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Research Article

Enhancing Heat-Electrical transfer properties of Polyvinyl Glycol Using Carbon Nanotube

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Abstract

Carbon nanotubes (CNTs) suspended in polyvinyl glycol were synthesized and their thermal or electrical conductivity enhancement rate were investigated. Polyvinyl alcohols/CNT based nan fluids have been synthesized by dispersing nan composites of Polyvinyl alcohol/CNT in distilled water without any surfactant. The results showed that well-dispersed Polyvinyl alcohols/CNTs nan fluids with varying concentration of Polyvinyl alcohol/CNT can be synthesized using the present method. The effective thermal and electrical conductivity of CNT/water and polyvinyl alcohol is measured with different concentration and temperatures (30–50 °C). Dispersed CNT was found to enhance thermal and electrical conductivities of base liquid. However the ratios of thermal conductivities for various concentration of CNT were to have marginal difference where electrical conductivity show appreciable variations. Polyvinyl alcohol based coolants were found to show high thermal and electrical conductivity in comparison to coolants without Polyvinyl alcohol based coolants. Variation of electrical and thermal conductivities were explained on the bases of molecular interactions between constituent materials. The proposed explanation agree quite well with the experimental data.

Keywords: Carbon nanotubes, nan fluids, Polyvinyl alcohol, Stability, thermal and electrical conductivities enhanced

Introduction

Continuous technological development in automobile industries has increased the demand for high-efficiency engines. The efficiency of engine depends on its better fuel economy and less emission. Conventional heat transfer fluid used as water and ethylene glycol cooling fluids in heat engine ,and have relatively poor heat transfer performance. Other method for increasing heat transfer in engine uses nan fluids [1]. The nanofluids were found to exhibit more stable and higher thermal conductivity. Nanotubes (CNTs) have drawn worldwide attention since its discovery in 1991. CNTs are excellent nanoparticles for preparing nanofluids because they have superior thermal conductivity (750–6600 W/m K)[2]. Nan fluids, as a new technology are obtained by dispersing nanoparticles on the base fluid. In the present study, nanoparticles were used in a mixture of distilled water, polyvinyl alcohol as a base fluid. Then thermal performance of a heat engine was studied. The experiment was performed for different volumetric concentrations of nanofluids of different flow rates and inlet temperatures (30-50°C).The result showed that superior increment of thermal and electrical conductivity. We use a PVA (poly vinyl alcohol) is a semi crystalline synthetic polymer. PVA is a creamy or whitish and nontoxic polymer [3]. It is tasteless, odorless and biodegrable in fluid [4]. Its physical and chemical properties make very versatile material for modern technology. Its good water-solubility, high tensile strength and elasticity, as well as good dispersing power makes it a useful polymer.

In this paper, PVA polymer is selected due to its amazing properties and a variety of other application. PVA can be used as good thermal stability enhancer material.PVA is an environmentally safe product, inexpensive and has good mechanical and optical properties also [5]. In present paper we study thermal and electrical conductivity mechanisms in CNT-based Polyvinyl alcohol. The PVA-CNT and distilled water were used for preparing samples. The sample was prepared by solution mixing method using ulrasonicator. We found that its electrical and thermal conductivity is increased as compared to base fluid.

Experimental Methodology

(1) Preparation of PVA-CNTs Nanocomposites

The PVA-CNT Nanocomposites were prepared by solution mixing method using an ultrasonicator .The nanocomposites samples have been prepared by the following procedure:

A known weight (15gm) of PVA dissolved in 100ml distilled water. After that 0.2g CNT is dissolved in the sample by using ultrasonicator for 15 minutes at the room temperature (27^0C Fig.1). After that mixture was filtered using filter paper (Whatman Filter Paper No 0). The prepared fluid was used as base material for preparation of other fluid with different concentration. We measured the thermal and electrical conductivity of the samples using in-house build liquid thermal conductivity meters. (Fig.2). Solution of PVA,CNT in water and black in colour.

