12TH CONFERENCE ON COLLOID CHEMISTRY

Programme and Book of Abstracts

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NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY
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PROGRAMME BOOKLET

12TH CONFERENCE

ON

COLLOID CHEMISTRY

Programme and Book of Abstracts

From fundamentals to sustainable application

Budapest, Hungary

September 27–30, 2026

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Welcome

Dear Colleagues,

Since the early discoveries in the world of colloids colloid and interface science has expanded as an interdisciplinary intersection of branches of chemistry, physics, biology, nanoscience and other fields dealing with colloidal heterogeneous systems. The development of the scientific hardware allowed to go beyond the resolution of the Zsigmondy microscope opening the “nano era” a few decades ago. Thanks to the interdisciplinary nature of the colloid and interface science, the new results have been promptly turned to nanotechnology, leading to the birth of the era of materials science. Colloidal, nanoparticulate, and nano-structured systems and interfaces occupy an important role among the innovative materials that are engineered to promote sustainable development and a liveable future. Colloid particles, novel in size, shape or surface chemistry, offer attractive functional properties for a range of formulated products, from drug delivery systems to coatings and cosmetics. Nanotechnologies provide a wide variety of economic benefits in the field of nanoformulation, sensors, imaging and diagnostics. On the other hand, not all the colloidal systems are benign. Colloid and surface science plays a pivotal role in our fights for a cleaner environment: air and waters, and against global climate change.

The idea of this conference was to bring together experts from different sub-disciplines in academia, industry and business to discuss the scope and recent progress in the field and to promote collaborative efforts.

The organizers of 12^{th} CCC sincerely hope that you will all enjoy stimulating and fruitful days. Since their inception, these conferences have especially welcomed students and young colleagues. Their fresh ideas and questions bring an invaluable contribution to the momentum of scientific discussion.

We thank you all for your participation and also thank our speakers and exhibitors for contributing to the high scientific level of the conference.

Krisztina László

Conference Chair

PROGRAMME

SUNDAY, 27 SEPTEMBER 2026

16:00-18:00 REGISTRATION

18:00-20:00 WELCOME

MONDAY, 28 SEPTEMBER 2026

08:00-09:00 REGISTRATION

09:00-09:30 **OPENING CEREMONY (ROOM A)**

Chair: Krisztina László

Péter Szalay
Miklós Zrínyi

09:30-10:15 **OPENING LECTURE (ROOM A)**

Chair: Krisztina László

Joaquin Silvestre-Albero: Structural flexibility in porous materials upon an external stimulus

10:15-10:45 COFFEE BREAK

ORAL SESSION 1/1 (ROOM A)

Chair: Angéla Jedlovszky-Hajdú

10:45-11:00 **OL01 – Xiangyang Shi**: Multifunctional dendrimer nanogels: a versatile platform for next-generation cancer therapy and immunotherapy

11:00-11:15 **OL02 – Attila Forgács**: Protein based biopolymer aerogels as pH-responsive drug delivery systems

11:15-11:30 **OL03 – Kristóf Molnár**: Investigation of the pH dependent swelling of electrospun hydrogel fiber mats

11:30-11:45 **OL04 – Yong Mei Chen**: Multifunctional self-healing and injectable dynamic nanocomposite hydrogels

11:45-12:00 BREAK

Chair: Attila Forgács

12:00-12:15 **OL05 – Angéla Jedlovszky-Hajdú**: Composite meshes for biomedical applications

12:15-12:30 **OL06 – Mingwu Shen**: Phosphorus dendrimer-based protein delivery systems for osteoarthritis therapy

12:30-12:45 **OL07 – Ami Saito**: Novel antioxidant nanozymes cocktails to combat oxidative stress in IBD

12:45-13:00 **OL08 – Freya Fan**: Introduction of Nanomedicine Therapeutics journal

13:00-14:00 LUNCH BREAK

SPECIAL SESSION IN HONOR OF IMRE DÉKÁNY'S 80TH BIRTHDAY (ROOM A)

Chair: Zoltán Kónya

14:00-14:15 **Zoltán Kónya**: Laudation

14:15-14:30 **OL09 – Volker Zöllmer**: Functional composites and advanced sensor technologies: honoring the legacy of Prof. Imre Dékány

14:30-14:45 **OL10 – Róbert Kun**: From classical colloid chemistry to modern battery science: aqueous heterocoagulation for the assembly of electrochemically active lithium–sulfur cathodes

14:45-15:00 **OL11 – G. Julius Vancso**: Nanolignins as pickering emulsifiers in enhanced oil recovery: fresh tricks by an old workhorse

15:00-15:15 **OL12 – Sándor Puskás**: Reservoir and formation stimulation by nanoemulsion treatment of the bottom hole zone of oil and gas wells for improved oil recovery

15:15-15:30 **OL13 – Davor Kovačević**: From gold nanoparticles to adsorption of arsenic: decades of collaboration in colloid chemistry

15:30-15:45 **OL14 – Edit Csapó**: Effect of size reduction on the optical properties of noble metal nanostructures

15:45-16:15 COFFEE BREAK

Chair: Róbert Kun

16:15-16:30 **OL15 – Tamás Szabó**: Mastering the flat plane: a brief overview of nearly 50 years of research on layer-structured materials in Szeged

16:30-16:45 **OL16 – Krisztina László**: Relevance of surface chemistry in performance of nanostructured carbon materials

16:45-17:00 **OL17 – Klemen Bohinc**: Factors affecting bacterial adhesion to surfaces

17:00-17:15 **OL18 –László Janovák**: Biopolymer-based nanosystems for enhanced drug delivery

17:15-17:30 **OL19 – Saule Aidarova**: Surfactant and nanoparticle systems for enhanced foam stability

17:30-17:45 **OL20 – István Szilágyi**: Colloidal interactions in nanoplastic-PFAS systems

17:45-18:45 **POSTER SESSION**

Chair: Borbála Tegze

20:00-22:00 STUDENTS' PARTY (Optional)

TUESDAY, 29 SEPTEMBER 2026

08:00-09:00 REGISTRATION

9:00-9:45 **PLENARY LECTURE (ROOM A)**

Chair: Róbert Mészáros

Juraj Bujdák: Dye–smectite colloids: from fundamentals to photoactive materials

ORAL SESSION 1/2 (ROOM A)

Chair: Benjámin Gyarmati

9:45-10:00 **OL21 – Justyna Gaweł**: Development and optimization of SA-HA hydrogels and PCL-RF scaffolds for potential application in wound healing

10:00-10:15 **OL22 – Karen Contreras Muñoz**: Enzyme responsive fluorinated nanoprobe for OFF/ON ^{19}F MRI detection of MMP 9

10:15-10:30 **OL23 – Attila Cserményi**: Modified lifetime of bioactivity of phototrexate by colloidal molecular environment

10:30-11:00 COFFEE BREAK

ORAL SESSION 2 (ROOM B)

Chair: Mónika Kéri

09:45-10:00 **OL24 – Lucian Baia**: Formation of graphene oxide membranes by self-assembly

10:00-10:15 **OL25 – Nikoletta Kovács**: Development of magnetic adsorbents for broad-spectrum removal of trace micropollutants from real waters

10:15-10:30 **OL26 – John Chagu**: Synthesis and immobilization of Fe_3O_4/Ag_3PO_4 photocatalyst onto ceramic paper for photocatalytic purpose

10:30-11:00 COFFEE BREAK

ORAL SESSION 3/1 (ROOM A)

Chair: Edit Csapó

11:00-11:15 **OL27 – Régis Guegan**: Heterostructures based on the colloidal association of graphene oxide and titanium disulfide nanosheets for possible supercapacitor applications

11:15-11:30 **OL28 – Lilla Nánai**: A brief overview: from the formation of thin films to the production of carbon nanotube forests

11:30-11:45 **OL29 – Hadjra Ben Haoua**: Effect of tri-metallic catalyst on grow carbon nanotube

11:45-12:00 **OL30 – Monica Baia**: Colloidal noble metal nanoparticles as versatile SERS substrates for diverse applications

12:00-12:15 **OL31– Dániel Zámbó**: Multimetallic nanoparticle-based porous nanocatalysts

12:15-12:30 **OL32 – Dániel Simon Berkesi**: Design, standardization, and challenges of visible and UV photocatalytic reactors for nanomaterial testing

12:30-14:45 LUNCH BREAK & **POSTER SESSION** (*Chair: Borbála Tegze*)

ORAL SESSION 4 (ROOM B)

Chair: András Deák

11:00-11:15 **OL41 – Mónika Kéri**: Hydration properties of carbon aerogels by NMR relaxation methods

11:15-11:30 **OL42 – Szilárd Sáringer**: Characterizing concentrated antibody solutions with small-angle X-ray and light scattering

11:30-11:45 **OL43 – László Kiss**: Influence of solvent composition on the electropolymerization of selected organic compounds

11:45-12:00 **OL44 – Norbert Nagy**: Capillary bridge probe method for direct measurement of solid-liquid adhesion work

12:00-12:15 **OL45– Patrick Swolana** (KRÜSS GmbH): Progress through retraction: industrial insights from two years of easy receding angle measurements

12:15-12:30 **OL46– Henrique Brasil** (Anton Paar GmbH): Multiscale light- scattering analysis of thermoresponsive methylcellulose gels

12:30-14:45 LUNCH BREAK & **POSTER SESSION** (*Chair: Borbála Tegze*)

ORAL SESSION 3/2 (ROOM A)

Chair: József Kalmár

14:45-15:00 **OL33 – Galder Llorente**: Synthesis of fluorinated amphiphilic polymers for the aqueous dispersion of hydrophobic quantum dots, gold nanoparticles, and fluorinated molecules

15:00-15:15 **OL34 – Levente Novák**: Functionalized macromolecules as ligands for paramagnetic metal ions

15:15-15:30 **OL35 – Ziyoda Ganieva**: Selective Cu_2O shell deposition on gold nanoprisms via ligand-mediated surface engineering

15:30-15:45 **OL36 – Bianka Torma**: Noble metal nanoclusters surface-modified with amino acid derivatives

15:45-16:15 COFEE BREAK

Chair: Levente Novák

16:15-16:30 **OL37 – József Kalmár**: Mechanism of hydration and hydration induced structural changes in polyamide and polyimide aerogels

16:30-16:45 **OL38 – Péter Márton**: Tunig the surface properties of chitosan nanocoatings by the self-assembly of cationic surfactant molecules

16:45-17:00 **OL39 – Borbála Tegze**: Chitosan-based composite coatings of upconverting $NaYF_4$: Yb, Tm nanoparticles

17:00-17:15 **OL40 – Andrij Pich**: Mechano-responsive colloidal gels

19:00-22:00 CONFERENCE DINNER
Törley Visitor Centre

WEDNESDAY, 30 SEPTEMBER 2026

08:00-09:00 REGISTRATION

ORAL SESSION 5 (ROOM A)

Chair: László Kiss

09:00-09:15 **OL47 – Paweł Weroński**: Segmentation-free Fourier-based parametrization of particle monolayers from degraded optical microscopy images
09:15-09:30 **OL48 – Farshad Hamehkhani**: Adsorption-induced fluorescence enhancement of SYBR Green I on saponite dispersions: experimental and computational investigation
09:30-09:45 **OL49 – Oldamur Hollóczki**: Nanoplastics from theoretical chemistry
09:45-10:00 **OL50 – Maxim Varenicja**: On the interactions between nucleic acids and nanoplastics
10:00-10:15 **OL51 – András Deák**: Self-assembly of colloids studied at the single-particle level
10:15-10:30 **OL52 – George Kaptay**: Comparison of model equations for size- and shape-dependent integral and partial molar Gibbs energies of nano-phases to find the correct one

10:30-11:00 COFFEE BREAK

ORAL SESSION 6 (ROOM A)

Chair: Szilárd Sáringer

11:00-11:15 **OL53 – Róbert Mészáros**: A novel 3D liquid printing technique tested in aqueous two-phase systems
11:15-11:30 **OL54 – Csilla Sörös**: Physicochemical characterization and field performance of commercial tank-mix adjuvants in plant protection applications
11:30-11:45 **OL55 – Zsófia Árok**: Ion specific effects on the sol-gel behaviour of EOR polymers
11:45-12:00 **OL56 – Benjámin Gyarmati**: Study of the interaction between mucin and cationic polymers
12:00-12:15 **OL57 – Irena Petrinič**: Surface-modified magnetic nanoparticles as draw solutes in forward osmosis processes
12:15-12:30 **OL58 – István Bányai**: *In vivo* NMR relaxation study of human skin: effect of moisturization

12:30-13:00 **CLOSING CEREMONY**

Krisztina László

13:00-14:00 LUNCH

POSTER SESSION

P01 – Abelneh Terefe Mekuria: Apparent charge-selectivity reversal under sub-CMC surfactant exposure in polyelectrolyte multilayer nanofiltration membranes
P02 – Adrienn Márta Bors: Preparation and investigation of mesoporous TiO_2 sol-gel coatings with enhanced light transmittance and photocatalytic activity
P03 – Attila Bóta: Correlation between spectroscopic and stoichiometric protein to lipid ratios in erythrocyte-derived extracellular vesicles and nanoerythrosomes
P04 – Attila Csicsor: From humic heterogeneity to standardized fractionation: quantification of humic and fulvic acids by MSZ 1129:2026
P05 – Attila Vörös: Dual nanozyme immobilization on latex scaffolds
P06 – Balázs Borbás: Development of biopolymer-based composite coatings containing erbium doped upconverting nanoparticles
P07 – Bence Mihalovics: Controlling drug release using polyaspartamide-based fibrous matrices
P08 – Boglárka Szabó: Building nanoplastic models for molecular calculations
P09 – Dániel Balázs: Lead-oleate clusters in nanocrystal synthesis media: reaction, depletion and post-synthetic modification
P10 – Dániel Pércsi: Development of aerogel-based sorbents for the selective binding of precious metal compounds
P11 – Ditta Adrienn Gerbovits: Investigation of gemini surfactants for enhanced oil recovery applications
P12 – Domonkos Szabó: 3D printable porous enzyme support systems
P13 – Flórián Bencze: Effect of the protic vs. non-protic molecular environment on the cis to trans conformation change of phototrexate drug
P14 – Freya Fan: Introduction of OAE Publishing Inc.
P15 – Gabriella-Stefánia Szabó: Study of the anticorrosion properties of silica coatings modified with phytic acid (PA) and 3-glycidyloxypropyltrimethoxysilane (GPTMS) on zinc substrates
P16 – Kata Szayly: Toughness-enhanced mucosa-mimetic hydrogels
P17 – Katharina Wulz: Viscosity and dynamic surface tension measurement: a guideline for approriate measurement
P18 – Kinga Kovács: Titania and silica thin-film systems exhibiting selective light transmission and water repellency
P19 – Lilla Garas: Specific ion effects and underscreening in HPAM solutions for enhanced oil recovery
P20 – Mykhailo Filep: Photocatalytic degradation of organic dyes over $LaFe_{0.95}Cu_{0.05}O_3$ perovskite
P21 – Mykhailo Filep: Preparation and characterization of $Ag_{7+x}(P_{1-x}Si_x)S_6$ nanopowders
P22 – Petra Csicsor-Kulcsár: Investigation of the complexation properties of humic acid
P23 – Petra Demény: Eco-friendly encapsulated photocatalytic nanoparticles: synthesis and characterization
P24 – Qais Al-Madanat: Microplastic removal from power plant make-up water by single- and two-stage microfiltration with a future perspective on forward osmosis membranes
P25 – Sándor Puskás: Development, selection and application of surfactant-polymer solutions for enhanced oil recovery (EOR)
P26 – Şeyma Miray Simav: Colloid and enzyme-mimicking properties of ceria nanoparticles
P27 – Zoltán Csoma: Investigation of cobalt(II) ion adsorption on multi-walled carbon nanotubes
P28 – Zsófia Ly Nguyen: Design and study of macroporous polyaspartamide cryogels
P29 – Zsuzsanna D. Kónya: Surface modification of clay-based nanozymes to improve enzyme mimicry and colloidal stability

ORAL PRESENTATIONS

STRUCTURAL FLEXIBILITY IN POROUS MATERIALS UPON AN EXTERNAL STIMULUS

J. Silvestre-Albero[a]; C. Carrillo-Carrión[b]; A. Missyul[c]; J. Farrando-Perez[a]

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Removal of chemical contaminants (POP, CEC, PFOAs, etc.) in wastewater and air streams requires the design of novel adsorbents able to selectively retain/concentrate these pollutants with a high adsorption capacity. Activated carbons, zeolites, silicas, and metal-organic frameworks (MOFs) are among the most frequently used adsorbents to this end. Application of MOF materials offer significant advantages, e.g., porous structure and surface chemistry can be tailored to match specific applications, rendering them as highly versatile tools for adsorption processes. Zeolitic imidazolate frameworks (ZIFs), a sub-class of MOFs, are characterized by a high specific surface area, a hydrophobic porous structure, a high chemical and thermal stability and, more importantly, a unique structural flexibility.[1] These structural changes/transformations upon an external stimulus (e.g., gas adsorption, heat treatment, high-pressure), include gate-opening phenomena, phase-to-phase transitions, breathing effects, and so on.[2,3] Interestingly, the nature of these phenomena highly depends on the nature of the imidazolate linker, including the presence of functional groups, i.e., depends on the competition between strong non-bonding interactions, which favor the formation of highly dense structures, and bonding interactions, which favor the formation of a high symmetry, low-density crystal structures. Furthermore, these intracrystalline interactions can be altered/modified, depending on the nature of the adsorbate molecules, thus opening the gate to unexplored adsorption phenomena in gas and liquid-phase processes. In this communication we will summarize some examples of structural changes in ZIFs, their sensitivity to the nature of the probe, and how the knowledge of the associated mechanism can be used to design porous materials able to outperform in a wide variety of applications from gas storage/separation, to mechanical energy storage and liquid-phase selective separation processes.[4,5] Special attention will be given to liquid-phase adsorption processes to emphasize the crucial role of the solvent, and how the associated solvent-adsorbate and solvent-framework interactions define the presence of structural changes in ZIFs. (e.g., breathing phenomena).[6]

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1. Lively, R.P.; Dose, M.E.; Thompson, J.A.; McCool, B.A.; Chance, R.R., Koros, W.J. *Chem. Commun.*, **2011**, *47*, 8667.
2. Casco, M.E.; Cheng, Y.Q.; Daemen, L.L.; Fairen-Jimenez, D.; Ramos-Fernandez, E.V.; Ramirez-Cuesta, A.J.; Silvestre-Albero, J. *Chem. Commun.*, **2016**, *52*, 3639.
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DYE–SMECTITE COLLOIDS: FROM FUNDAMENTALS TO PHOTOACTIVE MATERIALS

Juraj Bujdák[a,b]; Tímea Baranyaiová Šimonová[b]; Viktória Planetová[b]; Peter Boháč[b]

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Smectites are layered silicates that spontaneously form stable aqueous colloidal systems composed of dispersed, plate-like nanoparticles with a thickness of approximately 1 nm. Through ion exchange with organic cations, a wide range of organoclays can be prepared, whose properties and functionalities depend both on the nature of the components and on the colloidal characteristics of the system. This lecture focuses on organic dye–smectite systems, beginning with an overview of the main research directions pursued in our work.

The molecular aggregation of dyes in silicate colloids has attracted considerable attention. Although the interpretation of the associated spectral changes, known as metachromasy, is well established, the underlying mechanisms remain insufficiently understood. While aggregation in homogeneous solutions typically occurs very rapidly, in colloidal systems it is several orders of magnitude slower.

A detailed kinetic analysis of dye aggregation has provided important insights into the general mechanisms governing the adsorption of organic cations on silicate colloidal particles. In particular, it has enabled the identification of diffusion processes occurring after the initial adsorption step. One such mechanism involves lateral diffusion along the particle surface. In addition, the kinetics of dye molecule diffusion between particles, previously not experimentally investigated, has been probed using Förster resonance energy transfer (FRET). This method sensitively reflects the statistical distribution of intermolecular distances among adsorbed species. The approach thus represents a novel and broadly applicable tool for monitoring diffusion processes in a wide range of colloidal systems.

In the second part of the lecture, selected examples of dye–silicate colloidal systems with potential applications will be presented. One notable phenomenon is the so-called *light-up effect*, or *adsorption-induced luminescence*. Upon adsorption, dye molecules often exhibit significantly enhanced photoactivity, increased chemical stability, and improved photophysical properties. Representative examples will illustrate which types of luminophores and conditions favor this effect. Finally, the use of dye–silicate colloidal systems as precursors for the modification of industrial polymers will be discussed, enabling the development of antimicrobial surfaces with photosensitizing activity.

Acknowledgement: This work was supported by the Slovak Research and Development Agency under the contract no. APVV-22-0150. The support provided by grants VEGA 1/0240/23 and VEGA 1/0484/24 is also acknowledged.

MULTIFUNCTIONAL DENDRIMER NANOGELS: A VERSATILE PLATFORM FOR NEXT-GENERATION CANCER THERAPY AND IMMUNOTHERAPY

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This report highlights recent advancements in the design and application of dendrimer-based nanogels (DNGs) as multifunctional platforms for cancer therapy and immunotherapy. Through a series of innovative studies, our team has developed stimuli-responsive DNGs capable of co-delivering therapeutic agents, nucleic acids, and immunomodulators with high precision and efficiency. Key developments include: (1) low-generation dendrimer nanogels for safe and efficient DNA delivery and gene therapy;[1] (2) pH/ROS-responsive DNGs for co-delivery of chemotherapeutic drugs and cytokines to overcome the blood-brain barrier in glioma treatment;[2] and (3) mannose-functionalized DNGs for dual-action mRNA vaccine delivery and glycolysis inhibition in melanoma treatment;[3] and (4) exosome-camouflaged dendrimer nanogels as a therapeutic vaccine against pancreatic cancer through reprogramming of multiple cell types.[4] These DNG platforms exhibit excellent biocompatibility, targeted delivery, controlled release, and potent antitumor immune activation. Collectively, our work demonstrates the versatility and translational potential of smart dendrimer nanogels in integrating multiple treatment modalities—including chemotherapy, gene therapy, immunotherapy, and metabolic intervention—for enhanced and personalized cancer therapy.

Acknowledgement: This work was financially supported by the National Key R&D Program (2022YFE0196900 & 2024YFE0108100), the National Natural Science Foundation of China (U23A2096 & 52350710203) and the Science and Technology Commission of Shanghai Municipality (24490711000, 23520712500, 23WZ2503300, 21490711500, and 20DZ2254900).

References:

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PROTEIN BASED BIOPOLYMER AEROGELS AS pH-RESPONSIVE DRUG DELIVERY SYSTEMS

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Biopolymer-based aerogels are increasingly recognized as promising platforms for advanced drug delivery systems due to their unique combination of physicochemical and functional properties. Their distinctive architecture – characterized by high porosity, large mesopore volume, and large specific surface areas – facilitates high drug loading and controlled. A particularly valuable feature is their tunable responsiveness to environmental stimuli, such as temperature, pH, and moisture, enabling the design of stimuli-responsive delivery systems. This adaptability is especially advantageous in local drug delivery applications, where site-specific and controlled therapeutic release can enhance therapeutic efficacy.

Biopolymer aerogels can be efficiently loaded with active pharmaceutical ingredients (APIs) via adsorptive precipitation using supercritical CO_2. This approach enables high drug loading while preserving the amorphous state of the APIs within the porous matrix. Furthermore, it ensures homogeneous drug distribution on internal pore surfaces and the precise control afforded by pressure-induced precipitation.

Gelatin, a collagen-derived protein composed of flexible polypeptide chains, forms stable three-dimensional networks through hydrogen bonding and hydrophobic interactions. Its excellent biocompatibility and low immunogenicity make it a widely used material in biomedical applications.

