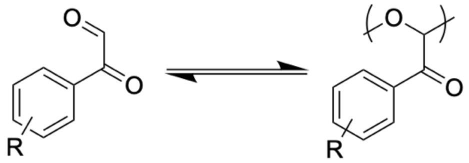
POSTER ABSTRACTS
2025 INTERNATIONAL SYMPOSIUM ON STIMULI-RESPONSIVE MATERIALS

1. Poly(Phenyl Glyoxal)s: A Versatile Class of Chemically Recyclable Polymers with Tunable Photochemistry, Anthony Engler, Assistant Professor, Louisiana State University

Polyaldehydes can be triggered to chemically depolymerize near ambient conditions due to their relatively low ceiling temperatures (Tc); however, they remain an underexplored class of polymers due to the low Tc necessitating cryogenic polymerizations, aldehydes require ionic polymerization mechanisms, and highly efficient end-capping reactions to ensure long-term stability. We report a new class of polyaldehydes based on the phenyl glyoxal (PG) monomer, conveniently prepared from commercial acetophenone derivatives that provide access to a large PG monomer library. These polymers can be degraded upon exposure to Deep UV photons via Norrish reactions. Monomer reactivity and polymer photochemistry can be tuned through electronic effects via functionalization of the aromatic ring, as well as modify material properties and offer post-polymerization modification routes to introduce functional groups intolerant to the ionic polymerization conditions. We expect poly(PG)s to be a versatile, stimuli-responsive polymer for next-generation engineering applications.



2. pH-Responsive Colloidal Membranes for Swelling-Enhanced Flow Control, Gideon Onuh, Oz M. Gazit* and Ofer Manor***,** Department of Chemical Engineering, Technion – Israel Institute of Technology, 320000, Haifa, Israel

We developed stimuli-responsive particle systems with tunable interfaces to control the transport of liquids. We model the natural tendency of clay particles to swell or shrink in response to changes in pH to design silica particles that can act as pH-responsive colloidal gates [1]. Sub-micron silica colloids are densely grafted with pH-sensitive polyelectrolyte brushes to create colloidal gates that actively shrink and swell in response to solution pH. Unlike traditional membranes, where swelling reduces porosity, this system expands upon swelling, enhancing permeability (up to 0.32 mL/min) and porosity (up to 0.82) at pH 8–9, while occluding flow at pH 2. Iterative grafting with 2,2-dimethyl-1,3-propanediamine as a linker enables tunable gating, validated by Darcy's law and Kozeny-Carman modeling. We correlate particle coagulation and dispersion with adjustable surface forces and interparticle interactions to demonstrate the key role of ionic strength and pH in governing transport phenomena in colloidal systems [2].

References
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[2] G. Onuh, R. Bar-On, and O. Manor, “Particle Network Self-Assembly of Similar Size Sub-Micron Calcium Alginate and Polystyrene Particles Atop Glass,” Macromolecular Bioscience, p. 2300219, Aug. 2023. [Online]. Available: https://onlinelibrary.wiley.com/doi/10.1002/mabi.202300219

3. Tunable Structural Color in Ethyl Cellulose–Poly(acrylic acid) Composites via Molecular Weight Blending

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Synthetic dyes used in packaging and textiles are vibrant and visually appealing, but they are often toxic, non-biodegradable, and difficult to remove from wastewater, contributing significantly to environmental pollution. Structural color offers a sustainable alternative, relying on nanoscale ordering to selectively reflect wavelengths of light and produce vivid coloration without pigments. Chiral nematic liquid crystals of ethyl cellulose (EC) in acrylic acid (AA), which can be photopolymerized into poly(acrylic acid) (PAA), have emerged as a promising platform for creating solid, structurally colored films. These systems enable tunable optical properties through control of polymer chain mobility and polymerization kinetics. However, a tradeoff exists between high EC chain mobility and the retention of liquid crystalline order after photopolymerization. Low molecular weight EC yields vivid, iridescent colors in the gel mesophase, but photopolymerization often causes a significant blue shift of the photonic bandgap or a complete loss of order. In contrast, high molecular weight EC maintains structural color in both gel and solid states but exhibits reduced angular dependence and lower reflectance intensity.

To address this challenge, we investigated how blending EC of different molecular weights (35 and 166 kDa) affects the optical and mechanical properties of the resulting EC–PAA composite films. Gel mesophases were prepared with varying blend ratios, and the evolution of the photonic bandgap and mechanical performance was characterized post-photopolymerization. We found that the peak reflectivity wavelength decreased linearly with increasing content of 35 kDa EC, while elastic modulus and tensile strength remained largely unchanged across all compositions. Notably, films containing just 20 wt% of 35 kDa ethyl cellulose exhibited significantly higher peak reflectance than those composed entirely of 166 kDa EC, while also showing a reduced blue shift compared to single-molecular-weight 35 kDa systems.

