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EFFECTS OF MgO NANO PARTICLES ON VISCOSITY OF TRANSESTERIFIED RAPESEED OIL

H. U. Jamo[1], E. Tolufase[2], F.U. Musa[3], U. I. Ismail[4], Aliyu S. A.[5] and M.B. Abdullahi[1]

[1]Department of Physics, Kano University of Science and Technology, Wudil, P.M.B. 3244 Kano-Nigeria
[2]Department of Physics, Nigeria Police Academy Wudil, P.M.B. 3474, Kano-Nigeria
[3]Science and Technical Schools Board, Plot 546 Yan-Awaki Quarters Opp IBB Way Kano
[4]Department of Physics, Sule Lamido University, Kafin Hausa P.M.B. 048 Jigawa-Nigeria
[5]Department of Physical Sciences, Rabiu Musa Kwankwaso College of Advanced Studies, Tudun Wada, Kano

Abstract

Biodiesel is a renewable, biodegradable, environmentally benign, energy efficient, substitution fuel which can fulfill energy security needs without sacrificing engine's operational performance. Thus it provides a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. This research aimed at investigating the effects of MgO nanoparticles on viscosity of transesterified rapeseed oil. The crude rapeseed oil was purified, transesterified and nanoparticles were dispersed in the transesterified oil with concentration ranging from 0.2% to 1.0% in 0.2% interval. X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used to observe the surface morphology and internal structure of the nanoparticles. Fourier Transform Infrared spectra (FTIR) were used to examine the structures of the samples. It was found out among other things that small amount of 0.6% of MgO nanoparticles in the oil could improve the viscosity of the fluid. It could be concluded that the optimum amount of MgO nanoparticles to be used for nanofliud is 0.6%. Hence, the transesterified rapeseed containing 0.6% of MgO nanoparticles has the potential to used as a biodiesel oil.

Keywords; MgO, Nano-fluid, Rapeseed oil, SEM, XRF, XRD

Introduction

Biodiesel is gradually gaining acceptance in the market as an environmentally friendly fuel and the demand is expected to increase sharply as an alternative renewable energy source in the near future. Biodiesel fuel is mono alkyl ester derived from vegetable or animal and it can be blended with diesel fuel which has characteristics similar to diesel fuel and has lower exhaust emissions [1–9]. On the other hand, the main drawbacks of vegetable oil have to overcome due to the high viscosity and low volatility which will cause a poor combustion in diesel engines. Transesterification is the process successfully employed to reduce the viscosity of biodiesel for lubrication and improve the other characteristics [10]. Lubricants are being utilized in all sectors of industry for lubricating their machines and materials. Reports indicate that nearly 39 million metric tons of lubricants were used globally in 2018, with a projected increase of 1.2% over the next decade [11]. Approximately 85% of lubricants being used around the world are petroleum-based oils. Enormous use of petroleum based oils, created many negative effects on environment. The major negative effect is particularly linked to their inappropriate use, which results in surface water and groundwater contamination, air pollution, soil contamination, and consequently, agricultural product and food contamination. Stronger environmental concerns and growing regulations over contamination and pollution will increase the need for renewable and biodegradable lubricants [12-23]. The addition of nanoparticles into a lubricating oil is expected to enhance significantly the oxidative stability, reduces the friction coefficient and increases the load-bearing capacity of the friction parts in mechanical systems.

Corresponding Author**:** Jamo H.U., Email: jamouhfce@gmail.com, Tel: +2348026274525

