Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 53 (2024) 120-129 EISSN 2543-5426

Evaluation and characterization of lithium grease from Palm kernel oil for automobiles and industrial machinery

Vivian Ogechukwu Amanambu* and **Chukwuemeka A. Nwadinigwe**

Department of Pure and Industrial Chemistry, University of Nigeria, Nsukka, Nigeria

*E-mail address: amanambuvivienoge@gmail

ABSTRACT

Grease is made up of a lubricant (typically petroleum oil) and a thickener (soap). The study focus on the production and characterization of grease for automobile and industrial machinery. The practicality and application of the technique were examined in order to decide whether the lithium grease produced from palm kernel oil might be used as an environmental friendly alternative to conventional grease. The aforementioned objective was achieved by mechanically extracting oil from palm kernel nuts. Lithium grease was produced through the saponification of lithium oxide with palm kernel oil. The lithium grease melting and drop points, flash point, and ash content were discussed. According to the study's findings, the lithium grease produced results that were acceptable and in accordance with ASTM standards, with the exception of its ash content, which will cause the grease to break off under pressure.

***Keywords*:** characterization, lithium grease, palm kernel oil, automobiles, industrial machinery

1. INTRODUCTION

Natural resource depletion and environmental problems are major concerns in finding alternatives to depletion of energy reserves and mitigating the environmental impact of gaseous pollutant emissions. In recent years, there has been a growing awareness of the environmental impact of leaks or spills of large quantities of lubricants and industrial fluids into the environment. These lubricant build-ups lead to environmental pollution if the lubricants have

(Received 03 January 2024; Accepted 31 January 2024; Date of Publication 02 February 2024)

poor biodegradability. Industrial lubricants in routine use today are predominantly based on mineral oils and are highly toxic to the environment. Mineral oil-based lubricants are not readily biodegradable by microorganisms. Recent studies have also shown that these oils are carcinogenic. Therefore, there is a clear need for lubricants based on environmentally friendly and renewable natural resources. Therefore, grease from biomass is needed to limit these dangerous situations.

Lubricants play an important role in the service life of automotive and industrial machinery parts. The effect of friction on cars is a big problem, because due to the wear and friction of cars and industrial machines, lubricants are essential for the longevity and operation of cars. Greases are lubricants necessary to protect auto parts and prevent them from breaking. Not only are they specially designed to prevent wear and tear, but they are also made to withstand the working conditions of automobiles and machinery. Grease prevent rusting and accumulation of debris on surfaces by forming a protective layer; in addition, the many properties of grease, such as their ability to flow at high temperatures while also being excellent at dissipating heat, make them valuable and widely used. The grease can be described as a semi-liquid to solid, multicolored lubricant. The main component of the grease is a liquid lubricant, which can be petroleum, vegetable oil and synthetic oil. The most common elements of grease are thickener, oil and additives (Kholijah et al., 2012; Shu et al., 2017). Lubricant compositions usually contain 70-95% base oil, 3-30% thickeners and 0-10% additives. The most commonly used thickeners are soaps such as calcium, aluminum, lithium and sodium.

Lithium thickeners are the most commonly used thickeners in rolling bearing lubricating greases. This is mainly due to their excellent thermal stability (Jane, 2019). As such, lithium grease is expected to be a lubricant for lubricating automobiles and industrial machinery. According to the literature, vegetable oil is one of the important renewable resources that can provide a safe, abundant, cheap and clean energy source. In this sense, vegetable oils have a number of technical advantages, such as high flash points, lubricity and biodegradability, non-toxicity, availability, renewable and portability as liquids, making them a promising renewable energy source (Bilgin et al., 2018; Gulum et al., 2018).

