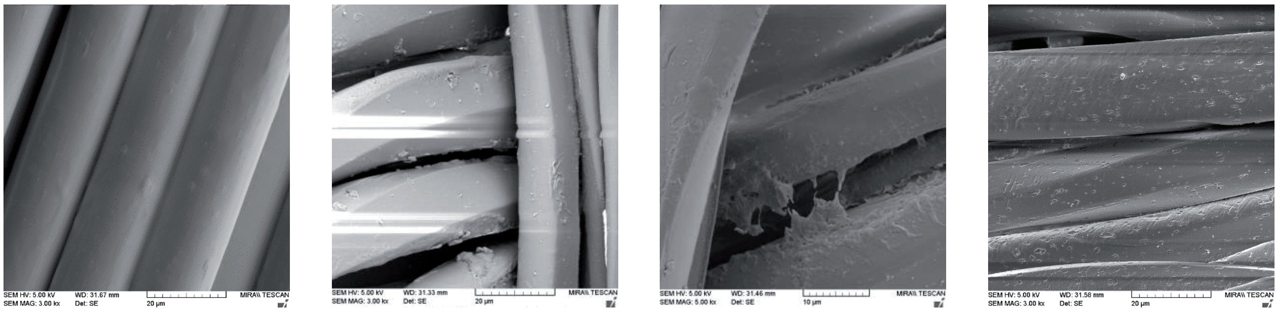
2. Eksperimentalni dio

U okviru prve faze provedeno je istraživanje hidrolize PET vlakana u tkanini kako bi se pronašao ekološki povoljniji postupak za aktivaciju površine uz poboljšanje hidrofilnosti i zadržavanje zadovoljavajućih mehaničkih svojstava. Provedena je alkalna hidroliza pri sniženim temperaturama te enzimatska hidroliza primjenom lipaza. Hidroliza je provedena na instrumentu Linitest, Original Hanau, uz omjer kupelji OK 1:50 pri temperaturama 60-100 °C u vremenu 5 min do 2 h. Za alkalnu hidrolizu korištena je 1,5 M NaOH bez i uz dodatak akceleratora 4 g/l kationskog tenzida heksadeciltrimetil amonij klorida (HDTMAC, 25 % vodena otopina, Fluka). Enzimatska hidroliza je provedena lipazama Amano Lipase A from Aspergillus Niger (ALA) i Amano Lipase from Pseudomonas fluorescens (ALAK) u alkalnom i kiselom mediju uz varijaciju koncentracije enzima. Određen je gubitak mase vaganjem prema ISO 3801:1977, gubitak prekidne sile nakon kidanja uzorka prema ISO 13934-1:2013 te analizom površine snimljene na skenirajućem elektronskom mikroskopu FE-SEM, Mira II, LMU, Tescan pri povećanju od 3000x.

U okviru druge faze pripremljene su sub-mikron čestice kitozana na uređaju Planetary Micro Mill PULVERISETTE 7 premium line primjenom keramičkih kuglica promjera 20 mm u vremenu 48 min pri 900 ok/min. Frakcije veće od 1 μm su odvojene sedimentacijom, a manje su odvojene isparivanjem.

3. Rezultati i rasprava

Nakon provedene alkalne i enzimatske hidrolize izračunat je gubitak mase i pad prekidne sile. Obradama su dobiveni traženi gubitci mase od 5 do 15 %, uz maksimalni gubitak prekidne sile do 30 %. Analizom rezultata obzirom na održivost procesa hidrolize utvrđeno je da su optimalni procesni parametri za obradu enzimom Amano Lipase A from Aspergillus Niger (ALA) sljedeći: koncentracija enzima 0,1 g/l, pH 9, 60 °C, 60 min, sl.1b. Enzim Amano Lipase iz Pseudomonas fluorescens (ALAK) učinkovit je i u kiselom i u lužnatom, no najpovoljniji uvjeti su: koncentracija enzima 0,2 g/l, pH 9, 60 °C, 60 min, sl.1c. Alkalna hidroliza može se provesti pri sniženoj temperaturi uz dodatak akceleratora. Najbolji učinci su na 80 °C, 10 min, sl.1d.



a. b. c. d.

Slika 1: SEM slike PET vlakana u tkaninama: a) Neobrađen, b) ALA-0,1g/l-pH9-60°C-60', c) ALAK-0,2g/l-pH9-60°C-60', d) NaOH+HDTMAC-80°C-10'

4. Zaključak

S obzirom na dobivene parametre nakon provedene alkalne i enzimatske hidrolize može se zaključiti kako se hidroliza površine PET tkanine može provesti na ekološki, energetski i ekonomski prihvatljiv način pravilnim odabirom parametara procesa. Predstoje istraživanja implementacije sub-mikron čestica kitozana na aktiviranu površinu vlakana kojom bi se dobio antimikrobni materijal za primjenu u bolničkom okruženju.

Zahvala

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Literatura

[1] Čorak, I.; Pušić, T.; Tarbuk, A.: Enzimi za hidrolizu poliestera, *Tekstil,* **68** (2019) 7-9, 142-151, ISSN 0492-5882

[2] Grancarić, A. M. i sur.: Utjecaj obrade na efekte alkalne hidrolize poliestera, *Tekstil,* **37** (1988) 1, 689-694, ISSN 0492 - 5882

[3] Guebitz G. M.; Cavaco-Paulo, A.: Enzymes go big: surface hydrolysis and functionalization of synthetic polymers, *Trends Biotechnol*, **26** (2008) 1, 32-38, ISSN 0167-7799

[4] Sikorski, D.; Gzyra-Jagiela, K.; Draczynski, Z.: The Kinetics of Chitosan Degradation in Organic Acid Solutions, *Marine Drugs*, **19** (2021) 5, 236, ISSN 1660-3397

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Naslov doktorskog rada	Adsorpcija cetilpiridinijevog klorida na celulozne supstrate
Mentor	prof. dr. sc. Tanja Pušić
Datum obrane teme doktorskog rada	28. 10. 2020.

ADSORPCIJA I DESORPCIJA CETILPIRIDINIJEVOG KLORIDA U ELEKTROKINETIČKOM ANALIZATORU

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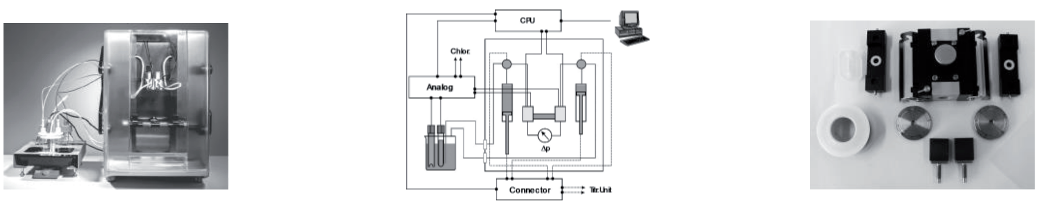
Sažetak: *Cetilpiridinijev klorid (CPC) je kationski tenzid koji spada u grupu kvaternih amonijevih spojeva. Koristi se u različitim područjima primjene, a najviše u kozmetici, farmakologiji i stomatologiji zbog baktericidne i antiseptičke aktivnosti. U ovom radu praćena je adsorpcija CPC-a iz micelarne otopine na standardu pamučnu tkaninu i njegova desorpcija metodom potencijala strujanja u elektrokinetičkom analizatoru pri različitim pH vrijednostima.*

1. Uvod

Kationski tenzid zbog pozitivnog naboja površinski aktivnog iona reagira s negativno nabijenim površinama [1]. Povećanom koncentracijom kationskog tenzida u vodenim medijima pod utjecajem van der Waalsovih sila dolazi do procesa samoudruživanja u agregate, koje se nazivaju micele. Ove organske koloidne čestice imaju veličinu od jednog milimikrona do jednog mikrona [2]. Kritična micelarna koncentracija (CMC) ovisi o kemijskoj građi tenzida, otapalu, prisutnosti elektrolita i temperaturi [3]. Prema literaturi CMC cetilpiridinijevog klorida u otopini kalijevog klorida (0,0013 mol/kg) iznosi 0,000266 mol/kg pri temperaturi od 25°C [4]. U ovom radu istražena je adsorpcija CPC iz micelarne otopine u sustavu koji koristi otopinu elektrolita (KCl) na standardnu pamučnu tkaninu pri različitim pH vrijednostima (pH 4, pH 6 i pH 9) i desorpcija CPC-a pri pH 6 pri 25°C.

2. Eksperimentalni dio

Adsorpcija CPC-a iz micelarne otopine na standardnu pamučnu tkaninu praćena je u elektrokinetičkom analizatoru SurPASS (A. Paar) sl. 1a i sl. 1b, metodom potencijala strujanja, pri čemu je korištena podesiva ćelija sl. 1c.



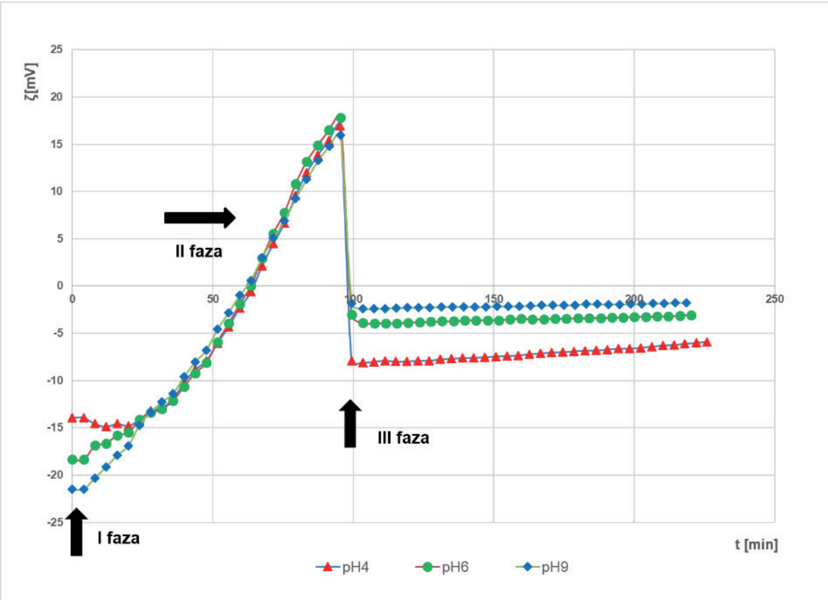
a. b. c.

Slika 1: SurPASS elektrokinetički analizator: a. SurPASS; b. shema instrumenta; c. podesiva ćelija, AGC [5]

Koncentracija CPC-a iznosila je 2,4 mmol/l, a koncentracija elektrolita (KCl) u sustavu 1 mmol/l. Zeta potencijal (ζ) pamučne tkanine mjeren je u ovisnosti o pH vrijednosti otopine elektrolita.

3. Rezultati i rasprava

Adsorpcija CPC-a iz micelarne otopine je istražena pri varijaciji pH vrijednosti u tri faze, sl. 2. Prva faza (I.) odnosi se na određivanje zeta potencijala kod pH 4 (ζ = -13,9 mV), pH 6 (ζ = -18,3 mV) i pH 9 (ζ = -21,5 mV). U drugoj fazi (II.) praćena je brzina adsorpcije CPC-a dodanim u točno definiranim alikvotima na pamučnu tkaninu za sve tri pH vrijednosti. Na sl. 2 je vidljivo da se krivulje adsorpcije u fazi II. kod sve tri pH vrijednosti preklapaju, a utrošak adsorbata za postizanje točke nultog naboja pamučne tkanine iznosi oko 350 μg/g. Treća faza (III.) odnosi se na desorpciju CPC-a s pamučne tkanine u otopini elektrolita pri pH 6. Prema prikazanim rezultatima razvidne su razlike između pojedinih krivulja u ravnotežnom stanju. Najstabilnija krivulja desorpcije dobivena je za sustav CPC-pamučna tkanina (pH 9), koju ujedno karakterizira najmanje negativan zeta potencijal. Negativnije vrijednosti za sustave pri pH 6 i pH 4 pokazuju manju stabilnost ovih sustava u odnosu na pH 9.



Slika 2: Adsorpcija CPC-a iz micelarne otopine na pamučnu tkaninu pri različitim pH vrijednostima (pH 4, pH 6 i pH 9) i njegova desorpcija pri pH 6 u elektrokinetičkom analizatoru

4. Zaključak

Rezultati istraživanja su pokazali neznatan utjecaj pH na adsorpciju CPC-a na pamučnu tkaninu. Međutim, dobivene razlike u desorpciji CPC-a s pamučne tkanine pokazale su da je najbolja stabilnost u zadržavanju CPC-a dobivena za adsorpcijski sustav CPC-pamučna tkanina-pH 9.

Literatura

[1] Soljačić, I.; Pušić, T.: Čišćenje u vodenim medijima, U *Njega tekstila–I dio*, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, ISBN 953-7105-08-3, Zagreb, (2005), 56-68

[2] Kallay, N. et al: Equilibrium of counterion association in micellar systems, Cetyltrimethylammonium bromide, *Annales Universitatis Mariae Curie - Sklodowska*, **63** (2008) 5, 61-67, Lublin, Polonia, ISSN 2083 358X

[3] Bigler, N.: *Die Tenside CIBA Geigy Rundschau 2*, CIBA, ISSN: 0366-5453, Zeitschrift, Print (1971)

[4] Mukhim, T.; Ismail, K.: Micellization of cetylpyridinium chloride in aqueous lithium chloride, sodium chloride and potassium chloride media, *Journal of Surface Science and Technology*, **21** (2005) 3/4, 113-127, ISSN 0970-1893

[5] Instruction Manual SurPASS™ Electrokinetic Analyzer; Copyright © Anton Paar GmbH, A48IB046en-B, Graz, Austria, (2013)

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Životopis

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Naslov doktorskog rada	Određivanje metalnih iona u tekstilnim materijalima za dječje igračke
Studijski savjetnik	prof. dr. sc. Branka Vojnović
Datum obrane teme doktorskog rada	

ODREĐIVANJE METALNIH IONA U TEKSTILNIM MATERIJALIMA IZ UZORKA DJEČJE IGRAČKE

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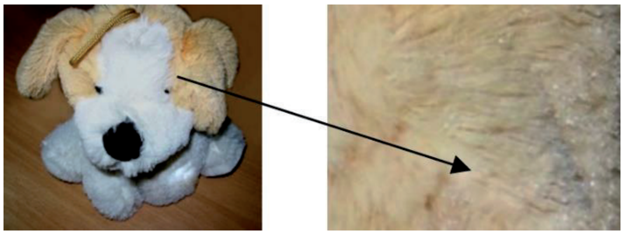
Sažetak: *U ovom radu prikazani su preliminarni rezultati određivanja razine pojedinih metala (Ag, Ba, Cd, Cr, Pb, Se) i metaloida (As) u igračkama dostupnim na našem tržištu. Za određivanje koncentracije i sadržaja metala i metaloida korištena je metoda pripreme uzoraka - određivanje specifične migracije prema smjernicama norme EN 71-3, uključuje ekstrakciju u 0,07 M HCl. Preliminarni rezultati ukazuju da se metalni ioni otpuštaju iz odabranog uzorka dječje igračke, pri čemu je sadržaj ispitanih metalnih iona u ispitivanom uzorku bio ispod granice migracije propisane normom EN 71-3.*

1. Uvod

Politikom Europske unije daje se iznimno visok prioritet sigurnosti proizvoda i zaštiti zdravlja građana, a prvenstveno zaštiti zdravlja djece. Samim time velika se pažnja posvećuje i osiguravanju sigurnosti dječjih igračaka koje moraju biti sigurne za njihovu svakodnevnu uporabu. Stoga je Europska komisija (EK) predložila postavljanje pravila za praćenje sadržaja niza organskih i anorganskih tvari u igračkama Direktivom o sigurnosti igračaka [1]. Direktiva je podržana i europskim normnim nizom EN 71 koji osigurava sukladnost s bitnim zahtjevima direktive [1] i uključuje 11 pojedinačnih normi. Norma EN 71-3 osmišljena je za procjenu migracije određenih kemikalija iz igračke u tijelo djeteta u slučaju gutanja igračke ili djela igračke te opisuje metodu određivanja količine topivih elemenata u tragovima koji migriraju iz materijala od kojeg je sačinjena dječja igračka [2]. Ovom normom utvrđuju se zahtjevi i metode ispitivanja za migraciju i metala i toksičnih elemenata kao što su Al, Sb, As, Ba, B, Cr(III), Cr(VI), Co, Cu, Pb, Mn, Hg, Ni, Se, Sr, Sn i Zn. U ovome preliminarnom istraživanju primijenjena je norma HRN EN 71-3 za određivanje specifične migracije određenih iona metala (Ag, Ba, Cd, Cr, Pb, Se) i metaloida (As) iz uzorka slučajno odabrane dječje igračke na domaćem tržištu. Sadržaj navedenih metala određen je metodom Induktivno spregnute plazme - optička emisijska spektrometrija, ICP-OES [1, 2].

2. Eksperimentalni dio

Standardne otopine za kvantitativno određivanje sadržaja metala na spektrometru ICP-OES priređuju se razrjeđivanjem certificiranih standardnih otopina od 1000 mg dm^{-3} pojedinog metala. Otopine simulanata su priređene razrjeđenjem koncentriranih kiselina. Određivanje sadržaja metalnih iona provedeno je na odabranom uzorku igračke s domaćeg tržišta. Uzorci za određivanje specifične migracije teških metala moraju sadržavati reprezentativne dijelove cjelokupne površine, koja često nije od iste vrste materijala, sl. 1. Uzorak za ispitivanje se sastoji od usitnjenog uzorka tekstilnog materijala, čija masa ne smije biti manja od 100 mg. Usitnjeni uzorci moraju biti dimenzija ne većih od 6 mm. Pri uzorkovanju treba voditi računa o reprezentativnosti uzorka, uzimajući u obzir sve vrste materijala i udio njihove zastupljenosti u svakom pojedinačnom uzorku, uz uvjet da uzorak mase između 10 i 100 mg treba uzeti iz osnovnog materijala.



Slika 1: Plišana igračka za ispitivanje

Ovaj postupak se izvodi prema HRN EN 71-3, Sigurnost igračaka - 3. dio: Procjena migracije metalnih iona provodi se uranjanjem igračke ili djelova igračke u 10 cm^3 0,07 M otopine klorovodične kiseline, čija koncentracija simulira želučanu kiselinu, na dva sata na 37 ± 2ºC. Nakon 2 h, uzorak treba odstajati 1h, profiltrira se preko membranskog filtra i u filtratu se određuju metalni ioni metodom ICP-OES. U tako simuliranim uvjetima, analitički se određuje sadržaj matala u kiselini kako bi se utvrdilo je li došlo do otpuštanja metalnih iona. Ako su metalni ioni prisutni u kiselini, znači da su 'migrirali' iz igračke u kiselinu i kao takvi, ovisno o pronađenim količinama, odražavaju potencijalnu opasnost (rizik) za dijete.

3. Rezultati i rasprava

Migracijske granične vrijednosti za igračke ili sastavne dijelove igrački razlikuju se u tri različite kategorije igračaka prema [1] i [2] od kojih svaka ima različita ograničenja za kemikalije povezane s vjerojatnošću gutanja:
a) suhi, lomljivi, praškasti ili savitljivi materijali za igračke
b) tekući ili ljepljivi materijali za igračke: koji se mogu progutati i/ili kojima je tijekom igre izložena dječja koža
c) materijali ostrugani s površine igračke: površinski premazi, polimeri (tvrdi), polimeri (meki), drugi materijali, drvo, tekstil, staklo, keramika, metali i legure [3, 4].

Ispitivanja su pokazala da se pojedini metalni ioni otpuštaju (migriraju) iz analiziranog uzorka dječje igračke. Uočava se povećan sadržaj kadmija u odnosu na ostale elemente, nešto manji sadržaj olova i barija, tab. 1, što ukazuje na otpuštanje iona barija iz uzorka s obzirom da je uzorak po sastavu od poliestera pri čijoj se proizvodnji koriste barijeve soli.

Tablica 1: Sadržaj metala u ispitivanim uzorcima izražen u [mg/kg] za specifičnu migraciju

metal / simulant	γ(Ag), mg/kg	γ(As), mg/kg	γ(Ba), mg/kg	γ(Cr), mg/kg	γ(Cd), mg/kg	γ(Pb), mg/kg	γ(Se), mg/kg
HCl (0,07 M)	0,019	0,001	n.d.	0,003	n.d.	0,003	n.d.
uz. 1 HCl (0,07 M)	0,514	0,004	n.d.	0,021	21,06	1,693	n.d.
uz. 2 HCl (0,07 M)	0,032	n.d.	0,245	1,524	2,060	n.d.	n.d.
uz. 3 HCl (0,07 M)	n.d.	0,001	0,476	0,016	7,669	3,352	n.d.
$\overline{uz.}_{1,2,3}$ HCl (0,07 M)	**0,182**	**0,002**	**0,240**	**0,520**	**10,263**	**1,682**	**n.d.**
σ	0,325	0,002	0,194	0,710	7,971	1,368	n.d.

n.d. - ispod donje granice određivanja

Opisanim istraživanjima nastojati će se razviti metoda određivanja određenih metalnih iona, ovisno o načinu pripreme uzoraka. Novorazvijenom metodom će se utvrditi postoji li potencijalna opasnost od migracije metalnih iona s dječjih igračaka u simuliranim uvjetima sisanja (simulant slina), trenja (simulant slina, znoj), gutanja (simulant HCl). Također je potrebno ispitati i mogućnosti migracije metalnih iona s tekstilnih igračaka, bojadisanih raznim bojilma jer je poznato da bojila za tekstilne materijale mogu sadržavati veće količine metala, bilo da su metali sastavni dio molekule bojila ili su metali dospjeli u bojilo kao katalizator ili onečišćenje u postupku sintere i proizvodnje bojila.

4. Zaključak

Ioni metala prisutni u većim količinama u ionskom stanju često mogu ugroziti zdravlje, pogotovo ukoliko se radi o zdravlju male djece te će se opisanim istraživanjima utvrditi potencijalna opasnost od migracije metalnih iona s dječjih igračaka. Ispitivanja su pokazala da pojedini metalni ioni migriraju iz analiziranog uzorka dječje igračke. Preliminarni rezultati određivanja specifične migracije ukazali su na to da metalni ioni migriraju iz igračke u slučaju simulacije gutanja ali su njihove koncentracije ispod graničnih (maksimalno dozvoljenih) koncentracija. U daljnjim istraživanjima nastojati će se ispitati i druga sredstva za migraciju (simulanti) kao što su umjetna slina i umjetni znoj, a dobiveni rezultati usporediti s određenom ukupnom količinom pojedinog metala u uzorku dječje igračke. Također će se ispitati i druge metode pripreme uzoraka za analizu migracije metalnih iona s tekstilnih materijala namijenjenih dječjim igračkama te načiniti usporedba rezultata.

5. Literatura

[1] Direktiva 2009/48/EZ Europskog parlamenta i vijeća od 18. lipnja 2009. o sigurnosti igračaka (Tekst značajan za EGP), Službeni list Europske unije L 170/1; 18.6.2009
[2] HRN EN 71-3:2019 Sigurnost igračaka -- 3. dio: Otpuštanje određenih elemenata, (EN 71-3:2019) European Committee on Standards (CEN), EN 71-3:1994 Safety of toys – Part 3: Migration of certain elements, ICS 97.200.50, 1994
[3] Zakon o predmetima opće uporabe (NN broj 39/13, 47/14 i 114/18)
[4] Pravilnik o sigurnosti igračaka (NN broj 83/14, 38/15, 35/17, 50/18, 60/19 i 48/21)

Josip Jelic

Životopis	Josip Jelić rođen je 1980. godine u Zagrebu. Osnovnu i srednju školu završio je u Zagrebu. Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu završio je 2015. godine. Na Tekstilno-tehnološkom fakultetu Sveučilišta u Zagrebu upisao je poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija 2017. godine.
Naslov doktorskog rada	Vlaknaste strukture različite geometrije dobivene elektroispredanjem iz taline
Studijski savjetnik	prof. dr. sc. Budimir Mijović
Datum obrane teme doktorskog rada	

PLA ELEKTROISPREDENI NOSAČI IZ TALINE ZA TKIVNO INŽENJERSTVO

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Sažetak: *Elektroispredanje iz taline polimera provodi se uz pomoć visokog napona i hladi kako bi se formirale strukture od mikrovlakana promjera deset mikrometara, iako studije ukazuju na promjere stotinke od mikrometra i nanometra. U tom smislu tehnika je važna u biomedicinskom području gdje se preferiraju nosači za tkivno inženjerstvo s bimodalnim (nano i mikro) vlaknastim strukturama u pogledu adhezije stanica tkiva. U ovom radu dat je pregled uređaja za elektroispredanje iz taline, nakon čega slijedi njihova usporedba s novim uređajem za elektroispredanje taline Spraybase. Ovaj uređaj omogućuje visoko precizno taloženje mlazom taline u 2D i 3D programirane arhitekture, sa raznovrsnim translacijskim brzinama kolektorske ploče u X-Y i glave taline u Z smjeru. Vlaknaste strukture iz taline su dizajnirane ovisno o vrstama stanica tkiva koje se koriste za razvoj nosača..*

1. Uvod

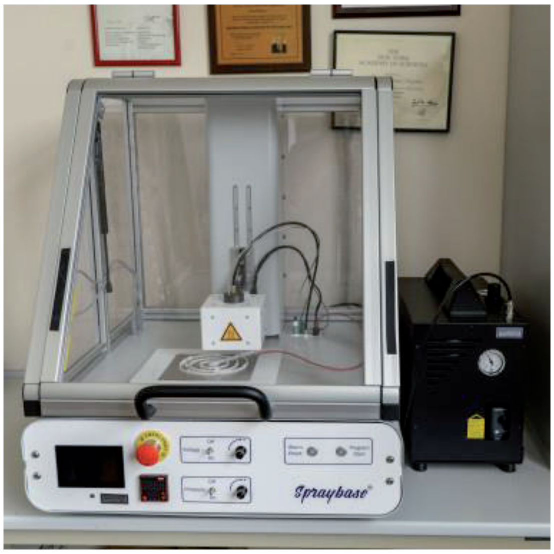
Elektroispredanje iz taline je relativno nova tehnologija ispredanja, a to potkrjepljuju i činjenice da su istraživanja koja su rađena na tom području, uglavnom iza 2011. godine. Također, udio dostupne literature o elektroispredanju iz taline zauzima samo 1% od ukupne literature o elektroispredanju [1]. Elektroispredanje polimerne taline idealna je tehnika za proizvodnju visoko poroznih nano ili mikro vlaknastih struktura koje su pogodne za biomedicinsku primjenu. U posljednjim desetljećima, elektroispredanje iz taline je poznato kao ekološki postupak jer eliminira citotoksične ekfekte otapala korištenih u elektroispredanju. Kao ekološki prihvatljiva metoda ispredanja mikro odnosno nano vlakana, elektroispredanje u poslijednje vrijeme privlači pozornost mnogih znanstvenika. Elektroispredanjem iz taline obično se proizvedu mikro-vlakna u rasponu od 5-40 μm, mada se pokazalo da ova tehnologija proizvodi vlakna promjera pola mikrona [2,3]. U području regenerativne medicine to je vrlo korisno jer elektroispredanje iz taline može proizvesti vlakna koja imaju veću razlučivost u usporedbi s 3D-tiskom. U posljednje vrijeme bilježi se ogroman porast potražnje za polimernim nano-vlaknima, koji se koriste za razne primjene, uključujući inženjering tkiva, zaštitnu odjeću, filtraciju i senzore.

2. Eksperimentalni dio

Za izradu uzoraka koristiti će se polimer polilaktid (PLA), dobiven iz prirodnih resursa čime se značajno smanjuju tragovi ugljika u usporedbi sa drugim polimerima. Komercijalni naziv PLA je Luminy® L175, homopolimer visoke točke taljenja, visoke viskoznosti, pogodan za ispredanje vlakana. U usporedbi sa standardnim PLA, ovaj homopolimer polilaktida ima veće talište i povećanu brzinu kristalizacije. Gustoća polilaktida je 1.24 g/cm^3.

Elektroispredanje polilaktida izvesti će se na uređaju *Spraybase*® AS-1204-000-01; Avectas Ltd., Irska u sklopu Zavoda za temeljne prirodne i tehničke znanosti na Sveučilištu u Zagrebu Tekstilno-tehnološki fakultet. Uređaj za elektroispredanje iz polimerne taline, sastoji se od sljedećih komponenti: 1) izvor visokog napona (električni napon do 20 kV), 2) glava sa spremnikom za taljenje polimera i mogućnošću gibanja po osi Z, 3) sustav grijanja (temperatura do 250 °C), 4) zračni kompresor za istiskivanje polimera (tlak do 5 bara), 5) kolektor u obliku metalne ravne ploče s mogućnošću gibanja po osi X i Y i dodatnim grijanjem i 6) zaštitna komora. Rad na uređaju za elektroispredanje iz polimerne taline provesti će se u više koraka.

Prvi korak je izrada 2D modela u programu "SEL program generator", zatim je potrebno generirati program i tablicu s koordinatama putanje kolektora u MSEL kontrolnom sustavu, koji također i služi za kontrolu uređaja. Na upravljačkoj ploči uređaja, postaviti će se željeni parametri. Odabrati će se željeni napon, tlak, te temperatura.



Slika 1: Uređaj Spraybase® AS-1204-000-01

Optimizacija procesnih parametara odnosi se na tlak zraka, temperaturu taljenja, električni napon, te udaljenosti glave sa spremnikom polimera od kolektora. Optimizaciji prethode podešavanja visine glave kolektora, brzine gibanja kolektora, broj ciklusa elektroispredanja (broj slojeva) te punjenje spremnika s granulama polimera.

3. Rezultati

Glavni cilj rada vezan je uz utjecaj geometrije i gustoće filamenta na poroznost i propusnost vlaknatih struktura. U skladu s tim, za svaki uzorak iz prve i druge skupine, izračunati će se poroznost pomoću digitalnog Dino Lite mikroskopa. Snimke uzoraka će se obraditi u *ImageJ* programu. U skupini uzoraka ispredenih iz taline u jednom sloju polimera PLA, izmjeriti će se propusnost zraka.

4. Zaključak

Tehnika elektroispredanja iz polimerne taline postaje popularna u novije vrijeme, a prednosti u odnosu na tehniku elektroispredanja iz polimerne otopine uključuju: ekološki prihvatljive uvjete proizvodnje, mogućnosti proizvodnje materijala ciljanih geometrija te proizvodnju mikrovlakana, što je poglavito poželjno na području biomedicine. U ovom radu će se istražiti mikrovlaknasti materijali iz taline polilaktida (PLA) uz detaljan opis dizajna 2D modela za izradu tri skupine materijala različitih geometrija odnosno gustoće filamenata

Literatura

[1] Hochleitner, G. et al: High definition fibrous poly(2-ethyl-2-oxazoline) scaffolds through melt electrospinning writing, *Polymers*, **55** (2014), 5017-5023, ISSN 2073-4360

[2] Dalton, P. et al: Electrospinning of polymer melts-Phenomenological observations, *Polymers,* **48** (2007), 6823-6833, ISSN 2073-4360

[3] Dalton, P. et al: Direct in vitro electrospinning with polymer melts*,* *Biomacromolecules*, **7** (2006) 3, 686-690, ISSN 1525-7797

Tea Jovanović

Životopis	Rođena je 1993. godine u Metkoviću. Srednju ekonomsku školu završava u Pločama 2012. godine kad upisuje preddiplomski sveučilišni studij na Tekstilno-tehnološkom fakultetu u Zagrebu. Godine 2018. upisuje poslijediplomski specijalistički studij na Tekstilno-tehnološkom fakultetu u Zagrebu, na kojem prethodno završava diplomski studij upisan 2015. godine. Trenutno zaposlena kao referentica prodaje u Wiip Technology d.o.o.
Naslov doktorskog rada	Krivulja histereze elastičnih pletiva
Studijski savjetnik	prof. dr. sc. Željko Penava
Datum obrane teme doktorskog rada	

KRIVULJA HISTEREZE ELASTIČNIH PLETIVA

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Sažetak: *Elastična pletiva imaju različitu funkcionalnu specifičnu namjenu. Od takvih pletiva se izrađuju prevencijske kompresijske čarape i čarape s gaćicama te kompresijske čarape koje koriste u medicinskoj terapiji. Mnoga suvremena rekreacijska odjeća u koju pripadaju različiti modeli hlača, majica ili grudnjaka također se izrađuje od elastičnih pletiva koja djeluju kompresijski na pojedine dijelove tijela. Steznici pripadaju u posebnu konstrukciju elastičnih pletiva koja imaju preciziranu namjensku funkciju. Npr. rukometaši i košarkaši te steznike najčešće nose na rukama. Funkcija im je veća izdržljivost mišića na napore kojima su podložni tijekom aktivnosti. Kod skijaša je cijelo tijelo izloženo specifičnim elastičnim pletivima koja pružaju osjet lakoće prilikom nošenja, održavaju toplinu tijela te zadržavaju mišićnu masu zagrijanom do početka utrke. Dizači utega koriste lagane elastične materijale kako bi imali što realniju tjelesnu masu te neometano sa istom podizali teret.*

1. Uvod

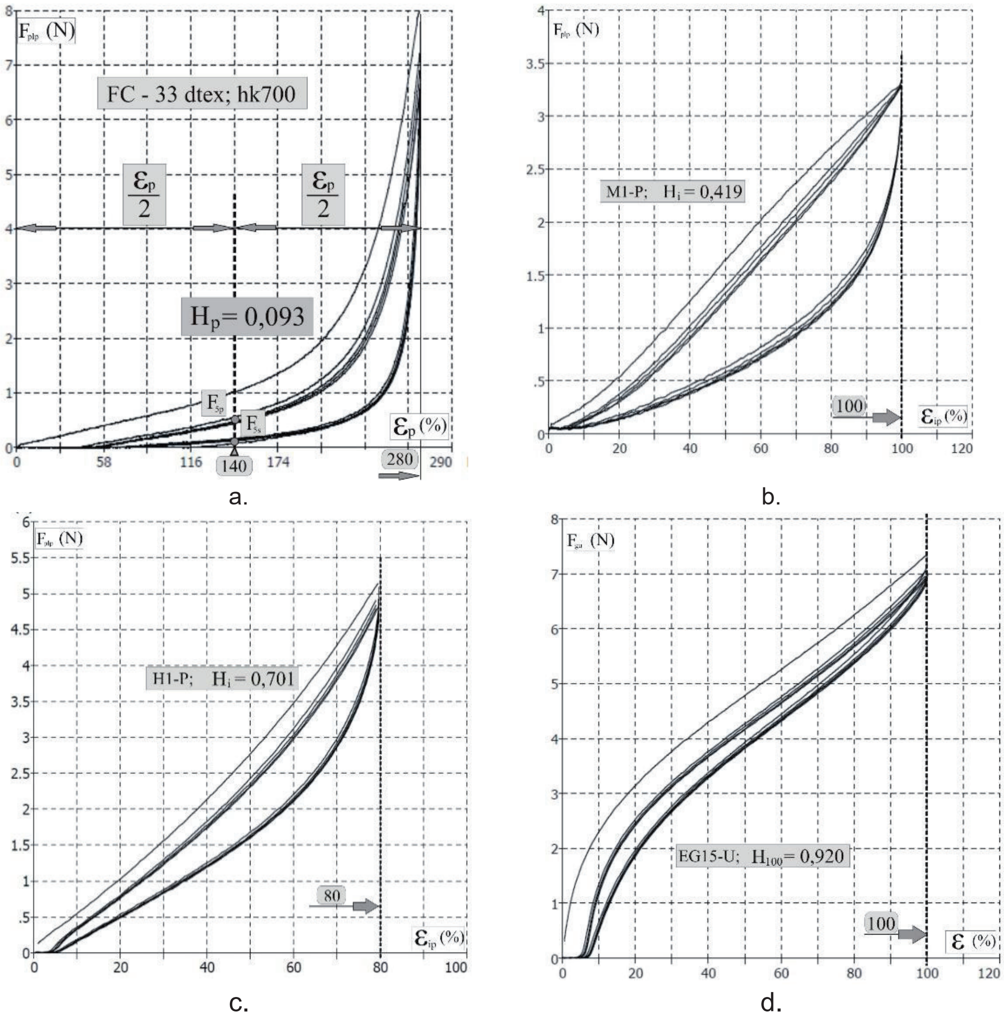
Pri tzv. statičkim vlačnim opterećenjima na dinamometru, pletiva se istežu najčešće poprečno i/ili uzdužno do prekida. Krivulja koja se dobije opisuje odnos sile i istezanja. Istezanje do prekida kod elastičnih pletiva veoma često je od 100 do 600 %. Dijagram sila/istezanje može se u osnovi podijeliti u tri dijela. Prvi dio dijagrama smatra se linearnim i pretpostavlja se da predstavlja elastično područje. Drugi dio dijagrama je zaobljen i predstavlja elastoplastično područje pletiva. Neke strukture pletiva su elastične i do kraja ovog dijela dijagrama. Treće područje počinje na početku drugog linearnog dijela dijagrama za koje se pretpostavlja da predstavlja početak plastične deformacije pletiva ili trajnu deformaciju i traje najčešće do najveće sile pri trganju pletiva. U karakterizaciji vlačnih svojstava pletiva prikladno je izračunati i navesti udjele istezanja za ova tri područja. Kod nekih struktura pletiva za analizu se uzima i točka tjemena krivulje sila/istezanje. U mnogo slučajeva ove tri točke koriste se kao osnovica pri višestrukom opterećenju pletiva u izučavanju njegovih vlačnih svojstava u upotrebi ili na dinamometru pri cikličkim mjerenjima. Kod mnogih elastičnih struktura pletiva, u ove tri točke ostvare se značajno različite deformacije [1, 2].

2. Eksperimentalni dio

Nakon pet cikličkih opterećenja istraživana je krivulja histereze elastičnih pletiva finih ženskih najlon čarapa (FC), rekreacijskih majica (M), rekreacijskih dugih hlača (H), kupaćih kostima (K) i elastičnih vrpci (EG). Za većinu tekstilnih elastičnih materijala indeks krivulje histereze nalazi se u području od 0 do 1. Ovdje navedeni rezultati cikličkih opterećenja pletiva prezentiraju preko krivulje histereze neke karakteristične strukture elastičnih pletiva. Uzorci za mjerenje vlačnih svojstava pletiva izrezani su u poprječnom i uzdužnom smjeru te istezani do tri navedene točke: 1. kraja elastičnosti, 2. točke tjemena i 3. točke početka trajne deformacije pletiva.

3. Rezultati i rasprava

Prvi navedeni dijagram krivulje histreze (sl. 1a) opisuje cikličko istezanje pletiva u poprečnom smjeru do početka trajne deformacije, tj. istezanja do 280 %. Pletivo predstavlja strukturu fine ženske najlon čarape (FC) koje naliježe na natkoljenični dio, a izrađeno je PA multifilamentnom pređom finoće 33 dtex. Pletivo ima najmanji indeks histereze (H_p) koji iznosi svega 0,093. Druge predstavljene krivulje histereze (sl.1b) nastale su pri poprečnom istezanju pletiva do točke tjemena krivulje sila/istezanje ili istezanja 100 %. Uzorak je izrezan iz neupotrebljavane rekreacijske majice (M). Krivulje histereza su znatno drugačijeg oblika nego prethodne i indeks histereze u točki tjemena (H_i) iznosi 0,419. Na sl. 1c predstavljene su krivulje histereze za neupotrebljavane rekreacijske duge hlače pri čemu je pletivo istezano poprečno do točke tjemena (80 %). Indeks histereze iznosi 0,701. Na posljednjoj slici (1d) predstavljene su krivulje histereza elastičnih vrpci koje se upotrebljavaju u izradi rublja i različite odjeće. Vrpca je bila širine 15 mm, istezana je 100 % i ima najveći indeks histereze koji iznosi 0,920.



Slika 1: Dijagrami krivulja histereza elastičnih pletiva: a. finih ženskih najlon čarapa (FC); b. majica (M); c. rekreacijskih dugih hlača (H) i d. elastičnih vrpci (EG)

4. Zaključak

Predstavljene krivulje histereza prezentiraju različite grupacije elastičnih pletiva pri višekratnom opterećenju (pet petlji). Dobiveni su indeksi histereze od 0,093 do 0,920. Prema dobivenim rezultatima može se zaključiti da krivulje histereze kvalitetno opisuju strukture i vlačna svojstva pletiva, naročito elastičnih te se ovi rezultati trebaju upotrebljavati pri izradi elastičnih proizvoda koji kompresijski djeluju na tijelo pri čemu treba uskladiti željenu kompresiju i veličinu istezanja pletiva. Analizom krivulja histereza može se ustvrditi razlika u statičkim i dinamičkim deformacijama pletiva i prognozirati pad kompresije pri upotrebi elastičnog pletenog proizvoda

Literatura

[1] Matsuo, M.; Yamada, T.: Hysteresis of Tensile load – Strain Route of Knitted Fabrics under Extension and Recovery Processes Estimated by Strain History, *Textile Research Journal*, **79** (2009) 3, 275-284, ISSN: 0040-5175

[2] DIN 53835-2/3/4/13/14: Prüfung von Textilien; Prüfung des zugelastischen Verhaltens; Textile Flächengebilde, einmalige Zugbeanspruchung zwischen konstanten Dehngrenzen

Nikolina Jukl

Životopis

Nikolina Jukl rođena je 1987. godine u Sv. Nedelji. 2010. godine završila je preddiplomski sveučilišni studij, a 2013. godine diplomski sveučilišni studij na Sveučilištu u Zagrebu, Tekstilno-tehnološkom fakultetu. 2013. godine upisala je poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija na Sveučilištu u Zagrebu Tekstilno-tehnološki fakultet. U razdoblju od 2003. do 2013. godine radila je povremeno u Konfeks d.o.o. gdje je stekla iskustvo u proizvodnom procesu, a od 2013. do 2022. godine je bila zaposlena kao voditeljica proizvodnje. Od 2022. godine zaposlena je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu kao asistent. Objavila je znanstveni rad u Q2 časopisu, stručni rad u domaćem časopisu te jedan znanstveni rad na domaćem skupu i jedan na međunarodnoj konferenciji. Istraživač je na znanstvenom projektu HRZZ IP-2018-01-6363 Razvoj i toplinska svojstva inteligentne odjeće.

Naslov doktorskog rada

Utjecaj vrste ugradbenih materijala i konstrukcije odjevnih kompozita na zbirna toplinska svojstva odjeće

Mentor

prof. dr. sc. Snježana Firšt Rogale

Datum obrane teme doktorskog rada

18. 12. 2019.

SIMULTANO ODREĐIVANJE OTPORA PROLAZU TOPLINE I TEMPERATURNIH GRADIJENATA ZAŠTITNE JAKNE

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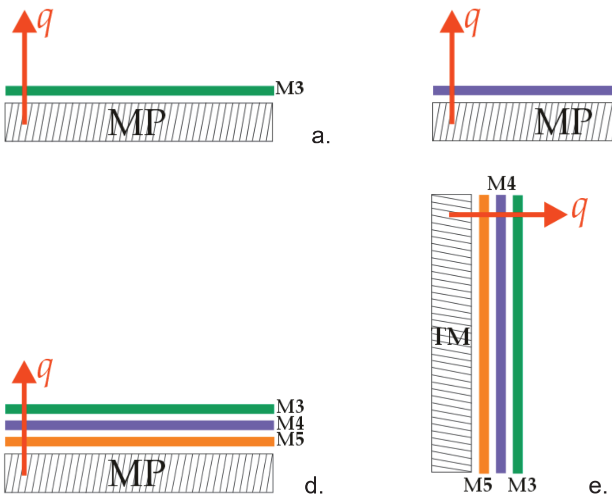
Sažetak *Prikazano je simultano mjerenje otpora prolazu topline kroz jedan ili više slojeva odjevnih kompozita i temperaturnih gradijenata slojeva odjevnih kompozita i zaštitne jakne. Prikazani su utvrđeni otpor prolazu topline toplinski gradijenti kao i rezultati mjerenja na temelju kojih je utvrđeno da ukupni otpor prolazu topline nije jednak algebarskom zbroju otpora pojedinih elemenata u odjevnom kompozitu u horizontalnom stanju, nego je veći zbog pojave malih zračnih slojeva uzrokovanih kovrčavošću i stršećim vlaknima pređe u tekstilnim plošnim materijalima. Isti kompoziti ugrađeni u zaštitnu jaknu u vertikalnom stanju omogućavaju stvaranje znatno širih zračnih slojeva koji povećavaju otpor prolazu topline.*

1. Uvod

Postoji velik broj objavljenih istraživanja koja se bave toplinskim svojstvima odjeće i tekstilnih materijala, te utjecajem zračnih slojeva koji se javljaju između tekstilnih materijala kao i u gotovim odjevnim predmetima [1-3]. Međutim, nisu istraživani temperaturni gradijenti u odjevnim kompozitima i gotovim odjevnim predmetima.

2. Eksperimentalni dio

Za ispitivanje su odabrani materijali koje se uobičajeno koriste u profesionalnoj proizvodnji zaštitnih jakni. Za izradu vanjske školjke odjevnog sustava korištena je tkanina od troslojnog laminata oznake M3 (tkanina – lice: 100 % PES; membrana: PTFE; tkanina - naličje:100 % PES fleece), za podstavu tkanina oznake M4 (100 % PES), te termoizolacijska tkanina od troslojnog romboidno prošivenog materijala oznake M5 (podstava: 100 %; punjenje: 100 % PP), sl. 1 [1].

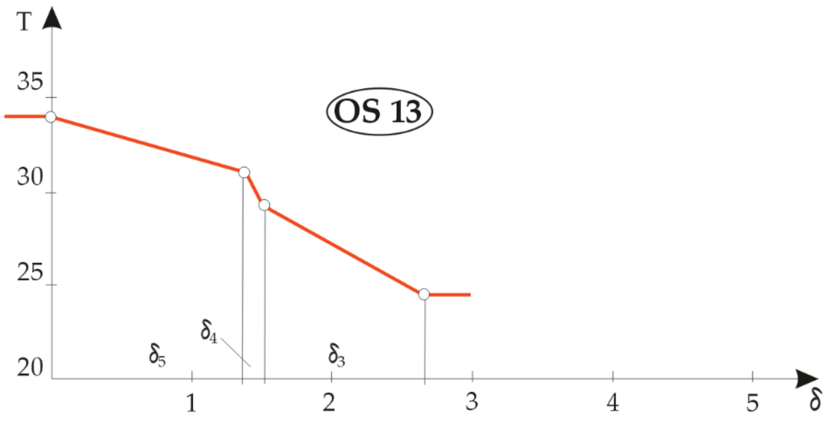


Slika 1: Mjerenja otpora prolazu topline za: a. materijal M3; b. M4 i c. M5 te simultano mjerenje otpora prolazu topline i temperaturnih gradijenata; d. na mjernoj ploči u horizontalnom stanju; e. na termalnom manekenu u vertikalnom položaju

Otpor prolazu topline i temperaturni gradijenti mjereni su u horizontalnom položaju na vrućoj ploči i u vertikalnom položaju, ugrađeni u jaknu, na termalnom manekenu koristeći novi mjerni uređaj za simultana mjerenja navedenih toplinskih svojstava. Provedena su mjerenja otpora prolazu topline za materijale M3, M4 i M5 te simultano mjerenje otpora prolazu topline i temperaturnih gradijenata na mjernoj ploči u horizontalnom stanju i zaštitne jakne, odnosno odjevnog sustava OS13 na termalnom manekenu u vertikalnom položaju [4].

3. Rezultati i rasprava

Prema rezultatima prikazanim na sl. 2 vidljivo je da je otpor prolazu topline veći na gotovom odjevnom predmetu, odnosno kod mjerenja na termalnom manekenu, nego na vrućoj ploči. Vertikalni položaj odjevnog sustava pri mjerenju omogućava stvaranje zračnih slojeva između slojeva tkanina odjevnog sustava, čime se povećava i otpor prolasku topline, a anatomska građa termalnog manekena također pridonosi stvaranju dodatnih zračnih prostora ispod linije grudi na prsima i leđima.



Slika 2: Grafički prikaz rezultata izračuna temperaturnih gradijenata za tri sloja ugradbenih odjevnih kompozita

4. Zaključak

Za mjerenje simultanih mjerenja pri određivanju otpora prolazu topline kroz jedan ili više slojeva odjevnih kompozita i temperaturnih gradijenata između slojeva kompozita korišten je novi mjerni sustav i novoutemeljena mjerna metoda u sklopu projekta HRZZ IP-2018-01-6363. Temeljem rezultata vidljivo je da, za razliku od zbroja izolacijskih svojstava pojedinih slojeva odjevnog kompozita koji je uvijek manji od realnih svojstava odjeće, algebarski zbroj padova temperatura unutar kompozita je jednak razlici temperatura između temperature mjerne ploče i temperature zraka ambijenta.

Zahvala

Istraživanja su izvedena u sklopu projekta HRZZ IP-2018-01-6363 Razvoj i toplinska svojstva inteligentne odjeće (ThermIC), financiranog od Hrvatske zaklade za znanost.

Literatura

[1] Gupta, D.; Srivastava, A.; Kale, S.: Thermal properties of single and double layer fabric assemblies. *Indian Journal of Fibre & Textile Research,* **38** (2013) 4, 387–394, ISSN: 9710426

[2] Pan, N.: Unique Thermal Properties of Clothing Materials, Global Challenges, **3** (2019) 1-7, ISSN 2056-6646.

[3] Xu, J.Y. et al: Influence of Layer Configuration on Protecting Effect of Thermal Protective Clothing Containing PCM, *Advanced Materials Research*, **796** (2013), 639–642, ISSN 1662-8985

[4] Firšt Rogale, S. et al. Measurement method for the simultaneous determination of thermal resistance and temperature gradients in the determination of thermal properties of textile material layers, *Materials,* **14** (2021), 22: 6853, 1-20, ISSN 1996-1944

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Životopis

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Radno iskustvo: od 2021. godine do danas radi kao tehnolog proizvodnog procesa u Calzedonia grupaciji.

Naslov doktorskog rada

Studijski savjetnik izv. prof. dr. sc. Maja Somogyi Škoc

Datum obrane teme doktorskog rada

ISTRAŽIVANJE I RAZVOJ DENTALNIH FLASTERA S BIOKOMPATIBILNIM I BIORAZGRADIVIM TEKSTILNIM NOSAČEM

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Sažetak: *Nema osobe koja nije bila kod zubara i nije imala neki od potrebnih dentalnih zahvata. Sve je u redu dok nema boli. Mnoga stanja nakon intervencije zubara, oralnoj sluznici uzrokuju znatnu i dugotrajnu bol koju je nekada teško ublažiti lokalnom primjenom, te se koristi injekcija koja kod pacijenata uzrokuje dentalnu anksioznost i bol od uboda iglom. Stoga je nužan razvoj materijala, za otpuštanje lijekova kao alternativna primjena. Kako je riječ o sluznici (lat. mucosa) potrebni su specijalni materijali, koji se mogu vezati za sluznicu i otpuštati anestetike, ali se pri tome ne smiju upijati u oralno tkivo.*

1. Uvod

Tekstilna tehnologija i njeni proizvodi danas su nezaobilazni dio našeg života, gdje ona pruža velike mogućnosti u svim područjima ljudske djelatnosti pa tako i u dentalnoj medicini. Ako je potrebno mogli bi zaštititi usnu šupljinu, tj. sluznicu pri operativnom zahvatu, pri nošenju mosta, proteze i sl. Rješenje za to postoji izradom tekstilije s nekom od novijih metoda tekstilne tehnologije (3D aditivna tehnologija, elektroispredanje) od biorazgradivih polimera. Dodatno, takva tekstilija može imati vezane aktivne supstance koje doprinose zaštiti sluznice, uspješnijem izlječenju sluznice i drugih stanja u usnoj šupljini. Aktivne supstance s tekstilnog nosača mogu se otpuštati različitim mehanizmima djelovanja, npr. pri različitim vrijednostima pH sluznice, uporabom spojeva različite ionske jakosti, djelovanjem temperature, djelovanjem mehanizma enzim-tekstilni podupirač i sluznica. Aktivne supstance prirodnog i umjetnog podrijetla u formi gela, mikrokapsula, ionskom obliku zasigurno bi doprinijeli u postupku liječenja ili zaštite sluznice.

2. Eksperimentalni dio

U polazišnoj osnovi istraživanja biti će hipoteza da se korištenjem dosadašnjih znanstvenih saznanja i dostignuća u području razvoja novih materijala može ostvariti novi doprinos u razvoju višefunkcionalnih tekstilija za primjenu u dentalnoj medicini.

U planiranju i izvođenju istraživanja koristit će se opća znanja iz područja metodologije znanstvenog rada – priprema materijala za potrebe istraživanja, provedba istraživanja i obrada dobivenih rezultata s ciljem ostvarivanja i potvrđivanja hipoteze.

Koristiti će se metode i postupci koji omogućuju ponovljivost obrada i morfoloških značajki istraživanih materijala uz primjenu suvremenih, pouzdanih, standardiziranih i novo razvijenih mjernih tehnika, s ciljem vrednovanja djelotvornosti nove tekstilije za primjenu u dentalnoj medicini.

3. Rezultati i rasprava

Istraživanje će obuhvatiti slijedeće cjeline, a što će se tijekom rada dopunjavat i mijenjat, ovisno o dobivenim spoznajama:

1. Odabir kemikalija, modifikatora, lijekova i dr.
2. Razvoj vlastitih receptura i izračun potrebnih količina kemikalija s ciljem odabira najbolje recepture
3. Razvoj metode i postupka razvoja tekstilije za primjenu u dentalnoj medicini
4. Konzultacije i suradnja s drugim institucijama o predmetu znanstvenog istraživanja
5. Razvoj tekstilije za primjenu u dentalnoj medicini, preliminarni uzorci i njihovo vrednovanje
6. Modifikacije, obrade i novi procesni parametri za dobivanje konačnih uzoraka i njihovo vrednovanje
7. Primjenjivost tekstilije i mogućnost komercijalne proizvodnje.

4. Zaključak

Očekivani rezultati doktorskoga rada su razvoj prototipa tekstilije za primjenu u usnoj šupljini te razvoj metodologije za vrjednovanje njene uporabne i funkcionalne kvalitete.

Literatura

[1] Goyal, A. K.; Singh, R.; Chauhan, G.; Rath, G.: Non-invasive systemic drug delivery through mucosal routes, *Artificial Cells, Nanomedicine, and Biotechnology*, **46** (2018) 2, 539-551, ISSN 2169141X

[2] Clitherow, K.H. et al: Mucoadhesive Electrospun Patch Delivery of Lidocaine to the Oral Mucosa and Investigation of Spatial Distribution in a Tissue Using MALDI-Mass Spectrometry Imaging, *Mol. Pharmaceutics*, **16** (2019), 3948−3956, ISSN 1543-8392

Ana Kalazić

Životopis

Ana Kalazić rođena je 1993. godine u Zagrebu. Nakon završetka opće Gimnazije Tituša Brezovačkog u Zagrebu, akademske godine 2012./2013. upisuje studij Računovodstva i financija na Ekonomskom fakultetu u Zagrebu gdje stječe zvanje stručne prvostupnice poslovne ekonomije. Godine 2015./2016. upisuje preddiplomski studij Tekstilne tehnologije i inženjerstva na Tekstilno-tehnološkom fakultetu u Zagrebu te 2019./2020. diplomira i stječe zvanje magistra inženjerka tekstilne tehnologije i inženjerstva. U akademskoj godini 2020./2021. zaposlila se na Tekstilno-tehnološkom fakultetu u Zagrebu kao stručni suradnik na projektu IRI II „Razvoj multifunkcionalne negorive tkanine za dualnu namjenu“, financiranog od EU iz Europskog fonda za regionalni razvoj. Iste godine upisuje poslijediplomski specijalistički studij Tekstilna znanost i tehnologija na Tekstilno-tehnološkom fakultetu u Zagrebu.

Naslov doktorskog rada

Studijski savjetnik prof. dr. sc. Stana Kovačević

Datum obrane teme doktorskog rada

PROPUSNOST VODENE PARE U VIŠEPOTKINIM TKNINAMA

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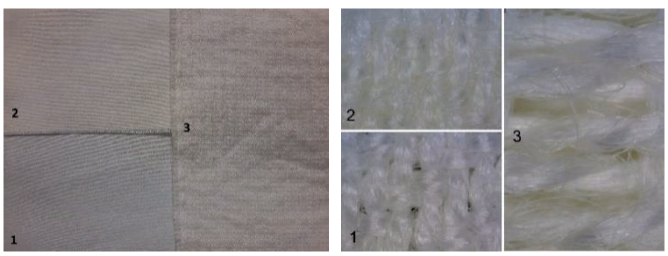
Sažetak: *U današnje vrijeme je sve zahtjevnije postići određena svojstva tkanina ili kompozita, koja su propisana standardima za određenu svrhu, a još je teže postići održivost tih svojstava tijekom uporabe. Tkanine s visokom razinom zaštite moraju imati svojstva udobnosti. Ispitivanjem propusnosti pare vode i otpornosti na prolaz kroz materijale može se definirati njihova prozračnost ili udobnost nošenja. Propusnost vodene pare (WVP) je svojstvo od izuzetne važnosti za izradu tkanina za vatrogasna odijela. Na poroznost tkanine i propusnost vodene pare utječu njeni konstrukcijski i strukturni parametri poput veza, gustoće, debljine, finoće pređe i td.*

1. Uvod

Zaštitna odjeća za vatrogasce koristi se prilikom gašenja požara ili sličnih aktivnosti gdje postoji opasnost od visokog stupnja toplinskog opterećenja i izravnog plamena. Ona štiti vatrogasca pri gašenju požara, spašavanju ljudskih života, te sprječavanju štete na imovini i okolišu. Zaštitna odjeća vatrogasaca mora zadovoljavati zaštitu od ostalih ekstremnih uvjeta kao što su zaštita od kiše i vode za gašenje. Razvoj učinkovite tekstilne zaštite od požara započinje pravilnim odabirom sirovine, tj. tekstilnih vlakana, koja moraju imati visoke performanse u vatrootpornosti. Također, zaštitna odjeća sa malom otpornošću na propusnost vodene pare može uzrokovati toplinski stres i nastanak velike količine znojenja, ometajući vizualna, kognitivna, fizička i psihička svojstva. U ovom radu analizirat će se propusnost vodene pare višepotkinih tkanina namijenjenih za vatrogasna odijela te usporediti s njihovom plošnom masom. Višepotkine tkanine sastoje se od jednog sustava osnovinih niti i najmanje dva sustava potkinih niti, koje stvaraju uzorak na tkanini. Potkine niti su gušće od osnovinih i vidljive su najčešće na licu i naličju tkanine, dok su osnovine uglavnom skrivene u sredini tkanine [1-4].

2. Eksperimentalni dio

U okviru eksperimentalnog dijela na automatskom laboratorijskom tkalačkom stroju tvrtke Fanyuan Instrument, model DW 598, otkana su tri različita višepotkina uzorka tkanina koji se koriste za izradu vatrogasnih odijela. Sirovinski sastav pređa korištenih za osnovu i potku je 95/5% Meta Aramid Conex NEO/Para Aramid Twaron raw i 45/55% Cotton/Modacrylic. Otkani uzorci i mikroskopske slike višepotkinih tkanina prikazani su na sl. 1. Na otkanim uzorcima napravljena je analiza propusnosti vodene pare.



a. b.

Slika 1: Višepotkine tkanine: a. otkani uzorci (1-dvopotkina; 2- tropotkina; 3- četveropotkina tkanina); b. mikroskopski izgled uzoraka uz pomoć Dino Lite digitalnog mikroskopa

Mjerenje propusnosti vodene pare tekstila vrši se prema normi ISO 15496. Iz dobivenih vrijednosti propusnosti vodene pare WVP, otpor vodene pare (R_{et}) može se odrediti prema formuli:

$$R_{et} = \frac{1}{WVP \cdot L_t}$$

Što je veća količina vodene pare koja se transportira kroz uzorak, to će manji biti otpor propuštanju vodene pare. Veza između WVP i R_{et} predstavlja latentnu toplinsku površinu (L_t) isparavanja vode na ispitnoj temperaturi u vodenoj kupelji 23 °C. Latentna toplinska površina isparavanja vode na temperaturi od 23 °C iznosi L (23 °C) = 0,67962 Wh/g [2].

3. Rezultati i rasprava

U tab.1 je prikazano kako se propusnost vodene pare WVP kretala od 0,1999 g/m^{2}Pah za uzorak 3, odnosno četveropotkinu tkaninu; 0,2609 g/m^{2}Pah za uzorak 2, odnosno tropotkinu tkaninu te 0,3383 g/m^{2}Pah za uzorak 1, odnosno dvopotkinu tkaninu.

Tablica 1: Rezultati plošne mase, propusnosti vodene pare WVP te otpor prolasku vodene pare R_{et} za višepotkine tkanine

Uzorak	m, g/m^2	WVP, g/m^{2}Pah	R_{et}, m^{2}PaW
1. dvopotkina	268,61	0,3383	4,35
2. tropotkina	328,54	0,2609	5,64
3. četveropotkina	378,76	0,1999	7,36

Otpor prolasku vodene pare R_{et} obrnuto je proporcionalan umnošku propusnosti vodene pare i latentne toplinske površine isparavanja vode na temperaturi od 23 °C i kreće se od 4,35 m^{2}PaW za uzorak 1; 5,64 m^{2}PaW za uzorak 2; 7,36 m^{2}PaW za uzorak 3. Također, iz danih podataka vidljiva je povezanost propusnosti vodene pare i mase uzoraka. Uzorak dvopotkine tkanine ima najmanju masu stoga je i propusnost vodene WVP/g/m^{2}Pah pare kod njega najveća, dok najmanju propusnost vodene pare, odnosno najveći otpor prolasku vodene pare ima četveropotkina tkanina koja ima i najveću masu.

4. Zaključak

Propusnost vodene pare je veća kod dvopotkinih tkanina zbog manje gustoće niti osnove i potke, utkanja, debljine i plošne mase u odnosu na tropotkine i četveropotkine tkanine. ISO 15 496:2018 navodi kako se ova metoda propusnosti vodene pare može koristi pri ispitivanju za kontrolu kvalitete, ali ima određena ograničenja u odnosu na normu ISO 11092, koja daje sveobuhvatniji i relevantniji rezultat za ocjenu propusnosti vodene pare.

Zahvala

Istraživanja su izrađena je u sklopu aktivnosti na istraživačkom projektu IRI II, „Razvoj multifunkcionalne negorive tkanine za dualnu namjenu“, financiranog od EU iz Europskog fonda za regionalni razvoj.

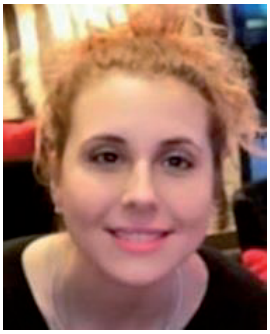
Literatura

[1] Kovačević, S.; Dimitrovski, K.; Hađina, J.: *Procesi tkanja*, Tekstilno-tehnološki fakultet, ISBN 978-953-7105-21-1, Zagreb, (2008.)

[2] Kiš, A.; Brnada, S.; Kovačević, S.: Influence of Fabric Weave on Thermal Radiation Resistance and Water Vapor Permeability, *Dostupan na*: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7182866/ *Pristupljeno*: 2021-12-13

[3] Hursa Šajatović, A. i sur.: Istraživanje stanja zaštitne odjeće za vatrogasce putem ankete, *Tekstil,* **65** (2016.) 11-12, 378-387, ISSN 0492 - 5882

[4] Schwarz, I. et al: Physical-mechanical properties of thermal protective fabric subjected to textile care, *Dostupan na*: https://www.researchgate.net/publication/342108708_Physical-mechanical_properties_of_ thermal_protective_fabric_subjected_to_textile_care *Pristupljeno*: 2021-12-15



Franka Karin

Životopis

Franka Karin rođena je 1986. godine u Zagrebu. 2012. godine diplomirala je na Tekstilno-tehnološkom fakultetu. Od listopada 2017. godine zaposlena je kao asistent Tekstilno-tehnološkog fakulteta u Zagrebu. U prosincu 2017. godine je upisala poslijediplomski sveučilišni studijTekstilna znanost i tehnologija. Područje istraživanja usmjerila je na održivu modu i komparaciju tradicije i održivosti.

Naslov doktorskog rada	Od tradicije prema suvremenom-održivost u modi
Studijski savjetnik	izv. prof. dr. sc. Irena Šabarić
Datum obrane teme doktorskog rada	

TRADICIJA I ODRŽIVOST U MODI

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Sažetak: *Problem modne industrije je prekomjerni tekstilni otpad koji je posljedica brze mode. Proizvodni trendovi spore mode nude nove pristupe u dizajniranju i proizvodnji odjeće te se javlja kao protuteža brzoj modi i podiže ekološku svijest, njeguje kulturne vrijednosti i očuvanje tradicije. U prvi plan stavlja svijest o dizajnu odjeće koji je bezvremen i vraća tradicijske zanate u proizvodnji. Tradicijska odjeća proizvodila se prema principima koje primjenjuje spora moda. Istraživanjem dobre prakse u tradiciji i primjeni u kontekstu suvremenog dizajna odjeće donosi primjenjive metode s ciljem održivosti u modi. Tradicijska odjeća glavno je polazište i inspiracija u radu kao spoj tradicije i suvremenih istraživanja održivih metoda.*

1. Uvod

Načini proizvodnje brze mode potiču potrošače da kupuju suvišne odjevene predmete u skladu s modnim trendovima što dovodi do gomilanja tekstilija kratkog vijeka trajanja. Modna industrija tako ostvaruje zaradu, a istovremeno stvara prekomjerni tekstilni otpad. Primjenom koncepata održivog razvoja u modi odjeći se produžuje uporabna komponenta i unaprijed se promišlja o njezinom adekvatnom zbrinjavanju. Jedan od pristupa održive mode bazira se na potpunom ili što većem iskorištenju materijala, a naglasak je na tradicijskoj proizvodnji i kvaliteti, a ne kvantiteti proizvoda. Najviše otpada nastaje od izrezivanja materijala u procesu krojenja. Tradicionalne metode krojenja uzrokuju do 15% tekstilnog otpada stoga su nova rješenja u skladu s održivim razvojem probudila svijest kod sve većeg broja modnih brendova [1].

2. Eksperimentalni dio

Nove smjernice u održivoj modi ne podliježu modnim trendovima već su okrenute prema bezvremenskom dizajnu. Održivim metodama cilj je što veće iskorištenje tekstilnog materijala [2]. Brza moda preplavila je tržište što je rezultiralo izumiranjem konvencionalne proizvodnje odjeće tradicijskim vještinama kojima se njegovala baština tradicijske odjeće. Smjernice spore mode vode prema održivom razvoju od početka dizajnerskog procesa [3]. Kroz koncept spore mode zastupljena je zero waste metoda koju možemo vidjeti u proizvodnji tradicijske odjeće kako u svijetu, tako i na području Hrvatske. Načini krojenja i dizajn bez tekstilnog otpada i tradicijska odjeća s prostora Hrvatske, mogu biti polazište za razvoj održivog dizajna odjeće. Pristup zero waste metode i pristup izrade narodnih nošnji hrvatskih prostora imaju iste ciljeve. Nošnja kao tradicijska odjeća bila je pokazatelj određene kulture koja se mijenjala sukladno razvojem društva, političkim i gospodarskim promjenama. Pojavom fenomena mode tradicijska odjeća zapostavljena je zbog društvenih, kulturnih i socijalnih promjena koji su je izgurali iz svakodnevnog odijevanja. Spona između tradicije i modernog je spora moda [4]. Svaki odjevni predmet, bilo da se radi o tradicijskom ili modnom, svojim postojanjem ima vrijednost i njegovo odijevanje dokumentira dio povijesti koji se odnosi na tekstil određenog vremena, proizvodnju, dizajn i tehnološke procese izrade [5]. Narodne nošnje i njihova izrada dobar su primjer tradicijskih vještina. U suvremenom kontekstu proizvodnje odjevnom predmetu se produžuje životni vijek i njeguju tradicijske tehnike izrade, a u kontekstu spore mode revitalizacija tradicijskih tehnika dobar su primjer za podizanje svijesti prema održivoj modi i njezinim pozitivnim utjecajima na društvo i okoliš.

3. Rezultati i rasprava

Cilj zero waste metode je svesti otpad na minimum dizajnerskim promišljanjima u procesu izrade krojeva. Praksa izrade odjeće stara je kao i odijevanje i osvrnemo li se na povijesne primjere izrade odjeće, možemo primijetiti sličnosti u formama, krojnim dijelovima i načinu iskrojavanja s pristupom zero waste-a koji se danas primjenjuje. Proces krojenja u standardnoj konstrukciji odjeće rezultira otpadom tkanine u industriji. Stoga je metoda uklapanja krojnih dijelova u površinu tkanine dobar pristup koji minimalizira otpad. Za to su zaslužne geometrizirane forme u odnosu na konvencionalne odjevne predmete. Izbjegavanje tekstilnog otpada u kreativnom procesu ne smije utjecati na estetiku i pristalost odjevnog predmeta. Glavno polazište prema načelima zero waste-a je tkanina, njezine dimenzije, vrsta, tekstura i njezini rubovi [6]. Krojni dijelovi uklapaju se u dimenzije tkanine. Prema tome možemo zaključiti da zero waste djeluje od najranije povijesti kada se odjeća izrađivala jednakom metodom. Osvrnemo li se na geometrizirane forme s vrlo malo tekstilnog otpada i usporedimo li ih s tradicijskom odjećom hrvatskih prostora, možemo vidjeti da su narodne nošnje odličan primjer zero waste-a. Način na koji se izrađivala tradicijska odjeća i iskorištenje materijala danas se koristiti u kontekstu spore mode. Tradicijski odjevni predmeti glavna su inspiracija za zero waste pristup. Neki od takvih primjera su kineske hlače iz 1956. godine sastavljene od dva velika pravokutnika s potpunim iskorištenjem tkanine. Možemo ih usporediti s muškim hlačama iz narodne nošnje Slavonije kao tradicijski primjer zero waste-a s prostora Hrvatske [6, 7]. Finska ženska bluza iz 1956. godine inspiracija je koju možemo usporediti s rubinama iz ženske narodne nošnje Slavonije zbog sličnosti u načinu izrade i iskorištenju tkanine [6, 8]. Cilj rada je istražiti načine krojenja narodne nošnje kako bi se dobilo što veće iskorištenje tkanine i kako su se dorađivale površine materijala da bi odjevni predmet bio što dugotrajniji te na temelju tih istraživanja usporediti suvremena istraživanja novih metoda krojenja odjeće kao što je zero waste i osmisliti nove načine izrade kolekcija odjeće u svrhu održivosti.

4. Zaključak

Nove metode u okviru koncepta održivog razvoja razvili su se iz potrebe da se osvijesti važnost održivih smjernica u modi i minimalizira tekstilni otpad. Jedna od metoda koja je proizašla iz spore mode je zero waste kojom se izrađivala tradicijska odjeća. Načini izrade, pristup prema krojenju i pristup prema tkanini zajednički su metodi zero waste-a i narodnim nošnjama hrvatskih prostora. Zero waste zahtijeva kontinuirani rad i istraživanje kako bi se ostvarili dobri rezultati u skladu s održivom modom. Bitno je promišljanje u dizajnerskom procesu i procesu proizvodnje odjeće. Forme krojnih dijelova baziraju se na geometrizaciji. Narodne nošnje Hrvatske izvor su raznih promišljanja u dizajnu odjeće koji se može primijeniti u skladu s održivošću. Proučavanjem tih metoda i stavljanjem u suvremeni kontekst uz primjenu novih tehnologija moguće je izraditi kolekciju na principima spore mode. Sinergijom tradicije i suvremenih spoznaja koncept spore mode može se primijeniti na proizvodnju odjeće te dugoročno vratiti ugled tekstilnoj industriji uz brigu za okoliš.

Literatura

[1] Styles, R.: *Ecologist: guide to Fashion*, Leaping Hare Press, ISBN 978-1-78240-102-5, London, (2014)

[2] Gwilt, A.; Rissanen, T.: *Shaping sustainable fashion changing the way we make and use clothes*, Routledge, ISBN 978-1-84971-241-5, Washington, (2011)

[3] Ninimäki, K.: *Sustainable fashion: New approaches*, Aalto University, ISBN 978-952-5572-5, Helsinki, (2003)

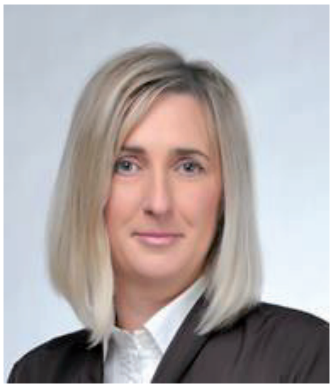
[4] Maglica, N.: *Baranja se šareni: Predajno ruho baranjskih Hrvata*, Etnografski muzej, ISBN 953-6273-25-X, Zagreb, (2003.)

[5] Mihalić, I.; Simončič, K. N.: Odjevni predmet kao muzejski artefakt, *TEDI*, **4** (2014.), 18-23, ISSN 1847-9545

[6] Rissanen, T.; Mcquillan, H: *Zero waste fashion design*, Fairchild Books, ISBN 978-1-4725-8198-3, New York, (2016)

[7] Radauš-Ribarić, J.: *Narodne nošnje Hrvatske*, Spektar, Zagreb, (1975.)

[8] Kolić Klikić, V.: *Ženske narodne nošnje zapadne Slavonije*, Gradski muzej Nova Gradiška, ISBN 978-953-95012-2-6, Nova Gradiška, (2007.)



Ines Katić Križmančić

Životopis

Ines Katić Križmančić rođena je u Zagrebu 1965. godine. Diplomski studij završila je na Tekstilno-tehnološkom fakultetu u Zagrebu. Poslijediplomski specijalistički studij Tekstilna znanost i tehnologija upisala je akad. god. 2019/2020. Ima više od trideset godina iskustva u tekstilnoj industriji, koje je stekla radeći kao tekstilni i odjevni dizajner, tehnolog te voditelj tekstilnog i kožarskog klastera. Njezin znanstveni interes vezan je uz temu inovativnih tekstilnih materijala za povećanje udobnosti sportske odjeće.

Naslov doktorskog rada

Studijski savjetnik izv. prof. dr. sc. Ivana Salopek Čubrić

Datum obrane teme doktorskog rada

ISPITIVANJE SVOJSTAVA PLETIVA U SVRHU OPTIMALIZACIJE IZVEDBE SPORTSKE ODJEĆE

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Sažetak: *Udobnost sportske odjeće rezultat je višestrukih interakcija između fizioloških i fizičkih čimbenika. Sportska odjeća ima aktivan odnos između tijela sportaša, vrste tjelesne aktivnosti i okoline. Glavna funkcija sportske odjeće je podrška i poboljšanje tjelesnih aktivnosti. Danas je velika pozornost, u industriji sportske odjeće, usmjerena na istraživanje višenamjenskog tekstila. Pozivajući se na globalna ekonomska izvješća, očekuje se da će tržište sportske odjeće do 2025. godine premašiti 100 milijardi američkih dolara. Ovi podaci pokazuju nam na važnost istraživanja svojstava materijala za izradu sportske odjeće i kreiranja smjernica za njihovo daljnje unapređenje. U eksperimentalnom dijelu ovog rada fokus je na ispitivanju vlačnih svojstava pletiva važnih za optimalne performanse tekstilnih materijala, posebice za proizvodnju specifične sportske odjeće. U radu se razmatraju dobiveni rezultati i daju smjernice za daljnja poboljšanja.*

1. Uvod

Bavljenje sportom, više ne samo profesionalno nego i rekreativno, postaje jedna od ultimativnih aktivnosti osviještenog suvremenog čovjeka. Takav trend postavlja nove zahtjeve u pogledu funkcionalnog dizajna i inovativnosti novih ekoloških materijala posebno u razvoju sportske odjeće. Poliester je tkanina koja se najčešće koristi za proizvodnju sportske odjeće. Također, za sportsku odjeću prikladna su i druga vlakna kao što su poliamid, polipropilen, akril i elastan. Glavna funkcija sportske odjeće je podrška i poboljšanje tjelesnih aktivnosti. Zbog toga je velika pozornost industrije sportske odjeće usmjerena na istraživanje višenamjenskog tekstila. Pozivajući se na globalna ekonomska izvješća, očekuje se da će tržište sportske odjeće premašiti 100 milijardi američkih dolara do 2025. godine [1]. Svi ovi podaci daju jasnu sliku o tome koliko je važno usmjeriti istraživanja na svojstva materijala namijenjenih izradi sportske odjeće. Glavna svojstva su mehaničko-fizička, kemijska i površinska [2].

2. Eksperimentalni dio

U ovom radu istražena su vlačna svojstva odabranog seta pletiva namijenjenih proizvodnji sportske odjeće. Tijekom niza sportskih aktivnosti sportaši se često nalaze u izravnom dvoboju sa suparničkim igračima i učestalo dolazi do povlačenje odjeće. Stoga su podaci o prekidnoj sili i istezanju materijala važni pri usporedbi i donošenju zaključaka vezanih za performanse materijala. Za ovaj pokus odabrana su pletiva, izrađena od poliesterske pređe, koje se razlikuju prema strukturi prepleta i gramaturi, što je prikazano u tab.1.

Tablica 1: Izabrana pletiva

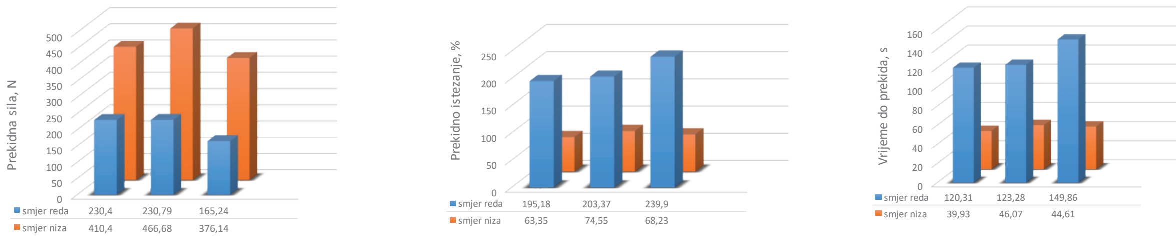
Naziv pletiva	Mikroskopska snimka uvećanje 50x	Sirovinski sastav	Preplet	Plošna masa u g/m²
PES-136		100% poliester	kulirni, desno-desni platirni	136
PES-153		100% poliester	kulirni, desno-desni šupljikavi	153
PES-158		100% poliester	kulirni, desno-desni šupljikavi	158

2.1. Metode mjerenja

U eksperimentalnom dijelu vlačna svojstva ispitivana su prema postupku opisanom u međunarodnoj normi ISO 13934-1 [3]. Za mjerenje je korišten vlačni tester Statimat M, proizvođača Textechno. Pripremljeni su uzorci dimenzija 50±0,5 mm x 200±0,5 mm. Uzorci su izrezani u oba smjera, smjeru niza i reda, jer pletiva nemaju homogenu strukturu u oba smjera. Ispitna brzina je postavljena na 100 mm/min^{-1}. Osigurana atmosfera, za predkondicioniranje i kondicioniranje uzoraka, odgovarala je preporukama danim u EN 20139 [4].

