American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-2, pp-103-108
www.ajer.org
Research Paper Open Access

Experimental Investigation of Electrical Conductivity and Ph of Mango Bark *(Mangifera Indica*) Based Nanofluid

[1]BARKI, E.[2]IBRAHIM, J. S. [3] KUHE, A [4] IORTYER, H. A.

[1] Department of Mechanical Engineering, Benue State Polytechnic, Ugbokolo, Nigeria.
[2,3,4] Department of Mechanical Engineering, University of Agriculture, Makurdi, Nigeria.

ABSTRACT: *Over two decades now the preparation and study of the propertiesof nanofluids based on metallic and non-metallic oxides have received considerable attention. This researchinvestigated the use of bio-material (mango bark) for the preparation of nanofluid with the aim of experimentally determining the effect ofnanoparticle volume fraction and temperature variation on pH and electrical conductivity of mango bark (mangiferaindica)based nanofluid.The volume fractions used were 0.1%, 0.5%, 1.0%, 2.0%, 3.0% and 4.0% withdeionized water as the basefluid.The results show that the electrical conductivity increased as concentration and temperature increase and the percentage enhancement for electrical conductivity is 112.07% for 4.0% volume fraction. The pH of the nanofluid also increased as concentration increased and decreased as temperature increased.*

Keywords: *bio-materials, electrical conductivity,mangiferaindica,Nanofluid, pH,*

I. INTRODUCTION

Nanofluid is a dilute suspension of nanometer size particles and fibres dispersed in a liquid. Most research works reported on nanofluidsare on thermal conductivity enhancement. Electrical conductivity is also an important parameter for characterization of nanofluidsthat requiresattention [1].

Only a few studies have been reported on the electrical conductivity of nanofluids [2]. investigation of a long-multiwalled carbon nanotube (MwCNT) and Single-walled carbon nanotubes (SwCNT) in a mixture of 50% deionized water and 50% ethylene glycolwere respectively carried out [2,3]. Concentrations between 0.05 and 0.5 wt. % of SwNCT were used for the experiment. Authurs reported increase of the electrical conductivity as 0.12 and 1.7 µS/cm for 0 and 0.5 wt. % respectively. They concluded that the total increase of electrical conductivity of nanotube at 0.5wt. % was around 13 times that of the basefluid. Similarly, electrical conductivity for aluminum oxide nanofluids with deionized water as basefluid was investigated [1]. The nanofluid samples were reported to be stable for several days without appearance of sedimentation. The results showed that the electrical conductivity of alumina increased almost linearly by increasing volume fraction of alumina nanoparticles. The electrical conductivity also increased as temperature increased.They also determined the rate of enhancement of the electrical conductivity by dividing the difference between the electrical conductivity of thenanofluid and that of the base fluid by the electrical conductivity of the base fluid for all volume fractions of nanofluid. Their results showed that the enhancement increased with increase of volume fraction and temperature.

Kalpana-Sarojini*et al*[3]experimented on the electrical conductivity of nanofluids containing metallic and ceramic particles (Cu, Al_2O_3, and CuO) with different volume fractions in the dilute regime, particle sizes, electrolyte effect, temperature and base fluids. They observed that, in both water and ethylene glycol (EG)-based nanofluids, the electrical conductivity increases with increasing particle concentration and reducing particle size. They argued that the effective dielectric constant and density are at the root of the counter intuitive observation that the electrical conductivity enhancement of ceramic nanofluids is more than that of metal-based ones which is substantiated by the Clausius–Mossotti relation for the polar fluids. They also found that the influence of surfactant increases the stability and decreases the electrical conductivity of the nanofluids by increasing its viscosity. Their report also showed a rise in electrical conductivityof nanofluids having low electrolyte concentration whereas a decrement was observed in nanofluids of high electrolyte concentration due to reduced surface conductance.

The increase in the difference between the pH value and isoelectric point (the pH at which a molecule carries no net electrical charge) of nanofluidhas been reported to affect the fluid properties [4].

