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Conference materials were prepared on the basis of summaries of poster presentations sent by Short Course participants.

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P1

Functionalization of PVA with alkyl chains as a strategy to improve hydrogel's mechanical properties.

Alexis Alvear Jimenez[1], Rebeca Hernández Velasco[2], Alejandro J. Müller Sánchez[1],

[1]*Department of Advanced Materials, Faculty of Chemistry UPV/EHU, San Sebastian, Spain.*

[2]*Institute of Polymer Science and Technology ICTP-CSIC, Madrid, Spain.*

e-mail: alexisfernando.alvear@ehu.eus

PVA is used in the manufacture of gels due to its ability to form stable three-dimensional networks through hydrogen bonding with water molecules. These networks provide a porous structure that can be used in drug release [1], as a substrate for cell and tissue culture [2], or water treatment [3].

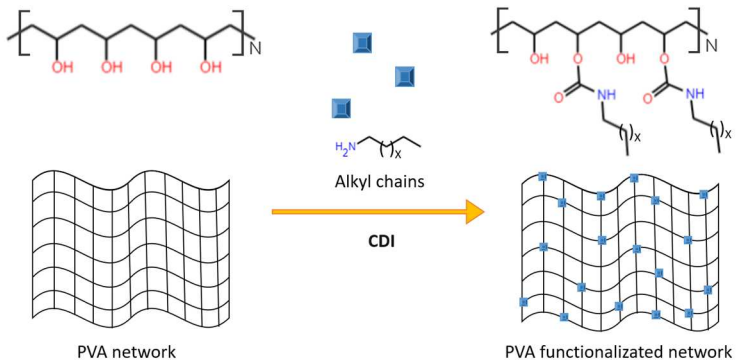

Figure 1. PVA functionalization.

The crystallization of PVA plays a fundamental role in the formation of stable gels with optimal mechanical and porous properties.[4] Thus, it is intended to covalently introduce alkyl chains that promote crystallization using a variation of the method reported by Zhao, L *et al*.[5] and studying its influence both on gel formation and on its properties at the nano, meso, and macroscopic scales.

Acknowledgment

This research was supported by an FPI grant from the Spanish Ministry of Science and Innovation (MCINN).

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The Development of Glycogen-Heparin Hybrids as Biodegradable and In-Blood Active Materials

Nadiia Davydiuk, Ann Maria Pandipilly Samson, Manfred Maitz, Uwe Freudenberg, Carsten Werner, Andreas Fery, Quinn A. Besford*

Leibniz-Institut für Polymerforschung e.V., Hohe Straße 6, 01069 Dresden, Germany

e-mail: besford@ipfdd.de

Glycogen is a naturally sourced biological nanoparticle that is bio-compatible and biodegradable, which has been leveraged in numerous theragnostic applications. Despite its desirable properties, glycogen naturally has minimal in-blood activity, which may lead to rapid immunological responses when the nanoparticles are injected intravenously. Heparin is a bio-active polymer that prevents and treats thrombotic disorders such as deep vein thrombosis, pulmonary embolism, and stroke, through specific interactions with components present in blood. In our work, we look to combine heparin with glycogen as new nanoparticle and hydrogel formulations as low-fouling, biodegradable and in-blood active materials.

The glycogen-heparin combination represents a promising approach for tissue engineering, such as wound healing, inflammation, and thrombosis treatments.

The hybrid materials are designed by thiol-Michael click reactions between thiol-modified glycogen and maleimide-modified heparin. Glycogen was modified with cysteine, endowing the particles with free thiol groups, whilst retaining the native biodegradability. The highly branched roughly spherical form of glycogen keeps during the modification, which was optimized to retain glycogen's inherent properties. The simple "click" reaction with heparin yielded in-blood active particles (e.g., delays blood clotting in human blood). Separately, we have used similar coupling chemistry to produce hybrid hydrogels by coupling glycogen with multi-maleimide heparin. The gel formation produced high elasticity of 2.0-2.5 kPa with the content of total thiol groups being in the range of 10-15%, and lowering rheological property of 0.8-1.0 kPa in the range of 15-30%. The combination of heparin and glycogen forms a stable and biocompatible gel that can potentially be administered topically. Together, our work demonstrates promising glycogen-heparin hybrid materials for theragnostic applications.

