Baltic Polymer
BPS
2023
Symposium 2023

BOOK OF ABSTRACTS

JELGAVA, LATVIA

SEPTEMBER 20-22, 2023

1862
RIGA TECHNICAL
UNIVERSITY

Organized by Institute of Polymer Materials

Faculty of Materials Science and Applied Chemistry, Riga Technical University

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PROGAMME

(CONFERENCE VENUE- The Latvian University of Life Sciences and Technologies (LBTU) at the Jelgava Castle)

	September 20
19.00-21.00	Welcome Drink- Pilsetas elpa, Pasta sala 1, Jelgava, LV-3001
	September 21
9.30-10.00	Registration- LBTU, Lielā iela 2, Jelgava, LV-3001
10.00-10.15	Opening -LBTU, Lielā iela 2, Jelgava, LV-3001
ORAL SESSION 1. Chairman: Prof. Remo Merijs-Meri	
10.15-10.45	**PLENARY**: INNOVATION FUND – NATIONAL RESEARCH PROGRAM FOR APPLIED RESEARCH DEVELOPMENT A. Anspoks Institute of Solid State Physics, University of Latvia, 8 Kengaraga Street, Riga, LV-1063, Latvia
10.45-11.00	INVESTIGATION OF RAW MATERIAL OF LITHUANIAN AND WESTERN UKRAINIAN FOLK HOME TEXTILE E. Kumpikaitė[1], D. Milašienė[1], O. Nykorak[2], L. Herus [2], T. Kutsyr[2], Ž. Rukuižienė[1], E. Nenartavičiūtė [3] [1]Department of Production Engineering, Kaunas University of Technology, Kaunas, Lithuania [2]Department of Folk Art, Institute of Ethnology of National Academy of Sciences of Ukraine, Lviv, Ukraine [3]Department of Exhibitions and Expositions, Open Air Museum of Lithuania, Rumšiškės, Lithuania
11.00-11.15	SYNTHESIS OF THERMOPLASTIC CELLULOSE ESTERS IN NOVEL IONIC LIQUID N. Savale[1], E. Tarasova[1], I. Krasnou[1], M. Kudryashova[2], I. Reile[3], A. Krumme[1] [1]Department of Materials and Environmental Technology, Tallinn University of Technology, Tallinn, Estonia [2]Department of Chemistry and Biotechnology, Tallinn University of Technology, Tallinn, Estonia [3]National Institute of Chemical Physics and Biophysics, Tallinn, Estonia
11.15-11.45	Coffee break

ORAL SESSION 2. Chairman: Dr.sc.ing., Natalja Savest

11.45-12.15 **PLENARY:**
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K. Haupt
CNRS Laboratory for Enzyme and Cell Engineering, Université de Technologie de Compiègne, Rue du Docteur Schweitzer, 60203 Compiègne, France

12.15-12.30 DEVELOMPENT OF NEW TRIPLET-TRIPLET ANNIHILATION PHENOMENA BASED MATERIALS FOR OPTOELECTRONICS
A. Bucinskas[1], A. Petrenko[2], P. Arsenyan[2], T-L. Chiu[3], O. Bezvikonnyi[1], D. Volyniuk[1], J. V. Grazulevicius[1]
[1]Department of Polymer Chemistry and Technology, Kaunas University of Technology, Kaunas, Lithuania
[2]Latvian Institute of Organic Synthesis, Riga, Latvia
[3]Yuan Ze University, Taoyuan City, Taiwan

12.30-12.45 IONIC LIQUIDS RECYCLING
I. Krasnou, A. Krumme
Department of Materials and Environmental Technology, Tallinn University of Technology, Tallinn, Estonia

12.45-13.00 DIRECT INJECTION MOLDING WITH OPTIMISED SCREWS AND ANALYTICS FOR ASSESSING THE MIXING QUALITY
G. Japins[1], J. Pape[2], R.-U. Giesen[1], H.-P. Heim[1]
[1] Institute of Material Engineering, Polymer Engineering, University of Kassel, Kassel, Germany
[2] PAPE GmbH, Porta Westfalica, Germany

13.00-14.00 Lunch

14.00-15.00 **POSTER SESSION WITH COFFEE, REFRESFMENTS, SNACKS**

ORAL SESSION 3. Chairman: Dr.sc.ing. U. Cabulis

15.00-15.15 CHARACTERIZATION OF WOVEN ELECTROMAGNETIC SHIELDING THERMOPLASTIC-FIBER COMPOSITES COMPARED TO NON-WOVEN ELECTROMAGNETIC SHIELDING CONCEPTS
T. Elsesser [1]; A. Ries [1]; H.-P. Heim[2]
[1]Bielefeld Institute for Applied Materials Research, Bielefeld University of Applied Sciences, Bielefeld, Germany
[2]Institute of Materials Engineering, University of Kassel, Kassel, Germany

15.15-15.30 POLYMER COMPOSITES FOR FRICTION AND SEALING UNITS OF TECHNOLOGICAL EQUIPMENT
O. Kabat, V. Sytar, J. Zicans, R. Merijs-Meri (Zoom presentation)
[1]Ukrainian State University of Chemical Technology, Dnipro-City, Ukraine
[2]Institute of Polymer Materials, Riga Technical University, Riga, Latvia

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K. A. Jefimova[1,5], U. Eismonts[2], A. Ščerbicka[3], K. Saleniece[2], A. Actiņš[1], R. Stūrmane[4], A. Kons[1], I. Reinholds[1,5], M. Bērtiņš[1], A. Vīksna[1], G. Ķizāne[5], A. Grīnbergs[5]

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[3]Agenskalns State Gymnasium, Riga, Latvia
[4]Riga State Gymnasium No. 1, Riga, Latvia
[5]Institute of Chemical Physics, University of Latvia, Riga, Latvia

15.45-16.00 HIGH PERFORMANCE EMI SHIELDING POLYMER COMPOSITES

S. Gaidukovs, M. Bleija, O. Platnieks

Institute of Polymer Materials, Faculty of Materials Science and Applied Chemistry, Riga Technical University, Latvia

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A CONTRIBUTION TO CIRCULARITY OF PLASTICS: THERMOPLASTICS LIGHTWEIGHT MATERIALS, BIO-BASED PLASTICS AND MATERIAL-FLOW-ORIENTED RECYCLING

Maik Feldmann

Head of Business Unit Polymer Applications at Fraunhofer Institute for Microstructure of Materials and Systems IMWS - Halle/Germany
Head of Polymer Processing Fraunhofer Pilot Plant Center for Polymer Synthesis and Processing PAZ - Schkopau/Germany
Professor for Polymer Processing - University of Applied Science in Merseburg/ Germany

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V. Klimkevičius[1,2], G. Jarockyte[2], K. Bolgova[1], A. Katelnikovas[1] and V. Karabanovas[2]

[1]Institute of Chemistry, Vilnius University, Naugarduko 24, LT-03225 Vilnius, Lithuania
[2]Biomedical Physics Laboratory of National Cancer Institute, Baublio 3B, LT-08406, Vilnius, Lithuania

9.45-10.00 DESIGN AND SYNTHESIS OF THE DONOR-ACCEPTOR-DONOR TADF MOLECULES FOR APPLICATION IN OLED

N. S. M. Jamel[1], L. Skhirtladze[2], M.K. A. Wahab[1], K. L. Woon[3], A. A. Hussein[4], J. V. Grazulevicius[2] and A. Ariffin[1,2]*

[1]Department of Chemistry, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.
[2]Department of Polymer Chemistry and Technology, Faculty of Chemical Technology, Kaunas University of Technology, Lithuania.
[3]Department of Physics, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur, Malaysia
[4]Department of Medical Laboratory Science Komar University of Science and Technology Sulaymania, 46001, Iraq

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R. Rutkaite
Department of Polymer Chemistry and Technology, Kaunas University of Technology, Kaunas, Lithuania

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C.L. von Boyneburgk[1], J.C. Zarges[1], H.-P.Heim[1]
Institute of Material Engineering, Polymer Engineering, University of Kassel, Kassel, Germany

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Department of Materials and Environmental Technology, Tallinn University of Technology, Tallinn, Estonia

11.30-11.45 UV CURING COATINGS ON NATURAL NAILS
Z. Grigale-Sorocina, I. Birks
Kinetics Nail Systems, Ltd

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J. Jaunbergs
SIA TENACHEM, member of the SOUDAL GROUP

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POSTER SESSION

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5.	**EFFECT OF CARBOXYLIC ACIDS AND TANNIC ACID AS COMPATIBILIZER ON MECHANICAL PROPERTIES OF RECYCLED POLYOLEFIN COMPOSITES WITH NATURAL FIBERS** A. Ābele, R. Bērziņa, I. Bočkovs, S. Motrončiks, J. Zicāns, R. Merijs-Meri, R. Bērziņš Institute of Polymer Materials, Faculty of Materials Sciences and Applied Chemistry, Riga Technical University, Riga, Latvia
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40.	**XRD and SEM/EDS STUDIES OF COBALT SULFIDE LAYERS ON POLYAMIDE 6** K. Vaičiukynaitė[1], R.Ivanauskas[1], S. Žalenkienė[1] [1]Department of Physical and Inorganic Chemistry of Kaunas University of Technology, Lithuania
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42.	**ELECTROSPUN MATERIALS IN TRIBOELECTRIC SERIES** N. Savest[1], I.Krasnou[1], A. Krumme[1], I. Dobryden[2], K. Håkansson[2], J.Edberg[3] [1]Laboratory of Biopolymer Technology, Tallinn University of Technology, Tallinn, Estonia [2] Bioeconomy and Health, RISE Research Institutes of Sweden, Drottning Kristinas väg 61, Stockholm, SE-114 28 Sweden [3] Printed-, Bio- and Organic Electronics, RISE Research Institutes of Sweden, Bredgatan 35, Norrköping, SE-602 21 Sweden

43.	**FEATURES OF THE PROCESSING THE POLYMER MIXTURE WASTE BASED ON GLASS-FILLED POLYAMIDE** S. V. Prystynskyi[1,2], V. P. Plavan[1] [1]Department of Chemical Technologies and Resource Saving, Kyiv National University of Technologies and Design, Ukraine [2]LLC Kostal Ukraine, Pereyaslav, Kyiv Region, Ukraine
44.	**POLYAMIDES MODIFIED BY COMPOUNDS WITH SILOXANE GROUPS** V. Sytar[1], O. Kabat[1], A.Ābele[2], R. Bērziņš[2] 1Ukrainian State University of Chemical Technology, Dnipro-City, Ukraine 2Institute of Polymer Materials, Riga Technical University, Riga, Latvia
45.	**DEVELOPMENT OF BIOBINDERS WITH IMPROVED PERFORMANCE AND ANTIOXIDANT PROPERTIES BY PARTIAL SUBSTITUTION OF BITUMEN WITH LIGNIN** V.Haritonovs[1], R. Merijs-Meri[2], J. Zicans[2], V. Straupe[1], V. Zabolotnii[3], M. Tamosiunas[3], R. Viter[3], A. Arnautovs[4] [1]Department of Roads and Bridges, Riga Technical University, Kipsalas street 6a, Riga, LV-1048, Latvia [2]Department of Polymer Materials Technology, Riga Technical University, Paula Valdena street 3, Riga, LV-1048, Latvia [3]Institute of Atomic Physics and Spectroscopy, University of Latvia, Jelgavas street 3, Riga, LV-1004, Latvia [4]Institute of Mechanics of Materials, University of Latvia, Aizkraukles street 23, Riga, LV-1006, Latvia

INNOVATION FUND – NATIONAL RESEARCH PROGRAM FOR APPLIED RESEARCH DEVELOPMENT

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In this talk I will summarise current activities in applied research development through national research programs in Latvia. The innovation fund is geared towards innovation development and pools the efforts of leading national institutions. This research program develops skills in mutual collaboration to solve existing market needs and create opportunities for new emerging industries. I will focus on the challenges and success factors that we have learned from our current development. The current topics of this program cover a wide range of materials and applications: from polymers to oxides, from photonics to packaging. I will also present possible future roadmaps that can multiply the impact of the current results.

Acknowledgement
This research is funded by the Latvian Council of Science, project "Smart Materials, Photonics, Technologies and Engineering Ecosystem" project No VPP-EM-FOTONIKA-2022/1-0001

INVESTIGATION OF RAW MATERIAL OF LITHUANIAN AND WESTERN UKRAINIAN FOLK HOME TEXTILE

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Lithuanian and Western Ukrainian home textile is one of the most important and beautiful part of tangible heritage in both countries. The main objects of this heritage are folk towels and bedspreads. One of the main structural parameters of folk textile is its raw material.

Home-made or rarer bought material was the most often used for folk Lithuanian and Western Ukrainian towels. Home-made materials were linen, hemp, tows, etc. In the end of the 19th century cotton yarns started to be used. Warp of folk towels was usually made from linen or cotton yarns and from tow yarns for household towels. Weft often was from linen, hemp or tow. Hemp was rare used in Lithuania; it was more common in Ukrainian towels. Often the warp was of bleached linen or white cotton and weft was of natural colour linen yarns. Sometimes the linen weft was lightly dyed with oak's bark; the pattern of such towels was more expressed in the background of white warp.

Raw material of folk bedspreads was more diverse in both countries. Warp the most often was cotton, linen, hemp (in Ukraine) or tow (for everyday bedspreads), but the variety of weft raw material was higher. Apart of the same composition as the warp, wool and since the 4th decade of the 20th century silk (in Lithuania) was used for the weft of bedspreads. Also the variety of bedspreads colours was more diverse in comparison to folk towels.

Thus, it can be seen that the tendencies of raw material in Lithuania and Western Ukraine were similar, but also had some unique features. It is important results for manufacturers of reconstructions of folk textile in both countries.

Acknowledgement

This investigation was supported by the Lithuanian Research Council and the Ministry of Education and Science of Ukraine [grant number in Lithuania S-LU-22-5, in Ukraine M/21-2022].

SYNTHESIS OF THERMOPLASTIC CELLULOSE ESTERS IN NOVEL IONIC LIQUID

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The production of thermoplastic polymers, primarily derived from nonrenewable sources like oil, is leading to environmental issues such as pollution and depletion of natural resources. Consequently, there is an urgent requirement to identify sustainable alternatives. Cellulose, an abundant and carbon-neutral renewable material, holds great potential as a raw material in diverse industries including food, paper, textiles, cosmetics, pharmaceuticals, and biomaterials. By means of esterification, cellulose can be chemically modified and transformed into valuable derivatives with desirable properties like thermoplasticity. Ionic liquids (ILs) have emerged as highly promising sustainable solvents for dissolving cellulose, enabling the production of homogenous functionalized cellulose esters with numerous industrial applications in plastics, coatings, and films. The objective of this study was to synthesize different cellulose esters in a novel distillable ionic liquid called 5-methyl-1,5,7-triazobicyclo-[4.3.0]non-6-enium acetate [mTBNH][OAc], eliminating the need for external catalysts. To reduce the viscosity of the overall solution, the co-solvent DMSO was added. Optimization of reaction parameters, such as co-solvent content, temperature, time, and reactant ratios, was carried out. The structure and degree of substitution (DS) of the cellulose esters were verified using advanced analytical techniques including FTIR and NMR. The thermal properties of the cellulose esters were evaluated using DSC, while their flow behavior as thermoplastics was studied using rheology. The findings of this study indicate that transesterification of cellulose with vinyl esters in ionic liquids is a promising environmentally friendly alternative to conventional esterification methods. The use of the novel distillable ionic liquid, [mTBNH][OAc], for cellulose ester synthesis without the need for external catalysts contributes to a more sustainable environment. The incorporation of the co-solvent DMSO reduced the dissolution time for cellulose and decreased the viscosity of the final solution, thereby making the overall synthesis more cost-effective. Therefore, this study presents exciting opportunities for utilizing cellulose as a sustainable raw material across various industrial applications. The study also opens the use of bio-based co-solvents and esterfication agents to further enhance the sustainability.

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MOLECULARLY IMPRINTED POLYMER NANOGELS - SYNTHETIC PEPTIDE ANTIBODIES FOR BIOMEDICAL THERAPY AND DIAGNOSTICS

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Molecularly imprinted polymers (MIPs) [1] are synthetic antibodies that specifically recognize molecular targets. They are cross-linked polymers synthesized in the presence of a molecular template, which induces three-dimensional binding sites in the polymer that are complementary to the template in size, shape and chemical functionality. MIPs against proteins are obtained through a rational approach starting with in silico epitope design. Chemically synthesized peptide epitopes can then be used as templates in a solid-phase protocol for MIP synthesis. We demonstrate the potential of MIP nanogels for diagnostics, bioimaging and medical therapy, on the example of cell surface as well as soluble protein targets.

