Particle Dynamics and Rheology of SWNT Suspensions under Shear and Electric Fields

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The particle orientation and electrorheology of dilute single-wall carbon nanotube (SWNT) suspensions is experimentally investigated. Ensemble-averaged nanotube orientation angles were measured with an optical polarization-modulation technique simultaneously with macroscopic electrorheological measurements. The results were compared with theoretical predictions of Mason's. The time scales of the particle-orientation and electrorheological responses differ by an order of magnitude, indicating that nanotube alignment under the external electric field does not directly affect the rheology of the suspension at low nanotube concentrations. Equilibrium particle-orientation angles for various shear rates and electric fields are found to collapse when plotted against the ratio of shear-flow to electrostatic forces, as predicted by classical theory. However, significant discrepancies exist between the measured and predicted orientation angles of the nanotubes. It is shown that the discrepancy is due to both hydrodynamic and electrostatic interactions between particles. It is discussed how such interactions can be significant in even classically dilute suspensions of highly anistropic particle under shear and electric fields.