International Communications in Heat and Mass Transfer 38 (2011) 513–517

Contents lists available at ScienceDirect

International Communications in Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ichmt

The effect of functionalized group concentration on the stability and thermal conductivity of carbon nanotube fluid as heat transfer media ☆

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ARTICLE INFO

Available online 8 January 2011

Keywords:
Nanofluids
Functionalized MWNTs
Thermal conductivity
Stability

ABSTRACT

In this research, the pristine CNTs sample synthesized by the CCVD method contains catalytic particles and the carbonaceous impurities, and then the special purification procedure was done. By different methods CNT functionalized with various concentration of COOH was prepared. The carboxylated CNTs were analyzed by back titration method for determining the COOH concentrations on the surface of the oxidized CNTs. Thermal conductivity of difference carbon nanotube fluid has been measured under the stable condition by KD_2 prob. For the first time, we have compared the effect of difference COOH concentration as important parameter in stability and heat transfer behavior of nanofluid. The results show that increasing the functionalized group causes better stability and higher thermal conductivity if the surface of MWNT does not damage in functionalize process.

1. Introduction

Nanofluids have attracted great attention of investigators for its superior thermal properties and many potential applications. Nanofluids are new engineered materials with great potential to handle thermal limitation of common thermal fluid (such as water, industrial oil and so on) for using in heat transfer equipments and electrical devices [1–3].

Preparation of nanofluids is the key step in the use of nanoparticles to improve the thermal conductivity of fluids. Two kinds of methods have been employed in producing nanofluids. One is a single-step method [4,5], and the other is a two-step method [6–9]. The single-step method is a process combining the preparation of nanoparticles with the synthesis of nanofluids, for which the nanoparticles are directly prepared by physical vapor position (PVD) technique or liquid chemical method. In this method, the processes of drying, storage, transportation, and dispersion of nanoparticles are avoided, so the agglomeration of nanoparticles is minimized and the stability of fluids is increased. But a disadvantage of this method is that only low vapor pressure fluids are compatible with the process. This limits the application of the method. The two-step method for preparing nanofluids is a process by dispersing nanoparticles in to base liquids. Nanoparticles, nanofibers or nanotubes used in this method are first produced as a dry powder by inert gas condensation, chemical vapor deposition, and mechanical alloying or other suitable techniques and the nanosized powder is then dispersed in to a fluid in a second processing step. This step-by-step method isolates the preparation of the nanofluids from the preparation of nanoparticles. As a result, agglomeration of nanoparticles may take place in both steps, especially in the process of drying, storage, and transportation of nanoparticles. The agglomeration will not only result in the settlement and clogging of microchannels but also decrease the thermal conductivity. Simple techniques such as ultrasonic agitation or the addition of surfactants to the fluids are often used to minimize particle aggregation and improve dispersion behavior [10,11]. Since nanopowder synthesis techniques have already been scaled up to industrial production levels by several companies, there are potential economic advantages in using two-step synthesis methods that rely on the use of such powders. But an important problem that needs to be solved is the stabilization of the suspension prepared. Many researchers have used a wide variety of nanoparticles such as copper, aluminium and their oxides for preparation of nanofluid [2–15]. In present work, the main reasons for choosing MWNT as the nanoparticle are for excellent chemical and physical properties of CNT and commercially available products. CNTs are nanostructures with remarkable electronic, thermal and mechanical properties [16–18], they have attracted scientific interest due to their unique structure and properties. For preparation of stable suspensions, it is known that MWNT has hydrophobic surface which is prone to aggregation and precipitation in water in absence of a surfactant. Many surfactants like sodium laurate, gum Arabia and sodium dodecyl sulfate are able to modify the hydrophobic surface of nanoparticles and, hence, stabilize its suspension in water [19,20]. Beyond the role of stabilizer for MWNT in water, surfactants can

☆ Communicated by W.J. Minkowycz.

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0735-1933/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.icheatmasstransfer.2010.12.035