II. MATERIALS AND METHODS

2.1Preparation and Stability of Nanofluid

Mango bark (*MangiferaIndica*) fibreswere used for preparation of the nanoparticles. The samples collected were washed with distilled water to remove impurities, cut into smaller sizes and sun dried to eliminate moisture. The dried specimen was charged into the 87002 LIMOGE- France milling machine at Federal Institute of Industrial Research Oshodi, Lagos, Nigeria for processing into nano particles. The nano particles were oven dried for two hours. The two step method was used for the preparation of the nanofluid. Nanoparticles were dispersed in de-ionized water (basefluid) and sonicated for 1 hour to produce nanofluids of volume fractions of 0.1%, 0.5%, 1.0%, 2.0%, 3.0% and 4.0% respectively.Characterization of the nanoparticles was carried out. A weighing balance of high accuracy was used to determine sample masses for the respective volume fractions.Hielscher ultrasonic processor (up200s) was used to Sonicatethe mixture for uniform dispersion of the nanoparticles in the basefluid. The mass fraction of the nanoparticles for each volume fraction was determined using the equation stated by Eastman [5] in equation 1 below.

$$\phi = \frac{M_{np}/\rho_{np}}{\frac{M_{np}}{\rho_{np}} + \frac{M_{bf}}{M_{bf}}} \quad (1)$$

Where,
ϕ is the volume fraction;
$m_{np}$is the mass of nanoparticle;
$\rho_{np}$is the density of the nanoparticle;
$m_{bf}$is the mass of the base fluid and
$\rho_{bf}$is the density of the basefluid

The surfactants used during the experimentation to enhance stability were Hexadecyltri methyl ammonia bromide ($C_{19}H_{42}BrN$), sodium dodecylsulfate ($C_{12}H_{25}NaO_4S$) and lauric acid. 10wt % surfactant was added to each samples and sedimentation reaction of each sample was observed.A similar approachwas used by Wang *etal*[6]to determine the stability of nano-particle suspension.The various volume fractions were ultrasonicated at various energy levels for sonication time of one hour to overcome the aggregation of particles resulting from effective Vander Waals forces [7]. The Table 1 and plate 1 below show the volume fractions and sedimentation rate for mango bark with and without surfactants.

Table 1: Volume Fractions, and Sedimentation Rate for Mango Bark Fibres with and without Surfactants

S/No	Name of specimen	Volume fraction %	Name of surfactant	Duration	Observation
1	M.B + DI – Water	0.1– 4.0%	Nil	2 wks.	No settlement of particles was observed.
2	M.B + DI – Water	0.1– 4.0%	H.A.B	2wks	No settlement of particles was observed.
3	M.B + DI – Water	0.1– 4.0%	S.D.S	1wk 1 to 2wks	No settlement of particles observed. Settlement of some particles was observed
4	M.B + DI – Water	0.1– 4.0%	Lauric Acid	1-2hrs	Particles reacted forming colloidal solution.

(a)

(b)

(c)

(e)

Plate1: view of Specimens (a) Specimen without surfactant observed 2 weeks after sonication (b) and (c) Specimenwith surfactant 2 weeks after sonication (d) Specimen with surfactant, 2 hours after sonication

2.2 pH Measurement

The JENWAY pH meter model number 3510 was used for the experiment. The experimental set up is as shown in the plate 2below. The pH meter was calibrated using buffer solution standard value at 20^0C. In order to study the pH variation with temperature, the sample was heated between 10^0C and 60^0C and the instantaneous values of pH and temperature recorded. The experiment was repeated for 0.1%, 0.5%, 1%, 2%, 3%, 4% volume fractions for nanofluid produced from mango bark fibres