Gelatin-based aerogels, were prepared through supercritical drying in CO_2, loaded with model drugs, and characterized using a comprehensive set of instrumental techniques including liquid phase nuclear magnetic resonance (NMR) relaxometry and solid-state NMR spectroscopy. The pH-dependent drug release features of these systems were correlated with the hydration and swelling properties of the different aerogel formulations.[1]

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INVESTIGATION OF THE pH DEPENDENT SWELLING OF ELECTROSPUN HYDROGEL FIBER MATS

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This presentation will discuss the morphology of poly(aspartic acid) hydrogel fiber mats (PASPDAB) made by electrospinning and their pH induced swelling behavior. Due to the fact that these soft, fibrous hydrogel mats resemble the native tissue, there is an increasing interest in their research. However, the swelling properties of these hydrogel membranes is not yet fully understood. Therefore, we synthesized PASPDAB which show pH dependent swelling behavior and investigated its properties.

Fiber mats were synthesized from premade polysuccinimide using a custom-made electrospinning setup with a rotating drum collector. Rotating speed and solution concentration was varied in order to obtain fiber mats with varied fiber orientation and thickness. Fiber morphology was investigated by SEM and fibers typically had diameters in the range of 300-1600 nm depending on synthesis parameters. Crosslinking was carried out by submerging the samples for 1 h into 1,4-diaminobuthane ethanol solution. Then, samples were hydrolyzed in pH 8 buffer to form PASPDAB fiber mats. SEM showed that the fibers in the fibrous samples slightly fused together during the crosslinking process, thus the mat transformed into an interconnected web. However, confocal microscopy showed that in a wet form the fibers did not fuse together. Samples were placed into pH 3 then pH 8 in repetitions to see the volume change, its kinetics and repetitiveness. The samples swelled in pH 8 and shrunk to about half of their size in pH 3. However, they did not show significant size change by submerging them in a broad concentration range of NaCl solutions. Based on the kinetic observations, the total size change occurred in approximately 360 min and the change followed a sigmoidal curve in logarithmic representation, indicating that the size change in logarithmic representation was linear between min 1 and 360.

These soft fibrous membranes are flexible and suturable alternatives for bulk gel implants which are many times brittle and fragile. It is our expectation that fibrous gels show much faster swelling response than their bulk counterparts.

MULTIFUNCTIONAL SELF-HEALING AND INJECTABLE DYNAMIC NANOCOMPOSITE HYDROGELS

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Biomacromolecules based injectable and self-healing hydrogels possessing high mechanical properties have widespread potential in biomedical field. However, dynamic features are usually inversely proportional to toughness. It is challenging to simultaneously endow these properties to the dynamic hydrogels. Here, we fabricated an injectable nanocomposite hydrogel stimultaneously possessing excellent autonomous self-healing performance and high mechanical strength by doping chitosan nanoparticles into dynamic polymer networks of oxidized sodium alginate and gelatin in the presence of borax. The synergistic effect of the multiple reversible interactions combining dynamic covalent bonds (i.e., imine bond and borate ester bond) and noncovalent interactions (i.e., electrostatic interaction and hydrogen bond) provide effective energy dissipation to endure high fatigue resistance and cyclic loading. The dynamic hydrogel exhibited excellent mechanical properties like maximum 2.43 MPa compressive strength, 493.91 % fracture strain, and 89.54 kJ/m3 toughness. Moreover, the integrated hydrogel after injection and self-healing could withstand 50 successive compressive cycles. Besides, the bovine serum albumin embedded in CS-NPs could be sustainably released from the nanocomposite hydrogel for 12 days. This study proposes a novel strategy to synthesize an injectable and self-healing hydrogel combined with excellent mechanical properties for designing high-strength natural carriers with sustained protein delivery.

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COMPOSITE MESHES FOR BIOMEDICAL APPLICATIONS

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Our work centers on creating polymer-based nanocomposite wound dressings that actively promote healing, rather than simply acting as protective layers. We produced polysuccinimide-based nanofibrous scaffolds via electrospinning, achieving fiber diameters below 500 nm, and incorporated metal-based nanoparticles along with, in some cases, therapeutic agents.

We successfully synthesized and embedded metal oxide particles into the fibrous structures, enhancing both antibacterial performance and mechanical strength. Nanoparticles prepared in the presence of drug exhibited excellent uniformity, improved mechanical properties, and strong antibacterial activity against both Gram-positive and Gram-negative bacteria. The amount of drug proved crucial: moderate levels increased antibacterial effectiveness, whereas higher concentrations reduced silver ion release.

Metal oxide nanoparticles and metal salts affected fiber structure and mechanical behavior, with salt acting as a plasticizer that increased flexibility—an advantage for wound healing. Notably, combining particles with salts produced a synergistic antibacterial effect, especially against Gram-positive bacteria. Selenium oxide nanoparticles showed high uniformity but limited long-term stability, and their antibacterial mechanism remains under study. Scaffolds containing iron oxide nanoparticles demonstrated strong MRI contrast and enhanced hyperthermic response in aqueous environments.

Overall, these findings highlight the potential to design nanofibrous wound dressings with adjustable mechanical and antibacterial properties, offering promising opportunities for advanced biomedical applications.

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PHOSPHORUS DENDRIMER-BASED PROTEIN DELIVERY SYSTEMS FOR OSTEOARTHRITIS THERAPY

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Therapeutic proteins hold immense therapeutic potential yet face challenges including poor membrane permeability, susceptibility to enzymatic degradation, and limited intracellular bioavailability. To overcome these barriers, we employ phosphorus dendrimers-nanocarriers distinguished by their structural rigidity, monodisperse nature, and easily functionalized surfaces, which facilitate efficient protein complexation while possessing inherent immunomodulatory activity. Our research has developed innovative dendrimer-based platforms for intracellular protein delivery, with a focus on osteoarthritis (OA) therapy.

We first developed a co-delivery system based on hydroxyl-terminated phosphorus dendrimers (G2-OH_{24}) that simultaneously delivers catalase (CAT) and quercetin (Que) [1]. The G2-OH_{24}/CAT@Que nanocomplexes (138.8 nm) retain >88% CAT activity, alleviate intracellular hypoxia via H_2O_2 decomposition, restore mitochondrial function, and scavenge ROS, thereby reprogramming macrophages toward the anti-inflammatory M2 phenotype. This nanosystem inhibits chondrocyte apoptosis, promotes osteogenic differentiation of BMSCs, and in an OA mouse model alleviates cartilage degradation, bone erosion, and synovitis, outperforming simple component mixtures and showing comparable or better efficacy than first-line clinical drugs. In parallel, we introduced structural asymmetry into phosphorus dendrimers (G0.PD-ABP) to enhance protein binding capacity. This asymmetric carrier efficiently delivers bromelain (G0.PD-ABP/Bro), achieving synergistic anti-inflammatory and anti-apoptotic effects in chondrocytes via enhanced intracellular protein delivery and macrophage M2 polarization[2].

Collectively, this work validates phosphorus dendrimers as versatile, biocompatible nanocarriers for targeted protein delivery, offering potent combination immunotherapies for OA and other inflammatory diseases.

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NOVEL ANTIOXIDANT NANOZYMES COCKTAILS TO COMBAT OXIDATIVE STRESS IN IBD

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Inflammatory bowel disease (IBD), including Crohn's disease and ulcerative colitis, is characterized by chronic inflammation and increased oxidative stress.[1] Excess reactive oxygen species (ROS) contribute to epithelial damage, inflammation progression, and increased risk of colorectal cancer. Current therapies such as biologics are often expensive and not always effective, highlighting the need for alternative strategies. In this study, we propose antioxidant nanozymes as a novel therapeutic approach to scavenge ROS.

Specifically, Prussian blue (PB) nanoparticles were evaluated for their superoxide dismutase (SOD)-like activity and cellular behavior. Nanozymes are nanoparticles that mimic enzyme functions, enabling catalytic ROS removal. The antioxidant activity of PB was quantitatively assessed using a SOD assay based on the xanthine oxidase (XO) system. In this assay, superoxide (O_2^-) generated by XO reacts with WST-1 to produce a colored formazan dye, and antioxidant activity is evaluated by the suppression of this reaction (measured at 440 nm).

The results demonstrated that PB exhibited concentration-dependent inhibition, confirming its SOD-like activity and ROS scavenging capability. To investigate cellular interactions, hyperspectral microscopy was employed using MDCK cells. PB was detected either inside the cells or on the cell membrane after 0 and 30 minutes of incubation. However, signal intensity decreased over time, suggesting potential instability of PB under cell culture conditions. Consistently, time-dependent reduction in SOD-like activity was also observed.[2]

To address this limitation, we explored the interaction between PB and positively charged peptides (TAT, a cell-penetrating peptide). Dynamic light scattering (DLS) and zeta potential measurements revealed that PB, initially negatively charged and well-dispersed, formed aggregates upon peptide addition due to electrostatic interactions. At higher peptide concentrations, re-dispersion occurred as surface charge shifted to positive, indicating successful PB–peptide complex formation. These findings suggest that PB possesses intrinsic antioxidant nanozyme activity but exhibits reduced stability in biological environments. Peptide modification may enhance cellular uptake and stability, providing a potential strategy to improve therapeutic efficacy.

Future work will focus on clarifying the intracellular localization of PB, optimizing conditions to prevent degradation, and evaluating the effectiveness of PB–peptide systems in targeting intracellular ROS in IBD models.

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INTRODUCTION OF NANOMEDICINE THERAPEUTICS JOURNAL

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Nanomedicine Therapeutics is dedicated to publishing high-quality research articles and reviews at the forefront of therapeutic nanomedicine. The journal aims to provide a global platform for innovative studies that bridge nanoscale material design with clinical therapeutic applications, promoting the translation of nanomedical discoveries from laboratory research into clinical practice.

Nanomedicine Therapeutics focuses on interdisciplinary research that integrates chemistry, materials science, biology, engineering, and medicine to develop advanced nanosystems for disease diagnosis and treatment.

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FUNCTIONAL COMPOSITES AND ADVANCED SENSOR TECHNOLOGIES: HONORING THE LEGACY OF PROF. IMRE DÉKÁNY

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This presentation honors the remarkable scientific legacy of Prof. Imre Dékány, whose pioneering work in materials science and nanotechnology has inspired advancements in functional composites and sensor systems. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) uses these innovations to address global challenges such as sustainability, individualization, and health. Key topics include the development of antibacterial and antiviral composites, 3D-printed electronics, and photocatalytic materials, which are tailored for applications ranging from environmental protection to predictive maintenance in industrial systems.
A special focus is placed on the collaboration between Fraunhofer IFAM and the University of Szeged, which began in 2004 under Prof. Dékány's leadership. This partnership has led to breakthroughs in graphene-based materials, aerosol jet printing, and advanced sensor technologies for detecting toxic chemicals. The presentation highlights the synthesis of reduced graphene oxide, the formulation of antiviral polyurethane coatings, and the development of ligand-based sensor arrays for chemical detection. These innovations illustrate the synergy between applied research and academic excellence, accelerating knowledge transfer and fostering industrial innovation. Prof. Dékány's contributions continue to inspire interdisciplinary collaboration, drive progress in functional materials and sensor systems that address important societal needs.

FROM CLASSICAL COLLOID CHEMISTRY TO MODERN BATTERY SCIENCE: AQUEOUS HETEROCOAGULATION FOR THE ASSEMBLY OF ELECTROCHEMICALLY ACTIVE LITHIUM–SULFUR CATHODES

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Although battery research is commonly associated with electrochemistry and materials science, many fundamental challenges in electrode fabrication originate from colloid and interface science. This contribution demonstrates how classical concepts of colloid chemistry can be successfully translated into the design of advanced electrode materials for post lithium-ion batteries.

An entirely aqueous processing route was developed for the fabrication of sulfur–graphene oxide nanocomposite cathodes for lithium–sulfur batteries. Hydrophilic, negatively charged sulfur particles were synthesized and subsequently modified with a polycationic additive to obtain positively charged particles, while graphene oxide nanosheets provided negatively charged building blocks. By controlling the surface charge and colloidal stability of the individual dispersions, spontaneous heterocoagulation was induced, resulting in the self-assembly of homogeneous sulfur–graphene oxide composite particles. The assembly process was governed by electrostatic interactions, demonstrating that classical heterocoagulation can serve as an efficient materials engineering strategy for constructing electrochemically active electrode architectures.

Following the reduction of graphene oxide, the obtained nanocomposite was evaluated as a lithium–sulfur battery cathode, exhibiting stable electrochemical performance and confirming the applicability of the colloid-based assembly approach.

Beyond the specific lithium–sulfur system, the presented work highlights that aqueous colloidal processing and heterocoagulation provide versatile, scalable, and environmentally benign routes for manufacturing functional battery materials. The study illustrates how the principles of classical colloid chemistry continue to offer valuable solutions to contemporary challenges in battery science and post lithium-ion energy storage.

NANOLIGNINS AS PICKERING EMULSIFIERS IN ENHANCED OIL RECOVERY: FRESH TRICKS BY AN OLD WORKHORSE

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Dedicated to Professor Imre Dékány on the occasion of his 80th birthday

The first recorded scientific study of solid-particle-stabilized emulsions, following Walter Ramsden's original discovery, was documented by Pickering in 1907, in what are now called Pickering emulsions. Applications of Pickering emulsions are driven by their strong stability, biocompatibility, and tunability, which enable them to replace molecular surfactants. Modern use of Pickering emulsifiers spans biomedicine, pharmaceuticals, food technology, cosmetics, advanced materials, and environmental & green technologies.

In this presentation, we first briefly recap our procedures for obtaining lignin nanoparticles (LNP) from wood flour and other lignin sources. We then discuss characterization of the LNPs by NMR, electron microscopy, light scattering, AFM, and surface tension methods. We show differences in the (surface) chemical structures of LNPs derived from different lignin sources, as determined by NMR. We then demonstrate how oil-water emulsions can be stabilized by LNPs using kerosene as the highly lipophilic phase.

Emulsification is a crucial process in chemical flooding operations at offshore platforms, designed to mobilize residual oil in the wells. It allows for the recovery of otherwise wasted large amounts of oil [1]. Thus, the technological focus of this work centers on Enhanced Oil Recovery (EOR) using the Pickering approach. To bring the focus closer to field studies, light sweet naphthenic Azeri crude oil (NACO) and heavy aromatic-naphthenic Azeri crude oil (ANCO) are also employed, along with kerosene.

A series of emulsification experiments and thermodynamic transient phase maps are discussed using the three different oil phases (kerosene, NACO, ANCO). Differences in the emulsification phase maps are explained by variations in the surface chemical structure of the LNP particles from different resources [2]. We show in the kerosene studies that emulsions can be demulsified at high pH, thereby recovering pure oil in an environmentally "green" process and enabling the reuse of the LNPs [1]. Finally, we demonstrate the synergistic effects of molecular surfactant-lignin nanoparticle system combinations in improving emulsification.

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RESERVOIR AND FORMATION STIMULATION BY NANOEMULSION TREATMENT OF THE BOTTOM HOLE ZONE OF OIL AND GAS WELLS FOR IMPROVED OIL RECOVERY

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Recommended to Professor Imre Dekany on the occasion of his 80th birthday

Nanoemulsions are emulsions in which the droplet size of the internal phase is smaller than 500 nm. Compared to macro and micro emulsions, nanoemulsions have improved properties due to their extremely small droplet size, because they are not subject of gravity driven separation owing to the density differences of the two phases.
Nanoemulsions are thermodynamically unstable systems, in contrast to microemulsions, because some nanoemulsions need significant energy to be formed. They are transparent or translucent systems with the small size of droplets and good optical clarity, which leads to an extremely high kinetic stability. Nanoemulsions are basically composed of oil, surfactants, and aqueous phase, and are manufactured using low surfactant levels with applications of external energy (high-pressure homogenization, microfluidization, high shear dispersing) to generate nanodroplets.
Nanoemulsions are capable for phase inversion (from water-in-oil to oil-in-water emulsion and vice versa) which can be generated changing in temperature at a constant composition (phase inversion temperature, PIT method)[1] or changing in the volumetric fraction of one of the phases at a constant temperature (emulsion inversion point, EIP method).
The kinetic stability and the nanoscale particle size of the dispersed phase allows a targeted delivery and delayed effect of the active agent in porous media (e.g. reservoir rock), which makes the nanoemulsions a potential novel reservoir/formation stimulation fluid.
One of their potential application in the oil industry is the vehicle for chemical additive delivery. Nanoemulsions containing oilfield chemicals usable for well treatments (scale inhibition, acidizing, etc.)[2]
Researchers of MOL Hungarian Oil and Gas Campany and the partner University of Szeged have investigated the potential oil field application of nanoemulsions and developed a novel formation stimulation fluid to increase the productivity of oil wells by targeted stimulating agent delivery to the oil saturated zones of the reservoir. The applicability and efficiency of the developed nanoemulsion as a formation stimulation fluid was tested and proved in one of MOL's calcareous marl oil reservoirs in Hungary.[3]

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FROM GOLD NANOPARTICLES TO ADSORPTION OF ARSENIC: DECADES OF COLLABORATION IN COLLOID CHEMISTRY

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Since the 1990s, the collaboration between Croatian and Hungarian colloid chemists, largely initiated through the efforts of Prof. Imre Dékány and Prof. Nikola Kallay, has steadily grown and strengthened over the years. The presentation will provide an overview of various activities, beginning with studies on the surface and structural properties of gold nanoparticles and their biofunctionalized derivatives in aqueous electrolytes solution[1]. It will also cover the studies focused on the adsorption of ibuprofen and dopamine adsorption on functionalized gold using surface plasmon resonance spectroscopy at solid-liquid interface[2], as well as the adsorption of arsenic on MgAl layered double hydroxide[3]. Groundwater in eastern Croatia and southeastern Hungary contains relatively high levels of arsenic, which can lead to chronic arsenic toxicity in humans. Therefore, the aim to engineer an effective composite sorbent that can be applied for arsenic water remediation is very important. The results obtained in the frame of the NATO collaborative linkage grant *Advanced Techniques for Arsenic Removal from Water* related to the abovementioned problem will be presented. As sorbing system, layered double hydroxide (LDH) was used. It was shown that the adsorption process could be interpreted in terms of Kroeker adsorption isotherm regardless to the presence of other ions in the groundwater. Additionally, the influence of phosphate concentration on adsorption of commercially obtained arsenic samples was examined and it was shown that there is no significant influence of phosphate on arsenic adsorption.

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EFFECT OF SIZE REDUCTION ON THE OPTICAL PROPERTIES OF NOBLE METAL NANOSTRUCTURES

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The growing importance of nanostructured materials with diverse compositional variations is evident across a wide spectrum of scientific fields, including but not limited to physics, chemistry, medicine, food processing, electronics, energy sectors, optoelectronics, and sensing. Within the large group of transition metal nanoparticles (MeNPs), the noble metal NPs (like Au, Ag, and Cu) are extremely investigated nano-objects due to their electric, magnetic, and unique size-, morphology-, and composition-dependent optical features. Their surface is easily functionalized with various biomolecules, creating functional "hybrid" nanostructures having tunable optical and structural properties. In Hungary, Prof. Imre Dékány was among the first to intensively deal with the size-controlled synthesis, structure characterization, and study of structure-dependent optical properties of gold (AuNPs) and silver (AgNPs) colloids[1,2]. Among the classical Me NPs having a size in the range of 1–100 nm, the sub-nanometer-sized dots (d < 2 nm for noble metals called nanoclusters (NCs)) are receiving a lot of attention internationally because by reducing the size, new optical, structural, and thus functional properties become available. The ultra-small gold nanoclusters (Au NCs) consisting of only a few gold atoms (or fewer than 100 atoms) show unique physical and chemical properties such as well-defined molecular structure, discrete electronic transitions, and characteristic photoluminescence (PL)[3]. In comparison to conventional quantum dots (QDs) (d < 10 nm) and larger plasmonic MeNPs, atomically precise metal NCs offer unprecedented tunability in terms of emission wavelength, quantum yield, photostability, and biocompatibility facilitated by the modulation of cluster size, composition (mono- or bimetallic), and quality of the ligand shell. Thanks to their mentioned extremely advantageous properties, it's not surprising that numerous research groups around the world – in Hungary, our research group is almost unique in this area – are working on the research of metal-based NPs or molecular metal nanostructures. Our research group has been working for many years on the design of new production processes for blue-, green-, yellow-, and red-emitting noble metal NCs[4]. We were among the first to demonstrate the applicability of small molecules (amino acids, vitamins, nucleotides, *etc*.) for the synthesis of Au and Ag NCs[5]. In the presentation we would like to summarize the main differences between noble metal colloids and nanoclusters, especially their differences in structure-dependent optical features.

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MASTERING THE FLAT PLANE: A BRIEF OVERVIEW OF NEARLY 50 YEARS OF RESEARCH ON LAYER-STRUCTURED MATERIALS IN SZEGED

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This presentation aims to commemorate the 80th birthday of Prof. Imre Dékány, who has been the head of the Department of Colloid Chemistry at the University of Szeged (former Attila József University), by providing a brief overview of the research, mostly led by him, on layer structured materials. This aim is hard (if not impossible) to achieve well: there were so many directions of science within the decades from the 1970-80's that an overarching insight into their details cannot be provided. Instead, I will focus on a few, peculiar areas that might be intersting for today's scientists as well. Note will be taken on the characterization of the wetting and liquid adsorption properties of clay mineral surfaces (characterized by binary liquid sorption excess isotherms, see Figure 1), a research which marked the era of the 1970's[1]. On the other hand, interesting results on "matering the plane" were published in later times, regarding sheet architecting of mono- and multilayered assemblies of colloidal platelets as well, pointing towards functional ultrathin films[2].

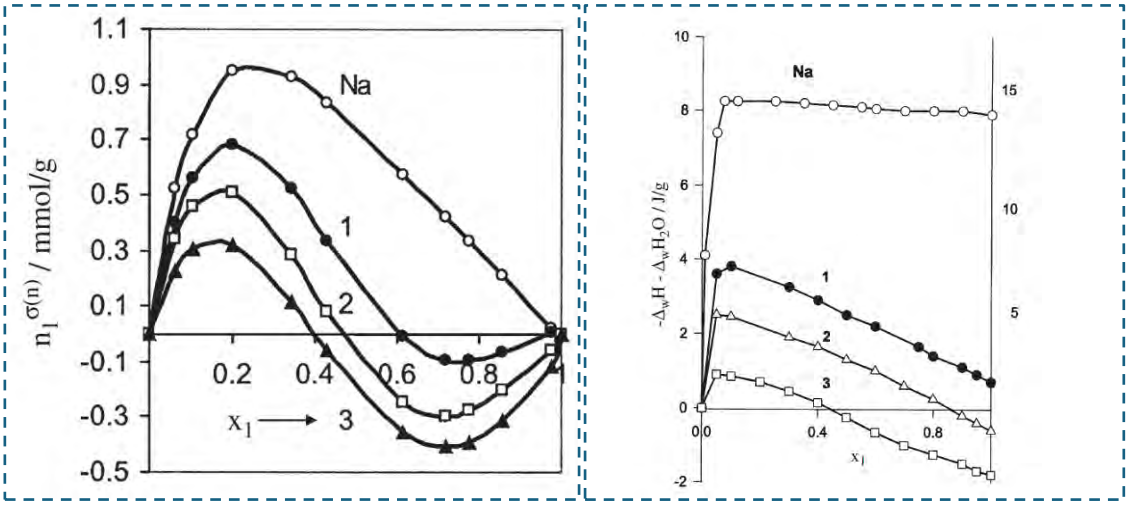

Figure 1. Left: Adsorption excess isotherms for Na+ illite (Na) and hexadecylpyridinium illites (1,2,3: increasing amounts of hexadecylpyridinium ions) in methanol(1)-benzene(2). Right: the corresponding immersional wetting enthalpy isotherms.

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RELEVANCE OF SURFACE CHEMISTRY IN PERFORMANCE OF NANOSTRUCTURED CARBON MATERIALS

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In spite of their hydrophobic character porous carbons have been considered as general adsorbents due to their sophisticated microporous character. Although the existence and relevance of polar/nonpolar sites on porous carbon surfaces were observed already in the 1960s , it was in the late 80s when the importance of carbon surface chemistry was first analyzed in depth, as neither the surface area nor the pore structure were sufficient to explain many of the behaviours of carbon-supported catalysts.

Chemical treatment, as well as impregnation or doping techniques, are often used to deliberately enhance the performance of carbon materials. Here we focus on carbons modified with O and N heteroatoms. Besides the delocalized electrons the surface chemical groups including these heteroatoms were found also responsible for the acid/base behaviour of the carbons in aqueous solutions.

