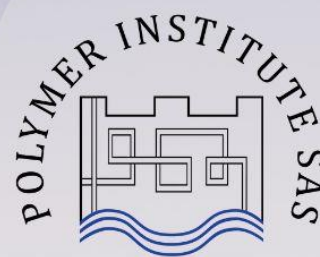


POLYMERS 2024

XIII. Slovak - Czech Conference



BOOK OF ABSTRACTS

October 1-4, 2024, Stará Lesná, Slovakia

PROGRAMME
&
BOOK OF ABSTRACTS

EDITORIAL

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Bratislava, 2024

WELCOME TO POLYMERS 2024

Dear Participants, colleagues, and friends,

After four years, the task of organizing the Slovak-Czech conference Polymers 2024 fell to the Slovak partner from the Polymer Institute of the Slovak Academy of Sciences. Considering the increased participation of foreign polymer chemists and physicists at the previous event organized by Czech partners from the Institute of Macromolecular Chemistry of the Czech Academy of Sciences, we decided to organize the conference internationally. We chose the Academia

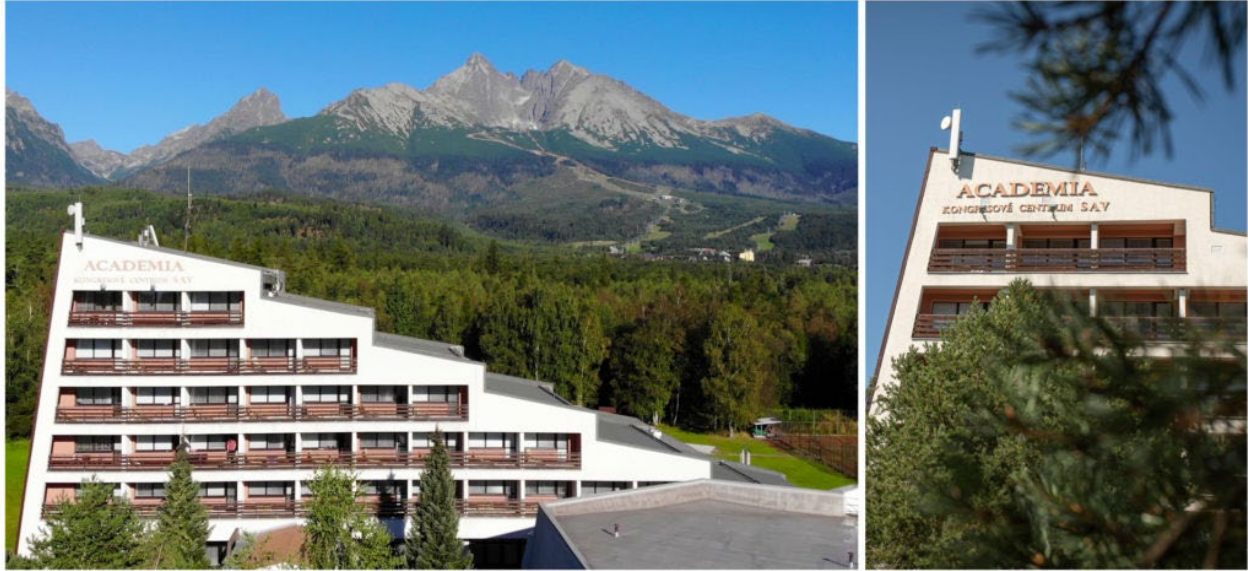
Hotel in Stará Lesná as the venue for the 13th edition of the Polymers 2024 conference, where the beginning of autumn creates a beautiful Tatra atmosphere. The goal of this conference has always been not only to present the participants' latest scientific results and outputs but also to create new scientific contacts and deepen cooperation between the Polymer Institute SAS and the Institute of Macromolecular Chemistry CAS. In addition to the broad focus of the conference's topics covering basic and applied research carried out by experimental or theoretical approaches, there is also space for the presentation of products by colleagues from the commercial sphere.

We believe that the tradition of this conference and the environment in which it will take place will attract scientists of all age categories including PhD students.

On behalf of the Organizing committee of Polymers 2024, it is my pleasure and privilege to welcome you to High Tatras, wish you a very nice stay here and a fruitful time.

Dr. Zuzana Benková
Chairwoman of Polymers 2024

VENUE



CONGRESS CENTRE ACADEMIA

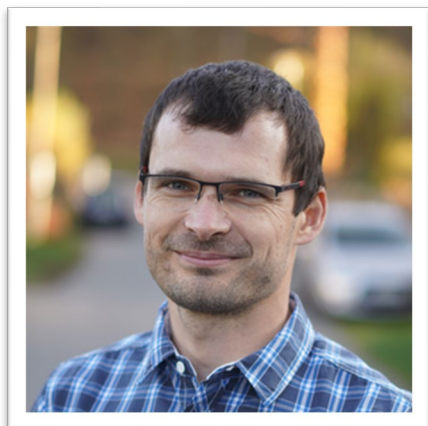
The Congress Center (CC) Academia is situated at the foot of the Lomnický peak in the eastern part of the Vysoké Tatry Mountains in Slovakia. It's located on the border of the Tatra National Park, in a quiet surrounding a short way off the towns Tatranská Lomnica and Starý Smokovec.

An advantageous situation is supplemented by small distances from the airport and the major Slovak routes in Poprad (only 15 km), as well as by nearness of the architectonic jewels of Spis region – Levoča, Kežmarok or Stará Ľubovňa.

More details about accommodation you can find on <https://kcacademia.sav.sk/en/>



PLENARY SPEAKER



doc. RNDr. Peter Košovan, PhD.
Charles University

[Curriculum Vitae](#)

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TITLE

Acid-base equilibria and partitioning of solutes in two-phase systems containing charged polymers and colloids

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PROGRAMME

Tuesday October 1, 2024		
17:00 - 18:30	Registration	
19:00	Welcome dinner	
Wednesday October 2, 2024		
9:00 - 9:20	Opening	
Session 1		
Chaired by	Jaroslav Mosnáček	
9:20 - 9:40	L-01 Pavol Alexy	Ecological materials from bio-based and bio-degradable polymers
9:40 - 10:00	L-02 Ivan Chodák	Modification of thermoplastic starch as a component in mixtures with biopolymers
10:00 - 10:20	L-03 Ivan Kelnar	Processing, blending and modifications of chitin/glucan complex in ionic liquids
10:20 - 10:50	Coffee Break	
Session 2		
Chaired by	Chih-Feng Huang	
10:50 - 11:10	L-04 Petr Štěpánek	Microfluidic preparation of polymer nanoparticles and giant polymer vesicles
11:10 - 11:30	L-05 Jozef Kollár	Exploring various techniques to produce polymeric nanoparticles
11:30 - 11:50	L-06 Vladimír Raus	Polysaccharide-synthetic polymer hybrids: from graft copolymers to blends and (nano)composites
11:50 - 12:10	L-07 Jaroslav Mosnáček	Oxygen tolerant surface initiated photochemically induced ATRP
12:10 - 12:30	L-08 Sachin Gupta	Functionality amplification for the straightforward synthesis of complex polymeric architectures
12:30 - 14:00	Lunch	
Session 3		
Chaired by	Zdenko Špitalský	
14:00 - 14:20	L-09 Shiao-Wei Kuo	Construction archimedean tiling patterns based on soft materials
14:20 - 14:40	L-10 Martin Danko	Dynamic polyester networks based on tulipalin a and ϵ -caprolactone crosslinked by thia-Michael reaction and activated by alkylation of thioether group
14:40 - 15:00	L-11 Katarína Borská	Poly lactide-based dynamic networks
15:00 - 15:20	L-12 Abolfazl Heydari	Dynamic networks in biomedical applications: connecting molecular behavior to macroscopic properties
15:20 - 15:40	L-13 Chih-Feng Huang	Investigations of efficient reactions towards polymerizations to the preparations of novel functional polyesters
15:40 - 16:00	L-14 Stepan Podzimek	Synthesis and molecular structure of acrylic copolymers containing bio-synthetic monomers
16:00 - 18:00	Poster session	
18:00 - 20:00	Excursion in Astronomical Institute SAS, dinner	
Thursday October 3, 2024		
Session 4		
Chaired by	Dušan Račko	
9:00 - 9:30	L-15 Peter Košován	Acid-base equilibria and partitioning of solutes in two-phase systems containing charged polymers and colloids
9:30 - 9:50	L-16 Pritam Guha	Tailoring 2-oxazoline based digradient copolymers for rifampicin delivery: synthesis, physicochemical properties, and colloidal behavior

9:50 - 10:10	L-17 Rafal Poreba	Well-defined poly(2-isopropenyl-2-oxazoline) brushes provide fouling resistance and versatility in surface functionalization
10:10 - 10:30	L-18 Zuzana Benková	Interactions of proteins with poly(ethylene oxide) modified surfaces in two different setups studied by molecular dynamics
10:30 - 10:50	Coffee Break	
Session 5		
Chaired by	Martin Hrubý	
10:50 - 11:10	L-19 Igor Lacík	Alginate-based microspheres for cell encapsulation in diabetes treatment
11:10 - 11:30	L-20 Michal Babič	Polymer particles as contrast agents for photoacoustic tomography
11:30 - 11:50	L-21 Krzysztof Jerczynski	Synthesis of molecular brushes with lubrication properties as component of novel injectable polymer gels for osteoarthritis treatment
11:50 - 12:10	L-22 Michal Pechar	Targeting of polymer drug delivery systems with recombinant proteins bound via tris(nitrilotriacetic acid)
12:10 - 12:30	L-23 Jiří Pflieger	Electronic memory phenomena in polymers – from digital memory to memristors and simulation of neuronal synapses
12:30 - 14:00	Lunch	
Session 6		
Chaired by	Zuzana Benková	
14:00 - 14:20	L-24 Peter Virnau	Knots in polymers, DNA and proteins
14:20 - 14:40	L-25 Dušan Račko	Knots in polymers and biopolymer and chirality
14:40 - 15:00	L-26 Renáta Rusková	DNA topology in Atomic Force Microscopy
15:00 - 15:20	L-27 Pawel Dabrowski-Tumanski	Borromean rings in proteins
15:20 - 15:40	L-28 Peter Cifra	Cavity confinement of semiflexible macromolecules
15:40 - 16:00	L-29 Ján Smrek	Active polymer melt
16:00 - 16:15	L-30 Stanislav Kukla	Chapters in Green chemistry
16:15 - 16:30	Coffee Break	
Session 7		
Chaired by	Zuzana Kroneková	
16:30 - 16:45	LS-01 Nafiseh Babaei	Synthesis and characterization of biocompatible and 3D printable poly (OEGMA-stat-MMA) thermoplastic elastomers via ATRP polymerization suitable for tissue engineering applications
16:45 - 17:00	LS-02 Ankita Meena	Propagation rate coefficient of methyl acrylate and 2-methoxy ethyl acrylate in water and ethanol/water mixtures
17:00 - 17:15	LS-03 Omid Moghaddam	Investigation of dynamic and static properties of cyclic polyacrylate melts
17:15 - 17:30	LS-04 Silvia Mares Barbosa	Natural nanofillers from <i>Aspergillus niger</i> as a highly efficient reinforcement in novel elastomers based on waterborne polyurethane
17:30 - 17:45	LS-05 Fereshteh Kazemi-Aghdam	Mechanical characterization of dual crosslinked alginate-based hydrogel formed via reversible covalent bonds
17:45 - 18:00	LS-06 Aakash Sharma	The unusual gelation in aspartate-based polyurea: effect of sniv salt on network structure
19:00	Conference dinner	
	Special evening lecture Ivan Chodák	Swing, an important part of jazz music, piano performance and comments

Friday October 4, 2024**Session 8**

Chaired by	Matej Mičušík	
9:00 - 9:20	L-31 Zdenko Špitalský	Antibacterial activity of 3D printed thermoplastic elastomers for biomedical applications
9:20 - 9:40	L-32 Radek Stocek	A detailed study of the effect of cyclic loading on the thermal expansion coefficient of reinforced styrene-butadiene rubber as a function of different carbon black types"
9:40 - 10:00	L-33 Anastasiia Stepura	Study of properties of novel HAVOH-based polymeric nanocomposites with 2D MXene
10:00 - 10:20	L-34 Mária Kováčová	Hydrophobic carbon quantum dots as antimicrobial agent in polymer coatings and their eco-toxicity study
10.20 - 10.50	Coffee Break	

Session 9

Chaired by	Igor Lacík	
10:50 - 11:10	L-35 Martin Hrubý	Stimuli-responsive polymers for bioapplications: From drug delivery systems to sensor
11:10 - 11:30	L-36 Juraj Kronek	Poly(2-isopropenyl-2-oxazoline) as a versatile functional polymer for advanced materials
11:30 - 11:50	L-37 Tibor Macko	Advanced analytical characterization of synthetic polymers with chromatographic and spectroscopic method
11:50 - 12:10	L-38 Zuzana Kroneková	Cationic poly(2-ethyl-2-oxazoline)s as new class of biocompatible modifiers of montmorillonites for sorption and decontamination of organic molecules
12:10 - 12:30	L-39 Matej Mičušík	Two-dimensional materials and hybrids for advanced application
12:30 - 13:00	Closing	
13:00 - 14:00	Lunch	

Wednesday October 2, 2024

P-01	Emrah Çelen	Silk fibroin nanoparticles: a novel carrier for bioactive agents in skin therapy
P-02	Tania Chopra	Synthesis of guanidine-based polycations for the preparation of multicomponent microcapsules
P-03	Öznur Emeklioğlu	Preparation of novel cardanol based polyurethane dispersions as fluorine free water repellents for textile applications
P-04	Oľga Fričová Natália Šmídová	Changes in molecular mobility in thermoplastic starch due to humidity and storage time – NMR study
P-05	Mária Gurská	Controlled polymerizations of furan-based monomers for developing sustainable (co)polymers
P-06	Shima Kalantarifard	Synthesis and characterization of soluble and insoluble β -cyclodextrin-Taurine polymers
P-07	Matus Kalina	Synthesis and morphological characterization of an PLA-PDMS-PEE ABC miktoarm star
P-08	Peter Machata	Conducting polymers as an efficient tool to enhance catalytic activity of Ni foam-based catalysts
P-09	Mayra Mariño	Synthesis and properties of ferulic acid-grafted nanocellulose radical-mediated
P-10	Alžbeta Minarčíková	Poly(2-isopropenyl-2-oxazoline) for sustainable delivery of ibuprofen: cytotoxic and bioimmunological effects
P-11	Vít Guiglielmo Mišurec	Nitroaromatic- and diselenide-based polymer radiosensitisers aiming higher radiotherapy efficiency
P-12	Alena Opálková Šišková	Kitchen waste-derived biochar: preparation and comprehensive characterization
P-13	Jiří Pánek	A new concept of polymer potentiometric-fluorescence sensor
P-14	Anita Rana	Poly(2-oxazoline)-stabilized nanoparticle-based carriers for binding to cell membrane receptors
P-15	Farnoush Salehtash	Feasibility of screen-printed sensor based on the kitchen waste-derived biochar
P-16	Mohamed Shaalan	The expression of virulence genes in Staphylococcus aureus after contact with HCQDS/PDMS
P-17	Oleksandr Shapoval	Liraglutide-labeled poly(methyl vinyl ether-alt-maleic acid)-coated upconverting nanoparticles for diabetes theragnostic
P-18	Manisha Singh	Controlled, rapid and straightforward synthesis of poly(n-(2-hydroxypropyl) methacrylamide, (poly(HPMAM))), brushes via interface-mediated reversible addition-fragmentation chain-transfer (RAFT) polymerization
P-19	Zita Tomčíková	Preparation of the biofilms mass dyed with food pigments
P-20	Anita Wysopal	Porous poly(methylhydrosiloxane)-based materials: modification using n-allylpiperidine
P-21	Justyna Żmuda	Multicompartment or not: structural insights into temperature- and concentration responsive copolymer micelles

BOOK OF ABSTRACTS

L-01: ECOLOGICAL MATERIALS FROM BIO-BASED AND BIO-DEGRADABLE POLYMERS

Pavel Alexy^{a,b}, Mária Mikolajová^b, Mária Fogašová^b, Vojtech Horváth^b, Andrej Baco^b,
Michal Ďurfina^b, Sára Vach Agócssová^b, Jozef Feranc^b, Roderik Plavec^b

^a*Slovak University of Technology in Bratislava, FCHPT, Institute of Natural and synthetic polymers; Radlinskeho 9, Bratislava (pavol.alexu@stuba.sk)*

^b*Panara a.s., Krskanska 21, Nitra; (pavol.alexu@panara.eu)*

Actual trends in environmental protection is focused mainly on decarbonisation of industry (reducing of fossil greenhouse gasses), elimination of littering in nature, saving of energy sources. Main ecological stream in polymer industry is focusing on recycling and protection of environment against micro particles, especially micro plastics. A lot of effort is devoted to collection, separation and recycling of plastic waste, while as the most effective methods are considering material recycling, chemical recycling and also energetical recovery of plastic waste. All these basic methods are strongly supported by European legislation. True is, that material recycling is not possible in case of plastics 100% and infinity times, so finally unrecyclable plastic waste is incinerated. In case of synthetic plastics green house gasses are produced by this way and, in addition, sources for production of new polymeric materials are not recovered. It is not long term sustainable solution. From this point of view, new ways should be evaluated for finding more effective and sustainable solutions. Based on logical analysis, the full ecological polymeric materials have to fulfill next basic criteria:

- fully bio-based, without fossil based raw materials
- fully biodegradable in all environments

optionally

- reusable
- recyclable

Many solutions in the present are based on PLA modified with fossil based polymers like PBAT, also frequently combined with modified starch. Pure biodegradable bio based polymers (BBP) like PLA, PHAs, PBS, STARCH do not fulfill application criteria, in addition PLA as the most frequently use BBP creates microplastics in free nature.

