MIT ChemE

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Surfactants, Colloids, and Electrolytes: Complex Fluids for Energy and the Environment

Fernando Temprano-Coleto

Postdoctoral Research Associate
Princeton University

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Transport in fluids mediates countless physical processes key to sustainability, ranging from the spread of harmful microplastics to the mining of lithium for batteries. Engineering these transport processes into applications often requires an understanding of complex fluids, where the physicochemical interactions between microscopic constituents critically affect the macroscopic dynamics. In this talk, I share three examples of complex fluids from my research, which highlight how uncovering fundamental physical mechanisms can directly inform new technologies in energy and the environment. First, I discuss surfactants, chemicals that adsorb onto interfaces between fluids and profoundly alter their motion. My work has revealed that these substances play a central role in the performance of "superhydrophobic" textured coatings aimed at reducing hydrodynamic friction in applications like marine transportation. Next, I will demonstrate how the spontaneous migration of colloids in chemical gradients, an effect known as diffusiophoresis, can be used to filter solid particles from water without membranes. I theoretically derive upper bounds for the efficiency of this separation process and demonstrate it using microfluidic experiments, paving the way towards new approaches to the remediation of microplastic pollutants. Finally, I illustrate the physics behind the evaporation of electrolytes, ionic solutions that can be found in nature in the form of brines.

kbriana@mit.edu

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