This information also efficiently widens the potential of amorphous and crystalline carbon nanoparticles and their composites, in various applications, e.g., as catalysts, (electro)catalytic devices, drug release vehicles, sensors, etc. For this communication, various forms of carbon materials with well-characterized O and N content were selected as examples to illustrate the relevance of surface chemistry in their performance.

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FACTORS AFFECTING BACTERIAL ADHESION TO SURFACES

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Surface can promote or inhibit bacterial adhesion. The promotion and inhibition ability can be modified by surface coatings which can also include nanoparticles with different properties. In addition, surfaces can have photocatalytic and self-cleaning properties. This type of surfaces have a strong impact in different technologies.

Before evaluating adhesion properties, surfaces must be characterized. This characterization is performed by measuring surface roughness, contact angle, and streaming potential. Bacterial adhesion is then assessed using scanning electron microscopy and crystal violet staining methods. Fluorescence microscopy is used to detect live and dead bacteria on the coated surface.

Recent results show that the bacterial adhesion is influenced by all above mentioned factors. Nano and micro-particles embedded into coatings substantially impact bacterial colonization of surfaces. The developed composite layer with controllable bacterial adhesion and obvious photo reactive properties is potentially useful in the area of different technological applications[1,2].

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BIOPOLYMER-BASED NANOSYSTEMS FOR ENHANCED DRUG DELIVERY

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The development of targeted and controlled drug delivery systems is one of the most dynamically evolving fields of modern bionanomedicine[1]. These systems enable enhanced therapeutic efficacy while minimizing systemic side effects. In this work, we present biopolymer-based carrier systems capable of regulating the release of encapsulated drugs in response to specific environmental stimuli, such as pH changes, enzymatic activity, external magnetic fields, or light.

Our research involved the preparation of self-assembled colloidal prodrug nanoparticles and injectable hydrogels based on chemically modified polyvinyl alcohol (PVA-SA) and chitosan (Chit-g-Pal). We demonstrated that these self-assembling systems are excellent carriers for anticancer (Mitomycin-C) and anti-inflammatory (Tilorone) drugs, where release kinetics can be precisely controlled[2]. The functionality of these systems was further enhanced by incorporating superparamagnetic iron oxide nanoparticles (SPION) for magnetic targeting, and MoS_2 nanosheets for near-infrared (NIR) light-responsive drug release[3].

Studies on biocompatible polyesters (PES, PET) revealed the critical roles of molecular weight and particle size in mucoadhesive properties and bioavailability enhancement[4]. Our results highlight that tissue acidosis-responsive hydrophobically modified chitosan nanocarriers provide an effective solution for the targeted treatment of ischemic tissues[5].

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SURFACTANT AND NANOPARTICLE SYSTEMS FOR ENHANCED FOAM STABILITY

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The research aims to address significant challenges in foam stabilization for various industrial applications by developing innovative composite foaming materials that utilize surfactants and nanoparticles. This study enhances foam stabilization through synergistic interactions between its components, especially under diverse application conditions.

Research methodologies involved characterizing the surface-active properties (surface tension, dilational elasticity, and viscosity) of pure anionic surfactant sodium dodecyl sulphate (SDS), silica nanoparticles (SiO_2), and their composites at the air/water interface. We determined the concentration range of SDS at which the surface-active properties of the composites are enhanced. Based on pH and salt presence, we further investigated the features and properties of SDS, SiO_2 nanoparticles, and their composites. Size distribution and zeta potential were measured, revealing that with increasing surfactant concentration, the sizes of composites decreased. This correlates well with the behavior observed in surface tension studies and dilational rheology.

The study of the dynamic surface tension for SDS and their mixtures with SiO_2 nanoparticles (0.1%) shows a reduction in dynamic surface tension compared to pure surfactant, suggesting that adding nanoparticles enhances foam stabilization efficiency. At 25 °C, the equilibrium surface tension of water decreased from 71,7 mN/m to 38 mN/m for SDS near the CMC, while the addition of 0.1 wt% SiO_2 further reduced the equilibrium value to approximately 33 mN/m. The addition of SiO_2 nanoparticles (0.1 wt%) to SDS also positively affected the interfacial rheological properties. Near the critical micelle concentration (CMC) of SDS, the dilatational elasticity of the adsorption layer increased from approximately 25-30 mN/m for pure SDS to 45–60 mN/m in the presence of SiO_2, indicating the formation of a more rigid and mechanically strong interfacial layer.

Furthermore, foaming abilities and foam multiplicity of surfactant and nanoparticle mixtures were evaluated under varying conditions such as salinity and pH. It was found that foam stability increases in the presence of SiO_2, with a slight increase in foam multiplicity and foam number at pH 7 in the presence of NaCl.

These comprehensive insights provide valuable information for further research and for the development of new materials for various industrial and domestic applications.

COLLOIDAL INTERACTIONS IN NANOPLASTIC-PFAS SYSTEMS

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The increasing prevalence of nano- and microplastics in aquatic environments raises significant concerns regarding their role as vectors for other emerging environmental pollutants, such as per- and polyfluoroalkyl substances (PFASs) leading to joint harmful effects on ecosystems. In the present work, results from a comprehensive analysis of the interaction between polystyrene-based nanoplastics and various PFASs is presented. First, it was demonstrated that plastics with charged surface groups exhibit a substantial adsorption capacity for PFASs, significantly influenced by environmental parameters such as pH, concentration and ionic strength. Most of the PFASs showed remarkable affinity to oppositely charged particles leading to charge neutralization and overcharging of the plastic surface leading to unstable and stable particle dispersions, respectively[1]. The role of PFASs fluorocarbon chain length on the adsorption efficiency was examined and the findings indicate that longer fluorocarbon chains greatly enhance the affinity for the surfaces compared to shorter chains, attributed to increased hydrophobicity in the order of C4 < C6 < C8 [2]. The correlation between colloidal stability and toxicity of nanoplastic-PFAS dispersions was investigated and enhanced stability of plastic-adsorbed PFASs in aquatic samples increases the likelihood of bioaccumulation and subsequent synergistic toxicity in living organisms[3]. In conclusion, the present research findings reveal the interactions between nanoplastic particles and PFASs, detailing how adsorption mechanisms, chain length variability and colloidal stability contribute to the transport and toxicity of PFASs in waters.

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DEVELOPMENT AND OPTIMIZATION OF SA-HA HYDROGELS AND PCL-RF SCAFFOLDS FOR POTENTIAL APPLICATION IN WOUND HEALING

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The aim of this study was to develop and optimize a hydrogel wound dressing based on sodium alginate (SA) and hyaluronic acid (HA) and to evaluate its properties for potential application in wound regeneration. Hydrogels with different SA and HA compositions were developed, and the crosslinking conditions using $CaCl_2$ were optimized. The influence of the formulation and processing parameters on the properties of the hydrogels was evaluated based on their mechanical properties, stability, and cytotoxicity.

In parallel, poly(ε-caprolactone) (PCL)-based scaffolds containing riboflavin (RF) and doped with antibiotic were developed and optimized. Their surface morphology was characterized using scanning electron microscopy (SEM), and their biological properties were evaluated. The presence of RF provides the possibility of using blue light to induce the generation of reactive oxygen species (ROS), which may potentially contribute to antimicrobial activity, while the incorporation of an antibiotic may provide an additional antimicrobial effect.

The obtained results provide a basis for the future development of a bilayer wound dressing system combining the optimized SA-HA hydrogel with the PCL-RF scaffold. Such a system could potentially integrate the properties of the hydrogel supporting the wound healing environment with the structural functionality of the scaffold and complementary antimicrobial strategies based on antibiotic delivery and blue-light-activated ROS generation.

ENZYME-RESPONSIVE FLUORINATED NANOPROBE FOR OFF/ON ^{19}F MRI DETECTION OF MMP-9

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^{19}F Magnetic Resonance Imaging (^{19}F MRI) is a valuable non-invasive technique for monitoring biological processes and pathologies[1]. In ischemic stroke, gelatinase-type matrix metalloproteinases 2 and 9 (MMP-2/9) contribute to blood–brain barrier disruption[2], yet no specific probes exists to detect them. We propose a smart fluorinated nanoprobe for ^{19}F MRI, based on encapsulating highly fluorinated Au nanoparticles[3] (F-Au NPs) within gelatin carriers (OFF) and releasing them through MMP-2/9-mediated gelatin digestion (ON). Gelatin NPs (Gel-NPs) were synthesized by desolvation of gelatin chains and cross-linking with EDC/NHS. Following a similar approach, F-Au NPs[3] were conjugated to gelatin chains to form Gel-F-Au NPs. The systems were characterized by Dynamic Light Scattering (DLS), Small-Angle X-ray Scattering (SAXS), ^{19}F NMR, and T_1 and T_2 relaxation times were measured. Optimized Gel-NPs showed homogeneous sizes (d_h = 221.4±8.4 nm). F-Au NPs[3] displayed suitable relaxation times for MRI (T_1 = 1564 ms, T_2 = 1174 ms) and were efficiently encapsulated in gelatin. The resulting Gel-F-Au NPs (DLS: d_h = 159.7 ± 2.2 nm; SAXS: d = 133.5 ± 0.5 nm) exhibited complete quenching of the ^{19}F signal (OFF). Upon enzymatic digestion with commercial MMP-9, release of F-Au NPs restored the ^{19}F signal (ON), demonstrating the responsiveness of the system. In summary, we have developed an enzyme-responsive MRI fluorinated nanoprobe for ^{19}F MRI and validated its OFF/ON switching capability upon MMP-mediated gelatin degradation.

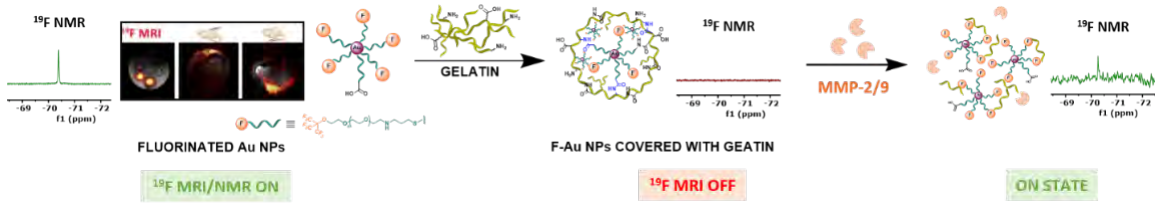

Figure 1. Graphical abstract illustrating the OFF/ON behavior of the ^{19}F MRI nanoprobe: **F-Au NPs** remain quenched when encapsulated in gelatin (OFF) and recover their ^{19}F signal upon MMP-9-mediated gelatin digestion (ON).

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MODIFIED LIFETIME OF BIOACTIVITY OF PHOTOTREXATE BY COLLOIDAL MOLECULAR ENVIRONMENT

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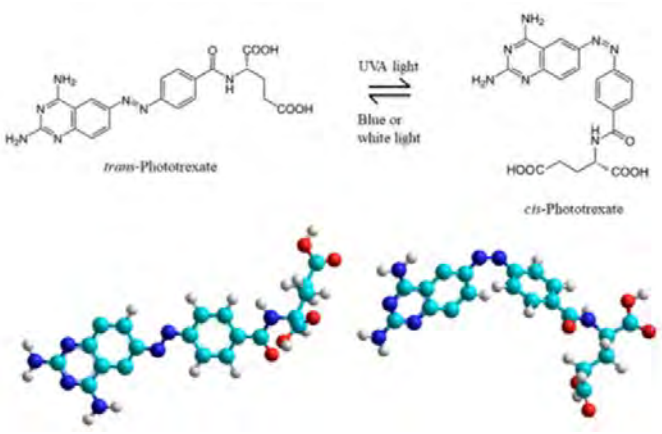
The anticancer drug phototrexate (PHX) is a photoswitchable derivative of the dihydrofolate reductase inhibitor methotrexate. It enables site-selective therapy by converting its thermodynamically stable, yet biologically inactive, *trans* conformer into the active *cis* form using 366 nm light exposure. However, the therapeutically active *cis* conformer is thermodynamically unstable and spontaneously reverts to the *trans* form. Therefore, the drug's therapeutic potential largely depends on the lifetime of this bioactive *cis* conformer.
This *cis* → *trans* conversion is known to be influenced by the molecular environment. Earlier study[1] highlighted that the presence of water clusters in protic aqueous environments and the altered permittivities or modified water cluster distribution when non-protic components are present. In that study, dimethyl sulfoxide (DMSO) was used to modify this environment.



Fluorolog tau3 spectrofluorimeter and Specord UV/vis photometer were applied to induce the formation of the *cis*-PHX and to determine the *trans*-PHX-HSA binding constants, respectively. To get information about the thermodynamics (ΔH, ΔS, enthalpy and entropy changes of trans-PHX-HSA complex formation) and kinetics (E_a activation energy of the *cis* → *trans* conversion) temperatures were varied in the 20 °C-40 °C range. Non-linear parameter fitting methods were applied for data-evaluation while the *cis* → *trans* conversion was followed by spectrophotometric measurements. 240 spectra during 20 hours are recorded per sample, these series recorded for five temperatures (20-40 ^{0}C) and either five different DMSO (0-20 %vol) concentrations or sodium-dodecylsulphate solutions below and above the CM concentrations in intracellular and extracellular ionic environment.
Conclusion: i) Weaker aqueous environment in micellar system enhances desorption of PHX from the HSA surface. ii) Micellar environment significantly modified the stability of the *cis*-PHX which property also affected by the intracellular or extracellular ionic composition.

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FORMATION OF GRAPHENE OXIDE MEMBRANES BY SELF-ASSEMBLY

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The interest in understanding graphene oxide membranes is increasing due to their potential in a large variety of applications, including filtration/desalination, (bio)sensing, electronics, energy storage, etc.. In light of their role in smart technologies, we propose the development of free-standing graphene oxide (GO) membranes through a scalable, non-toxic, and cost-effective self-assembly process.[1]
In the present work, a method is presented for obtaining versatile GO membranes by using the main precursors of Marcano-Tour's improved exfoliation method, additional work-up processes (e.g., sonication), different parameters (e.g., lower oxidation temperature and higher reaction time), and a more efficient post-synthesis separation pathway performed in a homogeneous medium.[2] This process gives rise to well-sorted GO fractions, one of which is used directly for the fabrication of free-standing GO membranes by means of a cost-effective self-assembly process. In order to elucidate the self-assembly mechanism that results in the formation of GO membranes, a comparative study was performed to examine the structural and morphological differences (e.g., sheet size, surface chemistry, and surface charge) between the sorted GO fractions. A structural model for the membrane formation during the self-assembly process was also proposed.[3] To understand the self-assembly mechanism that results in the formation of GO membranes, a comparative study was conducted to examine the structural and morphological differences (i.e., sheet size, surface charge and structural nature) among the GO fractions. Subsequent to the application of the coating, it can be peeled off, thereby yielding an unsupported membrane.
Given that these types of GO membranes are obtained in mild conditions and by using non-toxic components, it can be inferred that such materials can be successfully applied in specific areas,[4,5] such as the fabrication of biomedical platforms, environmentally friendly devices or even protective coatings for historical stone.

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DEVELOPMENT OF MAGNETIC ADSORBENTS FOR BROAD-SPECTRUM REMOVAL OF TRACE MICROPOLLUTANTS FROM REAL WATERS

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Organic micropollutants occur at trace concentrations and often as complex mixtures with varying polarity in the environment due to anthropogenic activities, posing risks to ecosystems and drinking water resources. The diversity in structure, and physicochemical properties poses a significant challenge for both quantification, and effective removal by conventional wastewater treatment technologies, necessitating advanced approaches such as adsorption in view of the EU implementation of fourth-stage treatment. Magnetic adsorbents are promising due to their high adsorption efficiency and facile separation from aqueous media using an external magnetic field.

Native and hydrophobically modified magnetite nanoparticles, as well as reduced graphene oxide–magnetite nanocomposites (rGO-MNP), were investigated for the removal of various micropollutants. Target compounds were quantified using UPLC-MS/MS, and removal efficiencies and adsorption capacities were determined. The high-sensitivity analytical methods enabled robust, simultaneous determination of target micropollutants, in complex aqueous matrices, ensuring accurate and reproducible evaluation of removal performance. Native magnetite showed excellent performance for glyphosate removal (>99%), with an adsorption capacity of 64 mg/g (Langmuir model), although regeneration proved challenging[1]. Oleate-modified magnetite exhibited efficient removal of less polar pollutants, such as BPA[2], carbamazepine, and venlafaxine at 100–2500 µg/L, with removal efficiencies of 77%, 50%, and 98.8%, respectively. The rGO-MNP composite acted as a multifunctional adsorbent for both hydrophilic and hydrophobic compounds, achieving removals above 90% for both glyphosate and BPA. Magnetophoretic separation was enhanced by increased ionic strength, demonstrating applicability in conditions relevant to real water matrices.

Key challenges include high production and regeneration costs and the potential release of adsorbent nanoparticles into water, which may pose ecotoxicological risks. These factors must be considered when integrating magnetic adsorbents into fourth-stage wastewater treatment as an advanced post-treatment for micropollutant removal, often combined with other techniques.

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SYNTHESIS AND IMMOBILIZATION OF Fe_3O_4/Ag_3PO_4 PHOTOCATALYST ONTO CERAMIC PAPER FOR PHOTOCATALYTIC PURPOSE

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Rapid industrialization and domestic activities have increased environmental pollution through the discharge of large volumes of wastewater into water bodies, leading to shortages of clean and safe water. Although conventional wastewater treatment methods are widely used, they are often ineffective in removing persistent organic pollutants (POPs). Recent studies highlight photocatalysis as a sustainable and efficient approach for degrading organic pollutants and POPs into harmless end products. However, most photocatalysts are applied in slurry systems, which suffer from particle aggregation, poor recovery, and secondary contamination. To address these limitations, immobilizing photocatalysts on solid supports has emerged as a promising strategy, offering improved stability, durability, and reusability.

Based on this approach, this study focuses on the synthesis and characterization of immobilized Fe_3O_4/Ag_3PO_4 photocatalyst on ceramic paper as solid support using *in situ* method. The synergistic combination of Fe_3O_4 and Ag_3PO_4 on ceramic paper is expected to enhance charge separation, light absorption, and photocatalytic efficiency if compared to individual components, but also the ceramic paper is expected to provide thermal stability, corrosion resistance, and uniform catalyst distribution which is the good advantage for industrial application of the composite to be fabricated. The photocatalytic performance of the composite is evaluated through methylene blue degradation and characterized by XRD, SEM, EDX, FTIR and DRS. The synthesized composite holds promising potential for future applications in water purification, photocatalytic processes and environmental remediation.

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HETEROSTRUCTURES BASED ON THE COLLOIDAL ASSOCIATION OF GRAPHENE OXIDE AND TITANIUM DISULFIDE NANOSHEETS FOR POSSIBLE SUPERCAPACITOR APPLICATIONS

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Decarbonization and the rapid growth of portable electronic devices are driving the need for efficient, compact, and sustainable energy storage systems. Supercapacitors are promising candidates due to their high power density, fast charge/discharge rates, and long cycle life, although their low energy density remains a key limitation. This study explores novel reduced graphene oxide (rGO)–TiS_2 heterostructures obtained from colloidal dispersions of oppositely charged graphene oxide (GO) and lithium-intercalated TiS_2 nanosheets. Electrostatic interactions enable the self-assembly of heterostructured films, whose organization depends on nanosheet size and concentration. Small nanosheets form interstratified alternating GO/TiS_2 stacks, while larger GO sheets act as supports for TiS_2 aggregates. In both cases, $LiTiS_2$ effectively limits graphene restacking. After thermal reduction to improve conductivity, the heterostructures showed significantly enhanced electrochemical performance, with capacitance increases of 30–40% compared with bulk rGO. These improvements result from the synergistic combination of higher conductivity, larger accessible surface area, reduced restacking, and facilitated charge transport. rGO–TiS_2 heterostructures therefore represent promising electrode materials for next-generation supercapacitors and advanced energy storage devices.

A BRIEF OVERVIEW: FROM THE FORMATION OF THIN FILMS TO THE PRODUCTION OF CARBON NANOTUBE FORESTS

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Forestlike vertically aligned carbon nanotubes (CNTs) can play a significant role in developments related to electrical and mechanical engineering, including as additives in composite materials.
The controlled formation of catalytic and support thin films is a fundamental requirement for the repeatable synthesis of CNT forests. This study summarizes the application of two main thin-film deposition methods: wet impregnation via dip coating, and gas-phase techniques, including atomic layer deposition (ALD), magnetron sputtering, and physical vapor deposition (PVD). These methods have been used to form bimetallic catalyst layers and insulating metal oxide support films. Thin metal oxide carrier layers are essential to prevent the migration and dissolution of catalyst nanoparticles into the metal substrate during catalytic chemical vapor deposition (CCVD) growth in a reductive environment and at high temperatures, as these processes compromise the uniformity of catalyst distribution required for the formation of a homogeneous and highly ordered CNT forests. Alongside the experimental work, the aim was to obtain a closer insight into the behavior of the catalyst layer and the synthesis processes within the employed reaction conditions; therefore, we supported our results by theoretical considerations.

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EFFECT OF TRI-METALLIC CATALYST ON GROW CARBON NANOTUBE

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Carbon nanotubes (CNTs) are promising materials for applications in energy storage, nanoelectronics, and advanced functional systems due to their exceptional mechanical, electrical, and thermal properties. However, achieving precise control over CNT growth particularly in terms of diameter uniformity and vertical alignment remains a significant challenge due to the strong dependence on catalyst composition and substrate properties. In this study, CNT growth is investigated using tri-metallic catalyst systems iron (Fe), cobalt (Co), nickel (Ni) (Fe: Co: Ni, Fe: Co: Mo, and Fe: Ni: Mo) deposited *via* physical vapor deposition (PVD) onto aluminum (Al) and titanium (Ti) substrates. The influence of catalyst composition and substrate type on nanoparticle formation, stability, and catalytic activity is systematically examined. Particular emphasis is placed on substrate-catalyst interactions and their role in controlling particle size distribution, nucleation density, and CNT morphology. The results indicate that both catalyst composition and substrate selection significantly affect CNT growth behavior, including alignment, density, and structural quality. Tri-metallic catalysts exhibit enhanced performance due to synergistic effects, enabling improved control over CNT characteristics compared to single- and binary-metal systems. Additionally, distinct differences between Al and Ti substrates highlight the critical role of substrate-dependent interactions in optimizing CNT growth. This study provides important insights into the design of multi-metal catalyst systems and substrate engineering strategies for the controlled synthesis of high-quality CNTs.

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COLLOIDAL NOBLE METAL NANOPARTICLES AS VERSATILE SERS SUBSTRATES FOR DIVERSE APPLICATIONS

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Colloidal noble metal nanoparticles (NPs) are one of the widely used substrates for Surface-enhanced Raman spectroscopy (SERS), a method that enables the detection of molecules at very low concentrations, thanks to the enhancement of the Raman signal from species adsorbed on a nanostructured metal surface. SERS has proven to be valuable for applications in diverse fields, such as personalized medicine, environmental monitoring, food safety, and materials science.[1] The performance of a SERS investigation is closely related to the amplification efficiency of the used substrate. Therefore, besides the simple noble metal colloidal NPs of various shapes and sizes a wide variety of SERS substrates have been developed during time by different approaches.[1]

In this regard, we obtained and tested different types of SERS substrates based on colloidal Au and Ag NPs and used them for different applications.[2-4] The simplest SERS substrates, consisting of colloidal Ag and Au NPs, served in our studies as a mimic of a biological interface and helped us to clarify the adsorption behavior of various pharmaceuticals and to identify any structural changes in the adsorbed species compared to the free molecules.[2] A new sandwich-like substrate, composed of colloidal Au NPs deposited on a Au film, was developed and used to detect metanephrine, a marker of neuroendocrine tumors. The SERS efficiency of the sanwich substrate for metanephrine detection was compared to that of the colloidal NPs and a limit of detection of 10^{-5} M was found, superior to that previously obtained for other catecholamines such as dopamine or epinephrine (10^{-4} M and $7 \cdot 10^{-4}$ M, respectively).[3] Moreover, a different type of SERS substrate based on small clusters of anisotropic colloidal Ag NPs embedded in a film of chitosan was obtained and its efficiency was assessed by employing Raman imaging and spectroscopy of adenine. Different distributions of SERS enhancement were observed depending on the adenine concentration and were correlated with the substrate morphology.[4] The single molecule detection was made possible by the presence of small NP aggregates, as proved by the correlation between AFM and SERS imaging.

