Influence of viscoelasticity-induced sheet formation on shear thickening of concentrated suspensions

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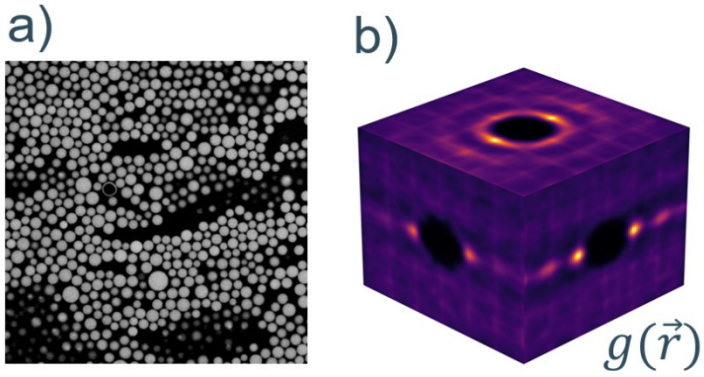
Semi-dilute polymer solutions exhibit viscoelastic properties such as shear thinning and normal stress differences under shear flow. These viscoelastic stresses can assemble suspended particles into string-like and, at higher concentrations, sheet-like structures in dilute and semi-dilute suspensions [1]. The resulting structures can be tuned by the applied flow protocol [2]. Here, we investigate whether these viscoelastic forces can be used to control the rheology and microstructure of concentrated particle suspensions. Concentrated suspensions in Newtonian media typically exhibit shear thickening due to hydrocluster formation and frictional contacts, a problematic property that can lead to clogging in industrial processes. By dispersing particles in a viscoelastic medium instead, we aim to harness viscoelastic structuring effects to modify this shear thickening behavior.
We disperse silica particles in glycerol-based viscoelastic polymer solutions to create refractive-index-matched viscoelastic model suspensions with varying degrees of elasticity. Rheological measurements show that the shear thickening behavior differs significantly from suspensions in Newtonian media. To identify the microstructural origin of this rheological change, we use 3D confocal microscopy with a mounted shear cell.This setup allows direct visualization across the full gap height and, using computer vision, enables quantification of the suspension microstructure after shear. This approach allows comparison with previous experiments in Newtonian media [3].
In viscoelastic media, particles organize into sheet-like structures aligned with the flow direction, in contrast to the structures observed in Newtonian suspensions. These sheet-like structures reduce particle collisions and hinder hydrocluster formation, which explains the observed changes in shear thickening. Our results show that viscoelastic stresses provide a route to control microstructure and flow behavior in concentrated suspensions.

Keywords:
Suspension Rheology, Viscoelasticity, Shear Thickening, Computer Vision, Self Assembly



a) Confocal microscopy image of particles (d= 7 micron) that have organized into sheets in a viscoealastic liquid after subjcted to shear flow b) The 3D-pair correlation function g(r) demonstrates the anisotropy

References:

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