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**27<sup>th</sup> CROATIAN MEETING  
OF CHEMISTS AND CHEMICAL ENGINEERS**

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**BOOK OF ABSTRACTS**

## **27<sup>th</sup> Croatian Meeting of Chemists and Chemical Engineers**

with international participation

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# **BOOK OF ABSTRACTS**

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## VENUE

Veli Lošinj, Vitality Hotel Punta, Croatia  
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**Zagreb, 2021.**

<b>Ivo Piantanida, Ksenija Božinović, Dragomira Majhen, Goutam Kumar Kole, Todd B. Marder, Marta Koščak</b> <i>2- and 2,7-substituted pyridine pyrenes derivatives and their DNA/RNA interactions .....</i>	85
<b>Magdalena Kralj, Sara Krivačić, Petar Kassal, Antonio Supina, Željka Boček, Ivan Halasz</b> <i>Avenue to facile medium-scale production of graphene quantum dots and graphene nanosheets.....</i>	86
<b>Ana Alebić-Juretić, Boris Mifka</b> <i>Airborne desert dust in the northern Adriatic area (Croatia): different sources .....</i>	87
<b>Sarah Mateša, Irena Ciglencečki</b> <i>Application of the electrochemical method for monitoring polysulfides (S<sub>x</sub>) in marine euxinic environment (Rogoznica lake, Croatia).....</i>	88
<b>Mario Špadina, Atiđa Selmani, Bertrand Siboulet, Davor Kovačević, Goran Dražić, Jean-Francois Dufreche, Klemen Bohinc</b> <i>Revising solute adsorption models in the case of loose TiO<sub>2</sub> nanotubes surfaces.....</i>	89
<b>Iva Rezić</b> <i>Investigation of allergenic metals on fashion accessories and decorative metallized yarns .....</i>	91
<b>Luka Pavić, Stjepko Fazinić, Hüseyin Ertap, Mevlüt Karabulut, Andrea Moguš-Milanković, Ana Šantić</b> <i>Model-free scaling of conductivity spectra: insight into electrical transport in iron phosphate-based glasses ....</i>	92
<b>POSTERS</b>	
<b>Chemistry</b>	
<b>Maša Buljac, Ivana Škugor Rončević, Nives Vladislavić, Marijo Buzuk</b> <i>Electrochemical behavior of natural reducers on carbon nanomaterials: a contribution to the optimization of electroanalytical methods.....</i>	94
<b>Ivana Škugor Rončević, Nives Vladislavić, Boris-Marko Kukovec, Marijo Buzuk, Maša Buljac</b> <i>Transition metal coordination polymers: synthesis, spectroscopic and electrochemical studies .....</i>	96
<b>Ivana Vrca, Vedrana Čikeš Čulić, Ivica Blažević, Tea Bilušić</b> <i>The influence of the black mustard sample preparation method on chemical composition, antiproliferative and proapoptotic effects .....</i>	97
<b>Dajana Gašo-Sokač, Valentina Bušić, Maja Molnar</b> <i>An eco-friendly preparations of izonicotinamide quaternary salts in deep eutectic solvents.....</i>	99
<b>Robert Kerep, Tino Šeba, Tin Weitner, Mario Gabričević</b> <i>Evaluation of thermodynamic parameters between antidepressant imipramine and human <math>\alpha</math>1-acid glycoprotein by isothermal titration calorimetry.....</i>	100
<b>Kristinka Vinković, Danijela Ašperger, Bruna Babić, Gabrijela Priščan</b> <i>Determination of pseudoestrogenic compounds in thermochromic printing ink .....</i>	101
<b>Josip Radić, Marija Bralić, Maša Buljac, Marina Šola</b> <i>Potentiometric response characteristics of carbon paste electrode for maprotiline determination.....</i>	102
<b>Antonela Ninčević Grassino, Sara Spalj, Tomislav Bosiljkov</b> <i>Evaluation of pectin biofilms with incorporated phenolic extracts of "karoma" spent espresso coffee grounds .....</i>	103
<b>Antonela Ninčević Grassino, Sara Spalj, Iva Sušić, Marina Šango</b> <i>Microwave-assisted extraction of polyphenols from coffee (green and roasted) and its by-products (silver skin and spent coffee ground) .....</i>	104
<b>Armands Sebris, Kaspars Traskovskis, Irina Novosjolova, Māris Turks</b> <i>Synthesis and photophysical properties of purine-carbazole donor acceptor systems.....</i>	105

