

Preparation and Characterization of MWCNT -Water Nanofluids for Heat Transfer Applications

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Abstract

The nanosized particle dispersed in the base fluid with proper size and optimized volume concentration would enhance the thermal conductivity of the mixture anomalously. In this work, the preparation and characterization Multi-walled Carbon Nanotubes (MWCNTs) nanofluids were experimentally investigated. The Chemical Vapour Deposition (CVD) process uses acetone as a carbon source for the synthesis of MWCNTs. The prepared nanotubes were redispersed in base fluid (deionised water from Millipore distiller), in the presence of Sodium Dodecyl Sulphate (SDS), which enables the nanofluids to be stable for long periods. Transmission Electron Microscope (TEM) technique used to assess the dispersion state of MWCNTs in suspension and confirms the formation of the stable homogeneous nanofluids of MWCNTs. The influence of the temperature on the thermo-physical properties of the anofluids were also studied. The thermal conductivity was measured by using the NETZSCH LFA 447 NanoFlash equipment. The thermal conductivity enhancement increased considerably at temperature greater than 302 K. Further the experimental results showed that addition of MWCNTs with 1% volume concentration in base fluid increased the thermal conductivity considerably, due the high aspect ratio of MWCNTs. The result show that thermal conductivities of the tested nanofluids are significantly higher than that of the corresponding basefluid and increase with increasing particle concentration and fluid temperature, demonstrating potentials in thermal conductivity enhancement. The prepared nanofluid with good fluidity and high thermal conductivity, would have potential applications as coolants in advance thermal system and

in various types of compact heat exchangers and double pipe heat exchangers.

Keywords: Nanofluids; thermal conductivity; carbon nanotube.

1. Introduction

The synthesis and functionality of nanotubes were investigated by various researches. Methane is the most readily available hydrocarbon, being the main component of “natural gas”, which is widely used as an energy source. The use of methane for CNTs production has been amply documented (Zhan et al, 2007).

The dispersion of metal, metal oxide nanoparticles and carbon nanotubes dispersed in the liquid medium increases the thermal conductivity and heat transfer rate were discussed in the recent years by various researchers. Duangthongsuk and Wongwises 2009, studied the forced convective heat transfer of a nanofluid by using TiO_2 nanoparticles in a double tube heat exchanger. The increase in heat transfer was shown 6-11%. Garg et al, 2009, Prepared multi-walled carbon nanotube (MWCNT) based aqueous nanofluids for heat transfer study. The maximum enhancement in thermal conductivity and convective heat transfer was found as 20% and 32% Tiruselvam et al, 2012, estimated the laminar and turbulent flow heat transfer characteristics of a double tube heat exchanger using Wilson Plot technique and proposed correlations for Nusselt numbers in addition to prepared a similarity between the heat transfer and flow. Madhesh et al, 2014, presented that the convective heat transfer coefficient of nanofluids increased with HyNC concentration and the Reynolds number. For the volume concentration of up to 1.0%, the convective heat transfer coefficient, Nusselt number, overall heat transfer coefficient of HyNF were enhanced by 52%, 49% and 68% respectively. The effective thermal conductivity and diffusion kinetics of HyNC in the fluid medium paved the way for the improved heat transfer characteristics of HyNF. Saidur et al, 2011, compiled and reviewed a comprehensive literature on the applications and challenges of nanofluids. Murshed et al 2008, reviewed various aspects of nanofluids including synthesis, potential applications, experimental and analytical studies on the effective thermal conductivity, effective thermal diffusivity, convective heat transfer and electrokinetic properties. Chang et al 2011, showed the enhancement in thermal conductivity of CuO nanofluid using various surfactant concentrations.

2. Preparation of Multi Walled Carbon Nanotubes

The MWCNTs were synthesised using the method of chemical vapour deposition (CVD) as described: The MWCNTs were obtained by using the horizontal quartz tube reactor. The Multicomponent metal oxide was used as a catalysts sample were placed in the reactor with the flexible graphite foil support. The constant volume ratio of argon to propane butane and at constant feed rate of propane butane supports the MWCNTs yield.

As prepared MWCNT were redispersed in the base fluid (deionized water from Millipore distiller) in the presence of sodium dodecyl sulphate (SDS) using UP200S-Hielscher ultrasonicator operated at 20-25 kHz frequency with 150 W of output power being generated. The dispersed particles stability in aqueous medium was observed after 24 hours and the well dispersed nanofluid was further used in this experiment. The thermal conductivity of MWCNTs-water nanofluids were measured using the NETZSCH LFA 447 NanoFlash equipment wherein, the sample enclosed in a plane crucible was heated by a short light pulse at one end and the resulting temperature increase was measured by an infrared detector located at the other end.

3. Results and Discussion

3.1 Morphology and surface structure

The morphology and surface structure of the as-prepared MWCNTs nanofluids being characterized, using the TEM, as shown in Fig. 1. The TEM result reveals the effective formation and growth of multiwall carbon nanotube. It also reveal that the MWCNTs evenly dispersed in the aqua medium. The structure of the MWCNT will play effects on their distribution in nanofluids and the particle with more wall will have higher affinity for aggregation in the fluid. It can be seen that the nanotubes are entangled and interweaved with ambient fibers. The samples prepared for the TEM observations acquire more detailed information about the nanotubes within the resolution limitation of the present TEM images. The Macroscopic view observation containing MWCNTs are all uniform black closed liquids and can keep stable for at least one month.