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DEVELOMPENT OF NEW TRIPLET-TRIPLET ANNIHILATION PHENOMENA BASED MATERIALS FOR OPTOELECTRONICS

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Numerous degradation mechanisms of organic light emitting diodes (OLEDs) that influence their lifetime were identified up today. For example, photochemical, electrochemical degradation, thermal or electric breakdown, presence of impurities etc.[1] Additionally, triplet-triplet or triplet-polaron annihilation (TTA or TPA) phenomena were also identified as the degradation mechanisms mostly observed for blue OLEDs with employed materials which possess long-lifetime high-energy triplet excitons [2]. One of main solutions is the search of new type of materials with much lower triplet energy (less than 1.8 eV) which employ TTA mechanism in the generation of singlet exciton followed by formation of photon. Most of efficient TTA emitters found by far are based on anthracene core [3]. In our work, in the search of potential TTA emitters we synthesized several groups of materials by introducing cyanotriphenylbenzene and anthracene core, respectively. In both series of new compounds various 3,6-disubstituted carbazole fragments were introduced into main structure.

The results of investigation of the thermal, photophysical, electrochemical, photoelectrical and charge-transporting properties of newly synthesized TTA emitters will be reported together with the potential results of their performance in OLEDs.

Acknowledgement

This work was supported by the project of scientific cooperation program between Latvia, Lithuania and Taiwan (grant LV-LT-TW/2023) and Research Council of Lithuania (LMTLT), Agreement No S-LLT-22-4.

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IONIC LIQUIDS RECYCLING

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Extraordinary prices and lack of efficient recovery technologies limits scale-up utilization of ionic liquids [1]. Ionic liquid recycling refers to the process of recovering and reusing ionic liquids. Their widespread use has raised concerns about their environmental impact and cost, leading to the development of recycling methods.

The recycling of ionic liquids typically involves the following steps:

Collection: Collected from industrial processes or research laboratories liquids may contain impurities or be mixed with other substances.

Purification: The collected ionic liquids undergo purification processes to remove impurities, contaminants, and any other undesired substances. Purification methods can include distillation, solvent extraction, adsorption, or membrane filtration, depending on the specific properties of the ionic liquid and the contaminants present.

Characterization: After purification, the ionic liquid is characterized to ensure it meets the required quality standards. This step involves analyzing the physical, chemical, and spectroscopic properties of the liquid to verify its composition and purity.

Reconditioning: If necessary, the ionic liquid may undergo reconditioning processes to restore its desired properties or to adjust its composition to meet specific application requirements. Reconditioning can involve adding certain additives or modifying the ionic liquid's structure.

Reuse or Disposal: Once the recycled ionic liquid meets the desired specifications, it can be reused in the same or different applications. Reusing the ionic liquid reduces the demand for new production and minimizes environmental impact. However, if the recycled ionic liquid cannot be reused due to degradation or excessive impurities, it may be disposed of properly according to environmental regulations.

The recycling of ionic liquids offers several advantages, including cost savings, reduced waste generation, and decreased environmental impact associated with the production and disposal of new ionic liquids. By implementing effective recycling strategies, industries can optimize their resource utilization and contribute to a more sustainable and efficient chemical process.

Acknowledgement

RESTA10 by Estonian Research Council

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DIRECT INJECTION MOLDING WITH OPTIMISED SCREWS AND ANALYTICS FOR ASSESSING THE MIXING QUALITY

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The standard process chain in plastics processing involves the compounding of initial polymers with additives by using for example a twin-screw extruder. The resulting granulate is then further processed into products with injection molding. Direct injection molding instead is a combination of preparation (compounding) and shaping (injection molding) in one process. It makes production faster, cheaper, more energy efficient and more flexible, which would allow much faster variate composition of compounds due to fewer technological steps. Nevertheless, despite all advantages that direct injection molding can have, it is still not popular in the industry due to the challenges it brings. The most significant one is the mixing of several polydisperse, organic and inorganic materials with a one screw machine. In current research the solution is the replacement of the original screw in a conventional injection molding machine with special mixing screws with a specific design to achieve higher mixing quality [1, 2]. In this research, various screw configurations were tested and estimated. The mixing quality of all produced materials was compared with the output of a standard screw and a standard compounding material (twin-screw extruder). Materials used for mixing were a styrene-based elastomer, polypropylene and a calcium carbonate powder. Mixing quality was evaluated with x-ray microtomography, Shore A hardness tests and visual assessment. It was found that a clear and robust solution for rapid and qualitative assessment of the degree of mixing is difficult to find.. Nevertheless, it was found that direct injection molding can be a perspective manufacturing approach for future productions.

Acknowledgement

The study was carried out as part of the German state-funded project "Development of direct compounding processes for the manufacture of single-use medical products (MeDiComP)"

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CHARACTERIZATION OF WOVEN ELECTROMAGNETIC SHIELDING THERMOPLASTIC-FIBER COMPOSITES COMPARED TO NON-WOVEN ELECTROMAGNETIC SHIELDING CONCEPTS.

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As a result of necessary weight reductions and increasing proportions of functionally integrated, modular systems, the construction and production methods are becoming increasingly compact and complex. Thus, in addition to metallic materials, plastics are increasingly being used. In contrast to metallic materials, fiber-reinforced plastics have significantly lower densities with comparably high strength characteristics. Consequently, fiber-reinforced plastics offer a high, specific lightweight construction potential with regard to possible applications in electromobility concepts. At the same time, however, high demands are placed on the functional and component safety of housings for electronic devices and systems that contain sensitive sensors, applied and conductive elements. Undesirable electromagnetic couplings between the electrical modules must be avoided. Plastics are dielectric, however, so magnetic and electric fields can pass through the plastics attenuated. This can cause stray fields to emanate from the individual electrical components, which in turn can cause interference in neighboring circuit parts and even lead to significant failures of the electronics. The aim of this research is to develop glass fiber composite semi-finished products with integrated, cost-effective protection against electromagnetic influences based on unidirectional tapes and commercially available metal-coated polymer woven materials. These composites are to be compared with already explored composites with a metalcoated non-woven polymer fabric EMI layer. For this purpose, glass fiber thermoplastic composites with various functional layers to form metallized woven fabric were produced by hot pressing. The samples were analyzed and, based on this, the processing procedure was optimized to achieve optimum consolidation of the hybrid composite. A particular challenge is that the shielding component must remain intact in all process steps in order to ensure the highest possible shielding effectiveness over a wide frequency range. The subsequent comparison of the specially analyzed quasi-static and dynamic properties of the hybrid composite concepts by means of quasi-static tensile and 3-point-bending tests as well as shear load tests complete the investigation portfolio. From this, a comparison of the two concepts of non-woven vs. woven fabric is derived with regard to the composite properties. This research and development project is funded by the German Federal Ministry of Education and Research (BMBF) within the “Forschungscampus” program (funding number 02P18Q750) and implemented by the Project Management Agency Karlsruhe (PTKA).

POLYMER COMPOSITES FOR FRICTION AND SEALING UNITS OF TECHNOLOGICAL EQUIPMENT

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Polymer composites (PCs) occupy leading positions among other structural materials in modern mechanical engineering.

It is known that according to BBC Research Report Overview "Engineering Resins, Polymer Alloys and Blends: Global Markets" by April 2022, the global market of structural polymers and composites based on them will increase from $70.7 billion in 2021 to $94.0 billion by 2026. Taking into account a number of unique properties (low level of density with fairly high strength values, resistance to the action of aggressive environments, the possibility of working in friction and sealing units without and with insufficient oiling, etc.) PCs are especially often used in friction and sealing units of technological equipment [1-3]. It is known [4] that friction and sealing units make the greatest contribution to the reliability and durability of technological equipment.

Therefore, it is an urgent task to develop such PCs that have a better level of properties than analogues used in friction and sealing units of technological equipment, which will allow to significantly improve its level of reliability and durability.

We developed PCs based on fluoropolymers and aromatic polyamides [4,5]. Density of these materials is in the range from 1370 to 2200 kg/m^3, stresses at the yield strength and elastic modulus under compression reaches to 280 and 3600 MPa, нardness reaches to 250 MPa. Also developed PCs have high level of heat resistance (to 460^{o}C) and Vicat softening temperature (to 330^{o}C). It can be stated that the developed PCs exceed metal alloys and approach low-carbon steels in terms of their physical and mechanical properties. At the same time, according to the investigated properties, they are at the same level and exceed the best foreign analogues based on polymers [6,7].

Accordingly, it can be argued that the developed PCs when used in friction and sealing units of technological equipment will contribute to the improvement of its reliability and durability than the analogues in use.

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SYNTHESIS OF ACTIVATED CHARCOAL / FERRIC FERROCYANIDE HYBRID COMPOSITE MATERIALS FOR REMOVAL OF RADIOACTIVE CESIUM FROM WATER

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The invasion of the Russian Federation in Ukraine and the deployment of nuclear warheads in the Belarusian territories raise concerns of potential cross-border threats of radioactive fallouts from the Nuclear Power Plants and danger to neighbor countries including Latvia attributed to contamination of water, soil and food sources with radioactive cesium (Cs-137) causing threats to human beings and animals.

Radiogardase-Cs is the antidote for Cs-137 based on the solid form of ferric ferrocyanide better known as Prussian Blue (PB), which is approved in in many European countries, and the United States of America, whereas it is not presently accessible within Latvian pharmaceutical channels. There are not available proper water decontamination sorbents.

Based on the study of PB oral antidotes this study is dedicated to modification of by physicochemical (ultrasonic) assisted and eco-safe mechanochemical methods resulting in structure modified PB (SMPB) nanoparticles with adjusted size/structure for improved sorption of radioactive cesium from water sources. The SMPB nanoparticles were used for the development of nanocomposite materials with wood based activated charcoal (AC) composites with different SMPB/AC ratios. Physicochemical methods based on Fourier-transform infrared spectroscopy, X-ray diffractometry (XRD) and X-ray fluorescence spectroscopy (XRF) and other methods were used to characterize the composites.

Water decontamination tests were provided based on artificially contaminated drinking, water samples with stable cesium (Cs-133) salts followed by provided model studies of cesium sorption- desorption mechanisms depending on the characteristics of the SMPB/AC. Changes of cesium concentration were monitored by using inductively coupled plasma mass spectrometry (ICP-MS) method and conformed sufficiently high adsorption of Cs from water based on optimized sorbent conditions.

The characteristic 111 and 333 reflexes of the cubic lattice were for the the first determined by the XRD method, which until now were found only by neutron diffractometry. Their presence and precise measurements of intensities allow to assess their correlation with the sorption properties of cesium ions in Prussian blue.

From the results it can be concluded that effective and ecosafe SMPB/AC sorbent was developed for the decontamination of water from Cs-137.

Acknowledgement

Funding from the Ltd. "MikroTik" supported University of Latvia Foundation project "Creating extemporaneous prescription of highly toxic and radioactive compounds of cesium, thallium and rubidium antidote" is acknowledged.

HIGH PERFORMANCE EMI SHIELDING POLYMER COMPOSITES

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The escalating challenges in safeguarding society against military, cyber, and hybrid threats have underscored the necessity for novel defence strategies. Among these challenges, securing mission-critical equipment and vital infrastructure against electromagnetic threats stands out. Key components of society's functioning, such as energy distribution networks, information and communication technologies, transportation systems, security mechanisms, and financial stability, are all vulnerable to electromagnetic interference (EMI). Despite modern advancements, mitigating high-frequency EMI remains a formidable issue.

A particularly concerning aspect is the proliferation of relatively compact, cost-effective yet potent high-frequency devices in the possession of terrorist groups. This dynamic threat landscape introduces new complexities. Addressing these challenges presents a significant opportunity for the advancement of emerging advanced polymer materials tailored for cybersecurity applications.

Acknowledgement

This research was funded by the Latvian State Research Program for Defense Innovation, Project “Enhanced electromagnetic protection and cybersecurity through field-deployable innovative shielding, monitoring and data destruction technologies”, Nr. VPP-AIPP-2021/1- 0007.

A CONTRIBUTION TO CIRCULARITY OF PLASTICS: THERMOPLASTICS LIGHTWEIGHT MATERIALS, BIO-BASED PLASTICS AND MATERIAL-FLOW-ORIENTED RECYCLING

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In the last few years, in addition to the reduction of CO_2 emissions by using renewable raw materials, for example, the aspect of "sustainability through increased recycling management" has also become increasingly important. Some future scenarios assume that in the middle of this century just a low 2-digit percentage of plastic products will consist of renewable raw materials and that these will also have to be recycled in order to meet losses but also the increasing demand for raw materials due to global growth. Some of these goals are already being addressed through increasing regulation, such as increasing recycling quotas. However, there is also a drive towards independence from fossil raw materials, which is also a major global dependency for many countries.

The demand for more circularity gives rise to many different technical issues and challenges. On the one hand, new materials are being developed and researched, especially from alternative raw material sources. On the other hand, functioning material cycles and recycling processes already exist for some material flows, which are partly opposed to the material diversity and innovations. At this point, e.g., cascading recycling concepts can be advantageous, whereby the complexity increases arbitrarily and support by IT-supported evaluation software becomes necessary in order to optimize the different criteria as much as possible.

In addition to the material aspects, suitable design methods for weight reduction in combination with comparatively easy-to-recycle materials are also playing an increasingly important role. Many thermoset applications are increasingly being implemented with thermoplastic materials, and ideally with a minimum amount of material, such as in the area of load-path-compliant reinforcement with continuous fibers.

The presentation highlights different aspects and presents examples from ongoing projects at the Fraunhofer IMWS in Halle and Schkopau in cooperation with Merseburg University of Applied Sciences and other research institutes.

POLYMER BRUSH COATED UPCONVERTING NANOPARTICLES WITH IMPROVED COLLOIDAL STABILITY AND CELLULAR LABELING

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Upconverting nanoparticles (UCNPs) hold significant potential for biomedical applications, particularly in the fields of cancer treatment and imaging. These nanoparticles possess the ability to absorb near-infrared (NIR) light and convert it into visible (Vis) and ultraviolet (UV) radiation. The NIR excitation enables deep tissue penetration through the 'biological NIR window.' The emitted UV-Vis and NIR photons can be utilized for cancer therapy and imaging, respectively, making UCNPs highly valuable for combined diagnostics and therapy [1]. However, the synthesis procedure of UCNPs involves the use of organic solvents, resulting in their hydrophobic nature, which leads to unstable behavior in aqueous solutions and poor biocompatibility. To address this issue, the surface of UCNPs can be coated with amphiphilic polymers or phospholipids, which not only hydrophilize the UCNPs but also facilitate the attachment of various biomolecules [2].

In this study, we demonstrate the successful surface modification of $LiYF_4$: Tm^{3+},Yb^{3+} UCNPs *via* exchange of hydrophobic oleate ligands with custom-made anionic polyelectrolytes p(MAA-*co*-PEG_9MEMA). We have observed that the composition of the synthesized polyelectrolytes affects the stability and optical properties of UCNPs. Our results demonstrated that the number of anchoring anionic groups in the polymer has a greater effect on the long-term colloidal stability of UCNPs than the number of PEGylated substituents. UCNPs modified with the P_9MAA-75 polyelectrolyte, containing a large number of anionic anchoring groups, showed exceptional long-term stability in all three investigated media: DI water, DMEM, and DMEM + 10% FBS. Furthermore, the surface modification with a highly charged P_9MAA-75 polyelectrolyte yielded additional increase of their upconversion emission intensity as compared to that of the bare UCNPs. Finally, the polymer coating has a vital role in UCNP cellular uptake. In protein-rich media, UCNPs modified with the P_9MMA-25 polyelectrolyte exhibit higher cellular accumulation compared to P_9MMA-75 modified counterparts. On the other hand, P_9MMA-75 modified UCNPs could be used for cellular uptake investigation in protein-free media, where P_9MMA-25 modified UCNPs are significantly less stable.

In conclusion, $LiYF_4$:$Tm^{3+,}Yb^{3+}$ UCNPs modified with anionic polyelectrolytes p(MAA-*co*-PEG_9MEMA) demonstrated good biocompatibility and exhibited enhanced accumulation in both phenotypes of breast cancer cells. Therefore, these UCNPs can be considered suitable candidates for future development of targeted carcer therapy

Acknowledgement. This project has received funding from the Research Council of Lithuania (LMTLT), agreement No [S-MIP-22-68].

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DESIGN AND SYNTHESIS OF THE DONOR-ACCEPTOR-DONOR TADF MOLECULES FOR APPLICATION IN OLED

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Organic light emitting diodes (OLED) are widely used in the display technology. It is considered as the main competitor to the existing display technologies such as liquid crystals and light emitting diodes (LED). OLED system relies solely in the organic emitters. The latest generation of OLEDs uses the thermally activated delayed fluorescence (TADF) as the operating principle. One of the important criteria in design TADF molecules is the smallest possible energy gap between the first excited singlet state (S1) and first excited triplet state (T1). This energy gap is referred to as ΔE_{ST}. One of the approaches to achieve small ΔE_{ST}, is the design of molecules with a twisted C(sp2)-N connection between donor (D) and acceptor (A) moieties.

Our interest in the development of Donor-Acceptor-Donor (D-A-D) TADF molecules prompted us to explore the design of the TADF molecules and methods for the formation of C(sp2)-N bond between the donor and acceptor units. TD-DFT were used in the design of the molecules. Carbazole, substituted carbazole, phenoxazine, phenothiazine, and acridine are normally used as the donors (D), whereas 1,4-disubstituted phenylene motif is the acceptor. We have recently reported the synthesis of D-A-D type TADF compounds via a two-fold Buchwald-Hartwig reaction. Combination of $Pd_2(dba)_3$/XPhos was used as catalyst [1] Here we report on the design and synthesis of TADF molecules. We have successfully reduced the reaction time of the two-fold Buchwald-Hartwig amination reaction from 12 – 24 h to 10 – 30 minutes assisted by the microwave synthesizer. To our knowledge, this is the first report on the two-fold decrease of the duration of the Buchwald-Hartwig amination reaction.