<b>Mirna Habuda-Stanić, Huiyu Dong, Antonija Kristek Janković</b> <i>Structural characterisation of modified bioadsorbents</i> .....	348
<b>Kristijan Vidović, Samo Hočevar, Irena Ciglencečki-Jušić</b> <i>A new approach for studying adsorption processes on solid electrodes in seawater conditions</i> .....	349
<b>Karla Plenča, Andrea Opačak, Sara Cvetković, Matija Cvetnić, Ana Lončarić Božić, Zvonimir Matusinović, Hrvoje Kušić</b> <i>Laboratory pyrolysis of biomass: gas product analysis</i> .....	351
<b>Andrea Opačak, Karla Plenča, Sara Cvetković, Matija Cvetnić, Tomislav Bolanča, Ana Lončarić Božić, Zvonimir Matusinović, Hrvoje Kušić</b> <i>Optimization of biomass pyrolyzation on laboratory pyrolysis system</i> .....	352
<b>Irena Ciglencečki, Ivica Vilibić, Jelena Dautović, Niki Simonović, Vjeročka Vojvodić, Božena Čosović, Petra Zemunik, Natalija Dunić, Hrvoje Mihanović</b> <i>Long-term (30 years) study of dissolved organic matter in the northern Adriatic sea; an indication of global changes and the bios variations</i> .....	353
<b>Marko Racar, Mia Gotovuša, Ivan Pucko, Fabio Faraguna</b> <i>Synthesis of fatty acid octyl esters combined with glycerol extraction and reuse of acid catalyst</i> .....	355
<b>Valentina Gluščić, Mirjana Čačković, Gordana Pehnc, Ivan Bešlić</b> <i>Content of ionic compounds in the ambient fine particulate matter fraction</i> .....	356
<b>Iva Šimić, Gordana Mendaš, Gordana Pehnc, Andrea Milinković, Sanja Frka</b> <i>Different performances of a bulk collector for the determination of PAHs and PCBs in total deposited matter</i> .....	357
<b>Materials and nanotechnology</b>	
<b>Irena Ivanišević, Sara Krivačić, Iva Gudan Pavlović, Stjepan Milardović, Petar Kassal</b> <i>Amphiphilic silver nanoparticles for inkjet printed electronics on flexible plastic substrates</i> .....	358
<b>Iva Rezić, Mislav Majdak, Lela Martinaga, Maja Somogyi Škoc, Vanja Ljoljić Bilić, ž</b> <i>Development and characterization of antibacterial coating with nanoparticles active against MRSA and MSSA</i> .....	359
<b>Andreja Žužić, Jelena Macan</b> <i>Permanganometric determination of oxygen nonstoichiometry in manganites</i> .....	360
<b>Jelena Bijelić, Manisha Sahu, Sugato Hajra, Dong Ik Oh, Hoe Joon Kim, Igor Djerdj</b> <i>Triple perovskite-based triboelectric nanogenerator: a facile method of energy harvesting and self-powered information generator</i> .....	361
<b>Dalibor Tatar, Pascal Cop, Ruben Maile, Yu Sun, Omeir Khalid, Patrick Esch, Sven Heiles, Herbert Over, Bernd M. Smarsly, Igor Djerdj</b> <i>Impact of aliovalent/isovalent ions (Gd, Zr, Pr, and Tb) on the catalytic stability of mesoporous ceria in the HCl oxidation reaction</i> .....	362
<b>Marija Tkalčević, Jordi Sancho Parramon, Matej Bubaš, Goran Dražić, Peter Nadazdy, Sigrid Bernstorff, Maja Mičetić</b> <i>Magnetron sputtering deposition of 3D networks of nanopores in alumina</i> .....	363
<b>Mateja Piljić, Maja Somogyi Škoc, Iva Rezić</b> <i>Preparation and characterization of silica-Nigella sativa L. hybrid materials</i> .....	365
<b>Ivana Periša, Marija Tkalčević, Lovro Basioli, Mile Ivanda, Sigrid Bernstorff, Maja Mičetić</b> <i>Magnetron sputtering deposition of core/shell Ge/Al quantum dot lattices in amorphous Al<sub>2</sub>O<sub>3</sub> matrix</i> .....	366
<b>Marko Robić, Mira Ristić, Stjepko Krehula, Svetozar Musić</b> <i>Synthesis and properties of electrospun fibres in the system Er<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub></i> .....	367
<b>Igor Jajčinović, Sara Pršić, Kristina Tolić, Vedrana Špada, Ivan Brnardić</b> <i>Aging of photocatalysts TiO<sub>2</sub>, TiO<sub>2</sub> / multiwall carbon nanotubes and TiO<sub>2</sub> / graphene oxide in air</i> .....	368

