



MATERIALS SCIENCE and ENGINEERING SEMINAR



Dr. Lilian Hsiao

Chemical & Biomolecular Engineering

North Carolina State University

Topological architectures hidden in disordered colloidal materials

Advances in modern science have made it possible to capture high-resolution and dynamic images of disordered matter ranging from biological tissues, battery electrodes, to life-saving medicine. While these systems appear to lack the clean periodic order that gives rise to the remarkable optical and electronic properties of crystals, disordered matter contains a rich variety of organized networks that govern nearly all functions of life and technology. The 20th century transformed materials development by identifying distribution functions, structure factors, and order parameters as the fundamental variables governing ordered matter. Yet no analogous organizing principle has emerged for the vast world of disordered matter, leaving one of the most ubiquitous classes of matter without a predictive framework linking structure to function.

Here, we use confocal microscopy and in situ rheometry techniques to generate network science-based structural metrics of a broad class of fluorescent colloidal systems, where the metrics produce highly predictive correlations with their mechanical and rheological properties. These systems span a broad class of colloidal gels, biopolymer composites, and porous elastomers. We show that cluster morphology, graph theory (GT), and topological data analysis (TDA) generate structure-property correlations at a mesoscale level that cannot be captured accurately by using classical interactions or distribution functions, with TDA in particular showing unusual and outstanding promise as a scale-free parameter. These characterization analyses are equally applicable to other types of real-space microscopy images such as that obtained from electron micrographs and tomography data and are also applicable to time-varying flows of materials in 3D printing and manufacturing processes.

BIOGRAPHY

Lilian Hsiao is the University Faculty Scholar and Associate Professor of Chemical and Biomolecular Engineering at North Carolina State University. She received her B.S. in Chemical Engineering from the University of Wisconsin-Madison in 2008, Ph.D. in Chemical Engineering from the University of Michigan in 2014 and conducted postdoctoral work at the Massachusetts Institute of Technology. Her research program specializes in the use of in situ confocal microscopy and rheological tools to understand the microstructure and function of deforming soft materials. Her research work has been featured in awards including the American Physical Society DSOFT Early Career Award, Society of Rheology Metzner Award, Camille Dreyfus Teacher-Scholar Award, Sloan Research Fellowship in Chemistry, and the American Chemical Society Unilever Award.

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