Properties of Aluminium Oxide in Nanofluids

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paper contains the research is to study what is the effect of aluminium oxide to the mixture of ethylene glycol and ultrapure water. Nanofluids are a fluid for instance oil or water containing nanometer-sized particles. These nanoparticles are usually metal oxides. The objective of this research is to study the properties of aluminium oxide on ethylene glycol-ultrapure water to determine the specific heat capacity, freezing point and thermal conductivity. For sample preparation, aluminium oxide powder measured in different masses for each sample by using an analytical balance. For sample 0.001, 397.4 mg of aluminium de powder, 795.4 mg for sample 0.002, 1194.58 mg for sample 0.003, 1594.38 mg for sample 0.004 and 1994.97 mg for sample 0.005. The experiment for specific heat capacity was conducted using differential scanning calorimetry, Perkin Elmer DSC6000 and each sample using specific amount which is 10mg. Hence, high concentration of nanoparticles gives high value of specific heat capacity. For the freezing point determination, the experiment was also conducted using differential scanning calorimetry, Perkin Elmer DSC6000. 10 mg of the mixture is taken for this experiment which resulting 0.003 as the best sample since the freezing point of this sample fulfill the requirement for the coolant. Lastly, for thermal conductivity, the samples were arranged in test tubes include radiator coolant and ethylene glycol with water in test tube rack. The test tube rack is soaked in the water bath until it reaches the set temperature. The sample is taken 3 times using KD-2 PRO probe to achieve average result and the best sample was 0.003. To be concluded, the volume fraction of 0.003 indicate best result because the results achieved the standard desired for thermal conductivity and specific heat capacity.

Keywords: Nanofluids ; Specific Heat Capacity ; Freezing Point ; Thermal Conductivity ; Aluminium Oxide

Nanofluids are the mixture between the nanoprticles with the base fluid, ethylene glycol with ultra pure water. The term nanoparticle comes from the Latin prefix 'nano'. It prefix is used to denote the 10-9 part of a unit. They two-phase systems with one phase (solid phase) in another (liquid phase). Recent development of nanotechnology brings out a new heat transfer coolant called 'nanofluids. Nanofluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water.

The nanofluids are a phrase based on various types of nanoparticles such as aluminium oxide, magnesium oxide others that made of metals oxide containing base fluid material such as ethylene glycol or water. The nanoparticles give some special characteristics according to their size, volume fraction or concentration to greatly enhance the heat and mass transfer in a fluid state because of the thermo physical properties of the nanoparticles. ce, for its applications, nanofluids are used in micro or nano-electrochemical devices, also used in advanced ling systems. In addition, the thermal conductivity enhancement rising even higher with increasing temperature ch conveys that it is suitable for cooling applications (Das & S.K., 2003). Other than cooling systems, it is use in management systems for example evaporators and heat exchanger.

Using nanofluids, the heat transfer can be intensified, which preferring nanoparticles in base fluid rather than the pure fluid because the suspended ultrafine particles are outstandingly enhance the thermal conductivity of the and improves the energy exchanges capabilities. Low volume fraction also helps the improvement for the transfer fluid in thermal conductivity (Tavman, Turgut, Chirtoc & H.P. Schuchmann, 2008). Thus, according to Et. Al, 2015, thermal conductivity of fluids acts as the main properties to be apprehensive in developing the efficient heat transfer equipments. In addition, Low thermal conductivity of process fluid hinders high pactness and effectiveness of heat exchangers, although a variety of techniques is applied to enhance heat sfer (Xuan & Li, 2000).

The factors such as the shape, size, volume fractions of the particles in the suspensions and also the thermal properties of the particle materials are the mainly enhancement of the nanofluid (Shanker, Reddy, & Rao, 2012). Karimzadehkhouei Et. Al (2017) specified that the type of nanoparticles used also attributes to the heat transfer enhancement. Addition of nanoparticles in the ethylene glycol with ultra pure water developing higher heat transfer coefficient affect the heat transfer coefficient (Kumar, Sonawane, & Sonawane, 2018). Besides that, according to Eastman & J.A., (2001), nanoparticles with 0.04 volume fraction, with size within 10nm along with pure copper helps increasing the thermal conductivity about 40%. According to Visinee Trisaki, (2007), the additives which are the nanoparticles is being applied into the nanofluid helps in improving the heat transfer performance for base fluids.