Vegetable oils used as bio-lubricants have very low volatility due to the higher molecular weight of the triglyceride molecule. They have unique properties that differ from mineral oils due to their unique chemical structure. Vegetable oils have a greater lubricating capacity and a higher viscosity index. Outstanding anti-corrosion properties are observed in vegetable oils and are caused by a greater affinity for metal surfaces. High flash points above 300^0C are classified as vegetable oils that are non-flammable liquids. It is important to note that vegetable oils obtained from seeds and nuts are often used as suitable substitutes for mineral oil-based lubricants obtained from petroleum. Natural vegetable oils are non-toxic, biodegradable and have good lubricating properties. Therefore, it is necessary to transform vegetable oils into industrial products such as bio-lubricants, transformer fluids and other important fuels that can be used as an alternative to fuel (Menkiti et al., 2017; Agu et al, 2019; Ofofule et al., 2019; Sabarinath et al., 2019). Oil derived from palm kernel seeds can be used as a renewable energy source. One of the vegetable oils suitable for grease production is palm kernel oil (PKO) (Elaeis guinueensis), which is widely grown in Nigeria.

Palm kernel oil is yellowish colored edible oil, extracted from the core of the palm fruit scientifically known as Elaeis guinueensis (Bahadi et al., 2019). Palm kernel is a major by-product of palm oil milling and processing. It makes up about 45-48% (by weight) of the palm fruit. Palm kernel oil yield is about 47-59% by weight.

Lauric acid is the predominant fatty acid in PKO, accounting for approximately 48.53% of the fatty acid composition. PKO is rich in saturated fatty acids (SFA) with a proportion of 79.91% (Liu et al., 2019). Due to the relatively high oil yield of PKO, many studies have been conducted on the use of PKO in the production of biolubricants (Alang et al., 2018; Shaba et al., 2018). For example (Heikal et al., 2017; Menkiti et al., 2017; Sharma and Sachan, 2019; Encinar et al., 2020; Cavalcanti et al., 2018; Sarno et al., 2018 and Shote et al., 2018) used various vegetable oils in the production of bio-lubricants using palm oil, J. curcas oil, Karanja oil, castor oil, soybean oil, spent edible oil and PKO respectively.

Although many studies on biolubricants have been documented in relation to the above references, evaluation and characterization of lithium grease from palm kernel oil are scarce in the published literature.

With this in mind, and as there are limited or no studies directed in this direction, the authors compared this study to the use of PKO (high oil yield, availability, and biodegradability) in grease production using mechanical extraction processes. This document therefore provides additional information on the evaluation and characterization of lithium palm kernel oil grease as an alternative to the conventional grease to reduce toxic gas emissions.

2. METHODS

2. 1. Preparation of Sample and Oil Extraction Process

The samples used in the study were palm kernel nuts purchased at a local market in Nsukka, Enugu. Palm kernel nuts were peeled and edible parts removed. Edible parts were grated and collected in a sterile container for oil extraction.

2. 2. Oil Extraction

For oil extraction, a mechanical extraction method was used. The method of Gopala et al., (2009) was used to mechanically extract the oil from the sample.

2. 3. Mechanical Palm Kernel Oil Extraction

Samples were ground with a mechanical grinder. The sample was weighed, poured into a sample container mixed with hot water and kept for 10 minutes. A mixture containing two immiscible liquids; the water and oil were decanted and the oil was allowed to settle on top of the mixture and separated using a separating funnel. The mixture, which contains water and oil, was decanted. For a pure oil collection, the oil was heated within a low temperature range of 30-40 °C and further filtered using muslin cloth.

2. 4. Saponification Reaction

Grease is formed after thickening palm kernel oil with a thickener. The thickener used in the manufacture of grease was formed in situ by saponification reaction. The saponification reaction involves a metal base (LiOH) with a fatty acid (palm kernel oil) to produce soap (a thickener). The reaction is endothermic and requires heating. For the saponification reaction, 25 g of lithium hydroxide was dissolve in warm water. 20.6 g of saturated lithium hydroxide filtrate was used in soap making. 20.6 g of saturated lithium hydroxide filtrate and 82.4 g of palm kernel oil was measured into a beaker and was stirred until the mixture is homogeneous.

It is heated to 90 °C and stirred continuously for 10 minutes, and was allowed to cool to complete the saponification process.