A variety of mechanisms have been proposed to explain the lubrication enhancement of the nanoparticle suspended lubricating oil (i.e., nano-oil), including the ball bearing effect [13], protective film mending effect and polishing effect. These mechanisms can be mainly classified into two groups. The first is the direct effect of the nanoparticles on lubrication enhancement. The nanoparticles suspended in lubricating oil play the role of ball bearings between the friction surfaces. In addition, they also make a protective film to some extent by coating the rough friction surfaces [14]. The other is the secondary effect of the presence of nanoparticles on surface enhancement. The nanoparticles deposit on the friction surface and compensate for the loss of mass, which is known as mending effect. And also the roughness of the lubricating surface is reduced by nanoparticle-assisted abrasion, which is known as a polishing effect.
However, paper wishes to investigate the effects of MgO Nano particles on viscosity of biodiesel extracted from rapeseed oil. The addition of small amount of MgO nanoparticles in biodiesel is expected to bring about boost in the viscosity of the biodiesel. Moreover, the use of nanoparticles as additives has proven to increase the efficiency of the vegetable oils. Hence, therefore, the aim of this research is to study effects of MgO nanoparticles on the viscosity of transesterified rapeseed oil

Methodology

X-ray Fluorescence (XRF)

The XRF of the MgO nanoparticles was observed at Umaru Musa Yaraduwa University Katsina, in order to study the percentage concentration of the oxide composed in the sample of nanoparticle used to carry out the research.

Scanning Electron Microscopy (SEM)

The surface morphology of the titanium oxides was observed using multipurpose Scanning Electron Microscope [SEM] PHENOM PROXMVE016477830, at Umaru Musa Yaraduwa University Katsina. Small amount of the sample powder was poured on the carbon tape which is attached to the holder. Then the excess powder was blown off with air gun to ensure that only small pieces of the powder remain on the tape. After that, it was put into in the SEM chamber for analysis. The SEM machine was operated at 10kV. A magnification of X100 was used to capture the photo of the sample.

X-Ray Diffraction (XRD)

The samples were subjected to X-Ray Diffraction (XRD) analysis using an X-Ray Diffractometer at Umaru Musa Yaraduwa University Katsina. The samples were analyzed by Cu Kα radiation with a scanning rate of 0.05^o per second 40 kV/20A, speed 0.05^o /min and scanning at $0^o \geq 2\Theta \leq 70^o$.

Sample Purification

The rapeseed oil was purified through the following procedure; 200 ml of the rapeseed oil was measured using measuring cylinder; the oil was pre-heated to 70 ^{o}C using hot magnet stirrer with thermometer. Then 1.5 ml citric acid was measured and added to the heated oil sample and continuously heated and stirred for 15 minutes at 70 ^{o}C.4 ml of 8 % NaOH (by dissolving 8 g NaOH in 100 ml of distilled water) was then be added to the oil and continuously heated and stirred for 15 minutes at 70 ^{o}C. The mixture was then transferred to the vacuum oven where it was heated at 85 ^{o}C for 30 minutes. Then the mixture was taken back to hot magnetic stirrer and heated to 70 ^{o}C after which a 2 g 0f silicone reagent was added while it was being heated and stirred for 30 minutes. Then the temperature was increased to 85 ^{o}C and 4 g of activated carbon was added to each 100 ml of the oil sample, heated and stirred for 30 munites. Then the mixture was separated using filter paper.

Trans-esterification

60g of the crude rapeseed oil was measured in 250ml of conical flask and was heated and stirred to a temperature of 60-65℃ on a hot magnetic stirrer plate, 0.6g of NaOH was measured using the electronic weight machine and allowed to dissolve in 21ml of methanol and then allowed to heat for 60 minutes with the stirrer on the hot magnetic plate. After 60 minute of uniform stirring and heating on the hot magnetic plate maintaining a temperature of 65℃, it was then poured into the separating funnel through a glass funnel. The mixture was allowed to cool for about 40 minute. Afterwards, it was observed that it separated into two liquid layers. The upper layer is the biodiesel and the lower layer is triglycrol fatty acid. The biodiesel was then separated from its byproduct.

Nano-fluids Preparation

The MgO Nano-particles powder was purchased from Sky Spring Nanomaterials, Inc., U. S. A, Nano-fluids are prepared by two step process. The volume concentration of 0.2%, 0.4%, 0.6%, 0.8% and 1% of powdered nanoparticles and purified rapeseed oil was made respectively. To make the nanoparticles more stable and remain more dispersed, each sample was stirred for 3-4 hours using magnetic stirrer, then the samples were taken for analysis.

