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Collection of Abstracts

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Radisson Blu Hotel, Zakopane, Poland.

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Structure and dynamics of food colloids

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Food emulsions are central to everyday products such as milk, yogurt, and cheese and play a key role in human nutrition. With the growing demand for sustainable, plant-based alternatives, understanding the structure and dynamics of food emulsions has become a major scientific challenge. Although food emulsions have been extensively studied over the past decades, the functional behaviour of complex, protein-stabilized emulsions are still not fully understood. In particular, the organization, size, shape, aggregation state, and interfacial dynamics of droplets within emulsions remain crucial open questions. Modern scattering techniques, including X-ray and neutron scattering, provide powerful tools to link these structural features to the underlying physicochemical mechanisms and macroscopic emulsion properties.

In this work, we focus on model food emulsions stabilized by β-lactoglobulin and phospholipids to establish a well-defined reference system. These emulsions were characterized by SANS, NSE, and complementary methods and analysed using the Zilman–Granek model and singular value decomposition. The results reveal how interfacial viscoelasticity and molecular dynamics control emulsion stability and droplet interactions. Building on these insights, we extend the approach to selected plant-based emulsions, aiming to transfer fundamental concepts from classical food emulsions to sustainable systems. Ultimately, this work contributes to a deeper, structure-based understanding of how proteins govern the functionality of complex food emulsions.

References

- Heiden-Hecht, T., Wu. B., Appavou, M.-S., Förster, S., Frielinghaus, H. and Holderer, O. (2023). Foods 12, 2023.
- Heiden-Hecht, T., Wu, B., Schwärzer, K., Förster, S., Kohlbrecher, J., Holderer, O. and Frielinghaus, H. (2024). Journal of colloid and interface science 655, 319-326.
- Heiden-Hecht, T., Müller, M., Prevost, S., Czakkel, O., Zolnierczuk, P., Schwärzer, K., Förster, S., Frielinghaus, H., and Holderer, O. (2025). Journal of colloid and interface science, 703, 139095.
- Schwärzer, K., Heiden-Hecht. T., Chen. Y., Holderer, H., Frielinghaus, H., Li., P., Allgaier, J. (2023). European Journal of Organic Chemistry 26, e202300632.

Antifoam in food: How it breaks the bubble

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Foams, made of gas bubbles in liquid or solid matrices, are found widely across industries, from food and beverages to pharmaceuticals, oil and gas, and wastewater treatment. While foams are valued in foods for their texture and appearance, uncontrolled foam generation during processing is considered a major issue, leading to contamination, reduced productivity, and equipment damage. Mechanical and thermal foam breaking methods can be energy intensive or unsuitable, so chemical antifoams like silicone oils or natural oils are still commonly used. However, the selection of an appropriate antifoam type and its optimal dosage remains highly empirical, as performance depends strongly on system-specific factors such as formulation chemistry, process conditions, and equipment design, typically requiring experimental screening and validation [1].

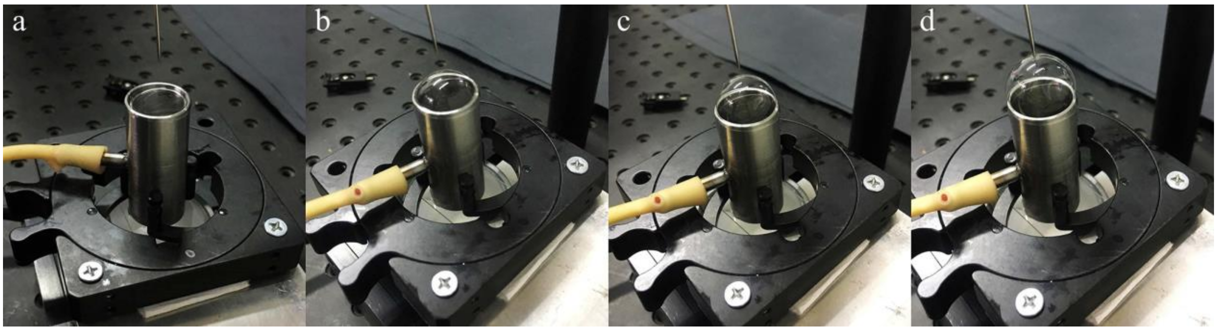

Figure 1: *Blowing process steps: (a) film formation; (b) start of bubble inflation; (c) growth of the bubble; (d) bubble and the needle interaction*

This study examines bubble rupture and bursting velocity of milk protein stabilized interfaces [2]. Sodium caseinate, milk protein concentrate, and whey protein isolate were selected as model dairy proteins with distinct structures and foamability, and their behavior was evaluated in the presence of two commercial antifoams (Magrabar® IP-3500 and Magrabar® PD-4447).

Our results show that antifoam addition increases bursting velocity, with IP-3500 exhibiting the strongest effect, particularly in milk protein concentrate systems. Antifoams also modify the relative bursting behavior across protein types, with stronger formulations inducing more pronounced changes. Notably, bubbles without antifoam were comparatively slow to rupture and typically required mechanical contact, whereas antifoam containing systems exhibited spontaneous bursting prior to contact, indicating facilitated film destabilization and an overall increase in bursting velocity. Overall, these findings provide practical insights that can support product developers in selecting appropriate antifoam types and dosages through simple, targeted experimental evaluation.

References

[1] D. Denkov, K. G. Marinova, S. S. Tcholakova, *Adv. Colloid Interface Sci.*, **2014**, 206, 57–67, DOI: 10.1016/j.cis.2013.08.004

[2] N. A. Di Spirito, S. Mirzaagha, E. Di Maio, N. Grizzuti, R. Pasquino, *Langmuir*, ***2022***, 38, 44, DOI: 10.1021/acs.langmuir.2c02059

Gels, microgels and microcapsules from rapeseed proteins

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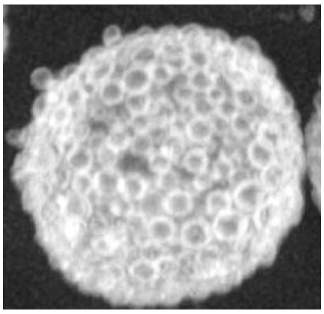
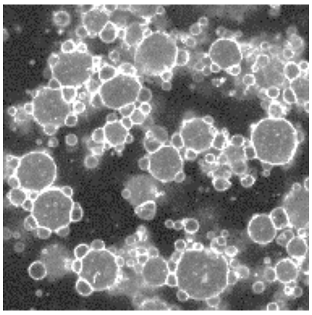
There is currently a drive to replace proteins derived from animals by plant proteins, which are perceived to be more sustainable. A promising source of are proteins from rapeseed (canola) which have a good composition of essential amino acids. Rapeseed is already widely cultivated to produce oil, but the residual press-cake rich in proteins has been so far been used principally as protein feed. Several methods have been developed to extract the proteins from the cake and since a few years rapeseed protein isolated (RPI) has been produced industrially and is commercialized. RPI contains essentially two types of proteins: napin and cruciferin. Napin is a small albumin ($1.4\text{x}10^4$ g/mol) with a high isoelectric point (pI = 9.5), whereas cruciferin is a much larger globulin $3.5\text{x}10^5$ g/mol with a lower pI = 6. Therefore the behaviour of these two components are expected to very different.

I will present results of an extensive investigation of the functionality of RPI and purified napin and cruciferin. I will discuss their solubility and their potential to form heat-set gels and emulsion gels as well as stable suspensions of microgels and microcapsules. The use of the latter to stabilize water in water emulsions will also be addressed.





References

[1] Mudau et al. *Food Hydrocolloids*, **2024** 154 110138
[2] Moutkane et al. *Food Hydrocolloids*, **2025** 166 111297
[3] Mudau et al. *Food Hydrocolloids*, **2025** 166 111338
[4] Moutkane et al. Journal of Colloid and Interface Science **2025** 699 138109
[5] Mudau et al. *Food Structure*, **2025** 46 100485
[6] Moutkane et al. *Food Hydrocolloids*, **2025** 174 112353

Research Roadmap for SoftComp Consortium via the Discovery Engine

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Soft Matter is very diverse, dynamic and interdisciplinary field which is difficult to map using traditional methods. SoftComp consortium unifies a vast number of experimental and theoretical laboratories across Europe. The Discovery Engine is a framework designed to bypass the limitations of traditional literature reviews by transforming individual publications into a unified, computationally tractable representation of the scientific domain [1]. Rather than treating scientific literature as a repository of text, the Discovery Engine ingests physical mechanisms, data, and causal relationships as a high-dimensional continuous Knowledge Graph.

In this framework, publications are distilled into structured ”knowledge artifacts” (concepts, methods, materials, phenomena) with strictly verifiable links to source evidence. These artifacts are encoded into a high-dimensional Conceptual Tensor, which captures and quantifies the deep interdependencies between different scientific components. By dynamically unrolling this tensor into explicit Knowledge Graphs (the CNM graph) it allows to visualize connections between concepts and see the knowledge gaps that worth exploring. It shifts the consortium’s strategy from a reactive, infrastructure-first approach to a predictive, topology-driven model, pinpointing the highest-yield experimental targets required to synthesize the next generation of soft matter.

References

[1] V.A. Baulin, A. Cook, D. Friedman, J. Lumiruusu, A. Pashea, S. Rahman, and B. Waldeck, The Discovery Engine: A Framework for AI-Driven Synthesis and Navigation of Scientific Knowledge Landscapes, arXiv:2505.17500.

Composite soft matter: from understanding gelation and phase behaviour towards engineering of structures with applications to food

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Complexity in soft matter is enlarged by, for example, introducing multiple types of molecules, structures, and by non-equilibrium phenomena, like in living soft matter, or during processing, storing, and transporting.

The complexity of the phenomena I will address will be illustrated in sequence of increasing complexity. This comprises a) understanding the gel strength of gelatin using a combination of critical scaling and a deflection length, b) stability of a more complex system of protein fibrils, liquid crystalline cellulose fibers and emulsion droplets, and c) formation of dense protein containing microgels and coacervates that lend themselves to realize high protein concentration heat stable liquids.

In engineering practically relevant structures, the use of a non-equilibrium pathways through a phase diagram (known as quenching) is useful. To this end, predicting equilibrium phase behaviour, preferably in practical multi-component systems, is essential as a first step. We will present work on the phase behaviour of 2-component biopolymer mixtures, in terms of experimentally accessible virial coefficients. We connect this to predictions of the phase diagram, and to extracting virial coefficients from literature data of phase diagrams.

Furthermore, we have extended the work towards the phase behaviour of multi-component (including, practical, polydisperse) mixtures by means of numerical, theoretical, and experimental work. Interestingly, part of the theoretical work is connected to a so called random matrix theory. This was applied to phase behaviour studies, with relevance to cells in biological systems.

In addressing properties of complex systems, a recent route using AI approaches was explored by us to encoding Neural Networks (NN's) with physics, to mitigate the general challenge of scarcity of data. The results suggest that encoding NN's with any disciplinary system based information yields promise to better predict properties of complex systems than NN's alone. Such encoding would also be scalable, allowing different properties to be combined, without repetitive training of the NN's.

This connects back to random matrix theory as this forms a basis of evaluating the performance by Neural Networks and extracting dominant information out of them. This is briefly summarised. Such unravelling of dominance of information is also successful applied in random matrix theory to phase separation in living cells.

In the above, quantification of complexity is relevant. We shortly address how such quantification has shown relevance to interpret food sensory perception dominance over time as a que to swallowing.

The work is aimed at better predicting the behaviour of complex soft matter and foods, which in turn will enable to adapt more easily to using different ingredient sources, thus facilitating the use of more sustainable materials.

Role of oil polarity on the interfacial phenomena of surfactants, proteins, and particles at fluid interfaces

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The formation of adsorption layers at fluid interfaces is essential in many industries, scientific disciplines, and biological processes. However, the effect of the oil phase on the structural transitions of proteins, adsorption of surfactants and particles, subsequent network formation, and layer strength at fluid interfaces has received little attention in interfacial experiments and emulsion design. This has been the cause for significant inconsistencies in the scientific literature, as experiments were often performed at arbitrary oils, which impeded the reproducibility and comparability as well as hampers the pathway to a generic description. Here, we summarize the effect of the oil phase on the adsorption, assembly, and interfacial rheology of surfactants, proteins, and particles at fluid interfaces and the resulting influence on emulsions [1-7]. Furthermore, we provide experimental guidelines for using oils in interfacial experiments, aiming to harmonize results and protocols in interfacial science.

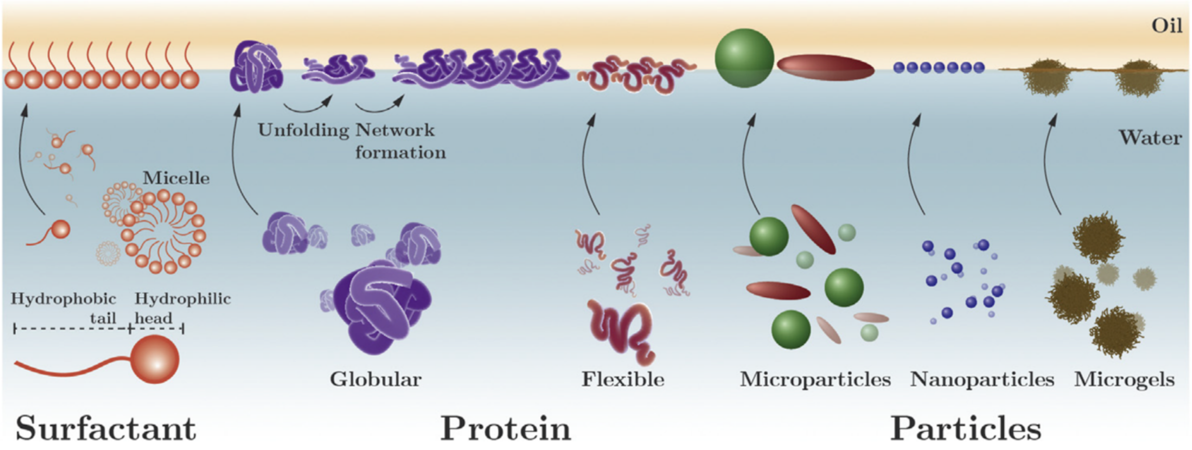

Figure 1: *The adsorption of surfactants, proteins (globular and flexible), and particles (micro- and nano-sized and soft particles) to fluid interfaces [6].*

References

[1] Bergfreund J, Bertsch P, Kuster S, Fischer P: Langmuir 34 (2018) 4929
[2] Bergfreund J, Sun Q, Fischer P, Bertsch P: Nanoscale Adv. 1 (2019) 4308
[3] Bergfreund J, Bertsch P, Fischer P: J Colloid Interface Sci. 584 (2021) 411
[4] Bergfreund J, Siegenthaler S, Lutz-Bueno V, Bertsch P, Fischer P: Langmuir 37 (2021) 6722
[5] Bergfreund J, Diener M, Geue T, Nussbaum N, Kummer N, Bertsch P, Nyström G, Fischer P: Soft Matter 17 (2021) 1692
[6] Bergfreund J, Bertsch P, Kuster S, Fischer P: Current Opin. Colloid Interf. Sci. 56 (2021) 101509
[7] Lin L-H, Bergfreund J, Fischer P, Bertsch P: Current Opin. Colloid Interf. Sci. 77 (2025) 101920

Adaptive Soft Matter at Liquid-Liquid Interfaces: Inspirations from Coffee & Food

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Responsive biointerfaces play a central role in food, pharmaceutical, and biotechnological systems, yet the mechanisms governing their formation and nanoscale organization at liquid–liquid interfaces remain insufficiently understood.

In this presentation, we explore how everyday complex fluids such as milk and coffee inspire the design of adaptive soft materials. Lipid-based interfacial nano-architectures serve as model systems to study how composition and interfacial reactions direct structure formation and, ultimately, material function. We show how reaction-driven self-assembly at oil–water interfaces enables control over physical, chemical, and biological properties.

Adapting and using in operando grazing-incidence X-ray and neutron scattering, combined with electron microscopy, chemical analytics, and microbiological assays, we investigate the formation and transformation of interfacial structures under dynamic conditions. In particular, we study enzymatic triglyceride hydrolysis as a model reaction, revealing how polar lipids and polymers reorganize at interfaces to form ordered nanostructures (Figure 1) [1,2]. We highlight how such systems can be harnessed as antimicrobial nanomaterials and as confined reaction environments enabling controlled polymerization [3,4].

These results demonstrate how concepts derived from food systems can be translated into a general framework for engineering adaptive soft matter at liquid–liquid interfaces, linking interfacial structure, reactivity, and function.

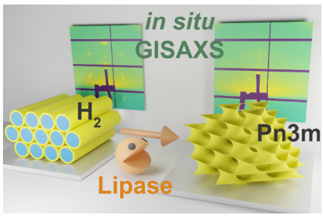

Fig 1. Enzyme-triggered nanostructural transformations in soft, nanostructured coatings for responsive materials.[2]

References

[1] M. Frigerio M., Leser M. E., Salentinig S., *J. Colloid Interface Sci.* **2026,** 706, 1091, 139561; https://doi.org/10.1016/j.jcis.2025.139561

[2] R. V. M. Freire, B. Tran, M. Debas, M. Zabara, H. Amenitsch, and S. Salentinig *ACS Applied Materials & Interfaces* **2024**, *16*, 61262-61271. https://doi.org/10.1021/acsami.4c12125

[3] M. Debas, D. P. T. Nguyen, A. F. M. Kilbinger, A. Glavic, H. Amenitsch, S. Salentinig *ACS Appl. Mater. Interfaces* **2025**, 17, 17, 26013. https://doi.org/10.1021/acsami.5c02607

[4] P. Kadakia, J. D. P. Valentin, L. Hong, S. Watts, O. A. Hameed, M. Walch, S. Salentinig, *Adv. Healthcare Mater. 2024*, 13, 2302596. https://doi.org/10.1002/adhm.202302596

Gels and Networks

Monday 18 May 15:00 – 17:40

Chiral Response in Ferrogel Torsional Actuators under Uniaxial Magnetic Fields

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Ferrogel actuators are soft magneto-responsive polymeric materials that can bend, elongate, contract, or twist under magnetic fields. The magnetic field stands out among other stimuli for actuation because it can be instantly applied, produce a quick response, and naturally penetrate most materials. In this work, ferrogel cylinders were prepared using soft magnetic particles (MPs), which show a chiral response and mechanical instabilities under certain experimental conditions. To achieve that, a uniform magnetic field is applied normally to the cylindrical axis to organize the soft MPs into chains that are permanently fixed during the gelation process (Figure 1). This fabrication process serves as a straight-forward strategy for the creation of an anisotropic magnetic susceptibility in composites. The response of these actuators is based on the magnetic anisotropy created by the MP arrangement. When a magnetic field is applied perpendicularly to the cylinder, the ferrogel deforms because of the partial alignment of MP chains with the external field lines to reduce magnetostatic energy. Experimentally, when one end of the composite is fixed, a chiral twist can be induced in the actuator under moderate magnetic fields. A simple theoretical model is developed that predicts the torsional response of the actuator, and two types of instabilities [1].

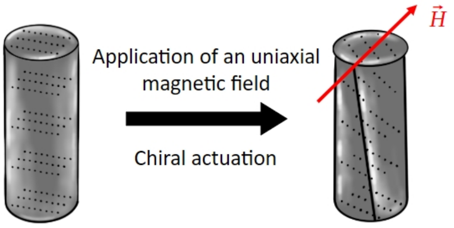

Figure 1: *Diagram of the MP arrangement in the composites and response under an uniaxial magnetic field. Adapted from [1], CC BY 4.0 (http://creativecommons.org/licenses/by/4.0).*

The cylindrical ferrogel actuators can deform into a chiral twisted state (Figure 1) and show two types of instabilities induced by the mechanical rotation of the base of the composite or reducing the magnetic field while in a twisted state. The theoretical model of their response predicts their detailed deformation, as well as the existence of nonequilibrium, metastable states, and the existence of the instabilities that are experimentally observed. The experimental results of the actuation are in good agreement with the theoretical model in most cases, including the angles at which the instabilities occur. However, some ferrogels show some discrepancies that are explained by the overestimation of the susceptibility anisotropy of these composites.

References

[1] F. J. Vazquez-Perez, A. Leon-Cecilla, L. Álvarez de Cienfuegos, J. E. Martin, M. T. Lopez-Lopez *Adv. Funct. Mater.*, **2026,** 36(6)**,** e15721, DOI: 10.1002/adfm.202515721

Field Induced Rheology of Magnetorheological Fluids with Size-Dependent Microstructural Evolution

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Magnetorheological fluids (MRFs) are one of the most interesting stimuli-responsive soft materials that exhibit a fast and reversible liquid-to-solid transition when external magnetic field is applied.

Under field, suspended particles behave as magnetic dipoles and align with strong interparticle coupling along the field direction, forming chain-like structures. This field-induced microstructural organization restricts particle mobility, resulting in a marked increase in viscosity and yield stress. Although in the literature have been presented investigations on MRFs as monodisperse suspensions based on either micro- or nanoparticles, most studies have focused on high volume fractions. The low volume fraction regime remains poorly understood, particularly in relation to particle size effects.

In this work, we investigate the field-induced rheological response of MRFs formulated with carbonyl iron microparticles or with magnetite nanoparticles, at identical low volume fractions (1.5%, 3%, and 8% v/v). The study aims to elucidate how particle size influences the field-driven transition from liquid-like to solid-like behavior, as well as the development of microstructure and the resulting macroscopic rheological response. Rheological measurements were performed using a rotational rheometer under magnetic fields up to 1 T.

The results show scaling of yield stress and viscoelastic moduli with magnetic field and particle concentration for micro- and nanoparticle-based systems. Microparticle-based MRFs exhibit a sharper and more pronounced transition toward solid-like behavior, associated with the formation of stronger field-induced structures. In contrast, nanoparticle-based systems display a more gradual transition, maintaining a partially liquid-like response over a wider range of field strengths. These findings provide insight into how particle size governs the field induced liquid-to-solid transition and structure-rheology relationships in MRFs, highlighting a previously underexplored regime where mechanical response can be finely tuned through particle-scale design.

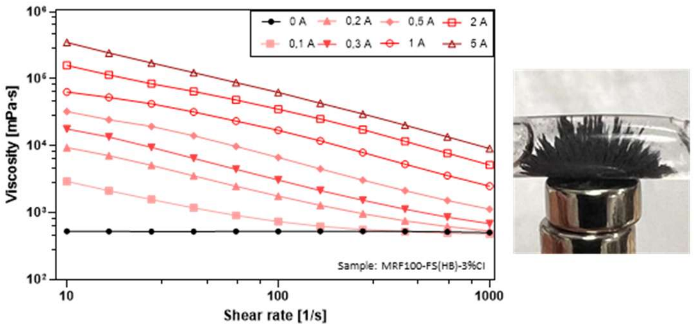

Figure 1: *On the left, magnetically induced rheological behavior of the microsized MRF at different field intensities. On the right, typical alignment of magnetic particles within the fluid under the influence of an external magnetic field.*

Viscoelasticity and Fluorescence of polymer-based magnetically switchable soft composite

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Switchable materials comprise an actual and eclectic area of research as well fundamental as applied research questions. While the implementation of magnetic nano- and microparticles into soft matrices principally opens the pathway to magnetically manipulable composites, it still remains a challenge to integrate magnetically switchable particles that fundamentally change their nature under the influence of external fields. One option to achieve this goal is the employment of nanoparticles composed of a spin-crossover Fe(II) complex in a polymer matrix,[1] as they can undergo an abrupt transition from a diamagnetic state (low spin electronic configuration) to a paramagnetic state (high spin configuration) with temperature. Despite their potential, the study of the viscoelastic properties of spin crossover soft nanocomposites remains relatively unexplored.[2]

In this work, the viscoelastic, fluorescent and spin crossover properties of composite gels are studied. The composites are prepared by dispersing Fe(II)-triazole based rod-shaped particles of various particle lengths in NaPSS aqueous solutions. The resulting $[Fe(Htrz)_2(trz)](BF_4)$/NaPSS composite systems are shown to exhibit a critical gel behaviour.[3] This behaviour is brought by the percolation of the particles within the NaPSS matrix, similar to what has been reported for other anisometric particle dispersions.[4] While their study is limited to the LS state due to their high LS-to-HS transition temperature ($T_{1/2} \approx 113°C$), composites prepared by using particles of the parent complex $[Fe(NH_2trz)_3]Cl_2$, exhibit a wide thermal hysteresis loop around room temperature, thus allowing the investigation of the viscoelastic and fluorescent properties for both spin state (HS and LS) near room temperature (see Figure 1).

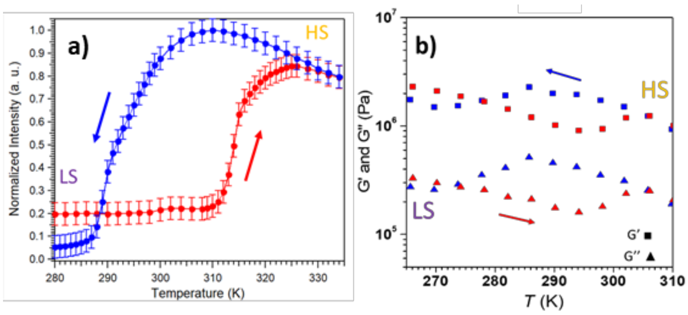

Figure 1: a) Normalized emission intensity (E_{max}) and b) storage G'(■) and loss G'' (▲) moduli as a function of temperature (K) for composite $[Fe(NH_2trz)_3]Cl_2$/NaPSS.

References

[1] A. Enriquez-Cabrera, A. Rapakousiou, M. Piedrahita Bello, G. Molnár, L. Salmon, A. Bousseksou, *Coord. Chem. Rev.*, **2020**, V 419, 213396.

[2] H. Voisin, C. Aimé, A. Vallée, A. Bleuzen, M. Schmutz, G. Mosser, T. Coradin, C. Roux, *J. Mater. Chem. C.*, **2017**, 5, 11542.

[3] M. Kermarrec, C.J. Gómez-García, M. Marchivie, P. Roquefort, T. Aubry, S. Triki, *J. Mater. Chem. C*, **2025**, 13, 5779–5787.

[4] K.J. Le Goff, D. Jouanneau, C. Garnier, T. Aubry, *J. Appl. Polym. Sci.*, **2014**, 131, 40676

Synthesis and properties of chitosan-based hydrogels and microgels with controlled microstructure

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Over the last two decades, bio-based soft colloids have received a lot of attention, especially polysaccharide-based microgels [2]. However, controlling their microstructure at different scales to evaluate systematically theirs rheological properties remains virtually unexplored. challenging. Nevertheless, their different architectures offer many bio-based alternatives to tailor the flow properties of the complex fluid [1]. In case of microgel, a free-defect structure, so-called “model”, means a homogenous crosslink density, without “loop” and free dandling chains, and a narrow distribution in size.

In this work, we aim to synthetize controlled chitosan-based soft colloids to investigate extensively their structure and their rheological properties in aqueous suspension. To do so, chitosan was chosen due to its versatility for chemical modification and as a semi-rigid biopolymer (persistence length from 8 nm [3]) which may provide a unique semi-rigid microgel.

Firstly, a strategy based on thiol-ene crosslinking chemistry [4] was optimised at macroscale to evaluate rheological properties of chitosan-based hydrogels prepared at different concentration. Then, the optimal synthesis conditions have been transferred at microscale ina in a water-in-oil emulsion, to produce chitosan-based microgels. Finally, there physical-chemical properties will be studied in water using rheology, scattering techniques and microscopy.

References

[1] D. Vlassopoulos and M. Cloitre, *Current Opinion in Colloid and Interface Science*, **2014** vol. 19, pp. 561–574, DOI: 10.1016/j.cocis.2014.09.007.

[2] D. J. McClements, *Advances in Colloid and Interface Science*, **2017** vol. 240, pp. 31–59, DOI: 10.1016/j.cis.2016.12.005.

[3] Y. Kang et al., *Carbohydrate Polymers*, **2021** vol. 271, pp. 118402, DOI: 10.1016/j.carbpol.2021.118402.

[4] N. Roas-Escalona, F. Becquart, T. Delair, and F. Dutertre, *Carbohydrate Polymers*, **2024** vol. 341, pp. 122329, DOI: 10.1016/j.carbpol.2024.122329.

Chitosan-Based Eutectic Gels for Neuromorphic BioElectronics

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Eutectic gels — deep eutectic solvents (DES) immobilized within a polymeric three-dimensional network — are gaining significant traction in soft materials research due to their unique properties, including low volatility, high flexibility, enhanced ionic conductivity, and biocompatibility [1]. Although conventional materials such as ionogels and hydrogels have been extensively investigated, they often exhibit limited mechanical stability, inferior conductivity, or high production costs, compared to eutectic gels [2]. Despite their immense potential for smart sensing and flexible electronics, the application of eutectic gels as electrolytes in electrolyte-gated transistors (EGTs) remains relatively unexplored. Eutectogels still face several open challenges, including low ionic conductivity compared to other electrolyte systems [2], poor environmental stability due to their hygroscopic nature [2, 3], and the need for more sustainable formulations through the replacement of toxic polymers (polyacrylic acid and polyacrylamide) [2, 4].

Here, we report the design and optimization of a eutectic gel based on a choline chloride/glycerol DES embedded in a polyvinyl alcohol and quaternary ammonium chitosan matrix [5]. The electrolyte was characterized in terms of printability, as well as conductivity and temporal stability via electrochemical impedance spectroscopy (EIS). Screen-printed layers with a thickness of 5-10 µm and a width of 500 µm were achieved, demonstrating potential for further scaling and integration. The material exhibits a conductivity of 4 mS/cm, which is among the higher values reported for eutectogels in the literature [2, 3, 4] and retains stable performance over 30 days. These findings point to the relevance of eutectic gels across multiple fields, particularly in electrochemical sensing [4]. This motivated us to investigate the eutectic gel as an electrolyte in EGTs, employing transistors based on PEDOT:PSS and graphene, fabricated on flexible PET and Kapton substrates. The PEDOT:PSS transistor exhibits an $\mathrm{I_{ON}/I_{OFF}}$ ratio of approximately 200, maximum transconductance $g_m = 0.7$ mS and subthreshold slope SS = 96 mV/dec. Notably, the ambipolar nature of graphene, combined with the high capacitance of the eutectic gel electrolyte, prompted us to explore these devices for neuromorphic computing, where they successfully exhibited synaptic transistor behavior, including potentiation and depression responses.

These results highlight the potential of eutectic gels as a versatile electrolyte platform for next-generation flexible and bio-inspired electronics.

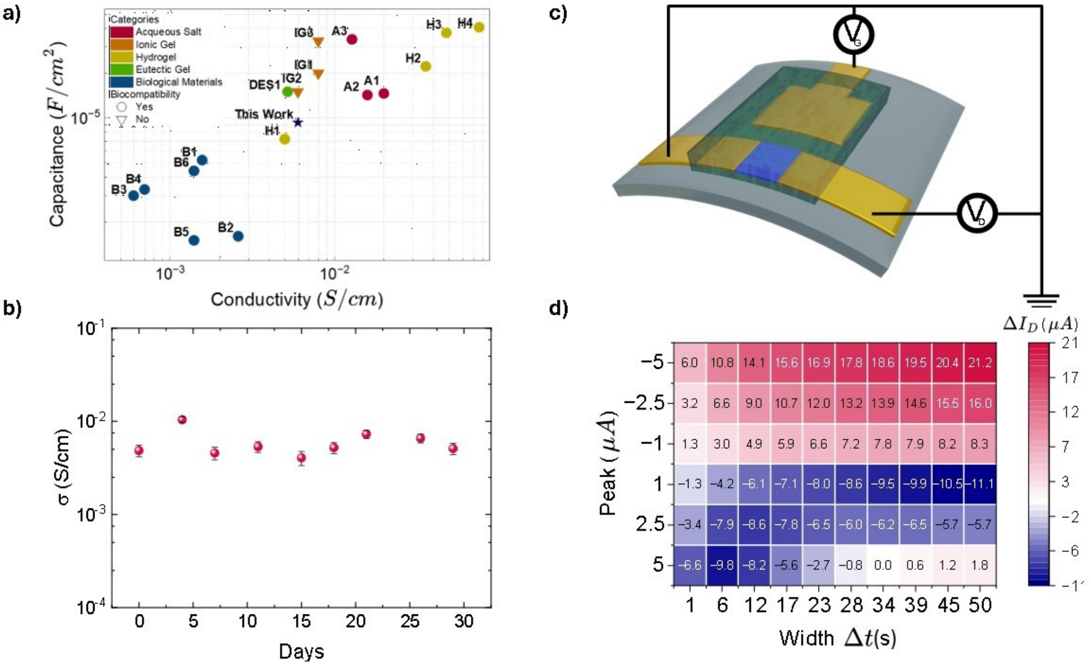

Figure 1: *a)Overview of electrolytes reported in the literature, classified in terms of conductivity and capacitance, highlighting the position of the present work; b) Temporal stability of the ionic conductivity of the eutectic gel electrolyte over 30 days; c) Schematic illustration of the EGTs; d) Color maps of drain current modulation under current pulses stimulation.*

References

[1] P. A. Mercadal et al., JACS Au, **2024**, 4, 3744–3758, DOI:10.1021/jacsau.4c00677.

[2] J. Wang, S. Zhang, Z. Ma, e L. Yan, Green Chem. Eng., **2021**, 2, 359–367, DOI:10.1016/j.gce.2021.06.001.

[3] S. Sun et al., Appl. Mater. Today, **2024** 39, 102342, DOI:10.1016/j.apmt.2024.102342.

[4] A.Nicolau, A. L.Mutch, S. C.Thickett, Macromol. Rapid Commun., **2024**, 45, 2400405, DOI:https://doi.org/10.1002/marc.202400405

[5] W. Liu et al., Int. J. Biol. Macromol., **2025**, 286, 138229, DOI:10.1016/j.ijbiomac.2024.138229.

Aging in Aqueous Capillary Suspensions Revealed by Spatially Resolved Laser Speckle Imaging

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S. Stoyanov[1,2], J. van der Gucht[1]
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Colloidal gels are formed by short-range attractive particle-particle interactions that produce space-spanning networks with elastic, solid-like mechanical properties [1]. An example of particular interest is capillary suspensions, where cohesion arises from liquid bridges rather than direct molecular interactions. We have recently introduced a new type of capillary suspension in which bridges arise from an aqueous two-phase system (ATPS), where coexisting PEG-rich and dextran-rich phases produce bridges with ultralow interfacial tension [2]. The resulting networks are soft gels with mechanical properties tunable through polymer concentration, making them well suited for studying the aging of capillary suspensions, a process largely unexplored for this class of material.

In this work, we study four compositions spanning 20 to 30 wt% total polymer concentration, which controls capillary bridge strength at fixed particle volume fraction. Aging is monitored simultaneously by bulk oscillatory rheometry and Laser Speckle Imaging (LSI), a non-invasive technique well suited to study opaque, highly scattering suspensions. From the pixel-level intensity structure function d_2, we construct time-resolved activity maps and extract parameters including global activity, spatial heterogeneity, and their co-evolution over 24 h.

