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Derleme Makalesi / Review Article

Investigate The Effect of Adding Nanoparticle to Palm Oil on Tribological of Lubricants -Review Study

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Abstract
Due to the growing up demand for fossil fuels and increases in the concerns about fossil fuel depilation which is considered the major source of lubrication. Biolubricants are an alternative solution for conventional oil to face the dangers of fossil fuel depletion. In internal combustion engines, Lubrication processes play a vital role due to the significant number of moving parts inside it. The primary function of Lubricants is to prevent friction generated between two moving parts and make the working of machines smooth. Biolubricants are renewable, biodegradable, have good tribological behaviors, are nontoxic, zero-emission for greenhouse gases, are non-hazardous, have low volatility, and are inexpensive. All these advantages of Biolubricants, yet their use as lubricants are constrained because it suffers from low oxidative stability. Therefore, various chemical modifications must be done on Biolubricants to reach the proper lubricant properties. These chemical modifications improved the thermo-oxidative stabilities of the Biolubricants, thereby enhancing the quality of biolubricants. This study reviews the physicochemical properties of Palm oil and summarized the chemical modifications of the Palm oil and sheds light on the tribological behavior of palm oil as a lubricant in internal combustion engines and its function to reduce the friction between the moving parts.
Keywords: Fossil fuels, palm oil, biolubricant, internal combustion engine, tribological behavior

1. Intoduction

In current decade, Fossil fuels are considered the biggest source of conventional lubricants production, all countries around the world depend on Fossil fuels to meet their energy needs. Fossil fuels have negative impacts on the environment by emitting harmful gases like Carbon Monoxide CO, Carbon dioxide CO_2, Hydrocarbons and Nitrogen oxides NOx (Hussein et al., 2021). Also, it has a negative impact on ocean organisms, by absorbing Carbon dioxide and resulting in ocean acidification (Narayana and Vinu, 2022). Fossil fuel have negative impacts on the environment through extreme weather events including Wildfires, hurricanes wind, and flooding all of these disasters have been costing the United State of America USA between 2016 and 2022 $ 607 billion, for example, last year in Europe, reaches have shown that 21% of the 5 million tons of lubricants utilize in discharged into the ecosystem (Garcés et al., 2011; Menkiti et al., 2017; Atabani et al. 2013). Mineral oil dominates on the world markets, because of their availability and cheap prices, non-degradation. Mineral oil has harmful emissions, that are emitted from fossil fuels which contribute to environmental pollution. The production of lubrication based on renewable sources is the focus of global attention. Biolubricants are renewable, biodegradable, highly lubricating, non-hazardous, zero-emission oils, sustainable sources. Biolubricants reduce the dependence on fossil fuel for lubrication issues, so they contribute to machines' lubricity. Biolubricants are characterized by low friction and low corrosive properties, due to good chemical composition, which consists of triglyceride molecules glycerol and esters derived from long chains of polar fatty acids (Encinar et al., 2020). Biolubricant uses in worldwide as can be seen in figure, and table 1. Internal combustion engines are considered the heart of the vehicle. They are considered a main mechanical device inside the vehicle. An internal combustion engine contains a huge number of moving parts, so it is exposed to friction, and wear. The main function of engine oil is to reduce friction thereby developing engine efficiency, where the mechanical losses resulting from engine wear parts, and friction in internal combustion engines are estimated about 80%. One of the important signs of the presence of friction inside the engine and high engine temperature, which negatively affects the engine efficiency, and lifespan of engine. Lubricant oils must be used to reduce the resulting friction between engine parts, motor oils work on forming a thin layer that separates the engine parts from each other (Sarma et al., 2022; Ren et al., 2020). Biolubricants suffer from low oxidative instability, and thermal instability, high viscosity. To improve the tribological properties of Biolubricants, they are chemically treated by several methods such as mixing it with biodiesel or the emulsification process, esterification process. Esterification process is the best and most popular process for chemically treating lubricant oils and improving their tribological properties (Haigha et al., 2012). Bio-lubricants have main disadvantages like them-oxidative stability, this feature represents the main barrier to bio-lubricants commercialization (Rasheed et al., 2020).

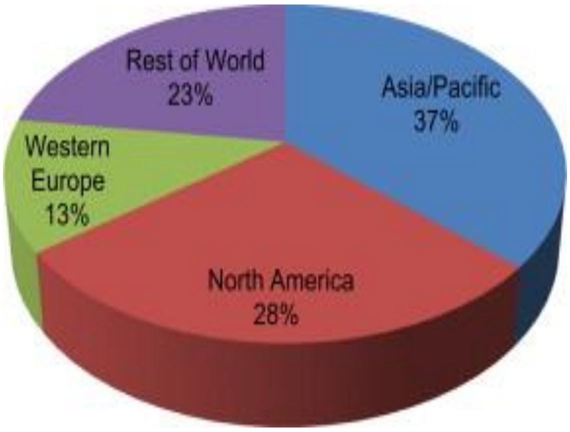


Figure 1. Biolubricant uses in worldwide (Gul et al., 2020).

