Materials Science and Engineering Department

Fall Seminar Series

Anisotropic Nanomaterial Liquid Crystal Dispersions: From Colloid Science to Manufacturing

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October 2, 2024
11AM-12PM | Hill Seminar Room (LeBow 240)

Investigating dispersions of one-dimensional (1D) and two-dimensional (2D) nanomaterials is expanding our fundamental understanding of liquid crystal and colloid science. Moreover, comprehending the rheology and phase behavior of anisotropic nanomaterial dispersions is essential for their fluid-phase manufacturing into films, fibers, and printed objects with desirable microstructures and properties.

This talk focuses on two systems: 1) aqueous dispersions of 1D sulfated cellulose nanocrystals (CNCs) and 2) aqueous dispersions of 2D $Ti_3C_2T_x$ MXenes produced by the minimally intensive layer delamination (MILD) process. Chiral nematic ordering in 1D sulfated cellulose nanocrystal dispersions can be harnessed to fabricate photonic films or unwound to create microelectromechanical devices with anisotropic mechanical properties. While CNCs are less polydisperse than many other nanomaterials, size fractionation significantly influences their dispersion microstructure, dispersion rheology, and the properties of assembled films.

The complex shapes and substantial polydispersity of MXenes lead to even richer dispersion rheology and phase behavior. Dispersions of large sheets (average lateral length ~ 3 μm) exhibit lyotropic liquid crystalline phase behavior with long-range order but are susceptible to flocculation and aggregation at higher concentrations. In contrast, dispersions of small sheets (average lateral length ~ 0.3 μm) display birefringence without large aggregates but lack the long-range order typically associated with liquid crystals. The phase behavior of mixtures of large and small sheets is highly dependent on sample preparation and tends to facilitate long-range liquid crystalline ordering at relatively low concentrations. The impact of intentional polydispersity on phase behavior, dispersion microstructure, rheological properties, and direct ink writing is discussed. Collectively, these findings highlight how size distribution can impact structure-process-property relationships for functional materials derived from anisotropic nanomaterial dispersions.

Dr. Virginia A. Davis is the Daniel F. and Josephine Breeden Professor of chemical engineering at Auburn University (AL, USA). Her research group is focused on structure-process-property relationships in fluid-phase manufacturing. She is particularly interested in how the lyotropic liquid crystalline self-assembly of anisotropic nanomaterials affects dispersion microstructure and rheological behavior. Her research group uses this understanding to produce films, fibers, and 3D-printed devices with controlled microstructures and properties. Davis' other active research interests include nanocomposites, thermoplastic polymer recycling, and STEM Education research.

Dr. Davis earned her Ph.D. in chemical and biomolecular engineering from Rice University after gaining ten years of manufacturing, research, and marketing experience in the polymer industry. Her honors include a Presidential Early Career Award for Scientists and Engineers (PECASE) as well as professional society and university awards for research, outreach, mentorship, and enhancing inclusivity.

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