For all compositions studied, aging proceeds as a progressive suppression of particle activity with a clear compositional ordering, confirmed by a monotonic increase in storage modulus G' measured by rheometry. This suppression is not uniform across lag-time scales: fast dynamics at short lag times flatten early and completely, while slow collective rearrangements persist longer and are punctuated by intermittent bursts of activity. The spatial mode of this arrest depends fundamentally on network strength and is not resolved by bulk rheometry, but is directly accessible by LSI. The weakest network ages homogeneously, while stronger networks develop pronounced spatial heterogeneity as residual mobility concentrates into increasingly small and localized regions. Two compositions with similar bulk elastic moduli follow qualitatively different spatiotemporal pathways: one through spatially extended rearrangements that shift across the sample, the other through compact hotspots that recur persistently at fixed spatial locations. Together, rheometry and LSI provide a more complete picture of aging dynamics than either technique alone, an approach extendable to other opaque colloidal gels where bulk measurements alone are insufficient.

References

[1] Y. M. Joshi *Annual Review of Chemical and Biomolecular Engineering* **2014**, *5*, 181. DOI:10.1146/annurev-chembioeng-060713-040230

[2] L. Ruiz-Martínez, F. Leermakers, S. Stoyanov, J. van der Gucht *Langmuir* **2025**, *41*, 11604. DOI:10.1021/acs.langmuir.5c00749

Surfaces, Interfaces, and Emulsions

Monday 18 May 15:00 – 17:40

Dirty Linen: evaporation and imbibition of blood droplets from and into fabrics

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It would be desirable if the forensic science of blood spatter analysis could be placed on a sound physics-based understanding, but the imbibition of complex fluids into capillary porous materials such as fabrics remains an underexplored and challenging problem for soft matter physics. In this contribution, I will present the work that we have done on two minimal models for fabric surfaces. On the superhydrophobic Glaco-coated surface a droplet of freshly drawn (not anti-coagulated) blood forms a sessile spherical cap. The evaporation and sedimentation dynamics mean that the dried droplet adopts the re-entrant, Gugelhupf-like, shape shown in the cryo-SEM image below. Optical coherence tomography measurements taken during the drying process, indicate that early in the process a skin layer is formed. The Gugelhupf-like shape and this skin layer seem to drive the characteristic single-crack that forms in the dried droplet.

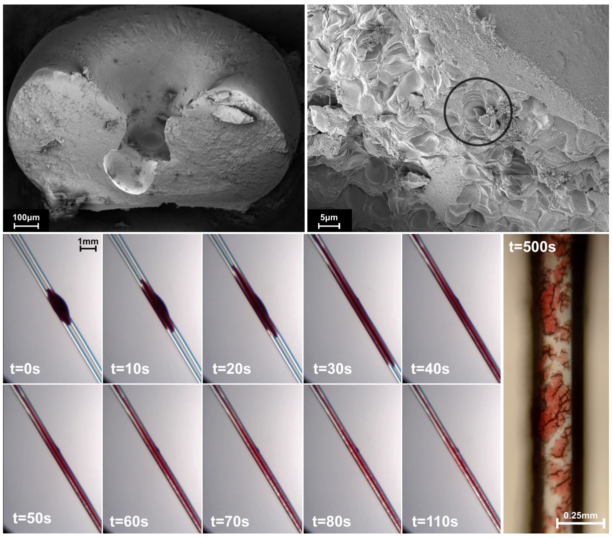

Figure 1: *The upper panel shows a cryo-SEM image of a droplet of blood after drying on a Glaco-coated superhydrophobic surface. The lower panel shows a blood droplet spreading and evaporating on two parallel nylon fibers which is our simplest model for a fabric.*

On two parallel fibers, capillarity leads to a zipping of the fibers. As discussed by Brochard-Wyart and Corpart, respectively, the cylindrical fiber geometry results in very different spreading & deposition characteristics than for flat substrates. I will also use phase field modelling to show that the physics can be captured by a particulate/polymer/volatile ternary, which should mean that the results translate to a wide range of formulated ternaries.

References

[1] F. Brochard-Wyart *J. Chem Phys* **1986**, *84*, 4664. DOI:10.1063/1.449993 ; Corpart *et al.* *J. Fluid Mechanics* **2023**, *957*, A2. DOI:10.1017/jfm.2023.59

Protein corona of Hevea brasiliensis field latex

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Hevea brasiliensis field latex are known to be stabilized by a complex interfacial layer composed mainly of proteins and lipids, forming a so-called protein corona surrounding the rubber particles. This surface layer plays a key role in determining the surface charge and colloidal stability of latex dispersions [1, 2, 3]. However, the nature, distribution, and role of these corona proteins in stabilizing the latex particles remain incompletely understood. In this work, we investigate the electrokinetic properties of field latex and the behavior of its protein corona in order to better understand the mechanisms governing latex stability. First, the electrokinetic behavior of Hevea brasiliensis field latex were investigated by examining the effects of ionic strength and pH on electrophoretic mobility. Fitting the mobility data using Ohshima's soft particle model yielded a charge density Z_N of approximately −373 mM and an ionic permeability layer thickness of ~2 nm, confirming the presence of a permeable polymer corona at the particle surface [4]. The effect of pH (2–12) revealed an isoelectric point around pH 3.5–4.0, consistent with the fact that the surface charge of field latex is imposed by the amphoteric properties of proteins on the latex external corona [2]. Then, we looked at the nature and distribution of these proteins. Adsorption of a cationic surfactant, sodium dodecyl sulfate (SDS), led to an increased negative electrophoretic mobility and more importantly to displacement of proteins from the latex corona to the serum [5]. An analysis of the total amount of the displaced proteins and of their nature by proteonomics is currently underway. The ultimate goal is to get a more precise description of the proteins stabilizing field hevea latex. Current work also aims to elucidate the interaction between SDS and the protein corona, by determining whether SDS primarily adsorbs onto the latex particle surface, partially replaces surface proteins, or whether both mechanisms occur simultaneously, through comparative analysis of protein distribution in the cream and serum phases.

References

[1] Blackley, D. C. (1997). Polymer Latices: Science and Technology (Vol. 1). Springer.

[2] Hunter, R. J. (1981). Zeta Potential in Colloid Science: Principles and Applications. Academic Press.

[3] Nawamawat, K., Sakdapipanich, J., & Ho, C. C. (2011). Characterization of proteins in the rubber particle surface of Hevea brasiliensis. Colloids and Surfaces B: Biointerfaces, 82, 424–429. https://doi.org/10.1016/j.colsurfb.2010.09.012

[4] Ohshima, H. (1995). Electrophoresis of soft particles. Advances in Colloid and Interface Science, 62, 189–235. https://doi.org/10.1016/0001-8686(95)00214-I

[5] Rosen, M. J., & Kunjappu, J. T. (2012). Surfactants and Interfacial Phenomena (4th ed.). Wiley.

Studying adhesion patches between DNA-coated colloidal droplets using optical tweezers

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(Dated: March 2025)

DNA functionalisation of colloids allows for specific binding between particles, making these systems suitable building blocks for the design of complex structures[1]. Our system consists of emulsion droplets coated with DNA, where DNA molecules can migrate through the surface of the droplets. As two droplets with complimentary DNA meet, DNA molecules accumulate on the binding site, forming a patch. The shape of the patch changes between disk-shaped and ring-shaped with different DNA concentrations[2], with the DNA molecules exerting forces strong enough to deform the droplets at the higher concentrations. Most previous studies have tuned adhesion through DNA coverage, surface tension, or temperature[3], and in our work we show that electrolyte concentration offers an equally powerful and complementary control parameter. Using confocal microscopy and optical tweezers, we quantify the patch size, DNA binder density, and morphological transition from ring to disk adhesion patches as a function of $MgCl_2$.

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[1] A. McMullen, M. Muñoz Basagoiti, Z. Zeravcic, and J. Brujic, "Self-assembly of emulsion droplets through programmable folding," *Nature*, vol. 610, no. 7932, pp. 502–506, 2022.

[2] A. McMullen, S. Hilgenfeldt, and J. Brujic, "Dna self-organization controls valence in programmable colloid design," *Proceedings of the National Academy of Sciences*, vol. 118, no. 46, 2021.

[3] N. Judd, A. McMullen, S. Hilgenfeldt, and J. Brujic, "Statistical Mechanics Approach to DNA-Driven Droplet Deformation and Adhesion," *Physical Review Letters*, vol. 134, p. 058202, Feb. 2025.

Probing the nanoscale structure of microgels at the air-liquid interface: *In situ* X-ray reflectometry

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Microgels are soft, three-dimensional colloidal networks whose surface activity and mechanical properties are precisely tuned *via* cross-linker density [1]. While their stimuli-responsive behaviour in the bulk phase is well-documented, the transition of these particles to a fluid interface induces dramatic structural deformations, typically resulting in a “fried-egg” morphology. Accurately capturing this interfacial arrangement requires characterisation that can resolve both vertical density profiles and lateral organisation without the artefacts inherent in film transfer.

In this work, we employ *in situ* specular and off-specular X-ray reflectivity to provide a comprehensive structural map of polymer microgels at the air-water interface [2]. While atomic force microscopy (AFM) offers high-resolution snapshots of transferred films, we prioritise off-specular scattering to directly probe the long-range lateral ordering and the of the microgel monolayer *in situ*. Specifically, we examine how this interfacial landscape is modulated by cross-linker density, subphase temperature, and ionic strength (i.e., specfic ion effects). Our results demonstrate that the cross-linker density has a clear impact on the lateral ordering of microgels (Figure 1), while temperature modulations drive a reversible collapse of the corona.

Furthermore, by comparing these *in situ* X-ray profiles with *ex situ* AFM of Langmuir-Blodgett films, we quantify the structural distortions introduced during the deposition process. This study highlights the necessity of off-specular X-ray techniques in resolving the complex, hierarchical structure of soft matter at fluid boundaries, providing a blueprint for the design of responsive, two-dimensional microgel assemblies.

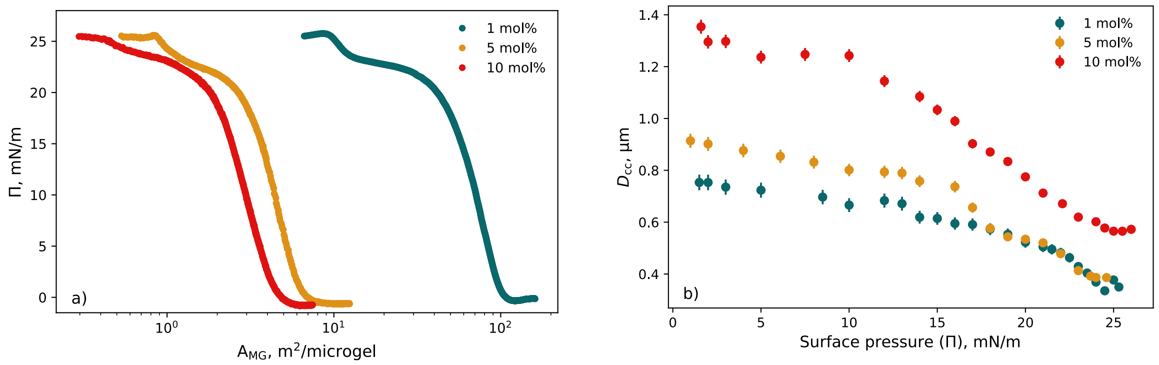

Figure 1: *a) Langmuir compression isotherms of a polymer microgel at the air-water interface as a function of cross-linker concentration. b) Corresponding microgel centre-to-centre distance* (D_{cc}) *as a function of surface pressure and cross-linker concentration.*

References

[1] M. Karg *et al. Langmuir* **2019**, *35*, 6231–6255. DOI: 10.1021/acs.langmuir.8b04304

[2] H. Robertson *et al. Soft Matter* **2026**, *22*, 127–138. DOI: 10.1039/D5SM00115C

From Tip to Ship: Characterisation of new Zinc-PDMS Anti-fouling Coatings After Ageing

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Biofouling is a well-documented problem on marine structures, with fouling of these surfaces increasing costs and reducing the operational lifetime of structures. Common anti-fouling strategies rely on biocides, killing fouling organisms coming in close contact with the coated surfaces during the early stages of biofouling, however these have detrimental impacts on marine ecology. One alternative method entails varying the surface energies of coatings via chemical microphase separation, preventing binding of fouling organisms. Herein, we investigate a promising new industrial strategy for a Zinc and PDMS polymer-based anti-fouling coating that combines these properties together with nanoscale control of the surface amphilicity. This strategy can easily be scaled up, however its specific mode of action and evolution after aging are not fully understood.

Using Atomic Force Microscopy in solution, we characterise differences between candidate coatings, quantifying nanoscale structural and viscoelastic properties after aging in seawater to reveal changes in these coatings' characteristics over time. These properties include the evolution in the coating surface microphase separation, with potential future testing investigating the quantity of fouling protein adhesion to quantify antifouling performance of the coatings upon ageing.

References

[1] D. S, Thomason J, Biofouling. 1st ed. Pg. 429. ISBN: 978-1-4051-6926-4

[2] Watson, G. J., Pini, J. M., Richir, J. Environmental Pollution, 2018, 243, Pg. 1498–1508. https://doi.org/10.1016/j.envpol.2018.09.091

[3] Pourhashem, S., et al. Journal of Materials Science & Technology, 2022 118, Pg. 73–113. DOI: 10.1016/j.jmst.2021.11.061

[4] Chen, R et al. RSC Advances, 2017, 7(63), Pg. 40020–40027. DOI: 10.1039/C7RA04840H

Slip dynamics in soft arrested materials under squeeze-flow deformation

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Abstract: This study investigates slip dynamics in soft-arrested materials using a squeeze-flow approach, with the aim of establishing a generic relationship between slip behavior and the degree of structural arrest or jamming. The study encompasses two major classes of physically arrested systems with distinct arrest mechanisms: field-responsive fluids, including electrorheological and thermoresponsive materials, in which jamming is induced by external electric fields or temperature variations; and physically aging soft glassy materials, where arrest arises from time-dependent microstructural evolution. Squeeze-flow experiments were performed under compression and elongation modes by measuring the normal force as a function of inter-plate gap while systematically varying the relevant jamming parameter (electric field strength, temperature, or sample age). A pronounced influence of structural arrest on squeeze-flow behavior was observed across all systems. The experimental data were analyzed using friction-based squeeze-flow models for compression and slip-layer models for elongation, enabling quantitative estimation of slip characteristics such as effective friction coefficient and slip-layer thickness. A strong correlation was found between the magnitude of slip and the driving force associated with physical arrest. These results establish a universal link between slip dynamics and jamming in soft-arrested materials and demonstrate that squeeze-flow fields and jamming strength can be used to tailor slip behavior for applications in microfluidics, precision printing, and industrial transport of complex fluids.

Keywords: squeeze-flow, electrorheological fluid, physically aging soft glassy material, wall slip

Young Scientists

Tuesday 19 May 09:45 – 12:55

Magnetic Hyperthermia in Soft Matter: A Physics-Informed Machine Learning Approach

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Magnetic Hyperthermia (MH) consists of generating heat by irradiating magnetic nanoparticles (MNPs) embedded into a matrix with an oscillatory magnetic field. This technology is widely used in oncology to eliminate malignant tumors as well as in polymer processing where it helps to heal materials and in chemistry where it plays a crucial role in catalysis. Beyond intrinsic MNPs properties, a major obstacle to the broader deployment of MH lies in the role of the surrounding environment. In soft matter systems in particular, MNPs translation and rotation can drastically modify the generated heat, making the matrix an active component of the process rather than a passive host.[1]

In this presentation, I will outline several strategies to rationalize the complex behavior of MNPs in soft matter, by relying on physical models of increasing sophistication. Our approach leverages computation and Machine Learning to iteratively develop and validate the underlying physics. First, I will show how heat-equation based physical models applied to a set of systematic experimental results enable the identification of a global scenario that serves as a baseline for more advanced methods. Then, I will introduce the Sparse Identification of Nonlinear Dynamics (SINDy) algorithm, proposing a purely statistical approach to fit the temperature vs. time curves. Finally, I will describe how the two previous methods can be combined into a Physics Informed Machine Learning [2] approach serving to fully rationalize MH in complex media based on a limited amount of experimental data. By pursuing this strategy, we seek to transform MH from an empirical technique into a predictive and transferable platform for a wide range of engineering applications.

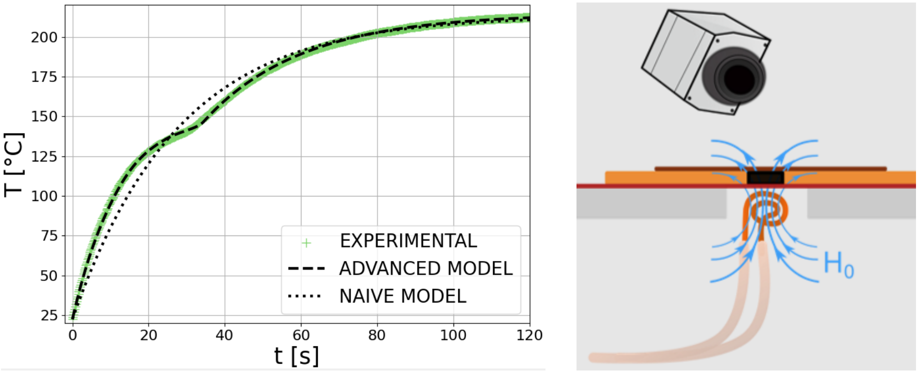

Figure 1: (Left) Temperature vs. time of a polypropylene matrix loaded with 12% vol. of MNPs irradiated with a 855 kHz magnetic field (IR camera measurement). (Right) Scheme of the experimental setup.

References

[1] A. Pommella, et al., ACS Nano, 2023, 17, 17394-17404.
[2] S. L. Brunton, J. L. Proctor and J. N. Kutz, PNAS, 2016, 113, 3932-3937.

Optimization of Existing Cyclic Peptide Binders Using a Structure-Guided Design Approach

S. Multari [1,2], C. Fregonese[1], M. Grazioso[3,4], T. Skrbic[1], M. Simeoni[3], M.A. Soler[1], M.S. Nobile[3], A. Angelini[1], A. Giacometti[1]
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Nucleic acid-based therapeutics, including DNA, RNA, and their synthetic analogues, hold immense potential for treating a wide range of diseases by modulating gene expression or encoding therapeutic proteins [1]. Despite their promise, efficient delivery to target cells remains a major challenge due to poor cellular uptake, susceptibility to nucleases, and off-target effects, which limit their clinical application. Active targeting using ligands that recognize specific cell-surface receptors has emerged as a promising strategy to enhance tissue-specific delivery. Among potential ligands, cyclic peptides offer a favorable combination of high receptor specificity, stability against proteolytic degradation, favorable pharmacokinetics, and scalable chemical synthesis, making them ideal candidates for targeted nucleic acid delivery [2]. We propose a structure-based Monte Carlo algorithm [3] for the *in silico* optimization of cyclic peptides, aiming to improve both binding affinity and selectivity toward tissue-specific receptors (Figure 1). The pipeline iteratively mutates a reference peptide, predicts three-dimensional structures using AlphaFold 3 [4], and evaluates interactions through molecular docking with Vina [5, 6] and molecular dynamics simulations with OpenMM [7, 8, 9]. A Metropolis acceptance criterion balances exploration and exploitation of the sequence space, enabling efficient identification of high-affinity variants [10]. The workflow was validated on a benchmark set of published peptide-receptor complexes [11], demonstrating robustness and reproducibility in predicting favorable binding conformations. Applied to the CD8 transmembrane glycoprotein [12], our approach successfully identified peptide variants with enhanced receptor engagement, suggesting their potential for improved tissue-selective delivery of nucleic acids. Future work will focus on further reducing computational cost by integrating deep learning–based screening methods to pre-evaluate peptide variants prior to molecular dynamics refinement. This integration aims to accelerate the discovery process while retaining the accuracy of structure-based evaluations. Overall, the proposed Monte Carlo framework provides a versatile and computationally robust strategy for the rational design of cyclic peptides, enabling accelerated development of targeted nucleic acid therapeutics with enhanced efficacy and minimized off-target effects.

References

[1] S. Naeem, J. Zhang, Y. Zhang, Y. Wang *Molecular Therapy Nucleic Acids* **2025**, *36*, . DOI:DOI

[2] A. Angelini, L. Cendron, S. Chen, J. Touati, G. Winter, G. Zanotti, C. Heinis *ACS Chemical Biology* **2012**, *7*, 817. DOI:DOI

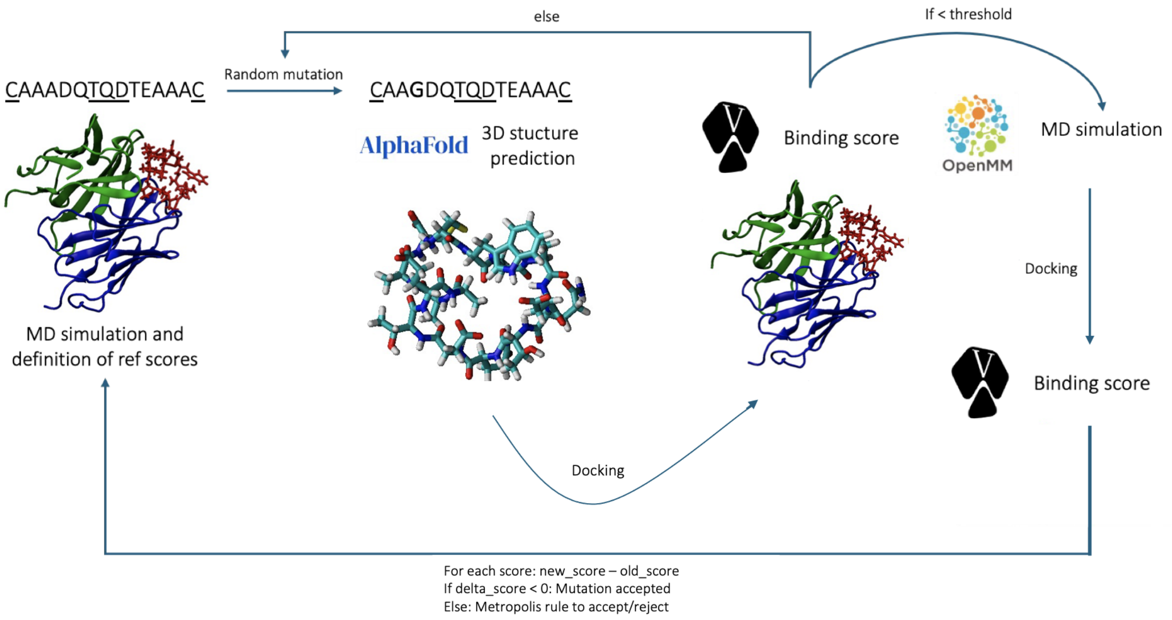

Figure 1: *Overview of the structure-based Monte Carlo pipeline used to optimize cyclic peptides.*

[3] N. Metropolis, S. Ulam *Journal of the American Statistical Association* **1949**, *44*, 335. DOI:DOI

[4] J. Abramson, J. Adler, J. Dunger, R. Evans, T. Green, A. Pritzel, O. Ronneberger, L. Willmore, A. J. Ballard, J. Bambrick et al. *Nature* **2024**, *630*, 493. DOI:DOI

[5] X.-Y. Meng, H.-X. Zhang, M. Mezei, M. Cui *Current Computer-Aided Drug Design* **2011**, *7*, 146. DOI:DOI

[6] O. Trott, A. J. Olson *Journal of Computational Chemistry* **2010**, *31*, 455. DOI:DOI

[7] M. P. Allen *Computational Soft Matter: From Synthetic Polymers to Proteins* **2004**, *23*, 1. DOI:DOI

[8] F. R. Salsbury Jr. *Current Opinion in Pharmacology* **2010**, *10*, 738. DOI:DOI

[9] P. Eastman, R. Galvelis, R. P. Peláez, C. R. A. Abreu, S. E. Farr, E. Gallicchio, A. Gorenko, M. M. Henry, F. Hu, J. Huang et al. *The Journal of Physical Chemistry B* **2023**, *128*, 109. DOI:DOI

[10] C. P. Robert, G. Casella *Introducing Monte Carlo Methods with R* **2009**, , 167. DOI:DOI

[11] M. A. Soler, A. Rodriguez, A. Russo, A. F. Adedeji, C. J. D. Foumthuim, C. Cantarutti, E. Ambrosetti, L. Casalis, A. Corazza, G. Scoles et al. *Physical Chemistry Chemical Physics* **2017**, *19*, 2740. DOI:DOI

[12] D. K. Cole, B. Laugel, M. Clement, D. A. Price, L. Wooldridge, A. K. Sewell *Immunology* **2012**, *137*, 139. DOI:DOI

Dynamics of highly viscous shear thickening droplet impact on a solid surface

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Investigations into droplet impact dynamics have focused extensively on Newtonian fluids and low-viscosity non-Newtonian fluids. However, research on highly viscous non-Newtonian fluids remains scarce [1-2]. This study focuses on polystyrene–glycerol suspensions to investigate both short-time impact dynamics and long-time spreading behavior of highly viscous shear thickening droplets impacting solid surfaces. Experiments reveal an initial freezing pattern upon impact, with shear thickening increasing the minimum droplet height. Most of the initial kinetic energy is dissipated by shear thickening at impact, whereby the thickened layer is concentrated in a thin region a few micrometers above the droplet base. Shear thickening significantly reduces the maximum value of the spreading index n in the power-law relation $R \sim t^n$, while also prolonging the period over which n continues to increase. Although n typically decreases with increasing Weber number, it can increase under shear thickening conditions. These phenomena unique to shear thickening droplets have significant implications for future control of droplet impact.

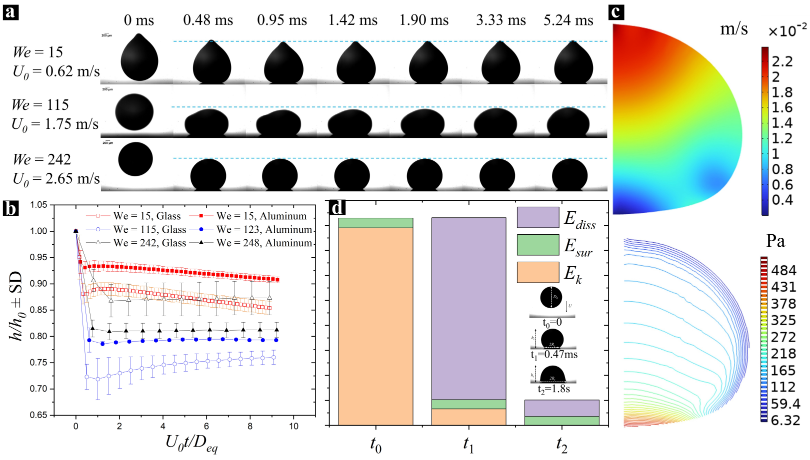

Figure 1: *Impact of 55 vol% polystyrene–glycerol droplets on glass: (a) Impact dynamics at different Weber numbers (b) Droplet height evolution on two substrates (c) Velocity and pressure distribution upon impact and (d) Energy composition at different instants, including dissipated energy* E_{diss}*, surface energy* E_{surf}*, and kinetic energy* E_k*.*

References

[1] F. Boyer, E. Sandoval-Nava, J. H. Snoeijer, J. F. Dijksman, and D. Lohse *Phys. Rev. Fluids* **2016**, *1*, 013901. DOI:10.1103/PhysRevFluids.1.013901

[2] A. Mobaseri, S. Kumar, and X. Cheng *Proc. Natl. Acad. Sci. U.S.A.* **2025**, *122*, e2500163122. DOI:10.1073/pnas.2500163122

Development of model systems and testing protocols for optimizing skin interactions with absorbent hygiene products

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Prolonged skin occlusion associated with absorbent hygiene products creates a microenvironment characterized by increased hydration, elevated temperature, and altered pH, which can disrupt epidermal barrier function and promote irritation, inflammation, and microbial imbalance. Excess moisture softens corneocytes and increases friction, while pH elevation weakens the antimicrobial defence of the skin and facilitates irritant penetration [1]. These processes contribute to the development of incontinence-associated dermatitis, a multifactorial inflammatory skin condition affecting millions of individuals with urinary incontinence worldwide [2]. The condition is particularly common among older or immobile individuals, whose skin is more fragile and slower to recover from mechanical and chemical stress. This research aims to develop reproducible experimental approaches to investigate skin-product interactions under conditions representative of prolonged occlusion. Multi-Purpose Artificial Urine (MP-AU) [3] was identified as a reliable surrogate for human urine, accurately reproducing key physicochemical parameters. The model fluid was used to investigate the wetting behaviour of multilayer absorbent materials. MP-AU was applied as a model fluid to each diaper layer to evaluate the contact angle, a parameter indicative of fabric wettability (contact angle > 90° hydrophobic, < 90° hydrophilic). These measurements provide insight into liquid-material interactions and liquid distribution dynamics within absorbent product supporting the development of standardized laboratory models for skin-product interaction studies and the design of skin-compatible absorbent materials that help maintain a healthier skin microenvironment. This work investigates a complex active soft matter system in which skin dynamically interacts with a multilayer porous material in the presence of a biologically relevant fluid. This engineering-driven approach enables quantitative analysis of coupled interfacial and transport phenomena at the skin-material interface, bridging soft matter science and absorbent product design.

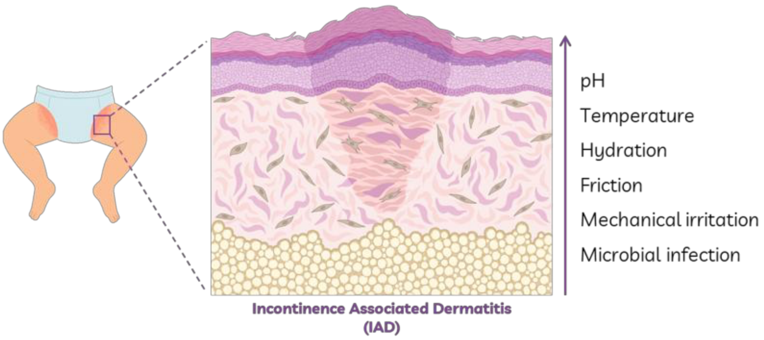

Figure 1: *Development of diaper dermatitis.*

References

[1] R. Liuzzi, A. Carciati, S. Guido, S. Caserta, *Colloids and Surfaces B: Biointerfaces*, **2016**, 139, 294-305, DOI: 10.1016/j.colsurfb.2015.11.064

[2] J. K. Bender, J. Faergemann, M. Sköld, *Dermatology and therapy*, **2017**, 7, 319-330, DOI: 10.1007/s13555-017-0189-y

[3] N. Sarigul, F. Korkmaz, İ. Kurultak, *Scientific reports,* **2019**, 9, 20159, DOI: https://doi.org/10.1038/s41598-019-56693-4

Thermal Signatures of Mucin-Based Samples Studied by Differential Scanning Calorimetry

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Mucus is a viscoelastic gel that protects the airways through mucociliary clearance (MCC). In chronic respiratory diseases such as COPD and cystic fibrosis, mucus becomes more concentrated and its solid fraction increases, altering its viscoelastic properties, reducing MCC efficiency, and promoting pathogen retention [1]. From a scientific point of view, testing uncontaminated mucus relies either on bronchoscopy with direct aspiration of mucus plugs or on cell cultures; in both cases, the amount of undiluted material available for analysis is often small and highly variable [2]. Analytical methods capable of working with limited sample quantities are therefore especially valuable.

Here we apply differential scanning calorimetry (DSC) to mucin based samples. Compared with pure water, mucin-containing samples display a broadened melting peak, consistent with cryoscopic lowering due to the presence of salts, proteins and mucins. In addition to this colligative effect, additional thermal features emerge upon cooling, reflecting the confinement of mucins and solutes between growing ice crystals.

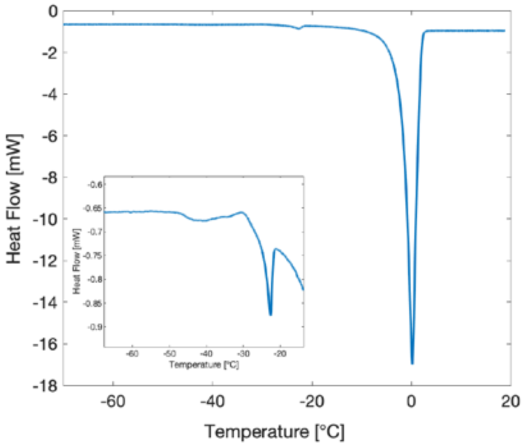

Figure 1: *Main: Characteristic thermogram of a mucin-based sample. Inset: zoom in on a region of the thermogram showing the glass transition temperature (T_g), the recrystallization temperature (T_r) and the hydroalite melting peak.*

Overall, our results show that DSC can detect composition and structure dependent changes in mucin based samples and may serve as a useful complementary technique for probing the physical state of respiratory mucus.

References

[1] Abrami, M., Biasin, A., Tescione, F., Tierno, D., Dapas, B., Carbone, A., Grassi, G., Conese, M., Di Gioia, S., Larobina, D., & Grassi, M. *International Journal of Molecular Sciences*, **2024**, 25, 1933, DOI: 10.3390/ijms25031933.

[2] J. Charriot, M. Volpato, A. Petit, I. Vachier, A. Bourdin, *Cells*, **2022**, 11, 812, DOI: 10.3390/cells11050812.

Design and function via frontal photopolymerisation: from printing to soft actuation

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Autonomous and origami-inspired material design has emerged as a powerful strategy for creating complex, functional structures, spanning multiple lengths and timescales, with applications ranging from soft robotics and biomedical devices to adaptive architectural components. Frontal photopolymerization (FPP) has emerged as a versatile and scalable approach to generate planar, multilevel and gradient polymer networks. FPP is a class of photopolymerization processes for which, under conditions of strong light attenuation and limited mass and diffusion processes, a sharp traveling solidification front develops and propagates into the liquid monomer. While the spatiotemporal evolution of FPP networks can become complex, and even autocatalytic for highly exothermic processes, a range of photopolymer systems exhibit surprisingly simple kinetics with time-invariant, propagating, conversion profiles. Here, we examine the spatiotemporal response and kinetics of asymmetric networks fabricated by FPP, focusing on the evolution of pattern curvature over time. We then design autonomous functional structures, able to perform directional jump, underwater 'push' and switch configuration driven by the response of asymmetric FPP networks.

From Nature to Nurture: Biomimetic Viscoelastic Scaffolds for Lung Tissue Regeneration

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Lung cancer is the leading cause of cancer-related deaths worldwide, accounting for the highest mortality rates[1]. Extracorporeal membrane oxygenation (ECMO) is used as a life-support tool for critically ill patients who cannot survive with optimal medical therapy. However, there is ongoing controversy over whether patients on ECMO should receive lung transplantation[2]. Lung transplantation remains the only option for approximately 25 million patients worldwide[3]. While the use of decellularized lung scaffolds has shown promise in regenerative medicine, progress is constrained by limited donor availability and inconsistencies in scaffold quality[4].

In the present study, we explore how biopolymers can effectively contribute to regenerate pulmonary tissue. The lung ECM is a macromolecular structure that provides mechanical support, stability and elastic recoil for different pulmonary cells[5]. Investigating viscoelastic biomaterials to replicate the lung ECM could lead to the development of models and, ultimately, real-life solutions for pulmonary diseases.

In this work, we investigate the mechanical, flow, and morphological properties of porcine lungs used as a benchmark, and biopolymers such as agar, alginate and chitosan, which can be promising materials for lung regeneration. Rheological and mechanical testing revealed that lung tissue exhibits viscoelastic behaviour characteristic of soft biological materials[6]. Preliminary results show that the double network Poly(vinyl alcohol)/Agar hydrogels prepared using the freeze-thaw method exhibit mechanical responses within the same range as native lung tissue, highlighting their potential as biomimetic scaffolds for lung regeneration.