It looks, that polymer blends based on the BBP is optimal solution. Especially combinations of various types of PLA with various types of PHAs give the wide range of materials which are fully biodegradable not only in compost, but also in soil and water, it means they do not create residuals in environment in form of micro plastics.

New types of materials were developed and introduced in industrial scale production. All of them are from BBP category and exhibit a wide range of application properties, from hard and strong materials to very flexible ones, including typical TPE materials, special types exhibit very good barrier properties. Basic types of them and principles how to achieve suitable combination of ecological and application parameters will be presented during conference.

Acknowledgment: *Work was supported by grants: APVV-20-0256, APVV-20-0193, APVV-23-0221*

L-02: MODIFICATION OF THERMOPLASTIC STARCH AS A COMPONENT IN MIXTURES WITH BIOPOLYMERS

Ivan Chodák, Hamed Peidayesh, Katarína Mosnáčková

Polymer Institute SAS, Bratislava, Slovakia (Ivan.Chodak@savba.sk)

Thermoplastic starch (TPS) is a valuable additive to a number of polymers. It is formed by plasticization of native starches, almost entirely with glycerol, although number of other plasticizers are available. The primary aim of the addition of TPS to bioplastics is usually a decrease of the price of the final product while maintaining the biodegradability of the plastics blend. However, modification of TPS, considering its physical and ultimate properties, is in many cases rather easy and straight forward process, and a number of different procedures are used to adjusting the final properties of the TPS. Certainly, the final effect of the addition of TPS consists not only in the price decrease but the mixture properties and possible applications depend significantly on the ultimate properties of both the matrix biopolymers and of the TPS.

In the lecture several options for TPS modification are briefly outlined and described, starting with the selection of native starch considering the origin of the starch. The effect of various plasticizers or even their mixtures are shown using the example of glycerol and urea.

The main concern is related to reinforcement of TPS using reinforcing fillers. Among these, especially precursors of nanoparticles are the most interesting since in that case a substantial reinforcement is achieved with the fiber content below 5 wt %, and the final material maintains its classification as biodegradable compostable mixture according to relevant standards. Some more advanced cases of TPS modifications will be presented, especially the effect of moisture uptake on mechanical and other physical properties of the TPS and the effect of long term storing resulting in so called retrogradation, while chemical modification consisting in starch crosslinking with citric acid or dialdehydestarch is described.

Few examples are shown of mixing TPS as the most simple glycerol plasticized additive in the blends with biodegradable polybutylene adipate terephthalate (PBAT), For this mixture, a special compatibilizer was used, namely liquid polyisoprene rubber with polar carboxyl moieties, interacting with the TPS by hydrogen bonds while the covalent bonds with PBAT were formed by initiating the reaction by thermal decomposition of organic peroxide by reactive processing together with homogenization procedure of the mixture. The final mechanical properties of the PBAT / TPS outperform substantially the mixtures of PBAT / TPS without compatibilizers, as well as with standard low-molecular compatibilizers and are the foils have higher both tensile strength and elongation at break compared to LDPE foils used for packagings.

***Acknowledgment:** The work was supported by projects VEGA 1/0751/21 and 2/0109/23*

L-03: PROCESSING, BLENDING AND MODIFICATIONS OF CHITIN/GLUCAN COMPLEX IN IONIC LIQUIDS

Ivan Kelnar, Miroslav Janata

*Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2,
Praha 162 00, Czech Republic; (kelnar@imc.cas.cz)*

Chitin/glucan complex (CGC) is material with high potential for biomedical applications due to favourable combination of antibacterial and immunostimulating activity of its constituents. At the same time, applications of CGC isolated mainly from various fungi like *Aspergillus niger* are limited by insolubility in most of solvents available. The only suitable solvents are various ionic liquids (IL) and deep eutectic solvents based on ionic mixtures. In this study we have applied 1-ethyl-3-methylimidazolium acetate IL, liquid at ambient temperature and “high temperature” IL 1-butyl-3-methylimidazolium chloride which is liquid over $\sim 70^{\circ}\text{C}$. We have found marked effect of CGC content, IL type and isolation process on final structure. In the case of 1-butyl-3-methylimidazolium chloride, combination of solidification-induced phase separation and subsequent extraction of IL leads at CGC content $< 5\%$ to formation of microfibrils, also suitable for preparation for composites, whereas continuous porous structure is formed at $\sim 10\%$ content. Mixing of CGC and tropocollagen solutions led to novel multifunctional material for tissue engineering and wound dressing applications. Finally, IL represent also suitable medium for effective chemical modifications of CGC. We have performed grafting with different contents of polycaprolactone chains. Effect of this modification on self-assembling ability and mechanical properties is discussed. Results achieved indicate that application of IL is important tool to prepare wide range of CGC- based materials for medicinal applications.

Acknowledgment: *This work was supported by Ministry of Education Youth and Sports of the Czech Republic (Grant LUAUS 23004)*

L-04: MICROFLUIDIC PREPARATION OF POLYMER NANOPARTICLES AND GIANT POLYMER VESICLES

Petr Štěpánek, Alessandro Jager, Eliezer Jager, Vladimir Sincari, Jiří Panek
Institute of Macromolecular Chemistry CAS, Praha, Czech Republic; (stepanek@imc.cas.cz)

We demonstrate that microfluidics is a very powerful technique in controlling the final properties of nanoparticles produced by nanoprecipitation. The effects of the flow rate ratio, polymer concentration and solvent nature on the quality of the polymer nanoparticles produced by three-dimensional hydrodynamic flow-focusing microfluidic device were studied using static and dynamic light scattering, and confocal laser scanning microscopy (CLSM). Almost monodisperse nanoparticles were successfully prepared with a controllable size in a range suitable for drug delivery (18–270 nm), as well as pH-responsive giant vesicles (40-100 μm) suitable as microreactors or development of cell mimicry approach.

A variety of biodegradable and biocompatible polymers was investigated including poly(ethylene oxide)-*b*-poly(D,L-lactide), poly(butylsuccinate-dilinoleic acid), poly(D,L-lactide-*co*-glycolide), poly(ethylene oxide)-*b*-poly[2-(diisopropylamino)ethyl methacrylate] (PEO-*b*-PDPA) dissolved in several organic water-miscible solvents. It was shown that the nature of the organic solvent plays an important role in final nanoparticle size and physicochemical properties when using both simple mixing and microfluidic nanoprecipitation, which was traced to differences in cohesive energy densities of the solvents.

The pH-dependent disruption of giant polymer vesicles can be utilized to fabricate pH-responsive delivery systems for various active compounds, microreactors, and artificial organelles, thereby paving the way towards cell mimicry.

1. L.J.C. Albuquerque,..., P. Štěpánek et al., “Microfluidic-Assisted Engineering of Quasi-Monodisperse pH-Responsive Polymersomes” *Langmuir*, vol.35, pp. 8363-8372 (2019)
2. V. Sincari,..., P. Štěpánek et al., “pH-Dependent disruption of giant polymer vesicles: a step towards biomimetic membranes “ *Polymer Chemistry*, vol.14, pp. 443-451 (2023)

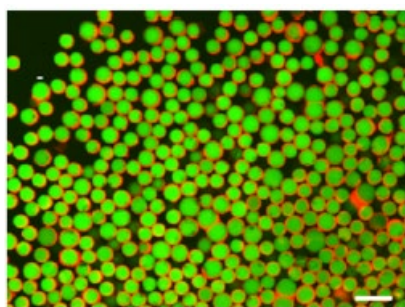


Figure 1

Confocal laser scanning microscopy image of the pH-responsive giant vesicles (scale bar 100 μm)

Acknowledgment: Support by the Ministry of Education, Youth and Sports of the Czech Republic (grant #LM2023053).

L-05: EXPLORING VARIOUS TECHNIQUES TO PRODUCE POLYMERIC NANOPARTICLES

Jozef Kollár, Christyowati Primi Sagita, Dmitrij Bondarev, Agnesa Fiedlerová, Jaroslav Mosnáček

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Preparation of polymers using environmentally friendly solvent such as water is of high importance, reducing economic and environmental costs. Polymeric nanoparticles dispersed in aqueous media enjoy great popularity in industrial scale application in various practical fields such as adhesives, coatings, drug delivery systems, in cosmetics or in optoelectronics.

This contribution describes various polymerization methods to produce latex polymers, including conventional emulsions, surfactant-free emulsions, photoATRP in batch or in flow reactor. In our synthetic approach we are focused on bio-derived monomers as well as on conventional petroleum-based derivatives. From the list of renewable monomers, derivatives with γ -butyrolactone structure are the subjects of our interest^{1,2}. The influence of processing technique, type of surfactant, surfactant concentration, monomer content and ionic strength of the aqueous phase on molar mass and size of nanoparticles has been studied. In order to prepare well defined nanomaterial with tunable macromolecular architecture and functionality, photo-induced emulsion atom transfer radical polymerization (photoATRP) of several acrylates and (meth)acrylates are performed in batch as well as in flow reactor.

1. J. Kollár et al., "Tulips: A Renewable Source of Monomer for Superabsorbent Hydrogels," *Macromolecules*, vol. 49, no. 11, pp. 4047–4056, Jun. 2016.
2. J. Kollár, M. Danko, F. Pippig, J. Mosnáček. Functional polymers and polymeric materials from renewable Alpha-unsaturated Gamma-butyrolactones. *Frontiers in Chemistry*, 2019, vol. 7, no. 845.

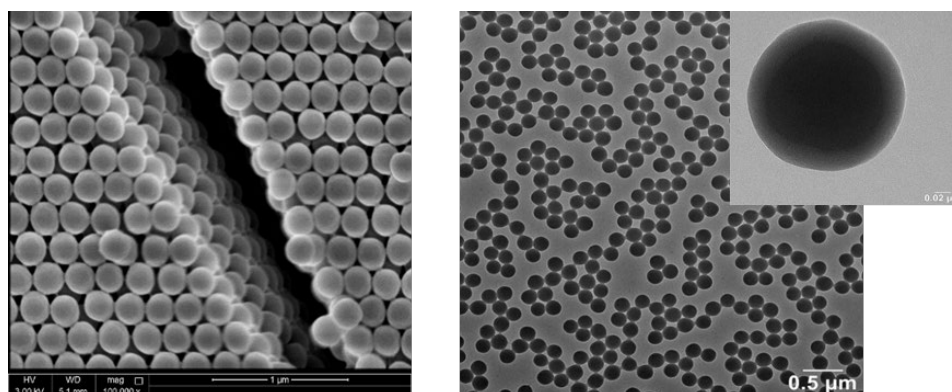


Figure 1: SEM of colloidal crystals and TEM of uniform PMBL nanoparticles.

Acknowledgment: Authors thank to APVV grant agency through grant no. APVV-21-0297 and SASNSTC-JRP-2023-02-MULTICOM for their financial support.

L-06: POLYSACCHARIDE-SYNTHETIC POLYMER HYBRIDS: FROM GRAFT COPOLYMERS TO BLENDS AND (NANO)COMPOSITESSachin Gupta, Miroslav Janata, Ivan Kelnar, Vladimír Raus*Institute of Macromolecular Chemistry, Czech Academy of Sciences, Heyrovského nám. 2, 162 06, Prague 6, Czech Republic; (raus@imc.cas.cz)*

Polysaccharide-based synthetic-natural hybrid polymeric materials have attracted considerable attention as they combine the tailorable properties of synthetic polymers with the unique characteristics of natural polysaccharide macromolecules, such as renewability, low cost, biodegradability, non-toxicity, and high functionality. However, the preparation of such hybrids is burdened by some less-convenient polysaccharide properties. For example, the synthesis of well-defined polysaccharide-based graft copolymers via reversible-deactivation radical polymerization (RDRP) is often complicated by the inefficient introduction of RDRP initiation/transfer sites into the polysaccharide substrate. Similarly, applications of polysaccharides in polymeric blends and (nano)composites are restricted by polysaccharide non-meltability, water sensitivity, or poor solubility in standard solvents, as well as the lack of good interfacial adhesion of polysaccharide fibers. These drawbacks often command the use of polysaccharide derivatives instead of the unmodified macromolecules, which removes some of the original advantages of these materials.

In this contribution, various approaches to addressing the abovementioned shortcomings will be presented. This will include our recently reported highly efficient procedure for copper-mediated RDRP initiation site introduction into cellulose substrates that enables the synthesis of cellulose backbone-based graft copolymers of unprecedented molecular weight and grafting density.¹ Further, a novel approach to the preparation of hybrid (crosslinked) polymer blends/hydrogels and (nano)composites containing chemically unmodified polysaccharides as one of the components will be discussed. This method is taking advantage of polysaccharide dissolution in ionic liquids with the use of common monomers as polymerizable cosolvents.² We envisage that the new preparation methods will unlock an access to new classes of previously inaccessible polysaccharide-based hybrids and extend thus significantly the application potential of this important material class.

1. S. Gupta, M. Janata, E. Čadová and V. Raus "Straightforward synthesis of complex polymeric architectures with ultra-high chain density" *Chem. Sci.* (2024) DOI: 10.1039/d4sc01739k.
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Acknowledgment: This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic (Grant LUAUS 23004).

L-07: OXYGEN TOLERANT SURFACE INITIATED PHOTOCHEMICALLY INDUCED ATRP

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In recent years, the reduction of the deactivator in atom transfer radical polymerization (ATRP) was reported using various stimuli allowing external control over the activator/deactivator ratio without addition of any additional chemicals.

Here photochemically induced atom transfer radical polymerization (photoATRP) using ppm amounts of copper catalyst complexes without degassing of polymerization mixture and with no need to introduce an external reducing agent to the system [1] was optimized for surface-initiated polymerizations of various vinyl polymers. Two various methodologies of modification of Si-wafers were used, while the effect of type of ligand and ligand to CuBr₂ ratio, type of monomer and light intensity on kinetics, thickness of the grafted polymer layer as well as size of the unmodified edges was investigated.[2] The studies were extended also on the modification of other metal oxide surfaces as well as surface of cotton fabrics.[3,4] Properties of all modified surfaces, such as antibacterial, antifouling, flame retardant etc., were also studied depending on the type of grafted polymers.

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L-08: FUNCTIONALITY AMPLIFICATION FOR THE STRAIGHTFORWARD SYNTHESIS OF COMPLEX POLYMERIC ARCHITECTURES

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Synthesis of complex polymeric architectures (CPAs) via reversible-deactivation radical polymerization (RDRP) currently relies on the rather inefficient attachment of monofunctional initiation/transfer sites onto CPA precursors. This drawback seriously limits the overall functionality of the resulting (macro)initiators and, consequently, also the total number of installable polymeric chains, which represents a significant bottleneck in the design of new polymeric materials. Here, we show that the (macro)initiator functionality can be substantially amplified by using trichloroacetyl isocyanate (TAI)¹ as a highly efficient vehicle for the rapid and clean introduction of trichloroacetyl groups into diverse precursors. Through an extensive optimization study, we created a library of copper-mediated RDRP (Cu-RDRP) conditions affording well-controlled TAI adduct-initiated polymerization of different monomer classes (styrene, acrylates, methacrylates) in a wide molecular weight range. Importantly, using comprehensive NMR and triple-detection SEC studies, we proved conclusively for the first time that the TAI-based initiation sites act as trifunctional, effectively amplifying the substrate functionality. Through a preliminary investigation we show that adducts of TAI with hydroxyl groups leads to hydrolytically stable carbamate linker. The TAI strategy was employed in preparation of a novel “star-on-star” architecture with unprecedentedly high chain density through straightforward protocol utilizing in situ/one-pot approach. The great utility of the TAI strategy in the synthesis of CPAs was exemplified using different precursors e.g., β -cyclodextrin (β -CD). In this way, β -CD-based stars with an extremely high number of arms were obtained in solution. In summary, the TAI strategy unlocks an access to a whole new group of unique CPAs based also on natural substrates.²

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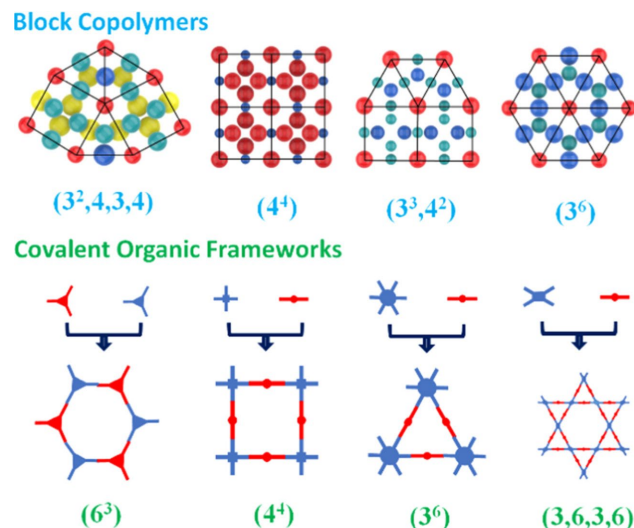
L-09: CONSTRUCTION ARCHIMEDEAN TILING PATTERNS BASED ON SOFT MATERIALS

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Soft materials based on block copolymers or covalent organic frameworks (COFs) that exhibit Archimedean tiling patterns have attracted significant interest due to their potential applications in nanopatterning, nanocomposites, and shape selectivity. Additionally, researchers have widely investigated the corresponding microporous or mesoporous materials with Archimedean tiling from COF or block copolymers as templates with high surface area and pore volume, or tunable porosity with different length scales, in separation, energy storage, drug delivery, photo-catalysis, photovoltaic solar cells, and chemical sensing. This talk highlights recent progress in constructing Archimedean tiling patterns based on the creation of ordered structures from block copolymers by self-assembly and the direct synthesis of COF materials with various topologies

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L-10: DYNAMIC POLYESTER NETWORKS BASED ON TULIPALIN A AND ϵ -CAPROLACTONE CROSSLINKED BY THIA-MICHAEL REACTION AND ACTIVATED BY ALKYLATION OF THIOETHER GROUP

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During the last decades polymeric networks containing dynamic covalent bonds have received high interest as a result of the possibility of increasing their lifetimes by self-healing, reprocessing or recycling upon triggering the reversibility or exchange between their dynamic bonds by different stimuli (heat, pH, UV, ox.-red. agents) without or with relatively low loss of their original mechanical properties and stability. Dynamic covalent bond-containing polymeric networks are called covalent adaptable networks (CANs) or Vitrimers¹.