Samples measurement Viscosity

Viscosity was measured using Brookfield viscometer in a speed range of 50 rpm with spindle size of 2 since a small quantity of the sample is to be measured. The following are the detailed procedure for viscosity measurement. The sample was poured into a beaker, the spindle was fixed and the machine was started, the angular speed was selected on the viscometer and the viscosity was read and recorded the same procedure was repeated for the purified rapeseed.

- **Dynamic Viscosity**

Dynamic (which is also known as absolute viscosity, or simple viscosity or sometimes, it is just called viscosity), represented by the symbol η, is the ratio of the shearing stress (*F*/*A*) to the velocity gradient (dv_x /dz) in a fluid.

$$\eta = \frac{\frac{F}{A}}{\frac{dVx}{dZ}} \quad (1)$$

Where F is the force applied and A is the area.

The more usual form of this relationship, called Newton's equation, states that the resulting shear of a fluid is directly proportional to the force applied and inversely proportional to its viscosity. The similarity to Newton's second law of motion (*F* = *ma*) should be apparent. (Patil, 2009).

$$\frac{F}{A} = \eta \frac{dvx}{dz} \quad (2)$$

$$F = \eta \frac{dv}{dt} \quad (3)$$

The SI unit of viscosity is the pascal second [Pa S]. The most common unit of viscosity is the dyne second per square centimeter [dyne s/cm2], which is given the name poise. Ten poise equal one pascal second [Pa S] making the centipoise [CP] and millipascal second [mPa S] identical.

Results and Discussions

SEM

Figure 1 shows the SEM image of MgO nanoparticle. The image reveals white irregular particles with porous texture.

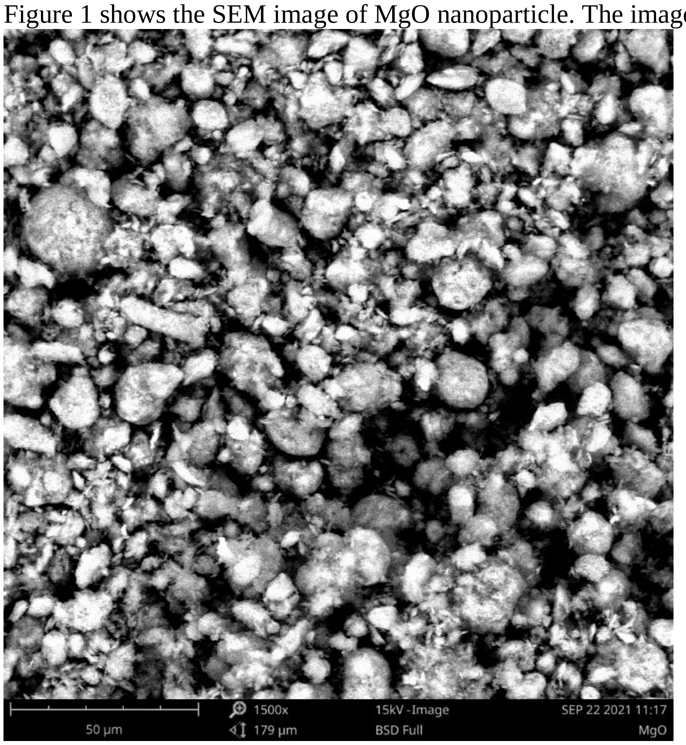

Figure 1: SEM of MgO

XRD

Figure 2 shows the XRD pattern of the MgO nanoparticles. The X-ray diffraction scanning angle is from 0° to 70°. The pattern indicated the crystalline phases which reveals that MgO nanoparticle crystalline is in nature. A similar pattern was reported by Anzelmo [23].