3. Rezultati i rasprava

Dobiveni rezultati vlačnih svojstava za uzorke PES-136, PES-153 i PES-158 sažeti su i prikazani u sl.1. Paralelno su prikazani rezultati mjerenja u smjeru reda i smjeru niza.



a. b. c.

Slika 1: Rezultati mjerenja vlačnih svojstava: a. prekidna sila; b. prekidno istezanje; c. vrijeme do prekida

Što se tiče prekidne sile, sl. 1a, vidljivo je da je prekidna sila znatno veća u smjeru niza nego u smjeru reda i to u prosjeku od 100 %. Rezultati prekidnog istezanja i vremena do prekida prikazani su na sl.1b i 1c Znakovito je da su oba značajno veća u smjeru reda nego u smjeru niza i to u prosjeku od 300 %.

4. Zaključak

Istraživanje vlakana, materijala i poboljšanje dizajna sportske odjeće važan je segment u razvoju njihove izvedbe, posebice udobnosti. Fokus ovog rada bilo je ispitivanje vlačnih svojstava. Daljnja istraživanja bit će usmjerena na širi raspon pletiva i istraživanje šireg spektra njihovih svojstava, vezanih uz uspostavljanje optimalne udobnosti i dugotrajne funkcionalnosti tijekom intenzivnih sportskih aktivnosti.

Zahvala

Ovaj rad u potpunosti je podržala Hrvatska zaklada za znanost u sklopu projekta IP- 2020-02-5041 Tekstilni materijali za povećanu udobnost u sportu - TEMPO.

Literatura

[1] Sportswear Industry: Global Market to reach US$ 108.7 Bn by the end of 2025 – QY Research, Inc., *Dostupan na:* https://www.globenewswire.com/news-release/2019/02/27/1743035/0/en/Sportswear-Industry-Global-Market-to-reach-US-108-7-Bn-by-the-end-of-2025-QY-Research-Inc.html, *Pristupljeno:* 2021-12-20

[2] Shishoo, R.: *Textiles in Sport*, Woodhead Publishing Limited, eBook ISBN 9781845690885, Cambridge, (2005), 89-90.

[3] ISO 13934-1 Textiles - Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method

[4] EN 20139 Textiles - Standard Atmospheres for Conditioning and Testing

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Studijski savjetnik	izv. prof. dr. sc. Sanja Ercegović Ražić
Datum obrane teme doktorskog rada	

MODIFIKACIJA POLIESTERSKE TKANINE HITOZANOM

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Sažetak: *Istraživanja u doktorskom radu usmjerit će se na funkcionalizaciju tkanine od poliesterskih vlakana biopolimerom hitozanom, kojoj će prethoditi kemijska (primjena kemijskog sredstva) i fizikalna (primjena hladne plazme) modifikacija površine. Utjecaj ovih (pred)obrada na svojstva poliesterske tkanine istražit će se fizikalno-kemijskim metodama analize i procijeniti njihov učinak na otpuštanje čestica hitozanom obrađenih poliesterskih tkanina u procesu pranja kroz analizu efluenata, filtrata i filtarskog kolača.*

1. Uvod

Proces pranja tekstilija od sintetskih polimera je identificiran kao jedan od izvora primarne mikroplastike (MP) koje sustavom odvodnje dospijevaju do uređaja za pročišćavanje otpadnih voda [1-3]. Ovaj problem iziskuje preventivne mjere koje se mogu provoditi na više razina. U doktorskom radu će se istražiti funkcionalna obrada prethodno predobrađene tkanine od poliesterskih vlakana biopolimerom hitozanom. Obzirom da tekstilije od poliesterskih vlakana nisu kompatibilne s biopolimerom hitozana, potrebno je provesti ciljanu modifikaciju površine i prirediti ih za postupak obrade hitozanom [4]. Istražit će se kemijska modifikacija u dvije varijante, a fizikalna modifikacija primjenom atmosferske plazme. Učinak obrade hitozanom procijenit će se kroz analizu otpuštenih čestica iz poliesterske tkanine u procesu pranja, te će se provesti analiza antimikrobne aktivnosti i biorazgradivosti obrađenih materijala [5].

2. Eksperimentalni dio

Prije obrade hitozanom, standardna tkanina od poliesterskih vlakana, će se kemijski predobradit s NaOH te s NaOH uz dodatak promotora - benzalkonijevog klorida i fizikalna modifikacija površine tkanine primjenom atmosferskog plazmenog mlaza uz optimirane parametre. Neobrađeni i hitozanom obrađeni uzorci poliesterske tkanine će se podvrgnuti cikličkim procesima pranja u skladu s normom HRN EN ISO 6330:2012.

3. Rezultati i rasprava

Nakon provedenih obrada i modifikacija svojstava tkanine iz poliesterskih vlakana provest će opsežna analiza svojstava primjenom fizikalno-kemijskih metoda, u svrhu provjere učinaka kemijske i fizikalne modifikacije i provedene obrade, tab. 1.

Tablica 1: Fizikalno-kemijske metode analize modificirane površine tkanine

Metoda	Pokazatelj/rezultat
Gravimetrijska	Gubitak/prirast mase
Identifikacija bojilom	Dubina obojenja
Potencijal strujanja	Zeta potencijal
Mikroskopija	SEM slika, digitalna slika
Remisijska spektrofotometrija	Stupanj bjeline, dubina obojenja
FTIR	FTIR spektrogram
Piling	Ocjena površine
Antimikrobni test	% redukcije
Određivanje prekidne sile/istezanja	Vlačna svojstva
Određivanje opipa	Ocjena opipa
Električna otpornost	Antistatička svojstva
Biorazgradivost	Razgradivost

Nakon procesa pranja neobrađene i hitozanom obrađenih tkanina analizirati će se efluent, filterski kolač i filtrat primjenom fizikalno-kemijskih metoda, tab. 2.

Tablica 2: Fizikalno-kemijske metode karakterizacije otpuštenih čestica

Metoda	Efluent	Filterski kolač	Filtrat
Laserska difrakcija	+	-	-
Određivanje isparnog ostatka (TS)	+	-	-
Određivanje ukupne otopljene tvari (TDS)	+	-	-
Određivanje ukupne suspendirane tvari (TSS)	+	-	-
Gravimetrijska	-	+	-
Određivanje mutnoće	+	-	+
Mikroskopska analiza	-	+	-
Pirolitička razgradnja uparena s plinskom kromatografijom i masenom spektroskopijom	-	+	-
Određivanje pH	+	-	+
Određivanje vodljivosti	+	-	+
Određivanje KPK	+	-	+
Određivanje BPK	+	-	+

4. Zaključak

Cilj doktorskog rada je provjera koncepta inovativne obrade poliesterske tkanine hitozanom prije i nakon kemijske i fizikalne modifikacije u smanjenju otpuštanja čestica iz poliesterske tkanine u procesu pranja kroz postavljene hipoteze:H1 Kemijska modifikacija poliesterske tkanine povoljno utječe na vezanje hitozana.
H2 Fizikalna modifikacija poliesterske tkanine povoljno utječe na vezanje hitozana.
H3 Hitozan-poliester struktura osigurava manje otpuštanje MP čestica nego neobrađena poliesterska tkanina u procesu pranja.

Zahvala

Doktorski rad je integrativni dio istraživanja na projektima Hrvatske zaklade za znanost, HRZZ IP-2020-02-7575 Procjena otpuštanja čestica mikroplastike u pranju poliesterskih tekstilija i HRZZ-PZS-2019-02-5276 Sinteza naprednih nanočestica i primjene u fotokatalizi i tekstilnim materijalima.

Literatura

[1] Haap, J.; Classen, E.: Analytical approach for the detection of micro-sized fibers from textile laundry, *In Proceedings of the International Conference on Microplastic Pollution in the Mediterranean Sea*, Springer, ISBN 978-3-319-71279-6, Cham, (2018), 73-79

[2] Bule, K. i sur.: Mikroplastika u morskom okolišu Jadrana, *Kemija u industriji*, **69** (2020.) 5-6, 303–310, ISBN 978-953-6894-70-3

[3] Hernandez, E.; Nowack, B.; Mitrano, D. M.: Polyester textiles as a source of microplastics from households: a mechanistic study to understand microfiber release during washing, *Environmental science & technology*, **51** (2017) 12, 7036-7046, ISSN 15205851

[4] Bhavsar, P. S.; Fontana, D. G.; Zoccola, M.: Sustainable Superheated Water Hydrolysis of Black Soldier Fly Exuviae for Chitin Extraction and Use of the Obtained Chitosan in the Textile Field, *ACS omega*, **6** (2021) 13, 8884-8893, ISSN 2470-1343

[5] Primc, G. et al: Biodegradability of oxygen-plasma treated cellulose textile functionalized with ZnO nanoparticles as antibacterial treatment, *Journal of physics. D, Applied physics*, **49** (2016) 32, 324002-324011, ISSN 0022-3727

Ana Kiš

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Naslov doktorskog rada	
Studijski savjetnik	prof. dr. sc. Stana Kovačević
Datum obrane teme doktorskog rada	

UTJECAJ STRUKTURE NA TOPLINSKU ZAŠTITU

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Sažetak: *Istraživanje se temeljilo na utjecaju strukture tkanine na otpornost tkanine na toplinsko zračenje. Na temelju rezultata utvrđuje se da vez utječe na strukturu tkanine koja se prenosi i na učinkovitost zaštite od visokih temperatura.*

1. Uvod

Zaštita ljudskog tijela od ekstremnih vanjskih uvjeta poznata je od davnina. Proizvodnja tkanina rezultirala je njihovom širokom primjenom u kućanstvu i odjeći za zaštitu od ekstremnih temperatura, oborina, vjetra, UV zračenja, mehaničkih udara itd. Izbor sirovina za zaštitnu odjeću mora pridonijeti najučinkovitijoj zaštiti. Tehnološkim razvojem, kao i pojavom umjetnih vlakana, razvoj zaštitnih tkanina uvelike se promijenio što je utjecalo na njihovu proizvodnju za ciljanu primjenu [1-3]. Zahtjevi koji se postavljaju pred tekstilne materijale za visokotemperaturnu zaštitnu odjeću dovode do inovacija u razvoju i proizvodnji tkanih tkanina [4-6]. Ovim radom istražit će se utjecaj strukture na učinkovitost zaštite od visokih temperatura.

2. Eksperimentalni dio

Ispitivanja su provedena na različitim vrstama tkanina koje su otkane iz iste osnove i potke: 16,7×2 tex 95% M-aramid Conex NEO + 5% P-aramid Twaron MOK3 u različitim vezovima. Gustoća niti osnove nije se mijenjala u brdu i iznosila je za sve uzorke 15 niti/cm. Gustoća osnove u tkanini nakon skidanja s tkalačkog stroja ovisila je o vezu. Na gustoću potke utjecao je također vez i napetost osnove koja se održavala konstantnom tijekom procesa tkanja. Strukturne i konstrukcijske karakteristike uzoraka određene su standardnim metodama i to: gustoća niti osnove i potke, debljina uzoraka i površinska masa. Učinkovitost zaštite od visokih temperatura određena je prijenosom topline zračenja koja je ispitana prema HRN EN ISO 6942: 2003, metoda B, s toplinskim tokom Q_0 = 20 kW/m². Ispitivanje je provedeno na uređaju proizvedenom prema propisima u normi. Pomoću kalorimetra izračunata je gustoća protoka topline kroz uzorak.

3. Rezultati i rasprava

Prema rezultatima ispitivanja otpornosti tkanine na toplinu zračenja, može se pronaći značajna razlika između struktura tkanina, tab. 1.

Tablica 1: Strukturne i konstrukcijske karakteristike te pripadajući rezultati ispitivanja otpornosti tkanina na zračenje toplinom

Uzorci, vez	Osnova, niti/cm	Potka, niti/cm	Debljina, mm	Površinska masa, g/m^2	t_{12}, s	t_{24},s	t_{24}-t_{12} ,s	Q_c, kW/m^2	TFQ_0, kW/m^2
Platno	17	23	0.58	142.0	6.70	12.42	5.72	11.56	0.58
Keper	17	24	0.70	149.5	6.90	13.73	6.83	9.67	0.48
Atlas	17	36	0.94	172.0	7.03	14.50	7.47	8.85	0.44
2-potkin	17	60	1.00	250.0	9.03	17.73	8.70	7.63	0.38
4-potkin	17	80	2.20	340.0	12.37	23.23	10.87	6.10	0.30
Štruks	17	40	1.18	187.0	7.60	15.07	7.47	8.87	0.43

Prema rezultatima ispitivanja otpornosti tkanine na toplinu zračenja, može se pronaći značajna razlika između struktura tkanina, tab. 1. Tkanina sa vezom od 4 potke dala je najveću otpornost na toplinu zračenja, a toplinski tok propuštanja iznosi 6,10 kW/m^2, a faktor prijenosa topline bio je 0,3 kW/m^2. Za porast temperature kalorimetra od 12°C bilo je potrebno 12,37 s, dok je za porast temperature kalorimetra od 24°C bilo potrebno 23,23 s. Druga tkanina u nizu koja je odolijevala zračenju topline bila je tkanina u tkanju od 2 potke. Iako je njegova debljina bila više nego dvostruko manja, njegova masa i gustoća bila je samo 25 % manja nego kod tkanine od 4 potke, otpornost na zračenje topline bila je očekivano dobra i iznosila je Q_c = 7,63 kW/m^2. Može se uočiti da povećanjem površinske mase uzorka raste otpor toplinskoj zaštiti, odnosno u ovom slučaju opada vrijednost Q_c. Tkanina štruks zauzela je treće mjesto po otpornosti na toplinu zračenja. Gustoća propuštenog toplinskog toka iznosila je Q_c =8,87 kW/m^2, a faktor prijenosa topline TFQ0 = 0,43 kW/m^2. Unatoč neravninama površine i vidljivim porama među naborima tkanine, pruža dobru zaštitu od zračenja topline. Uzorak u platno vezu dao je najlošije rezultate u pogledu učinkovitosti otpornosti na toplinu zračenja od samo Q_c =11,56 kW/m^2, a faktor prijenosa topline TFQ0 = 0,58 kW/m^2.Uzorci u atlas i keper vez imali su slične rezultate: Q_c = 8,85 kW/m^2 atlas vez, a Q_c = 9,67 kW/m^2 keper vez. Faktor prijenosa topline za atlas tkanje iznosio je TFQ_0 = 0,44 kW/m^2, a za keper tkanje TFQ_0 = 0,48 kW/m^2 te se po učinkovitosti toplinske zaštite nalaze iza višepotkinih uzoraka te uzorka u štruks vezu.

4. Zaključak

Različite vrste tkanja rezultiraju različitim parametrima strukture tkanine kao što su debljina tkanine, površinska masa i zaštita od zračenja topline.

U slučaju otpornosti tkanine na zračenje topline može se pronaći značajna razlika među strukturama tkanja. Tkanine s više potke (tkanje s 4 potke i 2 potke) i tkanina sa štruks vezom pružile su najveću otpornost na zračenje topline. Dvodimenzionalne strukture tkanja: platno tkanje, atlas tkanje i keper tkanje davale su manju otpornost na zračenje topline. Najbolji učinak u smislu toplinske zaštite dali su uzorci složene tkane strukture.

Zahvala

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Literatura

[1] Schwarz, I.; Kovačević, S.: Textile Application: From Need to Imagination, U *Textiles for Advanced Application*, InTec, ISBN 978-953-51-5429-7, Rijeka, Croatia (2017) 3-26

[2] Gilligan, I.: The prehistoric development of clothing: archaeological implications of a thermal model, *Journal of Archaeological Method and Theory*, **17** (2010) 1, 15-80, ISSN 1072-5369

[3] Magdalenić Bujanić, J.; Bujanić, B.: Aramid fibers, *Polimeri*, **32** (2011) 3-4, 130-134, ISSN 0351-1871

[4] Scott, R.A.: *Textiles for protection*, Elsevier, ISBN 978-1855739215, Cambridge, England (2005)

[5] Brnada, S.; Šomođi, Ž.; Kovačević, S.: A new method for determination of Poisson'sratio of woven fabric at higher stresses, *Journal of Engineered Fibers and Fabrics*, **14** (2019) ISSN: 15589250

[6] Hu, J.: *Structure and mechanics of woven fabrics*, Woodhead Publishing Limited, ISBN 9781845690403, Cambridge, England (2005)

Mateo Miguel Kodrič Kesovia

Životopis

Mateo Miguel Kodrič Kesovia rođen je 1987. godine u Dubrovniku. Godine 2006. upisuje redoviti studij restauracije i konzervacije na Sveučilištu u Dubrovniku, gdje 2012. godine završava i diplomski studij. Dio naobrazbe stječe na Institutu Palazzo Spinelli u Firenci i na Institutu za konzervaciju i restauraciju u Beču. Specijalizaciju analiziranja i katalogiziranja povijesnog tekstila (CIETA) usavršava 2011. godine u Firenci. Od rujna 2013. godine zaposlen na Odjelu za umjetnost i restauraciju Sveučilišta u Dubrovniku, a od 2021. godine na mjesto docenta. Godine 2014. upisuje poslijediplomski sveučilišni studij na Tekstilno-tehnološkom fakultetu u Zagrebu. Restauraciju tekstila dodatno usavršava 2017. godine na renomiranom institutu Abegg Stiftung u Švicarskoj. Znanstveni interes su mu interdisciplinarna istraživanja u području povijesti tekstilne tehnologije, metode rekonstrukcije i reprodukcije, te digitalizacije povijesnog tekstila.

Naslov doktorskog rada

Metoda analize i digitalizacije tehnološke dokumentacije povijesnih damastnih tkanina s područja Dubrovnika

Mentori

prof. dr. sc. Željko Penava
izv. prof. dr. sc. Katarina Nina Simončič

Datum obrane teme doktorskog rada

11. 6. 2018.

POSTUPAK DIGITALIZACIJE POVIJESNIH UZORAKA U KONZERVACIJI-RESTAURACIJI TEKSTILA NA SVEUČILIŠTU U DUBROVNIKU

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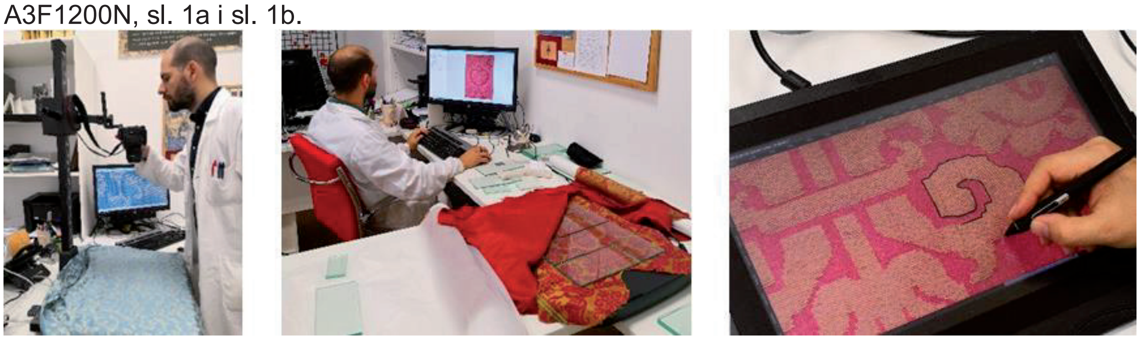
Sažetak: *Digitalizacija je nedestruktivna i vrlo korisna metoda u dokumentaciji kulturne baštine i kao takva predstavlja veliki potencijal za interdisciplinarna znanstvena istraživanja, nove metode konzervatorsko-restauratorskih zahvata, kao i u komercijalne svrhe – bez potrebe za direktnim djelovanjem na sam povijesni materijal. Digitalna tehnologija predstavlja praktičan, brz i vrlo jednostavan alat za korištenje, a zbog ubrzanog tehnološkog razvoja oprema za digitaliziranje umjetnina postaje sve šire dostupna. Obrađene su metode provedene na povijesnim tkaninama u sklopu doktorske teme „Metoda analize i digitalizacije tehnološke dokumentacije povijesnih damastnih tkanina s područja Dubrovnika“.*

1. Uvod

Digitalizacija je nedestruktivan i vrlo koristan postupak koji se danas sve više primjenjuje u dokumentaciji kulturne baštine. Na globalnoj razini se aktivno promovira kao optimalno sredstvo za dokumentiranje i očuvanje svih informacija sadržanih u povijesnim artefaktima. Europska komisija je 2017. godine kroz platformu *Europeana* pokrenula prve pripreme i smjernice za zemlje članice EU-a s ciljem digitalizacije kulturne baštine [1]. Redovito se objavljuju smjernice namijenjene muzejskim institucijama o metodologiji digitalizacije, kao i potrebnoj kvaliteti digitalno dokumentiranog zapisa. Već ranije se pokazala potreba za razvijanjem specijaliziranih alata za proučavanje digitalizirane građe, što je također pokrenulo i razvoj novih znanstvenih tema i pojmova, poput eng. *digital heritage, heritage science, digital humanities*, itd. O važnosti za digitalizacijom u kulturnom sektoru svjedoči i epidemija COVID-19, kada su brojne svjetske muzejske institucije omogućile svojim korisnicima „virtualne šetnje“ kroz njihove digitalizirane zbirke i druge sadržaje.

2. Eksperimentalni dio

S obzirom da se tijekom konzervatorsko-restauratorskog zahvata povijesne tkanine nerijetko moraju razdvojiti, ovo istraživanje se fokusira isključivo na tehnike 2D snimanja i skeniranja plošnih materijala jer one daju najbolji i stvaran prikaz povijesnog uzorka. Dokumentacija povijesnih uzoraka tradicionalno se izvodila ručnim precrtavanjem na prozirnu foliju, no s razvojem suvremene tehnologije omogućene su znatno brže i preciznije metode - fotografiranjem ili skeniranjem uzorkovanih tkanina u visokim rezolucijama. Na Odjelu za umjetnost i restauraciju Sveučilišta u Dubrovniku primjenjuju se različite metode digitalizacije. Ovisno o specifičnosti predmeta, kvalitetne digitalne fotozapise povijesnih uzoraka moguće je snimiti digitalnim fotoaparatom na postolju s podesivim stativom ili direktnim optičkim skeniranjem pomoću specijaliziranog A3 skenera Mustek A3F1200N, sl. 1a i sl. 1b.



a. b. c.

Slika 1: Različite tehnike digitalizacije uzoraka na povijesnim tkaninama: a. fotografiranje pomoću podesivog stativa; b. snimanje na plošnom skeneru; c. primjena grafičkog tableta za precrtavanje uzorka

Određeni tekstilni materijali zahtijevaju poseban pristup digitalizaciji. Primjerice, kod fotografiranja monokromatskih svilenih uzorkovanih tkanina, npr. kod damasta vrlo često može doći do refleksije svijetlosti zbog koje izgled uzorka ispada nejasan. U tom slučaju primjenjuju se tehnike snimanja pod različitim kutovima osvjetljenja i pod različitim intenzitetom. Kako bi zapisi bili dovoljno kvalitetni za daljnju obradu, poput provođenja preciznih fotogrametrijskih mjerenja ili digitalne rekonstrukcije uzorka, preporučljivo je da budu snimljeni pri visokoj rezoluciji i u sirovom, eng. *raw* TIFF formatu slike bez sažimanja [2].

Digitalizirane uzorke potrebno je zatim dodatno urediti pomoću računalnih programa za obradu slika. U tu svrhu koristi se program *Adobe Photoshop* CS6 koji posjeduje brojne grafičke alate za korekcije nepravilnosti dimenzija i deformacija materijala, za fotogrametrijska i kolorimetrijska mjerenja, za označavanje i digitalnu ekstrakciju ponavljajućeg raporta, za iscrtavanje i razlučivanje pojedinih efekata u uzorku, itd. Pomoćni računalni alat u ovom procesu predstavlja grafički tablet koji omogućava crtanje olovkom izravno na interaktivni monitor za brzo i precizno precrtavanje uzorka, sl. 1c. Nepotpune i oštećene uzorke moguće je digitalno rekonstruirati, poznavajući zakonitosti ponavljanja u tekstilnom dizajnu. Tehnikom preslikavanja i okretanja možemo nadomjestiti nedostajuće elemente uzorka preuzimanjem istih na očuvanim dijelovima dizajna. Digitalizirani raport uzorka, u kombinaciji s detaljnom tehnološkom dokumentacijom i postupkom obrnutog inženjeringa, eng. *reverse engineering*, omogućava stvaranje tkalačke uzornice u specijaliziranim programima, poput *ArahWeave* CAD/CAM i ArahPaint. Na temelju dobivenog nacrta može se izradit virtualna simulacija za bolje razumijevanje kompleksnih struktura ili izraditi reprodukcije povijesne tkanine na modernim tkalačkim strojevima [3].

3. Rezultati i rasprava

Interdisciplinarnom obradom dobivenih podataka mogu se razotkriti ključne, naizgled nevidljive informacije o povijesnim tkaninama. Digitalizacija doprinosi boljoj sistematizaciji i transmisiji podataka što su jedni od ključnih uvjeta za stvaranje digitalnih baza i repozitorija kao pristupačni spremnik i izvor ljudske kreativnosti i znanja. Implementacijom umjetne inteligencije bi se u budućnosti skratilo trajanje procesa prikupljanja, obrade i pretraživanje podataka o povijesnim artefaktima. Digitalna tehnologija se brzo i neprestano razvija, zbog čega je nužno kontinuirano usavršavati informatičke vještine te pratiti što su aktualne i inovativne mogućnosti njene upotrebe. Popularizacija i interakcija digitalne baštine sa zainteresiranim korisnicima bi, u odgovarajućim okolnostima, potaknula revitalizaciju i ponovnu primjenu velike količine zaboravljenog znanja o umjetnosti i tehnologiji u proizvodnji tekstila.

4. Zaključak

Priroda povijesnih uzoraka jest da se beskrajno ponavljaju i razmnožavaju u zatvorenom krugu recikliranja tekstilnog dizajna, u kojem se iznova posuđuju, osvježavaju i ponovno koriste na suvremenim tekstilnim proizvodima ili na drugim medijima. Međutim, izvorni dizajneri i umjetnici koji su kroz povijest stvarali ove bogate tekstilne dizajne nam do danas uglavnom ostaju nepoznati. Digitalizirana baština omogućava bržu diseminaciju i razmjenu informacija, bolju povezanost između zainteresiranih korisnika te potiče međuinstitucionalnu suradnju između stručnjaka iz različitih područja znanosti. Dokumentiranjem povijesnih uzoraka u digitalni format omogućeno je lakše pretraživanje i povezivanje sa sličnim primjercima, što znatno unaprjeđuje brzinu i preciznost datacije i atribucije određenog tekstilnog dizajna. U okviru konzervacije-restauracije otvaraju se alternativna rješenja za boljom zaštitom (često) fragilnih i osjetljivih povijesnih materijala gdje se oštećene tkanine mogu virtualno rekonstruirati ili napraviti vjerodostojne reprodukcije.

Literatura

[1] The Council of the European Union: The role of Europeana for the digital access, visibility and use of European cultural heritage. *Dostupan na* https://data.consilium.europa.eu/doc/document/ST-9643-2016-INIT/en/pdf. *Pristupljeno: 2021-12-15*

[2] Bülow, A. E.; Ahmon, J.: *Preparing Collections for Digitization*, Facet Publishing, ISBN 9781856047111, London, (2011)

[3] Cybulska M.: To See the Unseen – Computer Graphics in Visualisation and Reconstruction of Archaeological and Historical Textiles, In *Computer Graphics*, InTech, ISBN 978-953-51-0455-1, Rijeka, (2012) 213-228

Ivan Kraljević

Životopis

Ivan Kraljević je rođen 1991. godine. Upisuje studij na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 2010. godine. Preddiplomski sveučilišni studij Tekstilna tehnologija i inženjerstvo završio je 2013. godine, a dvije godine kasnije diplomski sveučilišni studij. U studenom 2016. godine upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija. Od veljače 2016. godine je zaposlen u Jadran Tvornici čarapa d.d., gdje od veljače 2017. godine radi kao voditelj pletionice i šivaonice. Kao doktorand je uključen u HRZZ projekt IP-2016-06-5278. U koautorstvu je publicirao deset znanstvenih radova, a područje znanstvenog interesa vezuje uz kvalitetu i ispitivanje inovativnih materijala za izradu čarapa i kože.

Naslov doktorskog rada

Čarape visoke funkcionalnosti i mogućnosti objektivnog vrjednovanja

Studijski savjetnik

prof. dr. sc. Antoneta Tomljenović

Datum obrane teme doktorskog rada

RAZVOJ METODIKE VRJEDNOVANJA OTPORNOSTI KRATKIH ČARAPA NA HABANJE

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Sažetak: *Ispitana je otpornost na habanje finih muških kratkih čarapa, izrađenih s najvećim udjelom pamuka u potpunom platiranju različitim pređama. Primijenjen je postupak ispitivanja prema zahtjevima norme HRN EN 13770, metode 1, primjenom habalice prema Martindale-u i dviju različitih habajućih glava – standardne i modificirane.*

1. Uvod

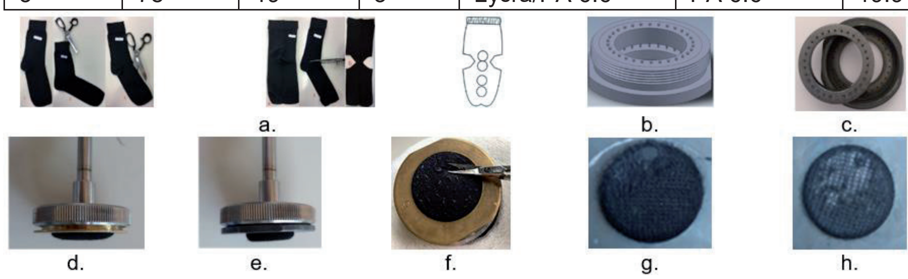
Na muške kratke čarape se postavljaju visoki zahtjevi uporabne trajnosti, pri čemu se posebna pozornost posvećuje otpornosti na habanje tijekom nošenja. Uz ostale proizvodne zahtjeve, veoma je značajno međusobno uskladiti i odabrati odgovarajuće pređe za njihovu izradu [1]. Stoga je u okviru istraživanja ispitana otpornost na habanje finih muških kratkih čarapa, izrađenih s najvećim udjelom pamuka u potpunom platiranju različitim pređama (sirovinskog sastava: poliamid 6.6, elastan/pamuk i elastan/poliamid 6.6). Primijenjen je postupak ispitivanja otpornosti pletiva čarapa na plošno habanje prema zahtjevima norme HRN EN 13770:2008 [2], primjenom habalice prema Martindale-u uz uzorkovanje pletiva iz stopalnog dijela i pete čarape. Pritom je primjenjujući istu metodiku prohabavanja, provedena usporedba rezultata ispitivanja dobivenih primjenom dviju različitih habajućih glava – standardne i modificirane, a u svrhu utvrđivanja primjenjivosti u okviru ovog istraživanja izrađenih modificiranih habajućih glava prilagođenih zahtjevima norme HRN EN 13770:2008, metode 1.

2. Eksperimentalni dio

Istraživanje je provedeno na tri skupine finih muških kratkih čarapa crne boje u veličini 42. Čarape su pletene u desno-lijevom prepletu u Jadran Tvornici čarapa d.d. na čaraparskom automatu finoće E14 Lonati promjera cilindra 95 mm, (3 ¾'') koji je pleo sa 168 igala te izglačane pri temperaturi od 120 °C na stroju Cortese. U tab. 1 su prikazana svojstva čarapa, uključujući vrijednosti sirovinskog sastava, mase jedne čarape i plošne mase pletiva čarapa.

Tablica 1: Svojstva triju skupina muških kratkih čarapa

Uzorak čarapa	Sirovinski sastav (%)			Platiranje čarape		Masa čarape (g)	Plošna masa pletiva (g/m²)
	Pamuk	PA 6.6	Lycra	Tijelo i stopalo	Prsti i peta		
1	78	21	1	PA 6.6	PA 6.6	19.9	189.9
2	91	6	3	Lycra/pamuk	PA 6.6	19.8	199.9
3	78	19	3	Lycra/PA 6.6	PA 6.6	19.9	237.6



Slika 1: Ispitivanje otpornosti na habanje: a) Uzorkovanje čarapa; b) Prikaz projektiranog i c) izrađenog donjeg dijela modificirane habajuće glave; Uzorak pletiva na d) standardnoj habajućoj glavi uz spužvasti međusloj, e) modificiranoj habajućoj glavi uz gumeni dodatak; f) Uklanjanje pilinga tijekom provjere; Izgled g) prekida, h) stanjenja uzorka pletiva

Otpornost čarapa na habanje, sl. 1, je ispitana pomoću habalice prema Martindale-u primjenom dviju različitih habajućih glava – standardne prema zahtjevima norme HRN EN ISO 12947-2 i modificirane prema zahtjevima prema HRN EN 13770, pri čemu su kružni uzorci pletiva promjera 38 ± 5 mm habani o referentnu vunenu tkaninu plošno se gibajući uz opterećenje od 12 kPa, simulirajući pritom Lissajous-ovu krivulju. Po provedbi definiranog broja habajućih ciklusa, grudice zamršenih vlakana na površini ispitivanog pletiva nastale habanjem, odrezane su škarama svinutog vrha. Postupak habanja se završava po pojavi rupice (odn. prekida niti u pletenoj strukturi) ili vidljivog stanjenja pletiva odn. odhabavanja predene pamučne pređe i pojave zaostale sintetske podloge iz niti pređe za platiranje te bilježi broj habajućih ciklusa.

3. Rezultati i rasprava

Iz prikaza u tab. 1 je razvidno da primjena elastanske pređe za platiranje značajno utječe na povećanje kompaktnosti strukture i plošne mase pletiva čarapa (usporedno približno jednake mase).

Tablica 2: Otpornost na habanje pete i stopalnog dijela čarape - utvrđena metodom prohabavanja

Uzorak čarapa	Standardna habajuća glava (HRN EN ISO 12947-2)		Modificirana habajuća glava (HRN EN 13770, metoda 1)	
	Opis načina prohabavanja/broj habajućih ciklusa kod prohabavanja			
	Peta	Stopalo	Peta	Stopalo
1	stanjenje/35000	stanjenje/35000	stanjenje/6500	stanjenje/6500
2	stanjenje/35000	prekid/30000	stanjenje/6500	prekid/6000
3	stanjenje/35000	stanjenje/45000	stanjenje/6500	stanjenje/7000

Analizom rezultata, u skupine čarapa 1 i 3 koje sadrže veći udio platirne poliamidne pređe, utvrđena je veća otpornost na habanje pletiva iz stopalnog dijela čarapa, što ujedno ukazuje i na njihovu veću uporabnu trajnost, tab. 2. Uzorci čarapa skupine 3, platirani primjenom elastanske pređe obavijene multifilamentnom teksturiranom poliamidnom pređom, u stopalnom dijelu čarape pokazuju najveću otpornost na habanje. Samo kod čarapa skupine 2 s najvećim udjelom pamuka, platiranih elastanskom pređom obavijene s pamučnom, do prohabavanja dolazi uslijed prekida niti i pojave rupice. Utvrđena je jednolikost u rezultatima ispitivanja kod pletiva uzorkovanog iz pete čarapa koje je u svih čarapa izrađeno na jednaki način. Primjenom modificiranih habajućih glava prilagođenih zahtjevima HRN EN 13770, metode 1, na habalici prema Martindale-u do prohabavanja dolazi prije, zbog veće napetosti uzorka pletiva na gumenom podlošku habajuće glave

4. Zaključak

Provedenim istraživanjem je potvrđena primjenjivost modificiranih habajućih glava prema HRN EN 13770, jer se njihovom primjenom vjernije simulira opterećenje pletiva čarape tijekom nošenja i umanjuje utjecaj elastičnosti pletiva na dobivene rezultate. Nastavkom istraživanja, planiran je razvoj habalice za čarape.

Zahvala

Istraživanja su provedena u sklopu istraživačkog projekta IP-2016-06-5278 Udobnost i antimikrobna svojstva tekstila i obuće financiranog od Hrvatske zaklade za znanost.

Literatura

[1] Kraljević, I. et al: The Abrasion Wear Resistance of Men's Socks, *Proceedings of International Conference MATRIB, Materials, Tribology, Recycling 2021*, Ćorić, D. *et a*l (ed), 281-290, ISSN 2459-5608, Vela Luka, Croatia, 30.6. - 2.7. 2021, Croatian Society for Materials and Tribology, Zagreb, (2021)

[2] HRN EN 13770:2008 Tekstilije - Određivanje otpornosti čarapa na habanje

Katarina Krstović

Životopis

Katarina Krstović završila je preddiplomski studij 2009. godine, a 2011. godine diplomski studij na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Radno iskustvo stekla je radom u tvrtkama: Amadeus M.A.J., Zagreb u razdoblju od 2012. do 2013. godine, Tvornici tekstila Trgovišće d.o.o. od 2013.-2019. godine te Taxo d.o.o. u 2019. godini. Na Tekstilno-tehnološkom fakultetu zaposlena je od 2020. godine na radnom mjestu asistenta u Zavodu za projektiranje i menadžment tekstila.

Naslov doktorskog rada

Studijski savjetnik prof. dr. sc. Vesna Marija Potočić Matković

Datum obrane teme doktorskog rada

MEHANIČKI PARAMETRI PLETIVA ZA SPORTSKE KUPAĆE KOSTIME

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Sažetak: *Materijali za kupaće kostime vizualno su vrlo slični: svi su pleteni; na prvi pogled se razlikuju samo u boji ili tisku. Ipak, mnoga istraživanja bave se poboljšanjem svojstava materijala za kupaće kostime. Svojstva prvenstveno ovise o ciljanoj skupini potrošača (za amatersko plivanje, trening, natjecateljsko plivanje). U ovom radu su opisana neka od ispitivanja mehaničkih svojstava pletiva, kao glavni pokazatelji ponašanja pletiva i u konačnici određivanja njihove namjene.*

1. Uvod

Tekstilni materijali se koriste u svim sportovima kao sportska odjeća, te u mnogim sportovima kao sportska oprema i sportska obuća. Kupaći kostimi su relativno malo, usko specijalizirano proizvodno područje u tekstilnoj industriji. Materijali za kupaće kostime vizualno su vrlo slični, na prvi pogled se razlikuju samo u boji ili printu. Sve su pletene. Ipak, iznenađujuće se mnogo istraživanja ulaže u poboljšanje svojstava materijala za kupaće kostime [1].

Kupaći kostimi su važni u natjecateljskom plivanju otkad je poznato da njihova izvedba bez sumnje utječe na natjecateljske performanse. Smanjenje trenja i otpora glavni su problemi u posljednje vrijeme. Pletiva s visokim postotkom elastomera i u posljednje vrijeme karbonskih vlakana za suzbijanje vibracija plivačkog tijela u središtu su istraživanja i razvoja. Provedeno je nekoliko studija u kojima su varijable bile vrsta materijala, dizajn kupaćeg kostima i pokrivenost tijela [2, 3].

Kupaći kostimi za trening obično su izrađeni od mješavine poliamida i elastana, a često i od 100 % poliesterskih vlakana. Postotak elastana je veći, popularan je 68 % PA/32 % EL sastav. Karakteristike ovakvog pletiva su dugotrajnost, otpornost na klor, veća udobnost. Dizajn, kroj, tisak i boja jednako su važni kao i za modne kupaće kostime, sa naglaskom na brzinu i hidrodinamiku [4]. Natjecateljski kupaći kostimi su potpuno druga kategorija kupaćih kostima izrađenih s visokim postotkom elastana, s često dodanim karbonskim vlaknima (na primjer 65 % PA/34 % EL / 1 % karbon). Karbonska vlakna tvore snažnu mrežu, te odjela imaju posebnu konstrukciju šavova i kompresijske panele [5].

a. b. c.

Slika 1: Pletiva za sportske kupaće kostime: a. Pletivo sirovinskog sastava 80 % PA/20 % EL; b. Pletivo sirovinskog sastava 71 % PA/29 % EL; c. Pletivo sirovinskog sastava 78 % PA/22 % EL

2. Eksperimentalni dio

U ovom radu proučavana su različita ispitivanja mehaničkih parametara pletiva namijenjena za proizvodnju sportskih kupaćih kostima. Ispitivanjem pletiva pod utjecajem sile može se testirati njegova izdržljivost. Pomoću dobivenih rezultata se može utvrditi da li je pletivo dovoljno dobro projektirano i jesu li dobivena željena svojstva. Ovisno o samoj namjeni pletiva, biraju se i mehanička ispitivanja koja će se provesti. Obradit će se više različitih i najčešćih ispitivanja pletiva pod utjecajem sile.

Ispitivanja pletenih proizvoda može se u grubo podijeliti na destruktivne i nedestruktivne. Što znači da neka ispitivanja podrazumijevaju izlaganje pletiva sili do pucanja i u konačnici raspada materijala.

2. Rezultati i rasprava

Kada se govori o mehaničkim svojstvima pletiva u prvom redu će se razmatrati vlačna čvrstoća i istezanje do prekida, te otpornost na probijanje. Za provedbu ispitivanja koriste se dinamometri i standardizirani postupak po standardu ISO 13934-1 [6]. Priređuju se epruvete veličine 20 cm x 5 cm u smjeru redova i u smjeru nizova te se postavljanjem na dinamometar izlažu konstantnoj brzini istezanja do pucanja pletiva. Vrijednosti koje se dobiju ovom metodom su prekidna sila i prekidno istezanje. Otpornost na probijanje se ispituje prema standardu ISO 13938-2 [7]. Specifičnost ove metode je da čelična kugla sferično rasteže tekstilni materijal, a kut primjene sile i površina materijala na koju sila djeluje kontinuirano se mijenjaju tijekom ispitivanja materijala [8]. Ispitivanjem otpornosti na habanje pletiva može se procijeniti ponašanje i njegovo trajanje u upotrebi. Prema standardu ISO 12947-3 [9] kružni uzorak montira se u držač uzorka i podvrgne definiranom opterećenju, trlja se o abrazivni medij translacijskim pokretom prateći tzv. lissajous figuru, pri čemu se držač uzorka dodatno može slobodno rotirati oko vlastite osi okomito na ravninu uzorka. Procjena otpornosti pletiva na habanje određuje se iz gubitka mase uzoraka, odnosno uzorak se važe prije i nakon procesa habanja te se izračuna razlika u masi. Ispitivanja pletenih proizvoda koja se provode nedestruktivnim metodama najčešće se provode prva. Analitička vaga i debljinomjer su instrumenti koji nam služe za mjerenje površinske mase pletiva i njegove debljine. Dobiveni rezultati nude nam dodatne podatke o pletivu iako nužno ne utječu direktno na mehaničke karakteristike pletiva.

4. Zaključak

Postupci ispitivanja mehaničkih svojstava pletiva daju značajne podatke prema kojima se u prvom redu može odrediti njihova namjena. Ispitivanjem srodnih pletiva i usporedbom dobivenih podataka može se zaključiti o njihovom ponašanju u samoj upotrebi za koju su namijenjeni. Također vrlo zanimljivo bi bilo usporediti mehaničke karakteristike pletiva koja su namijenjena izradi sportskih kupaćih kostima za trening i onih namijenjenih za natjecateljske kupaće kostime.

Zahvala

Istraživanja su provedena na istraživačkom projektu TEMPO - Tekstilni materijali za povećanu udobnost u sportu IP-2020-02-5041 TEMPO, financiranog od Hrvatske zaklade za znanost.

Literatura

[1] Manshahia, M.; Das A.: Thermo-physiological comfort of compression athletic wear, *Indian Journal of Fibre & Textile Research*, **39** (2014), 139-146, ISSN 09710426

[2] Morales, A. T.; Tamayo Fajardo, J.A.; González-García, H.: High-Speed Swimsuits and Their Historical Development in Competitive Swimming, *Frontiers in Psychology*, **10** (2019), 1-11, ISSN 16641078

[3] Foster, L.; James, D.; Haake, S.: Influence of full body swimsuits on competitive performance. *Procedia Engineering*, **34** (2012), 712-717, ISSN 1877-7058

[4] *Dostupno na* https://www.arenasport.com/en_us/women/swimwear/training-suits.html, *Pristupljeno:* 2021-03-31

[5] *Dostupno na* https://www.arenasport.com/en_us/women/swimwear/race-suits.html, *Pristupljeno* 2021-03-31

[6] ISO 13934-1:2013 Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method

[7] ISO 13938-2:2019 Textiles — Bursting properties of fabrics — Part 2: Pneumatic method for determination of bursting strength and bursting distension

[8] Potočić Matković V.M.; Skenderi Z.: Mechanical Properties of Polyurethane Coated Knitted Fabrics, *Fibres and Textiles in Eastern Europe*, **100** (2013), 86 - 91, ISSN 12303666

[9] ISO 12947-3 Textiles — Determination of the abrasion resistance of fabrics by the Martindale method - Part 3: Determination of mass loss

Anja Ludaš

Životopis	Anja Ludaš rođena je 1993. godine u Zagrebu. Titulu magistrice stječe 2019. godine po završetku sveučilišnog studija Tekstilna tehnologija i inženjerstvo na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija upisuje 2019. godine i zapošljava se na radno mjesto asistenta na Tekstilno-tehnološkom fakultetu. Kao suradnik sudjeluje na projektu Hrvatske zaklade za znanost HRZZ IP-2019-04-6418 Laserska sinteza nanočestica i primjene.
Naslov doktorskog rada	
Studijski savjetnik	izv. prof. dr. sc. Sanja Ercegović Ražić
Datum obrane teme doktorskog rada	

INKORPORACIJA NANOČESTICA U POLIMERE TIJEKOM PROCESA ISPREDANJA UMJETNIH VLAKANA I MODIFIKACIJA SVOJSTAVA

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Sažetak: *Metalne nanočestice dobivene laserskom ablacijom inkorporirati će se u polimere tijekom procesa ispredanja umjetnih vlakana. Dobivena vlakna modificiranih svojstava analizirat će se primjenom suvremenih metoda analize površine i funkcionalnih svojstava.*

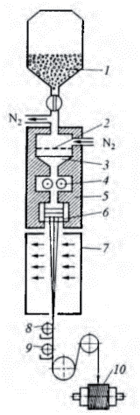
1. Uvod

U novije vrijeme nanotehnologija sve više doprinosi potencijalnom razvoju poboljšanih materijala s naprednim svojstvima za upotrebu u različitim područjima primjene. Atomi unutar nanočestica savršeno su poredani, ali dok se dimenzije materijala mijenjaju od makro-veličine do nano-veličine događaju se velike promjene u svojstvima materijala [1]. U narednim godinama razumijevanje svojstava nanomaterijala pruža prostor za razvoj materijala za poboljšanje kvalitete života. Nanomaterijali se postupno komercijaliziraju, koriste se u brojnim naprednim tehnologijama i proizvodima, uključujući veliko područje primjene: medicina, farmacija, tekstilna tehnologija, elektrotehnika, itd. Tekstilna industrija je jedan od značajnijih korisnika nanotehnologije i na tržištu je prisutan veliki broj nanotekstilija. Ti napredni tekstili nude različite funkcije poput zaštite od gorenja, samočišćenja, odbijanja prljavštine, vode i ulja, otpornosti na gužvanje, anistatičnosti, zaštite od ultraljubičastog zračenja, antibakterijsko djelovanje i dr. Također je i velika prednost što naslojavanje nanočestica ne utječe na udobnost i opip materijala [2]. Zbog činjenice da nanomaterijali neće biti prepoznatljivi nakon ispuštanja u okolinu, ti bi materijali mogli stvarati razne vrste ekoloških problema. Potrebno je izvršiti sveobuhvatnu procjenu rizika na nanomaterijalima koji predstavljaju stvarnu opasnost od izloženosti tijekom njegove izrade ili uporabe [3]. Zbog toga će se u ovoj doktorskoj disertaciji upotrijebiti nanočestice dobivene laserskom sintezom. Laserska sinteza nanočestica u tekućinama temelji se na procesu impulsne laserske ablacije metalne mete uronjene u tekućinu. Ova tehnika je poznata kao tehnika 'zelene sinteze' jer osigurava koloidne nanočestice koje se ne mogu inhalirati te ne ispuštaju kemijske nusproizvode, nije potrebno daljnje pročišćavanje. Ove otopine nanočestica su otopine bez soli koje omogućuju široku primjenu gdje je odsutnost soli obvezna (nano-bio, tekstil, polimeri, itd.) [4]. Mogućnost dodavanja aditiva i modifikacije svojstava je najelegantniji način modificiranja svojstava polimera. Kako bi se proveo tehnološki postupak kemijskog ispredanja umjetnih vlakana iz taline polimer mora posjedovati mogućnost prevođenja u termostabilnu talinu potrebnih reoloških svojstava, samo kod termoplastičnih polimera [5].

2. Eksperimentalni dio

Metalne nanočestice dobivene laserskom sintezom u tekućini inkorporirat će se u talinu u procesu ispredanja umjetnih vlakana, čime će se provesti postupak modifikacije svojstava budućeg umjetnog vlakna.

Ispredanje iz taline najjednostavniji je i najekonomičniji postupak ispredanja kemijskih vlakana pa se primjenjuje uvijek kada se iz polimera može prirediti termostabilna talina potrebnih reoloških svojstava da bi se proces ekstruzije taline kroz mlaznicu mogao provesti bez veće degradacije polimera te da bi se iz polimernog mlaza oblikovala vlakna. Polimeri pogodni za proces ispredanja iz taline (PET, PA, PE, PP, PVC, GF). Taj postupak obuhvaća više pojedinačnih procesa povezanih u cjelinu: pripremu taline, oblikovanje niti ekstruzijom taline kroz mlaznicu, skrućivanje niti hlađenjem zračnom strujom, navlaživanje i nanošenje preparacijskih sredstava te namatanje filamenata, sl.1 [5].



Slika 1: Shema kemijskog ispredanja vlakna iz taline [5]

3. Rezultati i rasprava

Inkorporacijom metalnih nanočestica dobivenih laserskom ablacijom u polimere tijekom procesa ispredanja umjetnih vlakana dobit će se vlakna modificiranih svojstava. Pritom će se provesti analiza modificiranih svojstava primjenom: FE-SEM (skenirajući elektronski mikroskop) za morfološka svojstva površine vlakana, FT-IR (Fourierova transmisijska infracrvena spektroskopija) za određivanje karakterističnih funkcionalnih skupina polimera, AFM (mikroskopija atomske sile) za dobivanje podataka o topografiji površine i druge slične metode analize. Tako proizvedeni polimeri s inkorporiranim nanočesticama ispitat će se na antibakterijski učinak prema standardnim gram-pozitivnim i gram-negativnim laboratorijskim bakterijskim sojevima, primjenom standardiziranih kvantitativnih mikrobioloških metoda.

4. Zaključak

Inkorporacijom metalnih nanočestica u polimere tijekom procesa ispredanja umjetnih vlakana poboljšat će se funkcionalna svojstva dobivenog filamenta s obzirom na očekivanu namjenu takvog tekstilnog materijala. Glavni cilj ovog doktorskog rada je postizanje multifunkcionalnog učinka ugradnjom nanočestica u polimernu matricu i ekstruzija tekstilnog filamenta kao materijala trajnih antimikrobnih i UV zaštitnih svojstava.

Zahvala

Ovaj je rad financirala Hrvatska zaklada za znanost projektom (IP-2019-04-6418).

Literatura

[1] Yang, G.; Park, S.J.: Deformation of single crystals, polycrystalline materials, and thin films: A review, *Materials*, **12** (2019), 2003-2018, ISSN 1996-1944

[2] Saleem, H.; Javaid Zaidi, S.: Sustainable Use of Nanomaterials in Textiles and Their Environmental Impact: A review, *Materials*, **13** (2020), 5134-5162, ISSN 1996-1944

[3] Kawai, S.; Niwano, M.; Sato, M.: A risk assessment framework for self-management of poorly soluble low toxic nanomaterials. *Heliyon*, **5** (2019), 1-7, ISSN 2405-8440

[4] Besner, S. et al: Ultrafast laser based “green” synthesis of non-toxic nanoparticles in aqueous solutions, *Applied Physics A*, **93** (2008) 4, 955-959, ISSN 0947-8396

[5] Čunko, R.; Raffaelli, D.; Šmit, I.: Vlakna, *Dostupan na*: https://tehnika.lzmk.hr/tehnickaenciklopedija /vlakna.pdf, *Pristupljeno:* 2021-12-14

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Eva Magovac

Životopis	Diplomirani inženjer tekstilne tehnologije s 18 godina radnog iskustva u upravljanju u razvoju proizvoda, dizajnu i osiguravanju kvalitete proizvoda u poslovnom okruženju u svim aspektima razvoja proizvoda od dizajna do komercijalizacije, dizajna, nabave i održavanja. Upravlja, kalibrira i provodi provjere rada laboratorijske opreme.
Naslov doktorskog rada	Površinska modifikacije pamučnih tekstilija usporivačima gorenja metodom nanosa sloj-po-sloj
Mentori	prof. dr. sc. Sandra Bischof
	prof. dr. sc. Bojana Vončina
Datum obrane teme doktorskog rada	20. 5. 2016.

EKOLOŠKA MULTIFUNKCIONALNA OBRADA PAMUKA – NASLOJAVANJE SLOJ-PO-SLOJ

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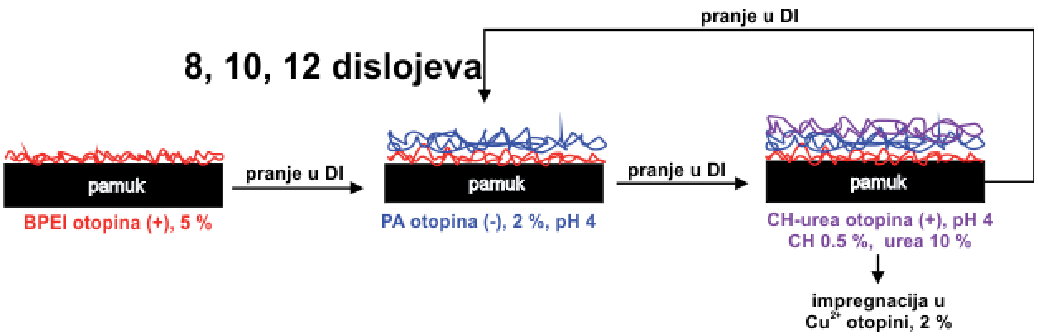
Sažetak: *Ekološko naslojavanje sloj-po-sloj upotrijebljeno je u svrhu postizanja antimikrobnog učinka pamučne tkanine smanjene gorivosti. Tkanina je naslojena pomoću 8, 10 i 12 dislojeva fitinske kiseline (PA) i kitozan (CH)-uree, te je nakon toga impregnirana otopinom bakrovog (II) sulfata. Dvanaest dislojeva PA/CH-urea+*Cu^{2+} *je zaustavilo gorenje pamuka za vrijeme vertikalnog testa gorenja (VFT) s vrijednošću graničnog indeksa kisika (LOI) 26 %. Podaci dobiveni mikrokalorimetrom sagorijevanja (MCC) pokazali su smanjenje stope oslobađanja topline (pHRR) za više od 61 %, dok se ukupna oslobođena toplina smanjila za više od 54 %. Antimikrobno testiranje pokazalo je smanjenje razvoja bakterije Klebsiella pneumoniae i Staphylococcus aureus za 100 %. U ovom radu pamučna tkanina je uspješno funkcionalizirana ekološkim sredstvima protiv gorenja i antimikrobnim sredstvom pomoću LbL naslojavanja.*

1. Uvod

Pamuk se danas koristi za mnogobrojne tekstilne materijale zbog mekoće i mogućnosti upijanja vlage i vode koje omogućuju hidrofilne reaktivne hidroksilne grupe unutar molecule celuloze zbog kojih je pamuk zapaljiv i podložan djelovanju mikroba [1]. Komercijalna sredstva za obrade protiv gorenja pamuka i pamučnih mješavina zasnivaju se na halogenim, organo-halogenim, antimon-organo-halogenim i organofosfornim spojevima od koji su neki toksični [2]. Da se smanji ili zaustavi rast mikroba, pamuk se obrađuje različitim animikrobnim sredstvima od kojih su neka i toksična [3]. Postojane obrade protiv gorenja, kao i antimikrobne obrade za pamuk se komercijalno primjenjuju u mokrim postupcima dorade, ekološki su nepovoljne zbog otpuštanja toksičnog formaldehida tijekom proizvodnje i upotrebe tekstilnih materijala. Zeleni alternativni pristup moglo bi biti naslojavanje sloj-po-sloj u kojem se kao otapalo različitih aktivnih sredstava (polimera, nanočestica, malih molekula itd.) upotrebljava voda. LbL naslojavanjem nabijena tkanina se impregnira u otopini polielektrolita suprotnog naboja kako bi se natataložio nanosloj. Cijeli postupak se može ponoviti koliko je potrebno da bi se dobio tekstil željenih multifunkcionalnih svojstava kao što su smanjenje gorivosti i antimikrobna svojstva [4].

2. Eksperimentalni dio

Materijal: : pamučna tkanina, polietilenimin (BPEI), urea, kitozan (CH), bakrov (II) sulfat pentahidrat ($CuSO_4$ x $5H_2O$), klorovodična kiselina (HCl), natrijev hidroksid (NaOH), hidrat dodekanatrijeve soli fitinske kiseline (PA), deionizirana voda (DI). Postupak obrade je prikazan na sl. 1.



Slika 1: Shematski prikaz naslojavanja LbL

Kationska otopina BPEI je pripremljena za primarno naslojavanje pamuka. Anionska PA otopina i kationska CH otopina su magnetski miješane 24 sata, a potom je dodana urea. Otapanjem $CuSO_4$ x $5H_2O$ u DI osigurani su kationi bakra, Cu^{2+}. Prije LbL naslojavanja, pH svih otopina (osim BPEI) je podešen na 4 pomoću NaOH ili

HCl. Šest uzoraka pamučne tkanine je najprije impregnirano otopinom BPEI, a zatim su uzorci naizmjenice impregnirani otopinom PA/CH-ureom 8, 10 i 12 puta. Na kraju postupka uzorci su impregnirani Cu^{2+} otopinom u svrhu postizanja antimikrobnih svojstava. Termička svojstva tkanina ispitana su na vertikalnom testu gorenja (VFT), uređaju za mjerenje granične vrijednosti kisika (LOI), mikrokalorimetru sagorijevanja (MCC) i uređaju za termogravimetriju (TG). Antimikrobna svojstva ispitana su prema AATCC TM 100-2019.

3. Rezultati i rasprava

Pamuk je uspješno obrađen ekološkim usporivačima gorenja na osnovi PA/CH-uree pomoću sloj-po-sloj naslojavanja. LOI vrijednost pamuka naslojenog s 12 dislojeva je 24,5 % i uzorak je prošao VFT s duljinom pougljenjenja 6,7 cm. Impregniranjem tako obrađenog pamuka Cu^{2+} otopinom dodatno se smanjuje gorivost uz postizanje antimikrobnih svojstava. Rezultat je u skladu s MCC vrijednostima, gdje je pHRR za pamuk obrađen s 12 dislojeva (PA/CH-urea) 132.2 W/g. Smanjenje stope otpuštanja topline (HRR) je više od 50 %, a smanjenje temperature najviše stope otpuštanja topline ($T_{pHRR)}$ je za više od 23 °C u odnosu na neobrađenu pamučnu tkaninu. U isto vrijeme termogravimetrijska (TG) analiza je pokazala da je obrada s 12 dislojeva pomaknula prvu temperaturu dekompozicije (T_1) prema temperaturama nižima za 57 °C. Dodatkom Cu^{2+} iona u LbL sustav ova razlika je još veća. Antimikrobno testiranje je pokazalo smanjenje razvoja bakterija, gram-negativne *Klebsiella pneumoniae* i gram-pozitivne *Staphylococcus aureus,* za gotovo 100 %.

4. Zaključak

U ovom radu pamučna tkanina je uspješno funkcionalizirana ekološkim sredstvima iz obnovljivih izvora za obrade protiv gorenja, kao i antimikrobnim sredstvima na osnovi bakrenih soli tehnikom naslojavanja sloj-po-sloj.

Zahvala

Istraživanja/doktorski rad izrađen je u sklopu aktivnosti na istraživačkom projektu Modernizacija Znanstveno-istraživačkog centra za tekstil (MI-TSRC) financiranog od EU.

Literatura

[1] Singh, S. P. et al: Cellulose-Based Graft Copolymers, In *Cellulose-Based Graft Copolymers: Structure and Chemistry*, CRC Press, ISBN 9781138827196, Boka Raton, (2015), 235–270

[2] Magovac, E.; Bischof, S.: Non-Halogen FR Treatment of Cellulosic Textiles, *Tekstil,* **64** (2015) 9-10, 298–309, ISSN 0492-5882

[3] Gao, Y.; Cranston, R.: Recent Advances in Antimicrobial Treatments of Textiles, *Textile Research Journal*, **78** (2008) 1, 60–72, ISSN 0040-5175

[4] Li, P. et al: Fully Bio-Based Coating from Chitosan and Phytate for Fire-Safety and Antibacterial Cotton Fabrics, *Carbohydrate Polymers*, **237** (2020), 1-10, ISSN 0144-8617

Maja Mahnić Naglić

Životopis	Maja Mahnić Naglić rođena je u Slavonskom Brodu. Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 2009. godine je završila preddiplomski studij Tekstilna tehnologija i, a 2011. godine diplomski studij. Od 2012. godine zaposlena je na Tekstilno-tehnološkom fakultetu kao vanjski suradnik, a od 2015. godine u suradničkom zvanju asistenta na Zavodu za odjevnu tehnologiju. 2013. godine je upisala poslijediplomski specijalistički studij Tekstilna znanost i tehnologija. Kao koautor je do sada objavila dva poglavlja u znanstvenim knjigama, sedam izvornih znanstvenih radova u časopisima citiranim u bazama WoS i Scopus, četiri izvorna znanstvena rada u drugim časopisima te 17 izvornih znanstvenih radova u zbornicima međunarodnih skupova.
Naslov doktorskog rada	Dinamičko ponašanje odjeće pod utjecajem biomehanike tijela
Mentor	prof. dr. sc. Slavenka Petrak
Datum obrane teme doktorskog rada	5. 7. 2015.

PRIMJENA 3D FLATTENING METODE U ANALIZI TIPOVA TIJELA

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Sažetak: *U radu je predstavljeno istraživanje karakteristika ženskog tijela pomoću suvremene računalne tehnologije sa specifičnom primjenom rezultata istraživanja u inženjerskom projektiranju odjeće i prilagodbi prema različitim tipovima tijela. Istraživanje je provedeno primjenom 3D skenera u statičkim i dinamičkim položajima, kako bi se dobio uvid u deformabilnost površine tijela u pokretu što je vrlo značajno za postizanje visoke razine pristalosti odjevnog predmeta. Skenirani i prilagođeni parametarski modeli tijela su primjenom 3D flattening metode segmentirani i transformirani u 2D površine određene anatomskim ravninama i karakterističnim linijama tijela. Na utvrđenim 2D površinama različitih tipova tijela analizirani su oblici kontura i vrijednosti površina. Dodatno su konture transformiranih površina analizirane i uspoređene s konturama krojeva konstruiranih prema konvencionalnoj metodi konstrukcije.*

1. Uvod

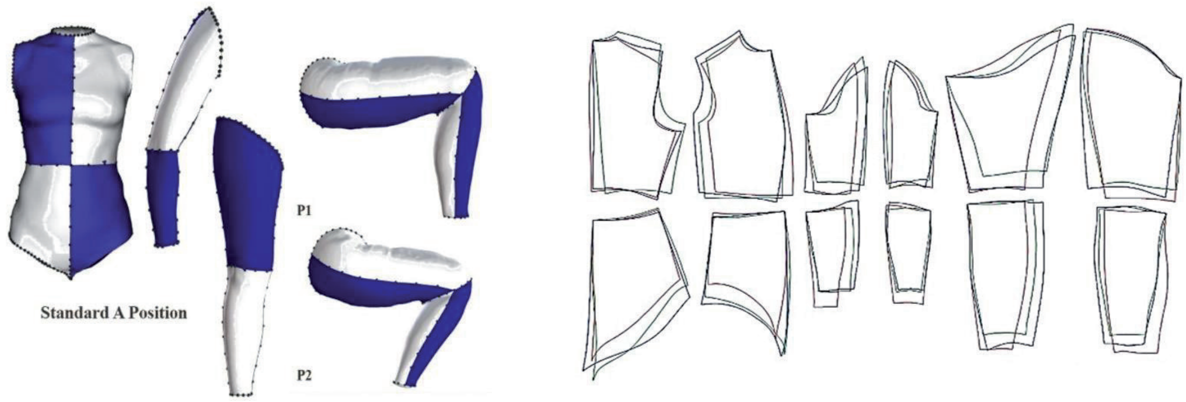
3D skeneri tijela omogućavaju precizno utvrđivanje tjelesnih mjera te analizu morfoloških karaktristika što je vrlo značajno u konstrukciji odjeće s visokim zahtjevima funkcionalnosti i pristalosti. Skenirani modeli tijela mogu se koristiti u CAD sustavima za konstrukciju i 3D simulaciju odjeće u procesu razvoja računalnih prototipova odjevnih predmeta prilagođenih prema individualnim mjerama [1, 2]. Tipovi ženskog tijela, karakteristični za pojedine dobne skupine i veličine tijela su prema različitim istraživačima različito definirani, a metode klasifikacije se najčešće baziraju na odnosu karakterističnih tjelesnih opsega [3, 4]. S obzirom da je primjenom standardnih sustava veličina i konvencionalnom metodom konstrukcije vrlo teško zadovoljiti visoke kriterije pristalosti odjeće prema različitim veličinama i tipovima tijela, dodatna prednost 3D skenera tijela je utvrđivanje podataka o dinamičkoj antropometriji koja omogućava analizu tjelesnih mjera i površinskih deformacija ovisno o pokretu [5]. 3D flattening metoda podrazumijeva konstrukciju odjeće direktno na računalnom modelu tijela, segmentiranje 3D površine i transformaciju 3D segmenata u plošne 2D površine te se najčešće koristi za konstrukciju odjeće pripijene uz tijelo [6].

2. Eksperimentalni dio

Tipovi ženskog tijela i morfološke karakteristike koje određuju pripadnost pojedinom tipu utvrđene su primjenom klasifikacijskog algoritma koji na temelju bočne krivulje tijela u frontalnoj ravnini razlikuje tri različite grupe tipova. Tip tijela F1 je pravokutni tip tijela s gotovo identičnim širinama tijela na području grudi, struka, trbuha i bokova. Tipovi tijela F2 i F3 imaju izražajnu bočnu krivulju tijela i razlikuju se u donjem dijelu torza pri čeu tip F3 ima veču zakrivljenost krivulje u području između linije struka i bokova. Kako bi se dobio uvid u deformabilnost tijela u pokretu, provedeno je skeniranje ispitanika i u tri dinamička položaja. Skenirani i parametarski modeli tijela, prilagođeni prema karakteristikama pojedinog tipa su primenom 3D flattening metode segmentirani i transformirani u 2D površine određene anatomskim ravninama i karakterističnim tjelesnim linijama koje se uobičajeno koriste u projektiranju i konstrukciji odjeće, sl. 1a.

Na izdvojenim dijelovima analizirani su oblici kontura i vrijednosti površina, sl. 1b. Vrijednosti transformiranih 2D površina su uspoređene s referentnim segmentiranim 3D površinama skeniranih modela tijela u statičkom i dinamičkim položajima. Oblici kontura utvrđenih 2D površina su analizirani i uspoređeni s konvencionalnom metodom konstrukcije pri čemu je uočeno da ograničen broj refrentnih tjelesnih mjera koje se koriste u tradicionalnim metodama nije dostatan za postizanje zadovoljavajuće prilagodbe i visoke dimenzijske pristalosti odjeće prema tipovima tijela.

Primjenom konvencionalne konstrukcijske metode i metodom 3D flatteninga računalno su konstruirani jednostavni modeli kombinezona za svaki tip tijela. Izvedene su fizikalne 3D simulacije konstruiranih modela te je provedena analiza dimenzijske pristalosti koja uključuje analizu naprezanja i istezanja odjevnih predmeta na odgovarajućim modelima tijela u statičkim i dinamičkim uvjetima.



a. b.

Slika 1: a. Skenirani 3D model tijela sa segmentiranim površinama u statičkom i dinamičkim položajima b. Usporedba oblika kontura transformiranih 2D površina za tri tipa tijela

3. Rezultati i rasprava

Provedena analiza segmenata površine skeniranih modela tijela pokazala je značajne razlike između pojedinih grupa tipova tijela. Unatoč činjenici da su svi ispitanici u istom rangu odjevne veličine, transformirane površine segmenata razlikuju se i po oblicima i u vrijednostima površina segmentiranih dijelova. Razlike kod promatranih tipova tijela naročito su vidljive u području donjeg dijela torza. 3D flattening metoda je pokazala bolje rezultate pristalosti odjevnog predmeta od konvencionalne metode konstrukcije. Analiza segmenata tijela u dinamičkim položajima također je pokazala razlike u vrijednostima transformiranih 2D površina kao i u vrijednostima volumena 3D segmenata ovisno o tjelesnom položaju.

4. Zaključak

Rezultati provedenog istraživanja oblika i vrijednosti segmenata površina tijela imaju direktnu primjenu u projektiranju i konstrukciji odjeće prilagođene prema individualnim mjerama ili pojedinom tipu tijela te se mogu koristiti za razvoj metoda prilagodbe odjeće. Dodatno, segmentiranje i 3D flattening metoda mogu se primijeniti u području dinamičke antropometrije gdje omogućavaju analizu deformacija i promjena volumena segmentiranih dijelova tijela ovisno o pokretu.

Literatura

[1] Gill, S.; Heyes, S.: Lower body functional ease requirements in the garment pattern, *International Journal of Fashion, Design, Technology and Education*, **5** (2012) 1, 13-23, ISSN 1754-3266

[2] Petrak, S. et al.: The impact of male body posture and shape on design and garment fit, *Fibres and Textiles in Eastern Europe*, **23** (2015) 6, 150-158, ISSN 1230-3666

[3] Fisher, T. et al.: Automatic morphological classification with Case-Based Reasoning, *Proceedings of 7rd International Conference on 3D Body Scanning Technologies*, DiApozzo, N. (ed.), 148-158, ISBN 978-3-033-05981-8, Lugano Switzerland, November 2016, Hometrica Consulting, Ascona, (2016)

[4] Vuruksan, A.; Bulgun, E.: Identification of female body shapes based on numerical evaluations, *International Journal of Clothing Science and Technology*, **23** (2011) 1, 46-60, ISSN 0955-6222

[5] Petrak, S.; Mahnic Naglic, M.: Dynamic Anthropometry – Defining a Protocols for Automatic Body Measurement, *Tekstilec*, **60** (2017) 4, 254-262, ISSN 0351-3386

[6] Petrak, S. et al.: Sizing and fit for swimsuits and diving suits, In *Anthropometry, Apparel Sizing and Design*, Elsevier, ISBN 978-0-08-102604-5, Amsterdam, (2019), 255-288

Mislav Majdak

Životopis

Mislav Majdak je rođen 1995. godine u Zagrebu. 2020. godine završava diplomski sveučilišni studij Tekstilna tehnologija i inženjerstvo na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. 2021. godine upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija na Tekstilno-tehnološkom fakultetu. Iste godine zapošljava se na projektu *Antibakterijska prevlaka za biorazgradive medicinske materijale*.

Naslov doktorskog rada

Studijski savjetnik

izv. prof. dr. dr. sc. Iva Rezić

Datum obrane teme doktorskog rada

ANTIMIKROBNE PREVLAKE S METALNIM NANOČESTICAMA NA MEDICINSKIM TEKSTILIJAMA

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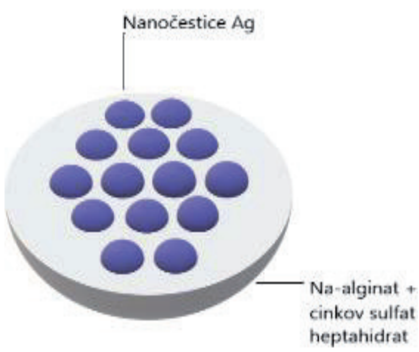
Sažetak: *UV/VIS spektroskopija omogućuje praćenje otpuštanja srebra iz mikrokapsula, te utvrđivanje kinetike.*

1. Uvod

Ljudsko tijelo sadrži razne simbiotske mikroorganizme koji štite i pomažu u funkciji mnogobojnih sustava [1, 2], no neke bakterije predstavljaju opasnost ljudskom zdravlju. Bakterije poput *Staphylococcus aureus*, mogu uzrokovati ozbiljna oboljenja, te u slučaju nastanka kroničnih rana smrt [3]. Kako bi se izbjegle štetne posljedice, veliki interes znanstvene zajednice je usmjeren na proučavanje i razvoj antimikrobnih formulacija koje imaju inhibirajuća ili baktericidna svojstva. U ovome radu, razvijat će se mikrokapsulirane formulacije koje sadrže nanočestice srebra, te srebrov nitrat. Srebro je poznato po svojim antimikrobnim svojstvima, zbog čega se i često koristi za izradu zavoja namijenjenih za liječenje kroničnih rana [4]. Srebrov nitrat i nanočestice srebra će biti inkapsulirani, čime se želi postići kontrolirano otpuštanje ciljanih koncentracija aktivnog sredstva, srebra, koje će imati potencijalna inhibirajuća ili baktericidna svojstva. Same mikrokapsule će biti vezane na pamučni tekstilni supstrat pomoću sol-gel postupka, čime će se postići jednostavna i brza obrada materijala.

2. Eksperimentalni dio

Za postizanje željene formulacije potrebno je provesti postupak inkapsulacije koji omogućuje pripremu mikrokapsula uz određenu kontrolu dimenzija. U svrhu dobivanja mikrokapsula, koristi se inkapsulator *Buchi Encapsulator B-390*, koji omogućuje jednostavnu, relativno brzu i neprekinutu inkapsulaciju željenih formulacija. U svrhu istraživanja unutar natrijeva alginata, i cinkovog sulfata heptahidrata inkapsulirane su nanočestice Ag ili srebrov nitrat. Ilustracija presjeka mikrokapsule je prikazana na sl.1.



Slika 1: Presjek mikrokapsule; vidljiva je jezgra koja uključuje srebro i vanjski omotač natrijeva alginata te cinkovog sulfata heptahidrata

Kako bi se pratilo otpuštanje srebra, tj. kinetika otpuštanja, koristi se UV/VIS spektroskopija, pri čemu se ispitivanje provodilo u ultraljubičastom i vidljivom području. U svrhu ispitivanja koristilo se 18 uzoraka mikrokapsula mase 1 ± 0,001g (za svaki sat po jedan uzorak). Za odabir mikrokapsula primijenjen je postupak jednostavnog uzorkovanja.

3. Rezultati i rasprava

Upotrebom UV/VIS spektroskopije omogućeno je praćenje otpuštanja srebra iz mikrokapsula u vodenom mediju. Na temelju dobivenih vrijednosti koncentracija srebra, moguće je dobiti uvid u samu kinetiku otpuštanja. Vrijednosti koncentracija su prikazane u tab. 1. Mjerenje je provedeno unutar 48 satnog intervala koji odgovara, vremenu previjanja kroničnih rana [4]. Iz tablice je vidljivo da vrijednosti koncentracija rastu u vremenu od 48 sati.

Tablica 1: Koncentracije srebra izražene u µg/ml

Vrijeme/sati	Koncentracije/ µg/ml		
1	0,011321	0,012026	0,009843
2	0,012866	0,012933	0,011321
3	0,014242	0,013604	0,011992
4	0,016234	0,015653	0,012664
24	0,017198	0,015048	0,013235
48	0,021060	0,020455	0,015451

4. Zaključak

Na temelju dobivenih rezultata može se zaključiti da se unutar 48 sati otpušta ona koncentracija srebra koja bi mogla inhibirati rast ili potpuno uništiti kolonije bakterija. Iako same vrijednosti koncentracija variraju, što će zahtijevati veći interes u budućnosti, uzorci prate identičan trend. Primjenom sol-gel postupka, mikrokapsule će nanijeti na tekstilne materijale, s ciljem postizanja učinkovite prevlake na antimikrobnom medicinskom materijalu.

Zahvala

Istraživanja se izvode u okviru istraživačkog projekta ABBAMEDICA IP- 2019-04-1381 voditelja izv. prof. dr. dr. sc. Ive Rezić koji financira Hrvatska zaklada za znanost.

5. Literatura

[1] Grice, E.; Segre, J.: The skin microbiome, *Nature Reviews Microbiology*, **9** (2011) 4, 244-253, ISSN 1740-1534

[2] Scotti, E. et al: Exploring the microbiome in health and disease: Implication for toxicology, *Toxicology Research and Application*, **1** (2017) 1,1-37, ISSN 2397-8473

[3] Rezić, I. et al: Development of Antibacterial Protective Coatings Active against MSSA and MRSA on Biodegradable Polymers, *Polymers*, **13** (2021) 4, 1-17. ISSN 2073-4360

[4] Somogyi Škoc, M.; Pezelj, E.; Ležaić, D.: Karakterizacija i učinkovitost medicinskih obloga za kronične rane, *Tekstil*, **63** (2014) 9-10, 293-305. ISSN: 04925882

Rajna Malinar

Životopis	Rajna Malinar rođena je 1985. godine u Zagrebu. 2015. godine završila je dodiplomski studij Tekstilna tehnologija i inženjerstvo na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. 2016. godine se zapošljava na Tekstilno-tehnološkom fakultetu kao stručni suradnik. 2017. godine upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija. Svoj znanstveni rad usmjerava prema istraživanju nastanka tekstilne prašine i njenom smanjenju te od 2018. do 2021. godine radi kao asistent na Tekstilno-tehnološkom fakultetu na projektu "Bolničke zaštitne tekstilije".
Naslov doktorskog rada	Razvoj i modifikacija pamučnih tkanina sa smanjenim generiranjem tekstilne prašine za primjenu u bolničkom okružju
Mentor	izv. prof. dr. sc. Sandra Flinčec Grgac
Datum obrane teme doktorskog rada	17. 2. 2021.

