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Euro-CASE

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EDITOR-IN-CHIEF'S FOREWORD

Dear Readers,

I am very pleased and proud to present to you, in this new issue of our Bulletin „Engineering Power", the contributions of the distinguished members of our Academy and their coworkers: Prof. Emer. Ana Marija Grancarić, Ph. D., Prof. Emer. Ivo Soljačić, Ph. D., Prof. Tanja Pušić, Ph. D., Prof. Sandra Bischof, Ph. D., Katia Grgić, Dipl. Eng., Ivona Jerković, Dipl. Eng., all from the Faculty of Textile Technology, University of Zagreb, Croatia and Prof. Vladan Končar, Ph. D., Director of GEMTEX Research Laboratory in Roubaix, France.

Prof. Ana Marija Grancarić, Ph. D., Member of the Academy in the Department of Textile Technology and Professor Emeritus at the Faculty of Textile Technology, University of Zagreb, is the Guest Editor of this issue of the Engineering Power.

You can also learn more on the HATZ News and Activities in 2015 on the last pages of this Bulletin issue.

Vladimir Andročec
Editor-in-Chief

CONTENT

GUEST EDITOR'S WORD

Dear Readers,

The issue of this Engineering Power edition is a part of the contribution of the University of Zagreb, Faculty of Textile Technology (TTF) to the European research area for growth and innovation in textiles through ten projects from the European funds (FP7, E!, LLP, IPA and ERASMUS+). These projects are mostly supported by AUTEX (Association of Textiles Universities), which belongs to EURATEX (European Apparel & Textile Confederation in Brussels, before ETP - European Textile Platform). The most important target of EURATEX are development of long-term strategic research agenda growth and innovation within this industry, the securing of the necessary finance for R&D, innovation, technology transfers, training for the textile and clothing sector. Important textile markets that have been identified consist of the next generation of intelligent personnel protection clothing and equipment, medical textiles for the future, a new light, highstrenght building materials for low –weight construction, safe and energy – efficient transport systems, buildings and infrastructure. It is to point out that EURATEX regularly supports the dissemination of collaborative research results to industry.

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Editor-in-Chief: Vladimir Andročec
Guest Editor: Ana Marija Grancarić
HATZ News Editor: Melanija Strika
Phone: + 385 1 4922 559 Fax: + 385 1 4922 569
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The European textile industry is a very strong player on a global scale and it is the second one after China. This industry should be looked from a value perspective and is much diversified, so it is feeding strongly into the entire major end applications, fashion, home/interiors and technical textiles which is a very unique position compared to other countries. Relating to research activity, we are proud of the TTF research excellence and long-standing experience in the field of textile, which resulted in its experts involved in the ETP working groups for dealing with major topics in drafting of the European Research Strategy till 2020. This edition issue presents the papers belonging to the three FP7 projects recently realized at TTF.

The first TTF project funded by the European Commission was FP7-SME-2007-217809: *Sustainable Measures for Industrial Laundry Expansion Strategies (SMILES): SMART Laundry-2015.* In the frame of this project the Croatian partner, Professor Tanja Pušić and co-authors present a part of systematic investigations of detergent components and their impact on the environment by analysing the laundering performance of detergent containing environmentally favourable peracetic acid (PAA) in variation of pH and finishing parameters.

The second FP7 project was coordinated by TTF and funded within the call FP7-REGPOT-2008-1, with grant 2298011, entitled: *Unlocking the Croatian Textile Research Potentials (T-Pot).* In the present paper this project coordinator, Professor Sandra Bischof presents the review of the project activities such as purchase of top class equipment, training of researchers and industrial representatives and know-how transfer from the experts from the EU partnering institutions. One of the project results was upgrading of Textile Science Research Centre (TSRC) potential and participation of Croatian SMEs and crafts as valuable entities in the research activities of the European Research Area.

For the third project TTF was a project partner, too. It was funded through the project NMP-FP7-2010-3.4-1-263159-2015 entitled: *One-shot Manufacturing on large scale of 3D up graded panels and stiffeners for lightweight thermoplastic textile composite structures (*MAPICC 3D). The Croatian project partner Professor Ana Marija Grancarić and co-authors present here the high performance textile reinforced composites and textile sensors. These sensors are developed from E-glass/polypropylene (GF/PP) commingled yarn and implemented during the weaving of 2D structures at the ARM loom due to checking the thermo-forming consolidation behaviour as important factor for several future applications. Co-author of presented paper is MAPICC 3D Research Coordinator, Professor Vladan Končar from ENSAIT (Roubaix, France).

Wishing you a pleasant reading!
Sincerely

Ana Marija Grancarić
University of Zagreb
Faculty of Textile Technology

Tanja Pušić, Katia Grgić, Ivo Soljačić
University of Zagreb Faculty of Textile Technology, Zagreb, Croatia

PERACETIC ACID EFFECTIVENESS IN LAUNDERING OF COTTON FABRICS

Abstract

Selection of proper chemicals in laundering should meet numerous requirements, e.g. efficient removal of various soils at low temperature and short time with minimal water consumption. Environmental considerations have a considerable influence in contemporary detergent formulations. Systematic investigations of detergent components and their impact on the environment have shown that some of them, in despite of their beneficial activity in laundering, are characterised by poor biodegradation, and present a considerable load on waste waters, either directly or through their interactions with other waste products in water. The aim of the study was to analyse laundering performance of detergent containing environmentally favourable peracetic acid (PAA) in variation of pH and finishing.

Keywords: cotton, laundering, detergent, peracetic acid

1. INTRODUCTION

Detergency is dependent on specific interactions among substrate, soil and detergent components. The impact of chemistry on stain removal ability depends upon the composition and concentration of laundering agents [1]. Surfactants are key elements, as they are, due to their hydrophobic-hydrophilic nature, essential for proper soil particle dispersion (soot) and emulsifying liquid soils (oils and fats that liquefy at the temperatures above 50°C [2]. Synergy of surfactants and other components significantly reduce redeposition in laundering. It was necessary to consider mutual interactions of the laundering components, but also the interactions among various classes of soil. The most difficult soil to remove from fabrics are pigments, such as carbon black (soot), inorganic oxides, carbonates and silicates Other problematic soils include fats, waxes, higher hydrocarbons, denaturated proteins, and certain natural dyes. Problematic stains are mostly present on fibres in the form of mixed soils, e.g. stains from food, kitchen or cooking [3]. The absorption and retention of soils by textile fibres occur by a variety of mechanisms, each contributing to the resultant greying, and yellowing and whiteness deterioration of a fabric. The presence of bleaches is of key importance due to decolourization of stains from textiles to be laundered. Bleach is not associated only with better performance but also with drawbacks such as fibre damage after frequent laundering [4]. Hydrogen peroxide is quite an effective bleaching agent at the temperatures above 70°C. Nowadays, sustainable requirements have resulted in continued efforts toward low temperature (LT) processes. The role of bleach is to decrease the risk of oxidative damages to cellulose fibres and eliminate the bacteria resistant to hydrogen peroxide, resulting in better hygiene of washing, even in LT processes [4]. Due to disinfection effectiveness and environmental benefits, peracetic acid (PAA) is an alternation to existing bleach component. Its products of decomposition are biologically degradable [5] It is mostly used in the main wash in the temperature range from 60 to 70°C. Above the 70°C, the PAA decomposes too rapidly. As a peroxy compound have an optimal bleaching effect in an alkali medium. The pH range for peracetic acid application is in the range of pH 8.0 – 10.0, depending on the requirements and other process parameters. If active oxygen from PAA in the last rinse is not neutralized, there is a potential risk that oxygen stored in the textiles becomes more reactive during drying or ironing, when it can cause a further chemical damage of the processed textiles. The executed research deals with laundering performance of ecologically applicable agents, including a peracetic acid (PAA), evaluated through primary and secondary effects before and after ironing (i).