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THERMORESPONSIVE POLYMERS: FROM SYNTHESIS TO APPLICATIONS

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Stimuli-responsive polymers can be triggered by various stimuli (e.g., temperature, pH, ionic strength, redox reactions, light, shear stress, enzymes, etc.) and change their physical properties, which can lead to dramatic changes in the macroscopic behaviour of polymer solutions, semisolid and solid formulations thereof. This permits also a certain control over properties of particles other formed bodies made of such polymers by environmental conditions that are characterized by changes in wetting properties of surfaces, charge density, topography, porosity, swelling and others.

Polymers able to respond to environmental stimuli have been recently under growing consideration to impart a “smart” behavior to the final product, which is highly desirable to provide it with a specific dynamic and an advanced function. In particular, thermo-responsive polymers, materials able to undergo a discontinuous phase transition or morphological change in response to a temperature variation, are among the most studied.

The development of various polymerization techniques has paved the way to a high degree of engineering for the polymer architecture and properties, which in turn brought to a plethora of sophisticated behaviors for these polymers by simply switching the external temperature. These can be exploited in many different fields, from separation to advanced optics, biosensors and biomedical applications.

Within these contexts, this presentation highlights the opportunities, challenges and future trends related to the latest advances in the development of thermoresponsive materials and their applications, with the focus on the structural and design aspects that are required to exploit such materials for cutting-edge applications in the biomedical field.

Furthermore, our achievements in synthesis of thermoresponsive graft copolymers based on synthetic and biopolymers, and studies of their properties will be discussed.

CORRELATIONS BETWEEN THERMOHYGROSCOPIC INFLUENCES AND MECHANICAL PROPERTIES IN WOOD-TEXTILE COMPOSITES (WTC)

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Wood-textile composites (WTC) based on willow wood fabrics and polypropylene were produced using a hot compacting process in order to open up new and innovative areas of applications for wood (Fig 1). Human sensory studies showed, that the design of the material is perceived as very positive by the participants on both a visual and a haptic level [1]. This is why WTCs appear to be particularly suitable for use in areas with a high visual impact, for example as a facade element. In tensile tests supported by digital image correlation (DIC) and 3-point bending tests it was shown, that the mechanical properties of WTCs are strongly dependent on the heterogeneous structure of the composite. Both strength and elongation depend on the loading direction and show a classical fibre reinforced composite behaviour despite the comparatively large dimension of the filaments [2]. In addition, the WTCs were subjected to various conditioning procedures and a subsequent impact bending test (Fig 2). It was shown that changing environmental conditions, in particular temperature and humidity, have a strong influence on the mechanical behaviour of the material [1].

Fig 1: Wood Textile Composite (WTC)

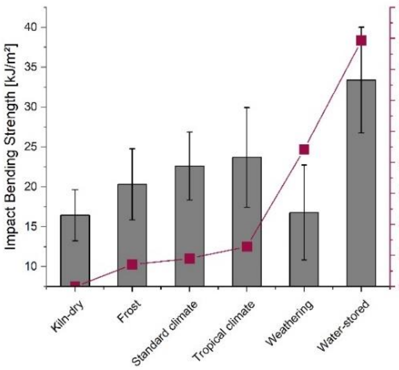

Fig 2: Correlation between moisture content and impact bending strength in WTC

The investigations carried out were possible to prove, that the characterization of WTC is possible with conventional test methods. However, the strong dependence on environmental influences requires further investigations and future modifications of the composite material to make outdoor use possible.

Acknowledgement

This work was supported by the project „VOTO - Weidengewebeverstärkter Kunststoff mit variabler Gewebedichte für Fassadenelemente im textilen Holzbau“, funded by the Federal Ministry for Economy and Energy based on a resolution of the German Bundestag.

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MOLECULARLY IMPRINTED POLYMER AS A SELECTIVE RECOGNITION ELEMENT FOR DETECTION OF AZOXYSTROBIN IN AQUEOUS MEDIA

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Azoxystrobin (Az) is a broad-spectrum systemic fungicide that is widely used to protect crops from fungal diseases. The increasing global use of Az has led to concerns regarding its presence in the aqueous environment that impacts directly and indirectly on human health [1]. Consequently, there is an urgent need to develop selective and reliable detection methods to monitor Az concentrations in water, ensuring environmental safety and public health.

To address this challenge, the present study focuses on the development of an electrochemical Az sensor utilising a Az-selective molecularly imprinted polymer (Az-MIP) as the recognition element, for the detection of Az compounds in aqueous matrices and the thin metal electrode (TFME) system connected to an electrochemical workstation to measure different pulse voltammetry-based signal (DPV). The Az-MIP was electrochemically synthesised on the working electrode of TFME, employing dual functional monomers. Several electro-polymerizable monomers (2-methyl-4-nitroaniline, 3-aminothiophenol, aniline, meta-phenylenediamine, pyrazole, and pyrrole) were assessed as possible monomers for synthesis of Az-MIP. Aniline was rationally selected due to its superior binding energy in the complex with Az, while meta-phenylenediamine functioned as an effective cross-linking agent, facilitating the formation of a three-dimensional polymeric network containing tailored recognition sites for Az.

The optimization of various synthesis parameters was conducted to enhance the overall performance of the sensor. These parameters included monomer concentration ratios, solution pH, charge density of the galvanostatic electrodeposition process, and incubation time. Additionally, DPV settings, such as potential step, pulse width, and pulse size, were optimised to quantify small relevant Az concentrations accurately and precisely in water.

The preliminary results demonstrate that MIP-based sensors achieved a low limit of detection of 2.0 nM and limit of quantification of 6.8 nM, indicating their high sensitivity. Furthermore, a good selectivity was displayed towards azoxystrobin in both milli-Q and tap water samples. This study showcases the potential of MIP-based electrochemical sensors for onsite detection of environmental contaminants in water, as well as the advancement of analytical tools for water quality monitoring and risk assessment.

Acknowledgement
This work was supported by the Estonian Research Council (grant PRG307).

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UV CURING COATINGS ON NATURAL NAILS

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UV-curing nail coatings have gained immense popularity for their rapid curing time and enhanced performance compared to coatings formed by drying polymer solutions [1]. The crucial aspect in formulating such coatings lies in understanding the methods needed to develop compositions that can achieve robust adhesion to the natural nail [2].

Coatings on natural nails possess specific technological properties, resulting in coatings with distinct physical-mechanical, surface, and adhesion characteristics. Therefore, the experience gained from current UV-curable coatings is not directly applicable [3].

The practical aim of this research was to devise a methodology for creating a composition that effectively polymerizes under controlled UV radiation, resulting in a coating that meets all the specified requirements for nail coatings.

A comprehensive methodology has been developed for the formulation of acrylate composite systems and for obtaining suitable cosmetic coatings through the process of UV-activated copolymerization. Throughout the investigation, industry-defined coating requisites were determined. Critical testing parameters, including rheological properties, surface wetting, color stability over time, polymerization duration and temperature, surface gloss, adhesion, and solubility of coatings were identified. The methods for their determination were also established. Simultaneously, the study unveiled existing challenges within the current Research and Development laboratory framework. These challenges encompassed ensuring foundational adhesion of the base layer to natural nails, guaranteeing the safety of raw materials, improving the color saturation of pigmented coatings, and enhancing the polymerization capabilities of pigmented coatings.

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POLYURETHANES FOR GLASS SEALANTS – EVOLUTION FROM FOSSIL-BASED TO RENEWABLE FEEDSTOCKS

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Polyurethane sealants are currently the most common type of sealant giving structural strength, moisture resistance, and gas barrier performance to insulated glass units used in Europe. While the performance requirements tend to become stricter, rising prices of fossil-based chemicals and ultimately the expected depletion of fossil hydrocarbon deposits provide a clear signal that sustainable alternatives must be introduced.[1] For polyurethanes, this means introducing renewable plasticizers, polyols, and polyisocyanates. One option is direct use of bio-based liquid chemicals,[2] such as vegetable oils, diols, and carboxylic acids. Another, more conservative approach is the production of traditional petrochemicals from hydrocracker gas stream that can be fed by bio-based oils or other organic liquids. Regardless of the production method, these bio-based polyurethane starting materials are subject to the same principal requirements – low viscosity and easy miscibility, functionality of 2-3 hydroxy groups or isocyanate groups per molecule, low dispersity of functionality among molecules, in order to obtain rubber-like high-strength elastomeric sealants. New types of suitable materials appear not only from botanical sources, but also as a result of biotechnological innovation. Only a few of these novel materials are currently used in polyurethane glass sealants.

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PROCESSING OF BIOCOMPOSITES CONTAINING HEMP SEED HULL WASTE

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Hemp is a high yielding annual crop currently experiencing a revival in production. Hemp fiber contains pectin, hemicellulose and lignin, while hemp seed oil contains unsaturated triglycerides with well-established nutritional and physiological properties [1]. The amount of waste increases with the growth of consumption, therefore, focus on the utilization of hemp processing waste in various industries is increasing globally. Hemp fiber is especially widely studied and used for biocomposites. It is known that hemp seed hulls (HH) can be used as fertilizer and cattle feed, however, the data on the use of this waste material in the production of bioplastic composites is scarce.

The aim of the work is to study the formation of thermoplastic biocomposites based on hemp seed hulls and other biobased materials of plant origin and to assess their mechanical properties. The hemp composite mixture was obtained by mixing hemp seed hulls (HH) of various particle size with cellulose acetate (AC) granules, which served as a binding material, and a plasticizer triacetin (TA). The content of TA in the compositions was 35%, the content of hemp seed hulls was 10% - 30%. Three fractions of crushed hemp shells were used: < 0.16 mm, 0.16 - 0.63 mm and 0.63 - 1.00 mm. The formation of bioplastic material was carried using a twin-screw extruder at a temperature of 130-190 °C. The production process to obtain thermoplastic biocomposites is presented in Fig 1.

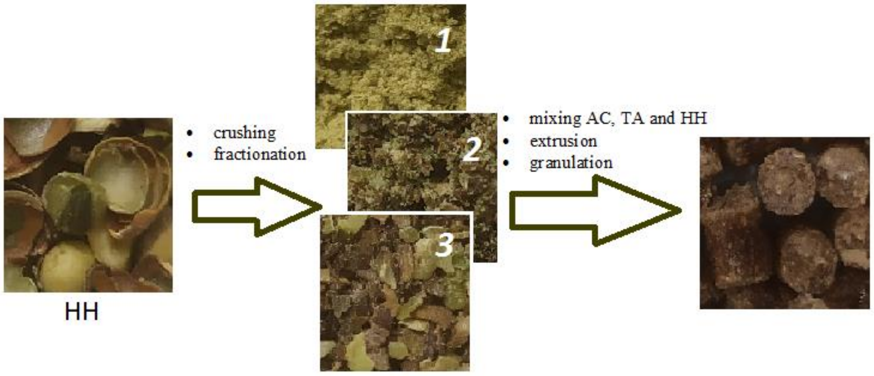

Fig. 1 Biocomposite pellet production process involving hemp hulls of various size: *1* – < 0.16 mm, *2* – 0.16-0.63 mm and *3* – 0.63-1.00 mm

The bioplastics of various composition were obtained. The effect of the amount of HH and particle size on the melt flow characteristics and mechanical properties of the products was evaluated.

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INVESTIGATION OF DIFFERENT NATURE POLYMERIC 3D PRINTED HEELS FATIGUE BEHAVIOUR

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The rapidly growing popularity of 3D printing technology enables the production of customised product designs, the creation of complex geometric shapes, and the reduction of waste in various industries. Therefore, 3D printing technology can be integrated into the production of orthopeadic footwear, which can facilitate and accelerate the production of customised footwear. The traditional method of making orthopeadic footwear has many limitations when it comes to adapting a specific design that meets the requirements of the movement function and combines the various details of footwear production.

In this work, 7 polymeric materials are used for the additive manufacturing process: PLA, ABS, PTEG, PA (NYLON), and TPC printed by the FDM method, PA12 by the SLS method, and photopolymer by the SLA method. These materials have high mechanical strength, hardness, thermal stability, wear resistance, and better adhesion than parts made from standard materials and are increasingly used in industry and research. It must be ensured that 3D printed parts resist mechanical and environmental influences. Therefore, it is important to investigate the mechanical strength of 3D printed polymer materials, especially their fatigue behaviour under cyclic loading conditions, as this could lead to fatigue crack propagation and material failure. The fatigue mechanism of 3D printed polymers is very important for the evaluation of these materials in structural applications. Therefore, this study aims to evaluate the fatigue properties of polymer materials for 3D printed shoe heels.

Cyclic compression tests were performed using a universal testing machine, Instron ElectroPuls E10000T. The 3D printed heel prototypes made of seven polymers of different natures were tested under fatigue loading at a frequency of 0.5 Hz and pressed up to a load of 1000N. Fatigue was applied in 50000 cycles simulating 8 hours of brisk walking. The changes in energy absorption with an increasing number of load cycles were analysed. The influence of the nature of the polymeric material used on fatigue behaviour was also assessed.

STUDIES OF POSSIBILITIES OF SYNTHETIC FIBRES SURFACE MODIFICATION WITH CUXSE

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Recently, researchers have faced the challenging task of finding a way to use industrial waste as secondary raw material for new applications. At this time, it has often been emphasised that textile waste is one of the largest sources of pollution in the world. The use of industrial textile waste for the creation of new functional composites is a viable area for the development of sustainable technologies. New composite materials for special purposes with varying combinations of physical and chemical properties can be obtained by using polymers modified with thin semiconductive or electrically conductive layers of binary inorganic compounds. In recent decades, semiconductor nanomaterials have received great attention of attention because of their novel electronic, optical, photoelectric, and thermoelectric properties. As an important semiconductor, copper selenide (Cu_xSe) with nanostructure has potential applications in various fields, such as optical filters, highly efficient solar cells, superionic conductors, electro-optical devices, photothermal conversion, electroconductive electrodes, microwave shielding coatings, etc.

In this study, part of the results of the investigation of possibilities of the formation of the copper selenide layer on the surface of the different fibres is presented. In previous work, the possibilities of modifying natural fibres with copper selenides were explored. The modified method was based on a two-stage adsorption-diffusion process. In this work, the possibility of applying analogous modification conditions to the treatment of synthetic fibres was sought. In the work, thread waste from Lithuanian companies was investigated. Synthetic fibres of different natures PA6, PA6.6, PES, and PAN were used for this experiment. It was found that the quality of formation of copper selenide crystal layer coating on the surface of the investigated all type fibres is highly dependent on the number of modification cycles.

DEVELOPMENT OF A BIOBASED COMPATIBILIZER AND ITS EFFECT ON RAPESEED FIBRES STRUCTURE AND PROPERTIES OF RECYCLED POLYMER COMPOSITES

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The trend in recent years has been to promote a circular economy and save non-renewable resources. Polymers most commonly are used in composites, where they can be combined with other polymers or fillers to produce a composite with desired properties. For example, natural fiber composites are an excellent way to obtain high-strength materials. However, to achieve this, the best possible compatibility between polymer matrix and natural fibers must be ensured. According to literature natural fibers need to be pretreated to obtain better interfacial interactions. Besides, it is necessary to use compatibilizers in creation of composites in order to improve the compatibility between polymer matrix and natural fiber, obtaining materials with higher mechanical properties. Maleic anhydride (MAH) grafted polymer is a compatibilizer, which is very effective and commonly used for natural fiber and polymer matrix at the interfacial agent. MAH is produced from non-renewable resources, so the aim of the work was to develop biobased compatibilizers and assess their effectiveness.

Tannic acid (TA), catechin hydrate (CA) and stearic acid chloride (SC) were used for the synthesis of the biobased compatibilizers (SCTA and SCCH). The synthesis process was carried out according to modified procedure of M.M.S.Abdullah [1].

The compatibilizer effect was evaluated for recycled polypropylene/polyethylene compositions with 10 % and 40 % rapeseed straw fibers.

The results of mechanical properties (tensile, flexural, impact strength) showed that the developed compatibilizers have the potential to replace MAH. Moreover, the addition of SCTA and SCCA to the composite showed excellent thermo-oxidative properties, providing very high stabilization in oxygen environment at 190 °C. Composites formed with SCTA and SCCA showed high surface wetting properties than with MAH; the wetting angle reached up to 90°, granting a more hydrophobic surface.

Acknowledgment

This work was supported by the Latvian Council of Science in the framework of FLPP "Obtaining multi-functional bio-based compatibiliser and its effect on the performance of recycled polymer composites with biomass reinforcement", lzp-2021/1-0347.