2. 5. Production of Lithium Grease

10.3g of freshly prepared lithium soap was compounded with 5ml of crude oil. This was carried out by crushing the soap in a crucible while the crude oil was gradually added. The mixture was gradually heated to 130 °C while being stirred constantly until the soap totally melted and formed a homogeneous phase. The remaining crude oil was added, coupled with intensified stirring to form the grease. After allowing the process to continue for 30 minutes to let the water evaporate, the crucible was removed, and the grease was left to cool and solidify.

3. RESULTS AND DISCUSSION

The soap and oil percentage yield in the compounding process were over 80%. As shown in Figure 1, the melting point of the soap was 170 °C, 92 °C for the grease sample, and 85 °C for the commercial grease. The melting point of the grease sample is higher compared to commercial grease. This makes lithium grease easier to lubricate and, due to its low melting point, run off at frictional temperatures, making it difficult to wash off. Lithium-based greases are most commonly used. Lithium-based greases have a higher melting point than calcium-based greases, but are not water resistant.

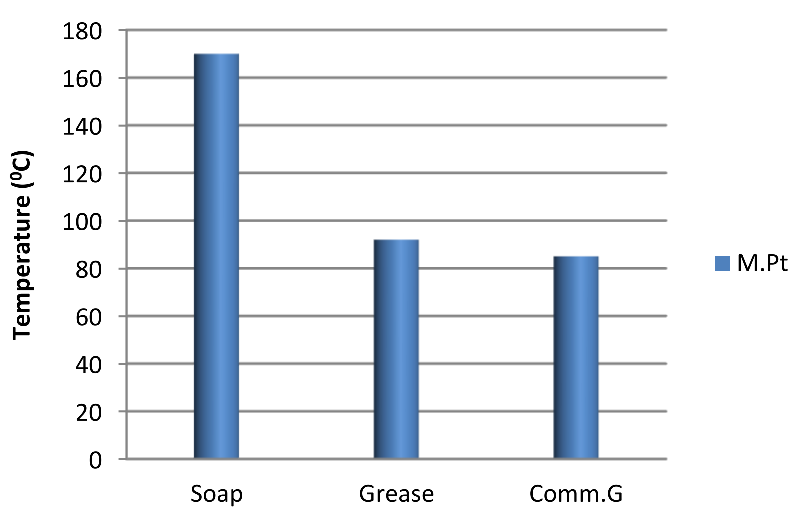

Fig. 1. Melting point of soap, grease sample and commercial grease.

As shown in Figure 2 below, the dropping point results for the grease sample were 105 °C and 94 °C for the commercial grease. As a result, it was found that the higher the dripping point, the easier it is for the grease to drip. Dropping point is a measure of the thermal stability of grease and can be defined as the lowest temperature at which the grease phase changes from semi-solid to liquid (Sadeghalvaad et al., 2019). The grease drop point is therefore the temperature at which a drop of grease falls from the test thimble-sized cup aperture under a given temperature ramp schedule. The dropping point is usually well above the maximum usable temperature of the grease. Additionally, the dropping point helps identify the type of grease thickener and plays an important role as a quality control test in grease manufacturing. Dropping point assesses the thermal stability of grease structures and helps identify grease types (lithium, lithium complexes, aluminum complexes, etc.).However, it is very important to keep in mind that the test does not have any bearing on service performance, aside from the fact that the grease cannot be expected to withstand spillage at temperatures near its dropping point. Once this dropping point is reached, the semi-solid grease loses its structure and desirable viscosity, resulting in a significant reduction in grease efficiency. This means that once the dropping point is exceeded, the quality of the lubricant deteriorates so much that it becomes virtually unusable. This finding is consistent with Kumar et al., (2020), who opined that greases with relatively high dropping point temperatures are in high demand in commercial vehicle applications, such as lubricating internal combustion engines in automobiles and tractor engines. On the other hand, greases with relatively low dropping point temperatures (ranging from 90 to 100 °C) can be used for lubricating valves, conveyors, springs and many other purposes due to the versatility of these greases (Kumar et al. al., 2020). Therefore, different dropping points correspond to different applications, and typically the higher operating temperatures of engines (coolants reach about 90.6 - 104.4 °C) demand higher dropping points for use in engine lubrication. The dropping point is simply the maximum temperature at which grease can maintain its structure and quality. Knowing this temperature is important in deciding when to apply and use particular grease on a mechanical component system such as an internal combustion engine. At elevated temperatures, grease behave differently than edible fats. It doesn't melt when heated like butter or coconut oil, but it doesn't change much as the temperature rises because the thickener holds the base oil together. The soap structure dissolves only when the critical temperature of the thickener is reached. This research confirms Nagendramma and Kumar's (2015) and El-Adly et al.'s (2015) findings with dropping point higher as compared to commercial grease.

