27 HSKIKI

VELI LOŠINJ
2021

27th CROATIAN MEETING OF CHEMISTS AND CHEMICAL ENGINEERS

WITH INTERNATIONAL PARTICIPATION • 5th SYMPOSIUM "VLADIMIR PRELOG"

5-8 OCTOBER 2021 • VELI LOŠINJ, HOTEL PUNTA, CROATIA

BOOK OF ABSTRACTS

27th Croatian Meeting of Chemists and Chemical Engineers

with international participation

5th Symposium Vladimir Prelog

5 – 8 October 2021

Veli Lošinj, Vitality Hotel Punta, Croatia

BOOK OF ABSTRACTS

SCIENTIFIC AND ORGANISING COMMITTEE

Dean Marković, *Chair*, University of Rijeka

Ernest Meštrović, *Co-chair,* Xellia d.o.o.

Vesna Tomašić, *Co-chair*, Faculty of Chemical Engineering and Technology, University of Zagreb

Senka Djaković, *secretary*, Faculty of Food Technology and Biotechnology, University of Zagreb

Zrinka Buhin Šturlić, Medic d.o.o.

Igor Dejanović, Faculty of Chemical Engineering and Technology, University of Zagreb

Stjepan Džalto, Hidroplan d.o.o.

Zvjezdana Findrik Blažević, Faculty of Chemical Engineering and Technology, University of Zagreb

Vesna Gabelica Marković, Faculty of Chemical Engineering and Technology, University of Zagreb

Nenad Judaš, Faculty of Science, University of Zagreb

Olgica Martinis, Education and Teacher Training Agency

Danijel Namjesnik, Faculty of Science, University of Zagreb

Jasna Prlić Kardum, Faculty of Chemical Engineering and Technology, University of Zagreb

Silvana Raić Malić, Faculty of Chemical Engineering and Technology, University of Zagreb

Marko Rogošić, Faculty of Chemical Engineering and Technology, University of Zagreb

Marin Roje, Ruđer Bošković Institute, Zagreb

Aleksandra Sander, Faculty of Chemical Engineering and Technology, University of Zagreb

Vladislav Tomišić, Faculty of Science, University of Zagreb

Andrea Usenik, Faculty of Science, University of Zagreb

Mario Vazdar, Ruđer Bošković Institute, Zagreb

Nikola Bregović, Faculty of Science, University of Zagreb

INTERNATIONAL SCIENTIFIC COMMITTEE

Jurica Bauer, Maastricht University, Maastricht, the Netherlands

David Bogle, University College London, London, UK

Paweł Dydio, Laboratory of Complex Systems in Synthesis & Catalysis (CosyCAT), Institute of Science and Supramolecular Engineering (ISIS), University of Strasbourg & CNRS, Strasbourg Cedex, France

Tomislav Friščić, McGill University, Montreal, Canada

Janez Plavec, Slovenian NMR Centre, National Institute of Chemistry, Ljubljana, Slovenia

Giovanna Speranza, Department of Chemistry, University of Milan, Milan, Italy

LOCAL ORGANISING COMMITTEE

Sandra Kraljević Pavelić, Gabriela Ambrožić, Maria Kolympadi Markovic, Tomislav Pavlešić, Alma Ramić

IMPRESSUM

ORGANIZERS

Croatian Chemical Society

Croatian Society of Chemical Engineers

PUBLISHED BY

Croatian Chemical Society

EDITORS

Dean Marković, Ernest Meštrović,
Danijel Namjesnik, Vesna Tomašić

DESIGN & LAYOUT

Danijel Namjesnik & Andrea Usenik

ISSN: 2757-0754 (Online)

VENUE

Veli Lošinj, Vitality Hotel Punta, Croatia

https://www.losinj-hotels.com/hr/hoteli-i-vile/hotel-punta/

Zagreb, 2021.

