Experimental Investigation into Viscosity and Thermal Conductivity of bio nanofluid produced from Periwinkle shell nanoparticles

Okafor A. A[1]., Dara J. E[1]., Okafor L. U[2].,Osazuwa O. K[1]., Agu P. T[1].,

[1]Department of Mechanical Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

[2]Department of Physics and industrial physics, Nnamdi Azikiwe University, Awka Anambra State, Nigeria

Corresponding Author's e - mail: aa.okafor@unizik.edu.ng

ABSTRACT

In this research for the first time, periwinkle shell nanoparticles produced for nanofluid application and the viscosity and thermal conductivity of the resultant nanofluids were measured. A Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM) were used to analyze the sizes of the particles produced (100nm). This paper presents new findings on the synthesis of bio material to obtain nanoparticles and subsequently produced bio nanofluids. Nanofluids are prepared by dispersing Periwinkle shell- nanoparticles in deionized water. An ultrasonic sonicator was used to ensure proper mixtures of different volume fractions (0.3%, 0.6 %, 0.9 % 1.2 % and 1.5%) of Periwinkle shell nanoparticles into base fluid (DI water). A Viscometer machine (SV-10) was used to measure the viscosity of the prepared nanofluids conveniently and water bath-thermometer setup was used to measure the thermal conductivity of various volume fractions of the Nanofluid. The experimental results show that all the values of viscosities and thermal conductivity obtained in this study at different volume fractions of the prepared nanofluids were found to be substantially higher than the values of the base fluids (deionized water). The experiments were conducted at varying temperature range (30 ^{0}C through 70 ^{0}C).

Key words: Nanofluids, Viscosity, Thermal Conductivity, Periwinkle Shell, Nanoparticles

INTRODUCTION

Nanofluids are liquid suspensions containing nanometer-sized particles, typically solid nanoparticles dispersed in a base fluid like water or oil. These nanoparticles enhance the thermal conductivity and other properties of the fluid, making nanofluids useful in various applications, such as cooling systems and heat transfer devices [1-2]. Viscosity and thermal conductivity are among the very important properties of nanofluids which are essential for the evaluation of heat transfer coefficient as well. These may vary with volume fraction and size of the nanoparticles and temperature of the nanofluid . Many research works [3-4] have been carried out for obtaining and measuring the viscosity and thermal conductivity of nanofluids made from metallic or non-metallic nanometers-size particles. However, there is lack of enough research on the viscosity and thermal of nanofluids made from natural materials. Hence, the need to test the viscosity and thermal conductivity of nanofluids made from natural materials (Periwinkle shell nanoparticles) becomes important. In this paper we synthesized periwinkle shell nanoparticles to prepare bio nanofluids and experimentally investigate the viscosity and thermal conductivity of the prepared nanofluid to ascertain the effects of nanoparticles and temperature on the viscosity and thermal conductivity of the nanofluid.

2. EXPERIMENT/MATERIALS

The materials used for the laboratory experiment are Periwinkle shell, Powdered Sodium Hydroxide (NaOH), Ethylene Glycol and Dionized water, RADWAG AS 220-R2 Sensitive weighing scale(10mg – 220g), ball mill, GAUTRACK POTCH Oven, GAUSTING GT225 Impact Grinder (ball miller)

PREPARATION OF NANOPARTICLES FROM PALM KERNEL

Bio-based materials such as periwinkle shell constitute environmental waste in some quarters and its conversion to useful products for engineering application will go a long way in solving environmental problems. In this study, the top-down approach was used to synthesize nanoparticles from periwinkle shell using a ball-milling machine [5].

