A mechanistic model to predict the interfacial tension of nanocolloids

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Nanofluids, often dubbed "smart fluids", have generated lot of research interest in the past decade owing to their unique properties. But physical understanding of the basic property of surface tension for such colloids is still not yet clear, though it plays a major role in many thermofluidic applications, particularly in 'microscale, interfacial' applications. The present work proposes a semi-analytical model based on the DLVO theory and physics of interfacial interactions to predict the surface tension of a nanofluid at different concentrations and temperatures.

Figure 1: Illustration of the molecular level interactions in nanofluids near the three phase contact region

The model for the prediction of surface tension (σ_{nano}) has been developed, and is expressed as

$$\sigma_{nano} = \sigma_{base} + \left\{ \frac{D_{dls}}{d_{np}} (P_d D_{dls}) \phi^{1/4} \right\} \quad (1)$$

Figure 2: Experimental [1] and predicted values of surface tension of aqueous TiO_2 (21 nm) nanofluids at different temperatures (denoted in legend)

Particle layering near the three phase contact line and the colloidal stability are proposed to play major role in interfacial characteristics and is modeled via the disjoining pressure (P_d), encompassing the van der Waals, electrostatic and the structural interaction components among the various molecules, in tune with the DLVO theory. The ratio of the hydrodynamic diameter (D_{dls}) of the particle to particle size (d_{np}) at the given concentration level ϕ is found to be a major parameter.

Figure 3: Experimental [2] and predicted values of surface tension of ethanol based Al_2O_3 (25 nm) and Al (18 nm) nanofluids

The proposed model shows good prediction and takes into account different contributing factors responsible for the interfacial characteristics of nanocolloidal systems.

References

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