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Tekstilno-tehnološki fakultet
Poslijediplomski sveučilišni studij
Tekstilna znanost i tehnologija

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Sadržaj

Doktorandi sa ostalih sastavnica Sveučilišta u Zagrebu

O poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija

Poslijediplomski sveučilišni studij **Tekstilna znanost i tehnologija** na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu (TTF) http://www.ttf.unizg.hr/index.php?str=104 ima posebno mjesto u istraživačkom prostoru visokog obrazovanja kao jedini studij u području tehničkih znanosti, znanstvenom polju tekstilna tehnologija u Republici Hrvatskoj.

Ovaj studij nastavak je diplomskog sveučilišnog studija u cilju obrazovanja znanstvenika koji će produbiti teorijska znanja, metodologiju istraživačkog rada, razviti kritičko razmišljanje i dodatne prenosive vještine iz tekstilne tehnologije. Temelji se na istraživanjima iz polja tekstilno-mehaničkog inženjerstva, znanosti o materijalima, tekstilne kemije, tekstilne i odjevne tehnologije, te dizajna tekstila i odjeće.

Program doktorskog studija

Program poslijediplomskog sveučilišnog studija Tekstilna znanost i tehnologija integriran je u strateške dokumente TTF-a, donesene 2014. godine: Strategiju istraživačkog rada TTF-a 2014.-2020. i Strategiju razvoja TTF-a 2014.-2020. Sukladno misiji TTF-a znanstvena istraživanja usmjeravaju se potrebama društvenog i gospodarskog razvoja, a nastavni proces je usklađen s tržištem rada i potrebama društva.

Studij traje 6 semestara i njegovim završetkom stječe se najmanje 180 ECTS bodova.
Nastavno opterećenje doktoranda iznosi 16,7 %, odnosno 30 ECTS, koje stječu polaganjem 8 kolegija (2 obvezna, 5 izbornih iz tekstilne tehnologije i 1 opći izborni). Dodatno se izrađuju Projektni zadaci u III., IV. i V. semestru kroz individualan rad doktoranda na zadanoj temi iz područja istraživanja, temeljem kojih doktorandi dodatno stječu 18 ECTS bodova. Doktorandi na TTF-u usmjeravaju se u znanstveno-istraživački proces, već nakon upisa na doktorski studij. Imenovani studijski savjetnik uvodi doktoranda u istraživanja, što mu pruža mogućnost kritičkog i analitičkog promišljanja, samostalnost u provođenju istraživanja usmjereno na jačanje znanstvenih i istraživačkih kompetencija.

Doktorska izobrazba je prema Strategiji razvoja Sveučilišta u Zagrebu Tekstilno-tehnološkog fakulteta od 2014.-2020. temeljena na kapacitetu, kritičnoj masi i raznolikosti istraživanja, što doktorande čini aktivnim suradnicima na istraživačkim projektima. Kritična masa ne znači nužno veliki broj doktoranada istraživača, već se odnosi na kvalitetu istraživanja i korištenje iznimno vrijedne znanstvene opreme s kojom TTF raspolaže. TTF se zalaže za stjecanje najviše razine ishoda učenja doktoranda tijekom studija, izgradnju povjerenja između doktoranda i nastavnika, te etičnost u znanosti kao temelj izobrazbe. Kroz doktorski studij TTF pruža doktorandima profesionalni razvoj i individualni napredak, te stjecanje vještina u provođenju i razumijevanju etike istraživanja. To uključuje mentorstvo visoke kvalitete i kompetencije mentora s TTF-a, ali i iz drugih institucija iz Hrvatske i šire, što omogućuje interdisciplinarnost, međuinstitucijsku mobilnost i suradnju između sveučilišta. Visoki stupanj znanja iz područja tekstilne tehnologije doktorandima omogućava uključivanje u razvojne projekte inovativnih i visoko sofisticiranih tehnologija koje su temelj prosperiteta i povećanja konkurentnosti gospodarstva. Doktorandi se motiviraju za dodatan znanstveno-istraživački rad koji se valorizira dodjelom:

1. Godišnje Dekaničine nagrade za izvrsnost na doktorskom studiju prilikom obilježavanja Dana fakulteta.
2. Godišnje stipendije za postignute znanstvene rezultate, gdje se doktoranda oslobađa plaćanja školarine.
3. Godišnje nagrade za najbolji znanstveno-istraživački rad iz područja tekstilne tehnologije na Natječaju koji raspisuje Znanstveno-istraživački centar za tekstil (TSRC).

Doktoranda se potiče na mobilnost i pruža mu se mogućnosti izrade jednog dijela doktorskog rada na drugoj instituciji. Izobrazbom stječe i kognitivne sposobnosti putem znanstvenog rada na istraživačkim projektima, prezentiranje rezultata istraživanja, njihov značaj i primjena u tekstilnoj industriji. TTF se zalaže i za planiranje i praćenje vremena trajanja izobrazbe (veću prolaznost), te praćenje karijere svakog završenog doktora znanosti.

Kvaliteta doktorskog studija Tekstilna znanost i tehnologija

Strategija istraživačkog rada Sveučilišta u Zagrebu Tekstilno-tehnološkog fakulteta za razdoblje 2014.-2020. koja je izrađena 2014. jasno je definirala aktivnosti za *Unapređenje kvalitete doktorskih studija* (Strateški cilj 3), koji uključuje:

- Praćenje mentorskih kompetencija,
- Praćenje i unapređenje nastavnog procesa na doktorskom studiju,
- Poticanje istraživačke produktivnosti doktoranada,
- Uključivanje studenata u istraživačke projekte,
- Stipendiranje i nagrađivanje doktoranada,
- Poticanje kognitivnih vještina doktoranada,
- Poticanje mobilnosti i postdoktorskih usavršavanja.

TTF organizira edukacijske i inspirativne radionice za mentore i doktorande, čime se ulažu dodatni napori u podizanju kvalitete mentorskog rada i efikasnosti doktoranda. U akademskoj godini 2015./2016. proveden je postupak Reakreditacije studija Tekstilna znanost i tehnologija, kroz izradu Samoanalize (http://www.ttf.unizg.hr/sadrzaj/files/Samoanaliza_doktorskog_studija_TZT_2016-04-20.pdf) i posjetu Stručnog povjerenstva 8. lipnja 2016. godine. Na temelju mišljenja o kvaliteti studija Agencija za znanost i visoko obrazovanje u postupku reakreditacije dijela djelatnosti Tekstilno-tehnološkog fakulteta Sveučilišta u Zagrebu 3. veljače 2017. dala je Ministarstvu znanosti obrazovanja i športa preporuku za:

1. Izdavanje potvrde o ispunjavanju uvjeta za obavljanje dijela djelatnosti na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu koji se odnosi na izvođenje studijskog programa poslijediplomskog sveučilišnog studija Tekstilna znanost i tehnologija na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu.
2. Naknadno praćenje dijela djelatnosti iz točke 1. Tekstilno-tehnološkog fakulteta Sveučilišta u Zagrebu koje obuhvaća sljedeće:
    - Donošenje akcijskog plana u cilju unapređenja kvalitete u roku od 6 mjeseci od dana dostavljanja potvrde i dostavljanje akcijskog plana Agenciji, te
    - Izvještavanje Agencije jednom godišnje o realizaciji akcijskog plana, uključujući ažuriranje uvjeta izvođenja u informacijskom sustavu kojeg koristi Agencija.

Ministarstvo znanosti i obrazovanja izdalo je 30 ožujka 2017. Potvrdu da Sveučilište u Zagrebu Tekstilno-tehnološki fakultet ispunjava uvjete za obavljanje dijela djelatnosti, koji se odnosi na izvođenje studijskog programa poslijediplomskoga sveučilišnog studija Tekstilna znanost i tehnologija, utvrđene odredbama Zakona o osiguravanju kvalitete u znanosti i visokom obrazovanju.

Zagreb, siječanj 2018.

Voditeljica doktorskog studija

prof. dr. sc. Stana Kovačević

Dekanica Tekstilno-tehnološkog fakulteta

prof. dr. sc. Sandra Bischof

Predgovor

U Akcijskom planu koji je izrađen prema uputama Agencije za znanost i visoko obrazovanje postavljeni su određeni zadaci koje provodi Vijeće doktorskog studija, a jedan od njih je organizacija Dana doktoranada.

Ovogodišnji Dan doktoranada je organizacijski osmišljen kroz dvije cjeline. U prvoj su usmena izlaganja već promoviranih doktora znanosti o istraživanjima provedenim u okviru njihovog doktorskog rada. U drugom dijelu su posterska priopćenja sadašnjih doktoranada, izuzev I. godine studija, u kojima će biti predstavljen tijek njihovih dosadašnjih istraživanja. Uz doktorande studija Tekstilna znanost i tehnologija uključeni su i doktorandi koji studiraju na drugim sastavnicama Sveučilišta u Zagrebu, a zaposlenici su Tekstilno-tehnološkog fakulteta. Vijeće doktorskog studija je odlučilo vrednovati doprinos doktoranada s 4 ECTS.

Ovo hrvatsko-englesko izdanje zbornika sadrži kratke životopise doktora znanosti i doktoranada, te cjelovite radove, proširene sažetke istraživanja odobrenih tema doktorskog rada ili nacrta doktorskog rada.

Cilj održavanja Dana doktoranada na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu je prvenstveno prezentacija tema istraživačkog rada doktoranada, bolja vidljivost istraživačkih tema i unapređenje međuinstitucijske suradnje.

Voditeljica doktorskog studija

Prof. dr. sc. Stana Kovačević

Goran Majstorović

Životopis

Dr. sc. Goran Majstorović rođen je 1965. u Bihaću. Diplomirao je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu.

Od 1990. do 1993. radio je u tt. Globusu Kiseljaku (BiH), prvo kao tehnolog, a nakon godinu dana rada i kao tehnički direktor. Od 1993. do 2015. radio je u tt. NicolaS, Beograd kao tehnički direktor. Od 2007. do 2010. radio je, u isto vrijeme, i u Juveli, Beogradu u razvoju namjenske i zaštitne odjeće. Od 2015. radi u tt. Weltex Čačak.

Godine 2015. stekao je doktorat na poslijediplomskom sveučilišnom studiju Tekstilna znanost i tehnologija pod naslovom *Određivanje toplinskih svojstava namjenske i inteligentne odjeće tijekom njihovog tehničkog projektiranja* pod mentorstvom prof. dr. sc. Dubravka Rogalea. Područje njegovog znanstvenog razvoja uključuje tehničko projektiranje i konstruiranje namjenske i inteligentne odjeće s aspekta toplinske izolacije

Naslov doktorskog rada	Određivanje toplinskih svojstava namjenske i inteligentne odjeće tijekom njihovog tehničkog projektiranja
Mentor	Prof. dr. sc. Dubravko Rogale
Datum obrane doktorskog rada	4. prosinac 2015.

TOPLINSKA SVOJSTVA INTELIGENTNE ODJEĆE

Goran MAJSTOROVIĆ[1] & Dubravko ROGALE[2]
Weltex, Djordja Tomaševića 160, 32 000 Čačak, Srbija[1]
Sveučilište u Zagrebu Tekstilno-tehnološki fakultet [2]

Sažetak: *U radu je prikazano mjerenje termoizolacijskih svojstava inteligentne odjeće u koju su ugrađene termoizolacijske komore koje mijenjaju svoju debljinu u ovisnosti o tlaku upuhanog zraka. Za ta mjerenja korišten je termalni maneken za statička i dinamička mjerenja pri simulaciji hodanja čovjeka s pripadajućim softverom i klima komorom za postizanje propisanih uvjeta. Mjerenja su izvođena pri neaktiviranim termoizolacijskim komorama i pri aktiviranim termoizolacijskim komorama u inteligentnom odjevnom pri čemu je mjerena potrebna snaga za održavanje konstantne temperature dijelova tijela termalnog manekena i izračunavana efektivna termička izolacija u ovisnosti o brzini simuliranog hoda.*

Ključne riječi: *inteligentna odjeća, termoizolacijske komore, toplinska svojstva*

1. Uvod

Kako bi se izbjegla potreba slojevitog oblačenja i skidanja slojeva odjeće u cilju postizanja potrebne vrijednosti efektivne toplinske izolacije odjevnog predmeta izumljena je inteligentna odjeća s adaptivnim termoizolacijskim svojstvima [1-2].

Ova vrsta odjeće ima ugrađene termoizolacijske komore čija debljina i termoizolacijska svojstva ovise o količini upuhanog zraka. Spomenuti odjevni predmeti imaju mogućnost mjerenja vanjske i unutrašnje temperature, donošenja odluke o optimalnoj toplinskoj izolaciji s pomoću ugrađenog mikroračunala i izvršavanja te odluke uključenjem mikrokompresora koji upuhuje zrak u termoizolacijske komore. Na taj način izvodi se automatska toplinska adaptacija odjevnog predmeta na promjene temperature okoliša ili tjelesne aktivnosti nositelja. Pri upotrebi takvog odjevnog predmeta izbjegava se potreba slojevitog oblačenja [3].

Više prototipova inteligentne odjeće s adaptivnim termoizolacijskim svojstvima izrađeno je u Zavodu za odjevnu tehnologiju Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu i ispitano tijekom praktičnog nošenja, međutim zbog nedostatka mjeriteljske opreme nikada nisu istražene i izmjerene vrijednosti efektivne toplinske izolacije takve vrste odjevnih predmeta [4-5]. Zbog toga je načinjen prototip termalnog manekena za istraživanja toplinskih svojstava odjeće, klima komora u kojoj je smješten maneken te sav potreban softver potreban za upravljanje radom komore i termalnog manekena te softver za mjerenja i obradu podataka. Korištenjem nove opisane mjeriteljske opreme su izmjerena efektivna termoizolacijska svojstva inteligentne odjeće pri različitim uvjetima nošenja i prikazana u ovom radu.

2. Eksperimentalni dio

Mjerenje termoizolacijskih svojstava odjeće se izvodilo na inteligentnom odjevnom predmetu s adaptivnim termoizolacijskim svojstvima u klima komori u kojoj je instaliran termalni maneken i drugi mjeriteljski sustavi potrebnih za određivanje mikroklimatskih stanja u komori i na manekenu te za mjerenja utrošene snage i energije.

Termoizolacijske komore se nalaze između vanjske školjke i podstave načinjene od voluminoznog poliamidnog netkanog tekstila trgovačkog naziva fleece debljine 1,21 mm. Za izradu vanjske školjke i podstave odjevnog predmeta s adaptivnim termoizolacijskim svojstvima odabran je model muške jakne koji nudi udobnost nošenja i slobodu pokreta, sl. 1. Odabrana odjevna veličina je 50.
Vanjska školjka načinjena je od osnovnog materijala sirovinskog sastava pamuk 100 % debljine 0,23

mm. Za podstavu je korištena mrežice PA 6 debljine 0,14 mm. Za rukave je korištena kombinacija podstave s punilom i voluminoznog netkanog PA/PES debljine 1,01 mm [1].
Komore su načinjene od visokoelastične poliuretanske folije Walopur 4201AU proizvođača Bayer Epurex Films GmbH, Njemačka. Folija ima visoko istezanje pri sili prekida, koje iznosi 550 %. Termoizolacijska komora je načinjena iz tri dijela povezana elastičnim materijalom debljine 0,25 mm.

Osnovne dimenzije kvadratičnog zračnog jastuka termoizolacijske komore iznose 5,7 x 5,7 cm, a širina spoja 0,4 cm. Kad se ispune zrakom tlaka 50 mbara zračni jastuci termoizolacijske komore poprimaju debljinu od 28 mm. Na prednjem dijelu je ukupno 25 komora, a na stražnjem dijelu 45 komora. Razmak između pojedinih komora je 0,5 mm.

Razvijeni termalni maneken, slika 1, te klima komora omogućava određivanje toplinskih svojstava odjeće prema tzv. serijskom i paralelnom modelu, u skladu s međunarodnim standardom ISO 15831 [6]. Prema standardu maneken mora biti konstruiran tako da održava konstantnu temperaturu od 33,8-34,2 °C. Temperatura u klima komori mora biti različita od temperature manekena minimalno 12 °C, a strujanje zraka u klima komori postavljena na 0,39-0,41 m/s [1].

Slika 1: Inteligentni odjevni predmet na termalnom manekenu

Nakon izvedenog zadanog broja uzastopnih mjerenja, rad uređaja se automatski zaustavlja, izvodi se izračun i statistička analiza, te se otiskuje protokol mjerenja s izmjerenim i izračunatim vrijednostima. Utvrđivanje toplinskih svojstava odjeće u dinamičkim uvjetima izvodi se na način da se spomenuti odljevak pokreće s odjevenim odjevnim predmetom tako da simulira kretanje hodom nositelja odjevnog predmeta pri čemu se protufazno pomiču obje noge i ruke nositelja, također u stalnim ili promjenjivim uvjetima okoliša simuliranim u klima komori. Pokretanje ekstremiteta izvodi se pomoću pneumatsko-polužnog sustava, ugrađenim u tijelo odljevka. Brzina gibanja ekstremiteta se može mijenjati u širokom rasponu i točno namjestiti zračnim prigušnicama tako da se npr. može ostvariti brzina pokretanja od 45±2 dvostruka koraka/min i 45±2 dvostruka pokreta rukama/min kod hoda, što odgovara normi ISO 15831. Uspostavljen je način upravljanja, regulacije, mjerenja i izračuna toplinskih svojstava na odjeći primjenom segmentiranog metalnog odljevka oblikovanog prema ljudskom tijelu s time da postoji mogućnost aktivacije i deaktivacije svih segmenata (cijelog odljevka) ili bilo koje skupine segmenta odljevka kao i mogućnost postavljanja radnih i mjernih parametara u skladu s normama ili za potrebe eksperimentalnih istraživanja.

Mjerni sustav ima razvijen softver koji omogućava da se postupak mjerenja i izračuna toplinskih svojstava kompozita ili odjeće može višestruko ponavljati u definiranim vremenskim intervalima nakon čega se mjerni sustav automatski zaustavlja, izvodi propisanu statističku obradu, prikaz rezultata te ispisuje protokol i utvrđene rezultate određivanja toplinskih svojstava na računalnom tiskalu.

Mjerenja su izvođena na način da je utvrđivana potrebna ravnotežna snaga grijača svih površina torza kada je termalni maneken bio u stanju mirovanja, te kada je simuliran hod manekena od 10, 20, 30, 40, 50 i 60 dvostrukih koraka/min i istodobnih pokreta rukama. Dužinu koraka u pokretu, mjereno od lijeve pete do desne pete, prema standardu, iznosila je 63 cm, a duljina pokreta ruku, mjereno između ručnih zglobova 53 cm. Temperatura grijanih površina manekena bila je 34,0 ^{0}C, a temperatura ambijenta 19 ^{0}C. Brzina strujanja zraka u komori bila je 0,4 m/s, a relativna vlažnost zraka 50 %.

3. Rezultati i rasprava

U ovom radu su izvedena mjerenja potrebne električne snage za održavanje konstantne temperature torza termalnog manekena kada je torzo manekena bilo odjeveno u inteligentni odjevni predmet s adaptivnim termoizolacijskim svojstvima. Mjerena je potrebna snaga pri aktiviranoj i neaktiviranoj termoizolacijskoj komori. Pri neaktiviranoj termoizolacijskoj komori je tlak zraka u komori je 0 mbar, pa je i razmak između slojeva termoizolacijske komore bio 0 mm. Pri aktiviranoj komori je tlak zraka u njoj bio 50 mbar te je izmjerena debljina komore između unutarnjeg i vanjskog sloja iznosio 28 mm.

U tab. 1 prikazane su potrebne snage grijača za održavanje konstantne temperature torza termalnog manekena pri aktiviranim i neaktiviranim termoizolacijskim komorama te pri mirovanju manekena i njegovom gibanju pri simulaciji hodanja od 45 koraka/min, što osigurava standardu ISO 15831:2004 [6].

Tablica 1: Potrebna snaga grijača za održavanje konstantne temperature torza termalnog manekena

	Neaktivirane termoizolacijske komore p=0 mbar		Aktivirane termoizolacijske komore p=50 mbar	
	Mirovanje manekena, 0 koraka/min	Gibanje manekena, 45 koraka/min	Mirovanje manekena, 0 koraka/min	Gibanje manekena, 45 koraka/min
Snaga grijača, P/W	79,0	85,0	57,5	59,0
Efektivna izolacija, I_{EF}/ m^2KW^{-1}	0,0886	0,0775	0,1475	0,1420

S aspekta termoizolacijskih svojstava važno je naglasiti da je pri mirovanju manekena s neaktiviranom termoizolacijskom komorom potrebno 79,0 W za održavanje konstantne temperature torza termalnog manekena, a pri aktiviranoj potrebna snaga smanji se na 57,5 W. Istodobno se efektivna izolacija s vrijednosti 0,0886 m^2KW^{-1} poveća na 0,1475 m^2KW^{-1} što iznosi povećanje vrijednosti efektivne izolacije od 66,5 %.

Pri određivanju efektivnih toplinskih izolacija odjevnog predmeta u gibanju, odnosno simulaciji hodanja izmjereno je još izrazitije povećanje efektivnih toplinskih izolacija od 0,0775 m^2KW^{-1} poveća na 0,1420 m^2KW^{-1} što iznosi povećanje vrijednosti efektivne izolacije od 83 %. Ovako visoka vrijednost povećanja vrijednosti efektivne toplinske izolacije može se pripisati povećanom brtvljenju zbog aktiviranih termoizolacijskih komora koje se tijesno pripiju uz tijelo i na taj način još više smanjuju prijenos topline kondukcijom s tijela u okolišni prostor, istodobno se izraženije smanjuju preostali zračni džepovi tako da se vrlo mala količina toplog zraka iz unutrašnjosti odjevnog predmeta pri gibanju, uz aktivirane termoizolacijske komore, prenosi u okolišni prostor.

Iz provedenih mjerenja i prikazanih rezultata može se zaključiti da termoizolacijske komore ispunjene zrakom mogu biti izrazito izolacijsko sredstvo pri realizaciji inteligentne odjeće s adaptivnim termoizolacijskim svojstvima.

4. Zaključak

U radu su izmjerena termoizolacijska svojstva inteligentne odjeće s adaptivnim termoizolacijskim svojstvima. Utvrđeno je da aktivirane termoizolacijske komore značajno povećavaju vrijednosti efektivne toplinske izolacije odjevnog predmeta. Pri mirovanju manekena i pri neaktiviranim termoizolacijskim komorama efektivna izolacija poprima vrijednost od 0,0886 m^2KW^{-1}da bi pri aktiviranim komorama porasla na 0,1475 m^2KW^{-1} pri čemu porast iznosi 66,5 %. Pri standardiziranom kretanju od 45 koraka/min vrijednost efektivne toplinske izolacije može porasti i do 83 %, jer se povećala s vrijednosti od 0,0775 m^2KW^{-1} na 0,1420 m^2KW^{-1} što se može pripisati boljem prijanjanju aktiviranih komora uz tijelo, smanjenju preostalih zračnih džepova u odjeći i smanjenom istiskivanju toplog zraka iz unutrašnjosti odjeće u okolišni prostor.

U ovim istraživanjima je također utvrđeno da se vrijednosti efektivne termičke vrijednosti smanjuju s porastom brzine hodanja. Trend smanjenja je izraženiji pri manjim brzinama hodanja s obzirom da se već samim prelaskom iz stanja mirovanja u hodanje istiskuju veće količine toplog zraka iz unutrašnjosti odjevnog predmeta. Pri aktiviranim komorama vrijednosti smanjenja toplinske izolacije su znatno manje pri povećanju brzine hodanja što se može pripisati boljem brtvljenju termoizolacijskih komora uz tijelo što dodatno smanjuje istiskivanje toplog zraka iz unutrašnjosti odjevnog predmeta.

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Naslov doktorskog rada	Utjecaj parametara šivanja na kvalitetu izrade navlaka za autosjedala
Mentor	Prof. dr. sc. Darko Ujević
Datum obrane doktorskog rada	10. ožujka 2015.

UTJECAJ PARAMETARA ŠIVANJA NA KVALITETU IZRADE NAVLAKA ZA AUTOSJEDALA

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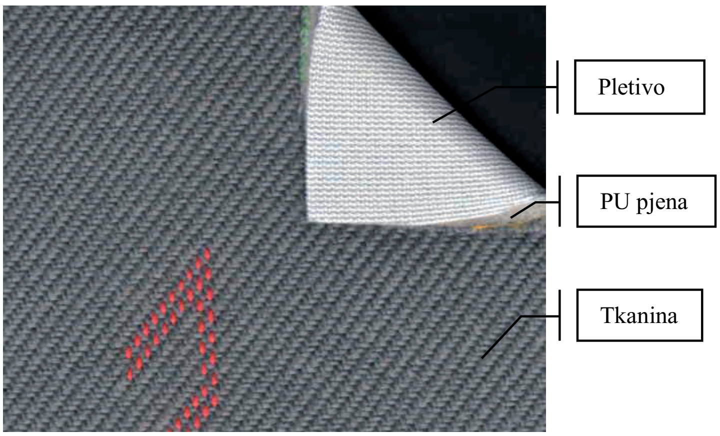
Sažetak: *Kompoziti za auto navlake pripadaju tehničkom tekstilu. U procesu šivanja auto navlaka dolazi do različitih naprezanja komponetni unutar kompozita što utječe na kvalitetu šava. Različitim brzinama lijepljenja komponenata u kompozit istraženi su optimalni uvjeti lijepljenja. Probodna sila i vrh šivaće igle imaju vrlo veliki značaj na kvalitetu šava. Promjenom debljine PU pjene i vrste šivaće igle tražilo se optimalno rješenje u cilju poboljšanja izgleda i čvrstoće šivanog šava.*

1. Uvod

Auto navlake spadaju u kompozitne materijale i predstavljaju dio svakog automobila. Tkanina se najčešće koristi kao površinska komponenta višeslojnog materijala za automobilske navlake. Tkanina daje udobnost i mekoću pri dodiru s tijelom, lakše se oblikuje u ergonomski oblik sjedala i ostalog interijera. Uglavnom je na površini tkanina otkana u temeljnim vezovima ili njihovim izvedenicama s manjim jedinicama veza. Pletivo je udobnije od tkanine, međutim zbog izrazito manje otpornosti na habanje i trajnosti, nestabilnosti i manje prekidne sile u odnosu na tkaninu, umjetnu kožu i prirodnu kožu koristi se najčešće kao treći sloj kompozitnog višeslojnog materijala za automobilske navlake za sjedala. Poliuretanska spužva, kao središnja komponenta unutar kompozita, daje mekoću i udobnost pri sjedenju. Prilagođavanjem automobilske navlake sve složenijem ergonomskom obliku sjedala zahtijeva sve veći broj i složenost krojnih dijelova, a time i sve veći udio šavova i sve zahtjevnije šivanje [1-4].



Slika 1: Kompozitni materijal za auto navlake

Materijal, igla i konac su nedjeljivi trio koji izravno utječu na kvalitetu šava. Veličina ušice šivaće igle i debljina konca moraju biti međusobno precizno usklađeni da bi konac mogao prolaziti kroz ušicu sa što manjim trenjem. Osim finoće šivaće igle vrlo važan je njen oblik vrška za kvalitetu šava i stupanj oštećenja materijala. Konci za šivanje automobilskih navlaka moraju imati iznimno visoku čvrstoću. Dobrim odabirom vrste uboda, šava i konca mogu se dobiti šivani šavovi točno određene čvrstoće i elastičnosti, što je osobito važno za automobilske navlake. Dobar izgled šava te njegova učinkovitost kod šivanja automobilskih navlaka je jedan od najvažnijih čimbenika u kvaliteti automobilske navlake za sjedanje. Prema vrsti i debljini materijala odabire se duljina i vrsta uboda, konac i oblik igle. Da bi se dobio pravilan šav bitno je optimirati napetost donjeg i gornjeg konca te obostrani pomak materijala što je izuzetno složeno zbog različitih debljina materijala u tijeku šivanja (sl. 2) [5].

Slika 2: Oštećenje tkanine na mjestu šava prilikom uporabe auto navlaka

2. Eksperimentalni dio

2.1. Tijek postupka ispitivanja

Ispitivanja su provedena na kompozitima namijenjenim za auto navlake s dvije debljine PU pjene. Kompozit se sastoji od tkanine na licu, PU pjene u sredini i pletiva na poleđini kompozita.
Termičkim lijepljenjem komponenti u kompozit s tri različite procesne brzine prolaza materijala (30, 34, 39 m/min) i dvije debljine PU pjene (2 i 4 mm) ispitat će se fizikalno-mehanička svojstva polukompozita (pletivo + PU) i konačnog kompozita (tkanina + PU + pletivo) te utjecaj svojstava komponenti na kompozit.

2.2. Materijali za ispitivanje

Tkanina: **s**irovinski sastav: 100 % poliester (PES) multi filament, vez: listovni, gustoća: osnova / potka: 29 / 20,5 (niti/ cm), finoća: osnova / potka: 620 f 144 dtex/ 167 f 48×3 dtex
Pletivo: sirovinski sastav: 100 % poliester (PES) multi filament, vez: kulirno podliježno pletivo 1+1, gustoća: nizovi / redovi: 130 / 110 (na 10 cm), finoća pređe: 75-84 f 36 dtex.
Poliuretanska pjena (PU): u dvije debljine: 2mm i 4 mm, dobavljač *Eybl*
Specifikacije strojeva za izradu tkanina, pletiva i kompozita:
Tkalački strojevi: Dornier tip: S 220 cm s unosom potke pomoću hvatala i opremljen elektronskom listovkom.
Pletaći strojevi: Terrot tip: S296-1; E28 30``.
Strojevi za lijepljenje komponenata kompozita s plinskim plamenom: Schmid, model: 1281/2200.

2.3. Metode i uređaji za ispitivanje

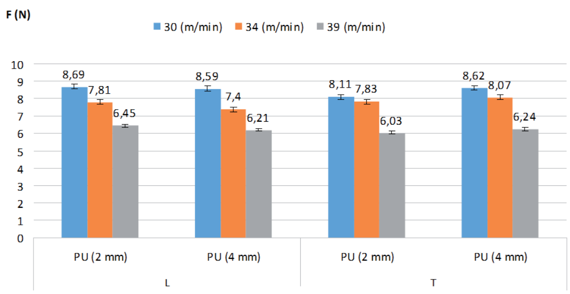
Ispitivanje po pojedinim metodama provodilo se u uvjetima strogo definirane vlage i temperature kako samog materijala koji se ispituje tako i prostora u kojem se ispitivanje provodilo. U standardnoj atmosferi za ispitivanje definirani su uvjeti vlage 65±2 % i temperature 20±2 ^{0}C.
Ispitivanje uzoraka:

- Prekidna sila i prekidno istezanje provedeno je na svim uzorcima u uzdužnom i poprečnom smjeru na dinamometru Pellizzato/Tinius Olsen, Tip H5KS, prema normi DIN EN ISO 13934-1.
- Ispitivanje sile razdvajanja komponenti s dvije debljine PU (polikompozita: pletivo + PU i kompozita: tkanina + PU + pletivo) provedeno je na dinamometru Pellizzato/Tinius Olsen, Tip H5KS, prema normi DIN 53 357.
- Ispitivanje probodne sile šivaće igle, provedena na inovativnom uređaju ITV, Denkendorf.

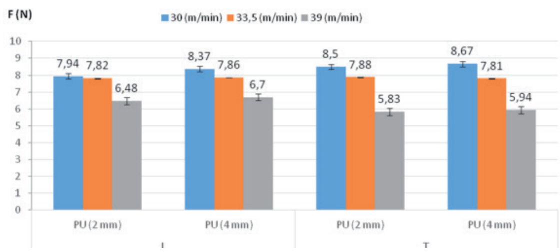
3. Rezultati i rasprava

Prema dobivenim rezultatima može se zaključiti da je sila razdvajanja najmanja kod uzoraka kod kojih su termički spajane komponente u kompozitu na 39 m/min, a najveća kod uzoraka koja su

termički spajana na 30 m/min. Time se može zaključiti da manja brzina termičkog lijepljenja pridonosi jačem spoju komponenti, što je pridonijelo većim taljenjem PU i prodiranjem u tkaninu i pletivo.
Prekidno istezanje se povećavalo s povećanjem brzine termičkog spajanja. Ova pojava se može protumačiti da je veća brzina spajanja utjecala na manju količinu taljenog PU, manju krutost materijala, a time i veće istezanje.

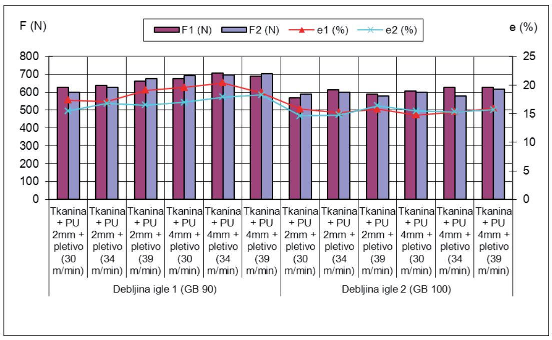


a.

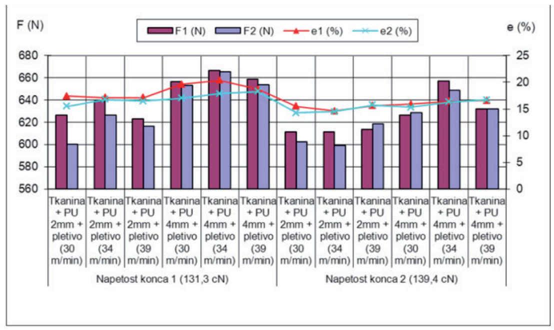


b.

Slika 3: a) Sile razdvajanja tkanine od PU i pletiva, b) Sile razdvajanja pletiva od PU pjene i tkanine
L – uzdužni smjer, T – poprečni smjer



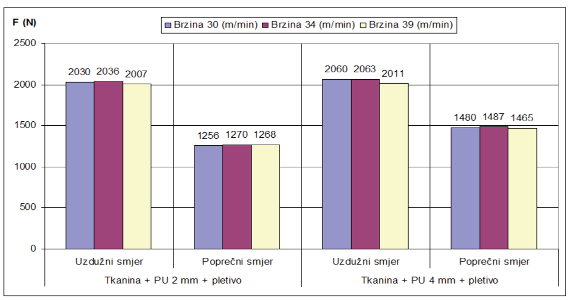
a.



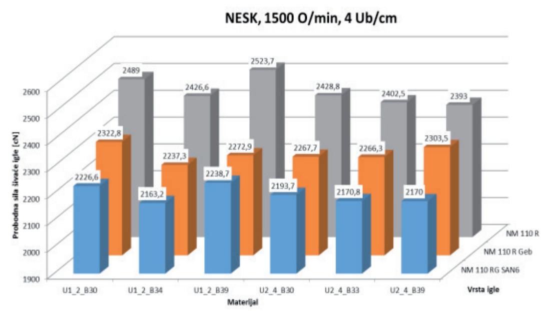
b.

Slika 4: a) Prekidne sile i prekidno istezanje u šavu kompozita uz debljine igle GB 90 i GB 100
b) Prekidne sile i prekidno istezanje uz napetost konca od 131,3 cN i 139,4 cN

Deblja igla uzrokovala je smanjenje prekidne i prekidnog istezanja kod svih uzoraka. Time se pouzdano može tvrditi da je deblja igla izazvala veće deformacije niti na mjestima uboda. Smjer kompozita također je utjecao na prekidne sile. Veće prekidne sile su u smjeru osnove, odnosno po dužini uzorka.
Manja napetost konca uzrokovala je većim prekidnim silama kod svih uzoraka u smjeru osnove i potke. Isto tako, manja napetost konca uzrokovala je i veće prekidno istezanje na mjestu šava. Promatrajući kompozite prema brzini spajanja komponenti moguće je uočiti da su prekidne sile kao i prekidno istezanje većinom najveće kod srednje brzine prolaza materijala (34 m/min).



Slika 5: Prekidna sila kompozita (tkanina + PU + pletivo) u smjeru osnove i potke u tri brzine lijepljenja komponenti



Slika 6: Probodne sile kod tri različite vrste igala po uzorcima kompozita

Promatrajući minimalne i maksimalne probodne sile šivaćih igala po vrstama igala može se utvrditi da su minimalne prekidne sile većinom najmanje kod svih uzoraka kod igle NM110RG SAN6 Geb, potom kod igle NM110R Geb, a najveće kod igle NM110R. Maksimalne sile se nisu bitno razlikovale po vrstama igala, no ipak je većinom isti tijek probodnih sila šivaćih igala kao i kod minimalnih.

4. Zaključci

Termičko spajanje pletiva i PU, a potom dobivenog polukompozita i tkanine u konačni kompozit, uzrokovalo je smanjenju debljine i mase kompozita u odnosu na debljinu i masu koju sačinjavaju komponente prije spajanja. To upućuje na činjenicu da se tkanina i pletivo u vrijeme površinskog taljenja PU prodiru u nastalu taljevinu, te je na taj način ostvaren čvrsti spoj. Promjenom brzine termičkog spajanja komponenti u kompozit, prekidne sile nisu se značajno mijenjale, no ipak se ponavljala najveća prekidna sila na srednjoj korištenoj brzini (34 m/min). Sila razdvajanja tkanine od PU i pletiva je veća od sile razdvajanja pletiva od PU i tkanine kod svih uzoraka u oba smjera i obje debljine PU. Prema dobivenim rezultatima može se zaključiti da se sila razdvajanja povećavala smanjenjem brzine termičkog spajanja. ,
Odabi odgovarajuće igle, probodne sile se značajno smanjuju što doprinosi smanjenju oštećenja materijala.

Zahvala

Zahvaljujem tvrtki Prevent, Visoko, BIH, za izradu uzoraka (tkanina i pletiva), te provedbi izrade kompozita

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Naslov doktorskog rada	Istraživanje međupodstava sa zaštitnim djelovanjem od mikrovalnog zračenja u odjevnom predmetu tijekom održavanja

Mentori	Prof. dr. sc. Darko Ujević (TTF)	Prof. dr. sc. Krešimir Malarić (Sveučilište u Zagrebu Fakultet elektrotehnike i računarstva)
Datum obrane doktorskog rada	16. prosinca 2015.	

MEĐUPODSTAVE SA ZAŠTITNIM DJELOVANJEM OD MIKROVALNOG ZRAČENJA U ODJEVNOM PREDMETU

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Sažetak: *U radu su istražena zaštitna svojstva funkcionalnih tekstilnih proizvoda za zaštitu od elektromagnetskog EM zračenja. U tu svrhu su odabrane međupodstavne tkanine s nanosom bakra, pletivo s posrebrenim nitima, te tkanina s inox vlaknima. Zaštitna svojstva navedenih materijala ispitana su na frekvencijama mikrovalnog zračenja 0,9 GHz, 1,8 GHz, 2,1 GHz i 2,4 GHz.*

1. Uvod

Elektromagnetsko zagađenje se ne može osjetiti na bilo koji način, nema boje, okusa ni mirisa [1]. Negativne zdravstvene posljedice mogu se manifestirati tek nakon dužeg vremenskog razdoblja izloženosti i obično se ne dovode u vezu s elektromagnetskim zagađenjem već s drugim čimbenicima (stres, loša prehrana, brzi tempo života i sl.) [2].

Posljednjih je godina javnost širom svijeta, izuzetno senzibilizirana glede pitanja o mogućoj štetnosti EM zračenja za ljude i ostale žive organizme uključujući i biljni pokrov. Često korištenje elektroničkih uređaja može utjecati na zdravlje ljudi odnosno može izazvati razne zdravstvene smetnje kao što su: promjene u ponašanju, povećanje stresa, nesanice, srčane aritmije i slične poteškoće. Rezultati istraživanja utjecaja EM zračenja (GSM, mikrovalne pećnice i sl.) na štakorima su potvrdila promjene u njihovu metabolizmu, radu mozga i živčanim aktivnostima [3,4]. Djelovanjem na metaboličke aktivnosti povećava se opasnost obolijevanja od raka što su pokazala medicinska istraživanja [5]. Epidemiološke studije razmatraju eventualno povećanje rizika od određenih tumora glave kod korisnika mobilnih i GSM uređaja u redovitoj primjeni [6]. Sve studije o biomedicinskim učincima radijskih valova u pokretnim komunikacijskim sustavima GSM na 0,9 i 1,8 GHz pokazale su da su toplinski učinci dominantni, jer u tim frekvencijskim područjima izmjenična elektromagnetska polja izazivaju samo vibracije i rotacije dipolnih molekula vode koja se u velikom postotku nalazi u ljudskom tijelu. Stoga se pri istraživanju učinaka elektromagnetskih valova na žive organizme kao jedan od najvažnijih elektromagnetskih parametara uzima gustoća zračene snage [7]. Dostupna literatura ne isključuje promjene zdravstvenog stanja, posebno bioloških funkcija, nakon izloženosti jačem intenzitetu EM zračenja.

Materijali koji se najčešće koriste za zaštitu od EM zračenja u odjevnim predmetima su poliamidne, poliesterske ili pamučne tkanine ili pletiva s nanosom bakra, srebra ili inoxa. Na slici 1 su prikazani međupodstavni materijali s metalnim nanosima koji se koriste za zaštitu od EM zračenja.

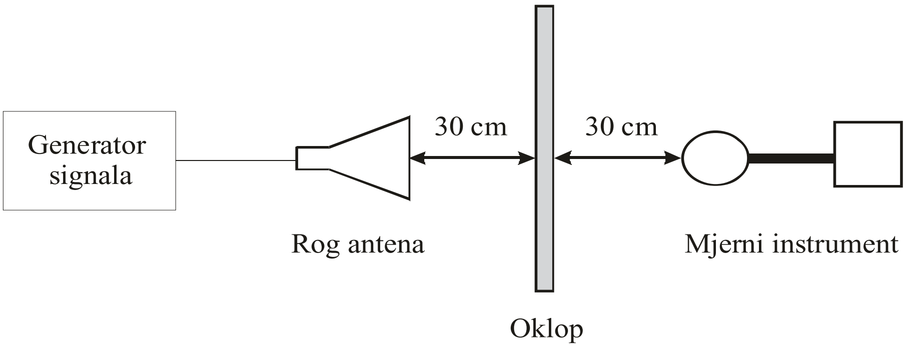
Slika 1: Međupodstavni materijali s metalnim nanosima za zaštitu od EM zračenja [8]

U radu je istražen utjecaj ciklusa kemijskog čišćenja na postojanost svojstava materijala u zaštiti od EM zračenja. Početna svojstva ispitivanih materijala su različita s obzirom na sirovinski sastav, značajke materijala, vrstu metalnog nanosa i namjenu. Karakterizacija površine zaštitnih svojstava ispitivanih tekstilnih materijala od EM zračenja prije i nakon ciklusa kemijskog čišćenja je načinjena metodom skenirajuće elektronske mikroskopije (SEM).

2. Eksperimentalni dio

Istražena su zaštitna svojstva međupodstavne tkanine načinjene od poliamidnog filamenta naslojenog bakrom, koja ima oznaku MP1.

Metalni nanos na površini materijala daje im funkcionalnost u postizanju zaštitnih svojstava od EM zračenja. Osnovna namjena međupodstavnog materijala MP1 je zaštita (oklapanje) od EM mikrovalnog zračenja, a predviđen je za ušivanje u džepove odjevnih predmeta (sakoa, jakni, hlača i drugih odjevnih predmeta) u kojima se najčešće nose mobilni uređaji. Tijekom pripreme uzoraka i ispitivanja, na uzorcima su korišteni slijedeći tehnološki postupci: krojenje, frontalno fiksiranje, šivanje, glačanje, kemijsko čišćenje i mokro čišćenje [9]. Na Sveučilištu u Zagrebu Fakultetu za elektrotehniku i računarstvo u Mikrovalnom laboratoriju (pri temperaturi 23±1 ˚C i relativnoj vlažnosti 50±10 %) Zavoda za radiokomunikacije primjenom novo razvijene metode i osmišljenog mjernog postava istražen je utjecaj otapala na zaštitna svojstva međupodstavne tkanine. Mjerni postav je osmišljen prema preporukama međunarodnih normi ASTM D-4935-89 [10], IEE-STD 299-97 [11] i MIL STD 285 [12]. Mjerni postav prikazan je na slici 2, a sastoji se od: drvenog oklopa, generatora signala, rog antene i mjernog instrumenta NARDA SRM 3000.

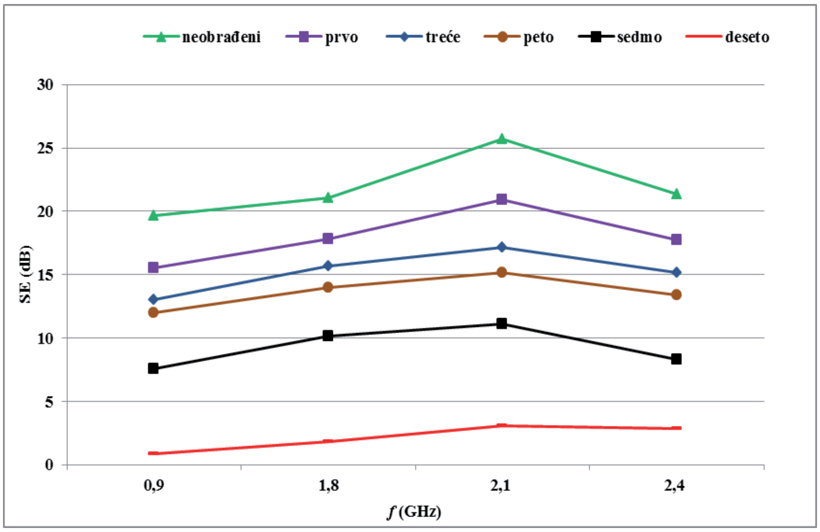


Slika 2: Mjerni postav za mjerenje oklopnih svojstava tkanina [9]

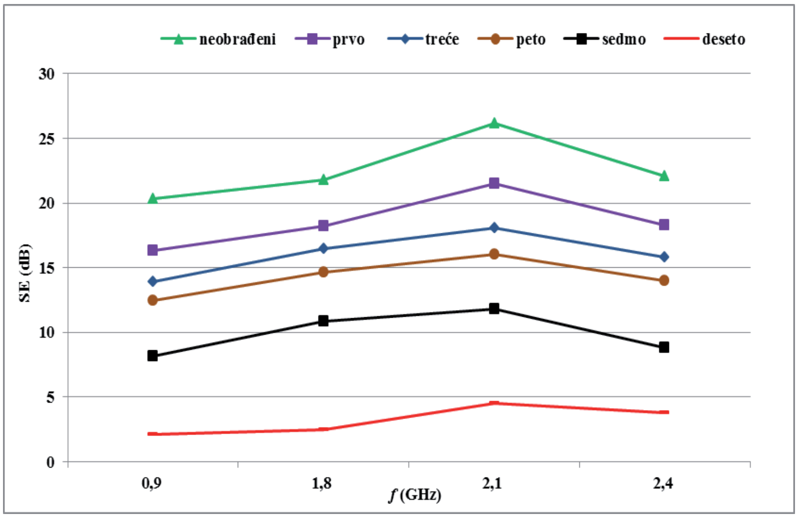
Na mjernom postavu su izvršena mjerenja zaštite (oklopa) lica i naličja međupodstavnih zaštitnih materijala Učinkovitost EM zaštite međupodstavnih materijaka prije i nakon (prvog, trećeg. petog, sedmog i desetog) kemijskog čišćenja ispitana je na frekvencijama: 0,9 GHz; 1,8 GHz; 2,1 GHz i 2,4 GHz [9].

3. Rezultati i rasprava

U rezultatima je dan primjer učinkovitosti zaštite od elektromagnetskog zračenja neobrađenih uzoraka te uzoraka nakon prvog, trećeg, petog, sedmog i desetog ciklusa kemijskog čišćenja poliamidne tkanine s bakrenim nanosom (MP1) na licu i naličju tkanine. Zaštitna svojstva (SE) neobrađenih uzoraka MP1 (lice) na frekvenciji 0,9 GHz imaju vrijednost 19,66 dB, dok su na frekvencijama 1,8 GHz; 2,1 GHz i 2,4 GHz te vrijednosti više od 20 dB (sl. 3a) SE vrijednosti neobrađenih uzoraka MP1 (naličje) na svim ispitivanim frekvencijama su iznad 20 dB (sl. 3b). Najbolja zaštitna svojstva (26,13 dB) međupodstave MP1 (naličje) postignuta su na frekvenciji 2,1 GHz. Usporedba zaštitnih svojstava MP1 (naličje) na svim frekvencijama su bolja za prosječno 1 dB od zaštitnih svojstava MP1 (lice). Ova mjerenja pokazuju da je međupodstava od poliamidnog filamenta s bakrenim nanosom (lice i naličje) najučinkovitija u zaštiti od elektromagnetskog zračenja na frekvenciji 2,1 GHz. Zaštitna svojstva MP1 (lice i naličje) približno su jednaka, što ukazuje na jednoličnost bakrenog nanosa na poliamidnom filamentu. Već nakon prvog ciklusa kemijskog čišćenja zaštitna svojstva MP1 (lice i naličje) se smanjuju što ovisi isključivo o frekvenciji. Promjena zaštitnih svojstava tkanine je jednoznačna, obzirom da je tkanina obostrano izložena utjecaju otapala koje ima brzi prodor u materijal u procesu kemijskog čišćenja. Tendencija smanjenja zaštitnih svojstava MP1 se nastavlja i u daljnjim ciklusima, tako da se nakon desetog ciklusa ova svojstva gotovo u potpunosti gube.



a.

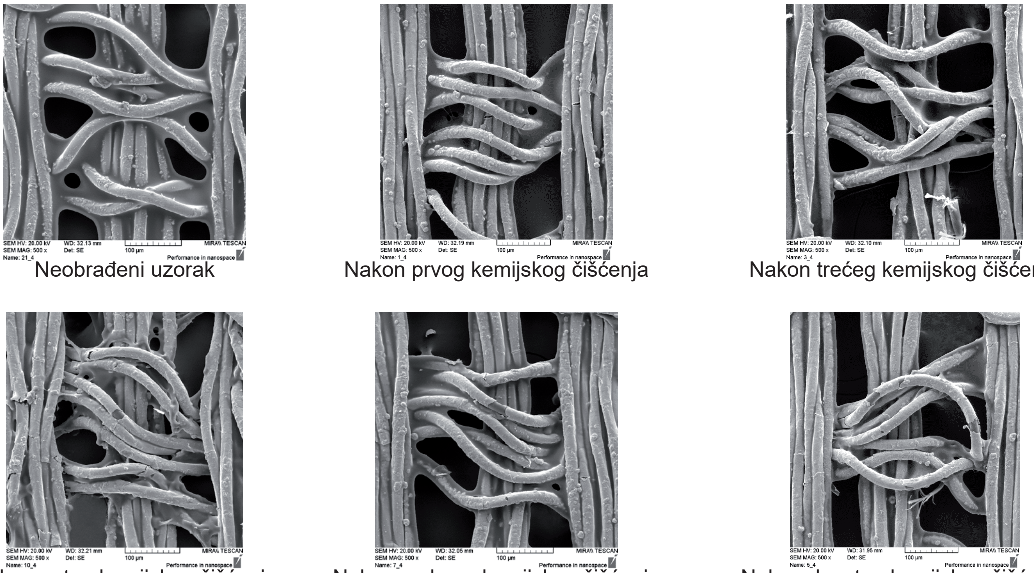


b.

Slika 3: Zaštitna svojstva neobrađenih uzoraka MP1 te nakon ciklusa kemijskog čišćenja (lice i naličje): a) lice tkanine prije i nakon ciklusa mokrog čišćenja na frekvencijama 0,9GHz; 1,8GHz; 2,1GHz i 2,4GHz, b) naličje tkanine prije i nakon ciklusa mokrog čišćenja na frekvencijama 0,9GHz; 1,8GHz; 2,1GHz i 2,4GHz

Snimke površine neobrađenih uzoraka i nakon ciklusa kemijskog čišćenja primjenom SEM, SE detektor uz povećanje 500x su date na slici 4. Snimak površina neobrađenog uzorka MP1 potvrđuje platno vez osnovne tkanine načinjene od poliamidnog filamenta koji je jednolično naslojena bakrom (sl. 4).

Na slici 4 je vidljivo da broj ciklusa kemijskog čišćenja utječe na površinu nanosa na MP1. Snimak površine uzorka MP1 nakon deset ciklusa čišćenja pokazuje jako oštećenje bakrenog nanosa s pojedinih filamenata. Posljedica pucanja bakrenog nanosa je gubitak zaštitnih svojstava međupodstavne tkanine MP1 radi većeg prolaza EMZ-a i smanjenja zaštitnih svojstava MP1.



Neobrađeni uzorak | Nakon prvog kemijskog čišćenja | Nakon trećeg kemijskog čišćenja

Nakon petog kemijskog čišćenja | Nakon sedmog kemijskog čišćenja | Nakon desetog kemijskog čišćenja

Slika 4: SEM slika neobrađenih uzoraka MP1 te uzoraka nakon kemijskog čišćenja

4. Zaključci

Udio metala u ispitivanom međupodstavnom materijalu osigurao je zaštitna svojstava i funkcionalnost u zaštiti od EM zračenja.. Početna zaštitna svojstva MP1 (lice i naličje) su približno jednaka, što ukazuje na kvalitetno naslojavanje i obostranu jednoličnost bakrenog nanosa na poliamidnom filamentu. U procesima kemijskog čišćenja dolazi do abrazije i pucanja nanosa bakra što implicira pad zaštitnih svojstava od EM zračenja.

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Naslov doktorskog rada	Utjecaj konstrukcijskih parametara na toplinska svojstva odjeće
Mentor	Prof. dr. sc. Dubravko Rogale
Datum obrane doktorskog rada	19. travnja 2016.

UTJECAJ KONSTRUKCIJSKIH PARAMETARA NA TOPLINSKA SVOJSTVA ODJEĆE

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Sažetak: *U doktorskom radu je istražen utjecaj konstrukcijskih parametara (konstrukcijski dodatak komocije odjevnog predmeta i duljina kroja odjevnog predmeta) na toplinska svojstva muških jakni, izražena kao vrijednost efektivne toplinske izolacije, i zadovoljstvo ispitanika podvrgnutih testiranjima u kontroliranim uvjetima prohladnih okoliša (ispitivanje toplinske ugodnosti ispitanika nošenjem odjevnih predmeta). Subjektivna percepcija toplinske ugodnosti pri nošenju ispitivane odjeće u specifičnim uvjetima okoliša vrednovana je analizom ocjena ispitanika koji su za vrijeme laboratorijskih ispitivanja ispunjavali upitnike s razrađenim ljestvicama subjektivnog ocjenjivanja. Istovremeno su praćeni uvjeti okoliša i mjerene vrijednosti fizioloških reakcija tijela (prosječna temperatura kože tijela, vlažnost kože, gubitak mase znojenjem) na zadane uvjete okoliša.*

1. Uvod

Gotovi odjevni predmeti u većoj ili manjoj mjeri pristaju uz ljudsko tijelo, a konstrukcija temeljnog kroja odjevnog predmeta predeterminirana je objektivnim ulaznim parametrima (temeljem glavnih tjelesnih mjera i analiza pokreta). U dizajnu i konstrukciji odjevnog predmeta valja dakle predvidjeti adekvatne iznose konstrukcijskog dodatka komocije. Na temelju proučene literature, postavljeni su ciljevi koji su istraženi u ovom doktorskom radu.

1.1. Cilj istraživanja, metodologija i hipoteze

Cilj rada je utvrditi utjecaj konstrukcijskih parametara (odabranih iznosa konstrukcijskih dodataka komocije muških jakni i duljine jakni) na vrijednosti efektivne toplinske izolacije tih jakni, a zatim i korelaciju fizioloških parametara ispitanika (vrijednost prosječne temperature kože tijela i relativne vlažnosti kože te gubitaka težine ispitanika) i toplinskih svojstava jakni. Istraživanjima u okviru doktorske disertacije se ispitao utjecaj funkcionalnog dizajna s aspekta prilagodbe antropometrijskim karakteristikama tijela i konstrukcije odjevnog predmeta na izolacijska svojstva odjeće i uspostavu termofiziološke ugodnosti.

Hipoteze:

- H1: Da se prilagođavanjem konstrukcijskih parametra u procesu konstruiranja odjevnih predmeta (muških jakni) može utjecati na konačna toplinska svojstva odjevnih predmeta.
  - H1a: Da postoji povezanost između iznosa konstrukcijskog dodatka komocije i izmjerene vrijednosti efektivne toplinske izolacije muške jakne.
  - H1b: Da postoji povezanost između duljine muške jakne i izmjerene vrijednosti efektivne toplinske izolacije muške jakne.
- H2: Da postoji korelacija između vrijednosti efektivne toplinske izolacije odjevnih predmeta i fizioloških varijabli tijela (vrijednost prosječne temperature kože tijela i relativne vlažnosti kože te gubitaka težine ispitanika), kojima se procjenjuje stupanj toplinske ugodnosti.
- H3: Da postoji korelacija između efektivne toplinske izolacije odjevnih sustava i ocjena ispitanika kojima se procjenjuje stupanj toplinske ugodnosti.
- H4: Da kada je ljudsko tijelo u pokretu, zrak spontano prelazi iz jednog u drugi dio mikroklimatskog međuprostora, i stvara se efekt vertikalnog dizanja toplijeg zraka u viša područja mikroklime, tzv. *chimney* efekt ili efekt dimnjaka.

1.2. Znanstveni doprinos

Znanstveni doprinosi ovog doktorsko rada su:

- Utvrđivanje korelacije između iznosa konstrukcijskog dodatka komocije i toplinskih svojstva odjeće.

- Utvrđivanje korelacije između duljine kroja i toplinskih svojstva odjeće.
- Utvrđivanje vertikalnih strujanja zagrijanog zraka u prostoru mikroklime (efekt dimnjaka).
- Utvrđivanje korelacije između vrijednosti efektivne toplinske izolacije muških jakni i fizioloških parametara tijela ispitanika pri laboratorijskim ispitivanjima toplinske ugodnosti.
- Utvrđivanje korelacije između vrijednosti efektivne toplinske izolacije muških jakni i odjevnih sustava s ocjenama ispitanika o zadovoljstvu toplinskim stanjem i odjevnim sustavima.

2. Eksperimentalni dio

Na temelju prikazanih teorijskih osnova je provedeno istraživanje utjecaja odabira konstrukcijskog dodatka komocije i duljine na toplinska svojstva odjeće i fiziološke varijable ispitanika.

2.1. Izbor odjeće za eksperimente i konstrukcija modela muških jakni

Za predviđene eksperimente odabrana su dva modela muških jakni namijenjenih zaštiti u prohladnom okolišu. Prvi je model letačke vjetrovke, koji je izrađen s četiri iznosa konstrukcijskih dodataka komocije. Dodatak komocije iznosio je redom 22, 26, 34 i 38 cm. Drugi je model nautičarske vjetrovke koji je izrađen s bazom na koju se mogu pričvrstiti aplikativni dodaci kako bi se mijenjala duljina kroja. Duljina kroja povećavala se za 20 cm dodavanjem novog modula. Pri ispitivanjima subjektivne percepcije ispitanici su bili odjeveni u odjevne sustave. Sveukupno je ispitano 10 odjevnih sustava koji su nastali kombiniranjem donjih odjevnih predmeta i neke varijante dva predložena modela muške jakne. Konstrukcija odjevnih predmeta izvedena je primjenom CAD sustava Lectra Systemes i programskog paketa Modaris. Termalni maneken u Zavodu za odjevnu tehnologiju je realistični aluminijski odljev muškarca visokog 1,85 m s opsegom grudi 100 cm pa je temeljna konstrukcija muških jakni namijenjenih ispitivanju toplinskih svojstava izvedena u odjevnoj veličini 50 za atletski tip građe muškarca.

2.2. Metode ispitivanja

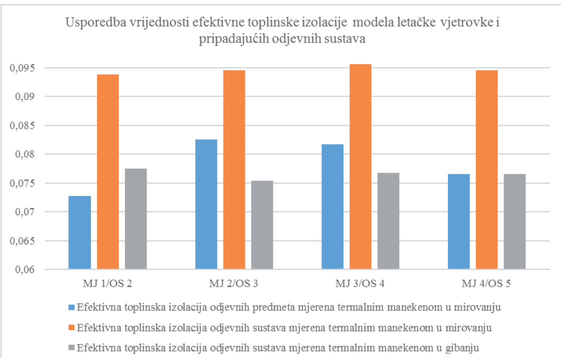
Sve su predložene varijante muških jakni izrađene od istog materijala. Za izradu vanjske školjke odabran je troslojni laminat tt. Čateks d.d. (lice 100 % PES, membrana (politetrafluoretilen) PTFE/(poliuretan) PU, 100 % PES (poliester). 2. sloj je laminirana membrana miješanog sirovinskog sastava PTFE i PU. Popratni odjevni predmeti (traperice, čarape, donje rublje, muška košulja) su izrađeni od 100 % pamuka.
Provedena je analiza strukturnih parametara pri čemu se utvrdio vez i struktura pletiva, tkanina, laminata, debljina materijala, površinska masa, masa, sirovinski sastav te je provedena analiza zrakonepropusnosti. Toplinska svojstva tkanina mjerena su aparaturom KES-F7 Thermo Labo II. Izmjerila se je konstanta toplinske provodnosti, otpor prelasku topline i otpor prelaska vodene pare [1]. Toplinska svojstva jakni ispitivala su se patentiranim mjernim sustavom za određivanje statičkih i dinamičkih toplinskih svojstava kompozita i odjeće, tzv. termalnim manekenom u kontroliranoj klima komori u skladu s međunarodnim standardom ISO 15831:2004 [2]. Parametri okoliša zadani prilikom mjerenja su kontrolirana ***temperatura okoliša***, zadana na vrijednost t_a=20˚C i ***brzina strujanja zraka*** unutar klima komore, zadana na vrijednost v_a=0,4 m/s. Ispitivanja su se provodila u statičkim i dinamičkim uvjetima, dakle s termalnim manekenom u mirovanju i pokretu pri brzini hoda od 90 koraka/min ili 0,95 m/s (3,4 km/h).

Fiziološki parametri ljudskog organizma ispitani u ovome radu su temperatura kože, vlažnost kože i frekvencija srca. Ispitivanje je vršeno pomoću mjernog sustava MSR 12 (Modular signal recorder) [3]. Ispitivanje utjecaja odijevanja u specifične odjevne predmete na zadovoljstvo ispitivanih ljudskih subjekata u zadanim uvjetima okoliša provedeno je na Univerzi v Mariboru Fakulteta za strojništvo, Oddelek za tekstilstvo. Provedena su laboratorijska istraživanja pri čemu su se u klima komori postigli kontrolirani uvjeti okoliša. Parametri okoliša zadani prilikom mjerenja su kontrolirana temperatura okoliša, zadana na jednu od tri vrijednosti temperature (t_{a1}=10˚C, t_{a2}=15˚C, t_{a3}=20˚C, t_{a4}=19˚) koje odgovaraju uvjetima prohladnih i umjerenih okoliša (od -5°C<t_a<20°C) i brzina strujanja zraka unutar klima komore, zadana na jednu od dvije vrijednosti (v_{a1}=1,2 m/s, v_{a2}=0,4 m/s). Za utvrđivanje vertikalnih temperaturnih varijacija u mikroklimatskom pojasu, temperaturni senzori mjernog uređaja pričvrstili su se na 5 mjesta (vertikala u prednjem dijelu tijela, vertikala u stražnjem dijelu tijela). Po završetku ispitivanja, pristupilo se obradi podataka i usporedbi dobivenih vrijednosti temperature, vlage i srčanog ritma s posebnim naglaskom na utvrđivanje vertikalnih promjene temperature zraka u dvije odabrane vertikala unutar mikroklime koja se stvara između slojeva odjeće.

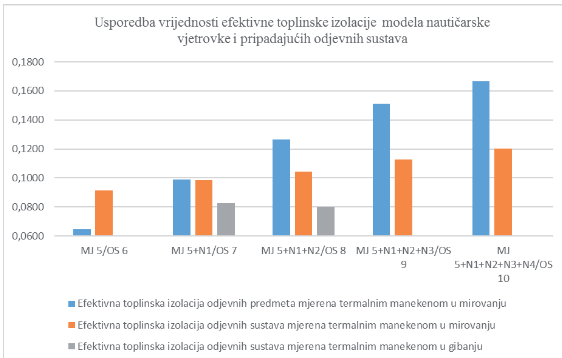
3. Rezultati i rasprava

Vrijednosti efektivne toplinske izolacije očitane pri ispitivanju utjecaja dodatka na komociju pri mjerenjima suhog prolaza topline se nisu značajno razlikovale na četiri različite muške jakne modela letačke vjetrovke. Sa svakim povećanjem dodatka na duljinu nautičarske vjetrovke u iznosu od 20 cm, upravno proporcionalno se povećala i vrijednost efektivne toplinske izolacije. Statističkom analizom t-testom izmjerenih vrijednosti efektivne toplinske izolacije modela letačke vjetrovke s različitim iznosima konstrukcijskog dodatka komocije je dokazano kako postoji statistički značajna razlika kada se iznos konstrukcijskog dodatka komocije povećava za 4, 12 i 16 cm, ali nije uočena statistički značajna razlika pri povećanju iznosa konstrukcijskog dodatka komocije za 8 cm. Time je djelomično dokazana prva podhipoteza da će se dodavanjem veće vrijednosti iznosa konstrukcijskog dodatka komocije povećavati i vrijednost efektivne toplinske izolacije muške jakne. Povećanjem iznosa konstrukcijskog dodatka komocije, vrijednosti efektivne toplinske izolacije će rasti do određene granice nakon koje se uočava pad vrijednosti. Pretpostavka je da pri velikim vrijednostima konstrukcijskog dodatka komocije dolazi do vertikalnog dizanja zraka uslijed slobodne konvekcije unutar mikroklime muške jakne i istjecanja topline kroz vratni izrez.

Pri usporedbi rezultata utvrđen je značajan pad efektivne toplinske izolacije odjevnih predmeta i sustava u dinamičkim uvjetima u odnosu na vrijednosti izmjerene manekenom u mirovanju, slika 1, a i b.



a.



b.

Slika 1: Usporedba vrijednosti efektivne toplinske izolacije između odjevnih predmeta i sustava: a) s modelom letačke vjetrovke, b) s modelom nautičarske vjetrovke

Tendencija negativnog ocjenjivanja vlastitog toplinskog stanja najizraženija je pri trećem obliku uvjeta okoliša u prvoj seriji ispitivanja subjektivne percepcije. Ispitanici su pritom bili podvrgnuti djelovanju najniže okolišne temperature, t_a=10 °C. Statistička obrada ocjena ispitanika provodila se je u skladu s standardom ISO 10551:2001 [4]. Ocjene ispitanika su bile relativno uniformne i prosječna ocjena odgovora na sva pitanja je bila 0 (neutralnost, odnosno potpuna toplinska ugoda). Iznimka su odgovori u drugoj fazi ispitivanja (gibanje), gdje je odjeća generalno ocjenjena kao udobna (1), što možemo pripisati osjećaju neugode uslijed znojenja.

Sveukupno, najniže prosječne ocjene dane su pri nošenju OS 4 i pri procjeni osobnog stanja, odjeće i okoliša.

Vrijednosti lokalne i prosječne temperature kože snižavao se padom temperatura okoliša i s povećanjem vremena izloženosti ispitanika nižim temperaturama, ali se organizam ispitanika pri dužoj izloženosti niskim temperaturama zraka unutar klima komore aklimatizirao. Niže prosječne vrijednosti relativne vlažnosti kože također su očitane su pri t_a=15 ℃ i pri nošenju OS 5 i OS 7. Na temelju razlika u masi odjevnih predmeta prije i nakon ispitivanja utvrdila se količina znoja koja se za vrijeme ispitivanja upije u svaki pojedini odjevni predmet. Zanimljivo se masa muških jakni rijetko mijenjala u svojim vrijednostima prije i nakon ispitivanja, što se može objasniti izradom vanjske školjke jakni od troslojnog laminata sa izrazito dišljivom teflonskom membranom. Pri t_a=19 ℃, uočene su nešto niže vrijednosti razlika u masi uslijed znojenja što možemo pripisati kraćem vremenskom trajanju ovih ispitivanja.

U prvoj fazi ispitivanja vertikalnih strujanja zraka se može uočiti kako dolazi do podudaranja izmjerenih vrijednosti temperatura u prednjoj i u stražnjoj vertikali, odnosno kako su u nekim slučajevima , vrijednosti temperature izmjerene vertikalno višim senzorima manje od vrijednosti na vertikalno nižim pozicijama. Međutim u drugoj fazi ispitivanja, kada su ispitanici u pokretu dolazi do jasnog vertikalnog profiliranja temperaturnih vrijednosti. Topli i zasićeni zrak se diže u više predjele unutar mikroklime pa su senzori na vertikalno višim pozicijama zabilježili više vrijednosti temperatura i u prednjoj i u stražnjoj vertikali.

4. Zaključci

Rezultatima je dokazano je da se prilagođavanjem konstrukcijskih parametra (dodatka komocije i duljine jakne) u procesu konstruiranja odjevnih predmeta može utjecati na konačna toplinska svojstva odjevnih.

Također je dokazano da postoji korelacija između vrijednosti efektivne toplinske izolacije odjevnih predmeta i fizioloških varijabli tijela, kojima se procjenjuje stupanj toplinske ugodnosti i da postoji korelacija između efektivne toplinske izolacije odjevnih sustava i ocjena ispitanika kojima se procjenjuje stupanj toplinske ugodnosti.

Analizom ocjena ispitanika dokazana je treća hipoteza da postoji korelacija između efektivne toplinske izolacije odjevnih sustava i ocjena ispitanika kojima se procjenjuje stupanj toplinske ugodnosti. Ispitanici će biti zadovoljniji toplinskom zaštitom odjevnih sustava i davati pozitivnije ocjene u okolišima s većom temperaturom okolnog zraka. Ukupno najvišom prosječnom ocjenom u prvoj seriji ispitivanja subjektivne percepcije pri tri seta uvjeta okoliša, ocjenjen je odjevni sustav 5, kojemu je središnji odjevni predmet muška jakna modela letačke vjetrovke sa najvećim iznosom konstrukcijskog dodatka komocije od 38 cm.

Potvrđena je pretpostavka da kada je ljudsko tijelo u pokretu, dolazi do vertikalnog gibanja zraka u mikroklimi odjeće i stvara se efekt vertikalnog dizanja toplijeg zraka u viša područja mikroklime, tzv. *chimney* efekt.

Zahvala

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Naslov doktorskog rada	Elektroispredeni nanovlaknasti materijali i filmovi za regulaciju topline	
Mentori	Prof. dr. sc. Budimir Mijović (TTF)	Prof. dr. sc. Tong Lin (Deakin University, Australia)
Datum obrane doktorskog rada	13. studenog 2015.	