COMFORT OF SOCKS MADE OF INNOVATIVE CELLULOSE MATERIALS

Juro Živičnjak,[a,*] Ivan Mihaljević,[a] Zenun Skenderi,[b] Antoneta Tomljenović[a]

[a] Department of Materials, Fibers and Textile Testing, University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia
[b] Department of Textile Design and Management, University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia
* juro.zivicnjak@ttf.unizg.hr

The socks are knitted next-to-skin-type garments worn on the feet and often covering the ankle and some part of the calf. They have to fulfill high demands of functionality, comfort, durability and design. As the comfort of socks depends on their construction and materials used, it is very important to select fibers and yarns for their production. The number of European standards related to testing of knitwear and socks are low.[1] With increasing demand for garment comfort, there are many studies related to the comfort properties of fabrics. However, there are significantly less studies examining the thermal comfort of socks, which are using thermal foot model.[2]

The socks are usually made from cotton yarns for softness and comfort and blended with polyamide or Lycra for improved fit, durability and shrink resistance. Therefore, and with the fact that the applicability of modal fibers and microfibers (man-made artificial fibers from cellulose which provide silky touch and exceptional contact comfort) in knitting of socks is insufficiently researched, as well as yarns made from them by unconventional rotor and air-jet process, in this paper properties of two groups of socks, made of innovative materials – single ring, rotor and air-jet spun yarns of the same linear density (all made of bright staple modal fibers of linear density of 1.3 dtex and modal microfibers of 1.0 dtex respectively) in full plating by textured polyamide 6.6 yarns of different linear density were evaluated. Evaluation of sock comfort was carried out by investigation of water vapor absorption and air permeability of socks knitted fabrics and socks thermal comfort before and after five repeated washing and drying cycles by measuring of thermal resistance on the thermal foot.

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

REFERENCES

[1] A. Tomljenović, et al., *Fibers & Textiles in Eastern Europe* **2016**, *24*, 129-138.

[2] Z. Skenderi, et al., *Leather & Footwear* **2017**, *66*, 12-21.

COMFORT OF SOCKS MADE OF INNOVATIVE CELLULOSE MATERIALS

Juro Živičnjak [a]*, Ivan Mihaljević [a], Zenun Skenderi [b], Antoneta Tomljenović [a]

[a] Department of Materials, Fibers and Textile Testing, University of Zagreb Faculty of Textile Technology

[b] Department of Textile Design and Management, University of Zagreb Faculty of Textile Technology

Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia

Introduction

The socks are knitted next-to-skin-type garments worn on the feet and often covering the ankle and some part of the calf. They have to fulfill high demands of functionality, comfort, durability and design. As the comfort of socks depends on their construction and materials used, it is very important to select fibers and yarns for their production.

a) b)

Figure 1. Male socks: a) in calf length, b) in over calf length

The socks are usually made from cotton yarns for softness and comfort and blended with polyamide or Lycra for improved fit, durability and shrink resistance. Recently innovative cellulose materials like modal fibers and microfibers (man-made artificial fibers from cellulose) which provide silky touch and exceptional contact comfort are used in knitting of socks, as well as yarns made by unconventional rotor and air-jet process.

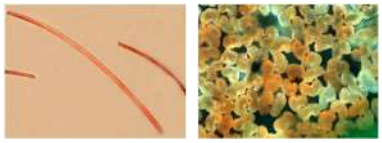

Figure 2. Microscopic images of longitudinal view and cross section of modal fibres

Figure 3. Structure of ring, rotor and air-jet spun yarns

Materials

With the fact that the applicability of modal fibers and microfibers in knitting of socks is insufficiently researched, as well as yarns made from them by unconventional rotor and air-jet process, in this paper properties of two groups of socks (A and B), made of innovative materials – single ring (P), rotor (R) and air-jet (A) spun yarns of the same linear density (all made of bright staple modal fibers (MD) of linear density of 1.3 dtex and modal microfibers (MMD) of 1.0 dtex respectively) in full plating by textured polyamide 6.6 yarns of different linear density were evaluated.

The socks were made using Lonati automatic sock-knitting machine with E9 gauge of cylinder diameter 95 mm (3 ¾ ‘’) with 108 needles and then ironed at a temperature of 120 °C using Cortese machine.