2. EXPERIMENTAL

2.1. Material

The evaluation of a primary laundering effect was performed on EMPA test fabric No. 103 (Tab. 1).

Table 1. Composition of EMPA cotton fabric

No.	Stain	Effect/Indication
221	Bleached cotton fabric	Redeposition
101	Carbon black/olive oil	General
111	Blood	Removal of the protein stain
112	Cocoa	
116	Blood/milk/ink	
115	Immedial black	Bleaching effect
222	Raw cotton fabric	
114	Red wine	

Secondary effects of laundering conditions (Tab. 2) are evaluated on a reference cotton fabric, SCC (DIN 53919-1, 1980).

Primary effect is evaluated by stain removal (DY) through spectral characteristics of EMPA 103 after a single laundering cycle. Secondary effects were evaluated by RAL-GZ 992/1 quality criteria, which included decrease in breaking strength, chemical wear, incineration residue and whiteness degree [6]. Surface characterization of cotton fabrics was performed by the streaming potential method in Electrokinetic Analyzer and Scanning Electron Microscopy (MIRA\FE-SEM) [7].

Table 2. Laundering conditions

Process	Agent	Dosage g/g	T °C	t min
Prewash	NaOH (48%) NS	2 2	40	10
Wash	NaOH (48%) NS PAA FWA	2 2 2 0.5	60	15
2 cycles rinsing				2 2
Neutralization	CH_3COOH	0.2		4
Rinsing				2
Extraction				5

NS-nonionic surfactant; FWA-fluorescent whitening agent

3. RESULTS

Stain removal from reference EMPA test fabric laundered in presented conditions, where pH of main wash varied, pH 8.4 (PAA*) and pH 9.8 (PAA) is presented in Tab 3.

Table 3. Stain removal

Textile material stained with		ΔY	
		PAA	*PAA**
221	–	9.56	8.47
101	Soot/olive oil	8.77	9.39
111	Blood	64.30	50.31
112	Cocoa	4.46	7.60
116	Blood/milk/ink	15.06	9.96
115	Sulphur soot	6.74	5.10
122	Raw fabric	6.43	6.59
114	Red wine	10.30	18.01
TOTAL ΔY		125.61	115.42

Laundering bath containing PAA* (pH 8.4) resulted with better bleaching effect analysed through removal of red wine (114). It proves better discoloration of stains and higher potential of PAA at 8.4 in comparison to pH 9.8. PAA is able to set protein stains, so a pre-wash was performed due to treatment of blood stained textiles before the use of PAA in a main wash. Protein stains (116 & 111) were better removed in a bath of pH 9.8. Protein stains require high alkali conditions.

Secondary laundering effect was analysed after 10 cycles by evaluation of *ash content*, *decrease in breaking strength, chemical wear*, *whiteness quality, zeta potential and SEM images*.

Table 4. Ash content (A) of cotton fabrics

Laundering bath/cycles	A (%)				
	0	**3**	**10**	**3i**	**10i**
PAA	0.35	0.26	0.18	0.28	0.18
PAA*		0.12	0.06	0.15	0.10

The results of ash content showed an absence of inorganic incrustations due to laundering in a soft water.

Table 5. Breaking strength (Fp) and decrease in breaking strength (ΔF) of cotton fabrics without and with ironing (i)

cycles	PAA		PAA*	
	Fp [N]	**ΔF [%]**	**Fp [N]**	**ΔF [%]**
0	913	–	913	–
10	851	6.79	717	21.46
10i	845	7.44	627	31.32

Decrease in breaking strength (ΔF) of the laundered cotton fabrics compared to the initial sample one show that laundering with at pH 8.4 (PAA*) caused higher reduction of mechanical properties than PAA at pH 9.8, Tab 5. Significant reduction of breaking force of laundered cotton fabrics (21.46%) and further increase after ironing (31.3%) could be attributed to the unbalanced conditions.

Table 6. Chemical wear (s) of cotton fabrics

Cycles/processing	PAA	PAA*
10	0.60	0.53
10i	0.74	0.46

Chemical wear of the cotton cellulose after 10 cycles with PAA and PAA*, without and with ironing (i) showed that high concentration of per-hydroxyl ions (HO_2^-) in a short span of time as well as their liberation and activity in the laundering bath caused damages to the cotton cellulose. PAA (pH 9.8) caused a stronger degradation of cotton cellulose than PAA* (pH 8.4), that was continued in ironing samples. Whiteness quality of cotton fabric is monitored through spectral parameters, Tab 7.

Table 7. Whiteness degree (W_{CIE}) of cotton fabrics

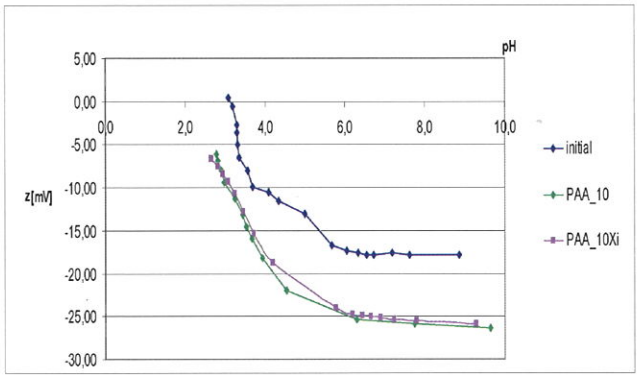
	W_{CIE}	
cycles	**PAA**	**PAA***
0	67.7	67.7
1	106.28	91.9
3	115.02	96.6
1i	104.99	91.8
3i	114.44	96.3

The whiteness degree of SCC before laundering is 67.7 that indicates an absence of fluorescent whitening agent (FWA). Laundering in a bath that contained FWA through 3 cycles stimulated a whiteness enhancement. Higher alkalinity (PAA) had better effect on a whiteness quality of SCC than PAA*.