In this work, linear and star-shaped poly(ϵ -caprolactone-co- α -methylene- γ -butyrolactone) P(CL-co-MBL) copolyesters with a pendant functional double bond of MBL comonomer were used as polymeric precursor for organo-gels formation². Crosslinking was carried out by light-initiated thia-Michael reaction using 1,5-pentanedithiol and pentaerythritol tetrakis(3-mercaptopropionate). The gel content and the crosslinking density varied based on MBL comonomer and crosslinker content and were highest for slight thiol to double bond molar excess (SH/vinyl; 2/1). The thermal and rheological properties investigation of the obtained materials was performed employing DSC, TGA and using frequency and temperature sweeps rheological measurements. The strength of the network was caused by the crystalline phase of the PCL segments up to a temperature of 50 °C. Formed thioether bond within the network were not reversible up to 150 °C as it was found based on temperature sweep rheology. Following, the activation and conversion of thioether bonds within the obtained materials into trialkylsulfonium salts was attained through the alkylation. The dynamic nature of the transalkylation at 150 °C allowed network rearrangement, which was proved by stress relaxation and creep recovery experiments.

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L-11: POLYLACTIDE-BASED DYNAMIC NETWORKS

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Poly(lactide) (PLA) is a biocompatible and biodegradable polymer obtained from renewable resources and is used in different applications. To improve PLA thermal properties and introduce shape stability, the multifunctional hydroxyl-terminated PLA (star PLA) could be coupled by diisocyanate and the poly(ester-urethane) network is formed. The disadvantage of such networks is that they cannot be reshaped or reprocessed. To solve this problem, the concept of “dynamic polymer networks” was created¹, according to which the networks can rearrange their structure due to the presence of linkages undergoing dissociative or associative exchange reactions under appropriate stimuli.

In the present contribution, PLA-based poly(ester-urethane) networks with additional low molecular weight diols containing weak covalent bonds susceptible to thermal dissociation were obtained. Disulfide² or tetraphenylethane³ groups were used as additional diols, able to reversible dissociation. Analogous networks without reversible bonds were synthesised for comparison. Thermal, mechanical and rheological properties of networks, with different reversible bond densities were studied together with their ability to be reprocessed. Samples containing dynamic bonds were suitable candidates for reprocessing with the 3D printing technique.

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Acknowledgement: *The study was performed within Grants NCN 2018/31/B/ST8/01969, DKRVO (RP/CPS/2022/003), VEGA 2/0168/21 and SAS-NSTC-JRP-2023-02 „MULTICOMP“.*

L-12: DYNAMIC NETWORKS IN BIOMEDICAL APPLICATIONS: CONNECTING MOLECULAR BEHAVIOR TO MACROSCOPIC PROPERTIES

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Dynamic hydrogels are an advanced class of biomaterials with broad applications in biomedical fields, including cell encapsulation, drug delivery, and tissue engineering. These hydrogels are distinguished by the incorporation of reversible bonds that can break and reform over experimental time scales, creating a dynamic network that closely mirrors the time-dependent mechanical properties of the native extracellular matrix (ECM). This dynamic behavior provides an adaptable microenvironment that supports essential cellular processes. By replicating key mechanical behaviors of the ECM, such as stress relaxation and hysteresis in stress-strain responses, dynamic hydrogels offer a promising approach to achieving the mechanical adaptability required for biomimetic scaffolds. Consequently, dynamic hydrogels are poised to significantly advance the design of implantable hydrogels and biomimetic scaffolds that closely replicate the functional dynamics of native tissues.

This study aims to establish methodologies for the tailored modification of sodium alginate, introducing functional motifs that facilitate the design of implantable hydrogels. We detail the synthesis and characterization of alginate derivatives, which incorporate both permanent charged groups for polyelectrolyte complexation and clickable moieties for the formation of dynamic covalent bonds. We demonstrate how these modified sodium alginate derivatives can enhance the performance of biomaterials, as exemplified by alginate-based microspheres designed for the immunoprotection of transplanted pancreatic islets in diabetes treatment, as well as injectable hydrogels tailored for cartilage tissue regeneration. The study emphasizes the relationship between molecular behavior and macroscopic properties in dynamic hydrogels, with the network-stabilizing reactions engineered to improve in vivo stability and biocompatibility. These modifications are also directed toward mimicking the dynamic ECM of native organs while providing environmental cues that support cellular function.

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L-13: INVESTIGATIONS OF EFFICIENT REACTIONS TOWARDS POLYMERIZATIONS TO THE PREPARATIONS OF NOVEL FUNCTIONAL POLYESTERS

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In the 1st part,¹ an efficient atom transfer radical addition (ATRA) reaction is intended to acquire aliphatic polyesters in the form of atom transfer radical polyaddition (ATRPA). As shown in **Fig. 1a**, AB-type inimers were synthesized and studied to obtain high molecular weight (MW) aliphatic polyesters ($M_w = 25550$) through Cu-ATRPA. We then used an eco-friendly iron catalyst to conduct Fe-ATRPA and a high-MW polyester was obtained ($M_w > 40000$) and further combined with CuAAC click reaction to produce polymer brushes with different hydrophilic/hydrophobic ratios and further examined the amphiphilic properties. This combination method (ATRPA-C-CuAAC) provides a novel strategy for the synthesis of functional aliphatic polyesters.

Another old organic reaction, herein multicomponent reactions (MCRs), is extended to multicomponent polymerizations (MCPs). Passerini-type MCPs (P-MCPs) can be achieved using 2 difunctional monomers with 1 mono-functional monomer, such as $A_2 \cap B_2 \cap C$, $A_2 \cap B \cap C_2$, and $A \cap B_2 \cap C_2$. In the 2nd part,² P-MCPs with various monomers were carried out and attained a variety of novel poly(carbamoyl ester)s (PCEs) as shown in **Fig. 1b**. We demonstrated an efficient, diverse, and facile approach through P-MCPs to render these novel PCEs with dual-cleavable linkages of ester and disulfide groups and an aggregation-induced emission (AIE) luminogen of tetraphenylethylene (TPE). We further introduced dynamic covalent bonds (DCBs) to prepare cleavable polymeric materials.

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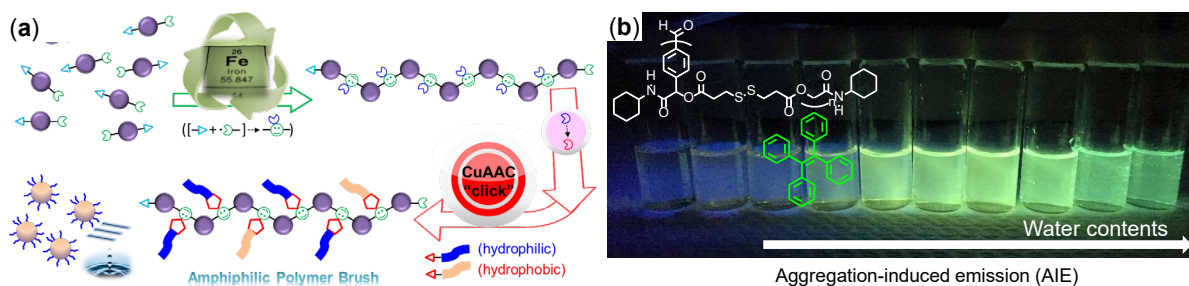


Fig. 1. Design and applications via (a) atom transfer radical polyaddition (ATRPA) and (b) Passerini-type MCPs.

L-14: SYNTHESIS AND MOLECULAR STRUCTURE OF ACRYLIC COPOLYMERS CONTAINING BIO-SYNTHETIC MONOMERS

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Acrylic copolymers prepared by free radical solution polymerization or emulsion polymerization can be modified by partial replacement of traditional monomers such as methyl methacrylate and butyl acrylate by bio-synthetic monomers based on vegetable oils. These novel monomers are prepared by oxidation of methyl esters of unsaturated fatty acids and subsequent acrylation of oxirane rings. The monomers are typically mixtures of compounds with one, two and three acrylic groups created from oleic, linoleic and linolenic acids, respectively. The monomers from polyunsaturated acids significantly affects the molecular structure of final products.

In case of emulsion copolymers, the bio-monomers from methyl esters of linoleic and linolenic acids partially crosslink the entire latex particles. The obtained latexes consist of soluble macromolecules and crosslinked particles (nanogels) that upon dissolution do not dissolve, but only swell.^{1,2} Due to the presence of ultra-high molar mass fractions and nanogels, the products cannot be characterized by size exclusion chromatography (SEC) as the ultra-high molar mass fractions are shear degraded and the nanogels can be completely absorbed by SEC columns. The only technique capable of characterization of molecular structure of such materials is asymmetric flow field flow fractionation (AF4) coupled with a multi-angle light scattering (MALS) detector and optionally also with an online viscometer (visco). The hyphenated AF4-MALS-visco technique provides detailed information about molar mass distribution, degree of branching, and content and compactness of nanogels.

In contrast to emulsion polymers, solution acrylic copolymers modified by bio-monomers do not contain nanogels. The products are branched and branching degree increases with increasing concentration of bio-monomer and/or content of polyunsaturated fatty acids in the oils used for bio-monomer production. Due to significantly lower molar mass, the polymers can be characterized by SEC.

The contribution will show several examples of application of AF4-MALS, AF4-MALS-visco, and SEC-MALS-visco for the detailed characterization of molecular structure of emulsion and solution acrylic copolymers modified by acrylated methyl esters of various vegetable oils.

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L-15: ACID-BASE EQUILIBRIA AND PARTITIONING OF SOLUTES IN TWO-PHASE SYSTEMS CONTAINING CHARGED POLYMERS AND COLLOIDS

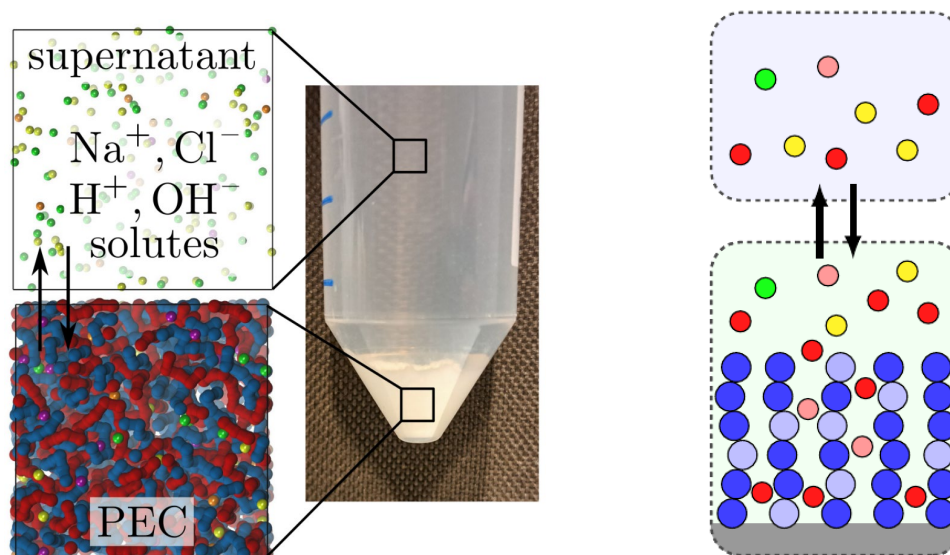
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A classical example of a charged two-phase system is a polyelectrolyte hydrogel in equilibrium with the surrounding supernatant solution. Other examples include solution of polyelectrolytes or proteins under dialysis, separated from the supernatant by a size-selective membrane. Mixing of oppositely charged polymers yields interpolyelectrolyte complexes, forming a polymer-rich phase in equilibrium with supernatant solution, which is almost free of polymer.

In each of the above systems, charges on the polymers need to be compensated by counterions, causing that Donnan potential builds up on the interface. As a result of the Donnan equilibrium, small ionic solutes can partition unevenly between both phases. Specifically, the uneven partitioning of H^+ ions causes that pH is different in each phase.

In this lecture, we show how the Donnan potential determines the pH difference between the supernatant and polyelectrolyte solutions, hydrogels and brushes. In polyelectrolyte complexes, the Donnan potential is almost zero. However, monovalent ions partition evenly between the polyelectrolyte complex and supernatant, whereas divalent ions prefer the polymer-rich phase. Using both simulations and experiments, we explain how this uneven partitioning can be exploited for sequestration of proteins or multiprotic weak acids.



L-16: TAILORING 2-OXAZOLINE BASED DIGRADIENT COPOLYMERS FOR RIFAMPICIN DELIVERY: SYNTHESIS, PHYSICO-CHEMICAL PROPERTIES, AND COLLOIDAL BEHAVIOR

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Amphiphilic gradient copolymers based on poly(2-oxazolines) represent an exciting class of polymers that can be prepared with one-pot synthesis and exhibit self-assembly similar to their block analogues. Peptidomimetic structure of poly(2-oxazolines) makes it a promising candidate for biomedical applications. Herein, the digradient copolymers are prepared for the first time in the living cationic ring-opening copolymerization^[1] of 2-ethyl-2-oxazoline and 2-(4-butyloxyphenyl)-2-oxazoline using 1, 3-bis(tosyloxy)propane as a bifunctional initiator. The composition of the prepared copolymers was close to feeding ratios as determined from ¹H NMR spectroscopy. Molar masses determined by gel permeation chromatography range from 7,800 to 11,000 g mol⁻¹, which corresponds to theoretical molar masses. Aggregation behaviour and interfacial properties are studied using dynamic light scattering and Langmuir-Blodgett technique. Results support nanoparticle stability over a period of 60 days with a higher percentage of drug encapsulation, loading and sustained release. Such digradient copolymers are used for the encapsulation of rifampicin, which as an efficient antibiotic for the treatment of latent or active tuberculosis^[2], leprosis, and staphylococcus or streptococcus infections, respectively. The docking simulation is carried out for the rifampicin inside the active site of RNA polymerase (PDB: 6N62) to explore the binding mode, probable conformation, and different types of interactions inside the pocket.

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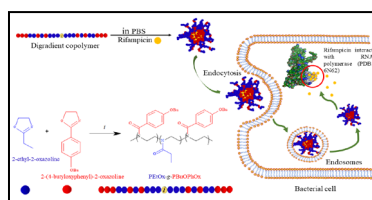


Figure: Schematic representation of rifampicin delivery through 2-polyoxazoline based digradient copolymeric nanoparticles.

Acknowledgment: Authors are thankful Slovak Research and Development Agency for the support in the project APVV-23-0635 and Slovak Grant Agency VEGA in the project 2/0170/24.

L-17: WELL-DEFINED POLY(2-ISOPROPENYL-2-OXAZOLINE) BRUSHES PROVIDE FOULING RESISTANCE AND VERSATILITY IN SURFACE FUNCTIONALIZATION

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Poly(2-isopropenyl-2-oxazoline) (PIPOx), a biocompatible polymer¹ to clean and orthogonal post-polymerization modifications, has recently emerged as a suitable candidate for the preparation of functional polymer brushes via surface-initiated reversible-deactivation radical polymerization (SI RDRP). However, the field currently lacks a universal SI RDRP method that would provide a straightforward control over the PIPOx brush thickness and be applicable to non-planar surfaces. Herein, we designed an aqueous, metallic copper-mediated RDRP (Cu(0)-RDRP) protocol for SI grafting of IPOx that manifests an excellent degree of temporal control over the PIPOx brush thickness up to more than 100 nm. The superior kinetic control was achieved through the use of an all-chlorine initiation/catalytic Cu(0)-RDRP system and careful ligand selection, demonstrating a clear advantage over previous approaches based on brominated initiators.² Additionally, we found that using neat water as a reaction medium for the Cu(0) catalyst generation in the standard disproportionation step significantly accelerates the brush growth. Importantly, a surface plasmon resonance analysis demonstrated for the first time the high resistance of PIPOx brushes against non-specific protein fouling, as documented by a significant (96 %) decrease in protein deposition from undiluted blood plasma and negligible adsorption from fetal bovine serum and other protein solutions. Finally, we showcased in model scenarios the versatility of the prepared well-defined PIPOx brushes by modifying them with suitable functional carboxylic acids under mild conditions in order to subsequently synthesize graft copolymer brushes or trigger a CuAAC click reaction. Our results highlight PIPOx brushes as an attractive platform for the fabrication of low-fouling, multifunctional surfaces.

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2. V. Raus, A. Hološ, J. Kronek, J. Mosnáček „Well-Defined Linear and Grafted Poly(2-isopropenyl-2-oxazoline)s Prepared via Copper-Mediated Reversible-Deactivation Radical Polymerization Methods“ *Macromolecules*, 53 (2020) 2077-2087.