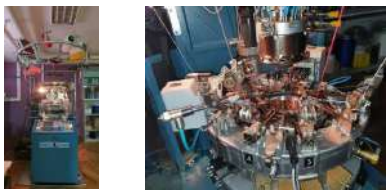

Figure 4. Lonati, Goal FL 626 automatic sock-knitting machine

The investigation was carried out on two groups of calf length male socks of the same size (EU 42). Plain knit stich was used in the foot and leg area, and rib stitch was used at the top of the socks. Textured polyamide multifilament yarn was knitted into toe, hell, foot and leg areas of socks for reinforcement and support along with the three soft single spun yarns made of modal or micromodal fibers. Single Lycra of higher linear density (54 tex) was knitted into the ribbing at the top of the all socks to prevent their falling down. Characteristics of male socks produced are shown in Table 1, including values of fiber content and yarn characteristics used for knitting.

Table 1. Characteristics of two groups of calf length male socks

Sock group	Sock content	Fiber content [%]		Yarn characteristics	
		plain	rib	plain	rib
A	MD or MMD	79	55	P, R or A of 20 tex 156 dtex f 42	P, R or A of 20 tex 156 dtex f 42
	PA 6.6	21	14		
	Lycra	/	31	/	54 tex f1
B	MD or MMD	71	52	P, R or A of 20 tex 220 dtex f 68	P, R or A of 20 tex 220 dtex f 68
	PA 6.6	29	19		
	Lycra	/	29	/	54 tex f1

Description: **P** - ring , **R** - rotor and **A** - air-jet spun yarns

Methods

The number of European standards related to testing of knitwear and socks are low. With increasing demand for garment comfort, there are many studies related to the comfort properties of fabrics. However, there are significantly less studies examining the thermal comfort of socks, which are using thermal foot model. Therefore, evaluation of sock comfort was carried out by investigation of water vapor absorption and air permeability of knitted fabrics of socks and socks thermal comfort before and after five repeated washing and drying cycles by measuring of thermal resistance on the thermal foot. Washing were performed according to the procedure 3M at 30°C (mild agitation during heating, washing and rinsing) with non-phosphate ECE reference detergent (without optical brightener) and drying by open-air drying (procedure A, line dry) of EN ISO 6330. Before testing all socks were conditioned at temperature: 20 ± 2°C and air relative humidity: 65 ± 4%.

Figure 5. Preparation of sock for water vapor absorption and air permeability test

Water vapor absorption is determined according to the ASTM D 2654-89a. Plain knit circular samples of 100 cm^2 were cut from conditioned body of the sock and weighted (m_k), then dried in an oven at 105 ± 2°C for 24 h and reweighted (m_{as}). The difference between the mass of conditioned and the mass of oven-dried samples is calculated as moisture regain in percentage according to the Formula 1:

$$M_r = \frac{m_k \cdot m_{as}}{m_{as}} \cdot 100 \qquad (1)$$

M_r – moisture regain [%],
m_k – mass of the conditioned sample [g] and
m_{as} – mass of the absolute dry sample [g].

Permeability of fabrics to air is determined according to the EN ISO 9237 using test surface area of 5 cm^2 and pressure drop of 100 Pa. Arithmetic mean of the 10 individual readings were calculated according to the Formula 2**:**

$$R = \frac{qv}{A} \cdot 167 \qquad (2)$$

qv – arithmetic mean of air flow [dm^3/min],
A – test surface area [cm^2] and
167 – conversion factor from dm^3/min cm^2 in mm/s.

Thermal resistance can be defined as the ability of the material to resist the heat flow through the it´s structure. Thermo-physiological sock properties were determined by measuring thermal resistance on a Thermal Sweating Foot Manikin System, size 42, which has 13 independent heating (35 ± 0.5°C) and measuring segments. The thermal resistance of the tested sock sample *Rct* is obtained from the difference R_{ctu} and R_{ct0} according to the Formula 3:

$$R_{ct} = R_{ctt} - R_{ct0} \qquad (3)$$

R_{ct} – thermal resistance of the tested sock [m^2 °C W^{-1}],
R_{ctt} – total thermal resistance of apparatus and sock [m^2 °C W^{-1}] and
R_{ct0} –thermal resistance of apparatus (Thermal Foot) [m^2 °C W^{-1}].

