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A study on the characteristics of carbon nanofluids at the room temperature (25 °C) ☆

Nam-Jin Kim [a], Sung-Seek Park [a], Sang Hoon Lim [b], Wongee Chun [a,*]

[a] Department of Nuclear & Energy Engineering (WCU Jeju National University R&D Center), Jeju National University, Jeju 690-756, South Korea
[b] New & Renewable Energy Research Division, Korea Institute of Energy Research, Daejeon 305-343, South Korea

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ABSTRACT

The proper mixture ratio of nanofluids was examined by measuring thermal conductivity via transient hot-wire method. Comparisons are made with the nanofluid prepared by dispersing oxidized Multi-Walled Carbon NanoTubes (MWCNTs) in distilled water (herein referred to as "oxidized nanofluid"). Viscosity measurements were also carried out for the PVP-added nanofluids and oxidized nanofluids by using a digital viscometer. The nanofluids with 300 wt.% PVP and oxidized MWCNTs exhibited better thermal conductivity than that reported in previous studies. The thermal conductivity of oxidized carbon nanofluids was the highest of those compared and the use of additives in the nanofluid preparation deems to increase viscosity. For industrial applications, the chemical dispersion method applied in the preparation of oxidized carbon nanofluids should be considered as it offers high thermal conductivity with a slight increase in viscosity.

1. Introduction

Thanks to the recent novel publications on the new physical phenomena and advanced material characteristics in the nanosized technology field, the newly introduced scientific category of nanotechnology has become recognized as one of the essential technologies in the 21st century [1–4]. The nanofluid terminology, which describes fluid combined nanoparticles, was introduced by Choi of the Argonne National Laboratory in the U.S. Department of Energy [5]. The carbon particles with metal lattice or graphite structures generally exhibit thermal conductivities that are hundreds of times greater than pure fluids. Especially due to their outstanding electric and thermal conductivities, carbon nanotubes (CNTs) have become an important entity in the scientific field [6]. Nevertheless, the peculiar characteristics of a nanofluid cannot be achieved by simply mixing the pure fluid and nanoparticles. Although the smallness of nanoparticles affords superior stability in particle dispersion, the Van der Waals force acts actively to attract particles, which works against the prominent characteristics of nanofluids. Accordingly, the fabrication of a uniform compound nanofluid by an appropriate method has become an important task in its applications. To promote the dispersion stability, researchers have tested two different techniques of the dispersion method. Of these, one takes the advantage of physical adsorption by adding the macromolecular compound of polyvinyl pyrrolidone (PVP) and surfactant sodium dodecyl sulfate (SDS). The other involves the chemical reformation process where hydroxyl radicals are combined with MWCNTs after oxidation treatment. Assael et al. [7] observed high conductivity and dispersion rate in the mixture of 100 wt.% SDS and multi-walled CNTs (MWCNTs) whereas an improvement in the dispersion stability of PVP mixture was reported by O'Connell et al. [8]. The latter, however, did not provide some detailed experimental data regarding the mixture ratio and its thermal conductivity. Riggs et al. [9] claimed the procurement of stable CNTs in an aqueous solution by oxidizing their surface through the mixture of nitric and sulfuric acids where oxygen contained hydroxyl radicals (COOH) adhered on CNTs' surface. Yet, however, no information is available for thermal conductivity measurements.

In this work, the production of nanofluids is considered by employing the physical dispersion method which involves the adding of macromolecular compounds of polyvinyl pyrrolidone (PVP) and by the chemical reformation process where hydroxyl radicals are combined with MWCNTs after oxidation treatment. Experiments are carried out to elicit the most proper mixture ratio of nanoparticles by measuring thermal conductivity via transient hot-wire method and applying the proper dispersion method which compares the oxidized carbon nanofluid and thermal conductivity. A rotary-type digital viscometer was also introduced to measure the viscosity of the PVP-added and oxidized nanofluids.

2. Carbon nanotubes characteristics and nanoemulsion production

2.1. Nanoparticles and base fluid

The carbon nanotubes (CNTs) used in this study were made by chemical steam deposition with 95% purity and can be classed as multi-walled carbon nanotubes (MWCNTs). These were purchased from Hanwha Nanotech Corporation whose properties are given in Table 1. To prepare the base fluid in making nanofluids, tap water has

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* Corresponding author.
E-mail address: wgchun@jejunu.ac.kr (W. Chun).

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