2. Method for electrical conductivity measurement:

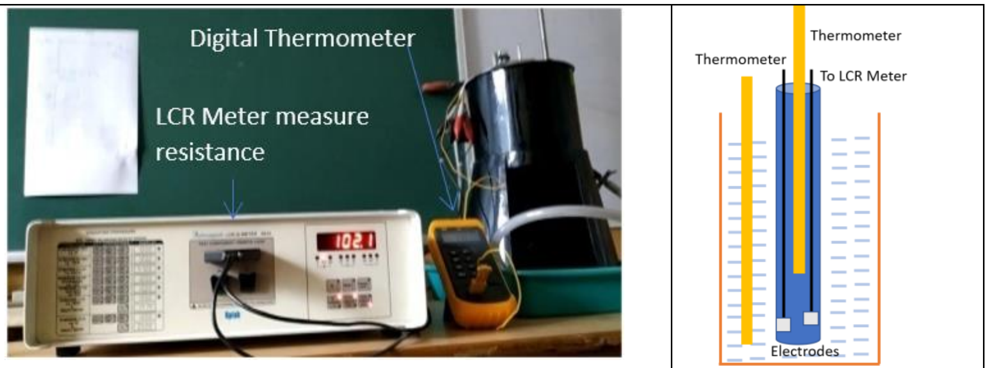

Fig. 1: Electrical conductivity measurement set–up.

The raw material used in present paper was as a fine powder of a commercially available polyvinyl alcohols .PVA is a polymer with a carbon chain backbone with hydroxyl group attached to a methane carbons. These hydroxyl groups can be a source of hydrogen bonding and responsible for the formation of polymer. We use this PVA (15g) dissolved with 100ml distilled water. After that 0.2g CNT dispersed in this sample. The powder were completely dissolved by using ultrasonicator for 15 minutes. For measuring electrical conductivity we used a LCR bridge. We take this sample in test tube having electrodes. Electrodes were attached to the LCR meter for the measurement of electrical resistance. Also, connections are made for the digital thermometer to measure the temperature of the fluid. This test tube is also kept in water bath for variation of temperature. The water is heated by a heating element. This increment of temperature is measured by digital thermometer. LCR meter measures the values of resistance and digital thermometer measures the value of temperature. The temperature was changed in the range of 30-50°C. We found that the increment of temperature decrease the electric resistance .The increase the electrical conductivity is attributed to the increase in concentration of CNT. It is clear that the temperature increase then electrical conductivity is increases.