<b>Maria Kolympadi Markovic, Robert Peter, Ivana Jelovica Badovinac, Iva Šarić, Marko Perčić, Rafaela Radičić, Dean Marković, Mato Knez, Gabriela Ambrožić</b> <i>Preparation of ZnO/organosilane/ZnO hybrid thin films via atomic layer deposition (ALD) and solution surface modification.....</i>	389
<b>Marko Dunatov, Andreas Puškarić, Luka Pavić, Lidija Androš Dubraja</b> <i>Structural and dielectric studies of bis(oxalato)chromium(III) complexes with azabicyclic cations .....</i>	390
<b>Antoneta Tomljenović, Juro Živičnjak, Veronika Stamać</b> <i>Usage durability of knitwear made of man-made artificial fibers from cellulose .....</i>	391
<b>Juro Živičnjak, Ivan Mihaljević, Zenun Skenderi, Antoneta Tomljenović</b> <i>Comfort of socks made of innovative cellulose materials.....</i>	392
<b>Sanja Perinović Jozić, Ivan Bajan, Miće Jakić, Branka Andričić</b> <i>Preparation of poly(ethylene oxide) film with variation of drying temperature.....</i>	393
<b>Ruža Frkanec, Ilija Brzić, Nikolina Kalčec, Ivana Vinković Vrček, Lucija Horvat, Tihana Kurtović, Leo Frkanec</b> <i>Towards nanobiosensor for coronavirus (Covid-19) detection: conjugation of monoclonal anti-SARS-Cov-2 antibodies to gold nanoparticles.....</i>	394
<b>Berislav Marković, Dalibor Tatar, Aleksandar Miletić, Ákos Kukovecz, Igor Djerdj</b> <i>Synthesis of 1,2-diketones from aldehyde using novel ceria-zirconia high-entropy oxides as actual catalysts .....</i>	395
<b>Josipa Bilić, Manuel Širola, Vedrana Špada, Neven Peko</b> <i>Analyses on chemical and mechanical stripping of coatings on metal plate mock-ups .....</i>	396
<b>Kamran Syed, Hrvoje Gebavi, Davor Ristić, Eduard Ilobet, Mile Ivanda</b> <i>Gas Sensors on Flexible Polyimide, Rigid Alumina and Silicon Substrate for the Nitrogen dioxide (NO<sub>2</sub>) and Ammonia (NH<sub>3</sub>) Gas Detection .....</i>	398
<b>Sara García-Ballesteros, Josipa Papac, Ana M. Amat, Hrvoje Kušić</b> <i>Environmental aspect of photocatalysis for the degradation of oxytetracycline in water: N-S-TiO<sub>2</sub> vs TiO<sub>2</sub>.....</i>	400
<b>WORKSHOPS</b>	
<b>Education</b>	
<b>Vlatka Husetović, Marijana Bastić</b> <i>Vertikalna povezanost kurikulumskih sadržaja kemije i prirode od ishoda na razini aktivnosti preko pokusa do vrednovanja .....</i>	405
<b>Martina Kalac</b> <i>Radionica aromaterapije u OŠ Maria Martinolića .....</i>	406
<b>Milan Nikolić, Olgica Martinis</b> <i>Pokusi i ishodi u nastavi kemije.....</i>	407
<b>Helena Peter Jelenčić, Olgica Martinis</b> <i>Analiza inicijalne provjere znanja iz kemije u srednjoj školi.....</i>	408
<b>Industry and entrepreneurship</b>	
<b>Ernest Meštrović</b> <i>Entrepreneurial skills – workshop .....</i>	409
<b>Spiridion Brusina Medal Lecture</b>	
<b>Tomislav Friščić</b> <i>Spiridion Brusina Medal Lecture: Solvent-free Notes on Natural Sciences [Predavanje povodom medalje Spiridion Brusina: naravoslovne crtice bez otapala].....</i>	410
<b>INDEX.....</b>	412