PRIMJENA ELEKTROISPREDENIH MATERIJALA U PASIVNOJ POHRANI TOPLINSKE ENERGIJE

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Sažetak: *Elektroispredeni materijali koji se primjenjuju za pasivnu pohranu toplinske energije izrađuju se na bazi materijala sa promjenom stanja (engl. phase change materials - PCMs). U ovom radu dan je kratki osvrt na istraživanje vezano uz razvoj ovakvih materijala na bazi biljnih ulja i polikaprolaktona.*

1. Uvod

Elektroispredeni materijali imaju veliku primjenu u pohrani energije, tj. koriste se za izradu litij-ionskih baterija, gorivih ćelija, solarnih ćelija, superkondenzatora i piezoelektričnih sustava, te u nešto manjoj mjeri i za izradu sustava za pasivnu pohranu toplinske energije na temelju kapsulacije komponenata s promjenom stanja [1]. Materijali s promjenom stanja (*engl. phase change materials - PCMs*) imaju sposobnost absorcije, pohrane i oslobađanja topline na određenoj temperaturi [2]. Osnovni zahtjevi koje trebaju zadovoljiti su: odgovarajuća temperatura taljenja, velika entalpija, malo pothlađenje, toplinska vodljivost, pouzdanost i adekvatna kapsulacija [3]. Kapsulacija PCM-a je izuzetno važna za održavanje strukture poglavito kod prijelaza PCM-a iz krutine u kapljevinu, odnosno na temperaturi taljenja. Osim konvencionalnog načina kapsulacije PCM-a (makro, mikro i nano) u zadnje vrijeme elektroispredanje se također koristi za kapsulaciju materijala s promjenom stanja. Proces uključuje izradu elektroispredenih nanovlakana s dvije konfiguracije: ko-aksijalna vlakna, gdje je PCM smješten u jezgri vlakna i vlakna pripremljena iz mješavine, gdje je PCM jednolično dispergiran unutar matrice [4]. Neka od istraživanja provedena do sada uključuju kapsulaciju masnih kiselina, npr. laurinsku kiselinu (LK), a kao matrica korišten je polietilen tereftalat (PET). Maseni udio PCM-a u PET-u bio je od 50-150 %. Iako se najveća entalpija postiže kod najvećeg udjela PCM-a, autori predlažu da je LK/PET 70/100 optimalna kombinacija u odnosu na homogenost strukture, te izostanak agregacije PCM-a, tj. maseni udio ispod omjera od 100/100. Također je utvrđena eksperimentalna entalpija za PET/LK 100/70 nešto više od 50 J/g [5]. Neka istraživanja prikazuju kapsulaciju PCM-a u poliamid 6 (PA 6) elektroispredena vlakna naknadnom adsorpcijom, a u tu svrhu korištena je eutektička mješavina kapronske kiseline (KK) s laurinskom, palmitinskom (PK) i stearinskom kiselinom (SK), kao PCM. Izračunate adsorpcijske moći elektroispredenog PA6 za KK–LK, KK–PK, KK–SK i KK iznosila su: 72.7 %, 81.9 %, 78.0 % odnosno 75.4 % [6]. Međutim ovaj postupak kapsulacije PCM-a u matricu ima i nedostatak, a to je deformacija porozne strukture elektroispredenog materijala zbog difuzije PCM-a u inter pore vlakana. Neke od postignutih entalpija kod dosadašnjih istraživanja dane su u tablici 1.

Tablica 1: Entalpije kompozitnih elektroispredenih vlakana iz dosadašnjih istraživanja

Materijali	PCM % maseni udio	PCM Hm/Hc (J/g)	Kompozit - Hm/Hc (J/g)	Ref.
LK/PA6	100/100	173.25/172.19	70.44/57.14	[7]
SK/PET	70/100	222.8/226.7 [8]	67.88/61.62	[5]
KK-SK/PET	200/100	156.8/147.1	95.24/93.67	[9]
Soja/PU	50	69.97/-	36.47/-	[10]
Dodekan/zein	14	196.88/196.88	27.552	[11]
PEG/CA	50	177.38/167.75	85.91/65.15	[12]
PEG/PA6	130/100	160.93/188.98	85.95/85.42	[13]

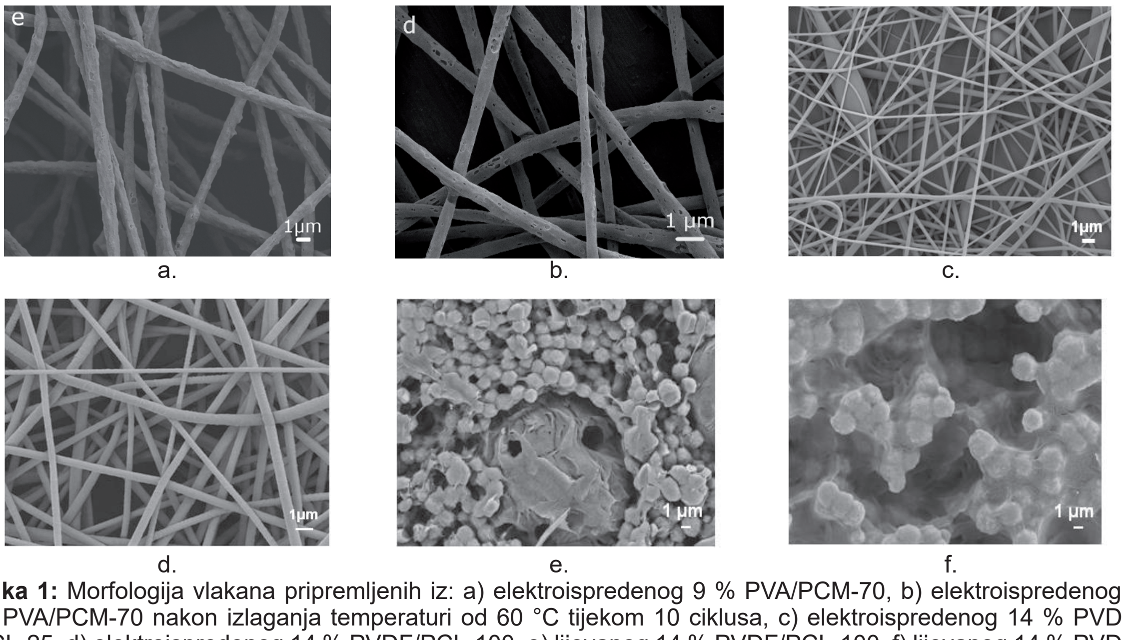
Dosadašnja istraživanja opisuju da se tehnikom elektroispredanja mogu proizvesti vlakna stabilne strukture dodatkom PCM-a, međutim samo nekoliko od njih ispituju stabilnost strukture pri temperaturi taljenja PCM-a. U ovom doktorskom radu sustavno je ispitano ponašanje materijala pri visokim temperaturama, tj. u stanju kapljevine PCM-a. U ovom radu dan je kratki osvrt na publicirana istraživanja iz doktorskog rada koja se bave problematikom razvoja elektroispredenih materijala za pasivnu pohranu toplinske energije.

2. Eksperimentalni dio

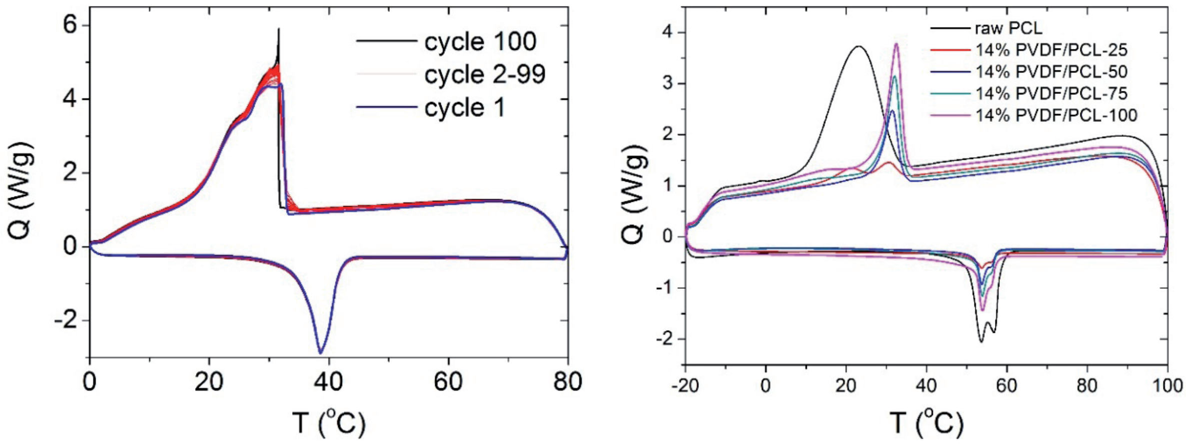
Materijali korišteni u doktorskom radu su polimeri: polivinil alkohol (PVA) i poliviniliden fluorid (PVDF), a kao materijali sa promjenom stanja ili PCM korištene su mješavine biljnih ulja te polikaprolakton (PCL). Elektroispredeni materijali u sastavu PVA/biljno ulje i PVDF/PCL pripremljeni su elektroispredanjem iz emulzije i elektroispredanjem iz mješavine, variranjem količine PCM u polimernoj matrici. Koncentracije polimernih materica bile su: 7 % i 9 % za PVA i 14 % za PVDF. Koncentracije (maseni udjeli) PCM-a u PVA-u i PVDF-u varirale su od 10 do 100 %. Pojedini materijali označeni su ovisno o koncentraciji PCM-a, npr. 9 % PVA/PCM-25 u slučaju kada je maseni udio komponenata 100/25. Za usporedbu sposobnosti pohrane toplinske energije PVDF/PCL sustava pripremljeni su i filmovi istog sastava postupkom lijevanja. Pripremljenim elektroispredenim materijalima određena su morfološka svojstva, distribucija PCM-a unutar polimernih vlakana, sposobnost pohrane toplinske energije i pouzdanost te funkcije, utjecaj PCM-a na promjene u kristalnoj strukturi matrice, gubitak mase i mehaničko ponašanje u funkciji temperature. Ponašanje materijala također je ispitano i nakon izlaganja istih višim temperaturama od temperature taljenja PCM-a u rasponu od 60 do 80 °C [14].

3. Rezultati i rasprava

U ovom radu dan je dio rezultata vezan uz morfologiju PVA/biljna ulja i PVDF/PCL sustava, te sposobnost i pouzdanost pohrane toplinske energije, kao i usporedba funkcije PVDF/PCL materijala s filmovima istog sastava. Slike 1 a i b su SEM slike 9 % PVA/PCM-70 prije i nakon toplinske obrade. Povećanjem količine PCM-a dolazi do postupnog povećanja promjera vlakana, te vlakna postaju grublja s povećanim brojem površinskih pora, te nepravilnim kružnim poprečnim presjekom. Najveća koncentracija PCM-a rezultira formiranjem nakupina i smanjenjem efikasnosti kapsulacije [4]. Slika 1 c i d prikazuje morfologiju PVDF/PCL sustava s najmanjom i najvećom koncentracijom PCM-a. Dodatak PCL-a, kao materijala s promjenom stanja, rezultira s istezanjem deformacija po duljini vlakna, a kod najveće koncentracije deformacije u potpunosti nestaju. Slika 1 e i f prikazuje strukturu lijevanog filma 14 % PVDF/PCL-100 prije i nakon temperaturne obrade. Porozna struktura filma se povećava nakon toplinske obrade što sugerira da dolazi do razdvajanja polimernih komponenata, za razliku od elektroispredenih vlakana koja pokazuju veću homogenost i stabilnu strukturu [15].



Slika 1: Morfologija vlakana pripremljenih iz: a) elektroispredenog 9 % PVA/PCM-70, b) elektroispredenog 9 % PVA/PCM-70 nakon izlaganja temperaturi od 60 °C tijekom 10 ciklusa, c) elektroispredenog 14 % PVDF/PCL-25, d) elektroispredenog 14 % PVDF/PCL-100, e) lijevanog 14 % PVDF/PCL-100, f) lijevanog 14 % PVDF/PCL-100 nakon izlaganja temperaturi od 65 °C u vremenu od 24 sata [4,14,15].



a. b.

Slika 2: DSC krivulje elektroispredenih: a) 7 % PVA/PCM-70 nakon 100 ciklusa hlađenja i grijanja i b) 14 % PVDF/PCL s različitom koncentracijom PCL-a [4,15].

Elektroispredeni materijali su pokazali pouzdanost u pohrani toplinske energije i nakon 100 ciklusa grijanja i hlađenja, slika 2a [4]. Dodatak PCL-a u PVDF rezultira sa smanjenjem odnosno nestajanjem endotermnog i egzotermnog dvostrukog pika, što ukazuje na to da PVDF matrica omogućuje bržu aktivaciju PCL-a odnosno pohranu toplinske energije, slika 2b [15]. U tablici 1 dane su karakteristične prijelazne temperature (T_{om} (početna), T_m, T_{oc} (početna), T_c) i entalpije taljenja ($H_{m,\ m1}$ – ciklus 1, $_{m10}$ – ciklus 10) i kristalizacije ($H_{c\ c1}$ – ciklus 1, $_{c10}$ – ciklus 10) nekih od elektroispredenih materijala na bazi biljnih ulja i PCL-a. Generalno, entalpije pri taljenju i kristalizaciji povećale su se s povećanjem količine PCM-a, te su dostigle maksimalnu vrijednost od ~85 J/g kod 9 % PVA/PCM-70. Također stupanj pothlađenja se smanjio povećanjem količine PCM-a, što je i zbog povećanja veličine PCM-a po duljini vlakna [4]. Povećanjem PCL-a unutar PVDF matrice rezultiralo je i povećanjem razlike u početnoj temperaturi taljenja i kristalizacije u odnosu na čisti PCL. Manja razlika između temperature taljenja i kristalizacije ukazuje na smanjenje stupnja pothlađenja, tj. na poboljšanje sposobnosti bržeg otpuštanja toplinske energije u slučaju elektroispredenog PVDF/PCL sustava. Najveća entalpija od 34.10 J/g postignuta je kod 14 % PVDF/PCL-100 što odgovara kapsulaciji od 50 %. U odnosu na lijevane filmove elektroispredena vlakna pokazuju bolju sposobnost pohrane toplinske energije zbog smanjenja stupnja pothlađenja za 8 °C i veće entalpije kod zagrijavanja i hlađenja [15].

Tablica 1: Temperature i entalpije taljenja i kristalizacije elektroispredenih PVA/PCM I PVDF/PCL sustava [4,15].

	PCM (biljna ulja)	**9 % PVA/ PCM-10**	**9 % PVA/ PCM-70**	**PCL**	**14 % PVDF/ PCL-25**	**14 % PVDF/ PCL-100**	**14 % PVDF/ PCL-100 (film)**
T_{om} (°C)	36.65	34.81	35.29	50.48	51.21	52.09	53.67
T_{m1} (°C)	40.34	37.21	38.46	53.63	53.72	53.92	55.96
T_{m2} (°C)	-	-	-	56.88	-	-	-
T_{oc} (°C)	33.08	33.30	32.83	32.27	34.23	34.90	30.78
T_{c1} (°C)	30.05	32.50	32.21	22.91	30.51	32.52	27.52
T_{c2} (°C)	-	29.68	26.51	-	21.22	-	-
T_{c3} (°C)	-	26.89	-	-	-	-	-
T_{c4} (°C)	-	22.81	-	-	-	-	-
H_{m1} (J/g)	221.2	17.96	84.72	73.02	9.31	33.90	19.46
H_{m10} (J/g)	221.5	17.81	84.41	70.94	9.33	34.10	-
H_{c1} (J/g)	221.8	18.18	83.83	71.32	8.68	33.08	22.11
H_{c10} (J/g)	221.5	18.77	84.58	70.43	7.96	32.16	-

4. Zaključak

Elektroispredeni PVA/biljno ulje i PVDF/PCL materijali pokazali su stabilnu strukturu i nakon izlaganja višim temperaturama, tj. u stanju kapljevine PCM-a, što nije bilo u slučaju lijevanih PVDF-PCL filmova. Također, materijali su pokazali pouzdanost u pohrani toplinske energije, te sposobnost brže aktivacije PCL-a odnosno pohranu ili otpuštanje toplinske energije, potvrđeno sa smanjenjem stupnja pothlađenja u odnosu na čisti PCL. Razvijeni elektrosipredeni sustavi na bazi materijala s promjenom stanja mogu se koristiti kod izrade uređaja za pasivnu pohranu toplinske energije ili materijala sa sposobnošću regulacije temperature.

Zahvala

Zahvala prof. dr. sc. Tong Lin i prof. dr. sc. Xungai Wang na suradnji i mogućnosti provođenja istraživanja iz doktorskog rada na Deakin University, Institute for Frontier Materials, Geelong, Australia u grupi za nanovlakna, u Laboratoriju za elektroispredanje.

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Martina Bobovčan Marcelić

Životopis	Martina Bobovčan Marcelić, dipl. inž. rođena je 22. 6. 1979 u Koprivnici. U veljači 2008. godine diplomirala je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Od 2006. godine zaposlena u tvrtci Galko d.o.o., a od 2011. godine zaposlena na radnom mjestu asistenta na Tekstilno-tehnološkom fakultetu u Zavodu za odjevnu tehnologiju. Doktorski rad izrađuje pod mentorstvom prof. dr. sc. Dubravka Rogela, u području spajanja polimernih materijala, procesnih parametara visokotehnoloških metoda spajanja i svojstava spojeva na zaštitnoj i inteligentnoj odjeći. Istraživački i znanstveni rad usmjeren je na tehničku znanost i odjevnu tehnologiju u području spajanja dijelove zaštitne i inteligentne odjeće. Njezina istraživačka djelatnost je usmjerena na istraživanje primjene različitih procesnih parametara za vrijeme spajanja polimernih materijala visokotehnološkim metodama na kvalitetu spoja.
Naslov teme 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	3. veljače 2014.

ODREĐIVANJE OPTIMALNIH PARAMETARA SPAJANJA DIJELOVA INTELIGENTNOG ODJEVNOG PREDMETA VISOKOFREKVENTNOM METODOM SPAJANJA

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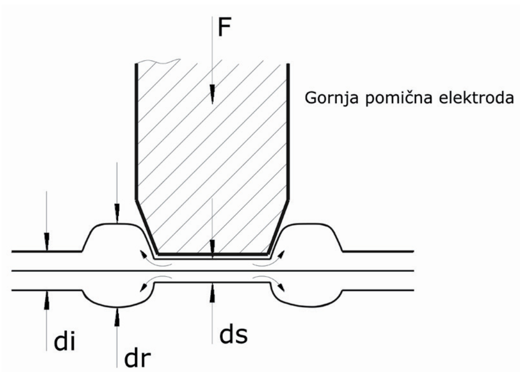
Sažetak: *Neke vrste spajanja elemenata inteligentne odjeće se mogu izvoditi konvencionalnim metodama spajanja šivanjem, ali se nužno moraju koristiti i visokotehnološke metode spajanja materijala i elemenata budući da konvencionalne metode ne mogu polučiti zadovoljavajuće tehničke i tehnološke uvjete. U ovom radu biti će opisan način spajanja zrakonepropusnih spojeva segmentiranih termoizolacijskih komora visokofrekventnom tehnikom (VF), kao i pojava neželjenog istiskivanja rubova spoja te način utvrđivanja optimalnih parametara VF spajanja uz minimalni efekt istiskivanja rubova.*

1. Uvod

Strojevi za visokofrekventno spajanje su prilagođeni specifičnoj tehnici koja se koristi za spajanje polimernih materijala. Materijal za spajanje postavlja se između elektroda priključenih na visokofrekventni (VF) generator. Djelovanjem VF generatora javlja se toplina u spajanom materijalu između dviju elektroda, a potom se djelovanjem sile F materijali spajaju [1,2].

2. Eksperimentalni dio

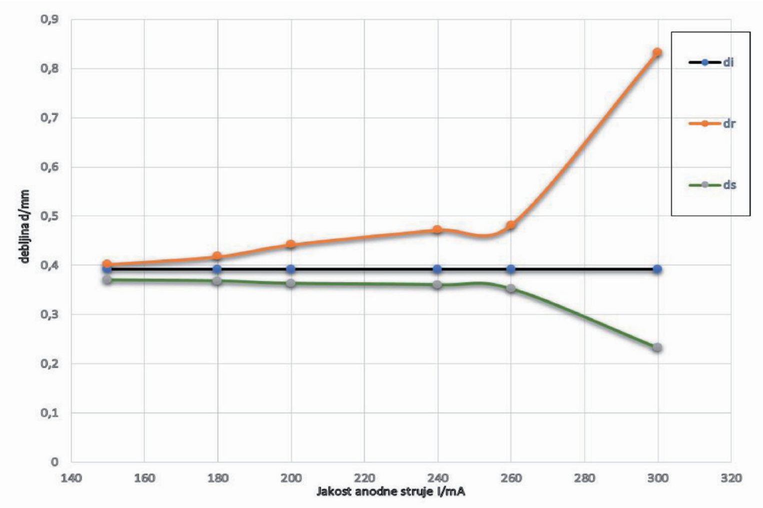
Za izradu termoizolacijskih komora inteligentnog odjevnog predmeta s adaptivnim mikroklimatskim stanjima korištena visokoelastična poliuretanska folija tt.Bayer Epurex Films GmbH. U Laboratoriju za procesne parametre na Zavodu za odjevnu tehnologiju Tekstilno-tehnološkog fakulteta izvedeno je spajanje segmenata spomenutih termoizolacijskih rebrastih komora visokofrekventnom metodom. Za spajanje segmenata korišten je visokofrekventni oscilator koji oscilira na frekvenciji od 27,12 MHz i ima pojačalo snage od 1 kW, kao i specijalno izrađena visokofrekventna elektroda oblikovane prema obliku spoja. Vrijeme spajanja je iznosilo 7 s, a mijenjala se anodna struja I od 150 mA, 180 mA, 200 mA, 240 mA, 260 mA, 300 mA uz konstantni anodni napon od 2700 V. Za mjerenje debljine spoja d_s debljine istisnutih rubova d_r i debljine izratka d_i, (sl. 1), korišteni su mikrometar tt. Insize i digitalni mikrometar tt. Toolcraft.



Slika 1: Shematski prikaz istiskivanja rubova pri spajanju

3. Rezultati

U provedenom eksperimentu mijenjana je anodna struja pri VF spajanju, a konstantnim je držana sila pritiska F na izradak, anodni napon pojačala te vrijeme spajanja. Pri tim uvjetima mjerila se debljina spoja d_s i debljina istisnutih rubova d_r. Pri tome su dobiveni slijedeći rezultati promjena debljina spoja i debljina istisnutih rubova te su prikazani u dijagramu na sl. 2. Vidljivo je da je debljina spoja razmjerno jednaka do vrijednosti anodne struje do 240 mA, a tada počinje poprimati niže vrijednosti. Istodobno se povećanjem anodne struje povećava i debljina istisnutog ruba što predstavlja negativan efekt pri VF spajanju. Debljina istisnutog ruba ostaje razmjerno mala pri vrijednosti anodnih struja od 150 do 240 mA. Porastom struje od 240 mA do 300 mA debljina istisnutog ruba naglo raste. Smanjenjem debljine spoja odražava se kao smanjenje čvrstoće spoja što je tehnološki neprihvatljivo. Iz utvrđenih rezultata može se zaključiti da se ovakvim ispitivanjima mogu utvrditi optimalni parametri VF spajanja i da oni u ovom slučaju kreću od donje granice optimuma od 180 mA pri čemu je izmjerena snaga iznosila oko 450 W do gornje granice optimuma od 240 mA i snage spajanja od aproksimativno 650 W.



Slika 2: Ovisnost d_i, d_s i d_r o anodnoj struji

4. Zaključak

Visokofrekventna tehnika spajanja ima vrlo dobre mogućnosti primjene pri izradi termoizolacijskih komora inteligentne odjeće. Pri tome valja odrediti donju i gornju granicu optimalnog spajanja. Ispod donje granice optimalnog spajanja ne pojavljuje se negativan efekt istisnutih rubova ali je snaga spajanja pre male da bi se postignula dovoljna čvrstoća spoja.

Iznad gornje granice optimalnih parametara spajanja dovedeno je previše energije pri čemu se javlja jako izražen efekt istisnutih rubova i smanjenje vrijednosti debljine spoja što se također manifestira kao pad čvrstoće spoja. Također se može zaključiti da se tehnološki proces VF spajanja treba izvoditi u blizini donje granice optimuma jer je potrošnja energije u tom području najmanja, anodna struja je najniža moguća čime se izravno utječe na resurse rada visokofrekventnog pojačala.

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Snježana Brnada

Životopis	Snježana Brnada rođena je 22. studenog 1977. godine u Zagrebu gdje je završila osnovnu školu i gimnaziju nakon koje upisuje Sveučilišta u Zagrebu Tekstilno-tehnološki fakultet na kojem je diplomirala. Po završetku studija zaposlila se u tvrtki Varteks, čiji je bila stipendist. Nakon pripravničkog staža, dobiva stalno radno mjesto u odjelu Osiguranja kvalitete kao Tehnolog kvalitete gdje su joj glavne dužnosti bile rješavanje tehnoloških problema. Nakon toga, dolazi na radno mjesto Inženjer razvoja tehnologije u odjelu Razvoja gdje su joj glavne dužnosti bile optimiranje procesa, povećanje efikasnosti proizvodnje, osiguravanje kvalitete i dr. Od 1. lipnja 2009. zapošljava se na Tekstilno-tehnološkom fakultetu na Zavodu za projektiranje i menadžment tekstila na radno mjesto znanstvenog novaka gdje su joj glavne dužnosti održavanje vježbi iz područja tkanja, rad na projektima te znanstveno istraživački rad.
Naslov teme doktorskog rada	Deformacije tkanina uvjetovane anizotropnošću
Mentor	Prof. dr. sc. Stana Kovačević
Datum obrane teme doktorskog rada	27. veljače 2014.

DEFORMACIJE TKANINA UVJETOVANE ANIZOTROPNOŠĆU

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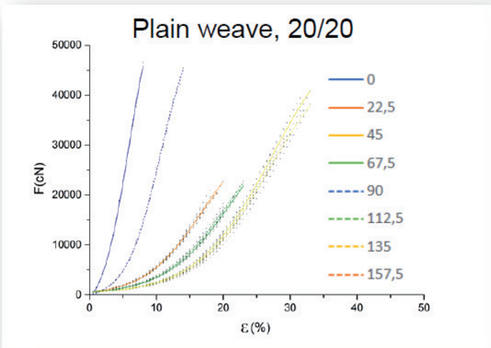
1. Uvod

Tkanine svojim mehaničkim svojstvima moraju održati (kao samostalne jedinice) ili osigurati (kao ojačivaći unutar kompozita) određenu stabilnost u uvjetima visokih naprezanja [1,2]. U tom smislu, kontrolirane karakteristike deformabilnosti mogu se postići projektiranjem tkanina određenih konstrukcijskih karakteristika kao što su vez, gustoća niti, sirovinski sastav, konstrukcijske karakteristike osnove i potke, površinske mase i dr. [3,4]. Primjena tkanina je vrlo široka, te uključuje sljedeća područja: odjevna industrija, građevina, autoindustrija, brodogradnja, filtracija, interijeri, zaštitna radna odjeća, balistička, vojna odjeća i oprema itd.

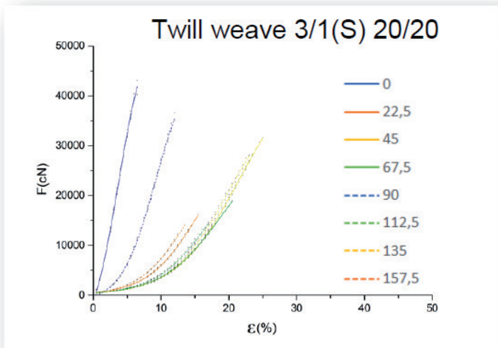
2. Eksperimentalni dio

Istražena su anizotropna svojstva tkanina pri čemu je utvrđena neortotropna karakteristika dijagonalno strukturiranih tkanina. Utvrđen je utjecaj napetosti i utkanja osnove i potke na deformacijska svojstva tkanine. Izrađen je mehanički model za opis vlačnog testa s bočnom restrikcijom te utvrđen Poissonov omjer, Youngov modul elastičnosti i smični modul po čitavom rasponu krivulje naprezanja.

3. Rezultati i rasprava



a.



b.

Slika 1: Aproksimacijske krivulje za uzorke tkanine: a) u platno vezu b) u keper 3/1S vezu

Iz linijskog grafa naprezanja (slika 1a) te rezultata K-S testa razvidna je izrazita ortotropnost tkanine u platno vezu, $g_o=g_p=20$ niti/cm. Razlika između maksimalnih sila po osnovi i po potci je relativno mala te iznosi svega 1325 cN (46675 cN u smjeru osnove i 45350 cN u smjer potke). Sve aproksimacijske linije imaju podudarnost s podacima veću od 99,5 % što je razvidno iz prilagođenog R^2 parametra. Također, male su razlike između maksimalnih sila pri istezanju uzoraka tkanina u zrcalnim pravcima. Očekivano, istezanje u smjeru potke je veće pri čemu na početku istezanja tkanina pruža najmanji otpor (male sile). Može se zaključiti da je uzrok manjeg otpora tkanine u smjeru potke na početku istezanja, veće utkanje niti po potci te niža napetost sustava potke u samom procesu tkanja (u odnosu na osnovu) što rezultira i nižom inicijalnom napetošću u tkanini. Kao rezultat većeg utkanja po potci, manji prirast sile pri vlačnom istezanju imaju uzorci tkanine čiji je kut zakreta bliži smjeru potke. Tako da je maksimalno istezanje pod kutovima 67,5° i 112,5° za 18 % veće nego što je to slučaj kod uzoraka ispitanih pod kutovima 22,5° i 157,5°, dok je razlika maksimalnih sila vrlo mala i iznosi oko 3 %. Pod kutom od 45° i 135°, maksimalno istezanje je najviše u odnosu na ostale kutove (33,5 %) dok je maksimalna sila prosječno 15 % niža od maksimalne sile u glavnim osima te prosječno 83 % viša nego pod kutovima od 22,5°, 67,5°, 112,5° i 157,5°.

Keper vez 1/3, je s jasnim strukturnim dijagonalama koje bi se mogle poistovjetiti s homogeniziranim modelom kompozita s nejednako širokim dijagonalnim trakama nejednakih svojstava. Kod tkanina u keper vezu s jednakim brojem niti po osnovi i po potci, kut koji dijagonala zatvara sa smjerom osnove jednak je 45°. Iz grafa s aproksimiranim krivuljama rastezanja (sl. 1b), vidljiva je bliskost linija pod kutovima od 45° i 135°, međutim aproksimirane zrcalno simetrične krivulje naprezanja u smjerovima odmaknutim od glavnih pravaca simetrije, nisu u bliskom odnosu što je i vidljivo iz K-S testa. Kod uzoraka pod kutovima 22,5° i 157,5° i kod onih pod kutovima 67,5° i 112,5° pri porastu naprezanja raste i razlika između njih, s tim da se u oba slučaja manja istezljivost i niže vrijednosti maksimalnih sila pojavljuju u donjem, desnom kvadrantu (smjer pružanja strukturne dijagonale) te se može zaključiti kako će tkanina u smjerovima bliskim smjeru pružanja dijagonale biti manje istezljiva i nižih vrijednosti sila.

4. Zaključci

- Uzorci tkanina simetričnih vezova izrazito su ortotropni.
- Dijagonalno strukturirani uzorci odstupaju od ortotropnog ponašanja kod barem jednog para identifikatora.
- Uzorci gustoće 24/24 (niti/cm) pokazuju ortotropnija svojstva od istih gustoće 20/20 (niti/cm).
- Uzorak u platno vezu gustoće 24/24 (niti/cm) s podjednakim vrijednostima utkanja osnove i potke ima dodatne dvije osi zrcalne simetrije – 45° i 135°.
- Veća gustoća osnove (napetijeg sustava) u odnosu na potku osigurat će manje odstupanje od ortotropnog ponašanja.

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Naslov teme doktorskog rada	Modifikacija tekstila pčelinjim proizvodima za apiterapiju i mogućnosti objektivne karakterizacije
Studijski savjetnik	Doc. dr. sc. Maja Somogyi Škoc
Datum obrane teme doktorskog rada	

MODIFIKACIJA TEKSTILA PČELINJIM PROIZVODIMA ZA APITERAPIJU

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1. Uvod

U ovom trenutku u Republici Hrvatskoj apiterapija ja alternativni način liječenja uporabom pčelinjih proizvoda. Sama riječ apiterapija dolazi od latinskih riječi: *apis*, što znači pčela i *therapia*, što znači liječenje [1]. Pod pojmom pčelinji proizvodi misli se na hranu, dodatke prehrani i prirodne lijekove, pomoću kojih možemo čuvati i jačati naše zdravlje i imunitet te preventivno utjecati na pojedina oboljenja. U literaturi se mogu naći slijedeći pojmovi apifarmakologija i apipreventiva obzirom na primjenu pčelinjih proizvoda [1].
Mnogi su autori kroz povijest, spominjali pčele, med, tj. pčelinje proizvode tako da su o uzgoju pčela pisali Aristofan, Varon i Heziod još prije nove ere [2]. Hipokrat, otac medicine, pisao je o pčelinjim proizvodima kao o vrlo tajanstvenim produktima, dok ga je otac eksperimentalne fiziologije Galen spominjao u svojim zapisima apiterapije. Car Karlo Veliki pisao je o svome liječenju pčelinjim ubodima, a u Kur'anu postoji zapis o korištenju apitoksina kao lijeka [2].

Upotrebom pčelinjih proizvoda to jest njihovim biološkim, kemijskim i fizikalnim djelovanjem može se doprinijeti izliječenu. Drugom polovicom dvadesetog i početkom dvadeset prvog stoljeća došlo je do velikog napretka i razvoja u farmaciji i medicini, a što je dovelo do velikog broja novih pripravaka i medicinskih preparata na bazi pčelinjih proizvoda. Pčelinji proizvodi po mnogim istraživanjima pozitivno utječu na tijek izlječenja. Primjena pčelinjih proizvoda u medicinskom tekstilu postoji, npr. kestenov med se koristi za obloge kroničnih rana kod dijabetičkog stopala (sl. 1) [3].

Slika 1: Liječenje medicinskom oblogom na bazi kestenovog meda do zadnjeg ulkusa [4]

Osim meda, pčele daju mnoge druge proizvode ali oni nisu samo njihov rezultat rada već i rad marljivih pčelara. Svaki proizvod, bio on rezultat rada same pčele ili pčelara, ima svoje prednosti kod ciljane primjene, za poboljšanje zdravstvenog stanja čovjeka, gdje tekstil može biti njegov izvanredan „nosioc".
Med, matična mliječ, propolis, pčelinji otrov, pčelinji vosak i drugi proizvodi mogu naći ciljanu primjenu za medicinske tekstilije bilo kao novi biološki materijali u smjeru biomimetike ili kroz do sada uhodane sol-gel obrade sa prirodnim aktivnim tvarima [5].

Obzirom da je riječ o pčelinjim proizvodima s ciljem primjene za medicinski tekstilni proizvod koji će se nanositi na otvorenu ranu poštivati će se pravila apiterapije kao metode liječenja ali i poboljšanja zdravlja pčelinjim proizvodima.

U ovom doktorskom radu kombinirati će se pčelinji proizvodi i to pojedinačno ili u raznim međusobnim kombinacijama, ali i s ekstraktima ljekovitog bilja s ciljem sinergističkog djelovanja. Odabrane su celulozne tkanine i pletiva gdje će se kroz ekološki prihvatljiv postupak nanositi i koristiti kemikalije u skladu sa europskim i svjetskim zahtjevima (*European Medicine Agency* (EMA), *Food and Drug Administration* (FDA ili USFDA)).

2. Eksperimentalni dio

U planiranju i izvođenju istraživanja koristiti će se opća znanja iz područja metodologije znanstvenog rada – priprema istraživanih materijala, provedba istraživanja i obrada dobivenih rezultata s ciljem ostvarivanja i potvrđivanja hipoteze. Upotrijebiti će se metode i postupci koji omogućuju ponovljivost obrada i morfoloških značajki istraživanih materijala uz primjenu suvremenih, pouzdanih standardiziranih mjernih tehnika (FTIR-ATR, SEM-EDS, AFM, DSC/TGA, mikrobiološka ispitivanja i dr.) s ciljem vrednovanja djelotvornosti učinaka. U obradi, analizi i vrednovanju dobivenih rezultata primijeniti će se odgovarajuće matematičko-statističke metode koje osiguravaju određeni stupanj pouzdanosti u donošenju zaključaka.
Istraživanje će obuhvaćati slijedeće cjeline:

1. Odabir pčelinjih proizvoda i tekstilnih materijala (medicinski program)
2. Odabir kemikalija u skladu s EMA i FDA
3. Razvoj vlastitih receptura i izračun potrebnih količina kemikalija s ciljem odabira najbolje recepture
4. Razvoj metode i postupka nanošenja, po potrebi razvoj odgovarajuće opreme
5. Konzultacije i suradnja s drugim institucijama o predmetu znanstvenog istraživanja (*Farmaceutsko-biokemijski fakultet*, *Fakultet kemijskog inženjerstva i tehnologije*, *Zavod za javno zdravstvo Dr. Andrija Štampar* i dr.)
6. Obrade i vrednovanje djelotvornosti postignutih zaštitnih učinaka
7. Primjenjivost obrađenih tekstilnih materijala i mogućnost komercijalne proizvodnje

3. Zaključak

Znanstveni doprinos ove doktorske disertacije moći će se sagledati u teorijskom i aplikativnom smislu. U teorijskom smislu detaljno će se istražiti način vezanja pčelinjeg proizvoda na celulozni supstrat u skladu s ekološkim kriterijima ali i rigoroznim zahtjevima FDA i EMA, a u aplikativnom smislu izraditi će se gotov proizvod za liječenje kroničnih rana apiterapijom.

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Katia Grgić

Životopis

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Naslov teme doktorskog rada

Studijski savjetnik: Doc. dr. sc. Anita Tarbuk

Datum obrane teme doktorskog rada

ADSORPCIJA KATIONSKIH TENZIDA NA PAMUČNE I POLIESTERSKE TKANINE

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1. Uvod

Kationski tenzidi se pojavljuju na tržištu 1933. godine kao umreživači kod direktnih i kiselih bojila na celulozna vlakna. Od 1940. godine upotrebljavaju se kao sredstva za omekšavanje u komercijalnim praonicama, a 1955. pojavljuje se prvi tekući omekšivač za domaćinstvo u Sjedinjenim Američkim državama. 1963. prvi put primijenjen u Europi. Njihovom uporabom poboljšao se opip tekstilnog materijala, smanjio statički elektricitet i miris tekstilnog proizvoda [1]. U današnje vrijeme kationski tenzidi imaju široku primjenu u tehnološkim procesima, a trenutno dobivaju na važnosti zbog njihove funkcionalnosti i zaštite okoliša. U ovom radu se istražuje njihova adsorpcija na standardnim tkaninama različitog sirovinskog sastava i desorpcija pomoću elektrokinetičkih pojava.

2. Eksperimentalni dio

Za istraživanje su korištene standardne tkanine (WFK) površinske mase 170 g/m^2; gustoće osnovinih i potkinih niti 27/27 cm^{-1} u platno vezu iz pređe finoće 295 dtex, različitog sirovinskog sastava: pamuk, poliester i mješavina pamuk/poliester. Oznake i opisi su u tab.1. Elektrokinetičke pojave standardnih tkanina određene su metodom potencijala strujanja na elektrokinetičkom analizatoru, SurPASS (A. Paar). Zeta potencijal (ζ) izmjeren je u ovisnosti o pH otopine elektolita 1 mmol/l KCl i o dodatku kationskog tenzida 1 mmol/l N-CPC (N-cetilpiridinijev klorid) u otopinu elektrolita na podesivoj ćeliji (AGC; *Adjustable Gap Cell*). Određena je izoelektrična točka, (IEP; *Isoelectric point*) i točka nultog naboja (PZC; *Point of Zero Charge*). Adsorpcija i kationskog tenzida 1 mmol/l l N-CPC na 0,072 g standardne tkanine kao i desorpcija N-CPC s tkanina praćena je na SurPASS-u pri pH 6 na 22 °C. Sposobnost zadržavanja vode (WRV; *Water Retention* *Value*) određena je prema DIN 53814.

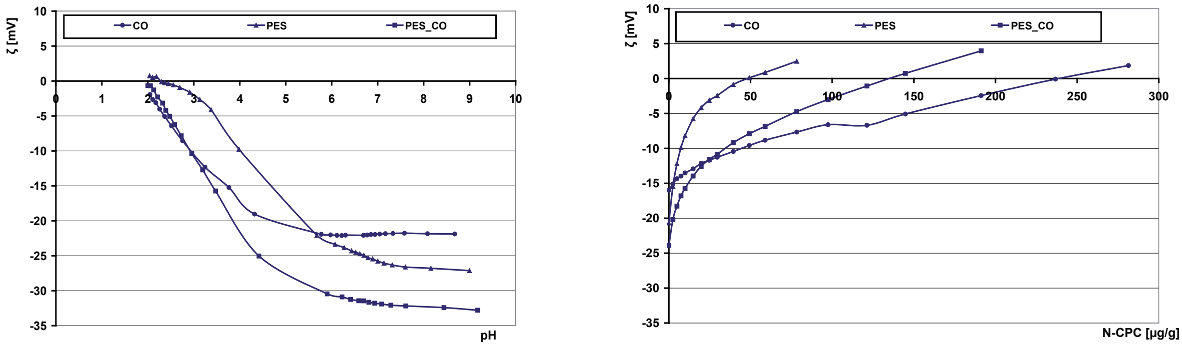
3. Rezultati i rasprava

Karakterizacija ispitivanih materijala načinjena na temelju elektrokinetičkog ponašanja i sorpcijskih svojstava te prikazana pomoću zeta potencijala i sorpcije vode, (tab. 1 i sl. 1).

Tablica 1: Rezultati zeta potencijala (ζ) pri pH 9 i pH 6, izoelektrična točka (IEP), točka nultog naboja (PZC) i sorpcije vode (WRV) standardnih tkanina

Oznake	Sastav	ζ (mV) pH 9	ζ (mV) pH 6	IEP	PZC (μg/g)	WRV (%)
CO	100 % pamuk	-21,9	-15,9	< 2	237,2	27,14
PES	100 % poliester	-27,4	-20,6	2,28	48,9	4,37
PES_CO	65 % poliester/35 %pamuk	-32,8	-23,9	< 2	134,6	14,59

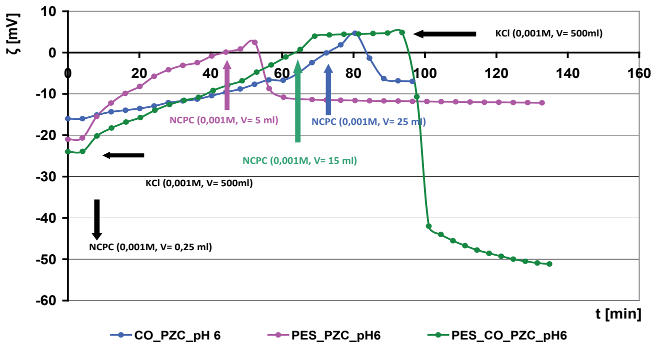
Iz rezultata je vidljivo da standardne tkanine od pamuka, poliestera i njihove mješavine imaju različite vrijednosti elektrokinetičkog potencijala u otopini elektrolita 1 mmol/l KCl. Pamučna celuloza zbog prisutnosti hidroksilnih i karboksilnih funkcionalnih skupina u alkalnim otopinama disocira i daje negativni naboj, kao i poliester zbog ester karboksilnih skupina. Poliester ima negativniju površinu, jer prema literaturi [2], hidrofobne površine imaju niži zeta potencijal od hidrofilnih radi sposobnosti adsorpcije vode (hidratacije) i nemogućnosti bubrenja. To potvrđuje i istražena sposobnost zadržavanja vode i adsorpcija kationskog tenzida (sl. 2). Zbog kemijske strukture i hidrofobnosti poliester adsorbira manju količinu kationskog tenzida nego pamuk. Adsorpcija kationskog tenzida ovisi o njihovom elektrokinetičkom naboju i njihovoj kemijskoj strukturi. Dobivene su velike PZC razlike poliesterske i pamučne tkanine, što se može objasniti razlikom u broju i dostupnosti aktivnih skupina.



a. b.

Slika 1. Elektrokinetički potencijal u ovisnosti o: a) pH otopine elektrolita 1 mmol/l KCl, b) dodatku kationskog tenzida 1 mmol/l N-CPC otopini elektrolita

Aktivne skupine pamučne tkanine otvaraju se postepeno, te je potrebna veća količina N-CPC za pobijanje naboja površine nego kod poliestera. Promatrajući desorpciju kationskog tenzida sa pamučne, poliester/pamuk i poliesterske tkanine, vidljiva je različita dinamika desorpcije, koja upućuje na potrebu primjene drugih metoda karakterizacije, koje mogu bolje pojasniti nastale pojave.



Slika 2: Adsorpcija i desorpcija 1 mmol/l N-CPC-a na SurPASS-u: pamučne tkanine, poliesterske tkanine, mješavine poliestera i pamuka

4. Zaključak

Rezultati su ukazali na potrebu istraživanja adsorpcije i desorpcije još nekih kationskih tenzida, koje će se uz elektrokinetičke veličine vrednovati drugim metodama, primjerice potencionetrijskom titracijom. Pri tome će se varirati koncentracija tenzida (ispod i iznad kritične micelarne koncentracije) te pH i temperatura kupelji sa svrhom tumačenja mehanizama, kinetike i izotermi adsorpcije uz potencijalnu izradu modela adsorpcije za pojedini tenzid.

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Radno iskustvo

Veljača 2013. – danas: Ispitivač u laboratoriju MIRTA-KONTROL d.o.o., laboratorijsko ispitivanje, certifikacija, vještačenje i inženjering

Naslov teme doktorskog rada	Razvoj metode za određivanje metalnih iona u tekstilnim materijalima za dječje igračke
Studijski savjetnik	Prof. dr. sc. Branka Vojnović
Datum obrane teme doktorskog rada	

RAZVOJ METODE ZA ODREĐIVANJE METALNIH IONA U TEKSTILNIM MATERIJALIMA ZA DJEČJE IGRAČKE

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1. Uvod

Sigurnost proizvoda, pa tako i onih sačinjenih od tekstilija, pitanje je od iznimne važnosti u svim državama članicama Europske unije. Posebna pozornost se mora posvetiti dječjoj odjeći, a naročito dječjim igračkama koje moraju biti sigurne za njihovu svakodnevnu uporabu. Takvi proizvodi koji su izrađeni od tekstilnih materijala različitog porijekla (prirodnog, sintetičkog, mješavine), često su obrađeni sredstvima u kojima se redovito nalaze metalni ioni. Neki od metalnih iona imaju dokazano štetno i toksično djelovanje pa je razumljiva briga oko sigurnosti takvih dječjih igračaka po zdravlje djece. Potrebno je obratiti pozornost na potencijalno otpuštanje metalnih iona tijekom svakodnevne upotrebe igračaka, posebno njihove ekstrakcije u slini ili pak u želučanom soku. Provoditi će se ispitivanja na prisutnost određenih metalnih iona u odabranim uzorcima dječjih igračaka. U tu svrhu primijeniti će se norma HRN EN 71-3 za određivanje ukupne, a dodatno i specifične migracije određenih iona metala iz odabranih uzoraka dječjih igračaka. Sadržaj navedenih metala određuje se metodom optičke emisijskespektrometrije s induktivno spregnutom plazmom, (ICP-OES). Obratit će se pažnja na pripremu uzoraka za analizu te mogućnost ekstrakcije iona metala iz različitih simulanata (umjetni znoj, slina, želučani sok, voda, octena kiselina).

2. Eksperimentalni dio

Određivanje sadržaja metalnih iona provodi se na odabranim uzorcima igračaka. Standardne otopine za kvantitativno određivanje sadržaja metala na spektrometru ICP-OES priređuju se razrjeđivanjem certificiranih standardnih otopina od 1000 mg/L pojedinog metala.
Uzorci za određivanje specifične migracije teških metala moraju sadržavati reprezentativne dijelove cjelokupne površine, koja često nije od iste vrste materijala. 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.

Određivanje globalne migracije:

Za određivanje ukupne migracije s uzoraka koristi se gravimetrijska metoda. Ukupna migracija se izračunava s obzirom na masu ukupne migracije s uzorka dimenzija 1 dm^2 u vodu te u otopine 0,07 M klorovodične kiseline i 3 % octene kiseline, a izražava se po površini ispitivanog uzorka. Uzorci se uzimaju s dječje igračke u jednom komadu, ali sa nekoliko različitih mjesta kako bi se osigurala reprezentativnost uzoraka, na što je potrebno posebno obratiti pozornost [1].

Određivanje specifične migracije:

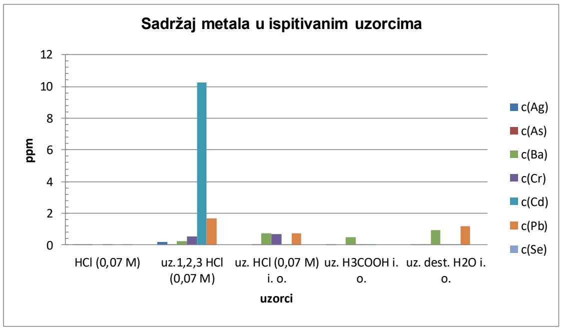
Ovaj postupak se izvodi prema EN 71-3:2013, Sigurnost igračaka-3. dio: Migracija određenih elemenata. U odgovarajuću tamnu bocu za mućkalicu stavlja se 180 mg uzorka igračke, zatim se dodaje točno 10 mL HCl (0,07 M). Postupak mućkanja traje 1h na 37 ± 2 ºC. Nakon mućkanja uzorak treba odstajati 1 h, profiltrira se i u filtratu se određuju metalni ioni metodom ICP-OES [2].

3. Rezultati i rasprava

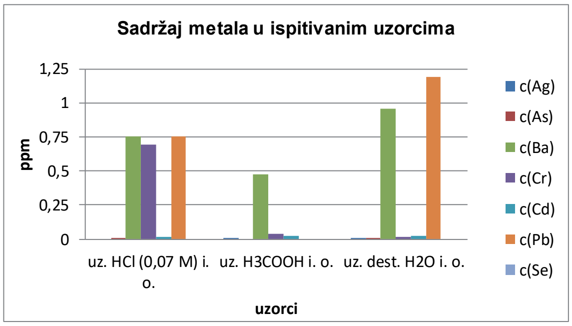
Kategorije materijala za izradu igračaka prema Direktivi o sigurnosti igračaka 2009/48/EZ, Prilog II. Posebni sigurnosni zahtjevi, 11.3. III. Kemijska svojstva (Rev 1.7, 13. 12. 2013.) i normi EN 71-

3:2013, Sigurnost igračaka – 3.dio. Migracijske granične vrijednosti pojedinih elemenata razlikuju se ovisno o materijalu igračke ili predmetnog sastavnog dijela a), b) ili c):

a) Suhi, lomljivi, praškasti ili savitljivi materijali za igračke: tvrdi materijali za igračke s kojih tijekom igre otpada praškasti materijal koji se može progutati, kontaminacija ruku materijalom dovodi do veće oralne izloženosti, gdje je pretpostavljena količina progutanog materijala 100 mg na dan.
b) Tekući ili ljepljivi materijali za igračke: koji se mogu progutati i/ili kojima je tijekom igre izložena dječja koža, gdje je pretpostavljena količina progutanog materijala 400 mg na dan.
c) Materijali ostrugani s površine igračke: površinski premazi, polimeri (tvrdi), polimeri (meki), drugi materijali, drvo, tekstil, staklo, keramika, metali i legure. Tvrdi materijali za igračke s premazom ili bez njega se mogu progutati kao posljedica griženja, struganja sa zubima, sisanja ili lizanja. Pretpostavljena količina progutanog materijala iz takvih površina je 8 mg na dan [2-3].



Slika 1: Grafički prikaz usporedbe uzoraka za specifičnu migraciju i pojedini metal u čvrstom ostatku nakon određivanja globalne migracije



Slika 2: Grafički prikaz sadržaja metala u ispitivanim uzorcima za pojedini metal u čvrstom ostatku nakon određivanja globalne migracije

Ioni metala prisutni u većim količinama u ionskom stanju često mogu ugroziti zdravlje, pogotovo ukoliko se radi o zdravlju djece. Ispitivanja su pokazala da se pojedini metalni ioni otpuštaju iz analiziranog uzorka dječje igračke, a koncentracija pojedinog metala ovisi i o sredstvu s kojim je ekstrakcija provedena (sl. 1, 2). Opisanim istraživanjima nastojati će se razviti metoda određivanja određenih metalnih iona, ovisno o načinu pripreme uzoraka, te novorazvijenom metodom nastojati utvrditi postoji li potencijalna opasnost od migracije metalnih iona s dječjih igračaka u simuliranim uvjetima.

4. Zaključak

Globalna migracija iz uzorka igračke je premašila graničnu koncentraciju. Ovim preliminarnim istraživanjima određivanja specifične migracije ukazalo se je na to da se metalni ioni otpuštaju iz odabranog uzorka dječje igračke u slučaju simulacije gutanja, ali su njihove koncentracije ispod normom propisanih graničnih koncentracija. U slučaju gutanja igračke ili pak dijelova igračke (npr. dlačice) osim potencijalne opasnosti od gušenja, javlja se i opasnost od štetnog djelovanja metalnih iona na dječji organizam. U daljnjim istraživanjima nastojati će se ispitati i druga sredstva za migraciju (simulanti) kao što su umjetna slina i umjetni znoj, iako ti simulanti nisu predviđeni normom. Također će se ispitati i druge metode pripreme uzoraka za analizu migracije metalnih iona s tekstilnih materijala namijenjenih dječjim igračkama.

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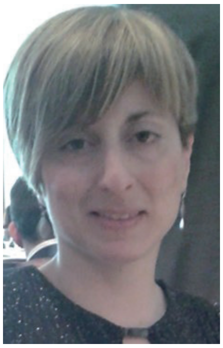
[2] HRN EN 71-3:2013, Sigurnost igračaka - 3. dio: Otpuštanje određenih elemenata (EN 71-3:2013), Europski odbor za standardizaciju (CEN), ICS 97.200.50
[3] Direktiva o sigurnosti igračaka 2009/48/EZ, Prilog II. Posebni sigurnosni zahtjevi, 11.3. III. Kemijska svojstva (Rev 1.7, 13. 12. 2013.)



Ivona Jerković

Životopis	Ivona Jerković diplomirala je 2006. na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu te završila Međunarodni europski master studij naprednog tekstilnog inženjerstva (*E-TEAM*) 2009. na Sveučilištu u Ghentu (Belgija). *E-TEAM* stručnu praksu *Leitat Technological Center-Universitat Politècnica de Catalunya-Universiteit Gent* iz područja automobilske industrije izvela je u Terrassi (Španjolska). U Hrvatskoj je radila u odjevnoj industriji; TKT Zlatna igla (2007.), Naftalina (2010.); marketingu, A.O.R. (2011.-2012.); te na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu na FP7 projektu MAPICC 3D (2012.-2015.). Od veljače do prosinca 2015. u okviru FP7 projekta boravila je na *Ecole Nationale Supérieure des Arts et Industrie Textiles (ENSAIT)*, Roubaix, Francuska. Od 2017. radi u Hrvatskoj agenciji za malo gospodarstvo, inovacije i investicije (HAMAG-BICRO) u Zagrebu.
Naslov teme 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(4-vinil-benzensulfonska kiselina)
Mentori	Prof. emerita. dr. sc. Ana Marija Grancarić (TTF); Prof. dr. sc. Vladan Končar (ENSAIT, Francuska)
Datum obrane teme doktorskog rada	14. srpnja 2016.

PRAĆENJE STANJA STRUKTURE TEKSTILOM OJAČANIH TERMOPLASTIČNIH KOMPOZITA S TEKSTILNIM SENZORIMA

Ivona JERKOVIĆ

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1. Uvod

Tekstilom ojačani termoplastični kompoziti imaju značajno mjesto u automobilskoj, željezničkoj i zrakoplovnoj industriji zbog mnogih prednosti u usporedbi s tradicionalnim materijalima poput metala i keramike [1]. Pametni tekstil ima važnu ulogu u realizaciji tekstilnih senzora kompatibilnih s kompozitnom tehnologijom. Vodljive pređe kao tekstilni senzori mogu se integrirati u tekstilne strukture raznovrsnim tehnologijama kao što su tkanje, pletenje i dr. [2]. U današnje vrijeme usmjeren je interes na mogućnost razvijanja tekstilnih senzora na temelju intrinzično vodljivih polimera koji se nazivaju i sintetski metali [3]. U ovom radu, tekstilni senzori temeljeni na vodljivom polimernom kompleksu poli [3,4-(etilendioksi)tiofen]-compl-poli(4-vinil benzensulfonska kiselina) (PEDOT-compl-PSS) integrirani su tijekom tkanja 2D tkanine. Izvršena su elektromehanička mjerenja razvijenih tekstilom ojačanih termoplastičnih kompozita radi in situ praćenja stanja strukture kompozita s tekstilnim senzorima tijekom vlačnog opterećenja.

2. Eksperimentalni dio

E-staklena/polipropilenska (GF/PP) pređa proizvođača *PD Fiberglass group* (Njemačka) korištena je za razvoj tekstilnih senzora s novom metodom naslojavanja primjenom valjaka [3]. GF/PP tekstilni senzori su integrirani tijekom tkanja 2D tkanine, saten tkanje (gustoća osnove, 4 niti/cm i gustoća potke, 6 niti/cm), debljina tkanine ~2.660 mm. Troslojni 2D tekstilni predoblici s integriranim tekstilnim senzorima su konsolidirani pod tlakom od 4-5 MPa i temperaturom od 185 °C tijekom 5 minuta nakon čega je uslijedilo hlađenje na 100 °C u vremenu od 2-3 minute. Izrađena su tri uzorka tekstilom ojačanih termoplastičnih kompozita s integriranim tekstilnim senzorima za izvođenje *in situ* praćenja stanja kompozita tijekom vlačnog opterećenja.

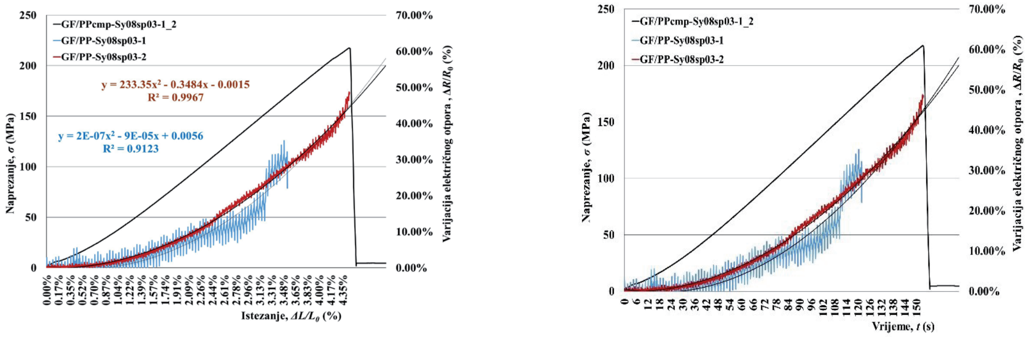
3. Rezultati i rasprava

Električni otpor tekstilnih senzora nakon njihovog razvoja u rasponu je između 350 Ω - 500 Ω i nešto viši nakon integracije u 2D tkaninu, 390 Ω - 550 Ω. Električni otpor tekstilnih senzora nakon konsolidacije GF/PP tekstilnih predoblika i neposredno prije elektromehaničkih ispitivanja u rasponu je od 16 kΩ - 240 kΩ.

Prvi kompozitni uzorak (slika 1) pokazuje slične krivulje električnog otpora-istezanja GF/PP tekstilnih senzora, dok drugi uzorci različite krivulje. Kompozitni prekid “u liniji” primijećen je nakon elektromehaničkog ispitivanja kod prvog uzorka. Raniji prijelomi unutar kompozitne strukture otkriveni su za druga dva kompozitna uzorka.

Kod drugog kompozita, krivulje varijacije električnog otpora tekstilnih senzora ($\Delta R/R_0$) u odnosu na vlačno istezanje ($\Delta L/L_0$) pokazuju nekoliko prekida u drugom dijelu krivulja zbog početka delaminacije i pukotina unutar kompozita. Lom jednog tekstilnog senzora koji se dogodio tijekom *in situ* praćenja stanja strukture je otkriven za posljednju GF/PP kompozitnu strukturu. Mjerni faktori za sve kompozitne uzorke su određeni iz polinomne jednadžbe stupnja 2.

Prekidna vlačna čvrstoća kompozita u rasponu je od 206,99 MPa - 217,33 MPa a prekidno vlačno istezanje u rasponu je od 4,40 % - 4,45 %. Vlačna naprezanja pri prekidu kompozitnih uzoraka izvedena su približno nakon 152 s, dok se značajne promjene u varijaciji električnog otpora tekstilnih senzora događaju nakon 85 s.



a. b.

Slika 1: Rezultati elektromehaničkog mjerenja GF/PP kompozita s integriranim GF/PP tekstilnim sensorima: a) vlačno naprezanje kompozita (*σ*) i varijacija električnog otpora tekstilnih senzora ($\Delta R/R_0$) u odnosu na istezanje ($\Delta L/L_0$), b) naprezanje kompozita (σ) i varijacija električnog otpora tekstilnih senzora ($\Delta R/R_0$) u odnosu na vrijeme (*t*)

4. Zaključci

Tekstilni senzori pružaju mogućnost praćenja vlačnog opterećenja i otkrivanje oštećenja u kompozitima *in situ*. U nekim slučajevima uočeno je nekoliko prekida zbog početka delaminacije i pojave pukotina unutar kompozita. Prvi kompozitni uzorak pokazuje slične krivulje električnog otpora-istezanja GF/PP tekstilnih senzora, dok su za druga dva kompozitna uzorka otkriveni raniji prijelomi unutar kompozitnih struktura. Lom jednog GF/PP tekstilnog senzora koji se dogodio tijekom *in situ* praćenja stanja strukture je otkriven za posljednji GF/PP kompozit.

Zahvala

Rad je dio europskog projekta “MAPICC 3D” u sklopu poziva NMP-FP7- 2010-3.4-1, broj 263159 pod nazivom: *One-shot Manufacturing on large scale of 3D up graded panels and stiffeners for lightweight thermoplastic textile composite structures.* Autorica zahvaljuje Europskoj komisiji na financijskoj potpori projektu.

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Nikolina Jukl

Životopis

Osobni podaci: Rođena 25. 10. 1987., Sv. Nedelja
Obrazovanje:
2013. godine: upis na poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet
2013. godine: mag.ing.techn.text., Sveučilište u Zagrebu Tekstilno-tehnološki fakultet
2010. godine: univ.bacc.ing.techn.text., Sveučilište u Zagrebu Tekstilno-tehnološki fakultet
2006. godine: završetak srednjoškolskog obrazovanja u Školi za tekstil, kožu i dizajn. Osvojeno 3. mjesto na Državnom natjecanju učenika "Dani odjeće 2006" u kategoriji tehnologija proizvodnja odjeće.
Radno iskustvo:
2013.: Konfeks d.o.o., voditeljica proizvodnje
2006.-2013.: Studentsko radno iskustvo u Konfeks d.o.o. (računalna konstrukcija, krojnica, šivaona i po potrebi ostale radne jedinice)
2003.-2006.: Srednješkolsko radno iskustvo u tt. Konfeks d.o.o. (pomoćni poslovi)

Naslov teme doktorskog rada	Utjecaj slojevitosti i vrste ugradbenih materijala na zbirna toplinska svojstva odjeće (radni naslov)
Studijski savjetnik	Izv. prof. dr. sc. Snježana Firšt Rogale
Datum obrane teme doktorskog rada	

ODREĐIVANJE OTPORA PROLASKU TOPLINE MUŠKIH RADNIH JAKNI NA TERMALNOM MANEKENU

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1. Uvod

Prema međunarodnoj normi HRN EN ISO 7730:2008 toplinska udobnost definirana je kao stanje svijesti koje izražava zadovoljstvo toplinskim uvjetima okoline [1]. Na toplinsku udobnost utječe ljudski faktor (fizička aktivnost, zdravstveno stanje), faktor odjeće (svojstva materijala, komocija, slojevitost) te faktor okoline (temperatura, vlažnost zraka, strujanje zraka) [2]. Kako bi se objektivno vrednovala termoizolacijska svojstva odjevnih predmeta ili odjevnog sustava koriste se mjerni sustavi i mjerne metode za određivanje parametara: toplinske vodljivosti tekstilnih materijala, propusnosti vodene pare te propusnosti zraka [3]. Na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu, izrađen je, konstruiran, patentiran i umjeren sustav za određivanje statičkih i dinamičkih toplinskih svojstava kompozita i odjeće koji se sastoji od termalnog manekena, vruće ploče, klima komore i softvera [4]. Navedenim sustavom omogućeno je objektivno mjerenje termoizolacijskih svojstava odjeće, odnosno mjerenje otpora prolasku topline koji se izražava u mjernim jedinicama (m^2KW^{-1}) te u (Clo) jedinicama.

2. Eksperimentalni dio

U eksperimentalnom dijelu rada provedeno je ispitivanje na dva modela muške radne jakne, koje su izrađene u tt. Konfeks, a čija se djelatnost odnosi na proizvodnju radne i zaštitne odjeće. Vanjske školjke jakni načinjene su od osnovnog materijala sirovinskog sastava 50 % pamuk i 50 % poliamid. Podstavna tkanina modela M1 je sirovinskog sastava 100 % poliester-*microfleece*, a kod modela M2 100 % viskoza. Ispitivanja otpora prolasku topline su provedena na termalnom manekenu, koji je dio sustava za određivanje statičkih i dinamičkih toplinskih svojstava kompozita [4]. Ispitivanje je provedeno prema normi HRN EN ISO 15831:2005 - Fiziološki učinci-mjerenje toplinske izolacije s pomoću termalnog manekena [4]. Kako je predviđena namjena jakni u zatvorenim objektima i izvan njih, što uključuje izloženost klimatskim promjenama kao što su kiša, vjetar i slično, svrha ispitivanja je utvrditi da li jakne zadovoljavaju uvjete za ostvarivanje toplinske udobnosti [5]. Slika 1 prikazuje modele jakni pripremljene za ispitivanje.

a. b.

Slika 1: Prikaz modela radnih jakni na termalnom manekenu: a) model M1 b) model M2

3. Rezultati i rasprava

U nastavku su prikazani rezultati ispitivanja otpora prolasku topline na termalnom manekenu, tablica 1. Rezultati prikazuju srednje vrijednosti dovedene električne snage potrebne za održavanje temperature mjerene površine na kojoj se nalazi odjevni predmet te vrijednost otpora prolasku topline temeljene na dvadeset uzastopnih mjerenja na termalnom manekenu. Ukupni toplinski otpor prazne površine mjernog uređaja (neodjevenog termalnog manekena) zajedno s graničnim slojem zraka uz površinu (R_{ct0}) iznosi 0,0749351 m^2KW^{-1}.

Tablica 1: Srednje vrijednosti dobivenih rezultata ispitivanja toplinskih svojstava, modela M1 i M2

MODEL	Vrijednost otpora prolasku topline (Clo)	Dovedena električna snaga (W)
M1	0,272126452	212,408900
M2	0,286079000	208,091900

Tablica 2 prikazuje rezultate statističke obrade dobivenih rezultata (jednofaktorska analiza varijance – ANOVA, uz razinu značajnosti α=0,05) koja je provedena kako bi se utvrdilo postoji li statistički značajna razlika između dobivenih rezultata.

Tablica 2: Rezultati statističkog testa na skupu mjerenih podataka modela M1 i M2

Anova: jednofaktorska analiza varijance						
Ispitane grupe podataka	Broj mjerenja	Zbroj svih dobivenih vrijednosti	Aritmetička sredina dobivenih vrijednosti	Varijanca		
M1	20	5,442529032	0,272126452	0,002169893		
M2	20	5,721580645	0,286079032	0,001119596		
ANOVA						
Uzrok varijacije	SS	df	MS	F	P-vrijednost	F krit
Između grupa podataka	0,001947	1	0,001946745	1,183615478	0,283474	4,098172
Unutar grupe	0,0625	38	0,001644745			
Ukupna vrijednost	0,064447	39				

Dobiveni rezultati pokazuju da su vrijednosti otpora prolasku topline (Clo) kod oba modela jakni približno jednake, a istovremeno model M2 ima manju dovedenu električku snagu potrebnu za održavanje konstantne temperature tijela manekena. Statistička analiza pokazuje da ne postoji statistički značajna razlika između dobivenih rezultata.

4. Zaključak

Na temelju dobivenih rezultata zaključak je da oba modela zadovoljavaju uvjete toplinske udobnosti definirane prema međunarodnom standardu HRN EN ISO 7730:2008, koji se odnosi na vrijednosti otpora prolasku topline pojedinačnih odjevnih predmeta. Prema navedenom standardu za jaknu je potrebno ostvariti 0,35 Clo, dok je npr. za laganiju, proljetnu jaknu definirana vrijednost od 0,25 Clo. Ispitani modeli su ostvarili vrijednosti od 0,27 Clo (model M1) i 0,29 Clo (model M2), a između dobivenih vrijednosti rezultata ne postoji statistički značajna razlika.

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Životopis	**Obrazovanje:** 1987.-1994. Tekstilno-tehnološki fakultet, TTF (dodiplomski studij) Dipl.inž. tekstilne tehnologije, smjer odjevna tehnologija 1995.-2007. TTF (poslijediplomski znanstveni studij Tekstilno inženjerstvo) magistra tehničkih znanosti iz polja tekstilne tehnologije 2012./2013. TTF (poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija) **Zaposlenje i zvanje:** 1994.-1995. Pamučna industrija Duga Resa d.d., Duga Resa, pripravnik 1995.-1996. Heruc d.d., Zagreb, tehnolog 1996.-2001. PI Duga Resa d.d., tehnički rukovoditelj 2001.-2005. Veleučilište u Karlovcu, asistent 2005.-2009. Veleučilište u Karlovcu, predavač 2009.- danas Veleučilište u Karlovcu, viši predavač **Publikacije:** 7 znanstvenih i 4 stručna rada u časopisima, 11 znanstvenih i 17 stručnih radova u zbornicima radova s međunarodnih skupova, 4 stručna rada u zbornicima radova s domaćih skupova.
Naslov teme doktorskog rada	Oblikovanje radnih metoda u tehnološkom procesu šivanja
Mentor	Prof. dr. sc. Zvonko Dragčević
Datum obrane teme doktorskog rada	15. listopada 2015.

OBLIKOVANJE RADNIH METODA U TEHNOLOŠKOM PROCESU ŠIVANJA

Snježana KIRIN
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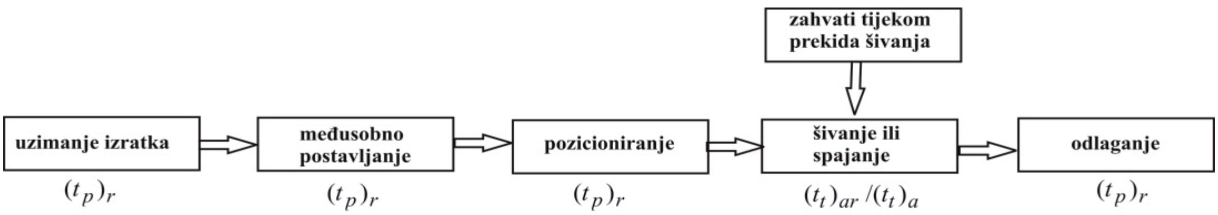
1. Uvod

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 približno sličnih karakteristika.
Za organizaciju kontinuiranog rada i protoka materijala na tim proizvodnim linijama potrebno je poznavanje točnih i ispravnih vremenskih normativa za svako radno mjesto i određivanje pogodne radne metode čime se ostvaruje kontinuirani protok materijala na proizvodnim linijama i normalno opterećenje radnika. U tehnološkim procesima šivanja tehnološke operacije imaju kratke cikluse izvođenja 15-60 s, visoki stupanj repetitivnosti uz znatno psiho-fizičko opterećenje radnika uzrokovano statičkim opterećenjem radnika pri sjedenju, visokim stupnjem koncentracije pogleda, kratkim pokretima ruku te učestalim izvođenjem kombiniranih i istovremenih pokreta. Istraživanja strukture dnevnog radnog vremena u fazi šivanja ukazuju da se 20 do 30 % vremena utroši za tehnološke strojno-ručne zahvate šivanja, 60 do 70 % vremena za pomoćno-ručne zahvate, dok se oko 10 % vremena utroši na neproizvodni rad (osobna higijena, planirani i neplanirani gubici vremena te nedisciplina) [1,2].

