Structure–mechanics coupling in particle-laden liquid-liquid interfaces

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Particle-laden liquid-liquid interfaces exhibit complex and tunable interfacial mechanics. The mechanical properties of these interfaces play a significant role in the formation and stability of Pickering emulsions. To date, most studies have focused on densely packed, monolayer interfaces, whereas less densely organized interfacial structures remain underexplored, despite their potential to exhibit pronounced mechanical properties. However, achieving robust elastoviscoplastic behavior at liquid-liquid interfaces remains challenging, particularly at sub-monolayer coverages. Single-component particle layers often fail to develop sufficiently connected interfacial networks, limiting their mechanical integrity under deformation [1]. In this work, we investigate how assembly pathways and interfacial composition govern the formation of mechanically robust interfaces.

One approach to address this challenge is the use of mixed particle interfaces, where differences in charge and surface properties enhance interparticle interactions and cooperative assembly [2]. By systematically varying the sequence of interface formation and particle addition, we observe a variety of interfacial (2D) assemblies, from local clusters to percolated networks, highlighting the role of bidispersity and the assembly protocol in controlling network connectivity.

The mechanical response of these interfaces is probed using interfacial shear and dilatational rheology across controlled surface coverages. Interfacial shear rheological properties are characterized by oscillatory time and strain amplitude sweeps using a double wall-ring geometry, while dilatational rheology is performed in a Quadro-trough to impose isotropic deformations and relate the response to microstructural changes [3]. Complementary imaging analysis provides insights into the evolving microstructure and its coupling to macroscopic viscoelastic properties.

These findings highlight the importance of particle composition, assembly protocol, and variations in particle interactions in controlling interfacial structure and, consequently, the rheological response of particle-laden interfaces.

Keywords:
Particle-laden interfaces, assembly mechanisms, interfacial microstructure, interfacial rheology

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