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P3

Revolutionizing Sportswear: Breakthroughs in Nanostructured Polymer Materials

Deepali Dhruvanshi

[1]*Affiliation: Technical University of Liberec,*

Faculty of Textile Engineering, Department of Clothing, Liberec, Czech Republic

e-mail: deepali.dhruvanshi@tul.cz

Through the incorporation of innovative materials, sportswear is undergoing a revolutionary transition. Nanostructured polymers, renowned for their exceptional adaptability and performance enhancements, are at the center of this paradigm shift. This poster examines the recent advances in enhancing the capabilities of sportswear fabrics by utilizing nanostructure polymer innovations.

The combination of polymers and nanotechnology has produced materials with nano-level properties that strike a delicate balance between durability, breathability, flexibility, and moisture management. This poster highlights the advancements made by tailoring nanostructured polymers such as polyethylene glycol diacrylate (PEGDA), polylactic acid (PLA), and polyurethane (PU) for sportswear applications. Strategically engineered with nanostructures, these materials provide exceptional moisture management and temperature regulation, significantly enhancing comfort during physical activities.

Furthermore, adding nanoparticles such as graphene and carbon nanotubes into polymer frameworks creates opportunities for enhancing mechanical strength and electrical conductivity. These advancements permit the creation of smart sportswear capable of monitoring vital signs and providing real-time feedback, thereby redefining athletic training and performance.

This poster illustrate the potential of nanostructure polymer materials, driven by the convergence of chemistry, nanotechnology, and textile engineering, to influence the future of sportswear. The presented innovations demonstrate their transformative impact and herald a new era of sportswear innovation that improves comfort and performance.

Keywords: Nanostructured polymers, sportswear, nanotechnology, clothing comfort, moisture management.

Acknowledgment

This work was supported by Technical University of Liberec, Czech Republic

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P4

Rheology and Printability of various Hydrogel Materials in 3D Extrusion Printing

Alejandro Hernández-Sosa[1,2], Diego Velasco[2], Rebeca Hernández-Velasco[1]

[1] *Institute of Polymer Science and Technology ICTP-CSIC, Madrid, Spain*

[2] *Department of Bioengineering and Aerospace Engineering, Universidad Carlos III de Madrid (UC3M), Spain*

e-mail: alejandrohs@ictp.csic.es

3D Extrusion Bioprinting has become very recently an emerging technique for manufacturing implants and scaffolds. This technology employs a hydrogel material known as biomaterial ink. The rheological properties of this biomaterial ink affect print quality of the scaffold, as well as the final application of the implant [1,2]. Thus, a rheological study that shows the critical parameters that will be involved in the 3D Bioprinting process is needed [3].

In this poster, the development of a series of hydrogels based on natural polymers is presented with emphasis on rheological characterization as a means to ascertain their suitability to be employed as biomaterial inks for 3D extrusión printing. Measurements of print quality are calculated, and together discussed with the rheological parameters for biomaterial inks based on alginate and their combination with microcrystalline cellulose (MCC) and nanofibrillated cellulose (NFC). Preliminary results on the rheological characterization of plasma derived hydrogels will also be presented.

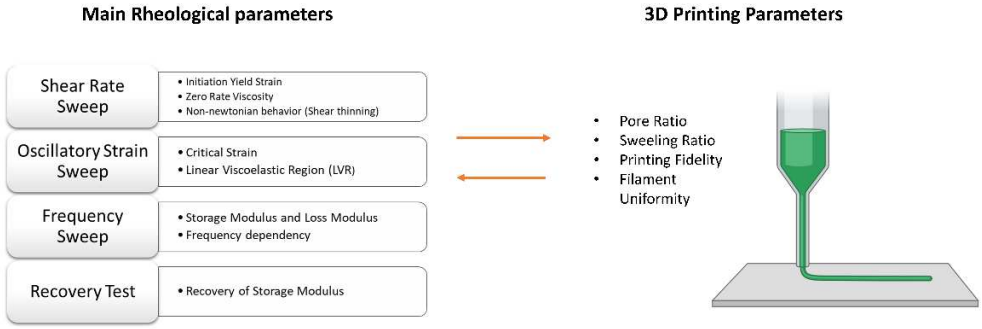

Figure 1. Rheological parameters extracted from the analysis and its correlation with 3D printing parameters

Acknowledgment

This research was financially supported by the project PID2020-113045GB-C22 funded by MCIN/ AEI /10.13039/501100011033.