2. Eksperimentalni dio

U okviru znanstvenih projekata rađenih u Zavodu za odjevnu tehnologiju Sveučilišta u Zagrebu Tekstilno-tehnološkog fakulteta izvršena su pomoću video opreme sustavna snimanja proizvodnih linija u odjevnoj industriji (Kotka, Krapina; Virovitičanka, Virovitica; Pounje, Hrvatska Kostajnica; Mara, Osijek; EMKA, Pregrada). Analizom videosnimki dobiveni su osnovni podaci o načinu izvođenja radnog procesa. Primjenom MTM-1 (Method Time Mesurement) sustava ukazala se mogućnost sustavne razrade i postavljanja standardnih sklopova pojedinih zahvata koji se temelje na logičkom slijedu osnovnih pokreta.
Prema strukturi izvođenja tehnološka operacija podijeljena je na zahvate: uzimanje, međusobno postavljanje, pozicioniranje, šivanje, ručne zahvate tijekom prekida šivanja i odlaganje (sl.1). Pojedini zahvati u strukturi tehnološke operacije mogu se izvesti na više načina ovisno o veličini i broju izradaka, načinu polaganja krojnih slojeva, stupnju tehničke opremljenosti šivaćih strojeva, veličini i obliku radne površine, potrebnim radnim zonama i vidnim poljima, te s obzirom na uvježbanost radnika [3,4].



Slika 1: Podjela tehnološke operacije šivanja prema zahvatima

Mjerna oprema se sastoji od: video kamere SONY DCR-HC42E s ugrađenim generatorom vremena s točnošću od ± 0,1 s; DVD rekorder SONY SLV D970P, osobno računalo i tiskalo u boji s mogućnosti usporenja snimke (1/2; 1/4; 1/8, odnosno *frame to frame*); osobno računalo Pentium 4, 2,8 GHz, 1024 MB RAM sa instaliranim Microsoft Windows 2000 sustavom, grafičkom karticom NVIDIA Ge Force Fx5200; računalni program Adobe Premier 5 i Corel Draw 11; računalni program ERGO-Plan, odnosno modul ERGO-Mas i modul ERGO-Man. (Univerza v Mariboru Fakulteta za strojništvo, Labaratoriju za načrtovanje proizvodnih sistemov).

3. Rezultati i rasprava

Za zahvat uzimanja razrađeno je i postavljeno devet mogućnosti izvođenja s obzirom na veličinu izradka, položaj svežnjeva, zakrivljenost i duljinu šava, te način polaganja krojnih dijelova. Za zahvat međusobnog postavljanja razrađeno je i postavljeno pet mogućnosti izvođenja s obzirom da li se izvodi međusobno postavljanje rubova kontura ili postavljanje na označeno mjesto. Za zahvat pozicioniranja izradka razrađene su dvije mogućnosti s obzirom na samo pozicioniranje pod pritisnu nožicu i strojnu iglu. U tehnološkom zahvatu šivanja vođenje izradka moguće je izvesti na tri načina: osnovno, pojedinačno, zajedničko. Samo začvršćivanje šava u tehnološkom zahvatu šivanja moguće je izvesti na tri načina (polugom mehanizma za začvršćivanje, tipkom za začvršćivanje ili automatski). Za zahvat odsijecanja konca postavljene su i razrađene četiri mogućnosti izvođenja (običnim ili specijalnim škarama, automatsko ili napravom za odsijecanje). Izrada šava olakšana je upotrebom pomoćnih naprava kao što su graničnici, porubljivači i podavijači za što su razrađene četiri mogućnosti. Za zahvat tijekom prekida šivanja postavljeno je i razrađeno pet mogućnosti izvođenja (poravnavanje rubova kontura, zakretanje oko igle). Odlaganje izradka na kraju tehnološke operacije moguće je izvesti na tri načina (jednom rukom, s obje ruke ili uz promjenu smjera) [5]. Temeljem postavljenih standardnih sklopova pomoću računalnog programa ERGO-Plan razrađeno je i oblikovano radno mjesto koje ukazuje na povoljniju metodu izvođenja u tehnološkoj operaciji šivanja.

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. Standardni sklopovi su vremenski određeni i njihovom kombinacijom se može unaprijed odrediti i postaviti optimalna metoda rada i pripadajuće normalno vrijeme izvođenja.
Primjenom razrađenih standardnih sklopova zahvata tehnološke operacije šivanja i računalnog programa ERGO-Plan omogućuje se postavljanje modelnog sustava oblikovanja radnih mjesta i utvrđivanje povoljnijih radnih metoda nižeg stupnja radnog opterećenja.

5. Literatura

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Mateo Miguel Kodrič Kesovia

Životopis	Rođen 2. ožujka 1987. godine u Dubrovniku. Godine 2006. upisuje redovit studij restauracije i konzervacije na Sveučilištu u Dubrovniku, gdje 2012. 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. u Fondazione della Arte Seta Lisio, u Firenci. Nagrađivan je sa Cum Laude i Summa Cum Laude diplomama, Rektorovom nagradom, a Ministarstvo znanosti, obrazovanja i športa imenuje ga među dvadeset najuspješnijih asistenata. Od rujna 2013. zaposlen je kao asistent na Odjelu za umjetnost i restauraciju Sveučilišta u Dubrovniku. Godine 2014. upisuje poslijediplomski sveučilišni studij na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Restauriranje tekstila dodatno usavršava 2017. na renomiranom institutu Abegg Stiftung u Švicarskoj.
Naslov teme doktorskog rada	Metoda analize i digitalizacije tehnološke dokumentacije povijesnih damastnih tkanina
Studijski savjetnici	Prof. dr. sc. Željko Penava Doc. dr. sc. Katarina Nina Simončič
Datum obrane teme doktorskog rada	

METODA ANALIZE I DIGITALIZACIJE TEHNOLOŠKE DOKUMENTACIJE POVIJESNIH DAMASTNIH TKANINA

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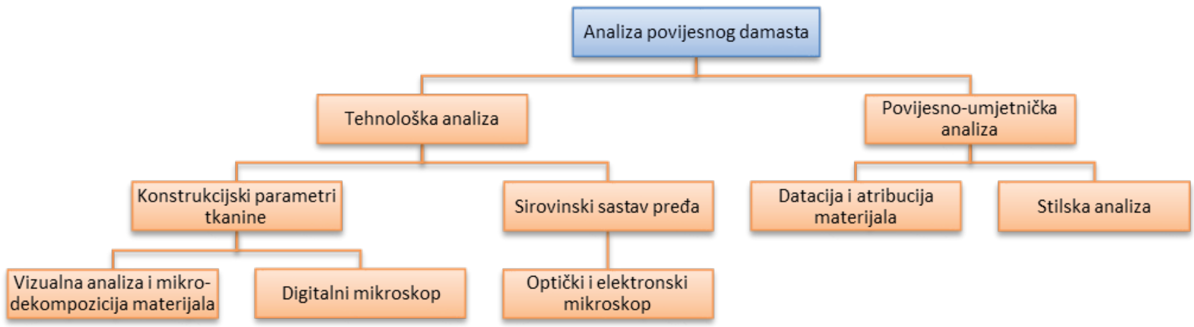
1. Uvod

Proučavanje povijesnih tekstilnih materijala zahtijeva složen interdisciplinaran pristup u kojem se suvremena tekstilna znanost integrira i povezuje sa znanjima iz drugih polja znanosti. Temeljni cilj ove doktorske disertacije biti će razviti interdisciplinarnu znanstvenu metodu analiziranja i dokumentiranja povijesnih damastnih tkanina koji zbog svoje široke upotrebe predstavljaju najrasprostranjeniju i najčešću vrstu tkanine evidentirane na umjetninama. Sintetizirat će se međunarodna klasifikacija i terminologija, tipologija kompozicije i strukture veza te dosadašnja saznanja o povijesnom i tehnološkom razvoju proizvodnje damasta. Definirat će se optimalan model dokumentacije uzornica i odgovarajućih tehnoloških parametara konstrukcije vrijednih očuvanih povijesnih damasta. Razvit će se metoda digitalne grafičke rekonstrukcije izgubljenih izvornih predložaka damasta, a ispitat će se i metode njihove reprodukcije sa suvremenim tiskarskim i tkalačkim tehnikama.

2. Eksperimentalni dio

Znanstvena ispitivanja biti će fokusirana i provedena na odabranom primjerku povijesnog damasta iz fundusa pokretne kulturne baštine na području Dubrovnika i njene okolice. Kako bi se cilj istraživanja ostvario primijenit će se interdisciplinarne znanstvene metode proučavanja tekstilnih materijala (sl. 1). Metodologija analitičkih metoda istraživanja provest će se na povijesnim tkaninama sukladno međunarodnim propisima i etičkom kodeksu konzervatorske-restauratorske struke [1].



Slika 1: Grafički prikaz analitičkih metoda za proučavanje povijesnih damasta

Suvremenom računalnom grafičkom tehnologijom i fotogrametrijskim tehnikama te interpretacijom geometrijskih i optičkih zakonitosti kompozicije uzorkovanih povijesnih tkanina provest će se digitalna rekonstrukcija izvornog izgleda, deformiranog, oštećenog ili nepotpunog [2]. Ispitat će se primjena dokumentiranih tehnoloških podataka i digitalnog raporta dezena u tkalačku shemu za potrebe virtualne i fizičke prezentacije analiziranog povijesnog damasta. Specijaliziranim računalnim programima za stvaranje tkalačke sheme projektirat će se analizirani damast za proizvodnju modernom žakard tehnologijom. Istražit će se mogućnosti reprodukcije analiziranih damastnih tkanina u svrhu supstitucije osjetljivih povijesnih izvornika (izrada replika) ili stvaranje novih kreacija, koristeći suvremene tehnike tekstilnog tiska (tehnike sitotiska ili digitalnog tiska) kao i tehnološki proces tkanja s odgovarajućim materijalima. Kvaliteta reproduktivnih tehnika primjenjiva za vrijedne povijesne damaste valorizirat će se metodom komparativnom analizom fizičkih i vizualnih svojstava, analizom postotka pogreške zadanih parametara, te metodom anketiranja ciljanih skupina i prikupljanja empirijskih podataka za znanstveno zaključivanje.

3. Rasprava

Metodologija konstrukcijske analize i stručna terminologija tekstilnih nazivlja (tehnoloških pojmova, vezova u tkanju, efekata, itd.) u Hrvatskoj nije prilagođena za proučavanje, dokumentiranje i definiranje povijesnih tkanina te će se stoga uskladiti s postojećim međunarodnim modelima. Analiza uzornice i konstrukcijskih parametara sastavni su dio konzervatorsko-restauratorske dokumentacije povijesnog tekstilnog predmeta. Tkalački predlošci za izradu povijesnih damastnih tkanina uglavnom nisu očuvani, no obrnutim procesom, temeljem tehnološke i stilske analize očuvanog damasta, moguće je grafički rekonstruirati izvorni nacrt [3]. Definiranje adekvatne forme dokumentacije i njeno usustavljeno provođenje preduvjet je za digitalizaciju i stvaranje umreženog repozitorija i galerije tehnoloških nacrta kakav trenutačno ne postoji u Hrvatskoj, ali ni u inozemstvu, a koji bi omogućio kvalitetniju suradnju između stručnjaka i institucija te potaknuo interdisciplinaran dijalog i znanstveni pristup u proučavanju povijesnih damasta. Također bi predstavljao tzv. „spremnik" povijesti ljudske kreativnosti iz koje suvremene industrije i kreativni dizajneri mogu crpiti nove inspiracije [4]. Nakon što se uspostavi ispravna metodologija rada i usustavi proces dokumentiranja damastnih tkanina, isti pristup biti će primjenjiv i za druge tipologije povijesnih tkanina. Metode izrade kopije i/ili replike umjetnine dobivaju sve više na popularnosti u suvremenoj konzervatorsko-restauratorskoj praksi. Projekti rekonstrukcije i reprodukcije sa suvremenim materijalima prihvatljive su u cilju konsolidacije, reintegracije i supstitucije fragilnih povijesnih materijala, iz potrebe da se spriječi daljnje propadanje ili poboljšati razumijevanje predmeta [5].

4. Zaključci

Dostupne suvremene tehnologije pružaju nam mnoge mogućnosti za očuvanje znanja tehnologije proizvodnje povijesnih tkanina kao i potencijalnu revitalizaciju rukotvorstva. Stoga je dužnost svih onih kojih se bave tekstilnom kulturnom baštinom adekvatno definirati i dokumentirati tehnike izrade povijesnih tekstilnih predmeta kako bi se, ne samo sačuvale estetske i povijesne vrijednosti, već i sačuvala izgubljena znanja njihove proizvodnje za buduće generacije. Implementacija interdisciplinarnog metodološkog pristupa u analizi povijesnih tkanina, razvoj metode digitalne rekonstrukcije izgubljenih predložaka te usavršavanje tehnološke dokumentacije i terminologije predstavljaju preduvjet za stvaranje inovativnog digitalnog repozitorija uzoraka i konstrukcijskih parametara damastnih tkanina očuvanih na području Dubrovnika. Postojanje takvog repozitorija bi u budućnosti omogućio kvalitetan pregled tekstilne baštine, unaprijedio metode komparacije, utvrđivanje autentičnosti materijala, datacije i porijekla izrade, kao i rasprostranjenost i utjecaj specifičnog dizajna, te rekonstrukciju i reprodukciju već oštećenih primjeraka upotrebom suvremenih tehnologija.

5. Literatura

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Životopis

Zorana Kovačević je zaposlena na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu (TTF) od završetka studija 2009. godine do danas. Tijekom rada na TTF-u obavljala je poslove asistenta na projektima FP7 – REGPOT-2008-1-229801: T-Pot i Revitalizacija tekstilne proizvodnje materijala iz brnistre, stručnog suradnika-specijalista za SEM, FTIR i TG, a od 2013. sudjeluje u izvođenju praktičnog dijela nastave na diplomskom i preddiplomskom studiju. Upisala je sveučilišni poslijediplomski studij na TTF-u akademske godine 2010./2011. Objavila je 1 knjigu, 1 poglavlje u knjizi, 2 rada u tercijarnim publikacijama, 2 u sekundarnim publikacijama, te 16 radova proizašlih iz sudjelovanja na priznatim međunarodnim i nacionalnim konferencijama i ljetnim školama. Dobitnica je nagrade Znanstveno-istraživačkog centra za tekstil u akad.god. 2015./2016. u kategoriji I za mlade znanstvenike.

Naslov teme doktorskog rada	Razvoj naprednih nanobiokompozita izrađenih od polilaktidnog polimera ojačanog vlaknima brnistre	
Mentori	Prof. dr. sc. Sandra Bischof (TTF)	Prof. dr. sc. Mizi Fan (Brunel University, UK)
Datum obrane teme doktorskog rada	20. veljače 2014.	

RAZVOJ NAPREDNIH NANOBIOKOMPOZITA IZRAĐENIH OD POLILAKTIDNOG POLIMERA OJAČANOG VLAKNIMA BRNISTRE

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1. Uvod

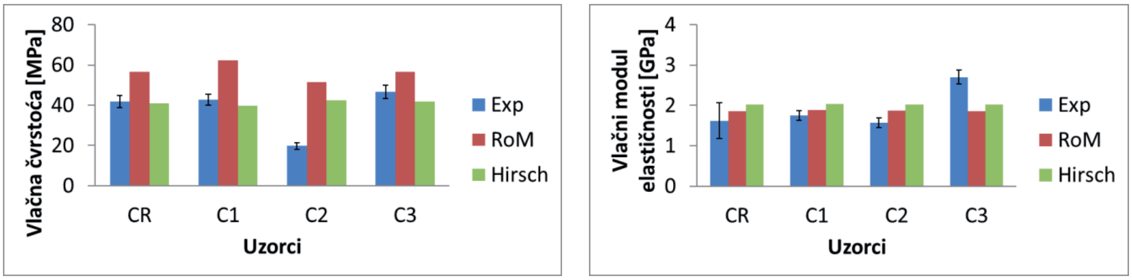
Sve veća osviještenost o okolišu i problemima rasta globalnog otpada utjecala je na koncepte razvoja održivosti i obnovljivih materijala. Zbog potrebe za pronalaženjem obnovljivih rješenja u razvoju novih materijala značajno se povećala uporaba kompozita izrađenih od biopolimernih matrica i prirodnih vlakana. S obzirom da su izdržljivi, sigurni i imaju izvrsna mehanička svojstva, kompozitni materijali ojačani prirodnim vlaknima uglavnom se koriste u automobilskoj industriji [1] za izradu raznih panela, sjedala itd. Iako su stabljična vlakna stoljećima uzgajana diljem svijeta, njihova je proizvodnja danas puno veća kako bi se zadovoljili zahtjevi globalnog tržišta i proizvodili reciklirani, obnovljivi, ‘’zeleni’’ proizvodi. Neke od najčešće korištenih biljaka za tu svrhu su: lan, konoplja, kenaf, ramija, juta itd. Dok se u ravničarskim dijelovima lan i konoplja uglavnom koriste kao tekstilna sirovina celuloznog podrijetla, u obalnom mediteranskom području od davnih vremena se koristi samonikla biljka - *Spartium junceum L.* (brnistra) [2].

2. Eksperimentalni dio

PLA polimer (6200D) je nabavljen od Nature Works LLC, dok su montmorilonitna glina (MMT) i NaOH kupljeni od Sigma-Aldrich, Velika Britanija. Brnistra je sakupljena u Hrvatskoj, u okolici grada Šibenika. Kao referentna vlakna (R) koriste se vlakna dobivena postupkom maceracije s NaOH provedenim u mikrovalnoj pećnici. Kako bi se poboljšala kompozitna međufazna, mehanička i toplinska svojstva vlakna su dodatno modificirana s NaOH (1), MMT (2) i smjesom MMT i limunske kiseline - MMT / CA (3). Prije izrade kompozita, vlakana i polimer su sušeni na temperaturi 60 °C u trajanju 48 h. Nakon sušenja polimer se talio u vakuumskoj peći na 170 °C te se preša s 20 % kratkih vlakana na temperaturi 170 °C uslijed djelovanja pritiska od 1 tone tijekom 5 minuta. Iz nastalih kompozitnih ploča izrezani su pravokutni uzorci (PLA, CR, C1, C2 i C3) dimenzija 40 x 5 x 1,5 mm. Mikromehanička karakterizacija kompozita i predviđanje njegove vlačne čvrstoće i vlačnog modula elastičnosti izvedeni su na temelju matematičkih modela: modificirani zakon miješanja (RoM) s Cox-Krenchel jednadžbama i Hirschovim modelom.

3. Rezultati i rasprava

Slika 1 prikazuje usporedbu eksperimentalnih i teoretskih vrijednosti vlačne čvrstoće i vlačnog modula elastičnosti. Predviđene vrijednosti vlačne čvrstoće korištenjem RoM modela bile su veće od eksperimentalnih, što je posljedica kvalitete vezanja između vlakana i matrice te diskontinuiranosti vlakana. Utvrđeno je da je faktor kompatibilnosti (f_C) dobar pokazatelj kvalitete vezivanja vlakna i matrice. U dobro povezanim kompozitima vrijednosti su bile unutar raspona od 0,16 do 0,20 [3]. Rezultati f_C za CR, C1, C2 i C3 kompozite su 0,18, 0,19, 0,17 i 0,17, što ukazuje na dobru povezanost vlakna i matrice, ali nije u skladu s prethodnim rezultatima niske čvrstoće za C2 uzorak (12 % prirasta kod čvrstoće u usporedbi s čistim PLA, što označava nedovoljnu povezanost). Hirsch-ov model pokazuje dobru korelaciju između eksperimentalnih i teoretskih rezultata. Predviđene vrijednosti vlačne čvrstoće bile su oko 10 % niže od eksperimentalnih vrijednosti, izuzev kod uzorka C2. Može se pretpostaviti da je kvaliteta veze matrica/vlakno u ovom uzorku bila vrlo slaba, u usporedbi s uzorkom C3, pri čemu je CA dodana kao ekološki pogodan umreživač s pozitivnim utjecajem na smanjenu gorivost celuloznih vlakana. Predviđene vrijednosti vlačnih modula elastičnosti bile su veće od eksperimentalnih vrijednosti, osim za uzorak C3 gdje su predviđene vrijednosti bile za 30 % i 20 % niže kod RoM, odnosno Hirsch-ovog modela. Razlozi koji mogu utjecati na predviđene rezultate su: upotreba modela koji dovoljno dobro odgovaraju slučajno orijentiranim vlaknastim ojačalima ali su primarno razvijeni za homogena i izotropna vlakna te stvaranje mikro-praznina između vlakana i matrice [3].



a. b.

Slika 1: Eksperimentalne i predviđene vrijednosti kompozitnih materijala**:** a) vlačne čvrstoće, b) vlačnog modula elastičnosti

4. Zaključak

Modificirana brnistrina vlakna korištena su kao ojačalo u kompozitnim materijalima s ciljem poboljšanja njihovih mehaničkih svojstava. Vlačna čvrstoća i vlačni modul elastičnosti kompozita ojačanog brnistrinim vlaknima modificiranim s MMT i CA (C3) porasli su za 164,0 % i 85,7 %, u usporedbi s čistim PLA uzorkom. Dobiveni rezultati potvrdili su poboljšanja mehaničkih svojstava primijenjenih uzoraka u usporedbi s prethodnim serijama – kompoziti ojačani vlaknima koja se prethodno nisu modificirala, niti se koristio umreživač u takvom sustavu. Usporedba eksperimentalnih i teoretskih rezultata vezanih za svojstava istezanja kompozitnih materijala provedena je korištenjem modela modificiranog zakona miješanja i Hirschovog modela. Predviđene vrijednosti vlačnih svojstava bile su usporedive samo s eksperimentalnim koeficijentom varijacije u slučaju CR uzorka, dok su predviđene vrijednosti vlačne čvrstoće pokazale djelomično dobro slaganje samo za Hirsch-ov model. Daljnja poboljšanja novih biokompozita zahtijevaju poboljšanje afiniteta između hidrofilnih vlakana (brnistrina vlakna modificirana s nanoglinom) i hidrofobne PLA matrice.

Zahvala

Istraživanja su provedena na Sveučilištu Brunel pri Fakultetu inženjerstva i dizajna u sklopu Zavoda za građevinarstvo u Uxbridgeu, Velika Britanija, a financiran je od strane zaklade British Scholarship Trust te Hrvatske zaklade za znanost u okviru projekta 9967 ADVANCETEX: *Advanced textile materials by targeted surface modification*.

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Ivan Kraljević

Životopis

Ivan Kraljević, rođen 1991. upisuje studij na Sveučilištu u Zagrebu Tekstilno-tehnološki fakultet 2010. Uspješno završava preddiplomski studij Tekstilne tehnologije i inženjerstva, smjer Projektiranje i menadžment tekstila, s temom *Vrednovanje kvalitete kože za izradu putnih torbi* 2013., a dvije godine kasnije i diplomski studij s temom *Ispitivanje postojanosti otiska na poluprerađenoj goveđoj koži* pod mentorstvom izv.prof.dr.sc. Antonete Tomljenović. U studenom 2016. upisuje poslijediplomski svučilišni studij Tekstilna znanost i tehnologija. Od veljače 2016. je zaposlen u Jadran Tvornici čarapa d.d., gdje od veljače 2017. radi kao voditelj pletione i šivaone. Kao doktorand je uključen u HRZZ projekt IP-2016-06-5278. Publicirao je četiri znanstvena rada, a područje znanstvenog interesa vezuje uz kvalitetu i ispitivanje novih materijala za izradu čarapa i kože.

Naslov teme doktorskog rada: Čarape visoke funkcionalnosti i mogućnosti objektivnog vrjednovanja

Studijski savjetnik: Izv. prof. dr. sc. Antoneta Tomljenović

Datum obrane teme doktorskog rada:

ČARAPE VISOKE FUNKCIONALNOSTI I MOGUĆNOSTI OBJEKTIVNOG VRJEDNOVANJA

Ivan KRALJEVIĆ
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1. Uvod

Broj europskih normi vezanih uz ispitivanje i karakterizaciju pletiva i čarapa je mali [1]. Gotovo da nema publiciranih radova koji obrađuju samo termofiziološku udobnost čarapa na termalnom stopalu. Mjerenja termofizioloških parametara čarapa obično se provode na termalnom stopalu skupa s obućom [2-4].

Iz navedenog proizlazi potreba proširenja istraživanja u području razvoja metodologije vrjednovanja njihove kvalitete te uporabne i funkcionalne trajnosti u uvjetima primjene. Stoga se u okviru planiranog doktorskog rada istraživanja usmjeravaju prema mogućnostima objektivnog vrjednovanja i razvoju metodologije za vrjednovanje uporabne i funkcionalne kvalitete čarapa, a u svrhu utvrđivanja optimalne termofiziološke udobnosti te funkcionalne učinkovitosti i trajnosti.

2. Eksperimentalni dio

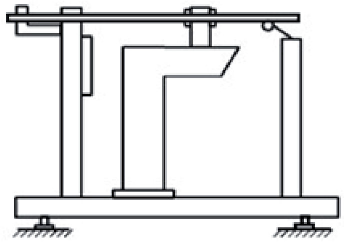
Ciljevi doktorskoga rada su:

- izraditi pletiva primjenom inovativnih pređa iz novih nedovoljno istraženih vlakana;
- primjenom normiranih metoda ispitati uporabna i funkcionalna svojstva pletiva;
- provesti analizu termofiziološke udobnosti pletiva u uvjetima stacionarne primjene definiranjem otpora prolazu vodene pare i toplinske otpornosti na vrućoj ploči;
- primjenom pređa različitog sirovinskog sastava i optimiranjem gustoće pletiva projektirati specifičnu više-zonsku strukturu čarapa u svrhu postizanja zadovoljavajuće udobnosti i visoke funkcionalnosti;
- izraditi čarape u komercijalnim uvjetima;
- ispitati termofiziološku udobnost čarapa mjerenjem otpora prolasku vodene pare i toplinske otpornosti primjenom nedestruktivnih metoda na Permetest-u (sl. 1a) i termalnom stopalu (sl. 1b);
- ispitati uporabna i funkcionalna svojstva čarapa prije i poslije opetovanih ciklusa simulirane uporabe i njege. Pritom uhodati metodu ispitivanja otpornosti pletiva čarapa na plošno habanje primjenom habalice po Martindale-u (sl. 1c) te razviti aparaturu za ispitivanje otpornosti čarapa na habanje (sl. 1d) prema HRN EN 13770:2008 [5].

a.

b.

c.



d.

Slika 1: Uređaji za ispitivanje čarapa: a) Permetest, b) termalno stopalo, c) modificirana habajuća glava habalice po Martindale-u, d) habalica za čarape [5]

3. Zaključci

Očekivani rezultati doktorskoga rada su:

- razvoj metodologije za vrjednovanje uporabne i funkcionalne kvalitete čarapa te
- razvoj prototipa udobnih čarapa visoke funkcionalnosti koje još nisu dostupne na tržištu.

Zahvala

Ovaj rad se financira sredstvima Hrvatske zaklade za znanost projektom IP-2016-06-5278 (*Udobnost i antimikrobna svojstva tekstila i obuće,* voditelj: prof. dr. sc. Zenun Skenderi).

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Suzana Kutnjak-Mravlinčić

Životopis	Suzana Kutnjak-Mravlinčić hrvatske je nacionalnosti i državljanstva, majka dvoje djece. Rođena je 26. 9. 1966. u Zagrebu, osnovnu završava u Ludbregu 1981., a srednju u Varaždinu 1985. godine. Na Tehnološki fakultet upisala se 1985. i diplomirala 1990., usmjerenje: projektiranje i oblikovanje tekstila i odjeće. Zapošljava se 1990. u Tekstilnoj srednjoj školi Varaždin, a 2007. u Srednjoj strukovnoj školi Varaždin. Na Filozofskom fakultetu Sveučilišta u Zagrebu – Pedagogijske znanosti 1993. završava dopunsko Pedagoško-psihološko obrazovanje. Odlukom Agencije za strukovno obrazovanje 2006. napreduje u zvanje profesor mentor, a 2011. u zvanje profesor savjetnik. Od 2007. radi kao vanjski suradnik u suradničkom zvanju asistent na Tekstilno-tehnološkom fakultetu Stručni studij Varaždin gdje je i zaposlena od ožujka 2015. u nastavnom zvanju predavač.
Naslov teme doktorskog rada	Utjecaj geometrije procesnih parametara pri 3D tisku akrilonitril butadien stirena na svojstva tiskanih šupljikavih struktura
Studijski savjetnici	Izv. prof. dr. sc. Ana Sutlović (TTF) Izv. prof. dr. sc. Damir Godec (Sveučilište u Zagrebu Fakultet strojarstva i brodogradnje)
Datum obrane teme doktorskog rada	

ISPITIVANJE MEHANIČKIH SVOJSTAVA I MOGUĆNOSTI BOJANJA 3D TVOREVINA OD AKRILONITRIL BUTADIEN STIRENA

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1. Uvod

Aditivna proizvodnja (AM) je proces povezivanja materijala pri izradi objekata izravno iz 3D računalnih modela, najčešće sloj na sloj. Iako ponekad postoji mogućnost izrađivati identičnu geometriju proizvoda od identičnog materijala kao i klasičnim postupcima, postoje razlike u svojstvima gotovih tvorevina. Stoga je odgovarajućim postupcima ispitivanja potrebno provjeriti kakva se mehanička svojstva mogu postizati postupcima aditivne proizvodnje. Za niskobudžetne 3D pisače najzastupljeniji materijal je akrilonitril butadien stiren (ABS) koji na tržištu dolazi u obliku polimera u žici (filament), a u trenutačnoj ponudi su uz crnu, bijelu i prozirnu, osnovne i sekundarne boje, izbor koji je često ograničavajući sa sastajališta dizajna [1-3].

2. Eksperimentalni dio

Eksperimentalni dio istraživanja sastoji se od ispitivanja utjecaja geometrije 3D ispitnih tijela na mehanička svojstva, te ispitivanja mogućnosti bojanja 3D tiskanih tvorevina postupkom iscrpljenja. Ispitna tijela modelirana suu računalnom programu *Rhinoceros* i tiskana iz ABS *MakerBot* filamenta na uređaju *MakerBot Replicator 2X*.

2.1 Ispitivanja utjecaja geometrije 3D tiskanih ispitnih tijela od ABS-a na mehanička svojstva

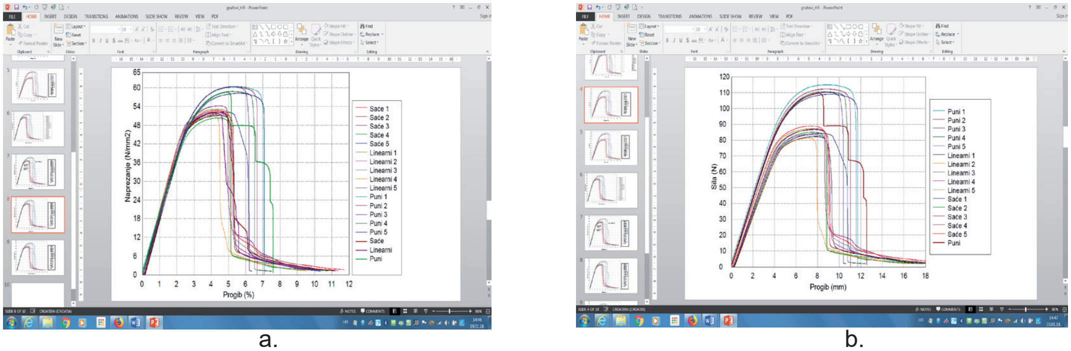
Provedena su istraživanja utjecaja ispune 3D tiskanih ispitnih tijela od ABS-a na savojna svojstva. Kako za sada nema posebnih normi koje propisuju ta mehanička ispitivanja korištena je norma za ispitivanje polimernih proizvoda načinjenih klasičnim postupcima proizvodnje, HRN EN ISO 178, Plastika - Određivanje savojnih svojstava. Za provedbu istraživanja, promjenjivi parametri koji su praćeni: gustoća i uzorak ispune. Odabrana su dva uzorka ispune, linearni i uzorak saća za koje je definirana gustoća ispune od 30 %, te puna ispuna. Stalni parametri ispisa su: debljina sloja 0,10 mm, broj vanjskih slojeva 3, temperatura glave pisača 230 °C i temperatura podloge pisača 110 ˚C. Računalni modeli (CAD) ispitnih tijela modelirani su prema dimenzijama propisanih normama. Prilikom 3D tiska ispitna tijela pozicionirana su uvijek na isti način na podlozi pisača, a u svakom je ispisu tiskano 5 ispitnih tijela za 3 seta uzoraka iz istog ABS materijala promjera 1,75 mm iz istog koluta. Za ispitivanje savojnih svojstava korišten je uređaj za ispitivanje mehaničkih svojstava proizvođača *Shimadzu*, maksimalne sile 10 kN. Snima se sila i odgovarajući progib uzorka tijekom ispitivanja koristeći automatski sustav snimanja te se određuju savojna naprezanja, progibi i istezanja definirana krivuljom savojnog naprezanja - istezanja i krivuljom savojnih sila.

2.2 Ispitivanja mogućnosti bojanja 3D tiskanih ABS tvorevina postupkom iscrpljenja

Ispitivanje mogućnosti bojanja 3D tiskanih tvorevina provedeno je postupkom iscrpljenja u aparatu Polycolor MATHIS disperznim, reaktivnim, kiselim i baznim bojilom Proces bojanja proveden je diskontinuiranim postupkom na temperaturi 90 ˚C uz omjer kupelji (OK) 1 : 30. Za ispitivanje mogućnosti bojanja 3D tiskanih ABS tvorevina postupkom iscrpljenja s ciljem ispitivanja mogućnosti postizanja šarenih, *ombre* efekata korištena su disperzna bojila.

3. Rezultati i rasprava

Iz dijagrama ispitanih savojnih svojstava vidljivo je da su maksimalna sila, maksimalno savojno naprezanje - istezanje i maksimalni progib kod serija linearne ispune i saća manji u odnosu na seriju ispitnih uzoraka pune ispune (sl. 1a i 1b). Ispitna tijela linearne ispune imaju u usporedbi s ispitnim tijelima pune ispune 25 % niža svojstva savojne čvrstoće, a ispitna tijela saćaste ispune 23 % niža svojstva. Iz dijagrama je vidljivo da su prikazane vrijednosti za ispitna tijela linearne ispune i saća vrlo slične, s manjim odstupanjima, dok su prikazane vrijednosti za ispitna tijela pune ispune nešto više.



a. b.

Slika 1: Dijagrami ispitanih mehaničkih svojstava: a) dijagram savojnog naprezanja – progiba za sve vrste ispuna, b) dijagram savojne sile – progiba za sve vrste ispuna

Bojanjem 3D tvorevina postupkom iscrpljenja, obzirom na kemijsku strukturu ABS-a, najbolja svojstva pokazala su disperzna bojila (sl. 2a). Druga bojila (sl. 2b-2d) nisu pokazala zadovoljavajuća bojadisarska svojstva. Kombinacijama disperznih bojila postignuti su kontrastni i tonski *ombre* efekti (sl. 2e).

a. b. c. d. e.

Slika 2: Obojani 3D uzorci postupkom iscrpljenja: a) disperznim bojilom, b) kiselim bojilom, c) reaktivnim bojilom, d) baznim bojilom i e) *ombre* efekti

4. Zaključci

Iz analize savojnih svojstava može se zaključiti da najbolja svojstva imaju ispitni uzorci pune ispune. Ukoliko željeni model mora trpjeti savojnu silu tijekom primjene preporučuje se izrada modela pune ispune iako i uzorci linearne i saćaste ispune mogu zadovoljiti dosta visoke kriterije, ali oko 25 % nižih savojnih svojstava. Dokazano je da se bojanjem 3D tiskanih tvorevina iz ABS-a postupkom iscrpljenja mogu dobiti zanimljiva i kreativna koloristička rješenja.

Zahvala

Rad se financira sredstvima Hrvatske zaklade za znanost u okviru projekta 9967, *Napredni tekstilni materijali dobiveni ciljanom modifikacijom površine*, ADVANCETEX.

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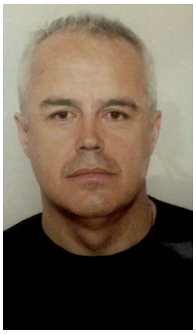

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Naslov teme doktorskog rada	Utjecaj tehnoloških parametara pletenja i konstrukcijskih karakteristika čarapa na kompresiju noge
Mentor	Prof. dr. sc. Zlatko Vrljičak
Datum obrane teme doktorskog rada	2. lipnja 2017.

UTJECAJ TEHNOLOŠKIH PARAMETARA PLETENJA I KONSTRUKCIJSKIH KARAKTERISTIKA ČARAPA NA KOMPRESIJU NOGE

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1. Uvod

Istezljivost i elastičnost pletiva omogućavaju čarapi da udobno priliježe uz nogu i bude samostojeća. Da bi čarapa mogla biti samostojeća potrebno je da opseg pletiva bude manji o opsega noge na koju čarapa naliježe. Različiti iznosi istezljivosti i elastičnosti se dobiju korištenjem pređa raznih sirovinskih sastava, struktura, finoća i rasteznih svojstava te prepleta [1,2]. Za izradu elastičnih čarapa koriste se poliamidne multifilamentne i elastanske pređe finoće 15 do 260 dtex [3,4]. Klasične kratke muške čarape izrađuju se s pamučnim ili vunenim pređama pri čemu se istovremeno upliće i PA mulitifilamentna pređa koja čarapi daje rastezljivost, a time i elastičnost. U okrajak čarape, koji omogućava čarapi samostojeći položaj, treba biti upletena grublja elastanska pređa, često finoće 25, 36, 44 ili 56 tex [5,6]. Iznos istezljivosti i elastičnosti utječu na udobnost nošenja čarape. Pritisak dijela pletiva čarape na nogu do 2,2 kPa (ili 16 mm Hg) smatra se malenim pritiskom i koristi se u svakodnevnoj upotrebi. Fine ženske čarape povećane kompresivnosti imaju kompresivnost do 2,5 kPa (ili do 19 mmHg). Medicinske čarape imaju kompresivnost 2,4 do 6,5 kPa, pa i više. Pojedini standardi imaju tri, četiri ili pet razreda kompresivnosti čarape na nogu [7-9]. Pri upotrebi čarapa, za mjerenje udobnosti nošenja ili ispunjavanja funkcije kompresije čarape, značajan je iznos pritiska čarape na nogu pri određenom rastezanju čarape. Funkcionalne medicinske čarape određenog stupnja kompresije izrađuju se po mjeri nogu osobe koja će nositi čarapu. Na taj je način omogućen zahtijevani pritisak čarape na određenom dijelu noge.

2. Eksperimentalni dio

Cilj eksperimenta je da se izmjeri kompresivnost čarape pri određenom stupnju istezanja. Također se za cilj može postaviti znatno složeniji zadatak, a to je da se izrade čarape s pređama određenih sirovinskih sastava, finoća i struktura te da se dobiju različiti pritisci čarape na pojedinom dijelu noge. Pri mjerenju kompresivnosti se uzimaju izmjere čarape u statičnom i aktivnom položaju i mjeri pritisak dijela čarape pri određenom rastezanju. U ovim istraživanjima, za mjerenje pritiska čarape na nogu izabran je model drvene noge na koju se čarapa navuče i mjeri pritisak. S pređama različitih finoća i različitim dubinama kuliranja izrađene su tri grupe kompresijskih čarapa s gaćicama za koje se pretpostavljalo da trebaju imati različite stupnje kompresije. U svakoj grupi bilo je po deset čarapa istih značajki.

3. Metoda rada

Kompresivnost čarapa se može mjeriti na razne načine [10-12]. Jedna od poznatijih i češće korištenih metoda je metoda drvene noge [10]. Osnovna koncepcija metode se zasniva na šest modela drvene noge različitih veličina. Modeli su napravljeni na osnovi statističkih podataka dobivenih mjerenjem populacije i teorijskom simulacijom rasporeda izmjera. Uređaj je namijenjen u prvom redu za mjerenje kompresivnosti kratkih, dokoljenki i dugačkih elastičnih i medicinskih kompresivnih čarapa te različitih oblika medicinskih proteza. Uređaj se sastoji od pet međusobno povezanih jedinica. Prvu jedinicu predstavlja model drvene noge određenih veličina na koji se navlači čarapa kao na kruto tijelo i mjeri tlačivost čarape na pojedinom dijelu njene duljine. Drugu jedinicu sačinjavaju mjerni senzori koji su postavljeni uzduž modela noge na pojedina mjesta značajna za mjerenje tlačivosti čarape na nogu. Treću jedinicu čini uređaj koji prikuplja podatke o tlačivosti i prikazuje ih na ekranu ili može obaviti ispis na vrpcu širine 56 mm. Četvrta jedinica nije obavezna, ali je poželjna u serijskom mjerenju, a to je računalo. Veoma kvalitetnim računskim programima skupljaju se rezultati mjerenja u računalu, obrađuju, sortiraju i po potrebi prezentiraju ili ispisuju u različitim oblicima. Peta jedinica je uređaj za umjeravanje cijelog mjernog sustava. Prema ustaljenoj liječničkoj praksi tlačivost čarapa se izražava u mmHg ili po želji u kPa.

4. Rezultati i rasprava

S medicinskog gledišta najveća kompresivnost kompresijske čarape treba biti iznad gležnja čarape. Izrađene su tri grupe kompresijskih čarapa s gaćicama koje imaju različite stupnjeve kompresije. Kompresivnost čarapa mjerena je na drvenom modelu noge veličine 4. Prva grupa čarapa je najmanje kompresivnosti. U području gležnja ima najveću prosječnu kompresiju koja iznosi 3,4 kPa (25,7 mmHg). Na dnu lista noge čarapa ima kompresiju 2,5 kPa (18,9 mmHg), ispod koljena 1,9 kPa (14 mmHg), iznad koljena 1 kPa (7,2 mmHg) i u preponama svega 0,24 kPa (1,8 mmHg). Druga čarapa ima malo veću kompresivnost koja u gležnju iznosi 3,9 kPa (29 mmHg), a u području prepona 0,17 kPa (1,3 mmHg). Treća čarapa ima najveću kompresivnost i u području gležnja iznosi 4,1 kPa (30,7 mmHg), a u području prepona svega 0,9 kPa (6,5 mmHg), ili 21,2 % u odnosu na kompresiju u gležnju. Najveća kompresivnost čarape je dobivena pri pletenju s najmanjom dubinom kuliranja. Pri ovakvom radu izrađuje se najuži dio pletiva u čarapi koji se i najmanje isteže pri upotrebi.

5. Zaključak

Kompresivnost čarapa moguće je izmjeriti na modelima drvene noge pri čemu je potrebno uskladiti veličine čarape i modela drvene noge. Veličina kompresivnosti ovisi o strukturama pređa, regulaciji stroja, vrsti prepleta i veličini rastezanja kod mjerenja kompresivnosti. Kod izrađenih uzoraka prosječna kompresivnost čarapa u području gležnja je iznosila 3,4 do 4,1 kPa, a u području prepona 0,17 do 0,9 kPa. Izrađene i analizirane kompresijske čarape mogu se koristiti kao prevencijske ili terapijske u liječenju kronične venske insuficijencije određenog stupnja oboljenja.

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Naslov teme doktorskog rada	Površinska modifikacija pamučnih tekstilija usporivačima gorenja metodom nanosa sloj-po-sloj
Mentori	Prof. dr. sc. Sandra Bischof (TTF) Prof. dr. sc. Bojana Vončina (Univerza v Mariboru Fakulteta za strojništvo)
Datum obrane teme doktorskog rada	20. svibnja 2016.

POVRŠINSKA MODIFIKACIJA PAMUČNIH TEKSTILIJA USPORIVAČIMA GORENJA METODOM NANOSA SLOJ-PO-SLOJ

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1. Uvod

Današnja komercijalna sredstva za obrade protiv gorenja pamuka na bazi halogenih, organo-halogenih i antimon organo-halogenih spojeva su toksična, a sredstva na bazi organofosfornih spojeva se za sada smatraju sigurnima za upotrebu, dijelom zbog nedostatka podataka o stvarnom utjecaju na okoliš i zdravlje [1-3]. Zbog brojnih ekoloških problema koji se javljaju u proizvodnji, uporabi i zbrinjavanju tako obrađenih tekstilnih materijala javlja se potreba za njihovom djelomičnom ili potpunom zamjenom novim alternativnim ekološki povoljnijim sredstvima i/ili tehnološkim rješenjima, a jedan od mogućnosti je postupak "sloj-po-sloj" (LbL) naslojavanje. LbL predstavlja površinsku adsorpciju dugolančanih molekula polielektrolita određenog naboja na supstrat suprotnog naboja, nakon čega slijedi faza ispiranja deioniziranom vodom. U drugoj fazi se na pozitivno nabijeni polielektrolit veže negativno nabijeni polielektrolit i tako naizmjenice. Na taj način moguće je slagati nekoliko slojeva istih ili potpuno različitih polielektrolita [4]. LbL naslojavanje je u eksperimentalnoj fazi ispitivanja u svrhu zaštite materijala od gorenja upotrebom različitih sredstava.

2. Eksperimentalni dio

Tri vodene otopine natrijevog fitata, PA (Carbosynth Ltd, UK) i razgranatog polietilenimina, BPEI (Sigma-Aldrich) pripremljene su pomoću 18,2 MΩ·cm deionizirane vode prema tablici 1. Devet uzoraka kemijski bijeljene pamučne tkanine gustoće 177 g/m^2 (Pamučna industrija d.d. Duga Resa) uronjene su naizmjenice u vodenu otopinu pozitivno nabijenog BPEI-a i negativno nabijenog natrijevof fitata stvarajući pritom 1, 5, 10 disloja. Nakon svakog uranjanja uzorci su isprani u deioniziranoj vodi, te sušeni na 50 °C.
Ponašanje pri gorenja uzoraka mjereno je na (LOI-u Limiting Oxygen Indeks, Dynisco) prema EN ISO 4589-2. Termalna stabilnost tkanine mjerena je termogravimetrijskom (TG) analizom na PerkinElmer Pyris 1 TGA uređaju za termogravimetrijsku analizu na temperaturama grijanja od 50 °C do 700 °C uz brzinu zagrijavanja 40 °C/min u zraku (protok: 30 ml/min). Kemijski sastav ostatka nakon grijanja na TG-u je analiziran na Tescan MIRA\\LMU FE-SEM elektronskom mikroskopu (BSE detektor, 20 kV) opremljenom EDS detektorom.

Tablica 1: Eksperimentalni dio i dobiveni rezultati vrijednosti LOI-a i masenog udjela ostatka nakon gorenja na TG-u.

Uzorak	BPEI (maseni udio %)	PA (maseni udio %)	Broj dislojeva	Ostatak nakon gorenja (%)	LOI (%)
0 – neobrađeni	n/p	n/p	n/p	0,000	18,5
1	1	5	1	1,712	19,0
2	1	5	5	1,714	20,0
3	1	5	10	7,275	20,0
4	1	10	1	4,565	21,0
5	1	10	5	2,568	22,0
6	1	10	10	4,850	22,0
7	1	50	1	29,387	29,0
8	1	50	5	2,275	29,0
9	1	50	10	2,282	29,0

3. Rezultati i rasprava

Za pamučnu tkaninu karakteristična je niska vrijednost LOI (18,5 %). LbL obrada povećava vrijednosti LOI-a na 20 % na uzorku 2 i 3 (maseni udio PA 10 %) prema tablici 1. Daljni porast LOI vrijednosti (22 % i 23 %) postiže se povećanjem masenog udjela PA iznad 10 %. Najveće LOI vrijednosti (28 % i 29 %) postignute su obradom pri masenom udjelu PA od 50 %. Porast broja dislojeva, međutim, ne prati porast LOI vrijednosti kako se teoretski očekuje. Vrijednost LOI vrijednosti pamučnih uzoraka obrađenih 5 % otopinom PA najveća je kod 5 dislojeva (21 %), zatim kod 1 i 10 dislojeva (20 %). LOI vrijednosti pamučnih uzoraka obrađenih masenim udjelom PA (10 %) je 22 % (1 disloj) i 23 % (5 i 10 dislojeva). Između 3 uzorka pamuka obrađenih masenim udjelom PA (50 %), najviša LOI vrijednost dobivena je na 1 disloj (29 %).
Teorijski bi se očekivalo da masa ostatka nakon zagrijavanja u TG-u linearno raste od neobrađenog pamuka do LbL obrađenog pamuka s povećanjem masenog udjela PA (5 %, 10 %, 50 %), kao i s povećanjem broja dislojeva (1, 5, 10). U ovome radu najviša masa ostatka nakon zagrijavanja u TG-u (29,387 %) dobivena je kod masenog udjela PA od 50 % u 1 disloju (uzorak 7). To znači da se natrijev fitat taloži na površinu pamučne tkanine obrađene BPEI-om kod visokog masenog udjela PA zbog zasićenosti vodene otopine natrij fitatom, no ne dolazi do naslojavanja negativno nabijenog fitata na pozitivno nabijeni BPEI. EDS kemijska analiza ostatka nakon gorenja pokazuje uglavnom sadržaj ugljika, fosfora, natrija i ostalih elemenata u tragovima (aluminij, magnezij, kalcij) kao nečistoće tehničkog natijevog fitata. EDS analiza nije dokazala postojanje dušika što znači da se tijekom zagrijavanja oslobađaju dušikovi plinski produkti.

4. Zaključci

Ekološki povoljni polielektroliti su uspješno naslojeni na pamuk uz pomoć LbL metode naslojavanja. Povećanjem broja BPEI/PA dislojeva (1, 5, 10), kao i koncentracije natrijevog fitata u vodenoj otopini (5 %, 10 % i 50 %), dobivene vrijednosti LOI-a, kao i mase ostatka nakon zagrijavanja u TG-u ukazuju na smanjenje gorivosti pamučnih tkanina. Povećanje PA koncentracije u vodenoj otopini uzrokuje kontinuirano smanjenje gorivosti pamuka. Istovremeno povećanje broja dislojeva pokazuje manje izražen utjecaj na gorivost pamuka uz istu koncentraciju PA. Kod vrlo visoke koncentracije polielektrolita (PA 50 %), LbL naslojavanje nije primjenjivo.

Zahvala

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Naslov teme doktorskog rada	Dinamičko ponašanje odjeće pod utjecajem biomehanike tijela
Mentor	Izv. prof. dr. sc. Slavenka Petrak
Datum obrane teme doktorskog rada	5. srpnja 2016.

DINAMIČKO PONAŠANJE ODJEĆE POD UTJECAJEM BIOMEHANIKE TIJELA

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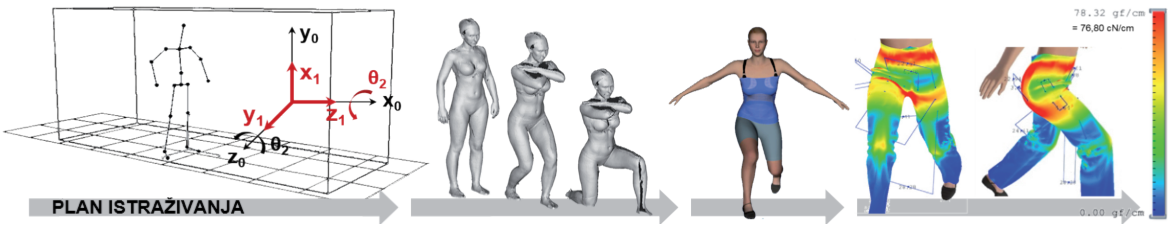
1. Uvod

Ljudsko tijelo, njegov oblik i kinematika kretanja, temelj su istraživanja u području dizajna i razvoja novih modela odjevnih predmeta. Razvoj računalnih tehnologija i CAD sustava za 2D/3D projektiranje odjeće omogućili su 3D simulaciju odjeće i analizu pristalosti računalnih prototipova, sa svrhom predviđanja izgleda i funkcionalnosti novih modela odjevnih predmeta u procesu konstrukcijske pripreme. Pristalost odjeće u statičkim uvjetima odnosi se na pristalost odjevnog predmeta obliku ljudskog tijela, a stupanj pristalosti ovisi o vrsti i namjeni odjevnog predmeta, kvaliteti konstrukcijskog rješenja te o vrsti i svojstvima ugrađenog materijala, koja se iskazuju na temelju vrijednosti pojedinih parametara mehaničkih i fizikalnih svojstava. Pristalost odjeće u dinamičkim uvjetima odnosi se na pristalost odjeće na tijelu u pokretu, pri čemu odjevni predmet ne smije ograničavati pokret tijela niti pokret smije izazvati pretjerano naprezanje u tekstilnom materijalu od kojeg je odjevni predmet izrađen, a visoki zahtjevi posebno su izraženi kod odjeće specijalnih namjena, koja mora osiguravati nesputane ekstremne pokrete [1,2]. Visoka pristalost odjeće postiže se kompleksnom analizom karakteristika oblika i kinematike ljudskog tijela te sustavnom primjenom stečenih znanja u procesu inženjerskog projektiranja odjeće. Integriranjem različitih suvremenih sustava za analizu ljudskog tijela i pokreta, poput 3D skenera tijela i *Motion Capture* (MC) sustava u proces računalnog 3D projektiranja, omogućena je detaljna analiza antropometrijskih i kinematičkih karakteristika tijela te primjena njihovih parametara u procesu konstrukcije kroja [3-6]. Istraživanja i računalne analize naprezanja odjevnog predmeta temelje se na fizikalnoj simulaciji ponašanja odjeće na tijelu u statičkom ili različitim dinamičkim položajima pri čemu se analiziraju deformacije geometrije računalnog prototipa odjevnog predmeta u interakciji s tijelom, određene kontaktnom mehanikom tijela i odjeće te parametrima fizikalnih i mehaničkih svojstava određene tkanine [7,8].

2. Metode istraživanja

U okviru eksperimentalnog dijela doktorskog rada provest će se analiza dimenzija segmenata površine tijela u statičkim i dinamičkim uvjetima te će se ispitati korelacija tipova oblika i razvijenosti tijela s promjenama dimenzija segmenata površine u dinamičkim uvjetima. Provest će se snimanje i biomehnička analiza ciljanih pokreta za tri različita tipa razvijenosti tijela. Na temelju rezultata provedenih analiza razviti će se matematički model za animaciju skeniranih modela tijela. Animirani modeli tijela koristit će se za računalnu simulaciju odjeće te će se analizom parametara mehaničkih svojstava simulirane tkanine kod malih opterećenja ispitati naprezanje odjevnog predmeta na karakterističnim kritičnim zonama u statičkim i dinamičkim uvjetima (sl. 1). Na temelju rezultata istražit će se i definirat funkcijski odnos između vlačnih svojstava tkanina, konstrukcije kroja i biomehanike tijela u pokretu.



Slika 1: Plan istraživanja doktorskog rada

3. Cilj i hipoteze

Glavni cilj doktorskog rada je razviti metodu za računalnu analizu pristalosti odjeće u dinamičkim uvjetima. U skladu s ciljem istraživanja postavljene su slijedeće hipoteze:

H1: Deformacije površine tijela u pokretu ovise o razvijenosti i obliku tijela te se razvojem i primjenom matematičkih modela za prilagodbu kinematičkih točaka na tijelu i deformaciju segmenata površine ovisno o pojedinom tipu tijela može ostvariti realistična animacija skeniranog modela tijela primjenjiva za računalnu 3D simulaciju odjeće u dinamičkim uvjetima.
H2: Modeliranjem ciljanog mehaničkog ponašanja tkanine pri simulaciji odjevnog predmeta, ostvarit će se deformabilnost površine odjevnog predmeta u korelaciji s deformabilnošću tipa tijela u zadanom pokretu.
H3: Na temelju analize deformacija geometrije računalnog modela odjevnog predmeta u interakciji s modelom tijela u pokretu, može se vjerodostojno vrednovati naprezanje odjevnog predmeta u dinamičkim uvjetima.

4. Očekivani znanstveni doprinos doktorskog istraživanja

Na temelju cjelovitog istraživanja razvit će se nova metoda za računalnu analizu dinamičkog naprezanja odjeće temeljena na 3D simulaciji mehaničkog ponašanja modela odjevnog predmeta na animiranom skeniranom modelu tijela. Modeliranjem ciljanih mehaničkih svojstava i ponašanja odjevnog predmeta pri 3D simulaciji na tijelu u pokretu omogućit će se analiza deformabilnosti površine računalnih prototipova, a time i analiza naprezanja na kritičnim zonama odjevnog predmeta. Doprinos doktorskog rada će biti novorazvijena metoda koja predstavlja inovativni pristup problematici ocjene pristalosti modela odjeće na individualiziranom računalnom modelu tijela u dinamičkim uvjetima.

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Naslov teme doktorskog rada	Kozmeto-tekstilije kao prijenosnici aktivnih tvari prirodnog porijekla na kožu
Mentor	Prof. dr. sc. Sandra Bischof
Datum obrane teme doktorskog rada	21. lipnja 2016.

KOZMETO-TEKSTILIJE KAO PRIJENOSNICI AKTIVNIH TVARI PRIRODNOG PORIJEKLA NA KOŽU

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1. Uvod

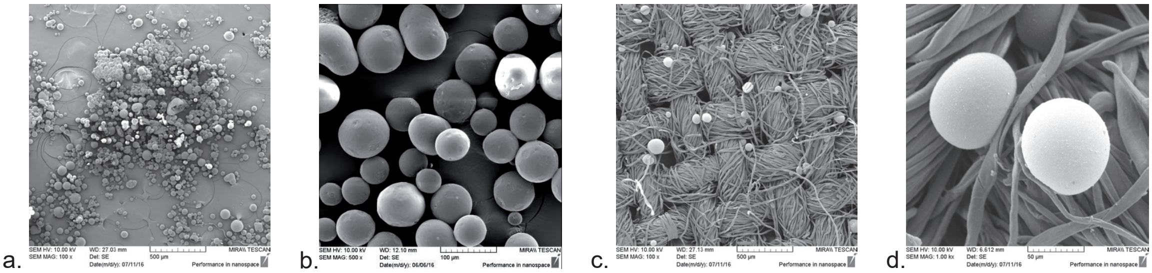
Tekstil i kozmetika su među najstarijim proizvodima koje je čovjek ikad napravio, ali povezivanje tekstila i kozmetike u obliku kozmeto-tekstilija je relativno novi koncept primjene i istraživanja koji je veoma značajan za 21. stoljeće [1,2]. Najzanimljiviji način „pohrane" kozmetičkog sredstva je mikrokapsulacija zbog mogućnosti kontroliranog otpuštanja aktivnog sredstva. Taj način je ujedno i najčešće primjenjivana tehnologija koja se koristi za ciljano, tj. kontrolirano otpuštanje sredstava [3]. Mikrokapsulacija je tehnika kojom se formiraju čestice u (tekućem, krutom ili plinovitom stanju) unutar ovojnice (ljuske) te se dobivaju proizvodi sfernog oblika, mikro ili nanometarske veličine. Ovojnica može štititi aktivnu tvar ili može biti porozna i ispuštati aktivno sredstvo [4,5]. Ovisno o učinku koji se želi postići na koži, npr. revitalizacija, hidratacija, zaštita kože, smanjenje ili sprječavanje nastanka akni, mrlja, ekcema itd., mogu se koristiti različite biljne supstance. One pružaju željeni efekt za ciljanu kozmetičku namjenu, ili više njih, jer svaka od supstanci najčešće ima više područja djelovanja [6]. Kada se govori o tekstilnim supstratima koji imaju sposobnost otpuštanja aktivnih supstanci uvjet je da su na vlakna/materijal prethodno nanesene supstance koji daju medicinska ili „*wellness*" svojstva. Općenito se na tekstilni supstrat aktivne supstance adsorbiraju, naslojavaju ili kapsuliraju [3]. Tekstilni supstrat može biti obrađen bioaktivnim supstancama u prisutnosti odgovarajućih aditiva kako bi se pospješilo kovalentno vezivanje sredstva na tekstil.

2. Eksperimentalni dio

Metodologija plana istraživanja: 1. Odabrati biljna, medicinska i/ili kozmetička sredstva koja će se kapsulirati u odgovarajuću matricu. 2. Provesti fizikalno-kemijske metode analize odabranog kozmetičkog sredstva (FTIR, HPLC, UV/VIS spektrofotometrija). 3. Odabrati tekstilni supstrat koji će biti prikladan za aplikaciju odabranog sredstva. 4. Optimizirat će se parametri za sintezu mikrokapsula. 5. Izabrat će se najprikladniji postupak nanašanja aktivnog sredstava. 6. Optimizirat će se parametri sušenja i fiksiranja aktivnog sredstva na supstrat. 7. Provesti karakterizaciju aktivnih sredstava na supstratu primjenom različitih fizikalno-kemijskih metoda analize („test kapi", mikrovalna ekstrakcija, FTIR, HPLC, UV/VIS spektrofotometrija). 8. Provesti karakterizaciju površine obrađenog supstrata. 9. Provesti ispitivanja mehaničkih svojstava kozmeto-tekstilija. 10. Istražiti potencijalni rizik primijenjenih kozmeto-tekstilija u direktnom kontaktu s kožom. U ovom radu su sintetizirane mikrokapsule gdje su jezgre ispunjene α-tokoferolom (DL-α-tocopherol, Calbiochem) obložene ovojnicom od etil celuloze (viskoznost 4cP, Sigma Aldrich) prema patentu US 6932984 B1. Dobivene kozmeto - mikrokapsule su postupkom impregnacije nanesene na pamučnu tkaninu.

3. Rezultati i rasprava

Sintetizirane mikrokapsule su uz pomoć SEM-a (sl. 1) okarakterizirane kao čestice sfernog oblika prosječnog radijusa 30 μm [7].



Slika 1: SEM slike mikrokapsula i kozmeto-tekstilije uz različita povećanje: a) mikrokapsule 100x, b) mikrokapsule - 500x, c) kozmeto-tekstilija - 100x, d) kozmeto-tekstilija - 1000x

4. Zaključci

Najzanimljiviji način „pohrane" kozmetičkog sredstva je mikrokapsulacija zbog mogućnosti kontroliranog otpuštanja aktivnog sredstva. Očekivani rezultati istraživanja imaju potencijalni značaj za daljnji razvoj materijala sa dodatnim svojstvima uz široku primjenu u kozmetičkoj industriji kao i u području medicine.
Znanstveni doprinos ove disertacije će biti:

1. Razvoj inovativnih, ekološki povoljnih i biorazgradivih kozmetičkih tekstilija koje mogu imati i medicinski učinak.
2. Poboljšanje učinkovitosti kozmeto-tekstilija optimiranjem metoda proizvodnih postupaka mikrokapsuliranja. Kao što je i vidljivo iz rezultata, sinteza se pokazala uspješnom.
3. Doprinos klasifikaciji i standardizaciji metoda za ispitivanje kozmetičkih, aromaterapeutskih ili medicinskih učinaka kozmeto-tekstilija uz pomoć SEM-a i HPLC-a.

Zahvala

Rad je podržan od strane Hrvatske zaklade za znanost pod projektom 9967 *Napredni tekstilni materijali dobiveni ciljanom modifikacijom površine*, ADVANCETEX.

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Naslov teme doktorskog rada	Projektiranje funkcionalnog odjevnog predmeta za osobe s tjelesnim deformacijama
Studijski savjetnici	Prof. dr. sc. Željko Penava Doc. dr. sc. Slavica Bogović
Datum obrane teme doktorskog rada	

PROJEKTIRANJE FUNKCIONALNOG ODJEVNOG PREDMETA ZA OSOBE S TJELESNIM DEFORMACIJAMA

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1. Uvod

Poboljšana medicinska skrb i sve starije stanovništvo u zemljama zapada dovodi do značajnog povećanja broja osoba s posebnim potrebama. Starija populacija je više izložena obolijevanju i utjecaju različitih bolesti koje mogu dovesti do teških stupnjeva invaliditeta i u takvom stanju mogu provesti još dugih niz godina pa se pojavljuje potreba za funkcionalnim pristupom u odijevanju kako korisnika tako i proizvođača odjeće.

Istraživanja pokazuju da odjeća za osobe s tjelesnim deformacijama koja se može pronaći na tržištu nije zadovoljavajuća. Uglavnom je unificirana, nedovoljno spolno i individualno prilagođena, nedostatna ponuda za korisnike u odnosu na standardnu odjeće, čime osobe s tjelesnim deformacijama osjećaju kako ova posebna odjeća još više naglašava njihove tjelesne nedostatke. Neki proizvođači odjeće izrađuju posebno dizajniranu odjeću za osobe u invalidskim kolicima. Međutim, osobe s tjelesnim deformacijama često se ne uklapaju u standardne veličine, čime izdvajaju veću količinu novčanih sredstava da bi imali funkcionalnu odjeću, nedovoljno prilagođenu njihovim potrebama. Problemi konstrukcije ovakve odjeće su kompleksni tako da se različiti zahtjevi pojavljuju za svaku kategoriju tjelesne deformacije [1-3].

Odjeća za osobe s posebnim potrebama podrazumijeva odjeću i odjevne sustave koji imaju svrhu zaštititi ljude od raznih opasnosti i utjecaja kojima su izloženi. Stoga, da bi se osigurala adekvatna funkcionalnost odjeće nužno je sustavno pristupiti ovoj problematici pri čemu je potrebno proučiti vanjske utjecaje, mehanička svojstva materijala (posmik i elastičnost) te iznaći kvalitetna rješenja pri projektiranju odjevnog predmeta s naglaskom na funkcionalnost, neškodljivost i udobnost.

Pravilno oblikovanje funkcionalnog odjevnog predmeta doprinosi boljoj zaštiti i osjećaju sigurnosti korisnika, a može se ostvariti individualnim pristupom u izradi odjevnog predmeta po mjeri. U tu svrhu je važno uspoređivati i analizirati obilježja digitaliziranih ljudskih tijela kao i iznalaženje novih računalnih metoda za bolju prilagodbu kroja određenom obliku tijela i bolju funkcionalnost odjevnog predmeta ili odjevnog sustava.

Kako su tekstilije za izradu odjeće za osobe s posebnim potrebama podložne deformacijama od iznimne je važnosti predvidjeti ponašanje materijala u određenim položajima tijela. Tako na primjer korisnicima invalidskih kolica i osobama koje duže vrijeme provedu u krevetu budući da imaju slabu cirkulaciju koja utječe na temperaturu tijela, bitna su svojstava toplinske udobnosti.

Osim navedenog, deformacija materijala na određenim dijelovima odjevnog predmeta prilikom upotrebe je od izuzetnog značaja. Određivanje posmika smatra se jednim od najvažnijih mehaničkih svojstava tkanine. Posmik izravno utječe na svojstva tkanine tijekom njezine upotrebe, jer zbog anizotropije tekstilnih plošnih proizvoda tj. osobine da u različitim smjerovima imaju drugačija fizička svojstva potrebno je provesti ispitivanje u različitim smjerovima. Očekivani rezultat eksperimenta bi trebali pokazati visoki stupanj korelacije između posmika i njegove aksijalne komponente, a koji bi se analizirali na odjeći za osobe s posebnim potrebama u svakodnevnom korištenju [2-4].

2. Metodologija

U radu će se digitalizirati ljudsko tijelo primjenom 3D skenera. Skeniranje će se provoditi u specifičnim položajima ovisno o namjeni funkcionalnog odjevnog predmeta i stupnju deformacije tijela. Na taj način će se moći analizirati maksimalni pokreti dijelova tijela i njihov utjecaj na kinematički lanac pokreta, koji se kod invalidnih osoba u velikoj mjeri razlikuje u odnosu na zdrave osobe.

Budući da deformacije tijela i pokretljivost određenih dijelova tijela neposredno utječe na oblik, pristalost i funkcionalnost odjevnog predmeta, nužno je individualno analizirati oblike i mjere tijela koji su temelj za projektiranje prilagođenog odjevnog predmeta.

Konvencionalno projektiranje odjeće za ljude s tjelesnim deformacijama, koji zbog invalidnosti koriste invalidska kolica, nije u dovoljnoj mjeri prilagodljivo za razvoj funkcionalnog odjevnog predmeta. Stoga će se u radu istraživati načini oblikovanja kroja i odjevnog predmeta koji će biti individualizirani i primjenjivi za osobe sličnih tjelesnih karakteristika. Iznalaženjem korelacije između ključnih korespondentnih točaka na tijelu i temeljnom kroju, te računalnom obradom ulaznih podataka i istraženih funkcionalnih svojstava odjevnog predmeta odabrat će se najpogodniji matematički model pomoću kojeg će se projektirati odjevni predmeti.

U obzir će se uzeti utjecaj sile smicanja u odnosu na kut smicanja jer su zbog specifičnosti oblikovanja kroja za osobe s tjelesnim deformitetima krojni dijelovi različito usmjereni u odnosu na smjer osnove.

Korištenje podataka dobivenih na temelju inicijalnog modula elastičnosti i početnog modula smicanja materijala pri projektiranju odjevnog predmeta doprinijet će boljoj udobnosti i funkcionalnosti u određenim područjima, lakta, koljena ili sjedalnog šava, koji su ključni u uvjetima smanjene pokretljivosti dijelova tijela [2-5].

3. Cilj istraživanja

Cilj istraživanja je pronaći korelaciju između sličnih oblika tijela s tjelesnim deformacijama koja će omogućiti individualno projektiranje odjevnog predmeta.

Na temelju korelacije će se definirati najpogodnija računalna metoda koja će omogućiti dodatnu prilagodbu kroja zbog razlika u mjerama u svrhu povećanja funkcionalnosti odjevnog predmeta za osobe sa tjelesnim deformacijama koje se kreću pomoću invalidskih kolica.

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Željka Pavlović

Životopis

Željka Pavlović je rođena 4. veljače 1987. godine u Zaboku. Nakon završene osnovne škole u Samoboru, upisuje Ekonomsku, trgovačku i ugostiteljsku školu te je završava 2005. godine. U periodu od 2005. do 2012. godine studira na Sveučilištu u Zagrebu Tekstilno-tehnološki fakultet, gdje je diplomirala s temom „*Upotrebna svojstva kratkih čarapa*“, mentor prof. dr. sc. Zlatko Vrljičak. Nakon završenog studija zapošljava se u Tvornici čarapa Jadran d.d., gdje je 3,5 godine radila kao tehnolog u proizvodnji. U 2015. godini zaposlena je kao asistent na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu, na Zavodu za projektiranje i menadžment tekstila. U 2016. godini 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.