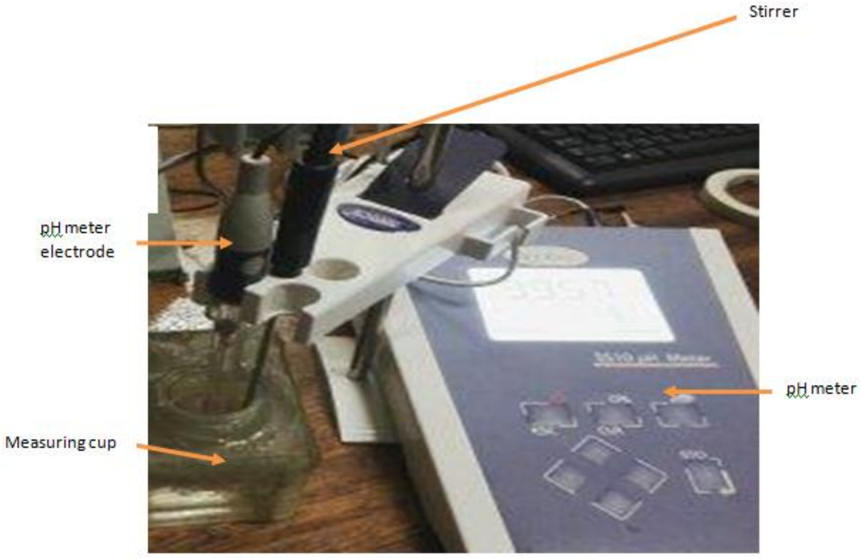


Plate 2: The JENWAY pH meter for measuring pH of nanofluids

2.3Electrical Conductivity

The electrical conductivity was measured using CON 700 conductivity / ^{0}C/ ^{0}F electrode meter. The experimental set up is as shown in plate 3 below. The instrument was calibrated with deionized (DI) water at 20^0C. The temperature of the water bath was varied between 10°C, 20°C, 30°C, 40°C, 50°C and 60°C and the electrical conductivity of the DI water was recorded accordingly with the instantaneous temperature. The electrode meter gives both temperature (°C) and electric conductivity (µs) values simultaneously at a given instant. Each volume fraction was transferred to the measuring cup and the meter electrode was dipped in the sample. The electrical conductivity enhancement was determined using Gangulyet *al.*,[1] equation as

$$Ek = \frac{E_{cnf} - E_{cbf}}{E_{cbf}} \qquad (2)$$

Where,
Ek is the electrical conductivity enhancement
E_{cnf} is the electrical conductivity of nanofluid
E_{cbf} is the electrical conductivity of basefluid

