American University of Nigeria, 1st International Conference Proceeding
ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

Effects of Addition of Silicon Oxide Nano Particles on the Rheology of Jatropha Biodiesel (Physic Nut)

A.Y. Fagge[1], H.U. Jamo[2]
{ayfagge@fugusau.edu.ng[1], jamouhfce@gmail.com[2]}

Department of Physics, Federal University Gusau, Zamfara State, Nigeria, 0808 649 0565[1], Department of Physics, Kano University of Science and Technology, Kano State, Nigeria[2]

Subject Classification: Pure and Natural Sciences (Material Science/ Renewable Energy)

Abstract
Due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions of Carbon and Hydrogen with small proportion of Sulphur and Nitrogen, there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, vegetable oil is a promising alternative because it is renewable and environment friendly. The recent trend is attempted to develop biodiesel from Jatropha oil and investigates the effects of SiO_2 nanoparticles on the rheological properties of Jatropha Biodiesel. The crude Jatropha oil was purified, trans-esterified and nanoparticles were dispersed in the trans-esterified oil with concentration ranging from 0.25% to 1.0% in 0.25% interval. Fourier Transform Infrared spectra (FTIR) was used to examine the structures of the samples, the Viscosity, Pour point, Boiling point and the Flash point were studied. It was found out among other things that small amount of (0.25% SiO_2) nanoparticles in the trans-esterified oil could improve the rheological properties of the fluid. The Nano-fluid with 0.25% concentration of SiO_2 appears to have optimum rheological property.

Key words: Biodiesel, Jatropha, Nano Particles, Rheology, SiO_2

1 Introduction

Vegetable oils are obtained from oil containing seeds, fruits, or nuts by different pressing methods or solvent extraction [3]. Crude oils obtained are subjected to a number of refining processes, both physical and chemical [4]. Biodiesel is produced from various sources of edible and non-edible oils such as Jatropha oil, Castor oil, Olive oil, Soybean oil, and Palm oil throughout the world [5]. Other advantages that encourage the use of vegetable oils include their relatively low viscosity-temperature variation; that is their high viscosity indices, which are about twice those of mineral oils [8]. Additionally, they have low volatilities as manifested by their high flash points [9]. Significantly, they are environmentally friendly: renewable, non toxic and biodegradable [7]. With the concern on the fire safety and environmental issues, alternative fluids are currently being considered [1]. In a comparison of jatropha oil and mineral based lubricants, jatropha oil based lubricants were found to be more effective in reducing the hydrocarbon and carbon monoxide emission levels, among other things. Hence, the present study wishes to investigate the effects of Addition of Silicon Oxide Nano Particles on the Rheology of Jatropha Biodiesel (Physic Nut) for the purpose of using it as transformer lubricating oil.

2 Materials and Methods

2.1 Materials

2.1.1 Chemicals

The materials and reagents used in carrying out the research are as follows: crude jatropha oil, 8 % sodium hydroxide (NaOH), 64 % citric acid ($C_6H_8O_7$, purity: 99.7 %), silicon (SiO_2) reagent, activated carbon and distilled water (H_2O).

2.1.2 Equipment

The equipment used in carrying out this study are: magnetic stirrer with thermostatically controlled rotary hot plate (IKA C-MAG HS10), Brookfield Digital viscometer {Brookfield,RVDV-I}, thermometer, measuring cylinder, Digital weight balance (Model GT2000 EC), beaker, 24 cm filter paper, funnel, Digital stop watch, sampling bottles, spatula.

3 Methodology

3.1 Sample Purification

The Jatropha oil was purified through the following procedure; 200ml of jatropha oil was measured using measuring cylinder; the oil was pre-heated to 70^oC using hot magnet stirrer with thermometer. Then 1.5ml citric acid was measured and added to the heated oil sample and continuously heated and stirred for 15minutes at 70^oC.4 ml of 8% NaOH (by dissolving 8 g NaOH in 100ml of distilled water) was then be added to the oil and continuously heated and stirred for

ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

15minutes at 70ºC. The mixture was then transferred to the vacuum oven where it was heated at 85ºC for 30minutes. Then the mixture was taken back to hot magnetic stirrer and heated to 70ºC after which a 2g 0f silicone reagent was added while it was being heated and stirred for 30minutes. Then the temperature was increased to 85ºC and 4g of activated carbon was added to each 100ml of the oil sample, heated and stirred for 30minutes. Then the mixture was separated using filter paper.