Various types of nanofluid can be produced by using variety of nanoparticles and base fluids combinations. Nanoparticles that commonly used are Aluminium Oxide (Al_2O_3), Magnesium Oxide (MgO) and Copper Oxide (CuO). In addition, water, ethylene glycol and oil are the base fluids that are also being used in major research. Meenakshi & Sudhan, 2016 stated that nanoparticles which providing an increasing in thermal conductivity could be achieved when compared with liquids without nanoparticles or larger particles. This result the enhancement of conductivity is affected by the volume fraction of the nanoparticles. Other than that, according to Eastman & J.A., (2001), 10mm copper oxide particles in ethylene glycol improve the thermal conductivity by 40% meanwhile it was 20% for cupric oxide with 4% of volume fraction. Singh, 2016 stated at temperature 30°C and 60°C, about 6.58% and 8.23% were achieved for the enhancement of thermal conductivity with aluminium oxide nanoparticles. On contrast, S. Singh, Sharma, & Gangacharyulu, 2015 mentioned that thermal conductivity of aluminium/water nanofluid compared to aluminium oxide/water nanofluid is 47% higher at 60°C thus making the aluminium/water nanofluid more suitable for energy density applications. In addition, according to Mahdi, Abdul, & Asst, 2016, from magnesium oxide nanoparticles, the enhancement occurs at 0.75 volume% for 16.31% over base fluid.

The dispersion of the nanoparticles in the base fluid would enhance a high efficiency heat exchange media. Nanofluid is basically used in heat transfer equipments such as refrigerator chiller, pharmaceutical processes and temperature of flue gas in boiler. It can also be applied for solar power applications (Hu, He, Zhang, & Wen, 2017). Three mechanisms that are possible to affect the enhancement of heat transfer are thermal boundary layer, velocity gradient on the heated surface and the flow interruptions. Otherwise, the suspensions tend to become unstable. On the other hand, if the solid material density is close one to the base fluid, viscosity of suspension is high and smaller radius of nanoparticles can improvised the suspension stability (Anbazhagan & Rejikumar, 2013).

Nanofluids with advanced properties affect fuel efficiency, engine performance, materials selection and emissions that could give more efficient vehicles. There are many advantages of the heat transfer using nanofluids, one of it is reduced weight that will help with the fuel economy improvement (Kulkarni, Vajjha, Das, & Oliva, 2008). Also, increased in the component life and it gives more efficient cooling

The studies that involved nanofluids in freezing point determination are limited (Usri, Azmi, Mamat, Hamid, & Najafi, 2015). Therefore, our research had been decided to include freezing point in our experimental results. The objective of this research is to investigate the thermal conductivity, freezing point and the specific heat capacity of the ethylene glycol-ultra pure water with the addition of the aluminium oxide nanoparticles. Five samples for aluminium oxide nanoparticles in ethylene glycol with volume percent 0.001, 0.002, 0.003, 0.004 and 0.005 are considered and results are compared with the coolant and ethylene glycol with ultra pure water.

I Sample preparation

Nanoparticles or other nanomaterials are first produced as dry powders by chemical or physical methods. aluminium oxide powder was measured using analytical balance and the weight recorded in Table 1. Aluminium oxide was weight using volume fraction equation. Next, five 200ml conical flask were filled with 100ml 70% ultrapure water and 30% ethylene glycol and appropriately labelled from 0.001 to 0.005 mol %. Then, the aluminium oxide is added to the conical flask with respect to its mass. These samples were then shaking in the 43 Incubator Shaker at 90 rpm, 25 °C for 17 hours.

$$\text{Volume fraction } (\Phi) = \frac{\frac{W_p}{p_p}}{\left(\frac{W_p}{p_p} + \frac{W_{bf}}{p_{bf}}\right)}$$

Sample	Mass of Aluminium Oxide (mg)	Volume fraction (%)
Coolant	-	-
Ethylene glycol + Ultrapure Water (Reference)	-	-
Ethylene glycol + Ultrapure Water (Sample 1)	397.4	0.001
Ethylene glycol + Ultrapure Water (Sample 2)	795.4	0.002
Ethylene glycol + Ultrapure Water (Sample 3)	1194.58	0.003
Ethylene glycol + Ultrapure Water (Sample 4)	1594.38	0.004
Ethylene glycol + Ultrapure Water (Sample 5)	1994.97	0.005

Table 1 : The mass and volume fraction of Aluminium Oxide powder for each sample.

Specific heat capacity

The specific heat capacity with respect to each of the blends was dictated by utilizing differential examining calorimeter, Perkin Elmer DSC6000. Differential scanning calorimeter run in temperature from 190 to 280K, with nitrogen gas as cleanse gas (50 mL min). The 70:30 proportions of ultrapure water and ethylene glycol blend were taken from the plastic compartment by utilizing micropipette hardware. The blend was then put into an alum pan. The mass of the blend taken was then measured until the point that it achieved 10mg by utilizing the milligram adjust, model no, AD 6000. The pan was then secured and put into the DSC. At to begin with, the DSC will keep up the temperature at 25°C for four minutes then will be warm up to 80°C and stay for five minutes. At that point, it will be chilled off to the beginning temperature (25°C). The readings for the specific heat capacity were then recorded after the temperature drops down to under 50°C. The experiment is repeated using 0.001, 0.002, 0.003, 0.004 and 0.005 volume fraction of Aluminium Oxide.

