UCI Samueli School of Engineering

Department of Materials Science and Engineering UCI

UNIVERSITY OF CALIFORNIA, IRVINE

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

SPECIAL SEMINAR

"DESIGNING SUSTAINABLE SOFT MATTER FROM THE MOLECULE UP"

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Wednesday, May 1, 2024

11:00 AM - 12:30 PM

Engineering Tower, Conference Room 652

Abstract: Soft matter constructed by nature harnesses chemically complex molecular subunits to generate finely tuned chemical, dynamical, and mechanical properties over nano- to macro-scales, motivating the use of bottom-up strategies to realize functional synthetic materials. Here, I present how a molecule-up approach to the design of supramolecular and covalent polymers elicits unique structure-property relationships in materials to address urgent challenges in water treatment and plastics waste. First, I discuss the development of aramid amphiphiles, self-assembling small molecules that incorporate a Kevlar-inspired domain to impart strong, cohesive intermolecular interactions between molecules. Aramid amphiphiles spontaneously organize in water to form nanoribbons with suppressed dynamic mobility and mechanical properties rivaling silk. Combining the aramid amphiphile motif with chemistries to tune interfacial behavior enables the synthesis of high (~200 m2/g) surface area nanomaterials capable of treating thousands of liters of lead-contaminated water per gram of material. Next, I explore how the molecular design of lignin-derivable methacrylates enables the chemical recycling of the resulting covalent polymers, 'closing the loop' on high (> 100 °C) glass-transition temperature materials obtainable from industrial waste. Influences of monomer chemistry and reaction atmosphere are investigated to enable quantitative thermal depolymerization to monomer with high purity. The reclaimed monomers are then upcycled to narrow-dispersity and block polymers, demonstrating valorization of lignin-derivable molecules over multiple life cycles. Employing a molecule-up approach to soft matter formulation offers a pathway to realize novel properties in synthetic soft materials towards addressing generational challenges in sustainability.

Bio: Ty Christoff-Tempesta is a postdoctoral scholar at the University of Delaware, where he researches performance-advantaged and closed-loop polymeric systems from renewable feedstocks. Previously, he completed his Ph.D. in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology, where his research focused on molecular design to produce robust molecular assemblies and their application to pressing challenges in water treatment. Outside of research, Ty has been actively involved in DEI initiatives and plastics sustainability efforts, including organizing the inaugural LGBTQ+ research symposium at the Spring 2024 MRS National Meeting and collaborating on single-use plastics policy as a fellow with the Massachusetts State government. Ty is a recipient of the National Science Foundation Graduate Research Fellowship, the Martin Society Fellowship for Sustainability, the Hugh Hampton Young Fellowship, and the ACS CAS Future Leaders award.