These studies demonstrated the remarkable potential of colloidal noble metal NPs to serve as effective SERS substrates in themselves or as building blocks for the development of effective SERS substrates for various target applications.

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MULTIMETALLIC NANOPARTICLE-BASED POROUS NANOCATALYSTS

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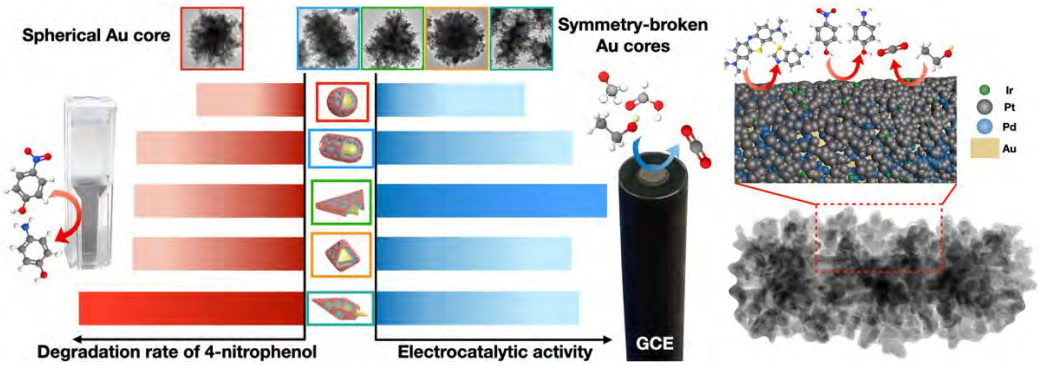
Unlike monometallic systems, multimetallic heterostructured architectures allow for multi-elemental synergy, enhancing catalytic activity while providing pathways for improved intraparticle charge carrier transport. By integrating multiple functional metals into a single nanostructure, the limitations of individual elements can be overcome, leading to robust nanocatalysts possessing expanded functionalities which can be exploited in the degradation of organic pollutants and electrooxidation of alcohols and acid.
In this work, we present a robust and versatile colloid chemical synthetic strategy for the fabrication of tetrametallic core/shell nanoparticles featuring a micro- and mesoporous PdPtIr shell grown around high-quality gold (Au) seeds. By employing micellar templates and controlling critical parameters, strict control over the shell porosity and overall particle morphology is achieved. This architecture significantly increases the density of accessible active sites and facilitates molecular mass transport through the porous shell. The role of core morphology - comparing nanospheres and various symmetry-broken shapes - in determining the final optical, structural, and catalytic properties of the tetrametallic particles is revealed. The resulting nanocatalysts demonstrate exceptional performance and morphological robustness across diverse applications, including the heterogeneous reduction of p-nitrophenol and dye degradation, as well as the electrocatalytic oxidation of alcohols and formic acid. The results highlight that the synergy between the core's geometry and the trimetallic shell's fine structure is a great tool for optimizing charge transport and catalytic efficiency, offering a novel platform for the design of functional electrodes.[1,2]



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DESIGN, STANDARDIZATION, AND CHALLENGES OF VISIBLE AND UV PHOTOCATALYTIC REACTORS FOR NANOMATERIAL TESTING

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Photocatalysis is a highly effective advanced oxidation process for the degradation of persistent organic pollutants, such as pharmaceuticals and dyes, in wastewater. However, the accurate evaluation of novel photocatalytic materials necessitates well-defined, standardized reactor systems to eliminate systemic errors and ensure reproducibility. This work presents the design, optimization, and standardization of custom-built visible-light and ultraviolet (UV) photoreactors for the testing of nanomaterials.

The visible-light reactor incorporates LED arrays and a water-cooling jacket. Initial testing revealed significant operational challenges, including solvent evaporation induced by uncontrolled aeration and subsequent temperature fluctuations. To address these issues, a calibrated synthetic air intake system with a low-range flow meter was integrated, mitigating mechanical disturbances and standardizing dissolved oxygen levels. Furthermore, comprehensive baseline protocols were established to accurately separate true photocatalytic degradation from dark adsorption and evaporation artifacts [1]. Under these optimized conditions, synthesized silver phosphate (Ag_3PO_4) demonstrated high visible-light activity, achieving approximately 80% degradation of methylene blue within 60 minutes [2].

For UV-driven processes, a dedicated photoreactor was constructed using a chemically resistant glass vessel equipped with a UV-transparent quartz window. Irradiation is provided by a low-pressure mercury vapor lamp, while thermal stability is maintained *via* a free-flow cooling jacket connected to an external thermostat unit capable of regulating temperatures between -20 °C and 150 °C with ± 0.1 °C precision. This configuration eliminates the hydraulic resistance encountered in earlier reactor designs. The reactor was utilized to evaluate basic bismuth nitrate (BBN) and bismuth-decorated titanium dioxide (TiO_2) composites[3].

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SYNTHESIS OF FLUORINATED AMPHIPHILIC POLYMERS FOR THE AQUEOUS DISPERSION OF HYDROPHOBIC QUANTUM DOTS, GOLD NANOPARTICLES, AND FLUORINATED MOLECULES

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The transfer of quantum dots (QDs) into aqueous environments remains a challenge, as these nanomaterials are commonly synthesized in organic solvents and stabilized by hydrophobic ligands.[1] Consequently, among the different methods reported to achieve their transfer into water, coating using amphiphilic polymers have emerged as an effective approach,[2] providing colloidal stability while preserving the optical properties. In this research, we present the facile synthesis of several fluorinated, hydrosoluble amphiphilic polymers, and we study the coating of TOPO-capped CdSe/ZnS QDs, as well as gold nanoparticles (AuNPs).[3] QDs were successfully transferred to water using a series of fluorinated polymers while preserving the optical properties such as the photoluminescence quantum yield (PLQY). Interestingly, polymer-coated QDs exhibited fractal-like arrangements, as revealed by small-angle X-ray scattering (SAXS) and transmission electron microscopy (TEM). In contrast, application of a similar strategy to AuNPs yielded individually coated nanoparticles. Finally, we employed these fluorinated polymers to transfer two highly hydrophobic and fluorinated molecules (PERFECTA and PFCE), commonly used in ^{19}F magnetic resonance imaging (^{19}F-MRI), into aqueous media.

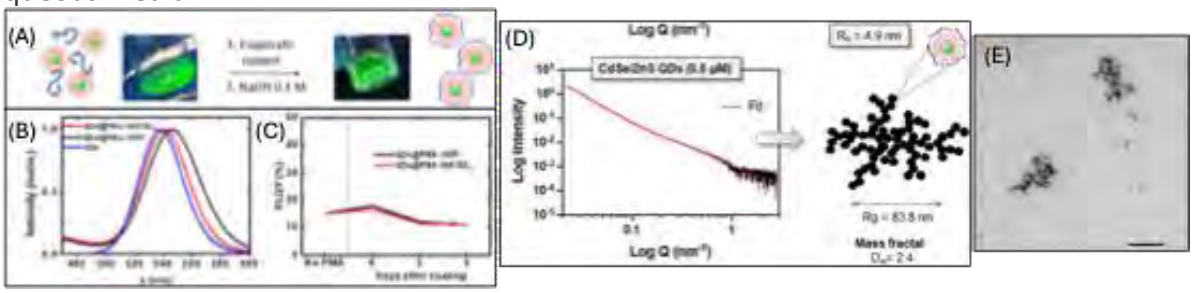

Figure 1. (A) Representation of the polymer coating process of QDs; (B) Photoluminescence of QDs; (C) PLQY of polymer-coated QDs; (D) SAXS analysis of fractal arrangements; (E) TEM micrograph o polymer-coated QDs (scale bar 100 nm).

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FUNCTIONALIZED MACROMOLECULES AS LIGANDS FOR PARAMAGNETIC METAL IONS

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Paramagnetic metal ions substantially increase the magnetic relaxation rate of water molecules they are coordinated to or which reside in their close proximity. This effect is mostly used in magnetic resonance imaging (MRI) to enhance the contrast between different tissue elements, although these metal ions should always be used in their complexed form due to their toxicity and hydrolytic instability. This comes at the cost of a diminished relaxivity, since the number of water molecules coordinated to the metallic center decreases as a result of complex formation. A possible way to restore and even further increase the relaxivity is to bind the metal ion to a large "platform" with a long rotational correlation time, this platform generally being a macromolecule. We synthesized carboxyl-functionalized polyetyleneimine[1] as well as fifth generation PAMAM dendrimer macroligands and investigated their possible structure, the relaxivity of their Gd(III) complexes at different pH values and metal-to-ligand ratios, and tried to approximate the observed behavior by using simple speciation models. The difficulty in these calculations comes from the fact that the polydispersity of the polymers and the presence of different intramolecular micro-environments make very hard to obtain reliable input parameters for the model, in contrast with small ligands of known structure.

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SELECTIVE Cu_2O SHELL DEPOSITION ON GOLD NANOPRISMS VIA LIGAND-MEDIATED SURFACE ENGINEERING

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Au/Cu_2O hybrid nanostructures are promising platforms for photocatalysis and light- driven applications, combining gold's plasmonic activity with the semiconductor properties of cuprous oxide. A key challenge is achieving spatial control over Cu_2O deposition, ideally keeping the plasmonically active nanoprism tips exposed while forming the metal-semiconductor interface on the faces and edges.

We addressed this by pre-treating gold nanoprisms (75±6 nm edge length) with 5-amino-2-mercaptobenzimidazole (AMBI) before Cu_2O shell growth. Without any surface modification, hydroxylamine reduction of $CuCl_2$ produced a uniform 20 nm shell around the entire particle. When AMBI was introduced at a moderate concentration (1 µM, ca. 25% of the monolayer coverage), the picture changed dramatically: Cu_2O nucleated preferentially on the prism faces and edges, leaving the tips bare. Plasmon resonance tracking confirmed that shell deposition was slower and less extensive compared to the unmodified case.[1] At higher AMBI concentrations (>10 µM), heterogeneous nucleation was suppressed entirely, with Cu_2O forming as free standing cubes in solution instead.

Peak- force AFM measurements on individual particles revealed that AMBI distributes unevenly across the nanoprism surface, creating high-density molecular patches that site-specifically block Cu_2O nucleation at the interface. The resulting inhomogeneous coverage is what drives the site-selective Cu_2O growth. The tip-exposed nanoprisms preserve both the intense near- field enhancement at the tips and the functional charge transfer interface, a combination well suited for photocatalytic and optoelectronic applications.[2]

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NOBLE METAL NANOCLUSTERS SURFACE-MODIFIED WITH AMINO ACID DERIVATIVES

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Nowadays, various noble metal nanostructures are the focus of numerous research projects. Thanks to their unique optical and structural properties, they can be used in wide range of application, including electronics, (bio)catalysis, (bio)sensorics and biomedical science.

Our research group has been investigating the synthesis of noble metal nanoparticles and nanoclusters for 12 years. One of the main directions is the production of gold and silver-containing nanoclusters stabilized and surface-modified with small molecules, as well as the characterization of their structure and the exploration of their sensor applications. We have previously proven the applicability of various amino acids, such as phenylalanine[1] and tyrosine[2], for the formation of blue-emitting nanoclusters. As a continuation of this research, we set out to investigate modified versions of the amino acids that had proven successful, with the aim of determining whether it is possible to tune or alter the structural and optical properties of the resulting clusters. The modification involved the incorporation of an electron-rich hydroxamic acid group with chelating properties in the case of the aforementioned phenylalanine and tyrosine ligands.

In my work, I investigated whether stable gold and silver nanoclusters with good optical properties can be prepared using hydroxamic acid derivatives of the amino acids tyrosine and phenylalanine. I primarily determined the experimental conditions governing the formation of the products, such as the ratio of the metal ion and the stabilizing ligand used, and the metal concentration, but I also examined the effects of temperature, pH, and reaction time. After the products were prepared, I also developed a protocol for their purification.

We determined the detection limit and, through temperature-dependent fluorescence quenching experiments, also determined the thermodynamic parameters of the quenching.

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MECHANISM OF HYDRATION AND HYDRATION INDUCED STRUCTURAL CHANGES IN POLYAMIDE AND POLYIMIDE AEROGELS

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Polyimide and polyamide aerogels exhibit outstanding mechanical properties, including high compressive strength, durability, flexibility, and machinability. These attributes, combined with their low density, open mesoporous nanoscale architecture, large specific surface area, and low thermal conductivity, make them highly versatile materials for advanced thermal insulation applications, including those in the demanding aerospace sector. A recent reduction in production costs will further enable their large-scale adoption in commercial aviation and the automotive industries.

In general, the macroscopic properties of nanostructured porous aerogels – such as Young's modulus and thermal conductivity – are strongly governed by their chemical composition and nanoscale architecture. The sorption of water molecules, e.g. from humid air, induces molecular-level structural changes that propagate to the nanoscale, ultimately altering macroscopic material properties.

Polyimide and polyamide aerogels were synthesized following established protocols and characterized in both their as-prepared (dry) and partially hydrated states. Morphological characterization was performed using low-voltage scanning electron microscopy (LV-SEM), nitrogen physisorption and small-angle neutron scattering (SANS). A series of techniques were used for the molecular level characterization of dry and hydrated aerogels, such as liquid-state nuclear magnetic resonance (NMR) relaxometry, cryoporometry, diffusiometry, and solid-state NMR (^{1}H MAS, ^{13}C CPMAS). The complementary insights provided by these techniques revealed the molecular interactions between water molecules and polymer chains, the resulting conformational changes, and the associated modifications in the nanoscale structure of the aerogel framework.[1]

The compressive strength of polyamide aerogels initially increases with water uptake up to a threshold – typically below 10 wt% water content relative to the dry state – followed by a decrease at higher water contents. At low hydration levels, water molecules act as intra-chain H-bond crosslinking agents in polyamide aerogels, rigidifying the polymer network and inducing anti-plasticization. At higher water contents, however, water disrupts interchain H-bonding, enhances segmental mobility, and leads to the plasticization of the aerogel structure.

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TUNIG THE SURFACE PROPERTIES OF CHITOSAN NANOCOATINGS BY THE SELF-ASSEMBLY OF CATIONIC SURFACTANT MOLECULES

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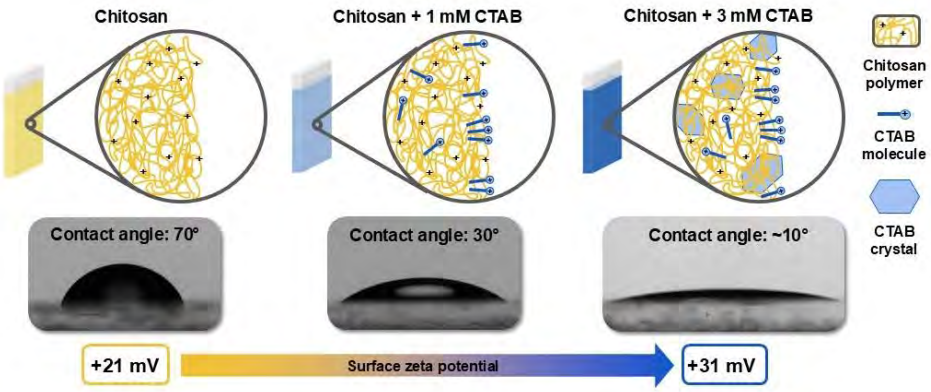
Chitosan is a cationic biopolymer produced by the partial deacetylation of chitin. In this study, approx. 200-300 nm thick chitosan nanolayers incorporating cetyltrimethylammonium bromide (CTAB) were deposited onto glass substrates via dip-coating from aqueous solutions containing 1% chitosan and 0–3.0 mM CTAB. AFM imaging and structural analyses via X-ray diffraction and solid-state NMR revealed that while low surfactant levels yielded homogeneous, semicrystalline films, CTAB concentrations above 1.0 mM induced phase separation and CTAB crystallite formation. Surface characterization demonstrated significant CTAB accumulation at the coating-air interface (confirmed by XPS), with enhanced hydrophilicity (a decrease in advancing water contact angles from 70° to approx. 10°) and increased positive surface zeta potential (from +21 mV to over +30 mV). Collectively, these results indicate a unique interfacial structure characterized by outward-facing cationic CTAB head groups, presenting a highly promising approach for the development of advanced antimicrobial coatings.



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CHITOSAN-BASED COMPOSITE COATINGS OF UPCONVERTING $NaYF_4$: Yb, Tm NANOPARTICLES

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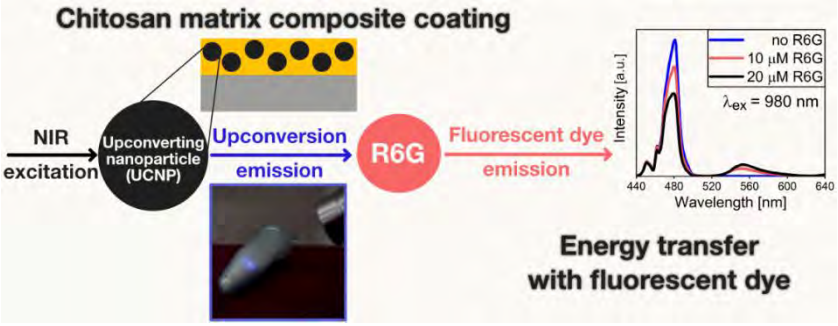
Upconverting nanomaterials are able to convert multiple photons of lower energy into a photon of higher energy. In various applications, such as optical sensors, UCNPs must be immobilized on a substrate. In our research, a novel composite coating design of UCNPs embedded into a chitosan biopolymer layer was investigated.
$NaYF_4$: Yb, Tm nanoparticles were synthesized via solvothermal method, and their properties (shape, size distribution, crystal structure, upconversion emission) were studied. Composite coatings of the UCNPs embedded in a biopolymer matrix were prepared on glass substrates with spin-coating method. Upconversion emission intensity of the UCNPs remains high after immobilization in the chitosan layer. The samples were immersed in aqueous solutions of model fluorescent dye molecules, and the energy transfer processes between the UCNPs and dye molecules were investigated. Energy transfer between UCNPs and Rhodamine 6G fluorescent dye molecules was confirmed to occur in the composite coatings: the chitosan layer can be permeated by aqueous solutions, enabling energy transfer between the embedded UCNPs within the coating and an organic species dissolved in aqueous medium. The composite coating design is promising for a variety of future applications, such as thin film based sensors for detecting biomolecules or metal ions.



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MECHANO-RESPONSIVE COLLOIDAL GELS

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Mechanical forces are critical in shaping biological processes and maintaining the structure and function of organisms at various levels—from cellular to organ systems. These forces play essential roles in a range of biological functions, including tissue development, wound healing, cell signaling, and the maintenance of homeostasis. Soft biological tissues are composed of macromolecular and low-molecular components, containing covalent and non-covalent crosslinks, and are assembled in a modular way exhibiting different hierarchy levels.[1] Such hydrogel-like materials often exhibit hysteresis effects and non-linearity of their mechanical properties, which is essential to functions like adaptability and time-programming.

Aqueous colloidal gels may serve as perfect model systems to understand many fundamental aspects of the mechano-chemistry, mechano-responsiveness and mechano-actuation because their properties can be tailored by precision synthesis methods and they can be used as colloidal building blocks to fabricate hierarchically structured soft materials in a modular way.

This contribution will focus on chemical design and behavior of mechano-responsive colloidal gels in force fields.[2] Synthesis approaches to obtain mechano-responsive colloidal gels exhibiting weak covalent (disulfide, diselenide) and non-covalent (host-guest complexes, ionic bonds or hydrogen bonds) crosslinks will be described.[3-6]

We demonstrate that obtained colloidal gels exhibit reversible temperature- or pH-triggered swelling/deswelling in aqueous solutions. Upon application of mechanical force colloidal gels show interesting properties like self-healing, on-demand degradation and controlled release of biomolecules.[7,8]

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HYDRATION PROPERTIES OF CARBON AEROGELS BY NMR RELAXATION METHODS

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There are several well-known, conventional techniques for the structural characterization of carbon aerogels. However, from the point of view of possible applications as electrode materials, where these materials are mainly immersed in liquid, characterizing the size, shape and accessibility of the pores, as well as studying the solid-liquid interface reactions or the description of the structural changes occurring under the influence of the liquid, are of primary importance. The complex use of liquid phase *n*uclear *m*agnetic *r*esonance (NMR) spectroscopy methods, like NMR relaxometry, cryoporometry, diffusometry, offers a joint solution for this, providing the opportunity for the non-destructive examination of the solid phase through the liquid medium. The behaviour of the liquid that partially or completely fills the pores provides information about the solid structure, the wetting of the pore surface, and last but not least, the mobility of the liquid in the pore system.

By measuring the T_2 relaxation times of the confined water in carbon aerogels during the saturation, the T_2 – filling factor curves provides information on the mechanism of wetting. Through a *k* parameter one can conclude if the surface is covered by liquid in a layer-by-layer way, or the pores are step-by-step saturated because of the poor wetting. When NMR cryoporometry provides pore-size data in the same liquid, the surface relaxation can be determined. This way the morphological changes of the porous carbon in different liquids can be detected, or the effect of different synthesis conditions can be studied in depth from a novel point of view.[1]

In case ionic liquid (IL) is mixed with water in the precursor solution in the first step of the synthesis, the IL strongly interacts with the monomers before the polymerization and solvates the formed polymer. This alters the morphology and pore size of the formed polymer and carbon aerogels. NMR relaxometry data on the carbon aerogels pointed out that IL modified their wetting mechanism, due to the formation of ultramicropores, which enhances the hydrophilicity.

The separate detection of similar pore sizes can be carried out with the use of test liquids of different polarity by NMR cryoporometry, while their unlike hydrophobicity can be revealed from T_2 relaxation measurements. This way even the displacement of immiscible liquids in the pores can be followed.

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CHARACTERIZING CONCENTRATED ANTIBODY SOLUTIONS WITH SMALL-ANGLE X-RAY AND LIGHT SCATTERING

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Monoclonal antibodies are often formulated above 100 mg/mL for self-administration, which leads to high viscosities and processing challenges in pharmaceutical applications. We use small-angle X-ray scattering (SAXS) to investigate structure and interparticle interactions in concentrated NISTmAb solutions (40–300 mg/mL) prepared in sodium acetate buffer (pH 5) at different ionic strengths and temperatures. SAXS measurements in quartz capillaries are combined with a rigorous data-treatment workflow including dark-current, transmission, empty-capillary and buffer corrections, concentration normalization, q-range merging, and capillary-to-capillary scaling. From the resulting high-quality intensity curves we derive structure factors S(q) and validate their low-q limits against independent static light scattering data. We show that seemingly minor choices in background and volume-fraction corrections can strongly affect S(q) at low q and thus bias any interaction modelling. The corrected SAXS dataset provides a robust, model-independent basis for linking protein–protein interactions to the viscosity of therapeutic antibody formulations[1].

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INFLUENCE OF SOLVENT COMPOSITION ON THE ELECTROPOLYMERIZATION OF SELECTED ORGANIC COMPOUNDS

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The electropolymerization reactions have high importance in respect of many practical applications. As microelectrodes have significantly higher susceptibility to deactivation due to their small size monomers with moderate susceptibility to polymer formation can be utilized as marker compound. Applying it in a uniform and optimal concentration the differences between the two solvents in the electropolymerization curve(s) allow consequences for estimation of solvent composition. In acetic acid-ethyl acetate binary mixtures we investigated two compounds successfully to use the differences. 4-methoxyphenol exhibited some fouling only in pure ethyl acetate and by very low acetic acid content. At high acetic acid contents diffusion-limited currents were recorded and the viscosity of mixtures which determine these currents provided useful consequences about the composition. Similarly, triethanolamine electrooxidation led to appearance of peaks in ethyl acetate and significant deactivation due to protonation reaction and nucleophilic attacks acetic acid modified remarkably the shape of voltammograms.