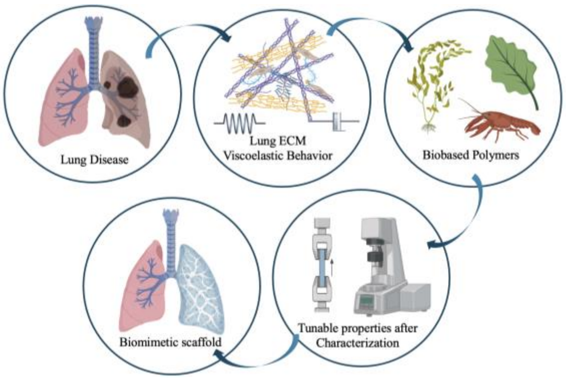


Figure 1: *Biobased polymers are being investigated to reproduce the lung ECM to serve as a scaffold*

References

[1] Li C, Lei S, Ding L, Xu Y, Wu X, Wang H, et al. Global burden and trends of lung cancer incidence and mortality. *Chinese Medical Journal*. 2023 Jul 5;136(13):1583–90. doi:10.1097/CM9.0000000000002529

[2] Toyoda Y, Bhama JK, Shigemura N, Zaldonis D, Pilewski J, Crespo M, et al. Efficacy of extracorporeal membrane oxygenation as a bridge to lung transplantation. *J Thorac Cardiovasc Surg*. 2013 Apr;145(4):1065–71. doi:10.1016/j.jtcvs.2012.12.067

[3] O'Neill JD, Anfang R, Anandappa A, Costa J, Javidfar J, Wobma HM, et al. Decellularization of Human and Porcine Lung Tissues for Pulmonary Tissue Engineering. *Ann Thorac Surg*. 2013 Sep 1;96(3):1046–56. doi:10.1016/j.athoracsur.2013.04.022

[4] Stabler CT, Lecht S, Mondrinos MJ, Goulart E, Lazarovici P, Lelkes PI. Revascularization of decellularized lung scaffolds: principles and progress. *Am J Physiol Lung Cell Mol Physiol*. 2015 Dec 1;309(11):L1273–85. doi:10.1152/ajplung.00237.2015

[5] White ES. Lung extracellular matrix and fibroblast function. *Ann Am Thorac Soc*. 2015 Mar 1;12(Suppl 1):S30–3. doi:10.1513/AnnalsATS.201406-240MG

[6] Suki B, Stamenović D, Hubmayr R. Lung parenchymal mechanics. In: Prakash YS, editor. *Comprehensive Physiology*. 1st ed. Wiley; 2011. p. 1317–51. doi:10.1002/cphy.c100033

Surfactant vesicle suspensions represent a paradigmatic class of soft colloidal systems with tunable interactions, finding applications in industrial formulations and in biomedical contexts. When charged vesicles coexist with electrolytes in solution, long-range electrostatic repulsion governs phase behaviour, microstructure, and transport properties, making these systems ideal model platforms to explore the interplay between microscopic interactions and emergent collective behaviour.

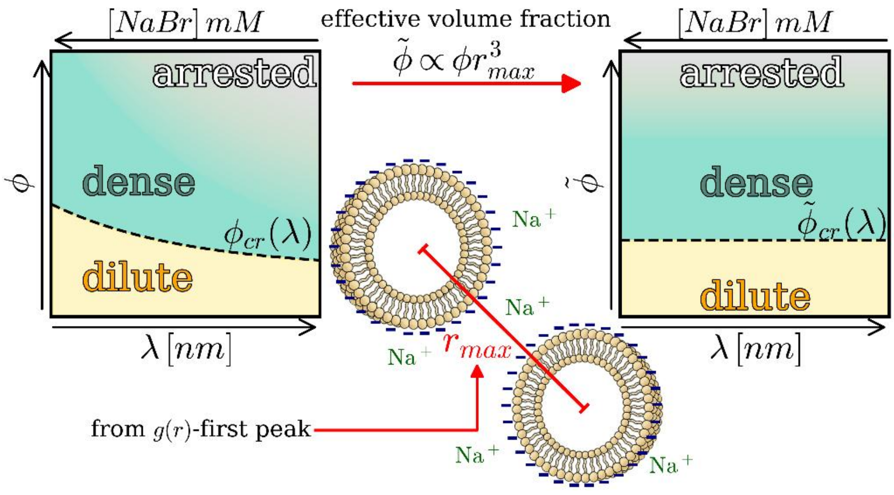
In this talk, I will present results [1] of a large numerical campaign of Brownian dynamics simulations of polydisperse charged vesicles in sodium bromide solutions, spanning a wide range of volume fractions and salt concentrations. Interaction parameters employed in our simulations are directly derived from microscopic force measurements between double layers of an amphiphilic surfactant commonly adopted in the formulation of vesicles for liquid fabric softners.

I will show that the inspection of the structural and dynamical microscopic features of the suspensions allows for the construction of a colloidal state diagram in which both the dilute-to-dense crossover in the fluid-like regime and the fluid-to-arrested state transition shift systematically towards lower volume fractions as salt concentration decreases.

Also, I will illustrate that a key result of our work is the clearcut identification of an effective volume fraction, which is capable of collapsing both thermodynamic and dynamic quantities onto salt-independent mastercurves. We further give an interpretation of this rescaling factors in terms of microscopic observables, thus assessing the long-standing issue of determining effective volume fraction in charged colloidal suspensions from a novel perspective.

All results that I will describe reveals a form of universality in the behaviour of charged vesicle suspensions, in which the emerging complexity of the system can be rationalized in terms simple structural indicators, offering a powerful predictive framework for the formulation of charged colloidal systems.

[1] Siciliano, A., Pastore, R., Greco, F., & Rusciano, F. (2025). An Effective Volume Fraction Controls Both Dynamics and Thermodynamics in Vesicle Suspensions with Tunable Electrostatic Interactions. *Industrial & Engineering Chemistry Research*, *64*(38), 18938-18949.



Biological Soft Matter I

Tuesday 19 May 15:00 – 18:00

Active membrane deformations of a synthetic cell-mimicking system

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Biological cells are fascinating micromachines capable of adapting their shape due to the complex interaction between a deformable membrane and the dynamic activity of the cytoskeleton. We investigate the behavior of an active synthetic cell-mimicking system (see Fig. 1) using simulations and experiments [1]. In simulations, the model consists of a fluid vesicle with a few encapsulated growing filaments. In experiments, giant vesicles contain an active cytoskeletal network composed of microtubules, crosslinkers, and molecular motors. These active vesicles show strong shape fluctuations reminiscent of shape changes of biological cells. We analyze membrane fluctuations and show how the intricate coupling between soft confinement and internal active forces results in fluctuation spectra with distinct spatial and temporal scales, differing significantly from those of passive vesicles. Simulations demonstrate the universality of this behavior, quantifying the impact of correlated activity on the dynamics of membrane deformations. This model makes a step toward quantitative description of shape-morphing artificial and living systems.

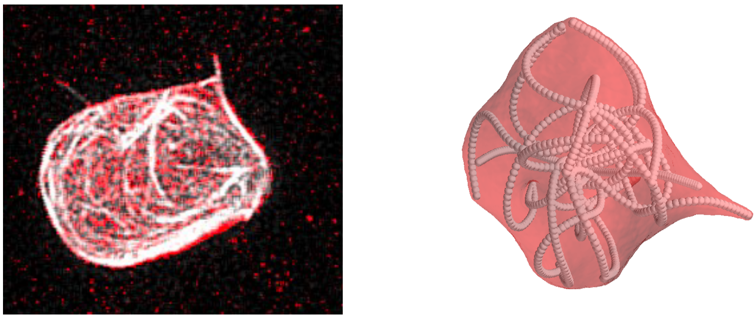

Figure 1: *(left) Confocal projection of a GUV (membrane in red) containing an active microtubule network (white). The GUV deforms and changes its shape. (right) Simulation of this active system, consisting of a vesicle and several semi-flexible filaments that grow and shrink.*

References

[1] A. Sciortino, H. A. Faizi, D. A. Fedosov, L. Frechette, P. Vlahovska, G. Gompper and A. R. Bausch, *Nature Physics*, **2025**, 21, 799–807, DOI: 10.1038/s41567-025-02839-3

Efficient generation of conformational ensembles of intrinsically disordered proteins using residue-local probabilities

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The high prevalence and functional significance of intrinsically disordered proteins (IDPs) in eukaryotes have established them as a key research focus. Unlike folded proteins, IDPs exist as conformational ensembles that dynamically navigate a complex energy landscape under physiological conditions. However, the description of this statistical ensemble remains a significant computational challenge. Our research has recently shown that the probability of an IDP molecular conformation can be described properly as the product of conformational probabilities of each residue, conditioned to the identity of the residue neighbors [1]. This reduced representation allows us to develop a novel protocol called probabilistic MD chain growth (PMD-CG), which combines the flexible-meccano and hierarchical chain growth methods with the statistical data obtained from tripeptide MD trajectories as the starting point [2].

In this work we have efficiently generated conformational ensembles of α-synuclein and its mutants using the PMD-CG method. The resulting ensembles were validated by comparison with experimental NMR J-couplings, chemical shifts, and small-angle X-ray scattering (SAXS) data, showing improved agreement with experiments compared with direct MD simulations.

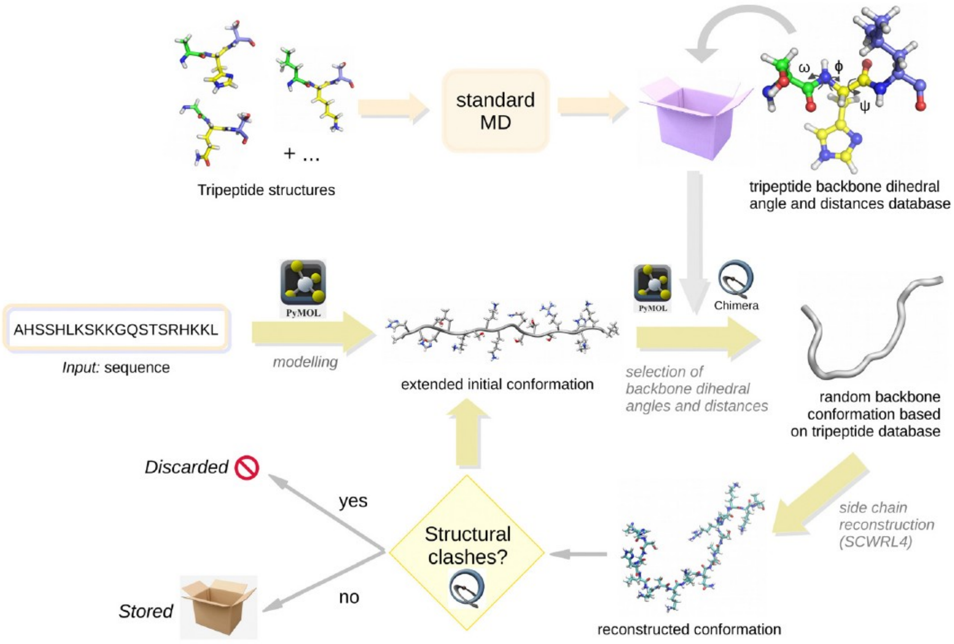

Figure 1: *Work-flow of the PMD-CG method.*

References

[1] A. Bastida, J. Zuniga, B. Miguel, M.A. Soler *Phys. Chem. Chem. Phys.*, **2023**, 25, 10512–10524, DOI: 10.1039/d2cp05970c.

[2] A. Bastida, J. Zuniga, F. Fogolari, M.A. Soler *Phys. Chem. Chem. Phys.*, **2024**, 26, 23213, DOI: 10.1039/d4cp02564d.

On the delivery of functional ingredients: Sponge phase lipid nanoparticles interacting with biomimetic membranes

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Lipid sponge phase nanoparticles (L_3NPs) are emerging as versatile carriers for biomolecular delivery as they are bicontinuous with curved flexible bilayer structures, with tuneable lipid composition, and relatively large (>10nm) aqueous channels [1,2]. Similar structures can also be found in cell organelles.

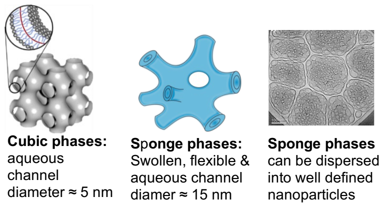

Figure 1: *Bicontinuous phases – lipid bilayers curve and form cavities allowing proteins to be encapsulated with maintained function and stability.*

We have previously shown that we can encapsulate myoglobin in lipid sponge phases [3]. The structural features of L_3NPs, based on mixtures of acyl glycerides and phospholipids and their interfacial behaviour at model lipid biomembranes was explored by using scattering, microscopy, and surface-sensitive techniques [4]. By using neutron reflectometry and different isotopic contrast, i.e. H_2O and D_2O buffers and deuterated lipids, we can separate between the different components, i.e. lipids and protein. Both lipids and protein cargo (Mb) from the L_3NPs exchange with a model POPC (1-Palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine) biomembrane. Notably, while lipid exchange is evident, the overall integrity of the POPC bilayer is preserved. This is confirmed by Electrochemical Impedance Spectroscopy measurement results and suggest that the L_3NPs do not induce substantial leakage of the model biomembrane. For the L_3NPs with Mb, the proteins seem to end up in the upper leaflet of the bilayer. These findings provide valuable insight for optimizing protein encapsulation and controlling release mechanisms of sponge phase delivery systems. L_3NPs appears not cause cell death but can enter the cell.

References

[1] M. Valldeperas, A. P. Dabkowska, G. K. Pálsson, S. Rogers, N. Mahmoudi, A. Carnerup, J. Barauskas. T. Nylander *Soft Matter*, **2019** 15, 2178-2189, DOI: 10.1039/C8SM02634C

[2] M. R. Machingauta, A. McEvoy, A. Karlsson, J. Barauskas, T. Nylander, J. Gilbert *Front. Soft Matter* **2025**, 5, 1708264, DOI: 10.3389/frsfm.2025.1708264

[3] J. Gilbert, S. Christensen, T. Nylander, L. Bülow. Front. Soft. Matter **2023**, 3, 1201561. DOI: 10.3389/frsfm.2023.1201561

[4] M. R. Machingauta, T. Kristersdotter, A. Luchini, I. De Santis, T. Naw Sut, J. Jackman, B. Humphreys, C. Prinz, D. Berti, K. Schillen, T. Nylander *Biophys. J.* **2026**, 125, 235a-236a.

Amino acids modulate biomolecular condensation by preferential partitioning

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Biomolecular condensates formed by intrinsically disordered proteins via liquid-liquid phase separation (LLPS) play a central role in cellular organization and regulation. While proteins and nucleic acids are among well-established drivers of condensate formation, the role of small metabolites remains poorly understood. Among these, amino acids which are highly abundant cellular metabolites are increasingly recognized as modulators of LLPS and dispersion stability in both biological and synthetic systems[1,2].

Here, we employ multiscale molecular dynamics simulations to investigate the partitioning behavior of amino acids in phase-separated condensates. We find that amino acids preferentially partition into the dense phase, with the extent and specificity of partitioning strongly dependent on both amino acid chemistry and condensate composition. Notably, distinct condensates display markedly different partitioning profiles for the same amino acids, indicating that selective metabolite enrichment is governed by the physicochemical environment within each condensate.

These findings reveal an underappreciated mechanism by which small metabolites modulate condensate properties, potentially influencing their stability, composition, and biological function.

References

1. Mao, Ting, et al. "Stabilizing effect of amino acids on protein and colloidal dispersions." *Nature* 645.8082 (2025): 915-921.

2. Matsuzawa, Takumi, et al. "Metabolites Shift Equilibria of Biomolecular Condensates." *bioRxiv* (2026): 2026-01.

Soft Defense: Mimicking natural deterrent strategies in plants

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Chemical pesticide usage in horticulture is increasing with the developmental resistance of pests as a contributing factor. Current efforts to reduce chemical pesticide usage involve synergistic approaches: resistant crop cultivars, natural biological control, monitoring, and predatory insects. Some plants produce an alternative strategy, glandular trichomes, which physically entrap pests. Here, we draw inspiration from these trichomes by fabricating sprayable, adhesive, soft, biosourced trichome mimics which immobilize a common pest, thrips. We create adhesive particles by milling oxidatively crosslinked triglyceride oils; a slow, controllable process where the adhesivity is tuned by adjusting the starting triglyceride composition. This approach creates adhesive particles as a 'physical pesticide' that are effective up to several days after spraying as shown with a thrip adhesion and leaf assay. Additionally, a method has been developed to load these trichomes with natural volatile compounds; the uptake and release kinetics of these volatile compounds with the oxidized oils shows a slow-release action that may attract pest for many days to weeks. The soft materials route offers a physical alternative to chemical pesticides that may reduce their global use.

Figure 1: *Designed artificial adhesive trichomes sprayed onto Chrysanthemum leaves.*

References

[1] R. van Zwieten, T.V. Bierman, P.G.L. Klinkhamer, T.M. Bezemer, K. Vrieling, T.E. Kodger, Mimicking natural deterrent strategies in plants using adhesive spheres, *PNAS,* 121 (21) e2321565121, https://doi.org/10.1073/pnas.2321565121 (2024).

Targeted Thrombolysis Using Red Blood Cell derived Nanoparticles

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Vascular thrombosis occurs when a blood clot (called thrombus) forms within a blood vessel, obstructing the flow of oxygenated blood and underlies to life-threatening conditions such as stroke or heart attack. Thrombolytic drugs that can effectively lyse these blood clots are critical in the treatment of thrombosis. However, their clinical use is significantly restricted due to a high risk of systemic hemorrhage and poor efficacy against structurally denser platelet rich clots[1]. Targeted drug delivery methods may address these limitations by promoting intra-thrombus delivery of drugs while reducing systemic interactions.

To that end, we propose Red Blood Cell derived Vesicles (RBCVs) as a biomimetic drug delivery platform for the targeted delivery of a potent thrombolytic drug, Streptokinase (SK). RBCVs are composed of the natural membranes of human erythrocytes which confers innate advantages to the system such as biocompatibility, optimal biodistribution, extended circulation, and a natural affinity to clot sites[2]. To further enhance thrombus-localisation, RBCVs are decorated with cyclic RGD- a peptide motif with strong binding affinity with activated platelets found in a thrombus. This RBCV-cRGD nanoparticle acts as a dual-targeted thrombolytic delivery platform.

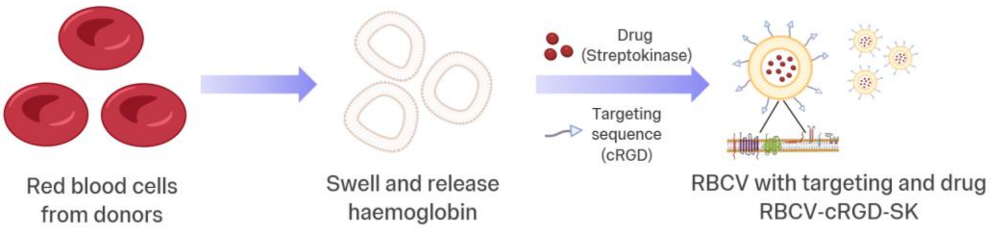

Figure 1: *Processing of RBCVs from natural red blood cells from human donors.*

In this study, we evaluated the thrombolytic performance of our targeted RBCV-cRGD nanoparticles against human ex-vivo thrombi with increasing concentrations of platelets to simulate the varying resistance found in clinical scenarios. Our results demonstrated that as platelet density increased, the targeted RBCV-cRGD system significantly outperformed free drug, achieving up to a twofold higher lysis rate at dose matched concentrations of SK. The mechanism of thombolysis was visualised with a pressure-driven occluded thrombus model and fundamental differences were observed in how the clot architecture breaks down with different drug formulations. While free SK typically caused a "leading-edge" digestion with significant residue left adhered to the capillary wall, the targeted RBCV formulations promoted a more spatially distributed digestion with near-complete thrombus clearance. These results suggest that functionalized biomimetic nanocomposites can effectively overcome the physical and biochemical barriers of resistant blood clots

References

[1] M.J. Daley, M.S. Murthy, E.J. Peterson*, Therapeutic Advances in Drug Safety* **2015***, vol* 6(2), 57-66, DOI: 10.1177/2042098615572333

[2] S. Malhotra, S. Dumoga, P. Sirohi, N. Singh, *ACS Applied Materials and Interfaces* **2019**, vol 11(25), DOI: 10.1002/jbm.a.32549.

Curvature-Responsive Supported Lipid Bilayers as Platforms to Study Protein-Lipid Interactions

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Biological membranes are fundamental to cellular organization, providing compartmentalization and regulated exchange between the cell and its environment. Far from being passive barriers, membranes are dynamic systems in which lipids and proteins continuously interact, as described by the fluid mosaic model. Supported lipid bilayers (SLBs) have therefore become widely used biomimetic platforms to replicate key structural and functional features of biological membranes under well-controlled conditions, enabling systematic studies of membrane dynamics and protein–lipid interactions. However, conventional SLBs are inherently planar and fail to capture membrane curvature, a critical physical parameter known to influence lipid organization and protein binding. In this context, the development of curvature-responsive membrane platforms offers new opportunities to investigate curvature-dependent protein–lipid interactions in a controlled and quantitative manner. [1,2].

Following this approach, curved substrates have been developed by incorporating nanoparticles of different sizes and compositions, enabling the controlled introduction of membrane curvature at the nanoscale. These engineered surfaces provide a versatile platform to systematically study their formation and physicochemical properties, as well as to subsequently support lipid bilayers of varying compositions, such as pure DOPC and mixed DOPC-DPPC systems. In addition, designed consensus tetratricopeptide repeat proteins (CTPRs) with catalytic activity have been incorporated on these membranes, offering a modular approach to explore curvature-mediated protein-lipid interactions and potential functional applications [3,4].

These curved surfaces were structurally characterized using atomic force microscopy (AFM), neutron reflectometry (NR), Grazing-Incidence Small-Angle X-ray Scattering (GISAX) and Quartz Crystal Microbalance (QCM), providing complementary information on surface morphology, bilayer formation, and nanoscale organization.

References

[1] Sarkis, J., & Vié, V. (2020). Biomimetic Models to Investigate Membrane Biophysics Affecting Lipid–Protein Interaction. Frontiers in Bioengineering and Biotechnology, 8. https://doi.org/10.3389/fbioe.2020.00270.
[2] Xiao Li et al. Ananostructure platform forlive-cellmanipulationofmembranecurvature. Natureprotocols 14.6 (2019),pp.1772–1802.
[3] Rivilla, I. I. et al. Discovering Biomolecules with Huisgenase Activity: Designed Repeat Proteins as Biocatalysts for (3 + 2) Cycloadditions. (2019) doi:10.1021/jacs.9b06823.
[4] Lucia Suarez-Menendez et al. Engineering curvature: block copolymer lithography for the fabrication of curved lipid membranes and their impact on protein–membrane interactions. J. Mater. Chem. B, 2025,13, 5769-5775

Polymers and Biopolymers I

Tuesday 19 May 15:00 – 17:40

Universal prediction of polymer molecular weight distribution from linear rheology using neural networks

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We present a methodology for inferring the molecular weight distribution (MWD) of polydisperse linear polymers from linear rheology using machine learning techniques. Complex, state-of-the-art tube models are not typically expressed in a convenient mathematical form for which the inverse problem of inferring MWD from rheology is practical. Our technique bypasses this by using a machine learning methodology. We first utilise the model of Das and Read [1] to generate large sets of artificial rheology data. These data are then used to train neural networks (NNs) to make MWD predictions from rheological measurements. We make use of the universality of flow behaviour of flexible polymers to transform the rheology data (using the entanglement time and plateau modulus) into a representation for which the analysis can be performed with a unified approach irrespective of the polymer chemistry. The NN is trained to predict the distribution in the number of entanglements, which is then converted to the MWD by knowledge of the mean entanglement molecular weight. We are primarily interested in predicting the properties of industrially relevant polymers and thus focus on broad MWDs. We present results for polymers with a range of backbone chemistries and MWDs, including commercial samples of polyethylene (HDPE and LLDPE), demonstrating good agreement with experimental gel permeation chromatography data. Finally, we also discuss how our work might be extended to detect and possibly quantify long chain branching. This research forms part of the research programme of DPI, project #861.

References

[1] C. Das, D.J. Read. A tube model for predicting the stress and dielectric relaxations of polydisperse linear polymers. Journal of Rheology. **2023**, 67, pp.693–721, DOI: 10.1122/8.0000605.

Pressure-Induced Coil to Globule Transition in Poly-Sulfobetaine Polymer Systems

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The coil-to-globule transition is a fundamental phase transition in which polymers switch from an extended coil conformation to a compact collapsed state. This transition is of great interest for numerous applications in materials science. Several studies have investigated non-ionic polymers exhibiting this behavior. One well-known example is poly(N-isopropylacrylamide) (PNIPAM), which displays a lower critical solution temperature (LCST). Below this temperature, the polymer chains remain in an expanded coil state, whereas above it the chains collapse, as polymer–polymer interactions become favored over polymer–water interactions.

In contrast, polymers exhibiting an upper critical solution temperature (UCST) show the opposite behavior and have been much less extensively studied. Among them are polysulfobetaine polymers, which are zwitterionic macromolecules bearing both a positive and a negative charge within the same repeat unit. Their phase transition arises from the formation of electrostatic bridges between positively charged ammonium groups and negatively charged sulfonate groups.

While the effect of temperature on these systems has been widely investigated in the literature, the influence of pressure remains largely unexplored, despite the fact that pressure can also trigger phase transitions in other polymer systems. This PhD project aims to investigate the role of pressure and its coupling with thermodynamic quantities such as entropy (ΔS), volume (ΔV), heat capacity (ΔCp), and isothermal compressibility ($\Delta \kappa T$) in polysulfobetaine polymers, both in solution and in brush form.

High-pressure neutron scattering experiments will be used to probe the phase transition in solution. In parallel, molecular dynamics simulations and thermodynamic modeling will be performed to develop a comprehensive description of the phase transition in these systems. Ultimately, this work aims to provide a deeper understanding of the mechanisms governing the coil-to-globule transition in polysulfobetaine polymers.

Two-Parameter Scaling in Polymer θ-Solutions Revealed by DWS Microrheology

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Investigating polymer solutions under θ-solvent conditions is essential to establish a theoretical baseline, as excluded-volume effects vanish and chains adopt ideal conformations.[1] However, experimental validation of high-frequency dynamics in semidilute entangled θ-solutions remains limited due to the mechanical constraints of conventional rheometers. To address this, we utilized diffusing-wave spectroscopy (DWS) microrheology,[2] to directly resolve these dynamic modes and validate theoretical predictions, including two-parameter scaling. Polyacrylamide in a water-methanol mixture was used as a model θ-solvent system, with 500 nm polystyrene microspheres added as probe particles. By measuring the intensity autocorrelation function of multiply scattered light, we obtained the probes' mean-square displacement (MSD). The complex specific viscosity was then calculated from the MSD using the generalized Stokes-Einstein relation. Applying time-concentration superposition collapsed the complex specific viscosity data onto master curves. This allowed clear resolution of the Zimm mode, Rouse mode, and the elastic plateau of entanglements. From the crossover points, the relaxation times of correlation blob τ_ξ and of entanglement strand τ_e were determined. Their scaling behaviors with the polymer volume fraction are in good agreement with the theoretical predictions (Fig.1c). Furthermore, from the values of these characteristic time extrapolated to $\phi = 1$, we estimated the Kuhn length and entanglement molecular weight, consistent with literature values. This study provides direct experimental validation of high-frequency polymer dynamics in semidilute entangled θ-solutions. Notably, the two-parameter scaling behavior was identified solely through dynamic rheological measurements, bypassing the need for complementary static characterization. These findings highlight microrheology's capability to probe hierarchical polymer dynamics beyond conventional limits.

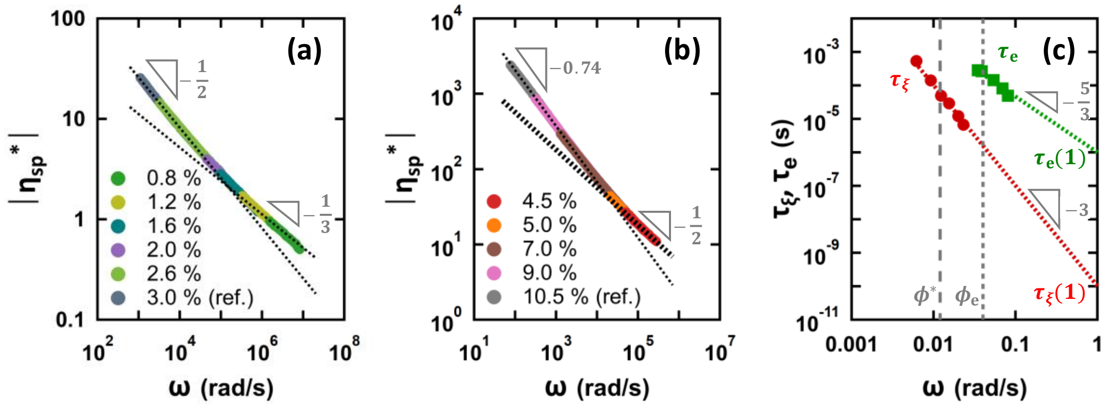

Figure 1: *TCS master curves for (a) Rouse-Zimm and (b) entangled-Rouse crossovers. (c) scaling behaviors of chracteristic times.*

References

[1] R. H. Colby, M. Rubinstein, *Macromolecules* **1990**, 23, 2753. DOI: 10.1021/ma00212a028

[2] T. Indei, T. Narita, *J. Rheol*. **2022**, 66, 1165. DOI: 10.1122/8.0000402

Swelling and de-swelling behavior of thermo-responsive polymers at phase transition

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Thermoresponsive polymer, such as poly(isopropyl acrylamide) (PNIPAM), changes its state in response to a temperature change across its phase transition point. PNIPAM-based polymers exhibit a broad hysteresis for the volume phase transition between swollen and collapsed states, displaying atypical behaviors such as bistability, remanence, information storage capabilities, and memory functions. The behavior of the polymer near the transition point, along with the long-term stability of swollen or collapsed polymer clusters within the temperature range of hysteresis, has been thoroughly investigated using scattering and electron microscopy techniques.

The phase transition from the swollen to the collapsed state (and reverse) has been studied in detail by dynamic light scattering and cryo-TEM. For that, samples were prepared across the transition point with a small temperature step. The broad hysteresis of PNIPAM-based polymers opens exciting possibilities for achieving bistability, remanence, and efficient reversible information storage. Our research highlights the potential of PNIPAM and its block copolymers, which significantly expand the hysteresis window, enhancing the material's capabilities.

Furthermore, the hysteresis is intricately connected to the dynamic assembly and disassembly of cluster domains during phase transitions, paving the way for advanced applications. Imagine writing information thermally with a laser or heated/cooled pen tips on a thin-film backscattering display. The versatility is astounding not only can the bistable state be smoothly changed by temperature, but also by pH, enabling an AND logic gate function. We also unveiled an intriguing memory state. Information can be visibly encoded within the hysteresis window while remaining hidden at elevated temperatures, adding a layer of complexity and creativity to information management.

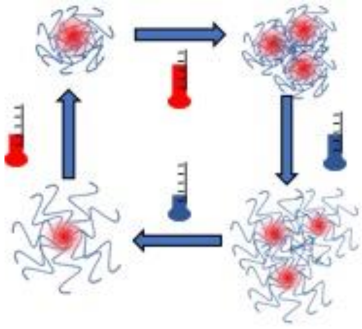

Figure 1: *Scheme of phase transition for PNIPAM-based polymer.*

References

[1] J. Michalska-Walkowiak, B. Förster, S. Hauschild, S. Förster, Bistability, Remanence, Read/Write-Memory, and Logic Gate Function via a Stimuli-Responsive Polymer. *Adv. Mater.* 2022, 34, 2108833. https://doi.org/10.1002/adma.202108833

From Solution Structure to Semicrystalline Morphology in Poly(2,6-diphenyl-p-phenylene oxide)

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Poly(2,6-diphenyl-p-phenylene oxide) (PPPO) is a high-performance semicrystalline polymer used in gas chromatography and sensing, including aboard NASA's Mars Curiosity rover. Its porous forms are commonly produced via non-solvent induced phase separation (NIPS), where solution-state organisation and crystallisation are expected to influence the final semicrystalline morphology. Previous studies have suggested that crystalline domains may contribute to sorption through a crystal-void-filling mechanism,[1] but the link between solution structure, crystallisation, and final morphology remains unclear. Here, we investigate PPPO solutions in four solvents of varying quality (DCM, chloroform, THF, toluene) across 0.5–20 wt% using small-angle neutron scattering (SANS), dynamic light scattering, powder X-ray diffraction, and electron microscopy. In poorer solvents (THF, toluene), time-dependent lateral association and crystallisation produce a lamellar-stack contribution in SANS, with crystal thicknesses of ~6.5 nm and long periods of ~21.5 nm. PXRD and SEM show that this solution-state evolution is reflected in the dried solids through higher crystalline fractions and coarser spherulitic or clustered morphologies. These results establish a precursor-level framework for future ternary PPPO/solvent/non-solvent NIPS studies, where preliminary results indicate that solvent choice can strongly alter porous morphology and surface area.

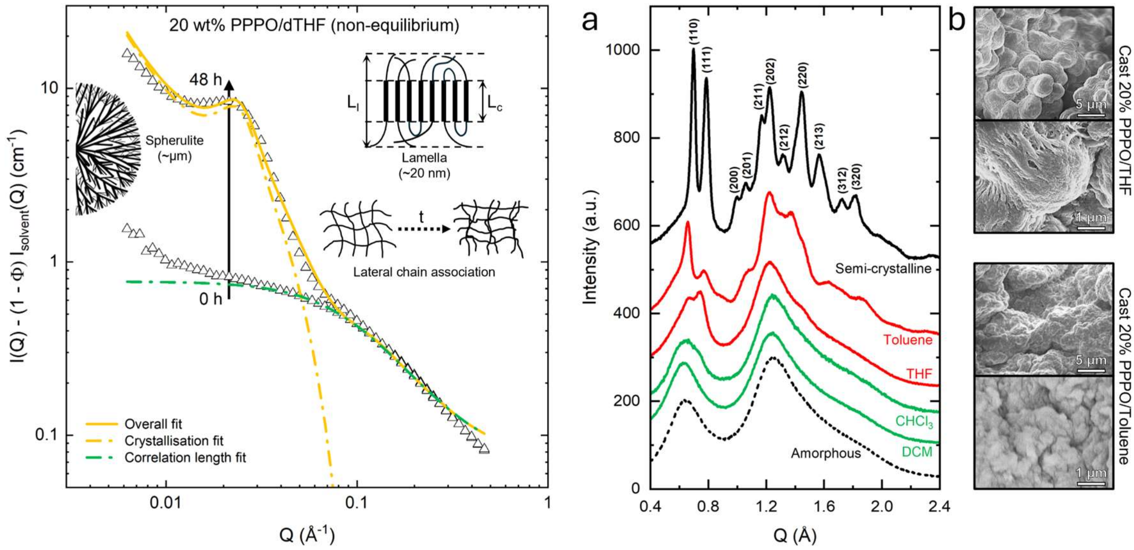

Figure 1: *(left) SANS profiles of 20 wt% PPPO/d-THF at 0 and 48 h with model fits. Insets show the proposed solution mesh, lamellar stack, and dendritic spherulites. (right – a) PXRD patterns of PPPO in as-received, annealed, and solution-cast states. (right – b) SEM images of THF- and toluene-cast PPPO, showing solvent-dependent morphology.*

References

[1] B. Alfeeli, L. T. Taylor, M. Agah *Microchemical,* **2010** 95, 259-267, DOI: 10.1016/j.microc.2009.12.011

Turning Complexity into Function: Humins as Blend Components, Graft Cores, and Dynamic Network Formers

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The transition toward sustainable polymeric materials requires not only renewable feedstocks but also a fundamental rethinking of industrial side-streams as next-generation starting materials. Rather than treating such a stream as waste, its inherent chemical complexity offers an opportunity to design functional, responsive systems. Humins, a major by-product of biomass conversion, remain largely underexplored despite having multiple reactive functionalities. A defining characteristic of humins is the coexistence of two prominent and chemically accessible functionalities: abundant hydroxyl groups and intrinsic furanic motifs. In the present work, we first systemically probe the reactivity of these functional groups using a range of esterification and functionalization strategies, establishing their role as versatile chemical handles for subsequent materials design. [1,2].