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L-18: INTERACTIONS OF PROTEINS WITH POLY(ETHYLENE OXIDE) MODIFIED SURFACES IN TWO DIFFERENT SETUPS STUDIED BY MOLECULAR DYNAMICS

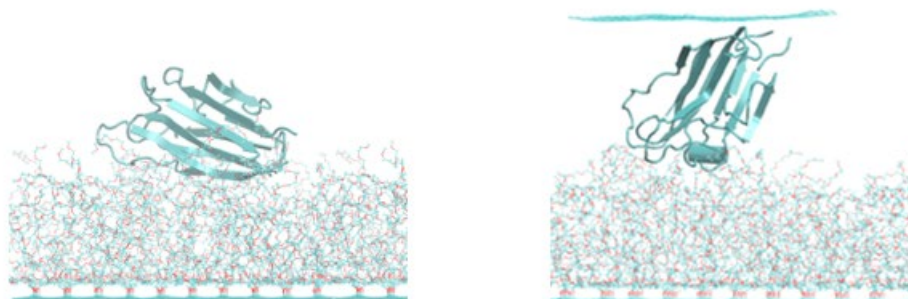
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The performance of biomaterials and biomedical devices in living systems is adversely affected by nonspecific adsorption of proteins, which additionally triggers an immune response. This undesired phenomenon can be suppressed by coating the surfaces of biomaterials with hydrophilic biocompatible polymer chains. Interactions of grafted polymer layers with proteins represent a complex problem composed of a large number of factors with mutual interplay between some of them. These interactions are often studied using atomic force microscopy or surface force apparatus, but these do not mimic conditions in living systems. Therefore, comparing the setup in which the protein is pushed against the grafted polymer layer with the setup in which the free protein interacts with the polymer layer would reveal whether equivalent conclusions can be drawn for the two systems. Understanding these setups requires an atomistic approach.¹ Molecular dynamics simulations have proven to be a suitable tool to study and compare a system where the protein is pushed against the polymer layer by an external force with a system where the free protein interacts with the polymer layer. The effect of the grafting density of poly(ethylene oxide) (PEO) chains on the interactions between PEO and protein in both setups was investigated. Stabilization and destabilization of the secondary structure elements of the protein during its interactions with the PEO layer were also studied. This is important for predicting the potential denaturation of the protein adsorbed on the PEO-coated biomaterial surface. It turns out that the experimental techniques based on pushing a protein against a grafted polymer layer do not necessarily provide results equivalent to conditions in living systems.



Acknowledgment: This work was supported by grants APVV-21-0346, VEGA 2/0098/23, and R1 09I03-03-V02-00001.

L-19: ALGINATE-BASED MICROSPHERES FOR CELL ENCAPSULATION IN DIABETES TREATMENT

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Despite the availability of insulins and increasingly accurate technical means for measuring sugar levels and insulin dosing, there is a high population of diabetic patients who cannot properly control their sugar levels.¹ In such cases, transplantation of functional pancreatic islets may be recommended, resulting in physiological control of blood sugar levels.² In the case of islets from a foreign donor, it is necessary to use immunosuppressants to protect the islets from the body's immune reaction.

Encapsulation of islets in a semipermeable polymer membrane provides a solution for islet transplantation without immunosuppressants. This membrane ensures the protection of transplanted islets from the immune system and, at the same time, allows the passage of glucose, insulin, oxygen, nutrients and metabolites.³ Our long-term goal is to develop hydrogel alginate-based microspheres with suitable physico-chemical and biological properties that are suitable for testing in various animal models.⁴

This contribution will present the results obtained during the last years within the international and national cooperation on this topic. The work has been focused on alginate microbeads stabilized by divalent cations and on multicomponent microcapsules stabilized by polyelectrolyte complexation. The results on interplay between polymer selection, encapsulation process, microcapsule properties before and after transplantation, and in vivo data in immunocompetent mice and primates led to a better recognition of factors important for survival of encapsulated islet and for biocompatibility of microspheres.

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Acknowledgement: *This work was supported by the JDRF Grant No. JDRF 2-SRA-2018-521-S-B, the Chicago Diabetes Project, an International collaboration established to find a functional cure for diabetes, supported by the Washington Square Health Care Foundation, and by the Slovak Research and Development Agency under contract numbers APVV-18-0480, APVV-20-0272, and APVV-22-0565.*

L-20: POLYMER PARTICLES AS CONTRAST AGENTS FOR PHOTOACOUSTIC TOMOGRAPHY

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Photoacoustic (PA) imaging detects an acoustic signal induced by light. This unique method provides simultaneously ultrasound anatomical information with high resolution along with a functional photoacoustic signal, which is created by transformation of a laser pulse to mechanical wave by some light absorbing chromophore. PA imaging shows great potential for various clinical procedures from diagnosis to therapy guidance, which arises from its ability to gather functional and molecular information in real-time regime with a high spatial resolution at clinically relevant depths together with the absence of ionizing beaming.

To maximize the contrast effect of the exogenous contrast agents (CA) in the living organism, the optical absorption of the CA should be optimally in the near-infrared (NIR) regions ~700 - 1100 nm and 1200 - 2000. We developed new heterogenous syntheses of polypyrrole (PPY) particles with PA contrast properties in NIR, which allow good control of size (10 nm step within the range 80-300 nm). Besides widely used linear water-soluble polymer stabilizers of the dispersion polymerizations, classical emulsifiers were also successfully employed in their synthesis, what broadens possibilities to employ less hydrophilic comonomers in the aqueous polymerization. Particles as CA for the PA were tested in vitro and in vivo.

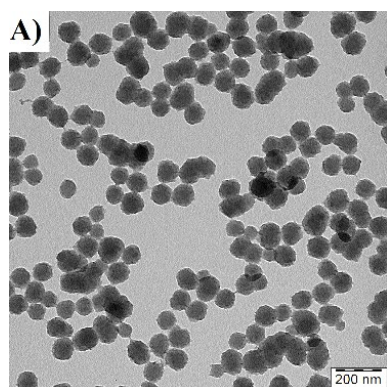


Figure: Transmission electron micrograph of polypyrrole contrast particles prepared for photoacoustic imaging.

Acknowledgment: This work was supported by the Ministry of Education, Youth and Sport of the Czech Republic [The project National Institute for Cancer Research (Programme EXCELES No. LX22NPO5102) and Czech-BioImaging LM2018129].

L-20': AMPHIPHILIC POLY(2-OXAZOLINE)-LIGAND CONJUGATES STABILIZED BY NANOPARTICLES FOR BINDING TO CELL MEMBRANE

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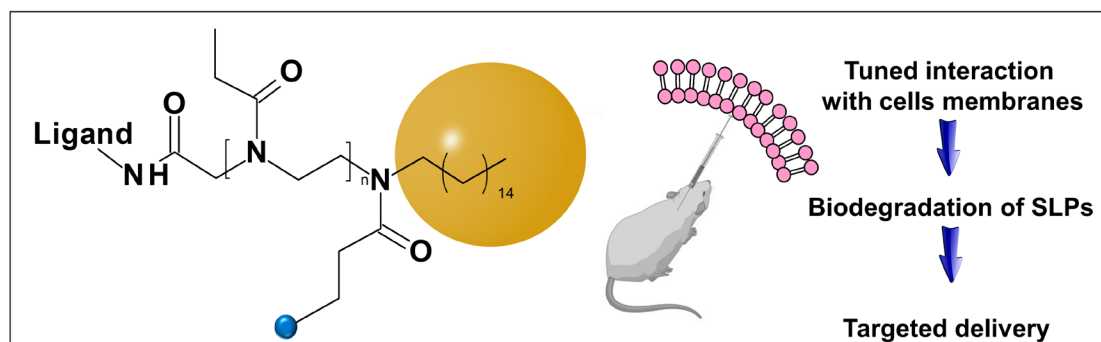
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The development of poly(2-ethyl-2-oxazoline)-stabilized, nanoparticle based carrier systems for biomedical applications has gained increased interest due to the systems non-toxicity and biocompatibility¹. In our present work, we have successfully synthesized solid lipid particles (SLPs) based on a cholesterol/tetradecanol core that carries water-soluble amphiphilic poly(2-oxazoline)-ligand conjugates with a hydrophobic end group (**Scheme 1**). This end group of poly(2oxazoline) is temporarily hidden by the biodegradable core of the SLPs, enabling the ligand to actively target cell membrane receptors. After administration, the particle core is metabolized, causing the release of the hydrophobic unit and enabling its non-specific binding to cell membranes. By establishing a synergistic interplay of non-specific and specific binding, this strategy enhances the ligand's targeting efficiency.

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Scheme 1: Development of biodegradable solid lipid particle based nanocarrier.

Acknowledgement: Authors are thankful Slovak Research and Development Agency for the support in the project APVV-23-0635.

L-21: SYNTHESIS OF MOLECULAR BRUSHES WITH LUBRICATION PROPERTIES AS COMPONENT OF NOVEL INJECTABLE POLYMER GELS FOR OSTEOARTHRITIS TREATMENT

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Osteoarthritis is a common joint disease that can lead to disability in older populations. Much effort and research are put into finding an effective and widely available ways of treating this disease.¹ Molecular brushes with proper chemical composition can possess lubrication properties demanded in osteoarthritis treatment and can be used separately or as a part of more complicated healing systems, i.e. injectable gels.² Injectable gels can be generated *in situ* by using chemically and/or physically crosslinking gels. Thus, they can be delivered into the body or a targeted site of a tissue through a syringe that can significantly reduce patients' discomfort and decrease healing time.

In presented research polymer gels were made of molecular brushes and polymer nanoparticles with compatible functional groups. Preparation of polymer gels involved: 1) synthesis of the backbone of molecular brushes via atom transfer radical polymerization (ATRP); 2) polymerization of poly(oligo(ethylene glycol) methyl ether methacrylate) (POEGMA, MW 300) and 2-hydroxyethyl methacrylate (HEMA) side chains with different degrees of polymerization using "grafting from" approach and ATRP; 3) modification of HEMA units with acryloyl chloride to introduce unsaturated bonds into structure of side chains; 4) crosslinking of molecular brushes with thiol-functionalized nanoparticles (PLA-PEG-SH) via Michael addition by mixing of both components in water. According to DLS measurements it was found that crosslinking occurred fast after mixing. Moreover, due to low concentration of molecular brushes solutions and nanoparticles dispersions, viscosity of final polymer gel was low which is desired property for injectable gels. However, further research is necessary to optimize key factors affecting crosslinking process and to investigate lubrication properties.

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Acknowledgment: Project co-financed/financed by the National Center for Research and Development as part of the 4th competition of the EuroNanoMed III program (ENM3/IV/6/CaPreCon/2021).



Politechnika Łódzka



Narodowe Centrum Badań i Rozwoju

L-22: TARGETING OF POLYMER DRUG DELIVERY SYSTEMS WITH RECOMBINANT PROTEINS BOUND VIA TRIS(NITRILOTRIACETIC ACID)

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Antibody-mediated targeting is an efficient strategy to enhance the specificity and selectivity of polymer nanomedicines towards the target site, typically a tumor. However, direct covalent coupling of an antibody with a polymer usually results in a partial damage of the antibody binding site accompanied with a compromised biological activity. Here, an original solution based on well-defined non-covalent interactions between tris-nitrilotriacetic acid (trisNTA) and hexahistidine (His-tag) groups, purposefully introduced to the structure of each macromolecule, is described. Specifically, trisNTA groups were attached along the chains of a hydrophilic statistical copolymer based on N-(2-hydroxypropyl)methacrylamide (HPMA), and at the end or along the chains of thermo-responsive di-block copolymers based on N-isopropylmethacrylamide (NIPMAM) and HPMA; His-tag was incorporated to the structure of a recombinant single chain fragment of an anti-GD2 monoclonal antibody (scFv-GD2). Static and dynamic light scattering analyses confirmed that mixing of polymer with scFv-GD2 led to the formation of polymer/scFv-GD2 complexes; those prepared from thermo-responsive polymers formed stable micelles at 37 °C. Flow cytometry and fluorescence microscopy clearly demonstrated anti-gen-specific binding of the prepared complexes to GD2 positive murine T-cell lymphoma cells EL-4 and human neuroblastoma cells UKF-NB3, while no interaction with GD2 negative murine fibroblast cells NIH-3T3 was observed. These non-covalent polymer protein complexes represent a new generation of highly specific actively targeted polymer therapeutics or diagnostics¹.

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Acknowledgment: This research was supported by the Czech Science Foundation (project No. 22-12483 S).

L-23: ELECTRONIC MEMORY PHENOMENA IN POLYMERS – FROM DIGITAL MEMORY TO MEMRISTORS AND SIMULATION OF NEURONAL SYNAPSES

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Memristor represents a fourth fundamental passive electronic component with resistance dependent on charge passing through it previously. We document such functionality on two polymer systems:

(i) Carbazole-linked bis-terpyridyl ligand was synthesized and complexed with different metal ions, forming a metallo-supramolecular polymers (SPM). In the two terminal memristor device arrangement and with the ligand only, a non-volatile bistable memory behaviour was observed, with ON/OFF ratio over 100, and the data retention time of 18 h, which makes the compound applicable in organic non-volatile memory devices. When complexed with Co(II) ions, a synaptic plasticity was documented by more than 400 reproducible potentiation and depression cycles. The combined electronic and ionic conductivity of the SPM together with the redox activity of the ligand and of the Co(II) complex play a role in continuous resistance changes of the active layer, which are responsible for its behavior simulating the synaptic plasticity.

(ii) Poly(methacrylamide) derivative with carbazole charge transporting group separated from the polymer backbone by an alkyl chain exhibit rewritable flash memory behavior with bistable conductivity. Depending on the layer thickness, electrode material and applied voltage range the electrical characteristics can change from bistable to analog behavior showing memristive properties. The main physical mechanisms driving the resistive switching have been attributed to the electric field induced reorientation of heterocycles and trapping/detrapping of charges. Memory persistence is strengthened by the physical crosslinking caused by hydrogen bonds between amide and carbonyl groups in the side chains.

The results show that the memristors with the active layer made of both polymers can learn and memorize like biological neurons and can be utilized in brain-inspired neuromorphic computing.

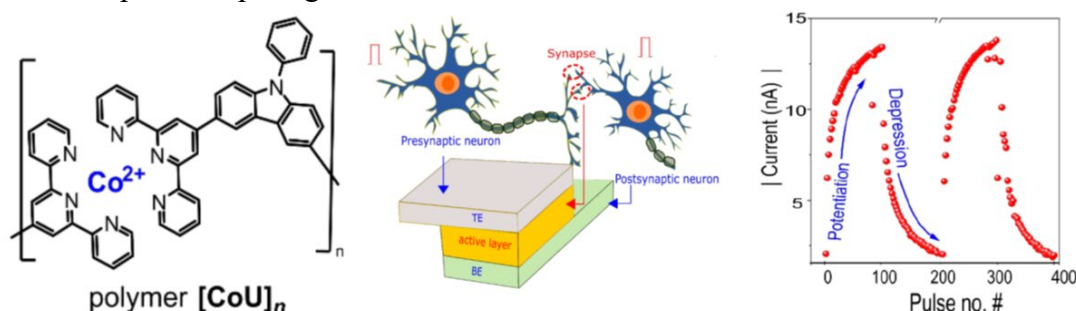


Figure 1. A sandwich structure formed by an active layer containing curly chains of $[CoU]_n$ metallo-supramolecular polymer exhibits memristive electrical properties that can mimic neurosynaptic plasticity.

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L-24: KNOTS IN POLYMERS, DNA AND PROTEINS

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Ever since Kelvin has conjectured that atoms are composed of knots in the ether, these peculiar objects have stimulated the imagination of mathematicians and natural scientists alike. In recent years the field went through a renaissance and progressed considerably, spurred by the discovery of knotted DNA and proteins. Interestingly, our intuitive understanding of knots at the macroscopic level often applies to objects at the nanometer scale as well.

After providing a general introduction to the topological classification of knots, I will discuss their occurrence in computer simulations of coarse-grained polymers. Amongst others this allows us to test from a topological point of view a long-standing paradigm of polymer physics, namely that chains in a polymer melt are well-represented by random walks¹. Coarse-grained polymer models can also be parametrized to capture topology in dsDNA² and serve as a basis for modelling biological processes such as loop extrusion on experimentally relevant time and length scales.

From an evolutionary point of view protein knots occur in all kingdoms of life and topology is typically preserved amongst homologs. Nowadays, knotted protein structures can even be created artificially in the context protein engineering. While knots in globular homopolymers are abundant, protein knots are rare and occur in less than one percent of all known structures. In this context, I will report on very recent developments facilitated by the artificial intelligence system AlphaFold, which has predicted millions of previously unknown three-dimensional protein structures. We have discovered in this data several novel knotted folds³ including a composite knot consisting of two methyltransferases. In the meantime, this fold has been confirmed experimentally, serving as an impressive validation for the prowess of AlphaFold.

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L-25: KNOTS IN POLYMERS AND BIOPOLYMERS AND CHIRALITY

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In this contribution, we report on our findings regarding the chiral behavior of knotted polymers. Knots in polymers occur naturally as self-entanglements of polymer chains and are typically characterized by their crossing number. As the crossing number increases, different knot types with the same crossing number but distinct topologies can arise. The complexity of knotting tends to increase with polymer length or concentration.

Previous studies have shown that while the crossing number of knots increases, this often reflects the emergence of multiple simpler, trivial knots rather than the formation of a single, complex knot with many crossings. When more than one trivial knot exists on a single chain, a composite knot is formed. Composite knots are the most common knot type in long polymers and biological systems. It has been demonstrated that in composite knots, the component trivial knots can pass through each other, forming meta-stable states with intertwined conformations where one knot is nested inside another [1].