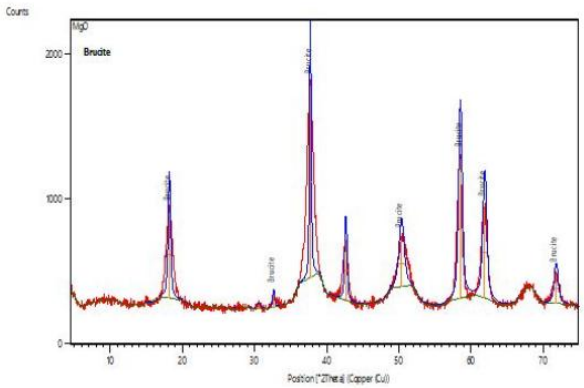

Figure 2: XRD of MgO Nanoparticles

XRF

Table1 shows XRF of the MgO nanoparticles, It could be seen that from the table that MgO (92.4) has the highest percentage in the sample followed by SiO_2 (2.49).

Table 1**:** The percentage concentration of the element

Element	MgO	SiO_2	CaO	SO_3	Al_2O_3	P_2O_5	K_2O	Cl	La_2O_3	NiO
Conc. (%)	92.4	2.49	2.20	0.86	0.69	0.47	0.38	0.28	0.06	0.05

Viscosity

The viscosity of a transesterified oil, i.e., biodiesel, is about an order of magnitude lower than that of the parent oil as shown in Figure 3. High viscosity is the major fuel property which explains why neat vegetable oils have been largely abandoned as alternative diesel fuel [20]. Viscosity increases with chain length (number of carbon atoms). This holds also for the alcohol moiety because the viscosity of ethyl esters is slightly higher than that of methyl esters [21]. As the lengths of the acid and alcohol segments in the ester molecules increased, so did the degree of random intermolecular interactions and consequently the viscosity.

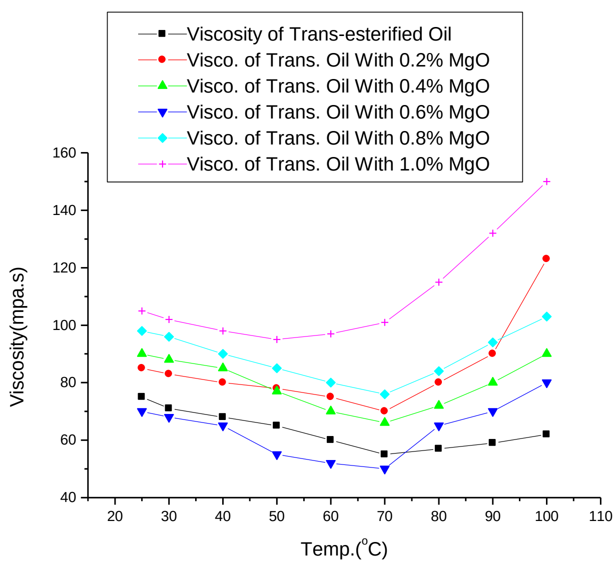

Figure 3: Viscosity Versus Temperature of Rapeseed Oil

Viscosity important parameters required by biodiesel and diesel fuel standards because of being key fuel properties for diesel engines. In a diesel engine, the liquid fuel is sprayed into compressed air and atomized into small drops near to the nozzle exit. The liquid fuel, usually, forms a cone-shaped spray at the nozzle exit and its viscosity affects the atomization quality, size of fuel drop and penetration [17]. Fuels with high viscosity tend to form larger droplets on injection which can cause poor fuel atomization during the spray, increases the engine deposits, needs more energy to pump the fuel and wears fuel pump elements and injectors. High viscosity consequently leads to poor combustion, increased exhaust smoke and emissions [18]. High viscosity also causes more problems in cold weather, because viscosity increases with decreasing temperature [19].

