EXPERIMENTAL INVESTIGATION ON VISCOSITY OF NANOFLUIDS PREPARED FROM BANANA FIBRE –NANOPARTICLES

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ABSTRACT

In this research for the first time, banana-fibre nanoparticles produced for nanofluid application and the viscosity of resultant nanofluids were measured.A Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM) were used to analyzethe sizes of the particles produced(200nm). This paper presents new findings on the synthesis of natural fibre to obtain nanoparticles and subsequently produced nanofluids. Nanofluids are prepared by dispersing Banana fibre- 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 Banana fibre nanoparticles into base fluid (DI water). A Vibro Viscometer machine (SV-10) is used to measure the viscosity of the prepared nanofluids more conveniently. For minimum and maximum volume fractions of *Banana* fibre-nanoparticles (0.3% and 1.5%) in deionized water,the viscosity was found to be 1.08 mPa.s and 1.23mPa.s, which increases slightly with an increase of particle volume fraction and decreases as the temperature increases.The experimental results show a maximum of 22% increasing of viscosity for 1.5% volume fraction of nanofluids as compared with the deionized water (base fluid). From the experimental study on prepared nanofluids conducted, results show that all the values of viscosities 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 (20^{o}C through 60^{o}C).

Key words: Nanofluids, Viscosity, Banana-fibre, nanoparticles

INTRODUCTION

Nanofluid which consists of nanoparticles in base fluid has the potential for high performance of heating and cooling in industrial processes and may create a saving in energy, reduce process time, raise thermal rating and lengthen the working life of equipment. Because of the suspended ultrafine particles has the potential to increase significantly the thermal conductivity of the mixture and improve its capability of energy exchange [1-3].The viscosity is one of the very important properties of nanofluids which are essential for the evaluation of heat transfer coefficient as well. This may vary with volume fraction and size of the nanoparticles and temperature of the nanofluid [4].

Many researchers [4-6] have been carried out for obtaining and measuring the viscosity of nanofluids made from metallic or non-metallic nanometers-size particles. However, there is lack of enough research on the viscosity of nanofluids made from natural fibers. Hence, the need to test the viscosity of nanofluids made from natural fiber (Banana fibre) becomes a paramount importance. In this paper we synthesized banana-fibre nanoparticles to prepare nanofluids and subsequently measured the viscosity.

Frankel and Acrivos [7] and Lee et al. [8] developed an equation for Al_2O_3 / water and ethylene glycol based nanofluids.

Many of the investigators [9-13] used different equations and they underestimate the effective viscosity of the nanofluids. Based on the literature [14], nanofluid viscosity significantly increases when particle volume fraction is increased and decreases when temperature increases.

EQUIPMENT

The banana stem was collected at Alhudahuda farm in Bauchi, Bauchi state, Nigeria.Nanoparticles were synthesis using ball milling machine at the National Institute for Chemical Technology Basawa Zaria, Nigeria. The temperature regime for the measurements was achieved using a programmable constant temperature thermal bath (LAUDA ECO RE1225 Silver). The bath was programmed with a ramp function to achieve a relatively uniform and steady control of the temperature of samples throughout the experiments. A digital Highland HCB1002 (max: 1000 g and precision: 0.01 g) weighing balance was used to measure the mass of the samples during preparation.
Samples nanofluids of 60cc prepared were sonicated for 40 minutes using Ultrasonic vibration with a 200 W, 24 kHz Hielscher ultrasonic processor (UP200S).

In order to synthesis the nanofluid samples used in this work, the well-known two-step techniquewas applied[15].The volume fraction (vf) of the nanoparticles was determined by calculating the equivalent mass of nanoparticles, using the mass of the base fluid and the densities of the nanoparticles as follows [13]:

$$\phi = \frac{Mp}{Mp+Mbf} \qquad (1)$$

where ϕ= volume fraction, Mp= mass of the particles Mbf = Mass of the base fluids.
Finally, the viscosity measurement was carried out using a constant shear rate vibro-viscometer (SV-10) from A&D, Japan. Figure1 shows the experimental set up. The measurements were done at the Nanofluids ResearchLaboratoryof the Department of Mechanical and Aeronautical Engineering, University of Pretoria. Pretoria, South Africa.