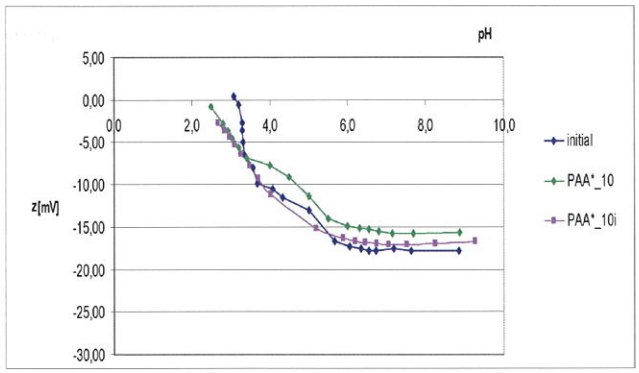
Fibres surface charge is an important parameter in the wet processing of cotton [7,8]. Surface characterization of cotton fabrics by zeta potential can be highly valuable for evaluation of secondary effects, Fig 1.

Zeta potential curves of cotton fabrics showed that alkali conditions of laundering bath caused changes of cotton fibre surface. Impact of PAA (pH 9.8) is higher than PAA* (pH 8.4) due to higher swelling capacity of cellulose. There is no significant impact of ironing on the surface of cotton cellulose.

SEM micrograph of the fabric before laundering show an integrated structure and recognizable appearance of the cotton fibres. Laundering caused changes in cotton, due to its high swelling in the alkali media, the impact of bleaches, mechanical agitation and ironing. Generally, SEM images of tested fabrics show a signs of damage in the case of cotton fabrics after 10 cycles through disintegrated surface and fibrillation, Fig 2. The surface changes are more pronounced on samples laundered in a bath with PAA*.



a.



b.

Figure 1. Zeta potential of cotton fabrics in dependence of pH of 1 mmole/l KCl

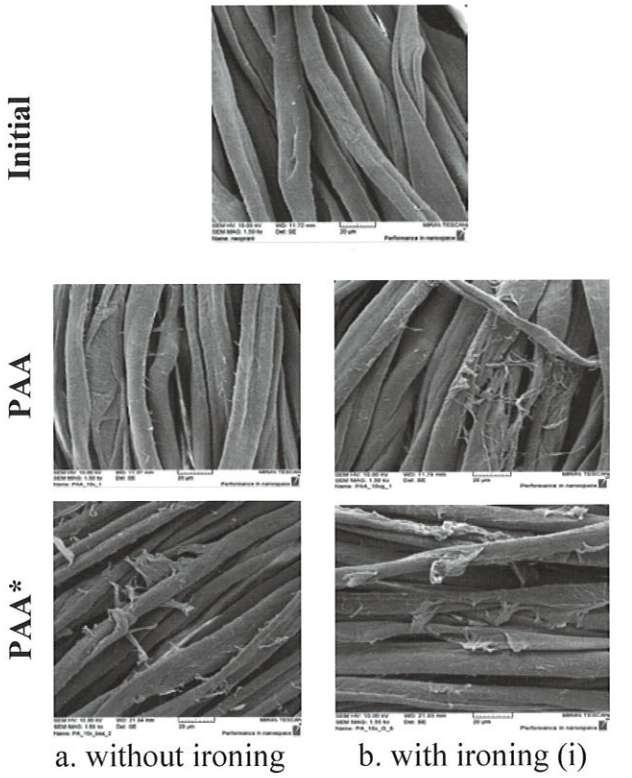


Figure 2. SEM images of cotton fabrics after 10 laundering cycles

4. CONCLUSIONS

Primary effect evaluated through total soil removal in laundering bath with the addition of PAA (pH 9.8) and PAA* (pH 8.4) varied in removal of protein and coloured stains. Blood was better removed at pH 9.8, while red wine was removed efficiently at pH 8.4. Secondary effects in laundering bath with PAA and PAA* proved that synergy of chemical and mechanical parameters impact on degradation of cotton fabrics and reduction of their mechanical properties. In general, PAA caused more pronounced changes of mechanical properties than chemical ones. Surface characterization of cotton fabrics by electrokinetic behaviour and SEM images proved to be convenient for evaluation of secondary effects. Finally, the overall results of primary and secondary effects showed that the application of peracetic acid in laundering is a sensitive procedure, so it necessary to optimize pH of laundering bath.

ACKNOWLEDGEMENTS

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More information on the project public website:
http://cordis.europa.eu/project/rcn/97981_en.html

Sandra Bischof
University of Zagreb Faculty of Textile Technology, Zagreb, Croatia

REINFORCING THE TEXTILE RESEARCH POTENTIALS THROUGH FP7 PROJECTS

Abstract

University of Zagreb, Faculty of Textile Technology was coordinating the FP7 project entitled Unlocking the Croatian Textile Research Potentials (T-Pot), funded by the European Commission in the amount of almost 1 million euro. This project was first in the row, aiming to reinforce textile research capacities of TTF. The main project goal was to upgrade institutional research capacities with emphasis on strengthening the cooperation with the industry. T-Pot project is funded under the Capacities funding scheme, where the activity of the integration of researchers and SMEs from the associated countries into the European Research Area is of great importance. This paper presents the review of the project activities such as purchase of top class equipment, training of researchers and industrial representatives and know-how transfer from the experts from the EU partnering institutions. The cooperation of the academy with the SMEs is a necessity which is consequently leading to their increased competitiveness outside the regional borders.

Keywords: FP7, FP7-REGPOT-2008-1:T-Pot, textile and clothing industry (T/C), innovations

1. INTRODUCTION

The overall objective of T-Pot was to unlock and upgrade the research potential of the Faculty of Textile Technology (TTF), particularly its newly established Textile Science Research Centre, enabling enhanced participation of Croatian textile organizations in research activities at the European level, in order to support the harmonisation and integration process of Croatian textile entities into the European Research Area.

The reinforcement of TTF's research potentials was done through the reinforcement of human and material potential, as well as the research infrastructure. Previously established Textile Science Research Centre (TSRC) was upgraded to become one of the components of the national innovation. Top scientists are attracted to the country for exchange of know-how and guidance of Croatian textile manufacturers.

That is why T-Pot addresses all major issues of improvement of research capacities, addressed in FP7 Capacities Work Programme: Research Potential, as topics for REGPOT-2008-1:

1. Reinforcement of S&T potential
2. Developing strategic partnerships with well established research groups
3. Supporting and mobilising the human & material resources
4. Facilitating communication between the centres having similar scientific interest
5. Disseminating scientific information and research results.
6. Improving the responses to socio-economic needs (of Croatia).

2. ABOUT THE PROJECT

The project has strong regional and national interest since TTF is the only HE institution in Croatia performing research activities in the textile and clothing sector. Textile Science Research Centre (TSRC), offering assistance in managing and counselling in the field of textile research, was significantly upgraded with the measures performed within this project. The Centre started to be the driving force of TTF's research and its major task is to strengthen links with other T/C research centres in EU or worldwide, so as with the industry at the other side.

The main purpose of one of the projects work packages (WP) was to develop strategic or twinning partnerships with related textile institutions. Purpose of such a partnership is pooling the experiences and collectively figures out the ways to address common problems. Through flexible framework collaboration common goals and objectives of knowledge based society were accomplished within the project.

