The role of interparticle friction in the rheology of non-Brownian suspensions

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The rheology of concentrated non-Brownian suspensions has undergone a small revolution in the last 15 years when the importance of the role played by solid contacts between particles was realized. Considering these contacts has allowed to explain the continuous or discontinuous shear-thickening in dense suspensions [1] and, more recently, the shear-thinning observed beyond the shear-thickening [2], i.e. in frictional non -Brownian suspensions [3]. In my talk, I will show that this shear-thinning can be explained by variable friction between particles [4].

Considering the low magnitude of the forces experienced by the particles of suspensions under shear flow, it is first argued that rough particles come into solid contact through one or a few asperities. In such a few-asperity elastoplastic contact, the friction coefficient is expected not to be constant but to decrease with increasing normal load. Therefore, since the viscosity has been shown to increase with friction, it is expected that a decrease of the friction coefficient with shear stress leads to a viscosity decrease. Numerical simulations based on the Force Coupling Method provide a model for the shear-thinning and show that the effective friction coefficient is specified by the effective normal contact force which is simply proportional to the bulk shear stress.

This scenario has been validated by coupled experiments of rheology and Atomic Force Microscopy that provide the variation of the pairwise friction coefficient with normal load. It is shown that introducing he experimental friction law into the viscosity model proposed by Lobry et al. [3] enables to fully capture the shear-thinning behavior of suspensions of polystyrene particles (40 µm in diameter) in a Newtonian mixture of water and Ucon oil, at various solid fractions. These results highlight the close links between the microscopic friction properties of the particles and the macroscopic rheological behavior of suspensions.

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