Subsequent research has revealed that the stability of these nested states is influenced by the mutual chirality of the knots [2, 3]. In our current work, we investigate the effects of confinement on composite knots and whether confinement promotes the persistence of trivial knots in either a nested or separated state. Our interest was sparked by previous findings that chiral confinements induce symmetry breaking, which can be exploited for knot separation in chiral membranes [4], knot detection in chiral pores [4], production of knots with chosen chirality in chiral pores [5], and the induction of knot chirality by the geometry of knot factories [6].

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L-26: DNA TOPOLOGY IN ATOMIC FORCE MICROSCOPY

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DNA is the most important biopolymer, without which there would be no life. Understanding its complex topological features could lead us to better understanding of the biological processes occurring in cells. Since the DNA molecule has very high length to diameter ratio [1], it can become entangled due to conformational moves or activity of enzymes. However, experiments through Hi-C contact maps proved that DNA is mostly without entanglements [2], which could inhibit biological processes or even break the DNA. It was found out that enzymes called topoisomerases constantly unknot the DNA [3], although if they would work randomly, the DNA would become even more entangled. The unknotting mechanism is currently under a debate and a novel method could shed more light in this matter. This study in collaboration with the University of Sheffield explores the possibility to detect under and over crossings in catenanes via atomic force microscopy (AFM). DNA catenanes (entangled rings) can be often found in bacteria, for example recombination of E.Coli produces right-handed 4-node catenane used in this study. Here, coarse-grained simulations were used as a background for experiments for their better understanding [4].

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L-27: BORROMEAN RINGS IN PROTEINS

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The mathematical loops can be arranged in various ways. In particular, they can pierce each other - the phenomenon well described by the Gauss Linking Number (GLN). Yet, in everyday life, these are the open polymers, which can get mutually entangled. Still, using its analytical expression, the Gauss Linking Number can be extended to the case of open polymers, measuring the mutual winding of two chains¹. Although this allows to characterize each pair of chains, yet there can be some three-chain non-trivial arrangements, which cannot be discriminated by GLN. In particular, the Borromean rings are a mathematical construct composed of three loops, which cannot be disjoined, although each pair could be separated (Fig. 1). To characterize such kind of topology, Milnor introduced an invariant (called Milnor Invariant²), which, along with pairwise GLN fully characterize the topology of three loops. Yet the invariant is usually defined algebraically, therefore having a limited value to actual polymers.

In this work the analytical formula for the Milnor Invariant, relying only on the polymer beads coordinates is derived, opening the way to calculate it for both open or closed loops. The formula is implemented in an open-source software, which is then used to characterize the Borromean rings topology for each triple of protein chains in PDB.

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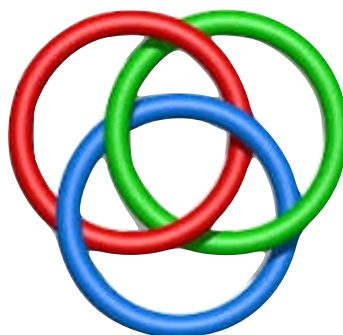


Figure 1 The example of Borromean rings. Each pair of loops is unlinked, yet the whole structure cannot be separated.

L-28: CAVITY CONFINEMENT OF SEMIFLEXIBLE MACROMOLECULES

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Polymers are often found in spaces much smaller than their natural size. An entrapment of polymers inside closed cavities of the spherical or comparable native shapes gives rise to quite strong confinement effects. The polymers in nano/microscale compartments are widely encountered in the biological milieu, for example, in sub-cellular structures or protein capsids. The confinement effects are common in biomimetic cavities produced by encapsulation of polymers such as enzymes, or polymer-drug conjugates into a shell.

We present results of simulations of flexible polymers in a sphere that show a steady reduction of the chain dimension with concentration. The 3D confinement leads to a 40 % shrinking of the chain size at the overlap concentration φ^* . The chain squeezing is intensified by the polymer depletion inside a sphere evaluated by a novel formula. The depletion induces the accumulation of polymers in the cavity center. Because this effect is ignored in the scaling theory, its predictions are not fully consistent with the simulation results. We provide the validation arguments that the shrinking of coils packed at the threshold φ^* in bulk solution is comparable to the squeezing of polymers in a cavity. The size contraction by about 10 % at φ^* in ring polymers in bulk lies midway between those for the linear polymers in bulk and confined polymers, in harmony with the free-energy penalty for penetration of surrounding restraints. For semiflexible macromolecules the situation is more complex because winding of the chain below the cavity wall has an additional opposite effect to the depletion.

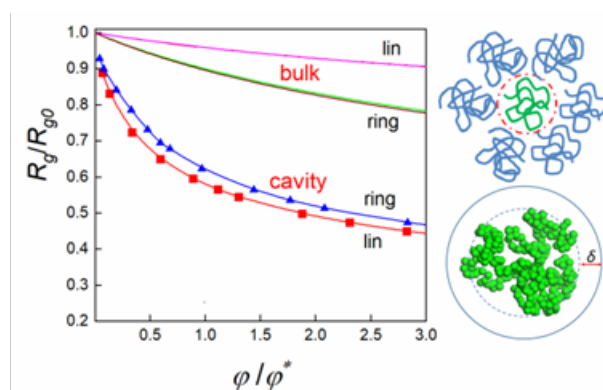


Fig. Comparison of shrinking coil size with concentration/confinement in bulk solution and in the cavity. P. Cifra, T. Bleha, *Macromolecules*, 57, 7, 3234–3241, 2024

L-29: ACTIVE POLYMER MELT

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Motivated by the heterogeneous (e.g. transcriptional) activity of chromatin fiber, I will discuss how the non-equilibrium conditions affect dynamics of polymers, made active by heterogeneous fluctuations.

I will show that the active polymer in a melt exhibits a persistence in motion on the chain scale and that this can arise spontaneously from isotropic but heterogeneous thermal-like fluctuations due to the presence of the topological constraints. Using scaling arguments supported by simulations we uncover that the topological restriction of the transversal relaxation modes results in an imbalance of internal chain tension of entropic origin, which generates the directional dynamics. I will briefly mention possible implications for the dynamics of highly transcribed genes, material science and a possible experimental model on micron scale.

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L-30: CHAPTERS IN GREEN CHEMISTRY

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L-31: ANTIBACTERIAL ACTIVITY OF 3D PRINTED THERMOPLASTIC ELASTOMERS FOR BIOMEDICAL APPLICATIONS

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3D printing provides a lot of varieties for the manufacturing of personalized biomedical devices. Incorporation of the nanoparticles with potential antibacterial activity to the printed materials is another added value. One example of such nanoparticles are hydrophobic carbon quantum dots (hCQDs), which are zero-dimensional redox-active materials with high chemical stability and low production costs. They produce singlet oxygen only when activated by a specific wavelength of visible blue light which allows for controlled antibacterial action and minimizes the chances of bacterial resistance emergence. We prepared and characterized polymer composites based on thermoplastic elastomers (TPE) doped with hCQDs (TPE/hCQDs). The composites were 3D printed using FDM method. In the first set of samples, a filament of pure TPE was immersed in a solution of hCQDs, then 3D printed, and compared with unmodified TPE filament. The mechanical properties, swelling behavior, hardness, and thermal stability of TPE/hCQDs were compared with the pure TPE printed samples. The production of singlet oxygen was confirmed by the electron paramagnetic resonance method. The antibacterial activity of the samples was tested according to ISO 22196 against *Staphylococcus aureus* and *Escherichia coli* after one hour of exposure to blue light, which completely inhibited bacterial growth. Besides, the cytotoxicity of samples was evaluated by MTT assay, and no significant effect of the materials on cell viability was observed. 3D printed materials with antibacterial activity represent a perspective for the future, especially in the field of personalized medicine, as well as in products for other industries.

1. M. Shaalan et al. "Antibacterial activity of 3D printed thermoplastic elastomers doped with carbon quantum dots for biomedical applications" *Polym. Bull.*, 2024. <https://doi.org/10.1007/s00289-024-05339-1>

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L-32: A DETAILED STUDY OF THE EFFECT OF CYCLIC LOADING ON THE THERMAL EXPANSION COEFFICIENT OF REINFORCED STYRENE-BUTADIENE RUBBER AS A FUNCTION OF DIFFERENT CARBON BLACK TYPES

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The fact that heat is generated in viscoelastic materials such as rubber by the gradual dissipation of energy under cyclic loading is well known as self-heating. In addition, rubber components are reinforced with various types of fillers, the most commonly used of which are carbon black (CB), which significantly affect the viscoelastic properties and therefore the heat development. It must also be taken into account, that in real applications the rubber is exposed to different ambient temperature conditions. In addition, fatigue degradation of the rubber matrix occurs under cyclic loading. The temperature effect, whether by ambient or self-heating or a combination of both, causes thermal expansion and directly affects the dimensional stability of the rubber component, which can affect both the accuracy and functionality of the application and, in particular, the life of the rubber product. The coefficient of thermal expansion (CTE) is then a physical parameter used to determine the rate of expansion of the material as a function of temperature and describes the key properties of the rubber in this respect. The CTE then determines whether damage to the rubber can occur due to thermal stress. Therefore, knowledge of the CTE is a prerequisite for selecting the right material for individual applications and thus ensuring its faultless functionality.

This work is the first to investigate the effect of different types and amounts of CB in styrene-butadiene rubber (SBR) on CTE as a function of cyclic loading. Considering the necessity of high accuracy of CTE determination to capture the effect of bond breaking in the filler-filler interaction, a completely new unique measurement methodology was developed as well as an experimental device was exclusively designed for the determination of CTE in rubber. Both the methodology and the testing device will be presented for the first time and the principle discussed in detail in the context of this study. As conclusion, the dependence of CTE on the type and amount of CB will first be discussed, with the most significant part of the final discussion being the presentation of the relationship of cyclic loading in the Payne effect region to CTE. The resulting relationships and values thus form a unique set describing the thermal properties of SBR reinforced with different type of CB in relation to the applied cyclic loading.

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L-33: STUDY OF PROPERTIES OF NOVEL HAVOH-BASED POLYMERIC NANOCOMPOSITES WITH 2D MXENES

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Highly amorphous vinyl alcohol (HAVOH) is relatively new matrix, with low oxygen permeability, excellent water solubility, ease of melt processing etc. [1]. MXenes are also relatively novel family of 2D (two-dimensional) nanoparticles [2]. They possess high electrical conductivity, hydrophilicity, high oxidation stability etc.

Here is reported preparation and characterization of novel HAVOH/SWCNTs (single-walled carbon nanotubes), HAVOH/MXenes, HAVOH/SWCNTs/MXenes polymeric nanocomposites. Composites were prepared using solvent casting method. Electrical properties study revealed increase of conductivity with increase of nanofillers load. Highest conductivity, 7.9×10^{-5} S/cm, was obtained for HAVOH/3.0 wt. % SWCNTs/2.0 wt. % MXenes. Structure study showed homogenous dispersion of the fillers within the. TGA results confirmed, that addition of carbon nanotubes and MXenes slightly improves thermal stability of the HAVOH polymer. Study of EMI-shielding properties revealed that composite sample with equally 3.0 wt. % of MXenes and SWCNTs shows great shielding properties, 55 dB, what is more than 100 times higher than for neat polymer. These nanocomposites can be used for future preparation of the materials with many potential applications, including for EMI-shielding purposes.

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L-34: HYDROPHOBIC CARBON QUANTUM DOTS AS ANTIMICROBIAL AGENT IN POLYMER COATINGS AND THEIR ECO-TOXICITY STUDY

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The microbial contamination of the environment in which we are present, as well as the materials and devices with which we are constantly in touch, is currently a major problem due to the spread of an enormous number of diseases. Therefore, great efforts are being made to develop novel materials and methods for the prevention and treatment of diseases caused by microorganisms, and to disinfect surfaces and medical devices. Specifically, there is a global need for self-disinfecting plastics in various forms and areas. This research is focused on the preparation of antimicrobial polymer coatings doped with hydrophobic carbon quantum dots (hCQDs). The effectiveness of this material can be easily controlled using ordinary blue LEDs. Light-activated coatings generate reactive oxygen species (ROS) responsible for microbial eradication. Very important advantage of this approach is that bacteria cannot develop resistance to ROS. Treatment time is too short for bacteria to develop resistance. Furthermore, unlike conventional antibiotics, the oxygen radicals do not target a single site in the bacteria. ROS, such as singlet oxygen, superoxide, hydroxyl radical, produced by a hCQDs upon light irradiation attack various microbial cellular structures and metabolic pathways.

These nanoparticles are soluble in various organic solvents, and can therefore be easily mixed with a wide range of commercially-available polymer coatings, paints, etc. They have a high photostability, and are cost- and time-effective. Moreover, hCQDs have a low or no cytotoxicity, and are environmentally friendly. One of the decisive methods in terms of real use of the material is eco-toxicity study. It was performed using model organism – terrestrial isopod *Porcellio scaber*. For antibacterial testing, two bacteria were selected: *Escherichia coli*, and *Staphylococcus aureus*. Prepared material was also tested using several chemical-physical methods. Polymer coatings with hCQDs are the ideal material for many applications that require sterile surfaces, and can be used on almost any surface.

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L-35: STIMULI-RESPONSIVE POLYMERS FOR BIOAPPLICATIONS: FROM DRUG DELIVERY SYSTEMS TO SENSORS

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Self-assembly of molecules into complex supramolecular units with qualitatively new properties is in the chemical foundations of life and is the essence of the ability of living organisms to react to the external environment. A specific case occurs when the hydrophobic part of the molecule, or the part of the molecule responsible for self-assembly significantly changes its physico-chemical properties, such as solubility in water, by the action of an external stimulus (changing temperature, pH, etc.). Then the self-assembly of such a system is controlled by such external stimulus and we are talking about systems sensitive to external stimuli. Several such systems designed for biomedical applications (more specifically, polymer theranostics¹⁻³ and electrochemical polymer sensors⁴ of pathophysiological conditions) will be presented in the lecture.

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L-36: POLY(2-ISOPROPENYL-2-OXAZOLINE) AS A VERSATILE FUNCTIONAL POLYMER FOR ADVANCED MATERIALS

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Poly(2-isopropenyl-2-oxazoline) (PIPOx) represents very promising functional polymer with a high potential in various biomedical applications. PIPOx has been used for the preparation of thermosensitive or cationic polymers, drug conjugates, hydrogels, brush-like materials, and polymer coatings available for drug and gene delivery, tissue engineering, blood-like materials, antimicrobial materials, and many others.¹ In our previous studies, we demonstrated PIPOx as non-toxic polymeric materials with interesting immunomodulation properties.^{2,3}

Here, we surveyed some examples for the preparation of advanced materials based on PIPOx chemistry. For all presented applications, PIPOx with pendant reactive 2-oxazoline groups was prepared in a controllable manner via atom transfer radical polymerization (ATRP). The reactivity of pendant 2-oxazoline has been used for the selective reactions carboxylic group-containing compounds without the presence of any catalyst what can be beneficial in the preparation of various advanced materials such as drug-conjugates, hydrogels, brushes, amphiphilic copolymers, or elastomers.

Drug conjugates have been prepared by addition reaction of PIPOx with ibuprofen as a potent non-steroidal anti-inflammatory drug providing sustainable release dependent on pH. Green-chemistry based hydrogels were prepared by the reaction of PIPOx with bio-based dicarboxylic acids leading to hydrogel materials with enhanced biocompatibility and mechanical properties. PIPOx was also used for the preparation of solvent-free and metal catalyst-free elastomers based on PDMS as a “green” alternative to commercial PDMS elastomers. In the last presented example, PIPOx was used as a platform for the preparation of amphiphilic copolymers able to provide self-assembly leading to stable colloidal (nano)particles.

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L-37: ADVANCED ANALYTICAL CHARACTERIZATION OF SYNTHETIC POLYMERS WITH CHROMATOGRAPHIC AND SPECTROSCOPIC METHODS

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The world-wide production of synthetic polymers amounts to about 300 million tons, of which 200 million tons are polyolefins.

Our group develops and applies chromatographic methods (size exclusion chromatography, solvent gradient liquid chromatography, temperature gradient liquid chromatography and two-dimensional liquid chromatography), which may be coupled directly or indirectly (after preparative fractionation) with various spectroscopic methods (IR, UV, NMR). This enables the characterization of the molar mass distribution as well as the chemical composition distribution of synthetic polymers. Such analytical characterizations are especially helpful in the development of new polymer materials as well as in revealing the underlying causes of issues in the practical application of polymer materials.

While size exclusion chromatography of polyolefins has been used in practice for about 60 years now, the first applications of liquid chromatography based on selective adsorption and desorption of polyolefins were published only in 2009.^{1,2} Since then, chromatographic systems have been elaborated for a wide range of ethylene/alkene and propylene/alkene copolymers, stereo block homopolymers of polypropylene, bimodal high density polyethylene, high impact polypropylene, polypropylene grafted with maleic anhydride, ethylene/acrylate copolymers as well as for low density polyethylene and ethylene waxes and ethylene/vinylacetate copolymers.³

In this lecture, advances in the analytical characterization of synthetic polymers will be presented and the potential of interactive liquid chromatography for hitherto unsolved challenges in this field will be outlined.