The effect becomes more evident at lower temperatures, where the molecular movements are even more restricted [22]. This research adopted transesterification of rapeseed oil in order to make it suitable for use as lubricant oil. It could be seen from the graph that the addition of nano 0.6% MgO nano particles in the transesterified oil causes the viscosity to decrease but within the standard range of values. This is as a result of the fact that one double bond was shown to increase viscosity, whereas two or three double bonds caused a decrease in the viscosity. By adding 0.6% MgO nano particles the presence of one double bond did increase the viscosity. In contrast, two or three double bonds (methyl linoleate and methyl linolenate, respectively) reduced the viscosity. Refaat [22] reported that the presence of one carbon-carbon double bond in the structure of oleates gave rise to stronger intermolecular interactions between the p electrons of the double bonds. This kind of interaction may have occurred because the spatial geometry of the cis configuration of the one double bond of the oleate still allowed a close packing between the molecules. Obviously, strong orbital interactions could not be found between the stearate molecules, where only weaker van der Waals interactions were possible. On the other hand, the interactions between the p orbitals in linoleates and linolenates were reduced because of the spatial geometry of these molecules, where the alternate double bonds, all in cis-conformation, led to a configuration like a coil, hindering the approach of the sp_2 atoms from the double bonds of neighboring molecules.

Conclusion

The objective of this study is to investigate the effects of MgO nanoparticles on rheological properties of transesterified rapeseed oil. SEM image reveals white irregular particles with porous. The XRD of pattern of the nanoparticles indicated crystalline phases. XRF result of the MgO nanoparticles reveals that MgO (92.4) is the major constituent of the sample followed by SiO_2 (2.49). The viscosity of the Transesterified oil decreases as the temperature increases, the viscosity also increases as the addition of the MgO nanoparticles increases between 0.1% up to 0.6%. But as the addition of nanoparticles increases above 0.6% the viscosity increases. It could be comcluded therefore, that nanofluid with 0.6% of MgO appears to be more suitable for usage in as a biodiesel.

References

[1] Shaafi, T., & Velraj, R. (2015). Influence of alumina nanoparticles, ethanol and isopropanol blend as additive with diesel–soybean biodiesel blend fuel: Combustion, engine performance and emissions. *Renewable Energy*, *80*, 655-663.

[2] Hoseini, S. S., Najafi, G., Ghobadian, B., Ebadi, M. T., Mamat, R., & Yusaf, T. (2020). Performance and emission characteristics of a CI engine using graphene oxide (GO) nano-particles additives in biodiesel-diesel blends. *Renewable Energy*, *145*, 458-465.

[3] Saxena, V., Kumar, N., & Saxena, V. K. (2017). A comprehensive review on combustion and stability aspects of metal nanoparticles and its additive effect on diesel and biodiesel fuelled CI engine. *Renewable and Sustainable Energy Reviews*, *70*, 563-588.

[4] Shaisundaram, V. S., Chandrasekaran, M., Mohan Raj, S., & Muraliraja, R. (2020). Investigation on the effect of thermal barrier coating at different dosing levels of cerium oxide nanoparticle fuel on diesel in a CI engine. *International Journal of Ambient Energy*, *41*(1), 98-104.

[5] Mahlia, T. M. I., Syazmi, Z. A. H. S., Mofijur, M., Abas, A. P., Bilad, M. R., Ong, H. C., & Silitonga, A. S. (2020). Patent landscape review on biodiesel production: Technology updates. *Renewable and Sustainable Energy Reviews*, *118*, 109526.

[6] Singh, D., Sharma, D., Soni, S. L., Sharma, S., Sharma, P. K., & Jhalani, A. (2020). A review on feedstocks, production processes, and yield for different generations of biodiesel. *Fuel*, *262*, 116553.

[7] Kim, H., & Choi, B. (2010). The effect of biodiesel and bioethanol blended diesel fuel on nanoparticles and exhaust emissions from CRDI diesel engine. *Renewable energy*, *35*(1), 157-163.

[8] Wang, X., Dou, P., Zhao, P., Zhao, C., Ding, Y. and Xu, P., 2009. Immobilization of lipases onto magnetic Fe3O4 nanoparticles for application in biodiesel production. ChemSusChem: Chemistry & Sustainability Energy & Materials, 2(10), pp.947-950.