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EFFECT OF CARBOXYLIC ACIDS AND TANNIC ACID AS COMPATIBILIZER ON MECHANICAL PROPERTIES OF RECYCLED POLYOLEFIN COMPOSITES WITH NATURAL FIBERS

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There has been an increased interest in producing more environmentally friendly materials. Polymer composites reinforced with lignocellulosic fibres seems to be an attractive source. The challenge of this type composites is compatibility between polymer matrix and lignocellulosic reinforcement. Interfacial adhesion between polyolefin and lignocellulosic fibers may be increased by adding compatibilizer, such as maleic anhydride grafted polymer (MA), but MA is expensive, non-biodegradable.

The use of multi- functional compatibilizer on the bases of carboxyl acid (CA) and tannic acid (TA) is good possibility to replace synthetic agents because carboxylic acid's carbon chain shows affinity to PP, but carboxylic group provides interaction with hydroxylic groups of lignocellulose fibers. Moreover, TA is natural source of polyphenol and is effective antioxidant due to its free radical scavenging capacity. Modification through esterification reduces hydrophilicity of tannins, improves compatibility with hydrophobic polymer matrix and shifts UV absorbance region by improving UV stability of the polymer matrix.

In the work carboxylic acids with different chain lengths were selected for development of bio based compatibilizers with TA. Carboxylic acids modification with TA is performed through esterification reaction to get multi-functional compatibilizer.

The compatibilizer effect was evaluated for recycled polypropylene/polyethylene compositions with 10 % buckwheat straw fibers.

From the obtained results was observed that modulus of elasticity increases by 30%. The reinforcement effect was found slightly higher by adding MAH. In the same time compositions with new bio based compatibilizer are characterized with higher tensile elongation than MAH containing compositions. After UV test (2 weeks), similarly to the MAH compatibilized systems, an increase in, e.g., tensile modulus, yield strength, was observed for the composition with bio based compatibilizers. Meanwhile, tensile elongation at break, ε_B, values of the biobased compatibilizer containing systems showed greater reduction than in the of MAH compatibilized compositions.

Acknowledgment

This work was supported by the Latvian Council of Science in the framework of FLPP "Obtaining multi-functional bio-based compatibiliser and its effect on the performance of recycled polymer composites with biomass reinforcement", lzp-2021/1-0347.

MECHANICAL BEHAVIOR OF THE LIGNOCELLULOSIC FIBER-REINFORCED RECYCLED PP/PE COMPOSITES

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Now days, it is impossible to think, about our everyday life, without polymer packaging materials, building and constructions, modern design furniture parts and etc. Europe plastic market data shows that in 2021 plastic production and demand got higher then before COVID 2019 pandemic. Production of fossil plastic on the same level as 2019 but post-consumer recycled plastic and bio-based plastics production growing. As data shows it is easy to recycle separately collected plastic (recycling rate 65%) and there is a great problem in case of mixed collected plastic (recycling rate 5%). Plastic with impurities and plastic blend recycling is one the edge (PP/PE, HDPE/LDPE, PC/ABS etc) [1].

This work contains matrix material recycled polypropylene/polyethylene mix rPPPE matrix that is not as popular as pure PP or PE recycled materials.

Last decade biobased polymers become more and more popular. Main component for biobased polymer composites is natural fibres. Most used are wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf, bamboo fibers. Most of them crosses with food security problem (corn as food or bio diesel fuel). That why for this work we decided to take a sweet clover fibre (SCS) which has limited use in the agricultural sector. SCS contain similar amount of cellulose as well known and investigated fibre. In the same time others authors works showed that SCS fibres could be perspective in practical use for biobased composites [2, 3]. To increase possible composite blend application field, we used 40 wt % of fibres it is maximal possible content for traditional injection moulding technology or extrusion process.

The work presents the variation of the mechanical properties of the composite (tensile, flexural, impact strength) using SCS.

Acknowledgement

This research was funded by The Latvian Science Council, grant number LZP 2021/1-0347.

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PREPARATION OF SILANE-TREATED LIGNOCELLULOSIC FIBRES FOR POLYMER COMPOSITES

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Every year the demand for polymer materials grows. This increased demand means that the amount of waste associated with this industry is also increasing. In order to reduce the environmental impact and increase the efficiency of available resources, scientists around the world are looking for ways to use recycled polymers. As the mechanical properties of thermoplastics deteriorate with recycling, their range of applications is significantly narrowed. In order to improve the mechanical performance of recycled polymers, they are reinforced with lignocellulosic fibers.

Based on multiple studies, it is known that composites based on polyolefin and lignocellulose are characterized by poor adhesion, forcing the surface modification of natural fibers before use. Chemical treatments can be based on reactions involving esterification methods like acetylation and benzylation, graft polymerization methods like treatments with triazine, isocyanates and maleic anhydride, silane coupling agents, other treatments include alkali, acrylation and acrylonitrile, permanganate, peroxide treatments and also steric acid, sodium chloride and oleoyl chloride. Surface modification of fibres reduces its moisture absorption tendency and improves their mechanical properties thereby increasing durability of the composites [1].

Recycled polypropylene and polyethylene are used as the matrix in this study. Buckwheat straw was chosen for reinforcement of the composite, as this agricultural crop is quite widespread on the territory of Latvia. In recent years there is a tendency to increase the area under buckwheat, for example, in 2022 the area of buckwheat fields increased from 15-20 thousand to 30 thousand hectares. Also, the possibilities of using this crop are little studied, although considering the rather high percentage of cellulose content (on average 38%) there are prospects.

Silanization was chosen as the surface modification method because silane has an excellent tendency to increase the hydrophobicity of the straw and perspective improve compatibility with pololefin matrix. FTIR, DSC, TGA, rheology, wetting angle test, mechanical performance test (impact strength, tensile strength and flexural strength) were used to investigate the obtained material.

Acknowledgment

This work was supported by the Latvian Council of Science in the framework of FLPP “Obtaining multi-functional bio-based compatibiliser and its effect on the performance of recycled polymer composites with biomass reinforcement”, lzp-2021/1-0347.

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ACCELERATED WEATHERING TESTING EFFECTS ON THE PROPERTIES OF POLY(3-HYDROXYBUTYRATE-CO-3-HYDROXYVALERATE AND ITS BIOCOMPOSITES WITH RAPESEED MICROFIBER

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The intensifying focus on environmental issues drives the demand for materials that exert minimal stress on ecosystems. Persistence of non-degradable plastics coupled with the challenges of landfill saturation and escalating water and land pollution concerns underscores the need for alternative solutions. As plastic consumption continues to rise and waste disposal capacities face strain, the importance of biodegradable plastics and plastic waste sustainable degradation has gained substantial attention.

Biodegradable polymers have emerged as a significant alternative to traditional plastics, which impose long-term environmental pollution. In contrast to conventional polymers, poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) is susceptible to biological degradation. Microorganisms naturally convert PHBV into elemental components, minimizing its environmental impact.

In this study, we investigate the behavior of PHBV polymer compositions reinforced with two types of fibers, treated by either mercerization or N-methylmorpholine N-oxide (nmmo). Our objective is to assess the effects of accelerated weathering on the properties of PHBV and PHBV/Rapeseed (RS) microfiber biocomposites. All developed samples were subjected to accelerated weathering conditions, including water spray, UV exposure, and conditioning for up to 500 hours. Our study aims to comprehensively evaluate how exposure to accelerated weathering conditions affects the mechanical, thermal, and other properties of these biocomposites. These insights provide valuable information about their potential durability and suitability for diverse applications.

Based on DSC analysis, the PHBV/RS biocomposite samples exhibited increased crystallinity. In accordance with Montagna et al. this phenomenon was attributed to the influence of UV radiation, which could have affected the amorphous regions of PHBV, causing chain breakage followed by recrystallization of shorter chains. Mechanical testing results indicated that the inclusion of RS microfibers significantly increased the material's mechanical strength while preserving its flexibility in spite of increased degradation level, as confirmed by means of carbonyl index (COi) measurements by Fourier transformed infrared spectroscopy.

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CHANGES IN RECYCLED PLASTICS AND POTENTIAL OF MICROPLASTIC FORMATION DUE TO UV IRRADIATION

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Plastics after prolonged exposure to UV irradiation start to degrade via photooxidative aging including free radical formation, oxidation, chain scission and/or crosslinking reactions. These chemical changes cause loss in mechanical strength, increase in hygroscopicity, surface embrittlement, and eventually surface erosion. The eroded particles are microplastics (MPs), which have been identified as a major threat to the environment and its inhabitants. In general, photodegradation of virgin plastics has been studied extensively, but there is not much literature on the degradation of recycled plastics. Recycled plastics quite possibly could have higher risk of producing MPs during degradation due to partial oxidation, contaminants and fragmented chains in their structure (Müller et al. 2021). This is especially important in the light of commitments (e.g. EU's Plastic Strategy) that promote recycling and reuse of plastic. Recycled plastics are widely used in such materials as wood plastic composites, which are exposed to harsh conditions during their use and can be a significant source of MPs. The goal of the study was to investigate the changes in recycled plastics caused by photodegradation and assess the potential risks of MPs formation. Plastic granules of one LDPE, two HDPE, and two PP recycled from different products were analysed. UV irradiation was performed in an accelerated weathering chamber for milled (< 400 µm) plastic powder to ensure homogeneous changes throughout the sample. Chemical and physical properties were investigated by ATR-FTIR, ICP-MS, DSC, TGA, and element analysis. Formation of microcracks was studied on plastic granules by SEM. The degradation of recycled plastics significantly differed between each other. After 500 h UV exposure, LDPE and one of the PP samples showed a significant increase in carbonyl index, O/C ratio as well as decrease in thermal stability indicating of plastic oxidation and degradation. Impact was observed also on the polymer crystallization characteristics, although the direction of the change was dependant on the plastic type. The other PP and one of the HDPE samples showed first signs of degradation only after 1000 h UV exposure. The other HDPE sample showed no noticeable changes in its properties. This plastic had also the highest amount of heavy metals detected by ICP-MS. The SEM revealed fragmentation on the surface for samples, which had noticeable degradation identified by other methods. These plastics have also the highest potential of MPs formation.

Acknowledgment
The authors gratefully acknowledge the financial support by the Latvian Council of Science, project No. lzp-2022/1-0639 "Study of microplastics formation from wood plastic composites and evaluation of prevention possibilities (MicroWPC)".

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EFFECTS OF MODIFICATION CONDITIONS ON STARCH ESTERS PROPERTIES

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Biodegradable polymers represent a solution to the problems of contamination caused by conventional synthetic polymers. For this purpose, starch is considered as one of the most promising materials because of its biodegradability, low price and renewability [1]. However, the inefficiency of starch in processability due to the existence of hydrogen bonding interactions and intermolecular forces impedes its applications. The replacement of starch hydroxyl groups by ester groups can reduce number of hydrogen bondings and increase molecular mobility at the same time by decreasing glass transition temperature and increasing hydrophobicity. The aim of this study was to synthesize thermoplastic starch esters and investigate the influence of modifying agent and substitution degree (DS) on the properties of modified starches.

In the first reaction stage potato starch was modified with octenyl succinic or dodecenyl succinic anhydrides. Subsequently, in the second stage the anhydride modified starches were additionally reacted with acetic anhydride. The obtained starch derivatives were characterized using Fourier-transform infrared spectroscopy, differential scanning calorimetry and thermogravimetric analyses. The changes in hydrophobicity of the derivatives were assessed by measuring the water wetting angle of the derivative surface.

In order to assess the changes of granular structure the derivatives have been examined by scanning electron microscopy. As shown in Fig 1 destruction of granules occurred during starch derivatives (dodecenylsuccinate or octenylsuccinate) modification with acetic anhydride at higher degree of substitution.

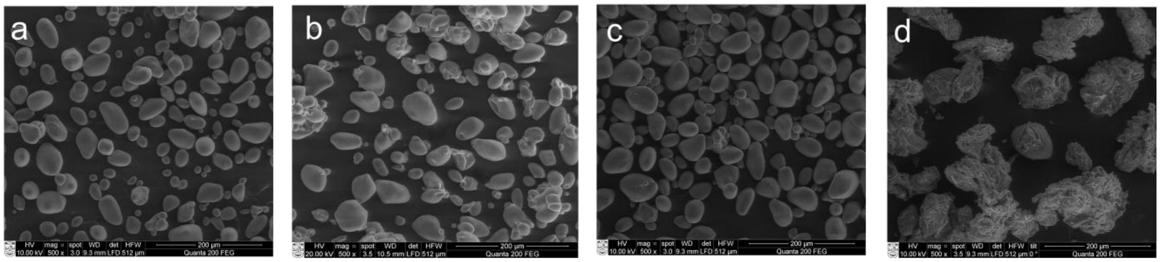

Fig. 1 Scanning electron microscope imagines (500x) of native starch (a), starch dodecenylsuccinate with DS_{DDSA}=0.02 (b), starch acetate dodecenylsuccinate with DS_{DDSA}=0.02, DS_{Ac}=0.38 (c) and starch acetate dodecenylsuccinate with DS_{DDSA}=0.02, DS_{Ac}=1.87 (d)

It was revealed, that destruction temperature of starch derivatives depended the anhydride used for modification and on the degree of substitution. When starch was modified with octenyl succinic or dodecenyl succinic anhydrides at low degree of substitution the glass transition (T_g) temperature was not observed. In the case obtained starch derivatives were additionally modified with acetic anhydride the T_g depended on degree of acetylation. Moreover, the T_g for those dually modified starches was also observed at lower degree of substitution compared to those of acetic anhydride modified starch.

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ACTIVE PAPER COATINGS CONTAINING ESSENTIAL OILS AND THEIR COMPONENTS

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Currently, interest in the production of active packaging using renewable and environmentally friendly materials is growing. Active packaging has been shown to extend the shelf life of food products and reduce the growth rate of certain microorganisms. Essential oils have long been recognized for their antibacterial, antifungal, and antioxidant properties. Due to the instability of essential oils, they cannot be directly added into the food packaging and require immobilization [1]. In this study, the clove essential oil (CL) eugenol (EU) and cinnamon aldehyde (CI) were immobilized in starch sodium octenylsuccinate (SSO). The obtained emulsions were applied on paper and bioactive properties such as antioxidant and antimicrobial activities of the coatings have been evaluated.

The aqueous emulsions consisting of 20 % (w/v) of SSO and 2.5, 5 or 10 % (w/w) of CL, EU or CI were prepared by using rotor-stator homogenizer. The coatings were obtained by casting the emulsions on paper. The antioxidant and antimicrobial activities of coated paper samples were assessed by using 2,2-diphenyl-1-picrylhydrazyl and disc diffusion methods, respectively (Table 1). The antioxidant properties evaluation revealed that high antioxidant activity reaching 76-92 % and 87-91 % was characteristic of CL and EU emulsion coatings, respectively. Meanwhile, coatings containing CI showed quite low antioxidant activity (4-9 %). However, it was established that paper coated with 10 % of CI emulsion had a greatest antimicrobial effect on studied microorganisms.

Table 1. Antioxidant and antimicrobial activity of paper coatings

Sample	**Antioxidant activity (%)**	**Inhibition zone (mm)**			
		C. albicans	*S. aureus*	*E. coli*	*B. cereus*
C-CL-2.5	76 ± 1.9	n	n	n	n
C-CL-5	90 ± 0.1	n	n	n	8.06
C-CL-10	92 ± 0.3	8.42	n	9.43	8.70
C-EU-2.5	87 ± 0.4	n	n	n	8.03
C-EU-5	91 ± 0.4	n	n	8.70	8.49
C-EU-10	91 ± 0.5	10.81	n	9.94	10.41
C-CI-2.5	4 ± 0.5	10.82	n	n	7.57
C-CI-5	5 ± 2.2	13.61	n	13.20	17.08
C-CI-10	9 ± 3.0	15.50	10.82	18.71	18.32

n – no inhibition zone detected

In conclusion, the clove essential oil and eugenol emulsions could be used as effective natural antioxidants, whereas cinnamon aldehyde emulsions as antimicrobial agent in food packaging systems aiming to improve the quality and extend the shelf life of selected food products.

Acknowledgements
The research was performed in the frame of the COST Action CA19124.

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EFFECT OF DIFFERENT MODIFIED CARDANOL COMPOUNDS ON THE MECHANICAL AND CLIMATIC RESISTANCE PROPERTIES OF THE MATERIAL

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Cardanol derivatives are widely used in various coatings because it has very good resistance to different climatic environments [1]. Cardanol is a renewable natural resource that is an excellent precursor for various syntheses, yielding a wide variety of materials with various applications [2]. Despite the fact that prepolymers for polyurethane systems have been developed [3], silyl-terminated prepolymer systems, which are in great need of protection in aqueous environments, have not been studied because their structure is typically made of polyether chains, which have poor water resistance.

Cardolite Ultra Lite 513, an epoxidized cardanol product, was used during the work, which was modified with two different secondary amine silanes, changing the functionality of the prepolymer (Fig 1).