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L-38: CATIONIC POLY(2-ETHYL-2-OXAZOLINE)S AS NEW CLASS OF BIOCOMPATIBLE MODIFIERS OF MONTMORILLONITES FOR SORPTION AND DECONTAMINATION OF ORGANIC MOLECULES

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Organo-modified layered clay minerals play an important role in the design of advanced materials in many (bio)applications, e.i. as sorption materials and flocculants, catalysts, fillers for (nano)composites, drug and gene delivery systems, or materials for tissue engineering.¹ From many options, modification of clay minerals with polycations can provide materials with novel properties and utilization in various applications.^{2,3}

Here, cationic copolymers prepared by partial hydrolysis of poly(2-ethyl-2-oxazoline) as a new type of polymeric modifier of clay minerals with improved biocompatibility toward potential utilization in biomedical and environmental applications are presented.

The different content of ethylene imine units of statistical poly(2-ethyl-2-oxazoline-co-ethylene imine)s (PEtOx-co-PEI) can affect physical properties of modified montmorillonites (MMT) and their *in vitro* cytotoxicity. We demonstrate that above 22 mol% of ethylene imine units prepared copolymers are positively charged as seen from Zeta potential measurements. The XRD patterns of the powdered samples of PEtOx-co-PEI organoclays show differences in the expansion of the interlayer space. We demonstrate the *in vitro* cytotoxicity of virgin clay minerals compared to modified ones determined on 3T3 mice fibroblasts and their potential for drug delivery, tissue-engineering applications. Moreover, we demonstrate the improved sorption and hydrolytic decomposition of model substrate paraoxon as a representative of organophosphates with a significantly higher hydrolytic effect of organo-modified MMT compared to non-modified MMT.

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L-39: TWO-DIMENSIONAL MATERIALS AND HYBRIDS FOR ADVANCED APPLICATION

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In recent years, two-dimensional (2D) materials such as graphene, graphene oxide, metal oxides and hydroxides, MoS₂, and many others have been intensively studied, because of their unique properties and high potential applicability. The expansion of a new 2D material research was triggered by the discovery of a new type of MXene particles, prepared from precursor - MAX phase. Due to the metallic conductivity, high mechanical strength and hydrophilic character of MXenes, they are regarded as one of the most promising materials for supercapacitor electrodes or in solar cells. Hybrids can be created by combination of 2D nanosheets with zero-dimensional (0D) nanoparticles as quantum dots, or 1D nanoparticles as carbon nanotubes (CNT). This combination used in polymeric composites provides interesting 3D structures and properties. Water soluble polymeric matrix, highly amorphous polyvinyl alcohol, was used for hybrid composite preparation and results, including EMI shielding, will be reported. MXenes were used in solar cell application, the effect of the Ti₃C₂T_x MXene modification of the SnO₂ electron transport layer (ETL) was studied for the concentration range 0 – 7.4 wt.% MXene. Power conversion efficiency (PCE) increased from 17.40 % to 18.30 % after the Ti₃C₂T_x MXene modification, using only 0.1 wt.% MXene-modified SnO₂.

2D materials and they hybrids exhibit extraordinary properties such as large surface area, good electronic conductivity, excellent electrochemical properties, and good chemical, electrochemical, and thermal stabilities, that are promising for various application.

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LS-01: SYNTHESIS AND CHARACTERIZATION OF BIOCOMPATIBLE AND 3D PRINTABLE POLY (OEGMA-STAT-MMA) THERMOPLASTIC ELASTOMERS VIA ATRP POLYMERIZATION SUITABLE FOR TISSUE ENGINEERING APPLICATIONS

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Thermoplastic elastomers (TPEs) are considered as a desirable substitute for thermoset elastomers, because thanks to the physical cross-links in their structure, not only they can resist the deformation induced by strain, but also, they demonstrate the ability to be reprocessed and recycled.¹ Furthermore, oligoethylene glycol methyl ether methacrylate (OEGMA) based TPEs have been largely used in biomedical applications due to their promising biological properties such as high elasticity, appropriate hydrophilicity and biocompatibility.^{2,3} In this study, the atom transfers radical polymerization (ATRP) was used to synthesis poly(OEGMA-stat-MMA) copolymers as functional TPEs. The synthesized polymers were characterized using various techniques, such as gel permeation chromatography (GPC) and proton nuclear magnetic resonance (¹H-NMR) spectroscopy. Also, Optimized copolymers in both dry and swollen states, demonstrated necessary strain-hardening capability, high elasticity, and appropriate young modulus in the range of 15–220 kPa thus providing mechanical properties suitable for soft tissue engineering applications. Furthermore, the resulting statistical copolymers show potential as extrudable ink for 3D printing in tissue engineering and other biomedical applications, with good shape fidelity, nontoxicity, and satisfactory cell viability toward mouse fibroblast cells.

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LS-02: PROPAGATION RATE COEFFICIENT OF METHYL ACRYLATE AND 2-METHOXY ETHYL ACRYLATE IN WATER AND ETHANOL/WATER MIXTURES

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The knowledge of the propagation rate coefficient (k_p) is crucial to understanding the radical polymerization kinetics and mechanisms. Previous studies have shown that k_p behavior varies with reaction conditions, such as the type of monomer, solvents, temperature, pressure, and conversion. The k_p values for the sparingly water-soluble monomers such as methyl acrylate (MA) and 2-methoxyethyl acrylate (MEA) have been studied so far only under limited conditions in water and alcohol/water mixtures.¹

In this work, the IUPAC-recommended pulsed laser polymerization combined with the size exclusion chromatography (PLP–SEC) technique is used to determine the k_p values of MA and MEA as a function of monomer concentration, temperature, and solvent compositions. Herein, for MA, we investigated k_p at concentrations of 1.2–5 wt% in water within the temperature range of 0–60 °C and at 5 wt% MA in a fraction of ethanol in ethanol/water mixtures from 0.015–1.00. Additionally, the k_p for MEA with concentrations of 5 and 10 wt% in water were determined at temperatures from 10 to 60 °C.

The k_p in water was unaffected by MA concentration but decreased with increasing MEA concentration, due to a reduction in the pre-exponential factor ($A(k_p)$). For 5 wt% MA and MEA, the k_p in water was approximately 15 and 9 times higher, respectively, than in bulk. The $A(k_p)$ in water for both the monomers is an order of magnitude higher than in bulk, which explains that the increase of k_p is due to enhanced rotational motion of the transition state for propagation, while the activation energy ($E_A(k_p)$) remains unchanged. For MA polymerized in ethanol/water mixtures, k_p decreased with increasing ethanol fraction, affecting both Arrhenius parameters. Since ethanol enhances MA solubility, it leads to complex formation in an aqueous environment, which activates the C=C bond and reduces $E_A(k_p)$ for propagation.

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Acknowledgment: *We would like to acknowledge BASF and project VEGA no.: 2/0143/23 for the financial support.*

LS-03: INVESTIGATION OF DYNAMIC AND STATIC PROPERTIES OF CYCLIC POLYACRYLATE MELTS

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Polyacrylates and polymethacrylates possess unique properties that are critical for bioapplications. In this study, atomistic molecular dynamics (MD) simulations were employed to investigate both the static and dynamic properties of cyclic polyacrylates in their melts, specifically poly(methyl acrylate), poly(ethyl acrylate), poly(isopropyl acrylate), and poly(*tert*-butyl acrylate), and poly(methyl methacrylate), below their entanglement length at three different temperatures. The primary interest is how the closed topology of these chains affects their static and dynamic properties. In addition, the influence of the branching and the size of the alkyl substituent group on the static and dynamic properties of polymer chains in their melts was scrutinized. Most experimental studies have focused on linear extension of the side chain¹ and there are only a scarce number of experimental studies focused on the branching of the side chain.² Extension of substituents by branching them instead of extending them linearly provided a non-monotonic trend in the size and dynamics of the linear chains. In the case of the cyclic polyacrylates, the trend in size monotonically increased with the substituent size. The results demonstrated that larger and more branched alkyl groups resulted in more symmetric polymer structures. Since chain diffusion decreased with chain size and increased with chain symmetry, a non-monotonic trend in diffusion consistent with the linear counterparts was obtained. Furthermore, branching in the substituent group was found to slow down the local dynamics. Poly(methyl methacrylate) possesses the most compact conformation and the slowest local and global dynamics.

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Acknowledgment: This work was supported by grants APVV-21-0346, VEGA 2/0098/23, and R1 09I03-03-V02-00001.

LS-04: NATURAL NANOFILLERS FROM ASPERGILLUS NIGER AS A HIGHLY EFFICIENT REINFORCEMENT IN NOVEL ELASTOMERS BASED ON WATERBORNE POLYURETHANE

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This study introduces novel elastomers synthesized from a waterborne polycarbonate-based polyurethane dispersion, which are reinforced with different amounts of chitin-glucan nanocrystals (ChGNCs). Using an environmentally friendly method, aqueous suspensions of the polyurethane prepolymer and of the ChGNC nanofiller were blended, subsequently cast and evaporated, thus yielding the final nanocomposite elastomers.

The incorporation of the high-aspect-ratio ChGNC into the polycarbonate-PUR markedly improved its stiffness (increase in modulus by 1 order), already at 1wt.% of ChGNC, without significantly reducing its excellent extensibility.

Chitin, the employed nanofiller, is the main structural material of fungal cell walls and crustacean shells, and is hence widely accessible. It displays very strong hydrogen bonding, and also two additional highly desirable properties: biocompatibility and biodegradability. Its complex with glucan (ChGC), which was used in this work, can be straightforwardly isolated from mushrooms and offers numerous benefits for biomedical applications, namely anti-inflammatory, anti-oxidant, and anti-cancer properties.

The ChGNC nanocrystals were obtained using an acidic deep eutectic solvent mixture (DES) for processing commercial chitin-glucan complex from *Aspergillus Niger*, which was a defibrinated dried mycelium. The so-performed disintegration of the chitin bundles into ChGNCs yielded a 1D nanofiller with very high aspect ratio, which proved to be a very efficient nanofiller.

The characterization of the synthesized PUR nanocomposite films includes their morphology (filler dispersion studied via X-ray scattering and electron microscopy), dynamic-mechanical thermal analysis, micro-tensile tests, relaxation-, and creep tests. The interaction with bacteria also was assessed.

The study employed organic-solvent-free procedures, and it used raw materials of biological origin, so that the products can meet the stringent quality requirements applying in tissue engineering and biomedical applications.

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LS-05: MECHANICAL CHARACTERIZATION OF DUAL CROSSLINKED ALGINATE-BASED HYDROGEL FORMED VIA REVERSIBLE COVALENT BONDS

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Dynamic hydrogels have emerged as promising scaffolds for tissue engineering due to their capacity to replicate the time-dependent mechanical properties of native cellular microenvironments. These hydrogels can be formed by incorporating reversible covalent and non-covalent bonds into a polymeric network¹. Reversible covalent bonds, which combine the strength of covalent bonds with the reversibility of non-covalent interactions, are particularly effective in replicating a wide range of the mechanical behavior found in human tissues. Additionally, a dual-crosslinking strategy within these dynamic hydrogels offers the potential to adjust network properties on demand².

In this study, we developed a dual crosslinked alginate-based hydrogel by combining reversible covalent acylhydrazone and boron ester bonds. For this purpose, sodium alginate, a cell-friendly and natural-based polymer, was first functionalized with adipic dihydrazide to introduce acylhydrazide groups. Subsequently, oxidized dextran, serving as the aldehyde counterpart for acylhydrazide, as well as a mixture of oxidized dextran with tannic-boronic complexation, were employed to form either an acylhydrazone hydrogel or a dual-crosslinked hydrogel. Mechanical properties of the resulting hydrogels, including compressive strength, stress relaxation, and cyclic deformation, were evaluated. Our results showed a significant increase in compressive strength in the dual-crosslinked hydrogel compared to acylhydrazone hydrogel. Additionally, the dual-crosslinked hydrogel demonstrated a dynamic network, as evidenced by its hysteresis in cyclic strain-stress and stress relaxation behavior. Our findings highlight the potential of dual-crosslinked alginate-based hydrogels as promising candidates for engineering strong yet dynamic tissues such as cartilage.

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LS-06: THE UNUSUAL GELATION IN ASPARTATE-BASED POLYUREA: EFFECT OF Sn^{IV} SALT ON NETWORK STRUCTURE

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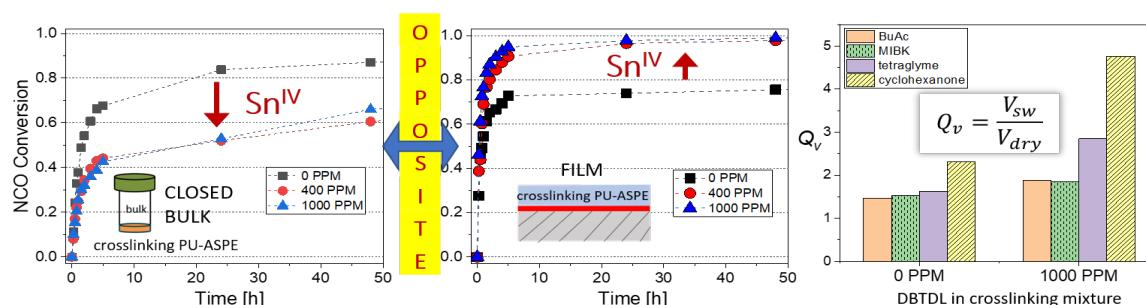
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Polyaspartate-based polyurea networks (PU-ASPE networks) are new and environmentally friendly alternatives to thermosetting polymers, such as epoxies and polyurethanes, with major applications in coatings. We investigated the chemical mechanisms underlying the aspartate amine-isocyanate curing process, focusing on the gelation process and the resultant network structure. We studied step-wise crosslinking system: the bis-aspartate amine ester – Desmophen[®] NH1420 was cured with a bio-based tri-isocyanate – Desmodur[®] eco N 7300. We compared the crosslinking behavior of “closed bulk” (reference system) *vs.* freely evaporating films. The gelation dramatically depended on the system: experiments in bulk *vs.* film showed just opposite trends upon addition of dibutyltin dilaurate (DBTDL) regarding the rate of NCO consumption. Applying a crosslinking model that includes other effects such as 1/*in-situ* formation of monofunctional reactant–ethanol, and 2/ additional branching of the components, we were able to explain the riddle. Briefly, in the *closed* system containing the DBTDL, the reaction of NCO with OH was preferred and lead to altered network while NCO-NH reaction was deterred. The impact of the side-processes could be experimentally evidenced from swelling and mechanical characterization of the networks. Swelling studies showed that the networks cured in absence of DBTDL exhibited lower swelling, indicating higher crosslink density, whereas at presence of DBTDL, the swelling increased indicating loose network and dangling chains. Furthermore, we evidenced the transformation of urea groups into stable hydantoin cycles *via* intramolecular de-esterification with cleavage of ethanol [1]. The chemical changes were analyzed using FTIR and C¹³-NMR spectroscopy, while thermal and mechanical properties were characterized by DSC, TGA, uniaxial tensile tests, and microindentation hardness tests.

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Acknowledgment: The Institute of Macromolecular Chemistry, institutional support RVO: 61389013

P-01: SILK FIBROIN NANOPARTICLES: A NOVEL CARRIER FOR BIOACTIVE AGENTS IN SKIN THERAPY

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Silk, a natural protein fiber from the *Bombyx mori* silkworm, primarily consists of silk fibroin (SF) and silk sericin (SS). SF is noted for its mechanical properties and biocompatibility, making it suitable for biomedical applications once the SS is removed through degumming, which can leave impurities [1]. The degummed fibers are solubilized using lithium bromide to create regenerated SF, ideal for drug delivery and tissue engineering due to its compatibility with human tissues [2]. SF was chosen for its ability to form nanoparticles, enhancing the stability and bioavailability of encapsulated active ingredients. In our study, SF nanoparticles incorporated vitamin C, an antioxidant promoting collagen synthesis and skin repair, and Alchemilla extract, which has antimicrobial and anti-inflammatory properties. These ingredients are crucial for improving skin health and wound healing. Desolvation, a common technique for producing protein-based nanoparticles, involves reducing SF solubility with organic solvents like acetone, ethanol, DMSO, and methanol, leading to phase separation and forming nanosystems [3]. The transition from Silk I to Silk II conformation is induced by dehydration using solvent and SF chain compaction [1]. In this study, silk nanoparticles (NPs) loaded with vitamin C and Alchemilla were developed for dermal drug delivery. Various solvents, including ethanol, acetone, and distilled water, were tested to produce the smallest nanoparticles. Initial characterizations showed diameters of 155.7 ± 67.31 nm for Silk NPs, 600.0 ± 171.1 nm for Alchemilla-loaded NPs, 212.3 ± 60.10 nm for vitamin C-loaded NPs, and 812.1 ± 182.5 nm for NPs loaded with both compounds, with vitamin C being released over 24 hours. In summary, Silk fibroin nanoparticles effectively encapsulate vitamin C and Alchemilla extract, enhancing their stability and bioavailability, and showing promise for improving skin health and wound healing.

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P-02: SYNTHESIS OF GUANIDINE-BASED POLYCATIONS FOR THE PREPARATION OF MULTICOMPONENT MICROCAPSULES¹

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A next-generation cure for type 1 diabetes relies on immunoprotection of insulin-producing cells, which can be achieved by their encapsulation in multicomponent alginate-based microcapsules that are reinforced by the interpolyelectrolyte complex (IPEC) formed using a guanidine-based polycation, poly(methylene-co-cyanoguanidine) (PMCG). To explore alternative routes for synthesizing PMCG-like biguanide-based polycations capable of forming more stable IPECs, we investigated the direct condensation of formaldehyde with *N*-substituted biguanides (metformin, phenformin, 1-(*o*-tolyl) biguanide, and 2-guanidinobenzimidazole). The polycondensation reactions were optimized to control the molecular weight and composition of the condensates by varying parameters such as stoichiometry, temperature, reaction time, pH, and isolation method. Further, we also synthesized copolymers bearing guanidine moieties in the side groups by controlled guanylation of amino polymers, such as poly(allylamine) and poly(ethyleneimine), to different degrees. The prepared polycations were characterized using NMR spectroscopy, size exclusion chromatography (SEC), and scattering methods. Preliminary results on the use of the polycations in microcapsule preparation will be also presented.