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P5

Reversible Capture and Release of (Macro)molecules by Stimuli-Responsive Hydrogels in Microfluidics

Chen Jiao[1,2], Dietmar Appelhans[1], Jens Gaitzsch[1*], Brigitte Voit[1,2*]

[1] *Leibniz-Institut für Polymerforschung Dresden e.V., Hohe Straße 6, 01069 Dresden, Germany*

[2] *Lehrstuhl Organische Chemie der Polymere, Technische Universität Dresden, 01062, Dresden, Germany*

e-mail: jiao@ipfdd.de, voit@ipfdd.de, gaitzsch@ipfdd.de

Stimuli-responsive hydrogels have a wide range of potential applications in microfluidics, which has drawn considerable attention. In order to fabricate the next generation of microfluidic devices, we have integrated double cross-linked stimuli-responsive hydrogels [1]. Our device is made of poly(*N*-isopropylacrylamide) (PNiPAAm) and polyacrylamide (PAAm) hydrogel with a permanent cross-linker (*N,N'*-methylenebisacrylamide, BIS) and a reversible cross-linker (*N,N'*-bis(acryloyl)cystamine, BAC). An array of hydrogel dots was integrated into a microfluidic chamber through photopolymerization. The capture and release of the protein bovine serum albumin (BSA) is achieved through thiol-disulfide exchange. Cleavage and re-formation of disulfide bonds of BAC changed the cross-linking density of the hydrogel dots, making them swell and shrink over various cycles. Rheological measurements allowed for selecting hydrogels that withstand long-term shear forces present in microfluidic devices. Reversible capture and release of the protein reached an efficiency up to 84% in release rate and could be repeated over three cycles within the microfluidic device. A similar reversible capture and release of (macro)molecules was reached through host–guest interactions of hydrogel dots with their targets [2]. Adamantane-modified molecules were captured successfully by host–guest interactions formed between the β-CD poly(2-methyl-2-oxazoline) (CD-PMOXA) grafted chains in the hydrogel network and the guest molecules in the solution. Then the captured ones are released by perfusing free β-CD as competing guest molecules. Two kinds of guest molecule, a small molecule and a polymer, were captured and released for three times, with release ratios of 46% and 92%, respectively. The reproducible capture and release of functional molecules with different sizes demonstrated the stability of this microfluidic system and provided an ample platform for flow-through applications in a biomedical context.

Acknowledgement

The authors gratefully acknowledge the financial support by China Scholarship Council (CSC) and Deutsche Forschungsgemeinschaft (Graduiertenkolleg "Hydrogelbasierte Mikrosysteme", DFG-GRK 1865).

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Hydrogel lasers via supramolecular host–guest complexation

Matias Paatelainen[1], Markus Lahikainen[1], Alex Berdin[1], Kim Kuntze[1], Werner M. Nau[2], Nonappa[1], Arri Priimägi[1,*]

[1]*Faculty of Engineering and Natural Sciences, Tampere University, Finland*

[2] *School of Science, Constructor University, 28759 Bremen, Germany*

e-mail: matias.paatelainen@tuni.fi

Supramolecular host–guest complexes are dynamic systems where typically macrocyclic host molecule encapsulates smaller guest within its cavity [1]. In one specific application, supramolecular host–guest complexes can be used in controlling the photophysical properties of light-emitting dyes [2–4]. Dye encapsulation can prevent photobleaching and aggregation-induced fluorescence quenching especially in highly concentrated polar solvents [2]. However, liquid environments pose limitations in terms of relatively bulky structures and requirement for confinement.