3.2Trans-esterification

60g of the purified jatropha 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 60minutes with the stirrer on the hot magnetic plate. After 60minute 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 40minute. 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 it is by product using separating funnel.

3.3 Nano-fluids Preparation

The SiO_2 Nano-particles powder was purchased from SkySpring Nano-materials, Inc., U. S. A, the size of the Nano-particles is 10-20nm and the surface was modified with Epoxy Group and it is dispersible as mentioned by the company. Nano-fluids are prepared by two step process. The volume concentration of 0.25%, 0.5%, 0.75% and 1% of powdered Nano-particles and purified palm oil was made respectively. To make the Nano-particles more stable and remain more dispersed, each sample was stirred for 3-4 hours using magnetic stirrer, then the samples were taken for analysis.

3.4Samples Measurement

3.4.1 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 jatropha oil.

3.4.2Pour Point

Using an improvised method, the experimental procedures of pour point measurement for both crude and purified oil are enumerated below; the cylindrical test tube was filled with the crude palm oil to a specific level mark (5ml). The test tube was clamped with a wooden clamp carrying the thermometer then placed in a bath of crushed ice (ice bath) and allowed to cool at a specified rate interval of 3ºC for flow characteristics the lowest temperature at which the movement of the oil is observed within 5 s is taken as pour point on the thermometer. ASTM 1999, D 97.The same procedure was repeated for the purified jatropha oil.

3.4.3Flash Point

The flash point for both crude and purified jatropha oil was also measured; A 100ml conical flask was filled to a specific mark level (10ml) with jatropha oil and heated at 14 t0 17ºC / min (25 to 30ºF/min) on the hot plate until the temperature is 56ºC (100ºF) below the expected flash point, the rate of temperature changes was then reduce to 5 to 6 ºC /min (9 to 11ºF/min) and the test flame was applied for every 2ºC (5ºF) until the oil burn for at least 5s. The flash point was taken at the lowest temperature when an application of the flame test caused the vapor above the sample to ignite. ASTM 1999, D 92. Thesame procedure was repeated for the purified and trans-esterified jatropha oil.

4 Results and Discussions

Good heat transfer and fluid flow are characteristics of insulating fluid, as a result of low viscosity which necessitated the additional study of this physical property. Figure 1 shows the graph of the crude, purified and trans-esterified jatropha oil. It could be seen from the Figure that the trans-esterified biodiesel has lower viscosity followed by purified and the crude has the highest viscosity. The viscosity for all the three oils decreases with increase in temperature until when the temperature reaches 100ºC. When the temperature increases, the energy level of the liquid molecules increases and the distance between the molecules increases. It causes a decrease in intermolecular attraction between them, which reduce the viscosity. Simultaneously increase in temperature of liquid increase the molecular interchanging between fluid layers interactions increases viscosity [2].

ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

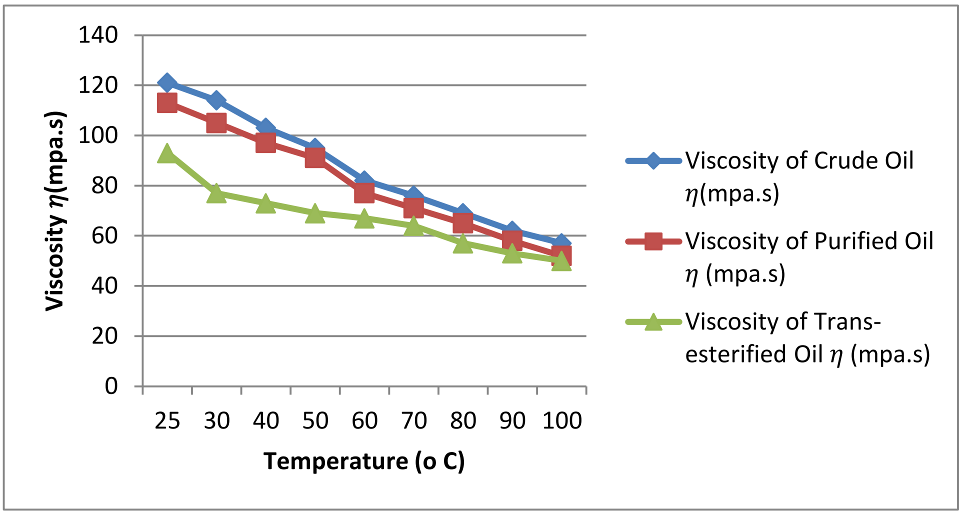


Figure 1: Graph of Viscosity η (mpa.s) versus Temperature (°C) of Jatropha oil.

Cooling equipment in industries is mainly governed by convection, so it is necessary to have low viscosity for that application. The lower the viscosity, the better the cooling and friction reduction. Figure 1; shows that the viscosity of Trans-esterified Jatropha oil at 70°C is 62mpa.s which is lower than the specified value 65mpa.s of standard motor oil given by Society for Automotive Engineers (SAE) at 70°C.

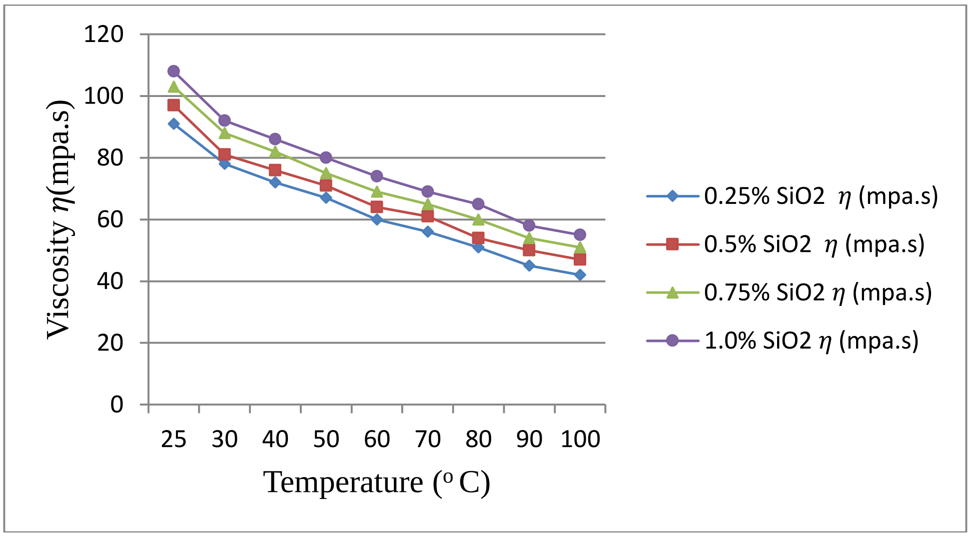


Figure 2. Graph of Viscosity η (mpa.s) versus Temperature (°C) SiO_2 Nano -Jatropha Fluid

Addition of Nano-particles resulted in additional decrease in viscosity of the fluid. Similarly, the percentage concentration shows a significant effect in the enhancement of the viscosity of the fluid. From ever day experience, it should be common knowledge that viscosity varies with temperature. In general, viscosity of sample liquid decreases with increase in temperature and the amount of time they spend in "contact" with their nearest neighbours' decreases. Thus, as temperature increases, the average intermolecular forces decreases.

4.1 Temperature Effect

It is necessary to investigate the temperature dependence of the fluid in order to act as lubricants/coolants. They take heat out of the system as a result, it is necessary to know heating effect of the fluid. The effects of temperature on a.c conductivity of the samples were studied from temperature of about 30°C to 70°C at interval of 10°C. Both crude, purified, trans-esterified and nano-jatropha fluid were found to increase with increase in temperature [6]. All samples appeared to have the same response to heat within the temperature range studied.