Periwinkle shells were placed into bucket filled with water to a level such that it will be completely submerged. The bucket was covered to prevent air from entering it; the soaking lasted for two weeks. After the two weeks, the periwinkle shells were removed from the water and washed with fresh water and sundry for two weeks to remove the absorbed water at constant temperature. The sun-dried periwinkle shells will then be oven-dried in a temperature range of 50–70◦C for 24 hours to ensure that the residual moisture will be completely removed. The dried periwinkle shells were feed into a ball-milling machine and allowed to run steady for two days to obtain palm kernel shell nanoparticles. The periwinkle shells were crushed thoroughly into very fine particles. 400g of the crushed bio materials shells particles was measured and passed through a thick cotton fabric with a pore size of about 100 nm, of which the nanoparticles was separated from other particles of periwinkle shells larger than 100nm . During the separation process, the nanoparticles pass into a container while particles larger than the cotton fabric's pore size are trapped on the fabric. The separation process was carefully done to ensure that particles obtained after separation are within the size range (<100nm).The obtained palm kernel shell nanoparticles were characterized using scanning electron microscope (SEM) to show the particle size and morphology of the nanoparticles.and X-ray diffraction (XRD) to determine crystal structure [12]. Nanoparticles obtained were washed using caustic alkali (NaOH) of 0.5M to remove impurities which would affect the nanofluid mixture. After washing with NaOH, the nanoparticles became basic. Hence, it was neutralized using Sulphur acid of 0.2M. pH indicator papers were used to test for the pH value of the nanoparticle during neutralization until the nanoparticles became neutral.

4. PREPARATION OF VARIOUS VOLUME FRACTIONS OF NANOFLUIDS

A 'two-step' method was used in the preparation of nanofluid from the fabricated bio-material nanoparticles since it is better method out of the two common methods in use [6]. A known mass of the palm kernel shell nanoparticles corresponding to a predetermined volume concentration were measured and mixed with a binary mixture of Ethylene Glycol (EG) and deionised water(base fluid) in a ratio of 50:50 .Volume fractions of nanofluid obtained ranged from 0.3%-1.5%, with five (5) samples of nanofluid formed for each bio materual nanoparticle. This was achieved using a mathematical model equation to calculate the weight of base fluid (ethylene glycol/ de-ionized water) and nanoparticles required to achieve various volume fractions

$$Volumetric\ fraction, \varphi \times 100 = \frac{\frac{W_P}{\rho_P}}{\frac{W_P}{\rho_P} + \frac{W_f}{\rho_f}} \qquad 1$$

Where Wp the weight of the nanoparticle is, ρ is the density of the nanoparticle, W_f, is the weight of base fluid and ρf is the density of the base fluid.

The density of the nanoparticles (ρ) was determined by measuring the weight of the nanoparticle for a given volume 1.78 grams of the nanoparticle was determined using a weighing balance as the weight of the nanoparticle for 5 ml. of the nanoparticle, of which the density of the nanoparticle was calculated using equation 2

$$\rho_p = \frac{\text{mass}}{\text{volume}} \qquad 2$$

After mixing the various weighed samples of nanoparticles with a measured volume of base fluid to achieve different volume fractions from 0.3-1.5, magnetic stirrer containing a magnetic stirring bar is used to stabilize the nanofluid mixtures for about 90 minutes for each volume fraction. This is to ensure proper mixing of the two phases of the mixture. All samples of the nanofluid were stored in a test tube.

The bio-materials nanofluids were prepared by dispersing or pouring different volume fractions (0.3%, 0.6 %, 0.9 % 1.2 % and 1.5%) of periwinkle shell nanoparticles into the base fluid. The nanofluids samples were homogenized by using an ultrasonic sonicator continuously for 40 minutes and the samples were observed for dispersion and stability.

5. MEASUREMENT OF VISCOSITY

Viscosity is a measure of a fluids resistance to flow. It is an essential property for various industrial and scientific applications. There are several methods to measure viscosity, each suitable for different types of fluids and precision requirements. In this work the viscosity of the base fluid and the bio-material nanofluids at different volume fractions and at different temperature range were measured using vibro- viscometer. Viscometers are specialized instruments designed to measure viscosity directly. The viscosity of the base fluid and the periwinkle shell nanofluids at different volume fractions (0.3%, 0.6%, 0.9%, 1.2% 1.5%) and at different temperature (30^0C through 70^0C) were measured, the results of these experiments are showed in figure 1.