Razvoj i modifikacija pamučnih tkanina sa smanjenim generiranjem tekstilne prašine za primjenu u bolničkom okružju

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Sažetak: *Svrha doktorskog rada je smanjiti količinu tekstilne prašine koja nastaje u korištenju tekstilije čime bi se smanjila mogućnost širenja zaraznih mikroorganizama i gomilanje prašine na sofisticiranoj opremi u bolničkom okruženju. Problemu se pristupa iz dva gledišta: mogućnost smanjenja prašine u fazi proizvodnje tkanine i smanjivanje prašine intervencijom u procesu održavanja tkanine. Parametri i svojstva tekstilija ispitat će se u skladu sa standardnim i prilagođenim metodama. Ispitat će se i udobnost obrađenog tekstilnog materijala, kao i zdravstvena ispravnost. Dobivene spoznaje o proizvodnim parametrima koji utječu na stvaranje prašine dati će smjernice za proizvodnju tkanina za bolničke namjene, a dodana sredstva u održavanju smanjuju količinu prašine i povećavaju antimikrobna svojstva mogla bi se primijeniti u praonicama na već postojeće bolničko rublje.*

1. Uvod

U bolničkom okruženju tekstilna prašina predstavlja problem iz više razloga. Mikroorganizmi se pomoću prašine šire zrakom, natložena prašina služi kao hranidbena podloga za razvoj mikroorganizama, a isto tako gomilanje prašine unutar sofisticirane opreme može dovesti do kvarova uređaja [1-4]. Time je jasno da postoji potreba za smanjenjem nastajanja tekstilne prašine u bolničkom okružju.

Tekstil u uporabi otpušta sitne čestice kao posljedicu trenja između površina vlakana. Poznato je da pamučne tekstilije otpuštaju veće količine čestica od npr. poliesterskih vlakana [5], međutim nije ispitana povezanost strukture materijala s generiranjem tekstilne prašine. S obzirom da konstrukcijske karakteristike tkanine kao što su materijal, vez i gustoća niti utječu na količinu trenja unutar tkanine može se očekivati da se različitim konstrukcijskim parametrima tkanine može smanjiti količina nastale tekstilne prašine.

Osim što se nastalim trenjem može manipulirati u procesu proizvodnje tkanine, jasno je da se površina tkanine troši u uporabi i održavanju, što dovodi do većeg trenja između niti, te time i većeg nastajanja tekstilne prašine. Zato je u drugom dijelu rada pažnja posvećena istraživanju i razvoju sredstva koje bi se moglo koristiti kao dodatak pri ispiranju u postupku održavanja tkanine, čime bi se zagladila površina i smanjilo nastajanje prašine.

2. Eksperimentalni dio

U prvom dijelu istraživanja ispitat će se utjecaj različitih konstrukcijskih karakteristika na generiranje tekstilne prašine. Uzorci različitih vezova i gustoća niti podvrgnut će se višestrukim postupcima održavanja kako bi se dobio uvid u generiranje tekstilne prašine tijekom duljeg razdoblja korištenja. Uzorci koji nakon ispitivanja pokažu optimalne rezultate generiranja prašine u odnosu na uporabnost, u drugom dijelu istraživanja biti će podvrgnuti postupcima održavanja s uključenim sredstvom za smanjenje tekstilne prašine u procesu ispiranja. Kada se postigne smanjenje prašine takvih uzoraka u odnosu na uzorke bez primijenjenog sredstva, na uzorcima će se ispitati udobnost i zdravstvena ispravnost. Tekstilni materijal za potrebe istraživanja proizveden je u različitim sirovinskim sastavima, vezovima i gustoćama potke. Pamučna pređa naručena je iz iste pošiljke radi ujednačenosti sirovine u 100 % pamučnoj pređi i pređi od pamučnih i poliesterskih vlakana (50 %/50 %). Odabrani su osnovni vezovi i njihove izvedenice: platno, rips uzdužni, panama, keper 2/2, keper 3/1 i atlas 4/1. Gustoća osnove za sve vezove je bila jednaka radi jednostavnosti proizvodnje, a gustoća potke varirana je između minimalne, optimalne i maksimalne preporučene gustoće za pojedine vezove. Materijal je nakon tkanja odškrobljen i kemijski izbijeljen. Na svim uzorcima provedeni su postupci održavanja prema HRN EN ISO 15797, „Tekstilije -- Postupci industrijskog pranja i oplemenjivanja za ispitivanje radne odjeće“, na 75 °C, sa standardnim deterdžentom i peroksioctenom kiselinom. Na uzorcima je provedeno 3, 10 i 50 postupaka održavanja. Generiranje tekstilne prašine ispituje se prema HRN ISO 9073-10 „Tekstil -- Metode ispitivanja netkanog tekstila -- 10. dio: Linter i druge čestice u suhom stanju“ pri čemu se dobivaju rezultati u obliku količine i veličine otpuštenih čestica sa uzoraka u pokretu kroz određeni vremenski period. Na uzorcima će se popratno ispitati mehanička i strukturna svojstva: promjena čvrstoće tkanine, promjena u površinskoj masi, gustoća niti, debljina tkanine, utkanje osnove i potke, a površina tkanine snimit će se i pregledati digitalnim mikroskopom. Statističkom obradom podataka utvrdit će se postoje li veze između pojedinih parametara strukture tkanine i broja otpuštenih čestica.

3. Rezultati i rasprava

Smanjenje generiranja prašine dodatkom sredstva u kupelji za ispiranje prilikom procesa održavanja istražit će se ispitivanjem učinkovitosti polietilen glikola (PEG) različitih molarnih masa. Ispitat će se i mogućnost nanošenja dodatnih pomoćnih sredstava. U ovoj fazi istraživanja provest će se i ispitivanje mogućnosti dodatka sredstva s antimikrobnim učinkom koje bi pozitivno djelovalo na bolničke tekstilije. Učinkovitost nanošenja PEG-a i dodataka ocijenit će se gravimetrijski, termogravimetrijski i spektrofotometrijski. Ispitivanje generiranja prašine na uzorcima provest će se prema ranije navedenoj metodi. Statistička obrada rezultata ocijenit će uspješnost primjene razvijenog sredstva na smanjenje generiranja tekstilne prašine.

Kako bi se osigurala funkcionalnost i sigurnost u korištenju ispitat će se utjecaji proizvodnih parametara i obrade tkanine na udobnost i zdravstvenu ispravnost. Udobnost navedenih tkanina pratit će se ispitivanjem sposobnosti upravljanja vlagom i dodirna svojstva na uređaju za ispitivanje opipa. Zdravstvena ispravnost novo razvijenih tkanina istražit će se s obzirom na antimikrobnu učinkovitost. Također, toksikološkim ispitivanjima će se utvrditi da li kemijske tvari korištene tijekom razvijanja tekstilija s učinkovitim antimikrobnim svojstvima predstavljaju rizik za zdravlje.

4. Zaključak

Tekstilna prašina je mogući prijenosnik mikroorganizama opasnih za zdravlje. Poznato je da je njenim smanjenjem moguće smanjiti i širenje zaraze u bolničkom okruženju. Istraživanje učinka različitih proizvodnih parametara tkanine na generiranje prašine dati će smjernice za proizvodnju tkanina za bolničku namjenu sa smanjenim generiranjem prašine. Također, razvoj sredstva koje se može dodati u fazi ispiranja pri procesu održavanja smanjilo bi generiranje prašine s postojećih bolničkih tekstilija uz mogućnost postizanja i antimikrobne učinkovitosti. Optimiranje takvog sredstva otvorilo bi vrata komercijalnom proizvodu koji bi se mogao ponuditi u praonice.

Zahvala

Ovaj rad je sufinancirala Hrvatska zaklada za znanost projektom UIP-2017-05-8780 “Bolničke zaštitne tekstilije” HPROTEX.

5. Literatura

[1] Rubbo, S. D.; Stratford, B. C.; Dixson, S.: Spread Of A Marker Organism In A Hospital Ward, *British Medical Journal*, **2** (1962), 282–287, ISSN 0959-8138

[2] Licina, D.; Nazaroff, W. W.: Clothing as a transport vector for airborne particles: Chamber study, *Indoor Air*, **28** (2018) 3, 404–414, ISSN 0905-6947

[3] Shiomori, T. et al.: Evaluation of bedmaking-related airborne and surface methicillin-resistant Staphylococcus aureus contamination, *Journal of Hospital Infection*, **50** (2002) 1, 30–35, ISSN 0195-6701

[4] Neely, A. N.; Maley, M. P.: Survival of enterococci and staphylococci on hospital fabrics and plastic, *Journal of Clinical Microbiology*, **38** (2000) 2, 724–726, ISSN 0095-1137

[5] Lamb, G. E. R.; Kepka, S.; Miller, B.: Particle Release from Fabrics During Wear, *Aerosol Science and Technology*, **13** (1990) 1, 1–7, ISSN 0278-6826

Paula Marasović

Životopis	Paula Marasović rođena je 1994. godine u Šibeniku. Godine 2018. završava diplomskia, a iste godine upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija. Godine 2019. objavila je znanstveni pregledni rad u međunarodnom znanstvenom časopisu Textile & Leather Review. Bila je demonstratorica na kolegijima Netkani i tehnički tekstil, Netkani tekstil i predenje. Od 2018. do 2019. godine radila je u tvornici tehničkih tkanina Kelteks d.o.o. u Karlovcu kao viši planer proizvodnje. Pisala je članke za razne web portale, najčešće o kulturnim temama te o održivoj modi. Od 2020. godine članica je uredništva međunarodnog znanstvenog časopisa Textile & Leather Review i planer proizvodnje.
Naslov doktorskog rada	Razvoj biorazgradivog netkanog agrotekstila iz prirodnih i obnovljivih izvora
Studijska savjetnica	izv. prof. dr. sc. Dragana Kopitar
Datum obrane teme doktorskog rada	

RAZVOJ BIORASTAVLJIVOG NETKANOG AGROTEKSTILA IZ PRIRODNIH I OBNOVLJIVIH IZVORA

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Sažetak: *Danas su ljudi svjesniji onečišćenja okoliša, ekološkog otiska, emisija CO_2 gdje se svi okreću održivijem razvoju i zaštiti okoliša. 90 % agrotekstila izrađeno je od sintetičkih polimera PP, PE, te u manjoj mjeri od naftnih derivata kao što su PA i PET, koji su ekološki sve manje prihvatljivi. Postoji trend razvoja proizvodnje agrotekstila od prirodnih vlakana kao što su juta, vuna, kenaf i celulozni regenerati (samo 10 %). S druge strane, agrotekstil na biološkoj bazi smanjuje negativan utjecaj na okoliš gdje se tijekom i nakon uporabe potpuno razgrađuje što ga čini ekološki prihvatljivim. U svrhu daljnjih opsežnih istraživanja provedeno je preliminarno ispitivanje trajnosti različitih tekstilnih materijala koje se koriste za suzbijanje korova (pod utjecajem vremenskih uvjeta) te potencijalno primjenjivih prirodnih materijala (uzimajući u obzir vrijeme i učinkovitost degradacije). Svi dobiveni rezultati važni su pokazatelji za daljnja istraživanja koja će se provoditi u sklopu projekta „Razvoj biorazgradivog netkanog agrotekstila iz prirodnih i obnovljivih izvora" (KK.01.2.1.02.0270).*

1. Uvod

Općenito, medijska pozornost, kampanje nevladinih organizacija i marketing proizvoda doveli su do porasta očekivanja potrošača u pogledu izvora materijala, proizvodnje i upotrebe proizvoda. Uz pritisak na tržište, postoji i stroža državna regulativa utjecaja na okoliš koji se odnosi na niz industrija; proizvođači tekstila, stoga i netkanih materijala, nisu imuni. Zbog različitih pritisaka, trgovci i proizvođači razmatraju utjecaj proizvoda na okoliš zajedno sa zahtjevima u pogledu performansi i troškova. Sukladno tome, potražnja za agrotekstilom izrađenim od prirodnih vlakana, sintetičkih biopolimera i biorazgradivih materijala koji smanjuju utjecaj na okoliš se povećava [1].

Za netkani agrotekstil uglavnom se koriste biljna vlakna zbog svojih vrhunskih svojstava; biljna vlakna mogu izdržati mnogo više topline i sunčeve svjetlosti od većine sintetičkih vlakana, a neka čak mogu izdržati i teške uvjete morskog okoliša. Međutim, za primjenu u vodenim ili muljevitim okruženjima, agrotekstili od biljnih vlakana nisu prikladni zbog niskog sadržaja lignina (~4 %), što ih čini osjetljivim na napad mikroorganizama. Neka od prirodnih biljnih vlakana koja se koriste za proizvodnju agrotekstila su juta, kokos, sisal, lan, konoplja i vuna [2]. Konvencionalni prirodni tekstilni materijali kao što su pamuk, vuna i lan mogu se biorazgraditi ako se odlažu na odlagališta otpada ili/ili industrijsko kompostiranje. Celulozna vlakna brzo propadaju, posebno lagani pamuk se može razgraditi, u kompostnoj hrpi, u razdoblju od 1 do 6 mjeseci. Vuna je otpornija, ali može se također razgraditi djelovanjem bakterija i gljiva zajedno s ličinkama kukaca, te se može potpuno razgraditi u tlu u razdoblju od 6 mjeseci. Alternativni prirodni materijali kombiniraju biorazgradljivost sa znatno manjim utjecajem ugljika i vode, uz poželjna fizička svojstva. Nedostatak prirodnih vlakana je njihov kratak vijek trajanja u odnosu na sintetičke materijale. Međutim, prirodni materijali čine samo 3 % tržišta netkanog materijala, tako da je njihov utjecaj na okoliš manje zabrinjavajući od sintetičkih materijala [1].

U siječnju 2018. Europska komisija objavila je novu strategiju za plastiku. Cilj za 2030. je postići recikliranje ili ponovnu upotrebu 60 % svih polimernih materijala. Cilj u 2040. godini je dostići 100 %. Trenutno se svake godine proizvede 674 tisuće tona novih proizvoda kako bi se pokrila velika potražnja poljoprivrednog tržišta, ostavljajući za sobom oko milijun tona otpada [3]. Sposobnost recikliranja netkanih materijala smatra se značajnim sredstvom za povećanje održivosti proizvoda smanjenjem količine netkanog materijala koji ide na odlagalište ili spaljivanje. Održivost netkanog proizvoda može se ocijeniti razmatranjem svakog aspekta zajedno s utjecajem proizvodnje i distribucije. Istinski održivi proizvod će pružiti opipljive koristi potrošaču, a istovremeno će smanjiti negativan utjecaj na okoliš [1]. S ekonomske točke gledišta, najisplativije je koristiti postojeće materijale (osobito prirodne otpadne materijale) umjesto sintetiziranja i proizvodnje novih, biorazgradivih polimernih materijala. Prekrivke za usjeve od tekstilnog otpada predmet su velikog interesa. Pod tekstilnim otpadom prvenstveno se podrazumijevaju polisaharidna vlakna: pamuk, lan, konoplja, juta i vuna (kao proteinsko vlakno) [4].

2. Eksperimentalni dio

Nakon proizvodnje netkanih uzoraka provest će se karakterizacija uzoraka kroz ispitivanje osnovnih fizikalno-mehaničkih svojstava (površinska masa, debljina, prekidna sila i sila prskanja), te će se provesti višegodišnje ispitivanje zakapanjem u tlo. Uzorci će se periodično iskapati i ispitivati kako bi se ustvrdilo vrijeme biorazgradnje.

3. Rezultati i rasprava

Proizvedeni biorazgradivi netkani agrotekstil služit će za suzbijanje korova i promicanje rasta biljaka koji će smanjiti ili eliminirati upotrebu kemijskih pesticida i insekticida, sa fizikalno-mehaničkim svojstvima konvencionalnog PP netkanog agrotekstila. Nakon korištenja, materijal će bit u potpunosti kompostiran u skladu s načelima "zero waste" filozofije koja osigurava organsku proizvodnju hrane.

4. Zaključak

Povećana svijest potrošača i zahtjevi za transparentnijim i ekološki prihvatljivijim procesima naveli su proizvođače i trgovce na razmatranje cjeloživotnog ciklusa netkanih materijala, ne uzimajući u obzir samo izvor materijala nego i utjecaj scenarija proizvodnje, isporuke, uporabe i eksploatacije. U smjeru održivog razvoja istražena je potreba za korištenjem biorazgradivog agrotekstila od prirodnih vlakana i recikliranih materijala. Može se zaključiti da s obzirom na utjecaj na okoliš, korištenje biorazgradivog i održivog agrotekstila smanjuje emisiju CO_2 i općenito pridonosi manjem onečišćenju tla u odnosu na konvencionalni agrotekstil izrađen od sintetičkih polimera.

Zahvala

Ovaj rad je sufinancirala Europska unija iz Europskog fonda za regionalni razvoj u sklopu projekta KK.01.2.1.02.0270 Razvoj biorazgradivog netkanog agrotekstila iz prirodnih i obnovljivih izvora.

Literatura

[1] Goswami, P.; O'Haire, T.: *Advances in Technical Nonwovens*, Woodhead Publishing, ISBN 9780081005750, Sawston, (2016)

[2] Paul, R.: *High Performance Technical Textiles*, John Wiley & Sons Ltd., ISBN 978-1-119-32501-7, Hoboken, (2019)

[3] Siwek, P. et al: Biodegradable agroplastics in 21st century horticulture, *Polimery*, **64** (2019) 7-8, 480–486, ISSN 00322725

[4] Gabryś, T. et al: *Modification and Properties of Cellulose Nonwoven Fabric-Multifunctional Mulching Material for Agricultural Applications*, *Materials,* **14** (2021),1-16, ISSN 1996-1944

Lela Martinaga

Životopis	Lela Martinaga završila je studij Ekoinženjerstva na Fakultetu kemijskog inženjerstva i tehnologije nakon čega upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Na istoj instituciji, u okviru projekta Hrvatske zaklade za znanost, radi kao asistentica na Zavodu za primijenjenu kemiju i bavi se proučavanjem biokatalitičkih procesa sinteze metalnih nanočestica u svrhu njihove primjene za razvoj funkcionalnih materijala. Koautorica je 9 znanstvenih radova te 19 sažetaka objavljenih u časopisima i zbornicima skupova. Dosad je održala 4 usmenih i 10 poster prezentacija na skupovima te bila neposredni voditelj 5 diplomskih i završnih radova. Dobitnica je stipendije Republike Austrije za znanstveno usavršavanje na Sveučilištu za prirodne resurse i primijenjene znanosti u Beču (BOKU), Austrija.
Naslov doktorskog rada	Enzimatska sinteza i karakterizacija nanočestica metala i metalnih oksida te njihova primjena u svrhu poboljšanja funkcionalnih svojstava tekstilnih materijala
Mentori	izv. prof. dr. dr. sc. Iva Rezić prof. dr. sc. Ana Vrsalović Presečki
Datum obrane teme doktorskog rada	5. 7. 2018.

EKOLOŠKI PRIHVATLJIVA SINTEZA NANOČESTICA ZLATA I SREBRA

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Sažetak: *Upotrebom nanočestica zlata (Au-) i srebra (Ag-NPs) u proizvodima prehrambene i tekstilne industrije je moguće unaprijediti njihova antibakterijska, UV zaštitna, vatroodbojna i/ili hidrofobna svojstva. U ovom je istraživanju provedena enzimatska sinteza Au- i Ag-NPs korištenjem dvaju oksidoreduktivnih enzima (celobioza dehidrogenaze (Mt CDH) i glukoza dehidrogenaze (Gc GDH)) kao prihvatljivija metoda sinteze kojom je moguće izbjeći pojedine nedostatke konvencionalnih metoda sinteze nanočestica. Ispitan je i optimiran utjecaj reakcijskih uvjeta na navedene reakcije te je određena reakcijska kinetika. Sintetizirane nanočestice su karakterizirane korištenjem UV-Vis spektroskopa, a prisustvo nanočestica zlata i srebra potvrđena je maksimalnim apsorbancijama na 540, odnosno 430 nm.*

1. Uvod

Korištenje metalnih nanočestica točno određenih svojstava i njihova sinteza posljednjih su desetljeća jedna od najpopularnijih istraživačkih tema. Nanočestice zlata (Au-) i srebra (Ag-NPs) smatraju se jednima od najzanimljivijih s obzirom na njihovu raširenu upotrebu, npr. u zdravstvu, elektronici, obnovljivoj energiji itd. [1]. Njihovom primjenom, moguće je postići unaprjeđenja pojedinih svojstava proizvoda prehrambene i tekstilne industrije kao što su antibakterijska, UV zaštitna, vatroodbojna i/ili hidrofobna svojstva [2].

U ovom je istraživanju provedena enzimatska sinteza Au- i Ag-NPs kao prihvatljivija metoda sinteze kojom je moguće izbjeći pojedine nedostatke konvencionalnih metoda sinteza nanočestica, poput korištenja agresivnih kemikalija i/ili reakcijskih uvjeta [3].

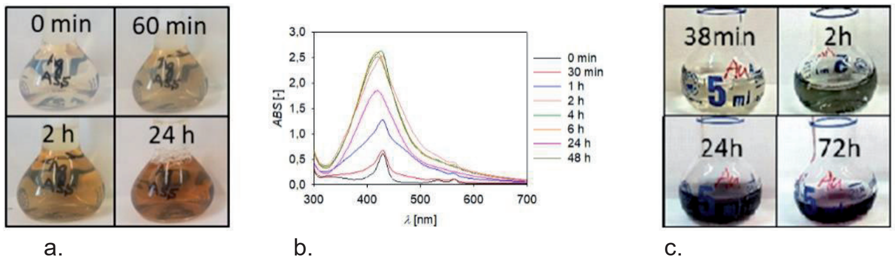
2. Eksperimentalni dio

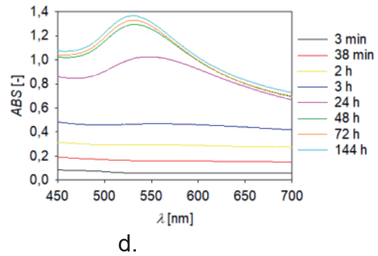
Enzimatska sinteza Au- i Ag-NPs provedena je korištenjem dvaju oksidoreduktivnih enzima: celobioza dehidrogenaze (*Mt* CDH) i glukoza dehidrogenaze (*Gc* GDH). Ispitan je i optimiran utjecaj reakcijskih uvjeta (temperature, koncentracije enzima i reaktanata, reakcijski medij, pH, prisustvo svjetlosti i kisika) na reakcije. Ispitana je i kinetika obje reakcije, a uspješno sintetizirane nanočestice karakterizirane su UV-Vis spektroskopijom.

3. Rezultati i rasprava

Enzimatska sinteza Ag-NPs provedena je korištenjem reakcije oksidacije celobioze katalizirane enzimom *Mt* CDH u kotlastom reaktoru. Kao optimalni uvjeti reakcije određeni su: 0.1 M acetatni pufer pH 5,5, 37 °C, bez miješanja te prisustva svijetla i kisika. Korištenjem navedene reakcije, ispitana je i kinetika enzima *Mt* CDH te utjecaj iona srebra na aktivnost enzima. Za enzimatsku sintezu Au-NPs provedena je reakcija oksidacije glukoze katalizirana enzimom *Gc* GDH u kotlastom reatoru. Kao optimalni uvjeti ove reakcije određeni su: 0,1 M fosfatni pufer pH 5,5, 37 °C, bez miješanja te prisustva svijetla i kisika. Ispitana je kinetika enzima *Gc* GDH te utjecaj iona zlata na aktivnost enzima.

Kinetike oba korištena enzima opisane su jednosupstratnom Michaelis-Menteničinom kinetikom s kompetitivnom inhibicijom ionima srebra, odnosno zlata. Reakcije su praćene UV-Vis spektroskopijom, a uočeni maksimumi apsorbancije na 540 i 430 nm potvrđuju sintezu nanočestica zlata, odnosno srebra (sl. 1a, 1b i 1c, 1d) [4, 5].





Slika 1: Rezultati sinteze Au- i Ag-NPs: a. promjena boje reakcijske otopine tijekom sinteze Ag-NPs; b. UV-Vis spektri tijekom sinteze Ag-NPs; c. promjena boje reakcijske otopine tijekom sinteze Au-NPs; d. UV-Vis spektri tijekom sinteze Au-NPs

4. Zaključak

Određivanje reakcijske kinetike i modela reakcija omogućili su uvid u reakcijski mehanizam enzimatske sinteze nanočestica zlata i srebra. Predloženi reakcijski mehanizam potvrđen je provođenjem reakcija u kotlastom reaktoru. Uspješna sinteza nanočestica zlata i srebra potvrđena je spektrofotometrijski, maksimumima apsorbancije prisutnim na 540, odnosno 430 nm.

Zahvala

Istraživanja se provode na projektima Projekt razvoja karijera mladih istraživača - izobrazba novih doktora znanosti (DOK-10-2015) te istraživačkim projektima "Sinteza i ciljana primjena metalnih nanočestica - STARS" (UIP-2014-09-1534) i "Antibakterijska prevlaka za biorazgradive medicinske materijale - ABBAMEDICA" (IP-2019-04-1381) financiranih od Hrvatske zaklade za znanost te u okviru stipendije Republike Austrije, Agencije za međunarodnu suradnju u obrazovanju i istraživanju (OeAD-GmbH).

Literatura

[1] Castro, L. et al: Mechanism and applications of metal nanoparticles prepared by bio-mediated process, *Reviews in Advanced Sciences and Engineering*, **3** (2014) 3, 199-216, ISSN 2157-9121

[2] Ahmed, S. et al: Biosynthesis of gold nanoparticles: a green approach, *Journal of Photochemistry & Photobiology B-Biology*, **161** (2016), 141-153, ISSN 1873-2682

[3] Adelere, I. A.; Lateef, A.: A novel approach to the green synthesis of metallic nanoparticles: The use of agro-wastes, enzymes, and pigments, *Nanotechnology Reviews*, **5** (2016) 6, 567-587, ISSN 2191-9089

[4] Zuber, A. et al: Detection of gold nanoparticles with different sizes using absorption and fluorescence based method, *Sensors and Actuators B-Chemical*, **227** (2016), 117-127, ISSN 0925-4005

[5] Ramirez, D.; Jaramillo, F.: Facile one-pot synthesis of uniform silver nanoparticles and growth mechanism, *DYNA*, **83** (2016) 198, 165-170, ISSN 0012-7353

Marija Nakić

Životopis	Marija Nakić rođena je u Širokom Brijegu, gdje je završila osnovnu i srednju školu. Završila je studij na Sveučilištu u Zagrebu Tekstilno-tehnološki fakultet, smjer projektiranje i oblikovanje tekstila i odjeće, te magistrirala na temu "Hrvatska etno baština na području Rame". Trenutno pohađa sveučilišni poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija. Radila je kao dizajner za interijere u nekoliko tvrtki u Hercegovini. Trenutno radi u Uredu za međunarodnu suradnju na Sveučilištu u Mostaru.
Naslov doktorskog rada	Kriteriji projektiranja povijesnog tekstila Hrvatskog primorja
Studijski savjetnik	doc. dr. sc. Željko Knezić
Datum obrane teme doktorskog rada	

KRITERIJI PROJEKTIRANJA POVIJESNOG TEKSTILA HRVATSKOG PRIMORJA

Marija NAKIĆ
Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, Prilaz baruna Filipovića 28a, 10000 Zagreb, mnakic@ttf.hr

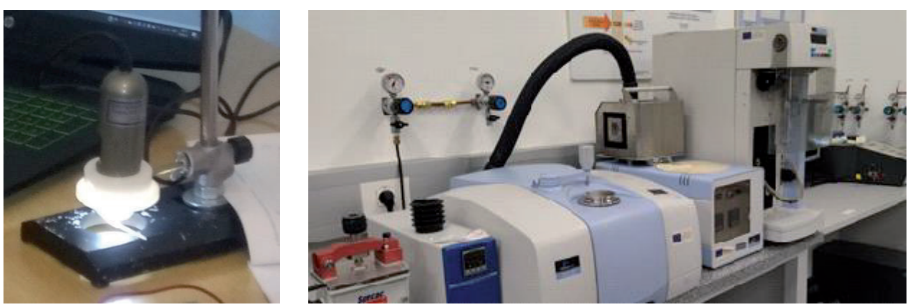
***Sažetak**: Odabir odjeće ovisi o klimatskim utjecajima, potrebnoj zaštiti od mehaničkih ozljeda, funkciji označavanja staleške pripadnosti, ranga na hijerarhijskoj ljestvici unutar organizacijskih skupina (npr. crkva, vojska i sl.), izražavanju stavova, te atributu uljepšavanja. Ovaj posljednji je uvijek bio važan, posebno ženama. One su, pa i pripadnice siromašnijih staleža, za izuzetne prilike, posjedovale poneki atraktivni, dragocjeniji odjevni predmet, koji su nabavljale od lokalnih trgovaca, trgovačkih putnika ili su pomorci donosili svojim ženama i djevojkama. Međutim, pojedini predmeti su izrađivani u „kućnoj" radinosti ili manufakturi/proizvodnji od autohtonih materijala. Povijesni tekstil kao dio hrvatske etnološke baštine i znanstvenog područja tekstilne tehnologije nije dovoljno istražen. Stoga će se, u sklopu doktorskog rada, na dostupnim primjerima povijesnog tekstila istražiti vrste materijala, njihov sirovinski sastav, načini izrade niti i tkanina te dorade dijelova odjeće i uporabnih predmeta. Temeljem prikupljenih relevantnih parametara načinit će se portfolio i izraditi replike.*

1. Uvod

Različiti izvori dokazuju kako tekstilno rukotvorstvo na tlu Hrvatske seže daleko u prapovijesno razdoblje [1]. Prije pojave industrijske proizvodnje na tlu današnje Hrvatske, odjeća se izrađivala ručno od tekstilnih plošnih materijala nastalih ručnim tkanjem ili pletenjem od dostupnih pređa životinjskog ili biljnog porijekla. Važno je uočiti razliku između odjeće koja je izrađivana od grubljih materijala (lan, konoplja, vuna, brnistra) za svakodnevne prilike i one od finijih materijala (lan svilenac, češljana vuna, prirodna svila, metalne i pozlaćene niti, te kasnije mercerizirani pamučni konac) koja se nosila u posebnim prigodama [2]. U Hrvatskom primorju ističu se mnogi dijelovi ženske odjeće koji su izrađeni s posebnom pozornošću od prirodnih materijala, ali tijekom vremena su izašla iz uporabe zbog promjene načina odijevanja kao i oštećenja nastalih nepravilnom upotrebom, održavanjem, čuvanjem itd.

2. Eksperimentalni dio

U sklopu doktorskog rada, koji je strukturiran kroz nekoliko faza, najprije će biti provedeno istraživanje pisanih tragova o originalnim tekstilnim uzorcima, zapisa temeljenih na usmenoj predaji (izvori, izdvajanje informacija, usporedba i provjera pouzdanosti). Terenskim istraživanjima ciljano će se izuzeti uzorci kroz dogovor s nadležnim institucijama. Uzroci će se podvrgnuti nedestruktivnim metodama analize, korištenjem znanstvene opreme, sl. 1 [3], kako ne bi došlo do oštećenja ili deformacije uzorka.



a. b.

Slika 1: Instrumenti za provedbu analize: a. digitalni mikroskop; b. FTIR – spektrofotometar sa TG-IR sučeljem

Također će se provesti računalna obrada i analiza prikupljenih podataka, kao i izdvajanje provjerenih relevantnih podataka za potrebe izrade replike. U završnoj fazi će se temeljem nalaza i tehnološke pripreme odabrati materijali i sredstva za izradu replike.

3. Rezultati i rasprava

Karakterizacijom korištenih materijala, načinom izrade niti i tkanina, dorade, načinom izrade uporabnih predmeta i dijelova odjeće, bit će načinjen portfolio i izrađena replika. Temeljem relevantno provedenih istraživanja i analize načinit će se usporedba originala i replike povijesnog tekstila hrvatskog primorja. Time će se povijesni tekstil, sam po sebi vremenit i sklon destrukciji, moći sačuvati kao dragocjeno kulturno i povijesno nasljeđe.

4. Zaključak

U doktorskom radu će se prikazati kriteriji projektiranja povijesnog tekstila hrvatskog primorja provedeni s posebnom pozornošću, bez narušavanja zatečenog stanja svakog pojedinog predmeta, uz krajnje mjere opreza da ne dođe do možebitnog oštećenja. Također će se provesti terenska istraživanja, pazeći na autentičnost institucija, kao i razgovori s odabranim dionicima naroda hrvatskog primorskog kraja. Tako prikupljeni podaci će se usporediti s pisanim zapisima i kritički analizirati. Na temelju svih dostupnih podataka i realiziranog istraživačkog koncepta projektirat će se što vjernija replika kao krajnji rezultat istraživanja.

Literatura

[1] Čunko, R. i sur.: Povijest proizvodnje tekstila u Hrvatskoj, U *Godišnjaku 2019 Hrvatske akademije tehničkih znanosti – Hrvatska tehnička i industrijska baština*, Akademija tehničkih znanosti Hrvatske, ISSN 1332-3482, Zagreb, (2020.), 76-103

[2] Firšt Rogale, S.; Rogale, D. i Knezić, Ž.: Povijest izrade i proizvodnje odjeće u Hrvatskoj, U *Godišnjaku 2019 Hrvatske akademije tehničkih znanosti – Hrvatska tehnička i industrijska baština*, Akademija tehničkih znanosti Hrvatske, ISSN 1332-3482, Zagreb, (2020.), 145-160

[3] Katalog znanstvene opreme - Zavod za tekstilnu kemiju i ekologiju, *Dostupno na*: https://www.ttf.unizg.hr/katalog-znanstvene-opreme/175, *Pristupljeno:* 2021-12-30

Željka Pavlović

Životopis	Željka Pavlović je rođena 1987. godine u Zaboku. Nakon završene osnovne škole u Samoboru, upisuje Ekonomsku, trgovačku i ugostiteljsku školu te je završava 2005. godine. Iste godine upisuje Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu. Nakon završenog studija zapošljava se u Tvornici čarapa Jadran d.d., gdje je 3,5 godine radila kao tehnolog u proizvodnji. 2015. godine zapošljava se kao asistent na Tekstilno-tehnološkom fakultetu. 2016. godine upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija na Tekstilno-tehnološkom fakultetu. Područja od posebnog interesa su joj projektiranje i proizvodnja čarapa te analiza rada pletaćih strojeva.
Naslov doktorskog rada	Termofiziološka svojstva pletiva uvjetovana procesom pletenja i strukturom pletiva
Mentor	prof. dr. sc. Zlatko Vrljičak
Datum obrane teme doktorskog rada	15. 7. 2020.

KRATKI OSVRT NA UTJECAJ PROCESA PLETENJA I STRUKTURE NA RASTEZNA SVOJSTVA DESNO-DESNIH PLETIVA

Željka PAVLOVIĆ
Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Prilaz baruna Filipovića 28a, 10000 Zagreb, zeljka.pavlovic@ttf.unizg.hr

Sažetak: *U svijetu se sve više izrađuju pređe koje će u primjeni zamijeniti klasične pamučne pređe dobivene prstenastim sustavom predenja. U izradi rublja često se koriste pamučne jednostruke pređe finoće 14, 16, 20 i 25 tex. Iz više razloga, s porastom broja stanovnika, proporcionalno se ne povećava i proizvodnja pamučnih pređa. Zbog toga se pristupa izradi pređa koje će zamijeniti ili nadopuniti pamučne pređe u različitim područjima primjene. Za ova istraživanja izrađene su četiri pređe nazivne finoće 20 tex koje se koriste za izradu kulirnih pletiva namijenjenih izradi različitih laganijih odjevnih predmeta, u načelu plošne mase 120 do 200 g/m*^{2}*. Pređe su izrađene prstenastim, rotorskim, SIRO i aerodinamičkim postupkom predenja iz pamučnih, viskoznih i modalnih vlakana. S navedenim pređama, jednom viskoznom Siro pređom i jednom pamučnom pređom, izrađeno je četiri uzoraka glatkih kulirnih desno-desnih pletiva na kružnopletaćem dvoigleničnom stroju finoće E17, promjera iglenica 200 mm (8 inča), koji je pleo s 8 pletaćih sustava pri brzini vrtnje 60/min.*

1. Uvod

S porastom broja ljudi na Zemlji i standardom življenja potrebno je povećavati i proizvodnju tekstilnih vlakana te područja njihove primjene [1, 2]. Na osnovi prikupljenih podataka procjenjuje se da je u 2013. godini bilo proizvedeno oko 92 mil. t. vlakana, ili oko 12 kg/stanovniku [3, 4]. Udio pojedine duljine vlakana i procesa izrade pređa biraju se prema željenoj strukturi pređe i upotrebnim svojstvima pređa, odnosno njenoj namjeni. Na ovaj način moguće je s umjetnim vlaknima dobiti neka svojstva pređa koja su znatno drugačija od pamučnih pređa, a time i plošni proizvod drugačijih svojstava. S novim strukturama pređa izrađuju se suvremeni proizvodi koji imaju dosadašnja, ali i neka nova područja primjene [1, 5].

2. Eksperimentalni dio

Za ova istraživanja izrađeno je s različitim sirovinama i postupcima predenja četiri pređe nazivne finoće 20 tex čije su strukture različite. Za izradu uzoraka korišten je kružnopletaći dvoiglenični stroj finoće E17, koji plete s 8 pletaćih sustava. Uzorci su izrađivani sa četiri navedene pređe različitih struktura i vlačnih svojstava. Rastezljivost desno-desnih kulirnih pletiva je znatno veća u smjeru redova nego nizova očica.

3. Rezultati i rasprava

Promjena svih parametara strukture pletiva se ogleda kroz plošnu masu koja za nedorađena pletiva iznosi 131±3 do 180±3 g/m^2, tab. 1. Svi uzorci su izrađeni na jednom stroju i pod istim uvjetima, tj. bez regulacije rada stroja. Sve su pređe bile finoće 20 tex, a dobivena je velika razlika u plošnim masama koja iznosi do 37 %. Radi se o značajno različitim strukturama pređa. Najlaganije nedorađeno pletivo ima plošnu masu 131±3 g/m^2 i dobiveno je pri pletenju s viskoznom i modalnom pređom, a najmasivnije pletivo ima masu 180±3 g/m^2 i dobiveno je pri pletenju s viskoznom Siro pređom.

Tablica 1: Osnovni parametri strukture izrađenih i analiziranih nedorađenih pletiva

Uzorci	**Plošna masa pletiva, m, g/m^2**	**Zapreminska masa pletiva, mz, g/cm^3**	**Koeficijent zbijenosti pletiva, C**	**Utrošak niti u očici, ℓ, mm**
P-KK	157 ± 3	0,246	0,97	3,15 ± 0,01
V-OE	131 ± 3	0,222	0,72	3,10 ± 0,01
SIRO	180 ± 3	0,251	0,89	3,13 ± 0,01
M-AJ	131 ± 3	0,218	0,78	3,13 ± 0,01

Gdje je: P-KK – pamučna, prstenasta pređa, V-OE – viskozna, rotorska pređa, SIRO – viskoza, Siro pređa i M-AJ – modal, aerodinamička pređa.

Tablica 2: Rezultati mjerenja istezljivosti pletiva u smjeru redova i nizova očica - poprečno i uzdužno

Uzorci	ε_{ep}, %	ε_{pp}, %	ε_{tp}, %	ε_{eu}, %	ε_{pu}, %	ε_{tu}, %
P-KK	200	280	364	12	28	51
V-OE	70	130	221	5	8	33
SIRO	100	160	250	25	36	64
M-AJ	200	270	382	7	13	34

Gdje je: ε_e – istezljivost ili produljenje pletiva, elastično područje, %; ε_p – istezljivost ili produljenje pletiva, do početka plastičnog područja, %; ε_t – istezljivost ili produljenje pletiva do trenutka trganja, %; s indeksom p označen je smjer reda očica – poprečno, a uzdužni smjer je označen s indeksom u.

4. Zaključak

Svi uzorci pletiva su izrađivani na jednom stroju pri jednakim uvjetima pletenja. Uzorci su izrađivani pređama nazivne finoće 20 tex, a dobivene su bitno različite strukture pletiva koje imaju plošne mase 131±3 do 180±3 g/m^2. Prekidna rastezljivost pletiva u smjeru redova očica ili poprečna rastezljivost se nalazi u granicama 221 do 382 %, a u smjeru nizova očica ili uzduž pletiva je znatno manja i nalazi se u području 33 do 64 %. Sve su razlike izazvane strukturom pređe i pletiva. Za komercijalnu primjenu analiziranih pređa preporuča se pomno odabrati parametre pletenja kako bi se dobila zadovoljavajuća struktura pletiva. Rezultati istraživanja ukazuju da je s navedenim pređama veoma teško dobiti istu strukturu pletiva koje će se koristiti u izradi jednog proizvoda.

Zahvala

Istraživanja su provedena u sklopu aktivnosti na istraživačkom projektu IP-2016-06-5278 Udobnost i antimikrobna svojstva tekstila i obuće financiranog od Hrvatske zaklade za znanost.

Literatura

[1] Pavlović Ž., Iveković, G.; Vrljičak, Z.: Utjecaj pređa različitih postupaka predenja na strukturu glatkih kulirnih desno-desnih pletiva, *Zbornik radova 11. znanstveno-stručnog savjetovanje Tekstilna znanost i gospodarstvo*, Ercegović Ražić, S. i dr. (ur.), 86-91, ISSN 2584-6450, siječanj 2018., Zagreb, (2018.)

[2] Koslowski H.J.: *Chemifaser Lexikon*, Deutscher Ferlag, ISBN 978-3-87150-876-9, (2008)

[3] Zdraveva, E. et al: Electrospun Poly(vinyl alcohol)/Phase Change Material Fibers: Morphology, Heat Properties, and Stability, *Industrial & engineering chemistry research*, **54** (2015) 35, 8706-8712, ISSN: 0888-5885

[4] *Dostupan na:* http://www.fao.org/faostat/en/#data/QC/visualize, *Pristupljeno*: 2021-12-27

[5] Siejak, V.: *The Fiber Years 2014*, PHP Fibers GmbH, Wuppertal, Germany (2014)

[6] Skenderi, Z., Iveković, G.; Kopitar, D.: Utjecaj tehnike predenja na fizikalno-mehaničke karakteristike pređe iz mikromodalnih vlakana, *Zbornik radova 11. znanstveno-stručnog savjetovanje Tekstilna znanost i gospodarstvo*, Ercegović Ražić, S. i dr. (ur.), 86-91, 205-210, ISSN 2584-6450, siječanj 2018., Zagreb, (2018)

Marijana Pavunc Samaržija

Životopis	Marijana Pavunc Samaržija završila je diplomski sveučilišni studij Tekstilna tehnologija i inženjerstvo 2012. godine na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Od 2013. do 2020. godine radila je na Tekstilno-tehnološkom fakultetu kao asistent, a od 2021. godine na radnom mjestu predavač. Njezin znanstveni interes pretežito je vezan uz tekstilna vlakna, konzervaciju i restauraciju tekstila te recikliranje tekstilnih materijala.
Tema rada	Istraživanje cjeloživotnog ciklusa vlaknima ojačanih kompozita – industrijski *vs.* potrošački otpad
Studijski savjetnik	prof. dr. sc. Edita Vujasinović
Datum obrane teme doktorskog rada	

ISTRAŽIVANJE CJELOŽIVOTNOG CIKLUSA VLAKNIMA OJAČANIH KOMPOZITA – INDUSTRIJSKI *vs*. POTROŠAČKI OTPAD

Marijana PAVUNC SAMARŽIJA
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Sažetak: *U svrhu smanjenja otpada, recikliranje i ponovna upotreba recikliranog materijala postaje nužna, ali nije uvijek jednostavna i učinkovita osobito ukoliko se radi o vlaknima ojačanim kompozitima. Često su dobiveni reciklirani materijali niže kvalitete čime je otežano predviđanje njihove daljnje upotrebe što nameće potrebu dizajna novih vlaknima ojačanih kompozita u skladu s održivim razvojem.*

1. Uvod

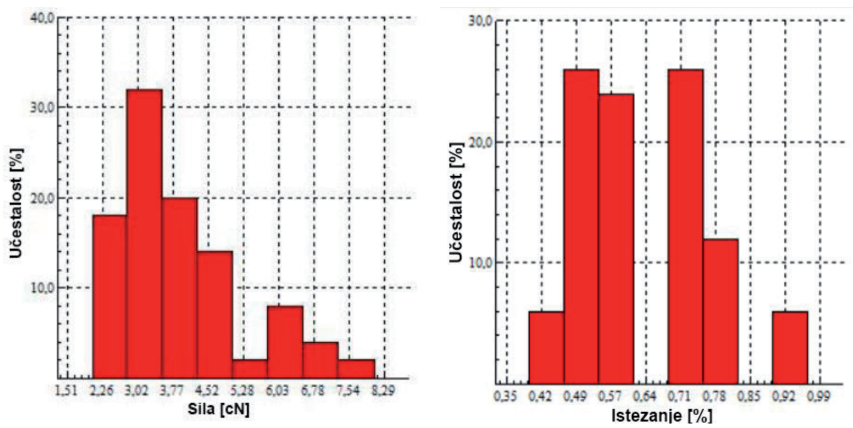
Danas se velika pozornost usmjeruje prema održivom gospodarenju resursima kao i smanjenju otpada bilo da se radi o potrošačkom otpadu koji nastaje na kraju životnog ciklusa nekog proizvoda ili industrijskom otpadu koji nastaje tijekom proizvodnog procesa nekog proizvoda. Sve veće gomilanje krutog otpada jedan je od najvećih problema današnjice, a rezultat je povećane potražnje za materijalima što je izravno povezano s povećanjem stanovništva, ali i još uvijek raširenim linearnim gospodarstvom kojeg karakterizira niska razina materijalne učinkovitosti. Oporaba otpada na najučinkovitiji način tj. njegova transformacija u novu sirovinu nužna je za održivi razvoj te predstavlja važan dio kružnog gospodarstva koje postaje ključni koncept za razvoj tehničkih i bioloških ciklusa zatvorene petlje [1]. Vlaknima ojačani kompoziti su zbog svojih iznimnih svojstava danas nezaobilazan materijal u mnogim industrijama (poput automobilske, građevinske, zrakoplovne, pomorske i sl.). Posljednjih je godina potražnja za vlaknima ojačanim kompozitima u konstantnom porastu što za posljedicu ima i potencijalno povećanje ove vrste otpada. Do sada najčešći modeli njihovog zbrinjavanja su trajno odlaganje na odlagalištima otpada ili njihovo spaljivanje, što danas, zbog ograničenih kapaciteta odlagališta, ali i sve strožih zakonskih regulativa, prvenstveno vezanih uz gospodarenje otpadom i zaštitu okoliša, nije opcija. Iako je predstavljeno nekoliko tehnologija njihovog recikliranja, još uvijek postoji potreba za optimizacijom tih procesa u svrhu dobivanja kvalitetnijih recikliranih materijala i/ili poboljšanja učinkovitosti procesa uz povećanje ekonomske isplativosti pri tome vodeći računa o svim mogućim štetnim utjecajima na okoliš. Povećana proizvodnja vlaknima ojačanih kompozita dovodi i do povećane potražnje za sirovinama potrebnim za njihovu proizvodnju osobito za visokoučinkovitim vlaknima poput ugljikovih vlakana čiji trenutni obim proizvodnje neće moći zadovoljiti povećanje potražnje u narednim godinama [2, 3]. Težnja prema održivom razvoju i zaštiti okoliša stoga nameće potrebu za ponovnu upotrebu vlakana dobivenih recikliranjem kompozita (potrošački otpad) ili onih koja potječu iz proizvodnog procesa (industrijski otpad). Međutim, kako bi se tako dobivena vlakna mogla koristi za nove proizvode, osobito one više dodane vrijednosti, poželjno je da njihova kvaliteta bude što više očuvana, a svojstva što je više moguće ujednačena.

2. Eksperimentalni dio

Zadatak ovog rada je odrediti vlačnu čvrstoću otpadnih ugljikovih vlakana koja potječu iz proizvodnje tzv. *roving tkanine* za upotrebu u vlaknima ojačanim kompozitima i usporediti ih sa stvarnim vrijednostima recikliranih ugljikovih vlakana dobivenih oporabom otpadnih ugljikovim vlaknima ojačanih kompozita. Prema literaturi [4], vlačna svojstva recikliranih ugljikovih vlakana dobivenih pirolizom (koja je prepoznata kao najprikladnija i najodrživija metoda recikliranja otpadnih ugljikovim vlaknima ojačanih kompozita) u odnosu na izvorna vlakna su za 2 % do 85 % manja. Ovako velika varijacija u vlačnim svojstvima recikliranih vlakana rezultat je različitih ciklusa pirolize. Za potrebe ovog istraživanja, vlačna svojstva otpadnih ugljikovih vlakana iz industrijske proizvodnje određena su metodom pojedinačnog mjerenja korištenjem uređaja Vibroskop i Vibrodyn 400, a ispitivanja su napravljena u skladu s normom ISO 5079:2020.

3. Rezultati i rasprava

Na sl. 1 prikazani su dijagrami učestalosti prekidne sile i prekidnog istezanja iz kojih se zamjećuje da su rasponi sila prekida i prekidnog istezanja za ispitivana vlakna veći nego što je to uobičajeno za visokoučinkovita vlakna (koeficijenti varijacije za visokoučinkovita vlakna iznose do 10 %, a u ovom slučaju su veći od 20 %).



a. b.

Slika 1: Dijagrami učestalosti: a. prekidne sile; b. prekidnog istezanja

Rezultati ispitivanja pokazali su da vlačna čvrstoća ugljikovih vlakana karakteriziranih kao industrijski otpad iznosi svega 20 % vlačne čvrstoće ishodišnih vlakana (4000 MPa za monofilament). Pošto su ugljikova vlakna izrazito krta i osjetljiva te time podložna degradaciji, najizgledniji razlog ovakvih rezultata je u neodgovarajućoj manipulaciji vlaknima nakon što su ona uklonjena iz proizvodnog procesa kao otpad.

4. Zaključak

Iako se za otpadna vlakna koja se koriste u industrijskom procesu za proizvodnju vlaknima ojačanih kompozita smatra da bi trebala imati svojstva malo niža ako ne i identična izvornim ugljikovim vlaknima, dobiveni rezultati su pokazali značajnu degradaciju čvrstoće tih vlakana za razliku od čvrstoće recikliranih vlakana iz otpadnih kompozita koja može iznositi čak 98 % čvrstoće izvorne sirovine. Prema tome, ukoliko bi se ta vlakna koristila u budućem proizvodnom procesu, bilo klasičnom tekstilnom ili onom za izradu vlaknima ojačanih kompozita, potrebno je s njima već na početku njihovog nastanka postupati oprezno kako bi se sačuvala što veća razina njihovih ishodišnih svojstava.

Literatura

[1] Mativenga, P.T. et al: Composites in a Circular Economy: A study of United Kingdom and South Africa, *Procedia CIRP*, **61** (2017), 691-696, ISSN 2212-8271

[2] Korniejenko, K. et al: Tackling the Circular Economy Challenges - Composites Recycling: Used Tyres, Wind Turbine Blades, and Solar Panels, *Journal of Composites Science*, **5** (2021) 9, 1-18, ISSN 2504-477X7

[3] Barnett, P. R.; Barnett, H.K.: A Review of Recent Developments in Composites Made of Recycled Carbon Fiber Textiles, *Textiles*, **1** (2021) 2, 433–465, ISSN: 2673-7248

[4] Zhang, J.et al: Current status of carbon fibre and carbon fibre composites recycling, *Composites Part B: Engineering,* **193** (2020), ISSN 1359-8368

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Naslov doktorskog rada	Perspektiva infracrvene termografije i njena primjena u sportu
Studijski savjetnik	izv. prof. dr. sc. Goran Čubrić
Datum obrane teme doktorskog rada	

PERSPEKTIVA INFRACRVENE TERMOGRAFIJE I NJENA PRIMJENA U SPORTU

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Sažetak: *U doktorskom radu istraživati će se korištenje infracrvene termografije kao važne metode za ocjenjivanje sportske odjeće. Sportska odjeća za aktivne sportaše ima različite funkcije koje obavljaju određene značajke i pomažu sportašima u postizanju boljih atletskih rezultata. U svakoj sportskoj odjeći fiziološki aspekt je od velike važnosti jer ima veliki utjecaj na učinkovitost i performanse sportaša. U skladu s navedenim, istražit će sposobnost prijenosa vlage, vrijeme sušenja i opip materijala koji se koristi za sportsku odjeću. Također će se izraditi protokol mjerenja termografskom kamerom, nakon kojeg će se pristupiti razvoju idejnog rješenja prikaza mapiranja temperature na tijelu sportaša.*

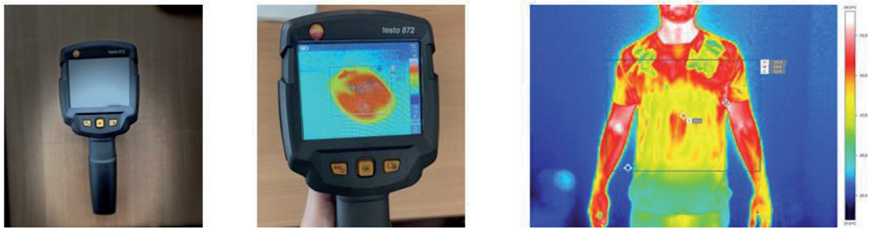
1. Uvod

Sportska odjeća danas predstavlja neophodan element za sve vrste tjelesne aktivnosti u svijetu. Proizvođači sportske odjeće uključeni su u proces dizajna koji kombinira estetiku i razne funkcije kako bi se zadovoljile sportske i tjelesne potrebe kod aktivnih sportaša. Kod sportske odjeće udobnost je veoma bitna, s obzirom da je u sportu potrebna nesmetana pokretljivost, odjeća mora biti prilagođena tijelu [1, 2]. Sportska odjeća je u interakciji s fiziološkim i fizičkim procesima koji utječu na temperaturu kože koja se može procijeniti infracrvenom termografijom (IRT). IRT uključuje korištenje infracrvene kamere koja može detektirati toplinsko zračenje i proizvoditi slike u boji, nazvane termogrami. Termogram sadrži podatke o temperaturi, a jedna od glavnih prednosti je ta što nam omogućuje vizualizaciju temperaturnih razlika na snimljenom objektu, koristeći razlike u boji koje su povezane s ljestvicom temperature i boje, sl. 1 [3, 4]. Uređaj za infracrvenu termografiju treba uzeti u obzir kao dragocjeni saveznik za karakterizaciju materijala i postupke procjena koja može pomoći u poboljšanju dizajna i izrade proizvoda [5]. Neka od područja primjene infracrvene termografije su: graditeljstvo, promet, elektroenergetika, strojarstvo, medicina, veterina te odjevna tehnologija [6, 7]. U području tekstilnog inženjerstva, termografija se koristiti za promatranje svojstva tekstilnih materijala, udobnosti odjeće, razvoj proizvoda. Mnogo pažnje posvećeno je mapiranju tijela temperature kako bi se tkanina i odjevni predmet prilagodili, da bi se bolje zadovoljile potrebe tijela [8]. Termografija također služi za ocjenu učinka odjeće za osobnu upotrebu [9], zaštitnu odjeću kao što su inteligentna i termalna adaptivna odjeća te za rekreativne i profesionalne sportaše [10]. Termografija kao što je navedeno ima široku primjenu u sportskoj znanosti. Valjanost i pouzdanost ove metode za mjerenje temperature kože dokumentirana je u brojnim sportovima. Tema doktorskog rada usmjerit će se na aspekte primjene termografije u evaluaciji termofiziološke udobnosti sportske odjeće.

2. Eksperimentalni dio

U eksperimentalnom dijelu doktorskog rada izradit će se protokol evaluacije parametara materijala vezanih uz percepciju opipa, ispitivanje svojstava koja određuju udobnost odjeće, analiziranje svojstva koja određuju udobnost materijala koji se koriste za izradu sportske odjeće, evaluacija svojstava sportske odjeće pomoću termografije, izrada idejnih prototipova odjevnog predmeta za ciljani sport, s obzirom na evaluirane parametre udobnosti materijala i odjevnog predmeta.

U svrhu istraživanja provest će se različite metode ispitivanja. Ispitivat će se fizikalno-mehanička svojstva materijala mjerenjem debljine, plošne mase, poroznosti, krutosti savijanja, vlačna svojstva, otpornost na probijanje, otpornost na habanje i piling ispitivanog materijala. Pomoću termografske kamere odredit će se sposobnost prijenosa vlage i vrijeme sušenja ispitivanog materijala te razdioba temperature na tijelu sportaša koji nosi definirani odjevni predmet, sl. 1.



a. b. c.

Slika 1: Termalna kamera TESTO 872: a. prikaz termalne kamere; b. ispitivanje uzoraka termalnom kamerom; c. primjer termograma

4. Zaključak

Infracrvena termografija vrlo je važna i često korištena metoda za procjenu brojnih parametara u različitim znanstvenim i stručnim područjima. Kada govorimo o području tekstila, termografija može podržati razvoj prilagođene sportske odjeće. U tom kontekstu, individualni temperaturni obrasci sportaša mogu biti korisni za ciljanje gubitka topline ili očuvanja topline. Infracrvena termografija u ograničenoj mjeri koristi se u području ergonomije sportske odjeće, posebice kada je riječ o sportskoj odjeći za određene sportove i profesionalne sportaše. Uzimajući u obzir specifičnost svakog sporta i potrebu za poboljšanjem performansi sportaša, brojni su primjeri gdje bi se termografija mogla koristiti kao pouzdana metoda za procjenu.

Zahvala

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Literatura

[1] Priego Quesada, J.I. et al: Assessment of Sport Garments Using Infrared Thermography, In *Application of Infrared Thermography in Sports Science*, ISBN 978-3-319-47410-6, Valencia, (2017), 159-179

[2] Salopek Čubrić, I.; Skenderi, Z.; Mijović, B.: Primjena termografije i subjektivnog ispitivanja pri evaluaciji udobnosti, *Sigurnost*, **51** (2009.) 3, 193-200, ISSN 0350-6886

[3] Fournet, D.; Redortier, B.; Havenith, G.: A method for whole-body skin temperature mapping in humans, *Thermology International*, **22** (2012) 4, 157–159, ISSN 1560-604X

[4] Meola, C.; Boccardi, S.; Carlomagno, G.: Nondestructive Testing With Infrared Thermography*, In Infrared Thermography in the Evaluation of Aerospace Composite Materials*, Woodhead Publishing, ISBN 978-1782421719, United Kingdom (2017), 85–125

[5] Meola, C.: Infrared Thermography in the Architectural Field, *The Scientific World Journal*, **14** (2013) ID 323948, 1–8, ISSN 1537-744X

[6] Tattersall, G. J.: Infrared thermography: A non-invasive window into thermal physiology, *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, **202** (2016) 12, 78–98, ISSN 15314332

[7] Usamentiaga, R. et al.: Infrared Thermography for Temperature Measurement and Non-Destructive Testing, *Sensors*, **14** (2014) 7, 12305–12348, ISSN 1424-8220

[8] Salopek Čubrić, I. et al: The comfort of knitted fabrics: interaction of sportswear and athlete’s body, *Communications in Development and Assembling of Textile Products*, **2** (2021) 1, 1-10, ISSN 2701-939X

[9] Mijović, B. et al: Thermographic Assessment of Sweat Evaporation within Different Clothing Systems, *Fibres & Textiles in Eastern Europe*, **20** (2012) 5, 81-86, ISSN 1230-3666

[10]Čubrić, G.; Rogale, D.; Nikolić, G.: Measuring the thermal insulation chamber with infrared camera, *Proceedings of 5th International Ergonomics Conference*, Lotens, W., Havenith, G (ed.) ISSN 1848-9699, Zadar, June, 2013, Tiskara Zrinski d.d. (2013)

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Životopis

Luka Savić rođen je 1988. godine u Zagrebu. Diplomirao je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Pohađao je programa Erasmus+ stručna praksa u trajanju od četiri mjeseca na University of Oxford. Radio je kao asistent u području elektroispredanja na istraživačkom projektu University of Oxford od 2019. do 2021. godine. Trenutno radi kao asistent na Tekstilno-tehnološkom fakultetu i pohađa poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija.

Njegov nastavni interes usmjeren je prema tehničkom tekstilu, a znanstveno-istraživački prema medicinskom tekstilu.

Naslov doktorskog rada

Studijski savjetnik izv. prof. dr. sc. Maja Somogyi Škoc

Datum obrane teme doktorskog rada

ELEKTROAKTIVNI I ELEKTROVODLJIVI POLIMERI KAO BIOLOŠKI TEKSTILNI PODUPIRAČI ZA POPRAVAK TKIVA I ŽIVACA

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Sažetak: *Pregledom dostupne literature i elektroničkih izvora uočen je velikih potencijal elektroaktivnih i vodljivih polimera za regeneraciju kako tkiva tako i živaca. Poremećaj funkcije npr. perifernih živaca može nastati zbog oštećenja samog živčanog vlakna, tijela živčane stanice, Schwannove stanice ili mijelinske ovojnice. Kada je oštećena mijelinska ovojnica i mijelin propadne, živci ne mogu normalno prenositi impulse. Istraživanja u doktorskom radu usmjeriti će se na polimere, postupak elektroispredanja gdje je potrebno postići prijenos impulsa i/ili regeneracije stanica uz druga svojstva polimera i mogućnost tvorbe linearnih i/ili plošnih tekstilija. Istraživanje će se usklađivati sa zahtjevima European Medicines Agency, The Food and Drug Administration i dr.*

1. Uvod

Elektroaktivni (electroactive polymer, (EAP)) i elektrovodljivi polimeri (electro-conducting polymers, ECP) pokazuju dobre rezultate kao linearni medicinski tekstili za tkivno i neuronsko inženjerstvo [1, 2]. Prijenos struje kroz elektroispredane i elektroaktivne mikro/nano filamente je dobra osnova za uzgoj stanica, gdje električni podražaj pomaže bržem i boljem rastu stanica na tekstilnom podupiraču. Zbog svoje električne vodljivosti tekstil izrađen od elektroaktivnih polimera izvrstan je za oponašanje stvarnog tjelesnog okruženja u kojem se stanice električki stimuliraju za rast [3]. Električne signale proizvode i osjećaju sve stanice, a ne samo živci i mišići; gdje in vivo, ove aktivnosti stvaraju bioelektrične krugove koji usmjeravaju ponašanje pojedinih stanica prema specifičnim anatomskim ciljevima [4].
Prema pregledu rada najvećih svjetskih istraživačkih skupina, postupak elektroispredanja je najbolji način proizvodnje novog materijala, tj. elektroaktivnog tekstila koji može oponašati izvanstaničnu matricu (extracellular matrix, ECM). Da bi se ušlo u srž samog oponašanja izvanstanične matrice potrebna su ciljana istraživanja i razvoj novih elektroispredanih i elektroaktivnih polimera. Danas u svijetu postoji potražnja za novim materijalima za pomoć pri liječenju raznih bolesti, poput bolesti motornih neurona, Alzheimerove bolesti, neurološke skolioze, spinalne mišićne atrofije (SMA) i sl. Polimeri kao što su polipirol (PPy), polianilin (PANI), politiofen (PT), poliviniliden fluorid (PVDF), poli(viniliden fluorid–trifluoroetilen) (P(VDF–TrFE)) pokazuju dobra elektrovodljiva svojstva koja se mogu koristiti u daljnjem istraživanju elektroaktivnog i elektrovodljivog tekstila [5]. Ugradnja EAP-a sa stanicama na oštećeno mjesto tkiva i/ili živaca, približava znanstvenike prema mogućnosti razvoja novih tekstilnih kompozita od organskih i anorganskih materijala.

2. Eksperimentalni dio

Razvijati će se i istraživati mogućnosti elektroaktivnih i elektrovodljivih polimera, kao linearne i/ili plošne tekstilije za primjenu u području medicine, a s ciljem razvoja novog medicinskog tekstila. Pri planiranju i provođenju istraživanja koristiti će se općim znanjima iz područja znanstvenog rada. Metodologija znanstvenog rada provesti će se pomoću tri osnovna načina: teorijskog, tehničkog i organizacijskog. Teorijski aspekt podrazumijevati će ispitivanje postavljenih hipoteza, teorija, spoznaja, stila, terminologije i dr. Tehnički aspekt odnositi će se na sam postupak prikupljanja, promatranja, sređivanja i mjerenja podataka dok će se organizacijski aspekt odnositi na osiguravanje racionalne tehnologije u provedbi znanstvenog istraživanja. Dobiveni rezultati istražiti će se i obraditi u svrhu realizacije i potvrđivanja hipoteza koje će se postaviti nakon višestrukog pregleda dostupne literature i kontakta s domaćim i stranim istraživačkim skupinama.

3. Rezultati i rasprava

Obrada i morfologija novih tekstilija provesti će se pouzdanim i standardiziranim mjernim tehnikama (Infracrvena spektroskopija (FTIR-ATR), Skenirajuća elektronska mikroskopija s energijsko disperzivnim detektorom X-zraka (SEM-EDS), Mikroskop atomskih sila (AFM), Diferencijalna pretražna kalorimetrija/ Termogravimetrijska analiza/ (DSC/TGA), raznim mikrobiološkim testovima, ispitivanjiem vodljivosti polimera, ispitivanjima neškodljivosti za in vivo primjenu, itd.) ali i u tom trenutku novim mjernim tehnikama. Koristiti će se metode i postupci koji omogućuju ponovljivost rezultata. Koristiti će se odgovarajući matematički statistički postupci kako bi se osigurala određena pouzdanost pri obradi, analizi i evaluaciji dobivenih rezultata.

Radni plan istraživanja sastojati će se od sljedećih cjelina:

1. Nabava, instaliranje i podešavanje uređaja za elektroispredanje
2. Modifikacija uređaja za ispredanja elektroaktivnih i elektrovodljivih polimera
3. Odabir polimera i kemikalija te dodatnih potrebnih sredstava
4. Optimiranje procesa elektroispredanja, dobivanje prvih uzoraka elektroaktivnih i elektrovodljivih polimera
5. Analiza svojstava prvih uzoraka elektroaktivnih i elektrovodljivih polimera ispitivanjem vlačnih svojstava, mikrobiološke aktivnosti, ispitivanjem električne vodljivosti, toplinskih svojstava, njihova razgradnja
6. Savjetovanje i suradnja s institucijama u Hrvatskoj i izvan nje
7. Podešavanje procesa elektroispredanja i/ili razvoj vlastitog uređaja, dobivanje konačnih uzoraka elektroaktivnih i elektrovodljivih polimera i njihovo ispitivanje
8. Moguće naknadne obrade proizvoda, ispitivanje primjene proizvoda i mogućnost komercijalizacije

4. Zaključak

Znanstveni doprinos ove doktorske disertacije ostvariti će se u teorijskom i aplikativnom smislu. Razviti će se i istražiti elektroaktivni i elektrovodljivi polimeri kao novi tekstilni materijali za primjenu u medicini - medicinski tekstil kao doprinos liječenju, poboljšanju života ili sprječavanju smrti.

Zahvala

Istraživanje i doktorski rad započeti će u okviru aktivnosti istraživačkog projekta HRZZ IP-2019-04-1381 "Antibakterijska prevlaka za biorazgradive medicinske materijale" - ABBAMEDICA, voditeljice izv. prof. dr. dr. sc. Iva Rezić financiranom od strane Hrvatske zaklade za znanosti.

Literatura

[1] Guo, X.; Facchetti, A.: The journey of conducting polymers from discovery to application, *Nature Materials* **19** (2020), 922–928, ISSN 1476-1122

[2] Zhang, X. et al: Electroactive electrospun nanofibers for tissue engineering, *Nano Today*, **39** (2021), 1-11, ISSN 1748-0132

[3] Chen, C. et al: Electrical stimulation as a novel tool for regulating cell behavior in tissue engineering, *Biomaterials Research*, **23** (2019) 25, 1-12, ISSN 2055-7124

[4] Levin, M.; Pezzulo, G.; Finkelstein, J.M.: Endogenous Bioelectric Signaling Networks: Exploiting Voltage Gradients for Control of Growth and Form, *Annual Review of Biomedical Engineering* **19** (2017) 1, 353–387, ISSN 1523-9829

[5] Picciani, P. et al: Advances in Electroactive Electrospun Nanofibers, In *Nanofibers - production, properties and functional applications*, InTech, ISSN 0104-1428, Rijeka (2011), 1-13

Ana Šaravanja

Životopis	Ana Šaravanja rođena je 1998. godine u Zagrebu. 2021. godine diplomirala je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Dobitnica je Dekanove nagrade za postignut uspjeh tijekom preddiplomskog sveučilišnog studija Tekstilna tehnologija i inženjerstvo. Nakon završetka diplomskog studija upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija na Tekstilno-tehnološkom fakultetu i zapošljava se na istom fakultetu kao asistent na projektu Hrvatske zaklade za znanost.
Naslov doktorskog rada	Utjecaj starenja na svojstva poliesterskih tkanina u pranju
Studijski savjetnik	doc. dr. sc. Tihana Dekanić
Datum obrane teme doktorskog rada	

UTJECAJ STARENJA NA SVOJSTVA POLIESTERSKIH TKANINA U PRANJU

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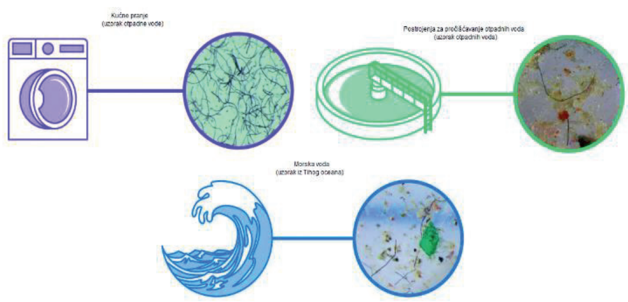
Sažetak: *Sintetička vlakna čine gotovo 60 % ukupne svjetske proizvodnje vlakana, od čega najveći udio pripada poliesteru (PET). Značajno svojstvo poliesterskih vlakana u tekstilijama s aspekta njege su dobra uporabna svojstva. Međutim, u posljednje vrijeme se ističe negativan utjecaj otpuštenih mikro/nano vlakana u procesu pranja na sastav efluenata. Istraživanja u doktorskom radu usmjerit će se na utjecaj fizikalnog i kemijskog starenja poliesterskih tkanina na svojstva i stupanj opterećenja efluenata od procesa pranja.*

1. Uvod

U tekstilnoj industriji koriste se velike količine vode za postupke predobrade i obrade. Upravo iz tog razloga su otpadne vode po kemijskom sastavu heterogene, te ih je potrebno pročistiti kako bi se mogle ispustiti ili ponovno koristiti. Heterogenost sastava otpadnih voda potječe od raznih sredstava i dodataka, otpuštenih vlakana, fragmenata i krhotina plastike koje se u posljednje vrijeme definiraju kao čestice mikroplastike (MP). Zagađenje okoliša putem čestica MP je ozbiljan i istraživački aktualan problem. Prisutnost u okolišu veže se za različite izvore onečišćenja, te se ovisno o tome MP obilježava kao primarna i sekundarna MP [1]. Primarni oblik sadrži mikrogranule koje se nalaze u kozmetici ili pastama za zube, a sekundarni oblici nastaju kada se razaraju veći plastični komadi [2]. Općenito je poznato da se plastični otpad koji dospije u vodeni okoliš ne razgrađuje, ali se zbog mehaničkih i fotokemijskih procesa generira MP (< 5 mm) ili nanoplastika (< 1 µm) [1]. Spora biotička razgradnja plastike dovodi do razdiobe plastike na manje čestice u okolišu, a jedna od nepovoljnih posljedica je opterećenje vodenih resursa. Čestice MP tekstilnog podrijetla potječu od sintetskih tekstilija, poput poliestera, poliamida, polivinilklorida, polipropilena,te polietilena.



Slika 1: Slikoviti prikaz mikrovlakana i MP u otpadnim vodama i morskoj vodi [3]

Istraživački plan obuhvatit će poli(etilen-tereftalat) PET, kao najzastupljeniji u skupini poliesterskih vlakana. Prema podacima iz 2017. godine ova vlakna predstavljaju 50 % od ukupno proizvedenih umjetnih vlakana, od čega je 14 % proizvoda od recikliranog PET-a [4]. Gustoća mu iznosi 1,37 – 1,45 g/cm^3 brzo tone, otporan je na atmosferske uvjete, te nije biorazgradljiv. Zbog svoje velike zastupljenosti u prirodi, ali i svojstva otpuštanja MP čestica, u bliskoj budućnosti može postati rizičan polimer u okolišu [1].

2. Eksperimentalni dio

Tekstil se smatra glavnim zagađivačima okoliša zbog otpuštanja vlakana, pri čemu se proces pranja smatra jednim od uzročnika [4]. Obzirom na istaknute probleme prisutnosti MP u okolišu, istraživanja u okviru doktorskog rada usmjerit će se na praćenje fenomena starenja poliesterskih (PES) tkanina, kao i njegova učinka na otpuštanje MP čestica u pranju. U doktorskom radu će se primjenom fizikalno-kemijskih metoda karakterizacije procijeniti učinci kontroliranog umjetnog starenja na otpuštanje MP čestica u pranju po standardnom i inovativnom postupku. Istraživanje će se provesti na standardnim PES tkaninama, koje će se podvrgnuti uvjetima kontroliranog starenja, pri čemu će se varirati: utjecaj atmosferilija, vrijeme i način izloženosti. Tijekom rada koristit će se različita znanstvena oprema: uređaj za starenje (Xenotest), FTIR, flourometar, dinamometar, digitalni mikroskop, SEM-EDX, uređaj za ispitivanje sposobnosti prijenosa vlage (MMT) i remisijski i UV/VIS spektrofotometar.

3. Rezultati i rasprava

U teoriji starenja polimernih materijala uvijek se razmatra fizičko i kemijsko starenje. Fizičko starenje PES odgovara promjenama koje se događaju u sastavu i konfiguraciji lanca. Glavne vrste fizičkog starenja su strukturalno opuštanje slobodnog volumena (tzv. relaksacija), te fizičko starenje koje se događa kada otapalo uđe u strukturu polimera ili pri otpuštanju plastifikatora. Kemijsko starenje posljedica je reakcija s vanjskim reagensima kao što su kisik, voda, UV ili ionizirajuće zračenje [5]. S obzirom na problematiku istraživanja, u okviru ovog doktorskog rada naglasak će biti dat ne samo na interakciji PES materijala s vodom, nego i na praćenju učinaka zračenja (intenziteta, duljine i načina izloženosti) na otpuštanje MP čestica iz PES materijala. Za očekivati je da će inovativni postupak pranja smanjiti otpuštanje MP čestica, ne samo u pranju nego i u uvjetima kontroliranog umjetnog starenja.

4. Zaključak

Sukladno zadanim ciljevima, u okviru ove doktorske disertacije očekuje se ocjena modifikacije PES materijala u uvjetima kontroliranog umjetnog starenja, kao i mogućnost kvantifikacije otpuštenih MP čestica iz PES materijala prije i nakon starenja u procesu pranja po standardnom i inovativnom konceptu.

Zahvala

Doktorski rad se izrađuje i sufinancira dijelom u sklopu aktivnosti na istraživačkom projektu HRZZ IP-2020-02-7575, „Procjena otpuštanja čestica mikroplastike iz sintetskih tekstilija u procesu pranja, InWaShed-MP“, te „Projektu razvoja karijere mladih istraživača - osposobljavanje doktoranada“, DOK-2021-02-6750 financiranih od Hrvatske zaklade za znanost.

Literatura

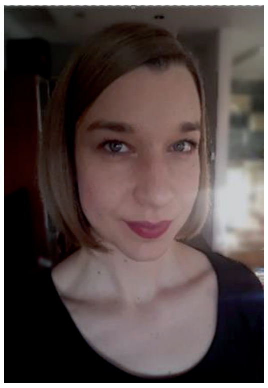
[1] Merlin, N. I., Balasubramanian, K.: Effect of microplastics in water and aquatic systems, *Environmental Science and Pollution Research*, **28** (2021), ISSN 1614-7499

[2] Kolbe, S.: Mikroplastika ili mikrovlakna?- koncepcijska zabuna, Istraživački institut za tekstil i odjeću (FTB), Sveučilište primijenjenih znanosti Niederrheim, Moenchengladbach, Njemačka, *Tekstil*, **67** (2018) 7-8, 235-236, ISSN 0492-5882

[3] Dostupno na https://www.cbc.ca/radio/quirks/nov-16-watching-wildfire-with-radar-the-return-of-race-science-and-more-1.5359599/your-laundry-and-plastic-pollution-which-fabrics-shed-the-most-microplastics-1.5359608, *Pristupljeno:* 2021-12-01

[4] Čorak, I. i sur.: Enzimi za hidrolizu poliestera, *Tekstil,* **68** (2019) 7-9, 142-151, ISSN 0492-5882.

[5] Napper, I. E.; Thompson, R. C.: Release of synthetic microplastic plastic fibers from domestic - washing machines: Effects of fabric type and washing conditions, *Dostupan na*: https://www.researchgate.net/publication/308736592_Release_of_synthetic_microplastic_plastic_fibres_from_domestic_washing_machines_Effects_of_fabric_type_and_washing_conditions, *Pristupljeno:* 2021-12-01



Marijana Tkalec

Životopis	Marijana Tkalec rođena je 1986. godine u Čakovcu. Nakon završetka diplomskog studija na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu radila je u tekstilnoj industriji kao tekstilna i modna dizajnerica i inženjerka. Dobitnica je nekoliko nagrada za svoj rad u području tekstilnog dizajna. Poslijediplomski sveučilišni studij na Tekstilno-tehnološkom fakultetu upisala je 2017. godine. Trenutno je zaposlena kao asistent na Tekstilno-tehnološkom fakultetu.
Naslov doktorskog rada	
Studijski savjetnik	prof. dr. sc. Martinia Ira Glogar
Datum obrane teme doktorskog rada	-

INTERAKCIJA BOJE I TEKSTILNE POVRŠINE - ANALIZA I UTJECAJ TOPOGRAFIJE TKANINE NA VIZUALIZACIJU BOJE

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Sažetak: *Kompleksnost tkanine, njene geometrijske karakteristike koje se odnose na tekstilnu površinu, poput debljine pređe, broja uvoja u pređi, gustoću pređe, debljinu tekstilije, itd., utječu na percepciju teksture tkanine te na izgled boje na površini tkanine. Sve čvrste površine, bez obzira na način oblikovanja, sadrže raznovrsne nepravilnosti. Površine tekstilnih tkanina također nisu apsolutno ravne i glatke; njihova površinska hrapavost ima značajnu ulogu i utječe na njihovu krajnju upotrebu. Ovaj rad bavi se analizom površinske teksture i utjecajem topografije tkanine na vizualizaciju boje pomoću računalnog programa, ImageJ. Program se koristi za analizu različitih površinskih tekstura tkanina i utjecaja istih na vizualizaciju boje pomoću statističke metode analize teksture GLCM (eng. Grey Level Co-ocurrence Matrix).*

1. Uvod

Konstrukcija tkanine mijenja se pomoću tri primarna konstrukcijska parametra: finoćom pređe, vrstom veza i gustoćom osnovinih i potkinih niti [1]. Primarni parametri konstrukcije tkanine su međuovisne varijable gdje izbor jednog parametra utječe na druge. Prema tome, finoća pređe utječe na gustoću tkanine kroz vrstu veza, a struktura tkanine utječe na njezinu površinsku teksturu [1]. Izgled teksture tkanine povezan je s geometrijskom strukturom vlakana i pređe; tekstura tkanine u konačnici je određena vezom tkanine. Složenost tekstilnih proizvoda, raznolikost tekstura i materijala daju promjenjivu boju koja ovisi o nekoliko parametara poput osvjetljenja, spektralne raspodjele boje, kao i o stanju površine [2]. Iako je dobro poznato da tekstura može vizualno i instrumentalno utjecati na boju uzorka, kvantiteta i kvaliteta tog učinka još nije dobro shvaćena. Obično, svi instrumenti za mjerenje boje tekstilnih uzoraka su izrađeni, namijenjeni i prilagođeni uzorcima ravnih površina. Spektrofotometri koji daju podatke o spektralnoj refleksiji uzoraka široko se koriste za mjerenje boje tekstilnih uzoraka, koji obično imaju strukturalne teksture [3]. Nepravilnosti površine tekstilije, nejednoličnost, hrapavost utječu na nanos tinte/bojila u (digitalnom) tekstilnom tisku. S obzirom na navedene karakteristike, istraživanje promjene boje kao rezultata varijacija u teksturi uzoraka tkanine je opravdano i istraživački svrsishodno [3, 4].