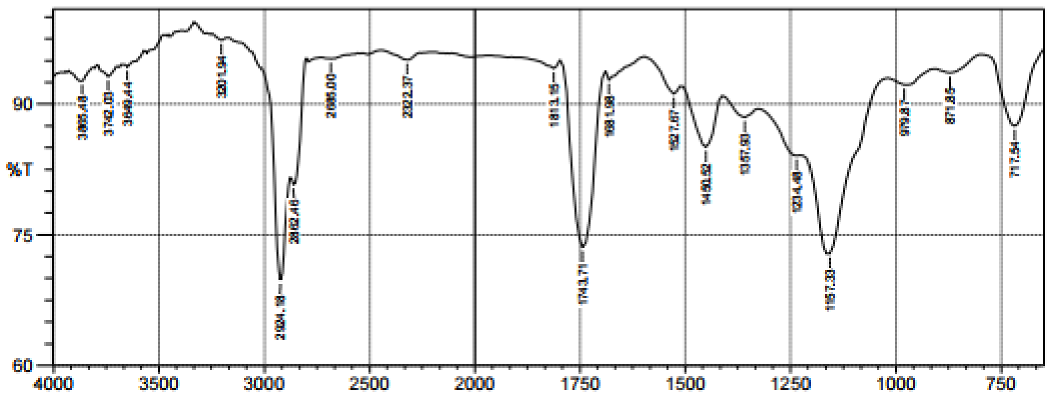
American University of Nigeria, 1st International Conference Proceeding
ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

Table 1. Pour Point, Flash Point and Fire Point Result

S/No.	Sample	Pour point (ºC)	Flash point (ºC)	Fire Point (ºC)
1	Crude Jatropha Oil	10	128	133
2	Purified Jatropha Oil	7	130	140
3	Trans – esterified	4	135	146
4	Trans - esterified (0.25w% SiO_2)	**2**	**142**	**158**
5	Trans - esterified (0.5w% SiO_2)	3	138	140
6	Biodiesel standard (ASTM)	-15 to 10	100 to 170	>130
7	Diesel standard (ASTM)	-15 to 5	60 to 80	60 to 80

Table 1. present the result of Pour point, Flash point and Fire point of Crude, Purified, Trans-esterified and Nano-jatropha fluids. It was observed that 0.25w% SiO_2 Nano-Jatropha fluid have good result with Pour point of 2ºC, Flash point of 142ºC and Pire point of 158ºCwhich are all within ASTM standard. High flash point of Jatropha Biodiesel has certain advantages compared to petroleum based fluid for greater safety during storage, handling and transport [10].

The FTIR analysis is employed in order to identify the presence of SiO_2 Nano-particles in the based trans-esterified jatropha oil, the FTIR spectra of all the samples were obtained using SHIMADZU FTIR-8400S Spectrophotometer at National Research Institute for Chemical Technology (NARICT) Zaria. It is an established fact that the fundamental vibrations of solids particle (fingerprint) are localized in the low frequency region (<1200 cm^{-1}) of the midrange (400-4000cm^{-1}) of the infrared spectrum. So the FTIR spectra of purified Jatropha and Nano-fluid are presented below.



