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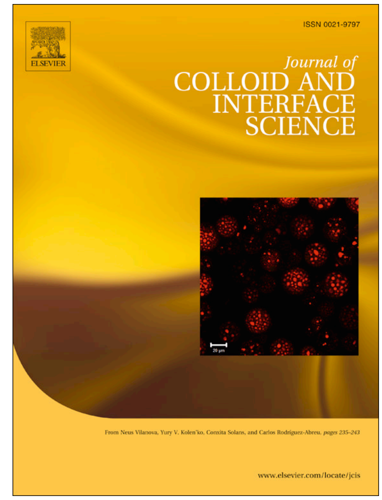

Short Communication

Prediction of the Rate of the Rise of an Air Bubble in Nanofluids in a Vertical Tube

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Prediction of the Rate of the Rise of an Air Bubble in Nanofluids in a Vertical Tube

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ABSTRACT

Our recent experiments have demonstrated that when a bubble rises through a nanofluid (a liquid containing dispersed nanoparticles) in a vertical tube, a nanofluidic film with several particle layers is formed between the gas bubble and the glass tube wall, which significantly changes the bubble velocity due to the nanoparticle layering phenomenon in the film. We calculated the structural nanofilm viscosity as a function of the number of particle layers confined in it and found that the film viscosity increases rather steeply when the film contains only one or two particle layers. The nanofilm viscosity was found to be several times higher than the bulk viscosity of the fluid. Consequently, the Bretherton equation cannot accurately predict the rate of the rise of a slow-moving long bubble in a vertical tube in a nanofluid because it is valid only for very thick films and uses the bulk viscosity of the fluid. However, in this brief note, we demonstrate that the Bretherton equation can indeed be used for predicting the rate of the rise of a long single bubble through a vertical tube filled with a nanofluid by simply replacing the bulk viscosity with the proper structural nanofilm viscosity of the fluid.

1. INTRODUCTION

The motion of bubbles in tubes/capillaries filled with aqueous suspensions of nanoparticles (nanofluids) is both of scientific and practical interest [1 - 5]. Recently, we reported [6, 7] the results of our experiments on the rate of the rise