6. MEASUREMENT OF THERMAL CONDUCTIVITY

The method used in this paper to measure the thermal conductivity of the nanofluids is water bath-thermometer setup [11]. The thermal conductivity of various volume fractions of the nanofluid were measured. 15 litres of water was placed in the water bath, which was set at a constant temperature of 75° C, and 500ml of water was placed in a 500ml beaker, which was also placed in the water bath. The setup was allowed to attain temperature stability for about 30 minutes, after which 25ml of a sample of the nanofluid with a volume fraction of 0.3 was placed in a test tube, and a thermometer was placed at the center of the test tube containing the nanofluid, the temperature of the sample was initially recorded to be 30°C, and it was placed in the beaker containing 500ml water in the water bath, the time taken for the temperature of the nanofluid to rise to 40°C was recorde. Also the time taken for the nanofluid to attain a temperature of 50°C, 60°C and 70°C, respectively, was recorded. This procedure was repeated for all remaining samples of the nanofluid with a volume fraction of 0.3-1.5. The results of these experiments are showed in figure 2.

7. RESULTS AND DISCUSSION

Figure 1 is the plot of viscosity versus temperature for base fluid and nanofluid. The plot shows the effects of temperature and periwinkle shell nanoparticle concentration on the base fluid and nanofluid. It could be seen from the plot that there is an enhancement in the viscosity as periwinkle shell nanoparticles concentration increases. Increase in temperature leads to decrease in viscosity. The plot shows that increase in periwinkle shell nanoparticles concentration causes increase in viscosity and increase in temperature leads to decrease in viscosity. This shows that introduction of periwinkle shell nanoparticle into the base fluid causes increase in the viscosity of the base fluid.

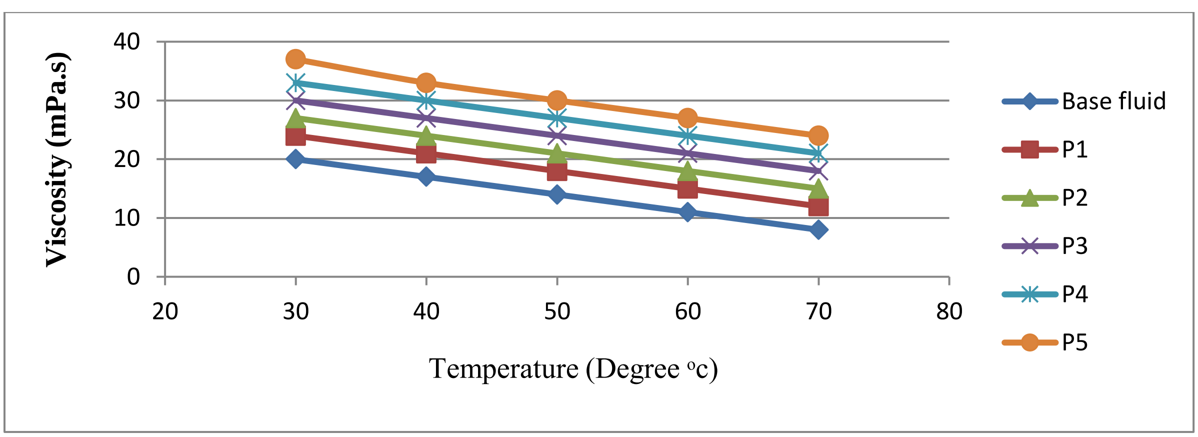

Figure 1: Effects of Temperature and volume fraction on Viscosity of 0.3 - 1.5 % volume concentrations of periwinkle shell nanofluid with Di ionize water/EG (50:50) Base Fluid

Figure 2 is the graph of thermal conductivity versus temperature for base fluid and biomaterial nanofluid. It could be seen from the plot that thermal conductivity of the bio materials (periwinkle shell nanoparticles) nanofluid increased with increase in temperature and volume concentration. Thermal conductivity values were recorded for volume concentrations of 0.3, 0.6, 0.9, 1.2 and 1.5 %, respectively. As the volume concentration increases, thermal conductivity also increases. Almost a linear variation is observed for the effective thermal conductivity against the volume fraction. The plot shows that the increase in temperature and nanoparticles concentration leads to increase in thermal conductivity.