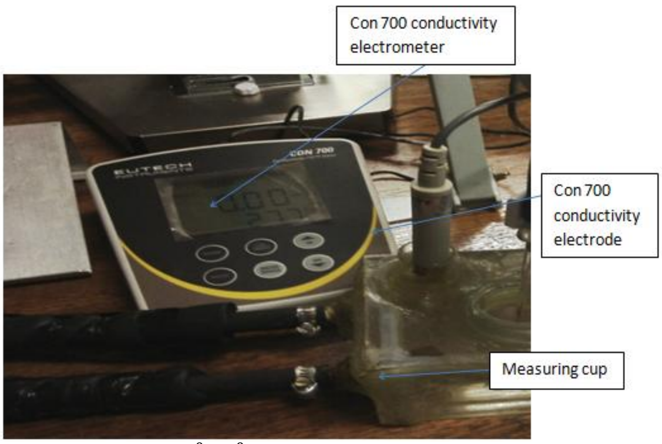


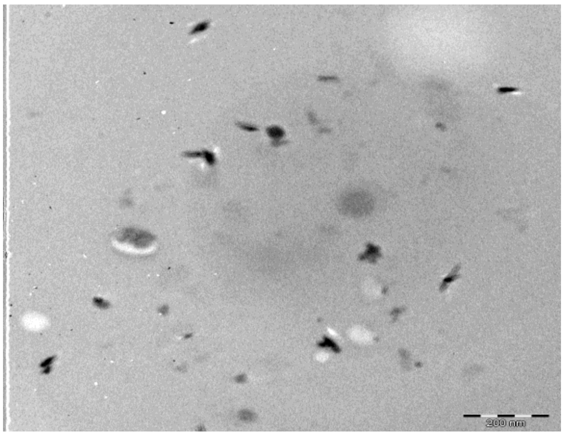
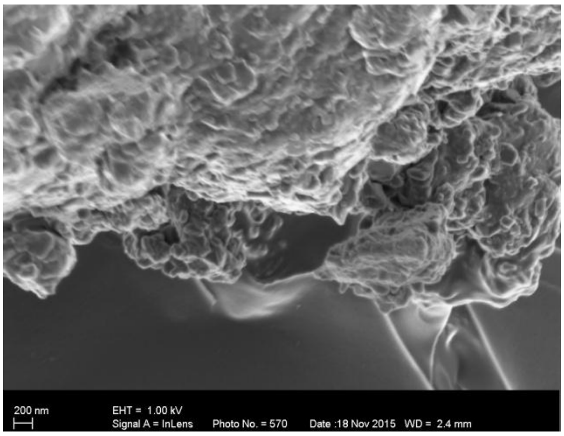
Plate 3: The CON 700 conductivity / ^{0}C/ ^{0}F electrode meter for measuring electrical conductivity

III. RESULTS AND DISCUSSIONS

3.1. Characterization of Nanoparticles

Plate 4ashowsthetransmission electron microscope **(**TEM)view for particle size of 200nm, and plate 4b the scanning electron microscope**(**SEM)view for 200nmrespectively for mango bark nanoparticles.

Mango bark based nanofluid without surfactant was used for the experiment as it shows good stability when compared with those with surfactants as shown in Table 1 above. The result of TEM showed that clustering of the nanoparticles occurred. This required the use of ultrasonication for uniform dispersion in the basefluid.

(a) **(b)**

Plate 4: (a) TEM View for 200nm (b) SEM View for 200nm for Mango Bark Nanoparticles

3.2 Variation of pH with Temperature

Fig.1 shows the effect of temperature on the pH of basefluid (de-ionized water) and mango bark based nanofluid for different volume fractions. Results show that the pH value increases slightly as the concentration of the nanoparticles increases in the basefliud for volume fractions of 0.5%, 1%, 2%, 3% and 4%. The values fluctuate but decreases slightly as the temperature increases for each of the volume fraction. The average pH values for 0.5%, 1%, 2%, 3% and 4% are 5.28, 5.39, 5.43, 5.45 and 5.44 respectively. For the basefluid, the pH value fluctuates within the same range 5.000 to 5.191 for temperatures of 10^0C to 55^0C. At 60^0C the pH values changes to 4.141.The average pH value on thebasefluid at temperature 10^0C to 60^0C is 5.000. The result also shows that for volume concentration of 0.1% volume fraction, the pH is slightly above that of the DI-water at 10^0C. The value decreases slightly as temperature increases. The average pH value for 0.1% volume fraction is 4.59.

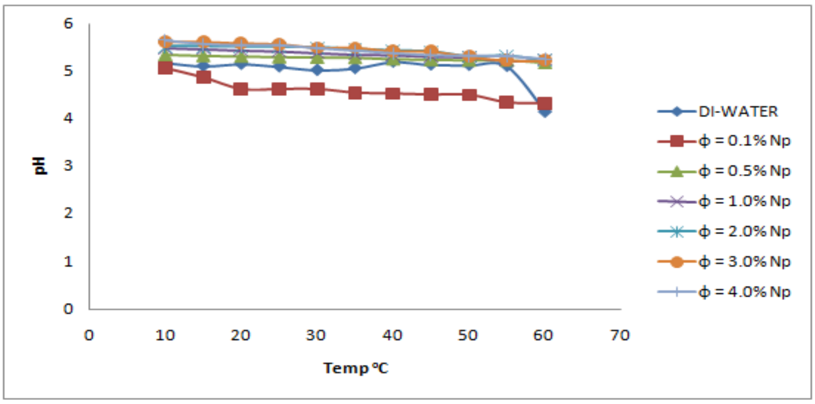


Figure1: pH vs Temp Variation at different Volume Concentrations for Mango Bark based Nanofluid

3.3 Variation of Electrical Conductivity with Concentration

Fig.2 shows the variation of electrical conductivity with temperature for mango bark based nanofluid for respective volume fractions of 0.1% to 4.0% compared to that of basefluid (de-ionized water). The results show a significant increase in the electrical conductivity of the nanofluid as the concentration of the nanoparticles increases. Similarly, the electrical conductivity increases with increase in temperature for all the volume fractions. The average electrical conductivity obtained for the volume fractions are 9.09, 74.9, 226.3, 330.4, 628.2, 927.1 and 1143.2µS/cm for volume concentration of 0%, 0.1%, 0.5%, 1.0%, 2.0%, 3.0% and 4.0% respectively.