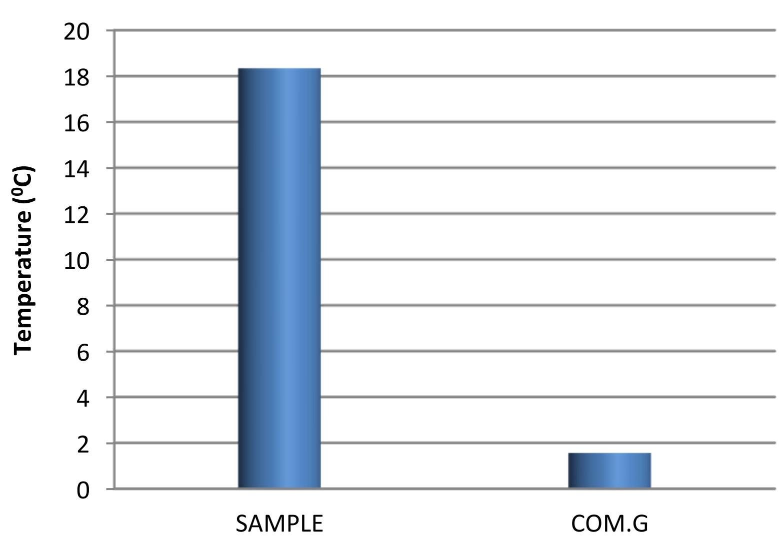

Fig. 2. Dropping point of grease sample and commercial grease.

Flash point can be defined as the temperature at which a fuel can ignite when exposed to a heat source. This is important for safe handling, storage and transportation (Agu et al., 2019). The flash point results are shown in Figure 3. The flash point result for the grease sample was 120 °C, while the commercial grease was 98 °C. Due to its high flash point value, the product is thus classified as nonhazardous. The lower the flash point, the easier it is to catches fire. For lubricants, flash point is the temperature at which some vapor is emitted from the lubricant to temporarily ignite a flame (Alang et al., 2018). Flash point is an important property to consider when evaluating the overall flammability hazard of a biolubricant. The results obtained were similar to those of Egbuna et al. (2021); Bahadi et al. (2019), Allan et al. (2018) and Shaba et al. (2018) PKO on biolubricants. The flash point value of the produced PKO grease were similarly in the same ballpark as those for Neem biolubricant reported by Aji et al. (2015).

This discovery also backs up Vunguturi and Irfanuddin (2017). According to the researchers, lubricants with high flash points are safer since they are more difficult to ignite when exposed to ignition sources. Furthermore, biolubricants with low flash points are extremely dangerous since they easily catch fire and have the ability to deposit oxides on metal surfaces. Good lubricant characteristics include high thermal stability, high flash point and non-flammability, and the ability to function over a wide temperature range. PKOs typically have all of the above properties and are considered biodegradable. Flash point indicates the maximum temperature at which a lubricant can be used. The lower the flash point, the greater is the risk. Products with flash point less than 38 °C will usually require special precautions for safe handling.

