**Predator-Prey Interactions between Droplets Driven by Nonreciprocal Oil Exchange**

**Abstract**: Chemotactic interactions are ubiquitous in nature and can lead to nonreciprocal and complex emergent behavior in multibody systems. However, developing synthetic, inanimate embodiments of a chemomechanical framework for generating nonreciprocal interactions of tunable strength and directionality has been challenging. Here we show how chemotactic signaling between microscale oil droplets of different chemistries in micellar surfactant solutions can result in predator-prey-like nonreciprocal chasing interactions. The interactions and dynamic self-organization result from the net directional, micelle-mediated transport of oil between emulsion droplets of differing composition and are powered by the free energy of mixing. Our findings demonstrate how chemically-minimal systems can be designed with controllable, nonreciprocal chemotactic interactions to generate emergent self-organization and collective behaviors reminiscent of biological systems.