## USAGE DURABILITY OF KNITWEAR MADE OF MAN-MADE ARTIFICIAL FIBERS FROM CELLULOSE

Antoneta Tomljenović,<sup>a,\*</sup> Juro Živičnjak,<sup>a</sup> Veronika Stamać<sup>a</sup>

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Cellulose is a raw material with a wide variety of uses in the chemical industry for producing man-made textile fibers. Conventional regenerated cellulosic fibers are generally produced by the indirect viscose process (viscose fibers), while high-tenacity modal fibers are produced using a modification of the basic procedure. Viscose production is based on deriving cellulose with carbon bisulphide. Lyocell fibers are produced by a more environmentally friendly procedure from a solution of non-derivative cellulose in a solvent spinning process, where cellulose is dissolved directly in the organic solvent N-methylmorpholine-N-oxide, without the formation of derivatives.<sup>[1]</sup> Different production processes cause differences in the structure of the fibers despite the same chemical composition.

Knitwear that are worn in direct contact with the skin, are often made of viscose, modal or lyocell fibers, that provide silky touch, high hydrophilicity and exceptional comfort. They were usually knitted with spun yarns produced by conventional ring spinning system. More recently unconventional rotor and air-jet spun yarns have been appeared, resulting with yarns of different structure and properties.<sup>[2]</sup> Therefore, in this paper circular weft double jersey knitted fabrics for lingerie made of single ring, rotor and air-jet spun yarns, all made of bright staple viscose, modal and lyocell fibers of the same linear density were evaluated. Raw and finished knitwear usage durability were compared by determination of moisture regain, breaking strength and breaking elongation, dimensional change after laundering, air permeability, propensity to surface piling and abrasion resistance, all according to the standardized test methods.

**Acknowledgments.** This paper is funding by the Croatian science foundation within the Project IP-2016-06-5278.

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- [2] Z. Skenderi, et al., *Tekstilec* **2019**, 62, 2019, 42-53.





## Introduction

Cellulose is a raw material with a wide variety of uses in the chemical industry for producing man-made textile fibers. Conventional regenerated cellulosic fibers are generally produced by the indirect viscose process (viscose fibers), while high-tenacity modal fibers are produced using a modification of the basic procedure. Viscose production is based on deriving cellulose with carbon bisulphide. Lyocell fibers are produced by a more environmentally friendly procedure from a solution of non-derivative cellulose in a solvent spinning process, where cellulose is dissolved directly in the organic solvent N-methylmorpholine-N-oxide, without the formation of derivatives. Different production processes cause differences in the structure of the fibers despite the same chemical composition.

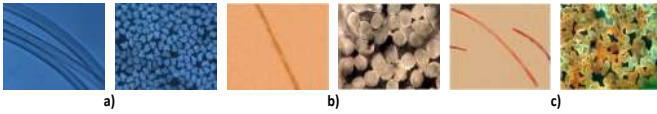


Figure 1. Microscopic images of longitudinal view and cross section of: a) viscose, b) lyocell and c) modal fibers

## Knitwear

Knitwear and lingerie, that are worn in direct contact with the skin, are often made of man-made artificial fibers from cellulose (eg. viscose, modal or lyocell) which provide silky touch, high hydrophilicity and exceptional contact comfort.



Figure 2. Knitwear products: a) T-shirts, b) turtleneck and c) underwear

## Yarns

Yarns were usually knitted with spun yarns produced by conventional ring spinning system. More recently unconventional rotor and air-jet spun yarns have appeared, resulting with yarns of different structure and properties. Therefore, in this paper circular weft double jersey knitted fabrics for lingerie made of single ring (P), rotor (R) and air-jet (A) spun yarns of same linear density (20 tex), all made of bright staple viscose (CV), modal (MD) and lyocell (CLY) fibers of linear density of 1.3 dtex and length of 38/40 mm were evaluated.

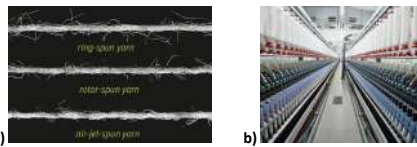


Figure 3. Structure of ring, rotor and air-jet spun yarns a), spinning in the production plant b)

## Materials

Knitted fabrics samples were made using circular double-bed knitting machine with E17 gauge and needle bed diameter of 200 mm (8 inches). All dry relaxed knitted fabrics (raw samples) were finished in the production plant: firstly washed thoroughly at 40°C, further with addition of stabilization agent at 95°C, then rinsed, cold washed with neutralization and softening; and dried at 150°C with a passage rate of 0.15 m/s.