2. Eksperimentalni dio

Metode korištene u ovom radu odnose se na slikovnu obradu i analizu, eng. *Image processing and analysis*; suvremenu metodu koja omogućava identifikaciju tekstilija te analizu određenih karakteristika poput površinske teksture. Slikovna analiza podrazumijeva ekstrakciju značajnih informacija iz slika korištenjem računalnih algoritama; omogućava precizno mjerenje parametara teksture tkanine, poput veza (strukture) tkanine, broja pređe te hrapavosti površine [5]. Automatska i objektivna procjena izgleda teksture materijala s obzirom na karakteristike geometrijske strukture, površinska i mehanička svojstva materijala te estetski izgled, važna je zbog sve veće potražnje za visokokvalitetnim tekstilnim proizvodima [6].

ImageJ je računalni program koji će se koristiti za analizu različitih površinskih tekstura tkanina i utjecaja istih na vizualizaciju boje. Jedna od najčešće korištenih statističkih metoda analize teksture temelji se na izračunavanju matrice pojavljivanja razine sive, eng. *Grey Level Co-ocurrence Matrix*, GLCM), koja je također poznata kao matrica prostorne ovisnosti razine sive. Ova matrica prati koliko se često različite kombinacije – parovi – vrijednosti intenziteta piksela (razine sive) pojavljuju na slici u određenom prostornom odnosu i udaljenosti [7]. Različiti parametri teksture: energija, kontrast, korelacija, inverzni diferencijalni moment (IDM), entropija, bit će izračunati iz matrica GLCM-a pomoću *ImageJ-ovog* GLCM dodatka *Texture analysis*.

Topografski parametri: kvadratni prosjek visine profila po jedinici duljine (Rq = RMS), aritmetička sredina apsolutnih vrijednosti visine profila po jedinici duljine (Ra), maksimalna dubina dna profila (Rv) i maksimalna visina vrha profila (Rp) izračunat će se pomoću *ImageJ*-ovog dodatka *SurfCharJ*.

3. Rezultati i rasprava

Topografija površine tekstilije istraživana je u različitim znanostima te je definirana na različite načine ovisno o zahtjevima određenog područja. Završne obrade poput bojadisanja i tiska proučavaju interakciju boje i tekstilne površine gdje je ključna objektivnost kod percepcije boje te reprodukcija iste na različitim strukturalnim teksturama, različitog sastava, što je važno u industrijskom proizvodnom procesu. S obzirom na nepravilnost površinske teksture tekstilije te njezinu nejednoličnost i hrapavost, istraživanje promjene boje kao rezultata varijacija u teksturi uzoraka tkanine je opravdano. Međutim, nemoguće je dobiti jednostavan skup parametarskih čimbenika za sve potencijalne teksture u industrijskoj primjeni. Umjesto toga, svaka tekstura ili vrsta teksture trebala bi se proučavati zasebno.

4. Zaključak

Dosadašnja istraživanja dokazuju da površinska tekstura tekstilije neminovno utječe na izgled boje, odnosno na dimenzije boje te da utjecaj teksture na boju/intenzitet efekta teksture više ovisi o vrsti strukturalne teksture nego o hrapavosti teksture. Suvremeni zahtjevi uključuju sveprisutnu sastavnu komponentu ekologije i etike, usmjeravaju se na prikaze vizualne teksture koja je, primjerice, ključni faktor u području digitalne mode, odnosno virtualnog dizajna i digitalne proizvodnje.

Literatura

[1] Koester A. W.: Analyzing the Color, Design and Texture of Fabric, *Dostupan na* https://www.semanticscholar.org/paper/Analyzing-the-color%2C-design%2C-and-texture-of-fabric-Koester/8081a31a51386e48757b6c83c1e3fbc80e78c352#paper-header *Pristupljeno:* 2021-12-11

[2] Moussa, A. et al: Colour change as a result of textile transformations, *Coloration Technology*, **124** (2008) 4, 234-242, ISSN 1478-4408

[3] Gorji Kandi, S., Tehrana, M. A.; Rahmatib, M.: Colour dependency of textile samples on the surface texture, *Coloration Technology*, **124** (2008), 6, 348-354, ISSN 1478-4408

[4] [Bae, J. H., Hong, K. H., Lamar, T. M.: Effect of Texture on Color Variation in Inkjet-Printed Woven Textiles, *Color Research and Application*, **40** (2014) 3, 297-303, ISSN 0361-2317

[5] [Alase, J., Hulle, A.: Image Analysis Technique for Quality Evaluation of Textiles, *International Journal on Textile Engineering and Processes*, **4** (2018) 4, 35-39, ISSN 2395-3578

[6] Chilkuri, S. i sur.: Fabric texture analysis using image processing techniques, *Journal of emerging technologies and innovative research*, **7** (2020) 3, 392-297, ISSN 2349-5162

[7] Hladnik, A. et al: Assessment of paper surface topography and print mottling by texture analysis, *Dostupan na* https://www.researchgate.net/publication/262420212_Assessment_of_paper_surface_topography_and_print_mottling_by_texture_analysis, *Pristupljeno:* 2021-12-11

Irena Topić

Životopis

Irena Topić rođena je 1983. godine u Zagrebu. Radi kao profesorica likovne kulture i likovne umjetnosti u osnovnim i srednjoj školi. Diplomirala je na Sveučilištu u Zagrebu Tekstilno- tehnološkom fakultetu stručni studij, a 2011. godine sveučilišni diplomski studij kostimografije. 2013. godine diplomirala je na Akademiji likovnih umjetnosti, sveučilišni studij likovne kulture, smjer slikarstvo. U razdoblju od 2004. do 2006. godine sudjelovala je kao terenski mjeritelj na projektu Hravatski antropometrijski sustav (HAS) voditelja prof. dr. sc. D. Ujevića. Radila je kao asistent na Tekstilno-tehnološkom fakultetu od 2011. do 2017. godine, a vanjski suradnik od 2018. do 2021. godine. Pohađa poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija. Stručno se usavršavala u brojnim inozemnim institucijama u okviru projekata i stipendije. Objavila je 2 poglavlja u knjizi, radove u zbornicima znanstvenih i stručnih skupova i jedan rad u drugim časopisima.

Naslov doktorskog rada

Istraživanje tjelesnih proporcija u postupcima konstruiranja i dizajniranja odjeće za pretilu populaciju

Mentor

prof. dr. sc. Darko Ujević

Datum obrane teme doktorskog rada

ISTRAŽIVANJE TJELESNIH PROPORCIJA U POSTUPCIMA KONSTRUIRANJA I DIZAJNIRANJA ODJEĆE ZA PRETILU POPULACIJU

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Sažetak: *Istraživanja tjelesnih proporcija mogu doprinijeti kvalitetnijim postupcima konstruiranja i modeliranja odjeće za pretile muške osobe. U okviru doktorskog rada cilj je znanstveno utvrditi trend porasta pretilosti u odraslih muškaraca u gradu Zagrebu u odnosu na posljednje veliko provedeno STIRP HAS istraživanje. Na osnovu rezultata provedenih antropometrijskih mjerenja muških pretilih radno aktivnih osoba utvrditi će se relevantni kriteriji za mušku pretilu populaciju i omogućiti prijedlog novih tipova tijela te unapređenje postupaka konstruiranja, dizajniranja i izrade muške trodijelne jakne (vanjske, srednje i unutrašnje).*

1. Uvod

Istraživanja tjelesnih proporcija mogu doprinijeti kvalitetnijim postupcima konstruiranja i modeliranja odjeće za pretile muške osobe. Sagledavanje ovih komponenti pomaže kvaliteti života i zaštiti zdravlja posebno za pretile osobe koje su izložene težim fizičkim poslovima. Duboko u povijest mogu se pronaći istraživački napori koji se odnose na proučavanje dimenzija i proporcija tijela. Antropometrijska mjerenja provode se već od 1900. godine s ciljem unapređenja i razvoja sustava veličina i tipova tijela. Pristupi istraživača i načini mjerenje mijenjali su se i unaprjeđivali razvojem antropometrijskih instrumenata. Tjelesnim proporcijama određuje se sukladnost i međusobni odnos pojedini tjelesnih mjera, u konkretnom slučaju baviti će se temom pretilosti muškaraca i/ili odstupanja od prosječne građe.

2. Eksperimentalni dio

Antropometrijska mjerenja u okviru ove doktorske disertacije provodit će se kompletom antropometrijskih instrumenata kojeg čine: antropometar s jednim i /ili dva kraka, mjerna vrpca, jednostrani i/ili obostrani kutomjer, kljunasti klizni antropometar, ogrlica za određivanje opsega vrata i digitalna vaga [1, 2]. Za planiranje, organizaciju i provedbu istraživanja koristit će se znanja iz znanstvenog rada – priprema i provedba istraživanja, statistička obrada rezultata s ciljem ostvarivanja relevantno postavljenih hipoteza.
Istraživanje se provodi u četiri faze, i to:

1. faza: priprema plana istraživanja, cjelokupni pregled publicirane literature, razvoj suradnje s drugim znanstvenim i istraživačkim institucijama i proizvođačkim tvrtkama.
2. faza: planiranje opreme za istraživanje, izrada anketnih upitnika i obrazaca za antropometrijska mjerenja s planom 54 mjerenja po jednom pretilom ispitaniku.
3. faza: provedba sustavnog istraživanja, organizacija i provođenje terenskog mjerenja uz poštivanje aktualnih mjera protiv Covid 19 pandemije
4. faza: sređivanje dokumentacije, matematičko- statistička obrada podataka mjerenja, definiranje novih tipova tijela i sukladno tome definiranje i preporuka dopune odjevnih veličina radi primjene u postupku konstruiranja i dizajniranja odjeće .

U doktorskom radu izvršiti će se antropometrijska mjerenja (sve 54 antropometrijske mjere po ispitaniku) na 200 muških radno aktivnih ispitanika u dobi do 65 godina na području grada Zagreba. Temeljem provedenog mjerenja rezultati će se prezentirati prema utvrđenim međuveličinskim intervalima od 4 cm počevši od opsega grudi 108 cm što je i uvjet za uključivanje u studiju.

3. Rezultati i rasprava

Rezultati antropometrijskih mjerenja dobiveni ovim istraživanjem imaju cilj utvrditi trend promjene tjelesnih proporcija na pretilim muškarcima, s opsegom grudi od 108 cm na više. Taj trend zahtjeva utvrđivanje novih tipova tijela. Pretraživanjem relevantne znanstveno-stručne literature utvrđena je slaba zastupljenost objavljenih radova u području teme istraživanja doktorskog rada. Najveći broj referenci koje će se koristiti vezan je uz područje višegodišnjeg istraživanja prof.dr. sc. Darka Ujevića, posvećenim istraživanju tjelesnih dimenzija, postupcima konstruiranja, izrade hrvatskog tehničkog izvještaja, te EN normi kao višegodišnji član europskog udruženja CEN.

Izradi ovog rada posebno se pristupilo i zbog spoznaje da postoji izraziti trend pretilosti kod muške populacije u RH, čime će se omogućiti znanstveni napredak objektivnog sagledavanja ovog trenda u Republici Hrvatskoj. To će se pokušati dokazati i usporedbom s rezultatima provedenog STIRP HAS istraživanja. Rezultati ovog istraživanja doprinijeti će suradnji s više tvrtki čiji djelatnici obavljaju teške fizičke poslove na otvorenome u različitim vremenskim uvjetima, čime će se i značajno doprinijeti očuvanju zdravlja.

4. Zaključak

Na osnovu provedenih istraživanja i dobivenih rezultata utvrdit će se relevantni kriteriji za pretilu mušku populaciju u Republici Hrvatskoj što će omogućiti prijedlog novih tipova tijela i međuveličinskih intervala, u odnosu na osobe prosječne građe. To će omogućiti i objektivnu znanstvenu usporedbu, kao i usporedbu s populacijom drugih država, zemalja članica EU i šire. Primjenom rezultata istraživanja doprinijet će se daljnjem razvoju definiranja veličina odjeće, izradi novog tehničkog izvještaja za navedenu skupinu, cjelovitom unaprjeđenju konstruiranja, dizajniranja i izrade ergonomskih trodijelnih jakni u cilju bolje zaštite zdravlja na radu muške radno aktivne pretile populacije.

Literatura

[1] Anthropometric System – Measuring and Size Designation of Clothes and Footwear, CroatianTechnical Report, HRI 1148:2012 hr, HZN, February 2012, ICS: 01.040.61:61.020

[2] Ujević D.; Hrastinski M.: Prilog podlozi za nove hrvatske norme za veličinu odjeće i obuće te njihova označivanja - Podloga za nove hrvatske norme za veličinu odjeće i obuće, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, Zagreb, 2006., 407-23, ISBN 953-7105-09-1

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Naslov doktorskog rada	Utjecaj fizikalno-kemijskih svojstava inhibitora posivljenja na zeta potencijal opranih pamučnih materijala
Mentor	prof. dr. sc. Tanja Pušić
Datum obrane teme doktorskog rada	20. 5. 2016.

SADRŽAJ REZIDUA NA PAMUČNOJ TKANINI OPRANOJ DETERDŽENTOM U TVRDOJ I MEKOJ VODI

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Sažetak: *Istraživanja u doktorskom radu obuhvaćaju specijalne dodatke, inhibitore posivljenja, u formulaciji praškastog deterdženta. Odabrani inhibitori posivljenja su karboksimetil celuloza (CMC), karboksimetil škrob (CMS) i njihova kombinacija (CMC+CMS) čija je koncentracija prilagođena pranju celuloznih materijala na 40 °C, 60 °C i 90 °C u tvrdoj i mekoj vodi. Karakterizacija svojstava pamučnih tkanina nakon 10 ciklusa pranja u odnosu na neopranu načinjena je analizom rezidualnih tvari.*

1. Uvod

Razvoj sredstava za pranje uvjetovan je tehnološkim smjernicama, pri čemu je neophodno načiniti formulaciju u kojoj sve komponente djeluju sinergijski s preostalim čimbenicima Sinner-ovog kruga, temperatura, mehaničko djelovanje i vrijeme [1]. U posljednje vrijeme se promiču ekološki prihvatljivi niskotemperaturni procesi u malim omjerima kupelji, koji zahtijevaju visokoučinkovite tenzide, bildere, bjelila i njihove aktivatore, enzime i specijalne polimere u deterdžentima [2]. Inhibitori posivljenja imaju bitnu ulogu u primarnim i sekundarnim učincima pranja jer uz anionske tenzide i bildere dodatno elektronegativno nabijaju prljavštine i vlakno te fizički sprečavaju taloženje nečistoća na vlakno [3]. Da bi inhibitor posivljenja kao polimer bio efikasan mora biti srodan vlaknu koje se pere, kako bi se privremeno vezao na vlakno, povećao negativan naboj površine vlakna te odbijao negativno nabijenu česticu prljavštine i spriječio redepoziciju. Obzirom da je njihovo djelovanje povezano s površinom materijala, važno je poznavati njeno stanje i stupanj opterećenja određenim tvarima.

U ovom radu je istražen utjecaj tvrde i meke vode na sadržaj rezidualnih tvari na pamučnoj tkanini opranoj deterdžentom uz dodatak inhibitora posivljenja (CMC, CMS i njihova kombinacija, CMC+CMS) na 40 °C, 60 °C i 90 °C kroz 10 ciklusa.

2. Eksperimentalni dio

Ciklusi pranja standardne pamučne tkanine prema HRN ISO 4312 s deterdžentom kojem su dodani odabrani inhibitori posivljenja provedeni su u tvrdoj (T) i mekoj (M) vodi na 40 °C, 60 °C i 90 °C. Stupanj opterećenja pamučne tkanine rezidualnim tvarima prije i nakon pranja analiziran je kroz sadržaj pepela prema HRN ISO 4312 [4].

3. Rezultati i rasprava

Primijenjeni deterdžent sadrži bildere, zeolit i natrijev karbonat, čija je uloga omekšati vodu tijekom pranja i onemogućiti taloženje anorganskih taloga na površinu pamučnog materijala. Neovisno o tome, obzirom na varijaciju temperatura pranja, analiza rezidualnih tvari na standardnoj pamučnoj tkanini (PT) pokazala je opterećenost površine inkrustacijama. U tab. 1 prikazane su vrijednosti sadržaja pepela (P) na pamučnoj tkanini (PT) prije i nakon pranja deterdžentom različitog sastava u tvrdoj i mekoj vodi na 40 °C, 60 °C i 90 °C u laboratorijskoj perilici.

Neoprana tkanina (PT) sadrži 0,2 % pepela što je uobičajena vrijednost za kontrolnu pamučnu tkaninu. Iz rezultata prikazanih u tab. 1 razvidno je da tvrdoća vode i temperatura pranja utječu na vrijednosti pepela opranih pamučnih tkanina. Pranje pamučne tkanine deterdžentom uz inhibitore posivljenja u mekoj vodi tvrdoće 44,5 ppm nije povećalo sadržaj rezidualnih tvari. Visoki stupanj tvrdoće vode (404,1 ppm) utječe na vrijednosti sadržaja pepela na opranim pamučnim tkaninama, a u pravilu su veće od 6 do 10 puta u odnosu na vrijednosti pepela pamučnih tkanina opranih u mekoj vodi. Generiranje taloga na površinu pamučnih tkanina u pranju tvrdom vodom na 60 °C i 90 °C je veće u odnosu na 40 °C, čime se može zaključiti da ugrađeni bilderi nisu dostatni za vezanje iona zemnoalkalijskih elemenata u tvrdoj vodi pri višim temperaturama.

Tablica 1: Sadržaj pepela (P) nakon žarenja pamučnih tkanina prije i nakon 10 ciklusa pranja

Uzorak	Voda	P (%)		
		40 °C	60 °C	90 °C
PT	-	0,2		
P_PT_CMC	T	1,2	1,1	1,2
P_PT_CMS		0,6	0,7	2,0
P_PT_CMC+CMS		0,6	1,4	1,5
P_PT_CMC	M	0,2	0,2	0,3
P_PT_CMS		0,2	0,3	0,3
P_PT_CMC+CMS		0,2	0,2	0,2

Sastojci deterdženta za pranje standardne pamučne tkanine (bez zaprljanja) kroz 10 ciklusa nisu se fenomenološki orijentirali na uklanjanje prljavština. Moguće je da su i neke organske komponente u deterdžentu, npr. sapun i anionski tenzidi, interakcijom s kalcijevim i magnezijevim ionima generirale teško topive i/ili netopive taloge, koji su dodatno opteretili površinu pamučne tkanine i povećali sadržaj rezidualnih tvari (ukupan pepeo).

4. Zaključak

Vrijednosti sadržaja pepela koje upućuju na sadržaj rezidualnih tvari na opranim pamučnim tkaninama u mekoj vodi gotovo su podjednake vrijednostima neoprane pamučne tkanine, što potvrđuje da sastav deterdženta variran kroz inhibitore posivljenja i temperatura pranja u mekoj vodi nemaju utjecaj na te vrijednosti. Iz pregleda prikazanih rezultata vidljivo je da visoki stupanj tvrdoće vode i temperatura pranja imaju dominantan utjecaj na sadržaj ukupnog pepela na opranim pamučnim tkaninama.

Literatura

[1] Jakobi, G., Löhr, A.: *Detergents and Textile Washing: Principles and Practice*, ISBN 0-89573-687-X, Baden-Württemberg (1987)

[2] Smulders, E. et al: Recent developments in the field of laundry detergents and cleaners, *Tenside Surfactants Detergents*, **34** (1997) 6, 386-392, ISSN 0932-3414

[3] Soljačić, I., Pušić, T.: *Njega tekstila: Čišćenje u vodenom mediju*, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb, ISBN 9537105091, (2005)

[4] HRN ISO 4312:2001 Površinski aktivne tvari - Procjena određenih učinaka pranja - Metode analize i ispitivanja za čistu kontrolnu pamučnu tkaninu (ISO 4312:1989)

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Naslov doktorskog rada	
Studijski savjetnik	izv. prof. dr. sc. Ivana Schwarz
Datum obrane teme doktorskog rada	

TAPISERIJE KAO TRADCIJSKA KULTURA I KULTURNA BAŠTINA SJEVERNE DALMACIJE

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Sažetak: *Nužnost suvremenog svijeta jest shvaćanje vlastite kulturološke prošlosti, koja predstavlja odraz nacionalnog identiteta, kao i postavljanje prioriteta u očuvanju kulturnog nasljeđa od odumiranja i potpunog nestajanja. Najveća bogatstva kulturne baštine očituju se kroz spoznaje o segmentima kulture življenja i umjetničkog djelovanja te traženja vlastitog kulturnog identiteta u suvremenim kulturnim i civilizacijskim okolnostima. Umjetnost izrade tapiserije predstavlja veliki značaj ne samo za hrvatsko tekstilno blago, već i za povijesni tekstil uopće.*

1. Uvod

Izrada tapiserija je određena tehničkom pravilnošću tkanja što na prvi pogled izgleda kao ograničavajuća okolnost, no to je zapravo definira stvaranje struktura umjetničkih djela. Tapiserija je vrsta klečanog čilima, gdje se između niti osnove provlače niti potke koje oblikuju motive [1].

Upravo je četiri desetljeća takovog umjetničkog stvaralaštva iznimnih pojedinaca, bračnog para Tomljanović, rezultiralo formiranjem bogate zbirke tapiserija, koje predstavljaju najupečatljiviji dokaz tkalačke tradicije sjeverne Dalmacije, no kroz inovativan umjetnički izričaj – vunenu tapiseriju.

2. Eksperimentalni dio

Vrijednost navedene zbirke tapiserija temelji se prije svega na činjenici da se radi o velikom objedinjenom opusu umjetnika [2]. Svakako treba istaći i likovnu vrijednost, autorskog pristupa temeljenog na sinergiji prirodne palete boja vune (inspiriranog bogatstvom nijansi vune iz brdskih krajeva Dalmacije) u odnosu na geometrijsku, apstraktnu i figurativnu tematiku. Riječ je o pristupu u kojem se autori poigravaju sa širokom paletom tonova i discipliniranog istraživanja onoga što se čini nalik jednostavnoj slici.

Ističu se tapiserije s kršćanskom tematikom, velebitskog pejzaža te one posvećene gradu Zadru, dočarane i upotpunjene skladom naravnih boja vune (čija je proizvodnja i primjena obilježila tekstilnu povijest hrvatskog i lokalnog područja sve do danas), što predstavlja beskonačnu inspiraciju i bijeg od svih hirova pomodnosti.

Vrijednost zbirke tapiserija umjetničkog para Tomljanović temelji se na činjenici da se procesu izrade pristupilo cjelovito i samostalno, od same ideje do realizacije. U stvaranju su polazili od ideje predstavljene u obliku crteža ili slike te ju prenosili na kartone prema kojima su tkali. Za materijal tapiserija birana je prirodna ovčja, domaća vuna, koju su autori samostalno prikupljali, pripremali, prali te ručno preli, a poslije toga i sortirali prema prirodnim nijansama, od svijetlih oker tonova, preko smeđih do smeđe crvenkastih i sivih nijansi [3].

Linijom i plohom građene su kompozicije kao u finoj grafici, ritmizirajući površinu stvarajući dinamične apstraktne slike nijansirane strukture preplitanja, apstraktnih, stiliziranih oblika kamene strukture krša i biljnih elemenata iz prirode.

Izričaj ovih umjetničkih djela karakterizira spoj suvremenog likovnog izraza i klasičnih metoda tkanja, i kad se radi o dekorativnim stiliziranim, nefigurativnim prirodnim oblicima, ali i u vrlo složenim figurativnim kompozicijama. Temeljna značajka djela je strogi, suspregnuti sklad, iznimna disciplina i jednostavnost [4].

3. Rezultati i rasprava

Tapiserije su tkane klasičnom tehnikom point de tapiserie na uspravnom tkalačkom stanu s okomito napetim nitima osnove, tzv. haute lisse, po francuskom sistemu [5]. Prema umjetničkoj ekspertizi doc. dr. sc. Katarine Nine Simončič iz 2018. godine, tapiserije se mogu podijeliti u četiri tematske cjeline.

- Geometrijska forma i apstrakcija realizirana kroz motive Velebita - gdje se kroz apstraktan izričaj zadržava vjernost poznavanju strukture tkanja, te pod vodstvom imaginacije prostora i vremena grade geometrijske kompozicije u slikarskoj maniri šezdesetih godina 20. stoljeća.

- Realizam kao polazišni pristup u oblikovanju pejzaža i motiva grada – gdje je ravnoteža postignuta ravnomjernim i pravilnim izmjenjivanjem ploha odnosno ponavljanjem kontrastnih tonaliteta svjetla i tame, odnosno vještom modulacijom tonova.

- Kršćanska tematika – odlikuje se ujedinjenjem likovnih elemenata (oblika tj. ploha u odnosu na obrisne linije, tonove, perspektive) u jedinstvene cjeline. Jedinstvo je ostvareno njihovim skladnim odnosom, kao i odnosom likovnih elemenata s kompozicijskim načelima.

- Portreti – koje karakterizira vrhunska tonska modulacija, kako likova tako i pozadine ili drugog plana, kojom je dočaran osjećaj volumena ili tijela u prostoru.

Važno je napomenuti kako se zaključci dobiveni provedenim analizama tumače kao dio interdisciplinarne suradnje različitih područja, uključujući tekstilnu tehnologiju, etnologiju, povijest umjetnosti, sociologiju i etnografiju.

4. Zaključak

Definiranje te dokumentiranje tapiserija, uključujući uspostavljanje i promicanje tapiserija, važni su aspekti kulturne baštine sjeverne Dalmacije. Dostupnost i istraživanje, kao i provedba detaljne analize, predstavljaju smisao razumijevanja i vrednovanja složenosti, ljepote i važnost tapiserije kao tekstilne umjetničke forme.

Literatura

[1] Kovačević S.: *Ručno tkanje*, Centar za kreativne alternative & Prometej, ISBN 953-6460-37-8, Zagreb, (2004)

[2] Lulić Štorić, J.: *Tapiserije: donacija Etnološkom odjelu Narodnog muzeja Zadar*: katalog izložbe. Tomljanović-Šokčević, A.; Tomljanović I. (ur.), Narodni muzej Zadar, Zadar, (2016)

[3] Tomljanović-Šokčević, A.: *Tragom izgubljene baštine*, Matica hrvatska, Ogranak Zadar, Zadar, (2016)

[4] Verlet P. et al: G*reat tapestries – The web of history from the 12th to the 20th century*, Edita S. A. Lausanne, (1965)

[5] Russell, C. K.: *Tapestry Handbook*, The Next Generation, Schiffer Publ. Ltd., ISBN 978-0-7643-2756-8, Atglen, PA, (2007)

Juro Živičnjak

Životopis	Juro Živičnjak rođen je 1995. godine u Zagrebu. Zvanje magistar inženjer tekstilne tehnologije i inženjerstva stekao je obranom diplomskog rada na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu 2018. godine. U sklopu diplomskog rada i u suradnji s profesorom Rogaleom izradio je uređaj pod nazivom: „Triboelektrični generator za pohranjivanje statičkog naboja iz odjeće“, koji je prvi put izložen i nagrađen na međunarodnoj izložbi inovacija, “INOVA - Budi uzor 2018.”, sa zlatnom medaljom i posebnom nagradom za najbolju inovaciju u primijenjenoj znanosti. Svoje obrazovanje nastavlja na poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija na Tekstilno-tehnološkom fakultetu, gdje od 2019. godine radi i kao asistent.
Naslov doktorskog rada	Mjerna metoda za utvrđivanje količine elektrostatskog naboja induciranog na tekstilnim materijalima korištenim u odjevne svrhe
Studijski savjetnik	prof. dr. sc. Dubravko Rogale
Datum obrane teme doktorskog rada	

MJERNA METODA ZA UTVRĐIVANJE KOLIČINE ELEKTROSTATSKOG NABOJA INDUCIRANOG NA TEKSTILNIM MATERIJALIMA PAMETNE I INTELIGENTNE ODJEĆE

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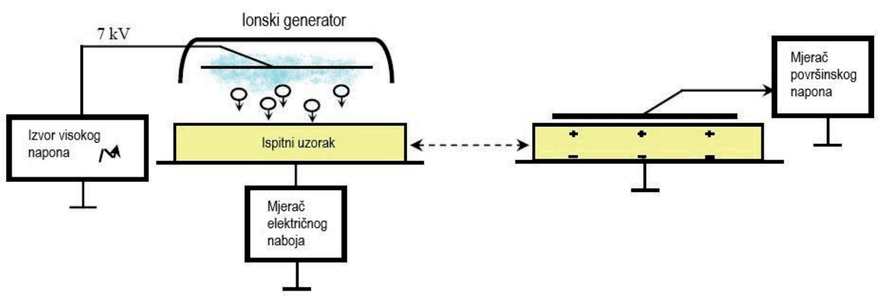
Sažetak: *U posljednje vrijeme bilježi se porast u upotrebi tehnološki unaprijeđene pametne i inteligentne odjeće, koja za svoj rad koristi električnu energiju. Glavni nedostatak takve odjeće ogleda se u ograničenom kapacitetu njihova izvora napajanja. Elektrostatski naboj je jedna vrsta električne energije koja se može generirati i primijeniti u tu svrhu, ali je potrebno provesti daljnja istraživanja u području elektrostatičkih svojstava tekstilnih materijala koji se koriste u odjevne svrhe. Kratki prikaz odabranih kontaktnih i beskontaktnih mjernih metoda te mjernih sustava za mjerenje elektrostatskog naboja generiranog na tekstilu je prikazan.*

1. Uvod

E-, pametna ili inteligentna odjeća sadrži elektroničke komponente, koje za svoj rad koriste električnu energiju. Vrijeme rada tako tehnički unaprijeđene odjeće je ograničeno kapacitetom njihove jedinice za pohranu energije i blizinom izvora napajanja. Zbog toga su uvedeni novi prenosivi generatori energije, primjenjivi za E-, pametnu ili inteligentnu odjeću, koji mogu iz različitih izvora energije, poput: biomehaničke, toplinske, solarne, ambijentalne, generirati električnu energiju [1]. Triboelektrični generator (TEG) je naziv za jednu vrstu takvog uređaja, koji pretvara elektrostatički naboj generiran na tekstilu u upotrebljivu električnu energiju. Princip rada TEG-a temelji se na ljudskim pokretima i elektrostatskom svojstvu tekstila, koja su opisana triboelektričnom serijom. No, serija se pokazala nepouzdanom u predviđanju učinka TEG-a [2]. Zbog toga je potreba za daljnjom analizom električnih svojstava tekstilnih materijala rezultirala proučavanjem niza istraživačkih radova. U radovima nisu promatrane samo vrijednosti električnog otpora, već vrijednost napona i kapaciteta, inducirane kontaktnom ili beskontaktnom metodom elektrifikacije. Pregled odabranih znanstvenih radova koji primjenjuju različite mjerne sustave i uređaje za ispitivanje elektrostatskih svojstava plošnih tekstilnih materijala.

2. Eksperimentalni dio

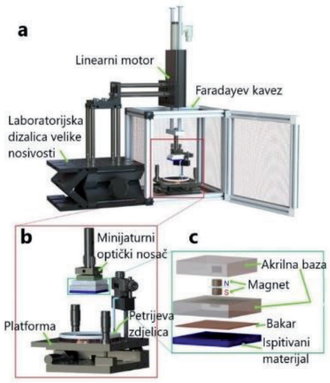
Beskontaktna metoda za mjerenje električnih svojstava, koju su uveli Žilinskas, P. J i suradnici [3], prvotno je bila namijenjena za ispitivanje plošnih izolacijskih materijala, poput plastičnih folija i ploča. Primijenjeni mjerni sustav, sl. 1, bio bi prikladan i za tekstilne materijale.



Slika 1: Naneseni naboj i mjerna shema površinskog potencijala

Proces elektrifikacije ostvaren je putem visoko naponskog izvora (7kV), koji periodično ionizira molekule zraka pozitivnim i negativnim ionima. Količina nanesenog naboja se prati putem površinskog potencijala, odnosno naponskih signala koji dolaze s mjernog uređaja na računalo putem analogno-digitalnog pretvarača.

Usporedno s beskontaktnom metodom, proces elektrifikacije kod kontaktne metode postiže se uzastopnim kontaktom ili trljanjem ispitivanog materijala direktno o metalnu elektrodu ili indirektno o polimerni materijal. Time broj i vrsta elementa uključenih u kontaktni mjerni sustav nije ograničen. Primjerice, mjerni sustav koji su uveli Zou, H. i suradnici [4], uključuje Faradayev kavez, sl. 2a, koji je ispunjen plinom dušika veoma visoke čistoće, na temperaturi od 20 ± 1 °C, pri atmosferskom tlaku i vlažnosti od 0,43 %, unutar kojeg se odvija kontaktna elektrifikacija. Jedna elektroda je pritom tekućem stanju, odnosno živa, a druga elektroda je bakar, koji je izravno nanesena na ispitivani materijal E-beam tehnikom.



Slika 2: a. Eksperimentalna postavka mjernog sustava; b. Statički i pokretni dio postavke; c. Držači uzoraka

3. Rezultati i rasprava

Beskontaktna metoda čiji su rezultati mjerenja zabilježeni u stvarnom vremenu (t), omogućila je praćenje površinskog potencijala (V), elektrostatskog naboja (Q) i volumnog otpora (R) te njihove međusobne omjere: površinskog potencijala o vremenu (V – t); omjer površinskog potencijala o nanesenom naboju (V – Q); omjer električnog kapaciteta o površinskom potencijalu (C – V); omjer volumnog otpora o površinskom potencijalu (R – V). Predstavljena kontaktna metoda periodičnim mjerenjem vrijednosti napona, nakon svakog uzastopnog kontakta ispitivanog materijala o živu, raspoznaje se značajno manje rasipanje u zabilježenim rezultatima. Što potvrđuje značajan utjecaj površinske nejednolikosti na mjerni rezultat.

4. Zaključak

Pravilan odabir i broj elemenata koji se definiraju prije određene vrste ispitivanja izravno utječu na dobiveni rezultat. Stoga, kada se ispituju elektrostatička svojstva tekstila, metoda ispitivanja ovisi o principu indukcije elektrostatičkog naboja (kontaktnom ili zbog električnog polja), ali i o mogućnostima mjernog uređaja.

Zahvala

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Literatura

[1] Riemer, R.; Shapiro, A.: Biomechanical energy harvesting from human motion: theory, state of the art, design guidelines, and future directions, *Journal of NeuroEngineering and Rehabilitation*, **8** (2011) 22, 1-13, ISSN 1743-0003

[2] Lei, R. et al: Sustainable high-voltage source based on triboelectric nanogenerator with a charge accumulation strategy, *Energy & Environmental Science*, **13** (2020) 7, 2178–2190, ISSN 1754-5706

[3] Žilinskas, P. J.; Lozovski, T.; Jurkšus, J.: Electrostatic properties and characterization of specific polymeric materials for building purposes, *Materials science*, **16** (2010) 1, 57–62, ISSN 1392–1320

[4] Zou, H. et al: Quantifying the triboelectric series, *Nature Communications*, **10** (2019) 1, 1–9, ISSN 2041-1723

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Naslov doktorskog rada	
Studijski savjetnik	izv. prof. dr. sc. Sandra Flinčec Grgac
Datum obrane teme doktorskog rada	

USPOREDBA MEHANIČKIH SVOJSTAVA VEGETABILNO ŠTAVLJENE KOŽE S VEGETABIL-ZEOLIT ŠTAVLJENOM KOŽOM

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Sažetak: *Proces štavljenja nezaobilazan je dio u proizvodnji gotove kože. Čvrstoće nastalih veza između kolagenskih vlakana koje doprinose svojstvima gotove kože ovise o vrsti štavnog sredstva. Najčešće se koriste vegetabilna, sintetička i kromna (mineralna) sredstva, a svako od navedenih na određen način negativno utječe na okoliš. Iz tog razloga dio štavnih sredstva u inovativnoj obradi u ovom istraživanju zamijenjen je zeolitom. Prvi uzorak obrađen je vegetabilnom štavom (VEG), a u drugom uzorku dio ovog štavnog sredstva zamijenjen je zeolitima (VEG+Z), pri čemu su korištena dva fužazitna tipa zeolita; jedan sa bakrom a drugi bez.dodatka bakra. Na obrađenoj koži ispitana je proštavljenost, otpornost na savijanje i pucanje lica.*

1. Uvod

Štavljenje je jedan od najvažnijih procesa obrade kože, u kojem reakcijom kolagena sa štavnim sredstvom koža postaje proizvod trajnih svojstava. Štavna sredstva mogu biti mineralna (Cr, Al), vegatabilna i sintetička. U proizvodnji kože diljem svijeta najčešće se koriste kromna štavna sredstva. Međutim, procjene utjecaja kroma na okoliš su ukazale na njegove toksične značajke. Sve veći broj istraživanja usmjeren je na zamjenu kroma u proizvodnim procesima kožarske industrije [1-3].

2. Eksperimentalni dio

U ovom istraživanju za proces štavljenja korištena je piklana goveđa koža. Uzorak kože štavljen vegetabilnim sredstvima ima oznaku VEG, a uuzorak označen sa VEG+Z štavljen je kombinacijom vegetabilnog štavnog sredstva i zeolita. Količina sredstava dozirana je prema masi sirove kože. Proces štavljenja proveden je u laboratorijskom uređaju Mathis. Oba uzorka su podvrgnuta istom procesu nadoštave. Postupci namakanja, luženja, odvapnjivanja, enzimiranja i piklanja provedeni su u industrijskim uvjetima. Količina sredstava dozirana je prema težini sirove kože.

Uzorak VEG je opran 10 minuta na 22 °C s dvostruko većom količinom vode na masu materijala. Voda je ispuštena. Slijedi proces štavljenja u trajanju od 420 minuta uz dodatak komercijalnih štavnih sredstava (8 % sredstva ekstrahiranog iz stabla, 8 % sredstva na bazi mimoze, 5 % sintetičkog tanina) i 2 % sredstva za mašćenje. Slijedi pranje na 35 °C, u trajanju od 10 minuta nakon kojeg se ispušta voda i dodaju štavna sredstva (10 % ekstrakta kestena, 1 % sintetičkog tanina) te 2 % sredstva za nadoštavu. Proces se nastavlja 360 min na 30 °C. Ponovno je dodano 2 % sintetičkog sredstva za štavljenje. Proces se nastavlja na istoj temperaturi 60 minuta, slijedi ispiranje s dvostruko većom količinom vode na masu materijala pri 40 °C u trajanju od 15 minuta.

Uzorak VEG + Z je štavljen kombinacijom vegetabilnog štavnog sredstva i zeolita. U ovom postupku 8 % vegetabilnog štavnog sredstva ekstrahiranog iz stabla zamijenjeno je s 10 % zeolita, koji je kombinacija 10 % CuFAU 225B i 90 % 5A. Nastavak procesa prati gore opisani postupak.

Oba uzorka nakon procesa štavljenja su podvrgnuta istom procesu nadoštave u industrijskim uvjetima. Ispitivanje proštavljenosti oba uzorka izvedeno je prema SRPS G.S2.035:1962; Metode ispitivanja gotove kože -- Ispitivanje proštavljenosti i postojanosti na kuhanje. Postupak ispitivanja postojanosti na savijanje proveden je prema HRN EN ISO 5402-1: 2017; Koža - Određivanje otpornosti na svijanje - 1. dio: Metoda fleksometrom. Određivanje otpornosti lica kože na pucanje i indeks pucanja lica proveden je prema HRN EN ISO 3379:2015; Koža - Određivanje rastezljivosti i čvrstoće površine (Ballova metoda prskanja).

3. Rezultati i rasprava

Nakon ispitivanja proštavljenosti, na ispitnim uzorcima kroz presjek kože nisu vidljivi svjetliji slojevi prije i nakon sušenja. Boja presjeka je ujednačena što ukazuje na potpunu proštavljenost kože.

Svrha ispitivanja ovih uzoraka kože na savijanje je utvrditi je li koža dovoljno otporna na savijanje iako uzorci nemaju završni sloj dogotove. Ukoliko koža nakon nadoštave nema potrebnu otpornost na savijanje, koža nakon nanešene dogotove također neće imati potrebnu otpornost na savijanje. Oba su uzorka pokazala dobru otpornost na savijanje i izdržala 100.000 ciklusa bez ikakvih vidljivih oštećenja.

Nakon određivanja otpornosti lica kože na pucanje, uzorak VEG pokazao je rastezanje do 8,73 mm pod opterećenjem od 79,62 kg, dok je uzorak VEG+Z pokazao rastezanje do 8,54 mm pod opterećenjem od 26,76 kg. Uzorak VEG+Z ima pukotine nakon 26,76 kg, dok uzorak VEG ostaje cjelovit, sl. 1. Oba uzorka zadovoljavaju standard za kožu za izradu obuće, 7 mm istezanja uz opterećenje od 20 kg.

a.

b.

Slika 1: Uzorci kože nakon ispitane otpornosti na pucanje: a. uzorak VEG; b. uzorak VEG+Z

4. Zaključak

Temeljem dobivenih rezultata može se zaključiti da zamjena vegetabilnog štavnog sredstva s 10 % zeolita mijenja mehanička svojstva gotove kože ispitane u ovom radu. Koža štavljena kombinacijom vegetabilnog štavnog sredstva i zeolita (VEG+Z) ima lošije rezultate u usporedbi s kožom štavljenom samo vegetabilnim štavnim sredstvom (VEG), pri čemu je važno napomenuti da svojstva oba uzorka zadovoljavaju navedene standarde.

Zahvala

Ovaj rad je djelomično financiran sredstvima kratkoročne potpore istraživanju Sveučilišta u Zagrebu 2020., TP2/20; Učinci obrade i održavanja tekstila i kože ekološki povoljnim sredstvima.

Literatura

[1] Yang, X. He et. al: Study on thermal degradation of cattlehide collagen fibers by simultaneous TG–MS–FTIR , *Journal of Thermal Analisis and Calorimetry*, **3** (2016) 127, 1-8**,** ISSN 13886150

[2] Kozarb O.P et al: Eco-friendly technologies of leather manufacturing useing natural minerals montmorillonite and zeolite, *Technology audit and production reserves*, **14** (2013) 6, 11-14, ISSN 2226-3780

[3] Gürler Karaman D. et al: Possibilities of usage of aluminisilicates as tanning material, *Tekstil ve Konfeksiyon*, **26** (2016) 1, 117-124, ISSN 13003356

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Životopis

Marija Zorić rođena je 1987. godine u Zadru. Osnovnu školu pohađala u Bibinjama, a maturirala u općoj gimnaziji Vladimir Nazor u Zadru. Na Fizičkom odsjeku Prirodoslovno-matematičkog fakulteta u Zagrebu (istraživački smjer fizike) diplomirala 2012. godine. Početkom svibnja 2013. godine postaje asistentica na odjelu fizike na Tekstilno- tehnološkom fakultetu u Zagrebu. Iste godine pridružuje se grupi dr. sc. Ane Smontare, kao vanjski suradnik Instituta za fiziku. 2013. godine upisuje Poslijediplomski studij na Prirodoslovno-matematičkom fakultetu u Zagrebu, polje fizika, smjer fizika čvrstog stanja te započima znanstvena istraživanja predviđena planom projekta. Doktorski rad nastavlja pod vodstvom dr. sc. Petra Popčevića. Rezultate znanstvenog rada prezentirala je na 11 međunarodnih konferencija te 2 domaće konferencije. Sudjelovala je na 2 međunarodne škole.

Naslov doktorskog rada

Transportna svojstva odabranih termoelektrika

Mentor

dr. sc. Petar Popčević

Datum obrane teme doktorskog rada

STRUKTURNA I FIZIKALNA SVOJSTVA Cu2-xSe

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Sažetak: Cu2Se, kao kompetitivni termoelektrični materijal, privukao je veliku pozornost u nedavnom razvoju termoelektrika [1], zbog velike vrijednosti vrijednosti ZT (1,5 na 1000K) koja je među najvišima za monokristalne spojeve. Izvrsne termoelektrične osobine povezane su s njegovim superionskim ponašanjem u visokotemperaturnoj β fazi koji također predstavlja potencijal za primjenu u čvrstim baterijama [2]. Iako je visokotemperaturna β faza opsežno istražena, još uvijek nedostaje sveobuhvatan uvid u niskotemperaturnu α fazu. Ona odražava složenost strukturnih i faznih odnosa. Stoga, motivirani izrazito velikim termoelektričnim potencijalom ovoga sustava, napravili smo detaljnu karakterizaciju termoelektričnih i magnetotransportnih svojstava Cu2-xSe na niskim temperaturama nadopunjenu strukturnim mjerenjima.

1. Uvod

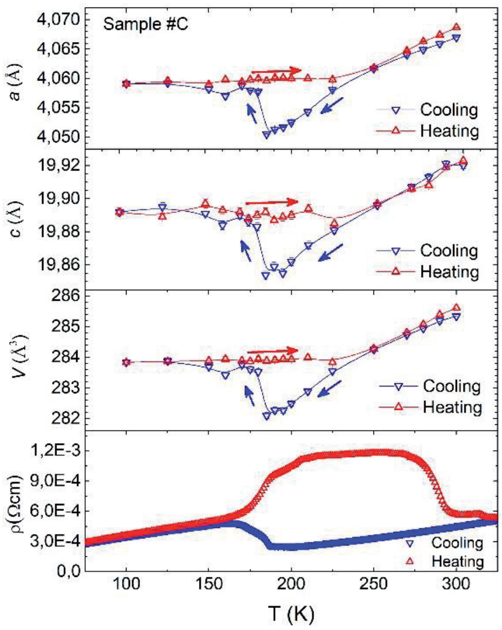
Fazni dijagram sustava CuSe, odnosno Cu2-xSe detaljno je istraživan ali usprkos tome, podaci se razlikuju u literaturi [3, 4]. Unatoč njegovoj jednostavnoj kemijskoj formuli, kristalna struktura bakarnih halkogenida zapravo je prilično složena. U usporedbi s visokotemperaturnom β-fazom iznad 400 K, struktura niskotemperaturne α-faze je znatno kompliciranija. Ranija istraživanja Cu2-xSe sustava pokazala su da je temperatura faznog prijelaza iz niskotemperaturne α u visokotemperaturnu β fazu funkcija odstupanja od stehiometrije tj. znatno ovisi o x, te se miješana faza nalazi između njih [5, 6]. Stehiometrijski spoj Cu2-xSe (x=0) prolazi kroz strukturni fazni prijelaz oko 400 K. Kako se x povećava temperatura prijelaza se smanjuje i za x=0,2 strukturni fazni prijelaz je vrlo blizu sobnoj temperaturi. Cu2Se pak pokazuje negativan termički koeficijent povezan s uređivanjem bakrovih iona pri faznom prijelazu [5].

2. Eksperimentalni dio

Mjerenja transportnih koeficijenata provode se korištenjem eksperimentalnih uređaja razvijenih na Institutu za fiziku. Detaljan opis principa i rada pojedinih mjernih uređaja opisan je u literaturi [7]. Mjerenja magnetootpora i Hallovog koeficijenta (Hallove otpornosti, $\rho_H(B,T)$) napravljena su koristeći PPMS (Physical Property Measurement System), a mjerenje magnetske susceptibilnosti korištenjem MPMS (Magnetic Property Measurement System) uređaja na Institutu za fiziku. Strukturna mjerenja napravljena su na sinkrotronu (The Advanced Photon Source, SAD) pod vodstvom dr. sc. Naveen Kumara sa Instituta za fiziku.

3. Rezultati i rasprava

Jedan dio uzoraka Cu2-xSe korišten za ovo mjerenje proizveden je u laboratoriju prof. dr. sc. Petera Gillea sa Ludwig-Maximilians –Universitäta u Münchenu, a drugi dio uzoraka proizveden je na Institutu za fiziku [8]. EDX analiza sugerira da je omjer ispitivanog uzorka Cu i Se 1,8: 1, što potvrđuju i rezultati PIXE analize, a to je konzistentno i s ranijim istraživanjima ovisnosti iznosa električne otpornosti na sobnoj temperaturi o sastavu uzorka [9]. Rezultati transportnih i termoelektričnih mjerenja našeg uzorka pokazuju veliku temperaturnu histerezu, sl. 1. Oblik histereze ovisan je jako o vremenu. Strukturna analiza pokazala je da naš uzorak sadrži oko 70 % Cu1.8Se faze i 30 % Cu3Se2 na sobnoj temperaturi. Polaganim hlađenjem, volumni udio Cu3Se2 faze varira s temperaturom, a dvije faze koegzistiraju zajedno. Promjena faznog udjela Cu3Se2 podudara se s drastičnim varijacijama u električnoj otpornosti i magnetskoj susceptibilnosti.Strukturno preuređenje tijekom faznog prijelaza može imati značajan utjecaj na samu strukturu elektronskog pojasa, a uređenje Cu iona može biti povezano s povećanjem entropije. Ovo su razlozi koji potencijalno doprinose nastanku široke histereze. Temperaturna ovisnost magnetske susceptibilnosti Cu1.8Se uzorka pokazuje dijamagnetsko i paramagnetsko ponašanje s histerezom također. Fazni dijagram CuSe sustava upravlja relativnim sadržajem dviju različitih faza prisutnih (dijamagnetske Cu2-XSe i paramagnesteke Cu3Se2) [6].



Slika 1: Parametri rešetke i električna otpornost Cu1.8Se uzorka

4. Zaključak

Fazni prijelaz povezan s histerezom je vjerojatno posljedica promjena koje se događaju uslijed uređenja bakrovih iona, te treba istražiti njegovu osjetljivost na primjenu tlaka (hidrostatskog i uniaksijalnog) kao i moguće načine poboljšanja termoelektrične učinkovitosti.

Literatura

[1] Liu, H. et al: Copper ion liquid-like thermoelectrics, *Nature Materials,* **11** (2012), 422–425, ISSN 1476-1122
[2] Hu, L.et al: Cu2Se nanoparticles encapsulated by nitrogen-doped carbon nanofibers for efficient sodium storage, *Nanomaterials,* **10** (2020), 302, ISSN 2079-4991
[3] Eikeland, E. et al: Extremely Low Thermal Conductivity and High Thermoelectric Performance in Liquid-like Cu2Se1-xSx, *Journal of Materials Chemistry,* **UCrJ4** (2017), 476
[4] Ogorelec, Z.et al: A new contribution to the equilibrium diagram of the Cu-Se system, *Journal of Materials Science,* **7** (1972), 8, 967-969, ISSN 0022-2461
[5] Smontara, A.: *Heat transport in charge density vawes*; PhD thesis, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Zagreb (1991)
[6] Ivkov, J.: *Hallov efekt u amorfnim slitinama prijelaznih metala*; Disertacija, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Zagreb (1991.)
[7] Tonejc, A.: Phase diagram and some properties of Cu2-x Se (2.01>2-x>1.75), *Journal of Materials Science* **15** (1980), ISSN 0022-2461
[8] Glazov, V. M., Pashinkin, A. S., Fedorov, V. A.: Phase equilibria in the Cu-Se system, *Inorganic Materials,* **36** (2000), 641-652, ISSN 1608-3172
[9] Chakrabarti, D.I., Laughlin, D.E.: The Cu-Se (copper-selenium) system, *Bulletin of alloy phase diagrams,* **2** (1981), 305-315, ISSN 0197-0216
[10] Vučić, Z., Gladić, J.: Growth rate of equilibrium-like-shaped single crystals of superionic conductor cuprous selenide, *Journal of Crystal Growth*, **205** (1999),136, ISSN 220248
[11] Ohtani, T. et al: Physical properties and phase transitions of β Cu2-xSe (0.20<x<0.25), *Journal of Alloys and Compounds,* **279** (1998),136-141, ISSN 0925-8388
[12] Blečić, V.: Graduate thesis, Faculty of Science, University of Zagreb, Zagreb (1979)

University of Zagreb Faculty of Textile Technology
Postgraduate university study Textile Science and Technology

PhD Students´ day 2022
Book of Proceedings

Zagreb, February 18th 2022

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Content

PhD students on other faculties of the University of Zagreb

On the postgraduate university study Textile Science and Technology

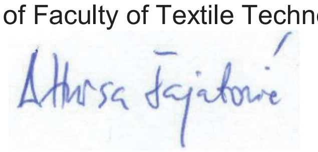
Doctoral study Textile Science and Technology (https //www.ttf.unizg.hr/en/textile-science-and-technology/226) is the only doctoral study in the field of textile science and technology in the Republic of Croatia and the most important in the region. The main objective of the study is to educate PhD students for independent scientific research, to promote innovation and to transfer the results of research in order to improve modern production processes in the textile and clothing industry. Global progress in the field of engineering particularly emphasises the research of materials and their properties, with an emphasis on the application of biotechnology and nanotechnology.

High achievements have been accomplished in composite materials, smart textiles, functional protective clothing and smart clothing. The International Council of Academies of Engineering and Technological Sciences (CAETS) has added materials research to its list of priorities, also including textile materials. The European textile industry focuses on the development of advanced technologies and materials and on the production of specialized products of high quality and functionality, while achieving high environmental standards. As part of this modern study program in Croatia, PhD students are educated to work at the university, in research and development institutions, and in the economy and the private sector. The high level of knowledge in the field of textile technology enables PhD students to participate in development projects for innovative and highly sophisticated technologies that form the basis for sustainable development and advancing economic competitiveness. Success in these processes is necessarily based on a high level of innovation, in-house research and development of new measurement methods and instruments using large laboratory facilities.

Head of Doctoral Study

Prof Snježana Firšt Rogale, PhD

Dean of Faculty of Textile Technology



Assoc Prof Anica Hursa Šajatović, PhD

Foreword

The devastating earthquake that damaged the facilities of the Faculty of Textile Technology and the worldwide pandemic COVID-19 have greatly affected the daily life, but also the scientific research work of all teachers and researchers, including our PhD students. In this context it is particularly pleasing that a large number of applications were received this year for the PhD Day of the postgraduate university study programme Textile Science and Technology.

In 2022, 40 extended abstracts of PhD students of the postgraduate university study Textile Science and Technology and one PhD student, an employee of our Faculty, who will soon defend the PhD thesis at the University of Zagreb, Faculty of Science, were published in the Proceedings of the PhD Programme. In addition to the extended abstracts of the PhD Students, the full papers of four PhDs who, since the previous PhD day, have received their PhD degree of the Faculty of Textile Technology and one of our employees who got a PhD degree of the University of Zagreb, Faculty of Humanities and Social Sciences, were published.

The Proceedings provide insight into the diversity and quality of scientific research topics and the involvement of our PhD students in the development of new, innovative methods, materials and technologies through the application of new ideas and engineering solutions.

Head of Doctoral Study

Prof Snježana Firšt Rogale, PhD

Ivona Jerković

Biography

Ivona Jerković was born in Zagreb in 1982. She graduated in 2006 at the University of Zagreb Faculty of Textile Technology, and completed the International European Master's Degree in Advanced Textile Engineering (E-TEAM) in 2009 at the University of Ghent (Belgium). In Croatia she worked in clothing industry; TKT Zlatna igla (2007), Naftalina (2010); marketing, A.O.R. (2011-2012); and at the University of Zagreb Faculty of Textile Technology on the FP7 project MAPICC 3D (2012-2015). As a part of the FP7 in 2015 she had spent at the Ecole Nationale Supérieure des Arts et Industrie Textiles, Roubaix, France. Since 2017 she has been working for the Croatian Agency for SMEs, Innovations and Investment in Zagreb on the monitoring the progress of the Croatian Smart Specialization Strategy 2016-2020 implementation and outputs and outcomes data analysis of the RDi projects at the national level.

Title of dissertation topic

New textile sensors for in situ structural health monitoring of textile reinforced thermoplastic composites based on conductive polymer complex poly[3,4-(ethylenedioxy) thiophene]-compl-poly(4-vinylbenzensulfonic acid)

Mentors

Prof. emerita Ana Marija Grancarić, PhD
Prof. Vladan Končar, PhD

Date of dissertation defense

August 26^{th}, 2021

THE INFLUENCE OF PEDOT-COMPL-PSS FILMS ON THE DEVELOPMENT OF NEW TEXTILE SENSORS AND TEXTILE REINFORCED COMPOSITES

Ivona JERKOVIĆ

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Abstract: *Smart textiles play an important role in science and various technologies due to commercial sustainability. The paper presents the influence of thin films of conductive polymer complex on the development of new textile sensors and composites.*

1. Introduction

Smart textiles play an important role in science and various technologies, primarily due to commercial sustainability and significant public interest [1]. This type of textile combines the knowledge of different scientific disciplines with the specific requirements imposed on textiles [2]. Research in this area has been growing steadily in recent years [3]. Different types of sensors can be used for smart textiles and applied in composite technology, which occupies a significant place in the automotive, railway and related industries [1, 3]. This paper presents the influence of thin films of the conductive polymer complex poly[3,4-(ethylenedioxy) thiophene]-compl-poly(4-vinylbenzensulfonic acid) (PEDOT-compl-PSS) on the development of new textile sensors and textile reinforced 2D thermoplastic composites.

2. Experimental

Aqueous conductive dispersion PEDOT-compl-PSS CLEVIOS P FORM. CPP105D (A, Heraeus, Leverkusen, Germany), or CLEVIOS F ET (B, Heraeus, Leverkusen, Germany), and an aqueous dispersion of acrylic esters, Latex Appretan 96100 (C, Clariant, Paris, France), were mixed under defined conditions for thin conductive films preparation and coating of conductive dispersion onto filament yarn [3]. Aqueous dispersion of acrylic ester copolymers was also used as a protective layer for bonding yarn filaments and to protect sensor yarn from abrasion [4].

The aqueous dispersion (A/C or B/C formation) was mixed on a magnetic stirrer (IKA Werke GmbH & Co. KG, Staufen, Germany) at a temperature of 50 °C to 40 % solvent evaporation (A/C) or 50 °C to 25 % solvent evaporation (B/C). The stirring speed of the dispersion was 550 rpm for the first 30 min and 1100 rpm for 4 h.

Thin PEDOT-compl-PSS films were prepared by applying 500 μL of conductive dispersion prepared by micropipette within cellulose acetate-based frames (dimensions 100 mm x 10 mm) onto plexiglass surface. After 48 h evaporation of the solvent under standard conditions, 20 °C and 65 % relative humidity, the thickness of the dry films was determined by an optical profilometer, Altisurf 500 (Altimet SAS, Thonon-les-Bains, France), an average of 10 profiles measured along each film. The final thickness for each conductive formulation was calculated as an average of three films. The percolation threshold of the PEDOT-compl-PSS polymer complex was determined after the completion of the electrical resistance measurements of the PEDOT-compl-PSS films by a standard Ohmmeter in a period of 75 days.

E-glass/polypropylene (GF/PP) commingled yarn, E-glass/poly(N,N'-hexamethylene adipamide) (GF/PA66) commingled yarn and E-glass (GF) yarn by PD Fiberglass group (Glasseiden GmbH, Oschatz, Germany) were used for textile sensors manufacture [4].

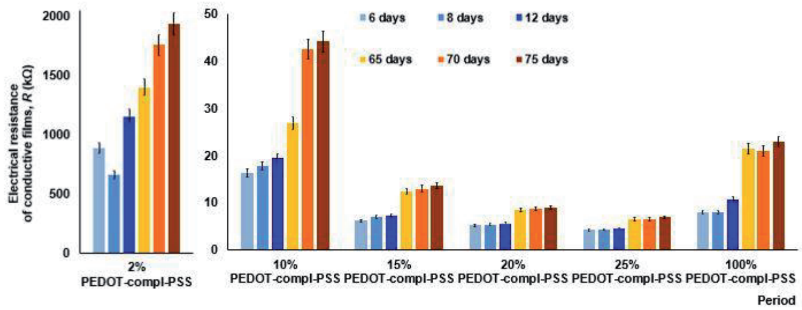
A new laboratory device with aluminum rollers and a plexiglass chamber has been developed to manufacture new textile sensors. The coating speed was 0.2 m/min due to later drying process of periodically yarn coated at a temperature of 170 °C (for GF/PP yarn) or 220 °C (for GF/PA66 and GF yarn) using HG 2310 LCD programmable intellitemp™ device (Steinel Professional, Herzebrock-Clarhol, Germany).

Textile sensors were made with only two conductive coatings of PEDOT-compl-PSS polymer complex applied according to defined protocol between two protective coatings of acrylic ester copolymer, and integrated during weaving (ARM, Biglen, Switzerland) 2D fabric, in the weft direction. 2D textile preforms (three layers) with integrated textile sensors were consolidated under defined conditions in a hot press (Dolouets, Soustons, France) into composites to perform in situ structural health monitoring of composite structures during tensile loading (Instron, Norwood, MA, USA) in real time.

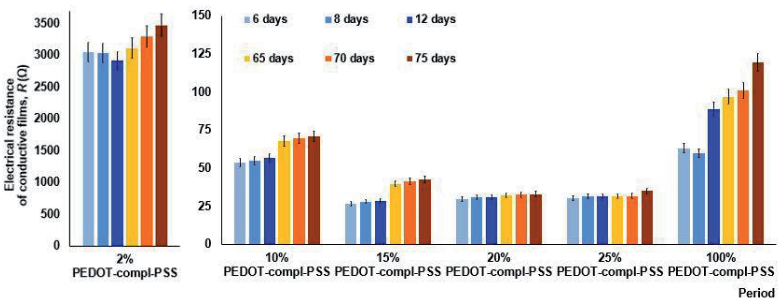
The morphology analysis of films, textile sensors and composites was performed by scanning electron microscope (SEM), MIRA\\LMU (Tescan, Brno, Czech Republic), at 3.6 kV or 5 kV and different magnification levels, and by tomography, Easy Tom machine (RX Solution, Chavanod, France), at a resolution of 10-15 µm.

3. Results and Discussion

The first group of dry PEDOT-compl-PSS films (formulation A/C) was made with a thickness range of 7 µm to 166 µm while the second group (formulation B/C) with a range of 21 µm to 169 µm. The values of the electrical resistance of these films were measured at a distance of 5 cm between the silver drops applied on the films surface, Fig 1.



a.

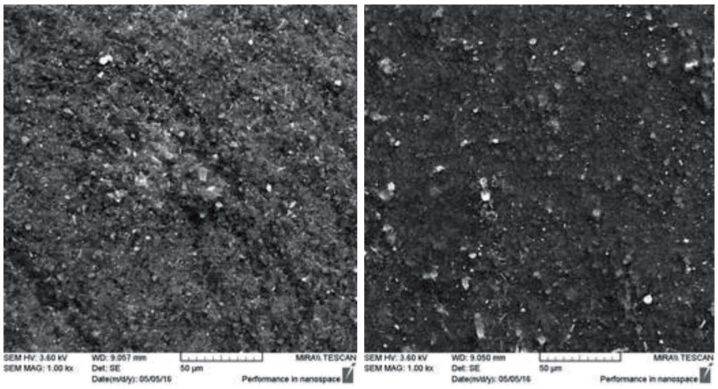


b.

Figure 1 Electrical resistance of PEDOT-compl-PSS films prepared by aqueou dispersion: a. A/C; b. B/C

In general, the electrical resistance of films decreased with decreasing thickness. Minor changes in the electrical resistance of all films were observed after 8 and 12 days of monitoring, while significant changes were observed after 65 days. The first group of films developed was less stable in terms of electrical resistance during the observed period of 75 days compared to the second group of films. As a part of the percolation threshold study [5], the logarithm of the electrical resistance values of the PEDOT-compl-PSS films was calculated to identify the threshold of polymer complex in the percolation zone. The appropriate ratio of the first formulation (A/C) corresponds to 15% PEDOT-compl-PSS (mixing A, 20 g, and C, 1.47 g). The ratio of the second formulation corresponds to 8% PEDOT-compl-PSS (mixing B, 20 g, and C, 7.13 g).

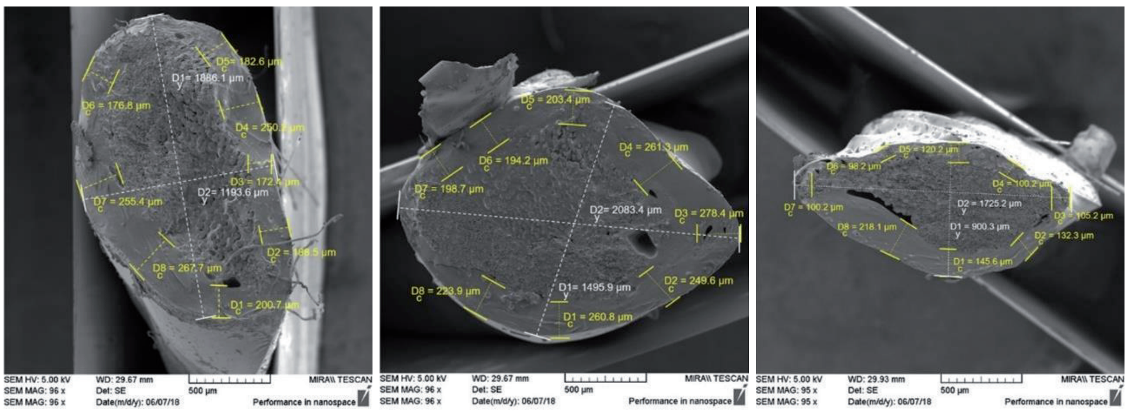
According to SEM analysis, Fig 2, the film of the second formulation (B/C, 135.67 mm ± 31 mm thick) has a more homogeneous surface compared to the film of the first formulation (A/C, thickness 30.60 mm ± 0.97 mm) due to lower percentage of PEDOT-compl-PSS polymer complex and higher presence of acrylic ester copolymer in its composition.



a. b.

Figure 2 Scanning electron micrographs of PEDOT-compl-PSS films: a. 15% PEDOT-compl-PSS film (A/C); b. 8% PEDOT-compl-PSS film (B/C)

The process of textile sensors manufacture affects the cross section of the yarn, Fig 3. The thickness of the coating depends on the mass content of the components. The higher the content of glass component, the lower the coating thickness: 212 ± 39 mm for GF/PP sensor yarn, 234 µm ± 33 µm for GF/PA66 sensor yarn, 128 ± 40 mm for GF sensor yarn. The results are in correlation with the interfacial phenomena of textile sensors. Besides, at some places within the textile sensors, hollows were detected in the conductive coating area, due to coating process, which indicates the need for more extensive study of their interfacial properties.



a b c

Figure 3 Scanning electron micrographs of: a. GF/PP sensor yarn; b. GF/PA66 sensor yarn; c. GF sensor yarn

According to tomography analysis, damaged area around the copper wire wrapped around the GF/PP sensor yarn was detected (with the addition of silver drops, textile sensor) inside the GF/PP textile reinforced 2D thermoplastic composite prior to electromechanical testing, Fig 4a. The main reasons for this damage were the temperature and pressure applied during the consolidation of the GF/PP 2D textile preform into a omposite [6]. After the electromechanical test, Fig 4b, GF filaments as a part of the sensor yarn were not completely damaged, while matrix cracks and fiber breakage within the composite were also observed.

a b

Figure 4 Tomography analysis - GF/PP composite with integrated GF/PP sensor yarn: a. Before; b. after elektromechanical test.

4. Conclusion

Conductive films have a granular morphology and a homogeneous surface. The electrical resistance of the films decreases with decreasing their thickness and significant changes were observed after 65 days. The process of textile sensors manufacture affects the yarn cross section, while the coating thickness depends on the mass content of components. The results are in correlation with the interface phenomena of textile sensors. Tomography analysis of composites indicates minor cracks, fiber breakage and sensor yarn damage.

Acknowledgement

This work has been prepared as a part of the FP7 project MAPICC 3D: One-shot Manufacturing on a large scale of 3D up graded panela and stiffeners for lightweight thermoplastic textile composite structures within the call NMP-FP7-2010-3.4-1, number 263159, funded by the European Commission.

References

[1] Grancarić, A. M. et al: Conductive polymers for smart textile applications, *Journal of Industrial Textiles*, **48** (2018) 3, 612-642, ISSN 1530-8057

[2] Van Langenhove, L.; Rambausek, M. L.: The future of smart textiles according to Systex, *Book of Proceedings of the 12th AUTEX World Textile Conference*, Mijović, B. et al (eds.) 61-68, ISBN 978-953-7105-47-1, Zadar, June 2012, University of Zagreb Faculty of Textile Technology (2012)

[3] Syduzzaman, M. et al: Smart textiles and nano-technology: A general overview, *Journal of Textile Science & Engineering,* **5** (2015) 5, 1-7, ISSN 2165-8064

[4] Jerković I., Grancarić A. M., Končar, V.: The electrical properties of poly(3,4- ethylenedioxythiophene)-poly(styrenesulfonate) films and its effect onto sensor yarn coating, *Journal of Industrial Textiles*, May 2020, ISSN 1530-8057

[5] Jerković, I., Končar, V., Grancarić A. M.: New textile sensors for in situ structural health monitoring of textile reinforced thermoplastic composites based on the conductive poly (3, 4-ethylenedioxythiophene)-poly(styrene sulfonate) polymer complex, *Sensors*, **17** (2017) 10, 1-21, ISSN 1424-8220

[6] Jerković I., Grancarić A. M., Končar, V.: Textile sensors validation to perform in situ structural health monitorıng of textile reinforced thermoplastic

Snježana Kirin

Biography

Snježana Kirin was born 1969. At the University of Zagreb, Faculty of Textile Technology she graduated with a bachelor degree in textile technology 1994. In 2007 she got a master's degree in engineering science. She got a PhD degree 2020. She worked as a technical manager in garment industry. At the Karlovac University of Applied Sciences, she has been permanently employed since 2001. Since 2021 she has been employed as college professor (engineering sciences, field of textile technology). Since 2006 to 2014 she was Head of the Textile Department, since 2014 she has been Head of the Department of Safety and Protection. She published 13 scientific papers and 3 professional papers in journals, 22 scientific papers and 20 professional papers at international conferences, 4 professional papers at domestic conferences. She published 2 books and one textbook.

Title of the Dissertation Thesis

Design of Working Methods in the Technological Sewing Process

Mentor

Assoc. Prof. Anica Hursa Šajatović, PhD

Date of dissertation defense

December 21st 2020

DEFINING STANDARD SETS OF MOTIONS IN THE TECHNOLOGICAL SEWING PROCESS USING THE MTM SYSTEM

Snježana KIRIN
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Abstract: *According to its performance structure, the technological sewing operation consists of support-hand suboperations: taking, putting together, positioning, suboperations during sewing breaks and laying off as well as the technological machine-manual suboperation of sewing. Each technological suboperation, depending on the type of clothing, position and function of the seams in the garment, and the shape and length of the contours of the seams has a different possibility of performance. The paper gives an overview of the possibilities of performing individual suboperations included in the technological sewing operation, and the methods of performing the technological suboperation of taking. Within the suboperation of taking, the methods of performance are presented, which depend on whether they are performed with one or both hands, from one, two or three bundles, and on the size of the workpiece and the length of the motion by which the workpiece is transported, thereby determining ten methods of performance. By systematic exploration of possible work methods, their standardization and elaboration to the level of basic motions using MTM (Method Time Measurement) system, standard logic sets of basic motions have been established, which can be used to determine the optimal work method which enables the determination of real norms and the reduction of workers workload.*

1. Introduction

The technological process of sewing clothes depending on the type of garment requires a relatively large number of technological operations to be carried out at workplaces. According to the organization, the technological sewing process belongs to the assembly (piece) type of the work process with the linear installation of work places, and individual technological sewing operations belong to the so-called stable workplaces of closed type with steady performance where the worker performs operations of approximately similar characteristic. This type of the workplace allows a higher degree of use of machines and devices, better workpiece transport through a production line, reduction of production cycle and increase in production capacity of each workplace, production lines and the whole production system [1]. Technological sewing operations are done usually in the sitting position at sewing machines, which have machine-manual features with a worker-machine relationship. This represents a closed cycle of necessary reactions to be performed whereby the worker plays a key role in performing the sewing process and/or making necessary decisions [2]. Such a working system requires a high degree of precision and coordination of motion with the required visual focus of the view in the central visual field with simultaneous controlling the sewing process using controlled foot motion to adjust the stitch rate of sewing and at the same time to control the distance of the seam line from the edge of the workpiece, mutual alignment of the edges of the workpiece and the length of the joint to the end of the seam [3]. The choice of working methods for a particular technological sewing operation is influenced by the shape of the seam contours (radius of curvature), the length of the seam contours, and an important role is played by the type and pattern of fabrics, the required quality and the position of the seam. In addition, the choice of a suitable working method depends on the design of the workplace (arrangement of bundles, size and height of the work surface, compatibility of the workplace with the anthropometric measurements of the workers), the type and degree of technical equipment of the sewing machine, and the system of the installation of work places [4 , 5].

The MTM system (Methods Time Measurement) provides a clear description of work methods with required normal times of individual motions, and determines the principles on the basis of which the worker with normal mental and physical abilities performs a certain sequence of motions. The MTM system consists of nine basic motions of fingers, hands and arms, two eye motions and ten motions of the body, legs and feet with about 400 normal times in performing basic motions whereby a movement symbol has been derived from the Basic English Terminology. According to possible performance variables (length of the movement, type, case, degree of accuracy etc.) the basic motions with the belonging normal times (t_n) are presented tabulated in the literature. By applying the MTM system, it is possible to determine the possibility of coordinated performance of combined and simultaneous movements. The time unit of the MTM system is TMU (Time Measurement Unit) being 10^{-5} ($3.6x10^{-2}$ s) [6, 7].

2. Experimental

Within the experimental part of the work, a systematic elaboration was carried out using the MTM-1 system, and standard sets of manual suboperations in technological sewing operations were developed. Individual suboperations in the structure of the technological operation can be carried out in several ways, depending on the size and number of workpieces, the degree of the technical equipment of sewing machines, the size and shape of the work surface, the necessary work zones and visual fields as well as the level of worker training. Tab 1 lists the possible methods of performing technological sewing operations. The sub-operations of the technological sewing process are divided into basic movements and the corresponding variables are determined according to the length of the movement, the accuracy and dynamics of the performance, the required visual and muscular control and the possibility of performance with combined and simultaneous movements. In this way, standard sets of the suboperations of the technological sewing operation were obtained, which can describe suitable working methods.

Table 1: Suboperations of technological sewing operations and methods of their performance

Suboperations	Method of performing the suboperation
taking	taking one workpiece from one bundle taking two workpieces from one bundle taking two workpiece from two bundles taking three workpieces from three bundles
putting together	putting together of one contour edges putting on the marked place
positioning	positioning under the presser foot positioning of the workpiece under the needle guided by the foot motion positioning of the workpiece in front of the needle
sewing	joint guidance basic guidance individual guidance guidance with puckering seam bartacking by the lever of the bartacking mechanism seam bartacking by the bartacking button programmed (automatic) seam bartacking guidance of the workpiece using a ruler tucking in using the hemmer tucking in using the tucking device thread trimming using the scissors thread trimming using the trimming device thread trimming using the automatic thread trimming mechanism
suboperation during sewing break	alignment of the contour edges rotation around the needle
laying off	with one hand with both hands

Next, the possibilities of performing the technological suboperation of taking regarding the workpiece dimensions, necessary sizes and shapes of work surfaces, and the possibility of performance according to the classes of sets of movements and within the frame of ergonomically suitable methods are presented. At an ergonomically designed workplace, a trained worker performs individual suboperations in a specific sequence of movements, making it possible to form logical groups of movements that represent a standard set of movements with a specific time of performance.

3. Results and discussion

Depending on the size of the workpiece, curvature and length of the seam, and the arrangement of the workpiece layers, the technological suboperation of taking can be performed in four groups of taking: one work from one bundle (A01, A02, A03, A04), two pieces from one bundle (A05, A06, A07), two pieces from two bundles with both hands (A08, A09), three pieces from three bundles (A10), Tab 2.

Table 2: Methods of performing the suboperation of taking workpieces from a bundle

Number of workpieces/number of bundles	Method of performing the suboperation	Size of workpiece	Class of sets of movements		
			30	50	80
One workpiece from one bundle	without lifting **(A01)**	large	x	x	
	with lifting **(A02)**	small	x	x	
		medium		x	x
	with both hands **(A03)**	large		x	x
		very large		x	x
	with rotating **(A04)**	medium		x	x
		large		x	x
Two workpieces from one bundle	without lifting **(A05)**	small	x	x	
	with lifting **(A06)**	small	x	x	
		medium		x	x
	with both hands **(A07)**	large		x	x
		very large		x	x
Two workpieces from two bundles with both hands	simultaneously with both hands **(A08)**	small	x	x	
		medium		x	x
	with both hands from one bundle, and then from the other bundle **(A09)**	large		x	x
		very large		x	x
Three workpieces from three bundles with both hands	simultaneously with both hands **(A10)**	small	x	x	
		medium		x	x

The basic taking movements are performed within the normal or maximum reach using the logical sequence of motions: reach (R) - grasp (G) -transport (M), whereby the workpiece is transported to the central working zone. In order to determine the length of the arm movement during reaching and transporting in the definition of model sets, the arm distance of 25 cm (class 30) and 45 cm (class 50) was determined, which are performed according to movement level III determining the zone of normal reach, while the distance of the arm length of 70 cm (class 80) is performed according to level IV within the zone of maximum reach. Depending on the dimensions, the cutting parts can be small (pockets, pocket bags, cuffs, plackets), medium (back of skirt, front of men's jacket, collar, lower and upper part of sleeves and yoke of men's shirt), large (front of skirt, front and back and sleeves of men's jacket, front of men's shirt) and very large (waistband of skirt, front and back of trousers and coats).The technological suboperation of taking one workpiece from one bundle with one hand without lifting for class 30 and 50 is presented, Tab 3, Fig 1.

