The Prediction of the Viscosity of Dense Brownian Hard Sphere Colloidal Suspensions Using Stokesian Dynamics

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ABSTRACT

Colloidal suspensions are particulate systems with particles of size between 1nm to 1μm suspended in liquids. This category of suspensions had a wide variety of applications such as in paints, inks, oil industry, mud drilling, energy storage. The rheology of colloidal suspensions exhibits a rich mosaic of phenomena that are difficult to predict theoretically due to the complexity of the interparticle forces involved. In the current paper, we present results for the total viscosity for different volume fractions (ϕ=0.4, 0.45,0.5, and 0.55), and various values of the Peclet number (ratio between the convection rate to diffusion rate) that vary between 0.1 to 10000. The Peclet number range ensures that the flow will be governed by either Brownian entropic forces, or Shear forces, or a mix of both. The numerical method used is based on the Stokesian dynamics, which is a molecular dynamics method, which treats the fluid around the particle as a continuum. The only interparticle force considered is that of a fractional force, by using a contact model like those used in DEM simulations. Only the lubrication part of the hydrodynamics interaction is used, since the long-range interactions are decaying as the space between the particles is reduced. The results obtained are compared with the numerical results of [1,2] and the experimental results of [3]. The total viscosity is decreasing as the Peclet number increases (i.e. shear thinning), due to the decrease of the Brownian stress as the shear rate increases, during the shear thinning process, the hydrodynamic stress attained a constant value. However, as the Peclet number increases further, the total viscosity started to grow (i.e. shear thickening) due to the increase of both the hydrodynamic and mainly the contact stress.

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