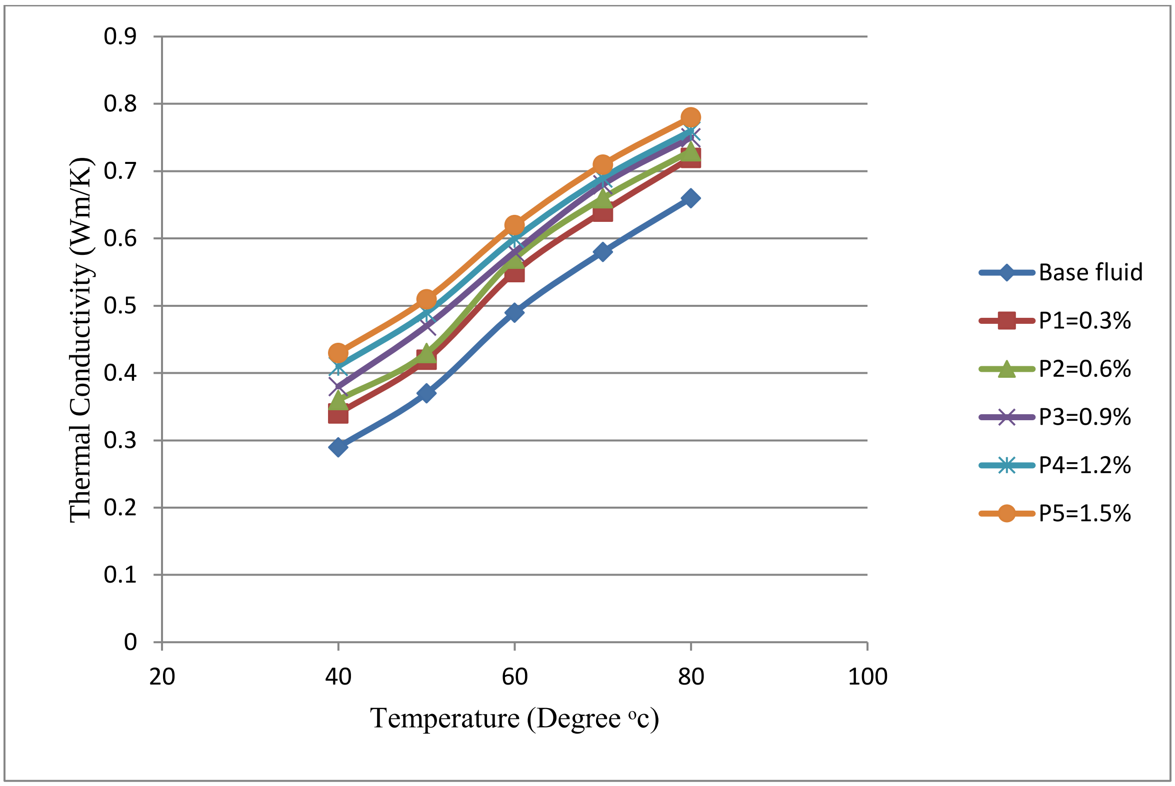

Figure 2: Effect of Temperature and volume fraction on Thermal Conductivity of 0.3 - 1.5 % volume concentrations of periwinkle shell nanofluid with Di ionize water/EG (50:50) Base Fluid

7. CONCLUSION

In this study, experimental investigations had been carried out to determine the viscosity and thermal conductivity of periwinkle shell nanofluids. It could be seen from the experimental data for viscosity that there is an enhancement in the viscosity as periwinkle shell nanoparticles concentration increases. Increase in temperature leads to decrease in viscosity. Also, the experimental data for thermal conductivity shows that thermal conductivity increase as periwinkle nanoparticles volume concentration and temperature increases.

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