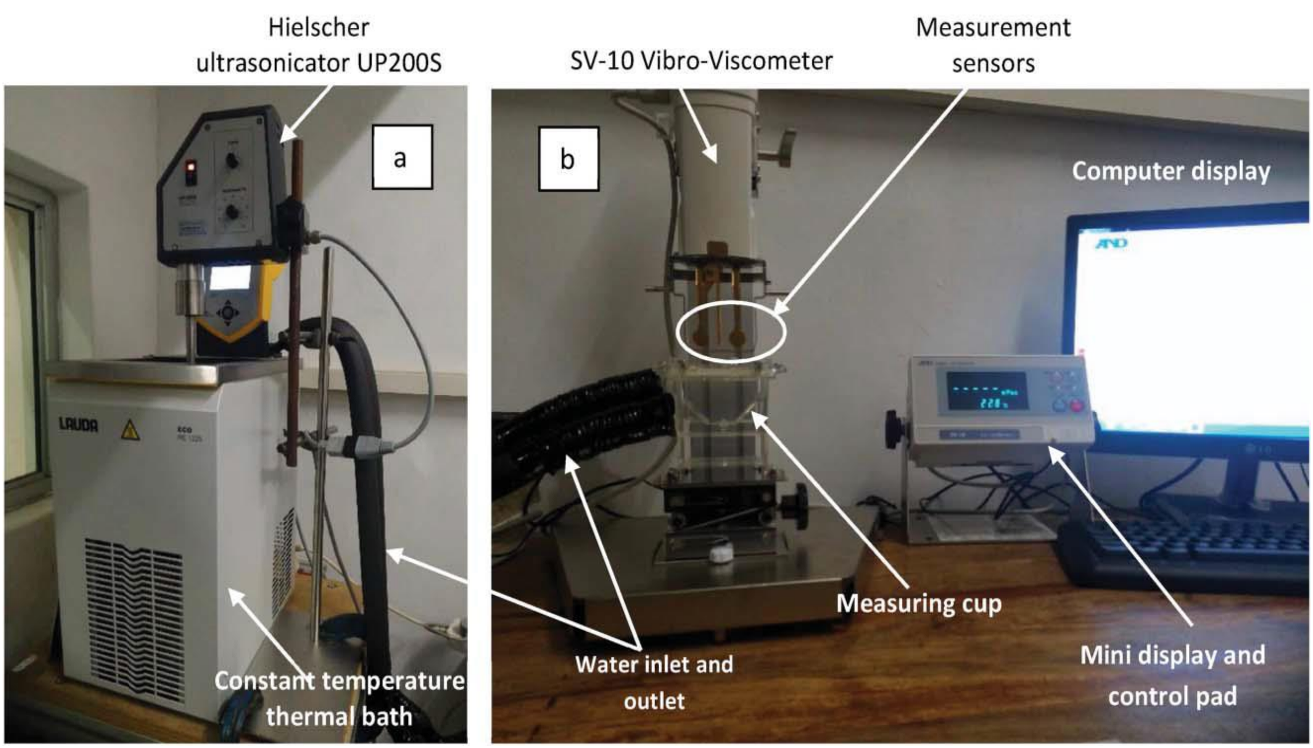

Figure 1: Experimental set up for measurement of viscosity

METHODS

Extraction of fibre from banana stem

The first step was to remove the leaves and flowers from the stem of matured banana tree. The stems were cut into pieces of different length and sizes. The pieces were then placed into a bucket filled with water to a level such that they were completely submerged. The bucket was covered to prevent air from entering it. The soaking lasted for two weeks. During the soaking period, tissues absorbed water and became swollen. Soluble compounds that can aid nourishment of decomposing bacteria were released. Bacteria and fungi broke down the soft tissues of the stem separating it from the cellulose material. It was then easy to remove the cellulose rich fibre. The decomposed stem was removed from the water after two weeks. It was washed with fresh water. The fibre was then separated from the soft tissue. These fibres makeup of the vascular tissue they contain both the vessels and the sclerenchyma fibres. The fibres were washed to remove all the epidermal and thick-walled woody xylem cells. After that the fibre was sun dried to remove water absorbed under constant temperature. Fig.2 shows the fibre obtained. The fibre was run into a ball milling machine to obtain nanoparticles as shown in figure 3.