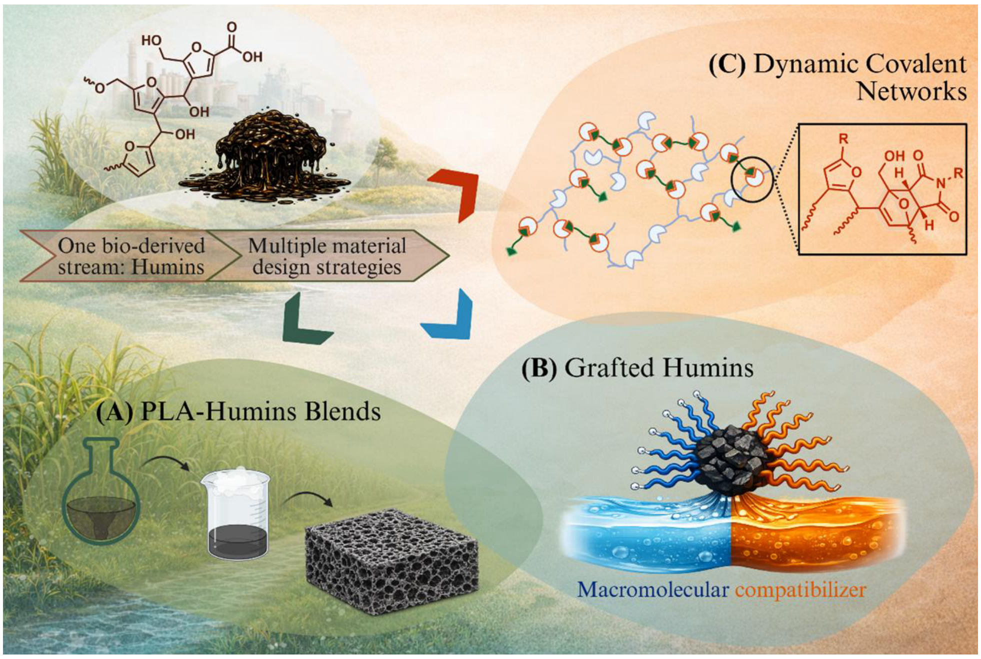

Figure 1: Material design routes derived from industrial humins. **(A)** PLA-humins blends yielding morphology-rich structures. **(B)** Grafted humins acting as macromolecular compatibilizers in chemically dissimilar polymers. **(C)** Dynamic covalent networks based on the intrinsic furan functionality of humins via Diels-Alder.

Building on this understanding, pristine humins are initially incorporated into PLA at high loadings, forming binary PLA-humins blends. In solution-processed systems, unmodified humins exhibit a pronounced plasticizing and compatibilizing effect, arising from their heterogeneous macromolecular structure, intrinsic polarity, and hydroxyl-rich character, and leading to morphology-rich, foamed structures (Figure 1A). These observations directly motivate the targeted chemical upgrading of humins, with particular focus on hydroxyl functionality. Specifically, the hydroxyl groups of humins are functionalized to introduce vinyl moieties, enabling the direct growth of polymer chains from the humins backbone. This approach yields grafted "humins-with-arms" architectures, designed to extend the compatibilizing concept beyond PLA to blends of chemically dissimilar polymers, particularly hydrophilic–hydrophobic systems (Figure 1B). These architectures are being developed as reactive compatibilizers for blends of chemically dissimilar polymers. Their behaviour in multiphase materials will be investigated through extrusion-based blending and interfacial rheology, providing insight into how bio-derived macromolecular additives influence macroscopic interfacial dynamics. [2]

Finally, the high intrinsic furan content of pristine humins is leveraged to form dynamic covalent networks via Diels-Alder chemistry. Reversible furan-maleimide cycloadditions generate macromolecular networks in which chemical bond formation directly translates into changes in viscoelastic and dielectric properties. Notably, an unconventional thermo-responsive behaviour is observed, in which network reinforcement is promoted at elevated temperatures under oscillatory shear, deviating from the classical Diels–Alder/retro-Diels–Alder description and enabling a transition from semiconductive to insulating electrical behaviour (Figure 1C).[3]

Together, these complementary strategies highlight how the same bio-derived stream can be utilized both "as-is" and in chemically upgraded forms to access blends, grafted architectures, and dynamic networks, positioning humins as a versatile and sustainable platform for functional materials design.

References

[1] Constant, S.; Lancefield, C. S.; Vogelzang, W.; Purushothaman, R. K. P.; Frissen, A. E.; Houben, K.; Bruijnincx, P. C. A., Green Chem. **2024**, *26*, 7739–7751.

[2] Kandemir, D.; Van Puyvelde, P.; Ginzburg, A., ChemSusChem **2024**, *17*, e202400403.

[3] Kandemir, D.; Mekala, M.; Cardinaels, R.; Van Puyvelde, P.; Ginzburg, A., *Synthesis of Thermo-Responsive Dynamic Covalent Networks based on Humins and the Diels–Alder Reaction*, under revision in Green Chemistry, preprint available on ChemRxiv **2025**.

Food Science I

Wednesday 20 May 09:55 – 12:25

Self-driving labs for formulating food

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Phase separation fundamentally governs material properties and cellular function on multiple organizational scales. Conventional approaches to studying this nonlinear phenomenon necessitate resource-intensive experiments. We present two automated setups developed to investigate phase separation behavior. The first set-up, PhaseXplorer, is a platform that combines microfluidics, microscopy, and machine learning to efficiently study phase separation systems [1]. PhaseXplorer autonomously designs, generates, and analyzes samples in a closed-loop active learning workflow until an accurate phase diagram is obtained. Using an acquisition function that balances exploration and exploitation, all the phase boundaries are located with minimal sampling. A convolutional neural network executes real-time image recognition to identify microfluidic droplets and phase separation within them in less than 1 ms per droplet. PhaseXplorer standardizes analysis across experiments and does not require calibration nor extensive post experiment analysis. We demonstrate PhaseXplorer's capabilities using a poly rA model system by creating a four-dimensional phase diagram 100 times faster than traditional methods while simultaneously consuming 10,000 times less material.

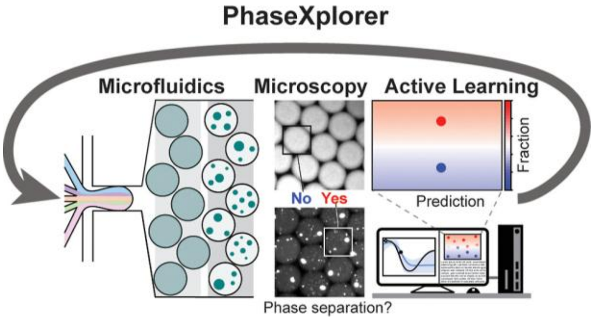

Figure 1, PhaseXplorer: A closed-loop active learning platform to study phase separation

Another automated platform our group has developed incorporates a pipetting system for sample formulation and an autonomous confocal microscope for particle property analysis [2]. My project uses this high-throughput set-up to map out the behavior of the individual bovine and recombinant casein proteins. This provides a basis for interesting chemical space to be further investigated with smaller length scales techniques, like scattering and super-resolution microscopy. This can highlight more fundamental origins of the behavior for the less complex singular protein systems. Building on this research, more complex mixed protein systems can be used to expand on this research, with the singular protein systems as a reference.

References

[1] Jansen, Stef A. H., Lasse S. A. Dreyer, Jule van Basten, et al. (**2025**). ACS Nano 19 (45): 38981–89. https://doi.org/10.1021/acsnano.5c07268.

[2] Leurs, Yannick H. A., Willem van den Hout, Andrea Gardin, et al. (**2025**). Nature Communications 16 (1): 9598. https://doi.org/10.1038/s41467-025-64617-2.

Controlling the Cold-Set Gelation of Bovine Serum Albumin Protein using Alcohol and Ionic Surfactant

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Increasing the temperature of protein dispersions initiates denaturation via breaking of hydrogen and disulfide bonds. These denatured proteins undergo hydrophobic attraction due to exposure of the hydrophobic sites of the protein, resulting in the formation of smaller protein aggregates, which finally leads to protein gelation by forming intermolecular network structure at the gelation temperature (T_G). Protein gels can also be obtained at lower relative temperatures, a process called cold-set gelation. Under "cold gelation", protein forms a gel at a much lower temperature than its original gelation temperature, which can be achieved by modifying various physicochemical conditions such as the pH of the solution, the presence of salts, etc. [1]. This method holds significant potential in various applications, including medicine and the food industry, due to its mild processing conditions. In this work [2], we examine the alcohol-driven cold-set gelation of BSA protein, where gelation could be achieved at temperatures as low as room temperature. The gel formation has been established by both macroscopically, using visual inspection and tube inversion tests and microscopically, using rheology measurements. We further probed the modification in inter-protein interactions during such gelation and resultant structures using SANS and DLS techniques. Interestingly, alcohol-induced cold gelation of protein could be completely suppressed with an addition of the ionic surfactant, SDS. The results are explained based on the interplay of interactions in the protein, manipulated by the presence of alcohol, elevated temperatures, and ionic surfactant.

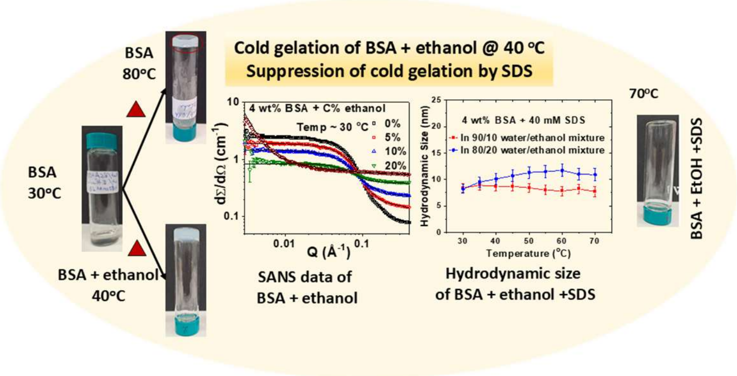

Figure 1: *Cold gelation of BSA protein using alcohol and the inhibition of cold gelation using ionic surfactant*

References

[1] J. Ryu, D.J. McClements, Food Hydrocolloids **2024**, 149, 109535. DOI: 10.1016/j.foodhyd.2023.109535.

[2] D. Saha, S. Kumar, P.S. Dubey, J.P. Mata, A.E. Whitten, J. Kohlbrecher, H. Frielinghaus, V.K. Aswal, Food Hydrocolloids **2026**, 172, 111991, DOI: 10.1016/j.foodhyd.2025.111991.

Minimally processed pea protein extracts promote protein–carbohydrate co-gelation

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The transition toward plant-based foods has intensified the need to understand how minimally processed protein ingredients assemble into functional soft materials. Pea protein isolates are widely used in food formulations; however, conventional extraction routes, which involve the complete extraction of protein isolates, typically require multi-step and harsher treatments and often remove non-protein components such as starch and small carbohydrates that may significantly influence gelation behavior. In industrially relevant, simplified extraction processes, these carbohydrates are frequently retained. Yet their structural role during thermally induced gelation remains poorly understood. While rheology and calorimetry provide insight into macroscopic mechanical development and molecular denaturation, resolving how protein and carbohydrate domains organize, interact, and co-assemble across multiple length scales requires neutron-based structural techniques. We investigate how carbohydrates retained in truncated pea protein extracts influence thermal gelation, with particular emphasis on resolving mesoscale organization using small- and ultra-small-angle neutron scattering (SANS/USANS) under contrast variation. Extracts were obtained via a less disruptive high-salt extraction (SE). The neutron-derived observation aligns with the rheological maturation behavior, where SE systems display prolonged structural development consistent with cooperative assembly and progressive domain coupling. Overall, our results demonstrate that minimally processed pea protein extracts obtained via high-salt extraction (SE) undergo protein–carbohydrate co-gelation, forming a shared gel matrix with residual mesoscale heterogeneity.

Coacervate Encapsulation of Red Ginger Oil: In Vitro Digestion and Biochemical Changes

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[2]*Estación Experimental del Zaidín, Consejo Superior de Investigaciones Científicas (CSIC), Granada, Spain*

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Red ginger (*Zingiber officinale* var. *rubrum)* contains higher essential oil content, with stronger antioxidant activity and potential to reduce pain sensitivity in diabetic neuropathy [1]. As monoterpenes are mainly absorbed through the gastrointestinal tract, the oil must be protected from harsh conditions such as extreme pH, bile salts, and enzymes [2]. Therefore, red ginger essential oil (REO) was encapsulated via complex coacervation using a mixture of 0.1% sonicated pea protein isolate (PP) (7500 W, 40% amplitude, 5 min) and 0.1% sodium alginate (SA) at mass ratios of 4:1, 2:1, and 1:1 (100 mL). REO (1% v/v) was emulsified with a rotor homogeniser (10,000 rpm, 5 min), followed by jet homogenisation (5 MPa of air pressure, 3 cycles). Coacervation was induced by adjusting the pH with HCl and NaOH to the isoelectric point of PP/SA mixture, followed by freeze-drying. The coacervates were evaluated for stability, particle size, zeta potential, encapsulation efficiency, and protein digestibility and REO release during in vitro digestion. Sonication reduced the volume-weighted average particle size ($D_{[4,3]}$) of PP from 126.8 to 14.5 µm, with further reduction observed after homogenization. This indicates that protein particles were denatured and unfolded due to shear forces, pressure, and cavitation. As shown in Fig 1. the PP/SA-REO emulsions had average particle sizes ($D_{[4,3]}$) of 1.25, 1.30, 1.28, and 2.00 µm for PP-to-SA ratios of 4:1, 2:1, and 1:1 and without SA, respectively. The coacervate particles exhibited irregular, non-spherical shapes with internal REO droplets due to aggregation of adsorbed biopolymers on their surfaces. The average particle sizes were 67.58, 117.00, and 236.00 µm for the 1:1 wall-to-REO ratio and 68.90, 130.00, and 130.20 µm for the 2:1 ratio at PP/SA ratios of 1:1, 2:1, and 4:1, respectively.

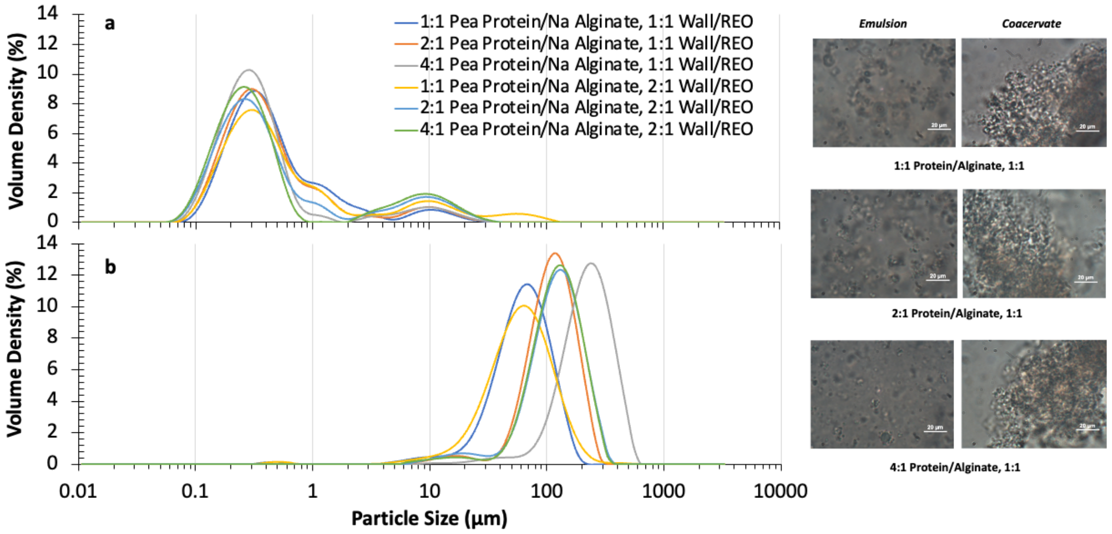

Figure 1. Particle size distribution and microscopy of encapsulated REO: (a) emulsion, (b) coacervate

Pea protein's spherical structure in the coacervated particles limited pepsin access, keeping gastric-stage digestibility below 20%. In the intestinal phase, digestibility increased to 99.3% at a 4:1 PP/SA ratio, having a bimodal particle size distribution. This improvement may be due to the pH rising to 7, which isaway from their isoelectric point, reduces protein–polysaccharide interactions, and forms looser structures that allow easier trypsin access. Low-SA concentration, however, showed limited REO release (33.5%), whereas higher-SA exhibited high REO release (99.3%). Coacervation particles produced via complex coacervation and freeze-drying exhibited losses of key volatiles, including camphene, D-limonene, neral, and citral. Monoterpene alcohols were mainly released in the gastric phase, while hydrocarbons were released in the intestinal phase. The results demonstrated that PP–SA ratios can regulate both matrix digestibility and REO release, with encapsulation efficiency being highest when used high PP concentration (PP–REO and PP/SA 4:1: 16.00% and 12.02%) and lower in formulations with reduced PP (2:1 and 1:1: 7.05% and 6.94%)

References

[1] F.A. Fajrin, E. D. Hidayanti, N. L. Khoiroh, G. Sulistyaningrum, N. Imandasari, A. Afifah, S. Hartono. *Jundishapur Journal of Natural Pharmaceutical Products*, 2021, 16(4). DOI: 10.5812/jjnpp.112353

[2] J. F. RDe Alvarenga, B. Genaro, B.L. Costa, E. Purgatto, C. Manach, J. Fiamoncini. *Critical Reviews in Food Science and Nutrition*, 2023, 63(10), 1352–1389. DOI: 10.1080/10408398.2021.1963945

Microbubble powders using freeze-dried Pickering emulsions

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Microbubbles are widely used in food formulations and in biomedical and pharmaceutical applications. Pickering-stabilized microbubbles, formed by the adsorption of solid nanoparticles at the gas–liquid interface, exhibit much higher stability than surfactant- or protein-stabilized microbubbles, which readily coalesce, break, and coarsen[1]. They are typically generated by dispersing gas into a nanoparticle suspension, allowing particles to adsorb at the interface. However, this method often gives low yields due to gas loss and produces relatively large bubbles with broad size distributions, reducing shelf life through Ostwald ripening[2]. To improve the yield and stability of microbubbles, we present here an alternative method. First, we create an oil-in-water (O/W) emulsion, which is known for its high stability and uniform size distribution[3]. After this step, we remove water by freeze-drying, leaving a microbubble powder behind.

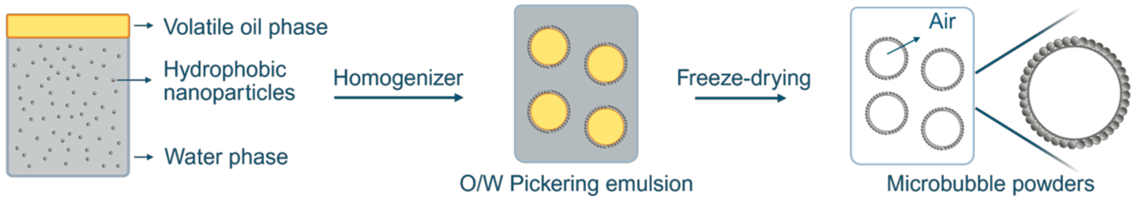

Figure 1: *Scheme of preparation of microbubble powders via Pickering emulsion templates*

In this work, we investigate the potential of hydrophobic silica and hydrophobic calcium carbonate ($CaCO_3$) nanoparticles to prepare stable microbubbles. Silica nanoparticles produced microbubbles that remained stable for up to a week, both in water and in solutions with enhanced osmotic pressure[4]. As a more sustainable alternative, modified CaCO3 nanoparticles yielded microbubbles that remained intact for over a month. To gain further insight into the enhanced stability of $CaCO_3$-stabilized microbubbles, the interfacial behaviour of the particles at the air–water interface is currently being investigated using a Langmuir Blodgett combined with AFM, and preliminary results will be presented if time permits. Overall, this work demonstrates that the Pickering emulsion template method is an effective approach for preparing tunable, food-grade microbubbles.

References

[1] Sun, J.; Dai, L.; Lv, K.; Wen, Z.; Li, Y.; Yang, D.; Yan, H.; Liu, X.; Liu, C.; Li, M. C. *Adv Colloid Interface Sci* **2024**, *328*, 103177. DOI: 10.1016/j.cis.2024.103177.
[2] Swanson, E. J.; Mohan, V.; Kheir, J.; Borden, M. A. *Langmuir* **2010**, *26* (20), 15726-15729. DOI: 10.1021/la1029432.
[3] Dickinson, E. *Current Opinion in Colloid and Interface Science* **2010**, *15* (1-2), 40-49. DOI: 10.1016/j.cocis.2009.11.001.
[4] Wang, Q.; Poortinga, A. T.; Li, Y.; Scholten, E.; de Vries, R. *Chemical Engineering Journal* **2026**, *527*. DOI: 10.1016/j.cej.2025.172095.

From side streams to novel hydrocolloids - fermentative production of xanthan-like polysaccharides

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From 2020 to 2023 the demand for plant-based milk alternatives has risen by 85 % in Germany and is still growing. Similar trends can be observed for other plant-based alternatives. The development of food products increases the interest in an expanded range of hydrocolloids. Furthermore, the production of food products such as oat milk also led to new side streams such as okara, which are mostly used to produce biogas or feed. For a more sustainable and economically feasible production, upcycling of these side streams is important. As some acetic acid bacteria are able to produce xanthan-like polysaccharides, the fermentation of products such as okara could be used for the production of sustainable hydrocolloids. However, this requires detailed knowledge on the formation, molecular structure, and technofunctional properties of the exopolysaccharides formed by the individual bacteria.

Therefore, the exopolysaccharide formation of eight acetic acid bacteria was characterized in detail. All strains were cultivated in both synthetic and complex media with different carbon sources which also occur in side streams such as okara. Subsequently, the produced exopolysaccharides were isolated and characterized. The molecular weight distribution was analyzed by using HPSEC-RI-MALLS and the structural composition was assessed by the analysis of the monosaccharide composition after acid hydrolysis by HPAEC-PAD. For this, an optimised methanolysis protocol was developed and applied. Several strains were found to produce exopolysaccharides of the xanthan (acetan) type, which was indicated by the presence of glucose, mannose and glucuronic acid as well as cellobiose, which was potentially derived from the cellulosic backbone. However, the exopolysaccharide composition, and thus the technofunctional properties, was dependent on the cultivation medium in some cases. Furthermore, some strains were found to produce exopolysaccharides containing varying proportions of glucose, mannose and galactose, but no glucuronic acid. Selected samples were also characterized with regards to their intrinsic viscosity and their glycosidic linkages. Overall, the fermentative production of xanthan-like exopolysaccharides could be used to obtain sustainable, regionally produced hydrocolloids for different food applications.

Glasses, Colloids and Self-Assembly I

Wednesday 20 May 09:45 – 12:45

Soft colloids at interfaces

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Microgels are soft polymeric objects with an internal gel-like structure and overall dimensions in the colloidal regime [1]. It is known that microgels strongly adsorb to liquid/liquid and liquid/air interfaces. Many studies in the last two decades attempted to understand the phase behavior of soft, deformable microgels at such liquid interfaces. Typically, the microstructures in dependence on applied surface pressure are studied *ex situ* using transfer of microgel monolayers from the liquid to a solid interface followed by investigation with different types of microscopies. Interestingly, *in situ* studies at the liquid interface are scare to nonexistent. We tackled two challenges in this respect: 1) We managed to synthesize core-shell microgels that are large enough to be studied by optical microscopy or small-angle scattering using light [2]. 2) We build a setup that combines a Langmuir trough with small-angle light scattering (LT-SALS) that allows for the large area study of monolayers during compression with excellent resolution in time [3]. In this work we present first results of the *in situ* analysis of microgel monolayers at air/water interfaces. Instead of the commonly reported solid-solid isostructural phase transition [4,5], we find a continuous compression of the monolayer with continuously decreasing interparticle distances [3]. Furthermore, drying of a thin liquid film with the monolayer at the liquid/air interface on hydrophilic and hydrophobic substrates shines light on the complex interplay between softness, adhesion and capillary interactions (see figure 1) [6].

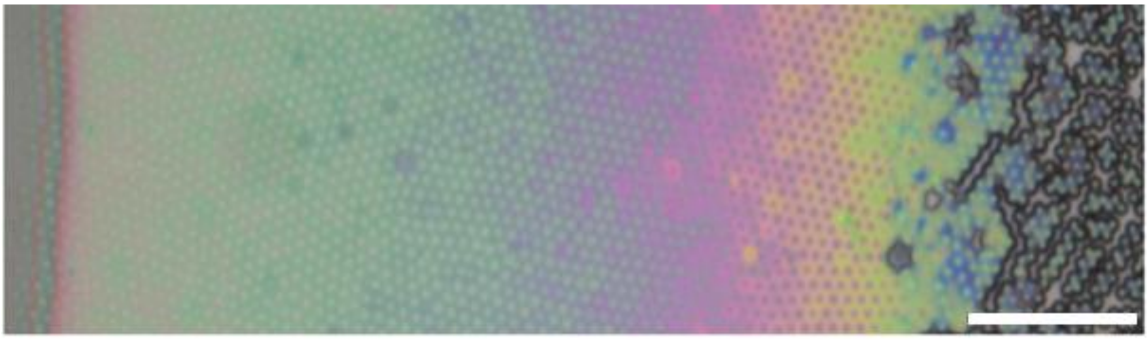

Figure 1: *Microgel monolayer during different states of drying (from right to left) on a hydrophobic substrate. Scale bar = 10 µm.*

We then studied the role of uniaxial compression/expansion by using our LT-SALS setup. Upon compression and/or expansion the monolayer remains somewhat anisotropic and a fast and a slow relaxation process is observed during an equilibration phase, i.e. when compression or expansion is stopped. Possible explanations for this behavior will be discussed.

References

[1] M. Karg, et al., *Langmuir* **2019**, 35, 6231-6255. DOI: 10.1021/acs.langmuir.8b04304

[2] K. Kuk, et al., *Gels* **2022**, 8, 516. DOI: 10.3390/gels8080516

[3] K. Kuk, et al., *Soft Matter* **2023**, 19, 175-188. DOI: 10.1039/D2SM01125E

[4] M. Rey, et al., *Soft Matter* **2016**, 12, 3545-3557. DOI: 10.1039/C5SM03062E

[5] A. Rauh, et al., *Soft Matter* **2017**, 13, 158-169. DOI: 10.1039/C6SM01020B

[6] K. Kuk, et al., *Adv. Sci.* **2024**, 11, 2406977. DOI: 10.1002/advs.202406977

Controlled microgel assembly monitored by light scattering techniques

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The development of efficient and sustainable nanoporous materials is of crucial importance for numerous applications in the fields of insulation, enforcement and structural coloration. Silica foams are promising due to their abundancy, high thermal and chemical stability [1]. Their macroscopic properties, however, depend heavily on pore size and packing structure, which is why precise control of these parameters is advantageous for material development.

In this work, we aim to fabricate silica foams with minute control over pore size and packing density using thermoresponsive microgels as a templating medium. Similar foams were achieved in [2], but they lacked the control over the assembly process that we seek here. First, the microgels are loaded with silica particles. Subsequently, the volume fraction of the collapsed microgels is adjusted so that it exceeds space filling upon swelling. This results in a highly packed assembly in which the interstitial space is filled with silica.

The swelling behavior of submicron sized microgels loaded with silica nanoparticles is characterized using dynamic light scattering (DLS), while dense packing is investigated using diffusion wave spectroscopy (DWS). At a defined effective volume fraction, a transition from liquid to solid is observed upon cooling of the sample. This demonstrates that the pore structure of the system can be controlled by regulating temperature-induced swelling. The final structure of the silica foam is analyzed using scanning electron microscopy (SEM). Further measurements will examine the structural coloration and insulation properties of this system in order to evaluate its performance.

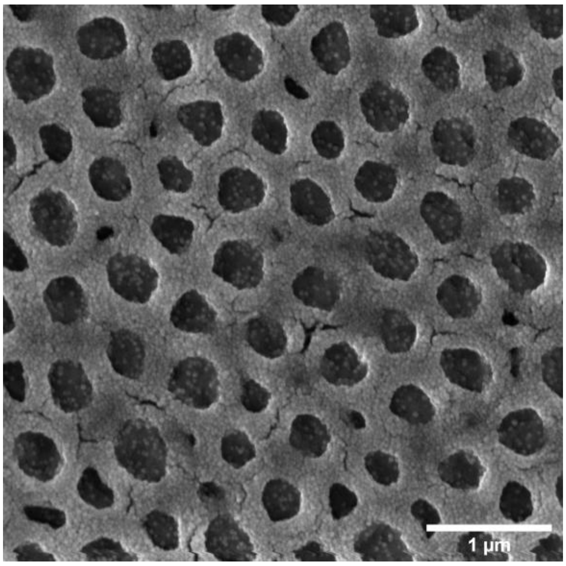

Figure 1: *SEM image of dried low-volume fraction silica-decorated microgels.*

References

[1] Drenckhan, W., & Langevin, D., **2010.** *Current opinion in colloid & interface science*, *15*(5), 341-358. https://doi.org/10.1016/j.cocis.2010.06.002

[2] M. J. Bergman, *et al., Small Methods,* **2022** vol.6**,** no.4, DOI: 10.1002/smtd.202101491

Hydrophobic Interactions in Complex Geometries

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Hydrophobic forces are ubiquitous in nature and consequential in material design, especially regarding colloidal self-assembly and biomolecular function [1,2]. Despite this ubiquity, there are still fundamental gaps in our understanding of the multiscale nature of the hydrophobic interaction. While detailed experimental studies have been performed, such as atomic force microscopy (AFM) and surface force apparatus measurements, it remains challenging to connect macroscopic observations to microscopic details of the solute–solvent interface [3]. Molecular simulations are limited by both length and time scales, as hydrophobic solvation requires large system sizes and computing solvation free energies requires convergence of enhanced sampling methods. Only recently have molecular studies been able to probe the interaction of spheres larger than 1 nm, and these are limited to the symmetric two-particle interaction [4]. **To extend beyond these limits, we use recent advancements in classical density functional theory (cDFT)—which treats atomistic and mesoscopic length scales on the same theoretical footing [5]—to understand how complex geometries affect the hydrophobic interaction.**

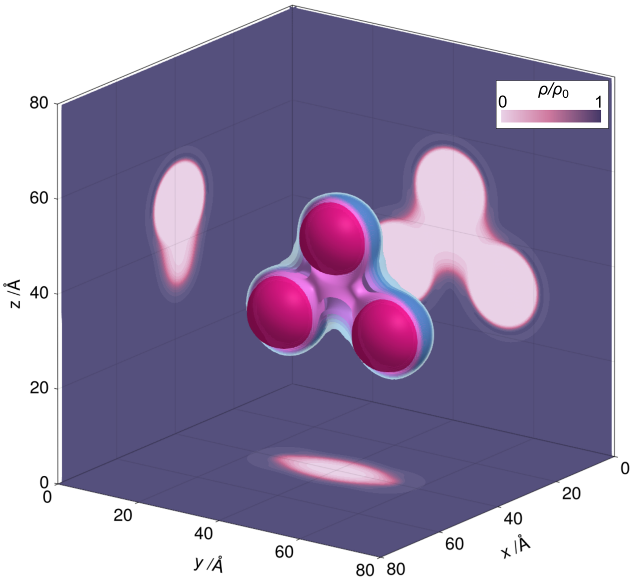

Figure 1: *3-D cDFT model of the water-mediated interaction of three hydrophobic solutes shows extended vapour bridging. Planes depict 2-D projections.*

In this work, we discuss multiscale modeling of systems with arbitrary solute geometries and >100,000 equivalent water molecules via a three-dimensional implementation of cDFT. We find that the transition from depletion interactions to vapour capillary-driven assembly is controlled by particle size, hydrophobicity, and system geometry, with many-body effects being critical to accurately capturing inter-particle forces.

References

[1] A. Sánchez-Iglesias, *et al. ACS Nano,* **2012**, 6, 11059–11065, DOI: 10.1021/nn3047605.
[2] A.J. Patel, *et al. J. Phys. Chem. B,* **2012**, 116, 2498–2503, DOI: 10.1021/jp2107523.
[3] R. Garcia, *ACS Nano,* **2023**, 17 (1), 51–69, DOI: 10.1021/acsnano.2c10215.
[4] H. Naito, T. Sumi, K. Koga, *J. Chem. Phys.* **2024**, **161**, 214501, DOI: 10.1063/5.0233808.
[5] A.T. Bui, S.J. Cox, *J. Chem. Phys.* **2024**, 161, 104103, DOI: 10.1063/5.0223750.

Lipid nanoparticle-based hybrids for next-generation MRI contrast agents

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The limited availability of positive (T_1) magnetic resonance imaging (MRI) contrast agents and safety concerns associated with certain Gd-based chelates have stimulated the search for alternative contrast-enhancing systems. Nanoparticle-based contrast agents have emerged as promising candidates and can be designed through several strategies, including: (i) incorporation of paramagnetic ions into inorganic nanostructured frameworks, (ii) formation of organic–inorganic hybrid nanostructures in which the paramagnetic functionality is located in either component, and (iii) nano-co-assemblies of organic components where at least one component carries paramagnetic functionality [1].

Among these approaches, lipid-based nanocarriers have attracted increasing attention due to their biocompatibility, physicochemical stability, and ability to enhance the intracellular delivery of contrast-providing entities. In addition, lipid nanostructures may improve longitudinal relaxivity (r_1), especially at diagnostically used magnetic fields, by modulating the local environment of paramagnetic centers [2,3].

In this work, we explore glyceryl monooleate(GMO)-based lipid liquid crystalline nanoparticles as self-assembled platforms for hybrid MRI contrast agents. Hybrid constructs were prepared by incorporating paramagnetic common metal oxides with both hydrophilic and hydrophobic characteristics, namely Gd_2O_3 and MnO for the comparison, into lipid liquid crystalline nanoparticles (LLCNPs@Gd_2O_3 and LLCNPs@MnO).

The physicochemical and biological properties of the resulting systems are evaluated with particular emphasis on the relationship between the internal structure of the self-assembled lipid nanoparticles, paramagnetic ion loading efficiency (including estimates per nanoparticle), biocompatibility, and relaxation performance. Other key aspects to be presented include ion release profiles under different environmental conditions, cellular uptake of the lipid-based nanoparticles and finally *in vitro* MR imaging performance.

