IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 12 (December. 2018), ||V (V) || PP 01-13

Effect of Titanium Oxide Nanoparticles on the Physical Properties of Jatropha and Neem Seed-Based Oils for use in Power Equipment

*Ado Musa and F.R.Tambuwal**

Department of Physics, Aminu Saleh College of Education, Azare, Bauchi State, Nigeria
***Department of Integrated science, ShehuShagari College of Education, Sokoto, Nigeria*
Corresponding Author: Ado Musa

Abstract: Environmental concern has brought forward esters derived from seed-based oils as viable alternative insulating fluids for oil-filled power equipment. Even though there are natural ester fluids that are developed from seed-based oils, research continues towards improving properties of natural ester fluids. Recent works show that well-dispersed nanoparticles in base fluids enhance thermal and high voltage insulation properties of the fluids. This paper presents the effect of dispersion of titanium oxide nanoparticles on the physical properties of Jatropha and Neem oils for use in power equipment. Calculated percentage of titanium oxide nanoparticles were dispersed in the oils. Dynamic viscosity, flash point and pour point of the insulating oils were evaluated. The results show 26.5% decrease in viscosity at room temperature and 31.2% and 43.2% decrease in the viscosity at 40ºC and 70ºC respectively with the dispersion of 1% nanoparticles in the base fluid. The flash and pour points of the nanofluid were observed to have increased by 9.5% and 45.5% respectively for the same weight per cent. This shows that the addition of titanium oxide nanoparticles to these oils has desirable effects on the dynamic viscosity and flash points but negative effects on the pour points of the nanofluids. The nanofluids could be efficient insulation oils for use in power equipment subject to other relevant tests such as loss tangent and breakdown tests.

Key Words: Dynamic Viscosity, Flash point, pour point

Date of Submission: 14-12-2018 Date of acceptance: 29-12-2018

I. INTRODUCTION

Mineral-based oil has for long been used efficiently for insulation in power equipment all over the world [Huifei, 2015]. But mineral oil is toxic and non-biodegradable, which causes serious health, safety and environmental (HSE) concern [Bandara*et al*; 2016]. This provided impetus for scientists to search for environmentally superior alternative insulating oils for applications in power equipment. Seed-based oils or natural esters provided such alternative [Okaforand Okafor, 2018]. Jatropha and Neem oils, for example, possess the potentialities to cater for such applications due to their various characteristics such as high seed yield, low requirement of water/drought resistant, non-edibility, availability, adaptability and high oil content [Michal *et al,* 2018; Evangelista *et al,* 2017,]. However, natural esters have high viscosity which reduces easy flow of insulating oil in power equipment [Rajab *et al*; 2011]. Dispersion of nanoparticles in these oils has been found to reduce the viscosity and improve other physicochemical properties such as pour point and flash point [Wong and Leon; 2016]. The idea of nanofluid came as a result of consistent research and technology advancements. Nanofluid can easily be referred to as the fluids with particles of said average size of less than 100 nm dispersed in it. Similarly, mineral-based insulating nanofluids have been reported to have achieved high electrical insulation [Sanchez and Rodriguez, 2016]. Nevertheless, thermal conductivity of the oils was reported to have ineffective characteristics on the insulating properties of the mineral-based fluid [Thanigaiselvan *et al,* 2015]. But the dispersion of nanoparticles to seed-based oils has been reported to have enhanced the electrical insulation as well as thermal properties of the base fluids [Rajalingam*et al,* 2016]. The improvement reported on the part of seed-based nano-insulating oils shows that these oils can replace the mineral-based insulating nanofluid in power equipment [Wei Yao *et. al,* 2018]. Poor stability and low heat-transfer capability of the insulating nanofluids are most likely attributable to the changing slowly and settling of the agglomerated particles in the base-fluid, correspondingly, it was reported to have poor cohesions between the nanoparticles and the base-fluid soon after the nanoparticles were introduced into the oils; the particles settled at the bottom of the base fluids within short time after dispersion [Madavan*et al,* 2018]. However, with the addition of right type of dispersants, compatibility between the nanoparticles and oil-based fluid can allow harmony and desirable qualities of the base-fluids to be achieved. This paper discusses on the effect of titanium oxide nanoparticles on some of the physical properties of Jatropha and Neem seed-based oils for use in power equipment.

II. MATERIALS AND METHOD

2.1. Materials

Jatropha curcas and Neem oils were obtained from National Research Institute for Chemicals Technology (NARICT), Zaria, Magnetic stirrer, NaOH solution, functionalized nano Titanium oxide powder of purity (99.5%) with 10-30nm particles size, Oleic acid, ethanol and citric acid, silica gel and Fuller's earth were obtained from Materials Science Lab., Department of Physics Ahmadu Bello University, Zaria.