This work provides a phenomenological framework for tuning structural color in EC–PAA composites through molecular weight blending, allowing for the design of materials with targeted optical properties while maintaining unaltered mechanical performance.

4. Unexpectedly Large Entropic Barrier Controls Bond Rearrangements in Vitrimers

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Vitrimers are a novel class of polymer networks that combine the structural stability of thermosets with the reprocessability of thermoplastics. Their dynamic covalent bonding nature enables network rearrangement under external stimuli (*e.g.*, heat, pH, or light) without degrading network integrity, resulting in exceptional properties such as recyclability, self-healing, shape memory, and weldability. These features make vitrimers attractive for sustainable materials and advanced manufacturing. Yet, the mechanisms governing their viscoelastic behavior remain poorly understood. Our detailed studies of relaxation dynamics and viscoelastic behavior of model vitrimers revealed that while increasing the dynamic crosslink density at fixed molecular weight between crosslinking has no influence on chain dynamics, it strongly affects linear viscoelasticity of vitrimers and induces a sol-gel transition consistent with predictions of classical gelation theory, demonstrating its applicability to vitrimers. In contrast, lowering molecular weight between crosslinks significantly increases vitrimers' glass transition temperature and slows down drastically their segmental relaxation. Surprisingly, their bond rearrangement time remains largely unaffected, particularly at elevated temperatures, demonstrating a clear decoupling between bond rearrangement and segmental mobility. Detailed analysis reveals a transition in bond rearrangement time from Arrhenius to non-Arrhenius behavior upon cooling, reflecting a recently proposed [1] shift from reaction rate-controlled to diffusion-limited bond rearrangement mechanisms. Finally, analysis of the Arrhenius regime shows an unexpectedly large negative activation entropy that substantially slows bond rearrangements despite their low activation enthalpy [2]. These findings emphasize the crucial role of entropy in vitrimer dynamics and offer new insights into the thermodynamic and kinetic control of dynamic covalent networks.

References
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(2) Cheng, S.; Rey, L.; Yao, B.; Popov, I.; Sokolov, A. P. Unexpectedly large entropic barrier controls bond rearrangements in vitrimers. arXiv preprint arXiv:2508.05824 2025.

5. Active Bacterial Nematogels: Towards Programmable Shape-Actuating Living Materials, Tammy Qiu[1], Luca V. D. Scharrer[3,4], Vincenzo Vitelli[3,4,5], Karen E. Kasza[2]
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One of the most abundant biopolymers available, cellulose, allows plants to direct movement and modulate mechanical properties based on the structural orientation of its microfibrils within their cell walls. Cellulose-synthesizing bacteria *Acetobacter xylinum* are "microbial material factories" capable of producing highly crystalline cellulose that interlink via hydrogen bonds to form macroscopic hydrogels, which we term *bacterial nematogels* due to their nematic ordering. While typically studied as a passive material, we propose reframing bacterial nematogels as active materials whose macroscopic properties emerge from microbial dynamics. By leveraging the coupling between bacterial motility, defect dynamics, and the aligning effect of the cellulose matrix, we introduce a novel method for fabricating shape-actuating active materials in situ. Towards its implementation, we are fabricating microfluidic bioreactors that enable live imaging, directional feeding, as well as custom geometric confinement with the goal of programming alignment and inducing topological defects. With this system, we are able to capture single-cell bacterial motility and cellulose configurations, which will inform a multi-scale hydrodynamic theory capable of explaining phase dynamics and aiding in the rational design of living materials in conjunction with living microorganisms themselves.

6. From the Nose to the Vagina: Treating Mucin Deficiencies with Shear-Labile Interaction Polymers (Slips), Ariana M. Tamura, Amanda E. Ojeda, Jessica Xhumari, Luiz F. W. Roesch, W. Gregory Sawyer, Brent S. Sumerlin*

Mucins are glycoproteins that act as lubricants, protective barriers against disease, and energy sources for cells. Given their prevalence across a range of biological systems, mucin depletions can lead to health concerns, including allergic rhinosinusitis, inflammatory bowel disease (IBD), and bacterial vaginosis (BV). Herein, we investigate a universal, polymer-based therapeutic to treat mucin deficiencies in multiple systems. Our formulation, shear-labile interaction polymers (SLIPs), is an ultra-high molecular weight, water-soluble polyacrylamide with pH-responsive boronic acids (BA) that provide gentle mucoadhesion. Instead of mimicking mucins directly, our approach leverages key physicochemical properties: lubricity through hydrophilicity and shear lability, viscosity from ultra-high molecular weights, and mucoadhesion via reversible BA binding to biological mucins and cells. Our polymers were synthesized via photoiniferter methods, tested for dissolution, and probed for pH-dependent viscosities. SLIPs was then investigated in nasal, gastrointestinal, and cervicovaginal systems. We found that SLIPs maintained biocompatibility and reduced dysbiosis. Our ongoing investigations will continue to push SLIPs as therapeutics in a variety of mucin-related applications.