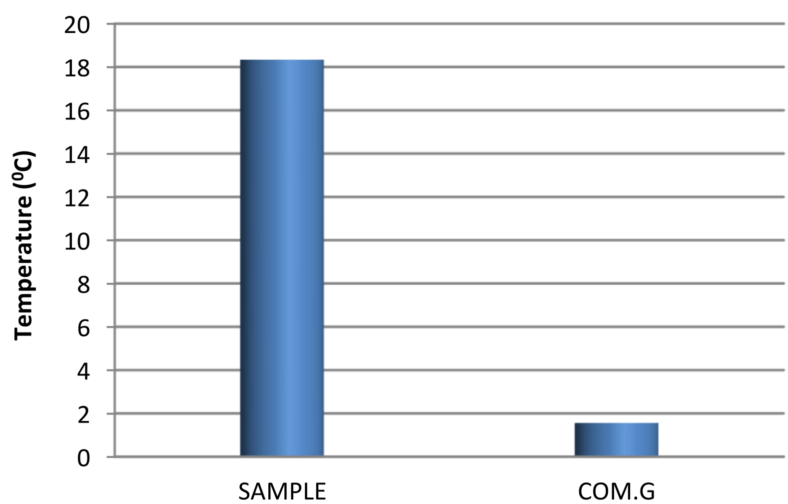

Fig. 3. Flash point of grease sample and commercial grease.

The percentage ash was 18.34% for the grease sample and 1.56% for the commercial grease. Ash is the non-flammable component of lubricating oil. It can exist as a solid or as an oil/water-soluble metal compound. These solid particles are often called sediments. Ash content results are shown in Figure 4. This result suggests high ash content in the lubricating oil samples. Low ash content is preferable, because if the ash content is high, it will break when pressure is applied. The likelihood of grease forming sludge or sediment increases with increasing ash content. Oils containing more than 0.05% ash are considered high ash oils. Oils with less than 0.02% ash are considered low-ash oils. Knowing the amount of ash-forming substances in a product provides information as to whether the product is suitable for use in the appropriate application. Ash content was considered an important test for assessing oil purity. Ash is known to represent mineral residues in the oil and its low content is evidence of the high purity of the processed oil. This is likely due to the mechanical extraction methods used in oil extraction. In addition to oil-organic mineral fortifiers, ash can also be formed from oil or water soluble metallic compounds or foreign substances such as dirt and rust (Hussein et al., 2014).

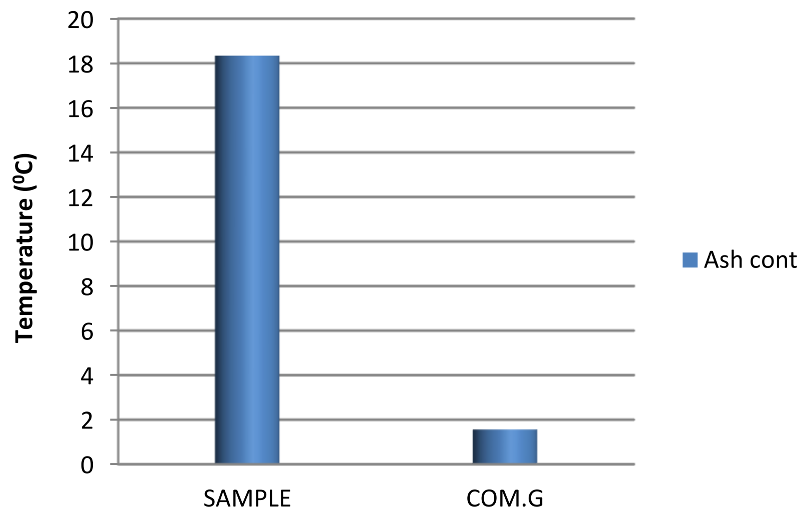

Fig. 4. Ash content of grease sample and commercial grease.