Naziv teme doktorskog rada	Utjecaj elastanske pređe i prepleta na elastičnost pletiva za čarape
Studijski savjetnik	Prof. dr. sc. Zlatko Vrljičak
Datum obrane teme doktorskog rada	

UTJECAJ ELASTANSKE PREĐE I PREPLETA NA ELASTIČNOST PLETIVA ZA ČARAPE

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1. Uvod

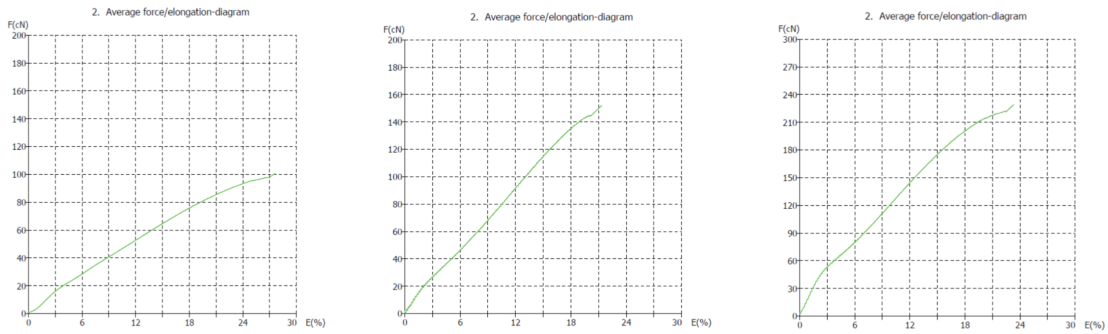
Elastanska vlakna su vrlo rastezljiva umjetna vlakna, velike sposobnosti elastičnog oporavka nakon rastezanja. Njihovo prisustvo u mješavini s drugim vlaknima, odjeći osigurava elastičnost i udobnost pri nošenju. Većim udjelom elastanskih pređa postižu se posebni kompresijski učinci tekstilnih proizvoda za posebne namjene [1]. Za izradu finih ženskih čarapa najčešće se koriste kombinacije poliamidnih (PA), poliesterskih (PES) i elastanskih (EL) filamentnih niti. Elastanska se nit može, pored PA multifilamentne niti, uplesti u svaki red, u pojedine redove ili samo na pojedinim dijelovima čarape [2]. Kompozitne elastanske pređe s omotanom jezgrom su ključni elementi za izradu pletiva s funkcijom medicinske kompresije, koje se obično ispredaju omotavanjem prirodnih ili sintetičkih filamentnih vlakana (npr. pamuk, poliamid, poliester, viskoza, polipropilen) oko rastezljive jezgre poput lateksa ili poliuretana (PU) [3].

2. Eksperimentalni dio

Cilj ovog eksperimenta je određivanje duljine poliamidne i elastanske pređe upletene u red pletiva u svrhu postizanja određene elastičnosti pletiva. Korišten je čaraparski automat promjera iglenice 4e″ koji je pleo s 400 igala na četiri pletaća sistema. Ispleten je uzorak čija je temeljna struktura pletena u desno-lijevom prepletu, s poliamidnom multifilamentnom pređom finoće PA 60 dtex f60, a platiralo se u svakom redu elastanskom pređom finoće 22/17 dtex f7. Utrošak niti u očici je najčešći parametar koji opisuje strukturu pletiva [5]. Kod ovakvih zbijenih struktura pletiva izrađenim finim multifilamentnim pređama nije jednostavno odrediti utrošak pređe za oblikovanje očice jer se pređe teško paraju [6]. Predopterećenje za mjerenje duljine PA multifilamentne pređe finoće 60 dtex f60 iznosilo je 3 g ili 0,5 cN/tex. Jedan kraj isparane niti je učvršćen u gornju hvataljku, a drugi kraj je uz slobodni pad opterećen utegom od 3 g. Za elastansku pređu nije bilo jednostavno odrediti predopterećenje jer se radi o omotanoj elastanskoj pređi koja se sastoji od elastanske niti finoće 22 dtex oko koje je omotana PA multifilamentna pređa sastavljena od 7 niti ukupne finoće 17 dtex. Zbog toga je duljina oparane elastanske pređe mjerena s tri opterećenja. Prvo je mjerenje obavljeno bez opterećenja pri čemu je elastanska pređa učvršćena u gornju hvataljku, a drugi je kraj slobodno padao. Mjerenje druge oprane niti provedeno je uz opterećenje mase 1 g. U trećem slučaju predopterećenje je bilo 2 g.

3. Rezultati i rasprava

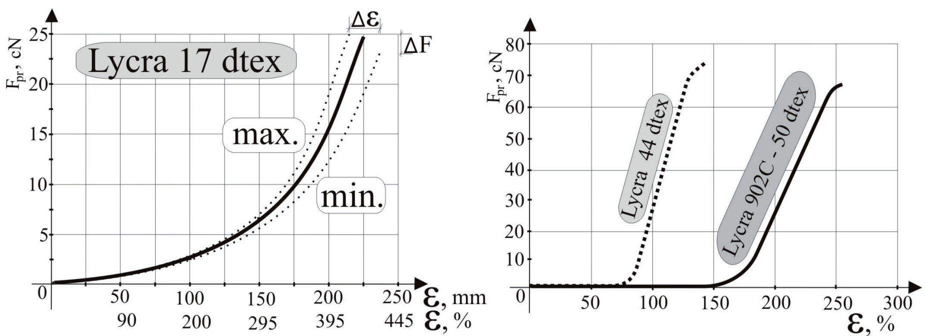
Duljina oparane poliamidne niti mjerene predopterećenjem od 3 g iznosila je od 875 do 910 mm u redu pletiva. Duljina oparane elastanske pređe mjerene bez predopterećenja iznosila je od 205 do 240 mm. Duljina oparane elastanske pređe mjerene s malim predopterećenjem od 1 g iznosila je od 455 do 480 mm. Duljina oparane elastanske pređe mjerene s predopterećenjem od 2 g iznosila je od 610 do 645 mm.



a. b. c.

Slika 1: Dijagrami naprezanja uzoraka PA multifilamentnih pređa finoće: a) 20 dtex f20, b) 40 dtex f 40 i c) 60 dtex f60

Na slici 1 su prikazana prekidna svojstva PA multifilamentnih pređa različitih finoća koje se koriste u izradi finih ženskih čarapa. Za uzorak pređe najmanje finoće (sl.1a) prekidna sila iznosi 100 cN a prekidno istezanje 28 %. Za uzorak pređe s finoćom 40 dtex (sl.1b) prekidna sila iznosi 153 cN, a prekidno istezanje 22 %. Za uzorak pređe s najvećom finoćom (sl.1c) prekidna sila iznosi 230 cN, a prekidno istezanje 23 %.



a. b.

Slika 2: Dijagram vlačnih svojstva elastanskih pređa različitih finoća koje se koriste u izradi finih ženskih čarapa: a) Lycra 17 dtex, F_{pr} = 25 cN, ε = 424 %, b) Lycra 44 dtex, F_{pr} = 73 cN, ε = 148 % i Lycra 902C, 50 dtex, F_{pr} = 64 cN, ε = 261 %

4. Zaključak

Dobiveni rezultati ukazuju da pri određivanju elastičnosti svojstava poliamidnih i elastanskih multifilamentnih pređa namijenjenih izradi ženskih čarapa od krucijalne je važnosti odrediti optimalno predopterećenje.

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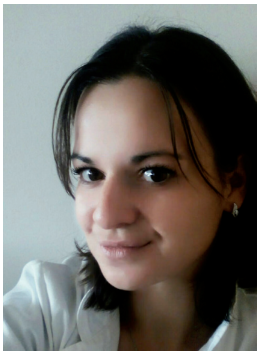

Marijana Pavunc Samaržija

Životopis	Marijana Pavunc Samaržija rođena je u Zagrebu. 2012. godine završila je diplomski sveučilišni studij Tekstilna tehnologija i inženjerstvo, modul Tekstilna kemija, materijali i ekologija na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu. Od svibnja 2013. zaposlena je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu na Zavodu za materijale, vlakna i ispitivanje tekstila kao asistent. Od početka znanstvenog rada njezin znanstveni interes pretežito je vezan uz tekstilna vlakna, konzervaciju i restauraciju tekstila te recikliranje tekstilnih materijala. Trenutno kao istraživač sudjeluje na istraživačkom projektu Hrvatske zaklade za znanost IP-2013-11-9967 *Napredni tekstilni materijali dobiveni ciljanom modifikacijom površine* u sklopu kojeg se bavi problematikom recikliranja i održivog gospodarenja tekstilnim otpadom te analizom cijeloživotnog ciklusa proizvoda (LCA).
Naslov teme doktorskog rada	
Studijski savjetnik	Prof. dr. sc. Edita Vujasinović
Datum obrane teme doktorskog rada	

ISTRAŽIVANJE CJELOŽIVOTNOG CIKLUSA VLAKNIMA OJAČANIH KOMPOZITA

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1. Uvod

Iako su kompozitni materijali poznati još od prapovijesnog doba, svoj puni potencijal ostvaruju tek u 21. stoljeću bez obzira radi li se o vlaknima ojačanim kompozitima s metalnim, keramičkim ili polimernim matricama. Njihov ubrzani razvoj prvenstveno je potaknut željom za stvaranjem novih inženjerskih materijala ciljanih svojstava, a time i zadovoljavanja sve većih zahtjeva postavljenih na materijale koji se upotrebljavaju u raznim industrijskim granama (poput građevinske industrije, automobilske industrije, zrakoplovne industrije itd.).

Međutim, unatoč njihovim brojnim prednostima, uz vlaknima ojačane kompozite vežu se i brojni ekološki i ekonomski problemi posebice glede njihovog zbrinjavanja. Naime, zbog svoje heterogenosti predstavljaju iznimno problematični materijal za zbrinjavanje, osobito recikliranje jer je odvajanje vlakana od matrice teško i zahtijeva složene termo-kemijske procese koji u većini slučajeva ekonomski nisu održivi. Zbog toga se često na kraju svog životnog ciklusa spaljuju ili završe na odlagalištima otpada što s jedne strane ekološki nije prihvatljivo pošto je većina komercijalno dostupnih vlaknima ojačanih kompozita načinjena od sintetičkih materijala koji su izuzetno otporni na razne utjecaje iz okoliša, a s druge strane na taj način gubi se cijenjena sirovina jer se za izradu kompozitnih materijala često primjenjuju visokoučinkovita vlakna poput npr. aramidnih i ugljikovih vlakana za čiju proizvodnju se koristi nafta čiji izvori nisu beskonačni. Stoga se danas, zbog želje za zaštitom okoliša, ali i sve rigoroznijih direktiva Europske unije o pitanjima zaštite okoliša, osim iznalaženja prikladnih i ekonomski isplativih metoda recikliranja vlaknima ojačanih kompozita, istraživanja sve više usmjeravaju prema upotrebi ekološki prihvatljivijih i održivih sirovina za njihovu proizvodnju. Pri tome posebnu pozornost dobivaju biokompoziti tj. kompoziti bazirani na biorazgradivim polimerima (poput biopolimera na bazi polilaktidne kiseline) ojačanih prirodnim vlaknima pri čemu se najčešće upotrebljavaju biljna tj. celulozna vlakana poput lana, kudelje, jute, kenafa, sisala itd. koja prvenstveno zbog dobrih mehaničkih svojstava, zatim niske cijene, obnovljivosti sirovine i biorazgradivosti postaju sve interesantnija za upotrebu u tekstilijama kao ravnopravna zamjena umjetnim vlaknima [1-3]. Jedna od industrija koja velike napore ulaže upravo u razvoj takovih kompozitnih materijala je automobilska industrija [4], a razlog tomu je upravo Europska direktiva 2000/53/EZ čiji je cilj sprečavanje stvaranja otpada od vozila kao i ponovna upotreba i povećanje stope recikliranja otpadnih vozila i njihovih komponenti [5].

Iako se biokompoziti smatraju ekološki prihvatljivijim i biorazgradivim materijalima čime ih je na kraju životnog ciklusa moguće zbrinuti kompostiranjem, valja imati na umu da se takvi materijali ipak ne mogu olako smatrati održivim. Prema literaturi [6] održivi biokompoziti trebali bi zadovoljiti nekoliko kriterija i to da su proizvedeni iz obnovljivih i/ili recikliranih sirovina, zatim sve modifikacije i postupci obrade potrebni za njihovu proizvodnju trebaju biti energetski učinkoviti, sve faze životnog ciklusa ne smiju biti ekološki nepovoljne i moraju se moći prikladno zbrinuti na kraju svog životnog ciklusa. Nadalje, potrebno je naglasiti kako osim biorazgradnje tj. kompostiranja kao jednog od načina mogućeg zbrinjavanja biokompozita, iznalaženje drugih načina njihovog recikliranja i definiranje njihove učinkovitosti učinilo bi ove materijale još zanimljivijim i ekološki prihvatljivijim.

2. Cilj i svrha istraživanja

Danas, prilikom razvoja svakog novog proizvoda neophodno je poštivanje načela održivog razvoja i usmjeriti se prema zaštiti okoliša. Stoga je potrebno istražiti sve potencijalno negativne utjecaje koje neki proizvod može imati na okoliš počevši od dobivanje sirovina, preko proizvodnje, upotrebe pa sve do krajnjeg odlaganja. U tu svrhu kao koristan i nezaobilazan alat pomoću kojeg je moguće sagledati okolišne performanse nekog proizvoda pokazao se tzv. LCT (engl. *Life Cycle Thinking*) pristup. Nadalje, sve veća pozornost usmjeruje se i na očuvanje sirovina i smanjenje otpada čime se indirektno zahtjeva da se prilikom razvijanja i dizajniranja novog proizvoda vodi računa i o mogućnosti njegovog recikliranja i ponovne upotrebe

recikliranih materijala tj. dizajn proizvoda u skladu s održivim razvojem pri čemu se izrada tzv. LCA (engl. *Life Cycle Assessment*) analize svakog novog proizvoda nameće kao imperativ.

Shodno navedenom, cilj ovog istraživanja je s jedne strane provesti LCA analizu novo proizvedenog biokompozita čime bi se dobio uvid u sve potencijalno negativne utjecaje proizvoda na okoliš, posebno uzevši u obzir mogućnosti njegovog recikliranja (kemijsko, toplinsko, mehaničko ili biološko). S druge strane cilj je definirati ekološko-ekonomski najučinkovitiji postupak recikliranja prirodnim vlaknima ojačanog biokompozita.

3. Zaključak

Od velike je važnosti već u ranoj fazi inovacijskih procesa i dizajniranja novog proizvoda ugraditi principe zelenog dizajna i voditi računa o ekološkoj sukladnosti proizvoda jer jedino će na taj način biti moguće smanjiti negativne utjecaje na okoliš, a time i otpad koji se generira na kraju životnog ciklusa takvog proizvoda.

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Jelena Peran

Životopis

Jelena Peran, rođena je 14. svibnja 1990. godine u Rijeci. Godine 2009. upisuje studij na Sveučilište u Zagrebu Tekstilno - tehnološki fakultet, modul Tekstilna kemija, materijali i ekologija. Titulu magistrice tekstilne tehnologije i inženjerstva stječe 2014. godine obranom diplomskog rada naziva *Primjena plazme u svrhu antibakterijskih svojstava celuloznih materijala* (mentor doc. dr. sc. Sanja Ercegović Ražić). U razdoblju od 2015. do 2016. godine radi na projektu „*Razvoj standarda kvalifikacija i preddiplomskih studijskih programa na Tekstilno-tehnološkom fakultetu*" kao projektni administrator. Poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija upisuje 2015. godine te trenutno radi kao asistent na Zavodu za materijale, vlakna i ispitivanje tekstila, Sveučilište u Zagrebu Tekstilno - tehnološki fakultet.

Naslov teme doktorskog rada

Studijski savjetnik — Doc. dr. sc. Sanja Ercegović Ražić

Datum obrane teme doktorskog rada

ANTIMIKROBNA UČINKOVITOST TEKSTILNIH MATERIJALA

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1. Uvod

Velika specifična površina, sadržaj vlage i kemijski sastav prirodnih materijala čine ih podložnim djelovanju mikroorganizama, posebice u uvjetima povećane vlage i topline. Ugljikohidrati u celulozi mogu poslužiti kao izvor hrane i energije mikroorganizmima pri čemu dolazi do enzimatske hidrolize. Proteolitički enzimi i enzimi keratinaze mogu razgraditi specifične proteine u vlaknima vune, svile i drugim proteinskim vlaknima. Većina umjetnih vlakana iz sintetskih polimera su otporna na djelovanje mikroorganizama, a proces degradacije, ukoliko je moguć, je veoma dugotrajan. Prisutnost mikroba na tekstilu, posebice patogenih vrsta bakterija, može uzrokovati ozbiljne zdravstvene probleme te degradaciju tekstilnih materijala u vidu pojave mrlja, neugodnih mirisa, gubitka čvrstoće i sl. [1,2]. Stoga se, u svrhu kontrole razvoja i razmnožavanja mikroorganizama, provode antimikrobne obrade tekstila. Kako bi se postigla maksimalna učinkovitost, postavljaju se određeni zahtjevi na antimikrobne obrade [3,4]: (i) djelotvornost na široki spektar mikroorganizama, uz istovremenu neškodljivost za ljudsko zdravlje i okoliš; (ii) antimikrobna sredstva ne smiju utjecati na prirodnu floru koja se nalazi na ljudskoj koži i predstavlja prirodnu zaštitu; (iii) postojanost u uvjetima uporabe te postupcima njege i održavanja; (iv) kompatibilnost s drugim kemijskim sredstvima i postupcima obrada tekstila; (v) bez utjecaja na izgled i kvalitetu tekstilnog proizvoda; (vi) otpornost u uvjetima sterilizacije (medicinski tekstil) i (vii) jednostavnost primjene te ekonomska opravdanost.
Cilj doktorskog rada je primjenom različitih sredstava i metoda aplikacije postići antimikrobna svojstva tekstilnih materijala dobre postojanosti u uvjetima primjene i njege.

2. Antimikrobna sredstva

Sredstva za antimikrobne obrade razlikuju se s obzirom na mehanizam i stupanj antimikrobnog djelovanja. Mogu djelovati kontaktom (pasivna sredstva), pri čemu aktivnost postižu u trenutku dodira s mikrobima, te difuzijom (aktivna sredstva), pri čemu difundiraju s tekstilne površine u okolinu kako bi ostvarila kontakt s mikrobima [4,5]. Biostati su antimikrobna sredstva koja inhibiraju rast i razmnožavanje mikroorganizama, dok biocidi potpuno uništavaju ciljane mikroorganizme. Poznata antimikrobna sredstva, često primjenjivana u tekstilnoj industriji su kvaterni amonijevi spojevi, polibiguanidi, triklosan, N-halamini, hitosan te nanočestice plemenitih metala i metalnih oksida [6]. S obzirom na potencijalnu toksičnost za ljudsko zdravlje i okoliš te slabu postojanost, primjena pojedinih sredstava je ograničena. Rezultati istraživanja antimikrobne učinkovitosti celuloznih tkanina obrađenih otopinama srebrovog nitrata dostupni su u prethodno objavljenom radu [7]. Posljednjih godina, istražuje se mogućnost primjene sredstava na bazi prirodnih biljnih ulja poput ulja iz sjemenki kima (*Nigella sativa L*) i lišća nima (*Azadirachta indica*) kao antimikrobnih sredstava [8]. Navedena sredstva, s obzirom na prirodno porijeklo, imaju veliki potencijal za primjenu u antimikrobnim obradama, bez potencijalnih štetnih posljedica za okolinu.

3. Postupci antimikrobnih obrada

Antimikrobna sredstva na tekstilu se troše prilikom svakog kontakta s mikroorganizmima, stoga postojanost antimikrobnog učinka i obrada predstavlja izazov. Sa svrhom postizanja antimikrobne učinkovitosti i poboljšane postojanosti, a ovisno o vrsti sredstava i tipu supstrata, razvijene su različite metode antimikrobnih obrada. U pravilu, antimikrobne obrade se mogu podijeliti u dvije skupine: (i) ugradnja antimikrobnog sredstva u sam polimer vlakna, te (ii) površinske tehnike naslojavanja [9]. Antimikrobno sredstvo može se dodati u granule polimera prije pripreme polimerne taline za ispredanje, te direktno u polimernu otopinu ili talinu prije postupka ispredanja. Aktivnost tako priređenih vlakana može biti smanjena zbog otežane difuzije sredstva koje je čvrsto vezano u polimernoj strukturi vlakna. Također, nedostatak predstavlja ograničenost primjene postupka na umjetna vlakna. Pored klasičnih postupaka mokrog oplemenjivanja tekstila (impregnacija na fularu, iscrpljenje kupelji) čija primjena uključuje veliku potrošnju vode, kemijskih sredstava i energije te rezultira stvaranjem velike količine otpadnih produkata, razvijene su nove, ekološki prihvatljivije metode. Postupci mikroenkapsulacije, sol-gel tehnologije, enzimatske površinske modifikacije te plazma tehnologije predstavljaju alternativne postupke koji mogu savladati glavne nedostatke mokrog oplemenjivanja.

4. Zaključak

Pružanje udobnosti potrošaču, kroz zaštitu od različitih klimatskih uvjeta, predstavlja primarnu ulogu tekstila. Danas, sa sve većim zahtjevima potrošača, odjevni predmeti moraju ispunjavati niz zahtjeva, od estetskih karakteristika do specijalnih svojstava koja će pružati zaštitu od ozljeda, vatrootpornosti, terapeutskih i rehabilitacijskih svojstava, sprječavanje neugodnih mirisa te antimikrobne zaštite. Premda je razvijeno niz antimikrobnih sredstava i postupaka, tekstilna industrija je stavljena je pred nove izazove. Potrebno je pronaći rješenje za povećanu otpornost mikroorganizama na konvencionalna antimikrobna sredstva, potencijalnu toksičnost za potrošača i okoliš te nepostojanost obrada. Nužno je provesti istraživanja sa svrhom razvoja ekološki prihvatljivih antimikrobnih sredstava i postupaka obrade.

Zahvala

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Naslov teme doktorskog rada	
Studijski savjetnik	doc. dr. dr. sc. Iva Rezić
Datum obrane teme doktorskog rada	

SINTEZA I CILJANA PRIMJENA METALNIH NANOČESTICA U TEKSTILU

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1. Uvod

Snažan razvoj nanotehnologije revolucionizirao je primjenu nanočestica u raznim područjima pa tako i u tekstilnoj i ambalažnoj industriji [1]. Kao svojstva najznačajnija za proizvode spomenutih industrija, na koja se može utjecati primjenom metalnih nanočestica, ističu se poboljšana antibakterijska aktivnost, svojstvo usporavanja plamena, UV-zaštita i superhidrofobnost [2]. Ograničenje u primjeni metalnih nanočestica u spomenutim industrijama predstavlja upotreba toksičnih kemikalija koje se koriste za njihovu sintezu zbog čega se sve više pažnje posvećuje pronalasku prihvatljivijih metoda sinteze, među kojima važno mjesto zauzima i biokatalitička sinteza kao ekološki, energetski i ekonomski prihvatljiv način sinteze metalnih nanočestica [3].

Ovdje predstavljena istraživanja dio su UIP, uspostavnog istraživačkog projekta *Sinteza i ciljana primjena metalnih nanočestica* (*STARS*) čiji su ciljevi primjena enzima za sintezu nanočestica, razvoj ekološki povoljnog procesa sinteze metalnih nanočestica, praćenje reakcija i mehanizama stvaranja nanočestica, karakterizacija sintetiziranih nanočestica te razvoj i ispitivanje novih funkcionalnih polimernih materijala s tankim slojem nanočestica za ciljanu primjenu u zaštitnim polimernim materijalima [4]. U okviru ovog sažetka će se dati kraći pregled dosadašnjih rezultata – ispitivanja procesa biokatalitičke sinteze nanočestica kalcijevog karbonata ($CaCO_3$) i optimizacije biokatalitičke sinteze nanočestica cinkovog oksida (ZnO) uz enzim ureazu.

2. Eksperimentalni dio

Proces biokatalitičke sinteze nanočestica $CaCO_3$ iz uree i kalcijevog klorida ($CaCl_2$) uz enzim ureazu ispitan je određivanjem kinetike enzima i utjecaja kalcijevih iona na kinetiku enzima u tri različita reakcijska medija (4-(2-hidroksietil)-1-piperazinil-etansulfonskoj kiselini (HEPES) i trietanolamin puferu (TEA) te vodi) na temperaturama 30 °C i 40 °C. Reakcije su provedene u kotlastim reaktorima uz stalno miješanje termostatiranom tresilicom (*MRC Orbital shaker incubator*), a tijekom reakcije praćene su koncentracije uree (kromatografski) i amonijaka koji nastaje hidrolizom uree (spektrofotometrijski). Prema dobivenim rezultatima postavljen je matematički model procesa validiran provođenjem biokatalitičke sinteze nanočestica $CaCO_3$ pri navedenim uvjetima. Sintetizirane nanočestice $CaCO_3$ analizirane su rendgenskim difraktometrom.
Biokatalitička sinteza nanočestica ZnO optimirana je provođenjem 25 eksperimenata temeljem metode dizajna eksperimenta. Ova metoda je statistički alat koji pomaže u planiranju, dizajniranju i analizi ključnih eksperimenata. Pomaže modelirati vezu između parametara koji utječu na proces uz što manji broj eksperimenata. Omogućava definiranje optimalnih vrijednosti parametara, tj. vrijednosti parametara koje daju najbolje ili željene karakteristike procesa koji proučavamo [5]. U ovom istraživanju ispitan je utjecaj četiri signifikantna parametra za proces (T, broj okretaja, c_{urea}, $c_{Zn(NO3)2}$) uz konstantnu koncentraciju enzima ureaze. Nanočestice ZnO sintetizirane dizajniranim eksperimentima analizirane su NTA metodom (NTA; *Nanoparticle Tracking Analysis*) s ciljem određivanja njihove veličine.

3. Rezultati i rasprava

Na temelju rezultata ispitane kinetike enzima ureaze u reakciji biokatalitičke sinteze nanočestica $CaCO_3$, utvrđeno je kako se radi o Michaelis-Menteničinoj kinetici. Procijenjeni su parametri navedene kinetike, maksimalna brzina reakcije (V_m) i Michaelis-Menten konstanta (K_m^S). Zaključeno je kako aktivnost enzima, tj. V_m raste s porastom temperature u HEPES i TEA puferu, dok je u vodi brzina reakcije podjednaka na obje temperature. Specifičnost enzima ureaze (K_m^S) veća je prilikom provođenja reakcije hidrolize uree pri višoj temperaturi u reakcijama provedenim u TEA puferu i vodi, dok je u reakcijama provedenim u HEPES puferu obrnuto. Ispitivanjem utjecaja iona kalcija pokazalo se da oni inhibiraju enzim ureazu, no prema procijenjenim konstantama inhibicije (K_i) navedena inhibicija nije značajna [4]. Analizom čestica rendgenskom difrakcijom dobiveni su difraktogrami eksperimentalno dobivenih i literaturnih podataka za očekivane kristalne modifikacije kalcijevog karbonata – kalcit, aragonit i vaterit te je utvrđeno kako je u svim uzorcima prisutan kalcit, vaterit je prisutan u malim količinama kod čestica sintetiziranih u vodi dok aragonit nije prisutan ni u jednom slučaju [4].

Za obradu rezultata dobivenih NTA analizom sintetiziranih nanočestica ZnO korišten je statistički računalni program *Design-Expert*® sa svrhom dobivanja modela koji opisuje ovisnost željenog rezultata – veličine sintetiziranih nanočestica o parametrima procesa (Jedn. 1). Prema dobivenom modelu mogu se predvidjeti veličine i koncentracije nanočestica koje će nastati sintezom pri točno određenim reakcijskim uvjetima. Dobivena su i optimalna rješenja čijom provedbom nastaju nanočestice minimalnih veličina.

$$
\begin{aligned}
ZnO\ size = {} & 188{,}44 + 27{,}89 \cdot c_{urea} - 2{,}64 \cdot c_{Zn(NO_3)_2} + 0{,}407 \cdot T - 0{,}13 \cdot rpm + 0{,}92 \cdot c_{urea} \cdot c_{Zn(NO_3)_2} \\
& - 0{,}57 \cdot c_{urea} \cdot T - 0{,}041 \cdot c_{urea} \cdot rpm - 0{,}17 \cdot c_{Zn(NO_3)_2} \cdot T - 0{,}019 \cdot c_{Zn(NO_3)_2} \cdot rpm \\
& + 0{,}0109 \cdot T \cdot rpm
\end{aligned}
\qquad (1)
$$

4. Zaključci

Na temelju prikazanih rezultata može se zaključiti da se korištenjem statističkih alata prilikom ispitivanja biokatalitičke sinteze nanočestica može planirati i voditi proces sinteze nanočestica metala i metalnih oksida. Nadalje, može se zaključiti kako su za sintezu nanočestica ZnO minimalnih veličina pogodni uvjeti niže početne koncentracije uree i više početne koncentracije $Zn(NO_3)_2$ te više temperature uz manji broj okretaja tresilice ili niže temperature uz veći broj okretaja tresilice.

Zahvala

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Naslov teme doktorskog rada	Analiza metalnih niti u povijesnom hrvatskom tekstilu od 17. do 20. stoljeća - sadržaj metala, sastav i struktura pređe
Mentori	Prof. emerit. dr. sc. Ivo Soljačić (TTF) Prof. dr. sc. Tihana Petrović Leš (FFZG)
Datum obrane teme doktorskog rada	14. lipnja 2016.

ANALIZA METALNIH NITI U POVIJESNOM HRVATSKOM TEKSTILU OD 17. DO 20. STOLJEĆA

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1. Uvod

Tekstil je neophodan za svakodnevni život u svim društvima. Koristi se u odjeći za zaštitu od zime i vremenskih i drugih nepogoda, ali i za označavanje klase i položaja, pokazujući bogatstvo i društveni status. Niti od plemenitih metala također su korištene u kombinaciji sa vlaknima za ukrašavanje kako bi se stvorile luksuzne tkanine za društvene i vjerske elite [1]. Analiza tih metalnih niti provedena je pretražnim elektronskim mikroskopom s energodisperzivnim detektorom X-zraka (SEM-EDX). Metoda je primijenjena kao najprikladnija, određujući približnu količinu pojedinačnih metala u uzorku, a provedena su i ispitivanja poprečnih presjeka zajedno s površinama [2]. Ova metoda uspoređena je s dvije druge metode rendgenskom fluorescentnom analizom (XRF) i česticama induciranom emisijom rendgenskog zračenja (PIXE).

2. Eksperimentalni dio

Istraživana je primjena srme (metalnih niti) uklopljene u tekstilnu pređu u Hrvatskoj na liturgijskom ruhu i svečanim narodnim nošnjama. Upotrebljavaju se dva osnovna oblika srme, a to su samostalne metalne niti i pređe koje su nastale kombinacijom jedne metalne ili čak dviju metalnih niti s tekstilnom pređom. Kombinirana tekstilno-metalna pređa dobivala se tako da su se metalne niti, ili samo jedna metalna nit, spiralno omatale oko osnovne tekstilne pređe koja se tako našla u središtu kao jezgra ili srž srmene pređe [1]. Mjerenja na metalnim nitina su provedena s tri tehnike; SEM-EDX, XRF i PIXE. Na Tekstilno-tehnološkom fakultetu provedena je SEM-EDX analiza (FE-SEM, MIRA Tescan) , radnog napona 20 kV i radne udaljenosti 25 mm. EDX detektor Bruker AXS, Quantax tipa SDD (Silicon Drift Detector) je silicijski detektor koji vrši detekciju od bora (B) do urana (U) [3]. XRF uređaj koji se koristio za analizu nalazi se u Prirodoslovnom laboratoriju Hrvatskog restauratorskog zavoda u Zagrebu. Karakteristike uređaja tip Arttax, proizvođača Bruker, rendgenske cijevi - anode Rh, napona 50 kV, jakosti 0,7 mA, kolimator RTG zraka 0,6 mm, SDD detektora XFLASH, Bruker, koji detektira od K (Z = 19) do U (Z = 92). PIXE mjerenja provedena su na Institutu "Ruđer Bošković" u postrojenju ionske mikroprobe, što je detaljno opisano drugdje [4]. Akcelerator 1 MV Tandetron osigurava 2 MeV protonske zrake fokusirane pomoću sustava magnetskih leća na dimenziju od 2 μm te skenira na odabranom području uzorka. Koriste se pravokutni ili kvadratični uzorci skeniranja različitih veličina (između 100x100 μm^2 i 1.3x1.3 mm^2) i različitog broja piksela (do 128x128). PIXE spektri su sakupljeni pomoću Si (Li) detektora smještenog na 135° u odnosu na smjer snopa na udaljenosti od oko 2 cm od cilja. Učinkovita energijska rezolucija rendgenskog zračenja od oko 160 eV za detekciju Mn Kα linije. Podaci su digitalno snimljeni softverom SPECTOR za prikupljanje podataka u popisu datoteka koja se može ponovo reproducirati. Nakon toga, prikupljeni podaci analizirani su pomoću softvera GUPIXWin [5] u iterativnom modu matrice i korištenjem normalizacije do 100 w %.

3. Rezultati i rasprava

Metalne niti iz povijesnog hrvatskog tekstila analizirane su kvalitativno s XRF i kvantitativno s SEM-EDX analizom. Uočena je velika razlika između kvalitativnih XRF i EDX kvantitativnih podataka na nekim analiziranim uzorcima. Zbog tih velikih odstupanja, uzorci su analizirani mikro-PIXE uređajem koji ima različitu dubinsku penetraciju od 20 μm za razliku od XRF analize 100-200μm i EDX 1μm.

Rezultati dobiveni EDX i PIXE analizom slični su za homogene uzorke, dok su za pozlaćene i posrebrnjene uzorke različiti, tablica 1. Zbog manje dubine penetracije EDX ima veći postotak zlata u pozlaćenim i srebra u posrebrnjenim uzorcima od PIXE analize. Kako bi se dokazalo da su uzorci pozlaćeni ili posrebrnjeni napravljena je i EDX analiza poprečnog presjeka [6].

Tablica 1: Razlika u analizi PIXE, EDX i EDX poprečnog presjeka

Uzorak	Metoda	Au (%)	Ag (%)	Cu (%)
pozlaćeni	PIXE	20,6	79,0	0,4
	EDX	86,9	12,9	0,2
	EDX poprečni presjek	0,3	99,6	0,1
posrebrnjeni	PIXE	0	19,5	80,5
	EDX	0	84,6	15,4
	EDX poprečni presjek	0	0,3	99,7

4. Zaključci

SEM-EDX i PIXE analiza daju slične kvalitativne rezultate na homogenim uzorcima (legurama). U slučaju pozlaćenih i posrebrnjenih uzoraka ove analize pokazuju veoma različite kvantitativne rezultate zbog komplicirane strukture uzorka i geometrije. Kako bi analiza pozlaćenih i posrebrnjeh uzoraka sa SEM-EDX -om bila pouzdana potrebno je napraviti i analizu poprečnog presjeka. SEM-EDX metoda je najprimjenjivija za analizu metalnih niti na povijesnom tekstilu. Metoda je jednostavna, pouzdana i ponovljiva. Analiza pokazuje glavne metale kao i elemente u tragovima u uzorcima metalnih niti. Bakar je pronađen na metalnim nitima u homogenim uzorcima, čistim bakrenim uzorcima, posrebrenjenim uzorcima, također pronađen je uzorak pozlaćenog bakra. Srebro je najčešće korišten element pronađen u homogenim uzorcima, pozlaćenim i posrebrnjenim uzorcima kao i čistim uzorcima srebra. Zlato se uglavnom nalazilo na pozlaćenim uzorcima, ali i homogeni uzorci imaju zlata samo vrlo mali postotak. Analiza metalnih niti dala nam je vrlo vrijedne informacije o starim tehnikama proizvodnje kao i o odgovarajućim postupcima čišćenja i konzerviranja.

Zahvala

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Sandra Škaro

Životopis

Sandra Škaro rođena je 17. 10. 1977. u Dubrovniku. Diplomirala je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu, smjer projektiranje i dizajn odjeće, 2006. Završava dvije studijske radionice University of the Arts, London, Central Saint Martins, 19. 7. – 6. 8. 2010. „Introduction To The History Of Art Part 1 and Part 2“. Od 2007. radi kao vanjski suradnik na kolegijima iz područja dizajna i kostimografije. Od 2012., zaposlena je na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu kao asistent gdje izvodi nastavu na kolegijima iz područja Kostimografije. Upisuje poslijediplomski sveučilišni studij Tekstilna znanost i tehnologija 19. 2. 2014. Pohađa radionicu: „Studio Workshop - Costume design: From design to drape“, 3. – 17. 5. 2014, Metropolitan Museum, New York. Pohađa istraživački centar „The Clothworkers“, prosinac 2014. u sklopu Victoria & Albert muzeja u Londonu.

Naslov teme doktorskog rada	Realizacija ženskog povijesnog kostima iz 18.st. u Dubrovačkoj Republici na temelju “Testamenta notariae”
Studijski savjetnik	Prof. dr. sc. Darko Ujević
Datum obrane teme doktorskog rada	

REALIZACIJA ŽENSKOG POVIJESNOG KOSTIMA IZ 18. st. U DUBROVAČKOJ REPUBLICI NA TEMELJU "TESTAMENTA NOTARIAE"

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1. Uvod

U doktorskoj disertaciji pristupit će se realizaciji ženske haljine iz 18. st za vrijeme Dubrovačke Republike. Istražit će se cjelokupna arhivska građa "Testamenta notariae" - oporuke Republike od 1282 - 1815 [1], koja se sastoji od 92 sveska (18400 testamenata), napisana na talijanskom i latinskom jeziku. Arhivski spisi će se čitati obrnuto, od novijeg datuma prema starijem, radi lakšeg razumijevanja jezika i rukopisa notara. Kao dodatni izvor istraživanja koristit će se neki dijelovi arhivske građe "Privata" [2] i "Diversa notariae" [3].

Spomenuta rukopisna ostavština do sada nije sustavno istražena. Obradit će se podaci pokretne imovine u obliku tekstila i odjeće 18. st. koje pronalazimo gotovo u svakom testamentu. Stari Dubrovčani su oporučno ostavljali svoje dragocjenosti, pri čemu su odjeća, nakit i namještaj zauzimali visoko mjesto na ljestvici vrijednosti i moguće ih je pratiti unutar pojedine obitelji i preko 100 godina.

2. Eksperimentalni dio

Provest će se definiranje tipova ženskih odjevnih predmeta koji se spominju u "Testamentima", utvrdit će se da li su isti uvezeni ili izrađivani i bojani na području Dubrovačke Republike. Utvrdit će se vrste prirodnih bojila, te načina bojanja i tiska na lanu, vuni, svili i pamuku. Analizirat će se tjelesne mjere pronađene u zapisima arhivske građe "Privata", s ciljem uvida u morfološke karakteristike populacije. Točno i precizno određene tjelesne mjere, osnova su za početak konstruiranja i izrade gotovog odijevnog predmeta [4]. Usporedbom dobivenih povijesnih podataka odabrat će se najbolji zapis ženskog odijevnog predmeta i pristupit će se njegovoj tehničkoj realizaciji, uz precizno dokumentiranje svih faza izrade.

U ovom radu jedno od poglavlja biti će istraživanje tjelesnih veličina populacije Dubrovačke Republike u 18. st. na temelju arhivske građe "Privata" gdje se pod signaturom 19/25 fol.41. nalazi dnevnik stanovitog Luja u službi Karla "sartora" - krojača.

Rekonstrukciji morfoloških karakteristika stanovništva pristupit će se na temelju zapisa tjelesnih izmjera iz narudžbi koje je krojač preuzimao. Ovdje govorimo o vlasteli i bogatim građanima, nažalost premali je uzorak ženskog stanovništva, jer robu uglavnom naručuju muškarci, tako da nije moguće dobiti ukupnu sliku populacije Dubrovačke Republike, nego samo određene segmente.

Provest će se istraživanje postupaka bojenja i tiska na tekstilnim materijalima prirodnim bojilima. Do sredine 19.st. tkanine su se tkanine bojale samo prirodnim bojilima, najčešće dobivenim od nekih vrsta biljaka, kukaca ili školjaka [5]. Izradit će se karta boja i tonova za 18.st., na temelju istraživanja povijesti prirodnih bojila i bogatih zapisa u arhivskoj građi "Testamenta notariae".

U slijedećim poglavljima pristupit će se konstrukciji ženske haljine 18. st. i adekvatnim tehničkim postupcima izrade. Konstrukcija povijesnih kostima je razumijevanje odgovarajućeg načina rezanja odjeće za određeno povijesno razdoblje, uz sve ekscentričnosti oblikovanja uzoraka, kako bi se došlo do prikladne vremenske siluete. Tkanina se manipulacijom dovodi do prikladnih oblika koji odražavaju stil razdoblja [6].

Za potpuno razumijevanje povijesne odjeće, potrebno je poznavanje unutrašnjosti odijevnog predmeta, te problematiku tehničke izvedbe pojedinih krojnih dijelova.
Povijest krojenja i izrade odjeće u Republici može se očitati iz rukopisne ostavštine u obliku korespodencije, sudskih zapisa, arhivske građe, te rjeđe knjiga. Nažalost vizualnih i materijalnih dokaza je veoma malo, osim manjeg broja portreta slavnih Dubrovčana u Kneževu dvoru i poneke gravure, primjerke iz 18. st. gotovo da je nemoguće pronaći.

Francuska moda i tkanine dopremali su se u Grad, gotovo cijelo stoljeće, posebno u zadnjoj polovini 18.st.
Osnovna razlika između dubrovačkog načina odijevanja u odnosu na onaj iz Francuske ili Engleske toga doba bila je u jednostavnosti, u ne pretjerivanju, odjeća je bila manje komplicirana od one u Europi i suzdržanija.

Neke gravure prikazuju krojače kako uzimaju mjere za korzete i haljine, dok dijagrami koji upućuju na izradu odijevnih predmeta mogu se naći u svega nekoliko knjiga. Benoit Boullay"Le Tailleur Sincere" 1671, "L'Art du Tailleur "1769 and "L'Art de la Lingere" 1771. Francois Alexandre Garasualt, autor je djela Descriptions des artes et métiers: L'Arte du tailleur 1769. i L'Arte de lingerie 1771. Denis Diderot i Jean le Rond D'Alembert objavili su 1776. Encyclopedie, koja je veliki izvor opisa dekorativnih umjetnosti i mode 18. st., sa odvojenim dijelom posvećenim krojenju, konstrukciji i izradi odjeće. Poslužit će kao važni izvor ovoj disertaciji [7].

3. Zaključak

Izvorni znanstveni doprinos je referentna baza podataka iz originalne rukopisne ostavštine, te unapređenje metodologije korištenja pisanih dokumenata u svrhu tehničke realizacije i izrade odjevnih predmeta za stalni muzejski postav i za sve vrste izvedbenih umjetnosti. Također, izniman je doprinos u očuvanju kulturne baštine.

4. Literatura

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Naslov teme doktorskog rada	CAD modeliranje obuće izrađene od pletiva s aspekta antropometrije i biomehanike stopala
Studijski savjetnici	Prof. dr. sc. Darko Ujević Prof. dr. sc. Budimir Mijović
Datum obrane teme doktorskog rada	

CAD MODELIRANJE OBUĆE IZRAĐENE OD PLETIVA S ASPEKTA ANTROPOMETRIJE I BIOMEHANIKE STOPALA

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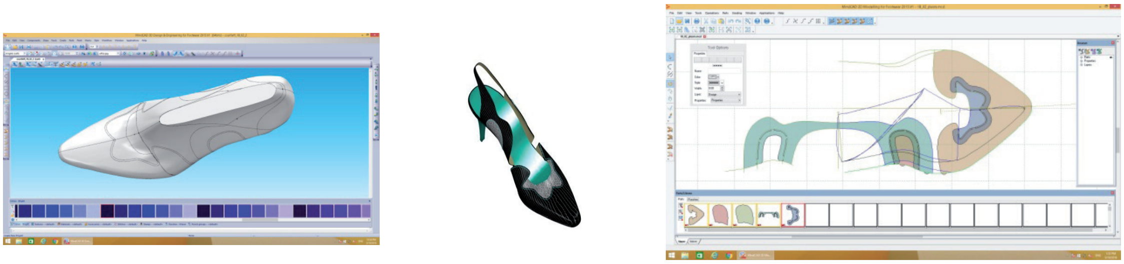
1. Uvod

Obuća, primarno napravljena kao zaštita stopala od vremenskih neprilika, kroz tisućljeća razvijala se kao modni dodatak, sukladno modnim trendovima odjeće u svakom povijesnom razdoblju [1]. Nepovoljni uvjeti suvremenog života (hodanje po ravnom tlu, sputanost slobodnih kretnji, neprikladna obuća) pridonose slabosti stopala, a posebice potpornih tvorbi i mišića koje tonusom održavaju njegov ustroj. Noge su najopterećeniji dio tijela; pješačenje, trčanje ili samo održavanje ravnoteže s jednom ili obje noge na tlu svakodnevne su, obične aktivnosti. Nošenje zatvorene obuće, neprilagođene obliku stopala i loše pristalosti,tj. nepoštivanje strukturalne i morfološke funkcije stopala može kod zdravog normalnog stopala uzrokovati probleme uslijed stvaranja biomehaničkih odstupanja, koje na kumulativnoj osnovi mogu mijenjati karakteristike nosivosti stopala, s promjenama prijenosa opterećenja od stražnjeg dijela stopala do prstiju [2,3]. Osim deformacija u području stopala, obuća također može biti uzročni faktor pojave rana na stopalu, ali i pojave bolova u cijelom tijelu, kao što su bolovi u koljenima i kralježnici, uzrokovani promjenom posture čovjeka [4-6]. Kod konstrukcije i izrade obuće potrebno je poznavati anatomske, antropometrijske i biomehaničke karakteristike stopala. Obuća može biti izrađena od kože, ali i drugih materijala kao što su tekstilni (tkanine, pletiva, netkani tekstil). Tekstilije u obući mogu se koristiti u izradi cijelog vanjskog dijela gornjišta, podstave i međupodstave. U radu će se analizirati udobnost i prilagodljivost obuće u smislu pristalosti stopalu, te će istraživanje biti usmjereno na analizu pletiva. Prvenstveno će se istražiti njihova primjena u izradi obuće na visoku petu, s ciljem poboljšanja udobnosti (prvenstveno kontaktne) u skladu s antropometrijskim mjerama stopala i biomehanikom hoda. Navedena istraživanja provest će se na točno specificiranim kritičnim mjestima na stopalu pri nošenju cipela na visoku petu.

2. Eksperimentalni dio

U doktorskom radu provesti će se antropometrijska mjerenja stopala ženske populacije pomoću *3D Pedus Footwear Human Solutions GmbH skenera za stopala* i pomoću *INFOOT USB skenera za stopala*. Provesti će se mjerenje statičnog i dinamičnog plantarnog pritiska pomoću *FOOTSCAN RSscan international mjerne ploče*. Dobiveni podaci će se obraditi, i provesti će se statistička analiza svih podataka. Odrediti će se antropometrijske mjere i orijentacijske točke, analizirati će se ciklus ljudskog hoda, u svrhu analize i određivanja potrebnih parametara za povećanje udobnosti cipela s visokom petom. Provesti će se ispitivanja pletiva: određivanje svojstava udobnosti; ispitivanje otpornosti - čvrstoća, izduženost. Ispitivanje karakteristika pletiva potrebno je radi sljedećeg eksperimentalnog dijela - izrade modela, jer je zbog konstrukcije potrebno poznavati koliko se materijal kao krojni dio isteže i deformira. U programu *MindCAD 3D inženjering i dizajn obuće 2015.V1.*izraditi će se trodimenzionalni modeli,u obliku kolekcije obuće asimetričnog kroja gornjišta (cipele, čizme i sandale), s tri različite visine pete (niska peta (<3 cm),srednja peta (3 - 6 cm) i visoka peta (>6cm). Zatim će se za sve modele u kolekciji (ukupno 9 modela) izraditi 2D osnove modela (krojni dijelovi gornjišta) u programu *MindCAD 2D modeliranje obuće 2015.V1.* Na prethodno određena kritična mjesta na stopalu (utvrđenih analizom provedenih antropometrijskih i biomehaničkih mjerenja) na određene krojne dijelove kompjuterski izrađenih modela, staviti će se pletivo, u svrhu poboljšanja kontaktne pristalosti cipele na visoku petu.



a. b. c)

Slika 1: Primjer izrade trodimenzionalnog modela cipele na visoku petu u programu *MindCAD 3D inženjering i dizajn obuće 2015.V1.*, (izrađeno na Fakultetu tekstila, kože i industrijskog menadžmenta, "GheorgheAsachi" Tehničko sveučilište u Iaşiu, pod vodstvom prof. dr. sc. A. Mihai, dizajn: I. Topić):a) izrada 3D modela gornjišta b) završeni 3D model cipele simetričnog kroja s visokom petom c) izrada Osnove modela sa svim krojnim dijelovima u programu *MindCAD 2D modeliranje obuće 2015.V1.*

Pomoću metode konačnih elemenata (*Finite element analysis-FEA*) za svaki model napraviti će se simulacija hoda i prikazati deformacije na određenim mjestima na gornjištu cipele. *FEA* metodom napraviti će se 18 simulacija, 9 za cipele s peltivom umetnutim na određenim krojnim dijelovima, te 9 za iste modele napravljene od kože, te će se rezultati simulacija usporediti i anlizirati dobiveni podaci.

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Naslov teme 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. svibnja 2016.

UTJECAJ FIZIKALNO-KEMIJSKIH SVOJSTAVA INHIBITORA POSIVLJENJA NA ZETA POTENCIJAL OPRANIH PAMUČNIH MATERIJALA

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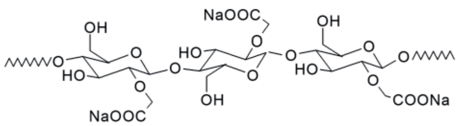
1. Uvod

U posljednje vrijeme se promiču ekološki prihvatljivi niskotemperaturni procesi pranja u malim omjerima kupelji, koji zahtijevaju visokoučinkovite kemijske komponente i specijalne polimere u deterdžentima [1]. Karboksimetilceluloza je biorazgradiva, a brzina njene razgradnje obrnuto je proporcionalna stupnju supstitucije (DS) [2]. Prvi put je uvedena u sastav deterdženta 1940. godine [3-5]. Istraživanja će obuhvatiti specijalne dodatke, karboksimetilcelulozu (CMC) i karboksimetilirani škrob (CMS), za praškaste i tekuće formulacije deterdženta. Dodatno će se istražiti sinergija specijalnih polimera i bildera u inhibiranju prljavština kroz mjerenje naboja površine i stupnja bjeline celuloznih materijala nakon višestrukih pranja. Istraživanja će ukazati kako specijalni polimeri u deterdžentu utječu na promjenu naboja površine opranih pamučnih materijala i spriječiti ponovno taloženje prljavštine iz kupelji za pranje [6,7].

2. Eksperimentalni dio

Specijalni inhibitor posivljenja dodan u formulaciju deterdženta je CMC, (sl. 1). U radu su primijenjene dvije vrste CMC, koje se razlikuju po udjelu CMC-a i morfologiji površine. Utjecaj na površinu je ispitan u pranju standardne pamučne tkanine pri 40 °C u tvrdoj i destiliranoj vodi.



Slika 1: Prikaz strukturne formule karboksimetilceluloze

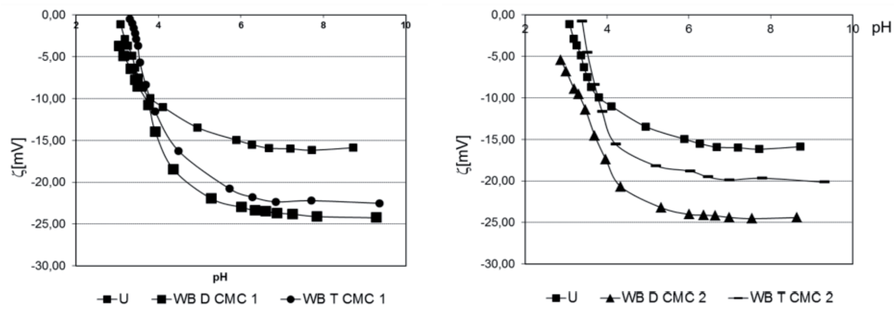
Stupanj modifikacije pamučnih materijala u definiranim uvjetima pranja se objektivno vrednovao metodom potencijala strujanja na elektrokinetičkom analizatoru, Anton Paar GmbH. Hidrodinamičko strujanje kapljevine uzrokuje preraspodjelu naboja na površini materijala, te se generira potencijal strujanja (Up), površina je hrapava pa se mjeri i otpor unutar mjerne ćelije te se zeta potencijal izračunava prema izrazu 1 [8].

$$\zeta = \frac{dU}{dp} \cdot \frac{\eta}{\varepsilon_r \cdot \varepsilon_0} \cdot \frac{L}{A \cdot R} \tag{1}$$

gdje su: ζ - elektrokinetički ili zeta potencijal (V), dU/dp - nagib potencijala strujanja naspram tlaka (V Pa^{-1}), η - viskoznost elektrolita (Pa s), ε_r - relativna permitivnost otopine (bez jedinica), ε_0 - permitivnost vakuuma (8,854 10–12 m^{-1} Ω^{-1} s), L - duljina kapilare strujanja (m), A - poprečni presjek kapilare (m^2) i R - otpor unutar mjerne ćelije (Ω).

3. Rezultati i rasprava

Rezultati pokazuju da je zeta potencijal pamučne tkanine (U) negativan. Pranje s CMC-om u destiliranoj i tvrdoj vodi utječe na naboj površine materijala. Zeta potencijal tkanine oprane u destiliranoj vodi je negativniji od tkanine oprane u tvrdoj vodi što potvrđuje utjecaj tvrdoće vode na naboj površine. Dvije različite vrste inhibitora posivljenja, CMC 1 s 75 % udjelom CMC i CMC 2 s 100 % udjelom CMC, su utjecale na negativniji naboj površine. Zeta potencijal pamučne tkanine oprane s CMC 2 iznosi -20 mV, a oprane s CMC 1 iznosi -23 mV, (sl. 2) Analiza površine na skenirajućem elektronskom mikroskopu (SEM) je pokazala da uzorak CMC 1 ima porozniju i manje kompaktnu strukturu od CMC 2, pa je očekivano da će se, unatoč manjem udjelu CMC, brže adsorbirati na površinu. To ukazuje na bitan utjecaj morfologije inhibitora posivljenja na naboj površine pamučnih materijala u pranju.



U - neoprana tkanina;
WB D - oprana tkanina u destiliranoj vodi
WB T - oprana tkanina u tvrdoj vodi

a. b.

Slika 2: Zeta potencijal pamučne tkanine prije i nakon pranja uz dodatak a) CMC 1 u destiliranoj i tvrdoj vodi i b) uz dodatak CMC 2 u destiliranoj i tvrdoj vodi,

4. Zaključci

Karboksimetil celuloza kao inhibitor posivljenja utječe na povećanje negativnog naboja površine pamučne tkanine. Istraživanja su pokazala da je prije upotrebe CMC u pranju neophodno načiniti morfološku karakterizaciju čestica primjenom SEM-a s ciljem odabira produkta koji može imati bolji potencijal adsorpcije, što dodatno utječe na smanjenje naboja površine u svrhu odbijanja prljavština u pranju.

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Naslov teme doktorskog rada	
Studijski savjetnik	Prof. dr. sc. Edita Vujasinović
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MODIFIKACIJA TEKSTILIJA HUMINSKIM TVARIMA I NJIHOV UTJECAJ NA OKOLIŠ

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1. Uvod

Gotovo svakodnevno, nesvjesnim korištenjem različitih proizvoda koji olakšavaju moderan život, svatko od nas ostavlja neizbrisiv trag na okoliš. Korištenjem okolišno stabilnih sintetičkih polimera utječe se na smanjenje kvalitete ljudskog života što može predstavljati velike ekološke probleme u budućnosti. Upravo zbog toga, mnoga istraživanja u 21. stoljeću usmjerena su na biorazgradive polimere i mogućnosti njihove razgradnje po završetku njihovog životnog ciklusa [1].

Modifikacijom/funkcionalizacijom tekstilija moguće je promijeniti njihova ishodišna svojstva i na taj način postići nova, željena svojstva u upotrebi. S tim ciljem, istražit će se mogućnost modifikacije biorazgradljivih vlakana (celuloznog i proteinskog porijekla) s huminskim tvarima (prirodnog i sintetskog porijekla).

Huminske tvari predstavljaju aktivan dio humusa, a nastaju biološkom razgradnjom biljnih i životinjskih materijala u vlažnim staništima kao što su npr. tresetišta. Huminske tvari su tamno obojeni, kiseli, uglavnom aromatični polimeri koji imaju veliku molekularnu masu. S obzirom na molekulnu masu, boju, sastav i topljivost mogu se podijeliti na tri osnovne skupine: huminska kiselina (sl. 1 a), fulvinska kiselina (sl. 1 b) i humin.

Iznimna svojstva huminskih tvari omogućavaju njihovu brojnu praktičnu primjenu u npr. razvoju apsorbera i filtera, poljoprivredi, medicini i sl. Prema literaturi, dosadašnja istraživanja huminskih tvari ukazuju na njihova antibakterijska i antiviralna svojstva [2-6].

a. b.

Slika 1: Huminske tvari: a) huminska kiselina b) fulvinska kiselina

Imajući na umu da su antibakterijske/antiviralne tekstilije iznimno važne u izradi zaštitne odjeće koja vrlo često predstavlja prijetnju za okoliš ukoliko nije pravilno zbrinuta, započeta su istraživanja u svrhu modifikacije/funkcionalizacije tekstilija huminskim tvarima s naglaskom na biorazgradivost tj. njihovu prihvatljivost za okoliš.

Preliminarna istraživanja su pokazala kako huminske tvari imaju potencijalno moguću primjenu u funkcionaliziranim tekstilnim strukturama. Pri tome, posebnu pažnju treba obratiti na metode aplikacije huminskih tvari na tekstilne strukture te na projektiranje takvih struktura kako bi se one dizajnirale u skladu s eko-dizajnom ili dizajnom za okoliš tj. kako bi njihov životni ciklus bio u skladu s održivim razvojem.

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Naslov teme doktorskog rada	Modifikacija i adaptacija relevantnih čimbenika u sustavu bojilo/vezivo/vlakno u Ink Jet tehnologiji tekstilnog tiska	
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MODIFIKACIJA I ADAPTACIJA RELEVANTNIH ČIMBENIKA U SUSTAVU BOJILO/VEZIVO/VLAKNO U INK JET TEHNOLOGIJI TEKSTILNOG TISKA

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1. Uvod

Digitalne tehnike tiska sve se više upotrebljavaju u tekstilnoj industriji obzirom na mogućnost brzog odgovora na visoke zahtjeve tržišta na širinu palete tonova, unikatnosti uzorka, ali i na zahtjeve za uštedom vode i energije. Međutim, zbog kompleksnog međudjelovanja specifičnih površinsko strukturnih karakteristika tekstila kao podloge, zahtjeva na sastav i reološka svojstva tiskarskih boja te tehnologiju formiranja kapljice, još uvijek postoji brojna problematika koju treba riješiti [1,2,3].
Dosadašnja istraživanja potvrđuju neriješenu problematiku u svim aspektima primjene Ink Jet tehnologije u tekstilnom tisku: problematika utjecaja površinsko strukturnih karakteristika tekstilnog materijala na formiranje, razlijevanje i penetraciju kapljice tiskarske boje, karakteristike poroznosti tekstilnog materijala, problematika modifikacije i adaptacije bojila i komponenti tiskarskih pasti za primjenu u Ink Jet tehnologiji, kao i problematika tehničkih zahtjeva uređaja za Ink Jet tisak koji dodatno otežavaju optimizaciju tiskarskih boja [4,5]. Naročito se visoki zahtjevi postavljaju na karakteristike vezivnih sredstava kao ključnih čimbenika kod primjene tiskarske boje na bazi pigmenta, a to su veličina čestice, površinska napetost, viskozitet, stabilnost, kompatibilnost s komponentama tiskarske boje i tehnologijom protoka tiskarske [6,7]. Prema literaturi, uloga površinske strukture tekstilnog materijala tek nedavno prepoznata kao jedan od temeljnih čimbenika kvalitete otiska, te postizanja optimalnog gamuta boja [8,9]. Općenito, optičke karakteristike tekstilne površine mogu se definirati kao suma vizualno perceptivnih atributa boje i površinske strukture, jedinstveno definiranih remisijskim spektrom tekstilnog uzorka. Razumijevanje fenomena površinsko – spektralne remisije važan je čimbenik u svim područjima primjene i reprodukcije boje [2,8,10]. Stoga će istraživanja utjecaja površinsko strukturnih karakteristika tekstilnog materijala na formiranje, razlijevanje i penetraciju kapljice tiskarske boje, doprinijeti razumijevanju navedenih fundamentalnih mehanizama.

1.1 Cilj istraživanja i metodologija

Cilj ovog rada je prvenstveno definirati postavke fundamentalnog razumijevanja uloge veličine čestice bojila i ostalih komponenti tiskarske boje u protoku i formiranju kapljice tiskarske boje te istražiti sve parametre međudjelovanja pojedinačne kapljice tiskarske boje s tekstilnom podlogom, kao i ulogu tog međudjelovanja u formiranju cjelovitog višebojnog otiska. Istražit će se promjene u izgledu i spektralnim karakteristikama boje u Ink Jet digitalnoj tehnologiji tiska u relacijama geometrijskih i optičkih karakteristika tekstila. Istraživanje će se provesti na tkaninama iz iste proizvodne serije; istovrsna pređa za osnovu i potku 100 % pamuk, u četiri različita veza te tri različite gustoće osnove i potke. Istraživanje započinje detaljnom karakterizacijom tekstilnih uzoraka te definiranjem faktora poroznosti odnosno faktora pokrivenosti površine, što uključuje izradu binarnih mikroskopskih slika uzoraka tekstilnih tkanina, te definiranje površinskog udjela vlaknate komponente i površinskog udjela ne vlaknate komponente (šupljine između osnove i potke). Proces tiska realizirat će se pomoću digitalnog tiskarskog stroja Azon Tex Pro, koji koristi pigmentne tiskarske boje na vodenoj bazi.

Također će se prikazati detaljna studija Kubelka – Munkove teorije koja je primarno postavljena za karakterizaciju pigmentnih slojeva, te omogućuje definiranje koeficijenta apsorpcije i raspršenja i tekstilne podloge i pigmenta. Pigmentne disperzije karakterizira svojstvo pigmenta koji ima sposobnost i apsorpcije i raspršivanja svjetlosti. Stoga je za karakterizaciju refleksije sa površine na kojoj se nalaze takve čestice, potrebno definirati i koeficijent apsorpcije i koeficijent raspršivanja pigmenta te same podloge. Primijenit će se i SEM analiza otisnutih uzoraka.

Struktura podloge izuzetno utječe na realizaciju najsitnijih tiskovnih elemenata. Na slici su to linije i rasterske točke (fototipijske ilustracije, tekst sa serifima i više-tonske ilustracije). Uspješnost njihovog generiranje moguća je utvrditi metodom slikovne analize pri čemu će se primijeniti optički mikroskop s povećanjima od 10x do 200x. Za potrebu takve analize koristiti će se sistem Personal IAS namijenjen za analizu Ink Jet otisaka. Upravo zbog različite površinske strukture tekstilne podloge za postizanje uvijek identičnih reprodukcija boje biti će potrebno izvršiti karakterizaciju procesnih otisaka uz primjenu kolorimetrijskih parametara čija je funkcija postizanja optimalnih nanosa tekućeg Ink Jet bojila [11]. Analiza boje u radu provodi se metodom instrumentalnog spektrofotometrijskog mjerenja, a rezultati su izraženi numerički prema CIE standardnom sustavu za prikaz objektivnih vrijednosti spektralnih i kolorističkih karakteristika boje. Cilj je prikazati sumarnu analizu izgleda boje u tehnologiji digitalnog Ink Jet tiska u odnosu karakteristike tiskarske boje, karakteristike tekstilne podloge te postupka naknadne obrade i fiksiranja nakon tiska.

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Studijski savjetnik	Doc. dr. sc. Sandra Flinčec Grgac
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PRAĆENJE TOPLINSKE RAZGRADNJE KOZJE KOŽE S NAGLASKOM NA UTJECAJ NA OKOLIŠ

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1. Uvod

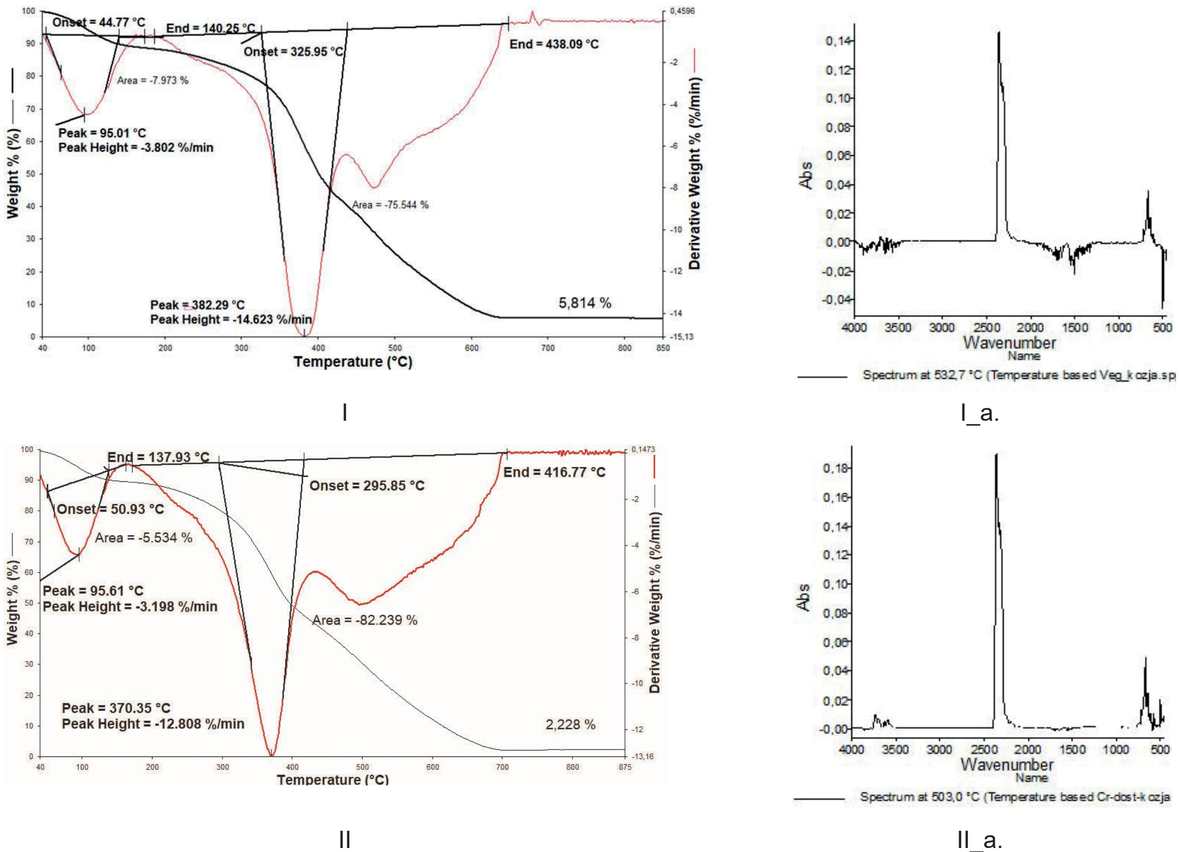
Kolagen je, kao glavna komponenta kože, uvelike odgovoran za njenu toplinsku stabilnost, elastičnost i mehanička svojstva. Kolagenska vlakna sačinjavaju 90 % suhe tvari kožnog sloja koji se različitim postupcima prerade pretvara u uštavljenu kožu [1,2]. Osim navedenog, proizvodnja kože zahtijeva niz operacija od kojih štavljenje ima najvažniju uloga za trajnost kože, stabilizirajući trostruku spiralnu strukturu kolagena [3]. Sredstva korištena u operacijama proizvodnje kože mogu imati nepovoljan utjecaj na okoliš prilikom zbrinjavanja kože. Toplinskom razgradnjom kože dolazi do gubitka vlage i raspadanja kolagena pri čemu se oslobađaju plinoviti produkti čiji sastav utječe na okoliš i zdravlje, a ovisi o vrsti koža te upotrijebljenim sredstvima prilikom njihove obrade i dogotove [4].

2. Eksperimentalni dio

U radu je praćena toplinska razgradnja dvaju uzoraka kože koji se međusobno razlikuju po primjenjenim sredstvima obrade i dogotove. KK1 je šèvrō uzorak kozje kože vegetabilno štavljene i kromno doštavljene, crno obojane s kazeinskom dogotovom. KK2 je velur uzorak kozje kože vegetabilno štavljene i kromno doštavljene, smeđe boje, bez dogotove. Termogravimetrijske (TG) analize provedene su na PerkinElmer TGA Pyris1 termogravimetru. Usitnjeni uzorci približne mase 5 mg podvrgnuti su analizi u temperaturnom rasponu od 50 °C do 850 °C uz brzinu zagrijavanja 30 °C / min s kontinuiranim protokom zraka. Uzorci su proučavani kombiniranom TG-IR tehnikom kako bi se bolje pratio i razjasnio proces razgradnje različito obrađenih uzoraka kozje kože. Za TG-IR analizu koristila se termička stanica za analizu plinova (TAGS) opremljena detektorom. Prijenosni vod, stanica prijenosa visoke temperature i TG sučelje grijani su na 280 °C tijekom izvođenja mjerenja kako bi se spriječila kondenzacija plina. Peristaltička pumpa prenijela je nastale plinove uz brzinu protoka od 60 ml / min.

3. Rezultati i rasprava

Rezultati termogravimetrijske analize uzorka KK1 i uzorka KK2 (sl. 1: I, II) pokazuju da se kod oba uzorka razgradnja odvija u tri razgradbena stupnja. Prva derivacija TG krivulje ukazuje da je i sama dinamika razgradnje kod oba uzorka vrlo slična kroz sva tri stupnja. Najveća dinamika razgradnje se odvija kod oba uzorka u drugom stupnju, no u trećem stupnju razgradnje vidljiva je veća razlika u temperaturi pri kojoj je izmjerena maksimalna razgradnja koja je kod uzorka KK1 (478,24 °C) znatno niža u odnosu na uzorak KK2 (528,72 °C). Završetak trećeg stupnja razgradnje kod KK1 je na nižoj temperaturi u odnosu na uzorak KK2 što ukazuje na usporavanje same razgradnje. Uzrok tome je prisutnost kazeina na površini i u samoj strukturi uzorka što je potvrđeno FTIR-ATR analizom čiji rezultati će biti predstavljeni u posterskom izlaganju. Stabilnost prema djelovanju topline vidljiva je i kroz razgradbeni ostatak koji je kod uzorka KK1 pri 850 °C 5,814 %, a kod uzorak KK2 2,326 %. Iz navedenog je vidljivo da kazeinska dogotova ima utjecaj na toplinsku stabilnost kožnog materijala, ali i na količinu i sastav plinovitih produkata (sl. 1 I_a. i II_a.). Uzorak KK1 pri 532 °C ima znatno manju količinu zabilježenih plinova koji su vidljivi u području valnog broja 2359 i 2322 cm^{-1} i pripadaju CO_2, te valnog broja 2179 i 2110 cm^{-1} koji pripada CO u odnosu na uzorak KK2. Plinoviti produkti uzoraka će se detaljno istražiti i na nižim temperaturama toplinske razgradnje kako bi se analizirali svi plinovi u svrhu sagledavanja utjecaja na okoliš.