Figure 4. Circular double bed knitting machine

## Methods

After the conditioning (at temperature: 20 ± 2°C and air relative humidity: 65 ± 4%), along with basic characterization, raw and finished knitted fabrics usage durability were compared by determination of:

- moisture regain (ASTM D 2654-89a),
- breaking strength and breaking elongation (EN ISO 13934-1) using the strip method (Fig. 5 a),
- dimensional change after washing and drying in tubular form (EN ISO 6330, procedure 4M and A),
- permeability of fabrics to air (EN ISO 9237) (Fig. 5 b),
- propensity to surface pilling (EN ISO 12945-2) and abrasion resistance (EN ISO 12947-2) by determination of specimen breakdown using the Martindale abrasion tester (Fig. 5 c).



Figure 5. Testing instruments:

- a) Strength Tester      b) Air permeability Tester      c) Martindale Abrasion and Pilling Tester

## Results and discussion

Air permeability and the breaking strength of finished knitted fabrics are changed primarily because of their dimensional and structural changes. After laundering, the overall deformability is lower and dimensional stability is improved in all finished fabrics. Lower propensity to surface pilling was observed in knitwear made of air-jet spun yarns because of their lower hairiness and specific structure. Knitwear samples made of ring spun yarns, that are highly twisted on the surface, show better abrasion resistance.

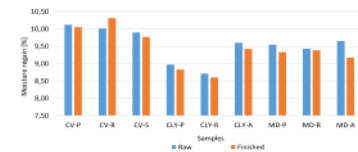


Figure 6. Moisture regain of raw and finished knits

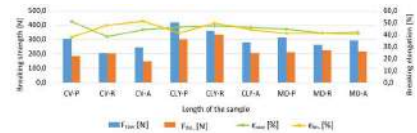


Figure 7. Breaking strength and elongation of raw and finished knits cut from the length of the sample

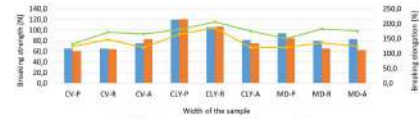


Figure 7.1. Breaking strength and elongation of raw and finished knits cut from the width of the sample

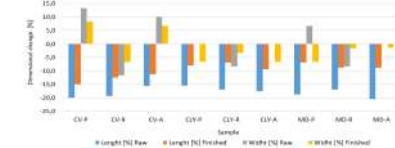


Figure 8. Dimensional changes in the direction of the length and width of raw and finished knits after one washing and drying cycle

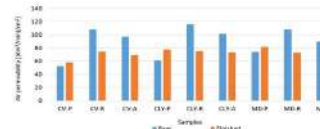


Figure 9. Air permeability of raw and finished knits

Table 1. Abrasion resistance of raw and finished lyocell knits – visual determination of specimen breakdown

Knitted fabrics sample	Abrasion resistance (endpoint)	
	raw	finished
Ring CLY		
Rotor CLY		
Air-jet CLY		

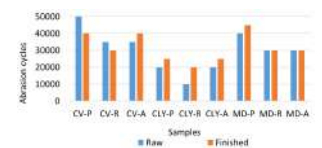


Figure 10. Abrasion resistance of raw and finished knits – visual determination of specimen breakdown

Table 2. Appearance of raw and finished knits made of lyocell fiber yarns after 7000 pilling rubs

Knitted fabrics sample	7000 pilling rubs	
	raw	finished
Ring CLY		
Rotor CLY		
Air-jet CLY		

Table 3. Visually assessed propensity to surface pilling of raw and finished knits

Samples	Raw	Finished
CV-P	2/3	3
CV-R	3/4	3
CV-A	2	2
CLY-P	2/3	2/3
CLY-R	3	2/3
CLY-A	3/4	3
MD-P	2	1/2
MD-R	3	2
MD-A	3/4	3

## Conclusion

On the basis of the results obtained, it was concluded that for selection of the spun yarns for knitted fabrics production is necessary to consider their structure and the characteristics, but also, the fact that yarn spinning technique, as well as the process of knitted fabric finishing significantly influence knitwear usage quality.

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