Strategic partnerships were established with research institutions and SMEs from Germany, Spain, Poland and Italy (STFI, Leitat, INFMP and GZE), presented in Figure 1.

Several face-to-face visits were organized to partner institutions, in order to establish or upgrade new partnerships. The first visit was to Grado Zero Espace (GZE), Italy, at their new premises at Montelupo, Italy in May 2010.

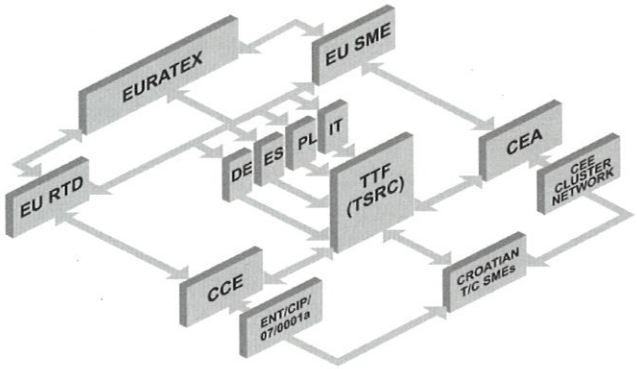

Figure 1. Cooperation scheme between Faculty of Textile Technology (TTF), its Textile Science Research Centre (TSRC), EU partners: STFI (DE), Leitat (ES), INF (PL), GZE (IT) and Croatian partners: Croatian Chamber of Economy (CCE) and Croatian Employers' Association (CEA) [1]

Next phase was organisation of research secondments of PhD students and researchers. The institutions involved were:

- EMPA, Switzerland
- INFMP, Poland
- University of Ljubljana, Slovenia
- University of Georgia, GA, USA
- University pf Leeds, UK
- LEITAT, Spain
- GZE, Italy.

Figure 2. T-Pot group with patented Quota zero jacket

Important part of the project was hosting of scientists.

The major advantage of hosting of chosen scientists was not only to have the honour to meet and listen top class scientist in different fields (e.g. FT-IR spectroscopy) and obtain new knowledge, but also to gain new contacts with other researchers, working on similar topic, who attended the seminars. Obtained know-how was of great importance for future carriers of many young scientists.

Further goal of T-Pot project was to improve scientific infrastructure according to EU standards. Therefore, two series of apparatus were purchased and located at two laboratories and offered a great benefit to scientific work. First serie is consisting of: FESEM (Field Emission Scanning Electron Microscope), EDS detector and sputtering device. Second one is consisting of: TGA (Thermogravimetric Analysis), DSC (Differential Scanning Calorimetry) and FT-IR (Fourier Transform Infra Red Spectroscopy).

Figure 3. Application of phosphorescent pigments at LEITATS premices, during one of the research secondments

Figure 4. Consultancy of Prof. Yang with TTFs PhD students at the premises of Textile Science Research Centre, Savska 16/9

Figure 5. New SEM Laboratory and researchers hired by T-Pot project

Part of the project was organization of in-house training events at partnering (host) institutions:

- LEITAT, Spain (topic: Functional finishing)
- Institute of Natural Fibres and Medicinal Plants, Poland (topics: Multifunctional fibres, Fibers reinforced composites)
- STFI, Germany, (topics: Technical textiles, Quality)
- GZE, Italy (topic: Functional Design),

so as the trainings organized in Croatia at the:

- Croatian Chamber of Economy (HGK), topic: Innovation,
- Croatian Chamber of Trades and Crafts (HOK), topic: Innovation management.

3. RESULTS

One of T-Pot's highest priorities was the improvement of scientific infrastructure in order to reduce the gap between our present state and EU standards. Investing in the equipment served another important purpose – to boost the development of applied research, development of methods, technologies, new products or services. Instrument supply significantly contributed to enhanced Croatian scientific capacity and targeted our research towards nanoscience and nanotechnology. Acquisition of the equipment in the area of morphological characterisation by SEM or thermal analysis by DSC, TGA and TG-FTIR techniques is significantly contributing to the reinforcement of Croatian internal scientific and technical capacities and enabling sharing the research resources with the project partnering institutions and SMEs. Our final results are sharing the research resources with a wider community and developing services in support of business and innovation.

Scientific cooperation, whether it regards use of equipment or project cooperation, takes place through the Textile Science Research Centre (TSRC) and its portal: http://www.ts-rc.eu. The long-term goal of the T-Pot project and the TSRC was to include as many Croatian SMEs and crafts as possible in the research activities of the European Research Area. It was done through the sustainable cooperation with the project partnering institutions and secondarily with any of the institutions in textile or related fields. TSRC, upgraded by the funds of T-Pot project, is open for further scientific cooperation.

4. CONCLUSION

Improvement of TSRCs scientific infrastructure served to important purpose – to boost the development of applied research, development of methods, technologies or new products. The acquisition of the chosen equipment is contributing to the reinforcement of Croatian internal scientific and technical capacities and enabling sharing the research resources with the project partnering institutions and SMEs. The expected final results include sharing the research resources with a wider community and developing services in support of business and innovation. The T-Pot project has gathered all the major stakeholders in the region in the field of textiless & clothing, becoming a strong point of knowledge transfer and industry support.

Future participation in the research activities of the European Research Area is enabled through joint research or new project initiatives, primarily with the project partnering institutions and secondarily with any of the institutions in textile or related fields.

Activities performed after the project finalization include continuous submission of project proposals, both to the national and international funding. Major goal of TTF's team is to establish stable funding for established TSRC. The possibility to enable it, we see in the funding scheme of Ministry of Science, Education and Sports (MoSES) – Centres of Excelence, where TTF had submited the proposal entitled Multifunctional Textile Materials (MTM). By extending Textile Science Research Centre (TSRC) of the Faculty of Textile Technology (TTF) to the Center of Excellence (CoE), interdisciplinary network of outstanding scientists who have a common goal: the development of advanced, environmentally-friendly multifunctional textile materials and products, will be achieved.

One of the specific objectives of MTM project is the implementation of research results into economy sector. The target group of SMEs is not only in textile sector but also in related areas such as defense, chemical, pharmaceutical, wood processing and creative industries.

Our further success is placement of project proposal entitled: Modernisation of Infrastructure of TSRC (MI-TSRC) at the indicative list of MoSES. Its funding is planned for 2016 from the ERDF 2014.-2020. funds.

ACKNOWLEDGEMENTS

The paper presents results of the EU project funded within the call FP7-REGPOT-2008-1, with grant 2298011, entitled: Unlocking the Croatian Textile Research Potentials (T-Pot).

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More information can be found on the project public website: http://www.t-pot.eu.

