Effect of particles size on viscosity of nanofluids containing ZnO nanoparticles suspended in poly(vinyl alcohol) aqueous solution

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Abstract

Nanofluids consist of solid nanoscale particles dispersed in a continuous liquid. Usually, the continuous liquid is Newtonian. Recently, nanofluids have gained significant attention due to their enhanced thermal properties and long-term stability.[1] Most of reports available in the literature focus on nanoparticles dispersed in a Newtonian fluid, but only a few focus on the non-Newtonian case.[2] Hence, with an eye towards biomedical applications, we investigate ZnO nanoparticles dispersed in poly(vinyl alcohol) aqueous solutions. Here, we focus on the effect of the particle size and the nanoparticle volume fraction on the viscosity of the suspension.

Surprisingly, we found that the relative viscosity of the suspensions increased with a decrease in the size of the ZnO nanoparticles (see Fig. 1). The measured viscosities at a volume fraction of 0.02% of the nanoparticles are significantly higher (up to approximately 34%) than the values predicted by the Einstein's expression (which predicts approximately 0.05%).[3] We also found that the viscosity of the suspension increases dramatically with an increase in the nanoparticle volume fraction. Einstein's expression is unable to predict this increase (see Fig. 2).

An alternative approach is to realize that the nanoparticles can form aggregates with an enhanced effective volume fraction and thereby increase the viscosity.[4] However, using reasonable values for the fractal dimension of the aggregate results in aggregate sizes that are significantly larger than that observed. Hence, we believe that aggregation of the nanoparticles might be insufficient to explain the increase in the viscosity and are currently seeking alternate explanations.

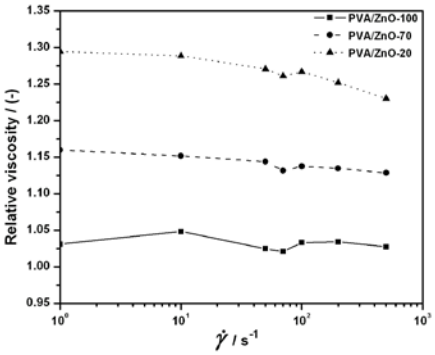

Fig. 1 Relative viscosity versus shear rate ($\dot{\gamma}$). PVA/ZnO indicates to the ZnO nanoparticles (volume fraction 0.02%) in the 10wt% PVA aqueous solution. The numbers in the legend refer to the diameter of the primary ZnO nanoparticles in the suspension.

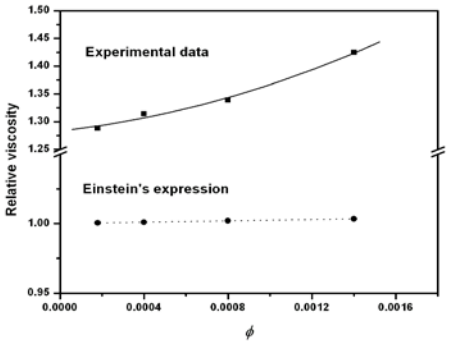

Fig. 2 Relative viscosity of PVA/ZnO-20 dependence with volume fraction (ϕ)

Keywords: Viscosty, Nanofluids, PVA aqueous solution, ZnO nanoparticles, Particle size.

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