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P-03: PREPARATION OF NOVEL CARDANOL BASED POLYURETHANE DISPERSIONS AS FLUORINE FREE WATER REPELLENTS FOR TEXTILE APPLICATIONS

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Due to fluoro carbon based water repellents' toxic effects on human health and environment, eco-friendly water repellents based on non-fluorine chemistries are extremely attracted by researchers. Cardanol, a byproduct of cashew nut industry, is a renewable resource containing mixture of monohydroxyl phenol with long saturated hydrocarbon chain in metaposition which leads this material having good flexibility and hydrophobic nature. In this study different types of waterborne polyurethane (PU) dispersions were synthesized by using HDI, IPDI and different types of cardanol based polyols with using prepolymer mixing method. PU dispersions were characterized by solid content, viscosity, pH measurements, mean particle size and particle size distribution. Moreover, chemical structure of dispersions were determined by FTIR. Film formation behaviours of dispersions were also examined and thermal properties of obtained films were characterized by DSC. In the end, obtained dispersions were applied on textile substrate via padding application and water repellency properties of the coated substrates were examined by. AATCC 22 Water Repellency: Spray test.

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P-04: CHANGES IN MOLECULAR MOBILITY IN THERMOPLASTIC STARCH DUE TO HUMIDITY AND STORAGE TIME – NMR STUDY

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The compression molded samples of glycerol plasticized corn starch prepared using a Brabender mixer (BR) and extruder (EXT), and EXT samples reprocessed in Brabender (EXT+BR) were studied using nuclear magnetic resonance spectroscopy (NMR). EXT samples were stored for three months in PE bags prior to molding. ¹³C and ¹H NMR spectra for these samples were acquired on as-supplied samples, as-supplied samples dried at 110°C and as-supplied samples stored 1, 2, 3 and 4 weeks in desiccators at relative humidity (RH) of 11 and 55%. The weight of the samples levelled off after 2 weeks of storage.

The shape of the starch anomeric carbon (C1) signal in ¹³C NMR spectra¹ for the as-supplied samples (not shown) indicated a small amount of ordered phase in the EXT sample, while BR and EXT+BR samples were amorphous. After one month of storage in PE bags the samples were dried to eliminate the influence of free water on ¹³C NMR spectra which revealed negligible changes in the samples structure (Fig. 1a). The same effect was observed for the samples stored at 11% RH. The ordered phase formation was facilitated successively by the storage at RH of 55% (Fig. 1b). ¹H NMR spectra show that the mobility of glycerol and water molecules is influenced by the presence of the ordered phase which creates higher free volume within the amorphous phase as would be deduced from the decreased line width of narrow signals in ¹H NMR spectra for hydrated samples (Fig. 1c, d).

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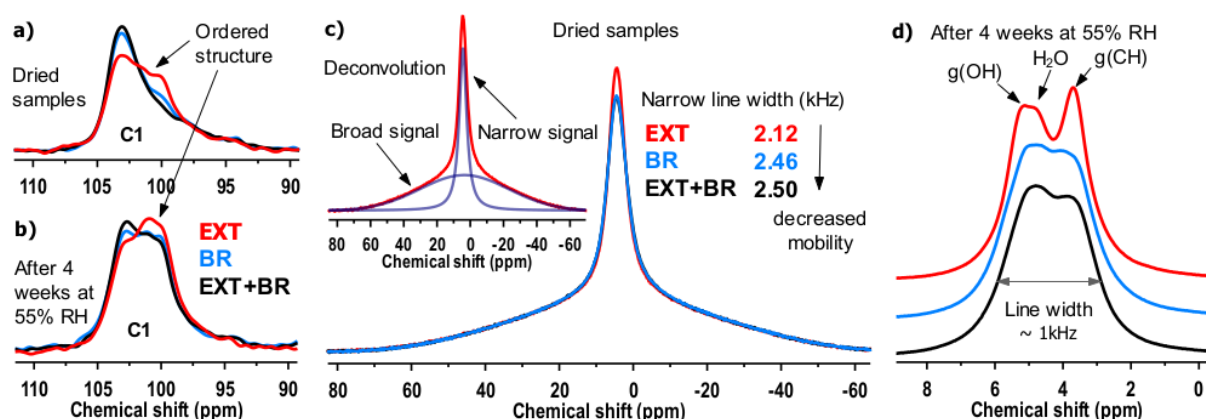


Figure 1 The signal of anomeric carbon in ¹³C NMR (a,b) and ¹H NMR spectra (c,d) for studied samples

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P-05: CONTROLLED POLYMERIZATIONS OF FURAN-BASED MONOMERS FOR DEVELOPING SUSTAINABLE (CO)POLYMERS

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The controlled polymerization of furan-based monomers is a key focus in the search for sustainable materials due to their potential to produce eco-friendly (co)polymers [1]. Furan derivatives, which are obtained from renewable biomass, offer an alternative to traditional petroleum-based monomers. The furan-based (co)polymers can have different structures and properties depending on the synthesis method and the specific monomers used. This study is focused on two controlled radical polymerization techniques, such as atom transfer radical polymerization (ATRP) [2] and nitroxide mediated polymerization (NMP) [3]. They were specifically chosen and optimized for furan-based monomers, which obtained by derivatization of 5-(hydroxymethyl)-furfural. The main goal of this work is understanding the mechanism pathways, optimizing reaction conditions, and achieving precise control over molar mass and polymer architecture. Notably, furan polymers are their exceptional thermal stability, enabling them to endure high temperatures and resist thermal degradation. Moreover, furan polymers exhibit high resistance to chemicals, solvents, and acids. As a result, they find suitability in applications such as refractory materials, coatings, crosslinking and adhesives that require elevated temperature resistance. In the presented work, we are currently focused on using these furan-based (co)polymers for creating nanofibers by electrospinning as packaging materials. Additionally, these synthesized copolymers also used for developing carriers for fluorescent materials or pharmaceuticals by post-modification reactions.

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P-06: SYNTHESIS AND CHARACTERIZATION OF SOLUBLE AND INSOLUBLE β -CYCLODEXTRIN-TAURINE POLYMERS

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Cyclodextrins (CDs) are cyclic oligosaccharides known for their hydrophobic inner cavities, formed by C-H bonds, and hydrophilic outer surfaces due to hydroxyl groups. These unique structural features allow CDs to encapsulate various molecules through non-covalent interactions, making them valuable in drug delivery and environmental applications. However, the functionalization of CDs with specific moieties can further enhance their properties¹. Taurine, a zwitterionic molecule with both hydrophilic and bioactive properties, is an ideal candidate for this purpose. Incorporating taurine into the polymer structure of β -cyclodextrin (β -CD) can potentially improve the solubility of hydrophobic drugs and increase the adsorption capacity of pollutants, thereby broadening the application range of β -CD polymers.

In this work, we synthesized and characterized soluble and insoluble β -CD polymer (PCDs) by epichlorohydrin in the presence of taurine. The soluble PCDs, which offer enhanced water solubility compared to β -CD polymer, were specifically examined for their ability to improve the solubility of hydrophobic drugs like resveratrol² and sulfasalazine. In contrast, insoluble PCDs were studied for their effectiveness in forming hydrogels capable of adsorbing pollutants such as phenol³, dyes (Methanil Yellow and Rhodamine), and antibiotics from wastewater. The preparation conditions were optimized to yield PCDs with either increased water solubility or greater affinity for guest molecules. The synthesized PCDs were characterized using Nuclear Magnetic Resonance (NMR), Fourier Transform Infrared Spectroscopy (FTIR), and Ultraviolet-Visible Spectroscopy (UV-Vis) confirming their structures and properties.

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P-07: SYNTHESIS AND MORPHOLOGICAL CHARACTERIZATION OF PLA-PDMS-PEE ABC MIKTOARM STAR

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The microphase separation in block copolymers (BCPs) occurs due to immiscibility of the constituent blocks and has attracted considerable attention over the years¹. The morphological possibilities considerably increase with increase in the complexity of the BCP architecture. A good example is ABC miktoarm star, where three chemically distinct polymeric chains are bound to a common point, forcing the separation of the incompatible arms, while constraining them to the same region. This project aims to discover complex morphologies known as Frank-Kasper phases, which have previously been observed in AB diblocks², but not in an ABC star. It utilizes the concept of conformational asymmetry, which describes differences in the chemical structure of the individual arms, affecting the way they pack³. The polymers are synthesized using anionic polymerization in order to obtain chains with narrow dispersity characteristics and are linked to a 1,1-diphenylethylene derivative and are partly based on previous work carried out at DTU by Sergey Chernyy and collaborators^{4,5}.

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P-08: CONDUCTING POLYMERS AS AN EFFICIENT TOOL TO ENHANCE CATALYTIC ACTIVITY OF NI FOAM-BASED CATALYSTS

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Hydrogen as a green energy source, has many advantages, such as high energy density (120 MJ Kg⁻¹), clean combustion products, and a wide range of applications.^{1,2} Therefore, it is considered as a one of the most important alternatives to fossil fuels.^{1,2}

Water-splitting is regarded as one of the most advanced technologies for converting electricity into hydrogen energy.³ The optimization of a water-splitting system requires the development of highly efficient, low-cost and stable electrocatalysts based on earth-abundant elements.⁴ In numerous research studies, the electronic configuration of electrocatalysts has been modified to promote the intrinsic activity by tuning components,⁶ controlling the morphology,⁷ designing the crystalline structures,⁸ etc. Recently, a new promising research pathway was developed, namely reducing bubble adhesion to produce electrocatalysts with superhydrophilic and consequently superaerophobic surfaces.⁹

In this work, a modification of Ni foam and hydrothermally synthesized MoSe₂ on Ni foam by hydrophilic polymer blend for enhancement of the catalytic efficiency will be presented. This work can provide a new way how to boost the Ni foam based catalytic efficiency by changing the wetting properties of electrocatalyst.

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P-09: SYNTHESIS AND PROPERTIES OF FERULIC ACID-GRAFTED NANOCELLULOSE RADICAL-MEDIATED

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The incorporation of ferulic acid in a polymeric hydrogel enhanced its antimicrobial and antioxidant properties. The combination of these properties aimed to obtain a hydrogel ideal as a vehicle in the culture of mesenchymal stem cells, aiming for its application in regenerative medicine. A preliminary exploration involved applying different mass ratios of ferulic acid: chitosan (1:2, 1:1, and 2:1) for the radical-mediated grafting copolymerization during 24 h at 90 °C. The quantification of total polyphenols by the Folin-Ciocalteu method evidenced a higher content by using a mass ratio of 1:1 (approximately 39 µg/µL). Next, the synthesis was carried out with nanocellulose (oxidized cellulose nanofibers-OCNF and cellulose nanocrystals- CNC), resulting in total polyphenol content of 49 µg/µL and 10 µg/µL, respectively. After demonstrating the effectiveness of chemical modification, we investigated changes in the cellulose's chemical structure, which were analyzed mainly for CNF using physicochemical techniques such as solid-state CP/MAS 13C- nuclear magnetic resonance (NMR), Fourier transform infrared (FTIR) and X-ray photoelectron spectroscopy (XPS). Another physicochemical characteristic monitored was the surface charge in water suspension by determination of the zeta potential before and after synthesis. Structural characterization study indicated that ferulic acid was successfully grafted into the sample with 2,2,6,6-tetramethylpiperidine-1-oxyl radical (TEMPO)-mediated oxidation, thus contributing to the development of promising results on hydrogels with adequate cell adhesion³, in addition to differentiated protective properties that guarantee the viability of stem cells for advanced therapies.

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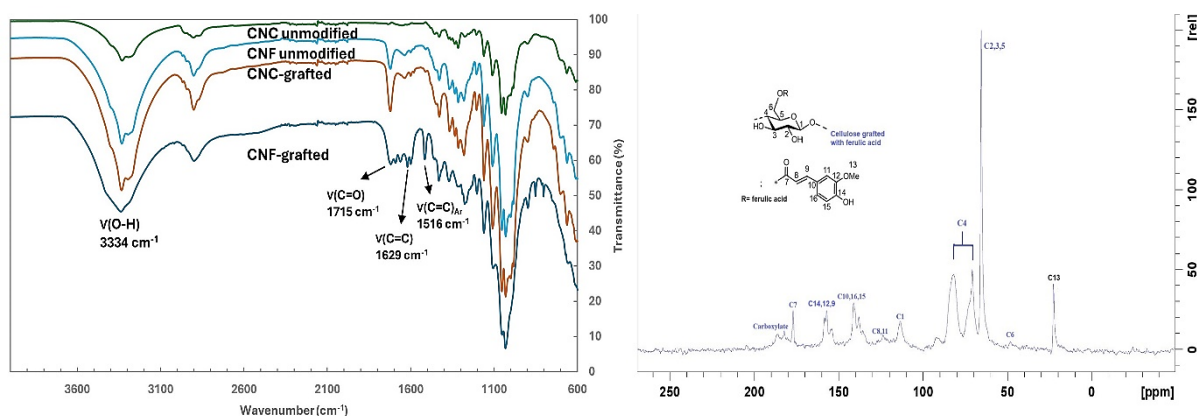


Figure 1. On the left: FTIR of nanocellulose samples before and after grafting with ferulic acid. On the right: solid-state ^{13}C NMR of CNF-grafted.

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P-10: POLY(2-ISOPROPENYL-2-OXAZOLINE) FOR SUSTAINABLE DELIVERY OF IBUPROFEN: CYTOTOXIC AND BIOIMMUNOLOGICAL EFFECTS

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Poly(2-isopropenyl-2-oxazoline) (PIPOx) has gained a significant attention as a polymer platform due to low cytotoxicity, immunomodulation properties, and the possibility of post-polymerization modifications with drugs, hydrophobic moieties in various fields of biomedical applications.^{1,2}

In this study, we focused on the modification of PIPOx prepared by ATRP with molar mass ranged from 3300 to 45,000 g·mol⁻¹ with ibuprofen as a representative of nonsteroidal anti-inflammatory drugs. PIPOx-ibuprofen conjugates were characterized by nuclear magnetic resonance spectroscopy, Fourier-transform infrared spectroscopy, and gel permeation chromatography. These conjugates represent amphiphilic copolymers able to form stable nanoparticles (~9 nm) irrespective of molar mass. Dynamic light scattering confirmed formation of nanoparticles stable in various temperatures. Ibuprofen release from the conjugates exhibited pH- and molar mass-dependence. Histological examination indicated PIPOx's non-cytotoxic nature across all molar masses tested. Immunological assessments revealed PIPOx's anti-inflammatory character. These findings highlight PIPOx as a polymer carrier enhancing the drug performance, thus having high potential in biomedical applications, offering controlled drug release and biocompatibility across various conditions.³

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P-11: NITROAROMATIC– AND DISELENIDE–BASED POLYMER RADIOSENSITISERS AIMING HIGHER RADIOTHERAPY EFFICIENCY

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FLASH radiotherapy, characterised by the delivery of ultra-high dose-rate radiation, has emerged as a groundbreaking approach in cancer treatment, offering the potential to minimise normal tissue damage while effectively targeting tumours. Since the efficacy of radiation therapy depends on the oxygen concentration within the treated tissue, hypoxic regions of the tumour are more resistant to radiation. Increased radiosensitising effects on hypoxic cells have been observed with nitroaromatic and structurally related compounds, such as misonidazole and tirapazamine, as well as diselenide compounds. The aim of this research is to enhance the efficacy of the radiotherapy by combining different radiosensitisers and using supporting moieties (eg mitochondria-targeting triphenylphosphonium) to exert additional effects on cancer cells. Preclinical tests are conducted on spheroids, which provide normoxic cells on the surface and hypoxic cells at the centre of the spheroid.

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P-12: KITCHEN WASTE-DERIVED BIOCHAR: PREPARATION AND COMPREHENSIVE CHARACTERIZATION.

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Annually, a staggering amount of food waste is generated, with approximately one-third of the global food supply ending up in landfills or incinerators¹. This not only represents a significant loss of resources but also contributes to environmental degradation. The high carbon content of food waste presents an opportunity to produce biochar, a sustainable alternative to carbon from fossil sources. Carbon, with its unique properties such as low weight, porosity, high strength, low temperature, electrical conductivity, and chemical stability, can be utilized in a variety of applications, from filtration to energy production, agriculture, and sensor technology².

This study aimed to reduce environmental issues associated with kitchen waste. We selected potato and root vegetable waste for our research activity. Thermal stabilization up to 250°C and carbonization up to 800°C were applied to reach the material with a high carbon content. The produced carbon materials were comprehensively characterized by SEM, EDS/SEM, elemental analysis, TGA/DTG, XRD, FTIR, and RAMAN.

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P-13: A NEW CONCEPT OF POLYMER POTENTIOMETRIC-FLUORESCENCE SENSOR

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In connection with urgent environmental issues, the problem of micropollutants is being discussed more and more intensively. We introduce a new concept of polymeric potentiometric-fluorescence micropollutant sensor. The detection is aimed mainly at ionic surfactants, polyvalent toxic metal ions, bacterial endotoxins (that can often cause inflammation leading to septic shock), as well as defensins (as markers of inflammation), which function similarly to cationic surfactants. The universal concept of the sensor can allow its miniaturization and easy use both in laboratories and in wastewater treatment plants, medical facilities or in field conditions during collection of samples. The proposed 2D-orthogonal sensor represents a combination of two independent methods, potentiometry and luminescence. Potentiometric detection enables the accurate determination of generally charged substances using an electrode that is oppositely charged to the investigated analyte and is at the same time partially hydrophobic. The polymer detection layers can be decorated with suitable molecules serving as ligands for the selected micropollutants. Since the attachment of a charged toxin molecule to the sensor layer causes a change in the charge distribution and a change in the hydrophobicity of the surface, it can naturally lead to a change in the light emission of the luminophore, which will be incorporated into the layer as well.