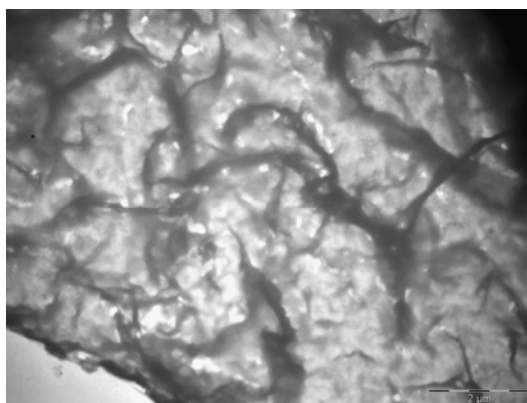


Fig. 1: TEM images of MWCNTs dispersed in deionized distilled water.

3.2 Effect of nanoparticles volume concentration on thermal conductivity

The results obtained from the experimental were used to estimate the thermal conductivity of MWCNTs- water nanofluids as a function of particle volume concentration. Fig. 2 shows that the thermal conductivity of MWCNTs- water nanofluids gets increased for different volume concentration from 0.1% to 1.0 for corresponding increase in temperature of nanofluids from 303 to 363 K. For heating and cooling applications in the heat exchanger the new novel naofluids plays the major

role in the enhancement of heat exchanger performance is left for the future study. The increases in thermal conductivity of nanofluid are depend upon the particle size, concentration and nature of the basefluid, temperature and the presence of nanoclusters.

When compared with the water the effective thermal conductivity of MWCNT nanofluids was increased by 23.5% for the volume concentration of 1.0%. The increase in concentration of nanotubes at the same time as increase in temperature cause to increase in thermal conductivity of fluid shown was depicted in the Fig. 2.

The interaction and collision between the particles depends upon the increase in specific surface area. Herein, the increased specific surface area of the MWCNTs enabled for having increased heat interactions due to the network of thermal interfaces being created with the base fluid molecules. The enhancement of thermal conductivity of the MWCNT nanofluids at a volume concentration of 1.0% was found to be higher than that of the result obtained by Xie et al, 2003, wherein they obtained about 7.0% enhancement in the thermal conductivity for the same concentration. The reason for this could be attributed to the surface modification and the specific surface area of the as- prepared MWCNTs. Furthermore, the enhancement of thermal conductivity of the MWCNT nanofluids can also be ascertained because of the possible agglomeration of the nanotubes being dispersed at higher volume concentration in base fluid (Prasher et al, 2006). The increased thermal conductivity of the MWCNT nanofluids as observed from the measurement result indicates that, there could be a constant phonon heat transfer taking place between the MWCNTs and the base fluid molecules (Kebllinski et al, 2002)

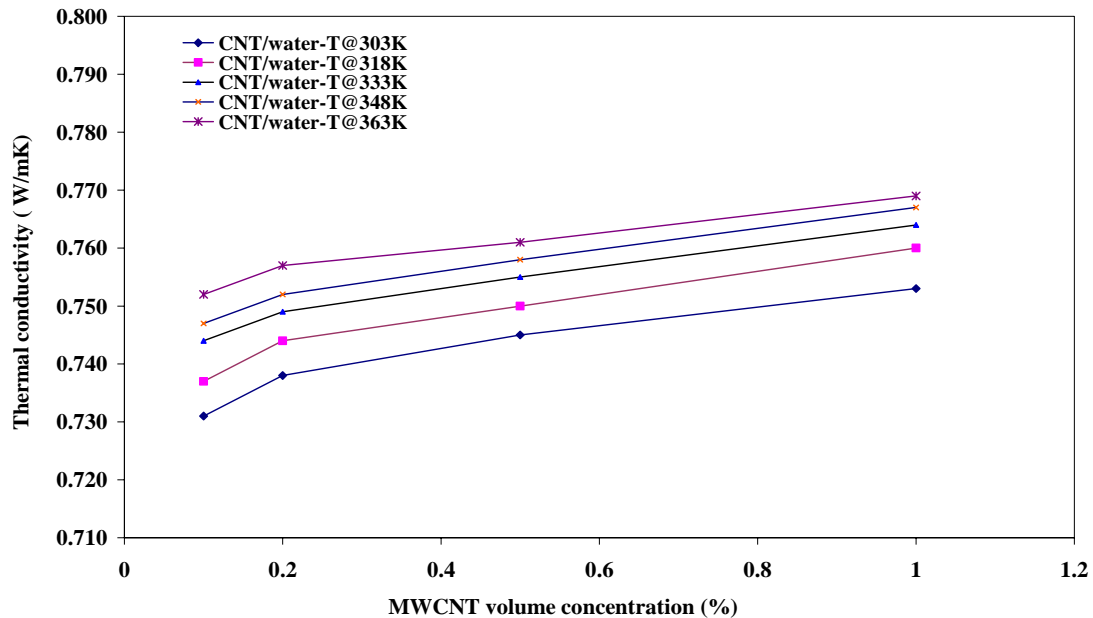


Fig. 1: Variation of thermal conductivity for MWCNT nanofluids with different volume concentration.

4. Conclusions

In this work the prepared the multi walled carbon nanotube for 0.1 to 1.0% volume concentration were dispersed in the base fluid. The TEM results conformed the morphology of MWCNTs. The increase in nanotubes concentration in base fluid and increase in temperature of nanofluid increases the thermal conductivity was shown in the result. The increase in thermal conductivity enhancement shows 23.5% for the volume concentration of 1.0%. The surface area of the MWCNTs found to increase the thermal conductivity of nanofluids. The aggregation as well as the phonon heat interaction of the nanotubes at higher concentration in base fluid were ascertained for the enhancement of the thermal conductivity of the MWCNT nanofluids.

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