Shear thinning rheology in a concentrated suspension of fibers: the role of attractive interactions

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Abstract

Fiber-reinforced composites are ubiquitously encountered in the engineering, automobile, and aerospace industries. Fabrication of these composites requires the mixing of fibers dispersed in a liquid, and the final structure is affected by fiber properties, interactions, and flow fields. A good understanding of the rheology of fiber suspensions can aid in the design and optimization of the fabrication processes. To this end, we simulate the simple shear flow of fiber suspensions by accounting for short-range lubrication, van der Waals attractive, electrostatic repulsion interactions, as well as friction between fibers. Direct numerical simulations are performed using the Immersed Boundary Method where the fibers are modeled as flexible slender bodies governed by the Euler-Bernoulli beam theory and the fluid flow is resolved using the Navier-Stokes equations. The simulation results for the suspension viscosity and yield stress are consistent with the experimental data from the literature for polyamide fiber suspensions. The shear-thinning behavior becomes stronger as we increase the magnitude of attractive interactions. Furthermore, we perform a parametric study varying fiber flexibility, volume fraction, aspect ratio, inertia and examine suspension viscosity and yield stress.

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