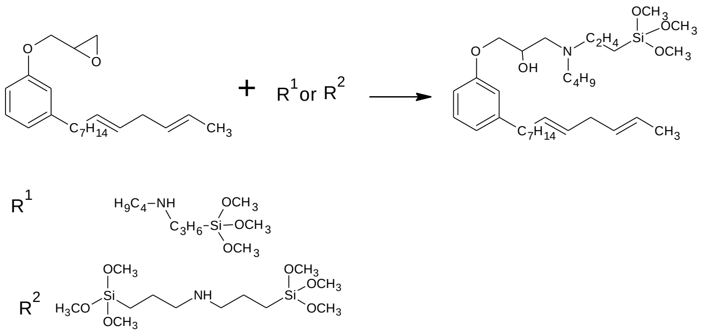

Fig 1. Modified cardanol compound synthesis

As the functionality increases, the cross-linking of the materials increases, as a result, the deformation properties of the materials decrease (Fig 2). Modified cardanol-type prepolymers increased the climatic resistance (combination of UV light, temperature (60 ºC) and water) of materials by .15% when add 10% of cardanol based prepolymer.

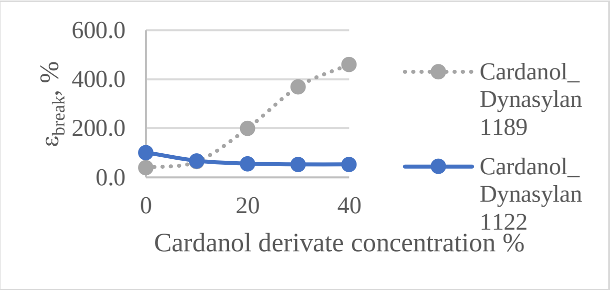

Fig 2. Dependence of material deformation on cardanol prepolymer content

Acknowledgement
The research was performed in the frame of the Latvia-Ukraine cooperation research, LV_UA /2023/8

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EFFECT OF SILYL-TERMINATED CARDANOL AND DIFFERENT FILLERS ON CURING DYNAMICS AND MECHANICAL PROPERTIES OF POLYETHER-BASED SILYL-TERMINATED PREPOLYMER

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Practically all industries are looking for opportunities to use raw materials that can be obtained from nature. Among the materials that are already used in different forms are cardanol-based compounds, because they affect different properties of the material, such as resistance against water and oxidative stability, which are very important for materials used in outdoor conditions. However, real adhesive systems are not only composed from polymers, largest part of the composition of the adhesive consists of fillers (w=40-80%), thus reducing their price, improving processability, as well as in many cases increasing climatic resistance, so it is important to understand how they will change the curing and mechanical properties of the system.

The commercial SAX 520 used in the study has a linear structure that requires structuration by particles, otherwise the polymer will form lumps during curing and will not develop its maximum possible properties. The obtained results of the mechanical properties in tension showed that the addition of modified calcium carbonate increases both the tensile strength (by 25%) and the deformation (by 15%). Silyl-terminated cardanol prepolymer was synthesized from epoxidized cardanol with trade name Cardolite Ultra Lite 513 and secondary amino silane (Fig. 1).

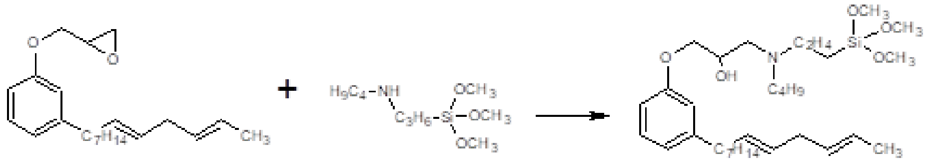

Fig 1. Synthesis of modified cardanol compound

Integration of the synthesized prepolymer in the composition of the two-component adhesive increased both the material’s elasticity and tensile deformation by increasing the silyl-terminated cardanol concentration (Fig. 2). Modified cardanol prepolymer significantly affected the curing dynamics of the SAX 520 by accelerating the hardening.

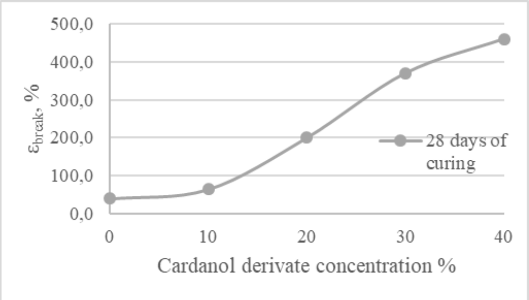

Fig 2. Changes in tensile strain depending on the concentration of modified cardanol

Acknowledgement
The research was performed in the frame of the Latvia-Ukraine cooperation research, LV_UA /2023/8

INFLUENCE OF LONG-TERM STORAGE AND UV LIGTH EXPOSURE ON RIGID PU FOAMS' CHARACTERISTICS

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Rigid polyurethane (PUR) foams is the most effective insulation material used in space launchers since the beginning of cryogenic fuel use, due to their outstanding thermal and mechanical properties. The Latvian State Institute of Wood Chemistry has been cooperating with the aerospace industry for a long time in developing cryogenic insulation for its specific requirements. The current requirements for materials used in space are the same as conventional materials, i.e. they must be environmentally friendly, non-toxic, and at the same time, the European Space Agency recommends using raw materials produced in Europe. In previous studies PUR foam formulations containing the 4th generation blowing agent HFO-1233zd, under trade name Solstice® LBA [1] and amine-based catalysts [2] were developed. This resulted in production and future development of low-density PUR foams as cryogenic insulation.

In this study, spray-applied PUR foams using different ratios of amine-based catalysts were produced. Due to climate changes, several restrictions have been made towards usage of blowing agents used for rigid PU foam production. Until this century mostly hydrofluorocarbons (HFCs) were used for foam production, but it was found out that HFCs are of high global warming potential (GWP). Therefore, Kyoto Protocol in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) and the European Parliament's developed regulations, have suggested hydrofluoroolefins (HFOs) as an alternative for rigid PU foam production due to their low GWP and ozone depletion potential (ODP). The change of blowing agents naturally altered the usage of catalysts.

Reactive amine-based catalysts are less hazardous because of their low volatility and ability to react successfully with isocyanate or polyols. Spray-applied rigid PU foams with potential application for cryogenic insulation were produced and tested for long-term storage analyzing parameters such as pH value of polyol composition, foaming kinetics (t_{rise}, t_{cream}) etc. Thermo-mechanical analysis (TG, DSC) was also acquired of developed materials, as well as artificial ageing by exposing samples to UV light.

It was discovered that PUR foams obtained using reactive amine-based catalysts, such as Polycat 203 and 218, have higher integral heat capacity, but polyol mixtures containing these catalysts cannot exceed storage time for more than 4 months. It was also observed from artificial ageing tests of PUR cryogenic insulation by exposing to UV light that thickness of degraded layer reached 0.8 mm (after 1000 h), but no significant destruction of cellular structure deeper in material was observed.

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ELECTROSPUN FIBROUS MEMBRANES FOR TATTOO WOUND CARE

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In the process of tattooing, wounds are created that require specific care to protect the wound, reduce the formation of scabs and not damage the visual appearance of the tattoo. Electrospun polymer nano and micro-size fibrous membranes can be used as materials for various applications including wound care and as a transdermal drug delivery system. The study aims to evaluate the suitability of electrospun membranes for tattoo wound healing and care. Each electrospun multilayer composite layer has a different active component (Brazilian green propolis, Aloe Vera extract, or Dermobacter). Polyvinyl alcohol is safe for humans which makes it a great base polymer for healing wounds combined with bioactive additives. The fibrous membranes are manufactured with Nanospider electrospinning equipment using a rotating cylinder electrode. Thickness, tensile properties, fibers diameters, membrane morphology, air permeability, antimicrobial properties, and solubility were measured to assess suitability for wound care. The study also analyzed the effect of membranes on the color of tattoo pigments to evaluate suitability for tattoo wound healing.

The obtained in vitro results show that fiber membranes can be used as antibacterial and antifungal materials against *P.aeruginosa, E.coli, S.aureus, and Candida*. The sample's solubility depends on additives (from 6 milliseconds to 10 minutes) and therefore, active substances released to the wound can be planned and predicted. There was no significant effect of active substances on tattoo pigments observed. The developed nanofiber membranes have potential for the application of bioprotection and may provide a microenvironment for medical treatment and care, bioactive delivery systems, wound protective layers, and elsewhere. In vivo tests are needed in the future to determine the effectiveness of membranes in wound healing and care.

THE EXTRACTED BIRCH OUTER BARK AS A FILLER FOR WOOD-PLASTIC COMPOSITE

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The birch outer bark is rich in extractives, which can be isolated in good yields with organic solvents. After the extraction, birch outer bark contains up to 45% (dry basis) of suberin. Thus, the remaining biomass can still be used to produce other high-added-value products.

The research will be conducted on the use of the extracted birch outer bark as a filler in a wood-plastic composite. The bark residue was obtained as a result of betulin (a non-aromatic diol with a pentacyclic ring structure) extraction. The binary polymer blend from recycled polypropylene (rPP) and polylactic acid (PLA) in the defined mass ratio was used as a polymer matrix. The samples were prepared with a filling degree from 10 to 50 wt. % by extrusion and moulding, using HAAKE MiniLab II and MiniJet devices. The study evaluated the following parameters: (1) filling degree; (2) extracted bark particle size; 3) coupling agent (4) lubrication.

It was found that a 10 wt% content of the bark particles in the composite slightly increased its mechanical properties. With an increase in the degree of filling, the mechanical properties of the composite deteriorated regardless of the filler particle size. In order to improve the compatibility between the polymer matrix and the extracted bark microparticles, Licocene PP MA 7452 as a coupling agent was used. According to the obtained results, a 3% content of the coupling agent in the composite led to a remarkable increase in the mechanical strength and modulus, regardless of the degree of filling and the size of bark particles. With an increase in the bark particle sizes, the tensile and bending strength values and contact angles of the composite samples decreased. The presence of suberinic acids in the extracted birch outer bark, performing a lubricant function, improved the processing parameters of the obtained composite from the point of view of energy consumption.

Acknowledgement

This work was carried out due to the financial support from the Base Financing provided by the Latvian Ministry of Education and Science for the Biogrant *3-2022* and partly funded by “BarkBuild– Tree bark as a renewable source of wood protection materials for building applications (*ES RTD/2022/14* within ERA-NET Cofund Action “ForestValue – Innovating the forest-based bioeconomy”).

OPTIMIZATION OF MICROENCAPSULATION OF ISOPHORONE DIISOCYANATE IN POLYUREA SHELL

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In the present environmental context, there is considerable interest in self-healing materials. The integration of self-healing microcapsules into coatings holds promise for waste reduction by extending the lifespan of these products through the repair of cracks and scratches that occur during their usage [1]. To effectively fulfill their intended purpose, microcapsules must possess specific dimensions, maintain structural integrity throughout storage, formulation, and coating application processes, contain an adequate quantity of healing agents, and readily rupture upon coating damage without compromising the mechanical properties of the surrounding matrix [2]. Isocyanates can be very effective in self-healing systems because of reactivity towards polyols, amines and aspartic acid esters, or even form a coating on their own due to partial hydrolysis to amines in moist environment. Isocyanates can be encapsulated in many different shells including polyurea, poly(urea-formaldehyde), poly(melamine-formaldehyde), and polyurethane [3].

This study was focused on encapsulation of isophorone diisocyanate into polyurea shell using interfacial polymerization method. Four key parameters (core-to-shell ratio, agitation speed, type of emulsifier, and reaction time) that have the potential impact on the core content and size of the microcapsules were tested. The Taguchi design methodology was utilized to determine the optimal process parameters through the use of signal-to-noise ratio analysis. Larger-the-better criterion was used to identify the optimal conditions to achieve the maximum core content, while the nominal-the-better criterion was used to determine the parameters that were most effective in producing microcapsules of desirable size. Various analysis methods (FT-IR spectroscopy, optical and scanning electron microscopy, TGA analysis) were employed to investigate the effects of different parameters on properties of the microcapsules.

The optimal conditions to get the highest amount of isophorone diisocyanate inside polyurea shell were achieved by using gum arabic (7 %) as emulsifier, core to shell ratio 4:1, agitation speed 3000 rpm and reaction time of 60 mins. The optimal microcapsule size of around 50 μm was achieved by using a mixture of poly(vinyl alcohol) (2 %) and gum arabic (3 %) as an emulsifier, core to shell ratio 4:1, agitation speed 5000 rpm, and reaction time of 45 min.

Acknowledgements

The study was supported by the project of the EU funds investment tool “Eksperimentas” „Polyaspartic coatings without volatile organic compounds for wooden surfaces“, No 13.1.1-LVPA-K-856-01-0104.

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DEVELOPMENTS OF POLYURETHANE CRYOGENIC INSULATION MODIFIED WITH PHASE CHANGE MATERIALS

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Poyurethanes (PUR) are used as structural materials e.g. in cryogenic insulation and sandwich structures for space applications. The *Ariane 6* space launcher will use cryogenic propellant engines in its main and upper stage and perfect insulation of cryogenic hydrogen and oxygen tanks there is the task to be solved. Usage of thermo-regulative phase change material (PCM) doped polyurethane (PU) foam (PUR-PCM) as a cryogenic insulation in liquefied gasses fuel tanks can promote energy saving in terms of cooling load reduction through utilizing its mutual advantage of insulation as well as adhesion characteristics of foam layer at cryo-schock conditions. The solid-solid or solid-liquid PCMs are mainly classified as inorganic, organic, eutectic.

CrodaTherm ME29P as an acrylic core shell particle powder was used as potential PCM for PUR-PCM composites. As ingredients for A-component is used polyols obtained from renewable resources, like as rape seed oil or tall oil, and the 4th generation blowing agent *Solstice®LBA* (HFO 1233zd) – material with low Global warming potential (GWP).

This research presents the properties of PUR foams modified with PCM obtained at a laboratory scale with potential to be up-scaled. The properties of the foams were also compared in relation to the method used for their production. Also different primers were modified with PCMs with idea to improve adhesion between metal, in our case aluminium and PUR cryogenic insulation.

Low density cryogenic PUR foams modified with PCM using the 4th generation blowing agent *Solstice®LBA* were developed. Using the optimal catalyst system for *Solstice®LBA* blowing agent in appropriate concentrations, it is possible to obtain foam with a density lower than 35 kg/m^3 and at the same time with a bond strength after cryoshock higher than 0.3 MPa and a safety coefficient higher than 3. The research shows the possibility that by combining more environmentally friendly catalysts and PCM it is possible to obtain PUR material, which in the future can serve as cryogenic insulation in liquefied natural gas (LNG) transportation or in space technologies.

PHLOROGLUCINOL-BASED SHAPE-MEMORY POLYMERS

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Shape memory polymers have a unique ability to obtain temporary shapes and return to their permanent shape in response to stimuli such as temperature, pH, light, electricity, microwave, solvent or ultrasound [1, 2]. Such polymers can be used in various applications such as medical smart devices, sensors, conductive electronics and etc. [3].

The aim of this work was to design and synthesize novel phloroglucinol-based shape- memory photopolymers and investigate their properties. The synthesis of phloroglucinol-based cross-linked polymers with three different biobased comonomers, phloroglucinol, 1,4-cyclohexanedimethanol and dianhydro-D-glucitol, was performed by cationic photopolymerization. Real-time photorheometry was used to monitor the evolution of the photocuring process. The storage modulus (G'), the loss modulus (G") and the complex viscosity (η^*) were recorded as a function of the irradiation time. The chemical structure of the obtained polymers was confirmed by Fourier transform infrared spectroscopy and Soxhlet extraction. Mechanical and thermal properties of polymers were investigated by tensile test, dynamical mechanical thermal analysis and thermogravimetric analysis. It was determined that rheological, thermal and mechanical properties depended on the amount and type of comonomer.

The thermo-responsive shape memory properties of phloroglucinol-based polymers were determined by their glass transition temperature (T_g from 33 to 67 °C). The polymer samples were heated above their glass transition temperature, deformed to the desired temporary shape and fixed by cooling the polymer sample below its T_g. All polymer samples were able to return to their permanent shape in a short period of time after heating above their T_g.

Acknowledgement
This research was funded by the Research Council of Lithuania (project No. S-MIP-23-52).

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PROTEASE PRODUCTION FROM E. *COLI* BL21(DE3)-PET32A-ASP AND ITS APPLICATION IN LEATHER DEHAIRING

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Proteases are one of the largest family of enzymes, which are divided into groups based on reaction mechanisms, site of action and active site structure [1]. Due to the high variety, proteases have a wide application in different industries such as leather, food and feed, detergent, chemical industry, waste management, medical field, etc. In leather industry, protease receives more attention because of its activity on non-collagenous proteins; these enzymes can be suitable for soaking, bating, dehairing [2]. This investigation aims to produce protease from recombinant E. *coli* BL21(DE3)-pET32a-asp and study its application in hide dehairing. After bacterial enzyme cultivation, protein concentration, molecular mass, caseinolytic and keratinolytic activity were evaluated. The crude enzyme (extracellular protease) was applied for dehairing to evaluate the possibility of enzyme use in leather processing. SDS-PAGE showed protein molecular masses and its changes during the induction. The caseinolytic and keratinolytic activity of the obtained product showed high specific activity toward the substrates. Although the extracellular protease of recombinant E. coli had a high specific activity, the enzyme concentration was too low to obtain any effect on the hide during dehairing.