4. CONCLUSIONS

Bio-lubricants are attracting attention as an alternative to petroleum-based lubricants because petroleum-based lubricants have a negative impact on living organisms and ecosystems. Growing concern about environmental issues has led the lubricant industry to produce and use biodegradable and environmentally friendly lubricants from renewable resources that have a relatively low environmental impact. The study concludes that the idea of using bio-lubricants from palm kernel oil in the production of lithium greases for automobiles and industrial machinery is feasible. Results from studies on palm kernel grease production using lithium hydroxide have shown similar results to commercial grease, with acceptable results in terms of several key properties such as melting point, flash point and dropping point. Based on this research, palm kernel oil could potentially be used to make lithium grease for automobiles and industrial machinery. It can be used as an alternative base oil source for grease manufacturing to replace mineral oil derived from crude oil. Therefore, palm kernel oil can be a promising base oil in the oil production industry. Further experimental work related to tribology, especially viscosity, is required to compare with commercial grease. To improve the tribology of grease, the addition of solid additives can be proposed. Finally, other parameters such as homogenizer temperature and speed can be investigated during the grease blending process.

References

[1] Agu C.M, Menkiti M.C, Nwabanne J.T and Onukwuli OD. (2019). Comparative assessment of chemically modified Terminalia catappa L. kernel oilsamples – a promising ecofriendly transformer fluid. *Ind Crops Prod.* 140: 111727. https://doi.org/10.1016/j.indcrop.2019.111727

[2] Aji M.M, Kyari S.A and Zoaka G. (2015). Comparative studies between bio Lu-bricants from Jatropha oil, neem oil and mineral lubricant (Engen super20w/50). *Appl Res J.* 1: 252-257

[3] Alang M.B, Ndikontar M.K, Sani Y.M and Ndifon P.T. (2018). Synthesis and characterisation of a biolubricant from cameroon palm kernel seed oil using a locally produced base catalyst from plantain peelings. *Green Sustain Chem,* 8: 275-287

[4] Bahadi M, Yusoff M.F, Salimon J and Derawi D. (2019). Optimization of response surface methodology by D-optimal design for synthesis of food-grade palm kernel based biolubricant. *Ind Crops Prod,* 139: 111452

[5] Bilgin, A. and Gulum, M. (2018). Effects of Various Transesterification Parameters on some Fuel Properties of Hazelnut Oil Methyl Ester. *Energy Procedia*, 147: 54–62. doi:10.1016/j.egypro.2018.07.033

[6] Cavalcanti E.D.C, Aguieiras E.C.G, da Silva P.R, et al. (2018).Improved production of biolubricants from soybean oil and different polyols viaesterification reaction catalyzed by immobilized lipase from Candida rugosa. *Fuel*, 215: 705-713

[7] Egbuna S.O, Nwachukwu U.J, Agu C.M, Asadu C.O and Okolo B. (2021). Production of biolubricant samples from palm kernel oil using different chemical modification approaches. *Engineering Reports* 3: e12422. https://doi.org/10.1002/eng2.12422

[8] El-Adly R.A, Yossef M.A, Modather F.H, Ismail E.A and Abbas D.M(2015) Biogrease based on biochar from rice straw and waste cooking oil. *International Journal of Advances in Pharmacy, Biology and Chemistry,* 4(1): 91-97

[9] Encinar J.M, Nogales-Delgado S, Sánchez N and González J.F. (2020). Biolubricants from rapeseed and castor oil transesterification by using titaniumisopropoxide as a catalyst: production and characterization. *Catalysts,* 10: 366. https://doi.org/10.3390/catal10040366

[10] Gopala K.A.G, Gaurav R, Ajit S.B, Prasanth K.P.K and Preeti C.(2009).Coconut oil: Chemistry, production and its applications - A Review. Department of Lipid Science & Traditional Foods, Central Food Technological Research Institute. *Indian Coconut Journal,* 1: 1-24

[11] Gulum, M., and Bilgin, A. (2018).An Experimental Optimization Research of Methyl and Ethyl Esters Production from Safflower Oil. *Environmental and Climate Technologies*, 22: 132–148. doi:10.2478/rtuect-2018-0009

[12] Heikal E.K, Elmelawy M.S, Khalil S.A and Elbasuny N.M. (2017). Manufacturing of environment friendly biolubricants from vegetable oils. *Egypt J Pet,* 26(1): 53–59. https://doi.org/10.1016/j.ejpe.2016.03.003