Figure 2: Banana-fibre produced

Figure3: Nanoparticles produced

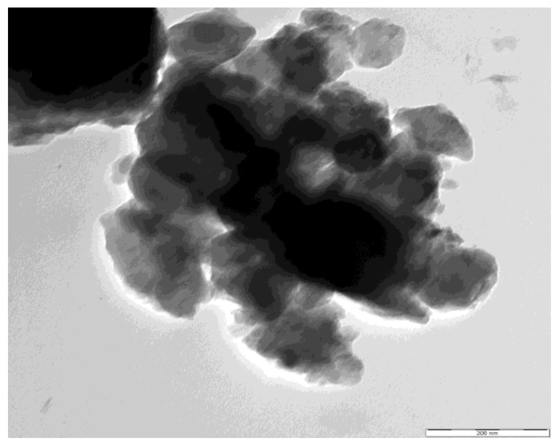

Figure4: TEM Image of banana-fibrenanoparticles

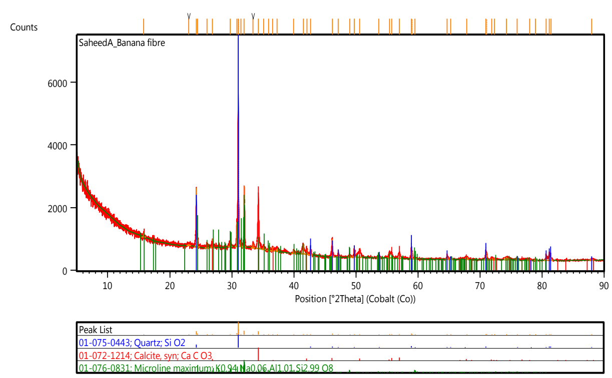

Figure5; X Ray Diffraction (XRD) pattern for Banana nanoparticle

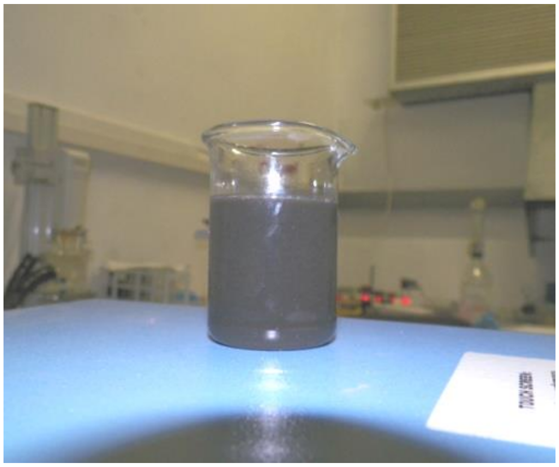

Figure 6: Image of prepared banana-fibrenanofluids

Nanofluids Preparation methods

Banana nanoparticles Nanofluids at different volume fractions (0.3 %, 0.6 %, 0.9 %, 1.2 %, and 1.5%) were prepared for property evaluation. Nanofluid samples were prepared by dispersing banana-fibre nanoparticles in the deionize water as base fluid. Different surfactant investigated to find the best for stability. Therefore, SDBS surfactant found as the best. To prepare nanofluid of specific volume fraction, samples were prepared by adding 0.1 % SDBS surfactant in all the different volume fractions prepared. The solution of the nanofluids was then stirred in a magnetic bath for 5 minutes. The samples nanofluids were homogenized using an Ultrasonic sonicator continuously for 40 minutes and the samples were observed for dispersion and stability.It was observed that, there was a negligible sedimentation of nanoparticles after 20 days.Fig. 6 shows the image of nanofluid prepared

EXPERIMENTATION

Measurement of Viscosity

The viscosity of the Dionize water (D I water) and the banana-fibre nanofluids at different volume fractions (0.3%, 0.6%, 0.9%, 1.2% 1.5%) and at different temperature (20^oC through 60^oC) were measured, the results of these experiments are showed in figure7.