The results highlight the potential of lipid liquid crystalline nanoparticles as versatile hybrid platforms for T_1-enhancing MRI contrast agents. At the same time, several limitations related to loading efficiency and cell-type-related uptake are identified, indicating directions for further optimization toward future *in vivo* imaging applications.

References

[1] J. Pellico, C.M. Ellis, J.J. Davis, *Contrast Media & Molecular Imaging*, **2019**, 1845637, 13 pages, DOI:10.1155/2019/1845637

[2] D. Flak, T. Zalewski, K. Fiedorowicz, et al., *Journal of Materials Chemistry B*, **2023**, 11(36), 8732-8753, DOI:10.1039/D3TB01110K

[3] L. Tei, M. Botta, C.F.G.C. Geraldes, *Acta Biomaterialia*, **2025**, 207, 468-494. DOI: 10.1016/j.actbio.2025.05.058

How lipid nanoparticles tune the nanomechanics of hybrid electrospun fibre membranes

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Electrospinning is a ubiquitous technique to produce polymer membranes with a sub-micron sized interconnected fiber network. It offers a reproducible approach in which the membrane thickness, its porosity, and morphology can be controlled by spinning time, applied voltage and relative humidity [1]. Electrospinning uses an electrostatically driven jet of polymer solution for deposition of nanofibers on a flat or rotating drum collector. The functional properties of fibre membranes are derived from the chemical nature of electrospinning materials, as well as different processing conditions [2]. Electrospun fibres incorporating new biomimetic lyotropic liquid-crystalline (LLC) nanoparticles [3, 4] offer promising potential as scaffolds for tissue engineering and cultivated-meat production. Their advanced biofunctions, e.g. specific cell adhesion/differentiation, are hypothesized to be closely linked to their morphology, anisotropy, and mechanical strength [5]. The latter underscores the importance of understanding nanodeformations of hybrid systems under external strain, a topic that has not yet been investigated.

In this contribution, I will present our recent advances in applying real-time tensile-SAXS to investigate nanoscale deformations of hybrid electrospun scaffolds whilis measuring the strain-stress curves and upon stress relaxations. The study provides valuable insights into how nanostructures regulate the mechanical microenvironment within scaffolds and how cells may respond to these hybrid electrospun biointerfaces.

References

[1] Maurya AK, Weidenbacher L, Spano F, Fortunato G, Rossi RM, Frenz M, Dommann A, Neels A, Sadeghpour A; Nanoscale; **2019**; 11:7176-87.
[2] Morel A, Domaschke S, Urundolil Kumaran V, Alexeev D, Sadeghpour A, Ramakrishna SN, Ferguson SJ, Rossi RM, Mazza E, Ehret AE, Fortunato G; Acta Biomater; **2018**; 81:169-83.
[3] Tien ND, Maurya AK, Fortunato G, Rottmar M, Zboray R, Erni R, Dommann A, Rossi RM, Neels A, Sadeghpour A; Langmuir; **2020**; 36:11787-97.
[4] Li Y, Murray BS, Ferreira C, Goycoolea FM, Sadeghpour A; Langmuir; **2025**; 41:30090-101.
[5] Liu Y, Guo Q, Zhang X, Wang Y, Mo X, Wu T; Advanced Fiber Materials; **2023**; 5:1241-72.

Pressure dependence of slow dynamics and rheology of Laponite® dispersions

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The slow dynamical behavior of Laponite® dispersions has been widely studied, yet the role of pressure in governing these processes has remained essentially unexplored. In this work, we probe the dynamics and rheology of concentrated Laponite® suspensions under high pressure by combining dynamic light scattering measurements of the slow relaxation time with flow-curve-based determinations of the yield stress. Our results show that increasing pressure markedly accelerates vitrification, producing a faster dynamical arrest and a significant increase in the fragility index. Consistent with this accelerated aging, the time-dependent yield stress also grows more rapidly under high pressure. By applying a fluidity model to relate the evolution of yield stress to the relaxation dynamics, we find that dynamical slowing alone cannot fully account for the observed rheological changes, pointing to the presence of additional pressure-dependent mechanisms. These findings establish pressure as a control parameter in the slow dynamics and rheology of aqueous colloidal dispersions.

J-aggregate-based Artificial Hyperbolic Metamaterials for Light-Matter Coupling at the Nanoscale

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Artificial hyperbolic metamaterials (HMMs) are highly anisotropic media where the real parts of the dielectric tensor's in-plane and out-of-plane components have opposite signs. This crucial characteristic results in a hyperbolic dispersion relation, which allows for the propagation of high-wavevector modes and enhances the photonic density of states. While conventional HMMs use metal-dielectric composites, their tunability is often limited. Organic-based HMMs offer an attractive alternative, promising molecular-level design and integration into flexible devices. Organic semiconductors naturally exhibit strong optical anisotropy and can support hyperbolic properties, where the orientation of the molecular transition dipole moments is key. Some organic films, like those made from certain polymethine dyes, exhibit natural hyperbolic dispersion due to spontaneous lamellar packing. However, controlling this molecular alignment in simple spin-coated films remains a challenge, as anisotropy is highly sensitive to the deposition process.

To overcome this, layer-by-layer (LbL) assembly is a robust alternative for fabricating artificial HMMs. LbL allows for precise control over thickness and composition, making it ideal for chromophores like J-aggregates whose assembly can be regulated in solution. J-aggregates are particularly useful because their narrow-band absorption allows them to achieve negative values for the real part of the dielectric tensor.

While studying diffractograms of synchrotron grazing-incidence wide-angle X-ray scattering (GIWAXS), we demonstrate the fabrication of fully organic artificial HMMs using carbocyanine J-aggregates via an electrostatic LbL protocol. Confirmed by atomic force microscopy (AFM) topography analysis, this technique provides a scalable way to achieve uniaxial films with highly anisotropic optical properties, overcoming the limitations of uncontrolled assembly. By controlling the dye's conformation in solution, we achieve a preferential in-plane orientation of the transient dipole momenta. Our multiscale analysis confirms that the structural ordering induced by LbL is responsible for the bulk hyperbolic response. This is validated by the anisotropic dielectric tensor measured via ellipsometry and the strong agreement between high-momentum angular reflectivity experiments and simulated reflectance. The method's versatility is proven by creating artificial HMMs for three different dyes, all supporting hyperbolic surface exciton polaritons (h-SEPs).

This work was supported by MCIN/AEI /10.13039/501100011033 and NextGenerationEU/ PRTR (Grants: TED2021-130522B-I00 and CNS2023-145364), the European Union under Grant Agreement #101129661-ADAPTATION and Xunta de Galicia/ERDF (Grant: GRC ED431C 2020/09). GIWAXS patterns were recorded at NCD-SWEET beamline with the collaboration of ALBA staff during the granted beamtimes 2022025594-2 & 2023097759. D.C. acknowledges FCT PhD Grant 2022.11947.BD (DOI: https://doi.org/10.54499/2022.11947.BD).

References

[1] J. N. Gama et al., arXiv:2512.20411 [cond-mat.mtrl-sci] (2025) https://doi.org/10.48550/arXiv.2512.20411

Food Science II

Wednesday 20 May 14:55 – 15:55

Non-Fickian diffusion within assemblies of the intrinsically disordered protein β-casein

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Understanding how proteins move within crowded environments is essential for explaining the behavior of biomolecular condensates and other complex systems. Combining quasi-elastic neutron scattering with molecular dynamics simulations, we present recent work [1] uncovering the non-Fickian motion of intrinsically disordered proteins within dense assemblies, by uniquely probing the self-dynamics on pico- to nanosecond time and nanometer length scales. We propose a picture of assemblies behaving as self-crowded microenvironments, leading to anomalous diffusion and heterogeneous dynamics. This framework links molecular crowding, assembly, and transport, providing quantitative insight into how macromolecular organization can fundamentally impact diffusion processes relevant to soft matter physics and biomedical science.

The molecular mechanisms governing internal fluctuations in intrinsically disordered protein (IDP) assemblies are crucial to the stability and dynamics of both regulated and aberrant toxic cellular aggregates, but remain poorly understood. By comprehensively combining high-resolution quasi-elastic neutron scattering with all-atom molecular dynamics simulations, we probe the motions of β-casein, a model IDP, inside its assemblies [1]. We uncover a previously unresolved slow relaxation process with phenomenological characteristics of anomalous non-Fickian diffusion. This anomalous signature emerges from a continuous mobility gradient governed by density and crowding within the assemblies; the core is denser and more compact, and mobility increases progressively toward the exterior. This dynamical heterogeneity underlies the non-Gaussian behavior and accounts for the observed spectral broadening. Our findings provide insight into how disorder and extreme local crowding within IDP assemblies can result in a fundamentally different behavior compared to, e.g., clusters of well-folded proteins. The deviations from Fickian diffusion arise from dynamic heterogeneity and can be captured within the framework by a model typically used for the jump diffusion observed in liquids, thereby extending its applicability [1].

References

[1] L.M. Miñarro, S. Chakraborty, C. Beck, A.C. Grundel, I. Mosca, F. Roosen-Runge, T.I. Morozova, J.-L. Barrat, F. Schreiber, and T. Seydel *Proceedings of the National Academy of Sciences (USA)* **2026**, *123(11)*, e2532636123. DOI:10.1073/pnas.2532636123

The complex rheological behaviour of lactoferrin-mucin systems

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Mucin–protein interactions play a central role in the sensory perception of protein-rich foods, influencing attributes such as thickness, stickiness, mouthcoating, and astringency, yet how protein structural changes regulate mucin affinity remains poorly understood. Here, bovine lactoferrin (LF) was used as a model to examine how thermal denaturation and microgelation affect mucin binding and viscoelastic behaviour. Heat treatment of native LF (nLF) induced partial unfolding and aggregation, yielding a denatured form of LF (dLF), while high-pressure homogenisation generated LF microgels (LFm). Quartz crystal microbalance with dissipation showed a 1.7-fold increase in mucin adsorption for thermally treated dLF relative to nLF, with a further 2-fold increase for LFm. Rheological measurements, including extensional rheology, revealed increased viscosity and prolonged filament break-up in all LF–mucin mixtures compared to mucin alone, indicating enhanced viscoelasticity. Taken together, this work shows how protein restructuring strengthens mucin interactions and redistributes the balance between viscous and elastic stresses during capillary thinning, linking molecular attributes to texture-related functionality in high-protein foods.

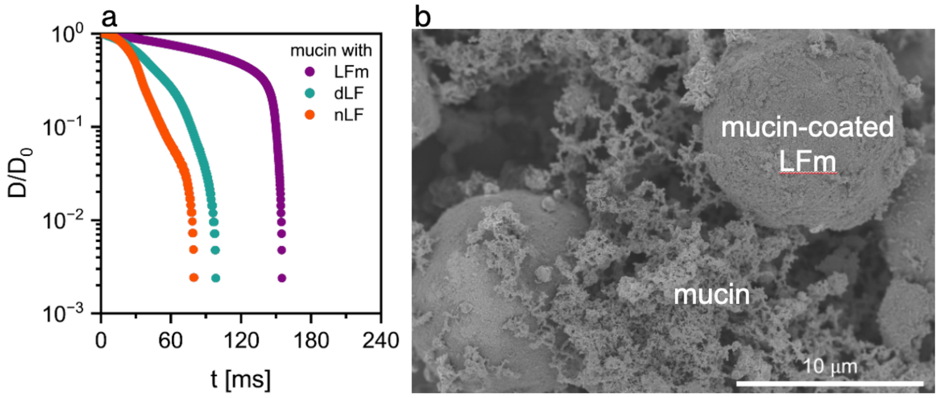

Figure 1: *Temporal evolution of the normalized filament diameter D/D0 for mucin dispersions with lactoferrin at either its native (nLF), denatured (dLF) or microgel (LFm) state. (b) SEM image of a mucin-LFm mixture showing mucin-coated LFm interconnected by mucin networks.*

References

[1] Hazt, B.; Read, D. J.; Harlen, O. G.; Poon, W. C. K.; O'Connell, A.; Connell, S. D.; Sarkar, A. Heat-Induced Structural Changes in Lactoferrin for Enhanced Mucoadhesion. *ACS Applied Bio Materials,* **2025**, 8 (11), 10255–10271. DOI: 10.1021/acsabm.5c01534

[2] Hazt, B.; Read, D. J.; Harlen, O. G.; Poon, W. C. K.; O'Connell, A.; Connell, S. D.; Sarkar, A. Mucoadhesion across scales: Towards the design of protein-based adhesives. *Advances in Colloid and Interface Science,* **2024**, 334, 103322. DOI: 10.1016/j.cis.2024.103322

Designing Function by Programming Assembly; PIESA-Driven Soft Nanomaterials for Food and Pharma

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Reaction-assembly networks offer powerful routes for the one-pot formation of functional macromolecular systems. Among them, polymerization-induced electrostatic self-assembly (PIESA) has emerged as a versatile strategy to generate coacervate-like and polyion complex (PIC) nanostructures with high precision. In PIESA, charged monomers are polymerized from a neutral stabilizing block in the presence of an oppositely charged template. Beyond a critical chain length, electrostatic interactions trigger phase separation, forming a dense micellar core that is sterically stabilized at the nanoscale. By coupling polymerization with self-assembly, PIESA enables direct control over nucleation, growth, morphology, and physicochemical properties, surpassing conventional PIC assembly routes (direct mixing of premade oppositely charged polyelectrolytes).

This approach provides access to a wide range of tunable nanostructures and dynamic morphological transitions, supported by advanced characterization techniques. Its electrostatically driven mechanism further allows incorporation of diverse cargos, including nucleic acids, proteins, and dendritic macromolecules.

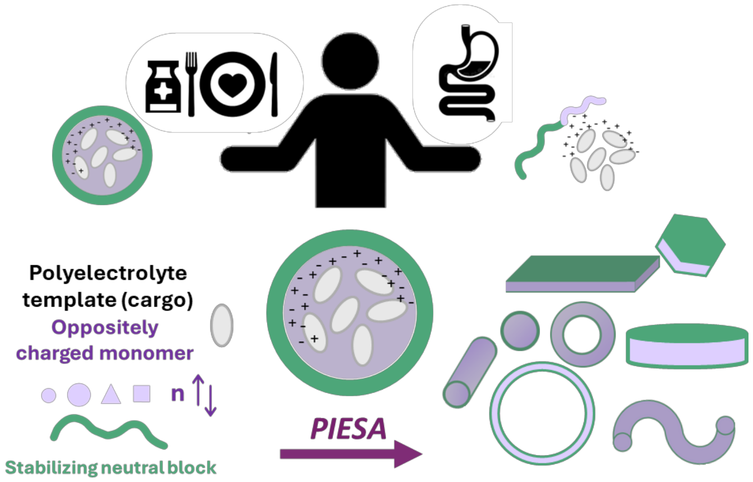

Figure 1: *PIESA as a platform for functional nanomaterials design*

By uncovering the key structure-property relationships governing these systems, PIESA establishes a scalable and modular platform for engineering next-generation soft nanomaterials, with applications in nanomedicine, gene delivery, and nutritional encapsulation.

References

[1] Li, C., Magana, J. R., Sobotta, F., Wang, J., Stuart, M. A. C., van Ravensteijn, B. G., & Voets, I. K. (**2022**). Switchable electrostatically templated polymerization. *Angewandte Chemie International Edition*, *61*(39), e202206780.

[2] Sobotta, F. H., van Ravensteijn, B. G., & Voets, I. K. (**2025**). Sequence-controlled neutral-ionic multiblock-like copolymers through switchable PIESA in a one-pot approach. ACS Macro Letters, 14(9), 1277-1283.

Polymers and Biopolymers II

Wednesday 20 May 14:45 – 17:25

Designing Sustainable Peptide-based Block Copolymer Electrolytes with Tunable Ion Transport and Mechanical Stability

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Nanostructured poly(ethylene oxide) (PEO)-based block copolymer electrolytes provide a promising route to solid polymer electrolytes with decoupled mechanical and ionic properties, but they typically rely on rigid, petroleum-derived polymers such as polystyrene (PS) for mechanical reinforcement and often exhibit limited ionic conductivity at ambient temperature. In this work, we introduce peptide-based block copolymer electrolytes composed of poly(L-histidine)-block-poly(ethylene oxide) (PHis-b-PEO) as a sustainable alternative to conventional PS-b-PEO systems. PHis-b-PEO/LiTFSI electrolytes show thermally activated, PEO-mediated ion transport while maintaining a predominantly solid-like mechanical response, with storage moduli in the MPa range over a broad temperature window, demonstrating effective mechanical–ionic decoupling. To address the limited room-temperature conductivity, we implement a proof-of-concept plasticization strategy by incorporating low-molecular-weight PEO into the block copolymer matrix. Structural characterization reveals selective swelling of the PEO-rich ion-conducting domains without disrupting the PHis-rich reinforcing framework. This leads to more than an order-of-magnitude increase in ionic conductivity and a transition toward diffusion-dominated ion transport, while preserving solid-state mechanical integrity. These results establish peptide-based block copolymers as a versatile and bio-derived materials platform for the design of mechanically robust and sustainable solid polymer electrolytes with tunable transport properties.

Probing molecular interactions between polymer and surface through hydrogel friction

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Polymer dynamics near solid surfaces is of great importance for mechanics, adhesion, friction, and interfacial flows, as it sets the boundary conditions and the macroscopic response of polymer systems. However, directly obtaining the physical characteristics of polymer/substrate interaction from macroscopic experiments can be challenging. Indeed, the macroscopic response of interfaces may strongly couple molecular contributions from the interfaces with mechanical response from the bulk. To isolate polymer/substrate interactions in gels, we develop specific friction experiments in which a spherical silica probe rotates and slides over swollen polymer networks often referred to as gels [1]. The set-up shown in the figure was designed to minimize bulk dissipative processes and allow homogeneous sliding at the interface.

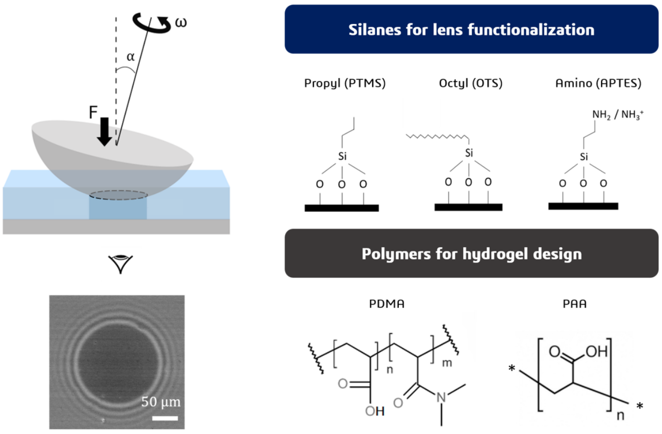

Figure 1: *Schematic of the experimental set-up with in situ contact visualization and the studied physicochemical conditions.*

In these systems, we demonstrated that measuring the velocity dependence of the friction force enables the determination of both the polymer/substrate interaction energy and the surface density of adsorption sites. The experimental results are analyzed using a theoretical model where energy dissipation at the sliding interface arises from sequences of polymer chain pinning, stretching, and desorption from the gel onto silica [1]. This dissipative mechanism is further explored by tuning the interface's physico-chemistry—using polyelectrolytes and neutral polymers, grafting polymer brushes with controlled length and density, or modifying silica lenses with various molecules through silanization.

References

[1] Ciapa, L. et al., Friction through molecular adsorption at the sliding interface of hydrogels: theory and experiments, *Soft Matter*, 2024, **20**, 5933-5943.

On the design of lightweight, multi-layered, single-material polymeric structures

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To enhance recyclability, design strategies increasingly aim to minimize material diversity. However, achieving high performance often necessitates complex multi-material architectures. This study presents a method to bridge this gap by engineering coupled mass and heat transport during the processing of semi-crystalline polymers, enabling the creation of multi-layered structures from a single material. By synchronizing the characteristic timescales of gas mass transport, heat transfer, and polymer crystallization, we established a precise processing window for controlled layering in terms of crystallinity and foaming. We introduce the Time-Temperature-Transformation-Layering (TTTL) diagram as a design tool, validated using Poly-l-lactic acid (PLLA) and Polyethylene terephthalate (PET), with CO_2 as a foaming agent. Our results prove that sustainability and high performance are not mutually exclusive, offering a scalable approach applicable to diverse materials and layering processes.

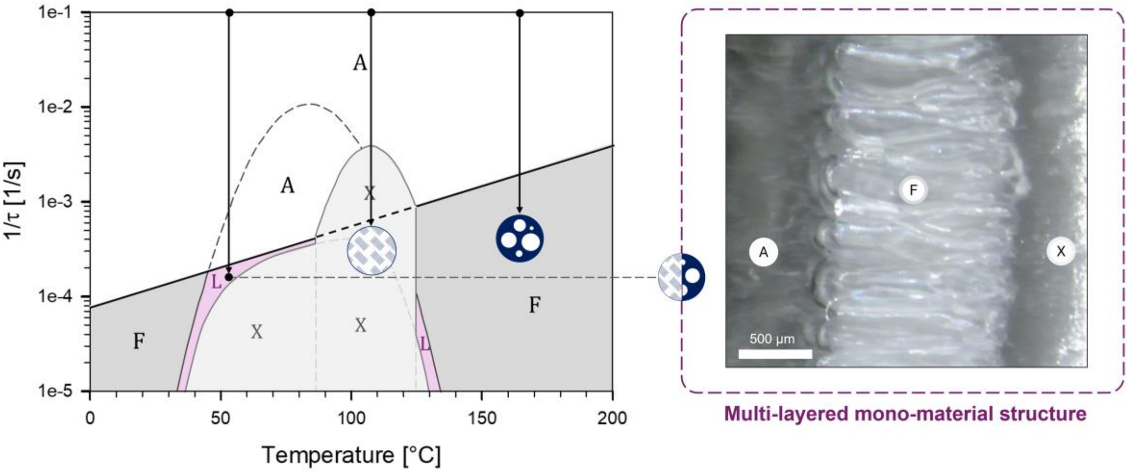

Figure 1: *TTTL diagram for PLLA (right) and optical microscopy of the cross-section of a PLLA sample foamed in an ad-hoc processing window (left).*

Understanding Polymer Behaviour at Fabric–Solution Interfaces via Coarse-grained Simulations

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Soil release polymers (SRPs) are a class of functional polymers found in modern detergent formulations that modify synthetic fabric surfaces to promote water transport and prevent the redeposition of oil-based soil particles during the wash cycle.[1] In this work, SRPs are modelled at fabric surface–water interfaces using dissipative particle dynamics (DPD). In collaboration with synthetic chemists and industry partners, this work aims to support the screening of more effective and environmentally friendly SRP candidates.

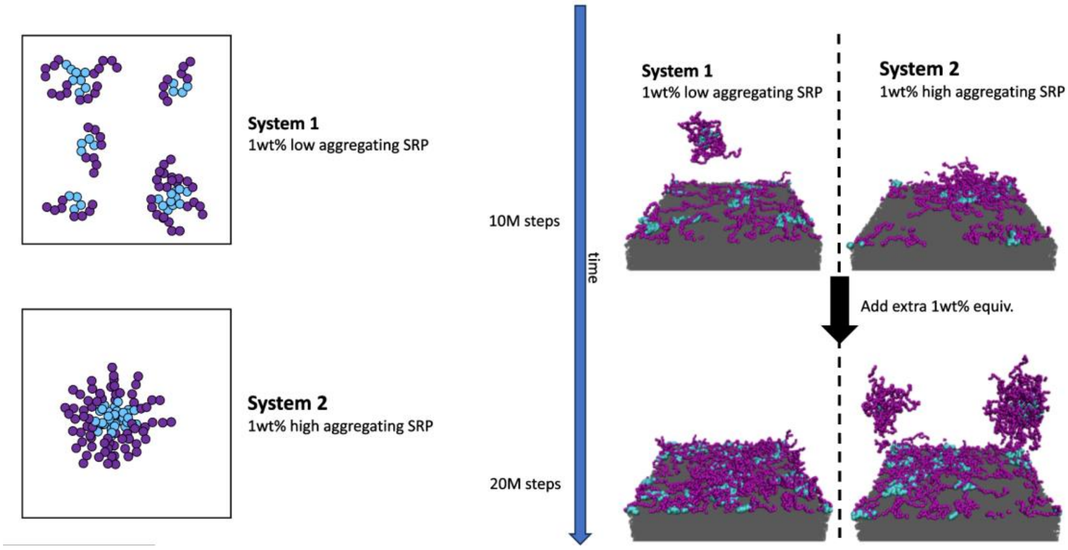

Figure 1: *Two SRP systems on PET surface, modelled in DPD. System 1 has low aggregation and forms even monolayer films. System 2 has high aggregation and forms uneven films.*

DPD is a coarse-grained modelling technique operating at length and time scales between atomistic molecular dynamics simulations and mesoscopic models.[2] This makes it well suited for studying interfacial phenomena over longer timescales while retaining chemical detail. We describe the parameterisation and validation of these simulations, including the design of a DPD PET surface model, and investigate how aggregation in solution affects soil-release performance. Finally, we present a novel DPD parameterisation workflow that leverages machine learning via Bayesian optimisation to automate parameter selection and improve prediction of SRP behaviour.

References

[1] M. Paderes, D. Ahirwal and S. F. Prieto, Phys. Sci. Rev., 2017, 2, 203-233.

[2] R. D. Groot and P. B. Warren, J. Chem. Phys., 1997, 107, 4423–443.

The adsorption of soil-releasing polymers at model fabric interfaces and their effectiveness in the removal of complex soils

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Hydrophobic fabrics, such as polyester or poly(ethylene terephthalate) (PET), prove to be a challenging surface to remove complex soils, such as sweat and sebum from. Creating a more hydrophilic surface can inhibit the adsorption and redeposition of these soils, and this can be achieved by chemical surface modification. Soil-release polymers (SRPs) are designed to promote hydrophilicity at the fabric surface, and a novel family of biosourced pyridine dicarboxylate SRPs have been developed, which are specific to PET1. The SRPs are triblock copolymers of polyester and poly(ethylene glycol) (PEG), where polyester binds to the fabric surface and the PEG outer blocks extend into the PET/water interface, forming a hydrophilic layer (Figure 1). This improves soil removal by increasing the affinity for aqueous laundry liquor and reducing its redeposition. Furthermore, these polymers can have a positive environmental impact, improving cleaning effectiveness at lower temperatures and shorter wash cycles. The pyridine dicarboxylate monomers are a sustainable alternative to petroleum-derived terephthalate. Within the family, we find that small variations in their chemical structure significantly influences their performance. The detailed arrangement of SRP on PET must be established to understand the structure-property relationship. Recent neutron reflection experiments at ISIS Neutron and Muon Source, Didcot, UK provided valuable insights to measure the SRP layer thickness before and after rinsing, the initial kinetics of the SRP-PET adsorption, and by using solutions with contrasting scattering length densities, their arrangement.

However, the structure of the SRP can change when in the presence of ‘laundry liquor’. To observe the SRP arrangement when surfactants are present, small-angle neutron scattering (SANS) techniques used to model this. By finding apporopriate models to fit the data on SasView, depending on whether SDS was present or not, the radius of gyration was established and showed that different structures of SRPs provide different performance rates.

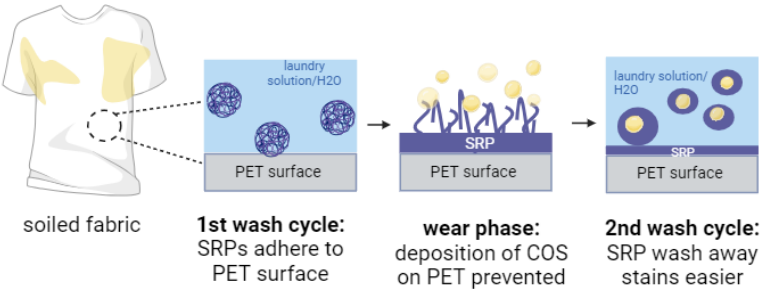

Figure 1: the adsorption of SRPs at the PET surface and their removal performance during washing.

Acknowledgements

Elle Fiandra and Dr Matthieu Starck within the Mahon Group at Durham University

The ANTENNA project with Durham University, Procter & Gamble and Imperial College London.

References

1. Starck, M., Fiandra, E. F., Binks, J., Si, G., Chilton, R., Sivik, M., Thompson, R. L., Li, J., Wilson, M. R., & Mahon, C. S. (2025). Surface Modification of Polyesters UsingBiosourced Soil-Release Polymers. JACS Au, 5(2), 666-674

2. Chi, Y. and Obendorf, S.K. (1998) ‘Aging of oily soils on textile materials: A literature review’, Journal of Surfactants and Detergents, 1(3), pp. 407–418. doi:10.1007/s11743-998-0044-0.

Encapsulation of small hydrophilic drug in centrifugally spun hydrophobic polymer fibers using hydrophobic ion pair formation

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In the past few decades, substantial efforts have been put to create novel dosage forms with optimal properties. Amongst these engineered dosage forms, polymer nanofibers have emerged as leading contenders for various biomedical applications like drug delivery [1], biosensing [2], tissue engineering [3], and regenerative medicine [4]. Centrifugal spinning, an innovative technology for fabricating fibers from polymeric solutions, draws inspiration from the operation of cotton candy machines. Its versatility extends to a broad selection of polymers and solvents. Unlike electrospinning, centrifugal spinning operates without the need for high voltage, offering a cost-effective process with potential for industrial scalability. In this research, prolamin protein fibers were fabricated using centrifugal spinning to encapsulate small hydrophilic molecule Metformin hydrochloride (MET).

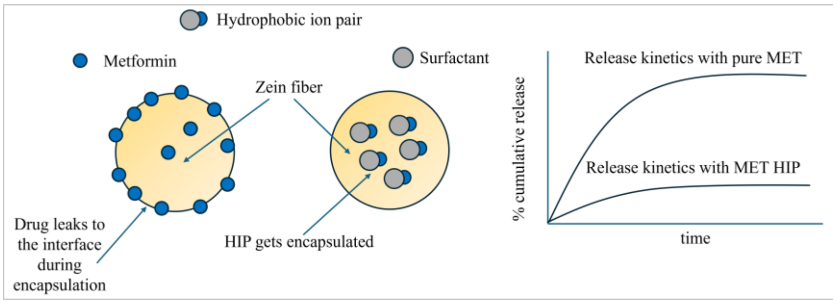

Figure 1: *Schematic representation of impact of hydrophobic io.*

The release behaviour and encapsulation efficiency of small hydrophilic molecules can be enhanced by incorporating them into hydrophobic polymer-based systems that enable sustained drug release and extended retention. However, their high-water solubility, hydrophilic character, and low molecular weight often result in weak interactions with polymers. This leads to poor encapsulation efficiency, unintended leakage, and an initial burst release. Metformin hydrochloride (MET), a cationic biguanide, is widely used in the long-term management of type 2 diabetes. Despite its effectiveness, MET has limitations such as relatively low bioavailability (40–60%), a short half-life, and the need for high and frequent dosing. These factors, combined with its side effects, can negatively impact patient adherence and overall treatment outcomes. Sustained-release formulations offer a promising solution by reducing dosing frequency and improving therapeutic consistency. One effective strategy to enhance the properties of hydrophilic, ionizable drugs like MET is hydrophobic ion pairing (HIP). In this study, metformin is stoichiometrically complexed with oppositely charged anionic surfactants through electrostatic interactions, forming hydrophobic, neutral ion-pair complex. This complex was then encapsulated in protein fibers using centrifugal spinning method. The effect surfactant tail length and chemistry on encapsulation efficiency and release kinetics was studied.

References

[1] Al-Enizi, A.; Zagho, M.; Elzatahry, A. Polymer-Based Electrospun Nanofibers for Biomedical Applications. Nanomaterials 2018, 8, 259. DOI: 10.3390/nano8040259.

[2] Horne, J.; McLoughlin, L.; Bridgers, B.; Wujcik, E. K. Recent Developments in Nanofiber-Based Sensors for Disease Detection, Immunosensing, and Monitoring. Sensors and Actuators Reports 2020,2 (1), 100005.

[3] Rampichov, M.; Buzgo, M.; Chvojka, J.; Proseck, E.; Kofronova, O.; Amler, E. Cell Penetration to Nanofibrous scaffolds: Forcespinning, an alternative approach for fabricating 3D nanofibers. Cell Adh. Migr. 2014, 8, 36–41. DOI: 10.4161/cam.27477.

[4] Chantre, C. O.; Gonzalez, G. M.; Ahn, S.; Cera, L.; Campbell, P. H.; Hoerstrup, S. P.; Parker, K. K. Porous Biomimetic Hyaluronic Acid and Extracellular Matrix Protein Nanofiber Scaffolds for Accelerated Cutaneous Tissue Repair. ACS Appl. Mater. Interfaces 2019, 11 (49), 45498−45510.

Applying the concepts of self-concentration and concentration fluctuations on a new type of dynamically asymmetric mixture of industrial interest

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Blending polymers is a simple path to develop new materials with desired properties, as the rubbers composing tires. Mixtures with Dynamical Asymmetry (DA) are defined by a strong difference in the characteristic time of the different components.

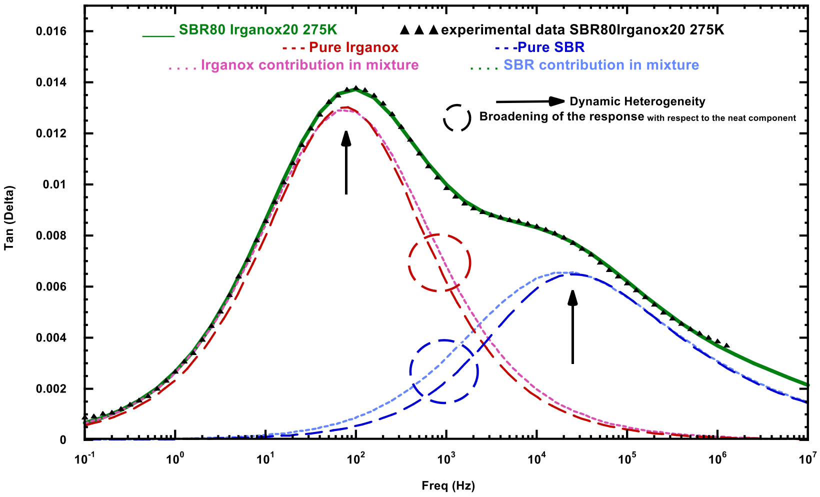

Figure 1: *Impact of blending on the segmental relaxation monitored by BDS of the components in an Irganox / SBR mixture.*

The effects of blending on the relaxation response of the resulting material are the Dynamical Heterogeneity (DH), resulting from the distinct time scale of the two components in the blend, and the broadening of the individual response (BR) respect to those observed in the neat materials. A model was proposed to account for both effects on blends of SBR – the main component of tires – and polystyrene using the concepts of Self Concentration (SC) and Concentration Fluctuations (CF), respectively[1]. Now we explore SBR mixtures with small-molar-mass organic additives that have much higher Glass transition Temperature (Tg).

In this study, we analyze the dynamics of mixtures at different scales and with various concentrations of additive to check the validity of the model for these new types of blends.

By the means of Differential Scanning Calorimetry (DSC), Broadband Dielectric Spectroscopy (BDS) we define the key parameters of the pure components governing their relaxation to describe the behaviors of the mixture with as few free parameters as technically feasible. In addition, we used Small Angle Neutron Scattering (SANS) to obtain direct information on the Concentration Fluctuations (CF).