We show stable and enhanced light emission in poly(N-isopropylacrylamide) (PNIPAm) hydrogel via supramolecular host–guest complex between cucurbit[7]uril (CB7) and rhodamine B acrylate (RhBa) and demonstrate a tunable distributed feedback hydrogel laser. [5]

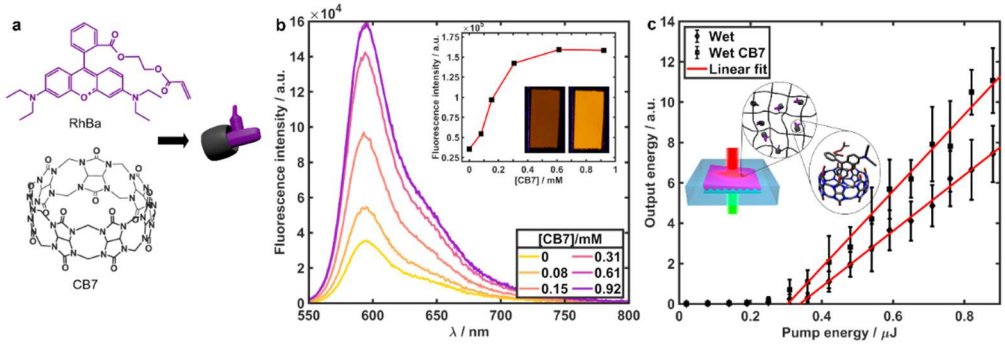

Figure 1: (a) Chemical structures and complexation schematics between RhBa and CB7. (b) Fluorescence emis-sion of hydrogel film with RhBa in water with increasing CB7 concentrations (Inset: Peak emission intensity change against CB7 concentration and photographs of hydrogel without (left) and with CB7 (right). (c) Laser in-put-output curves in the absence and presence of CB7.

Our results lay grounds for efficient, affordable, and small-scale portable optofluidic devices capable of directly interacting with liquid environments. As a continuation, we plan to utilize the responsiveness of hydrogels to gain dynamic control over light manipulation in similar systems.

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P7

Electronic Memory and Synaptic Plasticity in Diketopyrrolopyrrole- thiophene-based Polymer Doped with Organic Acceptor

Yadu Ram Panthi[1,2], Ambika Pandey[1,2], Bartosz Paruzel[1], Lubomír Kubáč[3], Jiri Pfleger[1]

[1]*Department of Polymers for Electronics and Photonics, Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, 16206 Prague 6, Czech Republic;*
[2]*Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, Prague 2, Czech Republic*
3Centre for Organic Chemistry, Rybitvi 296, 533 54 Rybitvi, Czech Republic
e-mail: panthi@imc.cas.cz

Memristive behavior and the possibility of mimicking synaptic plasticity were investigated in solid-state thin films of conjugated semiconducting copolymer mixed with low-molecular-weight organic acceptor. The polymer, poly[2,5-(2-octyldodecyl)-3,6-diketopyrrolopyrrole-alt-5,5-(2,5-di(thien-2-yl)thieno[3,2b]thiophene)], DPPDTT was combined with 2-diethylaminopropyl perylene (PDI) in 4 different weight ratios: 1:0, 9:1, 4:1, and 2:1 to explore the impact on memristive behavior.

The devices exhibited bipolar resistive switching showing hysteresis in the current-voltage characteristics. The current ON/OFF ratio up to 103, non-volatile memory effect in higher voltage, and synaptic plasticity reminiscent of biological synapses in low-voltage regime with a weight factor of 14% were observed at different operation regimes of the device. These effects were observed when PDI was added to DPP DTT up to 2:1 mass ratio. The electrical switching and hysteresis were attributed to the redox effect of copolymers, the trapping sites created by composites and the formation of space charge at the interfaces between DPP-DTT and perylene domains [1].

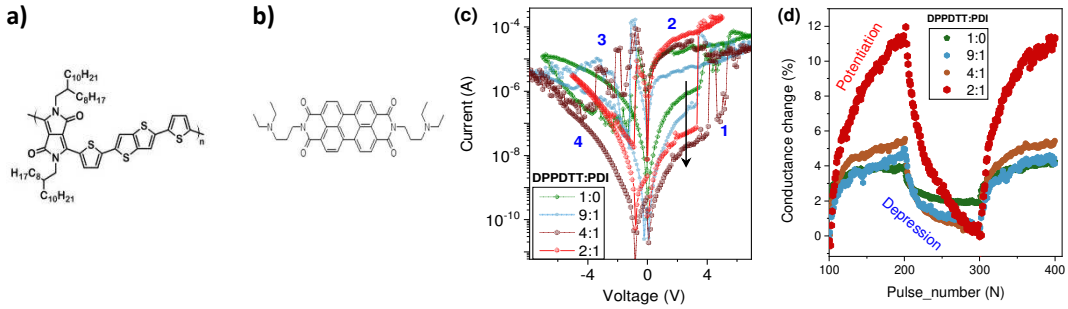

Figure 1: a)-b) chemical structure of DPP-DTT and PDI; c)-d) hysteresis in I-V characteristics and synaptic weight change in composites respectively.

