CPP 31: Responsive and Adaptive Systems

Time: Wednesday 9:30–11:30 Location: ZEU/0255

Invited Talk CPP 31.1 Wed 9:30 ZEU/0255

Hydrogels with a Pinch of Embodied Intelligence — •Andreas Walther — Department Chemie, JGU Mainz

Smart is good, but intelligent is better. The next frontier in soft matter research is to design life-like materials with embodied intelligence, featuring the integrated sensor-processor-actuator paradigm. Our work explores how hydrogels and soft robotic systems can be endowed with autonomous operation and decision-making capacity by embedding chemical reaction networks, enzymatic feedback loops, and mechanical gating principles. Such metagels and metamaterials are capable of self-strengthening behavior, strain-gated responses, and non-reciprocal motion, moving far beyond the limits of traditional responsive materials. By intertwining chemical, mechanical, and structural information, these systems provide a blueprint for programmable, adaptive matter that approaches the complexity and functionality of biological tissues.

CPP 31.2 Wed 10:00 ZEU/0255

Secondary crosslinking of thermoresponsive microgels for smart microgel-based membranes — •Jonas Runge[1,2], Stefanie Uredat[1,2], Aditi Gujare[1,2], Domenico Truzzolillo[2], Julian Oberdisse[2], and Thomas Hellweg[1] — [1]Physical and Biophysical Chemistry, Bielefeld University, Germany — [2]Laboratoire Charles Coulomb, Université Montpellier, France

Responsive microgels are crosslinked polymer networks of colloidal size, which undergo a so-called volume phase transition induced by a certain stimulus like e.g. temperature or pH. Temperature sensitive microgels undergo a strong decrease in size at the volume phase transition temperature (VPTT). Smart membranes are based on responsive polymers and allow to open pores triggered by an external stimulus [1]. Our project on smart microgel-based membranes (SmartBRANE) aims to incorporate an UV-crosslinker and form membranes by activating the UV-crosslinker [2]. The working temperature of low-temperature fuel cells is in the range of 80-100 °C. Since the VPTT of common acrylamides is close to the physiological temperature, we synthesized a hydrophilic acrylamide monomer (NIPMAMol) with an extrapolated VPTT of 85°C. In this work, we copolymerize NIPMAMol with NIPAM and the UV-crosslinker HMABP to increase the VPTT of the then formed membrane. The thermoresponsive properties of the microgels are characterized with PCS. The distribution of the UV-crosslinker within the microgels particles and the formed membrane is investigated with contrast-matching SANS experiments. [1]Runge,Gujare,Uredat, PCCP, 2024, 26, 2732.[2]Dirksen, RSC Advances, 2021, 11(36), 22014.

CPP 31.3 Wed 10:15 ZEU/0255

Photoresponsive Control of Fullerene Diffusion in Azo-BT Nanotraps — Dmitry A. Ryndyk[1,2] and •Olga Guskova[1] — [1]IPF Dresden, Dresden, Germany — [2]TU Dresden, Dresden, Germany

We present a light-switchable azobenzene-bithiophene (Azo-BT) self-assembled monolayer (SAM) on Au(111) that operates as a reversible nanotrap for C60. Using density-functional theory and QM molecular dynamics, we quantify C60 adsorption on planar layers and diffusion on the SAM and within a fixed 12 A slit-like pore. Direct adsorption on the cis layer is about twice as favorable as on the trans layer due to stronger dispersion interactions with exposed thiophene rings, whereas the densely packed trans layer presents mainly hydrogen contacts and weaker binding. In the slit geometry, the trans (and mixed) layers provide an open pore that captures C60, while photoisomerization to cis closes the slit and prevents release. Diffusion analysis shows that specific interaction sites along the slit walls and the effective degree of confinement - arising from local potential variations within the fixed 12 A slit - govern diffusion pathways and escape barriers. External electric fields or charging of the Au/Azo-BT/C60 complex enable active expulsion, offering design principles for light- and field-responsive nanocarbon trapping interfaces. The financial support from DFG (grant number 509039598) is highly appreciated.

CPP 31.4 Wed 10:30 ZEU/0255

Reversible Photoswitching of Arylazopyrazole-functionalized Polyacrylamide Thin Films under Water Vapor — •David P. Kosbahn[1], Morgan P. Le Dû[1], Simon A. Wegener[1], Feifei Zheng[2], Robert Cubitt[3], René Steinbrecher[4], André Laschewsky[4,5], Christine M. Papadakis[2], and Peter Müller-Buschbaum[1] — [1]TUM School of Natural Sciences, Chair for Functional Materials, Garching, Germany — [2]TUM School of Natural Sciences, Soft Matter Physics Group, Garching, Germany — [3]Institut Laue-Langevin, Grenoble, France — [4]Institut für Chemie, Universität Potsdam, Potsdam-Golm, Germany — [5]Fraunhofer Institut für Angewandte Polymerforschung, Potsdam-Golm, Germany

This study investigates the swelling behavior of p(AAPEAm-co-DMAm) films in both isomeric states of the novel photoswitchable molecule arylazopyrazole (AAP). The impact of reversible switching using two different wavelengths on swelling of the polymer in water vapor is examined, with the aim of controlling water uptake, expansion, and nanoscale morphology. This material shows potential for applications in reversible light sensors, photo-actuators, and drug delivery systems. We use time-resolved FTIR spectroscopy to monitor group vibrations during switching, gaining insights into molecular interactions throughout the isomerization processes. Additionally, in situ time-of-flight neutron reflectometry on a thin film provides time- and depth-resolved data on the water distribution along the surface normal. The results shed light on the influence of arylazopyrazole moieties on the polymer's microscopic properties.