n in

Figure 3: FT-IR Spectra of Crude Jatropha Oil

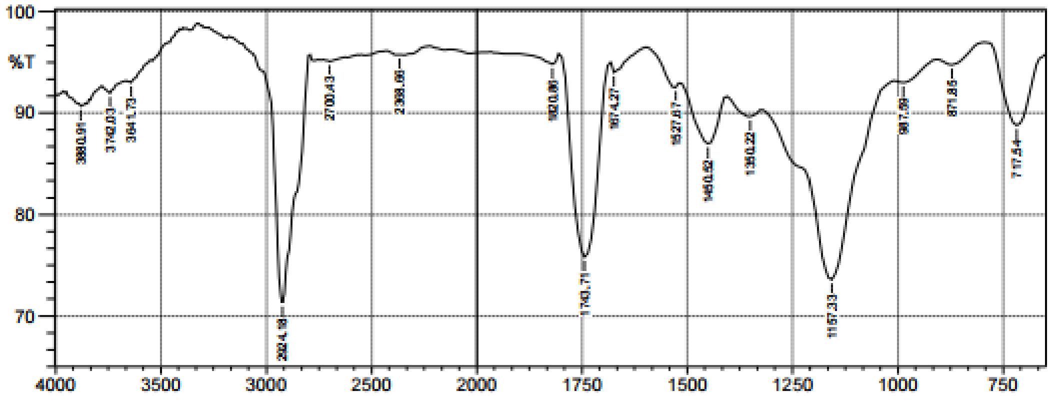


Figure 4. FT-IR Spectra of Purified Jatropha Oil

ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

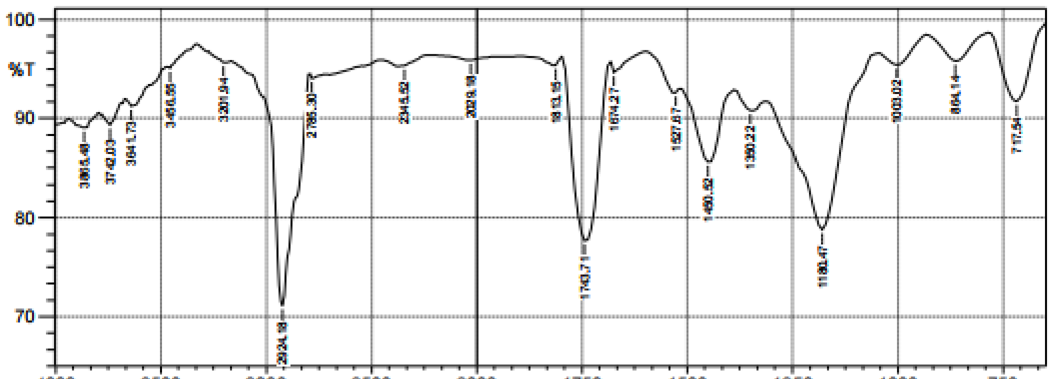


Figure 5.FT-IR Spectra of Trans-esterified Jatropha Oil

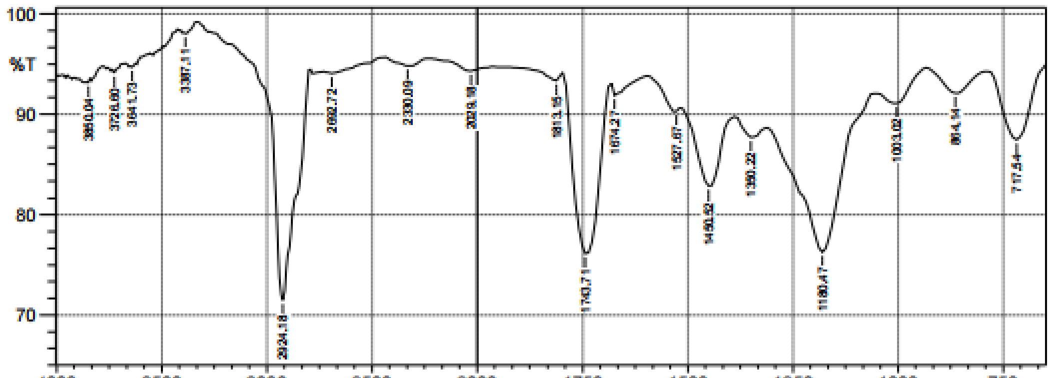


Figure 6: FT-IR Spectra of 0.25% nanoparticles concentration in jatropha oil

The FTIR spectra shown in Figures 3- 6, displayed the typical bands that exist in natural esters. The band with a peak at 2924 cm^{-1} describes C-H stretching. The bands with peaks at 1674 cm^{-1} and 1003 cm^{-1} are vibration of C=O and C-O. These are typical bands that describe esters. The bands with peaks at 1450 cm^{-1} is due to methylene scissoring and rocking.