Ana Marija Grancarić[1], Ivona Jerković[1], Vladan Končar[2]
[1]University of Zagreb Faculty of Textile Technology, Zagreb, Croatia
[2]Ecole Nationale Supérieure des Arts et Industries Textiles, Roubaix, France

TEXTILE REINFORCED COMPOSITES WITH INTEGRATED SENSORS

Abstract

Smart textiles progressively play a significant role in the European textile sector and help the textile industry in its transformation into a competitive knowledge driven industry. Nowadays, the integration of electrical and electronic systems within fabrics *and composites* is completely viable with t*extile sensors which find usage in many areas including transport industry, medicine and sports. In the case of high performance textile reinforced composites, textile sensors can be integrated during the weaving process. After integration in the reinforcement they not only act as a part of structural material but also have actuating, sensing, and microprocessing capabilities. In this paper, sensor yarns were developed from E-glass/polypropylene (GF/PP) commingled yarn and implemented during weaving of 2D structures at the ARM loom due to checking the thermo-forming consolidation behavior as important factor for several future applications.*

Keywords: smart textiles, conductive polymers, sensor yarns, 2D weaving fabrics, composites

1. INTRODUCTION

When electronics are combined with textiles the resultant is commonly referred to as "smart" textiles which have a promising realm in science and technology because of commercial viability and public interests [1-3]. Smart textiles progressively play a significant role in the European textile and clothing sector and help the textile industry in its transformation into a competitive knowledge driven industry [4]. For textile reinforced composites one possible solution is to use intelligent textile materials and structures, which provide real possibility for *on line* and *in situ* monitoring of structural integrity. Such intelligent materials are made by coating or treating textile yarns, filaments, or fabrics with nanoparticles or conductive and semi conductive polymers giving them specified performance [5].

Sensors or conductive yarns embedded inside the textile reinforcements during the weaving process have to present all the characteristics of traditional textile materials: flexibility, lightweight and capability of adopting the geometry of the reinforcement. Therefore, it is important that sensors integration does not modify their general behavior [6]. Textile materials are very flexible and easily deformable in all directions, and sensors used should be able to support, often all at the same time, tensile, shear, bending and even compression deformations [7].

Two sub-classes of sensors that may be integrated into textile structures based on conductive polymers are intrinsically conductive polymers (ICP) and conductive polymer composites (CPC) [7,8].

Intrinsically conductive polymers (ICPs), also known as conjugated polymers and synthetic metals, are the class of polymeric materials that can conduct electricity.

Different types of conductive polymers such as poly(pyrrole), poly(aniline) and poly(3,4 ethylenedioxythiophene) can be prepared with a broad range of conductivities i.e. from 10^{-10} to 10^{+5} S/cm. Among the wide range of conjugated polymers already developed perhaps the diethoxy substituted thiophene poly(3,4-ethylenedioxythiophene) or PEDOT is one of the most promising conducting polymer because of its many advantageous properties such as excellent transparency in the visible range, high conductivity (>300 S/cm) and good thermal stability [7]. Polystyrene sulfonic acid (PSS), a water-soluble polyanion, can be used during the polymerization of PEDOT as a charge balancing dopant. The water-soluble PEDOT:PSS complex has electrical and film-forming properties, shows high conductivity, transparency and possesses great environmental stability. However, PSS itself is a nonconducting material, which limits the conductivity of the PEDOT:PSS complex to the 1-10 S/cm range [9].

Extrinsically conductive polymers (ECPs), conducting polymers (CPs), or conductive polymer composites (CPCs) are obtained by blending, generally by melt mixing, an insulating polymer matrix, thermoplastic or thermosetting plastic, with conductive fillers like carbon black (CB), carbon fibres or nanotubes, conductive polymers or metallic particles. Its conductivity values are much lower than the conductivity values of ICPs [7,8].

In this work, sensor yarns inserted during the weaving process of 2D structure were presented and validated before and after 2D structures consolidation [9].

2. EXPERIMENTAL PART

2.1. Sensor yarns production

Sensor yarns of one meter total length were made from E-glass/polypropylene (GF/PP) commingled yarn with fineness of 842 tex and GF/PP mass content of 71:29 produced by P-D Fibreglass Group, Germany. Aluminum roll to roll mechanism with plexiglass bath was developed for sensor yarns production to obtain even coating thickness and uniform distribution 1).

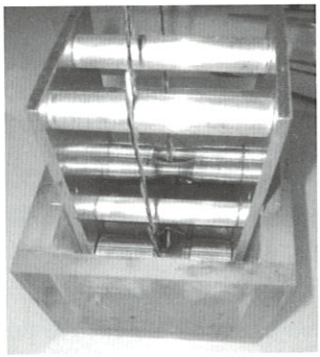


Figure 1. Roll to roll coating procedure: conductive coating process [9]

Coating speed of 0.2 m/min was taken during the process due to later slower drying of coated yarn at temperature of 170°C and distance less than 5 cm from the coated area. It is possible to produce ten or even more sensor yarns in one seria taking into account its final quality. Procedure was done at the Ecole Nationale Supérieure des Arts et Industries Textiles, ENSAIT, Roubaix, France.

Latex Appretan® 96100 50wt% (Clariant) was taken to insulate the sensor yarns for first and last coating steps. Mixture of Poly (3, 4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) CLEVIOS™ P FORM. CPP105D 1.3wt% (Heraeus) and Latex Appretan N96100 50wt% (Clariant) was used for conductive coating of yarns (two or three roll to roll coating layers). PEDOT:PSS/Latex solution in a ratio of 20:80 was prepared at ambient temperature. The ratio corresponds to the percolation threshold concentration studied earlier. Copper wires (Conrad), Φ 0.2 mm, were ligatured around the yarn in conductive coating area at distance of 5 cm as the effective sensor length. Additionally, conductive drops were applied only at places where wires were inserted to obtain its better connection with yarn. Length of copper wires is 1 m per each sample (Figure 2).

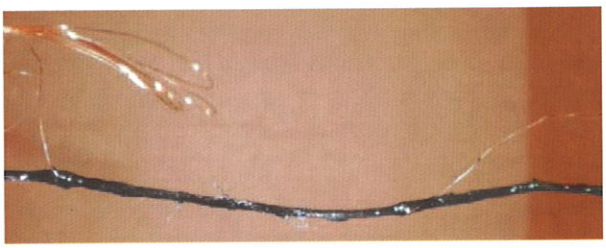


Figure 2. Sensor yarn

2.2. Sensor yarns implementation during the weaving of 2D structures

Pretests were made by insertion of four sensor yarns in weft (Figure 3) and four sensor yarns in warp direction during the weaving of 2D structures, 4-end satin weaves with repetiton at the ARM loom. GF/PP commingled yarn was used for the fabrics production as well.

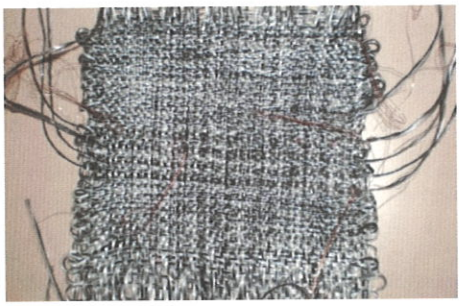


Figure 3. 2D structure with integrated sensors in weft direction [9]

Two stacks composed of three layers of 2D weaving fabrics with the middle layer with integrated sensor yarns were consolidated at the heating press under following conditions; temperature of 185 °C and pressure of 20-30 bar during 5 min (Figure 4) [9].