2.2 Method

Dijkstra and Opstal purification method was adopted. 500g each of crude Jatropha curcas and Neem oils was purified in a conical flask using NaOH, Silica gel and Fullers' earth. Citric acid was used as catalyst. The sample was heated to 70ºC and kept in a vacuum oven at 80ºC for 40 minutes to reduce water content. 5 g of Silica gel was added to the oil at 70ºC and then agitated for 30 minutes at 1200 rpm. 25 g of Fullers' earth was then added and stirred with a magnetic stirrer for 30 minutes at constant temperature. The oils were then filtered in the vacuum oven at 80ºC using filter paper.

50 g each of Jatropha and Neem seed oils was poured separately into a conical flask and heated to 70 °C for an hour. Five samples of nanofluid were prepared by adding 0.2wt%, 0.4wt%, 0.6wt%, 0.8wt% and 1.0wt% of titanium oxide (TiO_2) nanoparticles to the oil. TiO_2nanoparticles was functionalized with oleic acid. Each sample was stirred with a magnetic stirrer at the rate of 1200rpm for 20-25 minutes to disperse the nanoparticles and prevent agglomeration. Flash points and pour pointsof the nanofluids were determined. Dynamic viscosity was measured over a temperature range of 27 °C to 70 °C. The experiments were conducted at Materials Science Lab; Department of Physics, and Chemical Engineering Lab; Dept. of Chemical Engineering, A.B.U; Zaria, Nigeria.

III. RESULTS AND DISCUSSION

Figures 1 – 4 shows the experimental results for flash points, pour points, and dynamic viscosity.

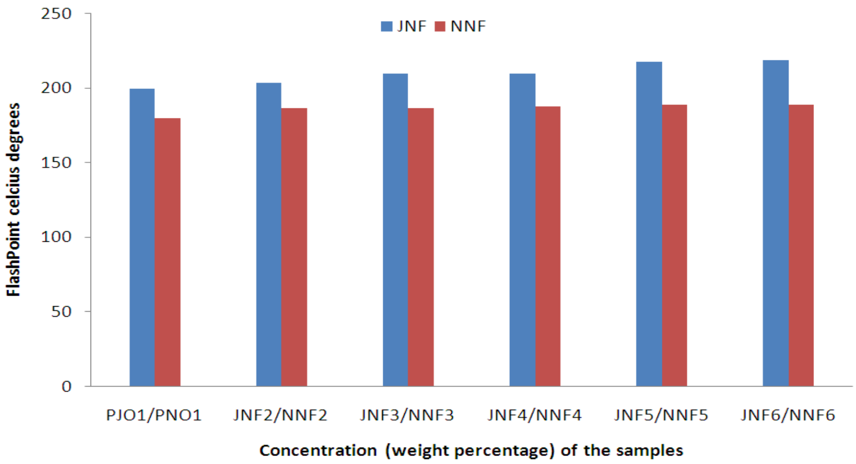

Figure 1: flash points vs. concentration (wt. %) of the samples

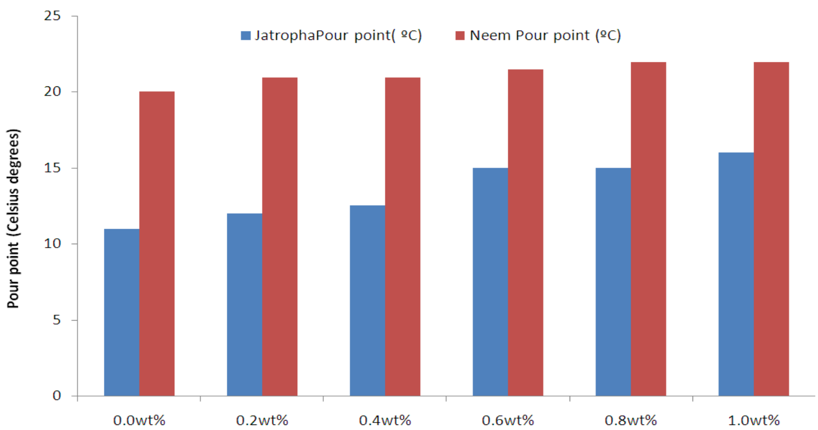

Figure 2: Pour points vs. Concentration (wt. %)

The results of this study indicate that both Jatropha and Neem oils have high flash points similar to most of vegetable oil. They fall in the category of high temperature oil. Meanwhile, the flash point of the oil samples was observed to have increased with the dispersion of titanium oxide nanoparticles. Increase in the amount of the dispersed nanoparticles was observed to lead to an increase in flash point as shown in Figure 1. The flash point of Jatropha nanofluid increased from 200°C to 219°C when 1 wt%nanoparticles was dispersed in the fluid while that of Neem nanofluid increased from 180°C to 189°C with the same concentration of nanoparticles, representing 9.5% and 5.0% increase respectively. On the other hand, the pour point of Jatropha nanofluid increased by 45.5% as shownin Figure 2, Neem nanofluid increased by 10.0% for 1.0wt% nanoparticles dispersion. The higher the flash point of the fluids, the more it is thermally stable, hence the increased flash point of thenanofluid samples is an advantage to it performance in power equipment. The number of saturated fatty acids in the oils may be attributable to the high flash point of the oils and the enhancement of the flash point with the dispersant may have resulted from the restriction of the triglycerides of the base fluids from dissociation.