RESULTS AND DISCUSSION

The viscosity, which is considered as factor that affect the heat transfer rate were measured at room temperature, the measurement was carried out at different volume fractions (0.3% 0,6%, 0.9%,1.2%,and 1.5%). For minimum and maximum volume fractions of *Banana* fibre-nanoparticles (0.3% and 1.5%) in deionized water,the viscosity was found to be 1.08 mPa.s and 1.23mPa.s, which increases slightly with an increase of particle volume fraction and decreases as the temperature increases. The viscosity results of the base fluid obtained in the present work at different temperature(20 through 60^o) are compared with the viscosity of the experimental work at different volume fractions (0.3 %, 0.6%, 0.9%, 1.2 % and 1.5 %). Results showed that the viscosities of the different volume fractions of prepared nanofluids are higher than the viscosity of base fluid as showed in fig7.

The measured viscosity of the banana-fibre nanofluids was observed to be decreasing exponentially with an increase in the nanofluid temperature and increases slightlywith the increased in the volume fraction. It can be also observed from the results that the trends in the change of viscosity with temperature for all the volume fractions of banana-fibre nanofluids are similar.

CONCLUSION

In this study, experimental investigations had been carried out to determine the viscosity of banana-fibre nanofluids. The study was achieved by viscometry machine considering the following parameters: volume fraction and temperature. From the results the viscosity of the prepared nanofluids it was observed to increase with increase in volume fractions of nanoparticles and exponential decrease with increase in temperature. For maximum volume fraction(1.5%),the increase in the viscosity was found to be 22%. This is a part of on-going research on using bio-material to produce nanofluids.

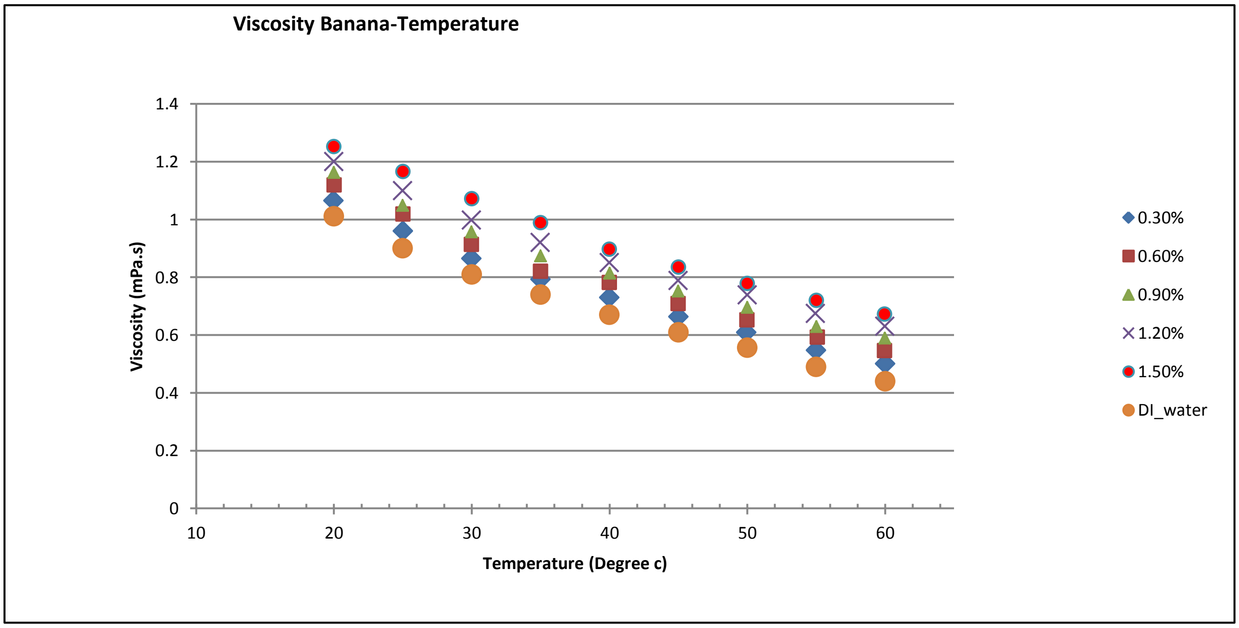

Figure 7: Comparison of viscosity results of de ionize water (base fluids) and different volume fractions of banana-fibre nanofluids

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