Slika 1: Termogravimetrijski prikaz razgradnje uzoraka KK1 (I) i KK2 (II) uz prikaz plinovitih produkata razgradnje pri maksimalnim intenzitetima zabilježenim na temperaturama 532,7 °C (I_a.) i 503 °C (II_a.)

4. Zaključak

Termogravimetrijskom analizom potvrđeno je da šèvrō uzorak, KK1, koji na licu ima nanesenu kazeinsku dogotovu ima veću toplinsku stabilnost i manje količine plinova otpuštenih prilikom razgradnje u usporedbi s velur uzorkom, KK2. Svojstvo povećane toplinske stabilnosti proizlazi iz kemijskog sastava kazeina koji u strukturi sadrži fosfor čiji su spojevi poznati kao dobri usporivači gorenja i toplinske razgradnje. U daljnjem istraživanju sagledat će se mogućnost primjene ekološki povoljnijih procesa obrade i dogotove kože sa svrhom smanjenja utjecaja na okoliš koje će biti sustavno istraživano kroz životni ciklus proizvoda.

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Naslov teme doktorskog rada	Evolucijska hiperheuristika za rješavanje problema izrade krojnih slika
Mentori	Prof. dr.sc. Marin Golub (FER) Prof. dr. sc. Tomislav Rolich (TTF)
Datum obrane teme doktorskog rada	13. srpnja 2017.

EVOLUCIJSKA HIPERHEURISTIKA ZA RJEŠAVANJE PROBLEMA IZRADE KROJNIH SLIKA

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1. Uvod

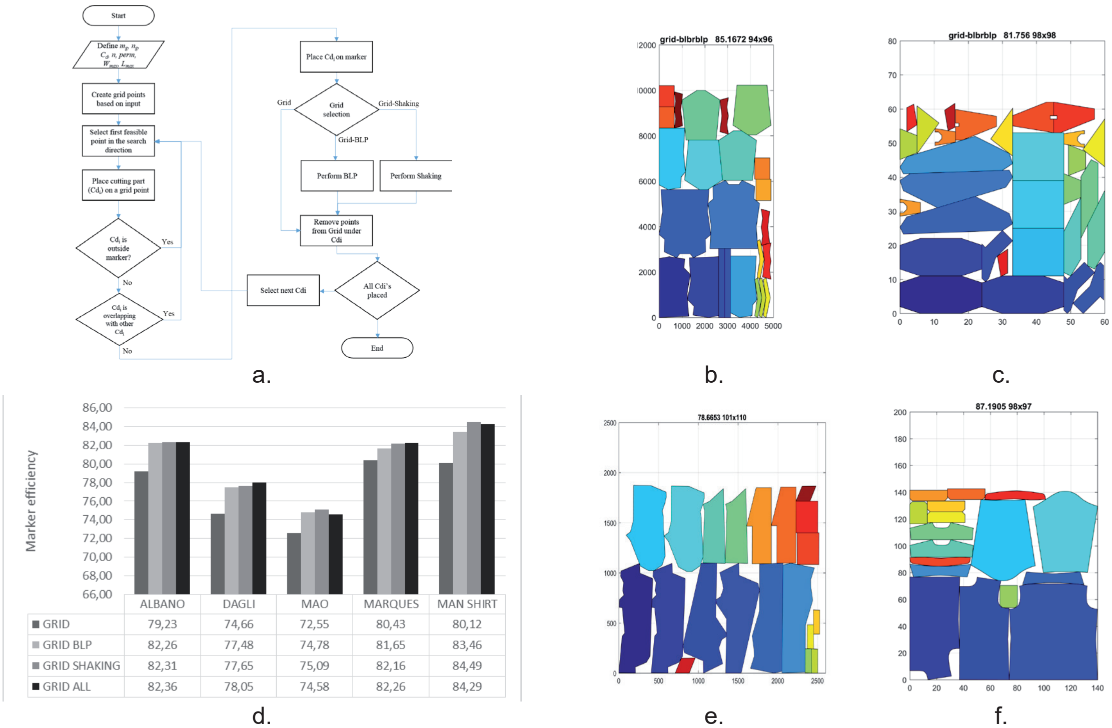
Napredak tekstilne i odjevne industrije leži u ulaganju u nove tehnologije, nove proizvode te specijalizaciji i izvozu. Odjevna industrija mora se prilagoditi novim tržišnim zahtjevima kojima pripada i brza i kvalitetna izrada individualno prilagođenih odjevnih predmeta. S tom motivacijom, u doktorskom radu istražit će se segment optimizacije proizvodnje odjevnog predmeta sa svrhom optimiranja utroška materijala pri uklapanju krojnih slika. U strukturi varijabilnih troškova odjevnog predmeta udio troškova materijala iznosi 60-70 %, dok je udio izrade 30-40 %. Stoga je u tehnološkoj fazi potrebno izvršiti optimalno uklapanje krojnih dijelova kako bi se što bolje iskoristio krojni materijal. Time se smanjuju troškovi proizvodnje i povoljno regulira zbrinjavanje otpada od iskrojavanja [1].
U računarskoj znanosti ovaj problem dio je šireg skupa problema koji se općenitijim pojmom naziva problemom pakiranja. Problem pakiranja takav je optimizacijski problem u kojem se više manjih elemenata mora, bez međusobnog preklapanja, rasporediti unutar granica spremnika. S obzirom na to da se problem pakiranja u praksi javlja u različitim granama industrije, problemi pakiranja dijele se prema aktualnoj Wäscherovoj taksonomiji [2]. Problem pakiranja može se uspješno riješiti primjenom algoritama zasnovanih na evolucijskom računanju. Evolucijski algoritam daje dobra rješenja za problem pakiranja u kombinaciji s nekim algoritmom lokalne pretrage.

2. Eksperimentalni dio

Cilj je istraživanja načiniti dovoljno općeniti i prilagodljivi algoritam koji bi mogao rješavati problem izrade krojnih slika s materijalima i krojnim dijelovima koji mogu biti proizvoljnog oblika i uz mogućnost određivanja područja kvalitete materijala, čime se omogućuje primjena algoritma na bilo kojem skupu ulaznih podataka. U tu svrhu osmišljena je *Grid* metoda koja se fleksibilno može primijeniti na različite tipove problema i ulaznih skupova, a može prepoznati i oštećenja spremnika (npr. rupe, oštećenja na tkanini/koži, zabranjena područja). Ujedno, izvođenje *Grid* metode neovisno je o obliku spremnika.
Kod *Grid* metode slobodni se prostor diskretizira mrežom točaka. U svaku se točku mreže postavlja referentna točka krojnog dijela i provjerava se preklapanje s ranije raspoređenim krojnim dijelovima. Ako ne postoji preklapanje, krojni se dio smješta na odabranu poziciju. Kako je cilj postići što gušće pakiranje, u disertaciji će biti razmotrena primjena nekoliko metoda zbijanja rasporeda krojnih dijelova (engl. *compaction method*): dolje-lijevo (BLP) i novo osmišljena *Shaking* metoda, čime se omogućuje popunjavanje praznog prostora između krojnih dijelova [3].
Osmišljene će algoritme birati hiperheuristika koja za svaku jedinku evolucijskog algoritma u generaciji omogućuje izbor algoritma pakiranja: *Grid*, *Grid-BLP* ili *Grid-Shaking* [4]. Pretpostavlja se da će uporaba hiperheuristike dodatno doprinijeti kvaliteti rezultata zbog mogućnosti istovremenog pristupa istom problemu s više različitih algoritama i parametara. U tu svrhu osmišljen je novi način prikaza jedinke evolucijskog algoritma koji se sastoji od četiri dijela: (I) permutacije koja određuje redoslijed pakiranja krojnih dijelova na materijal, (II) rotacije pojedinog krojnog dijela za 0° ili 180°, (III) gustoća dinamičke Grid mreže, (IV) izbor heurističke metode koja će obavljati pakiranje za tu jedinku (hiperheuristika).
Dodatno, osmišljena je nova metoda određivanja redoslijeda pakiranja *AEF* (engl. *All Equal First*) koja će rasporediti sve identične krojne dijelove jedne grupe na materijal prije nego nastavi s krojnim dijelovima sljedeće grupe. Prednost ove metode jest znatno smanjeni prostor pretraživanja.

3. Rezultati i rasprava

Ispitivanja su provedena na različitim ispitnim skupovima iz tekstilne industrije u aplikacijama načinjenima u MATLAB programskom okruženju prema pseudokodu sa slike 1a. Pri izvedbi evolucijskog algoritma korišten je toolbox GEATbx, a testirane su i različite verzije selekcije, križanja i mutacije jedinki.



	ALBANO	DAGLI	MAO	MARQUES	MAN SHIRT
GRID	79,23	74,66	72,55	80,43	80,12
GRID BLP	82,26	77,48	74,78	81,65	83,46
GRID SHAKING	82,31	77,65	75,09	82,16	84,49
GRID ALL	82,36	78,05	74,58	82,26	84,29

Slika 1: Hiperheuristika: a) pseudokod algoritma, b) ALBANO, c) DAGLI, d) rezultati mjerenja i najbolji rezultati za ispitni skup e) MARQUES i f) MAN SHIRT.

Rezultati ispitivanja prikazani su na slici 1d iz kojih je vidljivo da hiperheuristički pristup pronalazi najbolja rješenja, a od individualnih algoritama najbolja rješenja daju novoosmišljeni heuristički pristupi koji su poboljšanja osnovne metode (Grid-BLP i Grid-Shaking).

4. Zaključci

Osmišljeni memetički algoritmi mogu raditi s bilo kojim skupom ulaznih podataka i ostvaruju kompetitivne rezultate. Osmišljena hipereuristika omogućuje izbor najprikladnijeg memetičkog algoritma. Novim prikazom jedinke omogućuje se optimizacija parametara pomoću evolucijskog algoritma.

Zahvala

Zahvaljujem svojim mentorima prof. dr. sc. Tomislavu Rolichu i prof. dr. sc. Marinu Golubu na svesrdnoj pomoći pri mom istraživanju, provođenju eksperimenata i izradi disertacije.

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Naslov teme doktorskog rada	Kompleksni spojevi vanadija s derivatima 2-benzotiazolilhidrazona
Studijski savjetnik	Prof. dr. sc. Gordana Pavlović
Datum obrane teme doktorskog rada	-

KOMPLEKSNI SPOJEVI VANADIJA S DERIVATIMA 2-BENZOTIAZOLILHIDRAZONA

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1. Uvod

Vanadij je prijelazni element široko rasprostranjen u tlu, vodama i sirovoj nafti, a također je pronađen u tragovima u biološkim sustavima [1]. Kompleksni spojevi vanadija pokazali su raznovrsno farmakološko djelovanje te se ispituju u svrhu liječenja dijabetesa, karcinoma i parazitskih oboljenja [2]. Antitumorska svojstva vanadijevih kompleksa najviše se ispituju na vanadocenima, oksovanadijevim(IV) i dioksovanadijevim(V) kompleksima [3]. Odabirom pogodnih ligantnih sustava utječe se na stabilnost i transport, a sinergističkim djelovanjem mogu pojačati biološku aktivnost vanadijevih kompleksnih spojeva. Objedinjavanjem biološki aktivnih benzotiazolnih i hidrazonskih strukturnih fragmenata nastaju 2-benzotiazolilihidrazonski ligantni sustavi povećane koordinacijske sposobnosti i potencijalno pojačane biološke aktivnosti [4,5]. Pregledom literature uočeno je da postoji malo sličnih ligantnih sustava, a nisu pronađene strukture kompleksa vanadija s ovako funkcionaliziranim ligantnim sustavom. Ciljevi istraživanja su: prirediti vanadijeve komplekse ciljane strukture i svojstava modeliranjem sintetskog pristupa, usporediti biološku aktivnost 2-benzotiazolilhidrazona i njihovih vanadijevih kompleksa te istražiti supramolekulsku arhitekturu liganada i kompleksa i njezin utjecaj na svojstva priređenih spojeva.

2. Eksperimentalni dio

2.1. Sinteza

2-benzotiazolilhidrazonski ligandi (Bzt−NH−N=C−Ar; Bzt = benzotiazolil) prieredit će se kondenzacijskim reakcijama 2-hidrazinobenzotiazola s derivatima benzaldehida, naftaldehida, piridinkarboksialdehida i kinolinkarboksialdehida. Prilikom sinteze kompleksnih spojeva ispitat će se utjecaji sljedećih parametara na strukturu i svojstva priređenih kompleksa: vrsta ishodne vanadijeve soli (($VO(acac)_2$), $VOSO_4$, $NaVO_3$), temperatura i tlak, stehiometrijski omjeri reaktanata i dodatak baze.

2.2. Identifikacija priređenih spojeva i određivanje molekulske i kristalne strukture

Pripravljeni ligandi i vanadijevi kompleksi bit će identificirani sljedećim eksperimentalnim tehnikama: IR, TGA/DSC, PXRD, NMR te elementnom analizom. Molekulska i kristalna struktura priređenih spojeva odredit će se difrakcijom rengenskog zračenja u jediničnom kristalu.

2.3. Ispitivanje bioloških svojstava

U suradnji s drugim institucijama ispitati će se biološka aktivnost priređenih spojeva. Primarno će se ispitati antiproliferativni efekt priređenih spojeva na ljudskim tumorskim stanicama i zdravim fibroblastima kako bi se pronašli pogodni spojevi za potencijalna klinička ispitivanja.

3. Rezultati i rasprava

Priređeno je petnaest 2-benzotiazolilhidrazonskih liganada funkcionaliziranih: hidroksi skupinom na različitim mjestima u fenilnom fragmentu (L^1-L^6), metoksi skupinom na različitim mjestima u naftilnom fragmentu (L^7-L^9), različitim piridinskim jezgrama (L^{10}-L^{12}), različitim kinolinskim jezgrama (L^{13}-L^{15}).

Difrakcijom rengenskog zračenja na jediničnom kristalu potvrđena je imino tautomerna forma liganda L^1 i L^4, a amino tautomerna forma L^2, L^4, L^7-L^{14}. Ligand L^{13} je (*Z*) - geometrijski izomer u odnosu na C=N *egzo* vezu, a ostali ligandi su (*E*) - izomeri. Najučestaliji supramolekulski motiv pronađen kod liganda je centrosimetrični $R_2^2(8)$ dimer nastao preko $N_{hidrazino}$–H·$N_{tiazolil}$ intermolekularnih vodikovih veza.

Reakcijom ($V^{IV}O(acac)_2$) s $H_2L^{1,3\text{-}6}$ i $HL^{10,13}$ u alkoholnim otopinama u stehiometrijskom omjeru 1:1 nastalo je sedam kompleksa opće formule ($VO_2HL^{1,3\text{-}6}$) ili ($VO_2L^{10,13}$). Reakcijom ($V^{IV}O(acac)_2$) s $H_2L^{1,4,6}$ u etanolnim otopinama s ekvimolarnim dodatkom Et_3N nastala su 3 ionska kompleksa tipa $Et_3NH^+(V^VO_2L)^-$. Geometrija oko vanadijevog centra je deformirana kvadratno piramidalna, a VO^{2+} jezgra koordinirana je deprotoniranim O,N,N tridentatnim ligandima.
Antiproliferativni učinak ispitan je na ligandima L^1- L^9. Navedeni spojevi pokazali su snažan antiproliferativni efekt na svim ispitanim tumorskim stanicama pri mikromolarnim koncentracijama.

4. Zaključci

Kondenzacijskim reakcijama 2-hidrazinobenzotiazola s odabranim aromatskim aldehidima priređeno je petnaest 2-benzotiazolilhidrazonskih liganada. Antitumorska svojstva ispitana su na ligandima L^1-L^9 koji su pokazali snažan antiproliferativni efekt na svim ispitanim tumorskim stanicama pri mikromolarnim koncentracijama. Reakcijama liganada s ($VO(acac)_2$) priređeni su potencijalno biološki aktivni dioksovanadijevi (V) kompleksi čija se antitumorska aktivnost planira ispitati.

Zahvala

Zahvaljujem se dr.sc. Krešimiru Molčanovu na prikupljanju podataka dobivenih difrakcijom rengenskog zračenja na jediničnim kristalima liganada L^7 i L^9.

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Životopis

Petra Krpan rođena je u Zagrebu 1985. godine. Diplomirala je i magistrirala na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu na području teorije mode. Studirala je modno novinarstvo na *London College of Fashion* (Sveučilište u Londonu, London College of Fashion) te sudjelovala na brojnim međunarodnim radionicama i konferencijama. Radi kao asistentica na Zavodu za dizajn tekstila i odjeće na Tekstilno-tehnološkom fakultetu (TTF) gdje drži seminare i vježbe iz kolegija: *Teorija mode, Sociologija mode, Novi mediji i moda, Suvremena moda i Performativnost mode.* Završava Poslijediplomski studij književnosti, izvedbenih umjetnosti, filma i kulture na Filozofskom fakultetu u Zagrebu (FFZG).

Naslov doktorskog rada: Suvremena moda kao događaj-novi mediji i preobrazbe tijela

Mentori: Izv. prof. dr. sc. Žarko Paić (TTF); Akademik Boris Senker (FFZG)

Datum obrane teme doktorskog rada: 5. srpnja 2017.

SUVREMENA MODA KAO DOGAĐAJ-NOVI MEDIJI I PREOBRAZBE TIJELA

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1. Uvod

U doktorskoj disertaciji *Suvremena moda kao događaj: novi mediji i preobrazbe tijela,* nastojat će se uspostaviti odnos između područja i pojma suvremene mode koja se pojavljuje nakon 1980-ih godina XX. stoljeća, novih medija kao nove mogućnosti razvoja modnog procesa i događaja te njihova bitnog utjecaja na razumijevanje mode i artikulacije interdisciplinarnih studija mode (*fashion studies*). U istraživačkom i znanstvenom smislu, izvest će se temeljna postavka kako suvremena moda ne postoji bez utjecaja medija na tijelo i odjevni objekt u cjelini. To istovremeno mijenja logiku djelovanja u virtualnom svijetu na način da se moda pojavljuje na zaslonu kao *nova* slika, ali i u performativnom obliku kao moda-tijelo.

2. Eksperimentalni dio

Rad će utvrditi mogućnosti neprestanih preobrazbi suvremene mode u načinu reprezentacije tijela kroz promijenjenu ulogu novih medija i izvedbenih umjetnosti. Suvremena moda se pojavljuje u svojim najznačajnijim ostvarenjima kao reinterpretacija i reizvedba *događaja*. Tijelo u modi postavljeno je u središte izvedbenog djelovanja iz jednostavnog razloga što moda, posebno nakon 1990-ih godina XX. stoljeća, predstavlja sjecište različitih novomedijskih i izvedbenih oblika. Za razliku od tradicionalnog pristupa modi kao pokazatelju društvenih promjena u doba modernosti, ovdje se nastoji istražiti pristup prema dekonstrukciji društva modernog shvaćanja kulture. Čini se nužnim krenuti u smjeru onih shvaćanja kulture koja sjedinjuju u svojim dosezima pojmove identiteta, komunikacije i emergentne mreže. Suvremenu modu u analogiji s konceptualnom i performativnom umjetnošću kraja XX. stoljeća određuje tijelo u svim aspektima pojavljivanja. Tijelo se, međutim, više ne može razumjeti tek funkcijom ili strukturom neposrednog djelovanja čovjeka u unaprijed postavljenom svijetu, nego kao autonomno događanje u mreži slikovne reprezentacije. Moda otuda označava vizualnu konstrukciju tijela kao događaja i time se pokazuje nesvodivim fenomenom životnoga stila (*lifestyle*) u društvima spektakla današnjice.

3. Rezultati i rasprava

Zašto su novi mediji oni koji sada povezuju pojam mode i tijela u modno tijelo? Prepoznavanje modnog jezika kao i znakovnog sustava mode od posebne je važnosti u istraživanju jer se radi o pokušaju nove tvorbe identiteta subjekta, rodno/spolne diferencijacije unutar mode, ali i prelaska iz klasno-socijalnih modela u vizualnu semiotiku u postmodernim teorijama mode. Iz navedenih razloga istraživanja u okviru izrade doktorskog rada će se usmjeriti na dvoznačnost suvremene mode: s jedne strane mode kao slikovne reprezentacije, a s druge mode kao ekscentričnog tijela u procesu postajanja drugim i drukčijim. Moda se u okružju semiotike pojavljuje kao *tekst* koji se tumači iz različitih interpretacijskih okvira, dok se u izvedbi u virtualnom svijetu moda pojavljuje kao *tijelo* u događaju. Pritom ova epistemološka razlika upućuje na produbljeno istraživanje odnosa između teksta i slike, što je nakon Barthesa postalo nužno utoliko više jer se slika u digitalnome okružju, značenja više ne može dekodirati polazeći od jezika kao univerzalnoga označitelja [1]. Događaj je sada postao temeljnom kategorijom za nove interpretacije biti suvremene mode. Stoga je nužno pokazati kako se semiotički model u novim medijima preselio s teksta na ekran, iz jezika u kôd te kako se moda istražuje kao nova mogućnost tjelesnog događaja u modnom objektu.

4. Zaključak

Raspad društvene forme mode, rušenje pojma ljepote i apokalipsa tijela ono su što određuje suvremenu modu. Moda sada djeluje u Integralnoj stvarnosti Baudrillarda no ne može joj se precizno odrediti vrijeme [2]. Njezino linearno kretanje u povijesti mode olakšavalo nam je njezino istraživanje no kod suvremene mode više nema stvarne forme niti stvarnog vremena. Jedino što postoji jest medijsko vrijeme. Tijelo suvremene mode samo je posljedica terora povijesti, invazije novih medija i simulacije te u konačnici i nestanka subjekta. Ostaje na spektaklu i simulaciji da odluče hoće li tijelo suvremene mode biti još uvijek tijelo ili će se zauvijek izgubiti u prostoru mreže. Otvorenost sustava mode, koju je predložio Lipovetsky, pruža mogućnost totalne transgresije tijela [3]. Pojam medija i mode neodvojiv je, a to je i namjera ove disertacije: pokušati uspostaviti cjelinu između pojma medija i mode u novom događaju tijela. Moda postaje otvoreno područje u kojemu nailazimo na višeznačnost, sve ono što je Barthes, s kojim i započinje teorija mode, nagovijestio. Ta višeznačnost prisutna je i u performansu ili preciznije rečeno događaju mode što ga odvaja sada od pojma performansa. Posrijedi je nova izvorna otvorenost događaja, a time i nova mogućnost rekreiranja identiteta ili preciznije: u modi sada sve može biti *re-enactment.*

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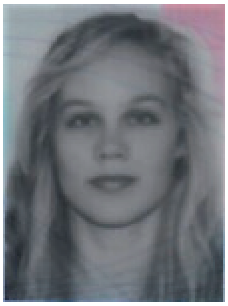

Lucija Ptiček

Životopis

U razdoblju od 2006. do 2011. godine studirala je na Sveučilištu u Zagrebu Prirodoslovno-matematičkom fakultetu (PMF) na Kemijskom odsjeku gdje je stekla titulu magistra kemije. Nagrađena je za izvrsnost u studiranju medaljom Kemijskog odsjeka. 2011. godine zaposlena na radnom mjestu analitičara Kontrole kvalitete, Pliva Hrvatska d.o.o. gdje stječe vrijedna znanja u analitičkim tehnikama te specifičnim metodama koje se koriste za ispitivanje farmaceutskih uzoraka. 2015. godine zaposlena je kao asistent na Sveučilištu u Zagrebu Tekstilno-tehnološkom fakultetu (TTF). Iste godine upisuje poslijediplomski sveučilišni studij na Prirodoslovno-matematičkom fakultetu, Kemijski odsjek. Objavila je jedan znanstveni rad, sudjelovala na 4 znanstvena skupa, te bila neposredni voditelj na 4 završna rada. Područja znanstvenog interesa su organska i medicinska kemija.

Naslov teme doktorskog rada

Sinteza i biološka aktivnost amidino-supstituiranih benzoksa(tia)zola

Studijski savjetnici

Izv. prof. dr. sc. Livio Racané (TTF)

Izv. prof. dr. sc. Ines Primožić (PMF)

Datum obrane teme doktorskog rada

SINTEZA I BIOLOŠKA AKTIVNOST AMIDINO – SUPSTITUIRANIH BENZOKSA(TIA)ZOLA

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1. Uvod

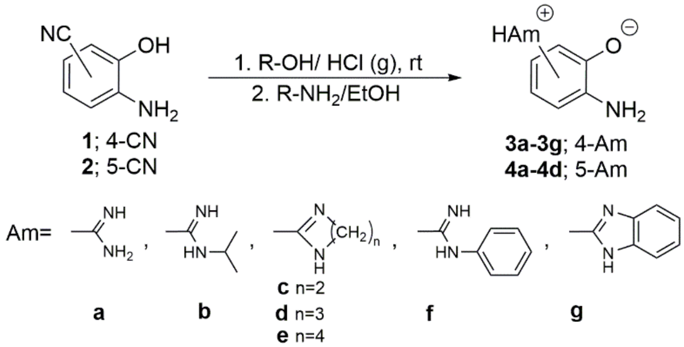
Amidino-supstituirani benzazolski spojevi pokazuju širok spektar biološke aktivnosti i kontinuirano se istražuju od strane više istraživačkih skupina [1,2] no za razliku od velikog broja biološki aktivnih amidino-supstituiranih benzimidazolnih i benzotiazolnih derivata, amidino-supstituirani benzoksazolni derivati su rijetki. Postoji samo nekoliko radova koji opisuju sintezu amidino-supstituiranih benzoksazolnih derivata i njihovu antitumorsku [3] i antimikrobnu aktivnost [4], te njihovo vezanje na DNK [5]. Razlog tome je nedostatak jednostavne i efikasne metode za njihovu sintezu koja bi se mogla temeljiti na kondenzacijskim reakcijama amidino-supstituiranih 2-aminofenola, kao ključnih prekursora koji nisu opisani u literaturi, s karboksilnim kiselinama, derivatima karboksilnih kiselina i aldehidima. Cilj istraživanja je pronalazak efikasne metode priprave novih amidino-supstituiranih benzoksa(tia)zola te utvrđivanje njihove antitumorske aktivnosti uz ispitivanja interakcija sa molekulom DNA u svrhu određivanja njihovog mogućeg mehanizma djelovanja. Računalnim metodama pokušat će se predvidjeti odnos kemijske strukture i antitumorskih svojstava priređenih spojeva kako bi se ciljano sintetizirali aktivniji i selektivniji spojevi sa antitumorskim djelovanjem.

2. Eksperimentalni dio

Organska sinteza provodi se iz komercijalno dostupnih kemikalija i reagensa uz uobičajena organska otapala. Istraživački rad obuhvaća višestupnjevitu sintezu različitih amidino-supstituiranih 2-aminofenola i 2-aminotiofenola, odnosno 2-aril- i 2-heteroaril-supstituiranih mono- i bisbenzoksa(tia)zolskih amidinskih derivata koji su strukturno i spektroskopski karakterizirani. Također je provedena elementna analiza nekih spojeva, a nekima je određena molekulska struktura rendgenskom difrakcijom na jediničnom kristalu.

3. Rezultati i rasprava

U sklopu ovog istraživanja pripravljeni su ključni prekursori koji predstavljaju izomerne, različito amidino-supstituirane 2-aminofenole i 2-aminotiofenole (sl. 1), a kasnije i novi benzoksa(tia)amidinski derivati kojima se ispituje antitumorska aktivnost s ciljem postavljanja suodnosa struktura-biološka aktivnost.



Slika 1: Izomerni amidino supstituirani 2-aminofenoli

Sintetizirani su 2-aril- i 2-heteroaril-supstituirani mono- i bisbenzoksa(tia)zolski amidinski derivati iz prethodno pripređenih izomernih amidino-supstituiranih 2-aminofenola i 2-aminotiofenola kondenzacijskim reakcijama s komercijalno dostupnim aril- i heteroarilnim aldehidima i karboksilnim kiselinama. Optimirane su metode kondenzacijskih reakcija 2-aminotiofenolnih derivata sa heteroarilnim aldehidima, te su nađene dvije komplementarne metode kondenzacije u octenoj kiselini i glicerolu. Monosupstituiranim arilnim i heteroarilnim amidinskim derivatima benzotiazola ispitana je antitumorska aktivnost te su QSAR analizom utvrđeni parametri koji najviše utječu na antitumorsku aktivnost.

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Naslov teme doktorskog rada	Termoelektrična i magnetotransportna svojstva SnSe monokristala
Studijski savjetnici	Dr. sc. Petar Popčević, (IF) Dr. sc. Ana Smontara (IF) Prof. dr. sc. Denis Sunko (PMF)
Datum obrane teme doktorskog rada	

TERMOELEKTRIČNA I MAGNETOTRANSPORTNA SVOJSTVA SnSe MONOKRISTALA

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1. Uvod

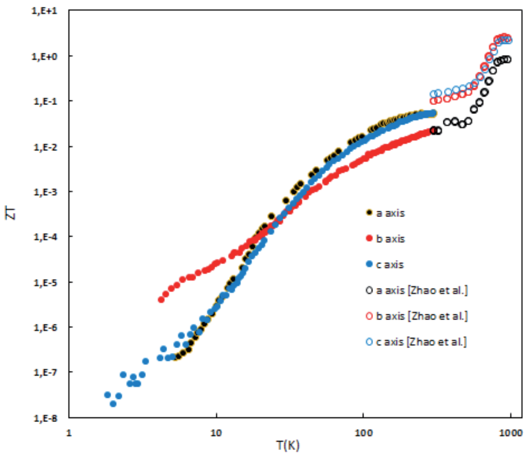
Termoelektrični materijali kao potencijalni novi izvor energije, predmet su intenzivnog istraživanja zbog svoje sposobnosti da izravno pretvaraju otpadnu toplinu u električnu energiju. Poboljšanje termoelektrične učinkovitosti jedan je od najvećih izazova u znanosti o materijalima.
Nedavno je objavljeno da SnSe u monokristalnom obliku ima izuzetno visoki termoelektrični koeficijent izvrsnosti (2,6 na 973 K) uglavnom zbog iznimno niske toplinske vodljivosti [1]. Ovaj rezultat uz činjenicu da je građen od relativno slabo toksičnih i široko dostupnih elemenata čini SnSe jednim od najperspektivnijih termoelektričnih materijala današnjice. Iako su fizikalna svojstva SnSe iznad sobne temperature dobro istražena, vrlo je malo istraživanja monokristalne faze na niskim temperaturama [2]. Motivirani da otkrijemo moguće uzroke izvanrednih termoelektričnih svojstava ovoga sustava, izmjerili smo termoelektrična i magnetotransportna svojstva monokristalnog SnSe na niskim temperaturama.

2. Eksperimentalni dio

Mjerenja transportnih koeficijenata (električne otpornosti, ρ(T), termostruje, S(T) i toplinske vodljivosti, κ(T)) napravljena su korištenjem eksperimentalnih uređaja razvijenih u Laboratoriju za fiziku transportnih svojstava, Instituta za fiziku. Detaljan opis principa i rada pojedinih mjernih uređaja (uređaj za mjerenje električnog otpora i termostruje, uređaj za mjerenje toplinske vodljivosti) nalazi se u literaturnom navodu [3]. Mjerenja magnetootpora i Hallovog koeficijenta (Hallove otpornosti, ρH (B,T)) napravljena su koristeći PPMS (*Physical Property Measurement System*).

3. Rezultati i rasprava

Budući da su do sad objavljena transportna svojstva SnSe pokazala često puta i kontradiktorno ponašanje [2,4,5], a motivirani izrazito velikim termoelektričnim potencijalom ovoga sustava [1], napravili smo detaljnu karakterizaciju termoelektričnih svojstava visokokvalitetnog monokristala SnSe u temperaturnom intervalu 1.5-300 K. Monokristali SnSe dobiveni su iz stehiometrijske smjese kositra i selena u zatvorenoj kvarcnoj ampuli upotrebom vertikalne Bridgmanove metode. Rezultati mjerenja električne otpornosti i termostruje dobro se slažu sa rezultatima Zhaove grupe [1], dok je toplinska vodljivost našeg kristala na sobnoj temperaturi dosta veća od iznimno niske toplinske vodljivosti kakvu su oni dobili, što se direktno reflektira na termoelektričnu učinkovitost (sl. 1). Ovdje valja napomenuti, da postoji nekoliko eksperimentalnih studija [2,6] koje također nisu uspjele reproducirati toplinsku vodljivost Zhaove grupe, a samim time niti tako veliku termoelektričnu učinkovitost. Analizirajući rezultate električnog transporta, došli smo do zaključka da se radi o jako dopiranom poluvodiču s koncentracijom nosioca naboja od $2x10^{17}$ cm^{-3} te da toplinskoj vodljivosti u ovom sustavu dominantno doprinosi samo kristalna rešetka, dok se doprinos elektronskog sustava može zanemariti. Jedina razlika do sada uočena među uzorcima je gustoća koja je prema autorima [1] bila oko 10 % niža od dobivenih vrijednosti u okviru ovog istraživanja, ostalih eksperimentalnih studija [6], kao i dobivenih teorijskih vrijednosti. Rezultati mjerenja magnetootpora i Hallovog koeficijenta ukazuju da su šupljine većinski nosioci naboja, te da na niskim temperaturama gdje su svi akceptorski nivoi zamrznuti prevladava preskakivanje promjenjivog dosega kao dominantni kanal vođenja električne struje. Tijekom istraživanja razmatran je i mogući način optimizacije niskotemperaturne termoelektrične učinkovitosti. Proučavani sustav ima fazni prijelaz na 750 K iz niskotemperaturne Pnma u visokotemperaturnu Cmcm fazu. Imajući na umu da fazni prijelaz iz Pnma u Cmcm fazu prati makroskopska promjena dimenzije kristala te da visokotemperaturna faza pokazuje značajno veću termoelektričnu efikasnost [1], postoje indikacije da bi primjena tlaka (kako hidrostatskog tako i uniaksijalnog) mogla sniziti temperaturu faznog prijelaza, te na taj način povećati efikasnost sustava na nižim temperaturama [7].



Slika 1: Vrijednosti termoelektrične učinkovitosti (ZT) monokristala SnSe: izmjerene vrijednosti -puni krugovi, podaci preuzeti iz [1] - prazni krugovi.

4. Zaključci

Toplinska vodljivost prema literaturi [1] ne odražava intrinzična svojstva monokristalne SnSe faze, iako električni otpor i termostruja ne pokazuju značajne razlike u odnosu izmjerene vrijednosti. Također, istraživanja se provode u smjeru primjene alternativne strategije za povećanje učinkovitosti SnSe-ove pretvorbe energije snižavanjem temperature faznog prijelaza primjenom uniaksijalnog tlaka.

Zahvala

Ovaj rad napravljen je u Laboratoriju za fiziku transportnih svojstava, Instituta za fiziku pod mentorstvom dr. sc. Petra Popčevića i dr.sc. Ane Smontare. Uzorci za mjerenje dobiveni su od prof. dr. sc. Petera Gillea sa Ludwig-Maximilians - Universität-a u Münchenu. U kolaboraciji sa grupom prof. dr. sc. Nevena Barišića sa Technische Universität-a u Beču napravljena su mjerenja magnetootpora i Hallovog koeficijenta.

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This study programme is a continuation of the graduate university study, aimed at educating researchers who will enlarge theoretical knowledge, methodology of research, develop critical way of thinking, together with transferrable skills in textile technology. The study programme is based on the research in the field of textile-mechanical engineering, material science, textile chemistry, textile and garment technology, as well as textile and fashion design.

Doctoral study programme

The programme of postgraduate university study Textile Science and Technology has been integrated into the Faculty strategic documents, accepted in 2014: Research Strategy of University of Zagreb Faculty of Textile Technology for the period 2014-2020 and Development Strategy of University of Zagreb Faculty of Textile Technology for the period 2014-2020. In accordance with the FTT mission, scientific activities have been aimed to fulfil the needs of social and economic development, while the teaching process has been matched to the needs of labour market and general needs of the society.

The study programme lasts for 6 semesters and upon completion the students are awarded at least 180 ECTS credits. Teaching load for the doctoral students is 16.7%, or 30 ECTS credits gained by passing exams in 8 courses (2 obligatory, 5 electives in textile technology and 1 general elective). Additionally, Project tasks are made in the III, IV and V semester, where student work individually on a particular topic in the field of research, earning additional 18 ECTS credits. The doctoral students enrolled at the FTT are directed into research at the very start of their study. Appointed study advisor introduces the student to research, developing his/her critical and analytical way of thinking, encouraging independence in research, all aimed at strengthening his/her scientific and research competences.

Doctoral studies are, according to the Development strategy 2014-2020, based on the capacity, critical mass and diversity of the investigations, which makes doctoral students active participants in the research projects. Critical mass does not mean necessarily an extensive growth in the number of doctoral student researchers. It mostly concerns the quality of the research and the usage of highly valuable scientific equipment available at the FTT. The FTT encourages attaining the highest possible level of learning outcome for the doctoral students in the course of their studies, developing mutual trust among doctoral students and their teachers, as well as developing ethics in science as an important basis of education. In the course of their doctoral study, FTT offers professional development and individual progress to doctoral students, together with gaining skills in pursuing and understanding research ethics. This includes top-quality mentorship and the competence of the FTT mentors and mentors from other Croatian and foreign institutions of higher education, which offers interdisciplinarity, mobility among institutions and collaboration with other universities. High level of knowledge in textile technology enables the doctoral students to be involved in development projects of innovative and highly sophisticated technologies, which are a necessary basis for prosperity and increased competitiveness of the economy.
The doctoral students are also motivated for additional effort in scientific research by evaluating this with awarding the following:

1. Annual Dean's award for excellence in the doctoral study, on the occasion of the Faculty Day.
2. Annual grant for research results, where the student is exempted from paying the tuition fee.
3. Annual award for the best scientific work in the field of textile technology, on the competition of the Textile Science Research Centre (TSRC).

Doctoral students are encouraged to mobility and are offered to make a part of their doctoral theses at some other institution of higher learning. Through well-planned education, the students also encourage to develop their cognitive abilities, primarily through their research within research projects, but also through the ability to present the results of their investigations, their impact and application in textile industry. The FTT encourages planning and monitoring duration of students' education process (higher passing rate), as well as monitoring each of PhD's career after their graduation from the study.

Quality of the doctoral study Textile Science and Technology

The Research Strategy 2014-2020 has clearly defined activities aimed at *Improving Doctoral studies quality* (Strategic goal 3). These activities include:

- Monitoring mentor competences,
- Monitoring and improving tuition process at the doctoral studies,
- Encouraging research productivity of doctoral students,
- Involving students into research projects,
- Grants and awards to doctoral students,
- Encouraging doctoral students' cognitive skills, and
- Encouraging mobility and postdoctoral specialisations.

The FTT organises educational and motivate workshops for mentors and doctoral students, investing thus an additional effort to raise the quality of mentors' work and students' efficiency. The procedure of Reaccreditation for the doctoral study Textile Science and Technology was conducted in the academic year of 2015/2016. This included making a Self-analysis (http://www.ttf.unizg.hr/sadrzaj/files/Samoanaliza_doktorskog_studija_TZT_2016-04-20.pdf) and a visit of an Expert Committee on June 8th 2016. According to their opinion on the study programme quality, the Agency for Science and Higher Education gave, in the procedure of reaccreditation for a part of the FTT activity, a recommendation to the Ministry of Science, Education and Sports, on February 3rd 2017, for the following:

1. Issuing a certificate of fulfilling the requirements for performing a part of the activities of the University of Zagreb Faculty of Textile Technology, regarding the organisation and conducting study programme of postgraduate university study of Textile Science and Technology at the University of Zagreb, Faculty of Textile Technology.
2. Further monitoring a part of the activity mentioned in 1, at the FTT to with the expectation of the following:
   - Adoption of an Action plan aimed at quality improvement in the period of 6 months from the day of receiving the above certificate and delivering the Action plan to the Agency, and
   - Annual report to the Agency on the realisation of the Action plan, including updating conditions of performing the programme in the computer system used by the Agency.

Ministry of Science and Technology issued on March 30th 2017 a Certificate by which the University of Zagreb Faculty of Textile Technology meets the requirements for performing a part of the activities, related to conducting a Postgraduate University Programme Textile Science and Technology, as defined by the provisions of the Law on Quality Assurance in Science and Higher Education.

In Zagreb, January 2018

Head of PhD study — *Dean of the Faculty of Textile Technology*

Prof. Stana Kovačević, PhD — *Prof. Sandra Bischof, PhD*

Foreword

The Action plan, made following the instructions proposed by the Agency for Science and Higher Education, has defined certain tasks to be performed by the Council of PhD study, one of them being the organisation of PhD Day.

This year PhD Students´ Day has been organised in two sections. The first one includes oral presentations of PhDs, promoted in previous academic year, on the topics of the investigations performed in the framework of their PhD theses. The second part involves poster communications of actual doctoral students, except the first year students, where they will present the course of their current investigations. Beside the doctoral students attending the study programme of Textile Science and Technology, all the other doctoral students employed by the Faculty of Textile Technology attending programmes at the other member institutions of the University of Zagreb, will present their research topics. The Council of PhD doctoral study has decided to evaluate the contribution of the participant doctoral students with 4 ECTS credits.

This Croatian – English edition of the Book of Proceedings contains short biographies of the PhDs and PhD students, as well as full papers, an expanded summary of the investigation for each approved theme of doctoral thesis or doctoral thesis plan.

The primary aim of organising the PhD Students´ Day at the University of Zagreb Faculty of Textile Technology is to present the topics of doctoral students' research, but also to offer better visibility of the research topics and improvement of the cooperation among different institutions.

Head of PhD study

Prof. Stana Kovačević, PhD

Goran Majstorović

Biography

Goran Majstorović, PhD, was born in 1965 in Bihać. He graduated from the University of Zagreb Faculty of Textile Technology.

From 1990 to 1993 he worked in Globus, Kiseljak (BiH), first as a technologist, then after a year of work as a technical director. From 1993 to 2015 he worked in NicolaS, Belgrade as a technical director. From 2007 to 2012 he worked at the same time and in Juvela, Belgrade, on the development of special and protective clothing. From 2015 he has been employed by Weltex, Čačak.

In 2015 he earned his PhD at the Doctoral study Textile Science and Technology, with thesis title *Determination of thermal properties of special purpose and intelligent clothing during their technical design*, under the mentorship of Prof. Dubravko Rogale PhD.

The area of his scientific work includes technical design and construction of multi-purpose and intelligent clothing from the aspect of extreme thermal insulation.

Title of dissertation topic	Determination of Thermal Properties of Special Purpose and Intelligent Clothing during Technical Design
Mentor	Prof. Dubravko Rogale PhD
Date or dissertation topic defense	December 4th, 2015

THERMOINSULATION PROPERTIES OF INTELLIGENT CLOTHING

Goran MAJSTOROVIĆ[1] & Dubravko ROGALE[2]
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Abstract: *The paper describes the measurement of thermoinsulation properties of intelligent clothing with incorporated thermoinsulative chambers, changing their thickness, which depends on the pressure of the inhaled air. For these measurements, a thermal manikin for static and dynamic measurements was used in simulating a walking person with accompanying software and air chamber to achieve the prescribed conditions. Measurements were performed with inactivated and activated thermoinsulative chambers in the intelligent article of clothing, in both static and dynamic situations, whereby the necessary force required to maintain constant temperature of body parts of the thermal manikin was measured and the effective thermal insulation was calculated, depending on the speed of simulated walking.*

Keywords: *intelligent clothing, thermoinsulative chambers, thermal properties*

1. Introduction

In order to avoid the need for layered clothing and remove layers of clothing in order to achieve the required value of the effective thermal insulation of clothing, intelligent clothing with adaptive thermal insulation properties has been constructed [1-2].

This type of clothing contains incorporated thermoinsulative chambers whose thickness and thermal insulation properties depend on the amount of inhaled air. The mentioned garments have the ability to measure internal and external temperatures, to make a decision on the optimal thermal insulation using the integrated microcomputer and to execute these decisions by activating the microcompressor which inhales air into the thermoinsulative chambers. In this way, automatic thermal adaptation of a garment to the changes in environmental temperature and physical activity status of a wearer is performed. When using such a garment, the necessity of wearing layered clothing is avoided [3].

Several prototypes of intelligent clothing with adaptive thermoinsulative properties were prepared in the Department of Clothing Technology of the Faculty of Textile Technology of the University of Zagreb and tested during practical wearing; however, due to the lack of measurement equipment the values of effective thermal insulation of this type of garments was not investigated and measured [4-5]. This was the reason why a prototype of the thermal manikin for studies of thermal properties of clothing, a climate chamber in which a manikin was positioned and all the necessary software required for operating the chamber and the thermal manikin and software for measuring and data processing. By using the new measuring equipment described, the effective thermal insulation properties of intelligent clothing in various wearing conditions were obtained and are presented in this paper.

2. Experimental

Measuring the thermal insulating properties of clothing was made on an intelligent article of clothing with thermoinsulative properties in a climate chamber in which a thermal manikin was installed and other measuring systems needed for determining microclimatic conditions in the chamber and on the manikin and for measuring the power used and energy.
The thermoinsulative chambers were located between the outer shell and the lining made of bulky polyamide nonwovens tradename fleece and 1.21 mm thick. For making the outer shell and the lining of the garment with adaptive thermoinsulative properties, a model of men's jacket, Figure 1, was chosen that provided wearing comfort and freedom of movement. Selected clothing size was 50.

The outer shell was made of the following material composition: 100% cotton in thickness of 0.23 mm, and the lining was made from polyamide 6 0.14 mm thick. The combination of the lining with filling and bulky polyamide/polyester nonwoven fabrics 1.01 mm thick was used for making the sleeves. The chambers were made of high-elastic polyurethane foil designated as Walopur 4201AU made by Bayer Epurex Films GmbH, Germany. It had high elongation at breaking force, amounting to 550%. The thermoinsulative chamber was made from three parts connected with an elastic material 0.25 mm thick.

Figure 1 Intelligent clothing on the thermal manikin

The basic dimensions of the square airbag of the thermoinsulative chamber were 5.7 x 5.7 cm and the joint width was 0.4 cm. When the airbags were inhaled with the air pressure of 50 mbar, the thermoinsulative chambers assumed the thickness of 28 mm. There were 25 front chambers and 45 back chambers. The distance between each chamber was 0.5 mm.

The created thermal manikin, Figure 1, and the climate chamber allowed determining thermal properties of the garment according to the so-called series and parallel model, in accordance with international standard ISO 15831 [6]. According to the standard, the manikin had to be constructed in such a way as to maintain the same average constant temperature of 33.8-34.0 ˚C. The air speed in the climatic chamber was set to 0.39-0.41 m/s [1].

After successive measurements were carried out, the operation of the machine stopped automatically, calculations and statistical analysis were performed, and a measurement protocol was printed out with the measured and calculated values.

Determining the thermal properties of clothing under dynamic conditions was performed so that the mentioned casting started with the garment put on and simulated the walk of the garment wearer whereby both arms and legs moved in counter-phase. The limbs were moved using a pneumatic-bar linkage system built in the body of the casting. Limb movement speed could be varied over a wide range and accurately adjusted by the air damper so that the motion speed 45±2 double steps/min was used and 45±2 double arm movements/min for walking, which corresponded to ISO 1583.

Furthermore, the measurements were performed thus that the equilibrium power of the heater of all torso areas was determined when the thermal manikin was standing and when the walk of the manikin was simulated with 10, 20, 30, 40, 50 and 60 double steps/min and the simultaneous movements of the arms. The step length, measured from toe to toe, was 63 cm, and the length of the arm movements, measured between the wrists at the base of the thumbs was 53 cm. The temperature of the heated areas of the manikin was 34.0 ˚C and ambient temperature 19 ˚C. Air velocity in the chamber was 0.4 m/s and relative humidity 50%.

The method of control, regulation, measurement and calculation of thermal systems on the garment was introduced using a segmented metal casting shaped to the human body, with the possibility of activation and deactivation of all segments (entire casting) or any segment group of the casting and the possibility of introducing and setting measurement parameters in accordance with the standards or for experimental research.

The measuring system had a developed software that enabled the process of measuring and calculating the thermal properties of composites or clothing to be repeated several times at defined intervals after which the measuring system automatically stopped running, carried out the required statistical analysis, presented the results and printed out a protocol and the determined results of thermal properties by the computer printer.

3. Results and discussion

This paper presents the measurements of necessary electric power to maintain the constant temperature of the torso of the thermal manikin when the manikin torso is dressed in an intelligent article of clothing with adaptive thermoinsulation properties. The electric power necessary for the activated and inactivated thermoinsulative chamber is measured. In the case of the inactivated thermoinsulative chamber, the air pressure of the chamber is 0 mbar, so the distance between the layers of the thermoinsulative chamber is 0 mm. In the case of the activated chamber, the air pressure is 50 mbar, and the measured thickness of the chamber between the inner and outer layers is 28 mm.

Table 1 shows the heater power required to maintain the constant temperature of the torso of the thermal manikin in the case of the activated and inactivated thermoinsulative chambers and in the case of thermal manikin standing and moving during simulation of walking with 45 steps/min, which meets the standard ISO 15831 [6].

Table 1 Heater power required to maintain the constant temperature of the torso of the thermal manikin

	Inactivated thermoinsulative chambers p=0 mbar		Activated thermoinsulative chambers p=50 mbar	
	Manikin standing n_s= 0 steps/min	Manikin moving n_s= 45steps/min	Manikin standing n_s= 0 steps/min	Manikin moving n_s= 45 steps/min
Heater power, P/W	79.0	85.0	57.5	59.0
Effective insulation, I_{EF}/m^{2}KW^{-1}	0.0886	0.0775	0.1475	0.1420

From the point of view of thermoinsulation properties, it is important to emphasize that in the case of thermal manikin standing in the inactivated thermoinsulative chamber it takes 79.0 W to maintain constant temperature of the torso of the thermal mannequin, and when activated, the power requirement is reduced to 57.5 W. At the same time, the effective insulation value of 0.0886 m^{2}KW^{-1} increases to 0.1475, m^{2}KW^{-1}, which is an increase of the effective insulation by 66.5%.

When determining the effective thermal insulation of clothing in motion, or the simulation of walking, an even more pronounced increase in effective thermal insulation of 0.0775 m^{2}KW^{-1} is measured, meaning an increase to 0.1420, m^2KW^{-1}, which is an increase in the effective insulation of 83%. Such a large increase in the value of the effective thermal insulation can be attributed to increased sealing due to the activated thermoinsulative chambers that tightly adhere to the body, and thus further reduce heat transfer from the body into the environment. At the same time, remaining air pockets are reduced so that a very small amount of warm air from the inside of the garment in motion in case of the activated thermoinsulative chamber is transferred into the environment.

Based on the performed measurements and presented results, it can be concluded that the thermoinsulative chambers filled with air can be an extremely adequate insulating means when creating an intelligent article of clothing with adaptive thermoinsulation properties.

4. Conclusion

The paper presents the thermoinsulation properties of intelligent clothing with adaptive thermoinsulation properties which are measured. The results obtained indicate that activated thermoinsulative chambers considerably increase the value of effective thermal insulation of a garment. In the case of standing thermal manikin and inactivated thermoinsulative chambers, effective insulation assumes the value of 0.0886 m^2KW^{-1}, while in the case of activated chambers it increases to 0.1475 m^2KW^{-1} meaning an increase of 66.5%. When standardized movements of 45 steps/min are used, the value of the effective thermal insulation can be increased up to 83%, because the value increases from 0.0775 m^2KW^{-1} to 0.1420 m^2KW^{-1} which can be attributed to better adherence of the activated chamber to the body, reducing remaining air pockets in clothing and reduced displacement of warm air from the inside of the garment into the environment.

This research also shows that the values of the effective thermal values decrease with increasing walking speed. The decreasing trend is more pronounced at lower walking speeds since the very transition from standing into walking force large amounts of warm air from the inside of the garment into the environment. In the activated chambers, the values of reducing thermal insulation are considerably lower when walking speed increases, which can be attributed to better sealing of thermoinsulative chambers to the body, which additionally reduces the displacement of warm air from the inside of the garment. The presented research methodology of thermoinsulation properties of intelligent clothing can greatly assist in further development of thermoinsulative chambers and intelligent clothing with adaptive thermoinsulation properties.

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Samir Pačavar

Biography	Samir Pačavar was born in 1964 in Jajce, Bosnia and Herzegovina. He completed the Grammar School in Jajce in 1982. He completed his graduate study at the University of Zagreb Faculty of Textile Technology, at the Department of Clothing Technology in 2001. He enrolled in the doctoral study at the same University and gained a PhD in the scientific field of Technical science, Textile technology in 2015. Since 2002 he has been working at the Central Textile, Leather and Design School in Sarajevo and has been employed as a professor of professional theoretical teaching of a textile group of subjects. In 2006 he became a certified DEZA / GTZ consultant under the sponsorship of Swiss Agency for Development and Cooperation DEZA and German Technical Co-operation GTZ. He has participated as a consultant in several international projects aimed at improving the clothing industry in Bosnia and Herzegovina
Title of dissertation topic	Influence of sewing parameters on the quality of car seat covers
Mentor	Prof. Darko Ujević, PhD.
Date or dissertation defense	March 10th, 2015

INFLUENCE OF SEWING PARAMETERS ON THE QUALITY OF CAR SEAT COVERS

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Abstract: *Textile composites for car seat covers belong to technical textiles. In the sewing process of car seat covers, there are various stresses within the composite component that affect seam quality. The optimal bonding conditions were investigated by the application of the various bonding speeds of the composite components. Needle penetration force and the tip of the sewing needle have a very high impact on seam quality. An optimal solution was sought in order to improve the appearance and strength of the sewing seam using a composite with different thickness of PU foam and various types of sewing needles.*

1. Introduction

Car seat covers are ranked as composite materials and are an integral part of every car. Woven fabric is most often used as a front side component of multi-layered material for car seat covers. Woven fabric gives comfort and softness in the contact area with the body, it is easier to transform into the ergonomic shape of the seat and the rest of the interior. In most cases, the fabric on the front side of the composite is woven in a basic weave patterns or its derivates with smaller weave units. Knitted fabric is more comfortable than woven, however, because of its low abrasion and wear resistance as well as low durability, instability and breaking force values compared to woven fabric. Artificial and natural leathers are most commonly used components for the third layer of multilayered composite for car seat covers. Polyurethane sponge, as the central component within the composite, provides softness and comfort when sitting. Adapting car seat cover to an ever more complex ergonomic seat shape requires an increasing number and complexity of cut-out parts, resulting in an increasing share of seams and more demanding sewing [1-4].

Figure 1 Composite material for car seats cover

The material, needle and thread are an indivisible trio that directly affects seam quality. The size of the sewing needle eye and thread thickness must be mutually aligned so that the thread can pass through the eye with the lowest possible friction values. In addition to the fineness of the sewing needle, the shape of the needle tip is of great importance for seam quality and the degree of material damage. The seams of car seat covers must be of extremely high strength. With a good selection of stitch type and sewing thread the exact, previously determined strength and elasticity of the seam can be obtained, which is especially important for car seat covers. A satisfying appearance of sewing seam and its sewing effectiveness are the most important factors which affect the quality of the car seat cover. In accordance with the type and thickness of the material, the length and type of stitch, sewing thread and needle tip shape are selected. In order to obtain proper seam quality, it is important to optimize the tension of the lower and upper thread and to ensure the same shift of the material from both sides, which is extremely complex due to different thickness of the material during the process of sewing (Fig 2) [5].

Figure 2 Woven fabric damage at the seam area appearing by using car seat cover

2. Experimental part

2. 1. Testing procedure

Tests were conducted on composites designed for car seat covers with two different PU foam thicknesses. The composite consisted of a woven fabric on the front side, PU foam in the middle, and knitting on the back side of the composite.
Composite components were joined using Thermal-bonding technology with three different processing speeds of material transfer (30, 34, 39 m / min) and two thicknesses of PU foam (2 and 4 mm). On the obtained samples, the physico-mechanical properties of semi-composite (knit + PU) and final composite (woven fabric + PU + knit) and the effect of the components properties on the composite were investigated.

2. 2. Testing materials

Woven fabric: Fibre content: 100% polyester (PES) multi filament, weave: leaf, warp and weft density: 29/20.5 (thread/cm), warp/weft count: 620 f 144 dtex/167 f 48 × 3 dtex
Knitted fabric: Fibre content: 100% polyester (PES) multi filament, structure: plain with floats 1+1, Wale/Course density: 130/110 (10 cm), yarn count: 75-84 f 36 dtex.
Polyurethane foam (PU): two thicknesses: 2mm and 4mm, Suppler *Eybl*

Machines for production woven fabrics, knitted fabric and composites

Weaving machines: Dornier, type: S 220 cm, rapier weft insertion, electronic dobby
Knitting machine: Terrot, type: S296-1; E28 30``
Bonding machine with gas flame: Schmid, model: 1281/2200.

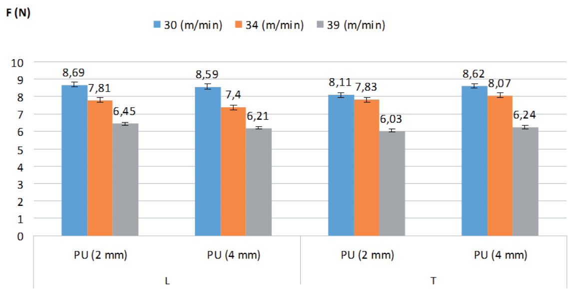
2. 3. Testing methods and devices

Testing by individual methods was carried out under strictly defined humidity and temperature conditions, as well as the test material itself and the space in which the test was conducted. Defined standard atmosphere for testing was: 65±2% of relative humidity and temperature of 20±2 °C.
Sample testing:

- Testings of breaking force and elongation at break were performed on all samples in the longitudinal and transverse directions on the Pellizzato/Tinius Olsen, Type. H5KS, according to DIN EN ISO 13934-1.

- Testing of separation force of the components with two thicknesses of PU foam (semi-composite: knit + PU and composite: woven fabric + PU + knit) was performed on tensile tester Pellizzato/Tinius Olsen, type H5KS, according to DIN 53 357.
- Testing of needle penetration force was conducted on an innovative ITV device in Denkendorf.

3. Results and Discussion



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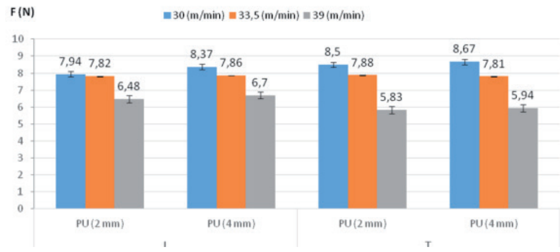
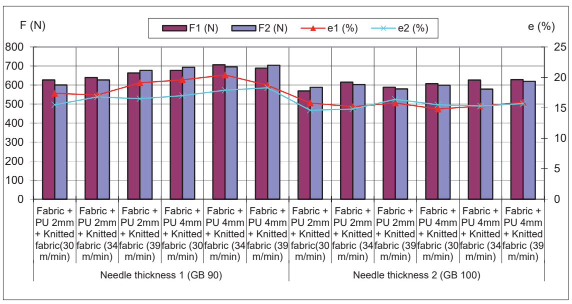
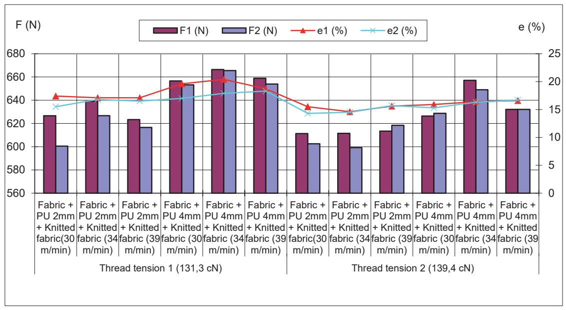


b.

Figure 3 a) Separation forces of woven component and PU foam, b) Separation forces of knitted fabric and PU foam; L - longitudinal direction, T - transverse direction



a.



b.

Figure 4 a) Breaking forces and elongations at break of samples sewn with the needle thickness of GB 90 and GB 100, b) Breaking forces and elongations at break with sewing thread tension of 131.3 cN and 139.4 cN

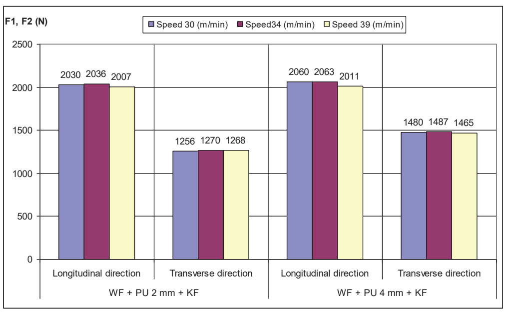


Figure 5 Breaking force of the composite (fabric + PU + knitted fabric) in the direction of the warp and weft in three bonding speeds of the components

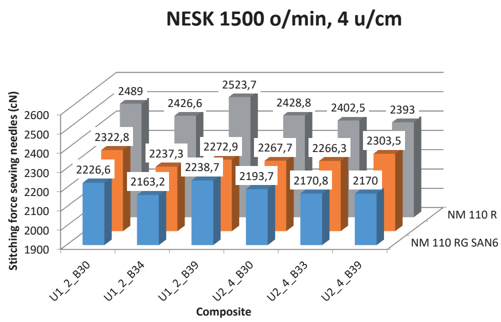


Figure 6 Needle penetration forces for three different types of needles by composite samples

According to the obtained results, it can be concluded that the separation force had lowest values on the samples in which the components were thermally bonded at the speed of 39 m/min, and the highest values on the samples that were thermally bonded at the speed of 30 m/min. It can be concluded that lower thermal bonding speeds resulting in stronger component compound, which was contributed to greater PU melting and penetration into fabric and knitwear.

Elongation at break increased with the increase of the thermal bonding speed. This phenomenon

could be interpreted in a way that the higher bonding speed influenced the lower amount of PU mud, lower material stiffness, and thus greater elongation.
A thicker needle resulted in lower breaking force and elongation at break in all samples. It can be reliably asserted that thicker needle caused greater deformations in the place of needle stitches. The direction of the composite also influenced breaking forces. Larger breaking force values were observed in the direction of the warp, i.e. in the length of the sample.
Lower thread tension caused higher breaking force on all the samples in the both directions (warp and the weft). Likewise, lower thread tension caused even higher elongation at break values in the seam position. Observing the composites by the speed of the component bonding, it was possible to notice that the breaking forces as well as the elongation at break were highest at medium speed (34 m/min).
By observing the minimum and maximum needle penetration forces by the type of needle, it could be seen that minimum breaking forces occurred mostly in all the samples sewn with NM110RG SAN6 Geb needles, followed by NM110R Geb needles, and NM110R needles. Maximum forces did not differ significantly by needle type, but the same tendency was observed for needle penetration forces as in the case of minimum forces.

4. Conclusions

Thermal bonding of knitted fabric and PU foam, and then the resulting semi-composite and woven fabric into final composite, caused the thickness and mass of the composite to be reduced in relation to the thickness and mass of the components prior to joining. This indicated that the woven fabric and the knitted fabric soaked into the PU melt at the time of surface melting of PU, and thus a solid joint was achieved.
By changing the rate of thermal bonding of the components to the composite, breaking force did not change significantly, but nevertheless the highest breaking force occurred at the mean speed (34 m / min). The separation force of PU foam and knitting fabric was greater than the separation force of PU foam and woven fabric in all the samples, in both directions and both thicknesses of PU. Based on the obtained results, it could be concluded that the separation force increased by decreasing the rate of thermal bonding. By selecting the appropriate needle, needle penetration forces were significantly reduced as well as material damage.

Acknowledgments

We would like to thank the company Prevent, Visoko, BIH, for making component samples (woven and knitted fabrics), and the composites.

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Bosiljka Šaravanja

Biography

Bosiljka Šaravanja was born in 1968 in Mostar and in 1993 she graduated from the University of Zagreb Faculty of Textile Technology (FTT). She worked as a technical director in the clothing industry. From February 2010 she has been employed by the FTT, as an assistant and from March 2016 as a postdoc. She was member the Organizing Committee of the International Scientific Conferences: Interational Textile, Clothing and Design Conference 2010, 2012, 2014 and 2016 and in the Organizing Committee of the Scientific-Professional Conference Textile Science and Economy from 2010 to 2018. She was one of the contributors to the scientific and professional project Development and Workers Uniform and Footwear Condition for The MoI of the Republic of Croatia and the Ministry of Defence of the Republic of Croatia project for the production of officers' jackets. She has participated in several scientific-research projects and research supports. She has published 25 scientific papers in proceedings of international and domestic conferences, 3 papers in international journals (CC and SCI) and 1 book chapter.

Title of dissertation topic

Investigation of interlinings with microwave shielding characteristics in a garment during textile care

Mentors

Prof. Darko Ujević, PhD (FTT)

Prof. Krešimir Malarić, PhD (University of Zagreb Faculty of Electrical Engineering and Computing)

Date or dissertation defense

December 16th, 2015

GARMENT INTERLININGS WITH MICROWAVE SHIELDING CHARACTERISTICS

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Abstract: *The paper describes the protective properties of functional textile products for protection against electromagnetic (EM) radiation. For this purpose, copper-coated interlining woven polyamide filament fabrics have been selected. The protective properties of these materials were tested at 0.9 GHz, 1.8 GHz, 2.1 GHz and 2.4 GHz microwave frequencies.*

1. Introduction

Electromagnetic pollution can not be felt in any way, it has no color, no taste or smell [1]. Negative health effects can occur only after longer period of exposure and are usually not considered to be caused by EM pollution but by other factors (stress, poor nutrition, live style etc.) [2]. In recent years, the world wide public has become highly sensitive about the potential harm of EM radiation to humans and other living organisms, including plants. Often the use of electronic devices can affect people’s health or may cause various health problems such as: behavioral changes, increased stress, insomnia, cardiac arrhythmia and similar difficulties. Results of studies on EM radiation (GSM, microwave ovens, etc.) on rats, confirmed changes in their metabolism, brain function and nerve activity [3,4]. The influence on the metabolic activity increases the risk of developing cancer, as reported by medical researches [5]. Epidemiological studies consider possible increased risk for certain brain tumors in every day mobile and GSM users [6]. All studies on the biomedical effects of radio waves in mobile communications systems at GSM of 0.9 and 1.8 GHz showed that the thermal effects are dominant, because in these frequency ranges alternating electromagnetic fields only cause vibrations and rotations of dipole water molecules that have high proportion in the human body. Therefore, when studying the effects of electromagnetic waves on living organisms the radiation density is taken as one of the most important EM parameters [7]. The available literature does not exclude changes in health status, especially biological functions, after exposure to high EM radiation intensity. The materials most commonly used for the protection of EM radiation in clothing items are polyamide, polyester or cotton fabric or knitted fabric with a coating of copper, silver or stainless steel. Figure 1 presents interlinings materials with metal coatings against EM radiation.

Figure 1 Interlinings materials with metal coatings against EM radiation [8]

The paper is concerned with the influence of dry cleaning cycle on the durability of textile materials shielding from EM radiation. The basic properties of the tested materials are different with respect to the raw material composition, the characteristics of the material, the type of metal coating and the purpose. Characterization of the material surface properties against EM radiation, prior and after dry cleaning, was done using scanning electron microscopy method (SEM).

2. Experimental part

Protective properties of interlining fabric made of polyamide filament coated with copper were investigated, and labeled MP1.

The metal coating on the surface materials enabled their functionalization to achieve shielding effect for EM protection. The primary purpose of MP1 interlining material was shielding from EM microwave radiation and the material was sewn into garment pockets (jackets, coats, pants and other garment's parts) most often used for mobile devices. The technological processes of fabric production included: patternmaking, frontal fixing, sewing, ironing, dry cleaning and wet cleaning [9]. The influence of the solvent on the protective properties of interlinings materials was investigated at the University of Zagreb, Faculty of Electrical Engineering and Computing in the Microwave Laboratory (temperature of 23±1˚C and relative humidity of 50±10%) Department of Radio-communications, using the newly developed method and a custom made measurement device. The setup was designed according to the recommendations of the international standards ASTM D-4935-89 [10], IEE-STD 299-97 [11] and MIL STD 285 [12]. The measurement setup is shown in Figure 2 and it consisted of: wooden armor, signal generator, antenna horn and NARDA SRM 3000 measuring instrument.

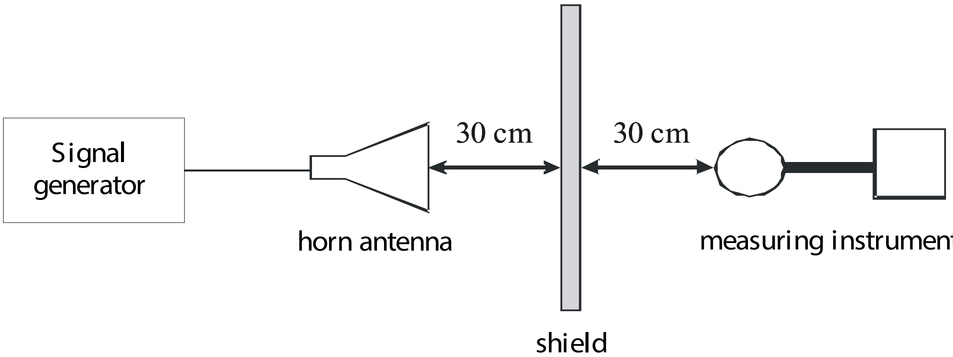
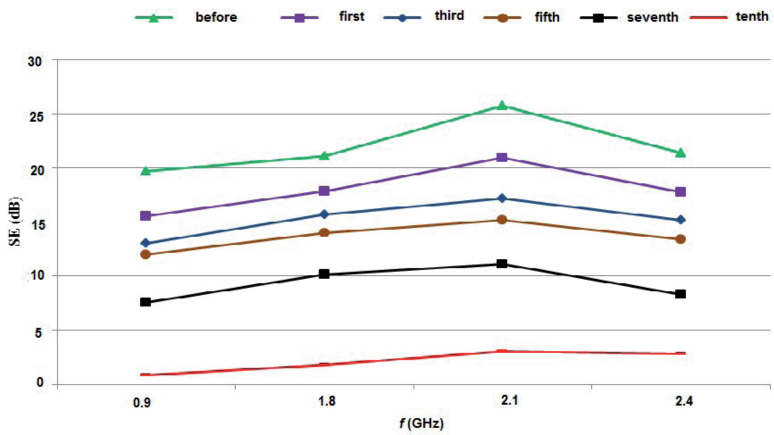


Figure 2 Setup for the fabric shielding properties measurement [9]

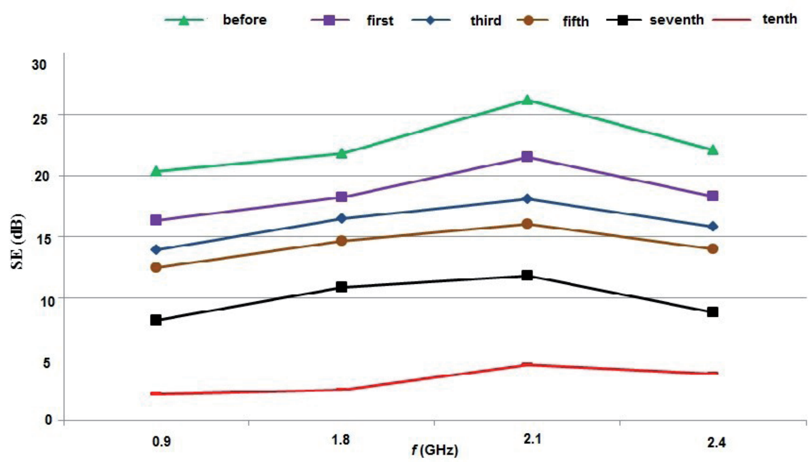
The measurements were carried on the face and back side of the interlinings shielding material. The efficiency of the EM protection of the interlining materials before and after (first, third, fifth, seventh and tenth) dry cleaning cycles was tested at the frequencies of: 0.9 GHz; 1.8 GHz; 2.1 GHz and 2.4 GHz [9].