Acknowledgement

The financial support of the Technology Agency of the Czech Republic. No. DP-TN02000067-001_Printed Electronics is gratefully acknowledged.

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P8

Metal-free and metal-based ionic liquids as catalysts towards fast carbon dioxide-epoxide cycloaddition: a green approach to non-isocyanate polyurethanes

Marwa Rebei[1,2], Ctirad Červinka[3], Andrii Mahun[1,2], Jan Honzíček[4], Petra Ecorchard[5], Hynek Beneš[1]

[1]*Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, Prague 6, 162 06, Czech Republic*

[2]*Department of Physical and Macromolecular Chemistry, Faculty of Science, Charles University, Hlavova 8, 12843 Prague, Czech Republic*

[3]*Department of Physical Chemistry, University of Chemistry and Technology Prague, Technická 5, CZ-166 28 Prague 6, Czech Republic*

[4]*Institute of Chemistry and Technology of Macromolecular Materials, Faculty of Chemical Technology, University of Pardubice, Studentská 573, 532 10, Pardubice, Czech Republic*

[5]*Institute of Inorganic Chemistry, Czech Academy of Sciences, Husinec-Řež 1001, 250 68 Řež, Czech Republic*

e-mail: rebei@imc.cas.cz

Recycling industrially produced greenhouse gases, such as carbon dioxide (CO_2), and their transformation into high-value-added chemicals is one of the most relevant strategies for reaching climate targets. In this study, we introduce a two-step strategy for designing non-isocyanate polyurethanes (NIPUs) from renewable CO_2. In the first reaction step, a mono-epoxidized monomer undergoes efficient conversion into cyclic carbonates under environmentally friendly reaction conditions and supercritical CO_2 (7.7 MPa, 80 °C). The use of imidazolium metal-free and metal-based (Zn and Co) ionic liquids (ILs) catalysts resulted in a high yield (98%) of cyclic carbonates. Comprehensive and detailed mechanistic insights provided by Density Functional Theory (DFT) and Nuclear Magnetic resonance (NMR) analyses elucidated the IL-catalyzed CO_2-epoxy reaction pathway. The second step involved the ring-opening reaction of cyclic carbonates with primary amines, resulting in the formation of urethane linkages. Consequently, this study presents a promising carbon-negative synthesis approach for designing NIPUs using CO_2 as an industrially abundant and readily available feedstock under mild and solvent-free reaction conditions.

Acknowledgement

The research was supported by the Czech Science Foundation (GAČR No. 22-05244S) and the Grant Agency of Charles University (GAUK No. 413022).

Chitosan-based composite beads for effective removal of heavy metals and radionuclides from aqueous solutions

Sabrina Shaikh, Asma Khan, Hemlata Bagla*
Kishinchand Chellaram College, HSNC University, Mumbai
e-mail: sabrina.shaikh@kccollege.edu.in

Addressing the critical challenge of heavy metal and radioactive contamination, especially prominent in developing nations, this research introduces an innovative approach using chitosan-based composite beads. These beads, formulated with dry cowdung powder (DCP), humic acid (HA), and bentonite (B), demonstrate remarkable potential for adsorbing silver and cesium from aqueous solutions. The primary objective of this study is to assess the efficacy of these composite beads as biosorbents while exploring their reusability.

The synthesis process is meticulously elucidated, accompanied by comprehensive characterization using advanced microscopy and spectroscopy techniques. Through systematic batch and column experiments, various parameters including pH, contact time, and metal ion properties are scrutinized for their influence on the adsorption process. In column adsorption, employing a 5mL bed at a flow rate of 30 mL/hr and 6-bed volumes/hr, 93±2% removal of Ag and 94±2% removal of Cs is achieved. Additionally, the desorption of metals exhibits 79±2% Ag and 72±2% Cs recovery, affirming the potential reusability of the composite adsorbent. This study not only presents an effective solution for contaminant removal but also contributes to sustainable practices through material recycling.