3. Method for the Thermal Conductivity Measurement

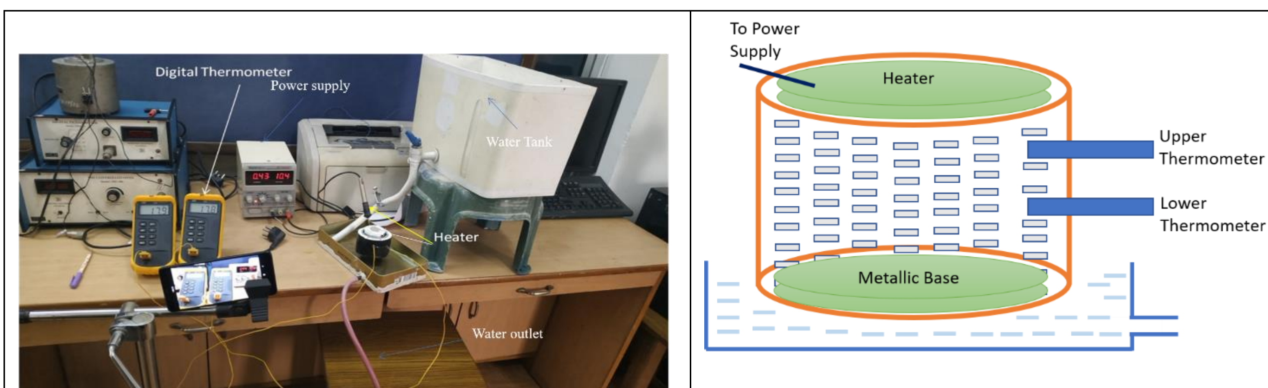

Fig.2: Thermal conductivity measurement set-up

Thermal conductivity of liquid is measured by layer method. Digital thermometers of sensitivity is 0.01°C for used to measure temperature of a section of a liquid kept in a container made of Teflon 4.7cm diameter and length 0.94 cm. Heating is done by an electrical metallic heater. Heating is done from top to bottom to minimize convection current.To ensure the unidirection heat flow the bottom of the chamber was filled with cooled running water. The temperature difference at two different levels was measured using two separate thermometer. The variation of temperature difference was recorded with time till steady state is reached. The temperature difference depends on the state is reached. The temperature difference depends on the thermal conductivity of liquid. Temperature difference were recorded for various concentrations and compared to find the relative increament of thermal conductivity.

TABLE: 1 PROPERTIES OF CNT,WATER AND PREPARED COOLANT			
PROPERTY	CARBON NANOTUBES	WATER	PVA+CNT+WATER(measured)
THERMAL CONDUCTIVITY	>3000W/mK	0.605W/mK	0.98377 W/mK
ELECTRICAL CONDUCTIVITY	10^6s/m	5.0 x10^{-6} s/m	866.32 x10^{-6}s/m

Table 1 : knows values of thermal and electrical conductivities of CNT, water, and prepared coolants. CNT has high thermal and electrical conductivity .When mixed with water +PVA +CNT it enhances the electrical and thermal conductivities of the prepared coolant.

Experimental Result

To have a stable solution of CNT in distilled water, the surfactant has to be used with it. In the present study, organic surfactants like PVA were used in the water –CNT system various compositions of the solution with carbon multi-walled carbon nanotubes and were subjected to thermal and electrical conductivity study. The present study is on the thermal and electrical properties of various proportions of coolant, water, and CNT. In this study concentration of CNT is ranged between1.16g/L to 1.90g/L. The behavior of electrical and thermal conductivity show by graphical representation for the different concentration of 1.16g/L, 1.54g/L and 1.90g/L. We measure the temperature difference and time of the prepared sample using the apparatus set-up in Fig.3.

Thermal conductivity is given as:

$$K = \frac{Q\ell}{tA(T_2 - T_1)} \quad \text{.......................................(1)}$$

The raw materials used in this wo

r

commercial polyvinyl alcohol (P

V

chloride (CoCl

2

) salt

with weight percentages (0, 1, 3, 5, 7 and

10 wt %). The films were prepared using the conventional

casting method by dissolving the powders with the appropriate

percentages in distilled water. The powders were completely

dissolved

by using magnetic stirrer for about 1hour and then

placed in Petri dish (5 cm diameter). The thic kness of the dried

samples was found to be ~ 0.045 cm

micrometer.

The method of the three

method of Teflon-isolated

circular electrodes) was used

according to ASTM D66-257

recommendations

effect of additives and temperature on the volumetric

conductivity of polymeric systems. The input electrical power

was regulated by using a (D.C.) power supply of Phillip

Harris Limited type having a voltage of (3

voltage used in this study was (1000) V. The current was

measured by a Digital Solid State Electrometer (616) with sensitivity of (10

-15

) and full gradation. The temperature was

changed in the range of (303-

373) K by using an electrical

oven of Yamato (DP61)

Here Q is heat flow in time t across length l through the area of cross-section A. Heat flow is Q=VIt. Here V is the supply voltage I is current to the heater. Let K_s and K_{st} are thermal conductivities of sample and standard liquids, $\left|(T_2 - T_1)\right|_s$ and $\left|(T_2 - T_1)\right|_{St}$ are temperature difference between to heaters for a sample and standard liquid respectively at the steady-state. If dimensional parameters are kept constant the ratio of thermal conductivities are given as:

$$\frac{K_s}{K_{st}} = \frac{\left|(T_2 - T_1)\right|_{St}}{\left|(T_2 - T_1)\right|_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

From the above relation, the thermal conductivity of the sample fluid is determined. Similarly, measurements for electrical conductivity of sample liquid are done by measuring the electrical resistance at a given temperature of the prepared sample. This is done using the apparatus set-up in Fig.3. Comparing ratios of their respective electrical resistances ,the electrical conductivity of the prepared sample is measured with the standard sample (Double distilled water at room temperature). At this concentration, we have drawn the graph for thermal and electrical conductivity [Fig.3 and 4]. Out of various compositions, organic surfactant PVA shows extraordinary performance.