Table 3 Standard set of motions for taking one workpiece form one bundle with one hand without lifting in classes 30 and 50

No.	Motion description	Symbol	Class of motion/Designation	
			30/ A01a30A	50/A01a50A
1	reach for the bundle	mRB	8.5	14,2
2	grasp the workpiece	G5/G2	5.6	5,6
3	transport the workpiece into the central work zone	MB	12.1	16,8
4	let off the workpiece	RL1	2.0	2,0
		∑TMU (s)	28,2 (1,02)	38,6 (1,39)

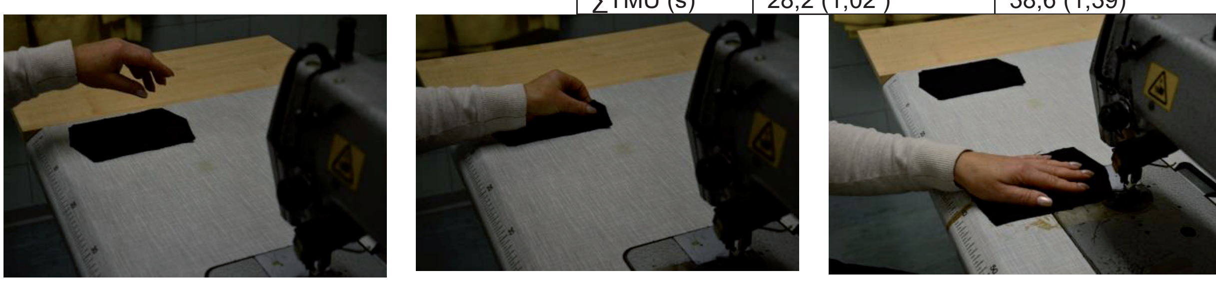

Figure 1 Sequence of motions for taking one workpiece from one bundle with one hand without lifting

These suboperations require a high level of worker training, their good motor skills and a good coordination of motions. The arrangement of the bundles in this method of taking should be such that the simultaneous performance of reaching, grasping and transport motions performed within the normal reach and the central visual field of the work surface is easily possible.

4. Conclusion

For the model system of defining work methods, standard sets of manual suboperations were analytically determined based on the logical sequence of the required motions depending on the length, case, type and dynamics of performance and the required visual and muscular control with the possibility of performing simultaneous and combined motions. The technological suboperation of taking, as the first suboperation in the structure of the technological operation, depends on whether it is performed with one hand or both hands, from one, two or three bundles and on the size of the workpiece and the length of the motion by which it is performed, can be performed applying ten methods of performance. The groups of logical motions that constitute the standard set of motions are determined by a specific sequence of motions in the technological suboperation of taking. The combination of such defined standard sets can already determine the optimal work method with appropriate normal execution times during the design of the production process and significantly influence the structure of the technological operation in terms of optimisation of technological sub-operations, resulting in shorter production time, more favourable machine efficiency and lower psychophysical stress for the workers.

References

[1] Kirin, S., Dragčević, Z., Firšt Rogale, S: Workplace redesign in the computer-aided technological sewing process, *Tekstil*, **63** (2014), 1-2,14-26, ISSN 0492-5882

[2] Dragčević, Z. Firšt Rogale, S.: Metode određivanja vremena strojno-ručnih tehnoloških zahvata šivanja, *Tekstil*, **51** (2000) 2, 51-63, ISSN 0492-5882

[3] Dragčević, Z.; Kirin, S.; Šaravanja, B.: A Method of Workplace Design for Sewing Operations, *Books of Proceedings 22nd International DAAAM Symposium „Intelligent Manufacturing & Automation: Power of Knowledge and Creativity“,* Katalinić B. (ed.), 0379-0380, ISSN 726-9679, Vienna, November, (2011)

[4] Kirin, S.: *Oblikovanje radnih metoda u tehnološkom procesu šivanja*, Doktorski rad, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb (2020)

[5] Kirin, S.; Hursa Šajatović, A.: Determination of Working Methods and Normal Times of Technological Sewing Operation using MTM System, *Tekstilec*, **63** (2020) 3, 203-215, ISSN 0351 3386

[6] Dragčević, Z., Kirin, S., Hursa Šajatović, A.: Systems of standard sets of motions in technological sewing operation, *Book of Proceedings of the 7th International Textile, Clothing & Desing Conference-Magic World of Textiles*, Dragčević, Z.; Hursa Šajatović, A.; Vujasinović, E. (ed.), 277-282, ISSN 1847-7275, Dubrovnik, October 2014, University of Zagreb, Faculty of Textile Technology, Zagreb, (2014)

[7] Aft, S.L.: Measurement of Work, Chapter 5.1. *In Maynard`s Industrial Engineering Handbook*, 5th Edition Kjell B. Zandin (ed.), McGraw-Hill, New York, USA, ISBN 0-007-041102-6 (2001) 5.3-5.22

Suzana Kutnjak-Mravlinčić

Biography	Suzana Kutnjak-Mravlinčić born in 1966 in Zagreb. She graduated in 1990 from the University of Zagreb, Faculty of Textile Technology. In 1993, she completed additional pedagogical-psychological education at the Faculty of Philosophy in Zagreb. Since 1990 she has been working at the School of Textile and Clothing Design in Varaždin. She was promoted to the title of professor mentor in 2006 and to professor advisor in 2011. As an external associate, she has worked as an assistant for Faculty of Textile Technology in Varaždin since 2007, where she became a full-time lecturer in 2015 and a senior lecturer in 2020. She has participated in 8 projects for the development of vocational and undergraduate study programs, as well as several scientific research projects. She has published 9 scientific papers at international conferences, 3 papers in international journals.
Title of dissertation topic	Influence of 3D print parameters produced by fused deposition process and geometry of lattice structures on properties of 3D printed products from acrylonitrile/butadiene/styrene
Mentors	Prof Ana Sutlović, PhD Prof Damir Godec, PhD
Date of dissertation defense	May 6th, 2021

TESTING OF MECHANICAL PROPERTIES AND COLORING POSSIBILITY OF 3D ACRYLONITRILE/BUTADIENE/STYRENE

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Abstract: *This dissertation researches the influence of parameters and geometry of 3D printing on the mechanical properties of 3D printed test specimens by the method of fused deposition modeling (FDM) from acrylonitrile/butadiene/styrene (ABS). The possibility of subsequently dyeing the 3D printed ABS products with disperse dyes by the exhaustion process and abrasion resistance was investigated. Using the determined optimal parameters of 3D printing, prototypes of heels were made from ABS.*

1. Introduction

Product design is a significant segment in which advanced science and technology enable an increased number of innovations in the industrial process, including the field of footwear production. One of the Additive Manufacturing (AM) processes that allows rapid creation of prototypes or small batches is the Fused Deposition Modeling (FDM) process [1, 2]. Although there are a number of different materials available for processing with FDM process, acrylonitrile/butadiene/styrene (ABS) is one of the most commonly used due to dimensional stability and low glass transition temperature [2]. In the last 10 years, significant progress has been made in the development of equipment and materials, but the determination of the product's mechanical properties and the influence of 3D printing parameters depending on the application is still in the research and development phase [1, 3]. According to the scientific literature, there is a small number of studies on the influence of 3D printing parameters on compressive strength. This is of great importance because many applicable products made by FDM are exposed to compressive load [3], in line with the research goal of this paper [4]. One of the limitations of 3D printing of ABS by FDM on desktop 3D printers is the printing of monochrome or two-color creations, which makes it difficult to meet the requirements of high-quality reproduction. That is why possible improvements to 3D color printing are being investigated [5, 6]. A review of scientific papers shows that there is no example of a study on the possibility of coloring 3D products printed with FDM technologies from ABS. This paper examines the possibility of subsequent straining of 3D printed products from ABS with disperse dyes by the exhaustion process. In order to obtain products with added value in the field of visual effects, the possibility of achieving ombre effects was further explored. AM procedures are leading to significant changes in many areas, including the fashion industry, and thus the application of 3D printing in the footwear sector [2, 4]. The research in this paper was carried out with the aim of applying it to the final product, constructing a prototype of a shoe's outer sole, i.e. high heels of women's shoes.

2. Experimental

This paper researches the influence of 3D printing parameters (infill, layer thickness, printing temperature) and geometry infill (honeycomb and linear filling at a 45° angle) on the mechanical properties (flexural, compressive, and impact) of 3D printed ABS test specimens. Testing of mechanical properties was executed according to the central composite design with three adjustable processing and two different geometric parameters. Determination of flexural and compressive properties was performed on a device for testing of mechanical properties of Shimadzu AGS-x, maximum force up to 10 kN, and the measurement of impact with an impact energy measuring instrument, so-called Charpy's bat. With the help of *Design Expert*, a computer program, the optimization of adjustable processing parameters was performed based on the so-called desirability functions [4]. Flexural and compressive properties, as well as infill tests, were achieved by prescribed standards: HRN EN ISO 178: 2011 Plastics – Determination of flexural properties, HRN EN ISO 604: 2003 Plastics – Determination of compressive properties, and HRN EN ISO 179-1: 2010 Plastics – Determination of Charpy impact properties.

The possibility of dyeing 3D printed ABS test specimens with disperse dyes by the exhaustion process with the aim of obtaining a uniform dyeing of good stability and achieving multicolor effects was researched. Due to the chemical structure of ABS, the test specimens were dyed with disperse dyes of primary tones (C.I. Disperse Yellow 3, C.I. Disperse Red 15, and C.I. Disperse Blue 27). The dyeing process was performed in a device for wet processing of textiles, brand Mathis AG model Polycolor, and the determination of color parameters with a remission spectrophotometer Spectraflash SF 600 plus + BIOGRAPHY UV. The dyeing was carried out with a bath ratio of OK 1:30, pH 4 was adjusted by the addition of 20% acetic acid, at 95 °C for 60 minutes [4, 6].

Abrasion resistance of mass and subsequently dyed ABS test specimens was tested using the Martindale abrader for testing of abrasion resistance and peeling tendency according to HRN EN ISO 12947-3: 2008. In line with the targeted purpose of the final product, the abrasion substrates were chosen on which the tests were performed. Substrates for indoor surfaces like linoleum and carpets made of polypropylene and wool fibers, as well as substrates of various finesses to simulate outdoor surfaces were selected [4].

Based on the geometry and dimensions of the scanned CAD model (women's shoe mold number 37 and the corresponding heel of 75 mm), in the computer program Rhinoceros 5 CAD models of prototype heels were constructed. From simpler and hollow to more complex geometric shapes. Heel prototypes were made using the determined optimal parameters of 3D printing [4]. Test specimens and heel prototypes were made by FDM from ABS on a desktop 3D printer MakerBot Replicator 2X.

3. Results and discussion

Using the central composite design, an analysis was made of the influence of three adjustable 3D print processing parameters (print layer thickness, infill, and printing temperature) and two geometric parameters (linear filling at an °45 angle (L45) and honeycomb (S)) on mechanical properties: flexural strength, flexural modulus, compressive strength, compressive modulus, and impact strength. Tab 1 shows the results of statistical data processing of mechanical properties analysis. The table summarizes the influence and trend of the influence of each adjustable parameter of 3D printing on the observed mechanical properties of the test specimens L45 and S.

Table 1 Influence of adjustable parameters of 3D printing on the observed mechanical properties

Parameter	Flexural strength σ_{fm} [N/mm^2]		Flexural modulus E_f [N/mm^2]		Compressive strength σ_x [N/mm^2]		Compressive modulus E_c [N/mm^2]		Impact strength a_{CN} [kJ/m^2]	
	L45	**S**	**L45**	**S**	**L45**	**S**	**L45**	**S**	**L45**	**S**
Layer thickness	↓	X	↑	↑↓	↓	↓	↓	↓	↑	↓↑
Infill density	↑	↑	↑	↑↓	↑	↑	↑	↑	↑	↓↑
Temperature	↓	X	X	X	X	↑	X	↑	X	↓↑

↑/↓ - *most significant positive/negative impact,*
↑/↓- *significant positive/negative impact*,
↑/↓ - *least significant positive/negative impact*,
X - *no impact*

It can be seen from the table that the most influential factor is the infill. As the infill increases, all mechanical properties increase because the active cross selection increases, which takes on the load to which the specimens were exposed during the testing. Layer thickness is the next parameter in terms of impact, but its influence on the observed mechanical properties of the specimens is not as unambiguous as in the case of infill. As a rule, an increase in layer thickness causes a (slight) decrease in the observed mechanical properties, except in the case of L45 flexural modulus and impact strength in honeycomb fillings where the impact is opposite. The least influential parameter of 3D printing on the observed mechanical properties is the printing temperature. The influence of printing temperature, on properties where it is significant, shows a complex interdependence with other print parameters.

Dyeing results of ABS specimens by the exhaustion process with disperse dyes; Cibacet Yellow 2GC (Y), Cibacet Red 3B (R), and Foron Blue RD GLF (B) in a dye concentration gradient of 0.2, 0.5, 1, 2, 3, and 4% with respect to the mass of the specimens are shown in Tab 2.

Table 2 Test specimens dyed with Disperse Yellow 3, Disperse Red 15, and Disperse Blue 27

Dye concentration with respect to the test specimens mass (*B*c, %)																	
0,2	0,5	1	2	3	4	0,2	0,5	1	2	3	4	0,2	0,5	1	2	3	4

An objective evaluation of the color of the specimens according to the CIEL*a*b* system was performed in order to determine the color parameters (*L**, *a**, *b**, *C**, *h*°). The results of spectrophotometric analysis of the specimens are presented by coloristic parameters according to the CIE system, remission, and K/S spectral curves. Fig 1 shows a comparative analysis of the test specimens of yellow, red, and blue tones in the a*/b* color space.

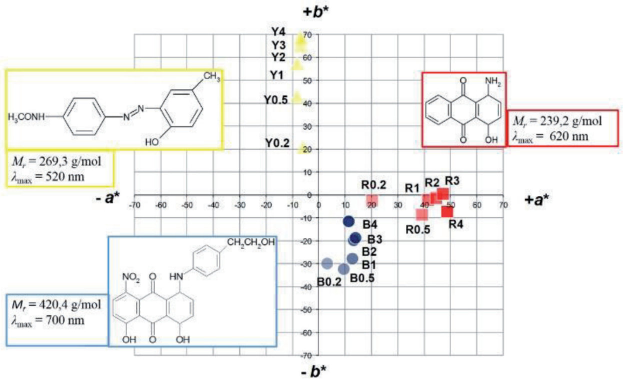

Figure 1 a*/b* color space of test specimens of yellow, red, and blue tones

Based on the obtained dye parameters, remission values, and Kubelka-Munk coefficient, dye mixtures and *ombre* effect were derived to obtain colorful patterns in the desired shades. By rotating the 3D printed ABS specimens, i.e. by changing the direction and type of dye, different multicolor effects were obtained (Fig 2).

Figure 2 *Ombre* effects of test specimens stained with a combination of primary disperse dyes

From artistic analysis point of view, since the final application is the design of footwear, it can be said that the effects show a high degree of harmonic balance and the color combinations are in a positive contrast relationship.

The results of the abrasion resistance test were evaluated by determining the change in mass after performing the abrasion procedure. The mass loss was determined based on the difference in mass after and before abrasion relative to initial mass. Based on the results obtained with indoor floor substrates, it can be noticed that the specimens have excellent abrasion resistance and their possible application for high heel creation is justified. On the other hand, the results of abrasion resistance tests under outdoor conditions show that the outer layers of the specimens are worn out with a significantly smaller number of cycles (750), which is to be expected given the roughness of such solid substrates.

The results show that mass-dyed specimens (original ABS color) are on average about 10% more resistant to abrasion compared to specimens subsequently dyed with disperse dyes. Based on the examination of optimal parameters and insight into the results of complex optimization of both types of filling, linear filling L45, layer thickness 0.15 mm, infill 40%, and printing temperature 205 °C was selected for 3D printing of ABS heels. The heel prototypes were made in cooperation with the development team of the footwear factory *Ivančica d. d.* Ivanec and were incorporated into functional and wearable models of women's shoes (Fig 3).

a b c d

Figure 3 Realized prototypes of women's shoes: a. prototype 1; b. prototype 2; c. prototype 3; d. prototype 4

Made prototypes of ABS heels are combined by classical methods of industrial production into a functional prototype of women's shoes, thus giving a scientific contribution by applying advanced technologies in the construction and production of small series of 3D prototypes or personalized shoe models in industrial footwear production.

4. Conclusion

The test results show that the geometry of the filling and the parameters of 3D printing of ABS specimens significantly affect the compressive and flexural properties as well as impact. Linear filling resulted in slightly higher properties compared to the honeycomb filling, but due to the very small difference, it can be concluded that both types of fillings result in satisfactory properties. The obtained results of dyeing 3D specimens from ABS have proven that ABS objects can be successfully dyed with disperse dyes, which is confirmed by the high values of the dyeing depth for the 4% dyes used. It has been determined that the mechanisms of the dyeing process itself can be monitored by analyzing the objective color and spectral parameters of the dye. This contributes to the optimization of the dyeing process parameters, optimization of the choices of dyes, and understanding the mechanisms of exhaustion and binding of dyes. The results show that 3D ABS products can be produced in one or more desired shades with satisfactory abrasion resistance. This undoubtedly represents an added value of 3D ABS materials and expands their application, in a dissertation in the fields of footwear design

Acknowledgement

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References

[1] Calzado, M.; Romero, L.; Domínguez et al: Additive Manufacturing Technologies: An Overview about 3D Printing Methods and Future Prospects, *Complexity (*2019), 1-3, ISSN 1076-2787

[2] Gibson, I.; Rosen, D.; Stucker, B.: *Rapid Prototyping and Direct Digital Manufacturing*, Springer, ISBN 978-1-4939-2113-3, New York, (2015)

[3] Bakir, A. A.; Atik, R.; Özerinç, S.: Mechanical properties of thermoplastic parts produced by fused deposition modeling:a review, *Rapid Prototyping Journal,* **27** (2021) 3, 537-561, ISSN 1355-2546

[4] Kutnjak-Mravlinčić S.: *Utjecaj parametara 3D ispisa postupkom taložnog očvršćivanja i geometrije šupljikavih struktura na svojstva 3D ispisanih proizvoda od akrilonitril/butadien/stirena*, Doktorska disertacija, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb, Hrvatska, 2021.

[5] Chen, G. et al: Color 3D Printing*, Color 3D Printing: Theory, Method, and Application, New Trends in 3D Printing*, InTechOpen, ISBN 978-953-51-2480-1, London, (2016), 25–51

[6] Kutnjak-Mravlinčić, S. et al: Innovative Development of Batch Dyed 3D Printed Acrylonitrile/Butadiene/ Styrene Objects, *Molecules,* **26** (2021), 21, 1-14, ISSN 1420-3049

Kristina Šimić

Biography

Kristina Šimić was born in 1984 in Metković. After graduating from the Gymnasium, she completed her undergraduate studies at the University of Dubrovnik, Department of Aquaculture, in 2004. For the best achievement in the academic year 2003/2004 she was awarded the Rector's Award by the University of Dubrovnik. She enrolled at the Faculty of Textile Technology at the University of Zagreb in 2003. She was awarded the Dean's Award in 2007 for her exceptional success in the 3rd year of study. In 2009 she graduated from the University of Zagreb, Faculty of Textile Technology. After graduating, she worked in the profession, and since 2012 she has been employed as an assistant at the University of Zagreb, Faculty of Textile Technology. She enrolled in the university postgraduate study "Textile Science and Technology" at the same faculty in 2013, and by the end of 2020 she defended her doctoral thesis.

Title of dissertation topic

Analysis of metal threads in the historical Croatian textile from 17^{th} to 20^{th} century – metal content, composition and structure of the yarn

Mentors

Prof. emeritus Ivo Soljačić, PhD

Prof. Tihana Petrović Leš, PhD

Date of dissertation defense

October 29^{th}, 2020

ANALYSIS OF METAL THREADS IN THE HISTORICAL CROATIAN TEXTILES

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Abstract: *Using physicochemical methods SEM-EDX (scanning electron microscope with energy-dispersive X-ray detector), XRF (X-ray fluorescence) and PIXE (particle-induced X-ray emission), an analysis of the composition and content of metals in the threads was performed. Independent metal threads wire and metal stripes were analysed, as well as combined, metal threads wrapped around the textile yarn called srma. The composition of non-metal textile yarn was determined by light microscopy.*

The aim of this paper is to determine which types and compositions of metal threads are used in different regions of Croatia, which can serve as a database for the restoration and conservation of valuable historical textiles. Also, according to the composition of metal threads, the technology of manufacturing threads and the approximate temporal and spatial dating of textile objects can be determined.

By comparing the methods, it was determined that SEM-EDX is the most suitable for the analysis of historical textiles if a cross-sectional analysis is performed to determine whether the metal threads are homogeneous, gilded or silver-plated.

1. Introduction

Precious metals have been used to decorate textiles since ancient times to create luxury items for the secular and religious elite. Metal threads appear in two forms, as independent or wrapped around non-metal textile yarn, in our country it is commonly known as "srma". Textile-metal yarn is obtained by wrapping a metal thread around a non-metal textile yarn that presents the core. Non-metal textile yarns can be made of cellulose fibres (linen, cotton, hemp) or protein (silk, wool). In the second half of the 20th century, synthetic fibres also appeared, most often in a mixture with natural ones. Metal thread consists of gold, silver or copper and their alloys. Aluminium began to be used in the second half of the 20th century, its silver shine can completely imitate silver, and a special process can give it a golden colour [1-5].

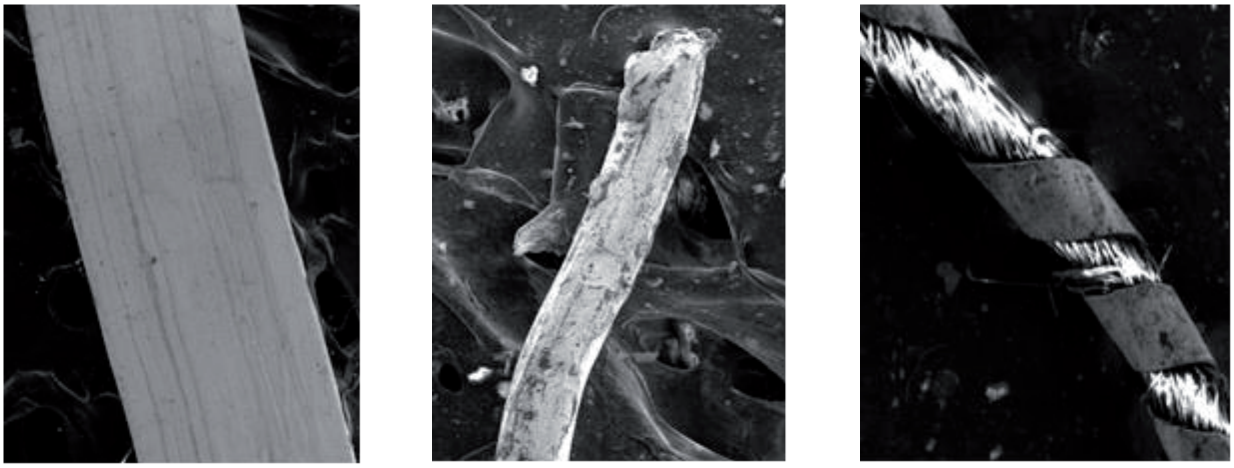
The purpose of metal threads in textiles since the beginning of their appearance has been to show power, wealth and honour. In ceremonial folk costumes, they signified a social role and showed whether it was a solemn, ritual or some other occasion. Valuable liturgical textiles decorated with shiny metal threads serve to express the glory of God. In recent times, metal threads also have some new roles such as material reinforcement or protection against static electricity or electromagnetic radiation [1].

The analysis was performed on Croatian historical textiles from several relevant Croatian museums and treasuries. With the special permission of the conservator-restorer, their supervision and cooperation were singled out, without compromising the integrity of the subject, the threads needed for research. 156 samples were analysed with three physicochemical methods (SEM-EDX, XRF and PIXE) in order to determine with greater reliability, more precisely, in what percentage the individual metals are present in the samples. A detailed analysis of the collected samples of metal threads and "srma" from historical textiles (folk costumes and liturgical attire) from the whole of Croatia was performed. In this way, a reference database was created and an analytical method for determining this type of samples was improved. The content of metals in metal threads determines their properties, purpose and origin, so physicochemical analysis is a very important step in their characterization. The analysis of metal threads in historical textiles also enables the correct choice of methods of cleaning, conservation and restoration of old, historically very valuable textile materials.

2. Experimental

The first phase of the research, collecting samples, required detailed planning of visits to museums and church treasuries throughout Croatia. The purpose of the visit to various institutions in Croatia was to inspect historical textiles, folk costumes and liturgical vestments and, if possible, to select samples of metal threads. Samples were obtained from items where sampling was possible without damaging valuable historical textiles. The collection of samples was followed by their detailed processing, visual inspection and analysis of metal and non-metal part (core) in "srma". Metal threads were analysed by SEM-EDX device, and a part of metal thread samples was analysed by XRF and PIXE methods, primarily due to the development and selection of the analytical test method. Surface and cross-sections were analysed with a SEM-EDX device to determine what type of metal thread was homogeneous or layered. The core of the "srma" was analysed with a light microscope, and it was determined which fibres it was made of.

The materials used in this paper are historical textiles, various items of liturgical vestments and folk costumes, from which samples of metal threads and silk were selected for analysis. Liturgical vestments were obtained from the Treasury of the Zagreb Cathedral (14 samples), the Varaždin City Museum (18), the Prilišće Homeland Museum (16), the Novigrad Homeland Museum near Zadar (16) and the Osijek Slavonia Museum (9). Objects of folk costumes were obtained from the Ethnographic Museum Zagreb (26 samples), Sinjska alka from Sinj (8), Ethnographic Museum Split (16), Ethnographic Museum Dubrovnik (18) and Museum of Slavonia Osijek (15). Careful sampling of only hanging threads yielded relatively small samples of individual metal threads (metal stripes and wires) and "srma", Fig 1.



a. b. c.

Figure 1 Three different metal threads analysed by SEM-EDX: a. metal stripe; b. wire; c. "srma"

SEM-EDX analysis was performed using a Tescan MIRA FE-SEM device, with an operating voltage of 20 kV and a working distance of 25 mm. The type of EDX detector is SDD (Silicon Drift Detector), silicon detector that detects from boron to uranium in vacuum. XRF analysis was performed on a device of the Artax type, manufactured by Bruker, equipped with an Rh anode X-ray tube, the voltage used was 50 kV, and the current of the electron beam was 0.7 mA. The SDD detector from XRF performs analysis of metals in the air, which allows for air pollution, and can detect elements from potassium to uranium. The characteristic X-rays from the PIXE device were excited by 2 MeV protons. Protons from a 1 MV Tandetron accelerator were used and focused using a magnetic lens system located on the ionic microprobe of the accelerator center. Measurements were made in vacuum using a PGT Si (Li) X-ray detector. The Olympus cx22 light, upright and transmission microscope, which is suitable for analysing the composition of non-metal textile yarns in "srma", was also used. The analysis was performed under a magnification of 10 x eyepieces, 10 x lenses and the total magnification was 100 x.

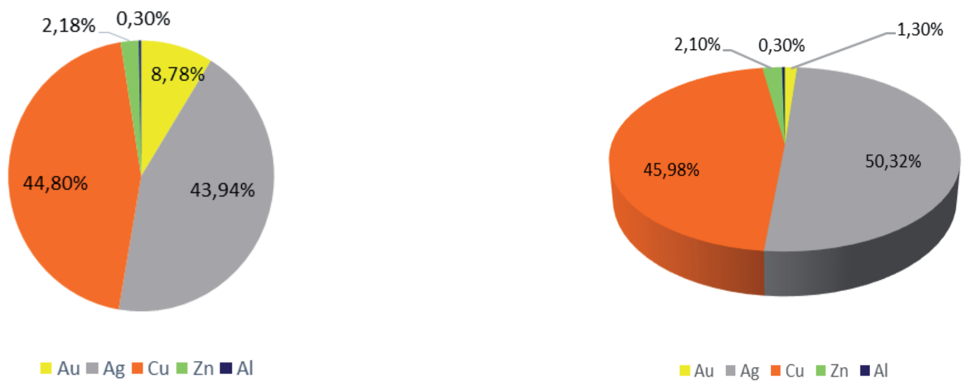
3. Results and Discussion

The analysis of "srma" established that silk and cotton are an integral part of the of "srma" core from folk costumes, while flax, along with silk and cotton, is found only in "srma" from liturgical vestments in Varaždin and Novigrad. Only silk can be found in the "srma" from the Treasury of the Zagreb Cathedral. Table 1 shows all types of metal threads according to the place which provided samples of liturgical vestment and folk costumes, it can be seen that "srma" predominates while the wire has the least.

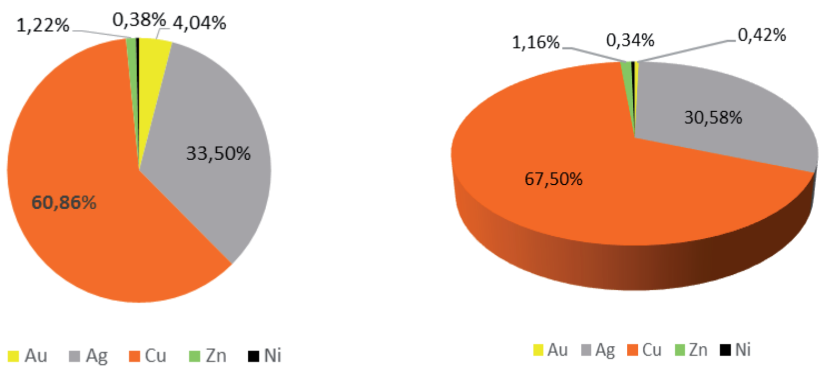
Table 1 Types of metal threads by for liturgical vestments and folk costumes

	Liturgical vestments					Folk costumes				
Metal threads	Zagreb	Varaždin	Prilišće	Novigrad	Osijek	Zagreb	Sinj	Split	Dubro-vnik	Osijek
metal stripe	3	7	3	4	1	-	2	5	-	1
wire	-	1	2	-	2	6	-	3	-	2
"srma"	11	10	11	12	6	20	6	8	18	12
total	14	18	16	16	9	26	8	16	18	15

The main difference between the chemical composition of metal threads from folk costumes and those from the liturgical costume is that in some threads from folk costumes nickel appears, and in some threads from the liturgical costume aluminium. However, these elements are minimally present in alloy samples with less than 0.50%. It is observed that there is more gold and silver on the threads of the liturgical vestment both on the surface and in the cross-section, accordingly less copper. Copper and silver are the most common elements on metal threads. Zinc is found only on some threads, the representation ranges from 1 to 3% and there is more on metal threads from the liturgical vestments, Figs 1 and 2. Samples from the Treasury of the Zagreb Cathedral are the most valuable, they are pure silver threads or gilded silver threads, and also the oldest threads dating from the 17th to the 18th century. Samples from the Museum of Slavonia Osijek are of the lowest quality copper predominates as metal, gold and silver are the least and only on the surface, this are the oldest threads from the 20th century. Figures 2 and 3 show the composition of metal threads from the liturgical vestments and folk costumes, their surface and cross section.



a. b.



a. b.

Figure 3 Composition of metal threads from folk costumes: a. surface; b. cross section

4. Conclusion

Among the analysed samples, there are the least threads that are made of pure silver or copper, as they darken over time and lose shine. There are more alloys, and these are mostly copper and zinc alloys, because they are more resistant to corrosion. Most of them are threads that are layered, have some kind of gilding. Most often, the base metal is silver or copper coated with a nobler metal, gold or silver. Cotton predominates in "srma" core, while silk is used in "srma" with a more valuable metal thread and is found in all samples from the Treasury of the Zagreb Cathedral. The composition of metal threads has changed over time, so there are two groups of samples; first is from the 17th and 18th centuries and the second from the 19th and 20th centuries. First group samples are richer in gold and silver, but also have some copper. Newer samples of metal threads from the 19th to the 20th century are mostly copper or from its alloy with zinc and less often nickel.

Comparison of used methods shows that SEM-EDX method needs surface and cross-sectional analysis as electrons do not penetrate deeper than 1 μm into the sample. The advantage is the possibility of a sample image. Protons from PIXE method penetrate up to 20 μm into the sample and gives a more precise quantitative analysis of the sample but an image of the sample cannot be obtained. X-rays from XRF pass through the entire sample (100 - 200 μm) and cannot be focused as SEM-EDX electrons and PIXE protons and accurate quantification is a problem because there are no appropriate standards. It is useful to combine SEM-EDX and PIXE methods as most sample information is obtained, while XRF can be used to quickly select many samples.

References

[1] Šimić, K.; Soljačić, I.; Pušić, T.: Primjena srme u Hrvatskoj od 11. do 20. stoljeća, *Tekstil*, **62** (2013) 3-4, 101-111, ISSN 0492-5882

[2] Raffaelli, D.; Čunko, R.; Dragičević, M.: Istraživanja srme s tla Dalmacije u razmaku od tisuću godina, *Tekstil*, **31** (1982) 12, 827-838, ISSN 0492-5882

[3] Rezić, I.; Ćurković, L.; Ujević, M.: Simple methods for characterization of metals in historical textile threads, *Talanta*, **82** (2010) 1, 237-244, ISSN 0039-9140

[4] Soljačić, I.; Čunko, R.: Hrvatski tekstil kroz povijest, *Tekstil*, **43** (1994) 11, 584-602, ISSN 0492-5882

[5] Járó, M.; Tamás, G. & Tóth, A.: The characterization and deterioration of modern metallic threads, *Studies in Conservation*, **45** (2000) 1, 95-105, ISSN 2047-0584

Petra Krpan

Biography

Petra Krpan was born in Zagreb in 1985. She graduated from the University of Zagreb, Faculty of Textile Technology, under the mentorship of Žarko Paić, PhD Full Professor. From 2012 to 2015 she worked as an assistant - external associate at the University of Zagreb, Faculty of Textile Technology, and since 2015 she has been employed as an assistant at the Faculty of Textile Technology. Petra Krpan was awarded a Rector's Award of the University of Zagreb for the work "Relief Surfaces as an Incentive in Textile Creation" in 2008 and the Dean's Award of the University of Zagreb, Faculty of Textile Technology in 2013 and the annual ULUPUH's award for best young artist in the year 2015.

Title of dissertation topic

Contemporary Fashion As An Event – The New Media and Body Transformation

Mentors

Prof Žarko Paić, PhD
Prof emeritus Boris Senker, PhD

Date of dissertation defense

February 24th, 2021

CONTEMPORARY FASHION AS AN EVENT – THE NEW MEDIA AND BODY TRANSFORMATION

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Abstract: *In my PhD dissertation 'Contemporary Fashion As An Event - The New Media and Body Transformation' I tried to establish the necessary interdisciplinary relationship between the field and the notion of contemporary fashion that emerges after the 1980s of the 20th century, new media as new opportunities for the development of the fashion process and events and their significant influence on the understanding of fashion and fashion theories after the postmodern as the new visual semiotics. This dissertation in the research and scientific sense developed the thesis that contemporary fashion cannot survive without the media influencing the body and fashion object, and at the same time changes the logic of acting in the virtual world by fashion-image appearing on the display of the media screen as the new image, but also in the performance sense as the fashion-body. The work presented the possibilities of contemporary fashion and ways of representing the body in fashion through new media and performance arts. Contemporary fashion appears as the reinterpretation and re-performance of the event. The body in fashion nowadays has an unusual role because fashion, especially after the 1990s, represents the intersection of various new media and performance forms. This dissertation represented why there is a necessary correlation between the domains.*

1. Introduction

Within fashion theories, contemporary fashion represents a significant field within the interdisciplinary social sciences and humanities. In addition to providing insights into the processes of the emergence of new identities, it also offers a accurate description of the state of fashion, in theoretical and practical terms, from the 1980s to the present day. In this doctoral thesis, the influence of performance studies and new media studies is considered, given the complexity and specificity of what we call contemporary fashion in analogy with contemporary art. The difference between theories of fashion dealing with one's own subject (such as contemporary fashion) in relation to performance theories and new media stems from the syncretic nature of the field, which has its conditional autonomy, and it is derived from understanding the essence of contemporary fashion as a transformation of the human body in society, culture, politics and the arts. Therefore, fashion theory can no longer be considered as applied discursive analyzes of sociology, anthropology, art history, psychology. The same is true for the flourishing of the already mentioned theories of performance and media studies, in terms of interdisciplinary approaches to the body, in the process of creating its all-encompassing meaning for human existence in the modern world. The reason for the growing theoretical desire to see the event by which clothing and fashion appear as an indicator of a new identity of the man in modern times stems from the globalized economy, politics and culture as a condition for recognizing the unrecognized world cultures, but also the desire to cross boundaries in understanding the body in its three modes of appearance — physical, symbolic, and visual. Contemporary fashion is autonomous, because it completely liberates the body and this has been made possible by new media and a new construction of fashion performance. Its autonomy is the result of the decline of social and cultural laws and prohibitions, while the theory of fashion is at the same time non-autonomous because "fashion cannot be understood from one scientific paradigm" [1]. Therefore, the main goal of this dissertation was to develop two basic theses which were presented in two parts: (1) Fashion derives from the legacy of semiotics and structuralism of the French theorist Roland Barthes and his organized system of the language of fashion. At the same time, the interpretation no longer insists on the rule of linguistic signifiers but the reversal takes place in the analysis of the field of fashion - image. The step towards the concept of contemporary fashion, as a performance event, stems from the change that is taking place in the deconstruction of the fashion system itself in the early 1990s. In all aspects of the relationship between new media and fashion, interactivity is at work, the transition to metamorphic states in which the boundary between the living body and the aesthetic object of fashion is shifting we can see the creativity of contemporary art. The field of fashion semiotics is crucial for understanding the emergence of fashion as a written and actual garment. Between 1957 and 1969, Roland Barthes developed a theoretical system dealing with the field of fashion codes in correlation with language. His key work from 1967 provided an exhaustive method of reading fashion photographs, but also the development of the notion of the intentionality of the advertising image. The advertisement explores the image and its meaning. The rhetoric of the image, for Barthes, has dominance over the image as an iconic sign. The complex body language that Barthes calls *vêtement* is becoming a fashion syntax. The relationship between image and language, however, does not mean the dominance of language over image, but it is an interaction in which it is the image that points to new boundaries of meaning and signification. Barthes' semiology, which ultimately deals with the relationship between image and language, is important for researching newer theories of fashion within contemporary fashion, as a discourse of revitalization and neo-historicism in the process of creating new, because it explores the meaning of image. symbolic form, and no longer just a mere message in a linear sequence from sender to receiver. (2) The reference to the field of fashion photography as a new visual essay [2], to which a separate chapter will be dedicated, seeks to plastically show and prove why the rule of pictorial in bodily event marks the idea of contemporary and the spectacular field of fascination of the observer and the effect of the utter de-realization of the fashion object. Fashion photography, too, not only serves as a visualization of the fashion archive, but is associated with the observation of a new type of consumption [3]. A new classification of consumption was also set by John Berger, talking about the suit and photography in his essay *The Suit and the Photograph* (1979). Berger, looking at photographs by August Sander (1876-1964), noticed a clear distinction between fashion and its protagonists. Fashion appears as a distinction between those who have purchasing power and those who do not, as class-social theories of fashion have claimed. Nevertheless, fashion photography, as a hybrid genre between art photography and advertising painting, in the era of the most important fashion photographers (such as Helmut Newton), clearly pointed to the main phenomenon of what the fashion body still challenges and constructs in the digital environment. Of course, it is the fetishism of the object that the psychoanalysis of Sigmund Freud and Jacques Lacan finds in the gap between nature and culture, that is, the imaginary and the symbolic. Getting closer to the secret of fashion photography and its enchanting impact on fans and fashion lovers undoubtedly means opening up the problem of the connection between contemporary fashion and fetishism, given the possibilities offered by the digital image; it is well known that Baudrillard, at an early stage of his thinking, sought to rethink this relationship with the notions of obscenity, image, longing for an object, and the hyper-reality of events. What makes contemporary fashion an attractive and at the same time simulated event of fascination with the image is certainly no longer a socio-critical analysis of capitalism of consumption at the highest level in history ever. Instead, it is necessary to start from what almost all fashion editorials want. And this, obviously, can only be what connects the image as information with the image as communication - the desire to merge with the object of desire in a way of ecstatic experience of pleasure, which Lacan places in the scopic field of vision [4].

2. Experimental

Contemporary fashion is a radical iconoclasm that destroys the logical structure of time thanks to the new media. It precedes the actuality but also includes it. Despite the significant influence of diverse social forms on fashion after the 1990s, we discern an independently developed system of language and image as new fashions. This does not mean that previous periods in the study of fashion history and its theories are not relevant. Rather that fashion is now realized as the priority of the image over language by the media construction of reality. The essence of modern fashion is the tendency to aestheticize the human body. This process began with the emergence of postmodern fashion and the thesis of the ‘end of fashion’ by the French philosopher and sociologist Jean Baudrillard (1976). From the 1960s to the early 1990s, we witnessed an attempt in the social sciences to describe the entry into a new era of the world that no longer rests on continuity of development but on discontinuity and the impossibility of a fixed identity of individuals and groups. Postmodern theories have certainly helped to understand fashion as a structured visual language, thanks primarily to French theorists Gilles Lipovetsky (1987) and Jean Baudrillard (1967). At the same time, they have contributed to the development of this interdisciplinary humanistic field through an innovative approach to fashion as a whole with a different understanding of culture and the media. Therefore, in this research, in part, we take their epistemological approaches-in the context of postmodern fashion theories, but also Roland Barthes in the semiotics of fashion and the organization of fashion language in the system, but even more in the study of advertising image in the case of fashion photography. Barthes is undoubtedly most credited for creating the notion of fashion language and what is called clothing code. To understand how clothing meaning is created we use the term dress code. What Lipovetsky, on the other hand, theoretically innovatively refers to clear structures that emphasize the dispersion and dislocation of fashion, precisely what defines contemporary fashion in the global order of neoliberal capitalism, but with the sociological premise of postmodern fashion. The second, on the other hand, is the loss of both fashion and its identity, within the newly formed social structures. But questions about fashion point to an attempt to preserve the fashion phenomenon itself within modern society. Lipovetsky clearly indicates that the form of completed fashion no longer has an epicenter and operates in different areas at different levels of collective life. New media are abolishing the epicenter of fashion, because the logic of their actions is networks without depth and borders. There is no doubt that entering the period, or paradigm, of postmodern fashion requires finding new concepts appropriate to increasing consumption, freedom in stylizing the life of the individual in the liberal-democratic culture of the West (USA and Europe in particular). What Lipovetsky calls open fashion, or a completed form of fashion, refers to the cessation of the entire structure of the modern way of articulating social relations.

3. Results and discussion

Contemporary fashion, in analogy with the conceptual and performance art of the late 20th century is determined by corporeality in all aspects of appearance. The body can no longer be understood only as a function, or structure, of the direct action of man in a predetermined world but as an autonomous event in a network of pictorial representation. Fashion hence signifies the visual construction of the body as an event and thus proves to be a fundamental phenomenon of lifestyle in today's spectacle societies. Contemporary fashion can only be constructed in the media, but there are some negative consequences for fashion and its body. As Baudrillard precisely determined, the body becomes metastatic, one that has the possibility of infinite change, but the term is associated initially with the emergence of a deadly disease, which reduces the essence of the body to the need to create a defence network against malignant influences [5]. Fashion, therefore, in the age of new media, takes place in cycles that alternate like a vertigo. It should be noted that cycles in fashion alternated as early as the early 1920s in the presentation of collections. What Baudrillard noticed as early as the late 1970s was that it was a kind of paradigm shift in society as a whole. The thesis of the end of fashion as the end of a society in which contradictions and binary contradictions of labor and capital disappear has led to a radically different understanding of the concept of fashion. The *end of fashion*, therefore, marks the end of the previous understanding of fashion and the fashion system of the 19th and 20th centuries, although we are still guided by the basic concepts set by Baudrillard. Modern fashion, as opposed to contemporary, appears as *ready-made*, while contemporary fashion is expressed in the performance act as an aestheticized event [1]. In this sense, it is necessary to show why fashion is now explained starting from the notion of the development of the technological basis of new media, and not from the irreducible essence of contemporary art. Thus, *ready-to-wear* becomes *ready-to-work*, because it starts from technology and its impact on the garment and body.

4. Conclusion

This PhD dissertation had the intent to connect the notion of performance in the context of the fashion body and its events within the new media space. Fashion research is very important for performance studies, because it represents a ‘meeting point’ for all kinds of art practices. It combines acting, dance, acrobatics and represents a physical-artistic theater, especially in the neo-historic performances of fashion designer John Galliano and his collections created in 1997, which show a combination of elements of *bricolage* and *pastiche.* This doctoral thesis had the task of analyzing the concept of fashion body, object and process in the field of performance theories, as well as the concept of fashion event that replaces the representation of fashion as a fashion collection. It is not just a mere change of place of marking, speaking in semiotic terms. The fashion collection always represents something, has a clearly defined intention, just the one Barthes talks about in the *Rhetoric of Image* review, when he says that the purpose of advertising image is intentional, which means that the commerciality of the product ultimately determines the meaning of image content. Fashion as a performance event points to the complexity of performance practices that have developed from the 1990s to the present day. Here, of course, it should be noted that shifting the focus from representation to the construction/deconstruction of the event itself, such as in the critique of spectacle and narcissism in McQueen's *Voss* (2001), is an inevitable way to reflect on the further possibilities of this dematerializing fashion. like a "ghost" and makes him an aesthetically profiled user-consumer of all the illusions and benefits of a society of hyper-consumption, as shown in his analysis by one of the most important fashion theorists Gilles Lipovetsky. Finally, this paper sought to look at the conditions under which contemporary fashion emerges, as well as the context in which its development takes place. This is done in taking over concepts from the other two key areas (media theory and performance theory), with a clear emphasis on the autonomy of fashion theories. With an interdisciplinary approach, we came to the synthesis of photography and film with fashion, which proved to be crucial for understanding the visual and medial of fashion. On the other hand, the performance of fashion discourse proves to be a turning point for understanding the essence of contemporary fashion practice. The difference between fashion and practice within the context of modernity stems from a different order or rank of concepts. Now, namely, the image precedes the language, which in a semiotic sense signifies a new order of meaning. The symbolic meaning of fashion today is primarily that it no longer refers to the frame of reference of modern society and postmodern culture. In the first case, fashion was still dependent on external factors of integration into the given social framework of the patriarchal order of values; in the second, on the other hand, everything is directed to the idea of equality and freedom of the unconquered body of the individual (democratization of fashion as anti-fashion and the predominance of marginal differentiation). What is an autonomous feature of contemporary fashion is shown in the event of body performance as the event of that traumatic and obscene, aesthetically seductive and narcissistically constructed self that immerses itself in the world of fashion as its 'natural' environment, because everything is in performance and nothing in representation, the long-gone social figures of early capitalism. Contemporary fashion marks the final synthesis of the visual and eventfulness. Everything we see happens simultaneously in virtual actualization, and it defines reality as the visual construction of fashion. Therefore, the fashion we watch does not necessarily have to be the fashion we wear, but it will certainly be the fashion we passionately want to watch, if we are not already given to decorate our own body with it. The most significant achievements of contemporary fashion designers such as McQueen, Galliano, Chalayan, Owens and van Herpen, constantly remind us that the magic and power of fashion are realized in the spectacular performance of the body in the event. From fashion, as from the world, in the end remains a catalog of fascinating images, a pure visualization of life as an aesthetic pleasure.

References

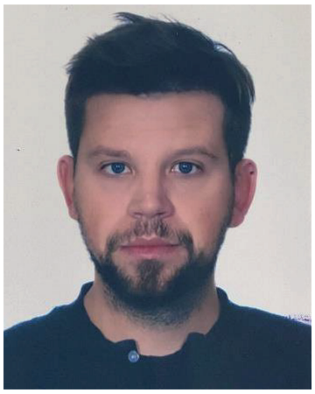
[1] Paić, Ž.: *Vrtoglavica u modi: prema vizualnoj semiotici tijela*, Altagama, ISBN 978-953-6934-30-0, Zagreb (2007)

[2] Shinkle, E.: *Fashion As Photograph: Viewing and Reviewing the Images of Fashion*, I. B. Tauris&Co Ltd, ISBN: 9780755696420 0755696425, London (2008)

[3] Radner, H.: *Fashion Cultures, Theories, Explorations and Analysis*, Routledge, ISBN 1136295445, 9781136295447, London (2000)

[4] Lacan, J: *Četiri temeljna pojma psihoanalize*, Naprijed, ISBN 9788634900255, Zagreb (1986)

[5] Baudrillard, J.: *Simulacija i zbilja,* Jesenski i Turk, ISBN 978-953-222-654-6, Zagreb (2001)



Ivan Beritić

Biography	Ivan Beritić was born in 1989. He graduated 2019 at the University of Zagreb Faculty of Textile Technology in the field of textile technology. During his studies he worked as an industrial designer, audio engineer, and performed curatorial activities in the ULUPUH Gallery. He is currently employed as an assistant at the University of Zagreb, Faculty of Textile Technology where he teaches Basics of Color Theory, Basics of Color Metrics, Special Printing Methods, Dyeing and Printing and Textile Printing.
Title of dissertation topic	
Study advisor	Prof Martinia Ira Glogar, PhD
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CONTINUOUS PICTURE-FORMING PRINT ON YARN

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Abstract: *The presentation of an idea of continuous yarn printing with the novelty of breaking the image into integral parts and positioning and printing each smallest part of the image on the yarn, so that later with the introduction of yarn into the system of rows and colums, ie knitting, creates a complete image. Each of these phases - image analysis, printing, knitting - must be computer-controlled and precisely programmed so that there is no error in the realization of the image at a later stage of knitting. The aim is to develop the principle of ring printing of yarn, and to examine certain aspects of the application of sublimation dyes in digital printing. By applying the methods of color objectification and testing the quality of the print, the idea is to test the difference between the image created in this way and the image printed in the current intermediate phase of textile fabric production, also the image conventionally printed on the finished textile fabric product would be analyzed and compared.*

1. Introduction

Continuous picture-forming print on yarn (C.P.F.P.) is designed as yarn printing, based on the principle of image breakdown into integral parts (pixels), and computer positioning and printing of precisely defined integral parts of the image on the yarn. By introducing such printed ("striped") yarn into a system of strings and rows, a complete picture would be formed on the garment. The yarn would be printed on all sides ("ring-shaped pixel") using a CMYK color mixing system. The printing will be carried out with sublimation dyes, using digitally controlled nozzles, through which a circular transfer to the yarn would be visible from all sides [1, 2]. This principle of yarn printing is designed as a pre-phase for a WholeGarment® 3D knitting device. Such devices have the possibility of producing ready-made knitted products in a ready-made number as desired, without the need for further stages of processing or sewing [3]. The advantage of such devices is the possibility of application on a wide range of products, whereby a simple change of dye enables use of on a wide variety of raw material yarn compositions. Continuous image printing on yarn brings additional flexibility to the already flexible WholeGarment® system.

2. Experimental

The experimental work will be carried out in three phases; In the first phase, the optimization of the composition and rheological properties of the printing paste, ie printing ink, will be carried out. Composition optimization involves the selection and testing of the rheological properties of thickeners, primarily viscosity as a key parameter in digital printing. In the context of the composition of the printing paste, the content of dyes, thickeners and auxiliaries will be optimized and their joint effect on the rheological properties of the finished printing paste will be examined. In the second phase, printing will be performed and the quality of the "proof of concept" prototype will be examined, as well as the quality of color reproduction. Testing the quality of color reproduction is carried out on the basis of color objectification, ie spectrophotometric measurement. Spectrophotometric measurement of the color of the prints will be performed using a remission spectrophotometer DataColor 850 with defined parameters of the measurement aperture, standard light D65 and measurement geometry d/8 °. Imprint quality testing involves testing the resistance to washing, light and friction. The tests will be carried out according to ISO standards ISO 105-B02:2013 Textiles — Tests for colour fastness — Part B02: Colour fastness to artificial light: Xenon arc fading lamp test, ISO 105-C06:2010 Textiles-Tests for colour fastness- Part C06: Colour fastness to domestic and commercial laundering, ISO 105-X12:2016 Textiles-Tests for colour fastness -Part X12: Colour fastness to rubbing and HR EN ISO 105-B02: 2013: Textiles - Tests for color fastness - Part B02: Color fastness to artificial light: Xenon lamp fading test. The tactile properties of the printed textile product will be tested with a tactile test instrument - FTT (Fabric Touch Tester, SDL-Atlas). The obtained results will be applied in the phase of improving the printing system, as well as the chemistry of the dyes themselves with the aim of realizing an improved "alpha" prototype. In the third phase, a market analysis will be carried out with the aim of setting a plan for the commercialization of the proposed printing system, and a plan for scientific cooperation will also be presented.

3. Results and Discussion

As a result of the research, in addition to the realization of a functional "proof of concept" prototype, the goal is to confirm the environmental sustainability and economic viability of the system. The realization of the prototype will be achieved through cooperation with IT and technical departments as well as with the manufacturers of devices for making 3D knits such as "Shima-Seki", and the integration of the system into the program for modeling garments [4]. The issue of mechanical parameters related to yarn tension during the introduction, as well as the development of a digital system for guiding the nozzles and the correct positioning of the image on the finished product will also be addressed. The results of dye objectification, expressed according to the CIE system, will analyze the interaction of dye and substrate and these results will be used to assess the interaction of dyes and fibers with the aim of wider use of yarn composition, as well as ecology and economy of the process. The goal is to develop an "alpha" prototype, which would be ready for the first market tests and cooperation. The research will focus on comparing pretreatment and printing of yarn compared to pretreatment and printing on finished, woven products, with the premise that yarn printing is more economical and long-term a more environmentally friendly printing option for the growing WholeGarment® sector. By exploring the possibilities of the system that would arise from the institutional and market cooperation itself, the possibility of applying the C.P.F.P. systems for the purpose of processing and refining in a continuous pre-phase.

4. Conclusion

Continuous picture-forming print on yarn allows very precise use of dyes, while 3d knitting machines enable a very fast response on the market. By connecting and perfecting these two technologies, the textile industry is one step closer to local production as needed, similar to J.I.T. system (Just In Time system) This approach would allow the development of local production of dyes, yarns and articles exactly as needed, with a globally guided design without storage and transport [5].

References

[1] Silva, M.C. et al: Digital Sublimation Printing on Knitted Polyamide 6.6 Fabric Treated with Non-Thermal Plasma, *Polymers,* **13** (2021) 12, 1-15, ISSN 2073-4360

[2] Stojanović, S; Geršak, J.; Trajković, D.: Compression Properties Of Knitted Fabrics Printed By Sublimation Transfer Printing Technique, *Advanced Technologies*, **10** (2021) 1, 46-53, ISSN 2406-2979

[3] Peng, J. et al: Development of whole garment formed on four-bed computerized flat knitting machine, *International Journal of Clothing Science and Technology*, **30** (2018) 3, 320-331, ISSN 09556222

[4] Peter, J.: Hack 1 Knit 2 - Making Whole - Garment Knitting More Open, Oslo School of Architecture and Design requirements for Master of Design, (2019)

[5] Rahman, Md. M.: Applications of the digital technologies in textile and fashion manufacturing industry, *Bangladesh Technium*, **3** (2020) 1, 114-127, ISSN: 2668-778X

Martina Bobovčan Marcelić

Biography	Martina Bobovčan Marcelić, BSc was born 1979 in Koprivinica. At the Faculty of Textile Technology, University of Zagreb, she graduated in 2008. From 2006 she was employed in company Galko d.o.o. From 2011 to 2021 she was employed as assistant at the Faculty of Textile Technology on Department of clothing technology. She works in field of welding thermoplastic polymer materials, process parameters of advanced joining techniques and the influence of welding process parameters on the properties and quality of weld.
Title of dissertation topic	Process parameters of high-tech welding methods and properties of welds on protective and intelligent clothing
Mentor	Prof Dubravko Rogale, PhD
Date of dissertation topic defense	February 30th, 2014

SIGNIFICANCE OF RESEARCH INTO THE INFLUENCE OF PROCESS PARAMETERS OF ADVANCED JOINING TECHNIQUES AND PROPERTIES OF WELDS ON PROTECTIVE AND INTELLIGENT CLOTHING

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Abstract: *In this paper, the influence of process parameters of applied advanced joining techniques on the properties of welds will be investigated. The welds to be tested were formed by welding parts of a clothing using ultrasonic welding, high frequency welding (HF), welding by thermal convection and conduction. These welding techniques are most often used in the production of protective and intelligent clothing where the welds must meet certain properties (airtightness, watertightness, elasticity, strength, etc.).*

1. Introduction

Some parts of intelligent clothing can be performed by using conventional technique of sewing, but advanced joining techniques must be used, as conventional technique of sewing can not obtain satisfactory technical and technological conditions [1]. The joining techniques used to make the welds are differ in terms of supplying and/or initiating heat at the welding zone [2]. Research has shown that the use of optimal values of welding parameters has a significant impact not only on the quality of the welds but also on other properties that are very important for a particular clothing to meet all the requirements defined by it's purpose [3].

2. Experimental

A sample of thermoplastic material (47% PU and 53% PES) was welded using the mentioned welding techniques, with different welding parameters, according to which good and bad welds were achieved, Fig 1.

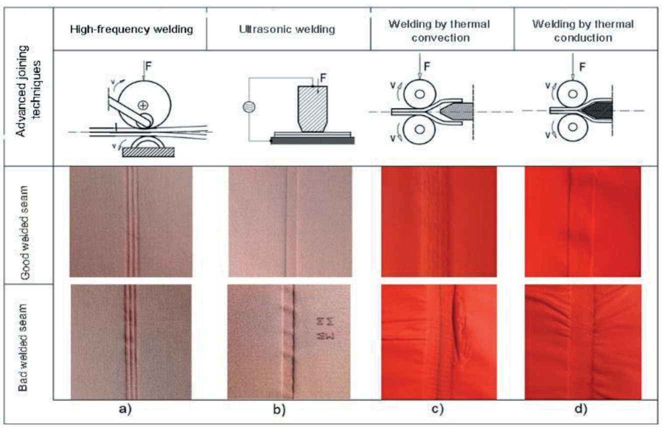

Figure 1 Advanced joining techniques and welds (good and bad): a. HF welding; b. ultrasonic welding; c. thermal welding by convection; d. thermal welding by conduction

Positively evaluated, good welds, has no accentuated extruded edges, no damage on the material, so such welds, have good strength and elasticity, and can be airtight, waterproof. It can be seen from Fig 1 that bad welds have very pronounced extruded edges, damage and wrinkling of the material in the welding zone, so these welds are unusable. During the ultrasonic welding, the welding parameters the power of the ultrasonic generator and the welding speed were changed. By HF welding, the welding parameters the anode current strength and welding time were changed. Welding by thermal convection and conduction, the welding speed and temperature were changed.

3. Results and Discussion

The parameters of ultrasonic welding with which a good weld was achieved is welding speed of 5 m/min and power of the ultrasonic generator 332 W, measurement breaking force is F_{max}=54 N and weld is airtight and watertight. Bad weld is welded at a lower welding speed, which corresponds to a longer exposure time of the material to the power of 372 W, has visible damage to the material, is airtight and waterproof, and the breaking force, F_{max}=22 N. By HF welding, a good weld was achieved at a welding time of 7 s and an anode current of 220 mA, breaking force is F_{max}=90 N and it is airtight and watertight. Bad weld was achieved by welding at a time of 7 s and an anode current of 300 mA, has pronounced extruded edges, no damage to the material in the welding zone, breaking force is F_{max}=72 N, and it is airtight and watertight. In the case of welding by thermal convection, a good weld was achieved by welding at a speed of 5 m/min and a temperature of 400 °C, the measured breaking force is F_{max}=62 N. The bad weld, with folds and damage in the welding zone, was achieved at a welding speed of 4 m/min and a temperature of 350 °C, the breaking force is F_{max}=51 N. In the welding by thermal conduction, a good weld was achieved at a speed of 5 m/min and a temperature of 350 °C and the breaking force is F_{max}=46 N. The bad weld is welded at a speed of 5 m/min and a temperature of 350 °C and the breaking force is F_{max}=34 N.

4. Conclusion

The application of optimal values of welding parameters and their combination, significantly affect the quality and properties of the welds. The use of one combination of welding parameters, eg in the HF welding, shorter welding time and higher anode current or longer welding time and lower anode current values, highly affects the visual appearance, but differs from other values of measured properties (breaking force, airtightness, watertightness) etc.). By analysing the results of properties of the welds, of four welding techniques, it can be concluded that the welds formed by HF welding technique, achieve the most favorable properties.

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References

[1] Rogale, D.; Bobovčan, M.; Firšt Rogale, S.: Suvremene tehnike spajanja elemenata na inteligentnoj odjeći, *Zbornik radova 4. međunarodno znanstveno-stručnog savjetovanja Tekstilna znanost i gospodarstvo*, Penava, Ž.; Ujević, D. (ur.), 167-172, ISSN 1847-2877, Zagreb, siječanj 2011., Tekstilno-tehnološki fakultet (2011).

[2] Grewell, D.; Benatar, A.; Park, J.: *Ultrasonic Welding in: Plastics and Composites Welding Handbook*, Hanser, ISBN 1-56990-313-1, München (2003) 142-188.

[3] Jakubčioniene, Ž. et al: Investigation of the strenght of textile bonded seams, *Journal of Materials Science*, **18** (2012) 2, 172-176, ISSN 0022-2461

Iva Brlek

Biography	Iva Brlek was born in Zagreb in 1988. Undergraduate University Study, Faculty of Textile Technology, Zagreb started 2007 and finished 2010. Graduate University Study, Faculty of Textile Technology, Zagreb started 2010 and finished 2013. doctoral study Textile Science and Technology Faculty of Textile Technology, Zagreb started 2014. In periode 2015 - 2017 worked as associate in science and higher education, employed by the project Croatian Science Foundation 9967 Advanced textile materials by targeted surface modification, ADVANCETEX at University of Zagreb Faculty of Textile Technology. Since 2017 she has been employed at the University of Zagreb Faculty of Textile Technology, Department of Textile Chemistry and Ecology as an assistent in the field of textile dyeing, printing and color metrics.
Title of dissertation topic	Cosmetotextiles – carriers of active natural substances to the skin
Mentor	Prof Sandra Bischof, PhD
Date of dissertation topic defence	June 20th, 2016

SPECTROPHOTOMETRIC ANALYSIS OF MICROCAPSULES WITH IMMORTELLE ESSENTIAL OIL

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Abstract: *Microcapsules with immortelle essential oil were synthesized for the purpose of potential textile application (cosmetotextile, wellness textile). Oil characterization is important for microcapsule identification. Analysis of immortelle essential oil, ethyl cellulose microcapsules with immortelle oil and oil-free microcapsules was performed using UV spectrophotometric analysis. Analyses were performed on a Cary 50 Solascreen UV absorption spectrophotometer (Varian Inc, USA). Qualitative spectrophotometric analysis of immortelle essential oil, followed by microcapsules containing it, confirmed the peak at 265 nm, which is characteristic for pinene. Analysis of oil-free microcapsules did not confirm the peak at the characteristic wavelength. The morphology of the microcapsules was carried out using field emission scanning electron microscope (FE - SEM) and obtained results confirm the regular spherical shape and size of the synthesized microcapsules.*

1. Introduction

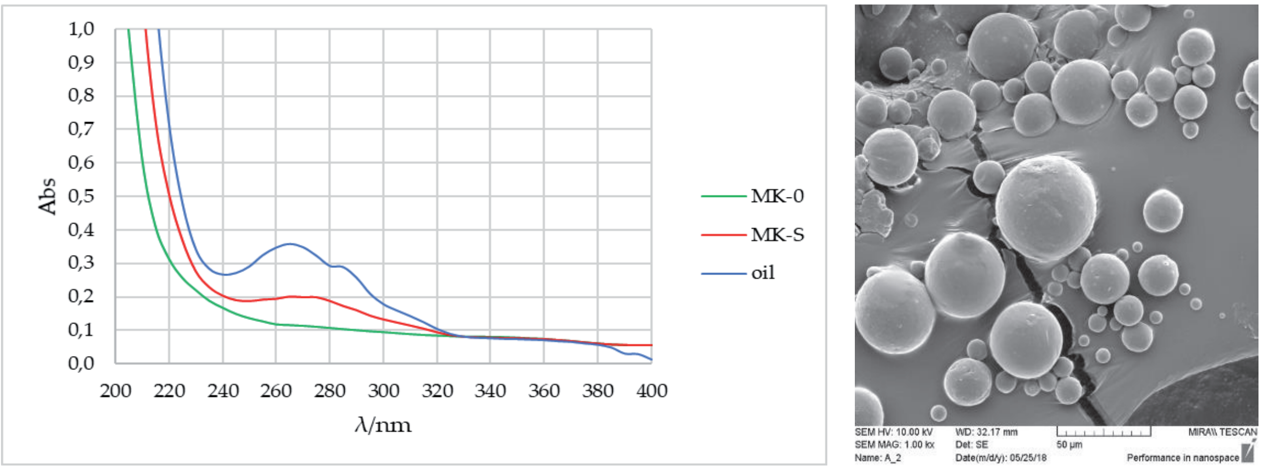
Microcapsules obtained by the microencapsulation process, micrometre size (1 μm) are divided into two parts: the core and the shell [1,2]. Microcapsules can be widely used, depending on the nature of the substance they contain, as well as the release properties, which are controlled by the shell material [3]. Immortelle (lat. *Helichrysum italicum*) is an aromatic plant of the Mediterranean area, and its medicinal properties have been known since ancient times [4,5]. Medical research tests are needed for further evaluation of a performance and promotion of immortelle as an important tool in the treatment of certain diseases [5]. Mediterranean essential oils consist of a high content of α-pinene (22%) and significant amounts of γ -curcumin (10%), β - selin (6%), netrylacetate (6%) and β-caryophyllene (5%) [1,2]. According to the literature, pinenes show a peak at 265 nm, so the aim of this study is to confirm the absorption peak of immortelle essential oil using UV spectrophotometry [6]. The same is performed for synthesized ethyl cellulose microcapsules with immortelle essential oil.

2. Experiment

The aim of this research is to characterize the essential oil of immortelle, Irex aroma d.o.o., Croatia, synthesized ethyl cellulose microcapsules with immortelle oil (MK-S) and oil-free microcapsules, i.e. empty microcapsules (MK-0) [7]. Extraction with hexane of all samples was performed before the measurement. Characterization of oil and microcapsules was performed on a UV absorption spectrophotometer Cary 50 Solascreen (Varian Inc, USA) at various wavelengths in the UV spectrum (200 - 400 nm). Surface characterization of the synthesised microcapsules was performed using Field Emission Scanning Electron microscope (MIRA\FE- SEM, Tescan, Czech Republic).

3. Results and Discussion

Spectrophotometric measurements of immortelle essential oil and ethyl cellulose microcapsules with immortelle oil (MK-S) yielded spectra with a peak at 265 nm, which confirms the literature [6]. Figure 1a shows the spectra of immortelle essential oil (oil), ethyl cellulose microcapsules with immortelle essential oil (MK-S) and oil-free ethyl cellulose microcapsules (MK-0). SEM figure, magnification 1000x (Fig 1b) confirmed the quality of the synthetized microcapsules with oil (MK-S), which were characterized by their regular spherical shape, the size range of 10-50 μm with an average diameter of 30 μm.



a. b.

Figure 1: Characterization of synthetized microcapsules by: a. UV spectre of immortelle essential oil (oil), ethyl cellulose microcapsules with immortelle essential oil (MK-S) and oil-free microcapsules (MK-0); b. SEM image of microcapsules (MK-S)

4. Conclusion

Based on the results, it can be concluded that UV spectrophotometric analysis of immortelle essential oil and immortelle essential oil in microcapsules is suitable method. The obtained results confirm the application of the presented method as relevant for the possible determination of microencapsulated oil on textile materials and their characterisation. SEM analysis confirmed the quality of the synthesized ethyl cellulose microcapsules, which were characterized by their regular spherical shape.

Acknowledgement

This work has been supported in part by the project HRZZ-IP-2013-11-9967 - ADVANCETEX, coordinated by prof. Bischof Sandra, PhD.

References

[1] Carvalho, I. T.; Estevinho, B. N.; Santos, L.: Application of microencapsulated essential oils in cosmetic and personal healthcare products – a review, *International Journal of Cosmetic Science*, **38** (2016) 2, 109–119, ISSN 14682494

[2] Lam, P.L.; Gambari, R.: Advanced progress of microencapsulation technologies: In vivo and in vitro models for studying oral and transdermal drug deliveries – a review, *Journal of Controlled Release*, **178** (2014) 1, 25-45, ISSN 01683659

[3] Jaâfar, F. et al: Impregnation of Ethylcellulose Microcapsules Containing Jojoba Oil onto Compressive Knits Developed for High Burns, *Fibers and Polymers*, **13** (2012) 3, 346-351, ISSN: 12299197

[4] Bakry, A.M. et al: Microencapsulation of Oils: A Comprehensive Review of Benefits, Techniques, and Applications, *Comprehensive Reviews in Food Science and Food Safety*, **15** (2016) 1, 143-182, ISSN 15414337

[5] Bezerra, F.M. et al: Controlled release of microencapsulated citronella essential oil on cotton and polyester matrices, *Cellulose*, **23** (2016) 2, 1459–1470, ISSN 1572882X

[6] Moore, R.N.; Fisher, G.S.: The Effect of Strained Rings on Ultraviolet Absorption Spectra, *Contribution from the Naval Stores Research section*, **78** (1956) 17, 4362-4364, ISSN 15205126

[7] Brlek, I.; Ludaš, A.; Sutlović, A.: Synthesis and Spectrophotometric Analysis of Microcapsules Containing Immortelle Essential Oil, *Molecules*, **26** (2021) 8, 1-9, ISSN 1420-3049

Darinka Cvetković

Biography	Darinka Cvetković was born in Zagreb 1962. In 1981 employed in Radio Industry in Zagreb at IETA (Electrical and Telecommunication Research). Worked in the lab for the recording and production of technical films (photographic, dry film, chemical copper double plates, galvanic baths and their analyses) and administrative work. 1984 enrolled the Faculty of Chemical Engineering and Labour. In 1990, after IETA bankruptcy, remain unemployed. In 1991 enrolled the Faculty of Chemistry and Technology, the course of the degree that graduated from. In 2009, enrolled a Distinctive Study at the Faculty of Textile Technology, in 2011 graduated from the Textile Chemistry, Materials and Ecology Course. Enrolled in doctoral studies at the Faculty of Textile Technology in 2016, with the aim of improving research competencies in self-employment. Finished school of Beekeeping PhD 2019/2020.
Title of dissertation topic	
Study advisor	Assoc Prof Maja Somogyi Škoc, PhD
Date of dissertation topic defense	

RESEARCH AND DEVELOPMENT OF THE OPTIMAL FORMULATION OF BEE PRODUCT ON A TEXTILE CARRIER FOR TISSUE REGENERATION

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Abstract: *Skin damage, i.e. wounds, is defined as a break in the continuity of the skin. According to the duration and nature of the wound healing process, they are divided into acute and chronic. Acute wounds are caused by damage or accident and heal within a predictable period of time until chronic wounds heal through the normal wound healing process. Wounds that cannot heal are the most common cause of biofilm-forming bacteria. Biofilm consists of groups of bacteria surrounded by a polymer matrix, which protects bacteria, i.e. prevents the action of antibiotics. For this reason, through the application of bee products and auxiliary active substances on the textile carrier, an attempt is made to find the optimal formulation that would prevent the formation of biofilm or open a three-dimensional structure and thus allow wound healing.*

1. Introduction

In humans, there are several types of tissues that can heal or regenerate such as skin and intestinal mucosa, and these tissues are recovered by stem cells that can proliferate and divide into a number of cell types [1]. The only human organ in which cells can proliferate and divide is the liver, in other organs after cells differentiate they stop dividing and proliferating [2]. The skin has a protective function in relation to the environment, and has regenerative properties in the process of wound healing, which includes cell proliferation (creation of new cells), migration and tissue reshaping. Difficulties in wound healing are caused by bacteria that form a biofilm that creates chronic inflammation and infections that are very difficult to treat [3]. That is, the biggest obstacle to the healing of chronic wounds is the virulence and pathogenicity of the biofilm. For the identification and heterogeneity of the biofilm, multichannel sensors based on gold nanoparticles have been developed that detect the physicochemical properties of the biofilm, after which it is treated with antimicrobial coatings [3, 4]. Modern dressings for wound healing and care contain various gels, alginate fibers, hydrocolloids, silver, charcoal, honey, PHMB (polyhexamethylene biguanide hydrochloride), silver sulfadiazine, etc. [5, 6]. Honey is also used for the treatment of chronic wounds, where there are works for manuka honey in which the effective action of honey against biofilm has been shown. Coatings with honey, mesh impregnated with honey, gel or alginate with medicinal honey, alginates with honey are just some of the combinations [6]. Honey penetrates the biofilm and kills the sessile cells trapped in the honey [7, 8]. The mechanism of antibacterial action of honey has a quadruple action. Due to its hygroscopicity, honey absorbs water from the environment and thus dehydrates bacteria. The acidity of honey stops the growth of microorganisms. High sugar content also prevents the growth of microorganisms, and hydrogen peroxide is the most important antibacterial component [9].

2. Experimental

Preliminary treatments were carried out in order to gain insight into the behavior and possibilities provided by the sol-gel process for textile modification using honey, propolis and royal jelly. By varying the type and concentration of bee products and auxiliaries, conditions, methods and procedures of processing textile fabrics with selected modifiers with variation of process parameters, the optimal processing conditions are investigated and determined which are expected to result in protective properties - prevent biofilm formation.

GLYMO + catalyst	→	Honey, propolis, royal, jelly…	→	Immersion of the flat samples in the homogenized solution at a defined speed	→	Networking Aditional fastening	→	Instrumental tehniques Antimicrobial efficacy testing

Figure 1 Schematic course of the examination

3. Results and Discussion

The use of bee products (honey, propolis, and royal jelly) and plant extracts (dandelion, sage, etc.) with the modification of textiles by sol-gel process allows obtaining the desired properties of the finished sample (antibacterial, antiviral and antifungal) while retaining textile character (touch). The sol-gel process proved to be suitable because the reactions take place at the room temperature, which is very important since some of the plants used do not tolerate high temperatures, as they lose their important medicinal properties.

4. Conclusion

Based on the findings of the review of scientific and professional literature, it turned out that the research of the possibility of using bee products in the fight against biofilm creation is relevant. Preliminary treatments are promising, honey is known to be a very rich source of vitamins and minerals, with a high sugar content and low water content, which allows it a high osmotic activity, which creates an unfavorable environment for the development of microorganisms. Preventing the adhesion of biofilm to bee products on a textile carrier seems to be a much better solution than treatment with various systemic antibiotic therapies, where the risk of developing resistance increases. By applying bee products and herbal preparations and choosing favorable compounds for wounds, it is considered that interesting products can be made with various textile carriers. Conclusions and research relate only to preliminary results, and due to many influential factors and very pronounced specifics, it is necessary to continue research by including more variations of process parameters and characterization methods in the synergy of natural and technical sciences with biomedicine and health.

Acknowledgement

The research is carried out within one of the activities of the research project HRZZ IP-2019-04-1381 "Antibacterial coating for biodegradable medicine materials, ABBAMEDICA, head of the project Assoc. Prof. Iva Rezić, PhD PhD, funded by the Croatian Science Foundation.

References

[1] Žlender, V.: Apoptoza - programirana smrt stanice, *Arhiv za higijenu rada i toksikologiju*, **54** (2003) 4, 267-274, ISSN 0004-1254Friar, G.: Stem Cells Evolution + Development Protein form and function. The science of self-repair: regeneration research at Whitehead Institute, *Dostupan na:* https://wi.mit.edu/news/science-self-repair-regeneration-research-whitehead-institute, *Pristupljeno:* 2.12.2021.

[2] Škrlin, J.: Utjecaj biofilma na cijeljenje rane i postupak za identifikaciju biofilma u rani, *Acta Med Croatica*, **70** (2016) 1, 29-32, ISSN 1330-0164

[3] Xiaoning, L. et al: Rapid Identification of Bacterial Biofilms and Biofilm Wound Models Using a Multichannel Nanosensor, *ACS Nano*, **8** (2014) 12, 12014-12019, ISSN 1936-0851

[4] Mihelič, M.; Planinšek Ručigaj, T.: The role of therapeutic dressings with silver in chronic wound therapy, *Acta Med Croatica*, **69** (2015) supl. 1, 73-75, ISSN 1330-0164

[5] Štilet, P.; Ručigaj Planinšek, T.: Obloge za liječenje kroničnih rana, *Acta Med Croatica*, **70** (2016), supl. 1, 69-77, ISSN 1330-0164

[6] Triller, C.; Huljev, D.; Planišek Ričugaj, T.: Suvremena pokrivala za rane, *Acta Med Croatica*, **67** (2013) supl. 1, 81-87, ISSN 1330-0164

[7] Kučišec-Tepeš, N.: Uloga antiseptika i strategija uklanjanja biofilma kronične rane, *Acta Med Croatica*, **70** (2016) 1, 33-42, ISSN 1330-0164

[8] Eteraf-Oskouei ,T., Najafi, M.: Traditional and Modern Uses of Natural Honey in Human *Diseases, Iranian Journal of Basic Medical Sciences,* **16** (2013) 6, 731-742, ISSN 2008-3866

Daniel Časar Veličan

Biography

Daniel Časar Veličan was born in Zagreb, where he finished primary and secondary school. In 2016, he completed his undergraduate studies in Textile Technology and Engineering at the Faculty of Textile Technology in Zagreb. Since April 2019, he has been employed as an assistant within the Research Project funded by the Croatian Science Foundation, IP-2018-01-6363 Development and thermal properties of intelligent clothing and in accordance with the approved work plan of the career development project of young researchers - training of new doctors of science HRZZ-DOK-2018-09-7933.