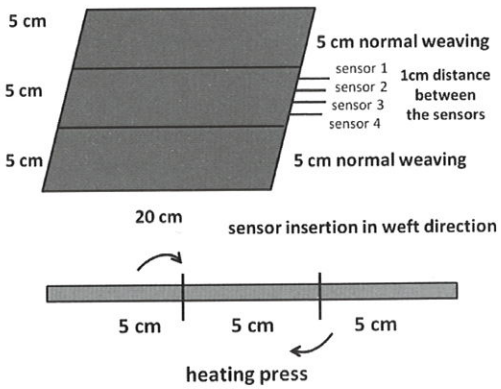


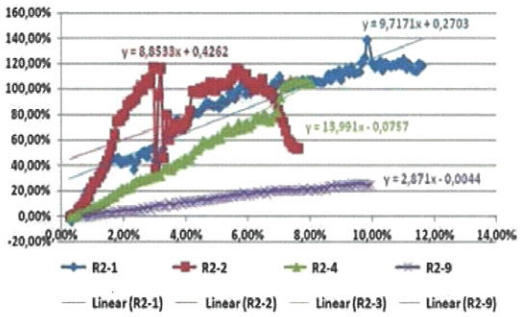
Figure 4. Scheme of weaving step and 2D structure arrangement for consolidation [9]

3. Results

Initial resistance of sensor yarns was measured after sensors development using a Keithley system and resistance box. Electromechanical tests of two and three roll to roll conductive coating GF/PP sensor yarns were done at MTS device by using speed of 100 mm/min with a pre-load of 0.5 N.

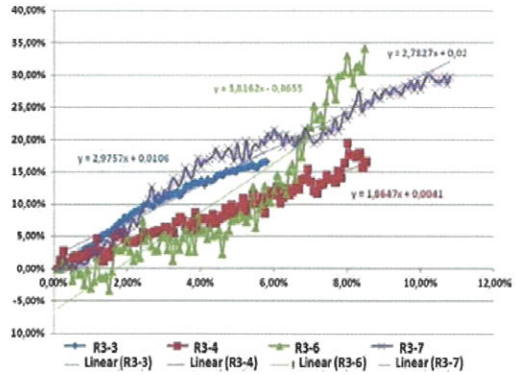
The electromechanical measurement is a combination of a strain and a resistance measurement made at the same time during a tensile test. The aim of electromechanical tests is to find the "k" factor, Eq. (1), between resistance variation and elongation:

$$\frac{\Delta R}{R0} = k \cdot \frac{\Delta L}{L0} \quad (1)$$



MEAN k= 8.8581
Stand. deviation 4.580

a.)



MEAN k= 2.8598
Stand. deviation 0.801

b.)

Figure 5. Electromechanical tests – graphs with $\frac{\Delta R}{R0}$ as y axes and $\frac{\Delta L}{L0}$ as x axes of sensor yarns: a) two roll to roll conductive coating layers, b) three roll to roll conductive coating layers [9]

According to electromechanical results three roll to roll conductive coating can be taken as better solution for sensor yarn production (Figure 5).

Initial resistance of sensor yarns after sensors development was measured also before and after consolidation of 2D structures with integrated sensors.

The aim is to develop sensor yarns workable after fabric consolidation and it is important to find better solution for its final validation. Tensile test at quasi-static speed and on-line monitoring of sensors can be done in that case.

4. CONCLUSION

Sensor yarns based on PEDOT:PSS were made from E-glass/polypropylene commingled yarn by new developed roll to roll procedure. It is possible to produce ten or even more sensor yarns in one seria taking into account its final quality. Two roll to roll conductive coating can be enough for sensor yarns preparation, but according to electromechanical results three roll to roll conductive coating can be taken as better solution. Mostly sensors work after its production and integration in 2D structures before consolidation, while its validation after consolidation of 2D fabrics has to be improved.

ACKNOWLEDGEMENTS

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HATZ News

2015 AWARDS OF THE CROATIAN ACADEMY OF ENGINEERING

The Presidency of the Croatian Academy of Engineering at its 13th Session held on April 18, 2016, has passed the decision of granting the 2015 Academy's Awards to the following nominees:

„THE POWER OF KNOWLEDGE" LIFE-LONG ACHIEVEMENT AWARD

Prof. Emer. Zlatko Kniewald, Ph. D.
Emeritus of the Academy
Secretary of the HATZ Department of Bioprocess Engineering (2013-2017)
President of the Academy (2003-2005 and 2005-2009)
Past-President of the Academy (2009-2013)
Chair of the HATZ Committee of the Scientific Fund (2005-2009 and 2009-2013)
University of Zagreb, Faculty of Food Technology and Biotechnology, Professor Emeritus (retired)

„RIKARD PODHORSKY" ANNUAL AWARD

Prof. Bojan Jerbić, Ph. D.
Member of the Academy
Secretary of the HATZ Department of Systems and Cybernetics (2013-2017)
University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Full Professor

Prof. Damir Ježek, Ph. D.
Member of the Academy
HATZ Department of Bioprocess Engineering
University of Zagreb, Faculty of Food Technology and Biotechnology, Full Professor and Dean

„VERA JOHANIDES" JUNIOR SCIENTIST AWARD

Tomislav Capuder, Ph. D.

University of Zagreb, Faculty of Electrical Engineering and Computing, Postdoctoral Researcher, Scientific Associate, Senior Scientific Assistant

Tomislav Pukšec, Ph. D.

University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Postdoctoral Researcher, Scientific Associate

Ana Belšak-Cvitanović, Ph. D.

University of Zagreb, Faculty of Food Technology and Biotechnology, Postdoctoral Researcher, Senior Scientific Assistant

Ivan Marović, Ph. D.
University of Rijeka, Faculty of Civil Engineering, Postdoctoral Researcher, Scientific Associate, Senior Scientific Assistant

The Awards shall be granted at the 31st Annual Assembly of the Academy (May 11, 2016, Great Hall of the University of Zagreb).

The Presidency of the Academy congratulates the distinguished awardees.

ACKNOWLEDGEMENTS TO THE DONATORS OF FUNDS FOR THE HATZ AWARDS

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Croatian Academy of Engineering
ACTIVITIES IN 2015

Meetings of the Academy's Bodies,
Academy's Auspices, Organization and Co-Organization of Meetings,
and Major Meetings of Public Interest in 2015

Meetings of the Academy's Bodies

The majority of the Academy's activities takes place in the Academy's Bodies: Departments, Standing Committees and Centers of the Academy, the Governing Board of the Academy, the Presidency of the Academy, the Scientific Council of the Academy and the Assembly of the Academy.