RESULTS AND DISCUSSIONS

To have a stable solution of CNT in distilled water, surfactant has to be used with it .In the present study organic surfactant like Poly Vinyl Alcohol were used in the water-CNT system various compositions of the solution with carbon multi-walled carbon nanotubes were subjected to thermal and electrical conductivity study.

The present study is on thermal and electrical conductivities of various proportions of coolant ,water and CNT .The behavior of electrical and thermal conductivity show by graphical representation

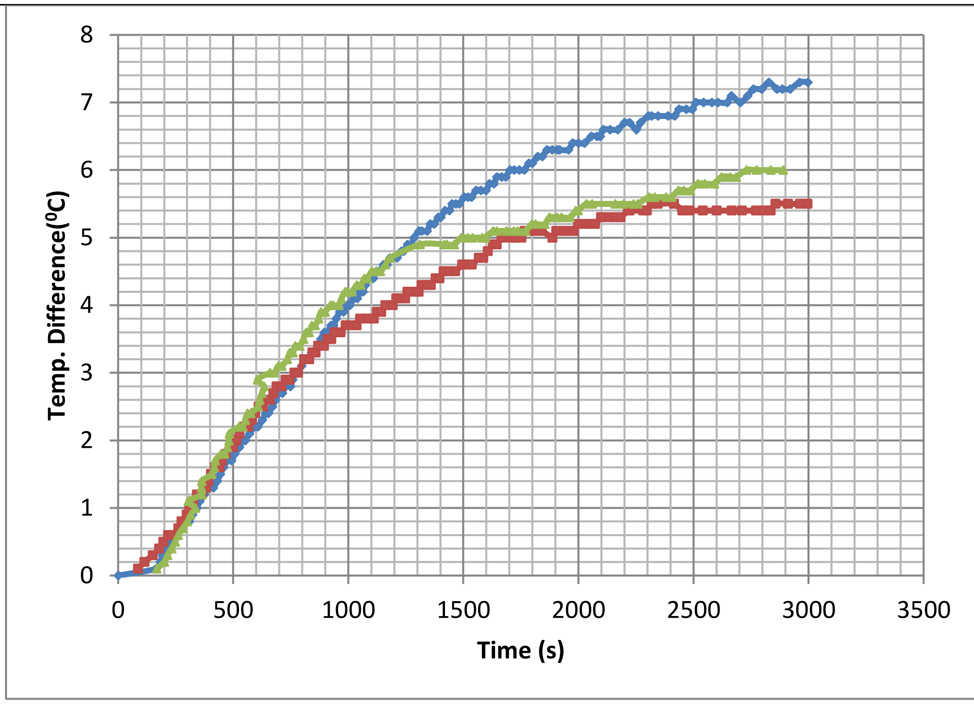

Fig.3: Thermal conductivity graph at various concentration

From fig.3 shows that the good thermal behavior at different concentration of cnt.In this fig.red line shows best conductivity at different temperature difference.The high thermal conductivity of the polymer blends can be attributed to comparatively strong hydrogen bonds with cnt.CNT participate in the formation of bonds with-OH groups in the side chains of PVA.In this study,the reduction of hydrogen bonds by the disturbance of cnt was observed in the fig.,judging from

slightly peak position decrease of the –OH group band in the fig.3.[7]