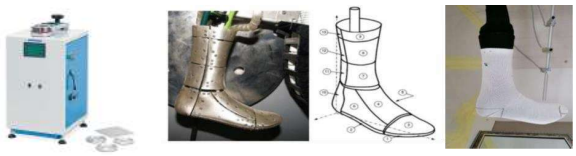

Figure 6. Testing instruments:
a) Air permeability Tester **b) Thermal Sweating Foot Manikin**

Results and discussion

By evaluating the comfort of socks - testing the ability to absorb moisture, air permeability and thermal comfort of socks (measured directly on the thermal foot by determining the resistance to heat transfer) before and after five washing and drying cycles of simulated home care, it was found that the amount of absorbed moisture depends primarily on the socks fiber content, air permeability on knits compactness and porosity, and socks heat transfer (thermal resistance) on the linear density of fibers used for production of spun yarns and structure and porosity of knits.

Table 2. Moisture regain before and after five washing and drying cycles

Sock sample	M_{r0} [%]	M_{rs} [%]	ΔM_{rs} [%]
MD-P-A	9.29	9.93	6.91
MD-P-B	8.19	9.37	14.43
MD-R-A	9.42	9.76	3.58
MD-R-B	8.29	9.34	12.62
MD-A-A	9.13	9.26	1.36
MD-A-B	8.19	9.69	18.36
MMD-P-A	9.63	9.65	0.19
MMD-P-B	8.39	9.79	16.77
MMD-R-A	9.30	9.75	4.89
MMD-R-B	8.37	9.12	8.93
MD-A-A	9.26	9.69	4.66
MMD-A-B	8.38	9.09	8.49

Description: M_{r0} moisture regain before five washing and drying cycles; M_{rs} - moisture regain after five washing and drying cycles; ΔM_{rs} - percentage difference between the M_{rs} and M_{r0}

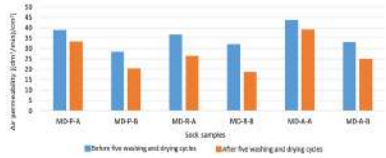

Figure 7. Air permability of socks from modal fibers

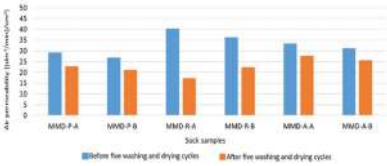

Figure 7.1. Air permability of socks from micromodal fibers

Table 3. Thermal resistance of socks before and after five repeated washing and drying cycles

Sock sample	*Rctt* [m²·°C/W]		*Rct* [m²·°C/W]		(*Rct*/ *Rctt*) x 100 [%]	
	Non-washed	5x washed	Non-washed	5x washed	Non-washed	5x washed
MD-P-A	0.15914	0.14074	0.01178	0.00178	7.41	1.27
MD-P-B	0.15674	0.14633	0.01684	0.00737	10.75	5.04
MD-R-A	0.15663	0.14627	0.01673	0.00731	10.68	5.00
MD-R-B	0.16176	0.14829	0.01440	0.00933	8.90	6.29
MD-A-A	0.16051	0.15107	0.01315	0.00765	8.20	5.07
MD-A-B	0.15728	0.15055	0.01317	0.00713	8.38	4.74
MMD-P-A	0.15083	0.14166	0.02558	0.01778	16.96	12.55
MMD-P-B	0.15635	0.14576	0.03110	0.02188	19.89	15.01
MMD-R-A	0.15777	0.14403	0.03251	0.02015	20.61	13.99
MMD-R-B	0.15497	0.14521	0.02971	0.02134	19.17	14.70
MMD-A-A	0.15293	0.14410	0.02768	0.02022	18.10	14.03
MMD-A-B	0.15272	0.14716	0.02587	0.02328	16.94	15.82

Description: ***Rctt*** - total thermal resistance of apparatus and sock; ***Rct*** - thermal resistance of the tested sock

Conclusion

After the simulation of care in all tested socks, changes in the values of the tested properties were determined, which justifies the application of the proposed methodology in evaluating their comfort and usability. The applicability of the innovative materials used for the production of socks has been confirmed.

ACKNOWLEDGMENT

This paper is funding by the Croatian science foundation within the Project IP-2016-06-5278 (Comfort and antimicrobial properties of textiles and footwear, principal investigator: Prof. Zenun Skenderi, PhD).