In 2015 HATZ Departments, Standing Committees and Centers have held more than 30 meetings in total. The activities included especially the procedures of election of new Emeriti, Members, Associates, International and Supporting Members of the Academy as well as procedures of evaluation of candidates for the Awards of the Academy and preparation of papers for the "Annual 2015 of the Croatian Academy of Engineering". The activities have also been strongly focused on the international cooperation of the Academy. Several Departments, Committees and Centers have prepared materials for the Guest Editorial participation in the Academy's Bulletin "Engineering Power".

The Governing Board has had 20 meetings, and the Presidency of the Academy has held 4 meetings, respectively, dealing with the most imminent as well as vital and long-term organizational and decision-making matters of the Academy's scientific, expert and professional activities, membership, finances etc.

The 30th Annual (Elective) Assembly of the Academy has been held on May 13, 2015 in the Great Hall of the University of Zagreb.

The Scientific Council of the Academy has had 2 meetings in 2015, dealing with domestic and international scientific cooperation and domestic scientific institutions' status and evaluation procedure. The Council had proposed peer-reviewers for the Academy's Awards candidacies and nominated members from the Academy's Departments to the editorial bodies of the Croatian Technological Encyclopedia, which is the joint project of the Croatian Academy of Sciences and Arts, Miroslav Krleža Institute of Lexicography and Croatian Academy of Engineering.

Academy's Auspices

- Faculty of Textile Technology in Zagreb – Scientific and Professional Colloquium "Textile Science and the Economy: Functional Materials, Clothing, Footwear and Accessories" (Zagreb, January 26, 2015)
- Faculty of Mechanical Engineering and Naval Architecture in Zagreb – Final Conference of the Projekt "Additive Technologies for Small and Medium Enterprises – AdTecSME" (Zagreb, March 11, 2015)
- 5th Domestic and 1st International Scientific and Professional Meeting "Water for All" (Osijek, March 20, 2015)
- Croatian Colours Association - International Colours Day 2015 (Zagreb, March 21, 2015)
- Croatian Association of Chemical Engineers and Technologists – 25th Croatian Meeting of Chemists and Chemical Engineers (Zagreb, Faculty of Chemical Engineering and Technology, April 21-24, 2015)
- 13th European Transport Congress (Zagreb, April 23-24, 2015)
- Croatian Society of Cartography – 11th Colloquium on Cartography and Geoinformation (Buzet, May 8, 2015)
- Croatian Energy Society – Presentation of Hrvoje Požar Foundation Annual Awards (Zagreb, July 6, 2015)
- Faculty of Geodesy in Zagreb – Professional and Scientific Meeting "Shareholders' Profile in Geodesy 3: Technological Development and Professions in Geodesy and Geoinformatics" (Zagreb, October 2, 2015)
- Faculty of Civil Engineering in Zagreb and Technological University in Prague – International Conference "Applications of Structural Fire Engineering – ASFE 2015" (Dubrovnik, October 15-16, 2015
- Faculty of Forestry in Zagreb – 26th International Conference on Wood Science and Technology "Implementation of Wood Science in Woodworking Sector" (within "Ambienta '15", Zagreb, Zagreb Fair, October 16, 2015)
- Faculty of Food Technology in Osijek and ICC – 8th International Congress "Flour-Bread '15" and 10th Croatian Congress of Flour Production and Processing Technologists "Flour-Bread '15" (Opatija, October 28-30, 2015)
- Faculty of Geodesy in Zagreb – 2nd Interdisciplinary Scientific Conference "The Western Balkans Meets the EU: Ongoings inside Geospatial Domain and Sustainable Development" (Zagreb, November 26-27, 2015)

Organization and Co-Organization of Meetings

- HATZ Department of Chemical Engineering and Pliva Croatia, Ltd., Zagreb – Scientific and Professional Meeting on Industrial Crystallization (Zagreb, January 23, 2016)
- HATZ Department of Systems and Cybernetics – Forum "Intelligent Transportation Systems" by Prof. Sadko Mandžuka, Ph. D. (Zagreb, February, 2016)
- 1st Joint Session of the Council and Coordination of the Four Academies (Croatian Academy of Engineering – HATZ, Academy of Medical Sciences of Croatia – AMZH, Academy of Legal Sciences in Croatia – APZH and Academy of Forestry Sciences – AŠZ) (HATZ, Zagreb, February 5th, 2015)
- HATZ and Croatian Engineers' Association - The Republic of Croatia Engineers' Day 2015 (under the auspices of HAZU and the Croatian Ministry of Economy) (Zagreb, March 2, 2015)
- HATZ Department of Transportation, HATZ Center for Traffic Engineering and Croatian Railway Traffic Employees' Syndicate – Round Table Discussion "The Necessity of Construction of the Lowland, Two-Gauge and Electrified Railway Rijeka-Zagreb-Botovo as a Section of the Corridor 11: Baltic-Adriatic i.e. Route C-65" (Rijeka, March 23, 2015)
- HATZ Department of Systems and Cybernetics – Forum "ICT in the Economy and at the University" by Prof. Željko Hocenski, Ph. D., Prof. Franjo Jović, Ph. D. and Prof. Niko Majdandžić, Ph. D.
- HATZ Department of Graphical Engineering and HATZ Center for Graphical Engineering – Symposium "Printing & Design 2015" (Zagreb, March 27, 2015)
- HATZ Department of Systems and Cybernetics and Faculty of Electrical Engineering and Computing in Zagreb – Forum "Elecrical Brain Signals" by Prof. Mario Cifrek, Ph. D. (Zagreb, April, 2015)
- 2nd Joint Session of the Council and Coordination of the Four Academies (HATZ, AMZH, APZH and AŠZ) (HATZ, Zagreb, April 13, 2015)
- Coorganization by Four Academies – Forum "Multidisciplinary Metrics for Prediction of Mental Resilience for Performing Stressful Jobs" (Zagreb, April 14, 2015)
- HATZ Department of Graphical Engineering, Graphical Faculty in Zagreb and Polytechnics in Zagreb – Lecture by Prof. Rajendrakumar Anayath, Ph. D., "A Foray into the Concept of Quality and How Its Focus Changed from Time to Time" (Zagreb, June 2, 2015)
- HAZU Scientific Council for Technological Development and HATZ Department of Systems and Cybernetics – Lecture "Cognitive Machines – A Challenge of Trans-Disciplinarity" by Prof. Bojan Jerbić, Ph. D. (June 11, 2015)
- Joint Forum by the Council of the Four Academies (APZH, HATZ, AMZH i AŠZ) - Prof. Davor Derenčinović, Ph. D., "Croatian Legal System After the Accession of the Republic of Croatia to the European Union" (Zagreb, June 16, 2015)
- 3rd Joint Session of the Council and Coordination of the Four Academies (HATZ, AMZH, APZH and AŠZ) (HATZ, Zagreb, June 29, 2015)
- HATZ Committee for Cooperation with the Economy and Regional Cooperation and Croatian Chamber of Commerce – Round Table Discussion "Application of New Technology in the Development of Alimentary Products – Situation in the EU and the Perspectives in the Republic of Croatia by 2020) (Zagreb, July 1, 2015)
- HATZ and HAZU – Round Table Discussion on Life and Work of Faust Vrančić (Zagreb, November 5, 2015)
- HATZ Department of Systems and Cybernetics and Faculty of Electrical Engineering and Computing in Zagreb – Presentation of the Book "Geometrical Linear Holography" written by Prof. Franjo Jović, Ph. D. (Zagreb, November 23, 2015)