CPP 31.5 Wed 10:45 ZEU/0255

Modeling the Viscoplastic Deformation of Azopolymers Under the Influence of Structured Light — •Nikolai Liubimtsev and Marina Saphiannikova — Leibniz Institute of Polymer Research Dresden, Germany

A distinctive feature of side-chain azopolymers is their ability to convert structured light into a well-defined stress field [1]. This field results from the alignment and elongation of polymer backbones along the light-polarization direction, which acts as a nematic director. Linearly or elliptically polarized irradiation induces uniaxial or biaxial chain orientation, and the stress tensor is proportional to the rate of change of the second-order orientation tensor, predicted from the spatial distribution of light intensity and polarization [1]. Using viscoplastic photoalignment modeling, we achieve excellent agreement with experimentally observed reshaping of azopolymer microstructures. Three-dimensional light fields - such as tightly focused Gaussian beams or q-plate patterns - produce directional photodeformations. These fields are incorporated into ANSYS either analytically or by directly mapping intensity, polarization, and ellipticity at each material point, the latter being especially useful for arbitrary SLM-generated patterns. Financial support from DFG grant GR 3725/10-1 is gratefully acknowledged.

References: [1] I. K. Januariyasa, F. Reda, N. Liubimtsev, et al., Stress-driven photo-reconfiguration of surface microstructures with vectorial light fields, arXiv:2506.06857 (2025), accepted for publication in Light: Science and Applications.

CPP 31.6 Wed 11:00 ZEU/0255

Impact of surface chemistry on the adsorption and dynamics of stimuli-responsive polymers — Baptiste Chabaud[1], Wanchung Chiang[1], Lionel Bureau[1], Ralf Richter[2], Rachel Auzély[1], Delphine Debarre[1], and •Galina Dubacheva[1] — [1]Université Grenoble Alpes, Grenoble, France — [2]University of Leeds, Leeds, UK

Stimuli-responsive polymers at interfaces underpin smart coatings, sensors and bioinspired materials, yet how surface chemistry controls their binding and dynamics remains poorly understood. We probe the interfacial behavior of redox- and thermosensitive polymers on well-defined model surfaces using QCM-D, SPR, ellipsometry, electrochemistry and fluorescence microscopy. For redox-active host/guest systems, we show that grafting strategy, linker flexibility and host/guest density govern the stability, specificity and reversibility of polymer assemblies. Kinetic analysis further reveals that small changes in surface chemistry, such as linker design or dilution with inert molecules, strongly tune multivalent superselectivity, enabling sharp discrimination of receptor densities. Using supported lipid bilayers as fluid interfaces, we correlate lateral mobility with contraction, dehydration and 2D aggregation of thermoresponsive polymer brushes. Overall, we identify interfacial density, mobility and flexibility as key parameters for controlling stimuli-responsive polymer assemblies and outline design rules for supramolecular and bio-inspired systems with high specificity and precision.

CPP 31.7 Wed 11:15 ZEU/0255

Modeling of magnetic hysteresis in magneto-active elastomers — •Pawan Patel[1,2], Dirk Romeis[1], and Marina Saphiannikova[1,2] — [1]Leibniz-Institut für Polymerforschung Dresden e.V, Hohe Straße 6, 01069, Dresden, Germany — [2]Faculty of Mechanical Science and Engineering, Dresden University of Technology, 01062, Dresden, Germany

Magneto-active elastomers (MAEs) are soft polymer composites containing magnetizable microparticles. MAEs exhibit field-dependent mechanical and magnetic properties. When subjected to an external magnetic field, MAEs display magneto-mechanical coupling effects such as tunable stiffness and reversible shape changes. This study presents a multiscale theoretical model to describe the magnetic hysteresis behavior of MAEs, focusing on the role of microstructure evolution during magnetization and demagnetization of microparticles. The total energy of the system is formulated as the sum of magnetic and micromechanical contributions, while macroscopic deformation of the cylindrical sample is constrained. The model incorporates both pure dipole–dipole interactions and near field effect to account for multipole higher-order particle interactions. The results reveal that magnetic hysteresis in soft magnetic MAEs arises primarily from microstructural rearrangements, where the spatial configuration of particles differs between increasing and decreasing magnetic fields. Simulations demonstrate that parameters such as particle volume fraction, sample geometry, and micromechanical stiffness significantly influence the hysteresis loop width.