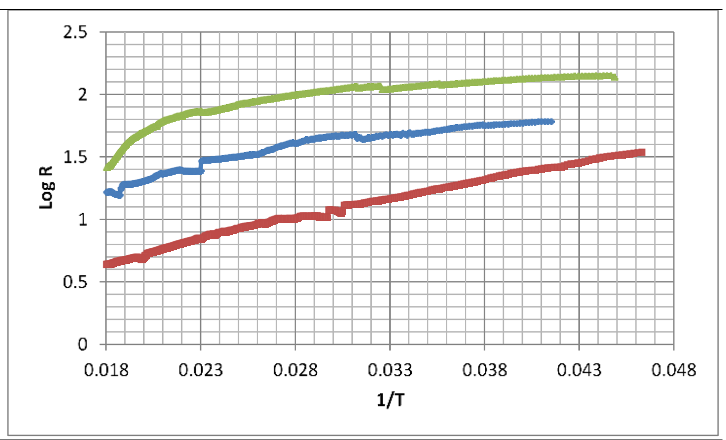

Fig.4: Electrical conductivity graph at various temperatures

From the Fig.4 shows that electrical conductivity increases due to the addition of CNT in PVA matrix.[8].This is due to the multiwalled CNT coordinated through ionic bonds with hydroxyl group belonging to the different chains in PVA. This reduces the intermolecular interaction between the PVA molecules and increases the required volume for ionic carriers to drift in the polymer matrix. This enhances the electrical conductivity increases.[9]

RESULT

The result showed that the conductivity increases with an increase in PVA concentration throughout the sample due to the larger number of charge carriers in polymer electrolyte system. It was found that the conductivity also increases with temperature up to 50^0C.When temperature increases, the increases vibration of molecules and increase the space between them which causes free ions receiving the thermal energy and increases the kinetic energy for their movement.[10]

The thermal conductivity of each sample was calculated with temperature difference value.The thermal conductivities of PVA/CNT nanofluid composites with different wt% of MWCNT-PVA are shown in fig.4.The thermal conductivity of the nanofluid composite at different concentration of CNT are1.90g/L,1.54g/L and 1.16g/L were 0.66643W/mK, 0.98377 W/mK and 0.8526W/mK respectively.The increase in conductivity was more pronounced at concentration of CNT 1.54g/L.

The electrical conductivity of each sample was calculated with the resistance value . The electrical conductivities of PVA/CNT nanofluid composites with different wt% of MWCNT-PVA are shown in Figure 5. The MWCNT-PVA affected the nanofluid composites. The conductivity increases with increasing amounts of MWCNT incorporated into PVA. The conductivities of the nanofluid composite at different concentration of CNT are1.90g/L,1.54g/L and 1.16g/L were 468.10×10-6 , 866.32×10-6 and 315.61×10-6 S/m respectively. The increase in conductivity was more pronounced at concentration of CNT 1.54g/L. [11].

Conclusion

We have successfully modified the PVA composite by adding CNTs. It was found that, with respect to concentrations CNT reinforced PVA composite showed the highest performance in thermal and electrical properties. The thermal and electrical properties have been drastically improved due to CNT content in the nanofluid.[12]

By obtaining results and comparison the conclusion has been done

*Cooling capacity increase with an increase in inlet coolant temperature.

*Cooling capacity using nanofluid is much higher than using base fluid.
*Thermal conductivity is increase as compared to the base fluid.

*Electrical conductivity is increase as compared to the base fluid.

*Both thermal and electrical conductivity show the optimization at a particular concentration.

*Fig 4 and Fig 5 shows extraordinary performance of electrical and thermal conductivity. Fig 4 shows the good thermal conductivity at higher temp. Fig 5 shows the performance of electrical conductivity at 50°C.

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14. Improved Electrical Conductivity of Polyvinyl Alcohol/ Multiwalled Carbon Nanotube Nanofibre Composite Films with MnO2 as Filler Synthesised using the Electrospinning Process Mohd Faiz Muaz Ahmad Zamri, Sharif Hussein Sharif Zein*, Ahmad Zuhari Abdullah and Nor Irwin Basir School of Chemical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia
15. this paper for representing graph Study of Electrical Properties of Poly (Vinyl Alcohol)/ Alumina (PVA/Al2O3)Nanocomposites Abdulameer Khalaf Arata , Dalal Hassan Abdulkadhimb , Maher Hasan Rashida aCollege of basic education ,department of science-physics, University of Babylon, Babylon, Iraq bCollege of Education pure of science, Department of physics, University of Babylon, Babylon, Iraq Abd_a1015@yahoo.com