The deviations from the sigmoidally shaped voltammetric curves could be utilized also by using triethanolamine with the technique linear sweep voltammetry in hydrocarbon-ethanol mixtures. Due to the reduction of ohmic distortion the mixtures were dissolved in ethyl acetate and competition of the own hydroxyl groups of triethanolamine and ethanol was the base of ethanol content estimation. It was manifested by becoming of curves more and more sigmoidal shaped by adding more and more ethanol.

CAPILLARY BRIDGE PROBE METHOD FOR DIRECT MEASUREMENT OF SOLID-LIQUID ADHESION WORK

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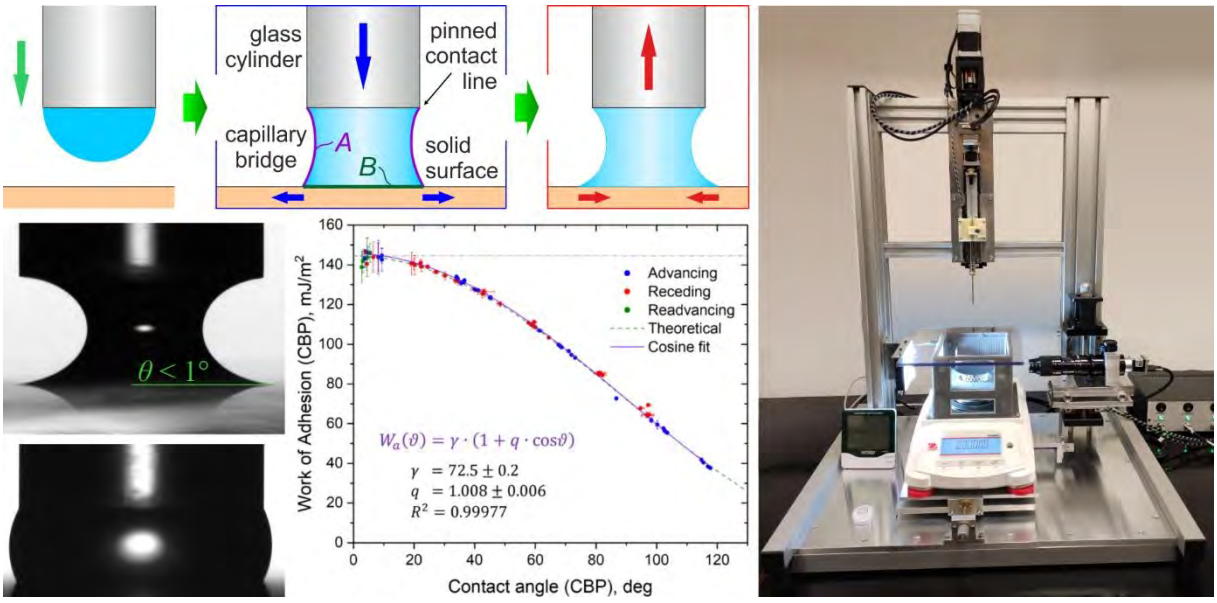
There is a long-standing need for the direct determination of solid–liquid work of adhesion due to its central role in numerous scientific and industrial applications. Moreover, the characterization of both high- and low-energy surfaces remains challenging because of the difficulty in accurately measuring very small and very large contact angles.
Our Capillary Bridge Probe method has been validated over a contact angle range of 0°–120°, and its capability has been demonstrated even for ultralow contact angles (<1°).[1,2] For superhydrophobic surfaces, a rigorous assessment of the method's accuracy was conducted using a series of highly realistic, synthetically generated images.
Furthermore, the method enables the direct and absolute determination of the work of adhesion, separately for both advancing and receding conditions.[3,4] In the advancing state, the work of adhesion quantifies the driving force behind spreading, while in the receding case, it represents the work required to remove the liquid from a unit of solid surface. The Capillary Bridge Probe provides an absolute thermodynamic quantity; hence, it is insensitive to experimental parameters.
These results will be summarized and discussed in this presentation.



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PROGRESS THROUGH RETRACTION: INDUSTRIAL INSIGHTS FROM TWO YEARS OF EASY RECEDING ANGLE MEASUREMENTS

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Two years ago, we introduced the *Stood-up Drop* (SUD) as a fundamentally new and experimentally robust method for determining the receding contact angle. By initially spreading a liquid into a transient, pancake-like thin film and subsequently allowing capillary forces to retract it into a stable "stood-up" configuration (see figure 1), the method ensures that the measured angle reflects a genuine dewetting state.
In this contribution, we briefly revisit the physical principles underpinning the SUD method and its experimentally validated connection to the receding contact angle, as recently demonstrated in *Soft Matter* (2026).[1] Building on this foundation, we summarise two years of applied laboratory and customer-driven studies highlighting the method's broad relevance. Representative examples include adhesion prediction for pressure-sensitive adhesives and PU-based glues, optimisation of plasma and flame treatments, cleanliness evaluation prior to welding or coating, and characterisation of functional polymer films.
Across these cases, the receding contact angle accessed via the SUD proved markedly more sensitive and discriminating than advancing or equilibrium angles, providing widened discrimination scales, reduced scatter, and directly interpretable metrics linked to interfacial energetics. We conclude by outlining open questions concerning film-retraction dynamics, contact-line pinning, and substrate heterogeneity.

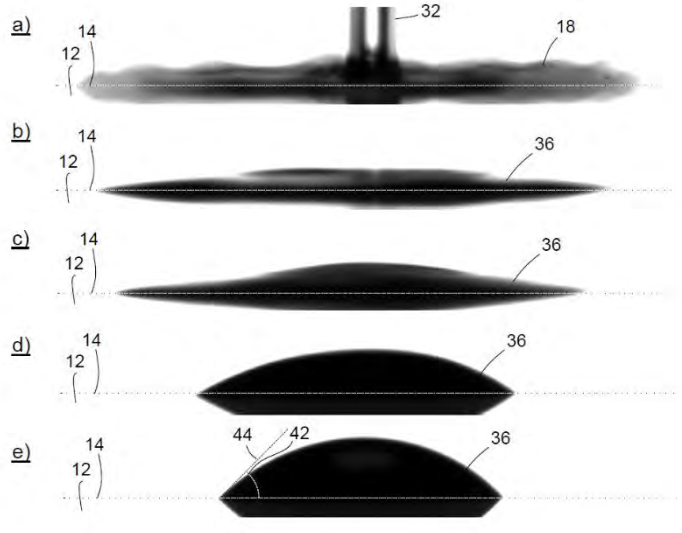

Figure 1. Temporal evolutions (from top to bottom) of "Stood-up drop" drop deposition process.

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MULTISCALE LIGHT-SCATTERING ANALYSIS OF THERMORESPONSIVE METHYLCELLULOSE GELS

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Dynamic light scattering (DLS) is often perceived primarily as a particle-size technique, yet its full potential extends far beyond mean hydrodynamic diameter. Methylcellulose (MC), a widely used thermoresponsive polymer in pharmaceutical and biomedical formulations, provides an excellent model system to demonstrate how modern DLS with integrated optical readouts can probe nanoscale dynamics, colloidal stability, and gelation behavior within a single experimental platform.

In this work, we employ temperature-resolved DLS to investigate MC solutions prepared in ultrapure water and 0.9% NaCl, providing a multiscale view of the sol–gel transition. By tracking not only the diffusion coefficient, D(T), but also the mean scattered-light intensity and transmittance, we resolve a sequence of regimes: an initial increase in molecular mobility in the sol, a plateau region consistent with early chain association, and a sharp collapse of D that signals dynamic arrest and network percolation, while macroscopic turbidity appears only at higher temperatures. These observations highlight how DLS reveals early-stage structural evolution long before bulk opacity or mechanical rigidity are detectable.

Beyond the specific gelation case, the same DLS workflow provides sensitive indicators of colloidal stability, such as changes in correlation-function shape, intensity levels, and the emergence of slow relaxation modes, offering richer insight than size distributions alone. In the case of MC, comparison between water and physiological saline shows that ionic strength lowers the apparent gelation temperature and accelerates association, illustrating how formulation variables can be quantified through accessible optical observables.

Overall, this study showcases DLS as a versatile tool for colloid and soft matter science, capable of simultaneously characterizing nanoscale dynamics, stability, and thermoresponsive gelation. By coupling diffusion-based observables with scattered-light intensity and transmittance measurements, DLS provides a non-invasive, highly sensitive complement to rheology and calorimetry for designing and controlling of colloidal formulations and smart hydrogel systems.

SEGMENTATION-FREE FOURIER-BASED PARAMETRIZATION OF PARTICLE MONOLAYERS FROM DEGRADED OPTICAL MICROSCOPY IMAGES

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Quantitative characterization of particle monolayers from microscopy images is a central task in colloid science, yet it typically relies on the detection of individual particles. This requirement severely limits the applicability of conventional methods to high-quality images. In optical microscopy of particle monolayers in wet environments, strong light scattering, noise, and blur often render particle edges undetectable, while apparent particle sizes become significantly distorted and polydisperse.

Here, we demonstrate that reliable structural parameters of particle monolayers can be obtained without particle identification, even under such adverse imaging conditions. The approach is based on a Fourier-domain analysis, in which theoretical power spectral density functions are fitted to those calculated from experimental images using a least-squares procedure. This enables direct estimation of particle radius and surface coverage without segmentation, extending our previously developed spectral parametrization framework.[1–4].

We show that the method remains accurate for optical microscopy images of micrometer-sized particle monolayers acquired in wet conditions, where standard image-processing techniques fail. Crucially, the approach exploits the fact that, despite severe distortions in particle shape and size, particle centers can still be determined, which is sufficient for robust parametrization. The obtained results confirm that the method is insensitive to blur, noise, and apparent size polydispersity.

The presented results substantially broaden the applicability of spectral methods for monolayer characterization and establish a practical route for extracting quantitative information from low-quality microscopy images. This makes the method particularly attractive for in situ studies of colloidal systems, where imaging conditions are inherently limited.

Acknowledgement: We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Center: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2026/019263. This work has been supported by the statutory funds of ICSC PAS.

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ADSORPTION-INDUCED FLUORESCENCE ENHANCEMENT OF SYBR GREEN I ON SAPONITE DISPERSIONS: EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION

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The interaction of fluorescent organic dyes with layered clay minerals has attracted considerable attention because of the unique ability of clay surfaces to modify the structural and photophysical properties of adsorbed molecules.[1,2] In this work, the interaction of SYBR Green I with aqueous saponite colloidal dispersions was investigated using UV–Vis absorption spectroscopy together with excitation–emission matrices (EEMs) measured by fluorescence spectroscopy. Samples with different dye loadings were prepared to examine the influence of surface coverage on fluorescence enhancement. Time-dependent measurements demonstrated a gradual increase in fluorescence intensity immediately after mixing, which continued during aging and became substantially more pronounced after one week. Temperature-dependent experiments further revealed a strong influence of thermal treatment on the fluorescence response. During heating from 25 to 100 °C, the fluorescence intensity increased continuously. Surprisingly, after cooling the suspension back to room temperature, the fluorescence intensity remained significantly higher than before heating, indicating an irreversible structural transformation within the dye–saponite system rather than a simple reversible temperature effect. The intrinsic effect of temperature, together with temperature-controlled diffusion processes, probably plays a role. To obtain molecular-level insight into the experimental observations, density functional theory (DFT), ORCA GOAT[3], ESD calculations[4] has been carried out. These findings contribute to a deeper understanding of hybrid clay-based materials and their potential applications in optical sensing and bioanalytical technologies.

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NANOPLASTICS FROM THEORETICAL CHEMISTRY

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Nanoplastic particles are at least two orders of magnitude smaller than eukaryotic cells, and therefore their environmental and health effects are likely to stem from their molecular level interplay with living organisms. The underlying interactions with biomolecular systems are, however, difficult to characterize experimentally, due to the complexity of polymer systems and the biological matrix they are embedded in. To overcome these obstacles, we employed molecular modeling, which helped us understanding the changes nanoplastics induce in the molecular structure of biomolecules in solution.

Modeling nanoplastics has its own challenges, in particular creating reasonable starting geometries for these polymer assemblies. We established an involved, rigorous workflow to generate nanoplastic models for molecular simulations through the self-assembly of polymer macromolecules[1]. To avoid such a series of simulations every time before simulating a system that contains nanoplastics, we created an online library, where the best obtained structures are freely available, aiding future modeling studies in the field. The self-assembly of the macromolecules composing the nanoplastics is strongly influenced by the solvent, as we found that the density of these particles varies significantly in different media. A similar protocol was used to predict the adsorption of antibiotics on nanoplastics through the example of tetracycline, and was found that this process can have a severe impact through the known Trojan horse effect, and also via hindering the absorption of drugs into the body during treatment[2].

Furthermore, we investigated examples of proteins, lipids, and nucleic acids in contact with polymer systems. Interactions of polyethylene particles with lipid bilayers showed significant perturbations in the membrane structure. Polystyrene was found prone to crossing membranes that resemble the blood-brain barrier. We found that the molecules adsorbed onto the surface of these plastics, i.e. the corona, have a decisive effect in this process. Interactions of polymers with proteins[3] and DNA[4] both triggered significant changes in the conformation and self-assembly of these biomolecules, which may also have severe biological impact. In future studies molecular modeling will be employed to more complex systems, which will enable us to connect the predictions from our calculations with direct toxic effects induced by these pollutants.

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ON THE INTERACTIONS BETWEEN NUCLEIC ACIDS AND NANOPLASTICS

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Micro- and nanoplastics (MNPs), formed through the degradation of larger plastic waste, can be detected even in remote environments and have been shown to enter the food chain and the human body. Increasing experimental evidence points to their potential epigenetic and mutagenic effects, suggesting direct interactions with DNA. However, the molecular-level mechanisms behind these effects remain unexplored. In our earlier study[1], we showed that positively charged polystyrene chains can induce a conformational transition in DNA from the canonical B form toward a more A-like structure. In this work, we explore through molecular dynamics simulations how different nanoplastics interact with DNA, through comparing an array of neutral and positively charged polymers. As a model system, we used practically relevant DNA sequences, as well as repeating AT- and CG-rich sequences. To generate DNA–nanoplastic complexes, we employed simulated annealing and high-temperature equilibrium simulations. While simulated annealing worked well for neutral systems, it proved less suitable for positively charged complexes, where short simulations at elevated temperature were more effective. The resulting structures were then simulated in aqueous environment. We found that neutral polystyrene, polyethylene, and nylon-6,6 oligomers tend to dissociate from DNA, indicating weak interactions. In contrast, positively charged polystyrene derivatives form stable complexes and induce pronounced structural changes in the DNA double helix, typically shifting it from B- DNA toward A-like conformations. Increasing the charge density on the polymer further makes these effects even more pronounced. Furthermore, comparing the interaction energies of B-DNA structures to other conformations reveals that the strongly interacting, charged plastics tend to induce even more severe changes in the DNA conformations. Thus, our results consistently show that they can significantly change DNA structure. This suggests that nanoplastics, in particular charged polymers, may have a direct impact on DNA-related biological processes.

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SELF-ASSEMBLY OF COLLOIDS STUDIED AT THE SINGLE-PARTICLE LEVEL

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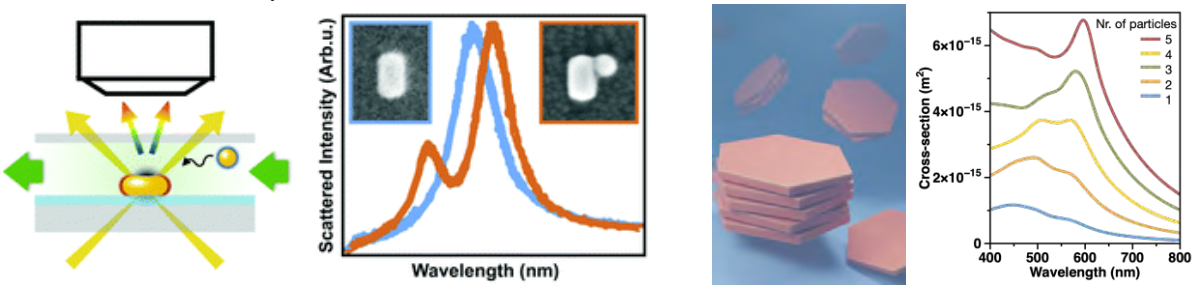
Nanoparticle self-assembly provides a very appealing bottom-up approach for the preparation of functional nanostructures, since it enables the integration of a large variety of different, individually designed building blocks. At the heart of the self-assembly process lies the control of the colloidal interaction between the nanoparticles, and hence model experiments exploring the correlation between the individual particles' properties and the resulting structure are of central importance.

In this presentation we show how optical studies backed by optical simulations performed on individual nanoparticles can contribute to the understanding of the nanoparticle assembly process. Two prototypical examples will be highlighted: the site-selective surface modification controlled directed assembly of plasmonic gold nanoparticles[1-3] and the formation of hematite nanoplatelet stacks.[4] The former can be studied based on the localized surface plasmon resonance of individual nanoparticles and the appearance of Fano-resonance associated spectral changes upon particle assembly. The hematite platelet stack formation on the other hand can be optically captured based on the self-assembly enabled Mie-scattering, which is related to the strong enhancement of the collective magnetic dipole mode of the assembly.



Spectral changes associated with the assembly of nanoparticles: the appearance of Fano-dip in the spectrum of a gold nanorod-nanosphere heterodimer (left) and the spectral evolution of assembling hematite nanoplatelet stack (right).[1,4]

Acknowledgement: Projects OTKA FK 142148 and NKKP Advanced 153064 have received financial support from the Ministry of Culture and Innovation of Hungary from the National Research, Development, and Innovation Fund (NRDI). Further support was provided by the National Research, Development and Innovation Office (EKÖP-25-4-I-BME-132)

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COMPARISON OF MODEL EQUATIONS FOR SIZE- AND SHAPE-DEPENDENT INTEGRAL AND PARTIAL MOLAR GIBBS ENERGIES OF NANO-PHASES TO FIND THE CORRECT ONE

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Equations for the integral molar Gibbs energy of nano-phases and the partial molar Gibbs energy of components dissolved in nano-phases have been derived here by extending the classical thermodynamics of Gibbs to nano-sizes in three different ways, found in the literature: according to Kelvin, the nano-effect is proportional to the curvature of the phase; according to Searcy (and later to Lee and Sim and recently to Wong and Wong), the nano-effect is proportional to dA/dV (where A and V are the surface area and the volume of the nano-phase respectively); according to the previous papers of the present author (and recently to Xue) the nano-effect is proportional to the specific surface area of the nano-phase defined as A/V. It has been shown in many experiments that for all possible shapes of all nano-phases their molar Gibbs energies are inversely proportional to their characteristic sizes, such as to the radius of a nano-sphere, to the side length of a nano-cube or to the thickness of a thin film. It is shown that the approaches due to Kelvin (curvature) and Searcy (dA/dV) lead to some controversial results vs experimental evidence, so they are excluded here. Moreover, they both contradict the nucleation theory of Gibbs, providing the same equations for the equilibrium size of a spherical nano-phase and for the critical size of the spherical nucleus, being the second reason to exclude these equations. It is also shown that the previous approach by the author (A/V) is free of such contradictions, so it is suggested for further use here.

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A NOVEL 3D LIQUID PRINTING TECHNIQUE TESTED IN AQUEOUS TWO-PHASE SYSTEMS

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Reconfigurable liquids represent a new type of material system, in which the shape of one of the liquid phases can be preserved thanks to jammed adsorbed material at the interface. These structured liquids have been synthetized sofar using 3D liquid printing methods and received a great deal of attention due to their potential applications in a variety of fields[1]. However, earlier systems investigated may not meet the requirements for biocompatible and environmentally benign formulations due to the use of organic solvents. Therefore, it is crucial to develop stable, all-aqueous reconfigurable liquids with tunable permeability between the liquid phases. To this end, an all-in-liquid printing method has been developed as a simple, cost-effective alternative to previous synthesis techniques that relied on 3D printers. The efficacy of this method was tested using poly(ethylene oxide)/dextran aqueous two-phase systems, where the interfaces can be stabilised by the interfacial association of silica particles with poly(diallyldimethylammonium) chloride[2]. It was demonstrated that the stability and permeability of the water/water interface of the printed constructs could be adjusted by varying the molecular weight of the uncharged polymers and concentration of the stabilisers. These results could facilitate the rapid evaluation of the stability and transport properties of all-in-liquid printed constructs.

Acknowledgement: This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00692/2024/VA and by the Slovak Research and Development Agency through project APVV-24-0603. The study was also supported by the National Research, Development, and Innovation Office under the project NKFIH 137980 K.

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PHYSICOCHEMICAL CHARACTERIZATION AND FIELD PERFORMANCE OF COMMERCIAL TANK-MIX ADJUVANTS IN PLANT PROTECTION APPLICATIONS

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Plant protection in modern agriculture is particularly challenging on difficult-to-wet crops such as cereals and many horticultural species, where the apolar, microstructured cuticle hinders uniform spray deposition and retention. A common strategy is the use of commercial tank-mix adjuvants, typically based on surfactants and/or vegetable oils, to enhance droplet spreading, wetting and adhesion at the liquid–plant interface; however, their proprietary and complex compositions, together with overlapping functional claims, make rational selection difficult in practice.[1]

In the case of 16 commercial preparations, we investigated how they influence the surface tension of the spray solution and the contact-wetting behavior on a standardized apolar PDMS resin as well as on wheat leaves and apple fruit surfaces. Surface tension and critical micelle concentration (CMC) were determined by pendant drop tensiometry, while advancing and receding contact angles were measured by the sessile drop method, enabling calculation of the work of adhesion. These physicochemical descriptors were used to compare and classify the wetting and adhesion performance of surfactant-based (including trisiloxane superspreaders) and oil-based formulations under controlled conditions.[2] To link laboratory measurements with agronomic relevance, three adjuvants with contrasting properties (Heliosol, Trend90 and Silwet Star) were selected for field trials in combination with fungicides. Procer 300 EC was applied to winter wheat at BBCH 39, and Bellis 380 WG was used in preharvest treatments of apple, each alone and with one of the selected adjuvants. Residues of prothioconazole (wheat flag leaves) and boscalid and pyraclostrobin (whole apple) were quantified by UHPLC–MS/MS using a QuEChERS protocol compliant with EN 15662 over 0–30 days after treatment in wheat and 0–100 days (including cold storage) in apple.

Our results reveal marked differences among adjuvants in surface tension reduction, advancing/receding contact angles and work of adhesion, with crop- and surface-specific effects on fungicide deposition and residue dissipation. On difficult-to-wet wheat leaves, certain adjuvants significantly reduced active ingredient residues during the plant-protection-critical period, despite favourable wetting on model surfaces, while others improved initial deposition. In apple, adjuvants differentially affected residue persistence during storage, indicating that optimized adjuvant choice is both crop- and use-pattern dependent. Overall, the study highlights that no universal wetting adjuvant exists; crop-specific selection requires integrating physicochemical characterization with real-plant residue dynamics.

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ION SPECIFIC EFFECTS ON THE SOL-GEL BEHAVIOUR OF EOR POLYMERS

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Although crude oil reservoirs are finite, they remain of undeniable importance, making the improvement of extraction efficiency a critical objective. Polymer flooding is a key technology among Enhanced Oil Recovery (EOR) strategies for optimising reservoir yields.
The rheological properties of injected polymer solutions are greatly affected by the temperature of the reservoir and the chemical composition of the available natural brine. The ratio of monovalent and divalent ions is crucial in determining the behaviour of polymers in solution, including sol-gel transitions which directly affect viscosity and consequently the efficiency of the process. At high salinity levels (≥50 g/L), the coherent gel structure of most synthetic EOR polymers breaks down and they transition into a sol state, which leads to decreased performance.