Viscosity is an important fluid property when analysing liquid behaviour. It is a measure of internal friction of the liquid when it is flowing. The dynamic viscosities of all the samples were measured against varioustemperatures as shown in Figure3 and Figure 4. The results indicate a general decrease in viscosities of both nanofluids at all recorded temperatures. But the rate of decrease approaches a certain minimum as the concentration of nanoparticles increases. At room temperature of 27°C, the dynamic viscosities of Jatropha and Neem nanofluids decreased by 26.5% and 26.8% respectively. At 70°C, however, the decrease in dynamic viscosities of both nanofluids was remarkably higher, being 43.2% for Jatropha and 72.9% for Neem at 1wt% concentration of nanoparticles. The viscosity of water based nanofluid is known to increase with the concentration of the nanoparticles dispersed in it. The reason for the decrease in the vegetable based nanofluids with increase in the concentration of the dispersed particles is not established yet.

IV. CONCLUSION

The addition of titanium oxide nanoparticles to seed-based oils has desirable effects on dynamic viscosity and flash points but with negative impact on the pour points of Jatropha and Neem nanofluids. This negative effect can be overcome with the addition of pour point depressant to reduce the pour point of the oil samples. The dispersion of titanium oxide nanoparticles to the seed-based oils appears to improve the thermo-physical properties of the base fluids, and hence, the produced nanofluid could be efficient insulation oils for use in power equipment subject to other relevant test such as the loss tangent and breakdown test.

REFERENCES

[1]. J. Huifei, *Dielectric strength and thermal conductivity of Mineral based Nanofluid,* doctoral diss., Delft University of Technology, Netherlands, 2015.

[2]. K. Bandara, C. Ekanayake, T.K. Saha, and P.K. Annamada, Understanding the aging aspects of natural ester-based insulation liquid in power transformer. *IEEE Transaction on Dielectric and Electrical Insulation*, *23*, 2016, 246-257.

[3]. K.O. Okafor and J.O. Okafor, Production and characterization of electrical transformer insulating fluid from blending Castor and Neem seed oils, *IOP Conference, Journal of Earth and Environmental Science*, 173, 2018.

[4]. K. Michal, Dielectric properties of biodegradable vegetable oil based nanofluid, *19th International Scientific Conference Paper on Electric Power Engineering (EPE)*, held on 16-18 May, 2018, IEEE, 2376-5631.

[5]. Jr. Evangelista, E. Fabricio, C. Bortot, A.O. Juliana, E. Carvalho, M.R. Araujo, L.S. Tania, and A.S. Miranda, Development of a new bio-based insulating fluid from Jatropha curcas oil for power transformers, *Advances in Chemical Engineering & Science, 7*, 2017, 235-255.

[6]. Rajab, A. Salaeman, S. Sudirhan, and A. Suwarnon, Comparison of dielectric properties of palm oil with mineral and synthetic type insulating liquid under temperature variation, *ITB Journal of Engineering Science, 43*, 2011, 191-208.

[7]. K.V. Wong, and O. De Leon, Applications of nanofluids: current and future, *Advances in Mechanical Engineering, 20*, 2016, 1-11.

[8]. M. Sanchez-Dominguez and C. Rodriguez-Abreu, *Nanocolloids: A Meeting Point for Scientists and Technologists*Elsevier, 2016.

[9]. R. Thanigaiselvan, T.S.R. Raja, and R. Karthik, Investigation of eco-friendly insulating fluids from Rapeseed and PongamiaPinnata oils for power transformer applications, *Journal of Electrical and Engineering Technology, 10*, 2015, 921-718.

[10]. Rajalingam, S.P. Jani, K.A. Senthil and K. Adam, The effect in Neem oil biodiesel properties due to the blending of cerium oxide nanoparticles, *International Journal for Research in Applied Science and Engineering Technology (IJRASET), 4(11)*, 2016, 2321-9653.

[11]. W. Yao,Z.Huang, J.Li, L. Wu and C. Xiang, Enhanced electrical insulation and heat transfer performance of vegetable oil based nanofluids, *Journal of Nanomaterials*, 2018, 12 pages.

[12]. R. Madavan, K. Senthil and I. Willuice, A comparative investigation on effects of nanoparticles on characteristics of natural esters-based nanofluids, *Elsevier Journal, 556*, 2018, 30-36.

Ado Musa. “Effect of Titanium Oxide Nanoparticles on the Physical Properties of Jatropha and Neem Seed-Based Oils for use in Power Equipment.” IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 12, 2018, pp. 13-16.