Abstract Submitted
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Derivation of the rheological properties of a dilute suspension of spheres in a dilute polymer solution using the method of ensemble averaged equations DONALD KOCH, ERIC LEE, Cornell University, IBRAHIM MUSTAFA, Yanbu Industrial College — Einstein derived the first effects of spherical particles on the rheology of a Newtonian fluid in the limit of small particle concentration. In the past, the only comparable analysis for a non-Newtonian fluid considered a second order fluid constitutive equation valid for very low Deborah number (defined as the shear rate times the polymer relaxation time). In this paper, the ensemble average stress of a dilute suspension of spheres in a dilute polymer solution governed by the Oldroyd B rheological equation is derived for Deborah numbers up to 4. The extra stress in the suspension arises from three physical processes: the stretching of the polymers due to the disturbance flow of the particles, the increased particle stresslet due to the polymer stress, and the modification of the Newtonian stress due to the flow perturbation caused by the polymers. We make use of an asymptotic analysis for small polymer concentration and the generalized reciprocal theorem to derive the third contribution. While a particle-free Oldroyd B fluid has no shear thinning or thickening, the particle suspension exhibits shear thickening and a nonlinear increase in the second normal stress difference with shear rate.

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