2.3 Freezing Point Determination

The freezing point was measured using the differential scanning calorimetry (Perkin Elmer DSC6000) technique for each of the mixture. The 70:30 ratio of ultrapure water-ethylene glycol mixture were taken by using micropipette equipment from the plastic container. The mixture was then placed into an alum pan. By using the milligram balance, model no. AD 6000, the mass of the mixture taken was then measured until it reached 10mg. The pan was then covered and placed into the DSC. The DSC6000 software method editor was then configured, firstly the DSC hold for 1.0 min at 15°C. Secondly, the DSC then cool down to -110°C at rate 10°C/min. Thirdly, the DSC then heat up from the -110°C to 15°C at rate 10°C/min. The experiments are repeated using 0.001, 0.002, 0.003, 0.004 and 0.005 volume fraction of Aluminium Oxide.

2.4 Thermal Conductivity

Samples including Proton Radiator Coolant and ethylene glycol with water that have been shaken for 17 hours is then poured into 7 test tubes. The test tubes are labeled based on the mole% and their respective mass which then arranged in the test tube rack. The water bath is filled with water and is heated to the set temperatures which are 30℃, 40℃, 50℃, 60℃, 70℃. The test tube rack is put into the water bath until it reaches the set temperature. After a few minutes, the thermal conductivity reading of each sample is taken 3 times to achieve average result by using KD-2 PRO device. Record the readings of each sample at each set temperature.

Result and Discussion

.1 Effect of Specific Heat Capacity on Temperature

The experimental data were obtained by testing the samples using Differential Scanning Calorimeter (Perkin Elmer DSC6000) with different values of temperature, with range from 40°C to 80°C for 10 minutes of each sample. After the samples that contains 70:30 of ultra pure water and ethylene glycol had been prepared with different concentration of aluminium oxide nanoparticles, it is observed that there is precipitation occur at the bottom of the conical flask. Stability of nanoparticle suspension was also affected by the precipitation of nanoparticle at the bottom of conical flask. It occurred to be because of the Van der Waals forces which making the repulsion forces to be less compared to attraction forces. The higher the molecular weight of the aluminium oxide nanoparticles, the higher the Van der Waals forces (attraction forces) value. Therefore, the tendency of the nanoparticle to agglomerate in the conical flask is higher. When the agglomeration of the nanoparticle occurs, it becomes denser thus forming precipitation at the bottom of conical flask.

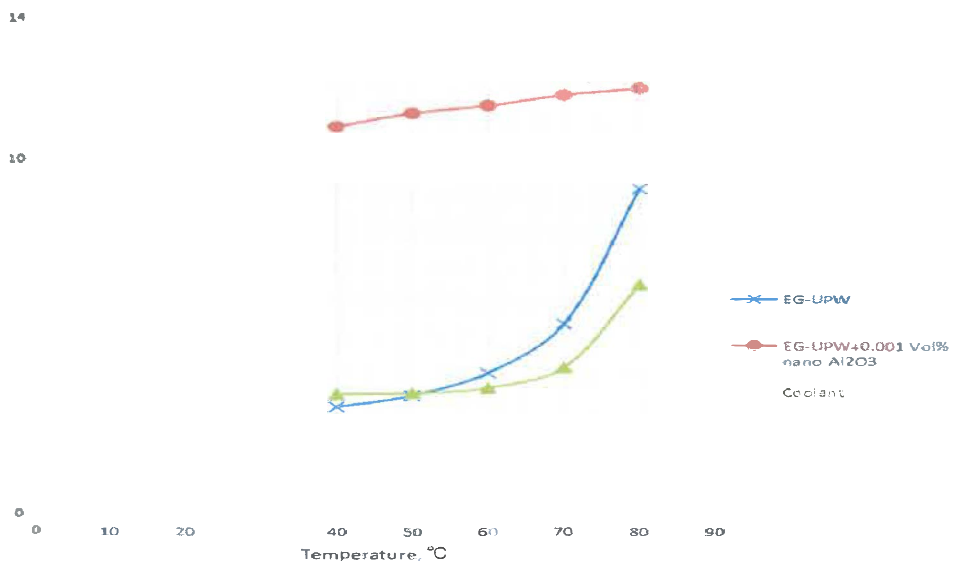

Figure 1: Comparison between coolant, ethylene glycol with ultra pure water and mixture of ethylene glycol and ultra pure water along with the addition of 0.001 volume fractions of Al2O3 nanoparticles.

Based on the figure 1 above, it indicates the comparison between the coolant, ethylene glycol with ultra pure water (reference) and the mixture of ethylene glycol and ultra pure water along with the addition of 0.001 volume fractions of Aluminium Oxide nanoparticles (Sample 1). In addition, about 193% of improvement of heat capacity had been achieved from the Sample 1 with respect to coolant. Sample 1 indicates about 151.25% of enhancement for heat capacity compared to references.