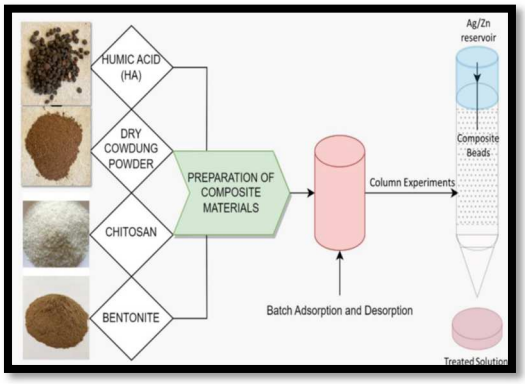

Fig. 1 Methodology & experimental procedure of using DCP-HA(CB) beads for batch and column Study

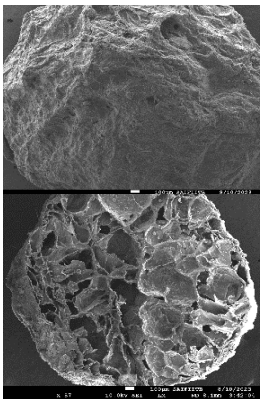

Fig. 2 FEG-SEM a) surface b)cross-section image of DCP-HA(CB)

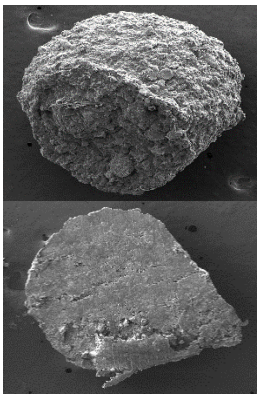

Fig. 3 FEG-SEM a) surface b)cross-section image of HA(CB)

Acknowledgment

We would like to acknowledge the Indian Institute of Technology- Bombay (IIT-B) for providing us with FEG-SEM and EDS results.

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P10

Radical Ring-opening polymerization of cyclic ketene acetals as a method to obtain branched, biodegradable polyesters

Fabian Mehner[1], Till Meißner[1,2], Martin Geisler[2], Albena Lederer[2,3], Jens Gaitzsch[3]

[1]*Technische Universität Dresden, Faculty of Chemistry and Food Chemistry, Organic Chemistry of Polymers, 01069 Dresden, Germany*

[2]*Leibniz-Institut für Polymerforschung Dresden e.V., Hohe Straße 6, 01069 Dresden, Germany*

[3]*Stellenbosch University, Private Bag X1, Matieland, 7602, Stellenbosch, South Africa*

e-mail: mehner@ipfdd.de

Microplastics and environmental pollution caused by vinylic polymers are known to be a threat to public health and environment. Following the need for (bio)degradable alternatives, radical ring-opening polymerization (RROP) of cyclic ketene acetals (CKAs) offers a method to synthesize branched polyesters with tunable properties.[1,2] A key feature of RROP is to incorporate various functionalities into the polymer backbone. In the work presented branching was proven to significantly impact macroscopic properties of P(CKAs) like viscosity and melting temperature and could thus be used as a tool to prepare polyesters with tailor made properties. To get an insight how to control the density of branches, kinetic studies on a potential PEG-surrogate revealed, that branching increased with monomer conversion and entirely independent of reaction conditions.[3] In line with earlier studies of a branched PCL, the polymer showed a mixture of two branching types: long chain branching and short chain branching.[4] This polymerization is hence key to develop modern functional polyesters with a wide range of targetable material properties.

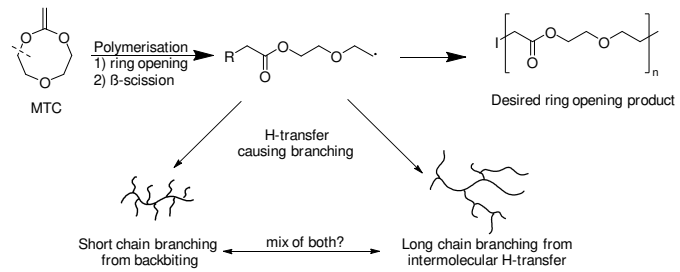

Figure 1: Polymerisation mechanism of the RROP of MTC leading to different branching types caused by H-abstraction within the polymerization.