3. Results and Discussion

The results show an example of the EM radiation shielding efficiency of untreated samples and after the first, third, fifth, seventh and tenth dry cleaning cycles of the copper coated polyamide fabric (MP1) on its face and back side. The shielding effect (SE) of the untreated MP1 sample (face side) at 0.9 GHz has the value of 19.66 dB while at 1.8 GHz frequencies, 2.1 GHz and 2.4 GHz, these values are above 20 dB (Fig 3a). The SE of the untreated MP1 sample (back side) at all tested frequencies is above 20 dB (Fig 3b). The best shielding effect (of 26.13 dB) of the interlinings MP1 (back side) is achieved at the frequency of 2.1 GHz. Compared to MP1 (back side) the shielding effect at all frequencies for the MP1 (face side) is better than the average of 1 dB. These measurements show that the polyamide copper coated filaments (face and back side) are most efficient in their shielding effect against EM radiation at 2.1 GHz. The shielding effect of MP1 (face and back side) is approximately equal, indicating the uniformity of the copper coating on the polyamide filaments. Even after the first dry cleaning cycle, the shielding effect of MP1 (face and back) is reduced depending solely on the frequency. Changing the shielding effect of the fabric is unambiguous, as the fabric is equally exposed to the influence of the solvent that rapidly penetrates into the material during the process of dry cleaning. The tendency of decreasing shielding properties of MP1 continues in further cycles, and after the tenth dry cleaning cycle these properties are almost completely lost.



a.

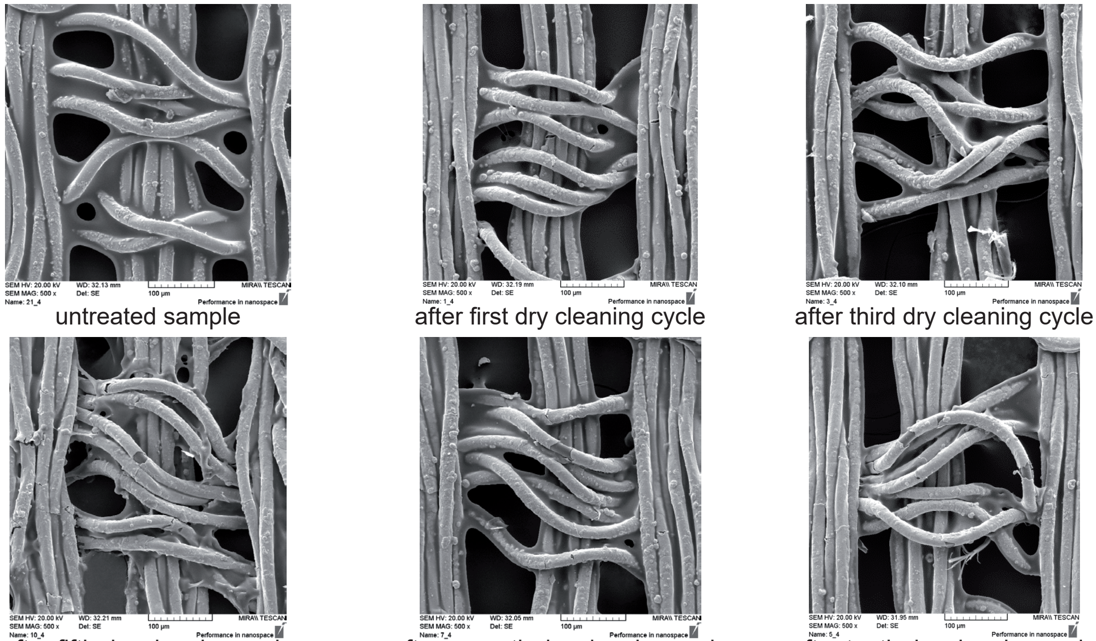


b.

Figure 3 Shielding effect of MP1 samples prior and after dry cleaning cycled (face and back side)
a) fabric face side before and after dry cleaning cycles at 0.9 GHz; 1.8 GHz; 2.1 GHz and 2.4 GHz, b) fabric back side before and after dry cleaning cycles at 0.9 GHz; 1.8 GHz; 2.1 GHz and 2.4 GHz

SEM surface characterization was carried for the untreated samples, and after the dry cleaning cycles. The SEM image (SE detector, magnification of 500 x) of the untreated sample MP1 confirms its canvas weave made of uniformly copper coated polyamide filaments (Fig 4).

Figure 4 shows that the number of dry cleaning cycles affects the coated copper surface of the MP1. The SEM images of the MP1 after the tenth dry cleaning cycle show a high degree of the fiber copper coating damage. Copper coating cracks are the result in shielding effect loss on the interlining fabric MP1, due to the more free passage of the EM radiation and the reduction of the MP1 shield effect.



untreated sample | after first dry cleaning cycle | after third dry cleaning cycle

after fifth dry cleaning cycle | after seventh dry cleaning cycle | after tenth dry cleaning cycle

Figure 4 SEM images of the untreated MP1 samples and samples after dry cleaning cycles

4. Conclusions

The metals in the tested materials provide their shield effectiveness and protection against EM radiation functionality. The initial shield effects of MP1 (face and back side) are approximately equal, indicating the quality of the coating and the proper coexistence of copper and the polyamide filaments. In dry cleaning processes copper abrasion and cracking occurs, which results in the reduction of protective properties.

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Ivana Špelić

Biography

Ivana Špelić, PhD was born in 1982 in Zagreb. In 2009 she graduated from the University of Zagreb, Faculty of Textile Technology and conffered the title of textile technology engineer.

Since May 17th, 2010 she has been working as the assistant at the University of Zagreb, Faculty of Textile Technology, where she enrolled on postgraduate doctoral study Textile Science and Technology. In 2016 she earned her PhD and defended the thesis enitled *The impact of construction parameters on thermal properties of clothing,* under the mentorship of the professor Dubravko Rogale, PhD.

The areas of her scientific interest include clothing thermal properties, heat transfer in body-clothing-environment system, energetics, technical thermodynamics and energy management in industry.

Title of the doctoral thesis	The impact of construction parameters on thermal properties of clothing
Mentor	Prof. Dubravko Rogale, PhD
Date or Thesis defence	April 19th, 2016

IMPACT OF CONSTRUCTION PARAMETERS ON THERMAL PROPERTIES OF CLOTHING

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Abstract: *This doctoral thesis investigates the impact of constructional parameters (ease allowance value and length of clothing garment) on thermal properties of male jackets, expressed as the value of effective thermal insulation, as well as the satisfaction of the examinees that undergo testing under controlled environmental conditions. Subjective perception of thermal comfort while wearing tested clothing under specific environmental conditions was evaluated by analysing examinees' grades, which underwent laboratory trials and completed forms with elaborated subjective judgement scales. Simultaneously, environmental conditions were monitored and physiological reactions of examinees (mean skin temperature and humidity of skin) were measured.*

1. Introduction

The finished garments fit human body in greater or poorer extent, while the basic pattern construction of the clothing garment is predetermined by the objective input parameters (basic body measurements and motion analysis). During garment design and pattern construction it is crucial to foresee the adequate value of the ease allowance. Based on the literature review, the research goals were appointed and investigated within this doctoral thesis.

1.1 Research goal, methodology and hypothesis

The goal of this work was to investigate the impact of construction parameters (chosen ease allowance values for male jackets and the jacket length) on the effective thermal insulation of those jackets. Afterwards, the correlation between the physiological parameters of the human subjects (the mean skin temperature, the skin's relative humidity and the body mass decrease) and the jackets thermal properties was investigated. The research within the doctoral thesis was done in order to investigate the impact of the functional clothing design, in accordance with the adjustments conforming the anthropological characteristics of human body and pattern construction, on the isolation characteristics of the clothing and the restoration of thermal equilibrium.

Hypothesis:

- H1: Constructional parameters of clothing affect final thermal properties of clothing garment.
  - H1 a: There is a correlation between the values of ease allowance to chest and waist circumference in garment pattern modification and the final value of effective thermal insulation of male jackets.
  - H1 b: There is a correlation between the values of total jacket length in garment pattern modification and the final value of effective thermal insulation of male jackets.
- H2: There is a correlation between effective thermal insulation of clothing garments and physiological outputs of human body (mean skin temperature and humidity of skin), which are the means of evaluating thermal comfort.
- H3: There is a correlation between effective thermal insulation of clothing ensembles and grades of examinees, which are the means of evaluating thermal comfort.
- H4: With body moving, the air at higher temperatures, which is trapped inside microclimatic layer, will start to rise vertically to higher spheres and *chimney* effect will occur.

1.2 Scientific contribution

Scientific contributions of this doctoral thesis are:

- Determining the correlation between the ease allowance value and clothing thermal characteristics.

- Determining the correlation between the length value and clothing thermal characteristics.
- Ascertaining the vertical currents of the warm air in the microclimate area (chimney effect).
- Determining the correlation between the effective thermal insulation value measured for male jackets and the physiological parameters of the human subjects performed during laboratory trials while investigating thermal comfort.
- Determining the correlation between the effective thermal insulation value measured for male jackets and the ensembles with the subjective judgement grades on personal thermal state and clothing ensemble.

2. Experimental part

Based on the observed theoretical foundations, the research was conducted to investigate the impact of ease allowance value and garment length on thermal properties of the clothing and physiological variables of the human subjects.

2.1 The choice of the clothing for the experiments and the construction of the male jacket models

To conduct foreseen experimentstwo models of male jacket were chosen, which were intended for thermal protection in cool environments. The first model of male jacket was pilot bomber jacket and it was made in 4 different variants, differing in the amount of ease allowance added. The value of ease allowance added in was in the following order of: 22, 26, 34 and 38 cm. The second model of male jacket was a modular parka jacket. It consisted of one basic module and four applicative modules which could be attached to the basis of the jacket to change the overall garment length. The length of the garment was increased by 20 cm by attaching each additional module. During the subjective judgement investigation, the subjects were dressed in the selected clothing ensembles. Altogether 10 ensembles were investigated, combined together by adding undergarments and one of the variants of the two proposed jacket models. The pattern construction of the clothing garments was done by CAD Lectra Systemes and software Modaris. The thermal manikin from the Department of the Clothing Technology was the realistic aluminium mould of the male 1.85 m tall and the chest girth of 100 cm so the basic pattern construction of the male jackets, intended for the research on the thermal insulation properties, and was made in clothing size 50 for the athletic body figure.

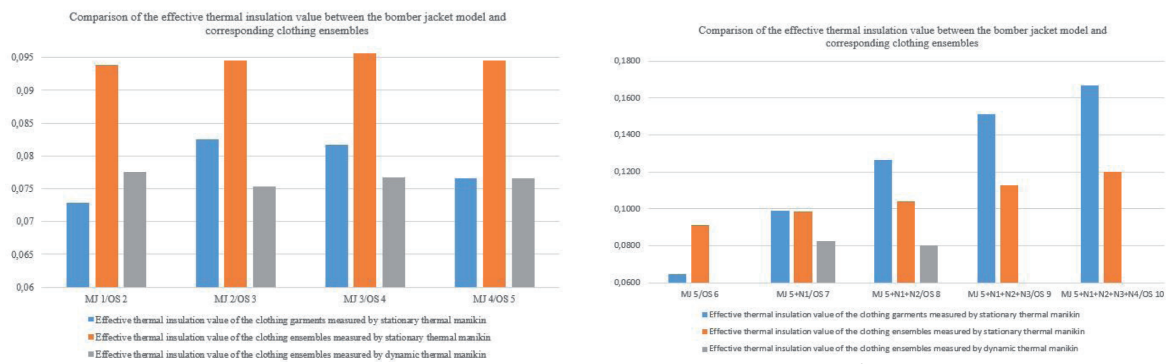
2.2 Research methods

All the proposed male jackets variants were made from the same material. The outer shell in both models was made of the three – layered laminate (outer layer and inner lining 100% polyester - PES, the middle layer polytetrafluoroethylene membrane - PTFE protected with polyurethane particles – PU). The lining was 100% PES fabric. The underlying basic garments were undershirt, underpants, classical male business shirt, and jeans. All of them were composed of 100% cotton.
The analysis of the structural and the physical characteristics of the materials was done, establishing the weave type and the structure of the knits, fabrics and laminates. Thickness, mass per unit area, material content and an air permeability were analysed. Thermal properties were calculated after the measurements of dry heat flux and evaporative heat flux with a Kawabata KES-F7 ThermoLabo II apparatus [1].
Thermal insulation values of the jacket variants were measured using the measuring system for the determination of static and dynamic thermal properties of composites and clothing, so called thermal in accordance to the international standard ISO 15831:2004 [2]. The results were expressed as effective thermal insulation values. During the trials, climatic conditions were set to be: ***the air temperature*** (t_a t_a) was set to: t_a=20 ˚C and ***the air speed*** inside the climatic chamber was set tov_a=0.4 m/s. Clothing' thermal insulation values were acquired in static conditions, with thermal manikin stationary while dynamic conditions were established with the walking speed set to 90 steps/minute or 0.95 m/s (3.4 km/h).
Human body physiological parameters investigated in this paper were mean skin temperature, skin relative humidity and heartbeat. The measurements were performed by the modular signal recorder MSR 12 [3].

The investigation of the impact of dressing in specific garments on subjective judgement expressed by subjects performing trials under given environmental conditions was conducted in the University of Maribor, Faculty of Mechanical Engineering, Institute of Engineering Materials and Design. Laboratory trials were conducted under controlled climatic conditions realised inside climatic chamber. The environmental parameters set during subjective judgement trials were controlled ambient temperature set to one of the four selected values (t_{a1}=10 ˚C, t_{a2}=15 ˚C, t_{a3}=20 ˚C, t_{a4}=19 ˚C), which corresponded to cool and moderate environmental conditions (from -5 °C <t_a< 20 °C) and the air speed inside the climatic chamber was set to two possible values (v_{a1}=1.2 m/s, V_{a2}=0.4 m/s).
If we presume that hot and humid air will lift vertically and spontaneously move to the higher areas of the microclimate inside the clothing, while the body is in motion, the sensors should be placed in the imaginary vertical axis to allow tracking of the vertical temperature and relative humidity changes inside the microclimatic layers. To prove this hypothesis, the sensors were placed in a line forming the imaginary vertical line (front and back axis). At the end of the trials, the data analysis was performed and comparison of the calculated results made for mean skin temperature, skin relative humidity and heartbeat, with special emphasis on the established vertical temperature changes of the microclimatic air, measured through two chosen verticals inside microclimate formed between the clothing layers.

3. Results and discussion

The values of effective thermal insulation, measured during research on the impact of the ease allowance value during the dry heat transfer, did not differed substantially between the four variants of the male bomber jacket. With each increase in the parka jacket length for 20 cm, the value of the effective thermal insulation increased proportionally.
The t–test performed for the effective thermal insulation values measured for the bomber jacket with different ease allowance added, proved significant statistical difference when the ease allowance value increased by 4, 8 and 12 cm, but there was no proven difference when the ease allowance value was increased by 8 cm. This partially verified the hypothesis that the increase in the ease allowance automatically induced the increase in the jacket effective thermal insulation value. The increase in the ease allowance value induced the increase in the effective thermal insulation value up to a certain threshold, after which the insulation values started to decrease again, as the result of presumable natural convection. The impact of forced convection and vertical microclimatic air lift was presumably more pronounced, especially with large ease allowances added, and by ventilation through the neck opening.
There was a significant drop in the effective thermal insulation values of the garments and the ensembles in the dynamic conditions when compared to static conditions, Figure1 a and b.



a. b.

Figure 1 The comparison of the effective thermal insulation values for garments and the ensembles: a) with the bomber jacket added as the outerwear garment, b) with the parka jacket added as the outerwear garment

The tendency to negative subjective judgements of the personal thermal state was pronounced most under lowest ambient temperatures (t_a=10 ℃) in the first series of the trials performed by the human subjects. The statistical analysis of the subjects' grades was done in accordance with the international subjects. The statistical analysis of the subjects' grades was done in accordance with the international standard ISO 10551:2001 [4]. The human subjects' grades were relatively uniform and the average grade in all the answers was 0, which corresponded to thermal neutrality. The exception were the answers given in the second trial phase during walking, where the clothing was generally assessed as comfortable (grade 1), which could be connected to the feeling of the discomfort due to sweating. Altogether, the lowest mean values of the grades were given for the ensemble CE 4 by evaluating both thermal state, the clothing and the environment. Local and mean skin values decreased with the decrease in the ambient temperatures and with longer exposures to lower ambient temperatures, but the subjects tended to acclimatize with longer exposing periods inside the climatic chamber. The lower mean skin relative humidity values were also measured under t_a=15 ℃ and while wearing ensembles CE 5 and 7. The calculation of the average difference in clothing ensembles weight was calculated on the basis of the mass variation due to sweat accumulation in the clothing, before and after the trials. Surprisingly, there was no significant difference in clothing weight during trials, which could be explained by the jacket fabrication from the three – layered laminate with permeable membrane. Under exposures to t_a=19 ℃, the lower differences in body mass loss due to sweating was recorded, which could be explained by shorter exposures times. During the resting phase in the vertical lift investigation, there was correspondence in measured temperature values in both the front and the back sensor vertical, respectively in some cases, the lower temperature values were recorded in vertically higher sensors then those measured by the sensors placed at lower vertical position. However, during the walking phase the air vertical lift was obvious and the sensors placed at the higher positions measured higher temperature values, proving the chimney effect inside the microclimate.

4. Conclusions

The results have proven the impact of construction parameters during pattern construction (such as ease allowance and length) on the thermal insulation properties of finished garments.
The correlation between the clothing effective thermal insulation and the human body physiological parameters has also been verified. Those physiological parameters are of great help during thermal comfort estimation. The correlation between the effective thermal insulation and the subjective grades, provided during laboratory trials deploying human subjects to valorise the degree of the clothing thermal protection, has been confirmed. The grades analysis has proven the third hypothesis on the existence of the correlation between the effective thermal insulation of the ensembles and human subjective judgements, when valorising the degree of the thermal protection. Human subjects which are more satisfied with the thermal protection provided by their clothing, will rate the clothing with higher grades, especially when exposed to higher ambient temperatures. Generally, the highest degree of comfort was given for ensemble CE 5, which was formed by adding the bomber jacket with the greatest ease allowance in the amount of the 38 cm.
The assumption on the existence of the vertical air lift inside the microclimate under human activity has been confirmed and *chimney* effect verified.

Acknowledgement

Many thanks to my colleagues and mentor Prof. Dubravko Rogale, PhD.

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Emilija Zdraveva

Biography	Emilia Zdraveva graduated from the University of Zagreb Faculty of Textile Technology in 2006. She received her Master's degree from the University of Ghent, Belgium in 2009. She has been employed at the University of Zagreb Faculty of Textile Technology as a research fellow since the end of 2009. In the period from 2013 to 2015 she has been working as a visiting PhD student at Deakin University, Institute for Frontier Materials, Geelong, Australia, in the Lab of electrospinning of Prof. Tong Lin, PhD. She received her PhD degree in 2015, and since 2016 she has been working as a postdoc at the FTT. She is a collaborator on the Croatian Science Foundation project, Prof. Budimir Mijović, PhD. Since 2017, she has been working as Deputy Head of the FTT IRO office and as Erasmus+ coordinator. She published 2 book chapters, 10 papers (5 CC), 1 professional paper, 14 papers and 5 abstracts in proceedings of scientific conferences.
Title of dissertation topic	Electrospun nanofibrous materials and films for heat managing applications
Mentors	Prof. Budimir Mijović, PhD (FTT); Prof. Tong Lin, PhD (Deakin University, Australia)
Date or dissertation defence	November 13th, 2015

APPLICATION OF ELECTROSPUN MATERIALS IN PASSIVE HEAT STORING

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Abstract: *Electrospun materials used for passive heat storage are based on phase change materials (PCMs). This paper gives a brief discussion on the research related to the development of such materials, based on vegetable oils and polycaprolactone.*

1. Introduction

Electrospun materials have many applications in energy storage, i.e. production of lithium-ion batteries, fuel cells, solar cells, super capacitors and piezoelectric systems, and to a lesser extent for the development of passive heat storing systems based on the encapsulation of phase change materials (PCMs) [1]. Phase change materials have the ability to absorb, store and release heat at a certain temperature [2]. Basic requirements that need to be fulfilled are: appropriate melting temperature, large enthalpy, low supercooling, thermal conductivity, reliability and adequate encapsulation [3]. PCM encapsulation is extremely important for maintaining the structure, especially when PCM transfers from solid to liquid at melting. In addition to the conventional PCM encapsulation (macro, micro, and nano), recently electrospinning has been used for the encapsulation of PCMs. The process involves the production of electrospun nanofibers with two configurations: co-axial fibers, where PCM is located in the fiber core, and polymers blend fibers, where PCM is uniformly dispersed inside the matrix [4]. Studies carried out so far included fatty acid PCMs, e.g. lauric acid (LA) in polyethylene terephthalate (PET) matrix. The PCM content in the PET was 50-150 wt%. Although the highest enthalpy was achieved with the highest PCM content, the authors suggested that PET/LA 100/70 (or ratio bellow 100/100) was the optimal combination concerning structure homogeneity, PCM agglomerations absence. The experimental enthalpy of PET/LA 100/70 was slightly higher than 50 J/g [5]. Some studies introduced PCM encapsulation in electrospun polyamide 6 (PA 6) fibers through additional adsorption, using eutectic mixture of capric acid (CA) with lauric, palmitic (PA) or stearic acid (SA), as PCMs. The calculated adsorption of electrospun PA6 for CA-LA, CA-PA, CA-SA and CA was 72.7 %, 81.9 %, 78.0 % and 75.4 % [6]. However, this type of PCM encapsulation had a disadvantage, i.e. deformation of the porous electrospun material structure due to PCM diffusion into the fibers inter-pores. Some of recently reported enthalpies are shown in Table 1.

Table 1 Enthalpies of electrospun composite fibers in previous studies

Materials	PCM mass fraction, wt%	PCM Hm/Hc (J/g)	Composite - Hm/Hc (J/g)	Ref.
LA/PA6	100/100	173.25/172.19	70.44/57.14	[7]
SA/PET	70/100	222.8/226.7 [8]	67.88/61.62	[5]
CA-SA/PET	200/100	156.8/147.1	95.24/93.67	[9]
Soy/PU	50	69.97/-	36.47/-	[10]
Dodecane/zein	14	196.88/196.88	27.552	[11]
PEG/CA	50	177.38/167.75	85.91/65.15	[12]
PEG/PA6	130/100	160.93/188.98	85.95/85.42	[13]

Previous studies reported that electrospinning could be produced form stable PCM fibers, but only a few of them have examined the fiber structure stability above PCM melting temperature. Thus, this PhD thesis systematically examines material behavior at high temperatures, i.e. in PCM liquid state. This paper briefly reviews already published PhD thesis research dealing with the problem of electrospun materials for passive heat storage development.

2. Experimental part

Materials used in this PhD thesis included: polyvinyl alcohol (PVA), polyvinylidene fluoride (PVDF) matrices, and mixtures of plant oils, and polycaprolactone (PCL) as phase change materials. Electrospun PVA/plant oils and PVDF/PCL were prepared by emulsion electrospinning and blend electrospinning, respectively, with different PCMs content in the polymer matrix. The polymers concentrations were: 7 % and 9 % for the PVA and 14 % for the PVDF. The PCMs content in PVA and PVDF ranged from 10 to 100 % by weight. Each material was labeled depending on PCMs concentration, e.g. 9 % PVA/PCM-25 in case of PVA/PCM mass ratio of 100/25. The PVDF/PCL heat energy storage ability was compared with the same composition of cast films. Prepared materials were analyzed concerning morphology, PCM distribution within polymer fibers, heat storage capacity and reliability, PCM effect on matrix crystal structure change, weight loss and mechanical behavior as the function of temperature. Material behavior was also investigated at high temperatures exposure, higher than PCM melting point, ranging from 60 to 80 °C [14].

3. Results and Discussion

This paper presents the morphology of some PVA/plants oil and PVDF/PCL samples, their heat storage ability and reliability, as well as PVDF/PCL properties comparison with the same composition of cast films. Figures 1 a and b show SEM images of 9% PVA/PCM-70 prior and after high temperature exposure. By increasing the PCM amount, there is a gradual increase in fiber diameter, and the fibers become coarse with increased number of surface pores and irregular circular cross-sections. The highest PCM concentration results in agglomerations formation and reduced capsulation efficiency [4]. Figure 1 c and d show electrospun PVDF/PCL morphology with the smallest and highest PCM concentration, respectively. The PCL addition results in beads elongation along fiber length, while at highest PCM concentration complete beads disappearance is observed. Figure 1 e and f show SEM images of the cast 14% PVDF/PCL-100 films structure prior and after heat treatment. The porous structure of the film increases after heat treatment, suggesting polymers separation, unlike the electrospun fibers, where improved homogeneity and stable structure is observed [15].

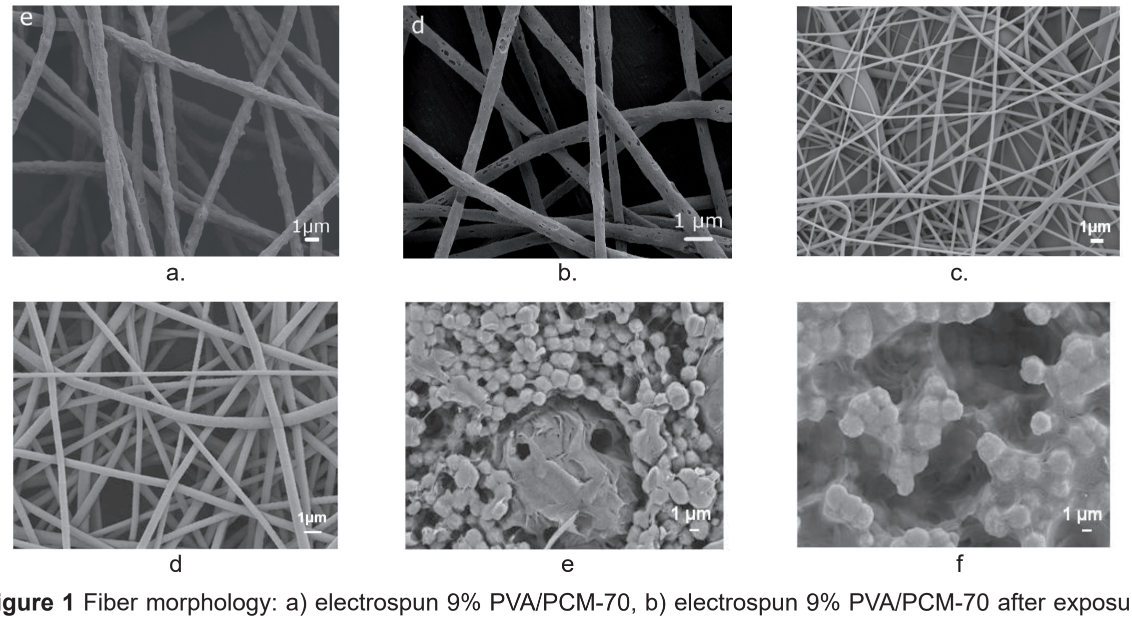

Figure 1 Fiber morphology: a) electrospun 9% PVA/PCM-70, b) electrospun 9% PVA/PCM-70 after exposure at the temperature of 60 °C over 10 cycles, c) electrspun 14 % PVDF/PCL-25, d) electrospun 14% PVDF/PCL-100, e) cast 14% PVDF/PCL-100, f) cast 14% PVDF/PCL-100 after exposure at the temperature of 65 °C for 24 hours [4,14,15].

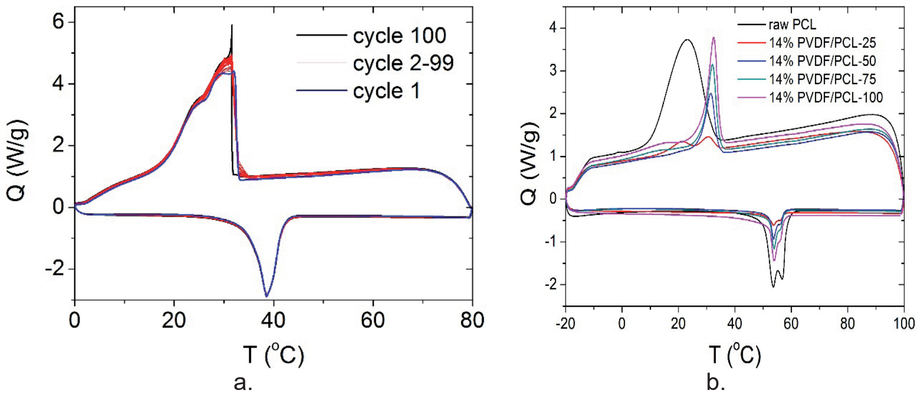

Figure 2 DSC curves of electrospun: a) 7% PVA/PCM-70 after 100 cycles of heating and cooling, b) 14% PVDF/PCL with different PCL concentration [4,15].

The electrospun materials show reliable heat storage after 100 heating and cooling cycles, Figure 2a [4]. PCL to PVDF addition results in bimodal endothermic and exothermic peaks disappearance, indicating that PVDF matrix enables faster PCL activation or heat storage, Figure 2b [15]. Table 1 presents the characteristic transition temperatures (T_{om} (onset), T_m, T_{oc} (onset), T_c), as well as melting ($H_{m,\,m1}$ – cycle 1, $_{m10}$ – cycle 10) and crystallization enthalpies ($H_{c\,c1}$ – cycle 1, $_{c10}$ – cycle 10) for some of the electrospun materials based on plant oils and PCL. In general, the melting and crystallization enthalpies increase with the increase in PCM amount and reach the maximum value of ~85 J/g for 9% PVA/PCM-70. Also, the supercooling effect decreases with increasing the PCM amount, which is due to the increase in PCM size along fiber length [4]. Increasing PCL's amount within the PVDF matrix also results in initial melting and crystallization difference increase compared to pure PCL. Less difference between melting and crystallization temperatures indicates supercooling effect decrease, or the ability of the PVDF/PCL to accelerate heat energy release. Highest enthalpy of 34.10 J/g, or encapsulation efficiency of 50% is measured for the 14% PVDF/PCL-100. Compared to cast films, the electrospun fibers show better heat storage capacity due to the reduction of supercooling for 8 °C and higher melt and crystallization enthalpy [15].

Table 1 Temperatures, melting and crystallization enthalpies of electropspun PVA/PCM and PVDF/PCL systems [4,15].

	PCM (plant oils)	**9% PVA/ PCM-10**	**9% PVA/ PCM-70**	**PCL**	**14% PVDF/ PCL-25**	**14% PVDF/ PCL-100**	**14% PVDF/ PCL-100 (film)**
T_{om} (°C)	36.65	34.81	35.29	50.48	51.21	52.09	53.67
T_{m1} (°C)	40.34	37.21	38.46	53.63	53.72	53.92	55.96
T_{m2} (°C)	-	-	-	56.88	-	-	-
T_{oc} (°C)	33.08	33.30	32.83	32.27	34.23	34.90	30.78
T_{c1} (°C)	30.05	32.50	32.21	22.91	30.51	32.52	27.52
T_{c2} (°C)	-	29.68	26.51	-	21.22	-	-
T_{c3} (°C)	-	26.89	-	-	-	-	-
T_{c4} (°C)	-	22.81	-	-	-	-	-
H_{m1} (J/g)	221.2	17.96	84.72	73.02	9.31	33.90	19.46
H_{m10} (J/g)	221.5	17.81	84.41	70.94	9.33	34.10	-
H_{c1} (J/g)	221.8	18.18	83.83	71.32	8.68	33.08	22.11
H_{c10} (J/g)	221.5	18.77	84.58	70.43	7.96	32.16	-

4. Conclusion

The electrospun PVA/plant oils and PVDF/PCL materials showed stable form structure after higher temperatures exposure, when PCM was in liquid state, which was not the case with cast PVDF-PCL films. Also, the materials showed reliability in heat storage and faster PCL activation, or faster storage or release of heat energy, due to reduced degree of supercooling compared to pure PCL. Developed electrospun systems based on PCMs can be used in the production of heat storage devices or thermoregulating materials.

Acknowledgement

We thank Prof. Tong Lin, PhD and Prof. Xungai Wang, PhD on the collaboration and the possibility to carry the PhD thesis research at Deakin University, Institute for Frontier Materials, Geelong, Australia.

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Martina Bobovčan Marcelić

Biography

Martina Bobovčan Marcelić, BSc was born on June 22st, 1979 in Koprivinica. She graduated in February 2008 from the Faculty of Textile Technology, University of Zagreb. In 2006, she was employed by the company of Galko d.o.o. In 2011 she was employed as an assistant at the Faculty of Textile Technology in Department of clothing technology.

She has been working on her dissertation under the mentorship of Prof. Dubravko Rogale PhD, in the field of welding polymer materials, process parameters of high-tech welding methods and properties of welds on protective and intelligent clothing.

Her research and scientific work involves engineering and clothing technology in the field of joining and welding parts of protective and intelligent clothing. Her research activities include investigating how different process parameters applied during welding polymer materials using high-tech methods affect the 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 or dissertation topic defence	February 3rd, 2014

DETERMINATION OF OPTIMUM PARAMETERS FOR JOINING PARTS OF INTELLIGENT CLOTHING USING HIGH-FREQUENCY WELDING METHOD

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Abstract: *Some types of joining elements on intelligent clothing can be made by conventional methods of joining, sewing, but it is now necessary to use many other high-tech methods of joining materials and elements since the conventional methods cannot provide satisfactorily technical and technological conditions. The paper describes the method of welding airtight joints of segmented thermoinsulative chambers using the high frequency method (HF), as well as the occurrence of undesirable extrusion of the edges of the weld and the method of determining the optimal parameters of HF welding with a minimum effect of the extrusion of the edges.*

1. Introduction

High-frequency welding machines are adapted to the specific technique used for welding artificial polymers. The material to be welded is placed between the electrodes connected to the high frequency generator. The HF generator operates in such a way that heat is generated in the material to be welded between two electrodes, and as the result of the application of force F the materials are welded [1,2].

2. Experimental

To make thermoinsulative chambers of the intelligent clothing with adaptive micro-climatic conditions, highly elastic polyurethane foil made by Bayer Epurex Films GmbH, was used. The segments of ribbed thermoinsulative chambers were welded using the HF method at the Laboratory for Process Parameters of the Department of Clothing Technology. To weld segments, a high frequency oscillator, which oscillates at frequency of 27.12 MHz, and a power amplifier up to 1 kW as well as a specially designed high frequency electrode shaped according to the weld, were used. Welding time was 7 s, anode current (I) of 150 mA, 180 mA, 200 mA, 240 mA, 260 mA, 300 mA changed with a constant anode voltage of 2700 V. To measure the thickness of the weld (d_s), the thickness of the extruded edges (d_r) and the thickness of the workpiece (d_i), Fig 1, a micrometer Insize Company and a digital micrometer Toolcraft Company were used.

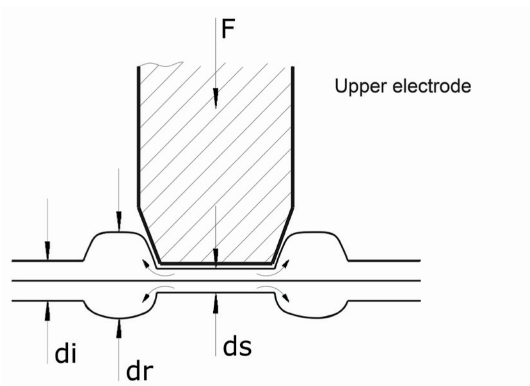

Figure 1 Schematic of the extrusion of the edges during welding

3. Results

The anode current was altered by high-frequency connection in the course of the performed experiment, while pressure force (F) on the workpiece, anode voltage of the amplifier and welding time were kept constant. Weld thickness (ds) and thickness of the extruded edges (dr) were measured under these conditions. In doing so, the following results were obtained by altering the thickness and the thickness of the circuit extruded edges, as shown in the diagram in Figure 2. It is evident that the thickness of the weld is proportionally equal to the value of the anode current up to 240 mA, and then it begins to assume lower values. At the same time, an increase in the anode current enhances the thickness of the extruded edge, causing a negative effect on HF welding. By increasing the current from 240 mA to 300 mA, the thickness of the extruded edge rapidly increases. Reduction of weld thickness is reflected in the reduction of weld strength, which is technologically unacceptable. The results obtained indicate that these tests can determine the optimum parameters of HF welding, ranging in this case range from the lower optimum limit of 180 mA, with the welding power of 450 W measured, to the upper optimum limit of 240 mA when welding power is 650 W.

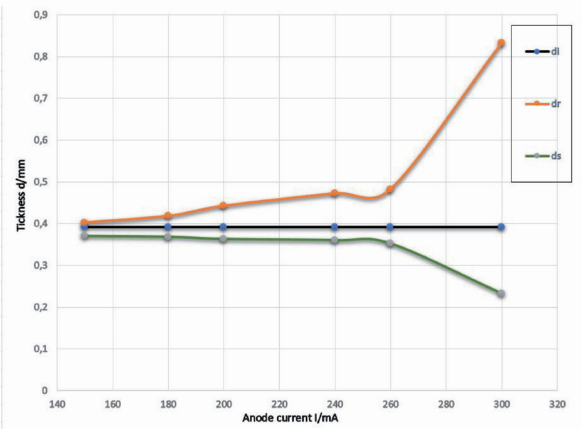

Figure 2 Dependence of the d_i, d_s and d_r on anode current

4. Conclusion

The high-frequency welding technique exhibits very good possibilities of using in the manufacturing of thermoinsulative chambers for intelligent clothing. This requires determining the lower and upper limit of optimal welding. Below the lower limit of the optimal welding there is no negative effect of extruded edges, but the welding power is too low to achieve sufficient weld strength. Above the upper limit of optimal welding parameters too much power is supplied, which causes a pronounced effect of extruded edges and the reduction of the weld thickness, which is also reflected in the reduction of weld strength. It is also quite evident that the technological process of HF welding should be performed near the lower optimum limit, as energy consumption in this area is the lowest, anode current is the lowest possible, and all of this directly affects the resources of high-frequency amplifier

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Snježana Brnada

Biography	Snježana Brnada was born on November 22nd, 1977 in Zagreb, where she completed elementary and high school education. Then she enrolled in the Faculty of Textile Technology, where she graduated. During the last year of her studies she got a scholarship from Varteks, where she was hired at the end of her studies. After internship, she got a permanent position in the Quality Assurance Division as Quality Technologist, where her main duties were solving technological problems. One year and three months later, she became a Technology Development Engineer at the R&D Department where her main duties were to optimize the processes, increase production efficiency, coordinate committee meetings etc. Since June 1st, 2009, she has been employed at the University of Zagreb Faculty of Textile Technology, Department of Textile Design and Management at the position Junior Researcher where her main duties are to teach courses in the field of weaving, work on projects and in scientific research.
Title of dissertation topic	Woven fabric deformation as a function of anisotropy
Mentor	Prof. Stana Kovačević, PhD
Date or dissertation topic defense	February 27th, 2014

WOVEN FABRIC DEFORMATION AS A FUNCTION OF ANISOTROPY

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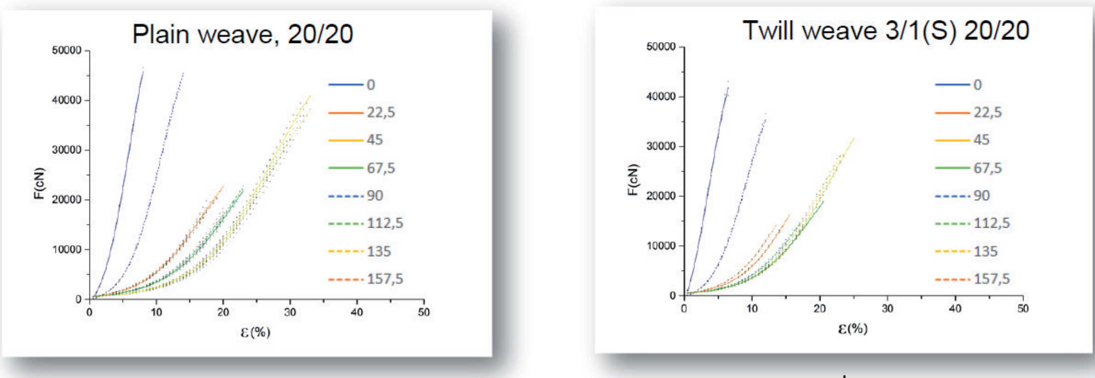
1. Introduction

Woven fabrics have to maintain their mechanical properties (as a single layer) or provide (as reinforcement within the composite) certain stability under high stress conditions [1,2]. In this respect, controlled characteristics of deformability can be obtained by designing fabrics of certain structural characteristics such as weave, warp/weft threads per length number, yarn composition, structural characteristics of the warp and weft, mass etc [3,4]. Woven fabrics are very widely applied and including the following areas: clothing industry, building construction, automotive industry, shipbuilding, filtration, interior textile, protective workwear, ballistic and military clothing and equipment etc.

In this doctoral thesis, anisotropic properties of the fabric were investigated and the deviation from orthotropic behaviour of diagonal structured fabrics was defined. The influence of tension and crimp on the deformation properties of the fabrics was determined. A mechanical model for the description of tensile test with the side restriction was established and the Poisson ratio, the Young's module of elasticity and the shear module were determined throughout the range of stress curves.

2. Results and discussion



a. b.

Figure 1 Approximation curves for fabric samples: a) in plain weave, b) in twill 3/1 S weave

From the linear stress-strain graphs (Fig 1a) and the results of the K-S test, a clear orthotropy of the plain weave fabric can be seen, with the same warp and weft density of 20 threads/cm. The difference between the maximum forces in the warp and weft direction is relatively small, only 1325 cN (46675 cN in the warp direction and 45350 cN in the weft direction). All approximation lines have a data matching of greater than 99.5%, which is apparent from the R2 parameter. Also, there are small differences between maximum forces of stretched fabric samples in symmetrical directions. Elongation in the weft direction is higher, at the beginning of stretching the fabric the resistance is smallest (small forces). It can be concluded that the cause of lower resistance to stretching of the fabric in the weft direction at the beginning is higher crimp value of the weft threads, and lower tension of the weft in the weaving process (compared to warp) which results in lower initial tension in the fabric. As the result of higher crimp values of weft threads, a smaller increase in tensile force is recorded in the samples of fabric whose angle of rotation is closer to the weft direction. Thus, the maximum strain values are at the angles of 67.5° and 112.5°, which is 18% higher than in the case of samples tested at the angles of 22.5° and 157.5°, while the difference in the maximum forces is very small, about 3%. At 45° and 135° angles, the maximum stretching is highest in compared to the other angles (33.5%), while the maximum force is 15% lower than the maximum force in the main axes and 83% higher than average at 22.5°, 67.5°, 112.5° and 157.5°.

The twill weave 1/3, has clear structural diagonal lines that could be identified with a homogenised composite model with diagonal lines that are unequally wide. When twill fabric is structured from the same number of threads in the warp and weft, the angle that the structural diagonal closes with the warp direction is equal to 45°. From the graph with the approximate elongation curves (Fig 1b), it could be seen that the lines at the angle of 45° and 135° are very close. This is not the case when it comes to symmetric approximated stress-strain curves in other directions, which is confirmed by the K-S test. In the case of samples at angles of 22.5° and 157.5° and for those at the angles of 67.5° and 112.5°, the increase of the strain results in more pronounced difference between symmetrical pairs of stress-strain curves. In both cases, less elasticity and lower values of maximum force appear in the lower right quadrant (the direction of the structural diagonal). It can be concluded that the diagonally structured woven fabric will have a lower elongation and force values in the directions close to direction of the structural diagonals.

3. Conclusions

- Symmetrically structured woven fabrics are extremely orthotropic.
- Diagonally structured woven fabrics deviate from orthotropic behaviour in at least one pair of identifiers.
- Woven fabric samples with higher thread density (24/24) shows more orthotropic properties compared to the same samples with lower thread density (20/20).
- Plain weave fabric with the higher thread number per length in warp and weft (24/24) has additional two axes of mirror symmetry at the angles of 45° and 135°.
- Higher warp density (more tensioned system), as compared to the weft, will provide less deviation from orthotropic behaviour.

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Darinka Cvetković

Biography	Born in Zagreb on July 22nd, 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 in the Faculty of Chemical Engineering as a part time student. In 1990, after IETA bankruptcy, she remained unemployed. In 1991 she enrolled in the Faculty of Chemical Engineering and Technology, on the degree course and graduated from it. In 2009, she enrolled on the bridging programme at the Faculty of Textile Technology and in 2011 graduated from Textile Chemistry, Materials and Ecology Course. She enrolled on doctoral studies at the Faculty of Textile Technology in 2016, with the aim of improving her research competencies in self-employment. Competent in English.
Title of topic of doctoral thesis	Modification of textiles by bee products for the purpose of apitherapy and the possibility of objective characterization
Study advisor	Assist. Prof. Maja Somogyi Škoc, PhD
Date of defense of doctoral thesis topic	

MODIFICATION OF TEXTILE BY BEE PRODUCTS FOR THE PURPOSE OF APITHERAPY

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1. Introduction

At this point, apitherapy is an alternative treatment in Croatia, using bee products. The word apitherapy comes from Latin words: *apis*, which means bee, and *therapy*, which means treatment [1]. The term "bee products" includes food, nutritional supplements and natural remedies, which can be used to preserve and strengthen our health and immunity and prevent individual diseases. In the literature, the following concepts of api pharmacology and api preventive can be found in the application of bee products [1].
Many authors throughout history mention bees, honey, i.e. bee products, so that Aristophan, Varon, and Hesiod wrote about bee breeding before the new era [2]. Hippocrates, the father of medicine, wrote about bee products as very mysterious products, while the father of experimental physiology, Galen, also mentioned apitherapy in his records. Charlemagne wrote about his treatment of a bee sting, and the use of apitoxin as a medicine is recorded in the Koran as well [2].
In the second half of the twentieth and beginning of the twenty-first century, there occurred a considerable progress and development in pharmacy and medicine, leading to a large number of new preparations and medicines based on bee products. Bee products have a positive effect on the healing process, as confirmed by numerous researchers. By using bee products, that is, by their biological, chemical and physical activity, we can certainly contribute to cure. In medical textiles, chestnut honey is used for treating chronic wounds in the diabetic foot and similar (Fig 1) [3].

Figure 1 Treatment ulcer with a chestnut- honey based dressing [4]

Apart from honey, bees provide many other products, which are the result of joint work of bees and hard working beekeepers. Each product, whether the result of bees themselves or beekeepers, has particular advantages in health care, while textiles can be outstanding "carriers of product properties". Honey, royal jelly, propolis, bee poison, beeswax and other products can find their targeted use in medical textiles, either as new biological materials in the field of biomimetics or through the well-proven sol-gel processing with natural active substances [5].

Since bee products are intended to be applied to medical textiles to be used on an open wound, apitherapy rules will be followed as a method of treating and improving the health of bee products.
In this doctoral thesis, bee products will be combined individually or in various combinations, as well as with medicinal herbs extracts aimed at synergistic action. Cellulose fabrics and knit fabrics are selected whereby the use of chemicals in accordance with European and world norms (*European Medicines Agency* (EMA), *Food and Drug Administration* (FDA or USFDA) will be applied through an environmentally acceptable procedure.

2. Experimental part

In the planning and carrying out of the research, general knowledge in the field of the methodology of scientific work will be used - the preparation of research materials, the implementation of the research and the elaboration of the obtained results with the aim of realising and confirming the hypothesis. Methods and procedures that will allow repeatability of the processing and morphological characteristics of the investigated materials will be used, employing modern, reliable and standardized metering techniques (FTIR-ATR, SEM-EDS, AFM, DSC/TGA, microbiological tests etc.) with the aim of evaluating the effectiveness of impact. In analysing and evaluating the results obtained, appropriate mathematical-statistical methods will be used, such that provide adequate degree of reliability in making conclusions.

The research will include the following units:

1. Selection of bee products and textile materials (medical program)
2. Selection of chemicals according to EMA and FDA.
3. Developing original recipes and calculating the required amount of chemicals for the best recipe.
4. Development of method and application procedure, and, if necessary, the development of appropriate equipment.
5. Consultation and cooperation with other institutions on the topic of scientific research (Faculty of Pharmacy and Biochemistry, Faculty of Chemical Engineering and Technology, Public Health Institute Dr. Andrija Štampar and others).
6. Processing and evaluating the effectiveness of the achieved protective effects.
7. Evaluating the applicability of processed textile materials and the possibility of commercial production.

3. Conclusion

The scientific contribution of this doctoral thesis will be considered in theoretical and applicative terms. In the theoretical sense, the method of binding bee products to the cellulose substrate will be investigated in accordance with the ecological criteria and rigorous requirements of the FDA and the EMA, and in the applicative sense a finished product will be prepared for the treatment of chronic wounds and apitherapy.

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Katia Grgić

Biography

Born in Dubrovnik on October 28th, 1978. Graduated from the University of Zagreb, Faculty of Textile Technology in 2006, on the topic *The Impact of UV absorber on the change of pastel coloured textiles in washing,* under the supervision of Prof. Tanja Pušić, PhD. She enrolled on the doctoral study Textile Science and Technology in 2009. Currently employed as an Associate Expert at the Faculty of Textile Technology. She has gained work experience as a technologist at Dorateks d.o.o., procurement coordinator at L'OREAL ADRIA d.o.o. and as a teacher at the Crafts School of Dubrovnik, teaching *Textile Materials* and *Mathematics*. Participated in 1 FP7 project, 1 EUREKA and 1 PoC 5 project and also in two Research grants. Her field of exploration are innovative technologies and characterisation of fabric surfaces. In addition to professional and research activities, she also works as *Occupational safety* and health specialists II. Degree.

Title of dissertation topic

Study advisor — Assist prof. Anita Tarbuk, PhD

Date or dissertation topic defense

ADSORPTION OF CATIONIC SURFACTANTS ON COTTON AND POLYESTER

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1. Introduction

Cationic surfactants appeared on the market in 1933 as levelling agents for direct and acid dyes on cellulose fibres. In 1940 they were widely used as finishing agents in commercial laundries. The first liquid softener appeared in 1955 in the United States. The first European product was applied in 1963 they offer a pleasant feel, reduced static electricity and pleasant smell of textile product [1]. Modern cationic surfactants are widely used in technological processes and are currently gaining importance because of their functionality and environmental benefits. This research investigates their adsorption on standard fabrics of different raw material composition employing electrochemical phenomena in evaluation.

2. Material and methods

Standard fabrics (WFK) were used for this research: area weight 170 g/m^2; pick count of warp and weft 27/27 cm^{-1} and linear density 295 dtex, plain weave, of different raw materials: cotton, polyester and cotton / polyester blends. Labels and descriptions can be seen in Table 1. Electrokinetic behaviour of the standard fabrics was determined by the method of streaming potential on the electrokinetic analyzer, SurPASS (A. Paar's). The zeta potential (ζ) was measured according to the pH of the 1 mmol/l KCl and the addition of the cationic surfactant 1 mmol/l N-CPC (N-cetylpyridinium chloride) in electrolytic solution on AGC (*Adjustable Gap Cell*). The IEP (*Isoelectric point*) and the PZC (*Point of Zero Charge*) were determined. Adsorption of the cationic surfactant 1 mmol/l N-CPC of 0.072 g on standard fabric was determined as well as the desorption on SurPASS at pH 6 and 22 ˚C. WRV (*Water Retention Value*), according to *DIN 53814.*

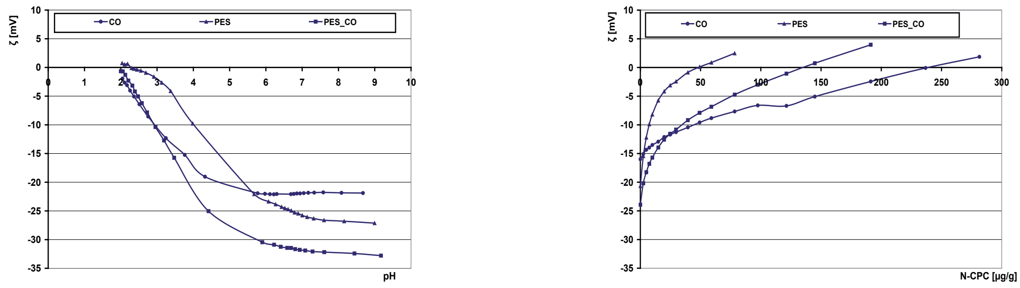
3. Results and discussion

The characterisation of fabric was performed based on electrokinetic phenomena and sorption properties. It is presented as zeta potential and water sorption, (Tab 1 and Fig 1.)

Table 1 Results of zeta potential (ζ), Isoelectric point (IEP), Point of Zero Charge, (PZC) and Water Retention Value (WRV) on standard fabric

Labels	Composition	ζ [mV] pH 9	ζ [mV] pH 6	IEP	PZC [µg/g]	WRV [%]
CO	100% cotton	-21.9	-15.9	< 2	237..2	27.14
PES	100% polyester	-27.4	-20.6	2.28	48.9	4.37
PES_CO	65% polyester/35%cotton	-32.8	-23.9	< 2	134.6	14.59

Standard fabrics of cotton, polyester and their blends have different zeta potential in electrolytic solution of 1 mmol/l KCl. Cotton fibres, due to the presence of hydroxyl and carboxyl functional groups in alkaline solutions, dissociate and give a negative surface charge as well as polyester due to a carboxyl ester group.Polyester exhibits the most negative zeta because, according to literature [2], hydrophobic fibres have lower zeta potential than hydrophilic, for the ability of water adsorption (hydration) and swelling. This is confirmed and investigated by the ability to WRV and adsorption of cationic surfactants (Fig 2). Polyester, due to its chemical structure and hydrophobicity, adsorbs less cationic surfactants than cotton. Adsorption of cationic surfactants depends on their surface charge and their chemical constitution.



a. b.

Figure 1 Electrokinetic potential of standard fabric: a) varying by 1 mmol/l KCl, b) *vs* the addition of cationic surfactant 1 mmol/l N-CPC

Polyester disperses the PZC in a relatively short time, which can be explained by the difference in the number and availability of active groups. Active groups of cotton fabrics are opened gradually, and a larger amount of N-CPC is required to counter the surface charge than on polyester. Observing the desorption of cationic surfactants with cotton, polyester / cotton and polyester fabrics, different desorption dynamics are evident, suggesting the need for other characterization methods that can better clarify the phenomena.

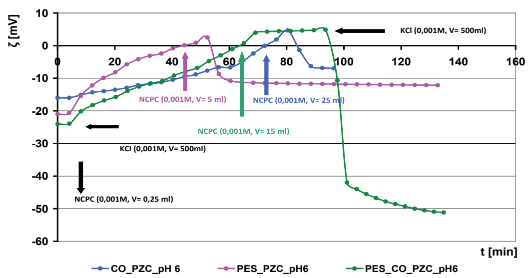


Figure 2 Adsorption and desorption of 1 mmol/l N-CPC on SurPASS: cotton fabrics, polyester fabrics, polyester and cotton blends

4. Conclusion

The results indicate the need for research of adsorption and desorption of some other cationic surfactants, where electrochemical phenomena will be evaluated by other methods, for example by potentiometric titration. The concentration of the surfactant (below and above the critical micellar concentrations) and pH and temperature of the bath, will vary with the purpose of interpretation of the mechanisms, kinetics and isotherms of adsorption along with potential formation of the adsorption model for each surfactant.

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Title of dissertation topic	Development of the method for the determination of metal ions in textile materials for children's toys
Study advisor	Prof. Branka Vojnović, PhD.
Date or dissertation topic defense	

DEVELOPMENT OF THE METHOD FOR THE DETERMINATION OF METAL IONS IN TEXTILE MATERIALS FOR CHILDREN'S TOYS

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1. Introduction

The safety of products, and even those made of textiles, is of exceptional importance in all EU Member States. Particular attention must be paid to children's clothing and in particular to children's toys that must be safe for daily use. Such products that are made of textile materials of various origins (natural, synthetic, blends) are often treated with agents which may contain metal ions. Some metal ions have exhibited harmful and toxic effects, so there is an understandable concern regarding the safety of such products for the health of children. Attention should be paid to the potential releasing of metal ions during the daily use of toys, especially their extraction in saliva or gastric fluid. Examination will be conducted for the presence of certain metal ions in selected samples of children's toys. Standard HRN EN 71-3 for the determination of total and additional specific migration of certain metal ions from selected samples of children's toys will be used for the purpose. The content of these metals is determined by the ICP-OES method. Attention will be paid to the preparation of samples for analysis and the possibility of extraction of ions of metals from different simulants (artificial sweat, saliva, gastric fluid, water, acetic acid).

2. Experimental

Determination of metal ions content was conducted on selected toy samples. Standard solutions for the quantitative determination of metal content on the spectrometer ICP-OES were prepared by diluting certified standardized solutions 1000 mg/L of individual metal. Samples for the determination of specific heavy metal migration had to contain representative parts of the entire surface which were often not made of the same type of material. The test sample consisted of a sample of textile material cut up in small pieces the mass of which was not to be less than 100 mg. Sample dimension of cut up small pieces did not exceed 6 mm. When sampling, it had to be taken into consideration that the sample was representative. Material types and the proportion of their presence in each individual sample was to be taken in account, provided that a sample of between 10 and 100 mg was taken from the basic material.

Determining global migration:

A gravimetric method was used to determine global sample migration. Total migration was calculated with respect to the mass of total migration from a sample of 1 dm^2 into the water and into the 0.07 hydrochloric acid solution and 3% acetic acid, it was expressed by the surface of the sample tested. Samples were taken from one whole children's toy, but from several different places to ensure sample representativity, with a special focus on [1].

Determining specific migration:

This procedure was performed according to EN 71-3:2013, Safety of toys-Part 3: Migration of certain elements. 180 mg of the toy sample was being placed in the appropriate dark bottle that fitted laboratory shaker. Then exactly 10 mL of HCl (0.07 M) was added. The shaking process lasted for 1h at 37±2 °C. After shaking the sample was left to rest for 1 h. After that, it was filtered and metal ions were determined by the ICP-OES method [2].

3. Results and Discussion

Categories of material for toys production according to the Toy Safety Directive 2009/48/EC, Annex II. Special safety requirements, 11.3. III. Chemical properties (Rev 1.7, 13. 12. 2013) and standard

EN 71-3:2013 Safety of toys - Part 3, Migration of certain elements. The migration limits of individual elements are different, depending on the material of the toy or the constituent part a), b) or c):
a) Dry, brittle, powder-like or pliable toy material: hard materials for toys from which the powder-like material is lost during the game and which can be swallowed during the game, hand contamination with material results in increased oral exposure, where the presumed amount of ingested material is 100 mg per day.
b) Liquid or viscous toy material: that can be swallowed and/or exposed to children's skin during the game, where the presumed amount of ingested material is 400 mg per day.
c) Scraped-off toy material: surface coatings, polymers (hard), polymers (soft), other materials, wood, textiles, glass, ceramics, metals and alloys. Hard materials for toys with coating or without that can be swallowed as a result of biting, scraping with teeth, sucking or licking. Assumed amount of ingested material is 8 mg per day [2-3].

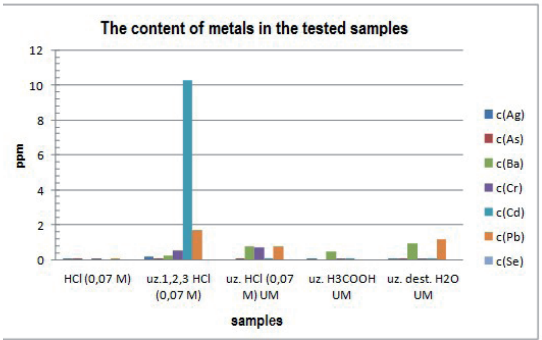

Figure 1 Graphical comparison of samples for specific migration and individual metals in solid residue after global migration determination

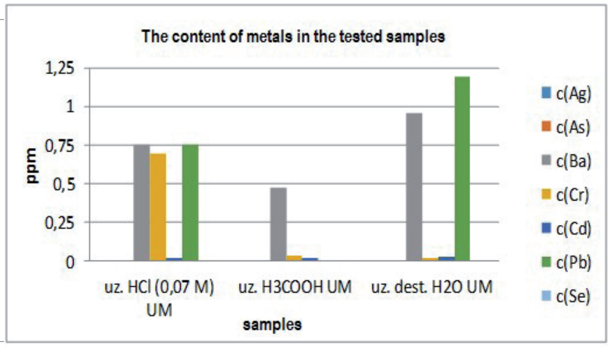

Figure 2 Graphical representation of the metal content in the samples tested for each metal in the solid residue after determining global migration

Metal ions present in higher amounts in ionic condition can often endanger health, especially in he case of the health of children. Tests have shown that certain metal ions migrate from the analyzed sample of children's toy and the concentration of each metal depends and on the medium (Fig 1,2) with which the extraction is carried out. Described investigations will attempt to develop a method for the determination of certain metal ions, depending on the method of sample preparation and with the newly developed method, we shall attempt to determine whether there is a potential risk of migration of metal ions from children's toys under simulated conditions.

4. Conclusion

Global migration from the toy sample exceeded the boundary concentration. This preliminary researches of the specific migration determination was aimed at pointing out that metal ions were released from the selected sample of children's toys in the case of simulation of swallowing but their concentrations were below the standard prescribed limit concentrations. In the case of ingestion of toy or parts of toy (eg. hair), in addition to the potential risk of choking, there was a risk of harmful effects of metal ions on the child's organism. Further researches will also attempt to investigate other migration agents (simulants), such as artificial saliva and artificial sweat, although these simulants are not proposed by the standard. Other methods of sample preparation for the analysis of migration of metal ions from textile materials intended for children's toys will also be tested.

5. References

[1] Law on general use items (NN 85/06, 75/09, 43/10)
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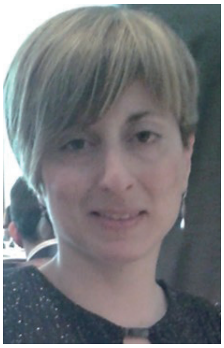
[3] Toy Safety Directive 2009/48/EC, Annex II. Special safety requirements, 11.3. III. Chemical properties (Rev 1.7, 13. 12. 2013)



Ivona Jerković

Biography

Ivona Jerković received her Bachelor of Science degree in 2006 from the University of Zagreb Faculty of Textile Technology (TTF) (Croatia) and the International European Master's (*E-TEAM*) degree in Advanced Textile Engineering in 2009 from the Ghent University (Belgium). In 2009 she performed *E-TEAM* 6 months automotive internship Leitat Technological Center-*Universitat Politècnica de Catalunya-Universiteit Gent* in Terrassa (Spain). In Croatia, she worked in clothing industry; TKT Zlatna igla (2007), Naftalina (2010); marketing; A.O.R. (2011-2012), and at University of Zagreb Faculty of Textile Technology for FP7 project MAPICC 3D (2012-2015). From February till December 2015, within the FP7 project she stayed at *Ecole Nationale Supérieure des Arts et Industries Textiles*, Roubaix, France. From 2017 she has been working for the Croatian Agency for SMEs, Innovations and Investments (HAMAG-BICRO) in Zagreb.

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-vinyl benzenesulfonic acid)

Mentors

Prof. emer. Ana Marija Grancarić (FTT)

Prof. Vladan Končar (ENSAIT, France)

Date or dissertation topic defense

July 14th, 2016

STRUCTURAL HEALTH MONITORING OF TEXTILE REINFORCED THERMOPLASTIC COMPOSITES WITH TEXTILE SENSORS

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1. Introduction

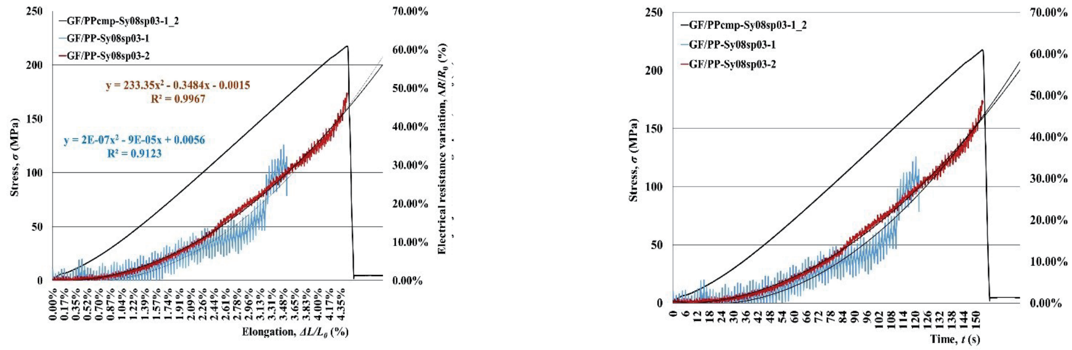
Textile reinforced thermoplastic composites have significant place in automotive, railway and aerospace industries due to many advantages compared to traditional materials, such as metals and ceramics [1]. Smart textile has important role in producing textile sensors compatible with composite technology. Conductive yarns as textile sensors can be integrated in textile structures by diverse technologies such as weaving, knitting, etc. [2]. Nowadays, interest is focused on the possibility of developing textile sensors from Intrinsically Conductive Polymers (ICPs) also called synthetic metals [3]. In this work, textile sensors based on conductive polymer complex poly[3,4-(ethylenedioxy) thiophene]-*compl*-poly(4-vinyl benzenesulfonic acid) (PEDOT-*compl*-PSS) were integrated during the weaving of 2D fabric. Electromechanical measurements of developed textile reinforced thermoplastic composites were carried out to enable *in situ* structural health monitoring of composites with textile sensors during tensile loading.

2. Experimental

E-glass/polypropylene (GF/PP) yarn by PD Fiberglass group (Germany) producer was used for textile sensors development with a novel roll to roll coating method [3]. GF/PP textile sensors were integrated during weaving of 2D fabric, 4-end sateen with repetition (warp density, 4 ends/cm and weft density, 6 ends/cm), and fabric thickness ~2.660 mm. Three layered 2D textile preforms with integrated textile sensors were consolidated under the pressure of 4-5 MPa and the temperature of 185 °C for 5 minutes, followed by cooling at 100 °C for 2-3 minutes. Three samples of textile reinforced thermoplastic composites with integrated textile sensors were prepared in order to perform *in situ* structural health monitoring of composites during tensile loading.

3. Results and Discussion

Electrical resistance of textile sensors after development was in the range between 350 Ω - 500 Ω and slightly higher after its insertion in 2D fabric, 390 Ω - 550 Ω. Electrical resistances of textile sensors after consolidation of GF/PP textile preforms and right before electromechanical tests was in the range between 16 kΩ - 240 kΩ. The first composite sample (Fig 1) showed similar electrical resistance-elongation curves of GF/PP textile sensors, while the other samples displayed different curves. Composite breakage “in a line” was observed after electromechanical test for the first sample. Earlier fractures inside the composite structures were detected for other two composite samples.
For the second composite, curves of electrical resistance variation of textile sensors ($\Delta R/R_0$) versus elongation ($\Delta L/L_0$) showed several interruptions in the second part of the curves, due to beginning of delamination and cracks inside the composite. Breakage of one GF/PP textile sensor, which occurred during *in situ* structural health monitoring, was detected for the last GF/PP composite structure. Gauge factor for all the composite samples was determined from a polynomial equation of degree 2. Stress at break of the composites was in the range from 206.99 MPa – 217.33 MPa while elongation at break was in the range from 4.40% to 4.45%. Composite specimen tensile loading until break was performed approximately after 152 s, while notable changes in electrical resistance variation of textile sensors occurred after 85 s.



a. b.

Figure 1 Results of electromechanical measurement of GF/PP composites with integrated GF/PP textile sensors: a) stress of composite (σ) and electrical resistance variation of textile sensors ($\Delta R/R_0$) versus elongation ($\Delta L/L_0$), b) stress of composite (σ) and electrical resistance variation of textile sensors ($\Delta R/R_0$) versus time (t)

4. Conclusion

Textile sensors exhibit the ability to follow tensile loading and to detect damages in the composites in situ**.** Several interruptions due to the beginning of delamination and cracks inside the composites were noticed in some cases as well. The first composite sample showed similar electrical resistance-elongation curves of GF/PP textile sensors, while for the other two composite samples earlier fractures inside the composite structures were detected. Breakage of one GF/PP textile sensor, which occurred during *in situ* structural health monitoring was detected for the last GF/PP composite.

Acknowledgment

The paper is a part of the EU project "MAPICC 3D" results within the call NMP-FP7- 2010-3.4-1, numbered with 263159 entitled: *One-shot Manufacturing on large scale of 3D up graded panels and stiffeners for lightweight thermoplastic textile composite structures.* The author would like to thank the European Commission for funding of the project.

5. References

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2010 – univ.bacc.ing.techn.text., University of Zagreb Faculty of Textile Technology
2006 – completion of high school education at the Textile, leather and design school. Achieved 3rd place at the state competition for high school students studying clothing, textile and design (Clothing days 2006), in the category-technology of clothing manufacturing
Work experience:
2013 – Konfeks d.o.o., production manager
2006 – 2013 – Student work experience in Konfeks d.o.o. (design of cutting patterns with CAD/CAM technology, sewing room and other work units)
2003 – 2006 – high school work experience in. Konfeks d.o.o.(auxiliary jobs)

Title of dissertation topic: The influence of different types of embedded materials and layering on cumulative Thermal Properties of Clothing (Work title)

Study advisor: Assoc. Prof. Snježana Firšt Rogale, PhD

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THE DETERMINATION OF THERMAL RESISTANCE OF WORK JACKETS FOR MEN WITH THERMAL MANIKIN

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1. Introduction

The international standard HRN EN ISO 7730: 2008 defines thermal comfort as the state of mind that expresses satisfaction with the thermal environmental conditions [1]. Thermal comfort is influenced by the human factor (physical activity, health condition), the factor of clothing (material properties, cutting parts, layering) and the environmental factor (temperature, air humidity, airflow) [2]. Objective evaluation of the thermal insulating properties of garments or clothing ensembles can be done by using measuring systems and methods for the determination of parameters such as: thermal conductivity of textile materials, water vapour permeability and air permeability [3]. At the University of Zagreb Faculty Of Textile Technology, a system for the determination of static and dynamic thermo physiological properties of composites and clothing was developed, constructed, patented and moderated and it enables objective measurement of thermal resistance (heat transfer resistance) of clothing, expressed in the units (m^2KW^{-1}) and (Clo) units [4].

2. Experimental

In the experimental part of the investigation thermal resistance test was performed (according to HRN EN ISO 15831: 2005) on two models of men's jackets (made by Konfeks). To determine if the jackets met the conditions of thermal comfort, measurements were performed on a thermal manikin that was developed at the University of Zagreb, Faculty of Textile Technology [4]. The outer shell of both jackets was made from the basic material containing 50% cotton and 50% polyamide, (Fig 1). The lining fabric of the model M1 was mad of 100% polyester-*microfleece* and of the model M2 of 100% viscose. Jackets were meant to be used in indoor facilities or outside.

a. b.

Figure 1 Models of jackets placed on the thermal manikin: a) model M1, b) model M2

3. Results and discussion

The results of thermal resistance test on thermal manikin, table 1, showed the average values of the electrical power required to maintain the temperature of the measured surface on which the garment was located and the value of thermal resistance based on twenty consecutive measurements on the thermal manikin. Total thermal resistance of the empty surface of the measuring device, along with the boundary layer of air at the surface (Rct0), was 0.0749351 m^2KW^{-1}.