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SYNTHESIS AND STUDY OF AZO GROUP CONTAINING POLYMERS

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A copolymer of trimer and pentamer, obtained by diazotization of m-phenylenediamine and azo coupling with m-phenylenediamine, was prepared with aniline and anisidine in molar ratios of 1:10, 1:20, 1:40 with ammonium persulfate, taken in a molar ratio of 1:0.8 in calculation for amino groups: The structures of the obtained polymers are confirmed by spectral methods NMR, UV-spec. It is shown that soluble polymers are obtained, the content of aniline or anisidine groups in their structure increases with an increase in their content in the initial mixture. It is shown that the high electrical conductivity of the obtained polymers is due to the content of quinonediimine groups in the structure. An electron-withdrawing model compound was also obtained by diazotization of the trimer and conjugation with quinoline.

Acknowledgement
The research was funded by the European Union's Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No. 823720.

Keywords: Conductive polymers, diazotation, azocoupling, copolymerisation, azo-group.

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MEASUREMENT OF THERMAL CONDUCTIVITY OF CARBON FIBER REINFORCED LAMINATES BY TRANSIENT PLANE SOURCE METHOD

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Determination of the in-plane thermal conductivity of a thin unidirectional carbon fiber reinforced lamina is a challenging task since most direct measurement methods use heat flowing perpendicular to the surface of the sample. Indirect methods, like the laser flash method, can be used for simultaneous measurement of both in-plane and through-the-thickness thermal conductivity of composite laminates [1, 2]. In this work, the orthotropic thermal conductivity properties of carbon fiber reinforced laminates were measured using the transient plane source method combined with a numerical inverse solution.

Unidirectional and quasi-isotropic laminates were used for testing. A set of two measurements with insulation and conductive blocks attached to samples were used to enhance the heat flow in in-plane and through-the-thickness directions, respectively, and simplify the separation of conductivity values in the fiber and transverse directions.

A numerical inverse solution technique was used for the identification of the orthotropic conductivity tensor of a single unidirectional lamina using experimental temperature increase curves from transient plane source measurements [3]. The proposed procedure was based on an inverse solution of a transient heat diffusion problem in layered anisotropic laminates with a finite element analysis used to solve the direct problem. An optimization procedure using Nelder-Mead method was employed for the estimation of the best-fit thermal properties of composite material.

Micromechanical analysis was used to estimate the axial and transverse thermal conductivity of carbon fibers. A developed computer program was used to generate a two-dimensional periodic representative volume element with the volume content of the fibers equal to 74% for the estimation of effective thermal conductivity of a unidirectional composite in transverse direction.

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THERMORESPONSIVE PROPERTIES OF ACENAPHTHYLENE LABELLED CHITOSAN GRAFT POLY(*N*-ISOPROPYLACRYLAMIDE) COPOLYMERS

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Poly(*N*-isopropylacrylamide) (PNIPAAm) is one of the most attractive thermoresponsive polymers that exhibits sharp solubility changes in water around a specific temperature which is well known as the lower critical solution temperature (LCST). Recently, copolymers with grafted PNIPAAm side chains are highly researched, taking into account their great opportunities in biomedical field including drug delivery systems. One of the most perspective biopolymers which could be used as backbone of the thermoresponsive graft copolymer is chitosan, because this natural polymer is biodegradable, biocompatible and non-toxic. Moreover, acenaphthylene (ACE) could be also introduced into PNIPAAm grafts and serve as a fluorescent marker for more detailed investigation of thermoresponsive behavior of synthesized copolymers.

In this study, seven ACE labelled chitosan-*graft*-poly(*N*-isopropylacrylamide) (CS-*g*-PNIPAAm-ACE) copolymers were synthesized by free-radical polymerization of CS, NIPAAm and ACE in aqueous solution using potassium persulfate (PPS) as an initiator and By changing the molar ratio of CS:NIPAAm:ACE from 1:0.25:0.0125 to 1:10:0.11 the ACE labelled copolymers with different grafting ratio were prepared.

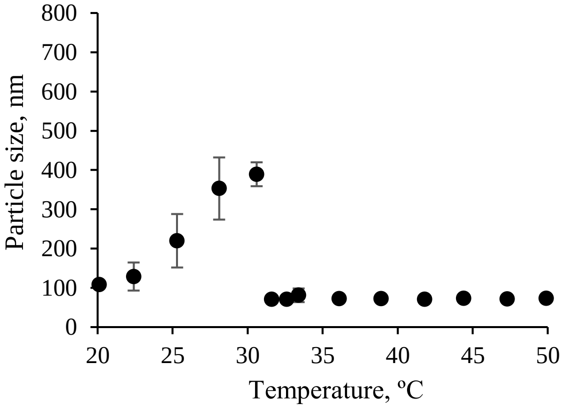

Fig1. Average particle diameter of CS-g-PNIPAAm-5-ACE in acetic acid solution versus temperature behaviour

The obtained copolymers were characterized by FT-IR, and H-NMR spectroscopy. Furthermore, the thermoresponsive behaviour of the prepared copolymers was investigated by cloud point, particle size (see Fig.1.), differential scanning calorimetry and fluorescence spectroscopy analysis. Moreover, the thermal properties of the copolymers were investigated by thermogravimetric analysis.

Acknowledgment
The financial support of the Research Council of Lithuania for the project No. S-LU-22-11 in the frame of Lithuanian–Ukrainian Cooperation Programme in the Fields of Research and Technologies is highly acknowledged.

NEW HOLE-TRANSPORTING MATERIALS FOR ORGANIC OPTOELECTRONICS BASED ON P-PHENYLENEDIAMINE SKELETON FUNCTIONALIZED WITH SULFUR-CONTAINING MOIETIES

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Hole transporting materials (HTMs) that are utilized in OLEDs have to be characterized by high hole mobility values, suitable HOMO levels to ensure low energy barrier for hole injection from the anode into the emissive layer, and a suitable LUMO level to prevent electron injection from the emissive layer to the hole transport layer. In order to fulfill the abovementioned requirements, organic HTMs typically have electron-donating moieties such as diphenylamine, carbazole, etc. in their molecular structures [1]. The simplicity and cost-effectiveness of their synthesis together with good thin film-forming properties and environmental friendliness makes them advantageous over their inorganic counterparts.This work focuses on the synthesis of four new HTMs that are based on sulfur-containing aromatic compounds. All the compounds were obtained via Buchwald-Hartwig cross-coupling reactions in good yields. The ionization potential (IP) values of the solid samples of the compounds were found to be in the range of 5.11-5.2 eV. The values of zero-field mobility μ^0 were obtained in the range from 4.6×10^{-5} to 7.6×10^{-5} $cm^2/V\cdot s$. Taking into account the low ionization potential and high hole mobility values of the compounds, their films have potential to be used not only for preparation of hole-transporting layers (HTLs) of OLEDs, but also for HTLs of perovskite solar cells.

Acknowledgement
The research was funded by the European Union's Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No. 823720.

Keywords: p-phenylendiamine, hole transporting material, OLED.

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DIBENZOTHIOPHENE AND TRIPHENYLAMINE DERIVATIVES AS EMITTERS IN ELECTROLUMINESCENCE DEVICES AND OPTICAL OXYGEN SENSORS

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Organic luminophores with a donor and acceptor structure have garnered significant attention for their potential application in organic light-emitting diodes (OLEDs), sensors, photonic devices, etc. [1]. Such interest is partly explained by the useful photophysical properties of donor-acceptor-type organic compounds such as room-temperature phosphorescence (RTP), thermally activated delayed fluorescence (TADF), or long persistent luminescence (LPL) [2]. Improved efficiency of TADF, RTP and LPL can be achieved for organic luminophores via molecular and/or film-forming engineering if it leads to improved efficiency of intersystem crossing and suppressed non-radiative relaxation processes [3]. For example, Adachi et al. observed efficient LPL for guest-host organic systems [4, 5]. Considering such examples, the invention of new compounds as well as film-forming approaches may lead to further improvement in the efficiency of organic luminophores.

In this work, we investigated photophysical properties of four derivatives of triphenylamine and dibenzothiophene dispersed in different liquids and solid media. Depending on the molecular structure and media used, the tested compounds exhibited either TADF, RTP or LPL. The derivatives were utilized as green emitters in OLEDs showing maximum external quantum efficiency of 13.9% in the best case. One compound with the most efficient RTP and LPL was selected as the active layer of optical oxygen sensors with a linear sensitivity in the range of oxygen concentrations of up to 10000 ppm. The Stern–Volmer constant of the best sensor was 4.55×10^{-4} ppm.

Acknowledgement
This project has received funding from the Research Council of Lithuania (Project “ELOS” No S-MIP-21-30) and from the Ministry of Education and Science of Ukraine (Project 0122U000760).

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SIMPLICITY AND EFFICIENCY: A HOST-FREE ORGANIC LIGHT-EMITTING DIODE ATTAINITG 4.6% OF EXTERNAL QUANTUM EFFICIENCY WITH DERIVATIVE OF 1H-1,2,3-TRIAZOLE AS BLUE EMISSIVE LAYER

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The most state-of-art thermally activated delayed fluorescence (TADF)-based organic light-emitting diodes (OLEDs) are fabricated using complicated multi-layered structures containing many functional layers typically based on guest-host/co-host systems with a specific combination of electronic properties of guests and hosts [1,2]. However, efficient TADF-based OLEDs with few host-free layers are limited due to the limited emitters with a perfect combination of required electronic properties. Especially in the case of blue OLEDs, device efficiencies decreased a lot when one or more functional organic layers are skipped from OLED structures. Our aim was to obtain favourable combination of electronic properties with emission in the blue spectral region by constructing OLED with a very simple structure ITO/CuI/TCTA/emitting layer(EML)/TPBi/Ca/Al. We utilised newly synthesized carbazole-containing derivatives of 1H-1,2,3-triazole as EMLs due to their TADF-originated bluish-green emission and high PLQYs in solid state. The maximum EQE of 4.6% was achieved for the device that consisted of 4-(9H-carbazol-9-yl)phenyl)(1-(m-tolyl)-5-(trifluoromethyl)-1H-1,2,3-triazol-4-yl)methanone as emitting layer. The fabricated OLED exhibited greenish-blue emission with electroluminescence spectrum characterized by Commission International de lʹEclairage (CIE) coordinates of (0.34, 0.46). Our research indicates, that by carefully engineering donor-acceptor type molecules based on 1H-1,2,3-triazole core, it is possible to fabricate efficient OLEDs even with very simple structure.

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MECHANOCHROMIC LUMINESCENCE, AGGREGATION-INDUCED EMISSION ENHANCEMENT AND THERMALLY ACTIVATED DELAYED FLUORESCENCE OF DERIVATIVES OF PHENOTHIAZINE AND DIFFERENTLY MODIFIED 3,5-DICYANOPYRIDINE

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Mechanochromic (MC) materials represent a type of smart materials that have a wide range of applications, including mechanosensors, security inks, organic light-emitting diodes, memory chips, luminescent switches, data storage devices, fluorescent bio-probes [1]. MC responses are typically caused by physical structural changes [2]. These responses are heavily influenced by the molecular conformations in the solid state, as well as by the molecular packing modes and intermolecular interactions. In order to enhance the versatility of MC materials, our goal was to develop organic materials exhibiting MC luminescence, aggregation induced emission enhancement (AIEE) and thermally activated delayed fluorescent (TADF).

In this work, we report on MC properties of three newly synthesized derivatives of phenothiazine and 3,5-dicyanopyridine. We investigated the samples in powder form before and after they underwent ground, solvent-fumed, heated and melt treatments. The compounds that were examined had photoluminescence spectra, which showed two bands that peaked at around 420 and 590 nm. These bands corresponded to deep-blue and orange emissions, respectively. The intensities of deep-blue and orange emissions could be controlled by external stimuli, resulting in the possibility of achieving even white emission (Fig 1). The TADF and AIEE properties exhibited by the compounds will be reported.

initial **ground** **fumed** **heated** **melt**

Fig 1. Photo of a sample after different external stimuli under UV excitation.

Acknowledgement

This project has received funding from the Research Council of Lithuania (Project “ELOS” No S-MIP-21-7).

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CARBAZOLE-BENZOPHENONE DERIVATIVES AS HOSTS FOR SOLUTION PROCESSABLE GREEN TADF OLED DEVICES

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Solution processable bipolar materials have been reported as emitters and host materials in organic light emitting diodes (OLEDs) [1]. These materials exhibited a thermally activated delayed fluorescence nature and have the capability of harvesting triplet excitons from excited triplet to singlet states by reverse intersystem crossing [2]. Thus, the TADF materials based organic LEDs have reached an internal quantum efficiency of nearly 100%. Herein, we have successfully designed and synthesized solution-processable bipolar carbazole-benzophenone derivatives as host materials. Structures of objective materials are shown in Fig 1.

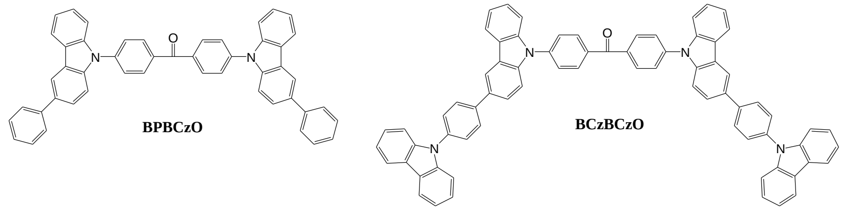

Fig. 1. Synthesis of objective benzophenone-based materials

These newly synthesized hosts exhibited high-triplet energies, balanced charge-transporting properties, suitable molecular orbital energy levels, good thermal stability, and good solubility, which are required to realize green TADF based organic LEDs. Initially, we fabricated two different types of TADF organic LEDs using these hosts and commercially available guest 4CzIPN as a green dopant and compared their device characteristics. A green TADF based organic LED employing BPBCzO host displayed excellent performance with a maximum external quantum efficiency (EQE, current efficacy (CE), and power efficacy (PE) as high as 23.2 %, 70.7 cd/A, and 55.6 lm/W, respectively. In particular, over 90% of EQE was reserved (EQE of 21.3%) at the practical luminance of 1,000 cd/m2, which is advantageous for display technology. At last, green OLED was also fabricated with a cross-linkable hole transport material 3,6-bis(4-vinylphenyl)-9-ethylcarbazole and realized PE of 63.6 lm/W with EQE of 25.3%, which could be very effective for lighting and display devices. These excellent outcomes demonstrate the big potential of the carbazole-benzophenone derivatives as host materials for next-generation solution-processable display and lighting technologies.

Aknowledgement
We acknowledge support from the Research Council of Lithuania (grant No. S-MIP-22-84).

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IN THE SEARCH OF NEW METAL-FREE EMITTERS FOR OLEDs EMPLOYING RPA TECHNOLOGIES

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Nowadays, organic light-emitting diodes (OLEDs) are widely used in digital displays and are a promising light-source for future technology[1,2]. Over the last few decades, huge resources have been devoted to the scientific search for new emitters and development of high-stability and efficient OLEDs. However, even today this problem remains a big challenge. To develop high-performance thermally activated delayed fluorescence (TADF) emitters for the 3rd generation of OLEDs, firstly, a minimal energy gap (ΔE_{ST}) between the lowest excited singlet (S1) and triplet state (T1) is mandatory for reverse intersystem crossing to happen. Another crucial element is the small spatial overlap between the HOMOs and LUMOs[3,4]. Concerning these parameters, we developed a semi-autonomous tool generating numerous new metal-free emitter structures for optoelectronics based on combinatorial screening, RPA (robotic process automation) technologies and quantum chemistry tools. Additionally, the developed system offers a significant advantage by operating continuously and autonomously on servers, without any interruptions, 24 hours a day, 7 days a week. Finally, all generated data and selected promising new compounds will be stored and presented for researcher overview and future experimental work. Here in, we will present the principles of our developed tool, which could significantly improve scientific work in the search of new metal-free TADF emitters.

Acknowledgement

This research was supported by the interinstitutional project (OLEDAI) funded by Kaunas University of Technology and Vytautas Magnus University. Grant No. (PP2023/39/5).

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PEROVSKITE SOLAR CELLS WITH MONOLAYER MODIFIED PTAA AND ITS APPLICATION TO ALL-PEROVSKITE TANDEM SOLAR CELLS

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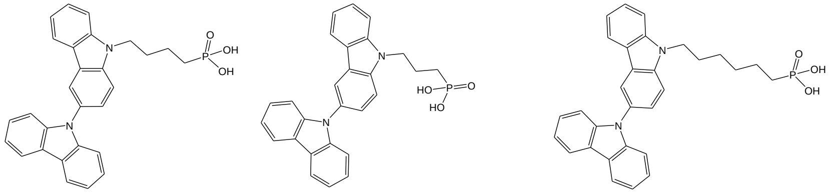
Organic-inorganic perovskite solar cells (PSCs) have achieved a recorded power conversion efficiency (PCE) of 25.7%.[1] Thus, PSCs are considered to be the dominant player in the next-generation photovoltaic market.[2] So far, single-junction PSCs with narrow bandgap values have attracted attention.[3] As a member of perovskite materials, wide-bandgap perovskite (WBG-PVK) can`t be ignored because it is important for tandem solar cells due to its matchable bandgap.[4] However, low PCE and the current of WBG-PSCs limited the efficiency of the tandem solar cell. So, it is necessary to further improve the PCE of wide bandgap PSCs.

