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Development of ethylene glycol and water mixture MWCNT-OH based nanofluid with high thermal conductivity

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ABSTRACT – The aim of this paper is to develop nanofluids and investigate the thermal conductivity value of MWCNT-OH based nanofluids where the base fluid is the mixture of EG:DI (20:80) at three different temperatures which are 6°C, 25°C and 40°C. The result reveal the inclusion of nanoparticles which have superior thermal conductivity value in the base fluid make a positive enhancement for all concentrations of MWCNT-OH based nanofluids. The enhancement of nanofluids's thermal conductivity is from 0.8121% to 16.96%. In conclusion, thermal conductivity is strongly depends on the temperature of nanofluids, weight percentage of surfactant and the thermal conductivity of nanoparticles.

1. INTRODUCTION

Many researchers have shown interests in the nanofluids fields since the used of nanoparticles can facilitates the enhancement of thermal and electrical properties of the fluids. Hence, they have superior thermal properties as compare to the conventional fluids such as deionized water (DI), ethylene glycol (EG) and oil [1]. However, limitations are discovered when using conventional fluids in the cooling system application due to low boiling point and a high freezing point of DI. Therefore, an antifreeze additive can be applied to overcome this problem. Previous researcher has stated that, the common fluid used as antifreeze additive are EG and methanol [2]. Thus, the mixture of antifreeze additive with DI in the formulation should improve the thermal properties of the fluid with proper concentration. Previous literature stated that, thermal conductivity of H_2O:EG based fluids with 1.0 vol% of SiC gives an enhancement about 33.84% at temperature 20°C [3]. Moreover, the enhancement of thermal conductivity of nanofluids with formulation of 60:40;EG:DI increases from 6.67% up to10.47% [4]. The thermal conductivity enhancement is still under investigation where the mixture between two types of conventional fluids is rarely study by the researcher. Therefore, this work investigates thermal conductivity of EG:DI mixture (20:80) with -OH functionalized multiwalled carbon nanotube (MWCNT-OH) based nanofluids as to fill the research gap.

2. METHODOLOGY

Hydroxyl functionalized Multiwalled Carbon Nanotubes (MWCNT-OH) nanoparticles used in this investigation were purchased from Nanostructures & Amorphous Material, Inc and surfactant polyvinylpyrrolidone (PVP) were purchased from Sigma Adrich Co. Whilst, the appropriate volume of EG and DI (20:80) were mixed together as a base fluid. All these formulations were prepared by two-step method. Firstly, an amount of MWCNT-OH was mixed into the base fluid from range 0.1 wt% to 1.0 wt% with inclusion of 0.1 wt% PVP in a clear sampling glass bottle. Then, the mixture was further homogenized and sonicated at the same time to achieved good dispersion using Wise Tis HG-15D homogenizer at 10000 rpm and Branson 8510DTH Ultrasonic Cleaner at 40 kHz for five minutes. The samples were shelved for 100 hours and the stability of the fluid was monitored by stability test rig (STR) [1]. The stable nanofluids were further test for their thermal conductivity properties by TC-KD2 Pro thermal analyser using of KS1 sensor at three different temperatures which are 6°C, 25°C and 40°C.

3. RESULTS AND DISCUSSION

Figure 1 shows the thermal conductivity of EG:DI based MWCNT-OH nanofluids at several concentrations ranging from 0.1 wt% to 1.0 wt% with 0.1 interval. Closer inspection on this plot, it shows that a significant improvement on the thermal conductivity value in the formulations. The standard thermal conductivity values of base fluid without the addition of nanoparticles for each temperature are 0.4440 W/m.K, 0.4556 W/m.K and 0.4600 W/m.K for temperature 6°C, 25°C and 40°C. The straight line in the figure represents the standard value line of base fluids. Interestingly, the highest thermal conductivity was achieved for 0.9 wt% of MWCNT-OH in the base fluid with value given 0.5380 W/m.K at temperature 40°C, 0.5170 W/m.K at

25°C and 0.4883 W/m.K at 6°C. This was followed by 0.3 wt% of MWCNT-OH with thermal conductivity value given 0.5170 W/m.K, 0.5063 W/m.K and 0.4850 W/m.K for 40°C, 25°C and 6°C. However, maximum concentration of 1.0 wt% results in no major influence on the thermal conductivity values with only 0.4810 W/m.K at 40°C, 0.4593 W/m.K at 25°C and 0.4623 W/m.K at 6°C. To sum up, all the thermal conductivity values of nanofluids is higher than the base fluid for all temperatures. In addition, the thermal conductivity of nanofluids is strongly depends on temperature where the high temperature tend to make the nanoparticles move and collide to each other and create the high energy transfer. However, high temperatures also can form the agglomeration in nanofluids and causes the reduction of thermal conductivity. Besides, previous research revealed that the inclusion of lower weight percentage of surfactant also influenced the increment of thermal conductivity value [5].

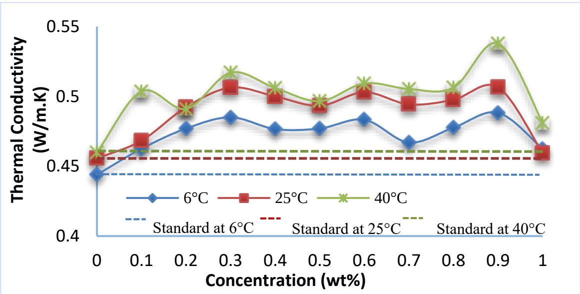

Figure 1 Thermal conductivity of EG:DI based nanofluid.

Table 1 shows the percentage enhancement of thermal conductivity for each concentration of nanofluids. The highest thermal conductivity enhancement occurs at the temperature of 40°C which about 16.96% and 12.39% for 0.9 wt% and 0.3 wt% of MWCNT-OH based nanofluids. Meanwhile, the lowest thermal conductivity enhancement is found out at concentration of 1.0 wt% MWCNT-OH based nanofluids for temperature 25°C which only 0.8121%.

Table 1 Percentage enhancement of thermal conductivity.

Concentration (wt%)	**% Enhancement of Thermal Conductivity (W/m.K)**		
	6°C	**25°C**	**40°C**
0.1	4.167	2.787	9.478
0.2	7.432	8.055	6.739
0.3	9.234	11.13	12.39
0.4	7.342	9.745	10.00
0.5	7.432	8.275	7.956
0.6	8.851	10.40	10.72
0.7	5.180	8.494	9.848
0.8	7.567	9.219	10.06
0.9	9.977	11.19	16.96
1.0	4.122	0.8121	4.565

To conclude, all concentrations of MWCNT-OH based nanofluids shows positive enhancement as the addition of nanoparticles which have superior thermal conductivity value compared to the conventional fluid. Thus, this fact is supported by previous researcher where the thermal conductivity enhanced with the dispersion and suspension of nanomaterials that have higher thermal conductivity into the base fluids [6].

4. CONCLUSION

The addition of nanoparticles in the base fluid mixture of EG as the anti-freezing additive with DI can contribute to the increment of thermal conductivity value. The values were found to be higher than the standard base fluids at all temperatures. The optimum condition with better thermal conductivity enhancement was achieved by 0.9 wt% of MWCNT-OH. Some issues that affected the thermal conductivity results is temperature where high temperature can enhance and lowers the thermal conductivity. The lower weight percentage of surfactant and thermal conductivity of nanoparticles are also another factor that can influence and enhance the thermal conductivity value of nanofluids.

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