Table 1 Average values of obtained thermal properties test results, models M1 and M2

Model	Heat transfer resistance value [Clo]	Electric power supply (W)
M1	0.272126452	212.408900
M2	0.286079000	208.091900

Table 2 shows the results of statistical analysis of the obtained results (single-factor variance analysis - ANOVA, with the significance level α = 0.05) that was performed to determine whether there was a statistically significant difference between the obtained results.

Table 2 Results of the statistical test on the set of measured data of models M1 and M2

Anova: Single Factor						
Groups	Count	Sum	Average	Variance		
M1	20	5.442529032	0.272126452	0.002169893		
M2	20	5.721580645	0.286079032	0.,001119596		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.001947	1	0.001946745	1.183615478	.	4.098172
Within Groups	0.0625	38	0.001644745			
Total	0.064447	39				

The results showed that thermal resistance values (Clo) of both models were approximately equal, but at the same time the M2 model had a lower electrical power required to maintain the constant body temperature of the thermal manikin. Statistical analysis showed that there was no statistically significant difference between the obtained results of the two jacket models.

4. Conclusion

Based on the it can be said that both models met the thermal comfort requirements defined by the international standard HRN EN ISO 7730: 2008, which refers to the thermal resistance values of individual garments. According to the mentioned standard, a jacket needs to achieve the value of 0.35 Clo, while a spring jacket needs to achieve the value of 0.25 Clo. The tested models achieved values of 0.27 Clo (model M1) and 0.29 Clo (model M2), and there is no statistically significant difference between the obtained results.

5. References

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Title of dissertation topic	Design of Working Methods in the Technological Process of Sewing
Mentor	Prof. Zvonko Dragčević, PhD
Date or dissertation topic defense	

DESIGN OF WORKING METHODS IN THE TECHNOLOGICAL PROCESS OF SEWING

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1. Introduction

By organization, the technological process of sewing belongs to the assembly (piece) type of the work process with the linear installation of workplaces, and individual technological sewing operations belong to the so-called stable workplaces of a closed type in performing routine work where the operator performs technological operations of approximately similar characteristics. For the organization of continuous work and material flow on these production lines it is necessary to know the correct time norms for each workplace and to determine a suitable working method, thus to achieve a continuous flow of materials on production lines and normal workload. In the technological process of sewing, technological operations have short execution cycles from 15 to 60 s, a high degree of repetition with considerable psycho-physical workloads caused by: static load of sitting workers, high degree of eye concentration, short arm movements and frequent combined and simultaneous movements. Research activities of the structure of daily working hours in the sewing phase indicate that 20 to 30% of time is spent on machine-hand suboperations of sewing, 60 to 70% of time on auxiliary hand suboperations, while about 10% of time is spent on non-productive work (personal hygiene, planned and unplanned time losses and lack of discipline) [1,2].

2. Experimental part

Within the framework of scientific projects organised at the Department of Clothing Technology of the Faculty of Textile Technology of the University of Zagreb systematic recording of production lines in the clothing industry was performed using video equipment (Kotka, Krapina; Virovitičanka, Virovitica; Pounje, Hrvatska Kostajnica; Mara, Osijek; EMKA, Pregrada). Basic information on how to perform the work process was obtained employing video recordings. Using the MTM-1 (Method Time Measurement) system, it was possible to systematically make and set up standard set of individual suboperations based on the logical sequence of basic movements. By structure of performing, the technological operations are divided into the following suboperations: taking, putting together, and positioning, sewing, hand suboperations during a pause in the sewing and laying off (Fig 1). Some suboperations within the structure of the technological operation can be performed in several ways, depending on the size and number of workpieces, the method of laying cutting layers, degree of the technical equipment of the sewing machines, size and shape of the work surface, required working zones and field of sight and considering operator training [3,4].

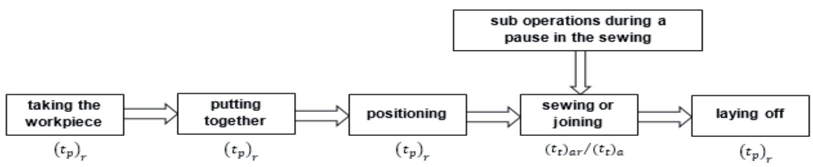

Figure 1 Division of the technological sewing operation according to suboperations

The measuring equipment consists of: a video camera SONY DCR-HC42E with time generator with an accuracy of ± 0.1 s; DVD recorder SONY SLV D970P, personal computer and colour printer are used for processing video recording; the video can be slowed down (1/2, 1/4, 1/8 or frame to frame);

a PC Pentium 4, 2.8 GHz, 1024 MB RAM with the installed Microsoft Windows 2000 operating system; a graphics card NVIDIA Ge Force FX5200: computer program Adobe Premier 5 and Corel Draw 11 are used. Computer processing of video recordings enables the analysis of the video recording “frame to frame” in Adobe Premier 5, where the time of performing particular technological suboperations in the structure of the technological operation is determined. Furthermore, typical static frames are transferred to the computer program Corel Draw 11; computer program ERGO-Plan or module ERGO-Mas and module ERGO-Man (University of Maribor, Faculty of Mechanical Engineering, Production System Design Laboratory).

3. Results and discussion

Nine possible performances regarding workpiece size, bundle position, seam length and curvature and the method of laying cutting parts were developed for the suboperation of taking the workpiece. For the suboperation of putting together, five possibilities of performance were developed depending on whether contour edges are put together or put on the defined place. For the suboperation of positioning the workpiece, two possibilities of positioning under the presser foot and the machine needle were developed. Three methods are possible in the technological suboperation of guiding the workpiece: basic, individual and mutual. Seam tacking in the technological suboperation of sewing can be performed in three ways (using the lever of the seam tacking mechanism, seam tacking button or automatically). For the suboperation of thread cutting off, four possibilities of performance were developed (using normal or special scissors, automatically or a thread cutting device). Making seams was facilitated by the use of auxiliary devices such as stops, hemmers and tucking in, for which four possibilities were developed. For the suboperation during a pause in the sewing, five possibilities of performance (aligning contour edges, swivelling around the needle) were developed. Laying off the workpiece at the end of the technological operation was possible in three ways (by one hand, both hands or by changing the direction) [5]. Based on the developed standard sets and using ERGO-Plan computer programme, workplace, pointing to a more favourable performance method in the technological process of sewing, was designed.

4. Conclusion

Standard sets of hand suboperations based on the logical sequence of necessary movements depending on length, case, type and dynamics of performance and necessary visual and muscular control with the possible performance of simultaneous and combined movements were analytically developed for the modelling system of designing working methods. Standard sets are timed and their combination can be used to determine and to set the optimal working method and the corresponding execution time.
By applying the developed standard sets of the technological operations of sewing and ERGO-Plan computer system, it is possible to develop a model system for workplace design and determine more favourable working methods with lower workload levels.

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Mateo Miguel Kodrič Kesovia

Biography

Born in Dubrovnik on March 2nd, 1987. In 2006 he enrolled on Conservation Studies at the University of Dubrovnik, where he also completed his MA Studies. He continued his education at the Palazzo Spinelli Institute in Florence and at the Institute for Conservation and Restoration in Vienna. He specialized in Analysis and Cataloguing of Historical Textiles (CIETA) in 2011 at the Fondazione della Arte Seta Lisio in Florence. Received Cum Laude and Summa Cum Laude diplomas, the Rector's Award, while the Ministry of Science, Education and Sports nominated him among the twenty most successful assistants. Since September 2013, he has been employed as an assistant at the Department of Art and Restoration, University of Dubrovnik. In 2014 he enrolled on PhD studies at the Faculty of Textile Technology in Zagreb. He specialized in restoration of textiles in 2017 at the renowned Institute Abegg Stiftung, Switzerland.

Title of dissertation topic

Method of analysis and digitalization of technical documentation of historical damask fabrics

Study advisors

Prof. Željko Penava, PhD

Assist. prof. Katarina Nina Simončič, PhD

Date or dissertation topic defense

METHOD OF ANALYSIS AND DIGITALIZATION OF TECHNICAL DOCUMENTATION OF HISTORICAL DAMASK FABRICS

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1. Introduction

Researching historical textiles requires elaborated interdisciplinary approach in which contemporary textile science is being integrated and linked with the knowledge from other fields of science. Main goal of this PhD thesis will be to develop interdisciplinary scientific method of analyzing and documenting historical damask fabrics which is due to their vast application and represent the most prevalent and common type of textiles found on artworks. International classification and terminology, typology of composition and structure of weave will be synthesized, along with the current findings on historical and technological development of damask production. An optimal model for documentation of weave drafts and corresponding technological parameters of valuable preserved historical damasks will be defined. Method for digital graphic reconstruction of original damask drafts will be developed and methods of their reproduction with modern printing and weaving techniques will be tested.

2. Experimental

Scientific analysis will be focused and implemented on a selected sample of historical damask from the collection of movable cultural heritage in Dubrovnik and surrounding area. In order to achieve the goal of this study, interdisciplinary scientific methods of researching textile materials will be applied (Fig 1). The methodology of research method analysis performed on historical textiles will be in accordance with international regulations and the code of ethics within the conservation profession [1].

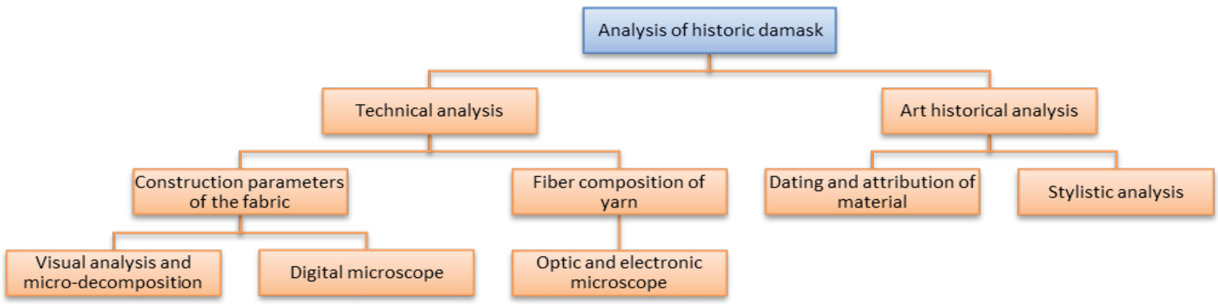

Figure 1 Graphical representation of analytic methods for researching historical damasks

Modern computer graphic technology, photogrammetric techniques and the interpretation of geometrical and optical laws of pattern composition of historical textiles will be used to digitally reconstruct the original appearance of deformed, damaged or incomplete designs [2]. Application of documented technological data and digital pattern layout into weave draft for virtual and physical presentation of analyzed historical damask will be examined. Using specialized computer software for creating weave drafts, the analyzed damask will be designed for the production using modern Jacquard technology. Potential for reproducing analyzed damask fabrics for the purpose of substituting fragile historical samples (making of replica) or designing new creations will be investigated, using modern techniques of textile printing (screen or digital printing) as well as technological process of reweaving with adequate materials. The quality of reproductive techniques applicable for precious historical damasks will be evaluated by methods of comparative analysis of physical and visual aspects, percent difference analysis of given parameters, survey method on specific target groups and the collection of empirical data for scientific conclusion.

3. Discussion

The methodology of construction analysis and expert textile terminology (technical terms, weave structures, effects, etc.) in Croatia is not adjusted for research, documentation and definition of historical textiles, thus it should be matched to existing international models. Pattern and construction analysis are an integral part of conservation-restoration documentation of historical textile objects. Weave drafts for creating historical damask fabrics have not been generally preserved, but in a reverse process, based upon technological and stylistic analysis of preserved damask, it is possible to graphically reconstruct the original design [3]. Defining an adequate model of documentation and its systematic usage is a precondition for digitalization and creation of interlinked repository and gallery of technical drafts which currently does not exist in Croatia, nor abroad, yet which would enable a quality collaboration between experts and institutions as well as stimulate interdisciplinary dialogue and scientific approach into the research of historical damasks. It would also represent a „container"for history of human creativity from which modern industries and creative designers may obtain new inspirations [4]. Once an appropriate methodology and organized process of documenting damasks has been established, same approach will be applied to other types of historical fabrics as well. Methods for producing copies and/or replicas of artworks gain more and more popularity within modern conservation practice. Projects of reconstruction and reproduction using modern materials are deemed acceptable for consolidation, reintegration and substitution of fragile historical materials, out of the necessity to prevent further degradation or enhance the understanding of the object [5].

4. Conclusion

Available modern technologies offer many possibilities for preserving the knowledge of production technology of historical textiles as well as for potential revival of craftsmanship. It is therefore the duty of everyone involved with textile cultural heritage to adequately define and document techniques of producing historical textile objects as to not only preserve the esthetic and historical values but also preserve the lost knowledge of their production for future generations. Implementation of interdisciplinary methodological approach in analysis of historical fabrics, developing method for digital reconstruction of lost weave drafts as well as perfecting technological documentation and terminology represent precondition for creating an innovative digital repository of patterns and construction parameters of damask fabrics preserved in the Dubrovnik area. The existence of such repository would in future provide a qualitative overview of textile heritage; improve methods of comparison, determining material authenticity, dating and production origin, the widespread and impact of specific designs, and enabling reconstruction and reproduction of already damaged samples with the use of modern technologies.

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Zorana Kovačević

Biography

Zorana Kovačević has been employed at the University of Zagreb Faculty of Textile Technology (FTT) since her undergraduate study (2009). Positions she has held during this time were assistant for the EU and national projects (FP7– REGPOT-2008-1-229801: T-Pot and Revitalisation of textile production of Spartium juncem L. – Development of autochthon Croatian product: From weed to fabric), associate – specialist for SEM, FTIR, TG, and since 2013th participation in the performance of practical training at the graduate and undergraduate study. Zorana has been enrolled on PhD study at the University of Zagreb Faculty of Textile Technology on ''Development of Advanced Polylactide Nanobiocomposites Reinforced with Spartium junceum L. Fibres''. Zorana Kovačević published 1 University book, 1 chapter in scientific book, 2 original scientific papers in tertiary publications, 2 original scientific papers in secondary publications and 16 papers arising from the participation in recognized national and international conferences and summer schools.

Title of dissertation topic	Development of Advanced Polylactide Nanobiocomposite Reinforced with Spartium junceum L. Fibres	
Mentors	Prof. Sandra Bischof , PhD (FTT)	Prof. Mizi Fan, PhD (Brunel University, UK)
Date or dissertation topic defense	February 20th, 2014	

DEVELOPMENT OF ADVANCED POLYLACTIDE NANOBIOCOMPOSITE REINFORCED WITH SPARTIUM JUNCEUM L. FIBRES

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1. Introduction

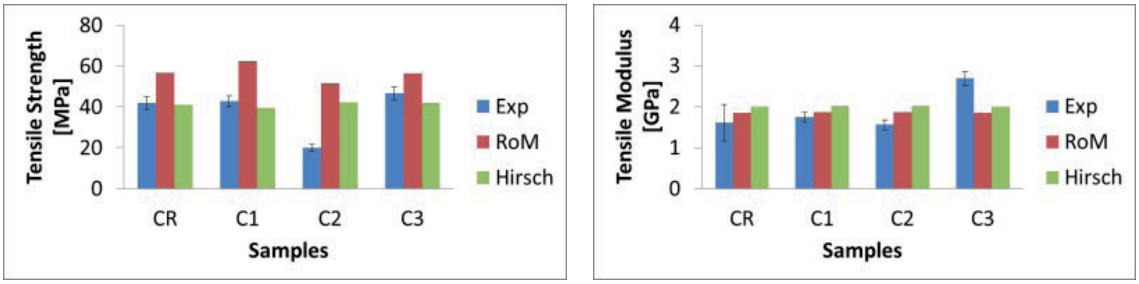
The rapidly increasing environmental awareness and growing global waste problem affected the development concepts of sustainability and renewable materials. Due to the need for finding renewable solutions in the development of new materials, the usage of composite materials made of biopolymer matrices and natural fibres has become increasing significantly. Considering they are durable, safe and have excellent mechanical properties, composite materials reinforced with natural fibers are mostly used in automotive industry [1] in the function of panels, seats, etc. Although, bast fibres have been grown for centuries throughout the world, their production is nowadays much higher in order to meet the demands of global market and to produce recyclable, renewable, 'green' products. Some of the most used bast plants are: flax, hemp, kenaf, ramie, jute etc. Whilst flax and hemp have been mostly used as textile raw material of cellulosic origin in plains, in coastal areas of the Mediterranean wild Spartium junceum L. - SJL has been used as textile raw material since ancient times [2].

2. Experimental

PLA polymer (6200D) was obtained from Nature Works LLC while Montmorillonite clay (MMT) and NaOH were purchased from Sigma-Aldrich, UK. SJL was collected in Croatia, in the area of the town of Šibenik. Fibres obtained by the maceration process with NaOH carried out in a microwave oven were used as reference fibres (R). Fibres were additionally modified with NaOH (1), MMT (2) and a mixture of MMT and Citric acid – MMT/CA (3) in order to improve composite interfacial, mechanical and thermal properties. Prior to composite processing, fibres and polymers were dried at 60 °C in an oven for 48 h. Polymer was melted in the vacuum oven at the 170 °C and hot pressed together with 20 wt.% of short fibres in a compression moulding machine at 170 °C under 1 tone pressure for 5 minutes. Rectangular specimens (PLA, CR, C1, C2 and C3) were cut from the sheets to the size of 40 × 5 × 1.5 mm. Micromechanical characterisation of composites and prediction of their tensile strength and tensile modulus were performed based on the mathematical models: Modified rule of mixtures with Cox-Krenchel equations and Hirsch model.

3. Results and Discussion

Figure 1 shows a comparison of the experimental and theoretical tensile strength and tensile modulus values. Predicted tensile strength values of mRoM were higher than experimental ones, which was the consequence of bonding quality between the fibres and matrix and fibres discontinuity. The compatibility factor (fC) was found to be a good indicator of the interface quality. In well-bonded composites, the values were within the range 0.16 - 0.20 [3]. fC results for CR, C1, C2 and C3 composites were 0.18, 0.19, 0.17, and 0.17, respectively, indicating good interface, which was not in agreement with the previous results of low strength for the C2 sample (12% of increment in strength compared to pure PLA, which denoted inappropriate interface). Hirsch model offered good correlation between the experimental and theoretical results. Predicted tensile strength values were approx. 10% lower than the experimental values, except for the C2 sample. It could be assumed that the interface quality in this sample was very poor, in comparison with C3 sample, where CA was added as an eco-friendly crosslinker with a positive impact on flame retardant properties of cellulose fibres. Predicted tensile modulus values were higher than experimental values, except for the C3 sample, where predicted values were 30% and 20% lower for mRoM and Hirsch model, respectively. The reasons that might affect predicted results were: the usage of models which fitted well enough for randomly oriented fibrous reinforcement but were developed for homogenous and isotropic fibres and formation of micro voids between the fibre and matrix [3].



a. b.

Figure 1 Experimental and predicted values of composite materials: a) tensile strength values; b) tensile modulus values

4. Conclusion

Modified Spartium junceum L. fibres were used as reinforcement in the NFRC materials with the aim to improve their mechanical properties. Tensile strength and tensile modulus of the composite reinforced with MMT and CA treated Spartium fibres (C3) were increased by 164.0% and 85.7% respectively, compared to pure PLA sample. Obtained results confirmed improvements of mechanical properties of applied samples in comparison to our previous series - reinforced with unmodified fibres and without any crosslinker. A comparison of experimental and theoretical results of NFRC tensile properties was conducted using modified Rule of Mixtures and Hirsch model. The predicted values of tensile properties were only comparable with the experimental coefficient of variation in the case of CR sample, while the predicted values of tensile strength showed partially good agreement only for Hirsch model. Further improvements of novel biocomposites require the enhancement of the affinity between hydrophilic fibre (nanoclay modified Spartium junceum L. fibres) and hydrophobic PLA matrix.

Acknowledgement

The present work was carried out at Brunel University, School of Engineering and Design, Department of Civil Engineering, Uxbridge, UK and funded by the British Scholarship Trust and Croatian Science Foundation under the project 9967 ADVANCETEX: Advanced textile materials by targeted surface modification.

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Ivan Kraljević

Biography

Ivan Kraljević, born in 1991, enrolled in the University of Zagreb Faculty of Textile Technology in 2010. He successfully completed undergraduate study of Textile Technology and Engineering (TTE) , the course Engineering Design and Management of Textiles, with the theme *Quality evaluation of leather for suitcases*, and two years later the graduate study with graduate thesis *Testing of prints durability on semi processed bovine leather*, under the mentorship of Assoc. Prof. Antoneta Tomljenović, PhD. November 2016 he enrolled on doctoral study Textile Science and Technology. Since February 2016 he has been employed in the main Croatian factory for sock producing, Jadran Tvornica čarapa d.d, where since 2017 he has occupied the position of the head of knitting and sewing department. He took part in the research project IP-2016-06-5278 financed by the Croatian science foundation. He published four scientific papers, whereas his area of research interest is testing and quality control of new materials for socks and leather industries .

Title of dissertation topic: High performance socks and possibilities of objective evaluation

Study advisor: Assoc. Prof. Antoneta Tomljenović, PhD

Date or dissertation topic defense

HIGH PERFORMANCE SOCKS AND POSSIBILITIES OF OBJECTIVE EVALUATION

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1. Introduction

Only a few European standards are related to testing and characterization of knitted fabrics and socks [1]. There are almost no published scientific papers, which would evaluate only the thermophysiological comfort of socks on thermal foot. Measuring thermophysiological parameters of socks is usually conducted on thermal foot together with the footwear [2-4].

According to the above, it is necessary to expand the research in the field of evaluation of their quality, and usage and functional durability in the conditions of use. Therefore, research within the doctoral thesis is focused on the possibilities of objective evaluation and development of methodology for evaluation of usage and functional quality of socks, with the purpose of determining optimal thermophysiological comfort, as well as functional efficiency and durability.

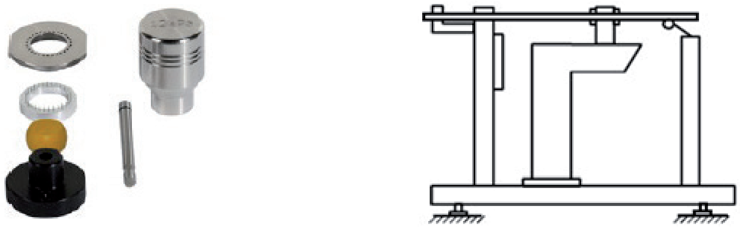
2. Experimental

The main goals of the doctoral thesis are:

- producing knitted fabrics using innovative yarns made of new insufficiently investigated fibres;
- testing the usage and functional properties of knitted fabrics using standardised methods;
- analysing thermophysiological comfort of knitwear under steady-state conditions by defining thermal and water-vapour resistance on the sweating guarded-hotplate test;
- design specific multi-area structured socks by using yarns of different composition and by optimizing the density of knitwear, with the purpose of achieving adequate comfort and high functionality;
- producing socks under commercial conditions;
- testing thermophysiological comfort of socks by measuring thermal and water-vapour resistance using non-destructive methods on Permetest (Fig 1a) and thermal foot (Fig 1b);
- testing the usage and functional properties of socks, before and after repeated cycles of simulated use and care. Implementing the test method for the determination of abrasion resistance of socks using the Martindale abrasion tester (Fig 1c) and developing abrasion tester for knitted footwear (Fig 1d) according to the HRN EN 13770:2008 [5].

a.

b.



c. d.

Figure 1 Testing socks: a) Permetest; b) thermal foot; c) modified specimen holders for Martindale abrasion tester [5]; d) abrasion tester for socks [5]

3. Conclusion

Expected results of the doctoral thesis are:

- developing of methodology for the evaluation of usage and functional quality of socks and
- developing a prototype of comfortable high performance socks that are not yet available on the market.

Acknowledgment

This work is funding by the Croatian science foundation within the project IP-2016-06-5278 (*Comfort and antimicrobial properties of textiles and clothing*, coordinator: Prof. Zenun Skenderi, PhD).

4. References

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Suzana Kutnjak-Mravlinčić

Biography	Suzana Kutnjak-Mravlinčić is of Croatian nationality and a mother of two children. She was born on September 26th 1966 in Zagreb, completed elementary school in Ludbreg in 1981 and high school in 1985 in Varaždin. She enrolled in the Faculty of Technology in 1985 and graduated in 1990 in planning and designing textiles and clothing. In 1990 she was employed at the Textile High School of Varaždin, and in 2007 at the Vocational Secondary School of Varaždin. In 1993 she completed the supplementary pedagogical-psychological education at the Faculty of Philosophy in Zagreb – Pedagogical Sciences. Agency for Vocational Education and Training promoted her to a mentor professor in 2006 and in 2011 to a professor advisor. Since 2007 she has been working as a part time associate at the Faculty of Textile Technology in Varaždin where she has been employed since March 2015 as a lecturer.
Title of dissertation topic	Influence of process parameter geometry at the 3D printing of acrylonitrile butadiene styrene on the properties of printed hollow structures
Study advisor	Assoc. Prof. Ana Sutlović, PhD (FTT); Assoc. prof. Damir Godec, PhD (University of Zagreb Faculty of Mechanical Engineering and Naval Architecture)
Date or dissertation topic defense	

TESTING OF MECHANICAL PROPERTIES AND COLOURING POSSIBILITY OF 3D ACRYLONITRILE BUTADIENE STYRENE

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1. Introduction

Additive manufacturing (AM) is the process of bonding materials when making objects directly from 3D computer models, most commonly layer upon a layer. While there is a possibility of sometimes creating an identical geometry of the product from the identical material, as well as classical methods, there are differences in properties of finished creations. Therefore, by appropriate test methods, it is necessary to determine what mechanical properties can be obtained by the additive manufacturing procedures. For low-cost 3D printers, the most prominent material is acrylonitrile butadiene styrene (ABS), which is available on the market in the form of a wire (filament) and is currently available; with black, white and clear, basic and secondary colours, which can often be limiting for design purposes [1-3].

2. Experimental part

The experimental part of the research consists of testing the impact of geometry of the 3D printed test bodies on mechanical properties and examining the possibility of colouring 3D printing works by exhaustion process. Test bodies are modelled in the Rhinoceros computer program and printed from ABS MakerBot filament on the MarketBot Replicator 2X 3D printer.

2.1. Examining the impact of geometry of the 3D printed test bodies from ABS to mechanical properties

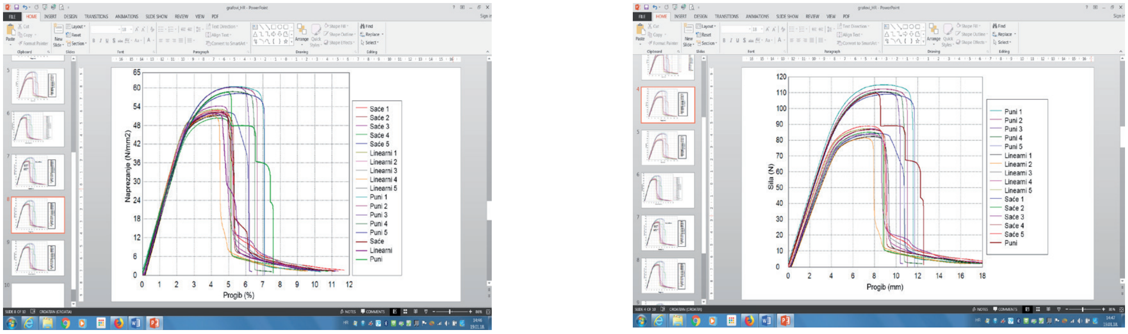
A lot of research has been conducted on the impact of the infill of 3D printed bodies on ABS on flexural properties. As there currently are no specific standards for these mechanical tests, the standard for testing polymeric products made by conventional production methods, HRN EN ISO 178, Plastics - Determination of flexural properties was used. For the implementation of research as variable parameters to be followed are: infill density and infill sample. Two infill samples, linear and honeycomb pattern specimens were selected, for which the defined density was from 30% and full infill. The permanent print parameters were: layer thickness 0.10 mm, number of outer layers 3, temperature of print heads 230 °C and temperature of printer substrate 110 °C. *Computer Aided Design (CAD)* models of printed bodies were modelled according to the dimensions determined by standard. During the 3D printing process, the test bodies were always positioned in the same way on the printer base, and in each print 5 test bodies were printed for 3 sets of samples from the same ABS material with a diameter of 1.75 mm from the same roll. For testing the flexural properties, a Shimadzu mechanical property testing device was used, with the maximum force of 10 kN. Force and corresponding breakage of the samples were recorded during the test, using an automatic recording system and the determination of the flexural strain, breakage and stretching defined by the flexural strain – stretching and the flexural force curve.

2.2. Testing the ability of colouring 3D printed ABS creations by the exhaustion process

Testing the ability of colouring 3D printed creations was performed by the exhaustion method in the Polycolor MATHIS apparatus with dispersion, reactive, acidic and base colouring. The colouring process was carried out by a discontinuous process at the temperature of 90 °C with the bath ratio of 1:30. For testing the ability of colouring 3D printed ABS creations by the process of exhaustion with the goal of examining the possibilities of achieving colourful, ombre effects, dispersed colouring was used.

3. Results and discussion

From the examined flexural properties diagram it can be seen that the maximum force, maximum flexural stress – strain and the maximum deflection in the series of linear infill and honeycomb infill are smaller in relation to the series of samples with full infill (Fig 1). Linear infill samples have 25% lower flexural strength compared to test bodies with full infill, and the samples with honeycomb infill have 23% lower properties.



a. b.

Figure 1 Diagrams of the examined mechanical properties: a) flexural stress – deflection diagram for all types of infills, b) flexural force – deflection diagram for all types of infill

By colouring the 3D creations by the exhaustion process, given the chemical structure of ABS, the best colouring properties are shown by dispersion colouring (Fig 2a). The other dyes (Fig 2b - 2d) do not show satisfactory dyeing properties. With the combination of dispersion dyes contrast and tone, ombre effect have been achieved (Fig 2e)..

a. b. c. d. e.

Figure 2 Coloured 3D samples by exhaustion process: a) dispersion colouring, b) acidic colouring, c) reactive colouring, d) base colouring, e) *ombre* effect

4. Conclusion

Flexural properties analysis indicates that test samples with full infill have the best properties. If the desired model has to withstand flexural force during the application, it is recommended to make a full infill model even though linear and honeycomb infills can meet a fairly high criterion, but with a 25% lower flexural properties. Thus is proven by colouring 3D printed ABS creations by the exhaustion process and the result can be interesting and colour solutions creative.

The work has been supported by Croatian Science Foundation under the project 9967 Advanced textile materials by targeted surface modification, ADVANCETEX.

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Title of dissertation topic	The impact of technological parameters of knitting and constructional characteristics of hosiery on leg compression
Study advisor	Prof. Zlatko Vrljičak, PhD
Date or dissertation topic defense	June 2nd, 2017

THE INFLUENCE OF TECHNOLOGICAL KNITTING PARAMETERS AND CONSTRUCTIONAL CHARACTERISTICS OF HOSIERY ON LEG COMPRESSION

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1. Introduction

Yarn elongation and elasticity enable hosiery to fit comfortably and be stay-up. For hosiery to be stay-up, the circumference of the knitted fabric must be smaller than the leg circumference. Different amounts of elongation and elasticity are achieved by using yarns of different composition, structure, fineness, and tensile properties as well as interlacing [1,2]. Polyamide multifilament and elastane yarns are used to make elastic stockings with counts of 15 to 260 dtex [3,4]. Classic men's socks are made of cotton or wool yarns with simultaneous interweaving of PA filament yarns, which provides elongation and thereby elasticity as well. Coarser elastane yarn, often with counts of 25, 36, 44 or 56 tex, should be woven into the stocking band, which enables the stocking to stay up [5,6]. The amount of elongation and elasticity affect the wearing comfort of hosiery. The interface pressure of a knitted part of 2.2 kPa (or 16 mm Hg) is considered low pressure and is used in everyday use. Fine women's hosiery with higher compressibility has the compressibility of 2.5 kPa (or up to 19 mmHg). The compressibility of medical hosiery is 2.4 to 6.5 kPa, and sometimes more. Certain standards have three, four or five grades of hosiery compressibility on the leg [7-9]. During hosiery use, in order to measure wearing comfort or fulfilment of compression hosiery function, a significant factor is the amount of hosiery interface pressure during particular hosiery elongation. Functional medical hosiery of a particular compression degree is custom-made for the hosiery wearer. This way it is possible to achieve the required interface pressure of hosiery at a certain section of the leg.

2. Experimental

The aim of the experiment is to measure hosiery compressibility at certain degree of elongation. A much more complex task can also be set as the aim, and that is to make hosiery with yarns of particular composition, fineness and structure and obtain different interface pressures at particular sections of the leg. When measuring compressibility, hosiery measurements in static and active position are taken and pressure of a hosiery section at particular elongation is measured. In this research, to measure interface pressure of hosiery, a wooden leg model is chosen onto which hosiery is mounted and the pressure is measured.

3. Methodology

Hosiery compressibility can be measured in different ways [10-12]. One of the better-known and frequently used methods is the wooden leg method [10]. The basic concept of the method is based on six wooden leg models in different sizes. The models are made based on statistical data obtained by measuring population and theoretical simulation of measuring arrangement. The device is primarily intended to measure compressibility of short knee-high stockings and elastic and medical compression tights as well as different shapes of medical artificial limbs. The device is composed of five interconnected units. The first unit is the wooden leg model in certain sizes onto which hosiery is mounted as on a solid body and hosiery compressibility on a certain section of its length is measured. The second unit is composed of measuring sensors placed along the leg model at certain spots, which are significant for measuring hosiery compressibility on the leg. The third unit consists of a device which collects data about compressibility and displays them on the screen or it can print them on a 56 mm ribbon. The fourth unit is a computer, optional, but desirable in serial measuring. By using high-quality computer programmes, measured results are collected, processed, sorted, and presented or printed in different forms. The fifth unit is the device for calibration of the whole measuring system. According to the established medical practice, hosiery compressibility is expressed in mmHg, or in kPa.

4. Results and discussion

From a medical point of view, the highest compressibility of hosiery compression should be above the hosiery ankle. Three groups of compressive tights with different levels of compression were made. Hosiery compressibility was measured on a size 4 wooden leg model. The first tights were of the lowest compression. In the ankle area, the tights had the highest compression, which was 3.4 kPa (25.7 mmHg). At the bottom of the leg calf the tights had the compression of 2.5 kPa (18.9 mmHg), under the knee 1.9 kPa (14 mmHg), above the knee 1 kPa (7.2 mmHg) and in the crotch only 0.24 kPa (1.8 mmHg). The second tights were of a slightly higher compression of 3.9 kPa (29 mmHg) at the ankle, and 0.17 kPa (1.3 mmHg) in the crotch area. The third tights were of the highest compression, 4.1 kPa (30.7 mmHg) in the ankle area, and only 0.9 kPa (6.5 mmHg) in the crotch area, or 21.2% in relation to the compression at the ankle. The highest compression was obtained at the smallest sinking depth. In this type of work, the narrowest part of hosiery knit was made since it stretched the least during use.

5. Conclusion

Hosiery compressibility can be measured on wooden leg models if the sizes of hosiery and the wooden leg model are harmonized. The amount of compressibility depends on yarn structures, machine regulation, type of interlacing and elongation size when measuring compressibility. Average compressibility in the ankle area of the produced hosiery samples is 3.4 to 4.1 kPa, and in the crotch area 0.17 to 0.9 kPa. The produced and analyzed compression hosiery can be used for prevention or therapy in the treatment of chronic venous insufficiency of a certain degree.

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Eva Magovac

Biography

Eva Magovac, BSc was born on October 20th, 1977 in Karlovac where she attended Karlovac Gymnasium. In 2002 she graduated at the University of Zagreb Faculty of Textile Technology, study of Textile and Clothes Design. After completing the studies, she worked for many private textile and leather companies. In 2009 she was employed at the Faculty of Textile Technology as an assistant in the EU project FP7-REGPOT-2008-1: T-Pot, where she enrolled in 2010 on postgraduate doctoral study in Textile Science and Technology. In 2011 she was employed at the Croatian Chamber of Economy in Karlovac as an associate in the International Relations Sector. In 2014 she was re-employed at the Faculty at the position of an associate continuing her doctoral studies. Her field of expertise includes scanning electron microscopy with energy dispersive X-ray spectroscopy.

Title of dissertation topic	Flame Retardant Surface Modification of Cotton Textiles using Layer-by-Layer Deposition	
Mentors	Prof. Sandra Bischof, PhD (FTT)	Prof. Bojana Vončina, PhD (University of Maribor Faculty of Mechanical Engineering)
Date or dissertation topic defense	May 20th, 2016	

FLAME RETARDANT SURFACE MODIFICATION OF COTTON TEXTILES USING LAYER-BY-LAYER DEPOSITION

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1. Introduction

Current commercially available flame retardants for cotton fabrics based on halogen, organo-halogen and antimony organo-halogen flame retardants are toxic, and those based on organo-phosphorus compounds are now considered safe to use partially due to a lack of data on their impact on the environment and health [1-3]. Due to numerous environmental problems that occur in the production, usage and disposal of textile materials treated with flame retardants there is a need for their partial or complete replacement by new alternative environmentally friendly agents and / or technological solutions, and one of the possible ways is "Layer-by-Layer" (LbL) deposition. LbL deposition means the surface adsorption of long-chain polyelectrolyte molecules of one charge onto the substrate of the opposite charge followed by washing with *deionised* water. The next step is adsorption of the positively or negatively charged *polyelectrolyte* onto the opposite charged polyelectrolyte and so on. In this way it is possible to arrange several layers of the same or completely different electrolytes of different properties [4]. LbL deposition is tested in the experimental stage on textile materials treated with flame retardants using a variety of flame retardants.

2. Experimental

Three aqueous solutions of sodium phytate, PA (Carbosynth Ltd, UK) and branched polyethylenimine, BPEI (Sigma-Aldrich) were prepared with 18.2 MΩ deionised water according to table 1. Nine chemically bleached desized 100% cotton samples with a density of 177 g/m^2 (Pamučna industrija d.d. Duga Resa, Croatia) were immersed into aqueous solutions of positively charged BPEI and negatively charged PA forming 1, 5 and 10 bilayers. Each immersion step was followed by rinsing in deionized water. Cotton samples were dried in the oven at 50 °C.
Burning behaviour of the fabric was evaluated by Limiting Oxygen Index (Dynisco) according to the EN ISO 4589-2. Thermal stability of the fabrics was evaluated by thermogravimetric (TG) analyses using PerkinElmer Pyris 1 TGA thermogravimetric analyzer. All the samples for TGA were measured from 50 °C to 700 °C at the heating rate 40 °C/min in the air (flow rate: 30 ml/min). The chemical composition of the char residue was studied using a Tescan MIRA\\LMU FE-SEM Scanning Electron Microscope (BSE detector, 20 kV) equipped with the EDS detector.

Table 1 Experimental and results of LOI, char residue after heating at TGA

Sample	BPEI (wt %)	PA (wt %)	Number of bilayers	Char residue (%)	LOI (%)
0 - cotton	n/a	n/a	n/a	0.000	18.5
1	1	5	1	1.712	19.0
2	1	5	5	1.714	20.0
3	1	5	10	7.275	20.0
4	1	10	1	4.565	21.0
5	1	10	5	2.568	22.0
6	1	10	10	4.850	22.0
7	1	50	1	29.387	29.0
8	1	50	5	2.275	29.0
9	1	50	10	2.282	29.0

3. Results and Discussion

Cotton fabric is characterized by low LOI (18.5%). Treatment with LbL enhances LOI values up to 20% and 21% when experiment 2 and 3 was applied (PA 10 wt%) according to table 1. Further enhancement of LOI values (22% and 23%) was obtained with the increase of PA concentration up to 10 wt%. The best LOI values (28% and 29%) were obtained by treating cotton samples with concentrated solution of PA (50 wt%). However, the increase in number of bilayers at the same PA concentration did not follow the LOI values as theoretically expected. The value of LOI of cotton samples treated with 5% concentration of PA was higher for 5 bilayers (21%), than for 1 and 10 bilayers (20%). The LOI values for cotton samples treated with 10% concentration of PA were 22% (1 bilayer) and 23% (5 and 10 bilayers). Among three cotton samples treated with 50 wt% concentration of PA, the highest LOI value was obtained with 1 bilayer (29%) according to table 1.

Theoretically it is expected that the mass of the final char residue after heating in TG shows linear growth from untreated cotton to LbL treated cotton (PA 5 wt%, 10 wt%, 50 wt%) as well as the number of bilayers (1, 5, 10). The highest mass of the final char residue (around 29%) was obtained in this work by PA 50 wt% in 1 bilayer (experiment 7) according to table 1, suggesting that at high PA content, the aqueous solution was saturated with sodium phytate, which deposited on the surface of the fabric treated with BPEI instead of negatively charged PA. The EDS analysis of the char residues mainly showed the content of carbon, oxygen, phosphorus, sodium and others in traces (aluminium, magnesium, calcium as impurities of the technical grade sodium phytate). The EDS analysis did not show any trace of nitrogen, suggesting that nitrogen gas compounds evolved during combustion.

4. Conclusion

Environmentally friendly electrolytes were successfully deposited onto cotton using LbL technology enhancing the initially low FR properties of the cotton material. Altering the number of BPEI/PA bilayers and the concentration of PA sodium salt hydrate in aqueous solution (5%, 10% and 50 wt%) the results of LOI, so as char residue mass of samples after TGA heating indicated reduced flammability of cotton fabrics. Increase of PA concentration caused continuous reduction of cotton flammability. At the same time the increase of LbL layers showed less pronounced influence on cotton flammability, using the same PA concentration. At the very high contest of polyelectrolyte (PA 50 wt%), the LbL deposition was not possible.

Acknowledgment

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Title of dissertation topic	Clothing dynamic behaviour influenced by body biomechanics
Mentor	Assoc. Prof. Slavenka Petrak, PhD
Date or dissertation defense	July 5th, 2016

CLOTHING DYNAMIC BEHAVIOUR INFLUENCED BY BODY BIOMECHANICS

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1. Introduction

Human body, its shape and kinematics of motion, are the research basis in the field of design and development of new garment models. The development of computer technologies and CAD systems for 2D/3D clothing design enabled 3D simulations and analysis of computer prototypes with the ability to predict the appearance and functionality of new garment models in the construction preparation process. The clothing fit in static conditions refers to the fit of a garment on the human body shape, where the degree of ease allowance depends on garment type and its purpose, the quality of the construction, and the embedded material with its properties that are expressed with the values of the particular physical and mechanical parameters. Clothing fit under dynamic conditions refers to the fit of clothing on the body in motion, whereby the garment must not restrict the body movement, or the movement may cause excessive strain on the textile material from which the garment is made. High demands are particularly expressed in special clothing, which must ensure unrestricted extreme motion [1,2]. High clothing fit is achieved through a complex analysis of the human body shape and kinematics characteristics, and systematic application of acquired knowledge in the process of engineering clothing design. By integrating a variety of modern systems for human body and motion analysis, such as 3D body scanners and *Motion Capture* (MC) systems into the computer 3D design, a detailed analysis of anthropometric and kinematic body characteristics and the application of their parameters in the garment construction process are enabled [3-6]. Research and computational stress test analysis are based on the physical simulation of a garment behaviour on a body in static or different dynamic positions with the purpose of analyzing garment computer prototype geometrical deformations in contact with the body model, defined by the contact mechanism between the body and the garment and the parameters of physical and mechanical properties of the particular fabric used [7,8].

2. Research methods

Within the experimental part, analysis of body surface segments dimensions in static and dynamic conditions will be performed and correlation of different body shape and constitution types with dimensional changes in dynamic conditions will be investigated. Capturing and biomechanical analysis of three different body constitution types in targeted movements will be carried out. Based on the performed analysis, a mathematical model for the animation of scanned body models will be developed. Animated scanned models will be used for computer garment simulations. Analysis of mechanical parameters at low load of simulated fabric will be used to investigate strains on characteristic garment zones in static and dynamic conditions, fig. 1. Based on the results, functional relationship between fabric tensile properties, pattern construction and biomechanics of the body in motion will be investigated and defined.

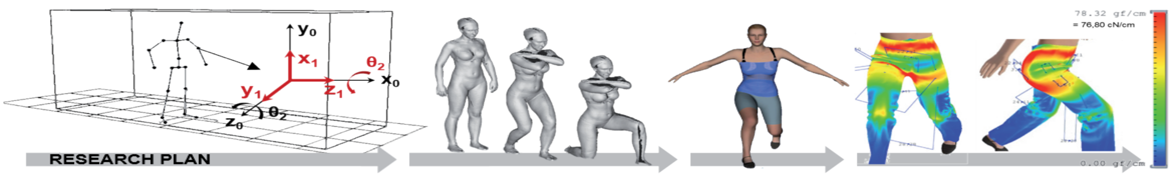

Figure 1 Doctoral paper research plan

3. Aim and hypothesis

The main goal of the doctoral work is to develop a method for computer analysis of clothing fit under dynamic conditions. The following hypothesis has been set for the purpose of the research:

H1: Body surface deformations in motion depend on the body constitution and shape. The development and application of mathematical models for the adaptation of body kinematic points and the deformation of the surface segments depending on the individual body type can result in realistic animation of the scanned body model applicable to computer 3D simulation of clothing under dynamic conditions.

H2: By modelling the targeted mechanical behaviour of the fabric during garment simulation, the deformations of the garment surface in the correlation with the deformations of the body type in the given motion can be achieved.

H3: Based on the analysis of garment computer model geometry deformations in interaction with the body model in motion, it is possible to predict and validate the strain on the garment under dynamic conditions.

4. Expected scientific contribution of a research

Based on the complete research, a new computer method for clothing dynamic stress analysis, based on the 3D simulation of the garment model mechanical behaviour on the animated scanned body model, will be developed. By modelling the targeted mechanical properties and behaviour of the garment in the 3D simulation on the body in motion, it will be possible to analyze the surface deformations of the computer prototypes, and thus stress analysis on the critical zones of the garment. The contribution of doctoral thesis will be a novel method that represents an innovative approach to the issue of assessing the fit of a garment on an individualized computer body model under dynamic conditions.

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Title of dissertation topic	Cosmetotextiles – carriers of active natural substances to the skin
Mentor	Prof. Sandra Bischof, PhD
Date or dissertation topic defense	January 21st, 2016

COSMETOTEXTILES – CARRIERS OF ACTIVE NATURAL SUBSTANCES TO THE SKIN

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1. Introduction

Textiles and cosmetics are among the oldest man-made products, but connection of textiles and cosmetics in the form of cosmetotextiles is a relatively new concept. Their application and research in this field have significant importance for the 21st century [1,2]. The most interesting method of „storing" a cosmetic preparation is microencapsulation, as it offers the means of controlled release of the active substance. Microencapsulation is the most commonly applied technology used for controlled release of active agent [3]. This technique is used for forming the particles (liquid, solid or gaseous state) inside the shell where products obtain spherical micro or nanometer size. The coating may protect the active substance or may be porous and release it [4,5]. Various vegetable preparations can be used, depending on the desired effect to be achieved on the skin (e.g. revitalization, hydration, skin protection, reduction and prevention of acne, spots, eczema, etc.). They provide the desired effect on the target cosmetic purpose, or more of them, because each of the preparations usually has several areas of activity [6]. The main requirement for textile substrates, the capability of which is to release active substance, is medical or wellness features by previously applied preparations on the fiber/material. The active substances are absorbed, coated or encapsulated on the textile substrate [3]. The textile substrate may be treated with active substances in the presence of appropriate additives to improve the covalent substance binding on textiles.

2. Experimental

Methodology of the research plan: 1. Vegetable, medical and/or cosmetic products will be chosen to be encapsulated in a suitable matrix. 2. Physical-chemical analysis methods will be used for the analysis of selected cosmetic products (FTIR, HPLC, UV/VIS spectrophotometry). 3. Textile substrate suitable for the appliance of selected products will be chosen. 4. Parameters for synthesize of microcapsules will be optimized. 5. The most appropriate procedure of applying active agents will be chosen. 6. Parameters of drying and fixation of the active agent to the substrate will be optimized. 7. Characterization of active products applied using various physical-chemical analysis methods („drop test", microwave extraction, FTIR, HPLC, UV / VIS spectrophotometry) will be processed. 8. Characterization of the surface of the treated substrate will be processed. 9. The analysis of mechanical features of cosmetotextiles will be processed. 10. The potential risk of applied cosmetotextiles in the direct contact with the skin will be investigated.

Cosmetic product α-tocopherol (DL-α-Tocopherol, Calbiochem) is chosen for core of microcapsule in a research. Ethyl cellulose (viscosity 4cP, Sigma Aldrich) is chosen for matrix. Synthesis procedure is described in patent No.: US 6932984 B1.

3. Results and Discussion

Synthesized microcapsules were impregnated on chosen cotton textile – cosmetotextiles. SEM figures, shown in Figure 1, confirmed their regular spherical shape. Microcapsules were in a size range with an average diameter of 30 µm. [7].

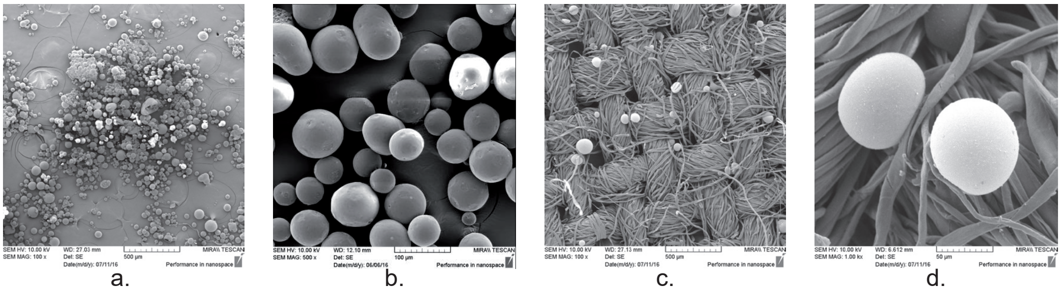

Figure 1 SEM figures of microcapsules and cometotextiles with different magnification: a) microcapsules 100x, b) microcapsules 500x, c) cosmetotextile 100x, d) cosmetotextile 1000x

4. Conclusion

The most interesting method of „storing“ a cosmetic preparation is microencapsulation, as it offers the means of controlled release of the active substance. The expected results of the doctoral thesis have potential importance for further development of materials with additional features with a wide appliance in the cosmetics industry and in the medical field. Therefore, scientific contribution of this dissertation will be:

1. Development of the innovative, environmentally friendly and biodegradable cosmetotextiles with additional medical application.
2. Improvement of the functionality of textile products by optimizing the methods of microencapsulation production. As is evident from the results, the synthesis is successful.
3. Contribution to the classification and standardization of the methods for testing of cosmetic, aromatherapeutic or medicinal effects of the cosmetotextiles with SEM and HPLC.

Acknowledgment

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Marija Nakić

Biography	She was born in Široki Brijeg, where she completed Elementary and Secondary School. After that, she won a degree in textile engineering, designing and engineering textiles and clothing at the University of Zagreb Faculty of Textile Technology. Afterwards, she won Master's degree at the same Faculty, Master theses entitled: *Woman Shirt of Rama* (BiH). Currently, she is a PhD student at the same Faculty. After graduation, she worked as an interior designer in several companies in Herzegovina, and now she is employed at the University of Mostar in the International Relations Office.
Title of dissertation topic	Designing functional clothing item for people with physical disabilities
Study advisors	Prof. Željko Penava, PhD Assist. Prof. Slavica Bogović, PhD
Date or dissertation topic defense	

DESIGN OF FUNCTIONAL CLOTHING ITEM FOR PEOPLE WITH PHYSICAL DISABILITIES

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1. Introduction

Improved medical care and increasing number of aged population in western countries resulted in rising of number of people with disabilities. This increasing number of people with limited functions has scientific consequences on research technology, especially the one related to textile industry in the areas with aged population. The aged population is more exposed to illnesses and the impact of various diseases, which can lead to severe disabilities for many years. There is thus a clear need for a functional approach to clothing by both users and textile manufactories.
Existing studies show that clothing for people with physical disabilities that can be found on the market, are unsatisfactory. In general, this clothing is unified, insufficiently distinguishing sex and individual cutting is not adjusted to users, resulting in standard clothing which makes people with physical disability feel that this particular clothing emphasizes their physical disadvantages even more Some textile manufacturers produce specially designed clothing for wheelchairs, but people with physical deformation of this category often are not standard size, so they need to invest a lot of money to purchase their clothing inadequately adjusted to their needs. The problems of constructing such clothing types are highly complex, and different needs should be noticed for each category of physical disability. In order to ensure adequate clothing functionality, it is necessary to have a systematic approach to the problem by examining the external elements, mechanical properties of woven fabric (shear and elasticity) and to find quality solutions in designing clothing with the emphasis on functionality, safety and comfort. Clothes for disabled people imply clothing and clothing systems designed to protect people from various dangers and impacts they are exposed to. Proper design of functional clothing items contributes to better protection and the feeling of safety on the part of the user and it can be achieved through individual access and tailored clothing.
For this purpose, it is important to compare and analyze the features of digitized human bodies as well as to find new computerised methods for better tailoring certain body shapes and more appropriate function of the clothing or clothing system.
Since woven fabrics made for people with special needs are exposed to physical deformation, it is of particular importance to foresee the behaviour of woven fabrics at certain positions of the body. Here are the examples of users of wheelchairs and persons who spend longer time in bed. Since they have a relatively low level of heat production, it is essential for them to have the properties of thermal comfort and the property of mechanical endurance of textile material used on certain parts of the clothing items during usage.
Shear determination is considered to be one of the most important mechanical properties of woven fabrics. Shear has a direct effect on woven fabric properties. Since woven fabric shows different physical properties in different directions during use i.e. an anisotropy characteristic, it is necessary to make testing procedures on shear in various directions. Testing will be done on cotton samples of different weft density and the same warp density. The samples will be fastened in two parallel tensile tester clamps. The experiment should result in the high degree of correlation between shear and fabric axial component. The results will be analysed on clothing for disabled people in daily life.

2. Methodology

Human body will be digitalized by a 3D scanner. Scanning will be performed in specific positions, depending on purpose of a functional clothing item and the level of physical disability. This method

will enable us to analyse maximum movements of body parts and their impact on cinematic chain of movements, which varies greatly In the case of disabled people in relation to healthy population.
Since physical disabilities and mobility of certain body parts affect directly the shape, adjustment and functionality of a clothing item, it is important to analyse individual body shapes and measures, which are the base for designing an individually adjusted clothing item. Conventional designing of disabled people clothing, for those who use wheelchairs due to their disability, is not properly adjusted for functional clothing item development. This work include investigation the way of cut shaping and clothing item itself, individualized and applicable for people with similar physical characteristics. The most appropriate mathematical model, used to design a women's clothing item, will be chosen by finding out correlation between the crucial correspondent points on the body and basic cut, as well as computer input data processing and explored functional features of the clothing item.
The impact of shear force in relation to shear angle will be taken into consideration, since there are special features of designing cut for disabled people, where cutting parts are differently directed in relation to warp direction.
The data based on an initial elasticity modulus and initial shear modulus of woven fabric in designing a clothing item will contribute to better comfort and functionality of the clothing item in its specified field (elbow, knees or setting seam), which are crucial in terms of limited body mobility.

3. Research aim

The aim of this research is to find out correlation between similar body shapes with physical disabilities which will enable individual designing of clothing items.

Based on this correlation, the most appropriate computer method will be defined, which will offer an additional cutting adjustment related to the differences in measures, in order to increase a clothing item functional for the people with disabilities whose mobility is restricted to a wheelchair.

The results of each specimen, which will be cut in weft direction at the different angles and tested under specified temperature and dampness conditions, will be statistically analysed by Microsoft Excel software and the appropriate diagrams of the mean values of the breaking tensile force and breaking elongation. The results with 3D points obtained by digitalization human body will be inputs and used for functional item of clothing design and for the purposes mentioned above. A computer programme will be created to enable tailor adjustment.

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Željka Pavlović

Željka Pavlović was born on February 4th, 1987 in Zabok. She completed elementary school in Samobor, enrolled in high school "Economic, Trade and Catering School" and graduated from it in 2005. From 2005 until 2012, she enrolled at the University of Zagreb Faculty of Textile Technology and graduated with the theme "Service properties of short socks", under the mentorship of Prof. Zlatko Vrljičak, PhD. After completing her studies, she was employed at the hosiery factory Jadran, where she worked for 3.5 years as a technologist. In 2015, she was employed at the Faculty of Textile Technology as an assistant, in the Department of textile design and management. In 2016 she enrolled on a PhD study "Textile Science and Technology" at the Faculty of Textile Technology. Her areas of special interest are engineering design and socks manufacturing, as well as knitting machine analysis.

Proposed title of dissertation topic	Elastic yarn and structure impact on elasticity of hosiery
Study advisor	Prof. Zlatko Vrljičak, PhD
Date or dissertation topic defence	

ELASTIC YARN AND STRUCTURE IMPACT ON ELASTICITY OF HOSIERY

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1. Introduction

Elastic fibres are highly stretchy artificial fibres, with high elastic recovery capabilities after stretching. Their presence in the mix with other fibres provides the clothing with elasticity and comfort in wearing. Special compression effects are achieved by a higher proportion of elastic yarns in textile products for special purposes [1]. For making fine female hosiery, combinations of polyamide (PA), polyester (PES) and elastic (EL) filament threads are most commonly used. The elastic thread may, in addition to the PA multifilament thread, be knitted in each row or into individual rows, or be knitted in only certain parts of socks [2]. Core-sheath composite elastomeric yarns are the key elements to ensure fabrics with medical compression function, which are commonly constructed by wrapping natural or synthetic filament fibres (e.g. cotton, polyamide, polyester, viscose, polypropylene) around a stretchable core such as latex or polyurethane (PU) [3].

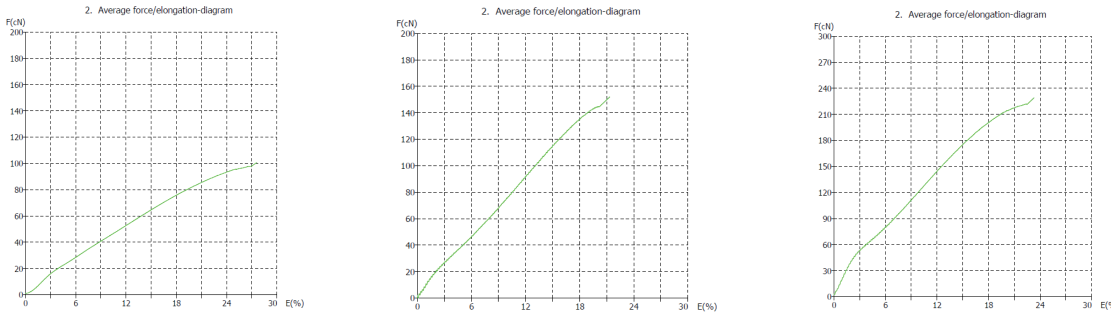
2. Experimental

The purpose of this experiment was to find out how many polyamides, and how much elastic yarns were knitted in a row of the knitted fabric. The knitting machine for hosiery with a diameter of needle bed 4e'' and 400 needles with 4 yarn feeders was used. The samples were made in plain structure, with polyamide multifilament yarn with a yarn count of 60 dtex f60, and were plaited in each row with elastic yarn with a yarn count of 22/17 dtex f7. The loop length was of the commonly known parameter describing the structure of knitted fabrics [5]. In a compact knitted structures made with fine multifilament yarns, it was not easy to determine the length of the yarn forming the loop, because those yarns were difficult to pull out [6]. In this experiment, the preload for measuring the length of PA multifilament yarn with a yarn count of 60 dtex f60 was 3 g or 0.5 cN/tex. One end of the yarn was fixed in the upper clamp, while the other end was loaded with the load of 3 g. For the elastic yarn, preload was not easy to determine because it was a wrapped elastane yarn made of elastane thread with the yarn count of 22 dtex wrapped around with a PA multifilament yarn made up of 7 threads of total yarn count of 17 dtex. For this reason, the length of elastane yarn was measured with three different loads. The first measurement was performed without a load, where the elastic yarn was fixed to the upper clamp, and the other end was free. The second measurement was made with the load of 1 g. The third measurement was made with the load of 2 g.

3. Results and Discussion

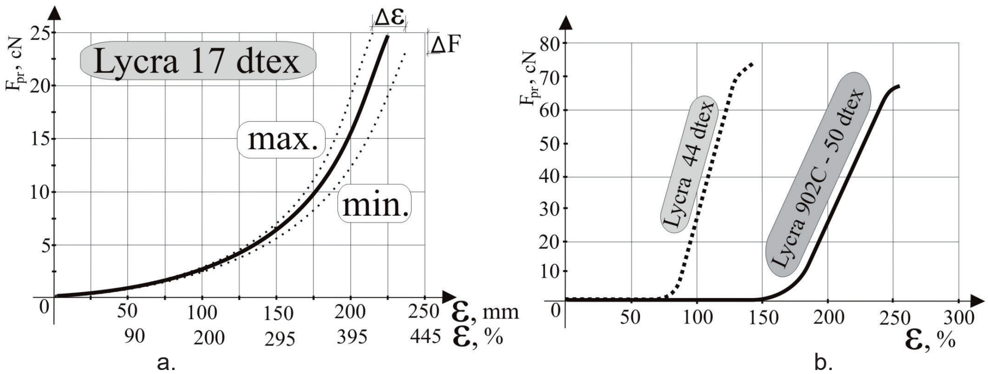
The length of the polyamide multifilament yarn measured with the load of 3 g was from 875 to 910 mm in one row. The length of the elastane yarn measured without a load was from 205 to 240 mm. The elastane yarn measured with the small load of 1 g was from 455 to 480 mm long. The length of the elastane yarn measured with the load of 2 g was from 610 to 645 mm.

Figure 1 shows tensile properties of PA multifilament yarns with different yarn count, used in making ladies' hosiery. Yarn of the smallest yarn count (Fig 1a) had the breaking force of 100 cN and elongation at break of 28%. The second yarn (Fig 1b) had the breaking force of 153 cN and elongation at break of 22%. The yarn with the highest yarn count (Fig 1c) had the breaking force of 230 cN and elongation at break of 23%.



a. b. c.

Figure 1 Strain diagrams of PA multifilament yarns of yarn count: a) 20 dtex f 20, b) 40 dtex f40 and c) 60 dtex f60



a. b.

Figure 2 Tensile properties of elastane yarns of different yarn count use in making fine ladies' hosiery: a) Lycra 17 dtex, F_{pr} = 25 cN, ε = 424%, b) Lycra 44 dtex, F_{pr} = 73 cN, ε = 148% and Lycra 902C, 50 dtex, F_{pr} = 64 cN, ε = 261%

4. Conclusion

When determining the fineness of polyamide and elastane multifilament yarns intended for the production of fine ladies' hosiery, special attention should be paid to preloading and to determine the optimum preloading for the selection of individual yarn count.

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Marijana Pavunc Samaržija

Biography

Marijana Pavunc Samaržija was born in Zagreb. In 2012 she completed graduate studies of Textile Technology and Engineering (branch Textile Chemistry, Materials and Ecology) at the University of Zagreb Faculty of Textile Technology. Since May 2013, she has been working at the University of Zagreb Faculty of Textile Technology (Department of Materials, Fibres and Textile Testing) as an assistant. Since the beginning of her scientific career her research interests has been directed to textile fibres, conservation and restoration of textiles and recycling of textile materials. As a researcher, she participated in the research project of the Croatian Science Foundation IP-2013-11-9967 *Advanced textile materials by targeted surface modification* within which she was engaged with the issue of recycling and sustainable management of textile waste as well as Life Cycle Assessment (LCA) analysis.

Title of dissertation topic

Study advisor — Prof. Edita Vujasinović, PhD

Date or dissertation topic defense

LIFE CYCLE ASSESSMENT OF FIBRE REINFORCED COMPOSITES

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1. Introduction

Although composite materials are known since prehistoric times, their full potential was achieved in the 21st century, regardless of whether it is a fibre reinforced composite with metal, ceramic or polymeric matrices. Their accelerated development is primarily due to the desire to create new engineered materials with targeted properties and thereby meet the increasing demands placed on materials used in various industries (such as construction industry, automotive industry, aerospace industry etc.).

However, despite their many advantages, numerous environmental and economic problems are related to fibre reinforced composites, especially those associated with their disposal. Namely, due to their heterogeneity, they represent extremely problematic materials for disposal, especially for recycling because separation of fibres from the matrix is very difficult and requires complex thermo-chemical processes, which are, in most cases, economically unsustainable. Therefore, at the end of their life cycle they are often incinerated or disposed in landfill, which is environmentally unacceptable, since most of commercially available fibre reinforced composites are made of synthetic materials that are extremely resistant to various environmental impacts. On the other hand, in this way the valuable raw materials is also lost because fibre reinforced composites are very often composed of high performance fibres (like aramid and carbon fibres) which are produced from petroleum, the sources of which are not endless. So today, due to the desire to protect the environment, and because of rigorous EU environmental protection directives, besides finding suitable methods for fibre reinforced composite recycling, research is increasingly directed towards the usage of environmentally friendly and sustainable raw materials for their production. Thereby, particular attention is focused on biocomposites i.e. composites based on biodegradable polymers (such as polylactide based biopolymers) reinforced with natural fibres especially cellulose fibres (such as flax, hemp, jute, kenaf, sisal etc.), which can be used in textiles as suitable substitute for artificial fibres, primarily due to their good mechanical properties, low price, renewability and biodegradability [1-3]. One of the industries that dedicate great efforts in the development of such composite materials is automotive industry [4]. The reason for that is the European Directive 2000/53/EC, the purpose of which is to prevent waste generation from the end of life of vehicles as well as to reuse and increase waste vehicles recycling rate and that of their components [5].

Although biocomposites are considered to be environmentally acceptable and biodegradable materials, which are suitable for composting at the end of their life cycle, it should be noted that such materials ca not be easily called sustainable. According to literature [6], sustainable biocomposites should meet several criteria: they must be produced from renewable and/or recycled raw materials, all modifications and processes required for their production should be energy efficient, all stages of their life cycle must be environmental friendly and they must have appropriate waste management options. Furthermore, apart from biodegradation i.e. composting as one the possible ways of biocomposites disposal, it should be emphasized that finding appropriate ways of their recycling would make these materials even more interesting and environmentally acceptable.

2. Research goal and objectives

When developing any new product today, it is necessary to respect the principles of sustainable development and focus on environment protection. Therefore, it is necessary to explore all potentially negative impacts that product may have on the environment, starting from raw materials, through production, usage and finally to their disposal. For this purpose, LCT (Life Cycle Thinking) approach appears as a useful and unavoidable tool to see environmental performance/impact of a new product. Furthermore, increasing attention is also focused on the preservation of raw materials and on waste reduction. This indirectly requires that the development and design of any new product must take into account the possible ways of its recycling as well as the reuse of recycled materials i.e. product design must be in accordance with sustainable development, whereby LCA (Life Cycle Assessment) analysis of each new product is imposed as imperative.

Accordingly, the aim of this research is to carry out an LCA analysis of the newly produced biocomposites in order to gain insight into all potentially negative impacts of the product on the environment, especially taking into account the possibilities of its recycling (chemical, thermal, mechanical or biological). On the other hand, the aim is to define the most ecologically and economically efficient recycling process of natural fibre reinforced biocomposites.

3. Conclusion

At the early stage of the innovation process and designing new product, it is essential to incorporate the principles of green design as well as to take into account the environmental compliance of product. In this way, it is possible to reduce negative impact of the product on the environment, and therefore reduce the waste generation at the end of the product life cycle.

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Jelena Peran

Biography	Jelena Peran was born on May 14th, 1990 in Rijeka, Croatia. In 2009, she enrolled at the University of Zagreb, Faculty of Textile Technology, module Textile chemistry, materials and ecology. She received her Master's degree in 2014 defending the theme *Application of plasma for achievement of antibacterial properties of cellulose materials* (mentor Assist. Prof. S. Ercegović Ražić, PhD). During the period from 2015 until 2016, she worked on the project "*Development of qualifications standards and undergraduate study programs of Faculty of Textile Technology"* as a project administrator. She has been working on her PhD on doctoral the study Textile Science and Technology since 2015 and is currently working as an assistant at the University of Zagreb Faculty of Textile Technology, Department of materials, fibres and textile testing.
Title of dissertation topic	
Study advisor	Assist. Prof. Sanja Ercegović Ražić, PhD
Date or dissertation topic defense	

ANTIMICROBIAL EFFECTIVENESS OF TEXTILE MATERIALS

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1. Introduction

Natural and natural-based textile materials are particularly vulnerable to the attack of microorganisms due to their large surface area, moisture content and chemical composition, especially in humid and warm conditions. Carbohydrates in cellulose can serve as a source of food and energy for various microorganisms, and can be broken down through a process of enzymatic hydrolysis. Wool, silk and other protein fibres can also be enzymatically degraded by proteolytic enzymes (protease) and/or keratinolytic enzymes. On the other hand, synthetic fibres are resistant to microbial attack, and the process of degradation, and are long lasting. The presence of microorganisms on textiles, in particular pathogenic types of bacteria, represent a health hazard. Their presence can be indicated by the appearance of different stains, odours and deterioration in terms of degree of polymerisation, strength and rigidity [1,2]. Antimicrobial treatments of textiles are carried out in order to prevent this hazard through control and elimination of growth and reproduction of microorganisms. There is a number of requirements for antimicrobial finishing [3,4]: (i) efficiency against broad spectrum of microorganisms, but at the same time low toxicity to consumers and the environment; (ii) antimicrobial agents must not affect the natural flora of non-pathogenic bacteria that exist on human skin and represent a natural protection; (iii) durability under different conditions (wear, laundering, dry cleaning and hot pressing); (iv) compatibility with different chemical agents and textile processes; (v) they should have no influence on the quality and appearance of textile, (vi) resistance to sterilization conditions (medical textiles) and (vii) ease of use and cost effectiveness.
The aim of the dissertation is to achieve durable antimicrobial effectiveness of textile materials using different antimicrobial agents and techniques.

2. Antimicrobial Agents

Antimicrobial agents differ by mechanism of antimicrobial activity and degree of efficiency. They can act by contact (passive agents) where they inhibit microbes only in the case of direct contact, or by diffusion (active agents) where they diffuse from textiles into the environment to get in contact with the microbes [4,5]. Biostats are antimicrobial agents that inhibit the growth and reproduction of microorganisms, whereas biocides completely kill certain types of microbes. Known antimicrobial agents regularly used in textile industry include quaternary ammonium compounds, polybiguanides, triclosan, N-halamines, chitosan, nanoparticles of noble metals and metal oxides [6]. Due to their potential toxicity, questionable ecological acceptability or durability issues, the usage of some of these antimicrobial agents is limited. In previous paper [7] researches dealt with antimicrobial efficacy of cellulose based fabrics treated with silver nitrate solutions. In recent years, the application of natural, plant based products, such as black cumin seed oil (*Nigella sativa L*) and neem leaf oil (*Azadirachta indica*) as antimicrobial agent is being investigated [8]. These natural compounds have exhibited potential antimicrobial activity without harmful effects to the surrounding medium.

3. Antimicrobial treatments

Taking into consideration that antimicrobial agents are consumed when in contact with microorganisms, the durability of antimicrobial performance under different conditions of use represents a challenge.