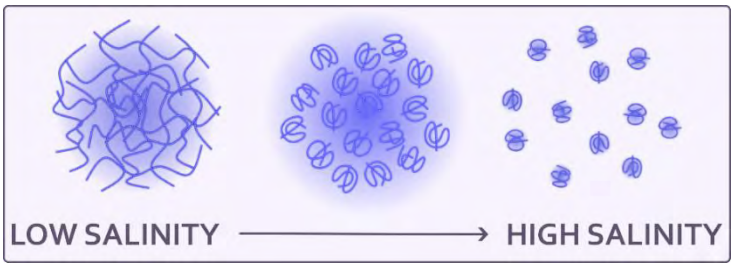

Figure 1. Effect of ionic strength on the sol-gel transition in HPAM polymer solutions

Despite extensive research into the general properties of synthetic partially hydrolyzed polyacrylamide (HPAM) polymers for EOR applications, there is still limited understanding of ion-specific interactions and their influence on the structural and rheological behaviour of these macromolecules. The aim of our work is to provide a deeper understanding of these interactions.
We investigated the structural and rheological behaviour of various HPAM-based polymer solutions in a broad salinity range.[1,2] The results showed that, at low ionic strength, these solutions exhibit a coherent, gel-like network structure. However, as the salt concentration increases, the system loses its structural cohesion and transitions to a viscous, liquid-like state. We also follow changes using dynamic light scattering and zeta potential measurements.
Based on the results, we conclude that the structural change is primarily driven by the combined effect of electrostatic screening between polymer chains and salt-concentration-modulated hydrophobic intermolecular interactions.
These findings may help in the development of more effective polymer flooding solutions.

Acknowledgement: This work was supported by National Research, Development and innovation Office via GINOP-2.3.4-15-2020-00006 project.

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STUDY OF THE INTERACTION BETWEEN MUCIN AND CATIONIC POLYMERS

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Mucosal surfaces possess numerous attractive properties for the development of more efficient drug formulations, such as high permeability, ease of administration, avoidance of clearance mechanisms, high vascularization, etc[1]. The two main concepts for utilising these surfaces are mucoadhesion and mucopenetration; both require the fine-tuning of colloidal interactions between the polymer excipient(s) of the formulations and the mucin proteins, the major components of the mucus secreted by the mucosa. Our goal here is to reveal the role of charge density in mucin-polymer interactions both in dispersion and in thin layers.
A special class of poly(amino acid)s, polyaspartamides, were chosen because of their chemical versatility, biocompatibility and biodegradability[2]. Polyaspartamides with different charge densities were synthesised, and their structure was confirmed by 1H NMR, potentiometric titration and size exclusion chromatography. The colloidal interactions between the mucin protein and polyaspartamides were tested by dynamic light scattering, zeta potential measurements and turbidimetric titration.

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SURFACE-MODIFIED MAGNETIC NANOPARTICLES AS DRAW SOLUTES IN FORWARD OSMOSIS PROCESSES

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The studies investigated the development and application of magnetite- and maghemite-based magnetic nanoparticles (MNPs) as draw solution (DS) agents in forward osmosis (FO) processes. Different hydrophilic coatings, including citric acid (CA), polyacrylic acid (PAA), and poly-sodium-acrylate (PSA), were applied to the nanoparticles in order to evaluate their effects on osmotic pressure, colloidal stability, magnetic properties, and FO performance. In all cases, the synthesized nanoparticles exhibited superparamagnetic behavior, enabling DS recovery and reconcentration through the application of an external magnetic field. The results demonstrated that nanoparticle surface modification, coating type, and coating stability play crucial roles in achieving high osmolality and efficient FO performance. PSA-coated MNPs with a PSA:MNP ratio of 1:1 achieved the highest osmotic pressure; however, the coating stability decreased during recycling steps, indicating challenges in long-term reuse. PAA-coated nanoparticles showed good colloidal stability and reusability, although osmotic pressure and water flux declined after magnetic recovery and reconcentration. Multicoated MNP@APTES@PAA nanocomposites exhibited significantly higher concentration-normalized osmotic pressure and improved stability compared to previously studied systems. Meanwhile, citric acid-coated MNPs demonstrated very low reverse solute flux compared to NaCl draw solutions, although water fluxes were lower due to stronger internal dilutive concentration polarization. Overall, the studies confirm the potential of magnetic nanoparticles as alternative draw solutes for FO applications because they combine magnetic recoverability with reduced reverse solute flux. At the same time, the findings emphasize that coating robustness, colloidal stability, and preservation of osmotic performance during repeated regeneration cycles remain key challenges in the development of efficient MNP-based draw solution systems for forward osmosis.

IN VIVO NMR RELAXATION STUDY OF HUMAN SKIN: EFFECT OF MOISTURIZATION

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The skin is the largest organ of the human body, serving multiple functions such as protecting internal organs, regulating body temperature, and synthesizing vitamin D. As its condition reflects the overall health of the body, understanding its properties as a colloid system—particularly its water content and water state—is crucial. Low-field NMR equipped with a single-sided probe, the NMR-MOUSE (Mobile Universal Surface Explorer), is well-suited for non-invasive skin analysis [1], providing promising data on skin aging and diseases. Due to the high magnetic field gradient of the NMR-MOUSE, diffusion significantly influences, and may even dominate, the relaxation rate. The classical Hahn-echo experiment is particularly sensitive to diffusion effects compared to the standard CPMG sequence due to its longer echo times. Figure 1 shows the Hahn-echo decay of water in the skin of two male volunteers. The two curves represent different ratios of "fast" and "slow" water molecules. The fitted curves demonstrate that the diffusion rate is characteristic of age and can be accurately determined.

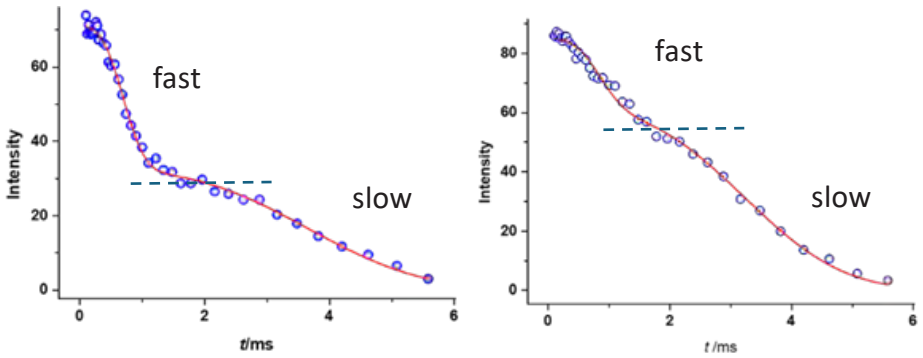

Figure 1. The Hahn-echo profile of a 70 years (left) and 25 years (right) old male person.

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POSTER PRESENTATIONS

APPARENT CHARGE-SELECTIVITY REVERSAL UNDER SUB-CMC SURFACTANT EXPOSURE IN POLYELECTROLYTE MULTILAYER NANOFILTRATION MEMBRANES

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Polyelectrolyte multilayer (PEM) nanofiltration membranes rely on coupled steric and electrostatic transport and are therefore sensitive to interactions with ionic surfactants. We investigated how sequential exposure to sub-critical micelle concentration (sub-CMC) levels of SDS and CTAB alters transport in PEM hollow-fiber membranes.

The strongest response occurred for an SDS-exposed PDADMAC/PSS membrane. Its initial salt-rejection pattern, characteristic of predominantly negative electrostatic exclusion, shifted toward the opposite hierarchy, with $MgCl_2$ becoming strongly rejected while Na_2SO_4 rejection decreased. At the same time, water permeance and apparent molecular weight cut-off decreased, indicating more restrictive size-selective transport. In contrast, an otherwise similar PAH/PSS membrane showed increasing permeance together with decreasing size exclusion and salt rejection. Thus, changing the polycation chemistry produced qualitatively opposite responses. CTAB exposure also caused pronounced changes in salt-rejection behavior.

The altered transport states persisted after surfactant removal attempts and continued to evolve during aqueous storage, suggesting a persistent, potentially irreversible modification or degradation of the PEM selective layer. This behavior is consistent with previous observations that surfactant exposure near or above the CMC can permanently alter PEM nanofiltration layers, whereas conventional polyamide NF membranes generally retain their active-layer integrity under comparable surfactant exposure. The present results indicate that substantial changes in PEM transport may already occur well below the bulk CMC.

PREPARATION AND INVESTIGATION OF MESOPOROUS TiO_2 SOL-GEL COATINGS WITH ENHANCED LIGHT TRANSMITTANCE AND PHOTOCATALYTIC ACTIVITY

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Titanium dioxide (TiO_2) has attracted remarkable research interest in diverse scientific fields, due to its semiconductor and photocatalytic properties that enable a broad range of applications in energy production and conversion as well as environmental purification. Due to the mesoporous structure, organic impurities can be adsorbed into the porous system, in addition, the degradation of these materials are catalysed by TiO_2 via UV light irradiation. Using mesoporous coatings, the light transmittance of transparent substrates can be enhanced in case of the fulfillment of thin-layer optical conditions. Herein we developed mesoporous TiO_2 coatings with simultaneously enhanced light transmittance and photocatalytic properties by a sol-gel process and dip-coating on glass substrates. The mesoporous structure was obtained by incorporating micelle-forming surfactants as templates into the precursor sol. To further enhance light transmittance, the template-containing samples were aged in ammonia vapour generated from an aqueous ammonia solution.[1] The light transmittance was measured by UV–Vis spectrophotometry, and the refractive index, layer thickness, and porosity were determined by fitting thin-layer optical models to the measured spectra. The photocatalytic activity was investigated through dye degradation experiments at both the solid-air and solid-liquid interfaces. The degradation of the dye molecules was quantified by UV-Vis spectrophotometry based on the decrease in absorbance of the dye molecules. The average transmittance increase (ATI) of the ammonia vapour-treated samples compared to bare glass in the visible wavelength range exceeded 4%, indicating improved light transmittance. In contrast, the untreated samples showed lower ATI values, ranging from negative values to slightly above zero, suggesting negligible or inconsistent changes in light transmittance. The dye degradation of all samples exceeded 50 % within 2 hours under both solid-air and solid-liquid interface conditions under UV light irradiation, while the best-performing samples reached up to 80 %.

Acknowledgement: The project supported by the Doctoral Excellence Fellowship Programme (DCEP) is funded by the National Research Development and Innovation Fund of the Ministry of Culture and Innovation and the Budapest University of Technology and Economics.

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CORRELATION BETWEEN SPECTROSCOPIC AND STOICHIOMETRIC PROTEIN TO LIPID RATIOS IN ERYTHROCYTE-DERIVED EXTRACELLULAR VESICLES AND NANOERYTHROSOMES

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The erythrocyte-derived extracellular vesicles and nanoerythrosomes show high similarities due to their same origins supporting their prosperous applicability for new generations of nanocarrier systems. The addition of a representant erythrocyte-membrane lipid (dipalmitoyl-phosphocholine, DPPC), different morphological and structural changes occurred in function of the increasing DPPC ratio. The integration of guest DPPC molecules, expressed in weight ratio extending approximately to an order of magnitude, yields the formation of standalone particles in nanoerythrosomes (NERYs), while the integration of DPPC molecules is significantly reduced with red blood cell derived extracellular vesicles (RBCEVs) resulting aggregations of these EVs. Despite the induced severe and different changes in morphological and structural characteristics, both systems show systematic changes in spectroscopical signals displaying quasi proportional alterations in their spectroscopical protein to lipid ratios. The study of series with controlled DPPC amount results in the observance of the correlation between spectroscopic and stoichiometric protein to lipid ratios. Independently from the selected spectroscopic lipid-determination (regarding to carbon-hydrogen and carbonyl vibrations), a relatively simple approximation for the stoichiometric protein to lipid ratio can be achieved in the knowledge of protein content or in case of its estimation. Based on the observed linear correlation, on the level of artificial intelligence the determination of an approximative lipid concentrations of natural NERYs and EVs comes to be possible without any lipid analytic.

FROM HUMIC HETEROGENEITY TO STANDARDIZED FRACTIONATION: QUANTIFICATION OF HUMIC AND FULVIC ACIDS BY MSZ 1129:2026

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Humic substances are chemically heterogeneous materials whose apparent humic acid (HA) and fulvic acid (FA) contents strongly depend on extraction and separation conditions. This complicates the comparison of humic materials and highlights the need for standardized analytical procedures. MSZ 1129:2026 introduces the Csicsor method, a gravimetric procedure for the determination of HA and FA in complex humic matrices.

The method distinguishes between free and extractable fractions. Free HA and FA are obtained by alkaline extraction with potassium hydroxide followed by acid precipitation of HA. Extractable fractions are determined after oxidative alkaline extraction using hydrogen peroxide. The procedure can be applied to leonardites, lignites, peats, soils, composts and other humus-rich matrices.[1]

Method performance was assessed in a 2024 interlaboratory study involving six laboratories and a leonardite sample. Mean values were 3.88% free FA, 71.4% free HA, 5.06% extractable FA and 83.4% extractable HA. Corresponding reproducibility coefficients of variation were 40.3%, 6.45%, 37.3% and 8.94%, respectively. HA determination therefore showed substantially better interlaboratory robustness than FA determination.

By defining standardized extraction and separation conditions, MSZ 1129:2026 provides operationally comparable HA and FA fractions and offers a practical basis for interlaboratory comparison, quality control and further harmonization of humic-substance analysis.[2,3]

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DUAL NANOZYME IMMOBILIZATION ON LATEX SCAFFOLDS

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Nanozymes - nanomaterials that exhibit enzyme-like catalytic activity - have attracted significant interest in biochemistry and materials science. This study investigates the co-immobilization of Prussian Blue (PB) and copper-containing layered double hydroxide (LDH)-based nanozymes onto large latex particles to evaluate the colloidal stability and enzyme-mimetic activity of the resulting hybrid systems. Using positively charged amidin latex (AL) as a scaffold, negatively charged PB nanoparticles were adsorbed onto the surface, followed by the immobilization of positively charged LDH to form AL–PB–LDH composites. For negatively charged sulfate latex (SL) particles, the assembly sequence was reversed to exploit favorable electrostatic interactions at each step. Successful immobilization was confirmed by electrophoretic mobility measurements, which provided insight into surface charge evolution during sequential adsorption and by high-resolution imaging using transmission electron microscopy (TEM) and atomic force microscopy integrated within scanning electron microscopy (AFM-in-SEM).

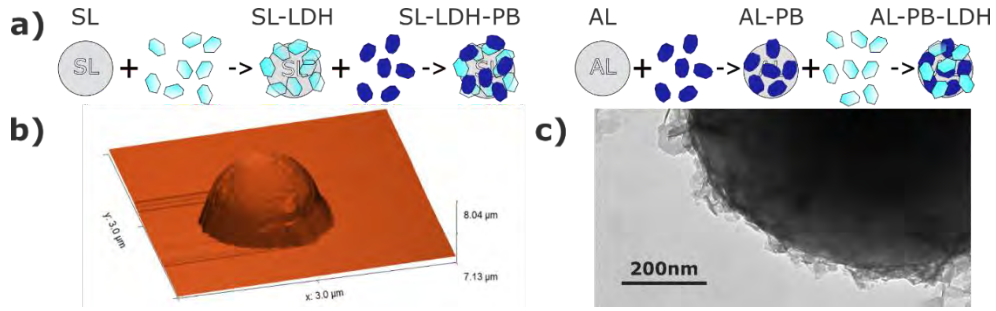

Figure 1. a) Shematic illustration of the nanozyme immobilization steps, b) AFM-in-SEM and c) TEM image of a LDH-covered SL particle.

Furthermore, the enzyme-mimetic activities were evaluated, focusing on superoxide dismutase (SOD)-like and peroxidase (POD)-like catalytic functions. Our results demonstrate that precise tuning of surface properties and assembly sequences allows for effective control over the nanozyme loading, stability, and catalytic performance. This approach provides a robust framework for the rational design of advanced functional materials in biosensing, catalysis, and environmental applications.

Acknowledgement: The research was supported by the National Research, Development and Innovation Office via the project 2024-1.2.3-HU-RIZONT-2024-00035.

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DEVELOPMENT OF BIOPOLYMER-BASED COMPOSITE COATINGS CONTAINING ERBIUM-DOPED UPCONVERTING NANOPARTICLES

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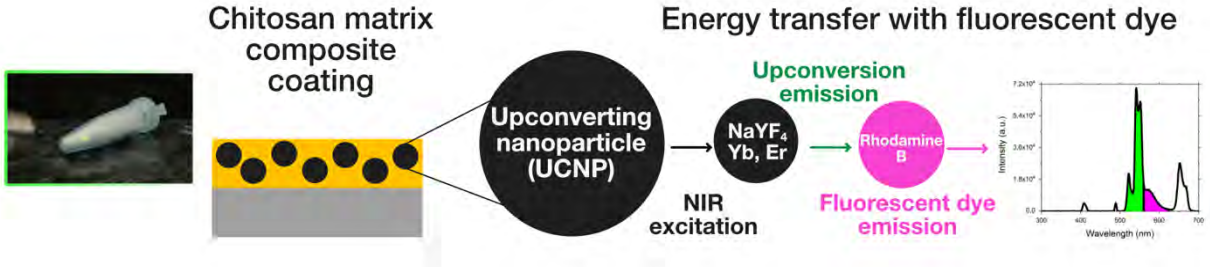
Upconverting nanoparticles (UCNPs) emit photons in the UV and visible ranges under low-energy near-infrared excitation through the sequential absorption of multiple photons (a process known as anti-Stokes emission). This higher-energy radiation enables applications across various fields, such as photodynamic cancer therapy, the development of photovoltaic devices, light sources, and non-contact optical sensors. The energy transfer within these novel composite coatings forms the foundation for numerous sensing applications that harness the upconversion phenomenon.

The main objective of the research was to design and characterize chitosan-based composite coatings that contain UCNPs doped with erbium activator and ytterbium sensitizer ion. The UCNPs were synthesized via a solvothermal method, dispersed in a biopolymer solution, then spin-coated onto glass and silicon substrates to form composite coatings. The structure and composition of $NaYF_4$: Yb^{3+}, Er^{3+} containing functional thin films were characterized by electron microscopy, while the anti-Stokes emission intensities of the UCNP-containing coatings were quantified via spectrofluorometry. The composition of the embedding matrix and the parameters of the coating process were optimized to maximize the upconversion emission intensity of the $NaYF_4$: Yb^{3+}, Er^{3+} nanoparticles.

The resulting biopolymer coatings are permeable to various small molecules, enabling energy transfer processes between these species and the embedded UCNPs. From an applications perspective, investigating such energy transfer processes is particularly important. Consequently, the energy transfer between UCNPs and Rhodamine B fluorescent model dye molecules was analyzed both in suspensions and within the developed composite coatings.



Acknowledgement: This work was supported by the EKÖP-25-3-BME-146 and STARTING 152904 Programs of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.

CONTROLLING DRUG RELEASE USING POLYASPARTAMIDE-BASED FIBROUS MATRICES

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With the advancements made in pharmaceutical development, new hurdles are identified in drug administration. New active pharmaceutical ingredients (API) have either poor aqueous solubility, low permeability, or both, leading to the need for high and regular dosing. Controlled drug delivery using amorphous solid dispersions (ASDs) is a potential solution to overcome these problems. In ASDs the API is dispersed in an amorphous form in a way that drug release is controlled mainly by the dissolution, degradation, and swelling of the matrix.[1]
The aim of our work was the development of controlled-release dosage forms using electrospinning. As a model drug, rifampicin, an API with poor aqueous solubility and hydrolytic stability, was used. Controlled drug release was achieved using polyaspartamide (PASPAm) derivatives of a wide range of hydrophobicity. PASPAms were synthesized and modified with alkyl as well as hydroxyalkyl side groups of different lengths. By changing either the length or the molar ratio of the side groups, different drug release mechanisms were achieved, namely diffusion-, swelling-, and dissolution-controlled release. The amount of dissolved drug after 60 min was controlled between 10 and 60 %.

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BUILDING NANOPLASTIC MODELS FOR MOLECULAR CALCULATIONS

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Molecular simulations of plastic nanoparticles have become increasingly important in uncovering the toxicity of micro- and nanoplastics. Modeling nanoplastics requires realistic starting structures, otherwise the simulations may produce faulty results. Building such structures most often relies on folding multiple polymer chains into a tightly entangled particle, which is a complex task and necessitates careful optimization. Here we present a systematic workflow that employs a simulated annealing approach to generate low-energy nanoplastic models. The resulting structures are further refined through semiempirical quantum chemical geometry optimizations with the GFN2-xTB method, followed by benchmark single-point energy calculations using both GGA and hybrid DFT functionals. We demonstrate the effectiveness of this protocol on six types of plastics: polyethylene, polypropylene, polystyrene, nylon-66 and polyurethane.

The most stable geometries obtained (Figure 1) show notable agreement with previously reported theoretical and experimental structures. Polyethylene, for instance, forms a highly ordered arrangement, with long chain segments predominantly in trans conformation, similarly to the crystal structure of this polymer. In contrast, polypropylene and polystyrene exhibit helical chain geometries characterized by alternating gauche and trans configurations along the backbone. For nylon-66, folding is more complex due to hydrogen bonding between amide groups, leading to parallel chains connected through hydrogen-bond networks within the particle. Finally, all optimized structures are made publicly available in an online repository, with the aim of supporting and advancing future simulation studies, including enabling ensemble-based investigations[1].

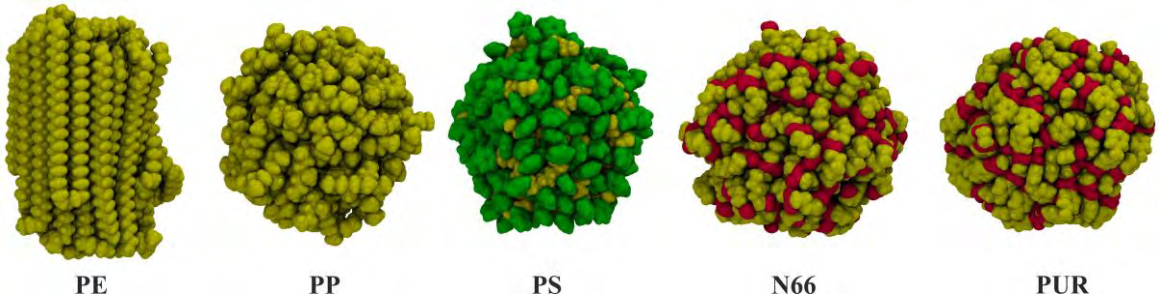

Figure 1. 3D structure of the obtained most stable plastic models

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LEAD-OLEATE CLUSTERS IN NANOCRYSTAL SYNTHESIS MEDIA: REACTION, DEPLETION AND POST-SYNTHETIC MODIFICATION

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Colloidal nanocrystals represent the boundary between solution and solid-state chemistry, between organic and inorganic materials, between molecular and bulk properties, between 0D and 3D behaviour. Especially in ordered arrays, unusual and exciting collective phenomena can be observed and exploited.[1-3] In the past three decades, a plethora of recipes have been developed for the synthesis of colloidal nanocrystals. These syntheses most often produce dispersed nanocrystals that are used to create films, pellets or ordered arrays in subsequent steps. Fewer reports describe direct formation of ordered arrays, where the collective phenomena can be directly studied. Developing reaction concepts that directly yield ordered arrays is an exciting direction towards broader application and impact. These methods would rely on fine-tuning the nanocrystal interactions in the reaction environment. Interestingly, while the chemistry, the reactivity and handling of the broad variety of reactants has been well described, less is known about the structure of the often in situ prepared precursors, and how they activate specific reaction pathways - including self-assembly during the synthesis. One of the reasons is that understanding their structure is challenging due to their size and inherent lack of long-range order. X-ray scattering is one of the few suitable tools to study the structure at the few-nanometre length scale that bridges the molecular and colloid size range. Here we report a thorough and multifaceted X-ray scattering analysis of the role of lead-oleate in the synthesis of lead telluride nanocrystals.[4] We show that lead oleate is present as nanoscale oligomers instead of molecular species, and characterize these newly discovered species. We study the formation mechanism of the superlattices, and explore the possibility of further chemical transformation, including tracking the process in situ. Through these findings, we showcase how efficiently a multipurpose SWAXS instrument can support modern chemistry and materials research.