References

[1] N. Shafqat, A. Alefgria, A. Arbe, N. Malicki, S. Dronet, L. Porcar, J. Colmenero, *Macromolecules,* **2022** 55, 7614-7625, DOI: 10.390/pol1200376

Glasses, Colloids, and Self-Assembly II

Wednesday 20 May 16:25 – 17:45

Interfacial ordering and confinement-induced phenomena in OMBD-grown liquid crystal thin films

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Nanoconfined soft matter systems provide a sensitive platform to probe the interplay between molecular interactions, interfacial effects, and emergent ordering phenomena. In particular, liquid crystalline thin films offer a unique opportunity to investigate how reduced dimensionality and substrate interactions reshape structural organization and dynamics beyond bulk behaviour.

In this contribution, we investigate ultrathin films of isothiocyanatobiphenyl-based liquid crystals from the nBT homologous series (where n denotes the alkyl chain length), prepared via organic molecular beam deposition (OMBD). The OMBD technique enables the formation of organic thin films under high vacuum conditions by depositing individual molecules, typically evaporated from a Knudsen cell, onto a cooled substrate [1]. This method enables controlled fabrication of well-defined films in the nanometer thickness regime, providing a versatile platform for systematic studies of confinement and interfacial coupling.

A combination of structural (GIWAXS, XRD), surface-sensitive (AFM), and spectroscopic (Raman, dielectric spectroscopy) techniques reveals a hierarchical ordering mechanism. At low thicknesses, molecular organization is dominated by substrate-induced constraints, leading to preferential arrangement of aromatic cores and alkyl chains. With increasing thickness, enhanced orientational order emerges, including alignment of polar isothiocyanate (–NCS) groups, indicating the onset of cooperative intermolecular interactions beyond the immediate interface.

Dielectric spectroscopy further demonstrates that confinement induces qualitative modifications of molecular dynamics, including additional relaxation processes absent in the bulk and a persistent high-frequency contribution attributed to an interfacial paranematic layer with restricted mobility [2].

Overall, these results establish OMBD-grown liquid crystalline thin films as model soft matter systems for studying interfacial ordering, confinement-induced dynamics, and nanoscale structure formation pathways [3]. Variations within the nBT series highlight how subtle changes in molecular architecture translate into distinct self-organization scenarios, providing insight relevant for the design of functional anisotropic nanomaterials.

Acknowledgements

A.D. gratefully acknowledges the Alexander von Humboldt Foundation for financial support through a Research Fellowship for Experienced Researchers.

References

[1] F. Schreiber, *Phys. Status Solidi* **2004**, 201, 1037-1054, DOI: 10.1002/pssa.200404334.

[2] A. Drzewicz, M. Krupiński, O. Tomchuk, E. Pięta, G. Lewińska, E. Juszyńska-Gałązka, *J. Mol. Liq.* **2025**, 437, 128573, DOI: 10.1016/j.molliq.2025.128573.

[3] A. Drzewicz, M. Wübbenhorst, *IEEE Trans. Dielectr. Electr. Insul.* **2025**, 32, 1631–1638, DOI: 10.1109/tdei.2025.3546175.

Molecular Ionic Glasses as Recyclable Alternatives to Glassy Polymers.

Y.Lu; S. Majumdar, J.Pees, D.Brake, Thomas E. Kodger, Jasper van der Gucht
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Polyelectrolyte complexes (PECs) are, in principle, thermally reprocessable ionically crosslinked polymer networks. However, the processing of conventional PECs typically relies on external plasticizers or humidity tempering, in which water molecules screen ionic interactions and plasticize the network, thereby limiting their applicability [1,2]. Alternatively, ionic interactions can be weakened by introducing bulky substituents close to the charged groups [3]. When these substituents are hydrophobic, the resulting materials become more resistant to moisture. Building on this concept, we have developed a series of molecular ionic glasses (MIGs) based on moderated ionic interactions between multivalent, sterically screened small molecules. This approach addresses the moisture-sensitive mechanical properties of earlier recyclable and biodegradable glassy supramolecular polymer networks that required an additional moisture-resistant coating[4]. While all MIGs rely on the same ionic moiety, varying the number of charged groups and the structure of the uncharged moieties allows access to a broad range of mechanical properties, from ionic liquids to soft malleable solids to hard brittle glasses. Moreover, the small molecules in MIGs enables easier processing via extrusion, hot-pressing and glass blowing, while a potential recycling strategy is proposed to recover the material from mixtures with other commodity polymers.

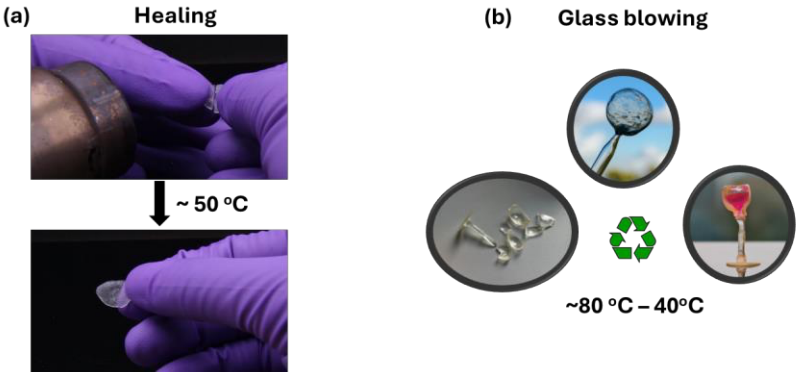

Figure 1: *a) Demonstrating of fracture to healing in MIG3s2s at 50 °C . b) Images showing glass blowing of MIG3s2s into a miniature "wine glass" at a temperature range of ~80 °C to 40 °C*

References

[1] P. Schaaf, J. B. Schlenoff, Adv.Mater, 2015 27 (15), 2420-2432., DOI: 10.1002/adma.201500176

[2] I. A. Ramírez Marrero, N. Kaiser, B. von Vacano, R. Konradi, A. J. Crosby, S. L. Perry, Macromolecules, 2025 58 (6), 2925-2938, DOI: 10.1021/acs.macromol.4c02819

[3] S. G. M. van Lange, D. W. te Brake, G. Portale, A. Palanisamy, J. Sprakel, J. van der Gucht, Science Advances, 2024, 10, DOI:10.1126/sciadv.adi3606

[4] Y. Cheng, E. Hirano, H. Wang, M. Kuwayama, E. W. Meijer, H. Huang, T. Aida, Science, 2024 386, 875–881, DOI: 10.1126/science.ado1782

What controls structural relaxation once a glass-forming liquid is cooled below the Mode-Coupling crossover temperature T_c? In this contribution, we address this longstanding question by means of large-scale simulations of a deeply supercooled liquid[1]. We show that, below T_c, relaxation is no longer governed by the same microscopic scenario that describes the moderately supercooled regime. Instead, a new microscopic mechanism distinctly arises in which particles escape from their cages also by performing rare, but very large hops (of the order of the nearest-neighbor distance), before becoming trapped again.

This picture reveals an unexpectedly simple and robust low-temperature dynamical regime that is qualitatively different from the Mode Coupling one at intermediate supercooling. The rare hopping events generate novel scaling-laws for the relaxation dynamics of deeply supercooled liquids: clear subdiffusive power laws in the mean-squared displacement and in the self-intermediate scattering function are identified.We also give a novel explanaition for the universal excess wing observed in the dynamical susceptibility.

Analysis of the self part of the Van Hove function further uncovers the coexistence of three distinct particle populations: those still caged, those that have already escaped the cage by small but correlated jumps and those that have performed hops. This highlights the strongly heterogeneous but highly interpretable nature of relaxation at low temperature.

Our results propose a unified microscopic framework for relaxation in glass formers close to the experimental glass transition, and identify rare cage escapes as the elementary process that drives dynamics in the deeply supercooled regime.

[1] Francesco Rusciano, Raffaele Pastore, Francesco Greco, Walter Kob, *Rare cage escapes drive relaxation in deeply supercooled liquids*, Under Review

Two Clocks, one event: dual relaxation mechanisms governing physical aging of polymeric glasses

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Amorphous polymers account for roughly one-third of global polymeric material usage, with properties rooted in their disordered, non-equilibrium microstructure [1]. Below the glass transition temperature T_g, these materials undergo physical aging, a spontaneous structural reorganization driven by the thermodynamic drive toward liquid-state equilibrium [2], which progressively alters mechanical, thermodynamic, and transport properties, with direct consequences for polymer composites, adhesives, and packaging materials [3]. Classical theory attributes glassy relaxation exclusively to the primary α relaxation with super-Arrhenius temperature dependence. However, a growing body of evidence points to secondary relaxation processes operating on timescales incompatible with α-relaxation alone [4], challenging the established picture and motivating the present work.

We employed fast scanning calorimetry (FSC) at 1000 K s^{-1} to investigate physical aging kinetics in poly(4-chlorostyrene) (P4ClS) over a broad temperature range (390–412 K) and aging times spanning six decades (10^{-1}–10^{5} s). Two observables were tracked simultaneously from FSC thermograms: the recovered enthalpy (ΔH), a direct thermodynamic measure of structural relaxation, and the width of the devitrification peak (ΔTg), an indirect probe of dynamic heterogeneities. Near T_g, both parameters equilibrate on identical timescales, consistent with α-relaxation control. Strikingly, at temperatures well below T_g ($T_a \approx T_g - 20$ K), enthalpy equilibration (τ_{eq1}) precedes the equilibration of ΔT_g (τ_{eq2}) by orders of magnitude, demonstrating that the glass can reach enthalpic equilibrium ($\Delta H = 0$) while structural heterogeneities remain unrelaxed ($\Delta G < 0$). Comparison with molecular relaxation times from step-response calorimetry and broadband dielectric spectroscopy [5] confirms that ΔT_g follows pure α-relaxation kinetics, while enthalpy recovery is accelerated by a secondary mechanism. This decoupling was reproduced in three additional polymer glasses, such as PCDM, PET, and PAr, establishing its generality. These findings reveal an inherent complexity in glassy dynamics that demands revision of current aging models and opens new avenues for the rational design of long-term stable glassy materials.

References

[1] P.G. Debenedetti, and F.H. Stillinger, Nature, vol. 410, pag. 259-267 (2001).
[2] J. M. Hutchinson, Prog. Polym. Sci., vol. 20, pp. 703-760 (1995).
[3] S. J. D. Smith et al., Acc. Chem. Res., vol. 53, 1381-1388 (2020).
[4] D. Cangialosi et al., Phys. Rev. Lett., vol. 111, pag. 095701 (2013).
[5] Z. Song et al., Sci. Adv., vol. 8, eabm7154 (2022)

New Methods and Techniques / Synthesis

Thursday 21 May 09:45 – 12:45

Experimental Platforms for SoftComp Users

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Soft-matter research requires a diverse range of experimental platforms ranging from large facilities (neutron scattering, X-ray scattering, NMR, and (Cryo-) electron microscopy) to smaller specialized equipment available through individual partners (light microscopy, rheometers/rheo-optics, and microscopy, spectroscopy, and scattering in combination with sample environments for the application of external fields such as temperature-gradients, electric and magnetic fields, and flow). The novel equipment offered by SoftComp is often home-build and not commercially available. Here, in this short presentation, we retrospect the existing SoftComp Experimental Platforms and introduce updated support, enabling access to the diverse set of equipment, in order to probe micro-structural order, dynamics, transport phenomena, and the response to external fields over a large range of length- and time scales in soft matter composites. The activity is available throughout working Network Areas (NA1, NA3, and NA4), under contacts of the local scientist to assess the availability of equipment and the feasibility of your planned experiments.

References

[1] https://eu-softcomp.net/research-platforms/experimental/

Detection of ultrafine particles in the air using fiber-tip optical sensors

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Ultrafine particles (UFPs, diameter < 100 nm) pose significant health risks as they penetrate deep into the respiratory tract and cross biological barriers. Current detection methods rely on bulky, expensive instruments unsuitable for distributed monitoring in schools and homes. We present a novel approach for detecting airborne UFPs based on a nanophotonic sensor on a standard optical fiber tip [1]. A photonic-crystal cavity patterned in a thin ($\sim$200 nm) InP membrane is transferred onto the fiber tip via van-der-Waals adhesion. The cavity confines light within a sub-micrometer volume, making the reflected signal highly sensitive to local refractive-index changes. We have demonstrated single-particle detection down to $\sim$50 nm in liquid.

A key challenge is efficiently delivering airborne UFPs to this small detection region. The sensor currently requires particle concentrations of order 10^8 cm^{-3}, whereas typical indoor UFP concentrations are around 10^3 cm^{-3}. To bridge this gap, we focus on an in-liquid delivery approach that works in three steps (Fig. 1): (1) capture of airborne UFPs into a microliter-scale droplet via electrostatic precipitation; (2) transport of the droplet to the fiber-tip detection region using electrowetting-on-dielectric (EWOD); and (3) optical detection of UFPs at the fiber tip. Our goal is to integrate all three steps on a single device based on a printed circuit board (PCB).

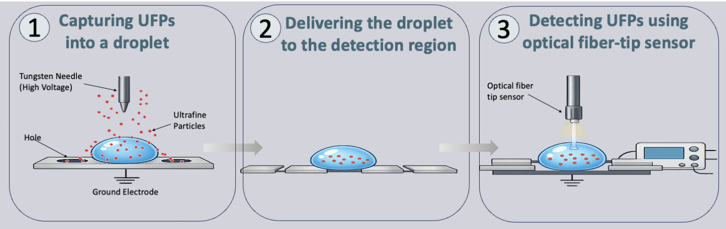

Figure 1: *Three-step detection approach: (1) capturing UFPs from air into a droplet via electrostatic precipitation, (2) delivering the droplet to the detection region using EWOD, and (3) detecting UFPs with the fiber-tip sensor.*

I will discuss how we address the challenges in each of these steps and how soft matter science can help resolve them. In particular, I will show how concepts from dynamic light scattering—specifically those dealing with intermittent and temporally heterogeneous dynamics—can be applied to the analysis of the optical detection signal, potentially improving the limit of UFP concentration that can be reliably detected.

References

[1] L. Picelli, P. J. van Veldhoven, E. Verhagen, A. Fiore *Nat. Nanotechnol.* **2023**, *18*, 1162–1167. DOI:10.1038/s41565-023-01435-x

Analysing DDLS data - Common Pitfalls and How to Avoid them

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Dynamic light scattering (DLS) is typically considered a powerful tool to measure dynamic properties of colloidal particles. In particular depolarized DLS is used to investigate the orientational dynamics of particles with anisotropic shape or dielectric properties.
We applied DDLS to investigate the dynamics of dilute suspensions of cellulose nano-crystals, which are considered rod shaped particles. Those had been characterized with atomic force microscopy beforehand to identify their length and diameter and the respective distributions.

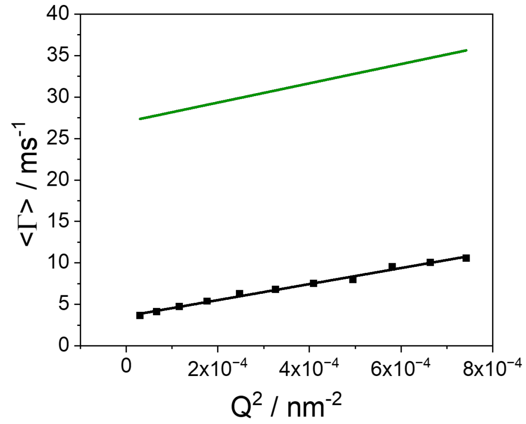

Figure 1: *Average relaxation rates of DDLS correlation functions determined by stretched exponential fitting vs. scattering vector squared. Symbols are experimental data with linear regression (black line). The slope is typically identified as twice the translational diffusion coefficient and the intersect with twelve times the rotational diffusion coefficient. The green line represents the expected trend calculated from the size and size distribution parameters determined by AFM.*

In a first approach we used the standard method to determine diffusion coefficients from DDLS, i. e. stretched exponential fitting and cumulant analysis of the intensity time auto correlation function. The results were compared to the diffusion coefficients which can be calculated from the size parameter using the cylinder model suggested by Ortega *et al.* [1]. We find that the experimental value of translational diffusion coefficient agrees reasonably well with the calculated value, while for the rotational diffusion the two values are almost an order of magnitude apart. In this contribution we will discuss the reasons for this deviation and the proper implementation of a symmetric top model [2] to avoid it.

References

[1] A. Ortega and J. Garcia de la Torre *J. Chem. Phys* **2003**, *119*, 9914. DOI:10.1063/1.1615967

[2] W. Eimer et al *Biochemistry* **1990**, *29*, 799. DOI:10.1021/bi00455a030

Inferring Extensional Viscosity from the Shape of Stretched Liquid Filaments in Airflow, from Newtonian Fluids to Saliva

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Liquid filament breakup plays a key role in many industrial processes such as inkjet printing and spraying, but it is also central in biomedical contexts, particularly in the airborne transmission of pathogens through saliva droplets generated during speech, coughing, or sneezing. These droplets originate from the stretching and rupture of thin saliva filaments formed between the lips and broken by the expelled airflow.

Here, we investigate the deformation and thinning of liquid filaments subjected to rapid uniaxial stretching and exposed to a controlled transverse air flow. Using a dedicated experimental setup, we analyze how Newtonian filaments thin and bend under the combined action of capillary forces and aerodynamic stresses.

By comparing the measured filament shapes with viscous and aerodynamic friction models, we infer the internal tension within the filaments. This approach provides a way to estimate an effective extensional viscosity directly from the filament geometry. The framework is finally extended to viscoelastic fluids such as human saliva, allowing their deformation and thinning behavior to be quantitatively characterized.

Making zein coacervates films more flexible: experiments and computer simulations

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The corn-derived protein zein is soluble in mixed solvents such as water/ethanol [1]. Upon increasing the water content of the solvent, zein will first exhibit liquid-liquid phase separation ("coacervation") before becoming completely insoluble [2]. Previously we have found that zein coacervates are very good starting material for zein film fabrication [3]: using industry-standard film applicators, the highly viscous and concentrated coacervate phase can be spread rapidly and uniformly on a suitable substrate. After drying (which is rapid) strong and hydrophobic films are formed (**Fig. 1a**). As with most biopolymer films however, the films are quite brittle. Here we investigate the effect of various plasticizers for zein coacervate films, using both experiments and computer simulations. In experiments we find that especially intermediate chain-length fatty acids (C8) and short PEG chains are effective plasticizers. To understand the impact of the plasticizers at the molecular level, we have started to do molecular dynamics (MD) simulations. Zein sequences contain repetitions of 20-amino-acid long sequence motifs. As a workable and generic model for zein simulations, we propose sequences consisting of 5 repeats of the characteristic repeat motif of α-zein. At all solvent conditions, the model zeins are found to be largely α-helical, but only at 70% ethanol are the helices fully extended (**Fig. 1b**). At both higher and lower ethanol concentrations, the helices fold up into globules, via loops induced by proline residues. We find that PEG acts much like ethanol in solubilizing zein. However, since it is non-volatile, it acts as a plasticizer in the dried films.

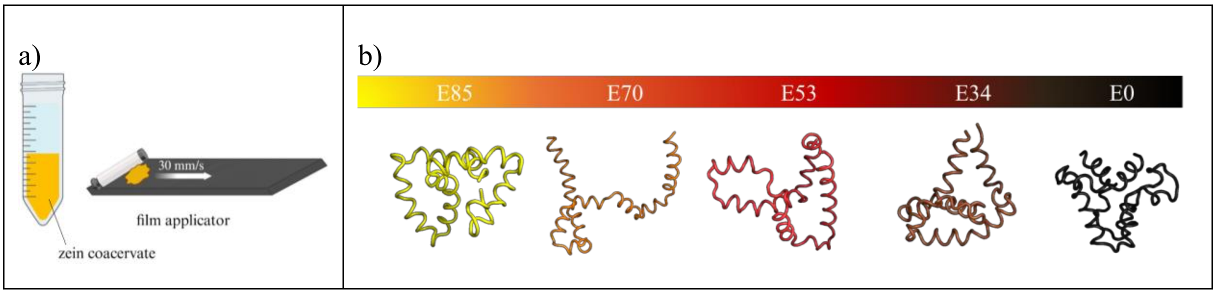

Figure 1: *a) Preparation of flexible zein coacervate films by using an industry-standard film applicator; b) Snapshots of model zein in 0-85% (w/w) ethanol-water mixtures from the final frame of 5 µs MD simulations.*

References

[1] A. R. Patel, K. P. Velikov, *Curr. Opin. Colloid Interface Sci.* 2014, **19**, 450–458, DOI: 10.1016/j.cocis.2014.08.001.

[2] X. Li, P. Erni, J. van der Gucht, R. de Vries, ACS Appl. Mater. Interfaces 2020, **12**, 15802–15809, DOI: 10.1021/acsami.9b20746.

[3] Y. Wang, L. Zhang, T. Li, Y. Wang, J. Jiang, X. Zhang, J. Huang, B. Xia, S. Wang, W. Dong, *Colloids Surf. A Physicochem. Eng. Asp.* 2023, **666**, 131255, DOI: 10.1016/j.colsurfa.2023.131255.

A silica-supported poly(ethylene glycol) (PEG) hydrogel developed for the removal of organic dyes in water remediation applications

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The contamination of water by organic dyes and chemical substances used in textile manufacturing, particularly in fast fashion production, represents one of the major sources of global environmental pollution, to which substantial financial resources are allocated each year. The use of systems capable of adsorbing large amounts of pollutants from water, while also being easily recovered and regenerated, appears to be the most promising strategy.

Silica particles are widely studied as efficient systems for pollutant removal thanks to their high porosity, hydrophilicity, chemical stability, and ease of regeneration. However, their direct use as powders in regenerable systems is mainly limited by the difficulty of recovering them after deployment in water.

Embedding silica particles as fillers within gel matrices offers a viable solution for easier recovery and regeneration, while also improving the mechanical properties of the gel.

In this work, poly(ethylene glycol) diacrylate (PEGDA) hydrogels were developed and loaded with porous silica particles, either unmodified or functionalized with amine groups, to enable the adsorption and removal of toxic organic pollutants from water. The materials were characterised using rheological, thermogravimetric, and spectroscopic analyses, along with adsorption tests employing model organic pollutants.

The results show that the incorporation of porous silica particles improves the mechanical properties of the hydrogel without compromising the particles' adsorption capability. In the case of amine-functionalized particles, although the mechanical performance is slightly reduced, adsorption tests reveal an expanded range of pollutant types that can be effectively captured. Overall, the findings demonstrate that hydrogel–silica systems are promising candidates for the removal of diverse families of organic contaminants from water, and this could potentially be extended to inorganic pollutants as well.

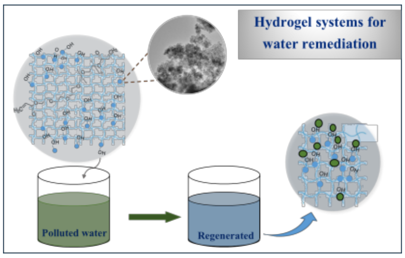

Figure 1: *Schematic diagram of water regeneration using silica hydrogel systems.*

Acknowledgements:

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From ionic liquid nanostructure to water purification: linking molecular dynamics with extraction and sorption performance

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Ionic liquids (ILs), salts with melting temperature lower than the boiling point of water, are highly versatile solvents whose physicochemical properties can be tailored through appropriate design of cation and anion structure. They are already recognized as nanostructured soft materials rather than uniform solvents. IL's nanoscale organization is governed by competition of local ordering, nanosegregation, and dynamic heterogeneity, which results from electrostatic interactions, steric effects, and solvophobic segregation, which directly affects molecular mobility, interfacial structure, and functionality. As far as the ILs in bulk are often considered toxic, non-environmental friendly, with a enormous life-cycle burden, or simply too expensive for real life applications, its importance was acknowledged in the area of supported ionic liquids (SILP – supported ionic liquid phase). These ionic liquids refer to ionic liquids that are immobilized on supports via chemical or physical interactions (or both). The idea of SILPs was already used fort the design of new catalysts, absorbents, and other functional materials, usually with unique surface properties such as great uniformity, high specificity, and tunaeble activity.

Here, we discuss structure-dynamics-function relationships in ammonium-based ionic liquids and ionic-liquid-functionalized nanocellulosic systems using NMR diffusometry, NMR relaxometry, SAXS, DSC, and FTIR. Our results show that changes in cation architecture, including alkyl chain elongation and quaternary-group geometry, induce pronounced differences in nanoscale ordering and ion dynamics. We further relate these effects to cellulose-containing and nanocellulose-based systems, where cation structure controls local packing and interfacial interactions. This becomes particularly relevant for hybrid sorbents, in which ionic-liquid structure influence sorption-site accessibility and pollutant affinity. The results demonstrate that extraction and water purification performance emerge from nanoscale ordering and molecular dynamics, providing a soft-matter framework for the rational design of ionic-liquid-based separation media and biobased sorbents.

Acknowledgemenets:

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Biological Soft Matter II

Thursday 21 May 09:45 – 12:45

Non-invasive NMR assessment of water status in soft and biological systems

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The dynamics of water molecules in soft matter, both biological and synthetic origin, can be successfully studied using non-invasive nuclear magnetic resonance (NMR) spectroscopy methods. For NMR measurements, we do not need staining, probes, or perfectly clean and transparent systems to investigate the physicochemical nature of matter. Using NMR, it is possible to determine the dynamics of water molecules in the context of different chemical and structural environments, and to describe their translational motion (diffusion) within various types of confinement.

By interpreting NMR relaxation times, we can obtain information about whether water in a system—for example biological systems such as seeds—behaves as free water or is structurally bound what can be critical for germination [1]. Similar experiments were also performed in synthetic materials, e.g. hydrogels, complementarily imaging the hydration process, and studying changing water mobility [2]. In such studies, we are not only able to assess the environment of water molecules through indirect physical parameters, but also to precisely link them to morphological transformations using NMR imaging methods (MRI – magnetic resonance imaging). Moreover, NMR diffusometry gives us the ability to observe translational movement of water, i.e. diffusion, and on that basis to evaluate its physical character and scale of possible restrictions. By observing diffusion in different periods, what is possible in NMR from single to hundreds of milliseconds, we can determine the distance at which water molecules encounter a barrier and conclude whether it is an effective obstacle for them or partially permeable. Such experiments can be used when studying roots taking up water from their surroundings and analyzing the influence of soil contaminants, e.g., heavy metals, on induced structural as well as biochemical changes and how they are linked to water molecules transport [3]. Similarly, diffusion of water can be considered in colloidal and hydrogel systems to gain knowledge about its restricted nature in entangled environment.

Information about water molecules dynamics obtained from NMR studies is unique – it allows assessment of behavior at both the molecular and macroscopic scales. Therefore, NMR is often utilized in applications, where processes such as water transport or hydration is important and should be considered complementary.

References

[1] K. Lechowska, S. Kubala, Ł. Wojtyła, G. Nowaczyk, M. Quinet, S. Lutts, M. Garnczarska, *International Journal of Molecular Sciences*, **2019**, 20, 540, DOI:10.3390/ijms20030540

[2] G. Nowaczyk, M. Kempka, B. Wereszczyńska, D. Flak, J. Gapiński, *Polymer Testing*, **2024**, 137, 108505, DOI: 10.1016/j.polymertesting.2024.108505

[3] R. Rucińska-Sobkowiak, G. Nowaczyk, M. Krzesłowska, I. Rabęda, S. Jurga, *Environmental and Experimental Botany*, **2013**, 87, 100– 109, DOI: 10.1016/j.envexpbot.2012.09.012

Active tension and flow in actin rings and cortical networks

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In vitro, a variety of filament-motor-crosslinker systems have been shown to display complex dynamic behaviour [1]. The interplay of the filaments, molecular motors, and crosslinkers leads to bending, buckling, and sliding of the filaments in either contractile or extensile systems [2, 3]. In biological cells, cortical actin cytoskeletons have been found to generate tensions of the order of $10 - 100\,\mathrm{pN}/\mu m$. However, the dependence of the tension on the cytoskeletal architecture and dynamics remains poorly understood.

Here, we use Brownian dynamics simulations to study mixtures of semiflexible polymers and Hookean springs–whose ends are attached to and propelled along the filaments–to quantify the active tension generated in acto-myosin rings and 2D acto-myosin networks, see Fig. 1. A turnover of both filaments and motors is essential for maintaining stable contractile rings and networks. We predict that an increasing number of filaments will increase active tension, and increasing filament turnover will decrease it. For sufficiently small filament turnover, we observe local (macroscopic) cytoskeletal flows. Our simulations allow us to correlate structure and dynamics at the filament level with active tensions at the cellular scale.

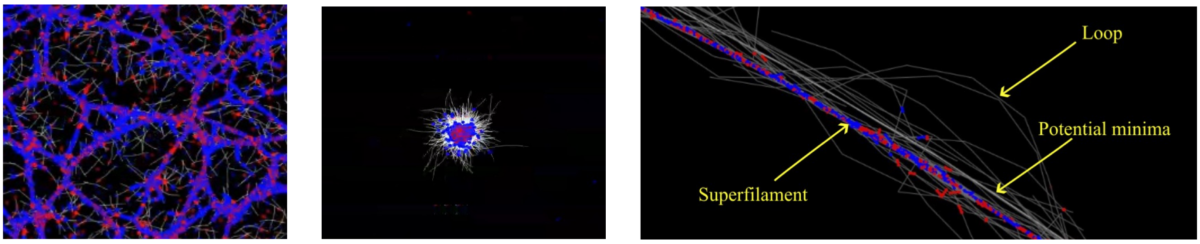

Figure 1: *Simulation snapshots of systems simulated using Brownian Dynamics containing actin filaments (white), molecular motors (red), and static crosslinkers (blue): (a) 2D actin network, (b) aster, and (c) part of an actin ring. The actin ring develops in a ring-shaped target parabolic potential (circular line) and–because of contraction–is pulled towards the center.*

References

[1] T. Sanchez, D. T. N. Chen, S. J. DeCamp, M. Heymann, Z. Dogic, *Nature* **2012**, *491*, 431. DOI:10.1038/nature11591

[2] G. A. Vliegenthart, A. Ravichandran, M. Ripoll, T. Auth, G. Gompper, *Sci. Adv.* **2020**, *6*, eaaw9975. DOI:10.1126/sciadv.aaw9975

[3] J. M. Belmonte, M. Leptin, F. Nédélec, *Mol. Syst. Biol.* **2017**, *13*, 941. DOI:10.15252/msb.20177796

Cell blebbing: a microgel-vesicle model

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Blebbing, i.e., the formation of lipid-bilayer buds that are detached from the cytoskeleton is common in cell motility and death [1]. Microgels are very versatile soft-matter systems with tunable size, shape, and deformability. Using a spring network model for the microgels and triangulated surfaces for the membranes, we study vesicle-encapsulated microgels with computer simulations and energy minimization [2]. This is a bio-mimicking model that can be used to systematically characterize the bleb formation.

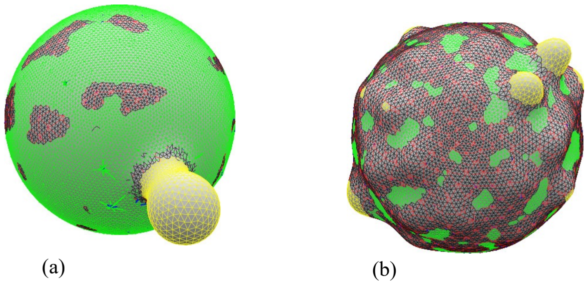

Figure 1: *Vesicle-encapsulated microgels: (a) single bud and (b) wrinkled membrane*

We encapsulate microgels with different Young's moduli within initially spherical vesicles and shrink the gels at different rate. The interplay of microgel and vesicle deformations is controlled by the competition between microgel elasticity and vesicle bending rigidity. We observe the formation of a single bud for slow and a wrinkled membrane for high shrinking rates, see Fig. 1. Also, the bud formation is slower for lower Young's moduli, similar to the osmotic compression of shells [3]. This study will allow us to comprehend the blebbing in cell physiology.

References

[1] G. T. Charras *J. Microsc.* **2008**, *231*, 466. DOI:10.1111/j.1365-2818.2008.02059.x

[2] T. Debnath, J. Midya, T. Auth, G. Gompper *ACS Macro Lett.* **2025**, *14*, 1412. DOI:10.1021/acsmacrolett.5c00424

[3] G. A. Vliegenthart, G. Gompper *New J. Phys.* **2011**, *13*, 045020. DOI:10.1088/1367-2630/13/4/045020

Understanding how proteins and lipids control cell death

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The complexity of membrane systems can make it difficult to obtain an overall picture of their organization. However, preparation of planar lipid bilayers and analysis with neutron reflectivity (NR) and attenuated total reflection- Fourier transform infrared spectroscopy (ATR-FTIR) can be used to identify the position of crucial proteins in respect to the membrane and to identify the kinetics of the interaction. We can characterize active biological processes in physiological conditions by employing hydrogen/deuterium labeling to create a strong contrast between the lipid and protein components.

One such crucial biological process is apoptosis, a programmed mechanism by which our body removed unwanted or unhealthy cells. This mechanism is tightly regulated by proteins at the mitochondrial outer membrane (MOM). In apoptosis, Bax protein is attracted to the MOM, where it induces membrane leakage. In healthy cells, small amounts of Bax are neutralized by the anti-apoptotic Bcl-2 residing in the MOM.[1]

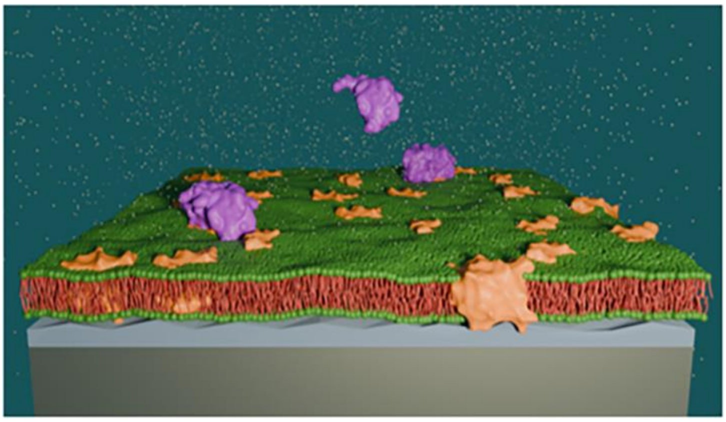

Figure 1: *Drawing of Bax proteins associating to a planar model of a mitochondrial outer membrane containing Bcl-2 protein.*

Our findings demonstrate that in the absence of Bcl-2, the Bax protein both inserts into the lipid bilayer and removes lipids, forming a lipid-protein complex on top of the original bilayer structure. However, our recent findings show that when Bcl-2 is reconstituted into lipid bilayers, Bax associates to the bilayer but does not insert into it or remove lipids. Initially monomeric Bax associates to Bcl-2 followed by further sequestration of Bax to the surface. Our results provide the first structural evidence of Bcl-2 preventing membrane perforation by Bax as part of its anti-apoptotic mechanism.