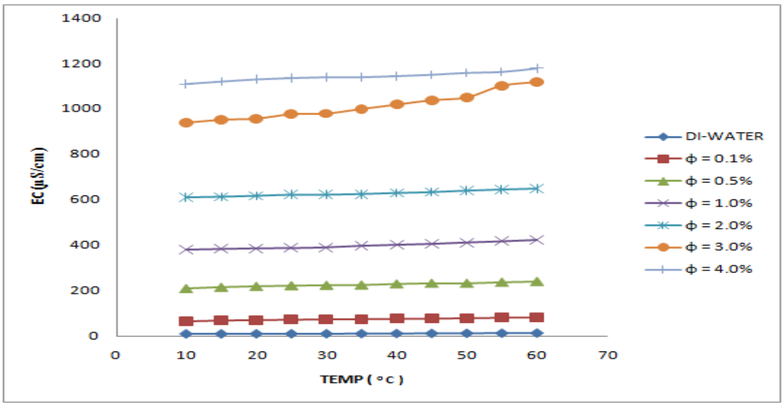


Figure2: Variation of Electrical Conductivity with Temperature for Mango Bark Nanofluidfor Volume Fractions of 0.1% To 4.0%

Fig.3 shows the electrical conductivity enhancements for mango bark based nanofluids using Ganguly *et al*. [1] equation. For 0.1% volume fraction of mango bark based nanofluid, an increase of 6.42% electrical conductivity was observed when compared with the basefluid. For 0.5% volume fraction, 20.39% electrical conductivity enhancement was obtained. The highest enhancement was observed for 4.0% volume fraction. The percentage enhancement at this volume fraction is 112.07%.

