Colloquium

Department of Physics, Temple University

Rigidity Percolation, Gelation, and Glass Transitions of Spherical & Anisotropic Colloidal Suspensions with Thermo-reversible Short-range Attractions

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Nanotechnologies ranging from cosmetics to protein therapeutics involve colloids due to their unique rheological properties and orientation-specific interactions. Recent experimental, simulation, and theoretical work have defined the central role of rigidity percolation in the dynamical arrest of the canonical adhesive hard sphere colloidal dispersion.[1, 2] However, we lack a unified understanding for how the coupled effects of particle geometry and interparticle interactions influence rigidity percolation or dynamic arrest transitions, such as gel and glass formation. To study these effects, a colloidal model system of adhesive hard rods (AHR) was developed with convenient control of the particle aspect ratio and thermoreversible, short-range attractions.[3, 4] The AHR system serves as a chemically consistent extension of the well-studied adhesive hard sphere system (AHS) composed of octadecyl-coated silica suspended in organic solvents. Variations in silica particle synthesis conditions were mapped to produce anisotropic silica particles with a wide variety in morphology and size. The AHR suspension rheology, static microstructure, and particle dynamics were mapped as a function of aspect ratio (L/D 3-7), volume fraction (0.1-0.5), and temperature-dependent attraction strength (15-40 C) using small-amplitude oscillatory shear, X-ray and neutron scattering, and dynamic light scattering, respectively. Quantitatively distinct yet qualitatively similar signatures of dynamic arrest were found for AHR, as compared to AHS. A connected rigidity percolation surface is proposed for quasi one-dimensional hard particles with short-range attractions. Analogous to the AHS system, evidence suggests AHR suspensions are bounded by a hard rod glass line at high volume fractions (excluded volume-driven dynamic transitions), while a gelation line extends and intersects a phase-separation region at low volume fractions (attraction-driven dynamic transitions). Many questions remain open for future experimental, theoretical, and computational investigations. The AHR system provides an adaptable experimental framework to systematically explore the coupled effects of particle shape, attraction strength, and concentration on the dynamic arrest transitions of anisotropic colloidal suspensions. Finally, recent work on the sub-diffusive dynamics of colloidal dispersions with intermediate range order will be discussed.

1. *Physical Review Letters*. **2011**;106(10). 2. *Langmuir*. **2012**;28(3):1866-78 3. *Langmuir*. **2016**;32(33):8424-35. 4. *Journal of Colloid and Interface Science*. **2017**;501:45-53

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