Acknowledgement

The presented work was supported by a scholarship of the Evonik Foundation.

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P11

New camouflage coatings dedicated to textile products used for military and operational purposes

Małgorzata Główczyńska[1], Anna Marzec[2], Adam Pacholczyk[1]

[1]*Miranda Spółka z o.o., ul. Jedwabnicza 1, 62-700 Turek*
[2]*Institute of Polymer and Dye Technology, Lodz University of Technology, Stefanowskiego 16, 90-537, Poland*
e-mail: *mglowczynska@miranda.pl, malgorzata.glowczynska@dokt.p.lodz.pl*

Camouflage has been used in military operations since the beginning of time. The key is to hide the object in such a way that the observer's gaze, sweeping the field of view, automatically glides over the masked object without separating it from the background of the environment [1]. The most important element of winter weather is snow, which gives the landscape its appearance in winter. It is important that any camouflage clothes/covers do not rustle and do not stiffen in the cold.

However, in the era of intensive development of sensors equipped with optoelectronic equipment used on the modern battlefield, camouflage protecting only in the optical range (380nm - 780nm) is not sufficient. Due to this, the range of its operation should be extended to include UV, NIR. By its nature, snow reflectance varies both spatially and temporally. It also shows significant changes from the dry snow period through the season of melting, adding impurities and changing the measurement geometry and lighting [2]. The reflectivity values for dry, wet, wet and littered snow for various instruments range from 0.63-0.97 in the near ultraviolet, visible and near infrared bands. The mapping of these values was undertaken and then patented by Reed F. Curry US8220379B2 "Camouflage in the near ultraviolet spectrum". The masking paste described in the patent can be used on fabrics, however, it is washable [4].

The purpose of this study was to examine the degree of reflection of electromagnetic waves in the near ultraviolet range from polymer coatings applied to a flat, polyester textile product. These coatings will contain a white substance of organic or inorganic origin, will be flexible and resistant to water washing. In the first stage of work, 'fillers' and 'binders' were selected, which will be the basic components of a new coating paste providing protection against UV detection.

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Highly Reflecting Stable White Paint for the Detection of Ultraviolet and Visible Radiations
J. B. Schutt, J. F. Arens, C. M. Shai, and E. Stromberg

P12

Development of specialized coatings for attenuation of radar signals by camouflage products

Dorota Latańska-Wulw[1,2], Anna Marzec[1],Adam Pacholczyk[2]

[1,2] *Lodz University of Technology, Institute of Polymer and Dye Technology, Stefanowskiego 16, 90-53, Poland*

[3] *Miranda Spółka z.o.o 62-700 Turek ul. Jedwabnicza 1 Poland*

e-mail: dorota.latanska-wulw@dokt.p.lodz.pl

Camouflage in the military is an important element of tactics, and has been used with varying degrees of success since the very beginning of armed conflicts.

A number of studies on camouflage materials can be found in the literature and numerous patents. Unfortunately, they mostly concern multi-layered products of rigid construction with very limited functional features [1],[2], or solutions providing only camouflage in a selected range of the electromagnetic radiation spectrum [3]. However, the main requirement of the modern battlefield is to provide effective protection against sensors operating in the entire range of the electromagnetic radiation spectrum (UV, VIS, TIR, NIR, RADAR) Fig.1.

Achieving effective multispectral camouflage requires combining different materials, means and technologies in a single product. Textiles are widely used at every stage of camouflage production. This project is focused on develop finishing paste, which, when applied to a textile product in the form of a warp knitted fabric, will provide the level of radar signal attenuation required by the Defence Standards [NO-10-A208-2014/2021]. The goal of my project is to develop textiles for camouflage products containing:

- metal powders: aluminium, copper, nickel,
- carbon compounds,
- knitted fabric with carbon fibre,
- knitted fabric with inox fibre.