References

[1] S. Qian, W. Zhong, Y. Wanting, H. Jonling, Y. Yinfeng, J. Wang, *Frontiers in Oncology*, **2022**, 12, 985363, DOI: 10.3389/fonc.2022.985363/full

[2] S. E. Ayscough, L. A. Clifton, J. Ådén, S. Köhler, N. Paracini, H. Wacklin-Knecht, G. Groebner et al., *ACS Chemical Biology*, 2026, 21(3), 565-576, DOI: 10.1021/acschembio.5c00913

Microfluidic Synthesis of Theranostic Liposomes for Combined Drug Delivery and MRI Contrast Enhancement

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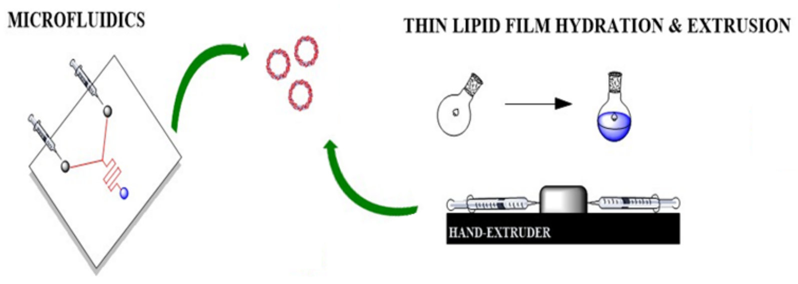
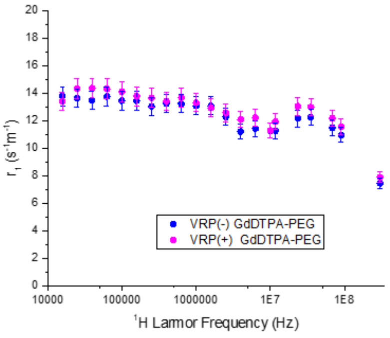
Nanoscience is one of the fastest-developing fields of modern science, particularly in biomedical applications. Multifunctional nano-objects produced using advanced fabrication methods exhibit unique physicochemical properties, versatile transport capabilities, and excellent biocompatibility, making them highly attractive for research and clinical applications. The wide range of chemical compositions available for nanocarriers enables precise tuning of their properties to meet specific biomedical requirements.

Lipid-based theranostic nanocarriers can act as efficient carriers for hydrophobic drugs or active substances such as photosensitizers. When enriched with paramagnetic metal ions, they may additionally function as magnetic markers for high-resolution magnetic resonance imaging (MRI). Furthermore, modifications of their structure, composition, or surface allow fine-tuning of their physicochemical and magnetic properties, expanding their potential applicability across a broad range of magnetic field strengths.

To evaluate the influence of paramagnetic components, particularly their effect on nuclear magnetic resonance (NMR) relaxivity, and to determine how their spatial localization within the nanoparticle structure affects these properties, detailed NMR relaxation studies are required. In addition, assessing the influence of nanoparticle size on MRI contrast performance requires NMR relaxation measurements across a wide range of magnetic field strengths. Finally, imaging experiments are necessary to confirm the potential of these nanocarriers as MRI contrast agents.

In this work, we compare liposomal systems prepared using a microfluidic method with analogous formulations produced by thin lipid film hydration (TLH) followed by size reduction via extrusion. Microfluidic preparation significantly influenced particle size, surface area-to-volume ratio, and the recovery of both paramagnetic ions and photosensitizers. Our results demonstrate the feasibility of microfluidic methods for theranostic liposome manufacturing, enabling the efficient co-encapsulation of therapeutic and imaging components in a single-step process with high yield.





Hydrogel substrates for controlling cell adhesion

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Living cells sense and respond to their microenvironment through complex physicochemical interactions, leading to behaviors such as adhesion, migration, proliferation, and differentiation. Therefore, substrates capable of controlling cell adhesion are highly important in cell biology [1]. Cell behavior at cell–material interfaces is regulated by surface properties such as chemistry, topography, and stiffness [2]. The substrates proposed here are glass slides modified by grafted hydrogels which are fabricated using a Cross-Linking And Grafting (CLAG) strategy in two steps: synthesis to obtain ene-functionalized polymers, followed by the development of micro-patterned surfaces using spin-coating, and photolithography. This versatile approach enables easy tuning of both chemical properties (e.g., charge density) and physical properties (e.g., topography and stiffness) of surface-grafted hydrogel films [3]. To study the influence of polymer charge, hydrogels based on poly(sodium acrylate) (PAA, negative), poly(2-(dimethylamino)ethyl methacrylate) (PDMAEMA, positive), and poly(*N*-isopropylacrylamide) (PNIPAM, neutral) were prepared. Ellipsometry and AFM techniques are used to characterize the thickness and swelling of grafted hydrogels, while nanoindentation evaluates stiffness under cell culture conditions. Cell culture experiments assess the toxicity of CLAG-derived hydrogel films and study cell adhesion using different cell lines (L292, U2OS, and HeLa-CFP). Cell adhesion was investigated as the first marker of cellular activity. The results demonstrate that the CLAG strategy is non-toxic for cells. Cells adhere mainly to the top of PAA hydrogel pillars (500 nm thick), while on PDMAEMA hydrogels, they preferentially adhere at the pillar base (30 nm thick). These hydrogel substrates are promising platforms for the selective spatial control of cell adhesion.

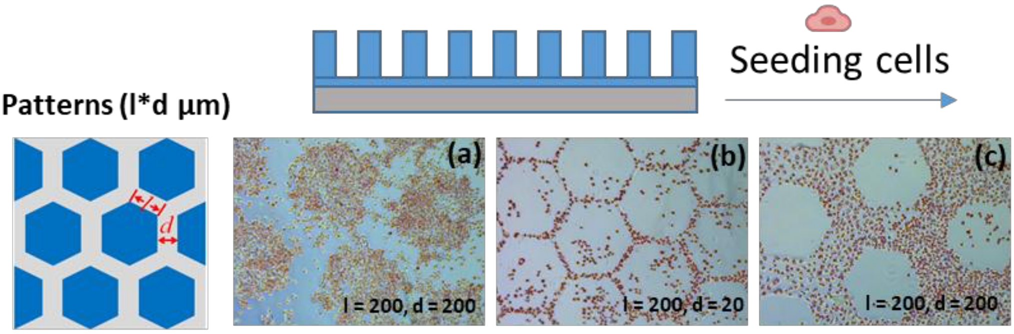

Figure 1: *Cell adhesion on PAA hydrogel occurs primarily on top of the pillars (a), whereas on PDMAEMA hydrogel, cells preferentially adhere at the base of the pillars (b, c).*

References

[1] J. M. Ino, P. Chevallier, D. Letourneur, D. Mantovani, C. Le Visage *Biomatter* **2013** *3*, e25414, DOI: 10.4161/biom.25414

[2] S. F. M. van Dongen, P. Maiuri, E. Marie, C. Tribet, M. Piel *Advanced Materials* **2013** *25*, 1687–1691, DOI: 10.1002/adma.201204474

[3] B. Chollet, L. D’Eramo, M. Li, E. Martwong, J. Macron, T. Q. Mai, P. Tabeling, Y. Tran *ACS Applied Materials & Interfaces*, **2016** *8*, 24870–24879, DOI: 10.1021/acsami.6b06720

Trypanosoma motility in complex environments

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Trypanosoma brucei is an extracellular parasite which causes african trypanosomiasis, also known as sleeping sickness. Trypanosomes have a complicated life cycle which involves both an insect vector, the tsetse fly, and a mammalian host. Throughout their life, parasites navigate through different tissue environments. We employ numerical simulations to investigate the motility of the parasite [1] in different tissue-like environments. Our model also includes hydrodynamics represented by the smoothed dissipative particle dynamics (SDPD) method [2]. For both the parasite and cells of a tissue, the model is based on a triangulated mesh network, see Fig. 1.

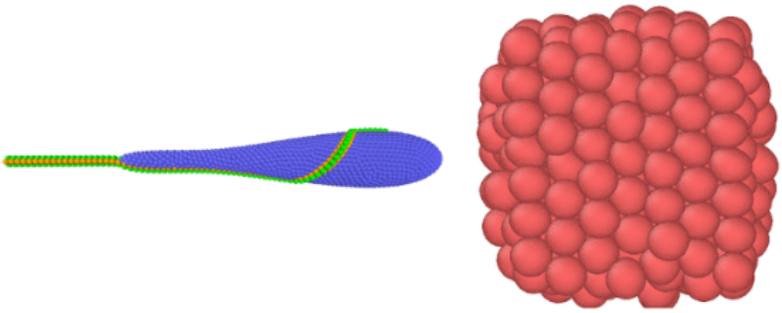

Figure 1: *(left) Trypanosoma model. (right) Tissue model composed of a collection of spherical capsules adhered to each other.*

First, the parasite motility is studied in a suspension of elastic biconcave disc-like cells inspired by erythrocytes, which mimics blood-like environment. The main result is that the parasite swimming speed increases with increasing cell density. Second, trypanosome motion in blood capillaries is investigated, showing that the parasite migrates toward the wall (or marginates) and primarily swims near the wall. Parasite motility is also studied in a tightly packed structure of spherical capsules, which adhere to each other and mimic a solid-like tissue environment. These results demonstrate that trypanosomes can efficiently propel through different tissues by using their internal soft-colloid composition.

References

[1] F. Overberg, N. Jamshidi, T. Krüger, M. Engstler, G. Gompper, D. A. Fedosov, *PLOS Computational Biology* **2025**, *21*, e1013111. DOI:10.1371/journal.pcbi.1013111

[2] P. Español, M. Revenga, *Physical review. E* **2003**, *67*, 026705. DOI:10.1103/PhysRevE.67.026705

Posters

Following the Dark Recovery of a Photoswitchable LOV Protein with Time-Resolved QENS

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Photoactivation in photosensitive proteins induces a photochemical reaction that propagates through structural and dynamical changes to ultimately modulate biological function. In this contribution, changes in protein dynamics throughout the photocycle of the pP-SB1-LOV protein are studied using quasi-elastic neutron scattering (QENS). Upon illumination, the chromophore forms a covalent bond with a nearby cysteine residue. The dark state is recoverered through thermal rupture. Neutron backscattering spectroscopy is employed to probe protein dynamics on the pico- to nanosecond timescale. Previous ex-situ illumination experiments revealed a reduction in the mean-squared displacement following photoactivation [1]. To support the interpretation of these observations, the results are compared with QENS observables derived from molecular dynamics simulations using the MDANSE software package. Current developments focus on implementing LED- and laser-based in-situ illumination within the constraints of a neutron backscattering spectrometer to follow dynamic changes during the dark-recovery process. Two complementary approaches are explored: reconstruction of full QENS spectra by repeating the photocycle and combining time-binned acquisition windows, and fixed-window scans monitoring dynamic changes during single photocycles. While time-resolved small-angle X-ray scattering experiments previously indicated that structural recovery occurs with a longer recovery time than the thermal rupture of the chromophore adduct observed by UV/Vis spectroscopy, time-resolved QENS measurements suggest shorter recovery times for the protein dynamics.[2, 3] Within this framework, pP-SB1-LOV serves as a model system to develop experimental strategies and data analysis approaches for time-resolved studies of photo-responsive systems using neutron backscattering spectroscopy. Pump–probe experiments are further being developed to investigate systems with faster photoresponses at the high-resolution spectrometer IN16B.

References

[1] Stadler et al. *Biophysical Journal* **2016**, *110*, 1064–1074. DOI:http://dx.doi.org/10.1016/j.bpj.2016.01.021

[2] Röllen K et al. *PLOS ONE* **2018**, *13*, e0200746. DOI:https://doi.org/10.1371/journal.pone.0200746

[3] Sarter et al. *in preparation*

Oxidative Damage in Keratin Fibres: A Correlative Study of Human Hair

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Human hair, together with fibres such as wool and mohair, belongs to the family of α-keratin fibres, which grow from follicles embedded in the skin and develop a complex hierarchical structure during differentiation [1]. The fibre consists of partially α-helical intermediate filaments embedded within an amorphous matrix, forming a highly organized biopolymer system. Understanding the response of this structure to chemical treatments is essential for elucidating structure–property relationships in biological soft matter.

In this study, the impact of oxidative bleaching on hair fibres is investigated using Differential Scanning Calorimetry (DSC), Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Attenuated Total Reflectance (FTIR-ATR) Spectroscopy. DSC is employed to probe the denaturation temperature of keratin within the fibre cortex; a key parameter correlated with mechanical properties such as tensile strength and resistance to breakage [2]. Bleached fibres exhibit a reduction in denaturation temperature, indicating decreased thermal stability.

FTIR-ATR reveals chemical modifications associated with oxidative damage on the hair surface, including formation of cysteic acid bonds due to oxidation of amino acids. Complementary electron microscopy highlights cuticle damage, including lifting and surface roughness.

By correlating molecular, thermal, and microstructural changes, this work demonstrates how oxidative treatments alter both the internal organization and external morphology of keratin fibres. The results establish human hair as a model keratin system for studying the effects of environmental and chemical stressors on hierarchical soft materials.

References

[1] C. Popescu and H. Höcker, Hair - the most sophisticated biological composite material, **2007,** *Chem. Soc. Rev.*, 36, 1282–1291.

[2] C.R.R.d. Lima, L.D.B. Machado, M.V.R. Velasco et al. DSC measurements applied to hair studies. J Therm Anal Calorim, **2018**, 132, 1429–1437, DOI:10.1007/s10973-018-7095-0

Bridging the Gap: Microstructural Origins and Yielding Behavior of Microfibrillated Cellulose Suspensions for Sustainable Food Design

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Cellulose is the most abundant biopolymer on Earth, used across diverse applications from electronics and medical devices to the paper industry and sustainable energy production [1]. Recently, its unique combination of properties—including mechanical robustness, biodegradability, high surface area, and excellent water retention—has driven growing interest in food applications as a fat substitute, texturizer [5], emulsifier [8], and bulking agent in low-calorie formulations[3]. Despite its expanding use, fundamental questions remain about how cellulose structure translates to functionality in food systems.

Microfibrillated cellulose (MFC), produced via pure mechanical disintegration of cellulose fibres, is a promising material to answer these questions. MFC offers a sustainable, chemical-free alternative to traditional cellulose derivatives and retains the native structural hierarchy of cellulose, characterized by alternating crystalline and amorphous regions [2].

In aqueous suspension, MFC fibrils form a sparse, entangled gel network with relevant yield stress at concentrations as low as $0.5wt\%$ through a combination of mechanical entanglement and hydrogen bonding [4, 7, 6]. The anisotropic nature of MFC fibrils contributes to hydrodynamic alignment under shear, producing strong shear-thinning behaviour.

A multi-scale approach - combining sedimentation kinetics and centrifugation with steady-state and oscillatory rheology - is here proposed in order to characterize the microstructural origin of this yielded system, the percolation threshold for stable MFC suspensions and the structural units forming the MFC hydrogel network. Preliminary results suggest a common gelation behaviour, confirming the role of the concentration $0.5wt\%$ as gelation threshold, independently from the level of fibrillation of the material (i.e. releasing nanofibrils, fibrillar fines, fibre fragments and microfibres which constitute the internal fractal-like structure of a fibre). This study provides a framework for understanding the structural transitions between microgel-like and fibrillar networks, offering a pathway to design the next generation of sustainable cellulosic material.

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References

[1] Edward B. Gordon, Inyoung Choi, Armaghan Amanipour, Yiwen Hu, Amin Nikkhah, Begum Koysuren, Champ Jones, Nitin Nitin, Reza Ovissipour, Markus J. Buehler, Nicole Tichenor Blackstone, and David L. Kaplan. Biomaterials in cellular agriculture and plant-based foods for the future. *Nature Reviews Materials*, 10:500–518, 7 2025.

[2] Nathalie Lavoine, Isabelle Desloges, Alain Dufresne, and Julien Bras. Microfibrillated cellulose – its barrier properties and applications in cellulosic materials: A review. *Carbohydrate Polymers*, 90:735–764, 10 2012.

[3] Nopparat Prabsangob. Plant-based cellulose nanomaterials for food products with lowered energy uptake and improved nutritional value-a review. *NFS Journal*, 31:39–49, 6 2023.

[4] Sadaf Shafiei-Sabet, Mark Martinez, and James Olson. Shear rheology of micro-fibrillar cellulose aqueous suspensions. *Cellulose*, 23:2943–2953, 10 2016.

[5] Tan Phat Vo, Hoang Khanh Linh Tran, Nhat Tien Pham, Tri Nguyen Tran, Thuy Hong Nhung Nguyen, Thuy Han Phan, Hyunjoo Lee, and Dinh Quan Nguyen. Application of bacterial cellulose in dietary fiber-enriched castella cake production. *CyTA - Journal of Food*, 21(1):321–327, 2023.

[6] Ravisara Wattana, Daehwan Park, and Chinedum O. Osuji. Ion specific effects on the rheology of cellulose nanofibrils in the presence of salts. *Soft Matter*, 21:4719–4729, 6 2025.

[7] Jingyuan Xu, Wen-Ching Liu, and Veera M Boddu. Viscoelastic properties of microfibrillated cellulose (mfc) produced from corn stover. *CELLULOSE CHEMISTRY AND TECHNOLOGY Cellulose Chem. Technol*, 52:337–342, 2018.

[8] Haibin Yuan, Xinghong Wei, Chen Chen, Haiyan Yu, Juan Huang, and Huaixiang Tian. Recent developments in cellulose-based emulsion systems for food applications: A review. *Food Hydrocolloids*, 163:111089, 6 2025.

Effect of ionic strength on the microstructure and rheology of potato protein hydrogels

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Plant-based proteins are increasingly investigated as building blocks for edible soft matter systems, where microstructure plays a critical role in determining mechanical properties and, ultimately, sensory perception. Among these, potato proteins represent a promising yet underutilized resource, as they are largely recovered as by-products of the starch industry despite their high nutritional quality and beneficial amino acid profile [1, 2]. However, their functional behaviour, particularly in terms of gelation and network formation, remains insufficiently understood [2, 3].

In this study, hydrogels were prepared from a potato protein fraction (~22 kDa) under two ionic conditions: pure water and 0.1 M NaCl. The protein system was first characterized in solution using SDS-PAGE, UV-Vis spectrophotometry, ζ-potential, and turbidimetry to assess its physicochemical behaviour and aggregation tendency. Gel microstructure was analysed by confocal laser scanning microscopy (CLSM), while rheological measurements were performed to evaluate viscoelastic properties.

Preliminary results suggest that ionic strength significantly affects protein–protein interactions, leading to distinct microstructural organization within the gel network. In particular, the presence of NaCl screens electrostatic repulsions, promoting aggregation and changes in network formation. These structural variations are reflected in the rheological response of the gels, indicating a strong relationship between microstructure and mechanical properties.

References

[1] Lv, Y., Xu, L., Tang, T., Li, J., Gu, L., Chang, C., Zhang, M., Yang, Y., & Su, Y. (2023). Gel properties of soy protein isolate-potato protein-egg white composite gel: Study on rheological properties, microstructure, and digestibility. *Food Hydrocolloids*, *135*, 108223. https://doi.org/https://doi.org/10.1016/j.foodhyd.2022.108223

[2] Zhang, Z., Chen, X., Liu, X., Liu, W., Liu, Q., Huang, J., Zhang, L., & Hu, H. (2022). Effect of salt ions on mixed gels of wheat gluten protein and potato isolate protein. *LWT*, *154*, 112564. https://doi.org/https://doi.org/10.1016/j.lwt.2021.112564

[3] Zhao, R., Liu, X., Liu, W., Liu, Q., Zhang, L., & Hu, H. (2022). Effect of high-intensity ultrasound on the structural, rheological, emulsifying and gelling properties of insoluble potato protein isolates. *Ultrasonics Sonochemistry*, *85*, 105969. https://doi.org/https://doi.org/10.1016/j.ultsonch.2022.105969

Molecularly Imprinted Polymers: highly crosslinked networks for the selective removal of pharmaceutical residues from wastewater

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Pharmaceutical residues in wastewater treatment plant effluents are an emerging environmental concern due to their persistence and potential ecological impact. Among these contaminants, compounds from several therapeutic classes are frequently detected in aquatic environments and are targeted by recent European regulatory frameworks on advanced wastewater treatment. Molecularly Imprinted Polymers (MIPs) are promising materials for selective adsorption owing to the presence of template-shaped recognition sites within the polymer matrix [1] (Figure 1 - Step 1). This work investigates the synthesis and preliminary characterization of MIPs for the selective removal of five pharmaceutical compounds. MIPs were synthesized by precipitation polymerization, producing uniform spherical microparticles with high surface area. The polymer network was highly crosslinked to ensure stable imprinted recognition sites [2]. Thermogravimetric analysis (TGA) confirmed template incorporation in the polymer. Adsorption tests and HPLC analysis were used to evaluate removal efficiency and selectivity. Flocculation tests assessed MIP sedimentation and recovery, showing that most MIPs could be recovered in wastewater treatment plants (WWTPs), thereby reducing potential microplastic release (Figure 1 - Step 2).

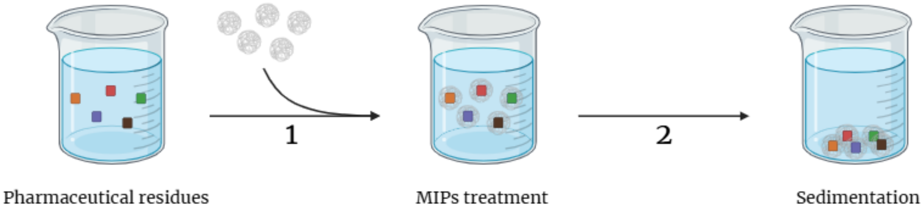

Figure 1: *Schematic representation of pharmaceutical (square dots) removal using molecularly imprinted polymers (MIPs). (1) Addition of MIPs for adsorption. (2) Addition of coagulant and flocculant to induce sedimentation.*

References

[1] Raju Khan and Ayushi Singhal, editors. *Molecularly Imprinted Polymers for Environmental Monitoring*. 2053-2563. IOP Publishing, 2023.

[2] Kai Li and Harald D. H. Stöver. Synthesis of monodisperse poly(divinylbenzene) microspheres. *Journal of Polymer Science Part A: Polymer Chemistry*, 31(13):3257–3263, December 1993.

Stretching mucins: Revealing the complex rheology of natural glycoprotein networks

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Mucus is a complex viscoelastic material that is essential for respiratory, oral, gastrointestinal, and reproductive health. These functions require mucus to exhibit a wide range of mechanical responses when subjected to different types of deformation. Although the shear and oscillatory rheology of mucus and extracted mucins is well characterised, their behaviour under extensional deformation — relevant to droplet breakup, airway clearance, and transport through constricted geometries — remains poorly understood. A key governing parameter is mucin concentration, which in vivo spans nearly two orders of magnitude. Here, we report the first experimental evidence of a concentration-dependent transition in the extensional behaviour of mucin dispersions, measured using a dripping-onto-a-substrate (DoS) experimental setup. At lower concentrations, mucin dispersions formed highly extensible filaments whose diameters decayed exponentially with time, consistent with an elastocapillary thinning observed in dilute polymer solutions. As concentration increased, filaments extensibility decreases, indicating a transition to a different thinning regime. This crossover occurs over a small change in concentration and has not previously been resolved experimentally in mucins. By revealing that mucin concentration controls this transition, this study provides a mechanistic link between molecular crowding and impaired mucus transport. This work positions extensional rheology as a diagnostic tool for evaluating mucus functionality, offering new design principles for bioinspired materials whose resistance to filament thinning can be tuned through controlled macromolecular interactions.

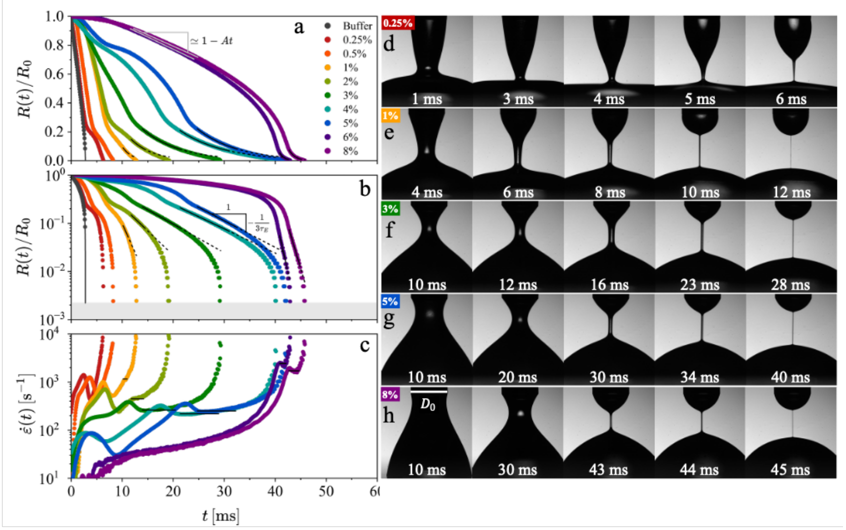

Figure 1: *Temporal evolution of the normalized midpoint filament radius $R(t)/R_0$ for BSM solutions from 0.25 wt% to 8 wt%, and for 10 mM HEPES buffer at pH 7.0. (a) Data presented on a linear-linear axis, (b) the same profiles shown on semi-logarithmic axes (logarithmic ordinate, linear abscissa), (c) The extensional rate $\dot{\varepsilon}(t)$ extracted from the radius evolution plotted as a function of time. Representative high-speed image sequences illustrate the capillarity-driven filament thinning and final breakup of the BSM solutions for (d) 0.25 wt%, (e) 1 wt%, (f) 3 wt%, (g) 5 wt%, (h) 8 wt%. The scale bar in (h) represents the nozzle diameter $D_0=2R_0=1.27$ mm.*

Segmental-Decoupled Lithium-Ion Efficient Transport in Ionogel Electrolytes

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Understanding how to achieve fast and selective lithium-ion transport in ionogel polymer electrolytes without sacrificing mechanical robustness remains a central challenge for next-generation solid-state batteries. Here, we report an ionogel polymer electrolyte constructed from a continuous polymer framework and formed by incorporating an ionic liquid and lithium salt into polymers with different chain lengths. Spectroscopic analyses, including FTIR, solid-state NMR, and Raman measurements combined with theoretical calculations, indicate that the polymer framework remains intact after gel formation and that Li^+ resides in a homogeneous competitive coordination environment involving both polymer segments and ionic-liquid species. The ionic liquid is further confined within the polymer framework, yielding a structurally uniform ionogel electrolyte.

Despite its more rigid framework and more restricted segmental motion, the short-chain electrolyte exhibits unexpectedly superior Li^+ transport behavior, including higher ionic conductivity, a higher Li^+ transference number (up to 0.65), and a lower activation energy than its long-chain counterpart. Preliminary diffusion analysis further suggests that Li^+ transport in the short-chain system is significantly faster, even though the mobilities of the coordinating polymer and ionic-liquid ligands are reduced. This behavior cannot be explained by the conventional segmental-motion-assisted transport model. Instead, the results support a segmental-decoupled transport mechanism in which Li^+ migrates through continuous, preorganized coordination sites via an efficient hopping process. These findings provide a new design principle for polymer electrolytes by decoupling lithium transport from polymer-chain dynamics and offer a promising strategy for developing high-transference, mechanically robust solid-state ion conductors.

References

[1] M. Armand, J.-M. Tarascon, “Building better batteries” *Nature* **2008**, *451*, 652–657.

[2] D. Lin, Y. Liu, Y. Cui, “Reviving the lithium metal anode for high-energy batteries” *Nature Nanotech* **2017**, *12*, 194–206

Adhesive microgel-microgel interactions controlling network reversibility during drying

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Concentrated microgel dispersions from gelling biomacromolecules are highly tunable soft materials whose rheological properties can be tailored through formulation and processing parameters. Their high water content, biocompatibility and ability to load active ingredients make fluid gels attractive for food and pharmaceutical applications. However, a major gap remains regarding loss of functionality upon drying and redispersion, and the limited understanding of how macroscopic rheological behavior arises from particle-scale interactions.

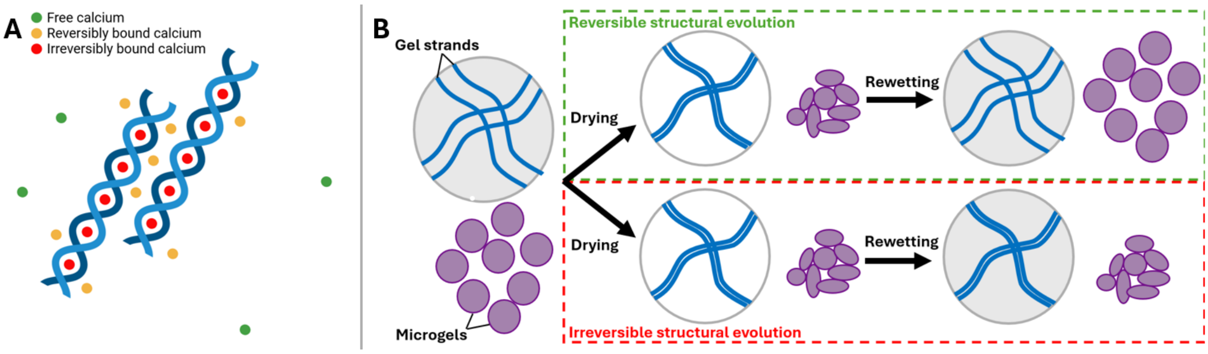

Figure 1: *a) calcium-gellan coordination into helices and different populations of calcium ions, b) Potential mechanisms for structural irreversibility through gellan strand aggregation and particle aggregation*

Irreversible particle aggregation upon drying potentially contributes to the non-recovery of rheological functional behavior, which makes microgel-microgel adhesion of interest. For gellan-based microgel dispersions, we observe an absence of sedimentation after a strong dilution factor at constant $[Ca^{2+}]_{free}$, while sedimentation is observed after diluting using milli-Q water. This suggests the formation of a percolated network, which would confirm the existence of adhesive interactions. Additionally, this indicates a $[Ca^{2+}]_{free}$ dependence on particle adhesion. Using confocal imaging of particle networks, AFM based microgel-microgel interaction measurements and bulk adhesion tests, we aim to quantify the calcium dependent adhesive behavior and relate it to network reversibility upon drying and redispersion.

Is DNA grooving geometrically optimal?

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In 1953, J.D. Watson and F. Crick proposed the helical structure of DNA, which exhibits unique structural features, including major and minor grooves. The structure has been thoroughly examined using crystallography, microscopy, and computer modeling. It is clear that interactions between base pairs at the molecular level determine the overall structure of DNA. Nevertheless, it is also known that DNA can undergo reversible transformation from B-type to A-type under modified external conditions [1]; that is, its overall geometry may change substantially despite an invariant primary structure. This raises the question of the geometrical pathway of these transitions. Therefore, we decided to examine DNA morphological changes using the Bonnet transformation of a helicoid [2]. Accordingly, we treat this complex double-stranded molecule as a simple, differently wound ribbon.

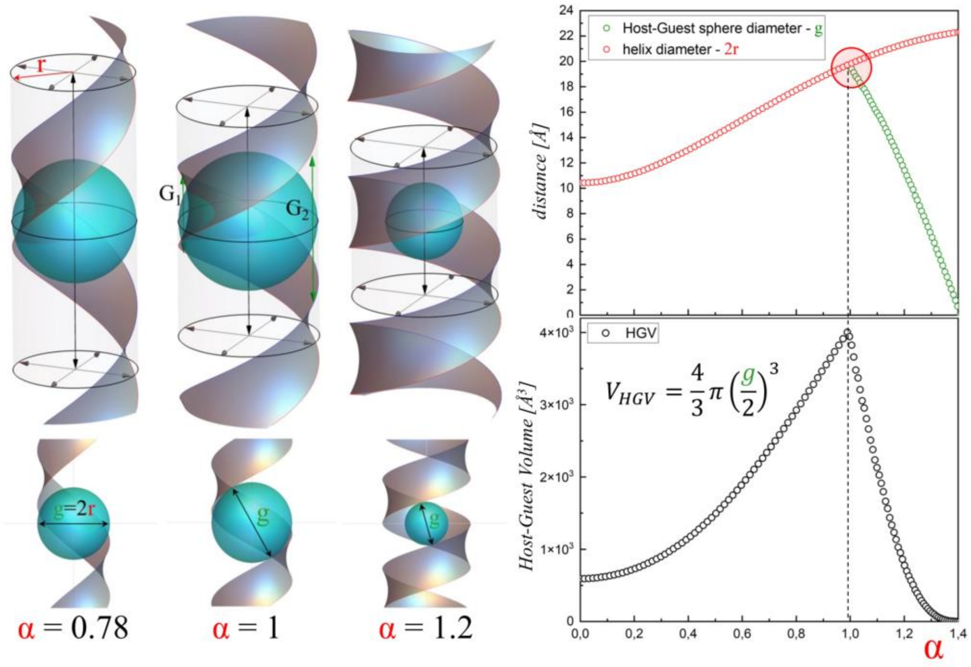

Figure 1: *Helicoid winding versus Host-Guest Volume*

Surprisingly, this very simple geometrical model yields quite intriguing results regarding the variation of the major groove with ribbon winding. We introduced a probe sphere (referred to as the Guest–Host sphere), which can be inserted into the helix volume while avoiding steric clashes. The size of the sphere depends strongly on the ribbon winding and reaches its maximum at the point where the sphere diameter matches the helix diameter. This specific point corresponds well with the grooving observed in B-type DNA.

References

[1] M. Bespalove et al. *Macromolecules,* **2022** 55**,** 6200-6210, DOI: 10.1021/acs.macromol.2c00657

[2] J. Sanchez-Reyes *Applied Mathematical Modelling,* **2016** 40**,** 1676-1682, DOI: 10.1016/j.apm.2015.07.011

Liquid Crystalline Block Copolymers for Enhanced Ionic Conductivity in Polymer Electrolytes

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Solid-state lithium metal batteries (LMBs) are considered very promising candidates for next-generation energy storage systems due to their high potential in terms of safety and energy density. However, the use of solid-state electrolytes introduces several challenges, including low ionic conductivity and difficulties in maintaining stable solid–solid interfacial contact during operation, which can lead to irreversible capacity losses. In addition, lithium dendrite formation, as well as issues related to air sensitivity, mechanical stability, electronic conductivity, and thermal stability, remain significant obstacles. [1,2]

Among solid electrolytes, polymer-based electrolytes are attractive due to their flexibility, which allows them to accommodate electrode volume changes during cycling. They can be classified as polymer-salt complexes, where both ions are mobile, or polyelectrolytes, where one ion is covalently bound to the polymer. Amorphous polymer-salt systems, such as polyethylene oxide (PEO)-based electrolytes, generally show higher ionic conductivity through ion–dipole interactions and polymer chain motion, which increases with temperature. Despite their advantages in flexibility, light weight, and safety, these electrolytes still suffer from low room-temperature conductivity and limited interfacial compatibility. [3,4]

In this context, this project aims to develop advanced polymer electrolytes based on liquid crystalline architectures. It involves the synthesis of liquid crystal (LC) monomers followed by polymerization via Reversible Addition–Fragmentation Chain Transfer (RAFT) to generate a macro chain transfer agent. Subsequently, block copolymers (BCPs) are prepared, comprising one LC block and a second block based on an ion-conducting segment derived from ethylene oxide units. When subjected to a strong electric field, the LC side chains align, promoting the formation of well-defined nanochannels. This ordered morphology, resulting from the assembly of oriented mesogens and flexible ethylene oxide chains, is expected to enhance ionic conductivity through ion hopping within the amorphous phase. The resulting polymer matrix is capable of dissolving lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) and forming a self-standing film. [5]

References

[1] Nitta, N.; Wu, F.; Lee, J. T.; Yushin, G. *Materials Today*, 2015, **18**(5), 252–264, DOI: 10.1016/j.mattod.2015.04.009

[2] Kim, T.; Song, W.; Son, D.-Y.; Ono, L. K.; Qi, Y. *J. Mater. Chem. A*, 2019, **7**(7), 2942–2964, DOI: 10.1039/C8TA10155A

[3] Li, S.; Zhang, S.; Shen, L.; Liu, Q.; Ma, J.; Lv, W.; et al. *Advanced Science*, 2020, **7**, 1903088, DOI: 10.1002/advs.201903088

[4] An, Y.; Han, X.; Liu, Y.; Azhar, A.; Na, J.; Nanjundan, A. K.; et al. *Small*, 2022, **18**(3), e2103617, DOI: 10.1002/smll.202103617

[5] Álvarez Moisés, I.; Król, M.; Keus, G.; He, Z.; Innocenti, A.; Passerini, S.; Ruokolainen, J.; Gohy, J.-F. J. Am. Chem. Soc., 2025, 147(24), 20347–20358, DOI: 10.1021/jacs.5c00278

Kneading as an efficient mixing method to enhance processability of graphite anode slurries

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Graphite anode slurries for lithium-ion batteries require precise rheological control to ensure optimal processing and improved electrode performance. Traditional sequential mixing of CMC solution, carbon black, graphite, and SBR often yields poorly dispersed, high-viscosity slurries with pronounced gel-like behavior. [1] This study investigates kneading, a high-shear process adapted from food-industry dough preparation, in which solid components and binder are mixed cohesively to form a dense, “dough-like” intermediate before dilution into a processable slurry. [2,3] To track structural evolution across the full process, all mixing stages are characterized rheologically, with particular focus on the dough intermediate - a stage critical to final slurry quality.