[9] Jamo, H. U., Abdu, S., Yusuf, B., & Auwalu, I. A. (2019). PREPARATION OF BIODIESEL FROM SOYBEAN OIL BY TRANSESTERIFICATION. *Journal Homepage: http://ijmr. net. in*, *6*(06).

[10] Jamo, H. U., Aliyu, A., & Yusuf, B. (2019). Influence of Na2CO3 Nanoparticles on the Physical Properties of Castor Oil. *Journal Homepage: http://ijmr. net. in*, *6*(06).

[11] Jamo, H. U., Aliyu, R., & Yusuf, B. (2019). EFFECTS OF ADDITION OF CEO2 NANO PARTICLES ON THE PHYSICAL PROPERTIES OF JATROPHA OIL. *Journal Homepage: http://ijmr. net. in*, *6*(05).

[12] Jamo, H. U., Umar, I. D., Yusuf, B., & Auwalu, I. A. (2019). ENHANCEMENT OF PHYSICAL PROPERTIES OF BIODIESEL EXTRACTED FROM PALM OIL BY THE ADDITION MgONANO PARTICLES. *Journal Homepage: http://ijmr. net. in*, *6*(05).

[13] Singh, D., Sharma, D., Soni, S. L., Sharma, S., Sharma, P. K., & Jhalani, A. (2020). A review on feedstocks, production processes, and yield for different generations of biodiesel. *Fuel*, *262*, 116553.

[14] Shrivastava, P., & Verma, T. N. (2020). An experimental investigation into engine characteristics fueled with Lal ambari biodiesel and its blends. *Thermal Science and Engineering Progress*, *17*, 100356.

[15] Prabhu, A., Venkata Ramanan, M., & Jayaprabakar, J. (2020). Effect of compression ratio on the performance of CI engine fuelled with freshwater algae biodiesel. *International Journal of Ambient Energy*, *41*(1), 80-83.

[16] Siniawski, M. T., Saniei, N., Adhikari, B., & Doezema, L. A. (2007). Influence of fatty acid composition on the tribological performance of two vegetable-based lubricants. Lubrication Science, 24(2), 101-110.

[17] Qi, D. H., Geng, L. M., Chen, H., Bian, Y. Z., Liu, J., & Ren, X. C. (2009). Combustion and performance evaluation of a diesel engine fueled with biodiesel produced from soybean crude oil. Renewable Energy, 34(12), 2706-2713.

[18] Sulaiman, N. F., Bakar, W. A. W. A., Toemen, S., Kamal, N. M., & Nadarajan, R. (2019). In depth investigation of bi-functional, Cu/Zn/γ-Al2O3 catalyst in biodiesel production from low-grade cooking oil: Optimization using response surface methodology. *Renewable Energy*, *135*, 408-416.

[19] Mahlia, T. M. I., Syazmi, Z. A. H. S., Mofijur, M., Abas, A. P., Bilad, M. R., Ong, H. C., & Silitonga, A. S. (2020). Patent landscape review on biodiesel production: Technology updates. *Renewable and Sustainable Energy Reviews*, *118*, 109526.

[20] Aghababaie, M., Beheshti, M., Razmjou, A., & Bordbar, A. K. (2017). Enzymatic biodiesel production from crude Eruca sativa oil using Candida rugosa lipase in a solvent-free system using response surface methodology. *Biofuels*.

[21] Li, H., Shen, B. X., & Yu, P. H. (2010). The cold temperature fluidities of biodiesel prepared from vegetable oil. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *32*(13), 1195-1200.

[22] Refaat, A. A. (2009). Correlation between the chemical structure of biodiesel and its physical properties. *International Journal of Environmental Science & Technology*, *6*(4), 677-694.

[23] Anzelmo, J. A. (2009). The role of XRF, inter-element corrections, and sample preparation effects in the 100-year evolution of ASTM standard test method C114. *Journal of ASTM international*, *6*(2), 1-10.