Participation at the Major Meetings of Public Interest

- Croatian Academy of Sciences and Arts (HAZU) – Mini-Symposium "Science in Croatia" (Zagreb, February 5, 2015)
- Office of the President of the Republic of Croatia - Ceremony of Decorations Awarding (Zagreb, February 9, 2015)
- HAZU and Ruđer Bošković Institute – Commemorative Meeting for the Late Academician Branko Souček (Zagreb, February 10, 2015)
- Faculty of Civil Engineering in Zagreb - Jubilary Session anent the Faculty Day (Zagreb, February 20, 2015)
- Academy of Medical Sciences of Croatia (AMZH) – Forum "Brain and the Art" by Academician Vida Demarin (Zagreb, February 24, 2015)
- HAZU – Round Table Discussion "National Research and Innovation Infrastructure in the Strategy of Education, Science and Technology" (Zagreb, February 26, 2015)
- Faculty of Electrical Engineering and Computing (FER) - Public Presentation of the Projects of the Faculty of Electrical Engineering and Computing in Zagreb, Co-Funded by the European Fund for Regional Development within the EFRD Call "Strengthening the Capacities for Research, Development and Innovation" (Zagreb, February 26, 2015)
- EURAXESS – EURAXESS RISE Information Day (Zagreb, March 6, 2015)

- HAZU – G. I. D.-EMAN Conference Parmenides VII – Common Heritage and Technologies: Enhancement of Heritage, a Key to Development (Dubrovnik, March 16-19, 2015)
- HAZU – Lecture by Academician Vida Demarin "A Brain That Lasts – The Newest Understandings on Brain Health Preservation" (Zagreb, March 19, 2015)
- Forum "DNA Analysis in the Function of Convicts' Rights Protection: American Experiences and Croatian Perspectives" (Zagreb, March 20, 2015)
- Faculty of Textile Technology in Zagreb (TTF) – Scientific Forum "The New Classification of Substances and Materials – Polymers and Neo-Polymers" (Zagreb, March 26, 2015)
- HAZU Department for Medical Sciences and AMZH – Forum "Croatian Stomatology since Austro-Hungarian Monarchy till the European Union" (Zagreb, March 31, 2015)
- Faculty of Science in Zagreb - Department of Geology and Institute of Geology and Paleontology – International Conference anent the 100th Anniversary of Birth of Academician Vanda Kochansky-Devidé (Zagreb, April 9, 2015)
- Croatian Cartographic Society (CCS) and HATZ – Session of the CCS Presidency (Zagreb, April 10, 2015)
- Meeting of the Representatives of the Four Academies (Croatian Academy of Engineering, Academy of Medical Sciences of Croatia, Academy of Legal Sciences of Croatia and Academy of Forestry Sciences) with the Representatives of the Croatian President's Protocol (Zagreb, April 14, 2015)
- HAZU – Professional Discussion "Academic Community and the EU Funds" (Zagreb, April 15, 2015)
- Ruđer Bošković Institute – CroArtScia2015 – Technological Innovation: Art&Science" (Zagreb, May 27-30, 2015 and Sisak, May 29, 2015)
- Faculty of Civil Engineering in Zagreb – Promotion of the University Textbook written by Prof. Dubravka Bjegović, Ph. D. and Prof. Nina Štirmer, Ph. D., "Theory and Technology of Concrete" (Zagreb, June 10, 2015)
- Anniversary Celebration of the Croatian-Korean Business Club (Zagreb, June 15, 2015)
- Celebration of the 21th Energy Institute Hrvoje Požar Day (Zagreb, July 3, 2015)
- Croatian Statehood Foundation (ZHDZ) – International Security Conference 2015 (Zagreb, September 18, 2015)
- Ministry of Science, Education and Sports of the Republic of Croatia (MZOS) and University of Zagreb – Opening of the BIOCenter – Bio-Sciences and Commercialization Incubation Center (Zagreb, September 25, 2015)
- TTF – Scientific Forum "3D Printers and Their Application in Clothing Production" by Prof. Darko Gojanović, Ph. D. (Zagreb, September 25, 2015)
- Faculty of Geodesy in Zagreb – Jubilary Session anent the Faculty Day (Zagreb, September 25, 2015)
- HAZU – Lecture "Light in Graphical Technology and Visual Arts" by Prof. Emer. Vilko Žiljak, Ph. D. (within the Symposium "Man and Light") (Zagreb, September 29, 2015)
- Faculty of Transportation and Traffic Sciences – The Faculty Day (Zagreb, October 12, 2015)
- CAETS Council Meeting (New Delhi, India, October 12-16, 2015)
- Jubilary Session anent the 96th Anniversary of the Faculty of Chemical Engineering and Technology in Zagreb (Zagreb, October 20, 2015)
- Croatian Gas Association and INA, Inc. - Working and Jubilary Session anent 13th Gas Days (Zagreb, October 20, 2015)
- Faculty of Forestry in Zagreb – Jubilary Session anent the 117th Anniversary and the Faculty Day (Zagreb, October 23, 2015)
- HAZU – Celebration of the 200th Anniversary of Birth of Bishop Josip Juraj Strossmayer (Zagreb, October 27, 2015)
- University of Zagreb – Dies Academicus / University of Zagreb Day (Zagreb, October 30, 2015)
- Euro-CASE Annual Conference „Engineering Smart Cities of the Future", Board Meeting and Executive Committee Meeting (Delft and The Hague, Netherlands, November 2-3, 2015)
- MZOS – National Technological Culture Award "Faust Vrančić" 2014 Presentation Ceremony (Zagreb, November 9, 2015)
- HAZU Scientific Council for Technological Development Elective Assembly and Lecture by Prof. Nedjeljko Perić, Ph. D., "Nikola Tesla Innovation Center – A Link Connecting Science and the Economy" (Zagreb, November 17, 2015)
- Faculty of Electrical Engineering and Computing in Zagreb – The Faculty Day Celebration (Zagreb, November 20, 2015)
- AMZH – Forum "Onco-Plastic Approach to Surgical Treatment of Breast Cancer" by Prof. Zdenko Stanec, Ph. D. (Zagreb, November 24, 2015)
- Faculty of Geodesy in Zagreb - 2nd International Interdisciplinary Scientific Conference "Western Balkans Meets the EU: Ongoings Inside Geodetic Domain and Sustainable Development" (Zagreb, November 26-27, 2015)
- Faculty of Mining, Geology and Petroleum Engineering in Zagreb (RGNF) – The Faculty Day (Zagreb, December 4, 2015)

Melanija Strika
HATZ News Editor