Rheological Properties of Nanofluids: Single-Walled Carbon Nanotube/Lube Oil Cuts

Gholamreza Vakili-Nejad [C, S]
Department of Chemical Engineering, Faculty of Engineering, University of Kashan, Kashan, Isfahan, Iran

Akram Dourani
Institute for Nanoscience and Nanotechnology, University of Kashan, Kashan, Isfahan, Iran

Nanofluids are solid-liquid mixtures consisting of solid nanoparticles or nanofibers with particle size <100 nm suspended in a continuous and saturated liquid [1]. Nanofluids have attracted much attention since their anomalously large enhancement in transport properties were described, especially thermal properties [2], but there are limited publications for the study of the viscosity of these fluids from both the experimental and theoretical points of view [3]. In this work, the effect of the concentration of single-walled carbon nanotubes (SWCNTs) on the viscosity index of the lube oil cut has been investigated. No surfactant was used here in making nanofluids, because of the good stability of the prepared nanofluids at some concentrations below 0.02 wt%. Experimental results showed that the kinematic viscosity of nanofluids increases with decreasing the temperature and increasing the SWCNT concentration. For nanofluids containing 0.02 wt% SWCNTs, the maximum enhancement of the viscosity index reaches 32.94 %. Investigation of the experimental results along with the theoretical models shows a nonlinear relationship between viscosity and SWCNT concentration and a strong temperature-dependent behavior of the prepared nanofluids. For the preparation of various nanofluids, the SWCNTs were dispersed in oil through sonication. The SWCNT powders were added to motor base oil fluids. Then the SWCNTs were dispersed by magnetic force agitation. The suspensions were then homogenized by intensive ultrasonics (Hielsher Sound UIP4000). The rotational speed of the rotor was ~24000 rpm. No surfactant was used in SWCNT/oil suspensions, and homogenization was employed for a period of time ranging from 2 h (for 0.01 wt%) to 6 h (for 0.2 wt%). Environmental Scanning Electron Microscopy images showed the well dispersed samples with 0.1wt% of SWCNT, and it was clear that SWCNTs have largely been disentangled. The viscosity of SWCNT/oil nanofluids was measured by using a Bohlin CVO rheometer (Malvern Instruments). The measurements were done on nanofluids of different SWCNT concentrations between 0.01-0.2 wt% and the temperatures between 25 and 100 ºC.

[1] X. Wang and S. Mujumdar, Heat transfer characterization of nanofluid: a review, *Int. J. Thermal Science* 2007, **46**, 1-19.
[2] Y. Ding, H. Alias, Heat transfer of aqueous suspensions of carbon nanotubes, *Int. J. Heat and Mass Transfer* 2006, **49,** 240-250.
[3] C. Nguyen and F. Desgranges, Temperature and particle-size dependent viscosity data for water-based nanofluid - hystersis phenomenon, *Int. J. Heat and Fluid Flow* 2007, **50**, 309-325.