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DEVELOPMENT OF AEROGEL-BASED SORBENTS FOR THE SELECTIVE BINDING OF PRECIOUS METAL COMPOUNDS

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Nowadays, the industrial application of noble metals is of increasing importance. Due to their limited natural availability and growing demand, increasing global attention is devoted to their efficient recovery. Noble metals are traditionally dissolved and extracted in acidic media and subsequently separated and refined from the resulting solution by solvent extraction, sorption, or ion-exchange methods. Among these techniques, sorption-based processes are particularly promising due to their cost-effectiveness, tunability, and high efficiency[1].

The foundation of various sorption methods lies in the development of suitably functionalized, efficient, and selective sorbents. Aerogels offer outstanding potential in this field, as their open mesoporous structure, high specific surface area, and facile functionalization make them well-suited for the selective binding of hydrated metal ions[2].

In this presentation we will discuss porous aerogels that were synthesized from different precursors using sol–gel methods[3]. The obtained sorbents were characterized by low-voltage scanning electron microscopy (LV-SEM), N_2 adsorption porosimetry, infrared (FT-IR), Raman, photoelectron, and solid-state NMR spectroscopic methods. Sorption properties were investigated through equilibrium and kinetic studies in a stirred reactor system. Metal ion concentrations were determined by ICP analysis. The synthesized sorbents exhibit a high affinity toward hydrated valuable noble metal ions. Sorption equilibrium was reached within a short time. The metal ions bound to the surface of the sorbents could be quantitatively recovered using solutions of small molecular ligands. The mechanisms of the surface complexations of the metal ions were investigated by various spectroscopic methods.

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INVESTIGATION OF GEMINI SURFACTANTS FOR ENHANCED OIL RECOVERY APPLICATIONS

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Surfactants play a crucial role in enhanced oil recovery (EOR) by improving oil mobilization and displacement efficiency. Among them, gemini surfactants have attracted significant attention due to their unique molecular structure and superior surface activity compared to conventional surfactants.

In this work, a series of gemini surfactants synthesized during the doctoral research were investigated with a focus on their potential application in EOR systems. The critical micelle concentration (CMC) and surface activity were determined using tensiometric methods.

The emulsification properties of the surfactants were evaluated using crude oil–water systems, and emulsion stability was monitored as a function of time. In addition, detergency tests were performed to assess the oil removal efficiency from solid surfaces. The influence of salinity on surfactant performance was also examined in order to better approximate reservoir conditions.

The results indicate that the synthesized gemini surfactants exhibit favorable emulsification behavior and promising detergency performance. These findings suggest that the investigated systems may be suitable candidates for further studies in EOR applications[1,2].

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3D PRINTABLE POROUS ENZYME SUPPORT SYSTEMS

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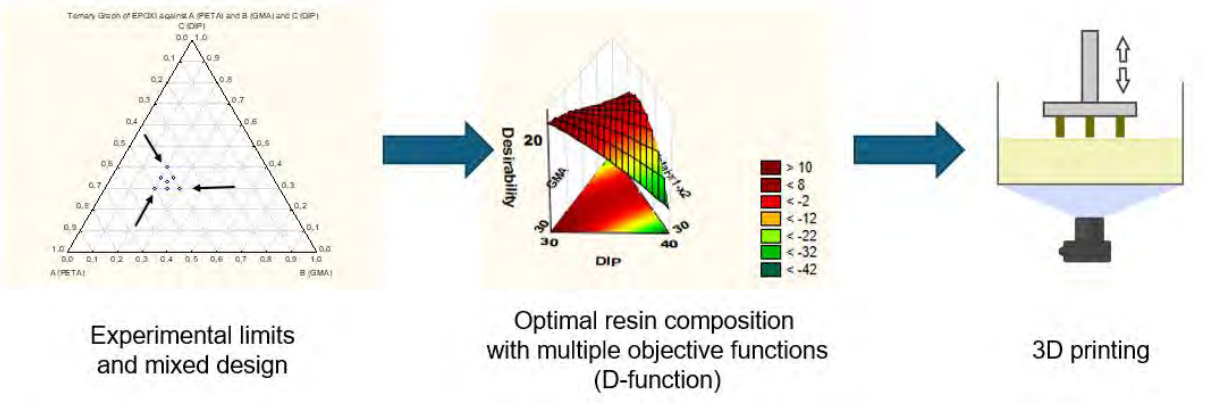
Functionalized, permeable meso- and macroporous enzyme support systems were developed by integrating polymerization-induced phase separation (PIPS)[1] into Digital Light Processing (DLP)-based 3D printing technology.
Previous attempts have been made to create porous systems using 3D printing[2], but with a few exceptions[3], high-precision, permeable, meso- and macroporous 3D-printed systems are rare. In response to this challenge, the PIPS method and photoinduction were combined.
In the present experiment, the polymerization of pentaerythritol tetraacrylate (PETA) was utilized as the primary material for the construction of the pore walls, with glycidyl methacrylate (GMA) serving as the epoxy group donor on the surfaces, and phthalates were employed as inert diluents. The experiments were conducted utilizing a mixture design (a variant of experimental design), with a d-function employed to optimize the final composition. The surface of the 3D-printed matrices contains approximately 1-2 mmol/g of epoxy groups, to which EDTA was attached via diaminobutane. We examined the specific surface area, pore size, ion-binding capacity, and mechanical properties of the porous matrices. In the next phase of the project, we plan to immobilize the phenylalanine ammonia-lyase (PAL) enzyme on the surface of the carrier and examine its enzymatic activity.



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EFFECT OF THE PROTIC VS. NON-PROTIC MOLECULAR ENVIRONMENT ON THE CIS TO TRANS CONFORMATION CHANGE OF PHOTOTREXATE DRUG

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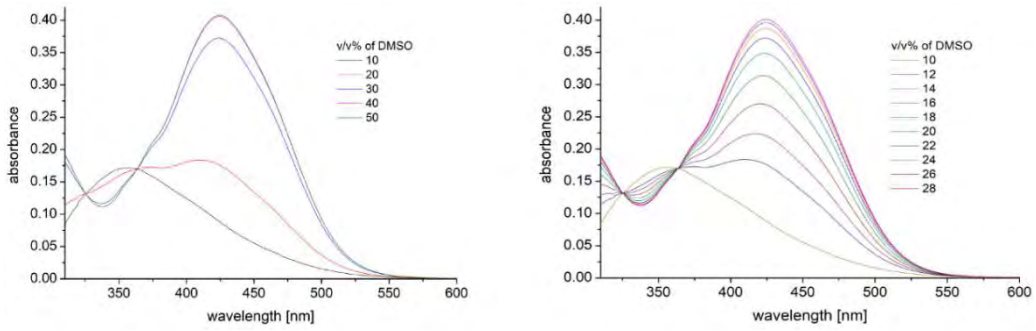
The therapeutic applicability of the anticancer drug phototrexate (PHX), a photoswitchable derivative of the antimetabolite dihydrofolate reductase inhibitor methotrexate, depends strongly on the stability of its bioactive isomer[1,2]. Since only the *cis* conformation is biologically active, this study examines how the molecular environment affects its stability. Similarly to the micellar systems, reistribution of clusters formed in protic solvents around the solutes can significantly modify the local permittivities compared to the permittivity of the bulk.[3] UV–vis absorption and fluorescence-based solvent relaxation methods were applied to follow the cis-to-trans conversion of PHX using mixture of methanol (protic) and dimethyl sulfoxide (non-protic) as medium-permittivity solvents. The results showed slower cis-to-trans isomerization and greater *cis*-conformer stability in methanol. Temperature-dependent measurements further indicated a higher activation energy in methanol.



Acknowledgement*:* Support of the Chinese-Hungarian Intergovernmental S&T Cooperation Programme (CH-10-6/2024, HU-2024-1.2.5-TÉT-2024-00006) are highly appreciated.

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INTRODUCTION OF OAE PUBLISHING INC.

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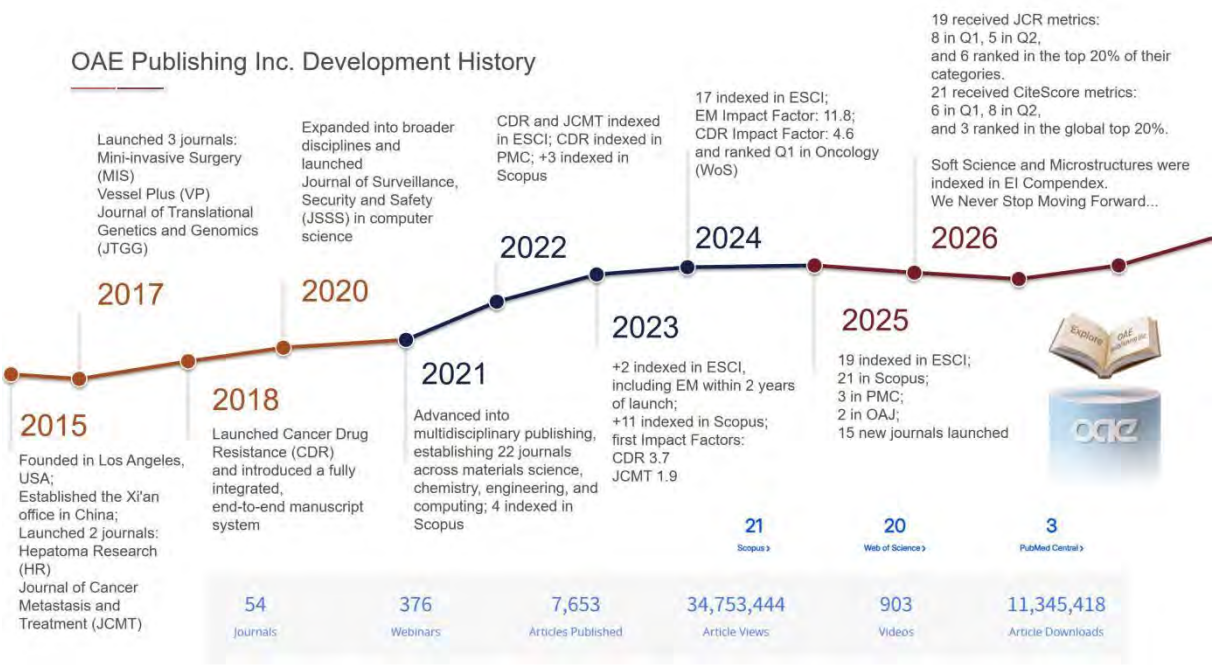

STUDY OF THE ANTICORROSION PROPERTIES OF SILICA COATINGS MODIFIED WITH PHYTIC ACID (PA) AND 3-GLYCIDYLOXYPROPYLTRIMETHOXYSILANE (GPTMS) ON ZINC SUBSTRATES

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This investigation focuses on enhancing the anticorrosion efficacy of eco-friendly, silica-based organo-hetero-hybrid composite coatings deposited on zinc substrates. Functional thin films were synthesized via sol-gel processing using tetraethyl orthosilicate (TEOS) and 3-glycidyloxypropyltrimethoxysilane (GPTMS) co-precursors at varying stoichiometric ratios under acid-catalyzed controlled hydrolysis and polycondensation. Deposition was performed via dip-coating at precisely controlled immersion and withdrawal velocities. To foster green synthesis protocols, the catalytic agent was varied by substituting conventional 0.1 M HCl with an organic chelator, 0.1 M phytic acid (PA). The surface morphology of the samples was investigated by scanning electron microscopy, while their wettability was evaluated by water contact angle measurements. The barrier functionality and electrochemical kinetics of the modified surfaces were investigated in a 0.2 g/L aqueous solution of Na_2SO_4 employing electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization measurements.

Impedance spectra and polarization parameters confirm that hybrid matrices with a 1:1 GPTMS:TEOS volumetric ratio exhibit superior charge-transfer resistance and marked corrosion inhibition compared to pristine silica control layers. Notably, the substitution of the acid catalyst with phytic acid synergistically enhanced the protective performance, demonstrating that PA-catalyzed GPTMS–TEOS hybrid networks offer a highly efficient and sustainable surface-modification strategy for mitigating zinc corrosion.

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TOUGHNESS-ENHANCED MUCOSA-MIMETIC HYDROGELS

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Mucoadhesive dosage forms can improve drug bioavailability in a patient-friendly manner[1] but their ex-vivo characterization is difficult, thus synthetic mucosa-mimetics are highly needed. Hydrogels are suitable candidates due to their high water content and mucosa-like viscoelasticity[2]. Mucin-containing poly(vinyl alcohol) (PVA) hydrogels are promising mucosa-mimetics[3,4], but a hydrogel with similar stiffness, yet with enhanced toughness, could model the mechanical properties of the mucosal tissues better[5].

Accordingly, as a new approach, mucin-containing PVA hydrogels were prepared in this work using PVA with different molecular weight (Mw) and characterized for their microstructural, rheological and mechanical properties. The adhesion of tablets made from generally used polymer excipient were analysed on the hydrogels. Increasing the Mw of PVA enhanced the toughness of the hydrogels which approximated the properties of native mucosa.

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VISCOSITY AND DYNAMIC SURFACE TENSION MEASUREMENT: A GUIDELINE FOR APPRORIATE MEASUREMENT

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Dynamic surface tension (DST) measurements are central to understanding interfacial processes in liquids of widely differing viscosities, from low-viscous inkjet formulations to highly viscous coatings and resin systems. Although surface tension itself is independent of viscosity, the *measured* DST at young surface ages can be strongly distorted by the transient flow required for a newly created interface to relax to its equilibrium shape. This relaxation process sets a fundamental lower limit to the surface age at which DST values can be interpreted reliably. At younger times, apparent time-dependent behavior may be mistaken for surfactant kinetics even though it is purely driven by viscous or inertial effects.

In our recent study published in the *Journal of Colloid and Interface Science* (2026), we systematically quantified this minimum reliable surface age across three widely used DST techniques—pendant drop, Wilhelmy plate, and bubble pressure—spanning viscosities from water-like to highly viscous silicone standards.[1] By using pure, surfactant-free liquids, we isolated viscosity-induced hydrodynamic artifacts and identified the characteristic time beyond which each method yields viscosity-independent values. The comparison reveals that each technique has a distinct operational regime: bubble pressure enables the youngest accessible surface ages for low-viscosity liquids, pendant drop becomes the most suitable for high-viscosity fluids, and Wilhelmy-plate measurements generally require substantially longer relaxation times.

Building on these insights, we present a practical phase-plot guideline that allows researchers to select the appropriate method and the youngest trustworthy surface age for any given viscosity. This ensures that observed DST dynamics truly reflect interfacial or surfactant behavior, rather than hidden viscosity effects. The updated guideline provides a simple and robust framework for scientists and engineers working with complex fluids to avoid misinterpretation and to perform more reliable dynamic surface tension measurements.

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TITANIA AND SILICA THIN-FILM SYSTEMS EXHIBITING SELECTIVE LIGHT TRANSMISSION AND WATER REPELLENCY

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The objective of this study was to tailor incident solar irradiation for a wide bandgap solar cell by decreasing the intensity of infrared light and increasing the intensity of the visible wavelength range. The presented research provides a method for the development of thin-film systems that possess both a selective light transmission and water repellent surface property. The study focuses on the optimization and preparation of thin films on glass substrates. The optimized optical properties required to achieve the objectives were determined via transmission spectra simulations based on thin-film optical models. These parameters were achieved experimentally through careful consideration of material systems, and by varying the withdrawal speeds of the dip coating deposition process.

Bi-, three- and four-layer samples were prepared from titania and silica precursor sols via the dip-coating technique. The stacking of the layers resulted in steep changes in the transmission spectra, and a hybrid silica coating ensured the water repellent properties.

Top-view scanning electron microscopy images revealed smooth and homogeneous surface morphology. Cross-sectional analysis yielded layer thickness values of 94-124 nm, in good agreement with values obtained from optical techniques, including UV-Vis spectrophotometry, scanning angle reflectometry and spectroscopic ellipsometry (109-130 nm).

Through experimental work, average transmittance change (ATC) values of 2.3% in the visible region and -9.4% in the infrared region were achieved for the three-layered sample, whereas the four-layered sample exhibited values of 2.3% and -7.8%, respectively. In terms of peak performance, maximum transmittance values of 99.70% (at 560 nm) and 99.34% (at 491 nm) were obtained for the four-layered and three-layered samples, respectively.

Water contact angles were measured using the sessile drop method. The equilibrium water contact angles of the coatings on glass substrates ranged from 80° to 85°, while the contact angle hysteresis remained below 10° for all the samples, ensuring water repellency.

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SPECIFIC ION EFFECTS AND UNDERSCREENING IN HPAM SOLUTIONS FOR ENHANCED OIL RECOVERY

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Partially hydrolyzed polyacrylamide (HPAM)-based compounds play a vital role in enhanced oil recovery (EOR). The efficiency of polymer flooding is significantly influenced by the salinity of natural reservoir brines and the chemical nature of the dissolved electrolytes.[1]
Our research aims to determine how brine solutions with specific compositions affect the physicochemical properties of various HPAM polymers. We also studied how these materials behave at very high salt concentrations. The "underscreening" phenomenon, as described in the literature, refers to the behavior of polymer solutions in high-salt environments (above 1 mol/L) that deviates from classical theories.[2] Since this topic has not been studied for HPAM polymers, our goal was to provide experimental evidence of the effects of high electrolyte concentrations on the physicochemical characteristics of EOR polymers. Finally, we investigated the idea of modifying real reservoir brines with monovalent salts.
Our measurements confirmed that polymer behavior is influenced by the ratio of monovalent to divalent cations. With monovalent cations, viscosity does not depend on the chemical nature of the cations and varies significantly only as a function of ionic strength. However, calcium ions form strong, ion-specific cross-links with the carboxylate side chains, leading to a drastic decrease in viscosity We successfully demonstrated the "underscreening" phenomenon in systems with extreme salinity; above a concentration of 1 M NaCl, the hydrodynamic radius and viscosity of the polymer increased again due to changes in macromolecular conformation. Furthermore, reservoir brine studies showed that modifying the chemical composition of formation waters with unfavorable ionic ratios may be a promising industrial direction.

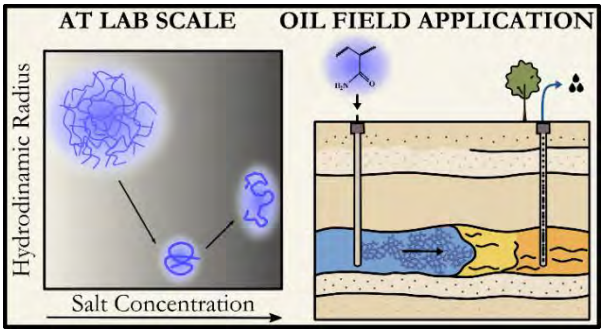

Figure 1. Illustration of the underscreening phenomenon in HPAM solutions and polymer application in EOR

Our research shows that the behavior of water-soluble polymers in reservoirs is affected not only by total salinity, but also by specific ionic interactions and the "underscreening" effect.

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PHOTOCATALYTIC DEGRADATION OF ORGANIC DYES OVER $LaFe_{0.95}Cu_{0.05}O_3$ PEROVSKITE

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Complex oxides with the perovskite structure are promising functional materials owing to their high stability, ionic conductivity, and capability for redox reactions. At the same time, their physicochemical properties can be tailored and enhanced through controlled doping. One potential application of perovskites is in photocatalytic reactions, which can be utilized for water purification. In this work, the effect of heterovalent (Fe^{3+} →Cu^{2+}) substitution on the photocatalytic properties of $LaFeO_3$ was investigated. The $LaFe_{0.95}Cu_{0.05}O_3$ powder was synthesized via a citrate sol–gel method with thermally induced auto-combustion. The resulting solutions were thoroughly homogenized, dried, and subsequently calcined at 900°C, yielding fluffy powders. The XRD phase analysis (AXRD Proto) reveal that synthesized samples $LaFe_{0.95}Cu_{0.05}O_3$ exhibit a single set of diffraction peaks corresponding to the orthorhombic perovskite structure. The photocatalytic activity of $LaFe_{0.95}Cu_{0.05}O_3$ were evaluated by measuring the efficiency of photocatalytic degradation of methylene blue (MB) and methyl violet (MV) dyes. For this purpose, 0.05 mL of 30% H_2O_2 and 50 mg and $LaFe_{0.95}Cu_{0.05}O_3$ were added to the dye solution (C_{dye} = 10^{-4}M). The reaction mixture was then illuminated with a UV lamp for 10 min (MV). The dye concentrations were monitored every 10 min, by taking 3 mL aliquots and measuring them using an Agilent Cary 60 spectrometer (Figure 1).

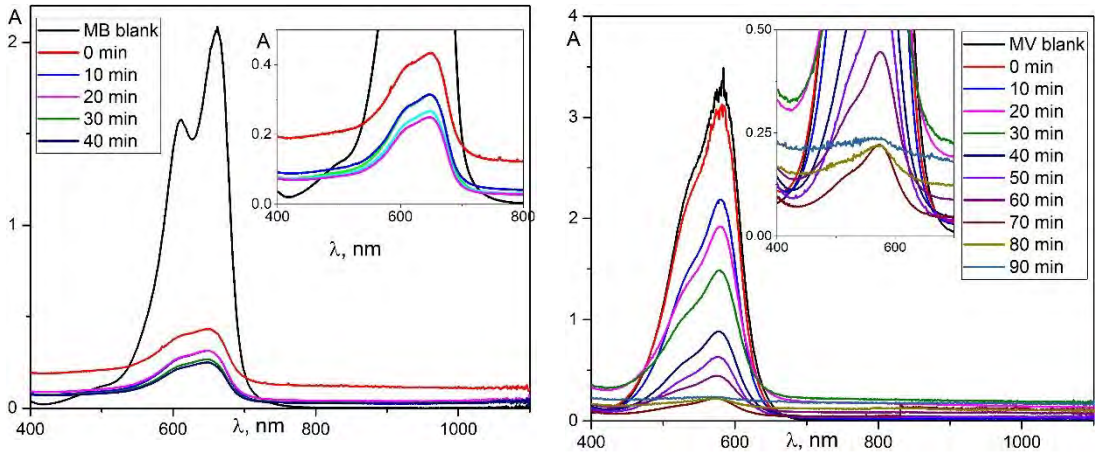

Figure 1. Absorption spectra of the $LaFe_{0.95}Cu_{0.05}O_3$ + MB (a) and $LaFe_{0.95}Cu_{0.05}O_3$ + MV (b) mixtures.

The experimental results demonstrated that the synthesized $LaFe_{0.95}Cu_{0.05}O_3$ exhibit notable photocatalytic activity toward the tested dyes. Specifically, $LaFe_{0.95}Cu_{0.05}O_3$ induced complete degradation of methylene blue in as little as 40 min, whereas complete degradation of methyl violet using $LaFe_{0.95}Cu_{0.05}O_3$ required 90 min.

PREPARATION AND CHARACTERIZATION OF $Ag_{7+x}(P_{1-x}Si_x)S_6$ NANOPOWDERS

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Thanks to their exceptionally high ionic conductivity, superionic argyrodite nanoparticles show great promise for the development of next-generation all-solid-state batteries with enhanced safety and energy density. In addition, the nanostructuring of these materials allows for effective control of their transport properties, opening up broad possibilities for applications in highly sensitive sensors and energy-efficient thermoelectric devices.

In the present work the preparation of $Ag_{7+x}(P_{1-x}Si_x)S_6$ (x = 0; 0.1; 0.25; 0.5; 0.75; 1) nanopowders is reported. Previously synthesized polycrystalline samples of $Ag_{7+x}(P_{1-x}Si_x)S_6$ solid solutions were ground in an agate mortar, and the resulting powders were sieved to obtain microcrystalline powders with crystallite sizes in the range of 10–20 μm. The prepared microcrystalline powders of each $Ag_{7+x}(P_{1-x}Si_x)S_6$ composition were further milled in a PQ-N04 planetary ball mill for 30 min and 60 min at a rotation speed of 200 rpm. XRD phase analysis (AXRD Proto) confirmed that the prepared samples crystallize in argyrodite structure in space groups: $P2_13$ (x = 0; 0.1; 0.25), F-43m/ (x = 0.5), and $Pna2_1$ (x = 0.75; 1). No material degradation is observed during milling. Analysis of the diffraction patterns indicates that increasing the milling time causes a decrease in peak intensity and broadening of the diffraction peaks for all $Ag_{7+x}(P_{1-x}Si_x)S_6$ compositions (Fig. 1).