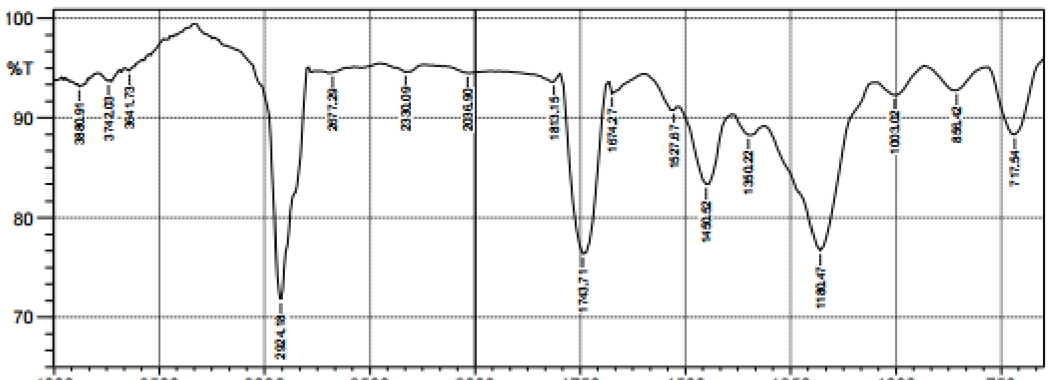


Figure 7.FT-IR Spectra of 0.5% nanoparticles concentration in jatropha oil

The addition of SiO_2 Nano-particles is expected to change the FTIR spectra of the fluid. Meanwhile no visible change was observed when the concentration of the Nano-particle in the fluid was 0.25% and 0.5%, a band was observed around 856 cm^{-1} and 864 $cm^{-1}$is believed to be shrouded ester C-O band.

5 Conclusion

ISBN: 978-978-783-870-9
e-ISSN: 3027-0650

The experimental results show that the sample has viscosity lower than conventional insulating fluid. Just like most insulating fluids, the dynamics viscosity decrease with increase in temperature. The addition of nanoparticles (0.25w% SiO_2) resulted in decrease in viscosity. The viscosity change may have contributed to the observed increase in with temperature. The Trans - esterified Nano-fluid with (0.25w% SiO_2) appears to be more suitable for insulation as the sample was observed to have lowest pour point of 2℃ and higher flash point of 142℃**.** This is due to the removal of gums in form of phospholipids from the crude oil. Hence, therefore, the result of the study shows that the trans-esterified Nano-fluid Jatropha oil with 0.25% oil is potential candidate for the production of lubricating fluid.

Reference

[1] Azhari, M. A., Suffian, Q. N., & Nuri, N. R. M. (2014). The Effect of Zinc Dialkyldithiophosphate Addition to Corn Oil in Suppression of Oxidation as Enhancement for Bio Lubricants: A Review. Journal of Engineering and Applied Sciences, 9(9), 1447-1449.

[2] Demirbas, A. (2005). Biodiesel Impacts on Compression Ignition Engine (CIE): Analysis of Air Pollution Issues Relating to Exhaust Emissions. Energy Sources, 27(6), 549-558.

[3] Ferreira, I. J., Alexandre, E. M., Saraiva, J. A., & Pintado, M. (2022). Green Emerging Extraction Technologies to Obtain High-Quality Vegetable Oils from Nuts: A Review. Innovative Food Science & Emerging Technologies, 76, 102931.

[4] Gharby, S. (2022). Refining Vegetable Oils: Chemical and Physical Refining. The Scientific World Journal, 2022.

[5] Gui, M. M., Lee, K. T., & Bhatia, S. (2008). Feasibility of Edible Oil vs. Non-Edible Oil vs. Waste Edible Oil as Biodiesel Feedstock. Energy, 33(11), 1646-1653.

[6] Ifijen, I., & Nkwor, A. (2020). Selected Under-Exploited Plant Oils in Nigeria: A Correlative Study of Their Properties. Tanzania Journal of Science, 46(3), 817-827.

[7] Rafiq, M., Shafique, M., Azam, A., Ateeq, M., Khan, I. A., & Hussain, A. (2020). Sustainable, Renewable, and Environmental-Friendly Insulation Systems for High Voltages Applications. Molecules, 25(17), 3901.

[8] Sajeeb, A., & Rajendrakumar, P. K. (2019). Comparative Evaluation of Lubricant Properties of Biodegradable Blend of Coconut and Mustard Oil. Journal of Cleaner Production, 240, 118255.

[9] Salih, N., & Salimon, J. (2021). A Review on Eco-Friendly Green Biolubricants from Renewable and Sustainable Plant Oil Sources. Biointerface Res. Appl. Chem, 11(5), 13303-13327.

[10] Singh, S. P., & Singh, D. (2010). Biodiesel Production through the Use of Different Sources and Characterization of Oils and Their Esters as the Substitute of Diesel: A Review. Renewable and Sustainable Energy Reviews, 14(1), 200-216.