[13] Jane M. A.(2019).The future of lubricating greases in the electric vehicle era. *Tribol Lubr Technol,* 75 (5), 38-44

[14] Kholijah, A. et.al (2012). Production of high temperature grease from waste lubricant sludge and silicone oil. *Journal of Applied Sciences (Faisalabad),* 12(11), 1171-1175

[15] Kumar K.B, Reddy C.J and Ramesh K.V. (2020).Experimental Study on Drop Point of Grease Samples for Various Lubricating Applications. *International Journal of Engineering Research & Technology,* 8, 16: 138-139

[16] Liu C, Meng Z, Chai X, et al. (2019).Comparative analysis of graded blends of palm kernel oil, palm kernel stearin and palm stearin. *Food Chem,* 286: 636-643

[17] Menkiti M.C, Ocheje O and Agu C.M. (2017).Production of environmentally adapted lubricant basestock from Jatropha curcase specie seed oil. *Int J Ind Chem,* 8: 133-144. https://doi.org/10.1007/s40090-017-0116-1.5

[18] Nagendramma P, and Kumar P. (2015).Eco-friendly multipurpose lubricating greases from vegetable residual oils. *Lubricants,* 3(4): 628-636. https://doi.org/10.3390/lubricants3040628

[19] Ofoefule A.U, Esonye C, Onukwuli O.D, Nwaeze E and Ume C.S. (2019). Modeling and optimization of African pear seed oil esterification and transesterification using artificial neural network and response surface methodology comparative analysis. *Ind Crops Prod*, 140: 111707

[20] Okeke C.G and Oluka S.I. (2017). Review of palm kernel oil processing and storage techniques in south East Nigeria. *J Exp Res,* 5(1): 50-56

[21] Sabarinath S, Rajendrakumar P.K, and Prabhakaran N. K. (2019). Evaluation of tribological properties of sesame oil as biolubricant with SiO2 nanoparticles and imidazolium-based ionic liquid as hybrid additives. *J Eng Tribol*, 0(0): 1-12. https://doi.org/10.1177/1350650119837831

[22] Sadeghalvaad M., Dabiri E., and Afsharimoghadam P. (2019). Lithium lubricating greases containing carbon base nano-additives: Preparation and comprehensive properties evaluation. *SN Applied Sciences,* 1, (3), 264. https://doi.org/10.1007/s42452-019-0289-7

[23] Sarno M, Iuliano M and Cirillo C. (2018). Optimized procedure for the preparation of an enzyme nanocatalyst to produce a bio-lubricant from wastecooking oil. *Chem Eng J,* 377: 120273. https://doi.org/10.1016/j.cej.2018.10.210

[24] Shaba M.I, Mohammed A, Musa D.S, Audu B.A, and Katamba Y.B. (2018). Synthesis and optimization process of ethylene glycol-based bio-lubricant from palm kernel oil (PKO). *J Renew Energy Environ,* 5(2): 1-9

[25] Sharma U.C and Sachan S. (2019).Friction and wear behavior of karanja oil derived biolubricant base oil. *SN Appl Sci* 1: 668. https://doi.org/10.1007/s42452-019-0706-y

[26] Shote A.S, Betiku E and Asere A.A. (2018). Characteristics of CO and NOx emissions from combustion of transmethylated palm kernel oil-based biodiesel blends in a compression ignition engine. *J King Saud Univ Eng Sci*, 31: 178-183. https://doi.org/10.1016/j.jksues.2018.02.005.22

[27] Shu J, Harris K, Munavirov B, Westbroek R, Leckner J and Glavatskih S. (2017) Tribology of polypropylene and Li-complex greases with ZDDP and MoDTC additives *Tribology International* 118, 189–95. https://doi.org/10.1016/j.triboint.2017.09.028

[28] Vunguturi, S and Irfanuddin, S. A.(2017).Evaluation of flash point and fire point of selected edible oil blends - A bio-lubricant. *International Journal of Trend in Research and Development*, 4(5), 2394-933