Title of dissertation topic

Research of process parameters of technique of joining thermoplastic polymeric materials by technique of high frequency electromagnetic field

Mentor

Prof Dubravko Rogale, PhD

Date of dissertation topic defense

RESEARCH OF PROCESS PARAMETERS OF TECHNIQUE OF JOINING THERMOPLASTIC POLYMERIC MATERIALS BY TECHNIQUE OF HIGH FREQUENCY ELECTROMAGNETIC FIELD

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Abstract: *In the doctoral thesis, the process parameters of the technique of joining thermoplastic polymeric materials using a high-frequency electromagnetic field will be investigated. The focus of the research will be on, so far, less researched process parameters such as the electrical capacity of the joint part, the phase angle between current and voltage and the angle of dielectric losses.*

1. Introduction

Intelligent clothing with adaptive thermal insulation properties is based on the use of segmented thermal insulation chambers [1]. Compressed air is blown into the chambers, and the degree of activation of individual chambers depends on the thermal protection of the garment by controlled conduction and convection of human body heat. Conventional methods of joining textiles by sewing methods can be used to make the outer shell of intelligent clothing, its lining and only a few built-in elements. In some cases, sewing is completely impractical and inadmissible method. For this reason, for the production of intelligent clothing, but also demanding protective clothing, it is necessary to apply new modern methods of joining parts. Modern high-tech joining methods used in the technical scientific field have proven to be excellent for the mentioned purposes. This especially refers to the joining of thermoplastic polymeric materials by ultrasonic technique, thermal techniques with the application of the conduction and convection effect and the application of the technique using a high-frequency electromagnetic field [2, 3].

2. Experimental

As part of the doctoral thesis, the determination of voltage amplitudes and shapes on connecting electrodes, current amplitudes and shapes on connecting electrodes, phase angles between voltage and current at connection, current strength, connection power, connection frequency, connection time, connection pressures and testing of strength of joints when varying process parameters will be performed. A laboratory device for determining the capacitance of connecting electrodes during connection using a high-frequency electromagnetic field, dielectric constant and loss angle of polymer connection systems will be constructed, patented and manufactured.

The design, patenting and construction of a laboratory device for determining process parameters in the connection of thermoplastic polymeric materials using high-frequency electromagnetic fields on a unit surface with the possibility of varying high-frequency voltage, current, power and frequency, connection pressure duration. A measuring system and a measuring method for determining the process parameters of the joint part will be established by applying a technique using a high-frequency electromagnetic field. Mathematical interdependencies of process parameters of joining polymeric materials of parts of intelligent clothing, but also conventional, especially protective clothing, will be investigated and discovered.

3. Results and Discussion

All process parameters characteristic of the technique of joining thermoplastic polymeric materials using a high-frequency electromagnetic field will be tested. Joining of thermoplastic polymeric materials will be performed on the machine Zemat mark Depta, Fig 1. The power of the machine is 4 kW, with the possibility of very precise regulation of process parameters in the whole area, and especially precise regulation of power around the value of 1 kW.

Special attention and research of the influence on the characteristics of the compound will be paid to the process parameters that have not been researched so far or have been insufficiently researched.

Figure 1 Machine for high-frequency joining of thermoplastic polymeric materials Zemat mark Depta

If the results of the research will be sufficient for the construction of own measuring equipment for determining the value of the stated process parameters, the realization and patent protection of the mentioned measuring device will be approached.

4. Conclusion

Using a state-of-the-art machine for joining thermoplastic polymeric materials, research will be performed on all relevant process parameters of joining thermoplastic polymeric materials using a high-frequency electromagnetic field, focusing on unexplored process parameters. Depending on the quality of the obtained results, a measuring device will be constructed and a new measuring method will be established.

Acknowledgement

The research is carried out as part of activities on the research project Development and thermal properties of intelligent clothing (IP-2018-01-6363) funded by the Croatian Science Foundation and as part of the Career Development Project for Young Researchers-Training of New Doctors DOK-09-2018-7373.

References

[1] Firšt Rogale, S. et al: *Inteligentna odjeća*, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, ISBN 978-953-7105-52-5, Zagreb, (2014)

[2] Mitelea, Ion et al: The High Frequency Welding Aptitude of Thermoplastic Polymers, *Materiale Plastice*, **46** (2009) 1,101-107, ISSN 2668-8220

[3] Qiu, J.: Thermal Welding by the Third Phase Between Polymers: A Review for Ultrasonic Weld Technology Developments, *Polymers* **12** (2020), 1-26, ISSN 2073-4360

Ivana Čorak

Biography

Ivana Čorak was born in Slavonski Brod in 1992. She graduated at the University of Zagreb Faculty of Textile Technology in 2015. Since 2019, she has been employed at the University of Zagreb Faculty of Textile Technology as an assistant in the Young Researchers' Career Development Project Bio-innovated polyester material aimed for use in a hospital environment (HRZZ-DOK-2018-09-4254). She worked as a quality specialist at Boxmark Leather d.o.o. She is a collaborator on the bilateral scientific research project and the project HRZZ UIP-05-2019-8780 Hospital protective textiles. She received the Interim Deans Award for Excellence at the Postgraduate University Study of Textile Science and Technology in 2019/2020 and the Textile Science Research Center Award in 2021. Her scientific interest is related to methods of modifying polyester fabrics and the development of antimicrobial textiles. She co-authored 2 scientific and 1 professional papers in the journal, 5 full papers in proceedings, and 2 abstracts.

Title of dissertation topic

Study advisor Assoc Prof Anita Tarbuk, PhD

Date of dissertation topic defense

BIO-INNOVATED POLYESTER MATERIAL AIMED FOR USE IN A HOSPITAL ENVIRONMENT

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Abstract: *Research within the doctoral thesis will include the development of bio-innovated polyester materials aimed for use in a hospital environment in three phases. The first phase is the activation of the polyester fabric surface by hydrolysis with emphasis on the sustainability of the process. The second phase involves the preparation of sub-micron chitosan particles into a homogeneous polymer and its implementation on the surface of the activated fabric. In the third phase, the antimicrobial efficiency will be tested along with the persistence of the treatment to the maintenance process.*

1. Introduction

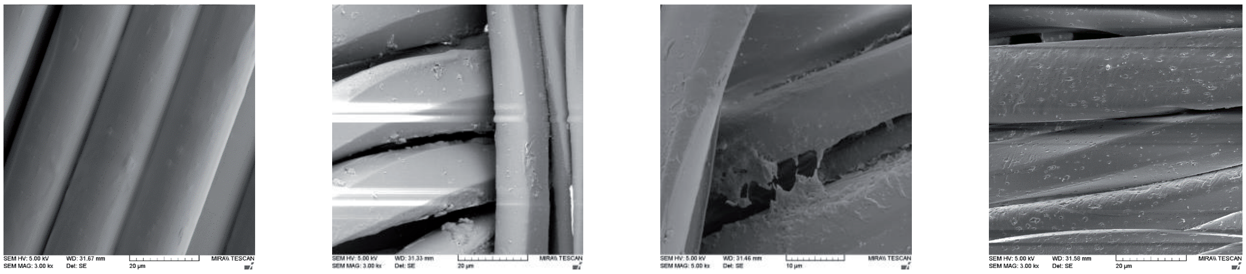
Poly(ethylene terephthalate), PET, is the most widely used synthetic fiber due to its excellent mechanical properties. However, due to the high crystallinity of PET, the fibers have low hydrophilicity, accumulate static electricity, piling, etc., which results in problems in wet finishing and in comfort when worn. These problems have been improved by alkaline hydrolysis and aminolysis, but these processes are not eco-friendly due to the use of strong alkalis and high temperatures and lead to irreversible damage of the material as well. Recently enzymes have been investigated as an alternative to the chemical treatment of alkalis and amines. For enzymatic hydrolysis of PET, the enzymes lipase, esterase, and cutinase can be used. It has been studied mainly on films and foils, and very little on textiles [1-3]. After cellulose, chitin is the second most abundant polysaccharide in the natural environment. Chitin is a structural polymer of marine invertebrate shells, fungal cell walls, and insect skeletons. Chitin is a linear polysaccharide consisting mainly of 2-acetamido-2-deoxy-β-D-glucopyranose residues and partly of 2-amino-2-deoxy-β-D-glucopyranose interconnected by β-(1→4) glycosidic bonds. Its chemical structure complicates its solubility in water and most organic solvents, and therefore numerous studies of the chemical modification of chitin that lead to a soluble form in readily available solvents have been conducted. Chitosan is a natural biopolymer obtained by enzymatic or chemical deacetylation of chitin and is considered to be its best-known derivative. It is widely available in various forms such as gels, membranes, nanofibers, micro- and nanoparticles. Due to its physico-chemical properties, it can be used to produce smart materials for hospital use. It dissolves in aqueous solutions of acids such as acetic, citric, formic, hydrochloric, and lactic acids. Great interest in this polymer stems from the properties of the polymer: biocompatibility, biodegradability, non-toxicity, antimicrobial and hydrating properties that positively affect the wound healing process [4].

2. Experimental

As part of the first phase, a study of the hydrolysis of PET fibers in the fabric was performed to find an eco-friendlier process for surface activation to improve hydrophilicity and keep satisfactory mechanical properties. Alkaline hydrolysis at low temperature and enzymatic hydrolysis using lipases were performed on a Linitest instrument, Original Hanau, with a bath ratio of LR 1:50 at temperatures of 60-100 °C from 5 min to 2 h. For alkaline hydrolysis, 1.5 M NaOH without and with the addition of an accelerator of 4 g/l cationic surfactant hexadecyltrimethylammonium chloride (HDTMAC, 25% aqueous solution) was used. Enzymatic hydrolysis was performed with Amano Lipase A from Aspergillus Niger (ALA) and Amano Lipase from Pseudomonas fluorescens (ALAK) in alkaline and acidic medium with variation in enzyme concentration. Weight loss was determined according to ISO 3801:1977, loss in breaking force according to ISO 13934-1:2013 and analysis of the surface by scanning electron microscopy on FE-SEM, Mira II, LMU, Tescan at 3000x magnification. In the second phase, sub-micron chitosan particles were prepared on a Planetary Micro Mill PULVERISETTE 7 premium line using ceramic balls with a diameter of 20 mm for 48 min at 900 rpm. Fractions larger than 1 μm were separated by sedimentation and smaller ones by evaporation.

3. Results and Discussion

After the alkaline and enzymatic hydrolysis, the weight loss and the decrease of the breaking force were calculated. The required weight losses of 5 to 15% were obtained by processing, with a maximum loss of breaking force of up to 30%. Analysis of the results with regard to the viability of the hydrolysis process showed that the optimal process parameters for treatment with the enzyme Amano Lipase A from Aspergillus Niger (ALA) are as follows: concentration 0.1 g/l, pH 9, 60 °C, 60 min, Fig 1b. The enzyme Amano Lipase from Pseudomonas fluorescens (ALAK) is effective in both acidic and alkaline media, but the most favorable conditions are: concentration 0.2 g/l, pH 9, 60 °C, 60 min, Fig 1c. Alkaline hydrolysis can be carried out at reduced temperature with the addition of an accelerator. The best effects are at 80 °C, 10 min, Fig 1d.



a. b. c. d.

Figure 1 SEM image of PET fibers in fabrics: a. Untreated; b. ALA-0.1g/l-pH9-60°C-60'; c. ALAK-0.2g/l-pH9-60°C-60', d. NaOH+HDTMAC-80°C-10'

4. Conclusion

Considering the obtained parameters after the alkaline and enzymatic hydrolysis, it can be concluded that the hydrolysis of the surface of PET fabric can be carried out in an environmentally, energetically and economically acceptable way by properly selecting the process parameters. Research on the implementation of sub-micron chitosan particles on an activated fiber surface to obtain antimicrobial material for use in a hospital environment is forthcoming.

Acknowledgement

The work has been supported in part by the "Young researchers' career development project – training of doctoral students" of the Croatian Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Croatian Science Foundation. This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-8780 **H**PROTEX.

References

[1] Čorak, I.; Pušić, T.; Tarbuk, A.: Enzimi za hidrolizu poliestera, *Tekstil,* **68** (2019) 7-9, 142-151, ISSN 0492-5882

[2] Grancarić, A. M. et al: Utjecaj obrade na efekte alkalne hidrolize poliestera, *Tekstil,* **37** (1988) 1, 689-694, ISSN 0492 - 5882

[3] Guebitz G. M.; Cavaco-Paulo, A.: Enzymes go big: surface hydrolysis and functionalization of synthetic polymers, *Trends Biotechnol*, **26** (2008) 1, 32-38, ISSN 0167-7799

[4] Sikorski, D.; Gzyra-Jagiela, K.; Draczynski, Z.: The Kinetics of Chitosan Degradation in Organic Acid Solutions, *Marine Drugs*, **19** (2021) 5, 236, ISSN 1660-3397

Katia Grgić

Biography	She was born in Dubrovnik 1978. Graduated on the University of Zagreb, Faculty of Textile Technology in 2006. The postgraduate doctoral study of Textile Science and Technology enrolled. From 2009 until today, has been employed as an expert associate at the Faculty of Textile Technology. Work experience has been gained as technologist at Dorateks d.o.o., procurement coordinator at L'OREAL ADRIA d.o.o. and as teacher at the Crafts School of Dubrovnik. Participated in FP7, EUREKA, PoC 5, OPCC projects as well as three Research grants. She is a member of the team on HRZZ and OPCC projects. Field of exploration is innovative technologies and characterization of fabric surface. In addition to the professional and research activities, also worked as Occupational safety and health specialists II. Degree until 2019.
Title of dissertation topic	Adsorption of cetylpyridinium chloride on cellulosic substrates
Study advisor	Prof Tanja Pušić, PhD
Date of dissertation topic defense	October 28th, 2020

ADSORPTION AND DESORPTION OF CETYLPYRIDINIUM CHLORIDE IN ELECTROKINETIC ANALYZER

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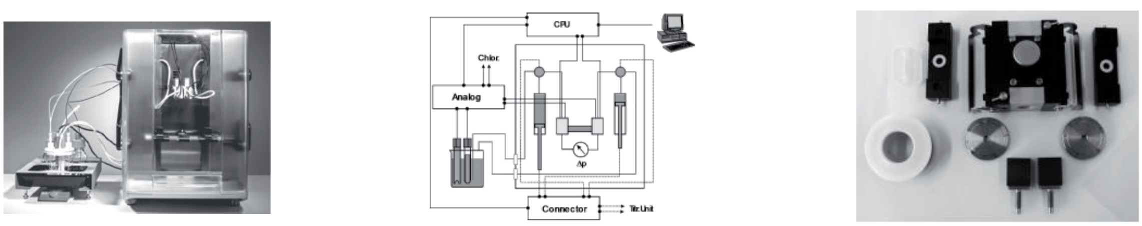
Abstract: *Cetylpyridinium chloride (CPC) is a cationic surfactant that belongs to the group of quaternary ammonium compounds (QAC). It is used in various fields of application, mostly in cosmetics, pharmacology and dentistry due to its bactericidal and antiseptic activity. The aim of this work is investigation of the adsorption of CPC from a micellar solution to a standard cotton fabric and its desorption by measuring the streaming potential in an electrokinetic analyzer at different pH-values.*

1. Introduction

The positive charge of the cationic surfactant reacts with negatively charged surfaces in the aqueous medium [1]. The increased concentration of cationic surfactant in aqueous media under the influence of van der Waals forces leads to a process of self-aggregation into micelles. These organic colloidal particles are within the range from one milimicron to one micron [2]. The critical micellar concentration (CMC) depends on the chemical structure of the surfactant, the solvent, the presence of electrolytes and the temperature [3]. According to the literature, the CMC of cetylpyridinium chloride in potassium chloride solution (0.0013 mol/kg) is 0.000266 mol/kg at a temperature of 25 °C [4]. The aim of this study is the adsorption of CPC from micellar solution to standard cotton fabric by the streaming potential method at different pH values (pH 4, pH 6 and pH 9) and desorption of CPC at pH 6 and 25 °C in an electrokinetic analyzer using electrolyte solution (KCl).

2. Experimental

The adsorption of CPC from the micellar solution on a standard cotton fabric was monitored in an electrokinetic analyzer SurPASS (A. Paar) Fig 1a and Fig 1b, by the streaming potential method, using an Adjustable Gap Cell (AGC) Fig 1c.



a. b. c.

Figure 1 SurPASS electrokinetic analyzer: a. SurPASS; b. schematic view; c. Adjustable Gap Cell (AGC) [5]

The measurement of the zeta potential (ζ) was performed depending on pH values (pH 4, pH 6 and pH 9) with 1 mmol/l KCl an electrolyte and 2.4 mmol/l CPC as an adsorbate.

3. Results and Discussion

Adsorption of CPC from micellar solution was investigated at different pH values (pH 4, pH 6 and pH 9) in three phases, Fig 2. The first phase (I) refers to the determination of zeta potential at pH 4 (ζ = -13.9 mV), pH 6 (ζ = - 18.3 mV) and pH 9 (ζ = -21.5 mV). The second phase (II) was dedicated to monitoring the rate of CPC adsorption reaching the equilibrium state. The measurement was performed with defined aliquots of the adsorbate for all selected pH values. Fig 2 shows that the adsorption curves at all pH values are monitored throughout the range. The Point of Zero Charge (PZC) of a cotton fabric was specified by 350 μg/g of CPC. The third phase (III.) refers to the desorption of CPC from cotton fabric in electrolyte solution (KCl) at pH 6 and 25 °C. According to the presented results, differences between individual desorption equilibrium curves are visible (phase III). The less negative desorption curve was obtained for the CPC-cotton fabric system (pH 9). The decrease in negativity is associated with less stable systems at pH 6 and pH 4.

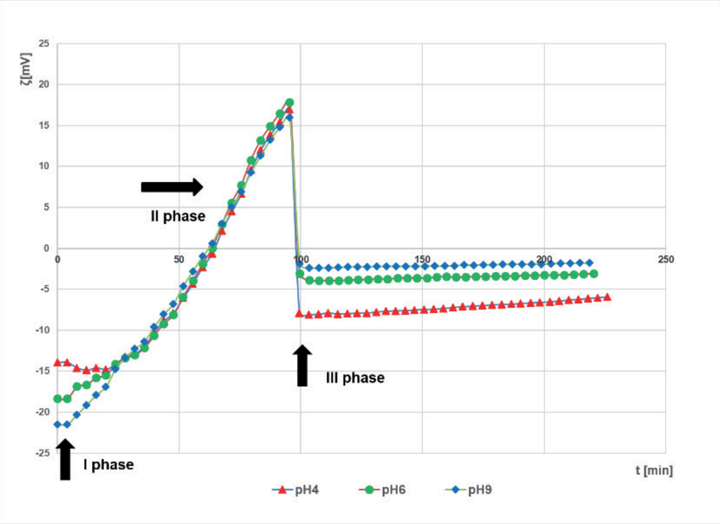


Figure 2 Adsorption of CPC from micellar solution on cotton fabrics at different pH values (pH 4, pH 6 and pH 9) and its desorption at pH 6 in an electrokinetic analyzer

4. Conclusion

The results of the study showed a negligible effect of pH on the adsorption of CPC on cotton fabric in an electrokinetic analyzer. However, the obtained differences in the desorption of CPC from cotton fabric showed that the best stability in CPC retention was obtained for the adsorption system CPC-cotton fabric-pH 9.

References

[1] Soljačić, I.; Pušić, T.: Čišćenje u vodenim medijima, U *Njega tekstila–I dio*, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, ISBN 953-7105-08-3, Zagreb, (2005), 56-68

[2] Kallay, N. et al: Equilibrium of counterion association in micellar systems, Cetyltrimethylammonium bromide, *Annales Universitatis Mariae Curie - Sklodowska*, **63** (2008) 5, 61-67, Lublin, Polonia, ISSN 2083 358X

[3] Bigler, N.: *Die Tenside CIBA Geigy Rundschau 2*, CIBA, ISSN: 0366-5453, Zeitschrift, Print (1971)

[4] Mukhim, T.; Ismail, K.: Micellization of cetylpyridinium chloride in aqueous lithium chloride, sodium chloride and potassium chloride media, *Journal of Surface Science and Technology*, **21** (2005) 3/4, 113-127, ISSN 0970-1893

[5] Instruction Manual SurPASS™ Electrokinetic Analyzer; Copyright © Anton Paar GmbH, A48IB046en-B, Graz, Austria, (2013)

Barbara Iskerka Pavlica

Biography	Barbara Iskerka Pavlica graduated from Faculty of Textile Technology the University of Zagreb, in 2012, Graduate study Textile Technology and Engineering. From February 2013 until today, she has been employed as an examiner in the laboratory MIRTA-KONTROL d.o.o., laboratory testing, certification, expertise and engineering. Since 2014, she has been attending the Postgraduate University Study, Textile Science and Technology.
Title of dissertation topic	Determination of metal ions in textile materials for children's toys
Study advisor	Prof Branka Vojnović, PhD
Date of dissertation topic defense	/

DETERMINATION OF METAL IONS IN TEXTILE MATERIALS FOR CHILDREN'S TOYS

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Abstract: *In this paper are presented preliminary results of determining the level of certain metals (Ag, Ba, Cd, Cr, Pb, Se) and metalloids (As) in toys available on our market. To determine the concentration and content of metals and metalloids, the method of sample preparation was used - determination of specific migration according to the guidelines of the standard EN 71-3, which includes extraction in 0,07 M HCl. Preliminary results indicate that metal ions are released from the selected toy sample, where the content of tested metal ions in the tested sample was below the migration limit prescribed by standard EN 71-3.*

1. Introduction

European Union policy gives extremely high priority to product safety and the protection of citizens' health, primarily the protection of children's health. Therefore, great attention is paid to ensuring the safety of children's toys, which must be safe for their daily use. The European Commission (EC) has therefore proposed laying down rules for monitoring the content of a number of organic and inorganic substances in toys by the Toy Safety Directive [1]. The Directive is also supported by the European standard series EN 71 which ensures compliance with the essential requirements of the Directive [1] and includes 11 individual standards. Standard EN 71-3 is designed to assess the migration of certain chemicals from a toy into a child's body in case of swallowing a toy or toy part and describes a method for determining the amount of soluble trace elements that migrate from the material of a child's toy [2]. This standard specifies requirements and test methods for the migration of heavy metals and toxic elements such as Al, Sb, As, Ba, B, Cr(III), Cr(VI), Co, Cu, Pb, Mn, Hg, Ni, Se, Sr, Sn and Zn. In this preliminary research the standard HRN EN 71-3 is applied to determine the specific migration of certain metal ions (Ag, Ba, Cd, Cr, Pb, Se) and metalloid (As) from a sample of randomly selected children's toy on the domestic market. The content of these metals was determined by the Inductively coupled plasma - optical emission spectrometry, ICP-OES method [1, 2].

2. Experimental

Standard solutions for the quantitative determination of the metal content on the ICP-OES spectrometer are prepared by diluting certified standard solutions of 1000 mg dm^{-3} of a individual metal. Simulant solutions were prepared by diluting concentrated acids. Determination of metal ion content was performed on a selected sample of toy from the domestic market.

Samples for the determination of specific migration of heavy metals must contain representative parts of the entire surface, which are often not made of the same type of material, Fig 1. The test sample consists of a sample of textile material cut up in small pieces whose mass should not be less than 100 mg. Sample dimension of cut up small pieces should not exceed 6 mm. When sampling, it should be taken into consideration that the sample is representative. Material types and the proportion of their presence in each individual sample should be taken in account, provided that a sample of between 10 and 100 mg should be taken from the basic material.

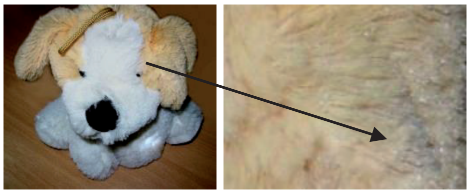

Figure 1 Plush toy for testing

This procedure is performed according to HRN EN 71-3, Safety of toys - Part 3: Assessment of metal ion migration is performed by immersing the toy or toy parts in 10 cm^3 of 0.07 M hydrochloric acid solution, the concentration of which simulates gastric acid, for two hours at 37 ± 2 ºC. After 2 h, the sample should be allowed to stand for 1 h and filtered through a membrane filter. Metal ions are determined by ICP-OES method from the filtrate. Under such simulated conditions, the acid content is determined analytically to determine if metal ion release has occurred. If metal ions are present in the acid, it means that they have 'migrated' from the toy to the acid and as such, depending on the amounts found, reflect the potential danger (risk) to the child.

3. Results and Discussion

Migration limit values for toys or toy components differ into three different categories of toys according to [1] and [2], each of which has different restrictions for chemicals related to the likelihood of ingestion:
a) dry, brittle, powder-like or pliable toy material
b) liquid or viscous toy materials: that can be swallowed and/or exposed to children's skin during the game
c) scraped-off toy materials: surface coatings, polymers (hard), polymers (soft), other materials, wood, textile, glass, ceramics, metals and alloys [3, 4].

Table 1 Metal content in the tested samples expressed in [mg/kg] for specific migration

metal / simulant	γ(Ag) [mg/kg]	γ(As) [mg/kg]	γ(Ba) [mg/kg]	γ(Cr) [mg/kg]	γ(Cd) [mg/kg]	γ(Pb) [mg/kg]	γ(Se) [mg/kg]
HCl (0,07 M)	0.019	0.001	n.d.	0.003	n.d.	0.003	n.d.
uz. 1 HCl (0,07 M)	0.514	0.004	n.d.	0.021	21.06	1.693	n.d.
uz. 2 HCl (0,07 M)	0.032	n.d.	0.245	1.524	2.060	n.d.	n.d.
uz. 3 HCl (0,07 M)	n.d.	0.001	0.476	0.016	7.669	3.352	n.d.
$\overline{uz.}_{1,2,3}$ HCl (0,07 M)	**0.182**	**0.002**	**0.240**	**0.520**	**10.263**	**1.682**	**n.d.**
σ	0.325	0.002	0.194	0.710	7.971	1.368	n.d.

n.d. - below the lower limit of determination

Tests have shown that individual metal ions are released (migrated) from the analyzed toy sample. There is an increased content of cadmium compared to other elements, slightly lower content of lead and barium, Tab 1, which indicates the release of barium ions from the sample since the sample is composed of polyester in the production of which barium salts are used. The described research will try to develop a method for determining certain metal ions, depending on the method of sample preparation. Newly developed method will determine whether there is a potential danger of migration of metal ions from children's toys in simulated conditions of sucking (saliva simulant), friction (saliva simulant, sweat), ingestion (HCl simulant). It is also necessary to examine the possibility of migration of metal ions from textile toys, dyed with various dyes, because it is known that dyes for textile materials may contain larger amounts of metals, whether metals are part of the dye molecule or metals have entered the dye as a catalyst or contaminant in the sintering and dye production process.

4. Conclusion

Metal ions present in larger quantities in the ionic state can often endanger health, especially if it is the health of young children. The described research will determine whether there is a potential danger of migration of metal ions from children's toys. Tests have shown that individual metal ions migrate from the analyzed sample of children's toy. Preliminary results of determining the specific migration indicated that metal ions migrate from the toy in the case of the swallowing simulation, but their concentrations are below the limit (maximum allowed) concentrations. Further research will try to test other means of migration (simulants) such as artificial saliva and artificial sweat, and compare the obtained results with a certain total amount of each metal in the sample of a toy. Other methods of sample preparation for the analysis of metal ion migration from textile materials intended for children's toys will also be examined and a comparison of the results will be made.

References

[1] Direktiva 2009/48/EZ Europskog parlamenta i vijeća od 18. lipnja 2009. o sigurnosti igračaka (Tekst značajan za EGP), Službeni list Europske unije L 170/1; 18.6.2009
[2] HRN EN 71-3:2019 Sigurnost igračaka -- 3. dio: Otpuštanje određenih elemenata, (EN 71-3:2019) European Committee on Standards (CEN), EN 71-3:1994 Safety of toys – Part 3: Migration of certain elements, ICS 97.200.50, 1994
[3] Zakon o predmetima opće uporabe (NN broj 39/13, 47/14 i 114/18)
[4] Pravilnik o sigurnosti igračaka (NN broj 83/14, 38/15, 35/17, 50/18, 60/19 i 48/21)

Josip Jelić

Biography

Josip Jelić was born 1980 in Zagreb, where he finished primary and secondary school. Graduation from the University of Zagreb Faculty of Textile Technology he earned 2015. Postgraduate Doctoral Study Textile Science and Technology he enrolled in 2017 at the Faculty of Textile Technology University of Zagreb.

Title of dissertation topic

Melt electrospun fibres varied in geometry

Study advisor

Prof Budimir Mijović, PhD

Date of dissertation topic defense

PLA SCAFFOLDS FABRICATED BY MELT ELECTROSPINNING FOR TISSUE ENGINEERING

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Abstract: *Electrospinning from polymer melt is carried out using high voltage and cooled to form microfiber structures with a diameter of ten micrometers, although studies indicate hundredths of a micrometer and nanometer in diameter. In this regard, the technique is important in the biomedical field where tissue engineering carriers with bimodal (nano and micro) fibrous structures are preferred in terms of tissue cell adhesion. In this paper, an overview of melt electrospinning devices is given, followed by their comparison with the new Spraybase melt electrosprayer device. This device enables high-precision melt jet deposition in 2D and 3D programmed architectures, with various translational speeds of the collector plate in the X-Y and the melt head in the Z direction. The fibrous structures from the melt are designed depending on the types of tissue cells used to develop the support.*

1. Introduction

Electrospinning of polymer melt is a relatively new spinning technology, as seen by the publications in this field that all date after 2011. Literature on polymer melt electrospinning accounts for just 1% of the overall electrospinning literature [1]. Polymer melt electrospinning is an ideal technique for the production of highly porous nano- or microfibre structures that are suitable for biomedical use. In recent decades, melt electrospinning has been recognised as an ecological procedure, as it has eliminated the cytotoxic effects of solvents used in electrospinning. As an ecologically acceptable method of spinning micro- and nanofibers, electrospinning has been attracting the interest of many scientists. There is increased interest also of direct 3D printing of biopolymers with a scaffold design in tissue engineering. Melt electrospinning typically produces microfibres with a diameter ranging from 5-40 μm, though this technology is also capable of producing fibres with a diameter of just 0.5 micrometres [2, 3]. In the field of regenerative medicine, this is highly applicable, as melt electrospinning is capable of producing tissues with a higher resolution than is possible using 3D printing. In recent years, there has been a massive surge in the demand for polymer nanofibers, that are used for a variety of applications, including tissue engineering, protective clothing, filtration and sensor systems.

2. Material and methods

Electrospinning of polylactides will be performed on the Spraybase® AS-1204-000-01; Avectas Ltd., Ireland, Fig 1, within the Department of Fundamental Natural and Engineering Sciences at the University of Zagreb, Faculty of Textile Technology.

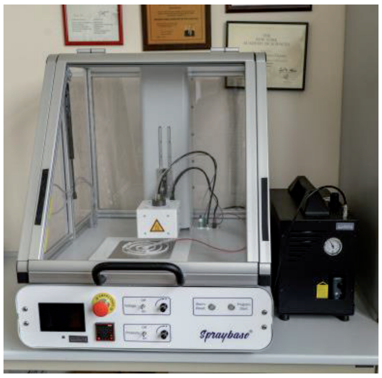

Figure 1 Spraybase® melt electrospinning device

Device for electrospinning from polymer melt, consists of the following components: 1) high voltage source (electric voltage up to 20 kV), 2) head with tank for melting polymer and the possibility of movement along the Z axis, 3) heating system (temperature up to 250 °C), 4) air compressor for extrusion of polymers (pressure up to 5 bar), 5) collector in the form of a metal flat plate with the possibility of movement along the X and Y axes and additional heating and 6) protective chamber. Work on the device for electrospinning from polymer melt will be carried out in several steps.

The first step is to create a 2D model in the program "SEL program generator", then to generate a program and a table with the coordinates of the collector path in the MSEL control system, which also serves to control the device. On the device control panel, the desired parameters will be set. The desired voltage, pressure, and temperature will be selected. Optimization of process parameters refers to air pressure, melting temperature, electric voltage, and distance of the head with the polymer tank from the collector. Optimization is preceded by adjustments of the head of the collector, the speed of movement of the collector, the number of cycles of electrospinning (number of layers) and filling the tank with polymer granules.

3. Results

The main goal of this research is related to the influence of filament geometry and density on the porosity and permeability of fibrous structures. Accordingly, for each sample from three groups, the porosity will be calculated using a digital Dino Lite microscope. Sample snapshots will be processed in the *ImageJ* program. In a group of samples spun from the melt in one layer of PLA polymer, air permeability will be measured.

4. Conclusion

The polymer melt electrospinning technique is becoming increasingly popular, with a number advantages over polymer solvent electrospinning techniques: more ecologically acceptable production conditions, ability to produce materials with specific geometry, and microfibre production, which has wide-ranging applications in biomedicine. In this study, microfibre materials were produced from polymer (PLA) melt electrospinning with a description of the design of the 2D model to make three groups of materials with differing geometry and filament density. The primary aim of this study will be to determine the influence of geometry and density of filaments on porosity and permeability.

References

[1] Hochleitner, G. et al: High definition fibrous poly(2-ethyl-2-oxazoline) scaffolds through melt electrospinning writing, *Polymers*, **55** (2014), 5017-5023, ISSN 2073-4360

[2] Dalton, P. et al: Electrospinning of polymer melts-Phenomenological observations, *Polymers,* **48** (2007), 6823-6833, ISSN 2073-4360

[3] Dalton, P. et al: Direct in vitro electrospinning with polymer melts*, Biomacromolecules*, **7** (2006) 3, 686-690, ISSN 1525-7797

Tea Jovanović

Biography	She was born in 1993 at Metković. In 2012 she finished High school of Economics at the city of Ploče. At that year she started her study at Faculty of Textile Technology. In 2018 she enrolled doctoral study at University of Zagreb Faculty of Textile Technology. She graduated at the same Faculty three years ago with Master's degree. Currently she is working as an Account Manager at Wiip Technology d.o.o.
Title of dissertation topic	Hysteresis curve of elastic knitted fabrics
Study advisor	Prof Željko Penava, PhD
Date of dissertation topic defense	

HYSTERESIS CURVE OF ELASTIC KNITTED FABRICS

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Abstract: *Elastic knitted fabrics have various specific functional purposes. Elastic knitted fabrics are used to make classic swimsuits and trunks. Similar knitted fabrics are used in the production of modern and luxury female underwear which compressively lies on the body. Preventive compression stockings, pantyhose and medical compression stockings are also made from special elastic knitted fabrics. Many modern recreational clothes, including different forms of pants, shirts or bras, are also made from elastic knitted fabrics which produce a compression effect on certain body parts. For example, handball and basketball players are wearing elastic knits on their sleeves. Their function is protection and to keep muscles active during a game. With skiers the whole body is exposed to specific elastic knits that provide a feeling of ease when wearing. They maintain body heat and keep muscles warm util the start of the race. Weightlifters use lightweight elastic materials due to the ease of lifting.*

1. Introduction

Under the so-called static tensile loadings on a dynamometer, knitted fabrics usually stretch transversally and/or longitudinally to break. The obtained curve describes the relation between force and elongation. Elongation at break in elastic knitted fabrics is very often from 100 to even 600%. The force/elongation diagram can be divided into three parts. The first part is considered linear and is assumed to represent the elastic area. The second part of the diagram is rounded and represents the elastic plastic area of the knitted fabric. Some knitted fabric structures are elastic up to the end of this diagram part. The third area starts at the beginning of the second linear part of the diagram. It is assumed to be the beginning of plastic deformation of the knitted fabric or permanent deformation, and usually stretches to the highest force at tear of the knitted fabric. When describing tensile properties of a knitted fabric, it is suitable to calculate and list elongation shares for the three areas. In some knitted fabric structures, the analysis also includes the vertex point of the force/elongation curve. In many cases, these three points are used as the basis in multiple loadings of the knitted fabric and in studying of its tensile properties during use or on a dynamometer under cyclic loadings. In numerous elastics knitted fabric structures, significantly different deformations are achieved at these three points [1, 2].

2. Experimental

The hysteresis curve of the elastic knitted fabric of fine women's stockings (FC), recreational shirts (M), pants (H), swimsuits (K) and elastic ribbons (EG) was studied after five cyclic loadings. In most textile elastic materials, the hysteresis curve index ranges from 0 to 1. The provided results of cyclic loadings of the knitted fabrics represent, through the hysteresis curve, some distinctive elastic knitted fabric structures. The samples for measuring tensile properties of knitted fabrics were cut out transversally and longitudinally and stretched up to the three given points: 1. End of elasticity, 2. Vertex point and 3. Point where permanent deformation of knitted fabric begins.

3. Results and Discussion

The first hysteresis curve diagram, Fig 1a describes transverse cyclic knitted fabric elongation to the beginning of permanent deformation, i.e., elongation up to 280%. The knitted fabric represents the structure of a fine women's stocking (FC) lying on the upper leg and made from PA multifilament yarn in the count 33 dtex. The knitted fabric has the smallest hysteresis index (H_p) of only 0.093. The other hysteresis curves presented, Fig 1b, are obtained by transversal knitted fabric elongation up to the vertex point of the force/elongation curve or 100% elongation. The sample was cut out from an unused recreational shirt (M). The hysteresis curves have significantly different shapes from the previous ones and the hysteresis index at the vertex point (H_i) is 0.419. Figure 1c shows hysteresis curves for unused recreational long pants, where the knitted fabric was stretched transversally up to the vertex point (80%). The hysteresis index is 0.701. Fig 1d shows hysteresis curves of elastic ribbons used to make underwear and various clothes. The ribbon was 15 mm wide, stretched to 100 % and has the largest hysteresis index of 0.920.

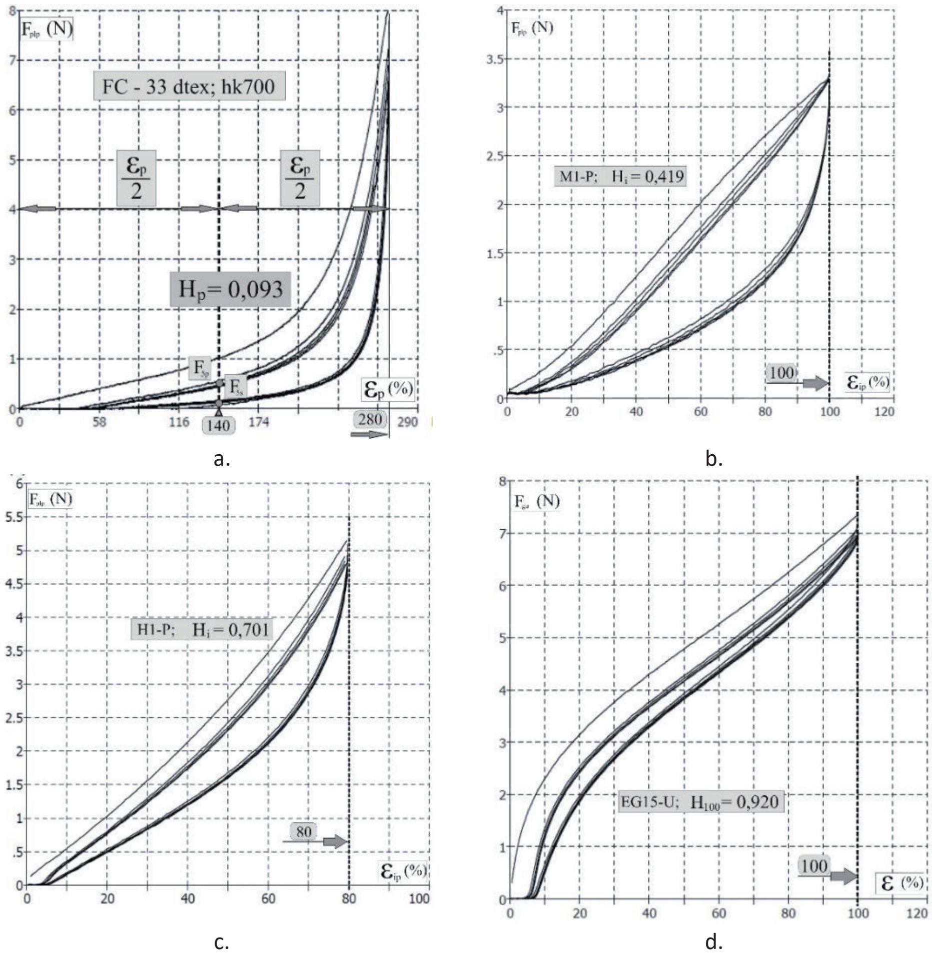

Figure 1 Hysteresis curve diagrams of elastic knitted fabrics: a. fine women's stockings (FC); b. shirts (M); c. pants (H); d. ribbons (EG)

4. Conclusion

The hysteresis curves shown represent different groups of elastic knitted fabrics under multiple loadings (five loops). The obtained hysteresis indices are from 0.093 to 0.920. The results indicate that hysteresis curves adequately describe structures and tensile properties of knitted fabrics, especially the elastic ones, and that these results should be used in the design of elastic products which exert compression on the body, where it is necessary to coordinate the desired compression and elongation amount of the knitted fabric. The analysis of hysteresis curves can help to determine the difference in static and dynamic knitted fabric deformations and predict compression drop during use of an elastic knitted product.

References

[1] Matsuo, M.; Yamada, T.: Hysteresis of Tensile load – Strain Route of Knitted Fabrics under Extension and Recovery Processes Estimated by Strain History, *Textile Research Journal*, **79** (2009) 3, 275-284, ISSN: 0040-5175

[2] DIN 53835-2/3/4/13/14: Prüfung von Textilien; Prüfung des zugelastischen Verhaltens; Textile Flächengebilde, einmalige Zugbeanspruchung zwischen konstanten Dehngrenz

Nikolina Jukl

Biography

Nikolina Jukl was born on October 25, 1987. in Sv. Nedelja. In 2010 she completed her undergraduate university studies, and in 2013 her graduate university studies at the University of Zagreb, Faculty of Textile Technology. In 2013, she enrolled in the postgraduate university study of Textile Science and Technology at the University of Zagreb, Faculty of Textile Technology. In the period from 2003 to 2013 she worked occasionally at Konfeks d.o.o. where she gained experience in the production process, and from 2013 to 2022 she was employed as a production manager. In 2022 she was employed at the University of Zagreb at the Faculty of Textile Technology as an assistant. She has published a scientific paper in Q2 journal, a professional paper in a domestic journal, one scientific paper at a domestic conference and one at an international conference. She is a researcher on the scientific project HRZZ IP-2018-01-6363 Development and thermal properties of intelligent clothing.

Title of dissertation topic	Influence of the type of embedded materials and construction of composite clothing on the overall thermal properties of clothing
Mentor	Prof Snježana Firšt Rogale, PhD
Date of dissertation topic defense	December 18th, 2019

SIMULTANEOUS DETERMINATION OF THE THERMAL RESISTANCE AND TEMPERATURE GRADIENTS OF A PROTECTIVE JACKET

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Abstract: *Simultaneous measurements of the thermal resistance in one or more layers of composite clothing and the temperature gradients between the layers of composite clothing and protective jacket with the same arrangement of the layers of previously tested materials are presented. The determined thermal gradients and measurement results are presented, based on which it was determined that the total thermal resistance is not equal to the algebraic sum of the thermal resistance of individual elements in the clothing composite in the horizontal state, but it is higher due to the formation of very thin air layers between the textile material layers due to the yarn crimp and protruding fibers of yarn in textile materials. The same composites built into the protective jacket in the vertical state allow the creation of significantly wider air layers that increase the heat resistance.*

1. Introduction

There is a large number of published studies dealing with the thermal properties of clothing and textile materials as well as the influence of air layers that occur between textile materials and in finished (sewn) clothing [1-3]. However, temperature gradients in composite clothing and finished clothing have not been investigated.

2. Experimental

Materials that are commonly used in the professional production of protective jackets were selected for testing. A fabric made of three-layer laminate designated as M3 (fabric - upper-side: 100% PES; membrane: PTFE; fabric - inner-side: 100% PES fleece) was used for the production of the outer shell of the clothing system. Material designated as M4 (100% PES) was used for the lining fabric of the clothing system and three layers of rhomboid stitched material designated as M5 (lining: 100% PES; padding: 100% PP) was used as thermal insulation fabric of the clothing system, Fig 1 [1].

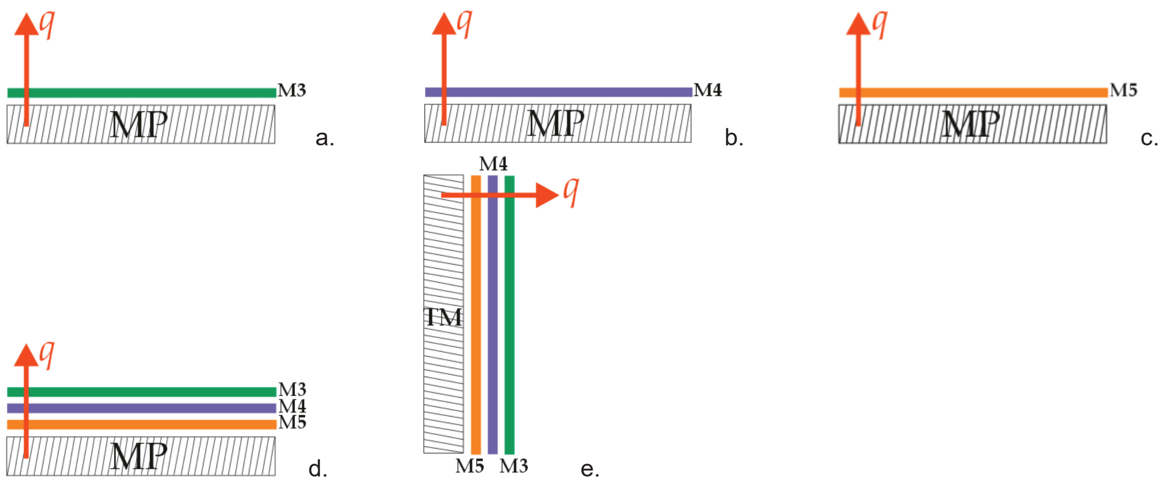

Figure 1 Measurments of the thermal resistance of: a. fabric M3; b. M4; c. M5 and simultaneous measurement of thermal resistance and temperature gradients; d. on a measuring plate in a horizontal position; e. on a thermal manikin in a vertical position

Thermal resistance and temperature gradients were measured in a horizontal position on a hot plate and in a vertical position, built into a jacket, on a thermal manikin using a new measuring device for simultaneous measurements of the stated thermal properties. Measurements of thermal resistance for materials M3, M4 and M5 were performed, as well as simultaneous measurement of thermal resistance and temperature gradients on the measuring plate in horizontal position and protective jacket, ie clothing system OS13 on thermal mannequin in vertical position [4].

3. Results and Discussion

According to the results shown in Fig 2 it can be seen that the thermal resistance value is higher on the finished garment, ie when measured on a thermal manikin, than on a hot plate. The vertical position of the clothing system during measurement allows the formation of air layers between the fabric layers of the clothing system, thus increasing thermal resistance. The anatomical structure of the thermal mannequin also contributes to creating additional air spaces below the chest line on the chest and the back.

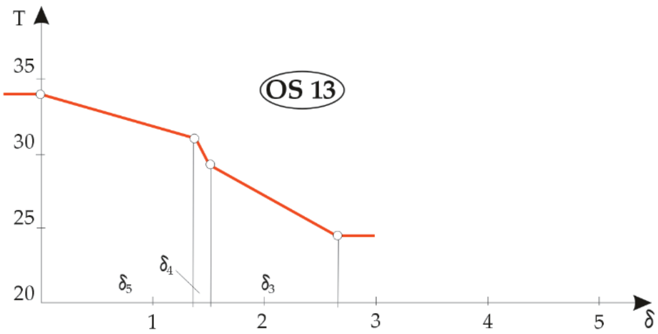

Figure 2 Graphical represantation of the results of temperature gradient calculations for three layers of embedded composite clothing

4. Conclusions

A new measurement system and a newly established measurement method within the HRZZ project IP-2018-01-6363 were used for simultaneous measurements in determining the thermal resistance through one or more layers of composite clothing and temperature gradients between composite layers. Based on the results it can be seen that unlike the sum of insulating properties of individual layers of clothing composite (which is always less than the real properties of clothing) the algebraic sum of temperature drops inside the composite is equal to the temperature difference between measurment plate and ambient air temperature.

Acknowledgement

The research was carried out as part of the reaserch project HRZZ IP-2018-01-6363 Development and thermal properties of intelligent clothing (ThermIC), funded by the Croatian Science Foundation.

References

[1] Gupta, D.; Srivastava, A.; Kale, S.: Thermal properties of single and double layer fabric assemblies. *Indian Journal of Fibre & Textile Research,* **38** (2013) 4, 387–394, ISSN: 9710426

[2] Pan, N.: Unique Thermal Properties of Clothing Materials, Global Challenges, **3** (2019) 1-7, ISSN 2056-6646.

[3] Xu, J.Y. et al: Influence of Layer Configuration on Protecting Effect of Thermal Protective Clothing Containing PCM, *Advanced Materials Research*, **796** (2013), 639–642, ISSN 1662-898

[4] Firšt Rogale, S. et al: Measurement method for the simultaneous determination of thermal resistance and temperature gradients in the determination of thermal properties

Jana Juran

Biography	She was born in 1994, Sveta Nedelja Education: 2021 enrolls in the postgraduate university study of Textile Science and Technology at the University of Zagreb Faculty of Textile Technology. In 2020 she graduated at the University of Zagreb Faculty of Textile Technology. In 2018 she completed her undergraduate university study at the University of Zagreb Faculty of Textile Technology. Work experience: from 2021 until today - Production process technologist in the Calzedonia group
Title of dissertation topic	
Study advisor	Assoc Prof Maja Somogyi Škoc, PhD
Date of dissertation topic defense	

INVESTIGATION AND DEVELOPMENT OF DENTAL PLASTERS WITH BIOCOMPATIBLE AND BIODEGRADABLE TEXTILE CARRIER

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Abstract: *There is no person who has not been to the dentist and has not had any of the necessary dental procedures. Everything is fine as long as there is no pain. Many conditions after dental intervention, oral mucosa causes significant and long-lasting pain that is sometimes difficult to alleviate by topical application, and injection is used which causes dental anxiety and pain from needle punctures in patients. Therefore, material development is necessary for drug release as an alternative application. As the mucosa (lat. Mucosa) is needed, special materials are needed, which can bind to the mucosa and release anaesthetics, but must not be absorbed into the oral tissue.*

1. Introduction

Today, textile technology and its products are an indispensable part of our lives, where it offers great opportunities in all areas of human activity, including dentistry. If necessary, it could protect the oral cavity, ie the mucous membrane during surgery, wearing a bridge, prosthesis, etc. The solution is to make textiles with one of the newer methods of textile technology (3D additive technology, electrospinning) from biodegradable polymers. Additionally, such textiles may have bound active substances, which may contribute, to the protection of the mucosa, more successful healing of the mucosa and other conditions in the oral cavity. The active substances from the textile carrier can be released by different mechanisms of action, eg at different pH values of the mucosa, using compounds of different ionic strength, temperature action, enzyme-textile support mechanism and mucosa. Active substances of natural and artificial origin in the form of gels, microcapsules, ionic form would certainly contribute to the process of treatment or protection of the mucous membranes.

2. Experimental

The starting point of the research will be the hypothesis that the use of current scientific knowledge and achievements in the field of development of new materials can make a new contribution to the development of multifunctional textiles for use in dentistry.

The planning and execution of research will use general knowledge in the field of methodology of scientific work - preparation of research materials, implementation of research and processing of results with the aim of realizing and confirming the hypothesis.

Methods and procedures will be used that enable the reproducibility of treatments and morphological characteristics of the researched materials with the application of modern, reliable standardized and newly developed measurement techniques, in order to evaluate the effectiveness of new textiles for dental applications.

3. Results and Discussion

The research will include the following units, which will be supplemented and changed during the work, depending on the knowledge gained:

1. Selection of chemicals, modifiers, drugs, etc.
2. Development of own recipes and calculation of required quantities of chemicals in order to select the best recipe
3. Development of a method and procedure for the development of textiles for use in dental medicine
4. Consultations and cooperation with other institutions on the subject of scientific research
5. Development of textiles for use in dentistry, preliminary samples and their evaluation
6. Modifications, processing and new process parameters for obtaining final samples and their evaluation
7. Applicability of textiles and the possibility of commercial production

4. Conclusion

The expected results of the doctoral thesis are the development of a prototype of textiles for use in the oral cavity, and the development of a methodology for evaluating its usable and functional quality.

References

[1] Goyal, A. K.; Singh, R.; Chauhan, G.; Rath, G.: Non-invasive systemic drug delivery through mucosal routes, *Artificial Cells, Nanomedicine, and Biotechnology*, **46** (2018) 2, 539-551, ISSN 2169141X

[2] Clitherow, K.H. et al: Mucoadhesive Electrospun Patch Delivery of Lidocaine to the Oral Mucosa and Investigation of Spatial Distribution in a Tissue Using MALDI-Mass Spectrometry Imaging, *Mol. Pharmaceutics*, **16** (2019), 3948−3956, ISSN 1543-8392

Ana Kalazić

Biography

Ana Kalazić was born in 1993 in Zagreb. After the completion of the Tituš-Brezovački Gymnasium, the academic year 2012/2013, started study Accounting and Finance at the Faculty of Economics & Business Zagreb, where earned a bachelor's degree in business economics. In 2015/2016 started undergraduate study of Textile Technology and Engineering at the Faculty of Textile Technology. In 2019/2020 graduated and earned a master's degree in textile technology and engineering. In the academic year, 2020/2021 accepted a job at the Faculty of Textile Technology in Zagreb as an expert associate on the IRI II project "Development of multifunctional non-flammable woven fabrics for dual purpose", funded by the EU from the European Regional Development Fund. In the same year, started the postgraduate doctoral study Textile Science and Technology at the Faculty of Textile Technology in Zagreb.

Title of dissertation topic

Study advisor

Prof Stana Kovačević, PhD

Date of dissertation topic defense

WATER VAPOR PERMEABILITY OF MULTI-WEFT FABRIC

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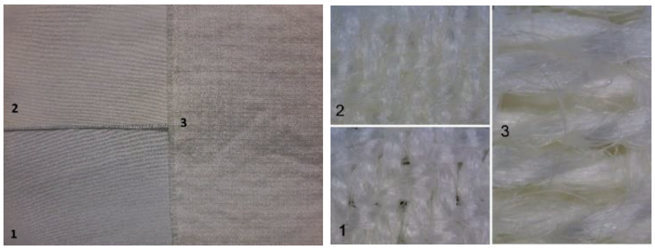
Abstract: *Nowadays is more complex to achieve certain properties of fabric or composites which are normalize by standards for a particular purpose but more difficult is to achieve the sustainability of these properties during use. Fabrics with a high level of protection must have comfort properties. By testing water vapor permeability and resistance to the passage through materials, their breathability or wear comfort can be defined. Water vapor permeability (WVP) is a property of great importance for the manufacture of fabrics for firefighting suits. The porosity of the fabric and the permeability of water vapor are influenced by its constructional and structural parameters such as weave, density, thickness, yarn fineness, etc.*

1. Introduction

Protective clothing for firefighters is used when extinguishing fires or similar activities where there is a risk of high heat load and direct flame. It protects firefighters in extinguishing fires, saving lives, and preventing damage to property and the environment. Firefighters protective clothing must meet protection from other extreme conditions such as rain and extinguishing water. The development of effective textile fire protection begins with the correct selection of raw materials, ie textile fibers, which must have high performance in fire resistance. Also, protective clothing with low resistance to water vapor permeability can cause heat stress and the formation of large amounts of sweat, interfering with visual, cognitive, physical and mental properties. In this paper, the water vapor permeability of multi-weft fabrics intended for firefighting clothing will be analyzed and compared with their surface mass. Multi-weft fabrics consist of one weft thread system and at least two weft thread systems, which form a pattern on the fabric. The weft threads are thicker than the warps and are most often visible on the front and back of the fabric, while the warps are mostly hidden in the middle of the fabric [1-4].

2. Experimental

In the experimental part, three different fabric samples used to make firefighting suits were woven on an automatic laboratory machine Fanyuan Instrument company, model DW 598. The raw material composition of the yarns used for the warp and weft is 95/5% Meta Aramid Conex NEO / Para Aramid Twaron raw and 45/55% Cotton / Modacrylic. The woven samples and microscopic images of them are shown in Fig 1. The analysis of water vapor permeability was performed on the woven samples.



a. b.

Figure 1 Mutli-weft fabrics: a. woven samples (sample 1 has 2 weft, sample 2 has 3 weft and sample 3 has 4 weft); b. microscopic appearance of the samples using digital microscope Dino Lite

Measurement of water vapor permeability of textiles is done according to standard ISO 15496. From the value of water vapor permeability WVP, determination of water vapor resistance (R_{et}) is calculated according to equation:

$$R_{et} = \frac{1}{WVP \cdot L_t}$$

The greater the amount of water vapor transported through the sample, the lower the resistance to water vapor transmission will be. The connection between WVP and R_{et} represents the latent thermal surface (L_t) of water evaporation at the test temperature water bath 23 °C. Latent heat of water evaporation at a temperature of 23 °C amounts L(23°C) = 0.67962 Wh/g [2].

3. Results and Discussion

Table 1 shows how the water vapor permeability of WVP ranged from 0.1999 g/m^2Pah for sample 3; 0.2609 g/m^2Pah for sample 2 and 0.3383 g/m^2Pah for sample 1.

Table 1 Results of surface mass, WVP water vapor permeability and R_{et} water vapor resistance for multi-weave fabrics

SAMPLE	m, g/m^2	WVP, g/m^2Pah	R_{et}, m^2PaW
1 → 2-WEFT	268.61	0.3383	4.35
2 → 3-WEFT	328.54	0.2609	5.64
3 → 4-WEFT	378.76	0.1999	7.36

The resistance to the passage of water vapor R_{et} is inversely proportional to the product of the permeability of water vapor and the latent thermal surface of water evaporation at a temperature of 23 °C. It ranged from 4.35 m^2PaW for sample 1; 5.64 m^2PaW for sample 2; 7.36 m^2PaW for sample 3. In addition, the data show a correlation between water vapor permeability and surface mass of the samples. The sample that has 2 wefts has the lowest mass, so the permeability of water vapor is the highest, while the lowest permeability of water vapor, i.e. the highest resistance to the passage of water vapor has sample with 4 weft, which has the highest mass.

4. Conclusion

Water vapor permeability is higher in 2-weft fabrics due to the lower density of warp and weft threads, weaving, thickness and surface mass compared to 3-weft and 4-weft fabrics. ISO 15 496: 2018 states that this method of water vapor permeability can be used in quality control testing, but has certain limitations compared to ISO 11092, which provides a more comprehensive and relevant result for the assessment of water vapor permeability.

Acknowledgement

The research was prepared as part of the activities of the IRI II research project, "Development of multifunctional non-flammable woven fabrics for dual purpose", funded by the EU from the European Regional Development Fund.

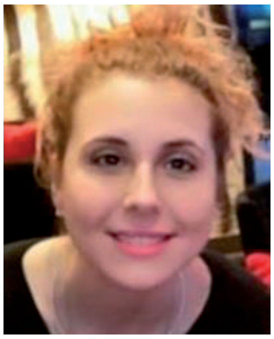
References

[1] Kovačević, S.; Dimitrovski, K.; Hađina, J.: *Procesi tkanja*, Tekstilno-tehnološki fakultet, ISBN 978-953-7105-21-1, Zagreb, (2008.)

[2] Kiš, A.; Brnada, S.; Kovačević, S.: Influence of Fabric Weave on Thermal Radiation Resistance and Water Vapor Permeability, *Dostupan na*: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7182866/ *Pristupljeno*: 2021-12-13

[3] Hursa Šajatović, A. et al: Istraživanje stanja zaštitne odjeće za vatrogasce putem ankete, *Tekstil,* **65** (2016.) 11-12, 378-387, ISSN 0492 - 5882

[4] Schwarz, I. et al: Physical-mechanical properties of thermal protective fabric subjected to textile care, *Dostupan na*: https://www.researchgate.net/publication/342108708_Physical-mechanical_properties_of_ thermal_protective_fabric_subjected_to_textile_care *Pristupljeno*: 2021-12-15



Franka Karin

Biorgaphy	Franka Karin was born in 1986 in Zagreb. 2012 she graduated at the Faculty of Textile Technology in Zagreb. Since 2017, she has been employed at the Faculty of Textile Technology. In 2017 she enrolled in the postgraduate doctoral program Textile Science and Technology. She focused her research on sustainable fashion and comparing tradition and sustainability.
Title of dissertation topic	From tradition to contemporary-sustainability in fashion
Study advisor	Assoc Prof Irena Šabarić, PhD
Date of dissertation topic defense	

TRADITION AND SUSTAINABILITY IN FASHION

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Abstract: *The problem of the fashion industry is excessive textile waste resulting from fast fashion. Slow fashion production trends offer new approaches in clothing design and production, appear as a counterbalance to fast fashion, raise environmental awareness, nurture cultural values and preserve tradition. It highlights awareness of timeless clothing design and restores traditional craftsmanship in manufacturing. Traditional clothing was produced according to the principles applied by slow fashion. By researching good practice in tradition and application in the context of contemporary clothing design, it brings applicable methods with the aim of sustainability in fashion. Traditional clothing is the main starting point and inspiration in the paper as a combination of tradition and modern research on sustainable methods.*

1. Introduction

The ways of producing fast fashion encourage consumers to buy superfluous clothes in accordance with fashion trends, which leads to the accumulation of short-lived textiles. The fashion industry thus makes money while generating excessive textile waste. By applying the concepts of sustainable development in clothing fashion, the usable component is extended and its adequate care is considered in advance. One of the approaches of sustainable fashion is based on the full or maximum utilization of materials, and the emphasis is on traditional production and quality, not the quantity of products. Traditional cutting methods cause up to 15% of textile waste, so new solutions in line with sustainable development have raised awareness among a growing number of fashion brands [1].

2. Experimental

New guidelines in sustainable fashion are not subject to fashion trends but are geared towards timeless design [2]. Fast fashion has flooded the market resulting in the extinction of conventional clothing production with traditional skills that nurtured the heritage of traditional clothing. Slow fashion guidelines lead to sustainable development from the beginning of the design process [3]. Through the concept of slow fashion, the zero-waste method is represented, which we can see in the production of traditional clothing both in the world and in Croatia. Tailoring methods and design without textile waste and traditional clothing from Croatia can be a starting point for the development of sustainable clothing design. Costume as a traditional garment was an indicator of a certain culture that was changing in accordance with the development of society, political and economic changes. With the advent of the fashion phenomenon, traditional clothing has been neglected due to social, cultural and social changes that have pushed it out of everyday wear [4]. Every item of clothing, whether traditional or fashionable, has value in its existence and its clothing documents a part of history that relates to the textiles of a particular time, production, design and technological processes of production [5]. In the modern context of clothing production, life expectancy is extended and traditional manufacturing techniques are nurtured, and in the context of slow fashion, revitalization of traditional techniques is a good example of raising awareness of sustainable fashion and its positive effects on society and the environment.

3. Results and discussion

The goal of the zero waste method is to reduce waste to a minimum by design considerations in the process of making cuts. The practice of making clothes is as old as dressing, and if we look at historical examples of making clothes, we notice similarities in shapes, cuts and ways of cutting with the zero waste approach applied today. Method of fitting cut parts into the fabric surface is a good approach that minimizes waste. The main starting point according to the principles of zero waste is the fabric, its dimensions, type, texture and its edges [6]. Therefore, we can conclude that zero waste has been operating since the earliest history when clothes were made by the same method. If we look at geometrized forms with very little textile waste and compare them with traditional clothing in Croatia, we can see that folk costumes are a great example of zero waste. The way in which traditional clothing was made and the use of materials is used today in the context of slow fashion. Some such examples are the 1956 Chinese pants made up of two large rectangles with full utilization of the fabric. We can compare them with men's trousers from the folk costume of Slavonia as a traditional example of zero waste from Croatia [6, 7]. The Finnish women's blouse from 1956 is an inspiration that can be compared to the rubies from the women's folk costume of Slavonia due to the similarities in the way of making and using the fabric [6, 8]. The aim of this paper is to investigate the ways of tailoring folk costumes and their processing of materials, and compare them with modern methods of clothes making, such as zero waste, for the purpose of sustainability.

4. Conclusion

New methods within the concept of sustainable development have evolved from the need to raise awareness of the importance of sustainable fashion guidelines and minimize textile waste. One of the methods that emerged from slow fashion was zero waste, which was used to make traditional clothes. Methods of production, approach to tailoring and approach to fabric are common methods of zero waste and folk costumes of Croatian areas. Croatian folk costumes are a source of various considerations in clothing design that can be applied in accordance with sustainability. By studying these methods and putting them in a modern context with the application of new technologies, it is possible to create a collection based on the principles of slow fashion. With the synergy of tradition and modern knowledge, the concept of slow fashion can be applied to the production of clothing and in the long run restore the reputation of the textile industry with care for the environment.

References

[1] Styles, R.: *Ecologist: guide to Fashion*, Leaping Hare Press, ISBN 978-1-78240-102-5, London, (2014)

[2] Gwilt, A.; Rissanen, T.: *Shaping sustainable fashion changing the way we make and use clothes*, Routledge, ISBN 978-1-84971-241-5, Washington, (2011)

[3] Ninimäki, K.: *Sustainable fashion: New approaches*, Aalto University, ISBN 978-952-5572-5, Helsinki, (2003)

[4] Maglica, N.: *Baranja se šareni: Predajno ruho baranjskih Hrvata*, Etnografski muzej, ISBN 953-6273-25-X, Zagreb, (2003.)

[5] Mihalić, I.; Simončič, K. N.: Odjevni predmet kao muzejski artefakt, *TEDI*, **4** (2014.), 18-23, ISSN 1847-9545

[6] Rissanen, T.; Mcquillan, H: *Zero waste fashion design*, Fairchild Books, ISBN 978-1-4725-8198-3, New York, (2016)

[7] Radauš-Ribarić, J.: *Narodne nošnje Hrvatske*, Spektar, Zagreb, (1975.)

[8] Kolić Klikić, V.: *Ženske narodne nošnje zapadne Slavonije*, Gradski muzej Nova Gradiška, ISBN 978-953-95012-2-6, Nova Gradiška, (2007.)

Ines Katić Križmančić

Biography

Ines Katić Križmančić was born in Zagreb 1965. She completed her graduate studies at the University of Zagreb Faculty of Textile Technology in Zagreb. The postgraduate doctoral study Textile Science and Technology she enrolled in 2019/2020. She has more than thirty years of experience in the textile industry working as a textile and clothing designer, technologist, and cluster leader. Her scientific interest is linked to the topic of innovative textile materials for enhancing the comfort of sportswear.

Title of dissertation topic

Study advisor

Assoc Prof Ivana Salopek Čubrić, PhD

Date of dissertation topic defense

THE PROPERTIES OF KNITTED FABRICS FOR OPTIMAL PERFORMANCE OF SPORTSWEAR

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Abstract: *The comfort in sports is the result of multiple interactions between physiological and physical factors. Sportswear has an active relationship between an athlete's body, type of physical activity, and environment. The main function of sportswear is to support and improve physical activity. Great attention of the sportswear industry is focused on the research of multipurpose textiles. Referring to global economic reports, the sportswear market is expected to exceed the US $ 100 billion by 2025. These data show us the importance of researching the properties of materials for making sportswear and creating guidelines for their further improvement. In the experimental part of this paper, the focus is on testing the tensile properties of knitted fabrics important for the optimal performance of textile materials, especially for the production of specific sportswear. The paper discusses the results obtained and provides guidelines for further improvements.*

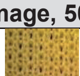
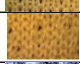
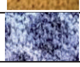
1. Introduction

Playing sports, no longer only professionally but also recreationally, is becoming one of the ultimate activities of a conscious modern man. Such a trend places new demands on the functional design and innovation of new ecological materials especially in the development of sportswear. Polyester is the most commonly used fabric for the production of activewear. Also, other fibers are suitable for sportswear such as polyamide, polypropylene, acrylics and elastane. The main function of sportswear is to support, and improve physical activity. Great attention of the sportswear industry is focused on the research of multipurpose textiles. Referring to global economic reports, the sportswear market is expected to exceed US $ 100 billion by 2025 [1]. All these data give a clear picture of how important is to focus researches on the properties of sportswear materials. The main properties are mechanical-physical, chemical, and surface-related [2].

2. Experimental

In this paper, the tensile properties of a selected set of knitted fabrics, intended for the production of sportswear, were investigated. During a number of sport activities, athletes are often in a direct duel with rival players where pulling of clothing commonly happens. Therefore, the information regarding the breaking force and elongation of materials is of interest when comparing materials and bringing conclusions related to the performance. For this experiment are selected knitted fabrics made of polyester yarn and differing according to the fabric structure, as shown in Tab 1.

Table 1 Selected materials

Sample ID	Microscopic image, 50x	Fabric composition	Fabric structure	Fabric surface mass, g/m^2
PES-136		100% polyester	rib knit stitch, plated	136
PES-153		100% polyester	rib knit stitch with eyelets	153
PES-158		100% polyester	rib knit stitch with eyelets	158

2.1. Measuring methods

In the experimental part, the tensile properties are determined following the procedure described in International standard ISO 13934-1 [3]. For the measurement, the tensile tester Statimat M produced by Textechno company was used. The specimens in form of stripes, dimension 50± 0.5 mm x 200 ± 0.5 mm, were prepared. The specimens were cut in both directions, direction of wales, and direction of courses, because the knitted fabrics don't have the homogenous structure in both directions. The test speed was set to 100 mm/min^{-1}. The atmosphere assured for the preconditioning and conditioning of specimens corresponded to recommendations given in EN 20139 [4].

3. Results and Discussion

The obtained results of tensile properties for specimens PES-136, PES-153, and PES-158 are summarized and shown in Fig 1. The results of measurements in the course direction and the wale direction are presented in parallel.

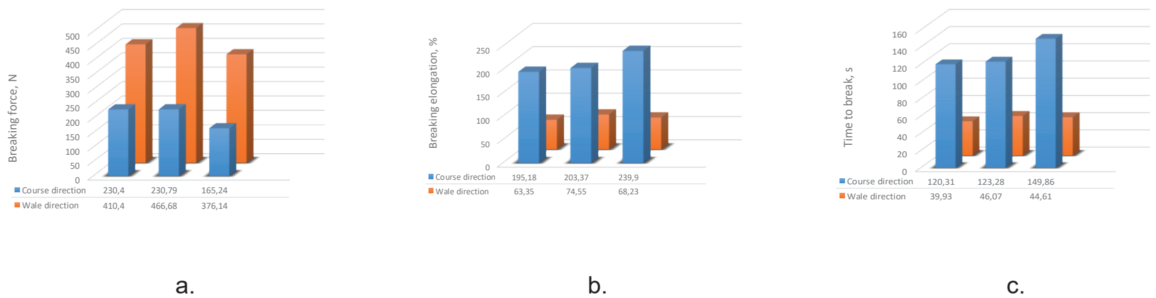


Figure 1 Results of tensile properties measurement a. breaking force; b. breaking elongation; c. time to break

Regarding the breaking force from Fig 1a can be seen that the breaking force is significantly higher in the wale direction than in the course direction, the average increase of 100%. The results of breaking elongation and time to break shown in Fig 1b and Fig 1c that elongation and time to break are significantly higher in the course direction than in the wale direction, the average increase of 300%.

4. Conclusion

Research into fibers, materials and improving the design of sportswear is an important segment in the development of their performance, especially comfort. The focus of this manuscript was tensile properties. Further research will be focused on a wider range of knits and research into a wide range of their properties related to the establishment of optimal comfort and long-lasting functionality during intensive sports activity

Acknowledgement

This work has been fully supported by Croatian Science Foundation under the project IP-2020-02-5041 Textile Materials for Enhanced Comfort in Sports - TEMPO.

References

[1] Sportswear Industry: Global Market to reach US$ 108.7 Bn by the end of 2025 – QY Research, Inc., *Dostupan na:* https://www.globenewswire.com/news-release/2019/02/27/1743035/0/en/Sportswear-Industry-Global-Market-to-reach-US-108-7-Bn-by-the-end-of-2025-QY-Research-Inc.html, *Pristupljeno:* 2021-12-20

[2] Shishoo, R.: *Textiles in Sport*, Woodhead Publishing Limited, eBook ISBN 9781845690885, Cambridge, (2005), 89-90.

[3] ISO 13934-1 Textiles - Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method

[4] EN 20139 Textiles - Standard Atmospheres for Conditioning and Testing

Tea Kaurin

Biography

Tea Kaurin was born in Zagreb. She graduated from the University Graduate Study of Textile Technology and Engineering 2016 at the University of Zagreb, Faculty of Textile Technology. She enrolled in the postgraduate university study of Textile Science and Technology in the same year when she was employed as an assistant at the same faculty. She was then employed as an assistant plant manager in the laundry Salesianer Miettex Lotos d.o.o. She is currently employed as an expert associate on the project "Development of multifunctional non-combustible fabric for dual use (KK.01.2.1.02.0064)" at the Faculty of Textile Technology.

Title of dissertation topic

Study advisor

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Date of dissertation topic defense

MODIFICATION OF POLYESTER FABRIC WITH CHITOSAN

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Abstract: *The research will be focused on the functionalization of polyester fabric, pretreated by chemical (application of a chemical agent) and physical (application of a cold plasma), with the biopolymer chitosan. The influence of these (pre)treatments on the properties of the polyester fabric will be studied by physico-chemical analytical methods. The shedding of particles from pristine and chitosan treated polyester fabrics in the washing process will be examined through the analysis of effluents, filtrate and filter cake.*

1. Introduction

The washing process of textiles derived from synthetic polymers has been identified as one of the sources of primary microplastic (MP) that enter the wastewater treatment plant through the sewage system [1-3]. This problem requires preventive measures that can be implemented at several levels. The concept of this research is based on the functional treatment of pretreated polyester fabric with biopolymer chitosan. Since polyester textiles are not compatible with the biopolymer, it is necessary to perform modification and prepare a surface for the treatment with chitosan [4]. The proposed research will be carried out by two chemical modifications and physical modifications by atmospheric plasma. The effect of the chitosan treatment will be assessed by analysis of the released particles from the polyester fabric during the washing process, and an analysis of the antimicrobial activity and biodegradability of the treated materials will be performed [5].

2. Experimental

Reference polyester fabric will be chemically modified with sodium hydroxide and sodium hydroxide with addition of a promotor, benzalkonium chloride, and physically by an atmospheric plasma jet with optimized parameters. Pristine and chitosan treated samples of polyester fabric will be processed by cyclic washing according to the standard HRN EN ISO 6330: 2012.

3. Results

Analysis of polyester fabrics will be carried out by physico-chemical methods to verify the effects of chemical and physical modification and processing, Tab 1.

Table 1 Physico-chemical analysis methods for the modified fabric surface

Method	Indicator/result
Gravimetric	Weight loss / gain
Dye identification	Depth of colour
Streaming potential	Zeta potential
Microscopy	SEM image, digital image
Remission spectrophotometry	Degree of whiteness, depth of colour
FTIR	FTIR spectrogram
Peeling	Area assessment
Antimicrobial test	% reduction
Determination of breaking force/elongation	Tensile properties
Determination of touch	Touch rating
Electrical resistance	Antistatic properties
Biodegradability	Degradability

After washing process of pristine and chitosan treated polyester fabrics, the effluents, filter cakes and filtrates will be analysed by physicochemical methods, Tab 2.

Table 2 Physico-chemical methods for characterization of shed particles

Method	Effluent	Filter cake	Filtrate
Laser diffraction	+	-	-
Determination of total solids (TS)	+	-	-
Determination of total dissolved solids (TDS)	+	-	-
Determination of total suspended solids (TSS)	+	-	-
Gravimetry	-	+	-
Turbidity	+	-	+
Microscopic analysis	-	+	-
Pyrolysis gas chromatography mass spectrometry	-	+	-
Determination of pH	+	-	+
Determination of conductivity	+	-	+
Determining the COD	+	-	+
Determination of BOD	+	-	+

4. Conclusion

The aim of the PhD thesis is proof of the concept of innovative treatment of polyester fabric with chitosan before and after chemical and physical modification in reduction of shed particles from polyester fabric in the washing process through hypothesis: H1 The chemical modification of polyester fabric has a positive effect on chitosan binding. H2 Physical modification of polyester fabric has a positive effect on chitosan binding. H3 Chitosan-polyester structure provides lower MP particle release than pristine polyester fabric in the washing process.

Acknowledgement

The PhD thesis is an integrative part of the research on projects of the Croatian Science Foundation, HRZZ IP-2020-02-7575: Assessment of microplastic shedding from polyester textiles in washing process (2021-2025) and Synthesis of advanced nanoparticles and applications in photocatalysis and textile materials, HRZZ -PZS-2019-02-5276 (2020-2023).

References

[1] Schwarz, I.; Kovačević, S.: Textile Application: From Need to Imagination, U *Textiles for Advanced Application*, InTec, ISBN 978-953-51-5429-7, Rijeka, Croatia (2017) 3-26
[2] Gilligan, I.: The prehistoric development of clothing: archaeological implications of a thermal model, *Journal of Archaeological Method and Theory*, **17** (2010) 1, 15-80, ISSN 1072-5369
[3] Magdalenić Bujanić, J.; Bujanić, B.: Aramid fibers, *Polimeri*, **32** (2011) 3-4, 130-134, ISSN 0351-1871
[4] Scott, R.A.: *Textiles for protection*, Elsevier, ISBN 978-1855739215, Cambridge, England (2005)
[5] Brnada, S.; Šomođi, Ž.; Kovačević, S.: A new method for determination of Poisson'sratio of woven fabric at higher stresses, *Journal of Engineered Fibers and Fabrics*, **14** (2019) ISSN: 15589250
[6] Hu, J.: *Structure and mechanics of woven fabrics*, Woodhead Publishing Limited, ISBN 9781845690403, Cambridge, England (2005)

Ana Kiš

Biography

I was born 1985 in Čakovec. In 2003 she enrolled at the Faculty of Chemical Engineering and Technology in Zagreb, where she graduated in 2010. She was employed by Čateks d.d. Through 11 years of work at Čateks d.d. under several positions: internship, development technologist, laboratory manager, production technologist, management representative for the quality management system. In 2018 she is enrolling in postgraduate university studies at the Faculty of Textile Technology in Zagreb. In 2021 she was employed by Franck d.d. in the position of quality control analyst. In 2022 she was employed by Vertiv Croatia d.o.o. to the position of quality suppliers engineer.

Title of dissertation topic

Study advisor

Prof Stana Kovačević, PhD

Date of dissertation topic defense

INFLUENCE OF STRUCTURE ON THERMAL PROTECTION

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Abstract: *The research was based on the influence of fabric structure on the resistance of fabrics to thermal radiation. Based on the results, it is found that the fabric structure has an impact on the structure of the fabric to be transferred and the effectiveness of protection against high temperatures.*

1. Introduction

The protection of the human body from extreme external conditions has been known since ancient times. The manufacture of fabrics resulted in their widespread use in household and clothing for protection against extreme temperatures, precipitation, wind, UV radiation, mechanical shocks, etc. Raw materials selection for protective clothing have to contribute to most efficient protection. With the technological development as well as appearance of man-made fibers, the development of protective fabrics greatly changed which affected their manufacture for targeted applications [1-3].The requirements placed on textile materials for high temperature protective clothing lead to innovations in the development and production of woven fabrics [4-6].

