The Role of Rolling Resistance in the Rheology of Wizarding Quidditch Ball Suspensions

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ABSTRACT

To elucidate the effect of particle shape on the rheology of a dense, viscous suspension of frictional, non-Brownian particles, experimental measurements are presented for suspensions of polystyrene particles with different shapes in the same solvent. The first suspension is made of spheres while the particles which compose the second suspension are globular but with flattened faces. We present results from steady shear and shear-reversal rheological experiments for the two suspensions over a wide range of stresses in the viscous regime. Notably, we show that the rheology of the two suspensions is characterized by a shear-thinning behavior, which is stronger in the case of the suspension of globular particles. Since the shear-reversal experiments indicate an absence of adhesive particle interactions, we attribute the shear thinning to a sliding friction coefficient which varies with stress as has been observed previously for systems similar to the first suspension. We observe that the viscosity of the two suspensions is similar at high shear stress where small sliding friction facilitates particle relative motion due to sliding. At lower shear stress, however, the sliding friction is expected to increase and the particle relative motion would be associated with rolling. The globular particles attain a higher viscosity at low shear stress than the spherical particles. We attribute this difference to a shape-induced resistance to particle rolling that is enhanced by the flattened faces. Image analysis is employed to identify features of the particle geometry that contribute to the resistance to rolling. It is shown that the apparent rolling friction coefficients inferred from the rheology are intermediate between the apparent dynamic and static rolling friction coefficients predicted on the basis of the image analysis. All three rolling resistance estimates are larger for the globular particles with flat faces than for the spherical particles and we argue that this difference yields the stronger shear thinning of the globular particle suspension.

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