Here, we demonstrate a series of self-assembled monolayer materials (SAMs) with different alkyl chain lengths as interfacial modifiers to modify the PTAA and perovskite layer for improving the optoelectronic properties of PSCs by improving the quality of perovskite films and increasing the transport and extraction of interfacial carriers (Fig. 1).



4,3BuPACz **3,3PrPACz** **6,3HePACz**

Fig 1. New SAMs (named 3,3PrPACz, 4,3BuPACz, and 6,3HePACz)

In conclusion, several new SAMs have successfully been used to modify the interface between PTAA and WBG perovskite layer. The experimental results show that after the introduction of 4,3BuPACz, the quality of the perovskite thin film has significantly improved. 4,3BuPACz/PTAA-based PSCs achieved a high PCE of 16.57% with a bandgap of 1.77 eV. The target tandem solar cells gave a PCE of 25.24%, which is the highest PCE of tandem solar cells based on IZO. This work reveals a buried interface improvement mechanism with 4,3BuPACz/PTAA which can provide valuable guidance for developing effective SAMs buried layer materials.

Acknowledgement
This work was supported by project S-LJB-22-2 from Research Council of Lithuania.

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NEW MONO-MOLECULAR HTL LAYER FOR WIDE BANDGAP LEAD PEROVSKITE SOLAR CELLS

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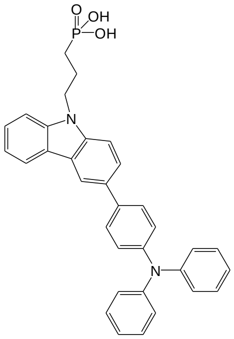
Recent years have reached intense research and development efforts of perovskite solar cells (PSCs), due to their growing efficiency [1]. Self-assembled molecules (SAMs) have been widely employed as hole transport materials (HTL) that can improve the power conversion efficiency (PCE) of perovskite solar cells (PSCs). In this study, newly carbazole-based material (**4dp3PACz**) was synthesized and used as HTL. The structure of compound is shown in Fig. 1.



4dp3PACz

Fig. 1. Structure of compound **4dp3PACz**

The experimental results showed that the mono-molecular layer of 4dp3PACz works as the hole transport layer better than previously reported 2PACz and PTAA. The perovskite layer fabricated on 4dp3PACz had better quality, such as less carrier trap densities and longer carrier lifetime. All-perovskite/perovskite tandem solar cells with 26.47% was reported by coupling the wide band gap device with 1.77 eV bandgap and narrow band gap device with 1.25 eV bandgap.

Acknowledgement

This work was financially supported by the NEDO project and by project S-LJB-22-2 from Research Council of Lithuania.

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POLYMERIC ORGANIC LIGHT-EMITTING DIODES BASED ON EMITTERS EXHIBITING THROUGH-SPACE CHARGE-TRANSFER TYPE THERMALLY ACTIVATED DELAYED FLUORESCENCE

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Thermally activated delayed fluorescence (TADF) emitters are among the most promising electroluminescent materials for organic light-emitting diodes (OLEDs) [1]. They were developed after the conventional fluorescent and phosphorescent emitters and are considered the third-generation OLED emitters. Over the past decade, a variety of TADF organic compounds have been synthesized with deep-blue to red emission. These compounds have been successfully used for the development of efficient OLED devices. However, the current fabrication process relies on expensive vacuum deposition techniques. Recently, there has been a significant interest in TADF polymers as they offer a simple, low-cost, and easily scalable solution for various methods such as spin-coating and ink-jetting. Through-space charge-transfer (TSCT) TADF polymers represent one of the most promising emitters for solution-processable polymeric OLEDs [2]. However, despite their potential, the efficiency of OLEDs based on TSCT polymers still lags behind the state-of-the-art values.

In this work, we focused on the photophysical and electroluminescent properties of new polymeric TADF emitters that exhibit TSCT [2]. These emitters have the ability to easily adjust the colour of their emission from blue to orange. They exhibit exciplex emission via TSCT mechanism. In addition, delayed fluorescence in the range between 0.35 and 6.2 μs in solid state was detected which makes the synthesized polymers promising materials for emitting layers of multicolour solution-processable OLEDs. Although photoluminescence quantum yields of the solid samples of synthesized alternating copolymers were relatively low (2.12% - 6.32%), the host-free solution-processable TADF OLED fabricated using one of alternating copolymer with green emission as emissive material showed promising external quantum efficiency of 7.84% [2]. The OLEDs exhibited stable electroluminescence spectra at various voltages, indicating good overall performance. The polymers are promising in terms of light emission, charge injection, and charge transporting properties and are potentially useful for multi-coloured, solution-processable electroluminescent devices.

Acknowledgement
This project has received funding from the Research Council of Lithuania (Project "ELOS" No S-MIP-21-30).

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BLUE AGGREGATION-INDUCED EMISSION MOLECULES CONSISTING OF PHENYLSULFONYL-BENZENE CORE AND TRIPHENYLETHENE-CARBAZOLE MOIETY FOF HIGHLY EFFICIENT OLEDS

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Organic light-emitting diodes (OLEDs) are becoming increasingly popular for use in display or phototherapy lighting applications due to their various advantages such as high-quality color, low energy cost, light weight, and flexibility [1, 2, 3].

New triphenylethylene compounds **EM1, EM2, EM3** were synthesized and are shown in Fig. 1. The photophysical, thermal, and electroluminescence characteristics of the designed emitters were investigated to clarify the molecular structure-property-performance relationship.

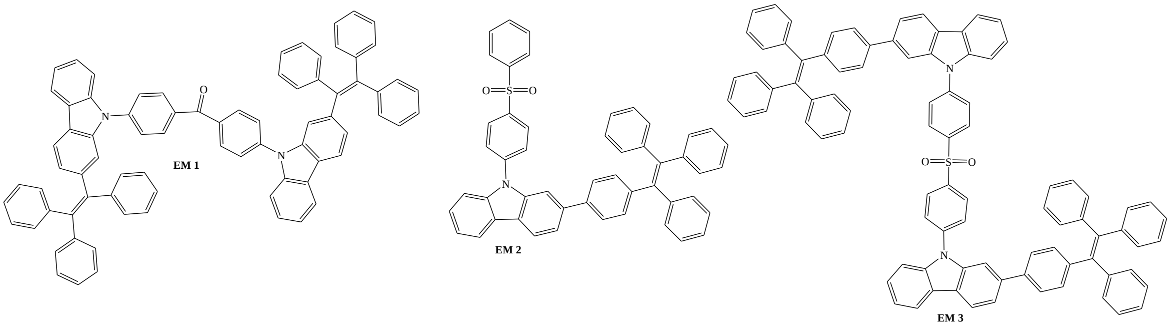

Fig 1. Triphenylethylene compounds.

The OLED device architecture of the doped OLEDs consists of ITO/TAPC/TCTA/mCP doped with **EM1**, **EM2**, or **EM3**/TmPyPB/LiF/Al. The efficiency decays of formed devices at 10^2 cd/m^2 were respectively estimated to be 17.6%, 0%, and 5.9%, demonstrating the advantage of **EM2**. These results indicate that the designed AIE molecules with (phenylsulfonyl)benzene core (i.e., **EM2** and **EM3**) have high potential for the development of blue-emitting OLEDs.

Acknowledgment

We are thankful to the Research Council of Lithuania (Grant No. S-MIP-22-84) for funding our research.

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RAMAN ANALYSIS OF Cu_xS THIN FILMS DEPOSITED ON the SURFACE OF POLYPROPYLENE

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Polypropylene (PP) is one of the most widely used thermoplastic polymers with great chemical, physical and mechanical properties. In this work, the preparation of electrically conductive Cu_xS/PP films by deposition of copper sulfide from an aqueous solution onto a polypropylene film surface r via chemical bath deposition method (CBD). Copper sulfide layers were deposited using a mixture of 0.05 M $CuCl_2$ and 0.05 M $Na_2S_2O_3$ solutions. The CBD process was carried out from 1 to 3 cycles at room temperature. The duration of each cycle was 16 hours.

In order to find the optimal technological conditions for the Cu_xS deposition process, the influence of deposition cycles was studied. Analysis of this material included studies of structure, morphology and electrical surface conductivity.

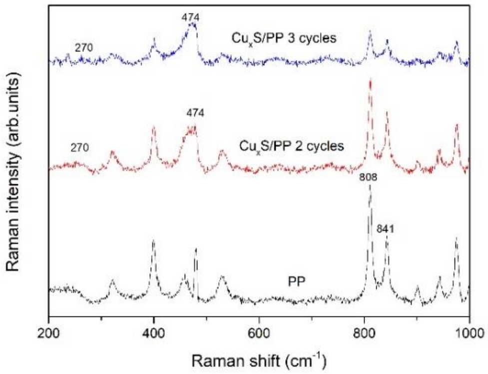

Fig. 1. Raman spectra of the Cu_xS/PP thin films

Raman Spectroscopy is a non-destructive chemical analysis technique which provides detailed information about chemical structure, phase and polymorphy, crystallinity and molecular interactions of materials. Raman spectrum of PP 6 (Fig. 1) shows *C–C* stretching at 808 cm^{-1} and 972 cm^{-1}, band at 841 cm^{-1} is related to rocking CH_2, rocking at 972 cm^{-1}and 998 cm^{-1} corresponds to CH_3 vibrations [1]. As shown in Fig. 1, the typical Raman spectra copper sulfide film samples (deposited at 2 and 3 cycles) exhibit similar peak positions. The spectrum reveals a pronounced peak at 474 cm^{-1}, which is assigned to vibrational (stretching) modes from the covalent S–S bonds [2] and a much weaker peak at about 270 cm^{-1} attributed to the Cu–S bond vibration [2]. Therefore, the main attention was paid to the analysis of the intensity of the most intense Raman mode at 474 cm^{-1}. Raman analysis confirms the composition of the copper sulfide on the surface of PP films.

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ANALYSIS OF CuxS THIN FILM DEPOSITED ON SURFACE OF POLYAMIDE – RAMAN SPECTROSCOPY

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The preparation of electrically conductive CuxS/PA films by deposition of copper sulfide from an aqueous solution onto a polyamide film surface is reported in this paper.
Copper sulfide (CuxS) layers were deposited on the surface of polyamide via the chemical bath deposition method (CBD) at room temperature using a mixture of 0.05 M $CuCl_2$ and 0.05 M $Na_2S_2O_3$ solutions for 16 h. The CBD process was carried out by varying the number of cycles (1, 2 or 3 cycles) of deposition. The influence of deposition cycles was studied to determine the optimum condition for the deposition process. The analysis of this material included studies on the structure, morphology and electrical surface conductivity.

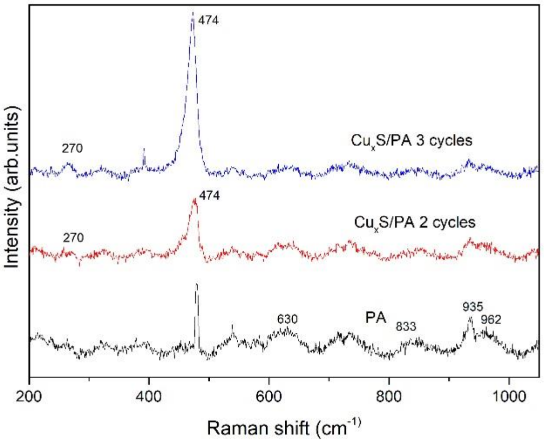

Fig. 1. Raman spectra of the CuxS/PA thin films

Raman spectroscopy is a useful spectroscopic technique to study the crystal phase, crystallinity and vibrational properties of the films. Raman spectrum of pure PA 6 (Fig. 1) shows *C–C* deformation mode at 630 cm^{-1}, band at 833 cm^{-1} is related to rocking CH2, while stretching mode of CH_2 is at 935 cm^{-1}, and 962 cm^{-1} corresponds to *CO–NH* vibrations [1]. As shown in Fig. 1, the Raman spectra of copper sulfide film samples (deposited at 2 and 3 cycles) exhibit similar peak positions. The spectrum reveals a pronounced peak at 474 cm^{-1}, which is assigned to vibrational (stretching) modes from the covalent S–S bonds [2] and a much weaker peak at about 270 cm^{-1} attributed to the Cu–S bond vibration [2]. Therefore, the main attention was paid to the analysis of the Raman intensity of the most intense mode at 474 cm^{-1}. Raman analysis confirms the composition of the copper sulfide on the surface of PA films.

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DIBLOCK COPOLYMERS OF METHACRYLOYLOXYETHYL PHOSPHORYLCHOLINE AND DOPAMINE METHACRYLAMIDE: SYNTHESIS AND SOLUTION PROPERTIES

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Hydrophilic polymers with phosphorylcholine head groups, such as poly(2-methacryloyloxyethyl phosphorylcholine) (pMPC), are antifouling materials that are suitable for creating biomimetic cell-membrane-like structures on various surfaces [1]. This property is valuable for applications involving biological entities like proteins and cells, biological samples like tears and saliva, and contact with plasma and blood [2]. Polymers containing MPC segments also serve as effective lubricants for surfaces in aqueous media.

To incorporate MPC segments onto surfaces, an anchoring polymer block is necessary. Remarkable adhesive properties are provided by catechol groups, which are present in both mussel adhesive proteins and recently developed synthetic polymers [3]. Polymers with catechol groups offer a fast and efficient method for decorating surfaces of different origins with appropriate monolayers.

In this study, bioinspired by excellent adhesion performance of mussels and superior lubrication performance of phospholipids, biomimetic diblock copolymers of 2-methacryloyloxyethyl phosphorylcholine (MPC) and dopamine methacrylamide (DOPMA) were synthesized via RAFT polymerization for the first time. To prevent undesired side reactions during polymerization, dopamine methacrylamide with acetonide-protected hydroxyl groups (ADOPMA) was used as a monomer. The diblock copolymers were characterized by SEC with triple detection, NMR spectroscopy and FTIR spectroscopy.

Amphiphilic diblock copolymers were synthesized starting with the pMPC block. The polymerization of MPC was well-controlled, resulting in polymers with a very low dispersity index (Đ about 1.1) and a degree of polymerization (DP) ranging from 20 to 80. Chain extension of pMPC as a macro-CTA by ADOPMA units produced diblock copolymers with a short pADOPMA block (DP approximately 10). NMR spectroscopy and DLS data confirmed the formation of amphiphilic diblock copolymers without residual pMPC. Deprotection of pADOPMA block by TFA was almost quantitative yielding the desired copolymers pMPC-*b*-pDOPMA.

The solubility and aggregation behaviour of the diblock copolymers of MPC and DOPMA, both with protected and unprotected catechol groups, were studied by DLS. The diblock copolymers with protected catechol groups exhibited full solubility in methanol but formed micelles with a pADOPMA core and a pMPC shell in aqueous solution. None of the solvents, including methanol, dissolved the diblock copolymers with unprotected catechol groups. Evidently, the catechol hydroxyl groups formed hydrogen bonds with each other, creating a tightly packed core structure regardless of the solvent. Surprisingly, raising the solution temperature to 45 °C resulted in the dissolution of the diblock copolymers in water, demonstrating the thermoresponsive nature of such copolymers.

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BIOBASED POLYESTER COMPOSITES FOR PACKAGING APPLICATIONS

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The increasing concerns of food packaging waste on the environment are raising interest on more sustainable polymer materials and their composites to reduce environmental impact. In this case bio-based polymers are considered as a less harmful alternative to traditional plastics [1]. To enhance the properties of bio-based polymer composites, additional natural fillers were chosen. The nanoclay filler was used as to improve the polymer matrix mechanical and thermal properties [2]. Additionally, to improve antibacterial properties chitosan with different degree of acetylation was used [3].

Bio-based polyester from NaturePlast with either 35% (PBE 001) or 50% (PBE 003) of bio-based polymer content was used as a matrix for packaging films. The bio-based polymer composite samples with nanoclay (Nanocor) at 1 – 5 wt.% and chitosan (C95 and C98) at 3 – 10 wt.% were prepared by laboratory two-roll mills. Samples for rheology, dynamic mechanical analysis and tear resistance tests were obtained by compression molding.

Results showed that C95 and C98 chitosan fillers from 3 to 10 wt. % increase melt viscosity of the bio-polymer matrix whereas the nanoclay effect on the viscosity increase was to a lesser extent. In contrast dynamic mechanical analysis showed that nanoclay filler at higher concentrations improved bio-based polymer composite storage modulus indicating on reinforcing effect while chitosan effect on this parameter was minimal. Similar reinforcing effect of the nanoclay was observed in tear test of the bio-based polymer films.

Acknowledgement

This research is funded by the Latvian Council of Science, project “Smart Materials, Photonics, Technologies and Engineering Ecosystem” project No VPP-EM-FOTONIKA-2022/1-0001

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PVA THERMOELECTRIC NANOCOMPOSITE CONTAINING MWCNT-Sb_2Te_3 AND MWCNT-Bi_2Se_3 HYBRID FILLERS

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Thermoelectric materials are known for their ability to convert heat energy in to electrical energy. This can be achieved due to their characteristic low thermal conductivity and high electrical conductivity. Usually these materials are various inorganic compounds consisting of Bi, Te and other metallic elements. However, in recent years polymer based thermoelectric composites have received attention because of many benefits that they can provide to thermoelectric materials like lower density, cost reduction and mechanical flexibility [1].