2. Experimental

Investigations of different types of fabrics woven from the same warp and weft yarns were carried out: yarn fineness is 16.7×2 tex, composition: 95% M-aramid Conex NEO + 5% P-aramid Twaron MOK3 in different weave structure. The density of the warp thread did not change in the hill and was 15 threads/cm for all samples. The density of the warp in the fabric after removal from the loom depended on the bond. Weft density was also affected by the bond and the tension of the warp, which was kept constant during the weaving process. The structural and constructional characteristics of the samples were determined by standard methods, namely: the density of the warp and weft threads, the thickness of the samples and the surface mass. The effectiveness of protection against high temperatures was determined by the transfer of radiant heat tested according to HRN EN ISO 6942: 2003, method B, with thermal flux Q_0 = 20 kW/m². The test was performed on a device manufactured in accordance with the regulations in the standard. Using a calorimeter, the heat flux density through the sample was calculated.

3. Results and Discussion

Table 1 Structural and constructional characteristics and related test results of heat resistance of fabrics

Sample, weave structure	Warp, threads /cm	Weft, threads /cm	Thick-ness, mm	Surface mass, g/m^2	t_{12}, s	t_{24},s	t_{24}-t_{12} ,s	Q_c, kW/m^2	TFQ_0, kW/m^2
Plain	17	23	0.58	142.0	6.70	12.42	5.72	11.56	0.58
Twill	17	24	0.70	149.5	6.90	13.73	6.83	9.67	0.48
Satin	17	36	0.94	172.0	7.03	14.50	7.47	8.85	0.44
2-weft	17	60	1.00	250.0	9.03	17.73	8.70	7.63	0.38
4-weft	17	80	2.20	340.0	12.37	23.23	10.87	6.10	0.30
Strucks	17	40	1.18	187.0	7.60	15.07	7.47	8.87	0.43

According to the test results of fabric resistance to radiant heat, a significant difference among weave structurescan be found, Tab 1.The fabric in a 4-weft weave provided the highest resistance to radiant heat, and the let-through heat flux averaged 6.10 kW/m^2 and heat transfer factor was 0.3 kW/m^2. It took 12.37 s to achieve a calorimeter temperature rise of 12 °C, while it took 23.23 s to achieve a calorimeter temperature rise of 24 °C. The second fabric in sequence that resisted to radiant heat was the fabric in a 2-weft weave. Although its thickness was more than twice as small, its mass and density was only 25% less than in the 4-weft weave fabric, resistance to radiant heat was expectedly good amounting to Q_c = 7.63 kW/m^2. It can be observed that by increasing the surface mass of the sample, the resistance to thermal protection increases, i.e. in this case the value of Qc decreases. The strucks weave fabric ranked third in resistance to radiant heat. The let-through heat flux density amounted to Q_c =8.87 kW/m^2, and heat transfer factor amounted to TFQ_0 = 0.43 kW/m^2. Despite its surface unevenness and visible pores among fabric crimps, it provided good protection against radiant heat. The sample in plain weave gave the worst results in terms of radiation heat resistance efficiency of only Q_c = 11.56 kW/m^2, and the heat transfer factor TFQ_0 = 0.58 kW/m^2. Samples in satin and twill weave had similar results: Q_c = 8.85 kW/m^2 atlas embroidery, and Q_c = 9.67 kW/m^2 twill embroidery. The heat transfer factor for atlas weaving was TFQ_0 = 0.44 kW/m^2, and for twill weaving TFQ_0 = 0.48 kW/m^2, and according to the efficiency of thermal protection they are behind multi-weft patterns and specimens in the construction connection.

4. Conclusion

Different types of weaves results in different fabric structure parameters such as fabric thickness, surface mass and protection against radiant heat. In the case of fabric, resistance to radiant heat a considerable difference can be found among the weave structures. The multi-weft weave fabrics (4-weft and 2-weft weaves) and the strucks weave fabric provided the highest resistance to radiant heat. The two dimensional weave structures: plain weave, satin weave and twill weave provided less resistance to radiant heat. The best performance in terms of thermal protection and breathability was given by samples with complexed woven structures.

Acknowledgement

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References

[1] Schwarz, I.; Kovačević, S.: Textile Application: From Need to Imagination, U *Textiles for Advanced Application*, InTec, ISBN 978-953-51-5429-7, Rijeka, Croatia (2017) 3-26

[2] Gilligan, I.: The prehistoric development of clothing: archaeological implications of a thermal model, *Journal of Archaeological Method and Theory*, **17** (2010) 1, 15-80, ISSN 1072-5369

[3] Magdalenić Bujanić, J.; Bujanić, B.: Aramid fibers, *Polimeri*, **32** (2011) 3-4, 130-134, ISSN 0351-1871

[4] Scott, R.A.: *Textiles for protection*, Elsevier, ISBN 978-1855739215, Cambridge, England (2005)

[5] Brnada, S.; Šomođi, Ž.; Kovačević, S.: A new method for determination of Poisson'sratio of woven fabric at higher stresses, *Journal of Engineered Fibers and Fabrics*, **14** (2019) ISSN 15589250

[6] Hu, J.: *Structure and mechanics of woven fabrics*, Woodhead Publishing Limited, ISBN 9781845690403, Cambridge, England (2005)

Mateo Miguel Kodrič Kesovia

Biography

Mateo Miguel Kodrič Kesovia was born 1987 in Dubrovnik. In 2006 he enrolled the full-time study of restoration and conservation at the University of Dubrovnik, where in 2012 he completed his Master. Part of his education took place at the Palazzo Spinelli Institute in Florence and at the Institute for Conservation and Restoration in Vienna. He specialized the analysis and cataloging of historical textiles (CIETA) in 2011 in Florence. Since September 2013, he has been employed at the University of Dubrovnik and works since 2021 as assistant professor. In 2014, he enrolled doctoral studies at the Faculty of Textile Technology in Zagreb. He perfected textile restoration in 2017 at the renowned Abegg Stiftung in Switzerland. His scientific interests are interdisciplinary research in the field of history of textile technology, methods of reconstruction and reproduction and digitization of historical textiles.

Title of dissertation topic

Method of analysis and digitalization of technical documentation of historical damask fabrics in Dubrovnik region

Mentors:

Prof Željko Penava, PhD
Assoc Prof Katarina Nina Simončič, PhD

Date of dissertation topic defense

June 11th, 2018

THE PROCESS OF DIGITALIZATION OF HISTORICAL PATTERNS IN TEXTILE CONSERVATION AT THE UNIVERSITY OF DUBROVNIK

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Abstract: *Digitization is a non-destructive and very useful method in the documentation of cultural heritage and as such has great potential for interdisciplinary scientific research, in new methods of conservation and restoration, as well as for commercial purposes - without the need for direct actions on the historical material itself. Digital technology is a practical, fast and a very esimple tool to use, yet due to its accelerated technological developments, art digitization equipment is becoming more and more available. Presented methods were used on historical fabrics that are in focus of the doctoral thesis "Method of analysis and digitalization of technical documentation of historical damask fabrics in Dubrovnik region".*

1. Introduction

Digitization is a non-destructive and very useful process that is increasingly used today in the documentation of cultural heritage. At the global level, it is being actively promoted as an optimal means of documenting and preserving all the information contained in historical artifacts. In 2017, the European Commission launched through the Europeana platform the first preparations and guidelines for EU member states with the aim of digitizing cultural heritage [1]. Guidelines for museum institutions about the methodology of digitization and the required digital quality standard, are regularly being published. The need to develop specialized tools for the study of digitized materials was already apparent, which also triggered the development of new scientific topics and concepts, such as *digital heritage, heritage science, digital humanities,* etc. The importance of digitization in the cultural sector was evident in the COVID-19 epidemic, when a number of world museum institutions provided its users “virtual walks” through their digitized collections and other contents.

2. Experimental

Since historical fabrics often have to be separated during the conservation and restoration treatment, this research focuses exclusively on 2D techniques of recording and scanning flat materials because they give the best and realistic view of the historical pattern. Documentation of historical patterns has traditionally been performed by hand, drawing on transparent foil, but with the development of modern technology, much faster and more precise methods have been made possible - by photographing or scanning of patterned fabrics in high resolutions. Various methods for digitization are applied at the Department of Art and Restoration of the University of Dubrovnik. Depending on the characteristics of the object, high-quality digital photographs of historical samples can be obtained with a digital camera on an adjustable copy stand or by direct optical scanning using the specialized A3 scanner Mustek A3F1200N, Figs 1a and 1b.

a. b. c.

Figure 1 Various techniques used for digitising historical textile patterns: a. photographing with adjustable copy stand; b. recording on a flatbed scanner; c. applying graphic tablet for tracing the pattern

Certain textile materials require a special approach to digitize. For example, when photographing monochromatic silk patterned fabrics (eg damask), light reflection can often occur, which makes the appearance of the pattern blurry and unclear. In this case, techniques of photographing at different angles lighting angles and under different intensities are applied. To obtain digital photos of sufficient quality for further image processing, such as accurate photogrammetric measurements or digital reconstruction of the pattern, it is recommended to record them at high resolution and in uncompressed raw TIFF format [2].

The digitized patterns then need to be further edited using computer image processing programs. For this purpose, Adobe Photoshop CS6 is used, which has a number of graphical tools for correcting dimensional irregularities and deformations of materials, for photogrammetric and colorimetric measurements, for marking and digital extraction of the repetitive pattern unit, for plotting and distinguishing individual effects in the sample, etc. A helpful tool in this process is a graphic tablet that allows drawing directly on an interactive monitor for fast and accurate tracing of the sample, Fig 1c. Incomplete and damaged patterns can be digitally reconstructed, by understanding the rules of pattern repeats in textile design. With mapping and rotating techniques we can replace the missing elements of the pattern from the preserved parts of the design. Digitized pattern sample, combined with detailed technical documentation and by applying the process of reverse engineering, allows the creation of a weaving draft in specialized programs, such as ArahWeave CAD/CAM and ArahPaint. Based on the obtained design, one can create a virtual simulation for better understanding of the complex structures or reproduce the historical fabric on modern looms [3].

3. Results and Discussion

Interdisciplinary interpretation of the obtained data can reveal some key, seemingly invisible information about historical fabrics. Digitization contributes to better systematization and transmission of the data which are one of the key conditions for creating digital databases and repositories as an accessible container and source of human creativity and knowledge. In future, the implementation of artificial intelligence would shorten the duration of collecting, processing and searching for data on historical artifacts. Digital technology is rapidly and constantly evolving, which is why it is necessary to continuously improve IT skills and monitor what are current and innovative possibilities of its use. Popularization and interaction of digital heritage with interested users would, in appropriate circumstances, encourage the revitalization and reapplication of a large amount of forgotten knowledge of art and technology in textile production.

4. Conclusion

The nature of historical patterns is that they are endlessly repeated and reproduced in a closed-loop recycling of textile designs, in which they are borrowed, refreshed and reused on contemporary textile products or on other media. However, the original designers and artists who have created these rich textile designs throughout history remain largely unknown to this day. Digitized heritage enables faster dissemination and exchange of information, better linkage between interested users and encourages inter-institutional cooperation between experts from different fields of science. Documenting historical patterns in digital format makes it easier to search and connect with similar samples, which significantly improves the speed and accuracy of dating and attribution of a particular textile design. In the field of conservation-restoration it opens up alternative solutions for better protection of (often) fragile and sensitive historical materials where damaged fabrics can be virtually reconstructed or an authentic reproductions can be made.

References

[1] The Council of the European Union: The role of Europeana for the digital access, visibility and use of European cultural heritage. *Dostupan na* https://data.consilium.europa.eu/doc/document/ST-9643-2016-INIT/en/pdf. *Pristupljeno: 2021-12-15*

[2] Bülow, A. E.; Ahmon, J.: *Preparing Collections for Digitization*, Facet Publishing, ISBN 9781856047111, London, (2011)

[3] Cybulska M.: To See the Unseen – Computer Graphics in Visualisation and Reconstruction of Archaeological and Historical Textiles, In *Computer Graphics*, InTech, ISBN 978-953-51-0455-1, Rijeka, (2012) 213-228

Ivan Kraljević

Biography

Ivan Kraljević was born in 1991. He enrolled University of Zagreb Faculty of Textile Technology in 2010. He successfully completed undergraduate university study in 2013, and two years after graduate university study. In 2016 he enrolled doctoral study Textile Science and Technology. Since 2016 he has been employed in the main Croatian factory for socks producing, Jadran Hosiery, where since 2017 he works as a head of knitting and sewing department. Scientifically works within research project IP-2016-06-5278 financed by Croatian science foundation. He published ten scientific papers, whereas his area of research interest is testing and quality control of innovative materials for socks industry and leather.

Title of dissertation topic

Study advisor

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Date of dissertation topic defense

DEVELOPMENT OF METODOLOGY FOR EVALUATING THE ABRASION RESISTANCE OF SOCKS

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Abstract: *The abrasion resistance of fine men's socks, made of high content of cotton in full plating by yarns of different composition were tested. The test procedure according to the HRN EN 13770, method 1, was applied, using Martindale abrasion tester and two different specimen holders – standard and modified.*

1. Introduction

On the men's socks are placed high demands of usage durability, with particular attention to the abrasion resistance during wearing. In addition to other production requirements, it is very important to harmonize and select yarns for their production [1]. Therefore, the abrasion resistance of fine men's socks, made of high content of cotton in full plating by yarns of different composition (polyamide 6.6, Lycra/cotton and Lycra/polyamide 6.6) were tested in this research. For determination of sock knits abrasion resistance, the test procedure according to the HRN EN 13770:2008 [2] was applied, using Martindale abrasion tester and sampling of socks from the sole and heel. Using the same methodology (determination of specimen breakdown), the comparison of test results obtained using two different specimen holders – standard and modified were carried out, with the purpose of determining the applicability of modified holders made within this research and adapted to the requirements of the HRN EN 13770:2008, method 1.

2. Experimental

The research was carried out on three groups of calf length fine casual, black coloured men's socks of the same size (EU 42). The socks were made using plain stich on Lonati sock knitting machine E14 of cylinder diameter 95 mm (3 ¾") with 168 needles and ironed at a temperature of 120 °C using a Cortese machine in Jadran Hosiery. Characteristics of socks are shown in Tab 1, including values of fibre content, weight of one sock and mass per unit area of knits.

Table 1 Characteristics of three groups of calf length casual man's socks

Sock sample	Fibre content (%)			Platting yarn		Weight of sock (g)	Mass per unit area (g/m^2)
	Cotton	PA 6.6	Lycra	Foot and leg	Toes and heel		
1	78	21	1	PA 6.6	PA 6.6	19.9	189.9
2	91	6	3	Lycra/cotton	PA 6.6	19.8	199.9
3	78	19	3	Lycra/PA 6.6	PA 6.6	19.9	237.6

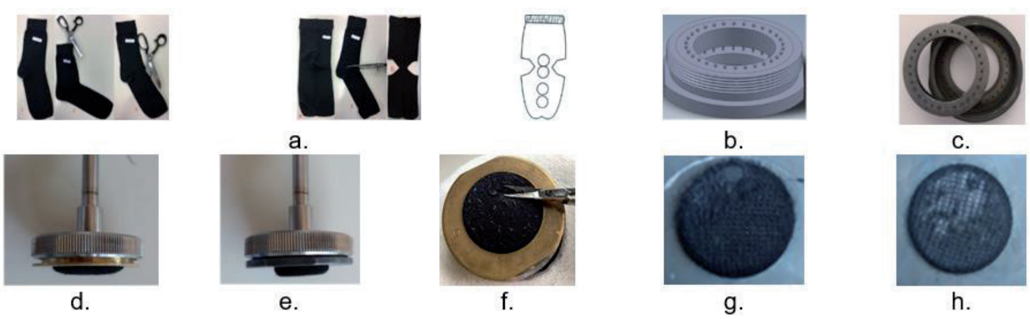

Figure 1 Testing of abrasion resistance: a. Sampling of socks; b. Presentation of the designed; c. produced lower part of modified specimen holder; Sock plain knits; d. standard specimen holder with foam backing; e. modified specimen holder with rubber sphere; f. Removing the pills during the specimen inspection; Appearance of g. hole; h. specimen thinning

The abrasion resistance of socks, Fig 1, was tested by Martindale abrasion tester using two different specimen holders - standard according to the HRN EN ISO 12947-2 and modified according to the HRN EN 13770, where circular plain knit specimens of diameter 38 ± 5 mm were abraded against the reference wool abradant with a cyclic planar motion in the form of a Lissajous figure, loaded with the corresponding weight of 12 kPa.

End point is defined as occurrence of hole (developed when one thread is broken) or significant thinning (when cotton spun staple yarn wears away leaving a base of the synthetic polyamide multifilament yarns) what is periodically checked. During the inspection, pills were removed with sharp scissors with curved blades. The number of rubs to reach endpoint were recorded.

3. Results and Discussion

Lycra plating threads change the structure of sock plain knits as the construction of such socks (of almost the same weight) were tighter and of higher mass per unit area, Tab 1.

Table 2 Abrasion resistance of heel and sole area of socks - determination of specimen breakdown

Sock sample	Standard specimen holders, HRN EN ISO 12947-2		Modified specimen holders, HRN EN 13770, method 1	
	Description of the endpoint/ number of rubs to reach endpoint			
	Heel	Sole	Heel	Sole
1	thinning/35000	thinning/35000	thinning/6500	thinning/6500
2	thinning/35000	hole/30000	thinning/6500	hole/6000
3	thinning/35000	thinning/45000	thinning/6500	thinning/7000

In the socks of the first and third group, that contain higher amount of polyamide plating threads, it is worth mentioning the higher abrasion resistance of knits from the sole area of the socks, Tab 2, indicating their better usage durability. Sock sample 3, plated with Lycra wrapped with polyamide 6.6, shows the highest abrasion resistance in the sole area. Only by sock sample 2 with the highest content of cotton, plated with Lycra wrapped with cotton, endpoint was determined with the appearance of a hole. Uniformity was found in the test results for knits sampled from the heel of socks, which was made in the same way in all sock samples. By applying of modified holders adapted to the requirements of the HRN EN 13770, method 1, a lower number of rubs to reach endpoint is required, because the tested specimens are equally stretched over a flattened rubber surface of Martindale specimen holders.

4. Conclusion

The application of modified specimen holders according to the HRN EN 13770 is confirmed because it more faithfully simulates the load of sock knits during wearing and reduces the influence of knit elasticity on the obtained results. In the continuation of the research, the abrasion tester for socks will be developed..

Acknowledgement

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References

[1] Kraljević, I. et al: The Abrasion Wear Resistance of Men's Socks, *Proceedings of International Conference MATRIB, Materials, Tribology, Recycling 2021*, Ćorić, D. *et a*l (ed), 281-290, ISSN 2459-5608, Vela Luka, Croatia, 30.6. - 2.7. 2021, Croatian Society for Materials and Tribology, Zagreb, (2021)

[2] HRN EN 13770:2008 Tekstilije - Određivanje otpornosti čarapa na habanje

Katarina Krstović

Biography

Katarina Krstović was employed at Amadeus M.A.J., Zagreb (2012-2013), Textile Factory Trgovišće d.o.o. (2013- 2019), Taxo d.o.o. (2019 -2019) employed. Since 2020, she has been working at the Faculty of Textile Technology, University of Zagreb, as an assistant. In 2009 she completed her undergraduate studies and in 2011 her postgraduate studies at the Faculty of Textile Technology.

Title of dissertation topic

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Date of dissertation topic defense

MECHANICAL KNITTING PARAMETERS FOR SPORTS SWIMWEAR

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Abstract: *The fabrics for swimsuits are visually very similar: all are knitted; at first glance, they differ only in colour or print. Yet a large amount of research is being devoted in improving the properties of swimsuit materials. Fabric properties primarily depend on the target group of consumers (amateur, training or competitive swimming). This article describes some tests of the mechanical properties of knitted fabrics, which serve as the main indicators of knitting behavior and ultimately determine their purpose.*

1. Introduction

Textile materials are used in all sports as sportswear and in many sports as sports equipment and sports footwear. Swimwear is a relatively small, narrowly specialized manufacturing niche in the textile industry. The fabrics for swimsuits are visually very similar, at first glance they differ only in colour or print. They are all knitted. Yet a surprisingly large amount of research is being invested in improving the properties of swimsuit materials. Swimwear has been important in competitive swimming since it was known that its performance without doubt affects racing performance. The reduction of friction and drag have been main issue lately. Fabrics with high percentages of elastomers and lately carbon fibres for the suppression of swimmer's flesh vibrations are in a centre of research and development. Several studies were conducted in which the variables were the type of material, design of swimsuit and body coverage.

Training swimsuits are usually made of polyamide and elastane blend, and often 100% polyester fibre. Percentage of elastane is higher, popular is 68% PA/32% EL composition. Fabric is described as long lasting, chlorine resistant, comfortable. Design, cut, print and colour are as much important as for fashion fabrics, but promise speed and hydrodynamics [13]. Competitive or race suits are completely different category of swimming suites made with high percentage of elastane, with often added carbon fibre (for instance 65% PA/34% EL/1% carbon). Carbon fibre form strong nets, and the suits have special seam construction and compression panels, Fig 1.

a. b. c.

Figure 1 Knitwear for sports swimwear: a. Composition of knitted material 80% PA 20% EL; b. Composition of knitted material 71% PA 29% EL; c. Composition of knitted material 78% PA 22% EL

2. Experimental

In this paper, various tests of mechanical parameters of knitted fabrics intended for the manufacture of sports swimwear were studied. By testing the knitted fabric under force, we can check its durability. Based on the results obtained, it is possible to determine whether the knitted fabric is well designed and whether the desired properties are achieved. Depending on the purpose of the knitted fabric, the mechanical tests to be performed are selected. Several different and the most common tests of knitwear under force are covered. Tests of knitwear can be broadly divided into destructive and nondestructive tests. This means that in some tests the mesh is subjected to a force until it cracks and the material eventually disintegrates. When it comes to the mechanical properties of knitted fabrics, the tensile strength and the tear strength as well as the puncture resistance are primarily considered.

3. Results and Discussion

When it comes to the mechanical properties of knitted fabrics, the tensile strength and the tear strength as well as the puncture resistance are primarily considered. Dynamometers and a standardized procedure according to ISO 13934-1 [6] are used to perform the test. Test tubes of 20 cm x 5 cm in the direction of courses and in the direction of wales are prepared and placed on a dynamometer, which is subjected to a constant stretching speed until the knitted fabric breaks. The values obtained by this method are breaking force and elongation [9]. The wear resistance test can be used to assess the behavior and duration of use. According to ISO 12947-3 [9], a circular specimen is clamped in the specimen holder and subjected to a defined load, which is rubbed against the abrasive with a translational motion following the Lissajous figure, while the specimen holder is also free to rotate about its own axis perpendicular to the plane of the specimen. The estimation of the wear resistance of knitted fabrics is determined on the basis of the weight loss of the samples, i.e. the sample is weighed before and after the wear process and the difference in weight is calculated. Tests of knitted fabrics carried out by non-destructive methods are usually carried out first. Analytical balances and thickness gauges are instruments used to measure the surface mass of the mesh and its thickness. The results obtained provide us with additional data about the knitted fabric, although they do not necessarily have a direct effect on the mechanical properties of the knitted fabric.

4. Conclusion

Methods for testing the mechanical properties of knitted fabrics provide meaningful data by which their intended use can be determined in the first instance. By examining related knitted fabrics and comparing the data obtained, conclusions can be drawn as to their behavior in the use for which they are intended. It would also be very interesting to compare the mechanical properties of knitted fabrics intended for the production of sports swimsuits for training and those intended for competition swimsuits.

Acknowledgement

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References

[1] Manshahia, M.; Das, A.: Thermo-physiological comfort of compression athletic wear, *Indian Journal of Fibre & Textile Research*, **39** (2014) 139-146, ISSN 09710426
[2] Morales, A. T.; Tamayo Fajardo, J.A.; González-García, H.: High-Speed Swimsuits and Their Historical Development in Competitive Swimming, *Frontiers in Psychology*, **10** (2019) 1-11, ISSN 16641078
[3] Foster, L.; James, D.; Haake, S.: Influence of full body swimsuits on competitive performance, *Procedia Engineering*, **34** (2012), 712 – 717, ISSN 1877-7058
[4] https://www.arenasport.com/en_us/women/swimwear/training-suits.html, *Pristupljeno*: 2021-03-31
[5] https://www.arenasport.com/en_us/women/swimwear/race-suits.html, *Pristupljeno* 2021-03-31
[6] ISO 13934-1:2013 Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method
[7] ISO 13938-2:2019 Textiles — Bursting properties of fabrics — Part 2: Pneumatic method for determination of bursting strength and bursting distension
[8] Potočić Matković V.M.; Skenderi Z.: Mechanical Properties of Polyurethane Coated Knitted Fabrics, *Fibres and Textiles in Eastern Europe*, **100** (2013) 86 - 91, ISSN 12303666
[9] ISO 12947-3 Textiles — Determination of the abrasion resistance of fabrics by the Martindale method - Part 3: Determination of mass loss

Anja Ludaš

Biography	Anja Ludaš, was born 1993 in Zagreb. She received her master's degree in 2019 after graduating from the University of Zagreb Faculty of Textile Technology. She has been working on her PhD on doctoral study Textile Science and Technology since 2019 and is currently working as an assistant at the Faculty of Textile Technology. She also participating in the project of the Croatian Science Foundation HrZZ IP-2019-04-6418 Laser synthesis of nanoparticles and applications.
Title of dissertation topic	
Study advisor	Assoc Prof Sanja Ercegović Ražić, PhD
Date of dissertation topic defense	

INCORPORATION OF THE NANOPARTICLES INTO THE POLYMERS DURING EXTRUSION PROCESS OF MAN-MADE FIBRES AND PROPERTY MODIFICATIONS

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Abstract: *Metal nanoparticles obtained by laser ablation will be incorporated into polymers during the spinning process of man-made fibers. The obtained fibers with modified properties will be analyzed using modern methods of surface analysis and functional properties.*

1. Introduction

Nanotechnology has contributed to the potential development of improved materials with advanced properties for use in different application areas these days. Atoms within nanoparticles are perfectly ranked, but while material dimensions change from macro-size to nano-size, major changes in material properties occur [1]. In the coming years, understanding the properties of nanomaterials provides a space for developing materials to improve quality of life. Nanomaterials are being gradually commercialised, used in a wide range of advanced technologies and products, including a large scope: medicine, pharmacy, textile technology, electrical engineering, etc.

The textile industry is one of the major users of nanotechnology and there is a large number of nanotextiles on the market. Nanotextiles are considered to be conventional textiles with the addition of nanomaterials. Coating the surface of textiles and clothing with nanoparticles is an approach to the production of highly active surfaces to have UV-blocking, antimicrobial, antistatic, flame retardant, water and oil repellent, wrinkle resistant, self-cleaning properties, etc. [2]. Due to the fact that nanomaterials will not be recognisable after release into the environment, these materials could create various types of environmental problems. A comprehensive risk assessment should be carried out on nanomaterials that pose a real risk of exposure during their manufacture or use [3]. Therefore, nanoparticles obtained by laser synthesis will be used in this doctoral dissertation. Laser synthesis of nanoparticles in liquids is based on the process of pulsed laser ablation of metallic target immersed in liquid.

This technique is known as the 'green synthesis' technique as it provides non inhalable colloidal nanoparticles with no residues or chemical by products, while often no further purification is required. These nanoparticle solutions are salt-free solutions allowing broad application where absence of salt is mandatory (nano-bio, textiles, polymers, etc.) [4]. The possibility of adding additives and modifying properties is the most generous way to modify the properties of polymers. In order to carry out a technological process of chemical spinning of man-made fibres from a melt, a polymer must have the possibility of translating into a thermostable thallium of the required rheological properties, only in thermoplastic polymers [5].

2. Experimental

The metal nanoparticles obtained by laser synthesis in the liquid will be incorporated into the melt in the spinning process of man-made fibers.

Melt spinning is the simplest and most economical process. So it is used whenever a thermostable melt of the required rheological properties can be prepared from a polymer so that the melt extrusion process through the nozzle can be carried out without major polymer degradation and to form fibres from the polymer jet. Polymers suitable for the melt spinning process are (PET, PA, PE, PP, PVC, GF). This procedure includes several individual processes connected as a whole: melt preparation, forming threads by extrusion of melt through a nozzle, solidification or cooling by air flow, wetting and application of preparations and winding of filaments, Fig 1 [5].

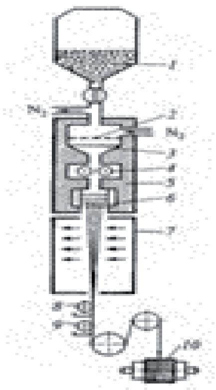

Figure 1 Scheme of chemical spinning of fibers [5]

3. Results and Discussion

By incorporating metal nanoparticles obtained by laser ablation into polymers during the spinning process of man-made fibers, modified properties of fibers will be obtained. Property analysis will be performed using these techniques: FE-SEM (scanning electron microscope) for morphological properties of the fiber surface, FT-IR (Fourier transmission infrared spectroscopy) to determine the characteristic functional groups of polymers, AFM (atomic force microscopy) to obtain surface topography data and other similar methods of analysis. Polymers impregnated with nanoparticles will be screened for their antibacterial potential against standard gram positive and gram negative laboratory bacterial strains, using the standardized quantitative microbiological methods.

4. Conclusion

The incorporation of metal nanoparticles into polymers during the spinning process of man-made fibers will improve the functional properties of the obtained filament with the expected purpose of such textile material. The main goal of this doctoral thesis is to achieve a multifunctional effect by incorporating nanoparticles into the polymer matrix and extrusion of textile filaments as materials with durable antimicrobial and UV protective properties.

Acknowledgement

This work has been fully supported by Croatian Science Foundation through the project (IP-2019-04-6418).

References

[1] Yang, G.; Park, S.J.: Deformation of single crystals, polycrystalline materials, and thin films: A review, *Materials*, **12** (2019), 2003-2018, ISSN 1996-1944

[2] Saleem, H.; Javaid Zaidi, S.: Sustainable Use of Nanomaterials in Textiles and Their Environmental Impact: A review, *Materials*, **13** (2020), 5134-5162, ISSN 1996-1944

[3] Kawai, S.; Niwano, M.; Sato, M.: A risk assessment framework for self-management of poorly soluble low toxic nanomaterials. *Heliyon*, **5** (2019), 1-7, ISSN 2405-8440

[4] Besner, S. et al: Ultrafast laser based “green” synthesis of non-toxic nanoparticles in aqueous solutions, *Applied Physics A*, **93** (2008) 4, 955-959, ISSN 0947-8396

[5] Čunko, R.; Raffaelli, D.; Šmit, I.: Vlakna, *Dostupan na*: https://tehnika.lzmk.hr/tehnickaenciklopedija /vlakna.pdf, *Pristupljeno:* 2021-12-14

Eva Magovac

Biography	Remarkably creative, proactive, and results-focused Textile Engineer with 18 years of immense management experience in product development, design, and quality assurance of products within highly competitive environments. Demonstrate strong command in all aspects of product development spanning from design to commercialisation, oversees the design, procurement and maintenance. Operates, calibrates, and conducts performance checks on laboratory equipment.
Title of dissertation topic	Flame Retardant Surface Modification of Cotton Textiles using Layer-by-Layer (LbL) Deposition
Mentors	Prof Sandra Bischof, PhD Prof Bojana Vončina, PhD
Date of dissertation topic defence	May 20th, 2016

ECO-FRIENDLY MULTIFUNCTIONAL TREATMENT OF COTTON - LAYER-BY-LAYER DEPOSITION

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Abstract: *Environmentally-applicable treatment, layer-by-layer (LbL) deposition, was used to obtain flame retardant and antimicrobial properties of cotton. Cotton fabric was coated with 8, 10, and 12 of phytic acid (PA) and chitosan (CH)-urea bilayers (BL) and then immersed into copper (II) sulfate ($CuSO_4$) solution. 12 BL of PA/CH-urea+Cu^{2+} were able to stop flame on cotton during vertical flammability testing (VFT) with the limiting oxygen index (LOI) value of 26%. Microscale combustion calorimeter (MCC) data showed a reduction of peak heat release rates (pHRR) of more than 61%, while the reduction of total heat release (THR) was more than 54% relative to untreated cotton fabric. Antibacterial testing shows 100% reduction of Klebsiella pneumoniae and Staphylococcus aureus. In this study cotton was successfully functionalized with multifunctional ecologically flame retardant and antibacterial nanocoating by LbL deposition.*

1. Introduction

Cotton is one of the most used textile materials for a variety of products. The reason why cotton is such a favorite material is its softness and water uptake, enabled by highly hydrophilic and reactive hydroxyl groups in the molecule of cellulose. The reactivity of these groups, however, makes cotton fabric very flammable and prone to microbial growth [1]. Commercially available compounds to reduce flammability of cotton and cotton-based materials are halogen, organo-halogen, antimony organo-halogen, and organophosphorus, some of them being toxic [2]. To stop or at least to reduce the bacterial growth, cotton is treated with different antibacterial compounds some of them being toxic [3]. Durable FR as well as antibacterial finishes for cotton are commercially applied by a pad-dry-cure process. The process is not ecological due to release of toxic formaldehyde derivatives during production and usage. A green alternative approach could be layer-by-layer (LbL) deposition, which uses deionized water as a solvent for various active compounds (polymers, nanoparticles, small molecules, etc.). By LbL deposition charged fabric is immersed into the oppositely charged polyelectrolyte solutions to deposit layered nanocoating in a form of layers. The process can be repeated as many times as necessary to obtain textiles with desired multifunctional properties such as flame retardancy and antimicrobial effect [4].

2. Experimental

Materials: cotton fabric, polyethylenimine (BPEI), urea, chitosan (CH), copper (II) sulfate pentahydrate ($CuSO_4$ x $5H_2O$), hydrochloric acid (HCl), sodium hydroxide (NaOH), phytic acid dodecanesodium salt hydrate (PA), deionized water (DI). The whole process is shown in Fig 1. A cationic BPEI solution was prepared for prime layering of cotton. An anionic PA solution and a cationic CH solution were magnetically stirred for 24 h. Urea was added to the CH solution after 24 h. Cu^{2+} solution was prepared by adding $CuSO_4$ x $5H_2O$ into DI. Prior the LbL deposition the pH of all of solutions (except BPEI) was adjusted to 4, with NaOH or HCl. Six cotton samples were first immersed into the BPEI solution and then alternately immersed into the PA/CH-urea solutions, depositing 8, 10, and 12 BL. At the end of process, samples were immersed into Cu^{2+} solution to achieve antibacterial properties. Thermal properties were measured by means of vertical flammability test (VFT), limiting oxygen index (LOI), microscale combustion calorimeter (MCC) and thermogravimetric analyzer (TGA). Antimicrobial properties were tested according to AATCC TM 100-2019.

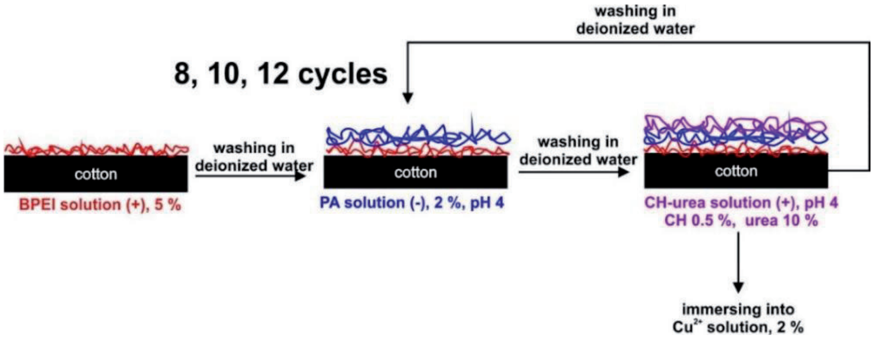

Figure 1 Schematic of LbL deposition

3. Results and Discussion

Cotton fabric was successfully treated with flame retardant coating consisting of PA/CH-urea via LbL deposition. The LOI value of cotton coated with 12 BL was 24.5 % and the sample passed VFT, with a char lenght of 6.7 cm. By immersing such treated cotton into Cu^{2+} solution, it is possible to achieve higher FR effect, as well as to obtain antimicrobial properties. The result is in accordance with MCC values, where pHRR for cotton, treated with 12 BL of PA/CH-urea, is 132.2 W/g. The reduction of heat release rates (HRR) is more than 50 % and the reduction of temperature peak heat release rates (Tp_{HRR}) is more than 23 °C relative to untreated cotton. At the same time the thermogravimetric (TG) analysis showed that 12 BL treatment moved first decomposition temperature (T_1) at the first decomposition stage to 57 °C lower value. By adding Cu^{2+} ions into the LbL system the difference is even more visible. Antibacterial testing showed the reduction of gram-negative Klebsiella pneumoniae and gram-positive Staphylococcus aureus for almost 100%.

4. Conclusion

In this study cotton was successfully functionalized with multifunctional ecologically flame retardant and antibacterial nanocoating by LbL deposition.

Acknowledgement

This work has been partly supported by project Modernization of Textile Science Research Centre Infrastructure (MI-TSRC) financed by EU.

References

[1] Singh, S. P. et al: Cellulose-Based Graft Copolymers, U *Cellulose-Based Graft Copolymers: Structure and Chemistry*, CRC Press, ISBN 9781138827196, Boka Raton, SAD, (2015), 235–270

[2] Magovac, E.; Bischof, S.: Non-Halogen FR Treatment of Cellulosic Textiles, *Tekstil,* **64** (2015) 9-10, 298–309, ISSN 0492-5882

[3] Gao, Y.; Cranston, R.: Recent Advances in Antimicrobial Treatments of Textiles, *Textile Research Journal*, **78** (2008) No. 1, 60–72, ISSN 0040-5175

[4] Li, P. et al: Fully Bio-Based Coating from Chitosan and Phytate for Fire-Safety and Antibacterial Cotton Fabrics, *Carbohydrate Polymers*, **237** (2020) 116173, 1-10, ISSN 0144-8617

Maja Mahnić Nagić

Biography	Maja Mahnić Naglić is born in Slavonski Brod. At the University of Zagreb Faculty of Textile Technology, she completed the undergraduate study Textile Technology and Engineering in 2009, and in 2011 she gained master degree. Since 2012, she has been employed at the Faculty of Textile Technology as an external associate, and since 2015 as an assistant. She participates in teaching in the field of 2D/3D CAD/CAM systems for clothing computer design. In 2013, she started doctoral study Textile Science and Technology. As a co-author she has published two chapters in scientific books, seven original scientific papers in journals cited in the WoS and Scopus databases, four original scientific papers in other journals and 17 original scientific papers in international conference proceedings.
Title of dissertation topic	Dynamic clothing behaviour under the influence of body biomechanics
Mentor	Prof Slavenka Petrak, PhD
Date of dissertation defense	July 7th, 2015

APPLICATION OF 3D FLATTENING METHOD IN BODY TYPES ANALYSIS

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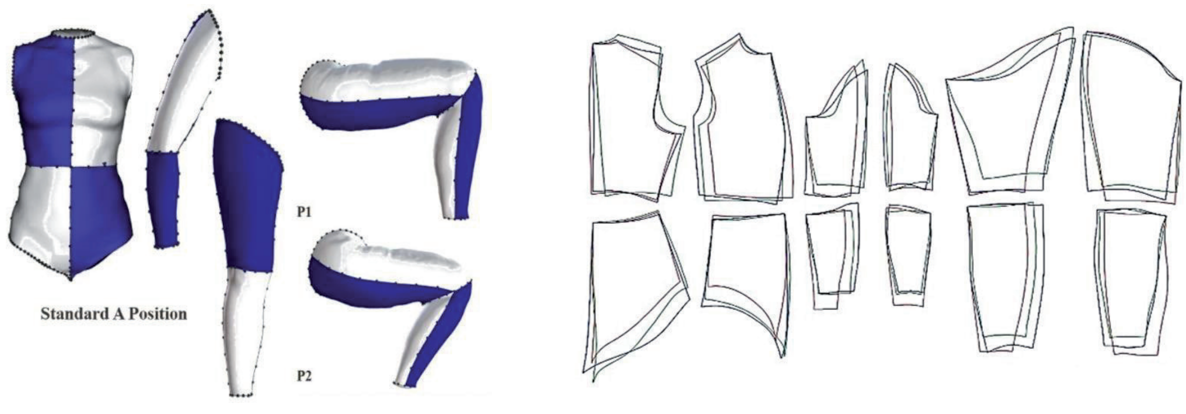
Abstract: *This paper presents research of female body characteristics using modern computer technology with specific application of research results in clothing engineering design and customization process according to different body types. Survey was conducted using 3D scanner, in static and dynamic body positions to gain an insight of body surface deformability in motion, important for providing high level of garment fit. Using 3D flattening method, both scanned and customized parametric body models were separated into the discrete 2D surfaces determined by anatomical planes and characteristic body lines. Discrete body surfaces of different body types were analyzed in terms of contour shapes and surface values. Contour shapes of flattened body segments were analyzed and compared with the patterns constructed according to standard garment construction methodology.*

1. Introduction

3D body scanners enable precise determination of body measurements and analysis of body shape and morphology, which is very significant for the construction of garments with high demands on functionality and fit. Scanned digital body models can be used in CAD systems for garment construction and 3D simulation, in the development process of digital garment prototypes customized according to individual measurements [1,2]. Female body types, characteristic for women of different ages and sizes, are differently defined according to different scientists. Classification methods are usually based on the ratio of characteristic body girths [3,4]. Since it is very difficult to satisfy high criteria on clothing fit for different sizes and body types using standard size systems and conventional construction methods, another advantage of 3D body scanners is obtaining dynamic anthropometry data, which enables analysis of body measurements and surface deviations due to body motion [5]. The 3D flattening method considers construction of a garment directly on a computer body model, separation of discrete 3D surfaces and transformation into the 2D flat surfaces, and is mostly used for construction of tigth fit garments [6].

2. Experimental

Female body types and morphology parameters that determine affiliation to a particular type were defined using the classification algorithm that defers three different groups of body shapes based on a side body curvature in frontal plane. Body type F1 is a rectangular type with almost same width on the chest, waist, abdomen and hips area. Body shapes F2 and F3 have pronounced side body curvature and differ in the lower part of torso where body type F3 has pronounced curve at the transition from the waist to hip line. To gain an insight of body surface deformability in motion, all test subjects were scanned in three dynamic body positions. Using 3D flattening method, both scanned and parametric body models, customized according to paritcular type, were separated into the discrete 2D surfaces determined by anatomical planes and characteristic body lines, commonly used for garment design and construction, Fig 1a.



a. b.

Figure 1 a. Scanned 3D body model separated into the discrete body surfaces in static and dynamic positions; b. Comparison of flattened 2D surface contour shapes for three body types

Discrete body surfaces were analyzed in terms of contour shape and surface values, Fig 1b. Values of flattened 2D surfaces were compared to the values of the referent 3D surfaces segmented on scanned body models in static and dynamic positions. Contour shapes of flattened body segments were analyzed and compared with the standard construction methodology which showed that limited number of referent body dimension included in traditional methods are not enough to obtain satisfying adjustment and high dimensional fit of garment according to body types. Simple garment overall was computer designed and constructed according to convenctional construction and 3D flattening method for every body type. Physically based 3D simulations of constructed garments were performed to analize garments dimensional fit, which included stress and stretch analysis of garments on referent body models in static and dynamic conditions.

3. Results and Discussion

The performed analysis of the scanned body models segments surface values showed significant differences between particular body shape groups. Despite the fact that all test subjects are in the same garment size range, flattened surface segments show different surface values and different contour shapes of segmented body parts. The differences between the observed types are particularly visible in the lower torso area. 3D flattening method showed better results of garment fit compared to conventional construction method. The analysis of body surface segments in dynamic positions showed differences in the flattened 2D surfaces values, as well as in 3D segment volume values, depending on the body position.

4. Conclusions

The results of the conducted research on flattened body segments surfaces and shapes have a direct application in the design and construction of garments customized according to individual mesurements, or particular group type and can be used for the development of garment customization methods. In addition, segmentation and 3D flattening method can also be applied in the field of dynamic anthropometry, enabling analysis of body segments surface deviations and changes in the body segments volumes depending on movement.

References

[1] Gill, S.; Heyes, S.: Lower body functional ease requirements in the garment pattern, *International Journal of Fashion, Design, Technology and Education*, **5** (2012) 1, 13-23, ISSN 1754-3266

[2] Petrak, S. et al: The impact of male body posture and shape on design and garment fit, *Fibres and Textiles in Eastern Europe*, **23** (2015) 6, 150-158, ISSN 1230-3666

[3] Fisher, T. et al: Automatic morphological classification with Case-Based Reasoning, *Proceedings of 7^rd^ International Conference on 3D Body Scanning Technologies*, DiApozzo, N. (ed.), 148-158, ISBN 978-3-033-05981-8, Lugano Switzerland, November 2016, Hometrica Consulting, Ascona, (2016)

[4] Vuruksan, A.; Bulgun, E.: Identification of female body shapes based on numerical evaluations, *International Journal of Clothing Science and Technology*, **23** (2011) 1, 46-60, ISSN 0955-6222

[5] Petrak, S.; Mahnic Naglic, M.: Dynamic Anthropometry – Defining a Protocols for Automatic Body Measurement, *Tekstilec*, **60** (2017) 4, 254-262, ISSN 0351-3386

[6] Petrak, S. et al: Sizing and fit for swimsuits and diving suits, In *Anthropometry, Apparel Sizing and Design*, Elsevier, ISBN 978-0-08-102604-5, Amsterdam, (2019), 255-288

Mislav Majdak

Biography	Mislav Majdak was born 1995 in Zagreb. In the year 2020 he graduated at the University of Zagreb Faculty of Textile Technology. In 2021 he enrolls on a doctoral study Textile Science and Technology University of Zagreb Faculty of Textile Technology. The same year he was employed on a project *Antimicrobial coating for biodegradable medicine materials*.
Title of dissertation topic	
Study advisor	Assoc Prof Iva Rezić, PhD PhD
Date of dissertation topic defense	

ANTIMICROBIAL COATINGS CONTAING METAL NANOPARTICLES ON MEDICAL TEXTILES

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University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10000 Zagreb, mislav.majdak@ttf.hr

Abstract: *UV/VIS spectroscopy allows for monitoring of silver release from microcapsules, as well as kinetics.*

1. Introduction

Human body is a host to many symbiotic microorganisms that protect and help regulate bodily functions [1,2], but some bacteria present a grave danger to human wellbeing. Bacteria such as *Staphylococcus aureus*, can cause health problems, and in the case of chronic wounds death [3]. To prevent the worst case scenario, scientists have been working on antimicrobial formulations that inhibit the growth or otherwise destroy colonies. In this paper, encapsulated formulations that contain silver nanoparticles, or silver nitrate will be researched. Silver is known for its antimicrobial properties, and thus has been widely used in bandages for chronic wound treatment [4]. Silver nitrate, and silver nanoparticles will be encapsulated, and thus allow for a slow and controlled release of intended concentrations of silver, which will potentially inhibit the growth, or destroy bacteria. Microcapsules will be bound on cotton textile material using sol-gel process, which will allow for a quick and easy treatment.

2. Experimental

In order to achieve the desired formulations, active agent needs to be encapsulated, by doing so microcapsules of intended dimensions can be obtained. For this purpose, *Buchi Encapsulator B-390* is used. This instrument allows for a quick, easy and continuous encapsulation of desired formulations. In this case, inside sodium alginate, and zinc sulphate heptahydrate, silver nanoparticles, or silver nitrate are encapsulated. The illustration of microcapsules cross section is presented in Fig 1.

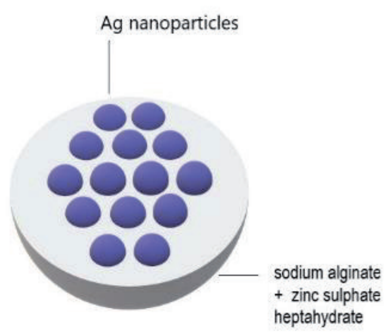

Figure 1 Cross section of microcapsules; the core which contains silver, and the outer layer made from sodium nitrate and zinc sulphate heptahydrate

For the purpose of silver release observation, that is kinetic observation, UV/VIS spectroscopy is used. Investigation was done in ultraviolet, as well as visible area. 18 samples weighing at 1 ± 0.001g were used (for every hour one sample). For the selection of microcapsules, simple sampling procedure was used.

3. Results and Discussion

Application of UV/VIS spectroscopy allowed for the observation of the release of silver in aqueous medium. It is possible to get the understanding of release kinetics by observing the obtained results. Concentration values are presented in Tab 1. Investigation was done in a 48 hour period, which coincides with the wound dressing [4]. From the values themselves, it can be seen that concentration values increase in a 48 hour period.

Table 1 Silver concentrations in µg/ml

Time/hours	Concentrations/ µg/ml		
1	0.011321	0.012026	0.009843
2	0.012866	0.012933	0.011321
3	0.014242	0.013604	0.011992
4	0.016234	0.015653	0.012664
24	0.017198	0.015048	0.013235
48	0.021060	0.020455	0.015451

4. Conclusion

Based on the obtained values, it can be concluded that within 48 hours a concertation of silver, that can inhibit or destroy bacteria colonies, is released. Although the concentration values vary among themselves, this will require a further investigation in the future, samples follow an identical trend. With the application of sol-gel process, textile materials will in the future be coated with microcapsules, with the purpose of obtaining an antimicrobial coating on medical material.

Acknowledgement

This work was financed by Croatian Science Foundation-s project ABBAMEDICA IP- 2019-04-1381, led by ass. prof. Iva Rezić Ph.D. Ph.D., for which the authors are very grateful.

References

[1] Grice, E.; Segre, J.: The skin microbiome, *Nature Reviews Microbiology*, **9** (2011) 4, 244-253, ISSN 1740-1534

[2] Scotti, E. et al: Exploring the microbiome in health and disease: Implication for toxicology, *Toxicology Research and Application*, **1** (2017) 1,1-37, ISSN 2397-8473

[3] Rezić, I. et al: Development of Antibacterial Protective Coatings Active against MSSA and MRSA on Biodegradable Polymers, *Polymers*, **13** (2021) 4, 1-17. ISSN 2073-4360

[4] Somogyi Škoc, M.; Pezelj, E.; Ležaić, D.: Karakterizacija i učinkovitost medicinskih obloga za kronične rane, *Tekstil*, **63** (2014) 9-10, 293-305. ISSN: 04925882

Rajna Malinar

Biography	Rajna Malinar was born in 1985 in Zagreb. In 2015 she completed her undergraduate studies in Textile Technology and Engeneering at the University of Zagreb Faculty of Textile Technology. In 2016, she was employed at the Faculty of Textile Technology as a professional associate through professional training. In 2017, she enrolled in the doctoral study Textile Science and Technology. She directs her scientific work towards research of textile dust generation and its reduction, and from 2018 to 2021 she worked as an assistant at the Faculty of Textile Technology on the project "Hospital Protective Textiles".
Title of dissertation topic	Development and modification of cotton fabrics with reduced textile dust generation for use in a hospital environment
Mentor	Assoc Prof Sandra Flinčec Grgac, PhD
Date of dissertation topic defense	February 17^{th}, 2021

DEVELOPMENT AND MODIFICATION OF COTTON FABRICS WITH REDUCED TEXTILE DUST GENERATION FOR USE IN A HOSPITAL ENVIRONMENT

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Abstract: *The purpose of this doctoral thesis is to reduce the amount of textile dust generated in the use of textiles, which would reduce the possibility of the spread of infectious microorganisms and the accumulation of dust on sophisticated equipment in a hospital environment. There are two viewpoints to consider for this problem: possibility of dust reduction in the fabric production phase and dust reduction by intervention in the fabric care process. The parameters and properties of textiles will be tested in accordance with standard and customized methods. The clothing comfort and health suitability will also be examined. The obtained knowledge of the production parameters that affect the generation of dust will provide guidelines for the production of fabrics for hospital use and an agent that reduces the amount of dust during the care process and increases antimicrobial properties could be applied in laundries to hospital linen currently in use.*

1. Introduction

In a hospital environment, textile dust presents a problem for several reasons. Microorganisms are spread by air through dust, accumulated dust serves as a nutrient for the development of microorganisms, and also the accumulation of dust inside sophisticated equipment can lead to device failures [1-4]. This makes it clear that there is a need to reduce the generation of textile dust in the hospital environment.

During use, textiles release fine particles as a result of friction between fibers. It is known that cotton textiles emit larger amounts of particles than polyester fibers [5], however, the connection between the structure of the material and the generation of textile dust has not yet been investigated. Since the construction characteristics of the fabric (material, weave and thread density) affect the friction within the fabric, it can be expected that different construction parameters can reduce the amount of textile dust generated.

Apart from the fact that the resulting friction can be manipulated in the process of fabric production, it is clear that the fabric surface is damaged in use and care processes, which leads to greater friction and thus greater dust generation. Therefore, in the second part of the paper, research is focused on development of agents that could be used as an additive in rinsing phase in the care process, which would smooth the surface and reduce dust generation.

2. Experimental

In the first part of the research the influence of different construction characteristics on the generation of textile dust will be examined. Samples of different weaves and thread densities will be subjected to multiple care processes to gain insight into the generation of textile dust over a longer period of use. In the second part of the research samples that show optimal results of dust generation in relation to usability, will be subjected to care processes with the included agent for reducing textile dust in the rinsing process. When a reduction in the dust of such specimens is achieved in relation to specimens without the agent applied, the clothing comfort and health suitability will also be tested on the specimens.

Textile material for research purposes was produced from different raw material compositions, weaves and weft densities. Cotton yarn was ordered from the same lot to maximize the uniformity of the raw material. The selected raw materials are 100% cotton yarn and blend of cotton and polyester fibers (50%/50%). Basic weaves and their derivatives were selected, total of seven different weaves. The weft density varied between the minimum, optimal, and maximum recommended densities for individual weaves, while warp density stayed same for all samples. The material was starched and chemically bleached after weaving. All samples were subjected to care processes according to EN ISO 15797, Textiles - Industrial washing and finishing procedures for testing of workwear, at 75 °C, with reference standard detergent and peroxyacetic acid. Samples were subjected to 3, 10 and 50 care processes.

Textile dust generation is tested according to ISO 9073-10 Textiles - Test methods for nonwovens - Part 10: Lint and other particles generation in the dry state, where results are obtained in the form of quantity and size of released particles from moving samples over a period of time. The samples will be examined for mechanical and structural properties: change in fabric strength, surface mass, thread density, fabric thickness, warp and weft crimp, and fabric surface will be examined by digital microscope. Statistical data processing will determine whether there are relationships between individual parameters of the fabric structure and the number of released particles.

3. Results and discussion

The reduction in dust generation by the addition of a rinsing bath agent during the care process will be investigated by examining the effectiveness of polyethylene glycols (PEG) of different molar masses. The possibility of applying additional agents will also be examined. The possibility of adding an antimicrobial agent that would have a positive effect on hospital textiles will also be investigated. The effectiveness of PEG will be evaluated gravimetrically, thermogravimetrically and spectrophotometrically. The dust generation testing will be carried out according to the previously mentioned method. Statistical processing of the results will evaluate the success of the application of the developed agent to reduce the generation of textile dust.

In order to ensure functionality and safety in use, the effects of production parameters and fabric processing on comfort and health will be examined. The clothing comfort of samples will be investigated by the moisture management ability test and on the fabric touch tester. The health safety of newly developed fabrics will be investigated with respect to antimicrobial efficacy. Also, toxicological tests will determine whether the chemicals used during the development of textiles with effective antimicrobial properties pose a health risk.

4. Conclusion

Textile dust is a possible carrier of microorganisms dangerous to health. It is known that its reduction can reduce the spread of infection in the hospital environment. Investigating the effect of different fabric production parameters on dust generation will provide guidelines for the production of fabrics for hospital use with reduced dust generation. Also, the development of an agent that can be added in the rinsing phase during the care process would reduce the generation of dust from existing hospital textiles also with the possibility of achieving antimicrobial efficacy. Optimizing such an agent would open the door to a commercial product that could be easily introduced into laundries.

Acknowledgement

The work has been supported by Croatian Science Foundation under the project UIP-2017-05-8780 HPROTEX.

References

[1] Rubbo, S. D.; Stratford, B. C.; Dixson, S.: Spread Of A Marker Organism In A Hospital Ward, *British Medical Journal*, **2** (1962), 282–287, ISSN 0959-8138

[2] Licina, D.; Nazaroff, W. W.: Clothing as a transport vector for airborne particles: Chamber study, *Indoor Air*, **28** (2018) 3, 404–414, ISSN 0905-6947

[3] Shiomori, T. et al: Evaluation of bedmaking-related airborne and surface methicillin-resistant Staphylococcus aureus contamination, *Journal of Hospital Infection*, **50** (2002) 1, 30–35, ISSN 0195-6701

[4] Neely, A. N.; Maley, M. P.: Survival of enterococci and staphylococci on hospital fabrics and plastic, *Journal of Clinical Microbiology*, **38** (2000) 2, 724–726, ISSN 0095-1137

[5] Lamb, G. E. R.; Kepka, S.; Miller, B.: Particle Release from Fabrics During Wear, *Aerosol Science and Technology*, **13** (1990) 1, 1–7, ISSN 0278-6826

Paula Marasović

Biography	Paula Marasović was born 1994 in Šibenik. In 2018 she obtained a master's degree in Textile Technology and Engineering, and in the same year enrolled in a postgraduate doctoral study in Textile Science and Technology. In 2019, she published a scientific review paper Overview and perspective of nonwoven agrotextile in an international scientific journal Textile & Leather Review. She was a student assistant for the courses Nonwovens and Technical Textiles, Nonwovens and Spinning. From 2018 to 2019, she worked in the technical fabric factory Kelteks Ltd. in Karlovac as a Senior production planner & scheduler. She has written articles for various web portals, most often on cultural topics and on sustainable fashion. Since 2020, she has been a member of the editorial board of an international scientific journal Textile & Leather Review.
Title of dissertation topic	Development of Biodegradable Nonwoven Agrotextiles from Natural and Renewable Sources
Study advisor	Assoc Prof Dragana Kopitar, PhD
Date of dissertation topic defense	

DEVELOPMENT OF BIODEGRADABLE NONWOVEN AGROTEXTILES FROM NATURAL AND RENEWABLE SOURCES

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Abstract: *Nowdays, people are much more aware of environmental pollution, ecological footprint, CO_2 emissions where everyone is turning to more sustainable development and environmental protection.Approx. 90% of the agrotextiles are made of synthetic polymers of PP, PE to a lesser extent from petroleum products such as PA and PET, which are becoming ecologically less acceptable. There is a trend of development of agrotextile production from natural fibres such as jute, wool, kenaf and cellulose regenerates (only 10%). Conversely, biobased agrotextiles reduce negative impact on environment where during and after use are completely decompose making them ecologically acceptable. A preliminary investigation of durability of various fabrics used for weed suppression (affected by weathering) and also those potentially applicable natural fabrics (taking into consideration the degradation time and efficiency) was conducted for the purpose of further extensive research. All the obtained results are important indicators for further research that will be conducted within the project "Development of biodegradable nonwoven agrotextiles from natural and renewable sources" (KK.01.2.1.02.0270).*

1. Introduction

Generally, media attention, NGO campaigns and product marketing have led to a rise consumer expectation regarding to materials sources, production and product usage. In addition to the pressure on the market, there has also been stricter government regulation regarding environmental impacts that apply to a range of industries; manufacturers of textiles therefore nonwovens are not immune. Due to different pressures, retailers and manufacturers are considering the environmental impact of the product along with performance and cost requirements. Accordingly, demand for agrotextiles made of natural fibres, synthetic biopolymers and biodegradable materials that reduce the environmental footprint increase [1].

Vegetable fibres cause of their superior engineering properties are mostly used for nonwoven agrotextiles; plant fibres can withstand much more heat and sunlight than most synthetic fibres where some can even withstand the harsh conditions of the marine environment. However, for applications in aquatic or muddy environments, agrotextiles made of vegetable fibres are not suitable because of their low lignin content (~ 4%), which makes them susceptible to microorganisms attack. Some of the natural vegetable fibres used for agrotextile production are jute, coconut, sisal, flax, hemp and wool [2]. Conventional natural textile materials such as cotton, wool and linen can be biodegraded if disposed on landfills or/and industrial composting. Cellulose fibres deteriorate quickly, especially light cotton patch can crumble in an effective compost pile in period from 1 to 6 months. Wool is more resistant, but it is also digested with bacteria and fungi along with insect larvae and can be fully decomposed burring in the soil in the period of 6 months. Alternative natural materials combine biodegradability with significantly lower carbon and water impacts, with desirable physical properties. The disadvantage of natural fibres is their short lifetime in relation to synthetic materials. However, natural materials make up only 3% of the fibre-based nonwovens market, so their environmental impact is less of a concern than synthetic materials [1].

In January 2018, the European Commission announced a new strategy for plastics. The goal for 2030 is to achieve recycling or re-use of 60% of all polymer materials. The goal in 2040. is to reach 100 %. At present, 674 thousand tons of new products are manufactured each year to cover the huge demand of agricultural practice, leaving behind about 1 million tons of waste [3]. The ability to recycle nonwoven materials is seen as a significant means of increasing product sustainability by reducing the volume of nonwovens going to landfill or incineration. The nonwoven product sustainability can be evaluated by considering each aspect along with impact of production and distribution. A truly sustainable product will deliver tangible benefits to the consumer whilst minimizing the negative impact on the environment [1]. From an economic point of view, it is most cost-effective to use existing materials (natural waste materials in particular) rather than synthesizing and producing new, biodegradable polymer materials. Crop covers made of textile waste are the subject of great interest. Textile waste is primarily understood as polysaccharide fibres: cotton, linen, hemp, jute and wool (as a protein fibre) [4].

2. Experimental

After the production of nonwovens, the samples will be characterized by testing the basic physico-mechanical properties (mass per unit area, thickness, breaking force and bursting strength), and will be conducted for many years by instillation into the ground. Samples will be periodically excavated and tested to determine the time of biodegradation.

3. Results and Discussion

The produced biodegradable nonwoven agrotextiles will serve to control weeds and promote plant growth that will reduce or eliminate the use of chemical pesticides and insecticides, with physico-mechanical properties of conventional PP nonwoven agrotextiles. After use, the material will be completely composted in accordance with the principles of the "zero waste" philosophy that ensures organic food production.

4. Conclusion

Increased consumer awareness and demands for more transparent and environmentally friendly processes have led manufacturers and retailers to consider the entire life cycle of their nonwoven fabrics, considering not only the source of the material but also the impact of the production, delivery, use and exploitation scenarios. In the direction of sustainable development, the need to use biodegradable agrotextiles made from natural fibers and recycled materials, has been explored. It can be concluded that given the environmental impact, the use of biodegradable and sustainable agrotextiles reduces CO_2 emissions and generally contributes to less soil pollution related to conventional agrotextile made of synthetic polymers.

Acknowledgement

This work has been supported by the European Union from the European Regional Development Fund under the project KK.01.2.1.02.0270 Development of biodegradable nonwoven agrotextiles from natural and renewable sources.

References

[1] Goswami, P.; O'Haire, T.: *Advances in Technical Nonwovens*, Woodhead Publishing, ISBN 9780081005750, Sawston, (2016)

[2] Paul, R.: *High Performance Technical Textiles*, John Wiley & Sons Ltd., ISBN 978-1-119-32501-7, Hoboken, (2019)

[3] Siwek, P. et al: Biodegradable agroplastics in 21st century horticulture, *Polimery*, **64** (2019) 7-8, 480–486, ISSN 00322725

[4] Gabryś, T. et al: *Modification and Properties of Cellulose Nonwoven Fabric-Multifunctional Mulching Material for Agricultural Applications*, *Materials,* **14** (2021),1-16, ISSN 1996-1944

Lela Martinaga

Biography	Lela Martinaga completed studies in Ecoengineering (Faculty of Chemical Engineering and Technology) and then enrolled in the Postgraduate Doctoral Study of Textile Science and Technology at the University of Zagreb, Faculty of Textile Technology. She works as an assistant at the same institution and studies biocatalytic processes of synthesis of metal nanoparticles for their application for the development of functional materials within the project of the Croatian Science Foundation. She has co-authored 9 scientific papers and 19 abstracts published in journals and conference proceedings. She had 4 oral and 10 poster presentations at conferences and was the immediate supervisor of 5 graduate and undergraduate thesis. She received a scholarship from the Republic of Austria for scientific training at the University of Natural Resources and Life Sciences (BOKU) in Vienna, Austria.
Title of dissertation topic	Enzymatic synthesis and characterization of metal and metal oxide nanoparticles and their application in improving functional properties of textile materials
Mentors	Assoc Prof Iva Rezić, PhD PhD Prof Ana Vrsalović Presečki, PhD
Date of dissertation topic defense	July 5th, 2018

ENVIRONMENTALLY ACCEPTABLE SYNTHESIS OF GOLD AND SILVER NANOPARTICLES

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***Abstract**: The use of gold (Au-) and silver nanoparticles (Ag-NPs) in the food and textile industry products can ensure many improvements in their antibacterial, UV protective, flame retardant and/or hydrophobic properties. In this research, to overcome the drawbacks of conventional NPs synthesis, enzymatic synthesis of Au- and Ag- NPs using two oxidoreductive enzymes (cellobiose dehydrogenase (Mt CDH) and glucose dehydrogenase (Gc GDH)) was carried out as a more convenient method. The influence of reaction conditions on the reactions was studied and optimized. The reaction kinetics was determined. The synthesized NPs were characterized by UV-Vis spectroscopy and the maximum observed absorbances at 540 and 430 nm confirmed the synthesis of Au and Ag-NPs, respectively.*

1. Introduction

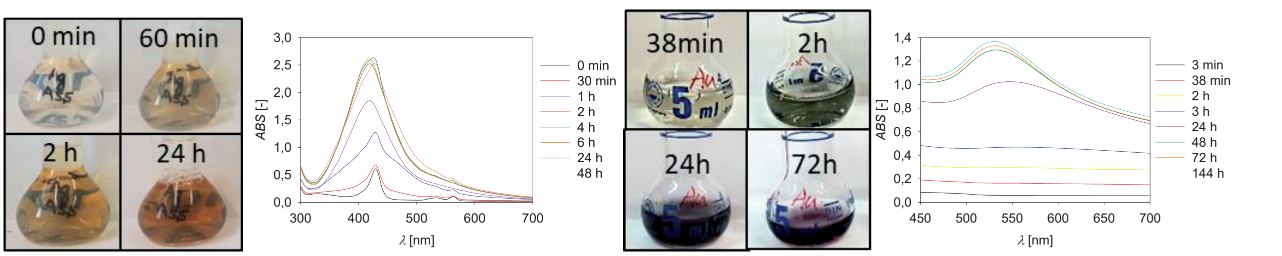
The use of metal nanoparticles with defined characteristics and their synthesis is one of the most studied research topics in recent decades. Gold (Au-) and silver nanoparticles (Ag-NPs) are considered the most interesting among nanoparticles due to their widespread application in health care, electronics, renewable energy and others [1]. Their use in food and textile industry products can provide many improvements in terms of antibacterial, UV protection, flame retardant and/or hydrophobic properties [2]. In order to overcome the drawbacks of conventional NPs synthesis, i.e. the use of harsh chemicals and/or reaction conditions, enzymatic synthesis of Au- and Ag-NPs was carried out as a more convenient method in this research [3].

2. Experimental

Enzymatic synthesis of Au- and Ag-NPs was performed using two oxidoreductases: cellobiose dehydrogenase (Mt CDH) and glucose dehydrogenase (Gc GDH). The impact of the reaction conditions (temperature, enzyme and reactant concentration, reaction medium, pH, light, and oxygen) was studied and optimized. The reaction kinetics were determined and the successfully synthesized NPs were characterized by UV-Vis spectroscopy.

3. Results and Discussion

An enzymatic synthesis of Ag-NPs was carried out in the reaction of the cellobiose oxidation catalyzed by the Mt CDH in a batch reactor. The optimal reaction conditions were as follows: 0.1 M acetic buffer pH 5.5, 37 °C, without mixing, presence of light and oxygen. In this reaction the kinetics of the Mt CDH and the influence of silver ions on enzyme activity were determined. The enzymatic reaction of the glucose oxidation catalyzed by the Gc GDH in a batch reactor was used for the Au-NPs synthesis. The optimal conditions for this reaction were: 0.1 M phosphate buffer pH 5.5, 37 °C, without mixing, presence of light and oxygen. The kinetics of the Gc GDH and the influence of gold ions on the enzyme activity were determined. Enzyme kinetics for both reactions were described by single-substrate Michaelis-Menten kinetics with competitive Au and Ag inhibition. The reactions were monitored by UV-Vis spectroscopy and according to the observed maximums of the obtained absorption peaks at 540 and 430 nm confirmed the synthesis of Au and Ag-NPs (Fig 1a, b and c, d) [4, 5].



b. c. d.

Figure 1 Results of the Ag- and Au-NPs synthesis: a. Colour change during the Ag-NPs synthesis; b. UV-Vis spectrums obtained during Ag-NPs synthesis; c. Colour change during the Au-NPs synthesis; d UV-Vis spectrums obtained during Au-NPs synthesis

4. Conclusion

Determination of reaction kinetics and development of a model enabled insight into the reaction mechanism of enzymatically catalyzed NPs synthesis. Therefore, a mechanism for the synthesis of Au- and Ag-NPs was proposed and validated by performing these reactions in a batch reactor. The maximum of the obtained absorption peaks at 540 and 430 nm confirmed the successful synthesis of Au and Ag-NPs, respectively.

Acknowledgement

This work was supported by the Croatian Science Foundation projects: "Young researchers' career development project - Training new doctoral students" (DOK-10-2015), "Synthesis and targeted application of metal nanoparticles - STARS" (UIP-09-2014-1534) and "Antibacterial coating for biodegradable medicine materials - ABBAMEDICA" (IP-2019-04-1381) and in part by the Scholarship of the Scholarship Foundation of the Republic of Austria (Undergraduates, Graduates, Postgraduates) awarded by the Austrian Agency for International Cooperation in Education and Research (OeAD-GmbH).

References

[1] Castro, L. et al: Mechanism and applications of metal nanoparticles prepared by bio-mediated process, *Reviews in Advanced Sciences and Engineering*, **3** (2014) 3, 199-216, ISSN 2157-9121
[2] Ahmed, S. et al: Biosynthesis of gold nanoparticles: a green approach, *Journal of Photochemistry & Photobiology B-Biology*, **161** (2016), 141-153, ISSN 1873-2682
[3] Adelere, I. A.; Lateef, A.: A novel approach to the green synthesis of metallic nanoparticles: The use of agro-wastes, enzymes, and pigments, *Nanotechnology Reviews*, **5** (2016) 6, 567-587, ISSN 2191-9089
[4] Zuber, A. et al: Detection of gold nanoparticles with different sizes using absorption and fluorescence based method, *Sensors and Actuators B-Chemical*, **227** (2016), 117-127, ISSN 0925-4005
[5] Ramirez, D.; Jaramillo, F.: Facile one-pot synthesis of uniform silver nanoparticles and growth mechanism, *DYNA*, **83** (2016) 198, 165-170, ISSN 0012-7353

Marija Nakić

Biography	She was born in Široki Brijeg, where she finished primary and secondary school. She graduated from the Faculty of Textile Technology at the University of Zagreb, study program of projecting and shaping of textile and garment and afterward she got a master's degree in the subject Croatian ethnical heritage in Rama area. She is currently a PhD student of the postgraduate study Textile Science and Technology. She worked as an interior designer for several companies in Herzegovina. Today she works in the International Relations Office of the University of Mostar.
Title of dissertation topic	Projecting criteria of the Croatian Coast historical textile
Study advisor	Assist Prof Željko Knezić, PhD
Date of dissertation topic defense	

PROJECTING CRITERIA OF THE CROATIAN COAST HISTORICAL TEXTILE

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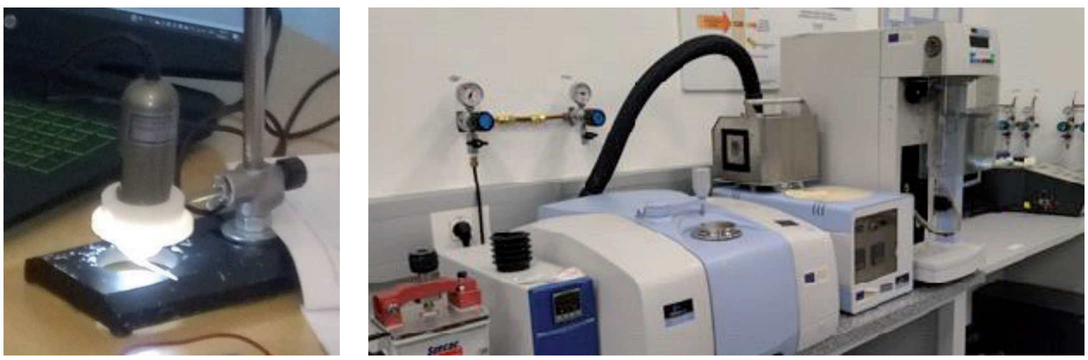
Summary: *The choice of garments depends on climatic influences, needed protection from mechanical injuries, highlighting of class affiliation function, rang identification of hierarchical scale in organisational groups (e.g. church, the military etc.), expression of attitudes and attribute embellishment as well. The last mentioned has always been important particularly for women. They possessed, even the underclass women, for the special occasions, some attractive, more valuable garments purchased from local merchants, traveling salesmen or the garments were brought their wives and girls by sailors. However, some particular items were homemade or manufactured from autochthonic materials. Historical textile as a part of the Croatian ethnical heritage as well as a scientific area of textile technology is not enough explored. Therefore, in the framework of PhD thesis at the available historical textile samples will be researched material types, raw material compositions, ways of making threads and fabrics as well as finishing of the parts of garments and utility items. Based on the collected relative parameters will be made portfolio and replicas as well.*

1. Introduction

Different sources prove that textile handiwork on Croatian ground dates from prehistorical period [1]. Before the industrial manufacture on today's Croatian territory the garments were handmade from fabrics created by hand weaving or knitting from available yarns of animal or plant origins. It is important to notice the difference between the garments made from the rougher materials (linen, hemp, wool, spartium junceum) for daily occasions and the garments made from the finest materials (silk linen, worsted, natural silk, metallic and gilded threads and then a mercerized cotton filament) worn in the special occasions [2]. On the Croatian Coast a lot of women's garment parts made from natural materials with remarkable attention are highlighted, but over the time they have gone out of use due to changes in the dress code as well as damage caused by improper use, maintenance, preservation, etc.

2. Experimental

In the framework of PhD thesis structured through the several phases, first will be conducted the research about written traces of the original textile samples, records based on oral tradition (sources, information extraction, comparison and reliability checks). With the field research will be made a target exemption of the samples according to the agreement with the competent institutions. In order not to damage or deform, the samples will be exposed to the non-destructive analysis methods using scientific equipment Fig 1 [3].



a. b.

Figure 1 Instruments for the analysis performing: a. digital microscope; b. FTIR spectrophotometer with TG-IR interface

3. Results and discussion

Portfolio and replica will be made based on the characterization of used materials, the way of making threads and fabrics, finishing, the way of making useful items and parts of clothes as well. Based on the relevant conducted researches and analysis will be made the comparison between the original and replica of the Croatian Coast historical textile. In that way the historical textile itself temporal and prone to destruction could be preserved as precious, cultural and historical heritage.

4. Conclusion

In the PhD thesis will be presented the projecting criteria of the Croatian Coast historical textile, which were conducted with remarkable attention, without violation of the existing condition of each particular item, with extreme caution in order to avoid possible damage. The field researches will also be conducted, with the attention paid to authenticity of the institution, as well as the talks with selected stakeholders of the Croatian coastal region. The data collected in this way will be compared with written records and critically analysed. Based on the whole data and realised research concept as the final result will be the replica designed as faithfully as possible.

References

[1] Čunko, R. et al:: Povijest proizvodnje tekstila u Hrvatskoj, U *Godišnjaku 2019 Hrvatske akademije tehničkih znanosti – Hrvatska tehnička i industrijska baština*, Akademija tehničkih znanosti Hrvatske, ISSN 1332-3482, Zagreb, (2020.), 76-103

[2] Firšt Rogale, S.; Rogale, D. i Knezić, Ž.: Povijest izrade i proizvodnje odjeće u Hrvatskoj, U *Godišnjaku 2019 Hrvatske akademije tehničkih znanosti – Hrvatska tehnička i industrijska baština*, Akademija tehničkih znanosti Hrvatske, ISSN 1332-3482, Zagreb, (2020.), 145-160

[3] Katalog znanstvene opreme - Zavod za tekstilnu kemiju i ekologiju, *Dostupno na*: https://www.ttf.unizg.hr/katalog-znanstvene-opreme/175, *Pristupljeno:* 2021-12-30

Željka Pavlović

Biography	Željka Pavlović was born 1987 in Zabok. After finishing primary school in Samobor, she enrolled in the School of Economics and finished it in 2005. In 2005 she enrolled at the Faculty of Textile Technology University of Zagreb. After graduating, she was employed in the socks factory Jadran d.d., where she worked as a production technologist for 3.5 years. In 2015, she was employed as an assistant at Faculty of Textile Technology. In 2016, she enrolled in the doctoral study Textile Science and Technology at the Faculty of Textile Technology. Her areas of special interest are the design and production of socks and the analysis of the work of knitting machines.
Title of dissertation topic	Thermophysiological properties of knitted fabrics as a function of the knitting process and structure
Mentor	Prof Zlatko Vrljičak, PhD
Date of dissertation topic defense	July 15th, 2020

BRIEF OVERVIEW OF THE INFLUENCE OF KNITTING AND STRUCTURE PROCESS ON ELONGATION PROPERTIES OF RIB KNITTED FABRICS

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Abstract: *In the world, more and more yarns are being made that will replace the classic cotton yarns obtained with a ring spinning system. Cotton single yarns of fineness 14, 16, 20 and 25 tex are often used in the production of underwear. For several reasons, with the increase in the number of people, the production of cotton yarn does not increase proportionally. Therefore, the production of yarns is approached, which will replace or supplement cotton yarns in different areas of application. For this research, four yarns of nominal fineness of 20 tex were made, which are used for the production of weft knits intended for the production of various lighter garments, surface mass from 120 to 200 g/m^2. The yarns are made by ring, rotor, SIRO and aerodynamic spinning process from cotton, viscose and modal fibers. With these yarns, one viscose Siro yarn and one cotton yarn, four patterns of plain rib knitted fabrics were made on a circular knitting two needle-bed of E17 gauge, needle diameter 200 mm (8 inches), knitted with 8 knitting systems at a speed of 60/min.*

1. Introduction

With the increase in the number of people on earth and the standard of living, it is necessary to increase the production of textile fibres and their areas of application [1,2]. Based on the collected data, it is estimated that in 2013, about 92 million tons of fibres were produced, or about 12 kg/capita [3,4]. The share of individual fibre lengths and yarn production processes are selected according to the desired yarn structure and the use properties of the yarn, i.e., its purpose. In this way, it is possible to obtain with yarn fibres some properties of yarns that are significantly different from cotton yarns, and thus a fabric with different properties. With new yarn structures, modern products are made that have existing, but also some new areas of application [1,5].