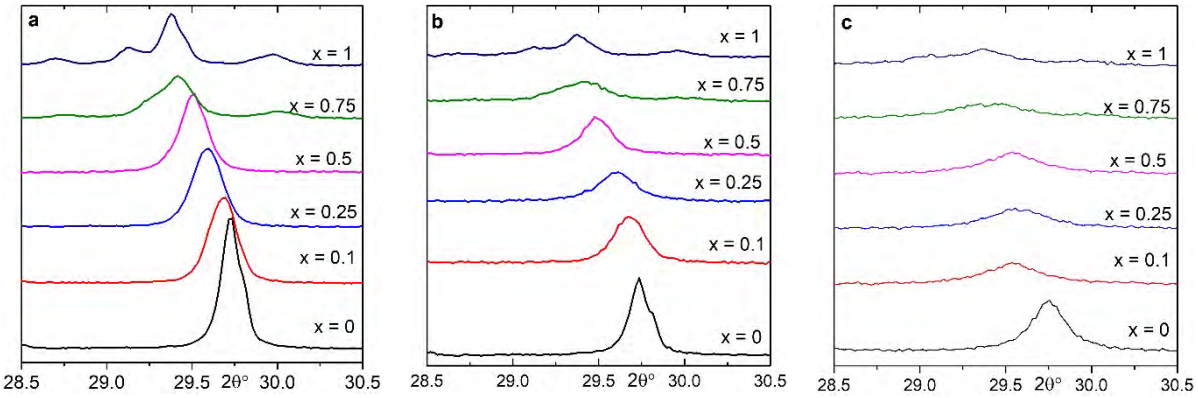

Figure 1. Comparison of XRD patterns of $Ag_{7+x}(P_{1-x}Si_x)S_6$ solid solution in form of microcrystalline (a) and nanopowders grinded for 30 (b) and 60 (c) min.

Comparison of caltulated crystallite size with determined by SEM (Vega Tescan) particle size indicates that obtained $Ag_{7+x}(P_{1-x}Si_x)S_6$ nanopowders consist of aggregated particles consisting of smaller crystallites.

INVESTIGATION OF THE COMPLEXATION PROPERTIES OF HUMIC ACID

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Humic acid represents one of the most complex fractions of natural organic matter, consisting of a heterogeneous mixture of structures with diverse molecular sizes and functional group distributions. Its abundant carboxylic and phenolic groups, together with other oxygen- and nitrogen-containing functionalities, provide numerous binding sites for metal ions[1]. Consequently, the complexation properties of humic acid play an important role in controlling the mobility, speciation, and bioavailability of metals in natural environmental systems[2].
In this study, the interaction of humic acid with selected metal ions was investigated using UV–Vis absorption and synchronous fluorescence spectroscopy. Cu(II) was used as a model ion to demonstrate the complex formation process and the associated changes in the optical properties of humic acid. Differential logarithmic absorbance spectra were applied to enhance subtle spectral changes and to distinguish wavelength regions associated predominantly with carboxylic and phenolic functional groups. This approach was further extended to Hg(II), Pb(II), Cd(II), and As(III) in order to compare their interaction patterns and evaluate the relative contribution of different functional groups to the complexation process.
Metal-induced fluorescence quenching was additionally evaluated using a modified Stern–Volmer approach to estimate conditional stability constants. The calculated values showed pronounced differences among the investigated ions, indicating metal-specific binding affinities. At both investigated fluorescence regions, the highest conditional stability was observed for Hg(II), followed by As(III), Cd(II), Cu(II), and Pb(II).
The combined application of differential absorbance and fluorescence-based methods provides complementary information on both the functional groups involved in metal binding and the relative stability of the resulting humic acid–metal complexes. These results contribute to a better understanding of the role of huin the fate and immobilization of potentially toxic elements.

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ECO-FRIENDLY ENCAPSULATED PHOTOCATALYTIC NANOPARTICLES: SYNTHESIS AND CHARACTERIZATION

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Photocatalytic nanoparticles can degrade organic pollutants through light-induced redox reactions, where electromagnetic radiation excites electrons from the valence to the conduction band, leaving holes behind. While effective for wastewater treatment, separation of nanoparticles from the cleaned water can be challenging. To achieve these goals the particles can be encapsulated in membranes or coatings, allowing the catalyst to be easily removed and reused without damaging the supporting matrix.
The aim of the research work was to develope particle-biopolymer composite nanolayers on various substrates (glass, silicon, zinc) to create a stable, reusable system. Photocatalytic C_3N_4 nanoparticles were dispersed in aqueous chitosan solutions and deposited ontosulid substrates via dip-coating and spin-coating. To ensure durability and controlled permeability, the chitosan was crosslinked using modifiers like citric acid. The cross-links were studied by Fourier-transformation infrared spectroscopy, the thickness and transmittance of the coatings were characterized by UV-Visible spectroscopy, scanning angle reflectometry and spectroscopic ellipsometry. The interaction between the composite coatings and water was studied by contact angle, swelling and electrochemical measurements. The photocatalytic efficiency of the systems were characterized by dye degradation tests with methyl orange as a model pollutant. The results demonstrate a viable method for immobilizing photocatalysts in a protective, permeable matrix for potential sustainable water purification applications.

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MICROPLASTIC REMOVAL FROM POWER PLANT MAKE-UP WATER BY SINGLE- AND TWO-STAGE MICROFILTRATION WITH A FUTURE PERSPECTIVE ON FORWARD OSMOSIS MEMBRANES

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High-purity make-up water is essential for power plant operation, as strict quality requirements preserve equipment integrity, maintain thermal efficiency, and limit corrosion, scaling, fouling, and environmentally relevant discharge impacts. Among source-water contaminants, microplastics are of increasing concern because they contribute to total suspended solids (TSS) and may intensify particulate fouling. Although microplastic removal by microfiltration has been widely studied, their impact on membrane performance and possible membrane damage remains insufficiently addressed. This study evaluates microplastic removal using Filtrak 388 (20–25 µm), VWR 413 (5–13 µm), and PORAFIL MV (0.45 µm) microfiltration membranes. One-stage filtration was first performed with 20–25 µm and 5–13 µm membranes, followed by a two-stage configuration combining 5–13 µm pre-filtration with 0.45 µm polishing. The study focused on 40 µm polyamide microplastics, nylon 11 ($C_{11}H_{21}NO$) and nylon 12 ($C_{12}H_{23}NO$), using 10 mg/L model solutions, raw Danube water, and mixed Danube water–microplastic solutions. Since standardized microplastic analysis methods are still lacking, total organic carbon (TOC) was used as an indirect indicator, despite interference from natural organic matter. The 5–13 µm membrane outperformed the 20–25 µm membrane, reducing TSS by 37.96% in raw Danube water, 66.42% in the model solution, and 58.63% in the mixed solution. Two-stage microfiltration further reduced final TSS to 17.13 mg/L, <10 mg/L, and 14.4 mg/L, corresponding to total TSS rejection rates of 59.01%, 66.42%, and 64.30%. Final TOC values were 3.35 mg/L, 1.097 mg/L, and 3.10 mg/L, while water recovery remained high at 98.5–99.3%. Both membranes retained microplastics, but signs of mechanical degradation were observed. As a future perspective, forward osmosis may offer a low hydraulic-pressure route for treating microplastic-contaminated wastewater, with potential advantages in energy demand and particle rejection. Further work is needed to assess durability, scalability, and performance in real wastewater matrices.

DEVELOPMENT, SELECTION AND APPLICATION OF SURFACTANT-POLYMER SOLUTIONS FOR ENHANCED OIL RECOVERY (EOR)

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The oil recovery factor, in favorable cases of depleted or partially depleted oil field with water displacement technology, can be maximum 30-35 percent. The current and the future oil demand of the world, along with the domestic oil demand, forces us not to be satisfied with producing only one third of the Original Oil in Place, i.e. losing two third of oil. To produce a part of this two third amount of the Original Oil in Place, the researchers and petroleum engineer experts developed the so-called EOR technologies. One of the most efficient EOR technologies is said to be the oil displacement by surfactant-polymer solution injection into reservoir. It is based on the physical, chemical and hydraulic principle that the oil/water interfacial tension in the field can be decreased by one-two or three magnitudes, the mobility ratio of oil/water can be modified, thus after the water displacement a part of the residual oil can be mobilized and it becomes producible from the reservoir rock .
In our presentation, we will present our results from surfactant development, through surfactant and polymer selection, to field application. Our paper demonstrate the effect, interaction, compatibility with polymers of gemini surfactants and cosurfactants, and what physicochemical factors influence their effectiveness under laboratory and oil reservoir conditions.[1,2,3]

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COLLOID AND ENZYME-MIMICKING PROPERTIES OF CERIA NANOPARTICLES

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Cerium oxide (ceria) nanoparticles (NPs) have attracted considerable attention in recent years due to their enzyme-mimicking properties and remarkable redox activities. These properties originate from the reversible transition between the Ce^{3+} and Ce^{4+} oxidation states. In this study, ceria nanozymes (NZs) were characterized from a physicochemical perspective, focusing on their colloidal stability and biocatalytic activity. The pH-dependent surface charge was determined by measuring the electrophoretic mobility of the NZ dispersions by electrophoretic light scattering (ELS), which identified conditions for obtaining electrostatically stabilized, positively or negatively charged particles depending on the pH. The colloidal stability of the NZs was further enhanced by the application of biocompatible polyelectrolytes such as chondroitin sulfate (CS) and polyacrylic acid (PAA). The appropriate polyelectrolyte-ceria composition was determined based on a systematic investigation combining ELS and dynamic light scattering (DLS) measurements. The enzyme-like activities of the ceria nanoparticles were investigated using different *in vitro* tests. Peroxidase-like activity was evaluated using the horseradish peroxidase (HRP) mimic test, while radical scavenging capacity was determined by the DPPH assay. Additionally, catalase-like (CAT) activity measurements were performed. These complementary methods allowed for a comprehensive evaluation of the multifaceted biocatalytic properties of ceria nanoparticles. Due to the polyelectrolyte functionalization, enhanced enzymatic activity relative to the ceria NPs was observed in some cases. Furthermore, cell viability tests confirmed the biocompatibility of the particles at the cellular level. We demonstrated that ceria NPs serve as robust alternatives to natural enzymes, offering high stability and less sensitivity to environmental conditions.

Acknowledgement*:* The research was supported by the National Research, Development and Innovation Office via the project 2024-1.2.3-HU-RIZONT-2024-00035 and by the Program of China Scholarship Council (No. 202406120370).

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INVESTIGATION OF COBALT(II) ION ADSORPTION ON MULTI-WALLED CARBON NANOTUBES

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In our research work, we investigated the adsorption of cobalt(II) ions on nitrogen-doped, bamboo-structured carbon nanotubes (BCNT). We determined the adsorption kinetics and pH dependence, and recorded the adsorption isotherm. The cobalt(II) ion concentration of the equilibrium solutions was determined by flame atomic absorption spectrometry (F-AAS) using an Agilent Technologies 240 AA instrument.

The nanotubes were synthesized at the Institute of Chemistry of the University of Miskolc. Catalytic chemical vapor deposition (CCVD) was applied to prepare the bamboo-like BCNT samples containing structural nitrogen[1]. The fringe edges on the walls of the bamboo-like nanotubes serve as high-energy adsorption sites that are easily accessible to various ions and molecules, thus forming relatively strong bonds with the adsorbent surface (ion-exchange adsorption, surface complexation)[2].

The adsorption kinetics of cobalt(II) ions were investigated in the contact time range of 0–1500 min. Based on the results, three time intervals were identified: the contact time between BCNT and the solution at $t \leq 90$ min, where the adsorbed amount gradually increases over time; the range of 90–720 min, where adsorption equilibrium was reached; and at $t > 720$ min, a partial desorption of Co^{2+} was observed. Furthermore, it was established that nearly 70% of the cobalt (II) ions were adsorbed on the surface of the BCNT immediately after mixing the nanotubes with the solution.

The relationship between pH and adsorption was studied in the pH range of 2–12. The pH value of the solutions decreased after adsorption, which can be explained by the acidic surface groups of the nanotubes. With increasing pH, the adsorbed amount gradually increased, reaching a maximum around pH 10. In strongly alkaline media (pH > 11), the structure of the nanotubes was damaged.

To quantitatively describe the adsorption of cobalt(II) ions, the adsorption isotherm was recorded. The coefficient of determination for the Langmuir model fitted to the experimental data was $R^2 = 0.996$, proving that this model is suitable for describing the adsorption of Co^{2+} on nitrogen-doped BCNT. The strong correlation between the experimental data and the Langmuir isotherm indicates a homogeneous surface character of the adsorbent and the formation of a monomolecular coverage. The maximum adsorption capacity of Co^{2+} was found to be $a_\infty = 17.1$ mg g^{-1}, accompanied by a relatively high affinity (adsorption equilibrium constant K = 15.0 dm^3 $mmol^{-1}$).

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DESIGN AND STUDY OF MACROPOROUS POLYASPARTAMIDE CRYOGELS

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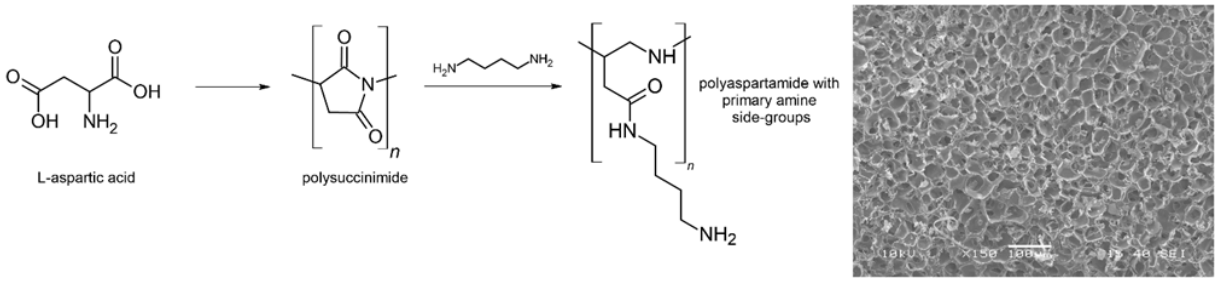
Modern recombinant DNA technology offers a wide range of possibilities to produce specific proteins and other biomolecules, but the downstream purification remains a costly step of the production process. To facilitate the purification of these recombinant proteins, a molecular "tag" (e.g. a polyhistidine sequence) is often introduced to enable highly selective and reversible interactions with appropriately engineered chromatographic supports. These supports usually contain chelate-complexed transition metal ions with strong affinity towards the polyhistidine sequence[1].



Macroporous polymeric cryogels are materials of great interest, since their interconnected and open pore structure makes them suitable chromatographic supports[2]. This unique structure results from the phase separation during the cryogelation process. Building on our previous experience with the modification of poly(aspartic acid) and the preparation of macroporous polymer gels[3], macroporous cryogels were prepared from polyaspartamides containing primary amine side-groups. From an application perspective, it is essential that the gel possess adequate mechanical properties and permeability, as well as a sufficient surface density of chelating groups for the selective binding of recombinant proteins. The ideal chemical composition of the cryogel was determined from the results of compression and flow resistance tests. The microstructure of the gel was studied using scanning electron microscopy to ensure that the pore structure is suitable for the intended use.

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1. E.L. Rodriguez, S. Poddar, S. Iftekhar, K. Suh, A.G. Woolfork, S. Ovbude, A. Pekarek, M. Walters, S. Lott, and D.S. Hage, *Journal of Chromatography B* 1157 (**2020**) 122332.
2. V.I. Lozinsky, I.Yu. Galaev, F.M. Plieva, I.N. Savina, H. Jungvid, and B. Mattiasson, *Biotechnology* 21 (**2003**) 445–451.
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SURFACE MODIFICATION OF CLAY-BASED NANOZYMES TO IMPROVE ENZYME MIMICRY AND COLLOIDAL STABILITY

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Known for their exceptional selectivity and efficiency, enzymes are often utilized biocatalysts in a variety of industrial sectors, including the food, cosmetics and textiles industries. However, their sensitivity to environmental factors (such as harsh pH and temperature conditions, or the presence of inhibitors), which may result in a decrease in their activity as well as irreversible deactivation, significantly limits their practical application. Thus, the development and implementation of enzyme mimicking materials, also known as nanozymes, have received considerable interest in recent years. Due to their high specific surface area and surface charge density, along with their tunable composition, layered double hydroxides act as promising candidates in the production of both Type 1 and Type 2 nanozymes[1]. Given the documented enzyme mimicking activity of iron-containing systems[2], our primary objective was to design Mg-Fe layered double hydroxide-based nanoparticles exhibiting enzyme-like functions. Our study began with the synthesis of Mg-Fe layered double hydroxide particles of various compositions. Their structure was characterized by X-ray diffraction (XRD) measurements and spectroscopic methods, while their morphology was mapped using transmission electron microscopy (TEM). Colloidal stability was increased via the adsorption of tannic acid on the surface of the particles. To evaluate the effect of tannic acid immobilization, dynamic light scattering (DLS) and electrophoretic mobility (EM) measurements were performed, while antioxidant assays were conducted to assess the activity of the resulting particles. By analyzing the stability and activity of the developed systems, our findings may contribute to the advancement of the synthesis and application of other iron-containing enzyme mimicking nanomaterials.

Acknowledgement*:* This research was supported by the National Research, Development and Innovation Office via the project 2024-1.2.3-HU-RIZONT-2024-00035 and by the University Research Scholarship Programme of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.

References:

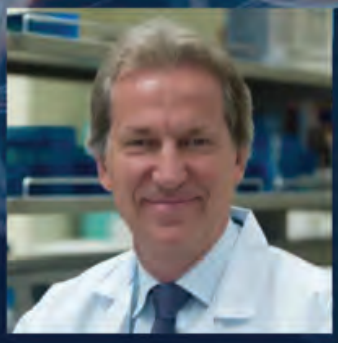
1. Szerlauth, A.; Kónya, Z.D.; Sugihara, K.; Pavlovic, M.; Varga, G.; Szilágyi, I., *Adv. Colloid Interface Sci.* **2026**, 352, 103832
2. Gao, L.; Fan, K.; Yan, X., *Theranostics* **2017**, 7 (13), 3207-3227.

WE LOOK FORWARD TO SEEING YOU AT OUR AUTUMN-WINTER EVENTS IN 2026/27!

31. ŐSZI RADIOKÉMIAI NAPOK

Balatonszárszó, SDG Családi és Konferencia Központ

2026. október 12–14.



Invited lecturer

Christer Halldin

Professor of Medicinal Radiochemistry
Karolinska Institutet
Department of Clinical Neuroscience
Stockholm, Sweden

Cosmetics Symposium 2026

HCS Hungarian Cosmetics and Household Chemicals Society

MKE

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Eötvös Loránd University
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November 24-25, Budapest, Hungary

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LABORTECH EXPO and Analytical Meeting

February 16-17, 2027

12CCC – 12th Conference on Colloid Chemistry – September 27–30, 2026 – Budapest, Hungary

SUNDAY, 27 SEPTEMBER 2026

16:00-18:00	REGISTRATION
18:00-20:00	WELCOME

MONDAY, 28 SEPTEMBER 2026

8:00	REGISTRATION
09:00	OPENING CEREMONY (ROOM A) Péter Szalay, Miklós Zrínyi *Chair: Krisztina László*
9:30	OPENING LECTURE (ROOM A) Joaquin Silvestre-Albero *Chair: Krisztina László*
10:15-10:45	COFFEE BREAK

ORAL SESSION 1/1 (ROOM A)

Chair: Angéla Jedlovszky-Hajdú

10:45	OL01 – Xiangyang Shi
11:00	OL02 – Attila Forgács
11:15	OL03 – Kristóf Molnár
11:30	OL04 – Yong Mei Chen
11:45-12:00	BREAK

Chair: Attila Forgács

12:00	OL05 – Angéla Jedlovszky-Hajdú
12:15	OL06 – Mingwu Shen
12:30	OL07 – Ami Saito
12:45	OL08 – Freya Fan
13:00-14:00	LUNCH BREAK

SPECIAL SESSION IN HONOR OF IMRE DÉKÁNY'S 80TH BIRTHDAY (ROOM A)

Chair: Zoltán Kónya

14:00	**Zoltán Kónya**: Laudation
14:15	OL09 – Volker Zöllmer
14:30	OL10 – Róbert Kun
14:45	OL11 – G. Julius Vancso
15:00	OL12 – Sándor Puskás
15:15	OL13 – Davor Kovačević
15:30	OL14 – Edit Csapó
15:45-16:15	COFFEE BREAK

Chair: Róbert Kun

16:15	OL15 – Tamás Szabó
16:30	OL16 – Krisztina László
16:45	OL17 – Klemen Bohinc
17:00	OL18 – László Janovák
17:15	OL19 – Saule Aidarova
17:30	OL20 – István Szilágyi
17:45-18:45	POSTER SESSION *Chair: Borbála Tegze*
20:00-22:00	STUDENTS' PARTY (Optional)

TUESDAY, 29 SEPTEMBER 2026

8:00	REGISTRATION
09:00	PLENARY LECTURE (ROOM A) Juraj Bujdák *Chair: Róbert Mészáros*

ORAL SESSION 1/2 (ROOM A)		ORAL SESSION 2 (ROOM B)	
Chair: Benjámin Gyarmati		*Chair: Mónika Kéri*	
09:45	OL21 – Justyna Gaweł	09:45	OL24 – Lucian Baia
10:00	OL22 – Karen Contreras Muñoz	10:00	OL25 – Nikoletta Kovács
10:15	OL23 – Attila Cserményi	10:15	OL26 – John Chagu
10:30-11:00	COFFEE BREAK	10:30-11:00	COFFEE BREAK

ORAL SESSION 3/1 (ROOM A)		ORAL SESSION 4 (ROOM B)	
Chair: Edit Csapó		*Chair: András Deák*	
11:00	OL27 – Régis Guegan	11:00	OL41 – Mónika Kéri
11:15	OL28 – Lilla Nánai	11:15	OL42 – Szilárd Sáringer
11:30	OL29 – Hadjra Ben Haoua	11:30	OL43 – László Kiss
11:45	OL30 – Monica Baia	11:45	OL44 – Norbert Nagy
12:00	OL31 – Dániel Zámbó	12:00	OL45 – Patrick Swolana (KRÜSS GmbH)
12:15	OL32 – Dániel Simon Berkesi	12:15	OL46 – Henrique Brasil (Anton Paar GmbH)

12:30-14:45	LUNCH BREAK AND POSTER SESSION *(Chair: Borbála Tegze)*

ORAL SESSION 3/2 (ROOM A)

Chair: József Kalmár

14:45	OL33 – Galder Llorente
15:00	OL34 – Levente Novák
15:15	OL35 – Ziyoda Ganieva
15:30	OL36 – Bianka Torma
15:45-16:15	COFFEE BREAK

Chair: Levente Novák

16:15	OL37 – József Kalmár
16:30	OL38 – Péter Márton
16:45	OL39 – Borbála Tegze
17:00	OL40 – Andrij Pich

19:00-22:00	CONFERENCE DINNER Törley Visitor Centre

WEDNESDAY, 30 SEPTEMBER 2026

8:00	REGISTRATION

ORAL SESSION 5 (ROOM A)

Chair: László Kiss

09:00	OL47 – Paweł Weroński
09:15	OL48 – Farshad Hamehkhani
09:30	OL49 – Oldamur Hollóczki
09:45	OL50 – Maxim Varenicja
10:00	OL51 – András Deák
10:15	OL52 – George Kaptay
10:30-11:00	COFFEE BREAK

ORAL SESSION 6 (ROOM A)

Chair: Szilárd Sáringer

11:00	OL53 – Róbert Mészáros
11:15	OL54 – Csilla Sörös
11:30	OL55 – Zsófia Árok
11:45	OL56 – Benjámin Gyarmati
12:00	OL57 – Irena Petrinič
12:15	OL58 – István Bányai
12:30-13:00	CLOSING CEREMONY (ROOM A) Krisztina László
13:00-14:00	LUNCH