In order to achieve antimicrobial effectiveness and improve durability, depending on the antimicrobial agent that is intended to be used and fibre type, different approaches have been developed. These can generally be divided into two groups: (i) inclusion of antimicrobial agent into polymer and (ii) grafting onto textile by surface coating techniques [9]. Antimicrobial agents can be incorporated into the fibre in chemical fibre formation stage by introducing agent into polymeric granules prior to the preparation of polymeric melt, or directly into polymeric melt or solution prior to spinning. The activity may be reduced due to restricted diffusion of the agent molecules through the polymeric matrix and the method is only applicable for synthetic fibres. Apart from conventional wet methods of coating (padding, bath immersion), which use large quantity of water, chemicals electrical energy and produce large volume of waste, new, eco-friendly techniques are being researched. These are microencapsulation, sol-gel coating, enzymatic surface modification and plasma technology. They could overcome the drawbacks of wet chemical finishing.

4. Conclusion

The primary function of textiles, which is to provide comfort of the consumers by protecting them from different climate conditions, has expanded. Clothing must perform multiple functions, from aesthetic to special functions such as injury and fire protection, therapeutic and rehabilitative function, odour control and microorganism protection. Although, a number of antimicrobial agents and techniques are currently being used, new challenges arise. Increasing microbial resistance to conventional antimicrobial agents, toxicity for human health and the environment, along with durability issues, need to be resolved. More efforts must be invested to research and develop more environmentally friendly techniques and antibacterial agents.

Acknowledgement

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Lela Pintarić

Biography

Lela Pintarić was born on March 1st,1991 in Koprivnica, Croatia. In 2015 she graduated from the university study program in Ecoengineering at the University of Zagreb on Faculty of Chemical Engineering and Technology. She was a Dean's Award winner for a remarkable student work in academic year 2014/2015. Since December of 2016 she has been enrolled on the postgraduate university study in Textile Science and Technology at the University of Zagreb Faculty of Textile Technology and she has been employed at the same institution as a research assistant on the project *Synthesis and targeted application of metal nanoparticles* (*STARS*) financed by Croatian Science Foundation. Research area of her interest is biocatalytic synthesis of nanoparticles. She has participated in a few scientific meetings and is a coauthor of two papers published in books of proceedings.

Title of dissertation topic

Study advisor — Assist. Prof. Iva Rezić, PhD, PhD

Date of dissertation topic defence

SYNTHESIS AND TARGETED APPLICATION OF METAL NANOPARTICLES IN TEXTILES

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1. Introduction

Strong development of nanotechnology has revolutionized the application of nanoparticles in various fields, together with textile and packaging industry [1]. Enhanced antibacterial activity, flame retardation, UV protection and superhydrophobicity are characteristics emphasized as the most important for the products of before mentioned industries, and they can be influenced by the application of metal nanoparticles [2]. The main constraint on the application of metal nanoparticles is the usage of toxic chemicals for their synthesis, which is why more attention is devoted to find more appropriate synthesis methods. Therefore, biocatalytic synthesis has an important role as an ecologically, energetically and economically acceptable method of metallic nanoparticle synthesis [3].

Research presented here is a part of the *Synthesis and targeted application of metal nanoparticles* project (*STARS*), whose objectives are the application and characterization of enzymes for the synthesis of nanoparticles, the development of an environmental friendly metal nanoparticles synthesis, monitoring of reactions and the detection of new mechanisms, characterization of the synthesized nanoparticles and the development and testing of new functional polymeric materials with thin layer of nanoparticles for targeted application in protective polymer materials [4]. This abstract represents a short review of the results obtained so far – results of testing the biocatalytic synthesis of calcium carbonate ($CaCO_3$) nanoparticles and results of optimization of the biocatalytic synthesis of zinc oxide (ZnO) nanoparticles with the enzyme urease.

2. Experimental

The process of biocatalytic synthesis of $CaCO_3$ nanoparticles from urea and calcium chloride ($CaCl_2$) with enzyme urease was investigated by determining the kinetics of the enzyme and the influence of calcium ions on the enzyme kinetics in three different reaction media (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid (HEPES) and triethanolamine buffer (TEA) and water) at the temperatures of 30 °C and 40 °C. Reactions were carried out in batch reactors with constant mixing in orbital shaker incubator (*MRC*). Concentration of urea and ammonia (as a product of a urea hydrolysis) were observed during the reaction chromatographically and spectrographically, respectively. According to the results obtained, mathematical model of the process was developed and validated by conducting the biocatalytic synthesis of $CaCO_3$ nanoparticles under exact reaction conditions. Synthesized $CaCO_3$ nanoparticles were analyzed by X-ray diffractometer.

Biocatalytic synthesis of ZnO nanoparticles was optimized by conducting 25 experiments designed by the *design of experiments method* (DoE). This method is a statistical tool that helps in planning, designing and analyzing key experiments as well as in modeling the connection between parameters that affect the process by conducting minimal number of experiments. DoE method allows us to define optimal parameter values, i.e. values of the parameters that will give the best or desired characteristics of the studied process [5]. In this study, the influence of four significant parameteres for the process (T, rpm, c_{urea}, $c_{Zn(NO3)2}$) with a constant concentration of the enzyme urease was tested. Synthesized ZnO nanoparticles were analyzed by NTA method (*Nanoparticle Tracking Analysis*) to determine their size.

3. Results and Discussion

Based on the results of the enzyme urease kinetics in the reaction of the biocatalytic synthesis of $CaCO_3$ nanoparticles was tested. Parameters of the Michaelis-Menten's kinetics, maximum reaction velocity (V_m) and Michaelis-Menten constant (K_m^S), were estimated. It was evident that the enzyme activity (V_m) increased with the increase of temperature in the HEPES and TEA buffer, while it was equal in the reactions carried out in water at both temperatures. The special feature of the enzyme urease (K_m^S) was higher in the reactions carried out at higher temperature in TEA buffer and water, while it was reversed in the reactions carried out in HEPES buffer. Calcium ions inhibit the enzyme urease, but according to estimated inhibition constants (K_i) the inhibition was not significant [4]. Based on diffractograms obtained from X-ray diffraction analysis it could be seen that calcite, as the first observed crystalline modification of $CaCO_3$, was present in all samples, vaterite was present in small amounts in the samples synthesized in water while aragonite was not present in any of the samples [4]. Statistical program Design-Expert® was used to interpret the results obtained by the NTA analysis of synthesized ZnO nanoparticles. The model that described the dependence of the result on process parameters was obtained (Eq.1). The model could also be used to predict the size of nanoparticles or their concentration synthesized under particular parameters.

$$ZnO\ size = 188{,}44 + 27{,}89 \cdot c_{urea} - 2{,}64 \cdot c_{Zn(NO_3)_2} + 0{,}407 \cdot T - 0{,}13 \cdot rpm + 0{,}92 \cdot c_{urea} \cdot c_{Zn(NO_3)_2} - 0{,}57 \cdot c_{urea} \cdot T - 0{,}041 \cdot c_{urea} \cdot rpm - 0{,}17 \cdot c_{Zn(NO_3)_2} \cdot T - 0{,}019 \cdot c_{Zn(NO_3)_2} \cdot rpm + 0{,}0109 \cdot T \cdot rpm \quad (1)$$

4. Conclusion

Based on the results presented, it can be seen that the usage of statistical tools during the biocatalytic nanoparticle synthesis experiments can obtain valuable information that could be helpful in planning and conducting future experiments. Moreover, lower initial concentrations of urea, higher initial concentration of $Zn(NO_3)_2$ and higher temperatures with lower mixing or lower temperatures with higher mixing are suitable for the synthesis of minimal sized ZnO nanoparticles.

Acknowledgment

This doctoral thesis is financed and supported by Croatian Science Foundation projects: 1) *Synthesis and targeted application of metal nanoparticles* (*STARS*) project UIP-2014-09-1534, and 2) *Young researchers' career development project – Training of new doctoral students,* both lead by Ass. Prof. Iva Rezić, PhD.

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Kristina Šimić

Biography

Kristina Šimić was born on July 13th 1984 in Metković, living in Zagreb on the address Prevoj 91.

Academic education

2002 - 2005 University of Dubrovnik, Aquaculture Study
2004 - 2009 University of Zagreb Faculty of Textile Technology (FTT)

Employment and titles

2012 - today Researcher/Assistant at Faculty of Textile Technology
2011 - 2012 Visual merchandiser in Diadema
2010 - 2011 Department manager in Zara
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Acknowledgments and rewards

University of Dubrovnik 2004. Rector\'s Award for best achievement in the academic year 2003/2004
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Title of dissertation topic

Analysis of metal threads in the historical Croatian textile from 17th to 20th century - metal content, composition and structure of the yarn

Mentors

Prof. emeritus Ivo Soljačić (FTT)

Prof. Tihana Petrović Leš, PhD (University of Zagreb Faculty of Humanities and Social Sciences)

Date or dissertation topic defense

June 14th, 2016

ANALYSIS OF METAL THREADS IN THE HISTORICAL CROATIAN TEXTILE FROM 17th TO 20th CENTURY

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1. Introduction

Textile is essential for everyday life in all societies, It is used in clothes for protection and warmth but also to indicate class and position, show wealth and social status. Threads from precious metals have also been used in combination with fibres for decoration in order to create luxury fabrics for secular and religious elites [1]. Analysis of these metal threads was performed with Scanning Electron Microscope with Energy Dispersive X-ray detector (SEM-EDX). The method was applied as the most suitable, determining the approximate amount of individual metals in the sample, while the investigations of cross-sections along with the surfaces was also performed [2]. This method was compared with two other methods X-Ray Fluorescence Spectroscopy (XRF) and Particle Induced X-Ray Spectroscopy (PIXE).

2. Experimental

Metal threads incorporated into textile yarns in Croatia on liturgical vestments and the festive folk costumes were investigated. Metal threads are used in two basic forms: as independent metal threads and yarns created from metal, or even two metal threads with a textile yarn. Combined textile metallic yarn is made of metal threads, or just one metal thread, spirally wrapped around the textile yarn that is thus situated in the center as the core of the yarn [1]. The measurements on these threads were performed using three techniques; SEM-EDX, XRF and PIXE. At the Faculty of Textile Technology, SEM-EDX analysis was performed on the device Tescan MIRA FE-SEM, operating voltage 20 kV and working distance 25mm. Bruker AXS, Quantax EDX detector type SDD (Silicon Drift Detector) that detects from boron (B) to uranium (U) [3]. XRF device Arttax, at the Croatian Conservation Institute, manufacturer Bruker, X-ray tube - the anode Rh, voltage 50 kV, intensity of 0.7 mA, a collimator X-ray beam of 0.6 mm, SDD detector XFLASH, Bruker, detection from K ($Z = 19$) to U ($Z = 92$). PIXE measurements were performed at the Ruđer Bošković Institute ion microprobe facility, which is described in detail elsewhere [4]. The 1 MV Tandetron accelerator provided 2 MeV proton beam which was focused by a triplet magnetic quadrupole lens system to a 2 μm spot size and raster scanned over selected sample areas. A rectangular or squared scan patterns were used of a different size (between 100x100 μm^2 and 1.3x1.3 mm^2) and a variable number of pixels (up to 128x128). PIXE spectra were collected using Si(Li) detector placed at 135° relative to the beam direction at the distance of approximately 2 cm from the target. The effective X-ray energy resolution was about 160 eV (for the Mn Kα line). Data were digitally recorded with the SPECTOR data acquisition software in a list file which can be replayed off-line. Afterwards, collected data were analyzed with the GUPIXWin software [5] in iterative matrix mode and using normalization to 100 w%.

3. Results and Discussion

Metal threads from the historical Croatian textiles were analysed qualitatively with XRF screening and quantitatively with SEM-EDX. High difference between XRF qualitative and EDX quantitative data, on some analysed samples, were observed. Because of these large deviations, samples were analysed by micro-PIXE device having a different depth of penetration 20 μm unlike XRF 100-200 μm and EDX1 μm. The results obtained with EDX and PIXE analysis were similar for homogeneous samples, while for gold gilded and silver gilded samples they were different, table 1. Due to less penetration depth EDX had a higher percentage of gold in gilded samples and silver in silver plated samples from PIXE. To prove that samples were gold or silver gilded we did EDX analysis of the cross section [6].

Table 1 Differences in PIXE, EDX and EDX cross section analysis

Sample	Method	Au (%)	Ag (%)	Cu (%)
Au gilded	PIXE	20.6	79.0	0.4
	EDX	86.9	12.9	0.2
	EDX cross section	0.3	99.6	0.1
Ag gilded	PIXE	0	19.5	80.5
	EDX	0	84.6	15.4
	EDX cross section	0	0.3	99.7

4. Conclusion

SEM-EDX and PIXE analysis showed similar quantitative results on homogeneous samples (alloys). In the case of gold gilded or silver gilded samples, SEM-EDX and PIXE showed very different quantitative results due to complex sample structure and geometry. Reliable analysis of gold gilded and silver gilded samples by SEM-EDX required measurements of cross sections as well. SEM-EDX method was the most suitable for metal content analysis of metal threads from historical textiles. The method was simple, reliable and reproducible. Analysis showed the main metals in the metal thread samples as well as the trace elements. Copper was found on metal threads in homogeneous samples, pure copper samples, silver gilded threads, also sample of gold gilded copper. Silver was the most widely used element found in homogeneous samples, gold gilded and silver gilded samples as well as pure silver samples. Gold was mostly found on gold gilded samples but homogeneous samples had very small concentration of gold. Analysis of metal threads gave us very valuable information about the old manufacturing techniques and about the appropriate treatment for cleaning and conservation.

Acknowledgment

Thanks to the Croatian Conservation Institute and the Ruđer Bošković Institute for the help with the analysis.

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Sandra Škaro

Biography	Sandra Škaro was born in Dubrovnik, Croatia in 1977. She received a diploma from the Faculty of Textile Technology in Zagreb, Design of Clothing and Textiles in 2006. She completed two study workshops at the University of Arts in London, Central Saint Martins, July 19th - August 6th, 2010. “Introduction To The History of Art Part 1 and Part 2”. Since January 2007 she has been working as a part-time associate in the area of design and costume design. Since September 10th 2012, she has been employed at the Faculty of Textile Technology as an assistant, teaching courses in the Costume department. She attended a workshop: “Studio Workshop - Costume Design: From Design to Drape”, May 3-17th, 2014, Metropolitan Museum, New York. “The Clothworkers” research center, December 2014, within the Victoria & Albert Museum, London.
Title of dissertation topic	Realization of The Women’s 18th Century Costume in Dubrovnik Republic out of the manuscript “Testamenta Notariae”
Study advisor	Prof. Darko Ujević, PhD
Date or dissertation topic defense	

REALIZATION OF THE WOMEN'S 18th CENTURY COSTUME IN DUBROVNIK REPUBLIC OUT OF THE MANUSCRIPT "TESTAMENTA NOTARIAE"

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1. Introduction

In this doctoral thesis the entire archival material "Testamenta notariae" - testaments of Dubrovnik Republic from 1282 to 1815 will be explored [1]. The document consists of a total of 92 volumes (18,400 testaments), written in Italian and Latin. The archives will be read in reverse, from a recent date to the older, for better understanding of the language and the manuscript of the notary. As an additional source of research, some parts of the archive material "Privata" [2] and "Diversa notariae" will also be used [3].

The mentioned manuscript legacy has not been systematically explored. The data of movable property in the form of textiles and clothing of the 18th century that we find will be processed. Clothing, jewelry and furniture occupy a high place on the scale of value and can be traced within a single family for over 200 years.

2. Experimental part

Types of women's clothing mentioned in the "Testaments" will be determined, with the aim to determine whether they were imported or made and dyed in the territory of the Dubrovnik Republic. Multiform of natural dyes, coloring and printing on linen, wool, silk and cotton will be described. The body measures found in the records of the archive material "Privata" will be analyzed, with the aim to investigate morphological characteristics of the population. Accurate and precisely defined body measurements are the basis for the beginning of design and manufacture of finished apparel [4]. By comparing the obtained historical data, the most detailed manuscript of women's clothing will be selected and accessed for its technical realization, with precise documentation of all stages of the production.

In this paper, one of the chapters will explore body sizing of the population of Dubrovnik Republic in the 18th century. Archive material "PRIVATA" 19/25 fol.41 is a diary of a tailor and will be used as a basis of the study. Reconstruction of the population morphological characteristics will be accessed from the tailors' measurements.

The investigation of dyeing and printing processes on textile with natural dyes will be performed. By mid 19th century the fabrics were only dyed with natural dyestuff, most often obtained from plants, insects or shells [5]. A map of colors and tones used in the18th century will be scientifically explored, based on the study of the history of natural dyes and rich records found in archival material "Testamenta notariae".

Construction of the 18th-century female dress and the appropriate technical methods will be studied in the next chapters. Construction of period costumes brings an understanding of the appropriate way of cutting textiles for a certain historical period, with all the eccentricity of the design, in order to obtain a suitable time silhouette [7].

For a thorough understanding of historical clothing, it is necessary to know the interior of the clothing item and to address the problem of the technical performance of all individual parts.

The history of cutting and making clothes in Dubrovnik Republic can be read from the manuscript legacy in the form of correspondence, court records, archive material, and few books. There are very few visual and material proofs, apart from a smaller number of costume pieces in Rector's Palace and some engravings, while 18th century copies are almost impossible to find.

French fashion and fabrics were imported to Dubrovnik for almost entire 18th century, especially in the latter half.

The main difference between the dressing style of Dubrovnik compared to that of France or England of the time was in simplicity, not exaggeration; the clothes were less complicated than those in Europe and more restrained.

Some engravings show the tailors taking measurements of garments, with diagrams pointing to the design. Garment items can be found in just a few books. Benoit Boullay "Le Tailleur Sincere" 1671, "L'Art du Tailleur" 1769 and "L'Art de la Lingere" 1771.

Francois Alexandre Garasualt was the author of the works Descriptions des artes et métiers: L'Arte du tailleur 1769 and L'Arte de lingerie 1771. Denis Diderot and Jean le Rond D'Alembert published Encyclopedie in 1776, which is a great source of descriptions of decorative arts and 18th century fashion, with a separate part dedicated to dressing, construction and cutting. It will serve as an important source of this dissertation as well.

3. Conclusion

The original scientific contribution is the reference database of the original manuscript heritage and the improvement of the methodology of the use of written documents for the technical purpose of recreating garments for museums and for all kinds of performing arts. It is also an extraordinary contribution to the preservation and promotion of our cultural heritage.

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Biography	2011 – 2017 – employment: assistant at the University of Zagreb Faculty of Textile Technology (UniZG FTT) 2016 – residency program at Cité Internationale Des Arts in Paris, France (2 months) 2016 – Erasmus + Program, 1 semester (5 months) at the Faculty of Textile, Leather and Industrial Management, “Gheorghe Asachi” Technical University of Iasi, Romania 2014 – today – doctoral study UniZG FTT 2013 – professional training - CFPIC Institute, Felgueiras, Portugal, within the Tied Shoe project (4 weeks) 2010 – 2013 – Academy of Fine Arts (ALU), visual arts university graduate study, teaching department, painting in the class of Prof. A. Rašić, master of arts 2009 – 2011 – UniZG FTT, university graduate study, TMD, costume design, master of textile and fashion design engineer 2007 – 2009 – ALU, teaching department, visual arts university undergraduate study, bachelor of arts 2009 – CEEPUS exchange, summer semester (3 months) at the Academy of Fine Arts and Design in Ljubljana, Slovenia 2005 – 2008 – Faculty of Kinesiology, Trainers’ department - Karate; advanced university student 2001 – 2006 – FTT, Textile design and clothing, higher fashion designer 1997 – 2001 – Private Classical Gymnasium
Title of dissertation topic	CAD modelling of footwear made from knitted fabrics in relation to foot anthropometrics and biomechanics
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CAD MODELLING OF FOOTWEAR MADE FROM KNITTED FABRICS IN RELATION TO FOOT ANTHROPOMETRICS AND BIOMECHANICS

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1. Introduction

Footwear, primarily made as a foot protection from weather conditions, has been developed for thousands of years as fashion accessory according to fashion trends in every historical period [1]. The conditions of modern living, if unfavourable (walking on flat ground, restriction of free movement, inadequate footwear) contributes to the weakness of the whole foot, and in particular the supportive muscles and muscles that maintain its structure. Legs are the most loaded part of the body; hiking, running or just maintaining balance with one or both feet on the ground are everyday, ordinary activities. Wearing a closed shoe with poor design, unadjusted to foot shape, and improper fit of the footwear, disregarding the structural and morphological foot function, can cause problems with normal feet due to biomechanical deviations, which can cumulatively change foot performance characteristics, with changes in loading from the back of the foot to fingers [2,3]. Apart from deformation in the foot area, footwear can also be a causal factor for foot injuries, but also the appearance of pain in the entire body, such as knee and back pain, caused by the change of human posture [4-6]. For the construction and manufacture of footwear, it is necessary to know the anatomical, anthropometric and biomechanical characteristics of the foot Footwear can be made of leather but as well of other materials such as textiles (woven, knitted, non-woven textiles). Textile for footwear can be used to fabricate the entire outer part of the upper, lining and interlining. The paper will examine the comfort and adaptability of footwear meaning fit, and the research will be focused on the analysis of knitted fabrics. Primarily, their application in the production of high heeled footwear will be researched, with the aim of improving comfort (primarily contact) in accordance with anthropometric foot measurements and gait biomechanics. The above-mentioned investigations will be carried out at precisely specified critical points on the foot when wearing high heel shoes.

2. Experimental

In the doctoral thesis, anthropometric measurements of the foot of female population will be measured using *3D Pedus Footwear Human Solutions GmbH foot scanner* and *INFOOT USB foot scanner*. Measurement of static and dynamic plantar pressure will be performed by *FOOTSCAN RSscan international measuring plate*. The data obtained will be processed, and a statistical analysis of all the data will be carried out. Anthropometric measurements and landmarks will be determined; a human gait cycle will be analyzed, as the purpose for analysis and determination of the necessary parameters to increase the comfort of high-heeled shoes. Testing of spacer knitted fabric will be conducted in order to define comfort properties; tensile tests – strength, elongation. Testing characteristics of knitted fabrics is necessary for the next part of model making, it is necessary in pattern making, to know how much the material extends and deforms as a pattern part. In *MindCAD 3D engineering and design for footwear 2015.V1* program a collection of three-dimensional shoe models with asymmetrical uppers will be created (shoes, boots and sandals) with three different heel heights (low heel (< 3 cm), middle heel (3 - 6 cm) and high heel (> 6 cm). Then, for all the models in the collection (total of 9 models), the 2D Master patterns will be created in *MindCAD 2D modelling for footwear 2015.V1.* At previously determined critical points on the foot, on certain pattern parts of computer-made models, spacer knitted fabric will be inserted in order to improve the contact fit of the high heeled shoes.

a. b. c.

Figure 1 An example of a three-dimensional high heeled shoe model in MindCAD 3D engineering and design for footwear 2015.V1 program (made at the Faculty of Textile, Leather and Industrial Management, "Gheorghe Asachi" Technical University of Iasi, under the supervision of Prof. A. Mihai, PhD, design: I. Topić): a) creating a 3D upper of shoe model, b) finished a 3D model of high heeled symmetrical shoe, c) making a Master pattern with all pattern parts in MindCAD 2D Footwear Model 2015.V1.

Using the method of Finite element analysis (FEA) for each model, there will be a gait simulation conducted and deformations will be displayed in specific places on shoe upper. There will be 18 simulations created by FEA method, 9 for shoes with spacer knitted fabrics placed on certain pattern parts, and 9 for the same models but made of leather, and the simulation results will be compared.

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Biography	Born on September 20th, 1983 in Varaždin, Croatia 2009 – graduated from the University of Zagreb, Faculty of Textile Technology, BSc Textile technology 2009 - 2013 - University of Zagreb Faculty of Textile Technology, associate/assistant on FP7-SME-2007-2-217809, SMILES: “Sustainable Measures for Industrial Laundry Expansion Strategies SMART LAUNDRY-2015” 2013 - 2013 - University of Zagreb Faculty of Textile Technology, associate at EUREKA project E! 5785 Flameblend “Improvement in the flame retardant properties of cotton and wool blends” 2013 - 2015 - Info Novitas Ltd., position Sales manager. 2015 - 2016 - University of Zagreb Faculty of Textile Technology, assistant, Department of Textile Chemistry and Ecology 2016 - Info Novitas Ltd., position Marketing director.
Title of dissertation topic	The impact of physico-chemical properties of anti-redeposition agents on the zeta potential of washed cotton materials
Mentor	Prof. Tanja Pušić, PhD
Date or dissertation topic defense	May 20th, 2016

THE IMPACT OF PHYSICO-CHEMICAL PROPERTIES OF ANTI-REDEPOSITION AGENTS ON THE ZETA POTENTIAL OF WASHED COTTON MATERIALS

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1. Introduction

Recently, environmentally-friendly low-temperature washing processes are being promoted in small bath ratio, which require high-performance chemical components and special polymers in detergents [1]. Carboxymethylcellulose is biodegradable and the rate of its degradation is inversely proportional to the degree of substitution (DS) [2]. For the first time it was introduced into the detergent composition in 1940 [3-5]. Special additives, carboxymethylcellulose (CMC) and carboxymethylated starch (CMS), for powder and liquid detergent formulations will be studied. Furthermore, inhibition of stains will be analyzed through the synergy of anti-redeposition agents and builders, measuring surface charge and whiteness degree of cellulosic materials after repeated washing cycles. The research will indicate how special polymers in detergent alter the surface charge of washed cotton material and prevent the redeposition of stains from the washing bath [6,7].

2. Experimental

A special anti redeposition agent added to the detergent formulation was CMC, Figure 1. Two types of CMC were used in the research, which differed by share in CMC and surface morphology. The impact on the surface was tested in washing standard cotton fabric at 40 °C in hard and distilled water.

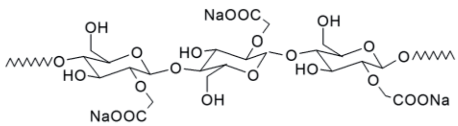


Figure 1 Representation of structural formulas carboxymethylcellulose

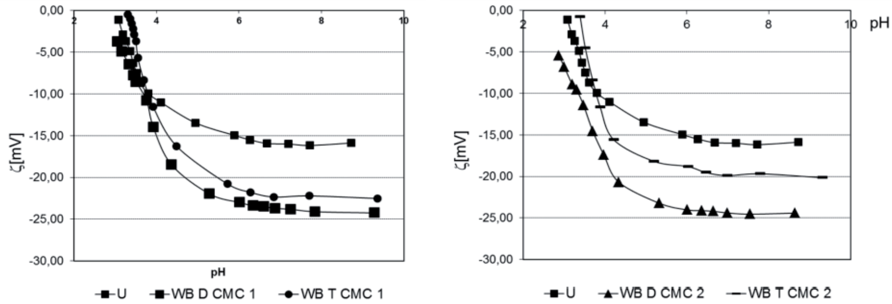
The degree of modification of cotton materials under defined washing conditions was objectively evaluated by the potential flow method on the electrokinetic analyzer, Anton Paar GmbH. The hydrodynamic flow of liquid caused re-distribution of the charge on the material surface, the flow potential was generated (Up), the surface was rough and the resistance within the measuring cell was measured, while the zeta potential was calculated according to expression 1 [8].

$$\zeta = \frac{dU}{dp} \cdot \frac{\eta}{\varepsilon_r \cdot \varepsilon_0} \cdot \frac{L}{A \cdot R} \qquad (1)$$

where are: ζ - electrokinetic or zeta potential (V), dU/dp - the slope of the flow potentials against the pressure (V Pa^{-1}), η - electrolytic viscosity (Pa s), ε_r - relative permittivity of the solution (no units), ε_0 - permissibility of the vacuum (8,854 10–12 m^{-1} Ω^{-1} s), L-capillary length flow (m), A- capillaries cross section (m^2) and R - resistance within the measuring cell (Ω).

3. Results and Discussion

The results show that the zeta potential of the cotton fabrics (U) is negative. Washing with CMC in distilled and hard water affects the surface charge of the material. The zeta potential of washed fabric in distilled water is more negative than for the fabric washed in hard water, which confirms the impact of water hardness on the surface charge of the material. Using two different types of graying inhibitors, CMC 1 with a 75% share, CMC and CMC 2 with a 100% share of CMC, has influenced the negative charge of the surface of the material. The Zeta potential of the cotton fabric washed with CMC 2 is -20 mV, while the one washed with CMC 1 exhibits -23 mV, Figure 2. Surface analysis on scanning electron microscope (SEM) has shown that CMC 1 sample has a porous and less compact structure than CMC 2, so it is expected that, despite the smaller CMC share, the CMC1 will be more rapidly adsorbed. This indicates the important influence of the morphology of the graying inhibitor on the surface charge of cotton materials in the washing process.



U – unwashed fabric
WB D – fabric washed in distilled water
WB T – fabric washed in hard water

a. b.

Figure 2 Zeta potential of the cotton material before and after washing: a) with the addition of CMC 1 in distilled and hard water, b) with the addition of CMC 2 in distilled and hard water

4. Conclusion

Carboxymethyl cellulose as an anti redeposition agent affects the increase in the negative charge of cotton fabric surface. Studies have shown that before using CMC in washing process it is necessary to establish morphological characterization of the particles using SEM in order to select a product that may have better adsorption potential, which further contributes to the reduction of surface charge with the aim of rejecting stains in the washing process.

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Tanja Vukelić

Biography

Tanja Vukelić was born in Ogulin. In 2014 she graduated from the University of Zagreb Faculty of Textile Technology and completed her bachelors study in Textile Technology and Engineering, and in 2016 she gained the title of Master of Engineering in Textile Technology and Engineering, defending her graduate thesis entitled „Amount of transferred fibers during physical attack depending on pretreatment of jeans“, made under the mentorship of Prof. Edita Vujasinović, Ph.D. Since 2016, she has been enrolled on the postgraduate university study Textile Science and Technology where she focuses her scientific interest in fiber structure, their properties and modifications, as well as on textile forensics. Since August 21st, 2017, she has been employed at the University of Zagreb Faculty of Textile Technology, as an assistant.

Title of dissertation topic

Study advisor: Prof. Edita Vujasinović, PhD

Date or dissertation topic defense

TEXTILES MODIFICATION WITH HUMIC SUBSTANCES AND THEIR ENVIRONMENTAL IMPACT

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1. Introduction

Almost daily, unconsciously using different products that make our modern life easier, each and every one of us leaves a permanent trace on the environment. The usage of environmentally stable synthetic polymers affects the quality of human life, which could represent enormous ecological problems in the future. This is why many researchers in the 21st century are focused on biodegradable polymers and their degradation potential at the end of their life cycle [1]. By modification/functionalization of textiles, it is possible to change their initial properties and thus achieve new, desirable properties in use. With this aim in mind, the possibility of biodegradable fibers (cellulose and protein origin) modification with humic substances (natural and synthetic origin) will be investigated.

Humic substances represent the active part of humus, and are formed by biological degradation of plant and animal materials in humid habitats such as peatlands. Humic substances are dark colored, acidic, mainly aromatic polymers with a high molecular weight. Considering the molecular weight, color, composition and solubility, they can be divided into three basic groups: humic acid (Fig 1.a), fulvic acid (Fig 1.b) and humin. Exceptional properties of humic substances enable their numerous practical applications in, for example, the development of absorbers and filters, agriculture, medicine and so on. According to literature, previous researches of the humic substances have indicated their antibacterial and antiviral properties [2-6].

a. b.

Figure 1 Humic substances: a) humic acid, b) fulvic acid

Having in mind that antibacterial/antiviral textiles are extremely important in manufacturing protective clothing that very often represent a danger for the environment if it is not properly disposed, the investigations whose goal is the modification/functionalization of textiles with humic substances with an emphasis on biodegradability, i.e. their environmental acceptability have been started. Preliminary research has shown that humic substances have potential application in functionalized textile structures. Thus, special attention should be dedicated to the methods of applying humic substances on textiles, as well as to the design of textile structures in accordance with eco design or environmental design principles, so that their life cycle could be consistent with sustainable development.

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Ivana Žanko

Biography	**Academic Education** 2009 graduated from the University of Ljubljana Faculty of Natural Sciences and Engineering in Ljubljana, University graduated engineer of textile and fashion design 2002 graduated at the University of Zagreb Faculty of Textile Technology (FTT) in Zagreb, Senior Fashion Designer **Employment History and Titles** 2010 Appointed Research Assistant, Scientific area of Technical Sciences, Scientific field of Textile Technology, Scientific branch of Textile and Clothing Design 2012 Appointed as Assistant, Scientific area of Technical Sciences, Scientific field of Textile Technology, Scientific branch of Textile and Clothing Design **Teaching Activity** Creative Patterning of Textile I, II, III, IV, V Creative Practicum I, II, III
Title of dissertation topic	Modification and adaptation of relevant factors in the dye / binder / fiber system in the inkjet technology of textile printing
Study advisors	Assoc. prof. Martinia Ira Glogar, PhD (FTT) Assist. prof. Igor Majnarić, PhD (University of Zagreb Faculty of Graphic technology)
Date or dissertation topic defense	

MODIFICATION AND ADAPTATION OF RELEVANT FACTORS IN THE DYE / BINDER / FIBER SYSTEM IN THE INKJET TECHNOLOGY OF TEXTILE PRINTING

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1. Introduction

Digital printing techniques are increasingly used in textile industry with the ability to respond rapidly to high market demands by the width of the range of tones, sample uniqueness, but also by water and energy saving requirements. However, because of the complex interaction of specific surface structural characteristics of textiles as a substrate, the requirements on composition and rheological properties of printing inks and the technology of forming droplets, there are still a number of issues to be solved [1-3].

Previous research has confirmed the unresolved issues in all the aspects of the use of inkjet technology in textile printing: the problem of influence of surface structural characteristics of textile material on the formation, discoloration and penetration of printing ink droplets, the characteristics of porosity of textile material, modification and color adaptation problems and the components of printing pastes for use in inkjet technology, as well as the technical requirements of inkjet printing devices that further complicate the optimization of printing colors [4,5]. Particularly high demands are placed on the characteristics of the binding agents, as key factors when applying pigment-based printing ink, such as particle size, surface tension, viscosity, stability, compatibility with printing ink components and printing flow technology [6,7].

Also, in research, according to the literature, the role of textile material surface structure has only recently been recognized as one of the fundamental factors of print quality and the achievement of an optimal color gamut [8, 9]. In general, optical characteristics of a textile surface can be defined as the sum of visually perceptual color attributes and surface structure, uniquely defined by the remissive spectrum of the textile sample. Understanding surface - spectral remission phenomena is an important factor in all the areas of application and color reproduction [2,8,10]. Therefore, the studies of the impact of surface structural characteristics of textile material on the formation, discoloration and penetration of printing ink droplets will contribute to understanding these fundamental mechanisms.

1.1 Objective of research and methodology

The objective of this paper is primarily to define the settings of fundamental understanding of the role of the dye particle size and other components of the printing ink in the flow and the formation of ink droplets, and to explore all the parameters of the interaction of a single drop of printing ink with textile backing as well as the role of this interaction in the formation of a complete multicolored print. Changes in appearance and color spectral characteristics of inkjet digital printing technology will be explored in the relation between geometric and optical characteristics of textiles. The research will be carried out on the fabrics produced from the same production series; identical warp and weft yarn of the raw material 100% cotton, in four different weaves and three different densities of warp and weft. The research begins with detailed characterization of textile samples and with defining the porosity factor respectively surface coverage factor, which includes making binary microscopic images of textile fabric samples, and defining the surface part of the fiber component and the surface part of the non-fiber component (the space between the warp and weft). The printing process will be realized employing a digital printing machine Azon Tex Pro, which uses water-based pigment printing ink.

A detailed study of Kubelka - Munk's theory, which is primarily set for the characterization of pigment

layers, will also be presented, as it allows the possibility to define absorption coefficient and dispersion of textile substrate and the pigment itself. Pigment dispersions are characterized by the property of the pigment itself to be able to absorb and disperse light. Therefore, for the characterization of the reflection from the surface on which such particles are present, it is necessary to define both absorption coefficient and pigment dispersion coefficient and the backing itself. SEM analysis of printed samples will also be used.
The structure of the backing has a great influence on the realization of the most subtle printing elements. In the picture there are the lines and raster dots (phototypical illustrations, texts with serifs and multi-tone illustrations). The success of their generation can be determined by the method of image analysis, using an optical microscope with increments of 10x to 200x. For such analysis, a Personal IAS system will be used to analyze inkjet prints. As different surface structure of the textile backing prevents printers to achieve identical color reproductions at all times, it will be necessary to make the characterization of the process prints using the colorimetric parameters whose function is to achieve optimum application of the liquid inkjet dye [11]. The color analysis in the paper is performed by the method of instrumental spectrophotometric measurement, and the results are expressed numerically, according to the CIE standard system for the display of objective values of spectral and coloristic characteristics of color. The objective is to present a summary analysis of the color appearance in the digital inkjet technology in relation to the characteristics of the printing ink, the characteristics of the textile backing, and the process of subsequent processing and fixing after printing.

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Franka Žuvela Bošnjak

Biography	Franka Zuvela Bosnjak was born on February 22nd, 1978 in Split. She earned her Bachelor of Engineering title in 2003, completing her course at the Faculty of Textile and Technology, Zagreb. In 1999 she was recognized as the best student and in 2000 she received Rectors award for her scientific work. After 13 years of work in the industry, she was accepted as an assistant at Faculty of Textile and Technology, with special interest in leather as a material and its usability and processing properties.
Title of dissertation topic	
Study advisor	Assist. prof. Sandra Flinčec Grgac, PhD
Date or dissertation topic defense	

MONITORING THERMAL DECOMPOSITION OF GOAT LEATHER WITH THE EMPHASIS ON ENVIROMENTAL IMPACT

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1. Introduction

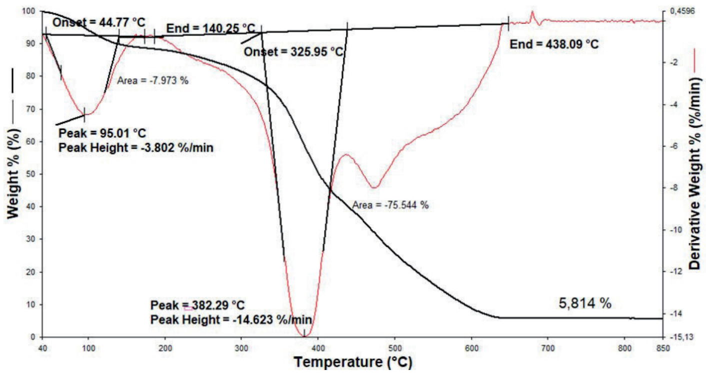
Collagen, as the main component of the leather, is largely responsible for its thermal stability, elasticity and mechanical properties. Collagen fibers make up 90% dry matter of raw leather, which is transformed into tanned leather using various processing methods [1,2]. In addition, leather production requires a number of operations, tanning playing the most important role in leather durability, stabilizing the triple helical structure of the collagen [3]. The agents used in leather production operations may have untoward environmental impacts during leather waste management. Thermal degradation of the leather results in loss of moisture and in collagen decomposition, releasing gaseous products the composition of which has serious effects on the environment and health, depending on the type of leather and the agents used in processing and finishing the leather [4].

2. Experimental

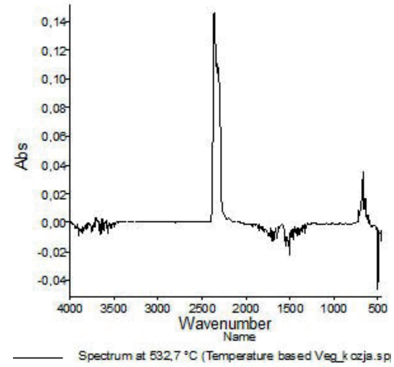
This paper describes thermal decomposition of two leather samples that differ in the applied processing and finishing agents. KK1 was a chevron sample of goat leather, vegetable tanned and Cr-retanned, black dyed with casein finishing. KK2 was velour sample of goat leather, vegetable tanned and Cr-retanned, brown dyed, without final finishing. Thermogravimetric (TG) analyses were performed on PerkinElmer TGA Pyris1. Subtracted samples of approximate 5mg weight were exposed to the analysis in the temperature range from 50 °C up to 850 °C, with the warming speed of 30 °C / min, employing continuous airflow. Samples were studied by combined TG-IR technique to follow and clarified thoroughly the decomposition process of differently processed goat skin samples. For the TG-IR analysis, a TAGS equipped with a detector was used. The transmission line, high-temperature transfer station and TG interface were heated at 280 °C during the measurement to prevent gas condensation. The peristaltic pump transmitted the generated gases at the flow rate of 60 ml / min.

3. Results and discussion

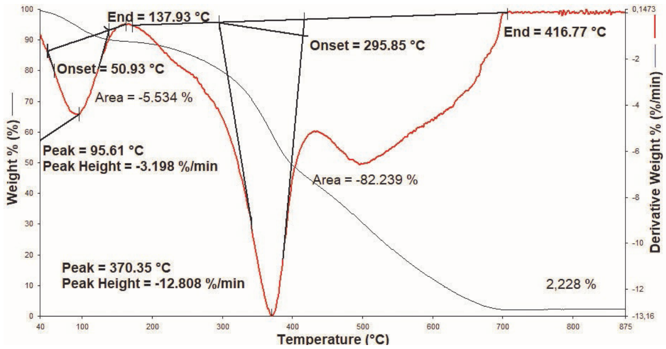
The results of the thermogravimetric analysis of the KK1 and KK2 samples (Fig 1 I and II) show that both samples were degraded in three degradation stages. The first derivation of the TG curve indicates that the degradation dynamics of both samples are very similar across all three stages. The highest dynamics of decomposition occurs in both samples in the second stage, but in the third stage greater difference is observed in the temperature at which the maximum degradation is measured. On KK1 (478.24 °C), it is significantly lower than that on KK2 (528.72 °C). The ending of the third stage degradation KK1 is at a lower temperature than the KK2 sample, which indicates slower degradation as well. The reason for this is the presence of casein on the surface and in the sample structure itself, as confirmed by FTIR-ATR analysis, the results of which will be presented in poster presentations. The thermal stability is also visible through the degradation residue of the KK1 sample at 850 °C (5,814%) and of KK2 (2,326%). It can be seen that the casein effects have impact leather material thermal stability, as well as the quantity and composition of the gaseous products (Fig 1 I_a. and II_a.). The KK1 sample at 532 °C exhibits a significantly smaller amount of recorded gases visible in the wavelength range 2359 and 2322 cm^{-1}, belonging to CO_2, and the wavelength of 2179 and 2110 cm^{-1}, which belongs to the CO in the to the KK2 sample. Gaseous product samples will be investigated in detail at lower thermal decomposition temperatures to analyze all gases for the purpose of environmental impact assessment.



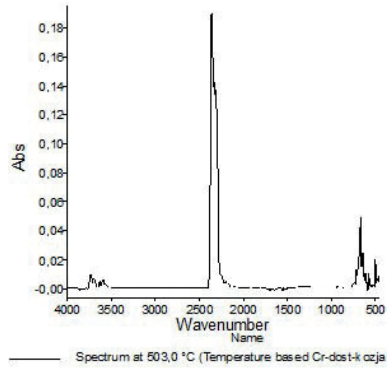
I



I_a.



II



II_a.

Figure 1 Thermogravimetric representation of the degradation of KK1 (I) and KK2 (II) samples, showing the gaseous degradation products recorded at maximum intensity I_a. and II_a.

4. Conclusion

Thermogravimetric analysis confirmed that the chevron KK1 sample with casein finishing had higher thermal stability and lower amount of released gases during decomposition, as compared to the velour KK2 sample. The property of increased thermal stability resulted from the chemical composition of casein, which contains phosphorus in the structure. Phosphorus compounds are known as good retardants of burning and thermal decompositions. Further research will explore the possibility of using environmentally more favorable processes of a leather tanning with the aim of reducing the environmental impact. These factors will be systematically investigated throughout the life cycle assessment of the product.

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Daniel Domović

Biography	Daniel Domovic was born on June 10th, 1987. in Zagreb, Croatia. He attended the V. Gymnasium in Zagreb, after which he enrolled in the Faculty of Electrical Engineering and Computing (FEEC), where he completed his undergraduate and graduate studies in Computer Science. Since 2012 he has been employed as a research fellow at the Faculty of Textile Technology (FTT) and in 2013 he enrolled in postgraduate doctoral study at FEEC.
Title of dissertation topic	Evolutionary Hyper-Heuristics for Solving Marker Making Problem
Mentors	Prof. Marin Golub, PhD (FEEC); Prof. Tomislav Rolich, PhD (FTT)
Date or dissertation topic defense	July 13th, 2017

EVOLUTIONARY HYPER-HEURISTICS FOR SOLVING MARKER MAKING PROBLEM

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1. Introduction

The progress of the textile and garment industry lies in investing in new technologies and products, specialization and export. The garment industry also has to adapt to new market demands to which the fast and high-quality production of individually tailored garments belongs. With this motivation, in this dissertation a segment of production optimization of a garment with the purpose of optimizing the consumption of material in marker making is dealt with. In the structure of the variable cost of a garment, the share of material costs is 60-70%, while the production share is 30-40%. Therefore, it is necessary to perform optimal fitting of cutting parts in order to make better use of the material in the technological phase. This reduces the cost of production and conveniently regulates waste disposal [1]. In computer science, this problem is a part of a wider set of problems commonly referred to as packing problems. Packing problem is such an optimization problem in which several smaller items must be placed within the boundaries of the container, without overlapping. Considering the packing problem applies to different industries, they are classified according to the current Wäscher taxonomy [2]. Packing problems can be successfully solved by applying evolutionary computation algorithms. An evolutionary algorithm provides good solutions to the packing problem in combination with local search algorithms.

2. Experimental

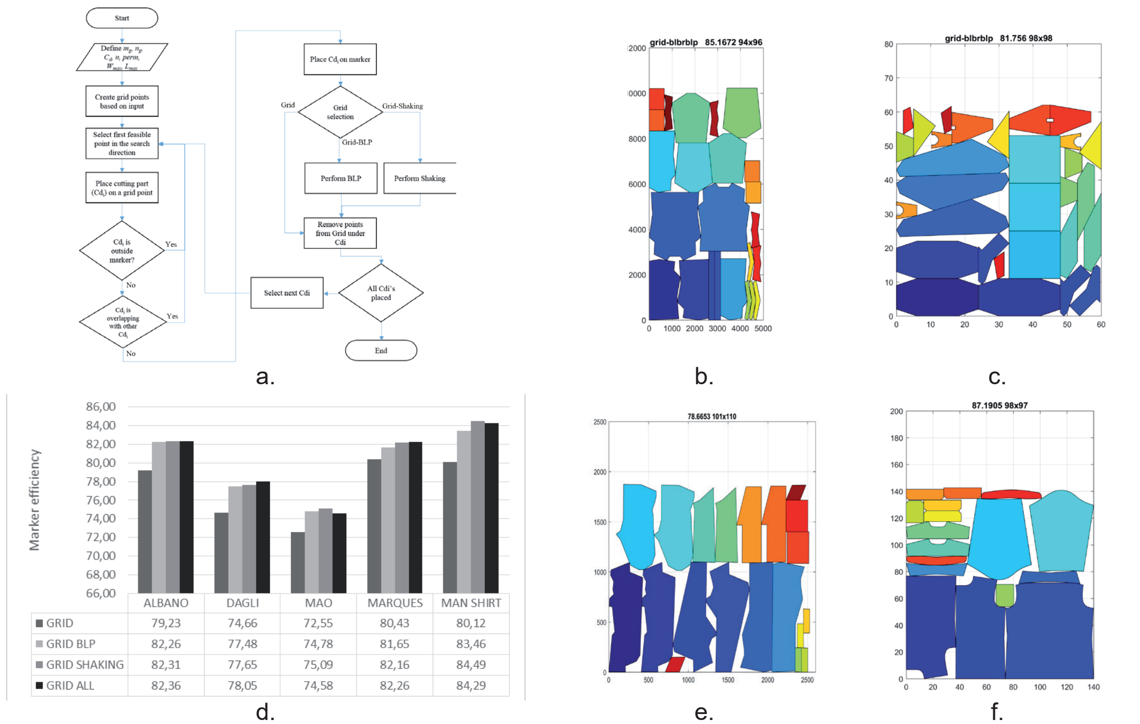
The aim of the research is to make a sufficiently general and customizable algorithm that could solve the problem of marker making with materials and cutting parts of arbitrary shape and with the ability to determine the area of material quality, enabling the algorithm to be applied to any set of input data. For this purpose, a Grid method has been introduced that can be applied to different types of problems and input data sets and also has the possibility to recognize damaged container parts (e.g. holes, fabric/leather damage, prohibited areas). Also, the execution of Grid method is independent of the form of the container.

Using Grid method the free space is discretized by a mesh of points. At each point of the mesh, the reference point of a cutting part is placed and the overlap with the previously placed cutting parts is examined. If there is no overlap, the cutting part will be placed in the selected position. As the aim is to achieve a dense marker, the application of several compaction methods: bottom-left (BLP) and a new Shaking method will be discussed in the dissertation, which allow filling the gap between the cutting parts [3].

The algorithms will be chosen by hyper-heuristics, which will allow the choice of the packing algorithm: Grid, Grid-BLP or Grid-Shaking for each individual in evolutionary algorithm [4]. It is assumed that the use of hyper-heuristics will additionally contribute to the quality of results because of the possibility of simultaneous access to the same set of problems with multiple algorithms and parameters. For this purpose, a new individual representation of evolutionary algorithm has been created that consists of four parts: (i) permutation determining the order of cutting parts placement, (ii) rotation of a cutting part at 0° or 180°, (iii) dynamic grid density, (iv) the choice of the heuristic method that will perform the packing for that particular individual (hyper-heuristic). In addition, the new AEF (*All Equal First*) sorting method is designed to distribute all identical cutting parts of a group on the material before continuing with the cutting parts of the next group. The advantage of this method is it significantly reduces the search space.

3. Results and Discussion

The experiments were carried out on benchmark datasets from the textile industry using the applications made in the MATLAB environment according to the pseudo code from Figure 1a. When implementing an evolutionary algorithm, the GEATbx toolbox was used, and different versions of the selection, crossover and mutation of the individuals were also used.



	ALBANO	DAGLI	MAO	MARQUES	MAN SHIRT
GRID	79,23	74,66	72,55	80,43	80,12
GRID BLP	82,26	77,48	74,78	81,65	83,46
GRID SHAKING	82,31	77,65	75,09	82,16	84,49
GRID ALL	82,36	78,05	74,58	82,26	84,29

Figure 1 Hyper-heuristics: a) algorithm pseudo code, b) ALBANO, c) DAGLI, d) experimental results and the best obtained results for datasets, e) MARQUES, f) MAN SHIRT

The results of the study are shown in Figure 1d. It can be seen that the hyper-heuristic approach offers the best solutions. Also, new heuristic approaches (Grid-BLP and Grid-Shaking) offer better results than the original Grid method.

4. Conclusion

Newly designed memetic algorithms can work with any input data set and achieve competitive results. The designed hyper-heuristics mostly chooses the most appropriate packing algorithm. With a new design of an individual, it is possible to optimize the parameters using the evolutionary algorithm.

Acknowledgment

I would like to thank my mentors Prof. Tomislav Rolich, PhD and Prof. Marin Golub, PhD for all the help in my research and preparation of the thesis.

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Robert Katava

Biography	Born in 1988 in Doboj in Bosnia and Herzegovina. Undergraduate study at University of Zagreb Faculty of Science, Chemistry, finished in 2011. Graduate Study in Chemistry, the research programme of inorganic/organic chemistry, completed in 2013 at the same Faculty. Diploma thesis in the field of catalysis and synthetic inorganic chemistry of molybdenum(IV) complexes is prepared under the supervision of Prof. M. Cindrić, PhD. Awarded by a medal of the Chemistry Department at the Faculty of Science for excellence. He spent six months in the Laboratory of coordination chemistry, University Paul Sabatier in Toulouse as Erasmus placement student. Since March 2014, employed at the University of Zagreb Faculty of Textile Technology, Department of Applied Chemistry. In October 2014, enrolled on the Doctoral study in Chemistry at the University of Zagreb Faculty of Science.
Title of dissertation topic	Vanadium complexes with 2-benzothiazolylhydrazone derivatives
Study advisor	Prof. Gordana Pavlović, PhD
Date or dissertation topic defense	-

VANADIUM COMPLEXES WITH 2-BENZOTHIAZOLYLHYDRAZONE DERIVATIVES

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1. Introduction

Vanadium is a transitional element ubiquitous in soil, water and crude oil, and is also found in traces in biological systems [1]. Vanadium complexes exhibit diverse pharmacological activity and have been proposed for the treatment of diabetes, cancer and parasitic diseases [2]. Antitumor properties of vanadium compounds are primary investigated on vanadocenes, oxovanadium(IV) and dioxovanadium(V) complexes [3]. Appropriate ligand systems improve stability and transport and can synergistically enhance the biological activity of vanadium complex compounds. Combining biologically active benzothiazole and hydrazone structural fragments creates 2-benzothiazolylhydrazone ligands with increased coordination capabilities and potentially enhanced biological activity [4,5]. A survey of literature revealed a few similar ligand systems, while structures of the vanadium complexes with such functionalized ligand system were not found. The main goals of the study are: to prepare vanadium complexes of targeted structure and properties by modeling the synthetic approach, to compare biological activity of 2-benzothiazolylhydrazones and their vanadium complexes, and to analyze supramolecular architecture of ligands and complexes and their influence on the properties of prepared compounds.

2. Experimental

2.1. Synthesis

The 2-benzothiazolylhydrazone ligands (Bzt−NH−N=C−Ar; Bzt = benzothiazolyl) was prepared by condensation reactions of 2-hydrazinobenzothiazole with derivatives of benzaldehyde, naphthaldehyde, pyridinecarboxyaldehyde and quinolinecarboxyaldehyde. In the synthesis of complex compounds, the effects of the following parameters on the structure and properties were evaluated: the type of the starting vanadium salt ($[VO(acac)_2]$, $VOSO_4$, $NaVO_3$), temperature and pressure, stoichiometric ratios of reactants and addition of a base.

2.2. Identification of prepared compounds and determination of molecular and crystal structure

Prepared ligands and vanadium complexes were identified by the following experimental techniques: IR, TGA/DSC, PXRD, NMR and elemental analysis. The molecular and crystal structure of prepared compounds were determined by a single crystal X-ray diffraction.

2.3. Biological assays

The biological activity of the prepared compounds will be examined in cooperation with other institutions. Primarily, the antiproliferative effect of the prepared compounds on human tumor cells and healthy fibroblasts will be investigated in order to find suitable compounds for potential clinical trials.

3. Results and Discussion

Fifteen 2-benzothiazolylhydrazone ligands were prepared and functionalized by: hydroxy group at different sites in the phenyl fragment (L^1-L^6), methoxy group at various positions in the naphthyl fragment (L^7-L^9), various pyridine moieties (L^{10}-L^{12}) and various quinoline moieties (L^{13}-L^{15}). The imine tautomeric form of ligands L^1 and L^4 and the amino tautomeric form of L^2, L^4, L^7-L^{14} were confirmed by a single crystal X-ray diffraction. Ligand L^{13} is a (*Z*) - geometric isomer relative to the C = N *exo* bond, and the other ligands are (*E*) - isomers. The most common supramolecular motif found in ligands was centrosimetric $R_2^2(8)$ dimer formed by $N_{hydrazino}$-H ⋯ $N_{thiazolyl}$ intermolecular hydrogen bonds.

The reaction of $[V^{IV}O(acac)_2]$ with $H_2L^{1,3-6}$ and $HL^{10,13}$ in alcohol solutions in a stoichiometric ratio of 1: 1 resulted in seven complexes of general formula $[VO_2HL^{1,3-6}]$ or $[VO_2L^{10,13}]$. The reaction of $[V^{IV}O(acac)_2]$ with $H_2L^{1,4,6}$ in ethanol solutions with equimolar Et_3N resulted in three $Et_3NH^+[V^VO_2L]^-$ complexes. Geometry around the vanadium center is deformed square pyramidal, and the VO_2^+ moiety was coordinated with deprotonated O, N, N tridentate ligands.

The antiproliferative effect was tested on ligands L^1-L^9. These compounds showed a strong antiproliferative effect on tumor cells at micromolar concentrations.

4. Conclusion

Condensation reactions of 2-hydrazinobenzothiazole with selected aromatic aldehydes afforded fifteen 2-benzothiazolylhydrazone ligands. Antitumor properties were tested on ligands L^1-L^9 which showed strong antiproliferative effect on all tested tumor cells at micromolar concentrations. Reactions of $[VO(acac)_2]$ with 2-benzthiazolyhidrazones afforded potentially biologically active dioxovanadium(V) complexes whose antitumor activity is going to be investigated.

Acknowledgment

I would like to thank Krešimir Molčanov, PhD for collecting data obtained by the single crystal X-ray diffraction on ligands L^7 and L^9.

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Petra Krpan

Biography	Petra Krpan was born in Zagreb in 1985. She has completed her education at the University of Zagreb Faculty of Textile Technology (FTT) in the field of Fashion Theory. She also studied Fashion Journalism at the University of London, London College of Fashion and has attended many conferences and symposiums abroad and in Croatia. She currently works as an assistant at the University of Zagreb Faculty of Textile Technology where she teaches: Fashion Theory, Sociology of Fashion, New Media and Fashion, Fashion Performance. She is also finishing her PhD at the University of Zagreb Faculty of Humanities and Social Sciences.
Title of dissertation topic	Contemporary fashion as an event: the new media and body transformation
Mentors	Prof. Žarko Paić, PhD (FTT); Academician Boris Senker (University of Zagreb Faculty of Humanities and Social Sciences)
Date or dissertation topic defense	July 5th, 2017

CONTEMPORARY FASHION AS AN EVENT-THE NEW MEDIA AND BODY TRANSFORMATION

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1. Introduction

In my PhD dissertation Contemporary fashion as an event: the new media and body transformation I will try to establish the necessary interdisciplinary relationship between the field and the notion of contemporary fashion that emerges after the 1980s, new media as new opportunities for the development of the fashion process and events and their significant influence on the understanding of fashion and the articulation of the interdisciplinary fashion studies. In the research and scientific sense this dissertation will develop the thesis that contemporary fashion cannot exist without the influence of the media on the body and the fashion object. At the same time it 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 performative sense as the fashion-body.

2. Experimental part

The work will also show the possibilities of constant transformations of contemporary fashion in the way of representing the body in fashion through the altered role of new media and performing arts. Contemporary fashion appears as the reinterpretation and re-performance of the event in all its most noted actualizations. The body in fashion is nowadays in the centre of the performing action because fashion, especially after the 1990s, represents the intersection of various new media and performative forms. Unlike the traditional approach to fashion as an indicator of social change in contemporary society, this approach deconstructs not only the society, but also the modern understanding of culture. It seems necessary to follow the path of understanding the culture that unites the concepts of identity, communication and the emergent network. Contemporary fashion in analogy with conceptual and performative art at the end of 20^{th} century is determined by corporeality in all its aspects of appearing. Body, however, cannot be understood just as a function or a structure of an immediate human action in a pre-set world anymore, but more as an autonomous event in a network of an image representation. Thus, fashion refers to the visual construction of the body as an event and in this way shows an irreducible lifestyle phenomenon in the spectacle of today's society.

3. Results

Why the media nowadays combine the terms fashion and body into the fashion body? Identification of the fashion language as well as the sign system of fashion is of great importance in the field of research, as we explore the attempt to create a new identity construction, gender/sex problems within fashion, as well as the transition from class-social model to visual semiotics in the postmodern theories of fashion. For these reasons this dissertation will focus on the ambiguity of fashion: on the one hand fashion as visual semiotics, and on the other fashion as the body in the process. Fashion in semiotics appears as a text whose layers have different levels of meaning while in performing in the virtual world fashion appears as the body in an event. Thereat, this epistemological difference suggests the intensified research of the relationship between the text and image, which afer Barthes became crucial since an image in the digital context cannot be decoded anymore simply by using the language as a universal signifier [1]. The event has become a crucial category of the new interpretations of contemporary fashion. It is therefore necessary to show how the semiotic model in the new media has moved from text to screen, from language to code, and how fashion is explored as the new possibility of a physical event in the fashion object.

4. Conclusion

The breakdown of social forms of fashion, the collapse of the concept of beauty and the body apocalypse are what determines modern fashion. Fashion now works in the Integral Reality of Baudrillard, but it is not possible to precisely determine its time [2]. Her linear movement in the history of fashion has made it easier for her research, but in modern fashion there is no real form or real time. The only thing that exists is the media time. The body of modern mode is only a consequence of the terror of history, invasion of new media and simulation, and ultimately the disappearance of the subject. It remains on speculation and simulation to decide if the body of modern mode is still a body or will be lost forever in the network space. The system openness, proposed by Lipovetsky, provides the possibility of complete transgression of the body [3]. The term media and mode is inseparable, and this is the intent of this dissertation: try to establish a whole between the notion of media and fashion in a new body event. Fashion becomes an open area in which we encounter multiplicity, all that Barthes, with whom he begins the theory of fashion, anticipated. This multiplicity is also present in performance or, more accurately, in the fashion event that separates it now from the concept of performance. It is a new original openness of the event, and thus a new possibility of recreating identity or more precisely: in mode now everything can be re-enactment.

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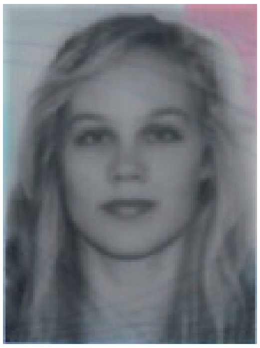

Lucija Ptiček

Biography

In the period from 2006 to 2011 she studied at the University of Zagreb the Faculty of Science, Department of Chemistry, where she earned her master's degree in chemistry. She was awarded the Medal for excellence in her studying by the Department of Chemistry. In 2011 she was employed in the position of Quality Control analyst by Pliva Hrvatska d.o.o. where she acquired valuable knowledge in analytical techniques and specific methods used to test pharmaceutical samples. In 2015 she was employed as a research and teaching assistant at the University of Zagreb Faculty of Textile Technology (FTT). In the same year, she enrolled on postgraduate studies at the Faculty of Science. She published 1 original scientific paper, participated in 4 scientific conferences, and acted as a principal investigator to 4 undergraduate students. Areas of her scientific interest are organic and medical chemistry.

Title of dissertation topic

Synthesis and biological activity of amidino-substituted benzoxa(thia)zoles

Study advisors

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Assoc. prof. Ines Primožić, PhD (University of Zagreb Faculty of Science)

Date or dissertation topic defense

SYNTHESIS AND BIOLOGICAL ACTIVITY OF AMIDINO-SUBSTITUTED BENZOXA(THIA)ZOLES

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1. Introduction

Amidino-substituted benzazole compounds show a wide spectrum of biological activity and are continually investigated by several research groups [1,2], but in contrast to a great number of biologically active amidino-substituted benzimidazole and benzothiazole derivatives, amidino-substituted benzoxazole derivatives are still rare. There are only a few reports on the synthesis of amidino-substituted benzoxazole derivatives, their antitumor [3] and antimicrobial activity [4], and their binding to DNA molecule [5]. The reason is the lack of general method for their preparation, which could be based on the condensation reaction of amidino-substituted 2-aminophenols, as key precursors not described in the literature, with carboxylic acids, carboxylic acid derivatives or aldehydes. The objective of this research is to find an efficient method for the preparation of novel amidino-substituted benzoxa(thia)zoles and to determine their antitumor activity, as well as to conduct a study of interactions with the DNA molecule in order to determine their possible mechanism of action. With the help of computational chemistry, we will attempt to predict the relationship between the chemical structure and antitumor properties of the prepared compounds in order to synthesize more active and selective compounds.

2. Experimental

Organic synthesis was carried out from commercially available chemicals and reagents with conventional organic solvents. The research involved multiple-stage synthesis of various amidino-substituted 2-aminophenols and 2-aminothiophenols as well as 2-aryl and 2-heteroaryl-substituted mono- and bis-benzoxa(thia)zolyl amidine derivatives. Resulting compounds were characterized by NMR spectroscopy and mass spectrometry. Elemental analysis of some compounds was also carried out, and molecular structures of some compounds were determined by the X-ray diffraction analysis.

3. Results and Discussion

2-aryl and 2-heteroaryl-substituted mono- and bis-benzoxa(thia)zolyl amidine derivatives were synthesized from previously prepared isomeric amidino-substituted 2-aminophenols (Fig 1) and 2-aminothiophenols by condensation reactions with commercially available aryl- and heteroaryl-aldehydes and carboxylic acids.

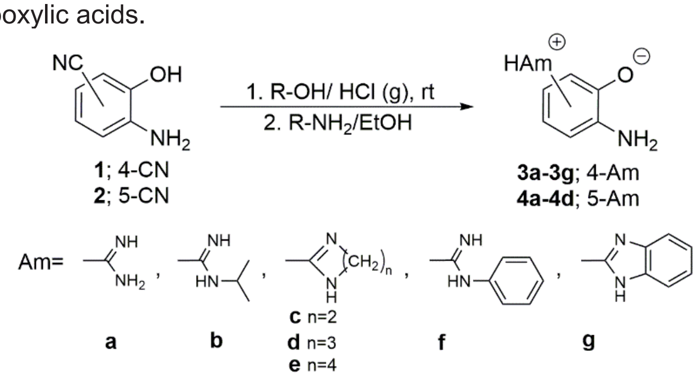

Figure 1 Isomeric amidino-substituted 2-aminophenols

Condensation reactions of 2-aminothiophenol derivatives with heteroaryl-aldehydes were optimized and two complementary methods of condensation were found in acetic acid and glycerol. Antitumor activity of mono-substituted aryl- and heteroaryl-derivatives of amidino-substituted benzothiazole was investigated and QSAR analysis determined the parameters that had greatest impact on antitumor activity.

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Marija Zorić

Biography

Marija Zorić was born on November 29th, 1987 in Zadar, Croatia. She attended primary school in Bibinje and high school ˝Gimnazija Vladimira Nazora˝ in Zadar. She graduated in physics, (research oriented study) at the University of Zagreb Faculty of Science, Department of Physics in 2012. Since May 2013 she has been working as an assistant at the University of Zagreb Faculty of Textile Technology. At the same time she joined the group of Ana Smontara, PhD, as a part-time collaborator of the Institute of Physics (IF). In 2013 she enrolled on the Postgraduate doctoral study program at the Faculty of Science, Department of Physics, and started her scientific career based on the project plan. Her scientific work results were presented at 6 international conferences (3 oral presentations and 5 posters) and 2 domestic conferences. She attended 2 international schools "C-MAC European School in Materials Science" with posters.

Title of dissertation topic

Thermoelectric and magnetotransport properties of single crystal SnSe

Study advisors

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THERMOELECTRIC AND MAGNETOTRANSPORT PROPERTIES OF SINGLE CRYSTAL SnSe

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1. Introduction

Thermoelectric materials as energy harvesters are a hot spot in research community due to their ability to directly convert waste heat into electrical energy. Improving the thermoelectric efficiency is one of the greatest challenges in materials science. It was recently reported that SnSe in single-crystalline form, exhibits high thermoelectric figure of merit (2.6 at 973 K), mainly due to its extremely low thermal conductivity [1]. As SnSe contains only earth abundant elements that are relatively low toxic, it is extremely attractive for potential large-scale applications. Although physical properties of SnSe above room temperature are well investigated, there are a few studies of low-temperature single-crystalline phase [2]. Motivated to determine the possible origins of these remarkable properties, we measured thermoelectric and magnetotransport properties of SnSe down to low temperatures.

2. Experimental

Measurements of transport coefficients (electrical resistivity, $\rho(T)$, thermopower, S(T) and thermal conductivity, $\kappa(T)$) were made using experimental devices developed in the Laboratory for the physics of transport properties, at the Institute of Physics. Detailed description of the principles and operation of certain measuring devices (electrical resistivity and thermopower measuring device, thermal conductivity measuring device) can be found in the literature [3]. Measurements of magnetoresistance and Hall's coefficient (Hall resistance, $\rho H(B,T)$) were made using the PPMS (Physical Property Measurement System).

3. Results and Discussion

Motivated by the extremely large thermoelectric potential of this system [1], and since the previously published transport properties of SnSe sample often showed contradictory behavior [2,4,5], we made a detailed characterization of the thermoelectric properties of the high-quality single crystal SnSe in the temperature range 1.5-300 K. Single crystals of SnSe were grown from a stoichiometric composition of tin and selenium in a closed silica ampoule using the vertical Bridgman method. Our values of the electrical resistivity and of the thermopower of a single-crystalline SnSe sample were in good agreement with the results of Zhao et al. [1], while the thermal conductivity of our crystal at room temperature was much higher than the extremely low thermal conductivity that they obtained, which directly reflected thermoelectric efficiency (Fig 1). It should be noted that there were several experimental studies [2,6] that also failed to reproduce the thermal conductivity of Zhao et al. [1] and hence no such high thermoelectric efficiency was achieved. Analyzing the results of electrical transport, we came to the conclusion that we had highly doped semiconductor with the charge carrier concentration of 2×10^{17} cm^{-3} and that thermal conductivity in this system reflected the phonon contribution while the electronic contribution could be neglected. The only difference so far observed among the samples was the density that was according to the authors [1] about 10% lower than the values obtained within this research and other experimental studies [6], as well as of the obtained theoretical values. The results of magnetoresistance and Hall coefficient measurements showed that majority charge carriers in our sample were holes, and that at low temperatures, where all acceptor levels were frozen, variable range hopping was a dominant channel of electricity flow. Possible ways of optimizing the low temperature thermoelectric efficiency were considered during the research.

SnSe undergoes a reversible phase transition at 750 K from low temperature Pnma to high temperature Cmcm phase. Bearing in mind that phase transition from Pnma to Cmcm phase is followed by macroscopic change of crystal dimension and that the high temperature phase shows a significantly higher thermoelectric efficiency [1], there are indications 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 [7].

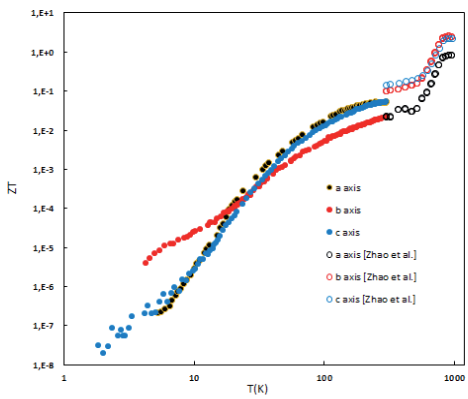

Figure 1 Thermoelectric efficiency (ZT) values of single SnSe crystals: measured values -full circles, data obtained from [1] -empty circles.

4. Conclusion

Thermal conductivity according to [1] does not reflect intrinsic properties of single crystalline SnSe phase, although electrical resistivity and thermopower do not indicate significant differences compared to measured values. Research is also being carried out in the direction of applying an alternative strategy to increase SnSe energy conversion efficiency by lowering the phase transitional temperature through the application of uniaxial pressure.

Acknowledgment

This work was made in the Laboratory for the physics of transport properties, Institute of Physics, under the supervision of Petar Popčević, PhD, and Ana Smontara, PhD. High-quality single crystals of SnSe were grown by the group of Prof. Peter Gille, PhD, from Ludwig-Maximilians–Universität in München. In collaboration with the group of Prof. Neven Barišić, PhD, from Technische Universität in Vienna we measured magnetoresistance and Hall coefficient.

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