The kneaded dough, unlike its food-based counterpart, is highly brittle, making direct mechanical characterization challenging. According to our results, systematic variation of kneading duration between 5 and 20 minutes reveals a monotonic decrease in viscosity at the coating-relevant shear rate of 100 s^{-1}. It leads to viscosity reduction of approximately 30%. Oscillatory tests reveal weakening of the slurry structure. When compared to traditionally mixed slurries - kneaded slurries exhibit 1.6–1.8 times lower viscosity and reduced yield stress. Fineness of grind analysis by grindometer (Hegman gauge) further highlights the dispersion advantage. Traditional mixing yields average fineness of 29–31 µm, while kneaded slurries consistently reach 20–23 µm across all tested durations. SEM imaging confirms these findings, showing complete elimination of carbon black agglomerates in kneaded samples. These results demonstrate that dough-based processing significantly improves final product - slurry homogeneity and processability. Enhanced dispersion may facilitate tighter control over electrode porosity and density, which in turn might enable more efficient Li^+ ion transport/diffusion which is a major factor in achieving high anode performance at scale.

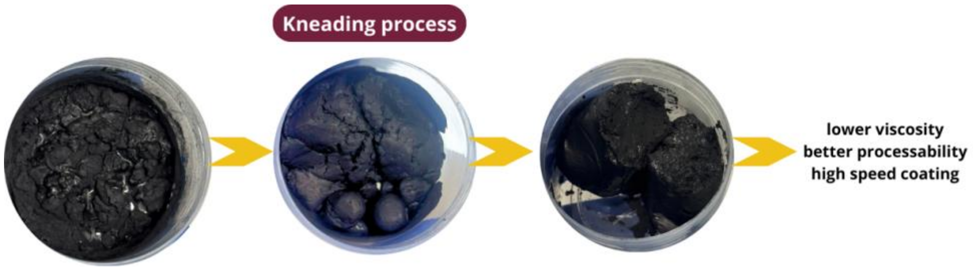

Figure 1: *Kneading process and ist advantages.*

References

[1] D. Grießl, A. Adam, K. Huber, A. Kwade, *J. Electrochem. Soc.*, 2022, **169**, 020531. DOI: 10.1149/1945-7111/ac4cdb
[2] A. Cappelli, L. Bettaccini, E. Cini, *Trends Food Sci. Technol.*, 2020, **104**, 91–101. DOI: 10.1016/j.tifs.2020.08.008
[3] K. Park, S. Myeong, D. Lee, H. E. Yoo, J. Kim, C. Kim, J. Kim, S. Sun, J. Kwon, S. C. Kim, K. Lee, C. W. Cho, U. Paik, T. Song, *Electrochim. Acta*, 2023, **464**, 142900. DOI: 10.1016/j.electacta.2023.142900

Microstructured polymer electrolytes with high Li-ion conductivity by tuning structural uniformity

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The pending demand by the automotive sector to cut off the emissions caused by the use of fossil fuel has generated a subset of motors which use electric energy as the main source of propulsion. This electric energy is stored in *Li*-ions rechargeable batteries: previous studies have pointed out the problem associated with the use of this kind of batteries, as well as the risks and hazards of their application for cars. To overcome these problems, alternatives based on polymer electrolytes and their gels have arisen. More specifically, the possibility of finely tuning the properties of the liquid electrolytes and solid polyelectrolytes by the addition of salts opens up various possibilities. This study wants to tailor the properties of gel polymer electrolytes with ethylene oxide units in the side chains, with the aim of enhancing the mobility of *Li*-ions without decreasing the mechanical properties. The mechanical and thermal properties of self-synthesized PEGMA and PEGA (Fig. 1) samples with different molecular weights and polydispersity, with *Li* or without, have been measured. Thermal measurements showed that the addition of *Li* and an increase in molecular weight act synergistically to increase the values of glass transition temperatures and the heterogeneity of the structure. In the investigated temperature range, moreover, the salt addition completely suppresses the melting and crystallization phenomena. Rheological measurements have been performed on the polymers in linear regime, and revealed that their microstructure exhibits mostly a liquid-like behavior at room temperature. The addition of *Li* increases the viscoelasticity of the polymers. Regardless of the degree of chains' dispersity, PEGA samples exhibit the lowest viscoelasticity, whereas PEGMA samples, especially with the addition of salt, show viscosity enhancements of almost three order of magnitude.

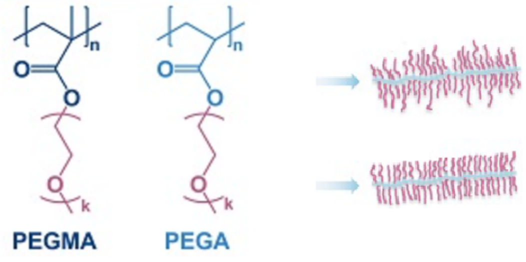

Figure 1: *On the left the molecular structures of PEGMA and PEGA. k can be variable (dispersed side chains) or constant (discrete side chains). On the right a representation of the final graft polymer brushes with either dispersed (top) or discrete (bottom) side chains*

References

[1] A. Vigolo, V. Vanoli, L. Laugeni, C. Pavón, R. Pasquino, E.M. Benetti, F. Castiglione, F. Lorandi *Chemistry of Materials* **2026**, *38*, 4. DOI:10.1021/acs.chemmater.5c03475

[2] M. Chen, Z. Yue, Y. Wu, Y. Wang, Yu Li, Z. Chen *Sustainable Materials and Technologies* **2023**, *36*, . DOI:10.1016/j.susmat.2023.e00587

Time-Dependent Water Permeability in Degrading PLA: A Molecular Dynamics Study

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Biodegradable polyesters like Polylactic Acid (PLA) are vital for sustainable and biomedical applications, yet quantitatively predicting their hydrolytic degradation remains challenging. Because standard molecular dynamics (MD) cannot access long-term reactive timescales, a critical disconnect exists between atomistic simulations and degradation. Specifically, a major gap remains in identifying short-term molecular proxies, such as water diffusion coefficients, that can correlate nanoscale behavior with macroscopic reaction-diffusion models and experimental degradation rates.

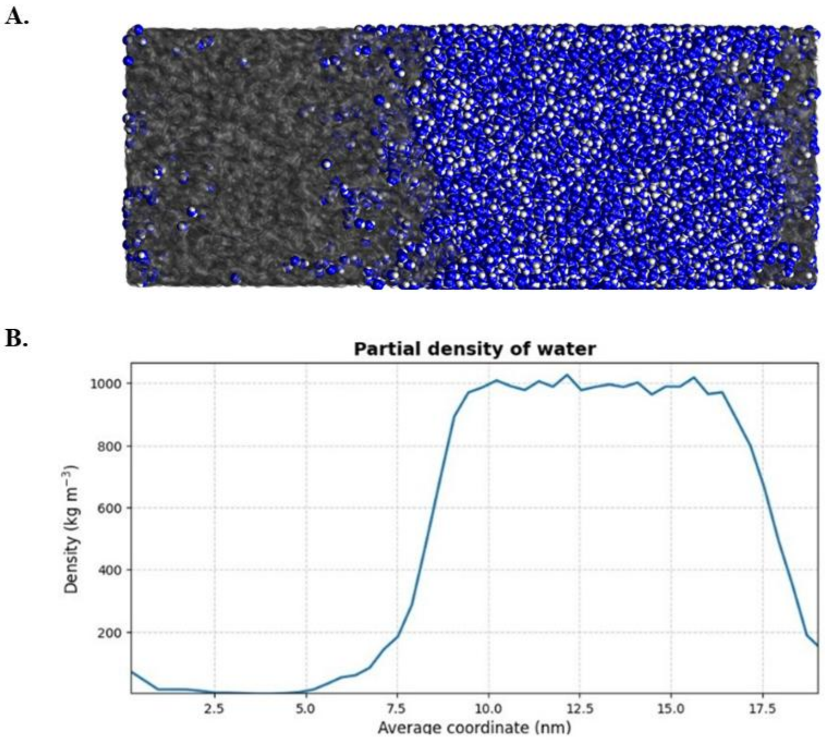

Figure 1: *Molecular dynamics (MD) simulation of PLA exposure to water. (A) Snapshot of the simulation box after 100 ns. (B) Partial density profile of water along the simulation box after 100 ns.*

A critical factor in hydrolytic degradation is that polymer properties and water permeability (Figure 1) alter dynamically as the material degrades. Assuming a constant diffusion rate therefore introduces significant error. To address this, we implement a stepwise degradation approach in our MD simulations. Within independent simulation boxes, ester bonds are randomly cleaved at targeted intervals (0%, 20%, 40%, 60%, and 80%) to mimic progressive stages of erosion. By calculating the diffusion coefficient across these distinct states, we generate a time-dependent diffusion profile. Ultimately, this dynamic parameter will feed into macroscopic models to enable accurate prediction of degradation kinetics.

X-ray Scattering Studies of Microgels at the Air–Liquid Interface

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Microgels (MGs), soft particles consisting of polymeric networks, order in a 2D hexagonal lattice at interfaces. While their form and structure are accessible via light-, x-ray- and neutron-scattering in the bulk phase, the situation is more challenging at the interface. High solvent content, softness and interaction with a deformable (soft) interface promotes the resolution of the MG structure to a non-trivial task. Some of these issues have been addressed employing markers [1, 2]. However, these studies investigated either the lateral or the vertical structure.

We present an *in-situ* strategy that combines specular and off-specular x-ray reflectometry (XRR/OSR). With this we investigated the structure in both dimensions on different length scales *in-situ*. [3]. The main challenge is to disentangle off-specular from small angle scattering. It turns out, that an incoherent superposition of both contributions is sufficient to qualitatively refine the scattering signal. This becomes possible if the 2D lattice structure is considered adequately; i.e., by convoluting the small angle signal with the slit collimation of the instrument.

To demonstrate the validity of this technique, we immobilized microgels using Langmuir-Blogett transfer MGs and compared the structures from real- and reciprocal space. Given that the interpretation of reciprocal space data is made via the kinematic approximation, its accuracy is astonishing. Additionally we present simulations within the dynamical wave born approximation that support our findings.

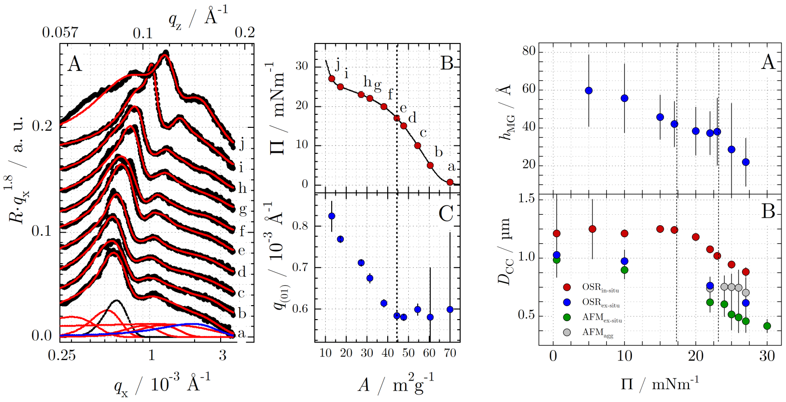

Figure 1: *Left: OSR on MG at the a/w-interface at pressures indicated in the isotherm (middle top) and peak positions (middle bottom). Right: (top) Apparent high of the floating MGs from XRR and (bottom) lateral distance between MG-cores from OSR, comparing various techniques.*

References

[1] M. Karg *et al.* *Langmuir* **2019**, *35*, 6231–6255. DOI: 10.1021/acs.langmuir.8b04304

[2] S. Bochenek *et al.* *Nat. Com.* **2022**, *13*, 37444. DOI: 10.1038/s41467-022-31209-3

[3] H. Robertson *et al.* *Soft Matter* **2026**, *22*, 127–138. DOI: 10.1039/D5SM00115C

Using QENS to Probe the Dynamics of the Tau Protein under Liquid-Liquid Phase Separation

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Tau is an intrinsically disordered protein (IDP) expressed in neurons. In contrast to well-folded proteins, IDPs lack a distinct stable 3D structure and sample a vast conformational space instead. Tau's biological function lies in its interaction with the microtubules. In patients with Alzheimer's disease, however, it is found to be part of protein filaments in the brain.

Solutions of tau can spontaneously demix into a dense phase (enriched in protein) and a light phase (depleted in protein) in a process called liquid-liquid phase separation (LLPS). LLPS is also the driving force of biocondensates such as the nucleolus [1]. In the presence of LLPS, tau has been found to aggregate more easily [2]. To understand diseases such as Alzheimer's disease on a molecular level, it might be important to shed light on the evolution of protein dynamics (center-of-mass diffusion and internal protein fluctuations) during LLPS and aggregation.

Previously, we studied the dynamics of tau and its hydration water in monomers and fibers [3]. Here, we extend our efforts to elucidating tau dynamics under LLPS by quasi-elastic neutron scattering (QENS) and complementary biophysical methods. The measured QENS signal represents the superimposed contributions of the protein center-of-mass translational diffusion (COM), of the protein tumbling (rotation), of internal protein fluctuations on the level of the protein backbone and side chains, and of the solvent [4].

Currently datasets from different instruments (inverse time of flight, backscattering, spin-echo) are analysed which will allow to describe the dynamics of tau monomers, tau LLPS induced by PEG, and its interaction with RNA on a large range of length and time scales. The usual approach to fit QENS data from well-folded proteins in solution assumes a clear separation of a global (COM/ rotation) and internal modes. This approach fails for IDP which have a broad distribution of hydrodynamics radii.

References

[1] Banani, S., Lee, H., Hyman *Nat Rev Mol Cell Biol* **2017**, *18*, 285–298. DOI:https://doi.org/10.1038/nrm.2017.7

[2] Yanxian Lin, Yann Fichou, Zhikai Zeng, Nicole Y. Hu, and Songi Han *ACS Chemical Neuroscience* **2020**, *11*, 4. DOI:10.1021/acschemneuro.9b00627

[3] Y. Fichou, G. Schirò, F. Gallat, C. Laguri, M. Moulin, J. Combet, M. Zamponi, M. Härtlein, C. Picart, E. Mossou, H. Lortat-Jacob, J. Colletier, D.J. Tobias, and M. Weik *Proceedings of the National Academy of Sciences* **2015**, *112*, 6365. DOI:10.1073/pnas.1422824112

[4] Marco Grimaldo, Felix Roosen-Runge, Fajun Zhang, Frank Schreiber and Tilo Seydel *Quarterly Reviews of Biophysics* **2019**, *52*, e7. DOI:10.1017/S0033583519000027

Synthesis and properties of PS-PMMA copolymers containing reversible covalent crosslinks as compatibilizers in blends

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Polymer blending is an effective strategy to enhance plastic performance and create new materials without developing entirely new polymers. Compatibilization is essential for producing polymer blends with desirable mechanical properties and for facilitating the recycling of mixed plastic waste.[1] Recent innovations, particularly vitrimer-crosslinked polymers, offer promising solutions in this respect.[2] These materials can be reshaped and reprocessed without compromising strength, and recent studies show that blending vitrimers with conventional polymers can significantly improve mechanical and rheological properties, enhancing the performance of degraded plastics.[3-4]

This project explores three strategies to improve compatibility of PS–PMMA blends, chosen as a model system: (1) classical copolymer compatibilization, (2) vitrimer-based systems, and (3) a hybrid approach. The first strategy involves synthesizing PS–PMMA copolymers with random and block architectures using RAFT polymerization. The second strategy introduces vitrimer functionality by incorporating boronic ester groups into PS and PMMA, followed by crosslinking with bis-dioxaborolane small molecule. The third, hybrid, approach combines copolymers and vitrimers to further enhance interfacial adhesion and mechanical strength. Each method will be evaluated through structural, rheological, and mechanical characterization. The goal is to develop the next generation compatibilizers that support sustainable and efficient plastic recycling.

This poster presents the synthesis of PS-PMMA random copolymers (reference system), PMMA vitrimer precursor, PS vitrimer precursor, and PS-PMMA vitrimer precursor via RAFT polymerization, along with their characterization using NMR and GPC. These copolymers were incorporated into PS-PMMA blends through extrusion to investigate the effect of compatibilization with and without vitrimers. The resulting blend morphology was analyzed by SEM, AFM and SAXS, while mechanical properties were evaluated using shear rheology and tensile tests.

References

[1] K. Yokoyama, Z. Guan, Angew. Chem. Int. Ed., **2024**, 63, e202317264, 10.1002/anie.202317264.

[2] M. Röttger, T. Domenech, R. van Der Weegen, A. Breuillac, R. Nicolaÿ, L. Leibler, Science, **2017**, 356, 62-65, 10.1126/science.aah5281.

[3] M. Ahmadi, A. Hanifpour, S. Ghiassinejad, E. van Ruymbeke, Chem. Mater., **2022**, 34, 10249-10271, 10.1021/acs.chemmater.2c02853.

[4] R.G. Ricarte, F. Tournilhac, M. Cloître, L. Leibler, Macromolecules, **2020**, 53, 1852–1866, 10.1021/acs.macromol.9b02415.

Programme

Annual Meeting 2026

CEST	Monday 18/5	
	Arrival and registration	
12:30-14:00	Lunch	
14:00-14:15	Opening remarks	
14:15-15:00	Plenary 1 HEIDEN-HECKT	
15:00-15:50	Gels and Networks	Surfaces, Interfaces, and Emulsions
15:50-16:20	Coffee break	
16:20-17:40	Gels and Networks	Surfaces, Interfaces, and Emulsions
17:40-20:00	Posters and Networking	NCC Meeting
20:00	Dinner	

	Tuesday 19/5	
09:00-09:45	Plenary 2 ZARE	
09:45-10:45	Young Scientists	
10:45-11:15	Coffee break	
11:15-12:55	Young Scientists	
12:55-14:00	Lunch break	
14:00-14:45	Plenary 3 NICOLAI	
14:45-15:00	Plenary SoftComp Road Map (15 min)	
15:00-16:10	Biological Soft Matter	Polymers and Biopolymers
16:10-16:40	Coffee break	
16:40-18:00	Biological Soft Matter	Polymers and Biopolymers
17:45-20:00	Posters and Networking	Research Road Map: hands off session
20:00	Dinner	

	Wednesday 20/5	
09:00-09:45	Plenary 4 VAN DEN LINDEN	
09:45-10:55	Food Science	Glasses, Colloids and Self-Assembly
10:55-11:25	Coffee break	
11:25-12:45	Food Science	Glasses, Colloids and Self-Assembly
12:45-14:00	Lunch break	
14:00-14:45	Plenary 5 FISCHER	
14:45-15:55	Food Science	Polymers and Biopolymers
15:55-16:25	Coffee break	
16:25-17:45	Glasses, Colloids and Self-Assembly	Polymers and Biopolymers
17:25-20:00	Posters and Networking	NGB Meeting
20:00	Conference Dinner	

	Thursday 21/5	
09:00-09:45	Plenary 6 SALENTINIG	
09:45-10:55	New Methods and Techniques & Synthesis	Biological Soft Matter
10:55-11:25	Coffee break	
11:25-12:45	New Methods and Techniques & Synthesis	Biological Soft Matter
12:45-13:00	Closing remarks	
13:00	Lunch	

Annual Meeting 2026, Monday 18 May

Start time	End time	Title of contribution	Speaker first name	Speaker family name	Start time	End time	Title of contribution	Speaker first name	Speaker family name
		Arrival anf registration							
12:30	14:00	Lunch							
14:00	14:10	Opening remarks							
14:10	14:15	Useful information							
14:15	15:00	Structure and dynamics of food colloids	Theresia	Heiden-Hecht	Chair person: Tommy Nylander				
15:00	**17:40**	**Gels and Networks (Chair Tommy Nylander)**			**15:00**	**17:40**	**Surfaces, Interfaces, and Emulsions (Chair Christophe Chassenieux)**		
15:00	15:30	Chiral Response in Ferrogel Torsional Actuators under Uniaxial Magnetic Fields	Alberto	Leon-Cecilla	15:00	15:30	Dirty Linen: evaporation and imbibition of blood droplets from and into fabrics	Simon	Titmuss
15:30	15:50	Field Induced Rheology of Magnetorheological Fluids with Size-Dependent Microstructural Evolution	Stefania	Scala	15:30	15:50	Protein corona of Hevea brasiliensis field latex	Tanaporn	Lekchupol
15:50	16:20	Coffee break							
16:20	16:40	Viscoelasticity and Fluorescence of polymer-based magnetically switchable soft composite	Matthieu	Kermarrec	16:20	16:40	Studying adhesion patches between DNA-coated colloidal droplets using optical tweezers	Jose	Muñetón-Díaz
16:40	17:00	Synthesis and properties of chitosan-based hydrogels and microgels with controlled microstructure	Inès	Elharar	16:40	17:00	Probing the nanoscale structure of microgels at the air-liquid interface: In situ X-ray reflectometry	Hayden	Robertson
17:00	17:20	Chitosan-Based Eutectic Gels for Neuromorphic BioElectronics	Antonella	Dadduzio	17:00	17:20	From Tip to Ship: Characterisation of new Zinc-PDMS Anti-fouling Coatings After Ageing	Benjamin	Devenish
17:20	17:40	Aging in Aqueous Capillary Suspensions Revealed by Spatially Resolved Laser Speckle Imaging	Leonardo	Ruiz-Martinez	17:20	17:40	Slip dynamics in soft arrested materials under squeeze-flow deformation	ISHU	Chaudhary
17:40	20:00	Posters and networking							
18:00	20:00	Network Coordination Committee (NCC)							
20:00		Dinner							

Annual Meeting 2026, Tuesday 19 May

Start time	End time	Title of contribution	Speaker first name	Speaker family name	Start time	End time	Title of contribution	Speaker first name	Speaker family name
09:00	09:45	Antifoam in food: How it breaks the bubble	Davoud	Zare	Chair person: Christophe Chassenieux				
09:45	**12:55**	**Young Scientists**							
09:45	10:05	Magnetic Hyperthermia in Soft Matter: A Physics-Informed Machine Learning Approach	Joan	Roux	Chair person: Agnese Pedato & Louise Overzet				
10:05	10:25	Optimization of Existing Cyclic Peptide Binders Using a Structure-Guided Design Approach	Silvia	Multari					
10:25	10:45	Dynamics of highly viscous shear thickening droplet impact on a solid surface	Quanrun	Dong					
10:45	11:15	Coffee break							
11:15	11:35	Development of model systems and testing protocols for optimizing skin interactions with absorbent hygiene products	Agnese	Pedato	Chair person: Joan Roux & Silvia Multari				
11:35	11:55	Thermal Signatures of Mucin-Based Samples Studied by Differential Scanning Calorimetry	Giorgia	Franzino					
11:55	12:15	Design and functions via frontal photopolymerisation: from printing to locomotion	Muhammad Ghifari	Ridwan					
12:15	12:35	From Nature to Nurture: Biomimetic Viscoelastic Scaffolds for Lung Tissue Regeneration	Louise	Overzet					
12:35	12:55	An effective volume fraction controls both dynamics and thermodynamics in vesicles suspensions with tunable electrostatic interactions	Annachiara	Siciliano					
12:55	14:00	Lunch break							
14:00	14:45	Gels, microgels and microcapsules from rapeseed proteins	Taco	Nicolai	Chair person: Stephan Förster				
14:45	15:00	Research Roadmap for SoftComp Consortium via the Discovery Engine	Vladimir	Baulin					
15:00	**18:00**	**Biological Soft Matter (Chair Alfons van Blaaderen)**			**15:00**	**17:40**	**Polymers and biopolymers (Chair Olaf Soltwedel)**		
15:00	15:30	Active membrane deformations of a synthetic cell-mimicking system	Dmitry	Fedosov	15:00	15:30	Universal prediction of polymer molecular weight distribution from linear rheology using neural networks	Robert	Elliott
15:30	15:50	Efficient generation of conformational ensembles of intrinsically disordered proteins using residue-local	Miguel A.	Soler	15:30	15:50	Pressure-Induced Coil to Globule Transition in Poly-Sulfobetaine Polymer Systems	Jean-Claude	Andonissamy
15:50	16:10	On the delivery of functional ingredients: Sponge phase lipid nanoparticles interacting with biomimetic	Tommy	Nylander	15:50	16:10	Two-Parameter Scaling in Polymer ?-Solutions Revealed by DWS Microrheology	Tetsuharu	Narita
16:10	16:35	Coffee break							
16:40	17:00	Amino acids modulate biomolecular condensation by preferential partitioning	Ashutosh	Kumar	16:40	17:00	Swelling and de-swelling behavior of thermo-responsive polymers at phase transition	Joanna	Michalska-Walkowiak
17:00	17:20	Soft Defense: Mimicking natural deterrent strategies in plants	Thomas	Kodger	17:00	17:20	From Solution Structure to Semicrystalline Morphology in Poly(2,6-diphenyl-p-phenylene oxide)	Mihai-Andru	Angheliu
17:20	17:40	Targeted Thrombolysis Using Red Blood Cell Derived Nanoparticles	Diya	Agrawal	17:20	17:40	Turning Complexity into Function: Humins as Blend Components, Graft Cores, and Dynamic Network Formers	Dilhan	Kandemir
17:40	18:00	Curvature-Responsive Supported Lipid Bilayers as Platforms to Study Protein-Lipid Interactions	Laura	Cervera Gabalda	17:40	18:00	Applying the concepts of self-concentration and concentration fluctuations on a new type of dynamically	Andreas	Almanric
18:00	20:00	Posters and networking					SoftComp Research Road Map: hands off session (Vladimir Baulin)		
20:00		Dinner							

Annual Meeting 2026, Wednesday 20 May

Start time	End time	Title of contribution	Speaker first name	Speaker family name	Start time	End time	Title of contribution	Speaker first name	Speaker family name
09:00	09:45	Composite soft matter: from understanding gelation and phase behaviour towards engineering of structures with applications to food	Erik	van der Linden	Chair person: Davoud Zare				
09:45	**10:55**	**Food Science (Chair Davoud Zare)**			**09:45**	**12:45**	**Glasses, Colloids and Self-Assembly (Chair Sophie Ayscough)**		
09:55	10:15	Self-driving labs for formulating food	Michelle	de Dood	09:45	10:15	Soft colloids at interfaces	Matthias	Karg
10:15	10:35	Controlling the Cold-Set Gelation of Bovine Serum Albumin Protein using Alcohol and Ionic Surfactant	Debasish	Saha	10:15	10:35	Controlled microgel assembly monitored by light scattering techniques	Miranda Jacqueline	Buil Contreras
10:35	10:55	Minimally processed pea protein extracts promote protein?carbohydrate co-gelation	Francesca	Dessì	10:35	10:55	Hydrophobic Interactions in Complex Geometries	Alex	Epstein
10:55	11:25	Coffee break							
11:25	**12:25**	**Food Science (Chair Erik van der Linden)**							
11:25	11:45	Coacervate Encapsulation of Red Ginger Oil: In Vitro Digestion and Biochemical Changes	Muhammad Gilang	Ramadhan	11:25	11:45	Lipid nanoparticle-based hybrids for next-generation MRI contrast agents	Dorota	Flak
11:45	12:05	Microbubble powders using freeze-dried Pickering emulsions	Qimeng	Wang	11:45	12:05	How lipid nanoparticles tune the nanomechanics of hybrid electrospun fibre membranes	Amin	Sadeghpour
12:05	12:25	From side streams to novel hydrocolloids - fermentative production of xanthan-like polysaccharides	Marcel	Schöffmann	12:05	12:25	Pressure dependence of slow dynamics and rheology of Lapoite® dispersions	Benoit	Loppinet
					12:25	12:45	J-aggregate-based Artificial Hyperbolic Metamaterials for Light-Matter Coupling at the Nanoscale	José N.	Gama
12:45	14:00	Lunch break							
14:00	14:45	Role of oil polarity on the interfacial phenomena of surfacta	Peter	Fischer	Chair person: Theresia Heiden-Heckt				
14:55	**15:55**	**Food Science (Chair Theresia Heiden-Heckt)**			**14:45**	**17:25**	**Polymers and Biopolymers (Chair Simon Titmuss)**		
14:55	15:15	Non-Fickian diffusion within assemblies of the intrinsically disordered protein ?-casein	Tilo	Seydel	14:45	15:15	Designing Sustainable Peptide-Based Block Copolymer Electrolytes with Tunable Ion Transport and Mechanical Stability	Emmanouil	Glynos
15:15	15:35	The complex rheological behaviour of lactoferrin-mucin systems	Bianca	Hazt	15:15	15:35	Probing molecular interactions between polymer and surface through hydrogel friction	Lea	Gaonac'h
15:35	15:55	Designing Function by Programming Assembly; PIESA-Driven Soft Nanomaterials for Food and Pharma	Neshat	Moslehi	15:35	15:55	On the design of lightweight, multi-layered, single-material polymeric structures	Emilia	Di Lorenzo
15:55	16:25	Coffee break							
16:25	**17:45**	**Glasses, Colloids, and Self-Assembly (Chair Tylo Seydel)**							
16:25	16:45	Interfacial ordering and confinement-induced phenomena in OMBD-grown liquid crystal thin films	Anna	Drzewicz	16:25	16:45	Understanding Polymer Behaviour at Fabric?Solution Interfaces via Coarse-grained Simulations?	Elliot	Findlay
16:45	17:05	Molecular Ionic Glasses as Recyclable Alternatives to Glassy Polymers	Yongfang	Lu	16:45	17:05	The adsorption of soil-releasing polymers at model fabric interfaces	Josephine	Binks
17:05	17:25	Rare cage escapes drive relaxation in deeply supercooled liquids	Francesco	Rusciano	17:05	17:25	Encapsulation of small hydrophilic drug in centrifugally spun hydrophobic polymer fibers using hydrophobic ion	Swaraj	Deodhar
17:25	17:45	Two Clocks, one event: dual relaxation mechanisms governing physical aging of polymeric glasses	Lorenzo Augusto	Rocchi					
17:25	20:00	Posters and networking							
18:00	20:00	Network Governing Board (NGB)							
20:00		Conference Dinner							

Annual Meeting 2026, Thursday 21 May

Start time	End time	Title of contribution	Speaker first name	Speaker family name	Start time	End time	Title of contribution	Speaker first name	Speaker family name
09:00	09:45	Adaptive Soft Matter at Liquid-Liquid Interfaces: Inspirations from Coffee & Food	Stefan	Salentinig	Chair person: Peter Fischer				
09:45	**12:45**	**New Methods and Techniques / Synthesis (Chair Sebastian Jaksch)**			**09:45**	**12:45**	**Biological Soft Matter (Chair Peter Fischer)**		
09:45	10:15	Experimental Platforms for SoftComp Users	Kyongok	Kang	09:45	10:15	Non-invasive NMR assessment of water status in soft and biological systems	Grzegorz	Nowaczyk
10:15	10:35	Detection of ultrafine particles in the air using fiber-tip optical sensors	Hans	Wyss	10:15	10:35	Active tension and flow in actin rings and cortical networks	Thorsten	Auth
10:35	10:55	Analysing DDLS data - Common Pitfalls and How to Avoid them	Peter	Lang	10:35	10:55	Cell blebbing: a microgel-vesicle model	Debnath	Tanwi
10:55	11:25	Coffee break							
11:25	11:45	Inferring Extensional Viscosity from the Shape of Stretched Liquid Filaments in Airflow, from Newtonian Fluids to Saliva	Christian	Ligoure	11:25	11:45	Understanding how proteins and lipids control cell death	Sophie	Ayscough
11:45	12:05	Making zein coacervates films more flexible: experiments and computer simulations	Qin	Li	11:45	12:05	Microfluidic Synthesis of Theranostic Liposomes for Combined Drug Delivery and MRI Contrast Enhancement	Tomasz	Zalewski
12:05	12:25	A silica-supported poly(ethylene glycol) (PEG) hydrogel developed for the removal of organic dyes in water	Fabiana	Tescione	12:05	12:25	Hydrogel substrates for controlling cell adhesion	Nalin	Maniwongwichit
12:25	12:45	From ionic liquid nanostructure to water purification: linking molecular dynamics with extraction and sorption	Roksana	Markiewicz	12:25	12:45	Trypanosoma motility in complex environments	Raj	Mishra
12:45	13:00	Closing remarks & Award ceremony							
13:00		Lunch							

SoftComp
SOFT MATTER COMPOSITES

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Annual Meeting 2026

Title of contribution	First name	Family name
Poster session		
Following the Dark Recovery of a Photoswitchable LOV Protein with Time-Resolved QENS	Theresa	Bosserhoff
Oxidative Damage in Keratin Fibres: A correlative Study of Human Hair	Naomi	Brown
Bridging the Gap: Microstructural Origins and Yielding Behavior of Microfibrillated Cellulose Suspensions for Sustainable Food Design	Caterina	Cocca
Effect of ionic strength on the microstructure and rheology of potato protein hydrogels	Karina	Cruz Tenjhay
Molecularly Imprinted Polymers: highly crosslinked networks for the selective removal of pharmaceutical residues from wastewater	Débora	De Bastos Oliveira
Stretching mucins: Revealing the complex rheology of natural glycoprotein networks	Bianca	Hazt
Segmental-Decoupled Lithium-Ion Efficient Transport in Ionogel Electrolytes	Zhenni	He
Adhesive microgel-microgel interactions controlling network reversibility during drying	Ward	Jansen
Is DNA grooving geometrically optimal?	Jacek	Jenczyk
Liquid Crystalline Block Copolymers for Enhanced Ionic Conductivity in Polymer Electrolytes	Garance	Keus
Kneading as an efficient mixing method to enhance processability of graphite anode slurries	Anna	Łapeta
Microstructured polymer electrolytes with high Li-ion conductivity by tuning structural uniformity	Luca	Laugeni
Time-Dependent Water Permeability in Degrading PLA: A Molecular Dynamics Study	Alireza	Mirzaalipourcheshmeh
Annual meeting 2026 X-ray Scattering Studies of Microgels at the Air?Liquid Interface	Olaf	Soltwedel
Using QENS to Probe the Dynamics of the Tau Protein under Liquid-Liquid Phase Separation	Finn	Sombrutzki
Synthesis and properties of PS-PMMA copolymers containing reversible covalent crosslinks as compatibilizers in blends	Arya	Vijayan