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Enhanced Thermal Conductivity of Water with Surfactant Encapsulated and Individualized Single-Walled Carbon Nanotube Dispersions

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Abstract

In the present work, the effective thermal conductivity of single walled carbon nanotube dispersions in water was investigated experimentally. Single-walled carbon nanotubes (SWNTs) were synthesized using the alcohol catalytic chemical vapour deposition method. The diameter distribution of the SWNTs was determined using resonance Raman spectroscopy. Sodium deoxycholate (SDC) was used as the surfactant to prepare the nanofluid dispersions. Photoluminescence excitation spectroscopy (PLE) reveals that majority of the nanotubes were highly individualized when SDC was employed as the surfactant. The nanofluid dispersions were further characterized using transmission electron microscopy, atomic force microscopy (AFM) and optical absorption spectroscopy (OAS). Thermal conductivity measurements were carried out using a transient hot wire technique. Nanotube loading of up to 0.3 vol% was used. Thermal conductivity enhancement was found to be dependent on nanotube volume fraction and temperature. At room temperature the thermal conductivity enhancement was found to be non-linear and a maximum enhancement of 13.8% was measured at 0.3 vol% loading. Effective thermal conductivity was increased to 51% at 333 K when the nanotube loading is 0.3 vol%. Classical macroscopic models fail to predict the measured thermal conductivity enhancement precisely. The possible mechanism for the enhancement observed is attributed to the percolation of nanotubes to form a three-dimensional structure. Indirect effects of Brownian motion may assist the formation of percolating networks at higher temperature thereby leading to further enhancements.