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P-14: POLY(2-OXAZOLINE)-STABILIZED NANOPARTICLE-BASED CARRIERS FOR BINDING TO CELL MEMBRANE RECEPTORS

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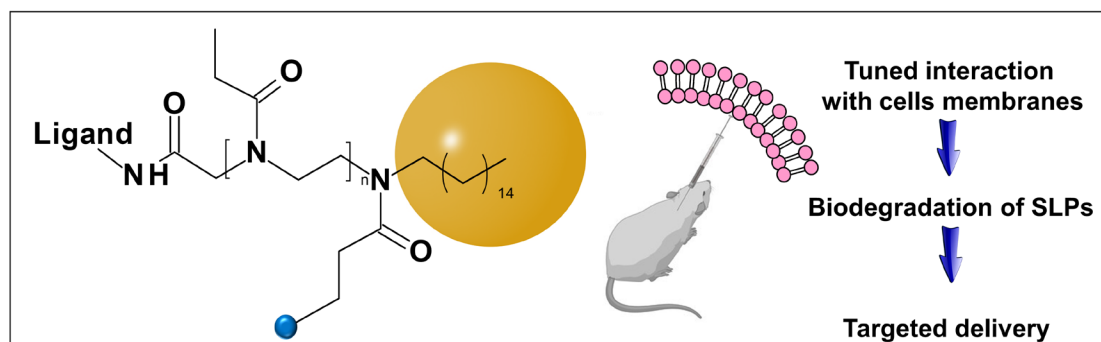
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The development of poly(2-ethyl-2-oxazoline)-stabilized, nanoparticle based carrier systems for biomedical applications has gained increased interest due to the systems non-toxicity and biocompatibility¹. In our present work, we have successfully synthesized solid lipid particles (SLPs) based on a cholesterol/tetradecanol core that carries water-soluble amphiphilic poly(2-oxazoline)-ligand conjugates with a hydrophobic end group (**Scheme 1**). This end group of poly(2oxazoline) is temporarily hidden by the biodegradable core of the SLPs, enabling the ligand to actively target cell membrane receptors. After administration, the particle core is metabolized, causing the release of the hydrophobic unit and enabling its non-specific binding to cell membranes. By establishing a synergistic interplay of non-specific and specific binding, this strategy enhances the ligand's targeting efficiency.

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Scheme 1: Development of biodegradable solid lipid particle based nanocarrier.

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P-15: FEASIBILITY OF SCREEN PRINTED SENSOR BASED ON THE KITCHEN WASTE-DERIVED BIOCHAR

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This work demonstrates the feasibility of using kitchen waste-derived biochar to create a cost-effective electrochemical sensor comparable to commercial sensors. Graphite and soot from fossil sources are replaced with an alternative material, namely biochar from kitchen waste.

Using kitchen waste to develop ultra-sensitive electrochemical sensors for early disease detection is promising in sustainable waste management and advanced diagnostic technology¹. This research, which integrates environmental sustainability with cutting-edge sensor technology, is a structured process involving various phases. The preparation of biochar from kitchen waste, particularly from root vegetables and potatoes, consists of a series of controlled carbonization processes². The resulting biochar undergoes a comprehensive characterization process using various techniques, including microscopy, thermal analysis such as TGA/DSC, and spectroscopic techniques like FTIR and Raman. This thorough evaluation is crucial in determining the functional properties of the biochar. High-viscosity dispersions that combine biochar with polymer binders are then prepared for screen-printing. Techniques such as ultrasonic homogenization and ball milling ensure printing dispersions' stability and desirable rheological properties.

The electrochemical performance of the screen-printed electrodes was evaluated through cyclic voltammetry, differential pulse voltammetry, and electrochemical impedance spectroscopy. The screen-printed sensor was tested for sensitivity to the small organic molecule dopamine.

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P-16: THE EXPRESSION OF VIRULENCE GENES IN *STAPHYLOCOCCUS AUREUS* AFTER CONTACT WITH HCQDS/PDMS

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Staphylococcus aureus is one of the most common opportunistic bacteria infecting human and causing skin infections, it is widely distributed and have a high survival rate in dry environments, e.g. on surfaces of inanimate objects. Virulence in *S. aureus* is largely under the regulation of two loci, *sarA* and *agr*.

Hydrophobic carbon quantum dots (hCQDs) are well-known for their antibacterial properties. They are activated by blue LEDs to produce singlet oxygen which exert potent antibacterial activity. Polydimethylsiloxane (PDMS) is used in various biomedical applications including catheters, bandages and medical implants as they are biocompatible and chemically stable. In order to add extra value – antimicrobial - for this polymer, hCQDs were incorporated in it. In this study we analyzed gene expression of 4 virulent genes (*agrA*, *psma*, *rsp* and *rsaC*) in response to contact with PDMS doped with hCQDs.

hCQDs were prepared according to procedure described by Stankovic et al.¹. The hCQDs/PDMS nanocomposites were prepared by dipping of PDMS samples in hCQDs solution in toluene. The hCQDs/PDMS nanocomposites were dried at 80 °C for 12 h to get rid of toluene.

Bacterial suspension of *S. aureus* (3.1×10^6 CFU/mL) was inoculated on the surface of PDMS/hCQDs samples and exposed to blue light for 5, 10 and 15 minutes. The samples were incubated at 37°C for 24 hours. Bacteria were recovered and total RNA isolation, cDNA generation, and real-time quantitative reverse transcription-PCR was performed on the recovered bacteria. The genes analyzed were *agrA*, *psma*, *rsp* and *rsaC*.

All four genes were downregulated in a time-dependent manner. The highest downregulation of gene expression occurred after 15 min of blue light exposure in *psma* and *rsp*, respectively. These genes are responsible for lytic activity against mammalian cells and triggering cutaneous inflammation and their downregulation would decrease the virulence of the bacteria.

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P-17: LIRAGLUTIDE-LABELED POLY(METHYL VINYL ETHER-*alt*-MALEIC ACID)-COATED UPCONVERTING NANOPARTICLES FOR DIABETES THERANOSTICS

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Polymer-based nanocomposites have been the focus of great attention due to their excellent drug delivery properties, which reduce the toxicity and improve function compared to the systemic administration. However, the use of these nanomaterials in the treatment of metabolic diseases has been limited. As a promising nanocarrier, upconverting nanoparticles (UCNPs), converting NIR light into UV/Vis radiation, offer unique opportunity for new treatments of diabetes, the leading cause of premature mortality worldwide. UCNPs can also improve the biodistribution of systemically administered drugs and combine therapy and imaging. Liraglutide (LGL) is a glucagon-like peptide-1 analogue, an incretin hormone approved by the U.S. Food and Drug Administration with important effects on blood glucose control and body weight regulation, improving therapeutic efficacy in patients with type-2 diabetes. This cell-targeting peptide is highly expressed in pancreatic cells and is considered as a promising targeting agent for delivering theranostic agents to pancreatic β -cells. Consequently, the combination of LGL with UCNPs enables precise delivery to the pancreas and provides *in vivo* monitoring of cells transplantation in early stages to detect islet graft rejection.

Here, core-shell (CS) NaYF₄:Yb,Er,Fe@NaYF₄:Nd UCNPs were successfully synthesized and coated with biocompatible poly(methyl vinyl ether-*alt*-maleic acid) [PMVEMA] polymer. The spherical UCNPs were monodisperse with a diameter of 35 nm. The incorporation of transition metal Fe²⁺ ions (5 mol.%) into the particles significantly influenced luminescence properties under 808 and 980 nm excitation. The hydrophilic PMVEMA coating rendered CS-UCNP@PMVEMA particles highly colloidal and chemically stable. A clinically used LGL was covalently conjugated to the surface of CS-UCNPs by nucleophilic acyl substitution between terminal amino groups of LGL and carboxyl groups of PMVEMA. The biocompatibility of CS-UCNPs was tested on INS-1E rat insulinoma cells, serving as a useful model for regulation of insulin secretion and investigation of pancreatic β -cells. Intramuscular injection of CS-UCNP@PMVEMA-LGL nanoparticles proved to be successful for specific targeting of pancreatic β -cells, which is urgently needed in diabetology.

Acknowledgment: This research was funded by the Czech Science Foundation, No. 24-10125S.

P-18: CONTROLLED, RAPID AND STRAIGHTFORWARD SYNTHESIS OF POLY(*N*-(2-HYDROXYPROPYL) METHACRYLAMIDE, (Poly(HPMAM)), BRUSHES VIA INTERFACE-MEDIATED REVERSIBLE ADDITION-FRAGMENTATION CHAIN-TRANSFER (RAFT) POLYMERIZATION

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Over the last three decades an incredible effort has been made to suppress non-specific adsorption of proteins onto surfaces that are brought into contact with biological media.¹ Despite the significant advances that have been accomplished in surface modification strategies, a simple and controlled yet reliable technique allowing fabrication of antifouling surfaces is missing. In this study we demonstrate a rapid and straightforward approach relying on interface-mediated (RAFT) polymerization (IM-RAFT) to fabricate poly(HPMAM) brushes that has been shown by several authors to prevent protein fouling even from undiluted blood plasma. Our approach enables precise control over brush growth, reaching thickness up to 72 nm within a remarkably short timeframe of just 4 hours. The high level of control was achieved by assessing crucial polymerization parameters with a specific emphasis on the immobilization of the RAFT agent onto the surface and the subsequent polymerization procedure. The selection and addition of the appropriate sacrificial chain transfer agent (CTA) into the polymerization solution significantly influenced the outcomes, furthermore, its solubility has a substantial impact on the polymerization process. This work provides a guideline allowing simple and rapid fabrication of poly(HPMAM) brushes in a well-controlled manner through IM-RAFT. Simultaneously, the approach presented herein offers a promising solution for the rapid advancement in the field of antifouling coatings on biomedical devices. This addresses challenges related to protein adsorption in complex biological environments, providing a straightforward alternative to currently used PEG-coating biomedical materials.

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P-19: PREPARATION OF THE BIOFILMS MASS DYED WITH FOOD PIGMENTS

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Biodegradable polymers are currently a major topic in the field of plastics. Much attention is paid to research and improvement of their properties. They are used in various industrial areas, e.g., agriculture, pharmaceutical industry, cosmetics, food industry and gastronomy, as well as in the engineering and automotive industries.

Our research was focused on the preparation of cast films based on PLA/PHB biopolymer Nonoilen mass dyed with food pigments (FP) Caramel-E150d, Chlorophyll-E141 and Carmine-E120. The Plasticizers laboratory line with an extruder's screw diameter of 18 mm and a slot width of 48 mm was used for research. Temperature settings of the extruder and die head, extruder load, screw speed of the extruder and speed of the cooled godets were monitored. The cast films were prepared from a mixture of Nonoilen and 3% masterbatches on the Nonoilen base containing food pigments.

By researching the process conditions, it was found that at an extruder temperature setting of 150°C and a die head of 160°C, it is possible to prepare Nonoilen film - standard. When the film is warm, it is flexible and has the properties of a stretch film. This state is not permanent and when the film cools off, it becomes hard and brittle. When the film is warm, it sticks together.

Subsequently, research was carried out on the process conditions of cast films with a content of 0.1; 0.5; 1.0 and 1.5 wt.% FP in films. Process temperatures for the preparation of films containing pigment E150d were the same as for the standard. With the increasing content of pigment E150d in the Nonoilen matrix, the screw speed of the extruder increased slightly. The use of pigment E141 resulted in a reduction of temperatures by about 10°C compared to the temperature of the standard and subsequent technology adjustment. The preparation of the cast film with a mixture of Nonoilen and masterbatch containing pigment E120 was the worst. It was possible to obtain only films with a low pigment content of 0.1 wt.% and 0.5 wt.%. At a higher concentration of 1.0 wt.% pigment E120, a thick and deformed film was obtained. In case of the food pigments E150d and E120, insufficient dispersion of pigment particles was noted at higher concentration levels.

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P-20: POROUS POLY(METHYLHYDROSILOXANE)-BASED MATERIALS:

MODIFICATION USING N-ALLYLPYPERIDINE

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Siloxane polymers are attracting a great interest in materials research due to their unique physicochemical properties, such as high thermal stability, durability, and environmental friendliness [1]. An example of a compound belonging to this group is polymethylhydrosiloxane (PMHS), which contains Si-H bonds in its structure. These bonds are prone to various chemical reactions, including hydrosilylation. This process is a catalytic addition of Si-H to multiple bonds, which, in the case of $>C=C<$ bonds leads to the formation of new Si-C bonds. In particular, PMHS can undergo hydrosilylative cross-linking in high internal phase emulsions (HIPEs), where the internal phase constitutes at least 74% by volume. Such cross-linking results in the formation of polyHIPEs, a specific type of porous polymer materials [2]. In case of an excess of Si-H groups, further enhancement of these materials' functionality may be achieved by hydrosilylation using *N*-allylamines. This modification broadens the potential applications of polyHIPE materials. By incorporating organic functionalities containing nitrogen atoms, polyHIPEs may acquire antimicrobial properties, effectively combating bacterial growth and contamination. This additional feature enhances their suitability for use in biomedical devices, environmental applications, and other areas requiring antimicrobial materials.

In this work, polyHIPEs were obtained by—crosslinking of PMHS with two vinylsiloxanes: 1,3-divinyl-1,3-tetramethyldisiloxane and 1,3,5,7-tetravinyl-1,3,5,7-tetramethylcyclotetrasiloxane in a water-in-oil HIPE. The obtained materials were then functionalized with a heterocyclic amine, *N*-allylpiperidine (Nap). Additionally, an attempt was made to quaternize the obtained materials using benzyl chloride (BnCl) and octyl bromide (OcBr). In order to better characterize porous materials, their non-porous counterparts were also synthesized. The obtained materials were studied by scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), ^{29}Si Magic Angle Spinning Nuclear Magnetic Resonance (^{29}Si MAS-NMR) and combustion elemental analysis. Degrees of swelling and helium densities of the obtained materials were also determined. Porosity degrees were calculated for porous materials.

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Acknowledgment: Financial support from the IDUB grant - "System of university grants for research work carried out with the participation of doctoral students" (no. 6408) is kindly acknowledged.

P-21: MULTICOMPARTMENT OR NOT: STRUCTURAL INSIGHTS INTO TEMPERATURE- AND CONCENTRATION RESPONSIVE COPOLYMER MICELLES

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Block copolymers are intensively studied for their versatility and wide range of applications, having the ability to form different structures from vesicles to micelles, and aggregates¹. Among these, multicompartment micelles with a compartmentalized core offer interesting opportunities for drug delivery, such as concurrent delivery of incompatible agents to the same target. Despite the extensive research done on polymeric micelles¹, delivery of drugs in multicompartment carriers remains less explored.

To achieve a well-tuned multicompartment drug delivery systems (DDS), it is important to understand the structural intricacies of these systems and the dynamic changes within the micelles upon drug encapsulation. Solid-state and solution NMR, combined with PXRD and SEM, provide a useful toolbox for a thorough analysis of different polymeric DDS. The current work employs these methods to analyze concentration-dependent and thermo-responsive bi- and terpolymer micelles, for small molecule encapsulation (Figure 1). The micelles consist of methoxy poly(ethylene oxide) as the hydrophilic block, poly(butyl acrylate) as the hydrophobic middle block and poly(N-isopropylacrylamide) as the thermo-responsive block in case of terpolymers^{2,3}. The investigation goes beyond their morphology such as shape and size, by probing more subtle characteristics – chain mobilities, interchain contacts and compartment composition. Moreover, the effects of drug loading are to be investigated in near future, to elucidate the polymer-drug interactions.

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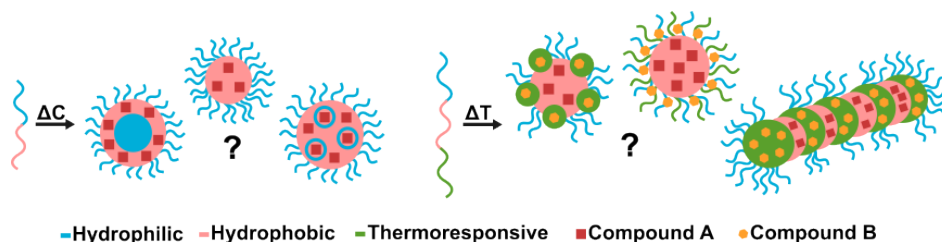


Figure 1 Possible structures and drug encapsulation of bi- and terpolymer multicompartment micelles. ΔC denotes the concentration dependence, ΔT the temperature dependence.

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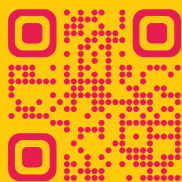
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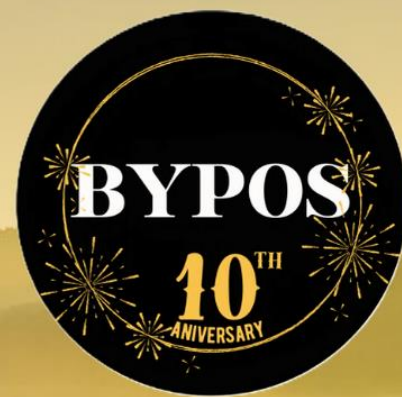


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