In this work thermoelectric Sb_2Te_3 and Bi_2Se_3 fillers were synthesized on multi-walled carbon nanotube (MWCNT) surface by physical vapor deposition method [2]. Then obtained hybrid fillers were mixed into aqueous polyvinyl alcohol (PVA) dispersion to obtain PVA/MWCNT-Sb_2Te_3 and PVA/MWCNT-Bi_2Se_3 thermoelectric polymer composites. Flexible free-standing films of thermoelectric polymer composites for the characterization were obtained by solution casting.

Results showed that PVA/MWCNT-Sb_2Te_3 and PVA/MWCNT-Bi_2Se_3 films presented significant Seebeck coefficient, electrical resistivity and power factor parameters at hybrid filler concentrations at 15 wt.%. Seebeck coefficient measurements indicated that MWCNT-Sb_2Te_3 possess p-type and MWCNT-Bi_2Se_3 possess n-type thermoelectric behaviour. Besides thermoelectrical properties, hybrid fillers showed improvement in storage modulus of PVA matrix above glass transition temperature indicating on additional reinforcement effect. Lower LCTE values of the both hybrid fillers containing composites indicated on formation of the filler network throughout the PVA matrix and thus improving the dimensional stability of the composite by restricting the PVA macromolecular movement [3, 4].

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PRE-LOVED BIOTEXILE SUBTITLE DESIGNING WITH UNRECYCLABLE TEXTILE FIBRES

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Over the last two years designers Sarmite Polakova and Mara Berzina have researched colour separated post-consumer fibres. In a collaborative project with Riga Technical University, the designers dived into the depths of a single colour – yellow - and translating it into a marble-like colour palette. Waste does not have a single tone. Instead it mesmerizes with depths and patterns that create a complexity visible once looked closer at. *Pre-Loved* creates an alternative to the flawed traditional textile recycling. A unique production method turns inferior mixed blends into a sturdy bio-textile suitable for fashion, interior and product design applications. The lightweight leather-like material reveals new aesthetics and highlights the previous lives of each worn garment through colour and structural nuances. *Pre-Loved* is part of a larger project investigating various waste streams from the textile industry. Post-consumer garments, production waste, fibres, dust and even dye waste are seen as a resource for the creation of new material concepts.

About Studio Sarmite: Studio Sarmite is a materials design and research studio founded in Amsterdam, Netherlands and currently based in Frankfurt, Germany. Led by Latvian designer Sarmite Polakova, the studio work focuses on transforming industry waste and various by-products into new closed-loop concepts that can be brought back to the market. The studio's design practice consists of hands-on experimental research with the manipulation of existing designing and production methods. This playful, sometimes even silly approach leads to surprising findings that also question our existing ways of producing, consuming and discarding.

Acknowledgment

This work was supported by COSME Programme of the European Union for the Competitiveness of Enterprises and Small and Medium-Sized Enterprises (SMEs) in the framework of the "WORTH Partnership Project II" Partnership between Studio Sarmite and Riga Technical University

Credits:
Studio Sarmite A design studio for non-heroic materials.
Designers Sarmite Polakova and Mara Berzina
Collaboration with Riga Technical University (RTU)

Website: https://studiosarmite.com
Instagram: @studio_sarmite

XRD and SEM/EDS STUDIES OF COBALT SULFIDE LAYERS ON POLYAMIDE 6

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For several decades, new composite materials with various combinations of physical and chemical properties have been rapidly gaining importance in various fields of modern technology. Polymers with thin sulfide layers classified as composites. Composite materials, in addition to the useful properties of the polymer, such as plasticity, resistance to external influences, and low cost, acquire a number of valuable properties of the inorganic layer. Transition metal chalcogenides such as CoSe, CoTe, and CoS have attracted worldwide interest due to their layer-resistant physical and chemical properties and are considered among the most promising electrode materials. It is known that the stoichiometric composition of cobalt sulfide [1], as well as different morphology and surface structure, have a great influence on the electrode characteristics of materials [2].

Therefore, it is very important to be able to control the quantitative and qualitative composition of the resulting layers.

In this work, layers of cobalt sulfide with different compositions of cobalt and sulfur were deposited on a polyamide substrate by a technologically simple and inexpensive two-stage adsorption-diffusion method. Strips of polyamide 1.5×7 cm in size, 500 mm thick and with a density of 1.13 g/cm^3 were used as the substrate. Higher polythionic acids ($H_2S_nO_6$) with $n > 6$, compounds containing chains of divalent sulfur atoms, were used as a sulfurization agent. Cobalt(II) sulfate ammonia complex solution was used as a source of cobalt. To sulfurization, the polymer, the strips were immersed in solutions of polythionic acids with a concentration of 0.01 mol/L for various durations at a temperature of 60 ºC. At the second stage, the samples were treated with a cobalt precursor solution for 20 min at various temperatures. The influence of the deposition conditions on the structural properties, morphological and chemical composition of the deposited layers of cobalt sulfide was studied by X-ray phase analysis (XRD), scanning electron microscope (SEM) and energy-dispersive spectroscopy (EDS). The results of X-ray diffraction and chemical analysis confirmed the formation of layers of cobalt sulfide particles on the surface of polyamide strips. It was also found that with an increase in the concentration of cobalt sulfide in the layer formed on the polymer, the structural order of these layers increases towards a uniform one.

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SCRATCH RESISTANCE OF HOT STAMPED MULTILAYER STRUCTURES VS ADHESIVE NATURE AND THICKNESS

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The quality of document security devices with embossed hologram in the multilayer polymer based film depends not only on the hologram embossing technology and security level, but also on the hot stamping quality, which can vary in dependence of hot stamping regimes and adhesive layer properties.

The aim of this investigation was to find out the influence of the nature and thickness on the hot stamping.

Three water-based adhesives (S35.3197 (A1) and S35.3213 (A3) (Nolax, Switzerland), OPU746 (A2) (Lotto, Germany)) and one solvent-based adhesive TC-03 (A4) (Centro Grafico DG SpA, Italy) adhesive with different concentrations and viscosity were selected for the research. Rods with dfferent wire diameter (d = 4, 14, 24, 50 and 80 μm) were used to apply the adhesive layer on the multilayer metallized polymer film with embossed hologram. The thickness of the formed adhesive layer was measured using the Coating Thickness tester, CEM DT-156 (as a result, an average of 6 measurements was selected). The hot stamping procedure was performed on the paper substrate (grammage of $80 g/m^2$) using different press head temperature (60º, 73º, 90º, 106º and 113ºC), press load of 18N and pressing duration τ =1s. Scrach tests at constant load of 261 mN, 290 mN, 310 mN, 330 mN and 359 mN was carried out in order to evaluate quality of coating as well as quality after hot stamping on the paper substarte. Adhesive layer structure, scrach groove width and shape was evaluated visualy by optical microscopy.

It was obtained that between rod wire diameter and adhesive layer thickness a linear dependence exists. The structure and quality of the adhesive layer formed on the multilayer film surface is highly dependent on the adhesive nature, its viscosity, and adhesive layer thickness. The scratch resistance of the adhesive layer depends on the structural parameters of the adhesive layer and scraching conditions. At small scrach loads a groove was not formed, and at higher scrach loads the shape and width depends on adhesive layer. The same tendency was carried out for hot stamped structures. The best quality of stamped structures was found in case of adhesive layer A1 (rod diameter *d*=14μm, hot stamping temperature T=106ºC; rod diameter d=24μm, hot stamping temperature T=73º, 90º, and 106ºC; rod diameter d=50μm, hot stamping temperature T=73º, 90ºC) adhesive layer A2 (rod diameter d=14μm, hot stamping temperature T=106ºC; rod diameter d=24μm, hot stamping temperature T=106ºC; rod diameter d=50μm, and hot stamping temperature T=90º, 106º C) and for adhesive A4 at rod diameter d=50μm and hot stamping temperature T=106º C. These structures were selected for final evaluation. It was found that at smaller loads (P = 261 and 290 mN) independent of the structural parameters of the adhesive layer, the groove was not formed, while in the case of higher scrach loads (P = 309.89, 329.5 and 358.92 mN), adhesive failure from the paper substrate or cohesive failure of the multilayer structure was observed.

ELECTROSPUN MATERIALS IN TRIBOELECTRIC SERIES

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Electrospun nanofibrous materials are known to be suitable for applications in many areas from fabric technology, healthcare to energy devices. The interest to these materials is increasing. Due to the nanostructured morphology, fibrous materials in nano size demonstrate the better properties comparing to bulk materials. Larger specific surface area, good uniformity, large porosity, and tiny size are the advantages of electrospun materials that can provide a new choice for the triboelectric series.

Electrospinning is known as an effective fibre processing method. Electrospinning technique allows to choose various polymers using more and more biodegradable ones and produce electrospun materials with different structural characteristics and improved properties. It is also believed that applying electrospinning the triboelectric effect of the polymer materials will be enhanced because of the fibrous structure.

The aim of this research is to produce cellulose based materials by electrospinning method for energy harvesting applications. Cellulose acetate, Nylon and carbon black as a conductive additive have been chosen to prepare positive, negative, and conductive mats and to be tested in triboelectric series. To achieve the conductivity of the electrospun mat carbon black concentration was investigated from 3 wt% up to 30 wt%. The properties of the produced electrospun materials were characterized with tensile testing to estimate mechanical durability of the material, SEM analysis to characterize morphology and the conductivity was measured by 4-probe and 8-probe methods. Voltage characterizations and charge density measurements have been performed showing stability in triboelectric series and promising results for energy harvesting.

Acknowledgement

This research is the joint project between RISE and Taltech funded by Södra Skogsägarnas Stiftelse för Forskning, Utveckling och Utbildning.

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FEATURES OF THE PROCESSING THE POLYMER MIXTURE WASTE BASED ON GLASS-FILLED POLYAMIDE

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The main difficulty in processing a mixture of polymers by injection molding or extrusion is the compatibility of materials, which requires the addition of compatibilizers[1)]. Considering the fact that the content of polymer materials in the mixture can be different by mass, there is a need for a more detailed study of the properties and behavior of the obtained composition, because changes in the properties of the material can occur due to the influence of the chemical structure of polymers and fillers[2,3)]. The purpose of this research is to study the rheological properties and morphology of the mixture obtained from multicomponent polymer waste from glass-filled polyamide 6 (PA6GF30) and polycarbonate (PC) in various ratios for further forecasting and understanding of the production process parameters.

During the experiment, defective parts and technological waste from PA6GF30 and PC were crushed on a Rapid 200 crusher. The resulting mixture of PA6GF30/PC (90/10% by mass) was divided into separate components by sorting the elements of the parts. The melt flow rate (MVR and MFR) was measured on an MFI-1322 device with data processing according to ISO 1133. The morphology of mixtures of multicomponent waste with PA6GF30/PC in different ratios was evaluated by microphotographs of the extrudate section after the melt flow rate was determined using microscopic equipment Mitutoyo QS250Z. During the research, a decrease in melt flow rate (MVR, cm^3/10 min) was observed by 19% on average with each step of adding 10% by weight of PC to PA6GF30 until reaching a distribution of PA6GF30/PC of 60/40% by mass. According to the distribution of PA6GF30/PC 40/60% by mass, an increase in MVR by 47% was established, which is the maximum value of the melt flow rate. This indicates the achievement of the eutectic effect, in which the components of the melt simultaneously crystallize at the appropriate temperature. It is likely that in this case the mixture has a temperature of simultaneous crystallization of the substances, which is lower than the individual polymer composition and the obtained secondary polymer mixture has properties that are not inherent to any component. When increasing the concentration of PC up to 80% by mass again, an increase in fluidity was observed. This indicates the superiority of the properties of PC over PA6GF30. According to the results of microscopic studies, it was established that PC is mainly distributed in the shell of PA6GF30. A wider distribution of PC in the PA6GF30/PC mixture (60/40% by weight) is also visualized. This in turn confirms the fact that the secondary polymer mixture acquires mainly the properties of PC.

The obtained results confirm the possibility of processing multicomponent waste polymer composite materials by injection molding without their separation in the absence of significant influence on the process parameters. The composition and properties of the RA6GF30/RS eutectic mixture, which has a higher melt flow rate than that of the individual materials, allows reducing the processing temperature and injection pressure. This simplifies the process of re-processing of unsorted multi-component waste as opposed to the processing of separate polymer compositions, which makes it possible to reduce the negative impact on the environment.

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POLYAMIDES MODIFIED BY COMPOUNDS WITH SILOXANE GROUPS

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The intensive development of various branches of technology requires the development of structural materials with a high level of strength properties in a wide temperature range. It is especially actual for the friction and sealing units of the machine and mechanisms. Based on this, aromatic polyamides were chosen as the polymer base to solve the tasks, the units from which are characterized by a high level of operational properties [1,2].

To improve the tribological properties, finely dispersed graphite was added to their composition, which had the effect of increasing wear resistance and reducing the coefficient of friction during frictional interaction with steel [3]. However, a decrease in the mechanical properties of the obtained polymer composites (PCs) is observed.

In order to improve the mechanical properties, studies were conducted on the modification of graphite-filled PCs with siloxane modifiers. This is due to the fact that internal stresses arise at the polymer-filler phase interface as a result of the inhibition of relaxation processes and the difference in the coefficients of thermal expansion of the polymer and the filler, the reduction of which can be achieved by modifying the surface of the filler with a damping layer.

It is this role that siloxane modifiers perform. When studying the properties of multicomponent systems based on aromatic polyamides, the most important thing is to establish a functional relationship between the values of strength and tribological properties and the factors that determine them.

It has been established that the introduction of siloxanes into PCs based on aromatic polyamides leads to improve their properties. This is due to a change in the energy of intermolecular interaction and the structure of the polymer, which opens up opportunities for its use in friction and sealing units. The obtained PCs are able to increase the service life and improve the tightness of the equipment, thereby solving the environmental problem of protecting the environment from toxic emissions.

The developed materials passed industrial tests as a seal for high-pressure compressors instead of babbit, which made it possible to increase their durability by 3-5 times. The use of developed materials for sealing pumps by Peroni Pompe (Italy) significantly increased the durability of this equipment.

Thus, the modification of aromatic polyamides with siloxanes significantly increases the operational properties of parts from these materials and has a wide perspective for their usage in friction and sealing units.

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DEVELOPMENT OF BIOBINDERS WITH IMPROVED PERFORMANCE AND ANTIOXIDANT PROPERTIES BY PARTIAL SUBSTITUTION OF BITUMEN WITH LIGNIN

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Most binders that are used for pavement materials are derived primarily from fossil fuels. Bio-binder is an asphalt binder alternative made from non-petroleum-based renewable resources, which should not rival any food material, and have environmental and economic benefits. The development of bio-based materials is consistent with the principles of Green Chemistry and Engineering, which pertain to the design, commercialization, and use of processes and products that are technically and economically feasible while minimizing the generation of pollution at the source and the risk to human health and the environment.

Lignin is the second most abundant natural polymer surpassed only by cellulose; millions of tons of lignin are produced from the pulp and paper industry annually, however very little amount of it has been transformed into value-added bioproducts. More than 50 million tons of lignin is generated from the pulp and paper industry annually, but only 2% of this waste has been utilized. Lignin is natural polymer that reflects the structure of bitumen and therefore it could be used as suitable modifier for bitumen.

The aim of the research is innovative use of lignin-based modifier FKL (fractionated Kraft lignin) for development of "bio-binders" with enhanced performance at high and low temperatures as well as antioxidant properties. Optimal percentages of crude oil bitumen and FKL as well as technological parameters for manufacturing of bituminous binder compositions were determined based on rheological, physical and mechanical characteristics. Substitution of bitumen with FKL has been carried out up to 60%

Production of bitumen-FKL compositions was carried out with a high shear mixer at 160ºC, with 5000-6000rpm and mixing time from 10 to 60 minutes.

The obtained results show that because of partial substitution of the bitumen B70/100 with FKL, rut resistance is improved, as the softening point and critical temperature, determined by DSR test, increase from 48ºC to 65ºC and from 65ºC to 76ºC respectively. A rapid increase in dynamic viscosity at 135ºC temperature is observed when replacing 50% of bitumen with FKL, which means high viscosity during asphalt concrete production and the need for viscosity-reducing warm mix asphalt (WMA) additive. A rapid increase in dynamic viscosity from 111 mPa·s to 3456 mPa·s when substituting bitumen with 60% FKL may mean a phase change, i.e. FKL becomes the continuous phase of the bitumen-FKL system. Determination of antioxidant properties of traditional bitumen B70/100 and modified B70/100-FKL has been performed by using FTIR, Raman and optical spectroscopy. Analysis of the structure and chemical properties of B70/100 and B70/100-FKL modified was performed. Effect of FKL modification to improvement in aging properties of B70/100 samples is discussed.

Acknowledgement

This research is funded by the Latvian Council of Science, project “Smart Materials, Photonics, Technologies and Engineering Ecosystem” project No VPP-EM-FOTONIKA-2022/1-0001