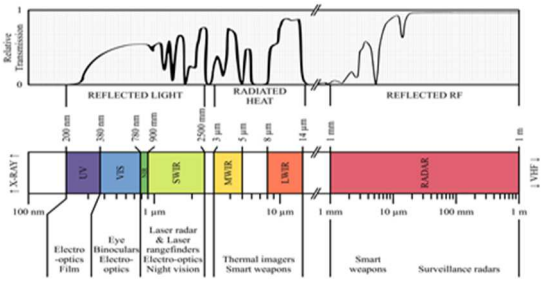

Fig.1 Spectrum of electromagnetic radiation

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P13

Designing a durable coating with thermochromic properties that reduces the energy demand of buildings

Jakub Lisowski, Anna Marzec

Institute of Polymer and Dye Technology, Lodz University of Technology, Stefanowskiego 16, 90-537, Poland
e-mail: jakub.lisowski@dokt.p.lodz.pl, anna.marzec@p.lodz.pl

According to Central Statistical Office in Poland (GUS), energy demand in households increased by 3 % in 2020 and by 0,4 % in 2021 [1]. Simultaneously, as stated in Energetic Regulation Office's raports, average selling price of electrical energy on market increased by 3 % in 2020 and by 10 % in 2021, and prices from II quarter of 2022 are even 84% higher than prices in the same quarter of 2021. Concerning household energy consumption, energy demand is growing, among other reasons, because of increasing interest in cooling buildings during warm months, which is result of globally growing temperatures. Considering steady growth of demand for energy and extreme increase in prices that accompanies it, it is reasonable to search for new methods of energy saving, especially if new material can affect more than one energy consuming sector (heating and cooling).Recently in simulation research it was estimated, that thermochromic materials can lead to significant changes in surface temperature, and therefore energy savings. This estimation has been confirmed by practical research, where thermochromic exterior coatings were prepared with satisfying thermal results, reducing wall temperature by 15 - 20°C, and roof temperature by as much as 25°C, and reducing Solar Reflection Index (SRI) at high temperatures with increased absorbance at lower temperatures [2].

However, mentioned research papers don't consider coatings' durability under atmospheric conditions, especially in terms of UV light stability, while it has been proven that thermochromic materials are vulnerable under UV exposition in other applications [3].

The aim of this project is to design durable elevation coating with thermochromic properties working as functional layer to reduce building's energy demand. The coating would remain dark in temperatures below set transition temperature (solar reflectance index below 20%), absorbing more heat from solar radiation and increasing heat transmission through the wall, reducing energy demand to keep warm inside, and would transit to light colour above this temperature, analogically reducing heat absorption and transmission, and therefore reducing energy costs for cooling during warm weather. Two main problems to solve are creating coating with transition effective enough to affect energy demand of the building, and durable enough to withstand atmospheric conditions for at least a year.

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P14

Tribological studies of bottle-brush polymers with anchoring group

Karolina Socha[1], Mahdi Rahimi[2], Gholamreza Charmi[3], Joanna Pietrasik[3], Xavier Banquy[4], Paulina Filipczak[1], Marcin Kozanecki[1]

[1] *Department of Molecular Physics, Lodz University of Technology, Poland*

[2] *Centre de Recherche, Hôpital du Sacré-Cœur de Montréal du CIUSSS NIM, Faculté de Médecine, Université de Montréal, Canada*

[3] *Institute of Polymer and Dye Technology, Lodz University of Technology, Poland*

[4] *Faculté de pharmacie, Université de Montréal, Canada*

e-mail: karolina.socha@dokt.p.lodz.pl

Osteoarthritis (OA) also called degenerative joint disease is a common disorder of the joints characterized by progressive deterioration of the articular cartilage or of the entire joint, including the articular cartilage, synovial membrane, the ligaments, and the subchondral bone. It is one of the leading causes of disability in the world population.

The key importance is the loss of component of synovial fluid, lubricin – a natural amino acid with a special spatial structure. The loss of synovial fluid leads to the changes in the joint functioning, including tribological properties, causing its degeneration.

An important aspect of this work is the synthesis and use of a new copolymer as a synthetic model of lubricin. New class of material was synthesized by reversible-deactivation radical polymerization [2]. These polymers have wide-ranging application possibilities, and due to their structure, they have very good lubrication properties which could be crucial in the treatment of the early stages of osteoarthrosis [3]. Molecular brushes were designed with blocks that help to anchor on the cartilage surface. The dynamic friction properties were evaluated using Surface Force Apparatus [4]. New advanced bottle-brush polymers seem to show the ability to be used to lower friction coefficient between surfaces.

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