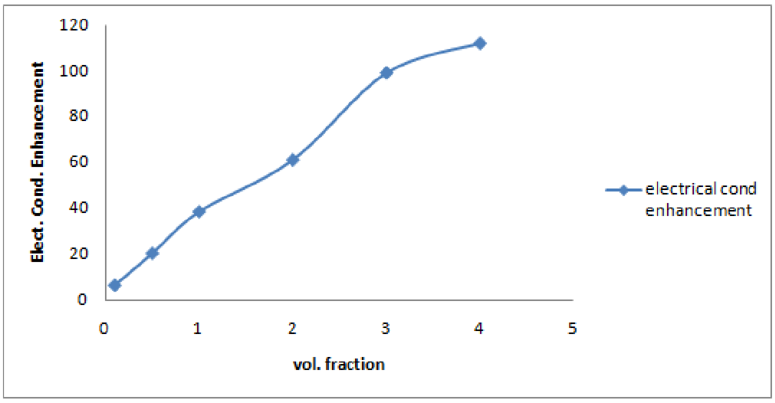


Figure 3: Electrical Conductivity Enhancement for Mango Bark based Nanofluid

The results were compared with existing work in the literature. It agreed with the works reported by some authurs in literature [1, 3, 8]. It also agreed with result of Glory *et al*[2] for lower volume fractions but vary at high volume fractions. Glover *et al*[8] investigated single-walled carbon nanotubes (SWCNT) in a mixture of 50% de-ionized water and 50% ethylene glycerol for concentration between 0.05 and 0.5wt% of SWCNT. They concluded that the electrical conductivity increases as concentration increases. Ganguly*et al.*[1]prepared aluminium oxide nanofluids with deionised water as basefliud. They stated that the electrical conductivity increases linearly with increasing volume fraction of alumina nanoparticles. Kalpana-Sarojini*et al.*[1] investigated the Cu, Al_2O_3 and CuO based nanofluid in both water and ethylene glycol. They concluded that the electrical conductivity increases with increasing particle concentration and reducing particle size. Glory *et al*[2] investigated long multi walled carbon nanotube with distilled water as the basefluid. They stated that the electrical conductivity for 0.01 wt % was 0.35 us/cm and increases to 0.448 us/cm for 0.1 wt %. However, at 2 and 3 wt %, they stated that there was no significant change in the electrical conductivity and the values were 0.454 and 0.453 us/cm respectively.

IV. CONCLUSION AND RECOMMENDATION

From the result of this research it has been shown that there is a linear increase in electrical conductivity of the nanofluid with particle volume fractionand a significant increase in electrical conductivity enhancement was also observed. The Result for pH investigation shows that the nanofluid has the same trend of increase in pH value as the concentration increases and decreases as the temperature increases. This is in agreement with reported works in literature for metallic and non-metallic oxide based nanofluids.

Research on viscosity and stability of mango bark (mangiferaindica) based nanofluid has been reported elsewhere [9].Based on the present works it can be stated that mango bark based nanofluid is a good substitute/alternative for metallic and non-metallic oxide nanofluids for heat enhancement. However, other important factorshave been reported to influence the heat transfer performance of the nanofluids. So, further works will include experimental investigations of heat transfer potentials of the bio-inspired nanofluid.

REFERENCES

[1] Ganguly, S., Sudipta S., and Somnath ,B.Experimental Investigation of the Effective Electrical Conductivity of Aluminum Oxide Nanofluids. *Powder Technology* vol. 196 (3),2009, 326 -330.

[2] Glory, J., Bonetti, M., Helezen, M., Hermite, M.M.L.and Reynaud, C. Thermal and Electrical Conductivities of Water-based Nanofluidsprepared with long Multiwalled Carbon Nanotubes. *Journal of Appl Phys.*vol.103, 2008, 303-309

[3] Kalpana- Sarojini, K.G. K., Manoj, S. V., Singh, P. K., Pradeep, T. and Das, S. K.Electrical conductivity of ceramic and metallic nanofluids*Colloids and Surfaces A: Physicochem. Eng. Aspects (417)*,2013, *39– 46*

[4] Xie, H., Wang, J., Xi, T., Liu, Y., Ai, F., and Wu, Q. Dependence of Thermal Conductivity of Nanoparticles-fluid Mixture on the Basefluid. *Journal of material sci. Letters 21(19)*,2002b, *1469- 1471*

[5] Eastman, J. A., Choi, U. S., Li, S., Thompson, L. J., and Lee, S. Enhanced thermal conductivity through the development of nanofluids. volume 457 of Materials Research Society Symposium - Proceedings. Materials Research Society, Pittsburgh, PA, USA, Boston, MA, USA,1997, 3-11

[6] Wang, X., Zhu, D., and Yang, S. Investigation of Ph and SDBS on Enhancement of Thermal Conductivity in Nanofluids. *ChemPhys Letters 470(1-3)*, 2009, *107-111*

[7] Cheng, Q., Debnath, S.andGregan, E. Ultrasound Assisted SWNTS Dispersion. Effects of Sonication Parameters and Solvent Properties.*Journal of physical chemistry* vol. 114,2010, 8821-8827.

[8] Glover, B. ,Keit h , W. W., Haiping , H., Arnab , M., and Edward, W. B. Effective Electrical Conductivity of Functional Single Wall Carbon Nanotubes in Aqueous Fluids . *Synthetic Metals* vol. 158 (12),2008, 506 -508.

[9] Barki, E., Ibrahim, J. S., Kuhe, A. and Iortyer, H. A. Experimental Studies of Viscosity and Stability of Mango Bark (*MangiferaIndica*) based Nanofluid.2nd African Conference / Workshop. An International Conference on all aspects of Nanotechnology held at University of Nigeria, Nsukka,Nigeria,2016.