2. Experimental

For these research, four yarns of fineness of 20 tex, whose structures are different, were made with different raw materials and spinning procedures. A circular two needle-bed knitting machine of E17 gauge, with 8 knitting systems, was used to make the samples. The samples were made with the four mentioned yarns of different structures and tensile properties. The extensibility of the plain rib knits is significantly higher in the course direction than the wale direction.

3. Results and Discussion

The change in all parameters of the structure is reflected through the mass per unit area, which for unfinished knitted samples is 131±3 to 180±3 g/m^2, Tab 1. All samples are made on one machine and under the same conditions, i.e., without regulation of machine operation. All yarns have fineness of 20 tex, and a large difference in mass per unit area of up to 37% was obtained. This is because significantly different yarn structures. The lightest unfinished sample has a mass per unit area of 131±3 g/m^2 and is obtained by knitting with viscose and modal yarn, and the most massive sample has a mass per unit area of 180±3 g/m^2 and is obtained by knitting with viscose Siro yarn.

Table 1 Basic parameters of the structure of made and analysed unfinished knitted fabrics

Samples	Mass per unit area m, g/m^2	Volume mass mz, g/cm^3	Tightness factor, C	Stitch length, ℓ mm
P-KK	157 ± 3	0.246	0.97	3.15 ± 0.01
V-OE	131 ± 3	0.222	0.72	3.10 ± 0.01
SIRO	180 ± 3	0.251	0.89	3.13 ± 0.01
M-AJ	131 ± 3	0.218	0.78	3.13 ± 0.01

Where: P-KK – cotton, ring yarn, V-OE – viscose, open-end yarn, SIRO – viscose, Siro yarn i M-AJ – modal, air-jet yarn

Table 2 Elongation of knitted fabrics in course and wale direction - transversely and longitudinally

Samples	εep, %	εpp, %	εtp, %	εeu, %	εpu, %	εtu, %
P-KK	200	280	364	12	28	51
V-OE	70	130	221	5	8	33
SIRO	100	160	250	25	36	64
M-AJ	200	270	382	7	13	34

Where: εe – knitted fabric elongation, elastic area, %; εp – knitted fabric elongation, to the beginning of the plastic area, %; εt – knitted fabric elongation to the moment of tearing, %; with the index p course direction is makred – transverse, and longitudinal direction is marked with index u.

4. Conclusion

All knitted samples were made on one machine under the same knitting conditions. The samples were made with four yarns of fineness of 20 tex, and significantly different knitted structures were obtained, which have mass per unit area from 131±3 to 180±3 g/m^2. The elongation of the knit in the course direction or the transverse elongation is in the range of 221 to 382%, and in the wale direction or longitudinal is much lower and is in the range of 33 to 64%. All the differences are caused by the structure of the yarn and the knit. For the commercial application of the analysed yarns, it is recommended to carefully select the knitting parameters in order to obtain a satisfactory knitting structure. The results of the research indicate that with the mentioned yarns it is very difficult to get the same structure of knits that will be used in the production of one product.

Acknowledgement

This work has been supported by the Croatian science foundation within the project IP-2016-06-5278 Comfort and antimicrobial properties of textiles and footwear.

References

[1] Pavlović Ž., Iveković, G.; Vrljičak, Z.: Utjecaj pređa različitih postupaka predenja na strukturu glatkih kulirnih desno-desnih pletiva, *Zbornik radova 11. znanstveno-stručnog savjetovanje Tekstilna znanost i gospodarstvo*, Ercegović Ražić, S. i dr. (ur.), 86-91, ISSN 2584-6450, siječanj 2018., Zagreb, (2018.)

[2] Koslowski H.J.: *Chemifaser Lexikon*, Deutscher Ferlag, ISBN 978-3-87150-876-9, (2008)

[3] Zdraveva, E. et al: Electrospun Poly(vinyl alcohol)/Phase Change Material Fibers: Morphology, Heat Properties, and Stability, *Industrial & engineering chemistry research*, **54** (2015) 35, 8706-8712, ISSN: 0888-5885

[4] *Dostupan na:* http://www.fao.org/faostat/en/#data/QC/visualize, *Pristupljeno*: 2021-12-27

[5] Siejak, V.: *The Fiber Years 2014*, PHP Fibers GmbH, Wuppertal, Germany (2014)

[6] Skenderi, Z., Iveković, G.; Kopitar, D.: Utjecaj tehnike predenja na fizikalno-mehaničke karakteristike pređe iz mikromodalnih vlakana, *Zbornik radova 11. znanstveno-stručnog savjetovanje Tekstilna znanost i gospodarstvo*, Ercegović Ražić, S. i dr. (ur.), 86-91, 205-210, ISSN 2584-6450, siječanj 2018., Zagreb, (2018)

Marijana Pavunc Samaržija

Biography	Marijana Pavunc Samaržija in 2012 completed graduate studies Textile Technology and Engineering (sections Textile Chemistry, Materials and Ecology) at the University of Zagreb Faculty of Textile Technology. Since 2013 till 2020 she was working at the University of Zagreb Faculty of Textile Technology as an assistant and from 2021 she was employed as a lecturer. From the beginning of her scientific work her research interests are directed to textile fibres, conservation and restoration of textile and recycling of textile materials.
Title of dissertation topic	Life cycle assessment of fibre reinforced composites - industrial *vs.* consumer waste
Study advisor	Prof Edita Vujasinović, PhD
Date of dissertation topic defense	/

LIFE CYCLE ASSESSMENT OF FIBRE REINFORCED COMPOSITES - INDUSTRIAL *vs.* CONSUMER WASTE

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Abstract: *In order to reduce waste, recycling and reuse of recycled material becomes essential, but it isn't always simple and effective, especially when it comes to fiber reinforced composites. Quality of obtained recycled materials are often lower, making it difficult to predict their further use, which imposes the need that new fibre reinforced composite design must be in accordance with sustainable development.*

1. Introduction

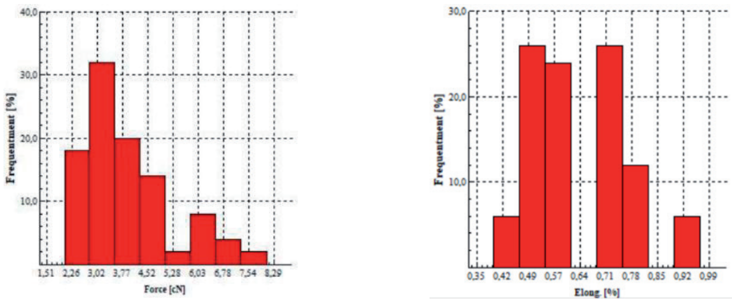
Today, great attention is paid to sustainable resource management and waste reduction, whether it is consumer waste generated at the end of the product life cycle or industrial waste generated during the production process. Increasing solid waste accumulation is one of the biggest problems today and it is associated with increased material demand which is directly related to population growth but also with a still widespread linear economy characterized by a low level of material efficiency. Waste recovery in the most efficient way, i.e., its transformation into a new raw material, represent an important part of the circular economy which is becoming a key concept for the development of technical and biological cycles of the closed loop [1]. Fibre reinforced composites, due to their excellent properties, are today inevitable material in many industries (such as automotive, construction, aerospace, marine, etc.). In recent years, the demand for fibre reinforces composites has been constantly increasing, which has resulted in a potential increase of this type of waste. Until now, the most common treatments at the end of their lives are permanent disposal in landfills or their incineration, which is not an option today due to limited landfill capacity and increasingly stringent legal regulations related to waste management and environmental protection. Although several technologies for fiber reinforced composites recycling have been presented, there is still a need to optimize these processes in order to obtain better recycled materials and/or improve process efficiency while increasing economic viability taking into account all possible harmful effects on the environment. Increased production of fiber reinforced composites also leads to increased demand for raw materials needed for their production, especially for high performance fibers such as carbon fiber, whose current production volume will not be able to meet increasing demand in the coming years [2, 3]. Sustainable development and environmental protection impose the need for reusage of fibers obtained by composites recycling (consumer waste) and those originating from the production process (industrial waste). However, to use recycled fibers for a new product, especially those with higher added value, their quality must be preserved as much as possible, and that their properties as uniform as possible.

2. Experimental

The aim of this paper is to determine the tensile strength of waste carbon fibers originating from the production of so-called *roving fabrics* for use in fiber reinforced composites and compare them with the actual values of recycled carbon fibers obtained by recovering carbon fiber reinforced composites waste. According to the literature [4], the tensile properties of recycled carbon fibers obtained by pyrolysis (which is recognized as the most appropriate and sustainable method of recycling carbon fiber reinforced composites at the end of their life cycle) are 2% to 85% lower than the virgin fibers. Such a large variation in the tensile properties of recycled fibers is the result of different pyrolysis cycles. For the purposes of this research, the tensile properties of industrial carbon fiber waste were determined by the method of individual measurement using Vibroscope and Vibrodyn 400. The tests were performed in accordance with ISO 5079:2020 standard.

3. Results and Discussion

Fig 1 shows the frequency diagrams of breaking force and breaking elongation. It can be seen that the ranges of breaking force and breaking elongation for the tested fibers are larger than usual ranges for high performance fibers (coefficients of variation for high performance fibres are up to 10%, and in this case are higher than 20%).



a. b.

Figure 1 Frequency diagrams: a. for breaking force; b. for breaking elongation

The test results showed that the tensile strength of carbon fibers characterized as industrial waste is only 20% of the tensile strength of the virgin fibers (4000 MPa for monofilament). Since carbon fibers are extremely brittle and sensitive, and thus prone to degradation, the most likely reason for such results is in the inappropriate manipulation with fibers after they have been removed from the production process as waste.

4. Conclusion

Although waste fibers used in the industrial process for production of fiber reinforced composites are considered to have slightly lower if not identical properties to the virgin carbon fibers, the results showed significant degradation of fibers strength. Opposite to them, the strength of recycled fibers from waste composites can be as much as 98% of the strength of the virgin fibers. Therefore, if these fibers are to be used in the future production process, either in the classical textiles process or for the production of fiber reinforced composites, they should be handled with care at the beginning of their emergence in order to preserve the highest possible level of their original properties.

References

[1] Mativenga, P.T. et al: Composites in a Circular Economy: A study of United Kingdom and South Africa, *Procedia CIRP*, **61** (2017), 691-696, ISSN 2212-8271

[2] Korniejenko, K. et al: Tackling the Circular Economy Challenges - Composites Recycling: Used Tyres, Wind Turbine Blades, and Solar Panels, *Journal of Composites Science*, **5** (2021) 9, 1-18, ISSN 2504-477X7

[3] Barnett, P. R.; Barnett, H.K.: A Review of Recent Developments in Composites Made of Recycled Carbon Fiber Textiles, *Textiles*, **1** (2021) 2, 433–465, ISSN: 2673-7248

[4] Zhang, J.et al: Current status of carbon fibre and carbon fibre composites recycling, *Composites Part B: Engineering,* **193** (2020), ISSN 1359-8368

Antonija Petrov

Biography

Antonija Petrov was born 1993. in Zagreb. In 2017, at the University of Zagreb Faculty of Textile Technology, she completed the university undergraduate study of Textile Technology and Engineering. She completed the graduate study of Textile Technology and Engineering in 2019 and obtained the title of Master of Textile Technology and Engineering. In 2021, she enrolled in the postgraduate university study of Textile Science and Technology, where she directed his scientific interest towards the perspective of infrared thermography and its application in sports. She is currently employed as an assistant on the research project of the Croatian Science Foundation Textile materials for increased comfort in sports - TEMPO, IP - 2019-04-1381.

Title of dissertation topic

Perspective of infrared thermography and its application in sport

Study advisor

Assoc Prof Goran Čubrić, PhD

Date of dissertation topic defense

PERSPECTIVE OF INFRAREDED THERMOGRAPHY AND ITS APPLICATION IN SPORT

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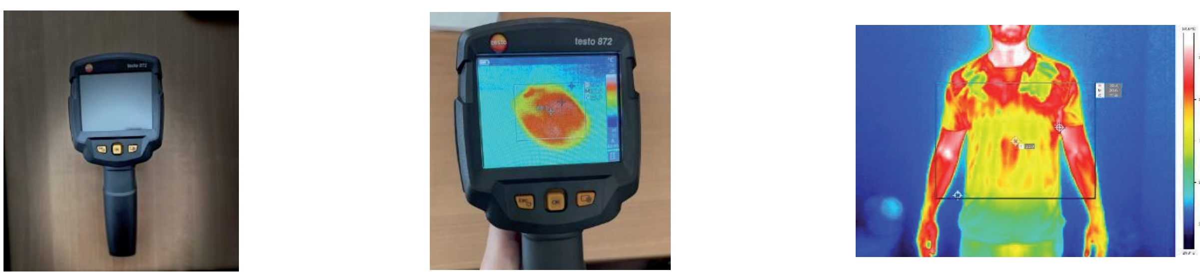
Abstract: *In PhD dissertation, research will be conducted using infrared terminology as an important method for evaluating sportswear. Sportswear for active athletes has various functions that perform certain features and help athletes achieve better athletic performance. In any sportswear, the physiological aspect is of great importance because it has a great impact on the efficiency and performance of athletes. Accordingly, the ability to transfer moisture, drying time, and feel of the material used for sportswear will be investigated. A protocol for measuring with a thermographic camera will also be developed, after which the development of a conceptual solution for displaying temperature mapping on the athlete's body will begin.*

1. Introduction

Sportswear today is a necessary element for all types of physical activity in the world. Sportswear manufacturers are involved in a design process that combines aesthetics and a variety of functions to meet the athletic and physical needs of active athletes. In sportswear, comfort is very important, since sports require unhindered mobility, clothing must be adapted to the body [1, 2]. Sportswear interacts with physiological and physical processes that affect skin temperature that can be assessed by infrared thermography (IRT). IRT involves the use of an infrared camera that can detect thermal radiation and produce color images, called thermograms. The thermogram contains temperature data, and one of the main advantages is that it allows us to visualize temperature differences on the recorded object, using color differences that are related to the temperature and color scale, Fig 1. [3, 4]. The infrared thermography device should be considered as a valuable ally for material characterization and evaluation procedures that can help improve product design and fabrication [5]. Some of the areas of application of infrared thermography are construction, transport, power engineering, mechanical engineering, medicine, veterinary, medicine, and clothing technology [6, 7]. In the field of textile engineering, thermography is used to observe the properties of textile materials, the comfort of clothing, product development. Much attention has been paid to mapping body temperature to adjust fabric and garments to better meet body needs [8]. Thermography also serves to evaluate the performance of clothing for personal use [9], protective clothing such as intelligent and thermal adaptive clothing, and recreational or professional athletes [10]. Thermography as stated has wide application in sports science. The validity and reliability of this method for measuring skin temperature have been documented in many sports. The topic of this Phd dissertation will focus on aspects of the application of thermography in the evaluation of thermo physiological comfort of sportswear.

2. Experimental

In the experimental part of PhD dissertation, a protocol for the evaluation of material parameters related to the perception of touch will be developed, testing of properties that determine the comfort of clothing, analyzing properties that determine the comfort of materials used for sportswear, evaluation of sportswear properties using thermography, prototypes of clothing for targeted sports, given the evaluated parameters of the comfort of materials and clothing. Various test methods will be conducted for research purposes.



a. b. c.

Figure 1 Thermal camera TESTO 872: a. display of thermal camera; b. testing of samples with thermal camera; c. example of thermogram

Physical and mechanical properties of the material will be tested by measuring the thickness, surface mass, porosity, bending stiffness, tensile properties, puncture resistance, wear resistance, and peeling of the test material. Using an IRT camera, we will determine the ability to transfer moisture and drying time of the material, as well as the temperature distribution on the athlete's body.

4. Conclusion

Infrared thermography is a very important and frequently used method for estimating a number of parameters in various scientific and professional fields. When it comes to the textile field, thermography can support the development of custom sportswear. In this context, individual temperature patterns of athletes may be useful for targeting heat loss or heat retention. Infrared thermography is used to a limited extent in the field of ergonomics of sportswear, especially when it comes to sportswear for certain sports and professional athletes. Considering the specificity of each sport and the need to improve the performance of athletes, there are numerous examples where thermography could be used as a reliable method of assessment.

Acknowledgement

This work has been fully supported by Croatian Science Foundation under the project IP-2020-02-5041"Textile Materials for Enhanced Comfort in Sports - TEMPO", and under the project DOK-2021-02-4746 „Young researchers' career development project - Training of new doctoral students - ATLETO".

References

[1] Priego Quesada, J.I. et al: Assessment of Sport Garments Using Infrared Thermography, In *Application of Infrared Thermography in Sports Science*, ISBN 978-3-319-47410-6, Valencia, (2017), 159-179

[2] Salopek Čubrić, I.; Skenderi, Z.; Mijović, B.: Primjena termografije i subjektivnog ispitivanja pri evaluaciji udobnosti, *Sigurnost*, **51** (2009.) 3, 193-200, ISSN 0350-6886

[3] Fournet, D.; Redortier, B.; Havenith, G.: A method for whole-body skin temperature mapping in humans, *Thermology International*, **22** (2012) 4, 157–159, ISSN 1560-604X

[4] Meola, C.; Boccardi, S.; Carlomagno, G.: Nondestructive Testing With Infrared Thermography*, In Infrared Thermography in the Evaluation of Aerospace Composite Materials*, Woodhead Publishing, ISBN 978-1782421719, United Kingdom (2017), 85–125

[5] Meola, C.: Infrared Thermography in the Architectural Field, *The Scientific World Journal*, **14** (2013) ID 323948, 1–8, ISSN 1537-744X

[6] Tattersall, G. J.: Infrared thermography: A non-invasive window into thermal physiology, *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, **202** (2016) 12, 78–98, ISSN 15314332

[7] Usamentiaga, R. et al: Infrared Thermography for Temperature Measurement and Non-Destructive Testing, *Sensors*, **14** (2014) 7, 12305–12348, ISSN 1424-8220

[8] Salopek Čubrić, I. et al: The comfort of knitted fabrics: interaction of sportswear and athlete's body, *Communications in Development and Assembling of Textile Products*, **2** (2021) 1, 1-10, ISSN 2701-939X

[9] Mijović, B. et al: Thermographic Assessment of Sweat Evaporation within Different Clothing Systems, *Fibres & Textiles in Eastern Europe*, **20** (2012) 5, 81-86, ISSN 1230-3666

[10] Čubrić, G.; Rogale, D.; Nikolić, G.: Measuring the thermal insulation chamber with infrared camera, *Proceedings of 5th International Ergonomics Conference*, Lotens, W., Havenith, G (ed.) ISSN 1848-9699, Zadar, June, 2013, Tiskara Zrinski d.d. (2013)

Luka Savić

Biography	Luka Savić was born on 1988 in Zagreb, Croatia. He finished his masters at University of Zagreb Faculty of Textile Technology and was involved in Erasmus+ project after 4 months with University of Oxford in 2019. From 2019 to 2021 he worked as research assistant in electrospinning for Univeristy of Oxford. Currently he works as an assistant at Faculty of Textile Technology and is involved in PhD studies at the same Faculty. His field of work is tehnical textiles and his scientific research is focused on medical textiles.
Title of dissertation topic	
Study advisor	Assoc Prof Maja Somogyi Škoc, PhD
Date of dissertation topic defense	

OVERVIEW OF ELECTROACTIVE AND CONDUCTIVE POLYMERS AND THEIR USE IN BIOMEDICINE AS ELECTROSPUN BIOSCAFFOLDS FOR TISSUE AND NERVE REPAIR

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Abstract: *Reviewing available literature and electronic sources revealed the great potential of electroactive and conductive polymers for the regeneration of both tissues and nerves. Functional disorder e.g. Peripheral nerves can occur due to damage to the nerve fiber itself, the body of the nerve cell, the Schwann cell or the myelin sheath. When the myelin sheath is damaged and the myelin collapses, the nerves cannot transmit impulses normally. The doctoral dissertation will focus on polymer research, electrospinning process where it is necessary to achieve impulse transmission and / or cell regeneration with other polymer properties and the possibility of forming linear and / or flat textiles. The research will be harmonized with the requirements of the European Medicines Agency, The Food and Drug Administration, etc.*

1. Introduction

Electroactive polymer (electroactive polymer, EAP) and electroconductive polymers (electroconductive polymer, ECP) have shown good results as linear medical textiles for tissue and neural engineering [1,2]. Current transmission through electrospinned and electroactive micro / nano filaments show good base for cell culture, where electrical stimulation helps cells grow faster and better on a textile backing. Due to its electrical conductivity, textiles made of electroactive polymers are excellent for mimicking the real body environment in which cells are electrically stimulated to grow [3]. Electrical signals are produced and felt by all cells, not just nerves and muscles; where in vivo, these activities create bioelectric circuits that direct the behavior of individual cells toward specific anatomical targets [4].

According to a review of the work of the world's largest research groups, the electrospinning process is the best way to produce new material, ie. an electroactive textile that can mimic an extracellular matrix (ECM). In order to get to the core of the imitation of the extracellular matrix, targeted research and development of new electrospinend and electroactive polymers are needed. Today, there is a demand in the world for new materials to help treat various diseases, such as motor neurone disease, Alzheimer's disease, neurological scoliosis, spinal muscular atrophy (SMA) and similar ones. Polymers such as polypyrrole (PPy), polyaniline (PANI), polythiophene (PT), polyvinylidene fluoride (PVDF), poly (vinylidene fluoride – trifluoroethylene) (P (VDF – TrFE)) show good electroconductive properties that can be used in further research of electroactive and electrically conductive textiles [5]. The incorporation of EAP with cells at the damaged site of tissues and / or nerves, brings scientists closer to the possibility of developing new textile composites from organic and inorganic materials.

2. Experimental

The possibilities of electroactive and electrically conductive polymers, such as linear and / or flat textiles for medical applications, will be developed and researched, with the aim of developing new medical textiles. General knowledge from the field of scientific work will be used in planning and conducting research. The methodology of scientific work will be implemented using three basic methods: theoretical, technical and organizational.

The theoretical aspect will include the examination of set hypotheses, theories, knowledge, style, terminology, etc. The technical aspect will refer to the process of collecting, observing, arranging and measuring data, while the organizational aspect will refer to the provision of rational technology in the implementation of scientific research. The obtained results will be researched and processed for the purpose of realization and confirmation of hypotheses that will be set after multiple review of available literature and contact with various domestic and foreign research groups.

3. Results and discussion

Processing and morphology of new textiles will be carried out by reliable and standardized measurement techniques (Fourier Transform Infrared spectroscopy - Attenuated Total Reflection (FTIR-ATR), Scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM-EDX), Atomic force microscopy (AFM), Differential Scanning Calorimetry /Thermogravimetric Analysis (DSC/TGA), various microbiological tests, polymer conductivity tests, safety tests for in vivo application, etc.) but also at that time new measurement techniques. Methods and procedures that allow reproducibility of results will be used. Appropriate mathematical statistical procedures will be used to ensure some reliability in the processing, analysis and evaluation of the results obtained.

The research work plan will consist of the following units:
1. Procurement, installation and adjustment of electrospinning device
2. Modification of the device for spinning electroactive and electrically conductive polymers
3. Selection of polymers and chemicals and additional necessary resources
4. Optimization of electrospinning process, obtaining the first samples of electroactive and electrically conductive polymers
5. Analysing properties of the first samples of electroactive and electrically conductive polymers for tensile tests, microbiological tests, electrical conductivity tests, thermal testing, decomposition studies.
6. Consulting and cooperation with institutions in Croatia and abroad
7. Setting up the electrospinning process and / or developing your own device, obtaining final samples of electroactive and electrically conductive polymers and testing them
8. Possible post-processing of the product, testing of the application of the product and the possibility of commercializationabout this research.

4. Conclusion

The scientific contribution of this doctoral dissertation will be realized in theoretical and applied sense. Electroactive and conductive polymers will be developed and researched as new textile materials for medical applications - medical textiles as a contribution to the treatment, improvement of life or prevention of death.

Acknowledgement

Research and doctoral work will begin as part of a research project Croatian Science Foundation, project IP-2019-04-1381 „Antibacterial coating for biodegradable medicine materials, ABBAMEDICA“, head of the project Assoc. prof. Iva Rezić, PhD PhD

References

[1] Guo, X.; Facchetti, A.: The journey of conducting polymers from discovery to application, *Nature Materials* **19** (2020), 922–928, ISSN 1476-1122

[2] Zhang, X. et al: Electroactive electrospun nanofibers for tissue engineering, *Nano Today*, **39** (2021), 1-11, ISSN 1748-0132

[3] Chen, C. et al: Electrical stimulation as a novel tool for regulating cell behavior in tissue engineering, *Biomaterials Research*, **23** (2019) 25, 1-12, ISSN 2055-7124

[4] Levin, M.; Pezzulo, G.; Finkelstein, J.M.: Endogenous Bioelectric Signaling Networks: Exploiting Voltage Gradients for Control of Growth and Form, *Annual Review of Biomedical Engineering* **19** (2017) 1, 353–387, ISSN 1523-9829

[5] Picciani, P. et al: Advances in Electroactive Electrospun Nanofibers, In *Nanofibers - production, properties and functional applications*, InTech, ISSN 0104-1428, Rijeka (2011), 1-13

Ana Šaravanja

Biography	Ana Šaravanja was born 1998 in Zagreb, Croatia. In 2021, she graduated from the University of Zagreb, Faculty of Textile Technology. She is the winner of the Dean's Award for Achievement during the undergraduate study of Textile Science and Technology, 2020. In 2021, he enrolled in the postgraduate university study of Textile Science and Technology at the Faculty of Textile Technology, and was hired at the same faculty as an assistant for a project of the Croatian Science Foundation.
Title of dissertation topic	Influence of ageing on the properties of polyester fabrics during washing
Study advisor	Assist Prof Tihana Dekanić, PhD
Date of dissertation topic defense	

INFLUENCE OF AGEING ON THE PROPERTIES OF POLYESTER FABRICS DURING WASHING

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Abstract: *Synthetic fibers account for nearly 60% of total world fiber production, of which polyester accounts for the largest share (PET). An important property of polyester fibers in textiles from the point of view of care is good utility properties. However, recently, the negative effects of released micro/nano fibers in the washing process on the composition of wastewater have been pointed out. The PhD research will focus on the effects of physical and chemical aging of polyester fabrics on the properties and degree of contamination of wastewater from the washing process.*

1. Introduction

In the textile industry, large amounts of water are used for pretreatment and processing operations. For this reason, wastewater is chemically heterogeneous and needs to be treated so that it can be discharged or reused. The heterogeneity of the wastewater composition stems from various active ingredients and additives, loose fibers, fragments and fragments of plastics, which have recently been defined as microplastics (MP) particles. The presence in the environment is associated with different sources of pollution, and depending on them, MP is referred to as primary and secondary form MP [1].It is well known that plastic waste entering the aquatic environment does not degrade, but MP (< 5 mm) or nanoplastics (< 1 μm) are formed by mechanical and photochemical processes [1]. The slow biotic decomposition of plastics causes plastics to break down into smaller particles in the environment, and one of the unfavorable consequences is the pollution of water resources, Fig 1. The particles of MP come from synthetic textiles, such as polyester, polyamide, polyvinyl chloride, polypropylene, and polyethylene [2].

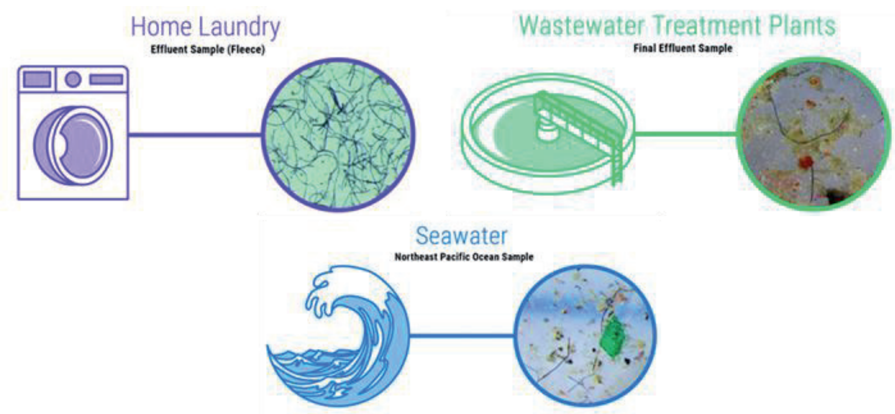


Figure 1 Visual representation of microfibers and MP in wastewater and seawater [3]

The research plan will include poly(ethylene terephthalate) PET, as the most represented group of polyester fibers. According to 2017 data, these fibers account for 50% of the total man-made fibers produced, of which 14% are products made from recycled PET [4]. Their density is 1.37 - 1.45 g/cm, it sinks quickly, is weather resistant and non-biodegradable. Due to its large occurrence in nature, but also due to the release properties of MP particles, it could become a risky polymer in the environment in the near future [1].

2. Experimental

Textiles are considered to be the main source of pollution due to the release of fibers, and the washing process is considered to be one of the causes [4]. Considering the highlighted problems with the presence of MP in the environment, the research in the PhD thesis will focus on monitoring the phenomenon of aging of polyester fabrics (PES)In the PhD thesis, the effects of controlled artificial aging on the release of MP particles in washing will be evaluated using physicochemical characterization methods according to a standardized and innovative procedure. The research will be conducted on standard PES fabrics subjected to controlled aging conditions, varying the influence of atmosphere, time and type of exposure. Various scientific devices are used during the work: Aging instrument (Xenotest), FTIR, Fluorometer, Dynamometer, Digital Microscope, SEM-EDX, Moisture Transfer Tester (MMT) and Remission and UV / VIS Spectrophotometer.

3. Results and Discussion

Physical and chemical aging are always considered in the theory of aging of polymeric materials. Physical aging of PES corresponds to the changes that occur in the composition and configuration of the chain. Chemical aging results from reactions with external reagents such as oxygen, water, UV or ionizing radiation [5]. Considering the research problems, this dissertation focuses not only on the interaction of PES materials with water, but also on monitoring the effects of radiation (intensity, duration and type of exposure) on the release of MP particles from PES materials. It is expected that the innovative washing process will reduce the release of MP particles, not only during washing, but also under the conditions of controlled artificial aging.

4. Conclusions

In accordance with the set objectives, this dissertation aims to evaluate the modification of PES materials under controlled artificial aging and the possibility of quantifying the released MP particles from PES materials before and after aging in the washing process according to standard and innovative approach.

Acknowledgement

The work of doctoral student Ana Šaravanja has been supported in part by the "Young researchers' career development project – training of doctoral students", DOK-2021-02-6750, of the Croatian Science Foundation. This work has been supported in part by Croatian Science Foundation under the project IP-2020-02-7575, InWaShed-MP.

References

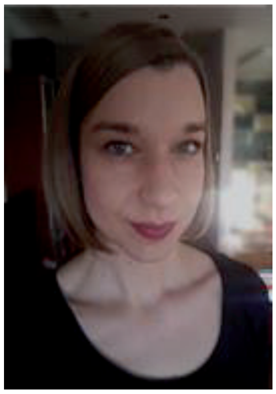
[1] Merlin, N. I., Balasubramanian, K.: Effect of microplastics in water and aquatic systems, *Environmental Science and Pollution Research*, **28** (2021), ISSN 1614-7499

[2] Kolbe, S.: Mikroplastika ili mikrovlakna?- koncepcijska zabuna, Istraživački institut za tekstil i odjeću (FTB), Sveučilište primijenjenih znanosti Niederrheim, Moenchengladbach, Njemačka, *Tekstil*, **67** (2018) 7-8, 235-236, ISSN 0492-5882

[3] Dostupno na https://www.cbc.ca/radio/quirks/nov-16-watching-wildfire-with-radar-the-return-of-race-science-and-more-1.5359599/your-laundry-and-plastic-pollution-which-fabrics-shed-the-most-microplastics-1.5359608, *Pristupljeno:* 2021-12-01

[4] Čorak, I. et al: Enzimi za hidrolizu poliestera, *Tekstil,* **68** (2019) 7-9, 142-151, ISSN 0492-5882.

[5] Napper, I. E.; Thompson, R. C.: Release of synthetic microplastic plastic fibers from domestic - washing machines: Effects of fabric type and washing conditions, *Dostupan na*: https://www.researchgate.net/publication/308736592_Release_of_synthetic_microplastic_plastic_fibres_from_domestic_washing_machines_Effects_of_fabric_type_and_washing_conditions, *Pristupljeno:* 2021-12-01



Marijana Tkalec

Biography	Marijana Tkalec was born in Čakovec in 1986. After graduation from the University of Zagreb Faculty of Textile Technology in the field of Textile technology, she worked in textile industries as a textile and fashion designer and engineer. She has received several awards for her work in the field of textile design. In 2017 she enrolled on a PhD study Textile Science and Technology at the Faculty of Textile Technology. She currently works as an assistant at the Faculty of Textile Technology.
Title of dissertation topic	
Study advisor	Prof Martinia Ira Glogar, PhD
Date of dissertation topic defense	

INTERACTION OF COLOR AND TEXTILE SURFACE - ANALYSIS AND INFLUENCE OF FABRIC TOPOGRAPHY ON COLOR VISUALIZATION

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Abstract: *The complexity of the woven fabric, meaning its geometrical characteristics related to the textile surface, such as yarn thickness, number of yarn twists, yarn density, textile thickness, etc., inevitably affects the perception of fabric texture and the appearance of color on fabric surface. All solid surfaces, regardless of the method of formation, contain various irregularities. The surfaces of textile fabrics are also not absolutely flat and smooth; their surface roughness plays a significant role and affects their end use. This paper presents the analysis of surface texture and the influence of fabric topography on color visualization using the computer program ImageJ. The image processing program is used for analyzing different surface textures of fabrics and their impact on color visualization using statistical method of texture analysis GLCM (Gray Level Co-ocurrence Matrix).*

1. Introduction

The construction of the fabric is defined by three primary construction parameters: the yarn fineness, the fabric structure (weave pattern) and the density of the warp and weft [1]. The primary parameters of fabric construction are interdependent variables where the choice of one parameter affects the others. Thus, the yarn fineness affects the density of the fabric depending on the fabric weave pattern, therefore the structure of the fabric affects its surface texture [1]. The appearance of the fabric texture is related to the geometric structure of the fibers and yarn; the fabric texture is ultimately determined by the weave pattern. The complexity of textile products, the diversity of textures and the materials used produce variable colour, which is dependent on several parameters such as illumination, spectral distribution of the colour stimulus, as well as the surface state of the textile [2]. Although it is well known that texture can visually and instrumentally affect the color of a sample, the quantity and quality of that effect is not yet well understood. Usually, all instruments for color measurement of the textiles are designed and adapted to flat surface patterns. Spectrophotometers that provide data on the spectral reflection of samples are widely used to measure the color of textile samples, which usually have structural textures [3]. Irregularities of the textile surface, non-uniformity and surface roughness affect the application of ink in (digital) textile printing technique. Given the above characteristics, the study of color change as a result of variations in the texture of fabric samples is justified and relevant [3, 4].

2. Experimental

The methods used in this paper relate to the image processing and analysis; a contemporary method that enables the identification of textiles and the analysis of certain characteristics such as surface texture. Image analysis is an extraction of meaningful information from images by using computer algorithms. It enables precise measurement of fabric texture parameters, such as weave pattern, yarn count and surface roughness [5]. Due to the increasing demand of consumers for highquality textile products, an automatic and objective evaluation of the fabric texture appearance is necessary with respect to geometric structure characteristics, surface and mechanical properties and aesthetic appearance [6].

ImageJ is an image processing program used in this research to analyze different surface textures of fabrics and their impact on color visualization. One of the most frequently used statistical texture analysis methods is based on computation of the grey level co-ocurrence matrix (GLCM). GLCM – also known as the grey level spatial dependence matrix – is a matrix that keeps track of how often different combinations – pairs – of pixel intensity (grey level) values in a specific spatial relationship and distance occur in an image [7]. Various texture parameters: energy, contrast, correlation, inverse difference moment (IDM), entropy, will be extracted from the grey level co-ocurrence matrices (GLCM) using ImageJ's GLCM Texture analysis plugin.

Topography parameters: root mean square roughness (Rq = RMS), arithmetic average of absolute values (Ra), maximum valey depth (Rv) and maximum peak height (Rp) will be calculated using ImageJ's plugin SurfCharJ.

3. Results and Discussion

The topography of the textile surface has been researched in different sciences and defined in different ways depending on the requirements of a particular area. Dyeing and printing processes study the interaction of color and textile surface where objectivity is of great significance in color perception and reproduction on different structural textures, different composition, which is important in the industrial production process. Given that textile patterns are rarely completely flat and the irregularity of the surface texture of textiles, its non-uniformity and roughness, the study of color change as a result of variations in the texture of fabric patterns is necessary. However, it is impossible to obtain a simple set of parametric factors for all potential textures in an industrial application. Instead, each texture or type of texture should be studied separately.

4. Conclusion

Previous research indicate that the surface texture of textiles inevitably affects the appearance of color, i.e. the dimensions of color, and that the influence of texture on color/intensity of texture effect depends more on the type of structural texture than on texture roughness. Contemporary requiremetns include the ubiquitous component of ecology and ethics, focus on visual texture representations, which is, for example, a key factor in the field of digital fashion, virtual design and digital production.

References

[1] Koester A. W.: Analyzing the Color, Design and Texture of Fabric, *Dostupan na* https://www.semanticscholar.org/paper/Analyzing-the-color%2C-design%2C-and-texture-of-fabric-Koester/8081a31a51386e48757b6c83c1e3fbc80e78c352#paper-header *Pristupljeno:* 2021-12-11

[2] Moussa, A. et al: Colour change as a result of textile transformations, *Coloration Technology*, **124** (2008) 4, 234-242, ISSN 1478-4408

[3] Gorji Kandi, S., Tehrana, M. A.; Rahmatib, M.: Colour dependency of textile samples on the surface texture, *Coloration Technology*, **124** (2008), 6, 348-354, ISSN 1478-4408

[4] [Bae, J. H., Hong, K. H., Lamar, T. M.: Effect of Texture on Color Variation in Inkjet-Printed Woven Textiles, *Color Research and Application*, **40** (2014) 3, 297-303, ISSN 0361-2317

[5] [Alase, J., Hulle, A.: Image Analysis Technique for Quality Evaluation of Textiles, *International Journal on Textile Engineering and Processes*, **4** (2018) 4, 35-39, ISSN 2395-3578

[6] Chilkuri, S. i sur.: Fabric texture analysis using image processing techniques, *Journal of emerging technologies and innovative research*, **7** (2020) 3, 392-297, ISSN 2349-5162

[7] Hladnik, A. et al: Assessment of paper surface topography and print mottling by texture analysis, *Dostupan na* https://www.researchgate.net/publication/262420212_Assessment_of_paper_surface_topography_and_print_mottling_by_texture_analysis, *Pristupljeno:* 2021-12-11

Irena Topić

Biography	Irena Topić was born in 1983 in Zagreb. She works as a teacher of fine arts in primary and secondary school. She graduated from the University of Zagreb at the Faculty of Textile Technology with a degree in costume design, and in 2011 with a university degree in costume design. In 2013, she graduated from the Academy of Fine Arts majoring in painting. 2004-2006 field surveyor on the project Croatian Anthropometric System (HAS). Assistant at the Faculty of Textile Technology from 2011 to 2017, and external associate from 2018 to 2021. Since 2014, he has been attending the doctoral study of Textile Science and Technology. Participates in the project Knwledge for footwear. She has published 2 chapters in the book, work in proceedings of scientific conferences, professional work in conference proceedings, work in other journals.
Title of dissertation topic	Investigation of body proportions in procedures of construction and clothing design for obese population
Study advisor	Prof Darko Ujević, PhD
Date of dissertation topic defense	

INVESTIGATION OF BODY PROPORTIONS IN PROCEDURES OF CONSTRUCTION AND CLOTHING DESIGN FOR OBESE POPULATION

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Abstract:
Research on body proportions can contribute to better quality procedures for designing and clothing construction for obese men. As part of the doctoral thesis, the aim is to scientifically determine the trend of increasing obesity in adult men in the city of Zagreb compared to the last large-scale STIRP CAS study. Based on the results of anthropometric measurements of obese male workers, the relevant criteria for the obese male population will be determined and new body types will be proposed and the procedures for constructing, designing and produciong men's three-piece jackets (outer, middle and inner) will be improved.

1. Introduction

Research on body proportions can contribute to better quality procedures for designing and clothing construction for obese men. Consideration of these components imprroves the quality of life and health protection, especially for obese people who are exposed to heavy physical work. Long in history one can find research efforts related to the study of body dimensions and proportions. Anthropometric measurements have been carried out since 1900 with the aim of improving and developing systems of body sizes and types. Researchers' approaches and methods of measurement have changed and improved with the development of anthropometric instruments. Body proportions determine the conformity and interrelation of individual body measures, in this case we will deal with the topic of male obesity and / or deviations from the average build.

2. Experimental

Anthropometric measurements within this doctoral dissertation will be performed with a set of anthropometric instruments consisting of: one-arm and/or twoarm anthropometers, measuring tapes, a specially designed protractor, a sliding anthropometer, neck circumferrence defininng necklaceand digital scale [1, 2]. For the planning, organization and implementation of the research, knowledge from scientific work will be used - preparation and implementation of research, statistical processing of results in order to achieve relevant hypotheses.

The research is conducted in four phases, as follows:

Phase 1: preparation of a research plan, complete review of published literature, development of cooperation with other scientific and research institutions and manufacturing companies.

Phase 2: planning of research equipment, development of questionnaires and forms for anthropometric measurements with a plan of 54 measurements per obese respondent.

Phase 3: implementation of systematic research, organization and implementation of field measurements in compliance with current measures against the Covid 19 pandemic

Phase 4: arranging documentation, mathematical and statistical processing of measurement data, defining new body types and, accordingly, defining and recommending the addition of clothing sizes for use in the process of designing and designing clothing.

In the doctoral thesis, anthropometric measurements will be performed (all 54 anthropometric measures per examinee) on 200 male working examinees under the age of 65 in the city of Zagreb. Based on the performed measurement, the results will be presented according to the established intersize intervals of 4 cm, starting from the chest circumference of 108 cm, which is a condition for inclusion in the study.

3. Results and Discussion

The results of anthropometric measurements obtained by this study aim to determine the trend of changes in body proportions in obese men, with a breast circumference of 108 cm and more. This trend requires the identification of new body types. A search of the relevant scientific and professional literature revealed a weak representation of the topic of the doctoral dissertation. Most of the references that will be used in this dissertation are related to the mentor prof. Darko Ujević,PhD; dir. prof. in a permanent position, his research for more than two decades and the publication of relevant works, which he is the author and in which he focused on researching body dimensions, construction procedures, Croatian technical report, and EN standards as a longtime member of the European Association CEN.

The preparation of this paper was especially approached due to the realization that there is a pronounced trend of obesity in the male population in the Republic of Croatia, which will enable scientific progress in objectively considering this trend in the Republic of Croatia. This will be proven by comparison with the results of the STIRP CAS survey. The results of this research will contribute to cooperation with several companies whose employees perform heavy physical work outdoors in different weather conditions, which will significantly contribute to maintaining health.

4. Conclusion

Based on the conducted research and the obtained results, the relevant criteria for the obese male population in the Republic of Croatia will be determined, which will enable the proposal of new body types and inter-size intervals, in relation to persons of average build. This will enable an objective scientific comparison, as well as a comparison with the population of other countries, EU member states and beyond. The application of research results will contribute to the further development of defining clothing sizes, drafting a new technical report for this group, comprehensive improvement of construction, design and manufacture of ergonomic three-piece jackets to better protect the health at work of male obese male population.

References

[1] Anthropometric System – Measuring and Size Designation of Clothes and Footwear, CroatianTechnical Report, HRI 1148:2012 hr, HZN, February 2012, ICS: 01.040.61:61.020

[2] Ujević D.; Hrastinski M.: Prilog podlozi za nove hrvatske norme za veličinu odjeće i obuće te njihova označivanja - Podloga za nove hrvatske norme za veličinu odjeće i obuće, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, Zagreb, 2006., 407-23, ISBN 953-7105-09-1

Ksenija Višić

Biography	She was born i 1983. Varaždin. She graduated at the University of Zagreb Faculty of Textile Technology in 2009. After graduation, she was employed at the same faculty as an associate/assistant on the FP7 project, FP7-SME-2007-2-217809. In 2013, she was engaged as a collaborator on the Eureka project, E! 5785 Flameblend. From 2013 to 2015 she was employed as a sales manager in the company Info Novitas d.o.o. From 2015 to 2016, she was employed at Faculty of Textile Technology as an assistant. In the period from 2016 to 2018, she was again engaged on the position of marketing director in Info Novitas d.o.o. From 2018 she was engaged at Faculty of Textile Technology as an assistant and as PhD student on the project K.K.01.1.1.04.0091 Biocomposites. She has published 2 original scientific papers in the citation database WoSCC, 2 papers in other journals, 2 abstracts and 13 papers in conference proceedings.
Title of dissertation topic	Impact of physico-chemical properties of anti-redeposition agents on the zeta potential of washed cotton materials
Study advisor	Prof Tanja Pušić, PhD
Date of dissertation topic defense	March 20th, 2016

RESIDUAL SUBSTANCES ON COTTON FABRIC WASHED BY DETERGENT IN SOFT AND HARD WATER

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Abstract: *Research in the doctoral thesis includes special additives, anti-redepostion agents (ARA), in the formulation of powder detergent. Selected ARAs are carboxymethyl cellulose (CMC), carboxymethyl starch (CMS) and their combination (CMC + CMS) whose concentration is adapted to washing of cellulosic materials at 40 °C, 60 °C and 90 °C in hard and soft water. Characterization of the properties of cotton fabrics after 10 washing cycles in relation to unwashed was made by analysis of residual substances.*

1. Introduction

The development of detergents is conditioned by technological guidelines, where it is necessary to make a formulation in which all components act in synergy with the other factors of the Sinner cycle, temperature, mechanical action and time [1]. Recently, environmental friendly low-temperature processes in small bath ratios have been promoted, which require high-performance surfactants, builders, bleach and their activators, enzymes and special polymers in detergents [2]. Anti-redepostion agents play an important role in the primary and secondary effects of washing because, in addition to anionic surfactants and builders, they additionally charge soil and fiber, and physically prevent the deposition of soils brom the bath on the fiber [3]. The efficiency of anti-redeposition agents should be based on the fiber affinity, as a basis for depostion to the fiber surface, increasing a negative surface charge and prevent redeposition by repulsion of negatively charged soil particles. . Since their action is related to the surface of the material, it is important to know its condition and the degree of load by certain substances.

In this paper, the influence of hard and soft water on the content of residual substances on cotton fabric washed with detergent with the addition of ARAs (CMC, CMS and their combination, CMC+CMS) at 40 °C, 60 °C and 90 °C for 10 cycles was examined.

2. Experimental

Washing cycles of reference cotton fabric specified by HRN ISO 4312 with detergent to which selected ARAs were added were performed in hard (T) and soft (M) water at 40 °C, 60 °C and 90 °C. The degree in loading of cotton fabric with residual substances before and after washing was analyzed through the ash content according to HRN ISO 4312 [4].

3. Results and Discussion

The detergent used contains builders, zeolite and sodium carbonate, aimed to soften the water during washing and prevent the deposition of inorganic matters on the surface of the cotton material. Regardless of this action, the analysis of residual substances on standard cotton fabric (PT) after washing at all temperatures showed the load of surface by inorganic incrustations. Tab 1 shows the values of ash content (P) on cotton fabric (PT) before and after washing with detergent in different compositions in hard and soft water at 40 °C, 60 °C and 90 °C in a laboratory washing machine. Unwashed fabric (PT) contains 0.2% ash which is the usual value for control cotton fabric. The results in Tab 1 show that water hardness and washing temperature affect the ash values of washed cotton fabrics. Washing of the cotton fabric with detergent with ARAs in soft water of 44.5 ppm did not increase the residual content.

The high degree of water hardness (404.1 ppm) affects the ash content values on washed cotton fabrics, that are generally from 6 to 10 times higher than the ash values of cotton fabrics washed in soft water. The generation of incrustations on the surface of cotton fabrics in washing with hard water at 60 °C and 90 °C is higher compared to 40 °C.

Table 1 Ash content (P) after incineration of cotton fabrics before and after 10 washing cycles

Sample	water	P (%)		
		40 °C	60 °C	90 °C
PT	-	0.2		
P_PT_CMC	T	1.2	1.1	1.2
P_PT_CMS		0.6	0.7	2.0
P_PT_CMC+CMS		0.6	1.4	1.5
P_PT_CMC	M	0.2	0.2	0.3
P_PT_CMS		0.2	0.3	0.3
P_PT_CMC+CMS		0.2	0.2	0.2

According to this results, it is clear that the builders are not efficient in binding of alkaline earth ions from hard water at higher temperatures. The ingredients of the detergent for washing of reference cotton fabric (without soiling) for 10 cycles were not oriented towards soil removal. It is possible that some organic components in the detergent, such as soap and anionic surfactants, interact with calcium and magnesium ions and generate sparingly soluble precipitate and/or insoluble deposits, which loaded the surface of the cotton fabric and increase the residual content (total ash).

4. Conclusion

The values of ash content on washed cotton fabrics in soft water are almost equal to the values of unwashed cotton fabric, which confirms that the detergent composition varied through ARAs and washing temperature in soft water do not affect these values. A review of the presented results shows that the high degree of water hardness and washing temperature have a dominant influence on the total ash content of washed cotton fabrics.

References

[1] Jakobi, G., Löhr, A.: *Detergents and Textile Washing: Principles and Practice*, ISBN 0-89573-687-X, Baden-Württemberg (1987)

[2] Smulders, E. et al: Recent developments in the field of laundry detergents and cleaners, *Tenside Surfactants Detergents*, **34** (1997) 6, 386-392, ISSN 0932-3414

[3] Soljačić, I., Pušić, T.: *Njega tekstila: Čišćenje u vodenom mediju*, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Zagreb, ISBN 9537105091, (2005)

[4] HRN ISO 4312:2001 Površinski aktivne tvari - Procjena određenih učinaka pranja - Metode analize i ispitivanja za čistu kontrolnu pamučnu tkaninu (ISO 4312:1989)

Ivana Vitlov

Biography

Ivana Vitlov was born 1983 in Slavonski Brod. 2008 graduated at the University of Zagreb Faculty of Textile Technology. Since 2010 she has been employed as a teacher of Clothing and textile design at the School of Applied Arts and Design Zadar. In 2011 she completed additional Pedagogical and Psychological Education at the Faculty of Teacher Education University of Zagreb. By the decision of the Agency for Vocational Education, in 2016 she was promoted to the title of mentor, and in 2021 to the title of advisor. Postgraduate university study Textile Science and Technology enrolls in 2018 and as co-author she published two papers in books of proceedings and one paper in journal articles.

Title of dissertation topic

Study advisor

Assist Prof Ivana Schwarz, PhD

Date of dissertation topic defense

TAPESTRIES AS A TRADITIONAL CULTURE AND CULTURAL HERITAGE OF NOTHERN DALMATIA

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Abstract: *The necessity of the modern world is to understand our own cultural past, which is a reflection of national identity, as well as to set priorities in preserving the cultural heritage from extinction and complete disappearance. The greatest resources of cultural heritage can be seen through insights into segments of culture of life, artistic activity and the search for their own cultural identity in contemporary cultural and civilizational circumstances. The art of making tapestries is of great importance not only for Croatian textile treasures, but also for historical textiles in general.*

1. Introduction

Tapestry production is determined by the technical regularity of weaving, which at first sight looks like a limiting circumstance, but it actually defines the creation of work of art structures. Tapestry is type of weave structure with geometrically shaped patterns, where weft threads run between the warp threads that form motives [1].

Exactly four decades of such artistic creation by exceptional individuals, the Tomljanović couple, resulted in the formation of a rich collection of tapestries, which are the most impressive evidence of the weaving tradition of northern Dalmatia, but through innovative artistic expression - woolen tapestry.

2. Experimental

The value of this tapestries collection is primarily based on the fact that it is a great united opus of the artists [2]. The artistic value of the author's approach based on the synergy of the natural palette of wool colors (inspred by richness of natural tones from mountainous parts of Dalmatia) in relation to geometric, abstract and figurative themes. It is an approach in which the authors play with a large palette of tones and disciplined exploration of what appears to be a simple picture.

Tapestries with Christian themes, the Velebit landscape and those dedicated to the city of Zadar are highlighted, dotted and complemented by the harmony of the natural colors of wool (whose production and application marked the textile history of the Croatian and local areas until today), which represents an endless inspiration and escape from all whims of fashion.

Value of the tapestry collection by the artist's couple Tomljanović is primarily based on the fact that process ot the tapestry weaving was approached completely and independently, from the idea to the realization. In creating, they started from an idea presented in the form of a drawing or painting and transferred it to the weaving card according to which they were weaving.Natural domestic sheep wool was selected for tapestry material, which the authors collected in its raw form, washed it and then sorted it by natural shades, from light ocher tones, through brown to brown reddish and grey shades [3].

With a line and a surface, composition were built as in fine graphics, rhythmizing the surface creating dynamic abstract images of the interweaving structure, abstract, stylized stone structure and plant elements from nature.

The expression of these works of art is characterized by a combination of contemporary artistic expression and classical weaving methods, even when it comes to decorative stylised, non-figurative natural forms, but also in very complex figurative compositions. The basic feature of this work is characterized by a precise, restrained harmony, exceptional discipline and simplicity [4].

3. Results and Discussion

Tapestries are woven with the classic point de tapisserie technique on a u high warp loom with vertically warp threads, so-called haute lisse, according to the French system [5]. According to the artistic expertise from 2018 by Assist Prof Katarina Nina Simončič, PhD tapestries can be classified into four thematic units.

- Geometric form and abstraction realized through the Velebit motives - where through abstract expression keeps faithful to the knowledge of the structure of weaving, guided by the imagination of space and time, creating geometric compositions like painting style of the 1960s.

- Realism as a point of shaping the landscapes and motives of the city - the balance is achieved by equal and regular alternation of surfaces, in other words, by repeating the contrast tones of light and darkness, by skillful modulation of tones.
- Christian themes – are characterized by the unification of artistic elements (shapes, i.e. surfaces in relation to contour lines, tones, perspectives) into unique entirety. Unity was achieved by their harmonious relation, as well as by the relation between artistic elements and composition principles.
- Portraits - characterized by superb tonal modulation, both of the characters and of the background or other plan, which conjured the feeling of volume or body in space.

It is important to mention that the conclusions obtained by the analyses are interpreted as part of interdisciplinary cooperation between various fields, including textile technology, ethnology, art history, sociology and ethnography.

4. Conclusion

The definition and documentation of tapestries, including establishing and promoting tapestries, are important aspects of the cultural heritage of northern Dalmatia. Availability and research, as well as the implementation of detailed analysis, represent a sense of understanding and valuing the complexity, beauty and importance of tapestry as a textile art form.

References

[1] Kovačević S.: *Ručno tkanje*, Centar za kreativne alternative & Prometej, ISBN 953-6460-37-8, Zagreb, (2004)
[2] Lulić Štorić, J.: *Tapiserije: donacija Etnološkom odjelu Narodnog muzeja Zadar*: katalog izložbe. Tomljanović-Šokčević, A.; Tomljanović I. (ur.), Narodni muzej Zadar, Zadar, (2016)
[3] Tomljanović-Šokčević, A.: *Tragom izgubljene baštine*, Matica hrvatska, Ogranak Zadar, Zadar, (2016)
[4] Verlet P. et al: G*reat tapestries – The web of history from the 12th to the 20th century*, Edita S. A. Lausanne, (1965)
[5] Russell, C. K.: *Tapestry Handbook*, The Next Generation, Schiffer Publ. Ltd., ISBN 978-0-7643-2756-8, Atglen, PA, (2007)

Juro Živičnjak

Biography	Juro Živičnjak was born 1995 in Zagreb. He obtained the title of master engineer of textile technology and engineeringn at the University of Zagreb Faculty of Textile Technology, in 2018. As part of his thesis and in collaboration with Professor Rogale, he made a device called: Triboelectric generator for storing static charge from clothing, which was first exhibited and awarded at the international exhibition of innovations, "INOVA - Be a role model 2018", with a gold medal and a special award for the best innovation in applied science. He continues his education at the postgraduate study of Textile Science and Technology at Faculty of Textile Technology, where he has worked as an assistant since 2019.
Title of dissertation topic	The measurement method for determining the amount of electrostatic charge induced on textile materials used for clothing purposes
Study advisor	Prof Dubravko Rogale, PhD
Date of dissertation topic defense	

THE MEASUREMENT METHOD FOR DETERMINING THE AMOUNT OF ELECTROSTATIC CHARGE INDUCED ON TEXTILE MATERIALS OF SMART AND INTELLIGENT CLOTHING

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Abstract: *More recently, the increase in the use of technologically advanced smart and intelligent clothing, that use electricity for their performance is recorded. Their main disadvantage is the limited power supply by which they are operated. Electrostatic charge is one type of electrical energy that could be generated and applied for this purpose, but further research of the electrostatic properties of textile materials needs to be conducted. A short overview of chosen contact and non-contact measurement methods and measurements systems applicable for measuring the electrostatic charge generated on textiles is shown.*

1. Introduction

E-, smart or intelligent clothing items contains electronic components, that are powered by electricity. Functionality time of such technically advanced clothing items is limited by the capacity of their energy storage unit and proximity to the nearest power supply. Therefore, new portable energy generators have been introduced, that are applicable for E-, smart or intelligent clothing, and can generate electrical energy from different types of energy sources, such as: biomechanical, thermal, solar, environmental [1]. One type of textile energy harvesting device is named triboelectric generator (TEG), and it can convert electrostatic charge generated on textiles to useable electric energy. The working principle of TEG is biased on human motion and electrostatic properties of textiles, which are defined by triboelectric series. But the series proved to be unreliable in terms of determining TEG-s future performance [2]. Therefore, the need for further analysis of the electrical properties of textile materials resulted in a series of research papers, that not only observed the values electrical resistance but also the values of voltage and capacity, induced by contact or non-contact electrification method. An overview of selected research papers, that used different measuring systems and devices for the testing of electrostatic properties of flat textile materials will be presented.

2. Experimental

The non-contact measurement method introduced by Žilinskas, P. J et al [3], was firstly intended for measuring electrical parameters of insulating planar materials such as plastic films and sheets. Their measurement system, Fig 1, could be applied for textile materials. The electrification process is achieved by a high voltage source (7kV), that periodically ionizes air molecules with positive and negative ions. The amount of deposited charge is monitored thru surface potential, i.e., voltage signals gained thru a measuring device connected to a computer with an analogue to digital converter.

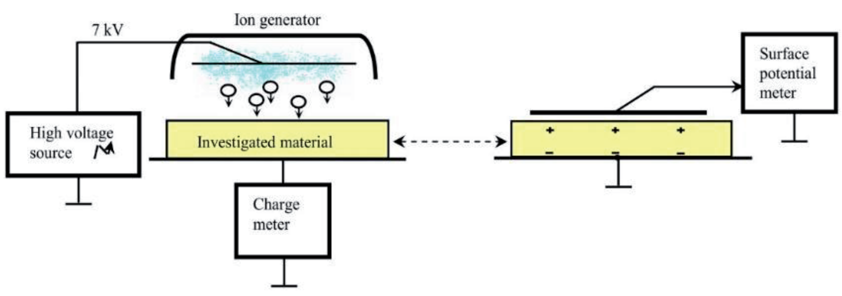


Figure 1 Deposited charge and the surface potential measuring scheme

In contrast to the non-contact method, the electrification process in contact methods can be achieved by repeated contact or by rubbing of tested material directly on the metal electrode or indirectly on the polymer material. Thus, the number and type of elements included in the contact measuring system isn't limited. For example, the measurement system introduced by Zou, H. et al [4] includes a Faraday cage (Figure 2, a) that is filled with ultra-high purity nitrogen gas, at a temperature of 20 ± 1 °C, at 1 atmospheric pressure, and humidity of 0.43 %, inside which contact electrification is performed. One electrode is liquid mercury and the other copper electrode is directly applied on the tested material by E-beam scattering technique.

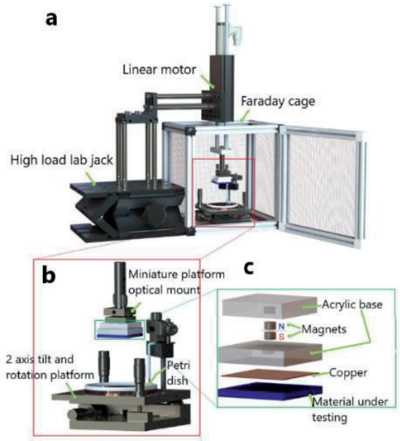


Figure 2 a. The measurement system experimental set-up; b. The static and the moving part of the setup; c. Sample holders

3. Results and discussion

The measurement results of the non-contact method recorded in real time (t) enabled the monitoring of the surface potential (V), electrostatic charge (Q) and volume resistance (R) values and their mutual dependencies: the surface potential in time (V-t); the surface potential and deposited charge (V- Q); the electric capacitance and the surface potential (C-V); the volume resistance and the surface potential (R-V).The presented contact method after each successive contact of the tested material with mercury, measures the voltage value, and the results obtained show significantly less scattering. Which confirms the significant impact of surface inequality on the measurement result.

4. Conclusion

Proper selection and the number of elements that are defined before a certain type of test, directly affect the result obtained. Therefore, when electrostatic properties of textiles are tested, the test method depends on the principle of electrostatic charge induction (contact or due to electric field), but also on the capabilities of the measuring device.

Acknowledgment

This work has been supported in part by the Croatian Science Foundation through the project IP-2018-01-6363 "Development and thermal properties of intelligent clothing (ThermIC)", as well as by the University of Zagreb through research grant TP11/21 "Parameters of ultrasonic joining of polymeric materials".

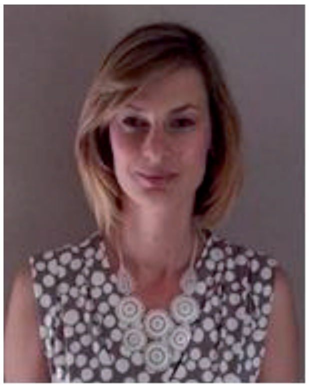
References

[1] Riemer, R.; Shapiro, A.: Biomechanical energy harvesting from human motion: theory, state of the art, design guidelines, and future directions, *Journal of NeuroEngineering and Rehabilitation*, **8** (2011) 22, 1-13, ISSN 1743-0003

[2] Lei, R. et al: Sustainable high-voltage source based on triboelectric nanogenerator with a charge accumulation strategy, *Energy & Environmental Science*, **13** (2020) 7, 2178–2190, ISSN 1754-5706

[3] Žilinskas, P. J.; Lozovski, T.; Jurkšus, J.: Electrostatic properties and characterization of specific polymeric materials for building purposes, *Materials science*, **16** (2010) 1, 57–62, ISSN 1392–1320

[4] Zou, H. et al: Quantifying the triboelectric series, *Nature Communications*, **10** (2019) 1, 1–9, ISSN 2041-1723



Franka Žuvela Bošnjak

Biography	Franka Žuvela Bošnjak was 1978 in Split. Bachelor of Engineering title she earned in 2003, completing her course at University of Zagreb Faculty of Textile Technology. In 1999 she was recognized as the best student and in 2000 she received Rectors award for her scientific work. After 13 years working in the industry, she was accepted as an assistant at Faculty of Textile Technology, in the field of technical sciences, scientific field textile technology, scientific branch textile chemistry. After employment, she enrolled in the postgraduate university study of Textile Science and Technology with special interest in leather. Areas of scientific interest are research into the structures and properties of different types of leather and the preparation and processing of leather.
Title of dissertation topic	
Study advisor	Assoc Prof Sandra Flinčec Grgac, PhD
Date of dissertation topic defense	

COMPARISON OF MECHANICAL PROPERTIES OF VEGETABLE TANNED LEATHER WITH VEGETABLE - ZEOLITE TANNED LEATHER

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Abstract: *The tanning process is indispensable part in production. The strength of the resulting bonds between the collagen fibers that contribute to the properties of the finished leather depends on the type of tanning agent. For this reason, part of the processing agents tried to be replaced by zeolite. The most commonly used are vegetable, synthetic and chromium tanning agents, each of them on its own way has a negative impact environment. The first sample is processed with vegetable tanning agents (VEG). In the second sample, part of the vegetable tanning agent was replaced by a combination of zeolite (VEG+Z). Two fujasite types of zeolite were used; one with copper and the other without the addition of copper. Tanning effect, resistance to bending and cracking of the face were tested on the treated leather.*

1. Introduction

Tanning is one of the most important processes of skin processing, by the reaction of collagen with tanning agent, the skin becomes a product with durable properties. Tanning agents can be mineral (Cr, Al), vegetable and synthetic. In leather production worldwide chromium tannins is used as a standard tanning method. However, its environmental impact assessments are in high level based on toxic features. A growing number of studies are focused on the replacement of chromium in the production processes of the leather industry [1-3].

2. Experimental

In this study, pickled bowine leather were used for tanning process. Sample mark as VEG were tanned with commercial vegetable tanning agants. Sample mark as VEG+Z ware tanned with combination of vegetable tanning agents and zeolite. The amount of agents are dosed according to the weight of the raw skin. Tanning processes were performed in a laboratory device Mathis. Same posttanning proces is aplied on both samples. Process of soaking, liming, deliming and pickling were carried out in conventional industrial conditions. Sample VEG was first washed for 10 min at 22 ° C with twice the amount of water per mass of material. Water is drained. Follows tanning process lasting 420 min with the addition of commercial vegetable tanning agents (8% tree extract, 8% mimosa extract, 5% synthetic tannin) and 2% fating agent. After washing at 35 °C for 10 min, water is draind and the tanning agent (10% chestnut extract, 1% synthetic tannin) and 2% retanning agent are added. The process was continued for 360 min at 30 ° C after which the 2% synthetic tanning agent was added again. The process is continued at the same temperature for 60 minutes followed by washing with twice the amount of water per mass of material at 40° C for 15 min.

Sample VEG+Z was tanned with a combination of a vegetative tanning agents and zeolite. In the VEG + Z sample, 8% of agent extracted from the tree was replaced with 10% zeolite. Zeolite is combination of 10% CuFAU 225B and 90% 5A. All other parameters are the same as in the previously described tanning process of the VEG sample.

Both samples after tanning process are subjected to same posttanning process in industrial conditions. Determination of tanning panetration of both samples was performed according to SRPS G.S2.035:1962; Leather test methods - Test for durability and resistance to cooking. Flex resistance test was performed according to EN ISO 5402-1: 2017 Determination of flex resistance: Flexometer method. Determination of resistance to grain cracking was performed according to ISO 3379:2015, Leather - Determination of distension and strength of surface (Ball burst method).

3. Results and Discussion

On both sample, after testing of tanning effect lighter layers are not visible on the strips after drying. The colour of the cross-section is uniform, which indicates the complete permeability of the leather. The purpose of testing these leather samples for flexing is to determine if the leather is sufficiently resistant. The samples do not have a final finish layer. If the leather after post tanning don’t have the necessary resistance to bending than finish layer of leather also won't have the necessary resistance to bending. Both samples showed good resistance to bending and endured 100.000 cycles without any visible damage.

After distension and grain crack strength sample VEG showed stretching up to 8.73 mm under 79,62 kg load while sample VEG+Z showed 8.54 mm stretching under 26.76 kg load. Sample VEG+Z is cracked after 26.76 kg while sample VEG stay whole, Fig 1. Both samples are satisfying minimum standard of 7 mm stretching with 20 kg load, for footwear leather.

a. b.

Figure 1 Leather samples after testing the resistance to cracking: a. sample VEG; b. sample VEG +Z

4. Conclusion

Based on the obtained results, it can be concluded that the replacement of vegetable tanning agent with 10% zeolite changes the mechanical properties of the finished leather tested in this paper. Leather tanned with a combination of vegetable tanning agent and zeolite (VEG+Z) has les good results compared to vegetable tanned leather (VEG). It is important to notice that results of both samples meet the stated standards.

Acknowledgement

This work has been supported in part by the short-term research support of the University of Zagreb in 2020, TP2/20, Processing and maintenance of textiles and leather with environmentally friendly agents.

References

[1] Yang, X. He et. al: Study on thermal degradation of cattlehide collagen fibers by simultaneous TG–MS–FTIR , *Journal of Thermal Analisis and Calorimetry*, **3** (2016) 127, 1-8**,** ISSN 13886150

[2] Kozarb O.P et al: Eco-friendly technologies of leather manufacturing useing natural minerals montmorillonite and zeolite, *Technology audit and production reserves*, **14** (2013) 6, 11-14, ISSN 2226-3780

[3] Gürler Karaman D. et al: Possibilities of usage of aluminisilicates as tanning material, *Tekstil ve Konfeksiyon*, **26** (2016) 1, 117-124, ISSN 13003356

Marija Zorić

Biography

Marija Zorić was born1987 in Zadar. Attended primary school in Bibinje, and highschool ˝Gimnazija Vladimira Nazora˝ in Zadar. Graduated in physics, (research oriented study) at the Faculty of Science in Zagreb, Department of Physics in 2012. At the beginning of May 2013 became Assistant of Physics at the Faculty of Textile Technology in Zagreb. In the same year joined the group of dr.sc. Ana Smontara, as an external collaborator of the Institute of Physics. In the 2013 enrolls in Postgraduate doctoral study programme at the Faculty of Science in Zagreb, Department of Physics, and starts the scientific research provided by the project plan. The scientific work results were presented at 11 international conferences and 2 domestic conferences.

Title of dissertation topic

Transport properties of selected thermoelectrics

Study Advisor

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STRUCTURAL AND PHYSICAL PROPERTIES OF Cu2-xSe

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Abstract: *Cu2Se, as a competitive thermoelectric material, has attracted much attention in recent developments of thermoelectrics [1], due to the large figure of merit (ZT), which is among highest for single crystalline compounds (1.5 at 1000K). The excellent thermoelectric performance of Cu2Se is predominantly associated with its superionic behaviour in the high-temperature β-phase. This hold potential for applicability for solid state batteries [2]. Although high temperature β-phase was extensively investigated, comprehensive insight of low temperature α phase is still lacking. It reflects the complexity of the structural and phase relations. Therefore, we present here detailed magneto-transport and thermoelectric properties of Cu2-xSe at low temperatures complemented with structural studies.*

1. Introduction

As an important member of the TMC family, the Cu2Se has attracted much attention in recent developments of thermoelectrics [1], due to the unique transport properties associated with its structural phase transition occurring at ~400 K, environmental compatibility and low toxicity. Non-doped β-phase Cu2Se have a figure of merit, ZT, of around 1.5 at 1000 K, which is the highest value among the bulk materials. This is predominantly associated with its superionic behavior in the high-temperature β-phase which also holds potential for applications in solid state batteries [2]. Although high temperature β-phase was extensively investigated, comprehensive insight of low temperature α phase is still lacking. It reflects the complexity of the structural and phase relations. The transition temperature from α phase to β phase considerably depend on x and mixed phase is between them [3,4]. Here we present detailed magnetotransport and thermoelectric properties of Cu2-xSe at low temperatures complemented with structural and magnetic studies.

2. Experimental

Measurements of transport coefficients (electrical resistivity, $\rho(T)$, thermopower, S(T) and thermal conductivity, $\kappa(T)$) were made using experimental devices developed at the Institute of Physics. Detailed description of the principles and operation of certain measuring devices is found in the literature [3,4]. Measurements of magnetoresistance and Hall's coefficient (Hall resistance, $\rho H(B,T)$) were made using the PPMS (Physical Property Measurement System) and measurements of magnetic susceptibility were made using MPMS (Magnetic Property Measurement System) at the Institute of Physics. Structure analysis performed on the basis of synchrotron radiation diffraction measurements were performed at The Advanced Photon Source, USA, governed by dr.sc. Naveen Kumar.

3. Results and Discussion

Phase diagram of the Cu-Se system around Cu2-xSe phase ($0<x<0.3$) is not consistent in literature, very probably due to metastability of the phase in the air [7,8,9]. Crystal structure of copper chalcogenides is actually quite complex, in spite of their simple chemical formula. Compared to high temperature β phase above 400K that crystallizes in fcc structure, the structure of low temperature α phase is much more complicated. Motivated to determine the possible origins of these remarkable properties, we measured thermoelectric and magnetotransport properties of Cu2-xSe down to low temperatures. A Cu2-xSe crystal was grown from an on-stoichiometric composition using the vertical Bridgman method by the group of prof. Peter Gille from Ludwig-Maximilians-Universität München. The second part of the Cu2-xSe samples was produced at Institute of Physics[10]. Both samples obtained in two different ways contain αCu2-xSe+Cu3Se2. EDX analysis of our samples performed on SEM suggests that ratio of Cu and Se is 1.8:1. Results of PIXE analysis also yield this composition. And based on our electrical resistivity results, this concentration is consistent with studies which report electrical resistivity variation in Cu2-xSe with concentration x [12]. The stoichiometric compound Cu2-xSe (x=0) undergoes structural phase transition around 400K. As x increases transition temperature is reduced and for x=0.2 the structural phase transition is very close to the room temperature. Just below the phase transition,strong negative thermal expansion due to the ordering of Cu atoms is observed [3] and our experimental results confirm that, Fig 1. Our transport and thermoelectric measurements show large temperature hysteresis. The shape of hysteresis is strongly time dependent. The Hall resistivity is linear with magnetic field and the Hall constant is positive, indicating predominant hole conduction.

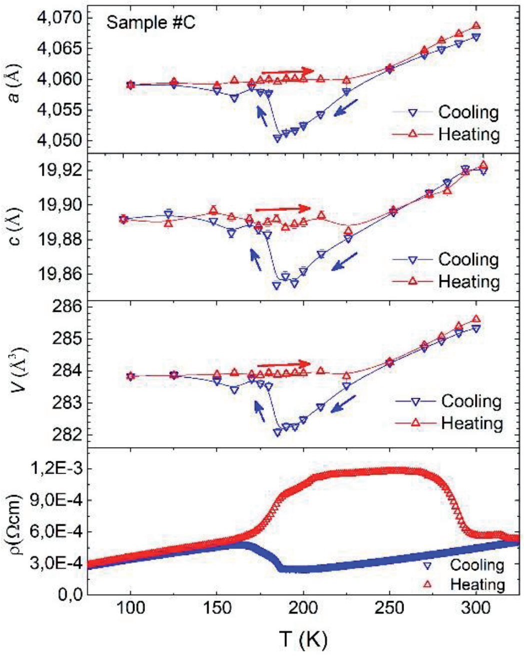

Figure 1 Lattice parameters and electrical resistivity of Cu1.8Se

Structure analysis performed on the basis of synchrotron radiation diffraction measurements proved that our sample contains about 70% Cu1.8Se+30% Cu3Se2at room temperature. While slowly cooling down, the volume fraction of Cu3Se2 phase vary with temperature and two phases still coexist together. The change in phase fraction of Cu3Se2 coincides with the drastic variation in electrical resistivity and magnetic susceptibility. The structural rearrangement during the phase transition may have a significant impact on the band structure and the Cu rearrangement may also be linked to an entropy increase. These are the reasons that potentially contribute to the origin of the wide hysteresis in our results. Temperature dependences of magnetic susceptibility of Cu1.8Se in cooling-heating cycles shows diamagnetic and paramagnetic behavior with hysteresis (170K-300K) also. The phase diagram of the Cu–Se system, in which 170K represents the eutectic isotherm [4], governs the relative content of the two phases. (diamagnetic Cu2-XSe and paramagnetic Cu3Se2). The dynamics of their transformation is strongly temperature and time dependent. Bearing in mind that strong negative thermal expansion due to the ordering of Cu atoms is observed just below the transition, there are indication that the application of pressure (both hydrostatic and uniaxial) could lower the phase transition temperature and thus increase the efficiency of the system at lower temperatures.

4. Conclusion

The phase transition associated with hysteresis is probably due to changes that occur due to the rearrangement of copper ions, and its sensitivity to the application of pressure (hydrostatic and uniaxial) as well as possible ways to improve thermoelectric efficiency should be investigated.

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References

[1] Liu, H. et al: Copper ion liquid-like thermoelectrics, *Nature Materials,* **11** (2012), 422–425, ISSN 1476-1122

[2] Hu, L.et al: Cu2Se nanoparticles encapsulated by nitrogen-doped carbon nanofibers for efficient sodium storage, *Nanomaterials,* **10** (2020), 302, ISSN 2079-4991

[3] Eikeland, E. et al: Extremely Low Thermal Conductivity and High Thermoelectric Performance in Liquid-like Cu2Se1-xSx, *Journal of Materials Chemistry,* **UCrJ4** (2017), 476

[4] Ogorelec, Z.et al: A new contribution to the equilibrium diagram of the Cu-Se system, *Journal of Materials Science,* **7** (1972), 8, 967-969, ISSN 0022-2461
[5] Smontara, A.: *Heat transport in charge density vawes*; PhD thesis, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Zagreb (1991)
[6] Ivkov, J.: *Hallov efekt u amorfnim slitinama prijelaznih metala*; Disertacija, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Zagreb (1991.)
[7] Tonejc, A.: Phase diagram and some properties of Cu2-x Se (2.01>2-x>1.75), *Journal of Materials Science* **15** (1980), ISSN 0022-2461
[8] Glazov, V. M., Pashinkin, A. S., Fedorov, V. A.: Phase equilibria in the Cu-Se system, *Inorganic Materials,* **36** (2000), 641-652, ISSN 1608-3172
[9] Chakrabarti, D.I., Laughlin, D.E.: The Cu-Se (copper-selenium) system, *Bulletin of alloy phase diagrams,* **2** (1981), 305-315, ISSN 0197-0216
[10] Vučić, Z., Gladić, J.: Growth rate of equilibrium-like-shaped single crystals of superionic conductor cuprous selenide, *Journal of Crystal Growth*, **205** (1999),136, ISSN 220248
[11] Ohtani, T. et al: Physical properties and phase transitions of β Cu2-xSe (0.20<x<0.25), *Journal of Alloys and Compounds,* **279** (1998),136-141, ISSN 0925-8388
[12] Blečić, V.: Graduate thesis, Faculty of Science, University of Zagreb, Zagreb (1979)