Table 1. Biolubricants sources around the world

Biolubricant	**Most used countries**
Palm Oil	Malaysia, Indonesia
Sunflower Oil	Europe, Russia, Ukrain, Argentina
RapeseedhOil	EU, US, Canada, Australia, China, India
Olive Oil	Spain, Italy, Greece
Soybean Oil	US, Argentina, Brazil, China, India
Canola Oil	EU, Canada, Australia, China, India
Corn Oil	US, China, Brazil, Argentina, Mexico
Camelina Oil	North Of Europe, Asia

Briefly, Esterification reaction, chemical reaction between Triglycerides, and methyl alcohol with a percentage of sodium hydroxide as a catalyst, and the product of the reaction is glycerol and fatty acids as shown in the Figure 4. This study reviews the physicochemical properties of bio-lubricants and summarized the chemical modifications of the bio-lubricants, and sheds light on the Tribological behavior of Palm oil as a bio-lubricant in internal combustion engines and its function to reduce the friction between the moving parts, the lubrication process plays an important role for cools warm parts and expeller for unwanted heat. Lubrication process in the internal combustion engines is carried out by forming a film layer between the two friction surfaces, The lubrication process is an important process in internal combustion engines, due to reducing the cost of maintenance and reducing the wear of parts to the maximum extent possible between the moving parts, thickness of the film layers plays an important role in determining the efficiency of the lubricant (Yunus et al., 2020). Several studies have been investigated the effect of utilize Palm oil as a bio-lubricant in internal combustion engines and its function to reduce the friction between the moving parts. (Mofiju, et. al., 2011) experimentally studied the effects of palm oil methyl ester unmodified indirect injections diesel engine's wear between cylinders liner and piston ring. Results have shown lower wear take places when engine lubricated with palm oil. Better oil viscosity range 80 to 120 (cSt) have been obtains when engine lubricated with palm oil. Engine lubricated with palm oil can be lowering the harmful emissions levels as CO, CO_2, HC, NO_x (Gul et al., 2020). In recent decades, Several studies have been observed that the addition of nanoparticles to engine oils causes a significant change in the viscosity of the oil, a change in the thermal stability, a change in the thermal properties of the oil due to small size , large specific area, high active surface, and significant effect on improving oil performance, and the development of the tripod properties is good by reducing wear rates and reducing coefficient of friction COF (Ali et al., 2019; Jia et al., 2019; Gulzar et al., 2016). Depending on the shape and size of the nanoparticles combine with each other and form a spherical shape between two surfaces to reduce friction, also, nanoparticles have an ability to protect worn surfaces from corrosion by sticking between two friction surfaces (Wu et al., 2007; Gulzar et al., 2016; Azman et al., 2016; Chou et al., 2010). It was found that adding copper oxide to MS_2 to chemically modified palm oils contributes to a significant reduction in corrosion, pressure reduction and improvement of anti-corrosion properties by 1.5 %. Several metal oxide nanoparticles have been used to improve lubrication efficiency, like Zno, Cuo, AL_2O_3, etc due to they have high specific surface, highest absorption for heat, and good anti-friction under various lubrication conditions. (L Gara and Zou, 2013; Azaman et al., 2016). They are adding graphene particles to palm oil and found that it contributes to improving the viscosity of the oil and the density of the oil and increases the acid number of the oil. It also found a significant reduction in the coefficient of friction and a significant reduction in the corrosion rates (Amari et al, 2022; Hussein et al., 2021). Experimentally studied the effect of adding Mg $(OH)_2$ to conventional engine oil SN500 HVI, experiment was conducted implicitly at different rates ranging from 5-60 ° C, change of shear stresses 650-13250 S^{-1}. The results of the experiment showed that adding of Mg $(OH)_2$ has positive effects in engine oils, especially in improving the tribological properties of engine oil, thus increasing engine performance, as well as increasing its lifespan of engine (Mokarian and Ameri, 2022). Recently, graphene nanoparticles (GP) most common lubricating additive because of their fine tribological behavior (Cho et al., 2013; De Wijn, 2016; Choopanya and Yang, 2016; Choopanya and Yang, 2016; Yang et al., 2019), moreover, mixed nanoparticles including GP enhance lubricants performance like Cu, Ws_2, MoS_2 (Zhang et al., 2013; Zheng et al., 2017; Nafchi et al., 2019). This study reviews the physicochemical properties of Palm oil and summarized the chemical modifications of the Palm oil and sheds light on the tribological behavior of palm oil as a lubricant in internal combustion engines and its function to reduce the friction between the moving parts.

2. Palm oil properties

Friction between two contact surfaces inside internal combustion engines is an important factor to reduce the efficiency of engines. Internal combustion engines lubrication process have a vital importance. It is works to reduce friction and wear,also, optimize engine efficiency. After growing up in the industrial and technology sector, lubrication demand have been increases in order to raise the efficiency of machines in manufactories. Increase in the fossil fuel prices and the growth of fears of its exhaustion, world's attention turned to find alternative, cheaper and renewable sources (Mofijur et al., 2012). Palm oil are derived from plant sources such as palm, soya, sunflower, corn, rapeseed, coconut oil, safflower, and peanuts, which means sustanble sources, as well as biolubricants can be manufactured from sources of synthetic esters and petroleum oils. Biolubricants have several advantages as followings:

- Palm oil have a higher flash point than mineral oils
- Palm oil have the ability to decompose, contributing to reducing environmental pollution.
- Palm oil have less toxicity than mineral oils.

- Palm oil are considered renewable sources and reduce dependence on fossil fuels.
- Palm oil have excellent lubrication, reduce friction losses and are more economical in fuel consumption.
- Palm oil have a low volatility, so they contribute to reducing harmful emissions.
- Palm oil used under different temperatures (Chowdary et al., 2021).

Palm oil one of the strongest candidates to replace mineral oils, especially in internal combustion engines, because of their unique properties such as low toxicity, high ignition temperature, high viscosity, good friction coefficient, low rates of harmful emissions, low evaporation rates, High abrasion resistance. , Physicochemical properties of various biolubricants as can be seen in table 2. Palm oil have a uniqe Physicochemical properties as following:

Viscosity

Palm oil viscosity is a very important property. Viscosity is defined as the fluid's resistance to flow and is strongly affected by temperature and pressure. Palm oil more viscose than mineral oils. This feature makes them more effective at high temperatures, and therefore they are suitable for working under wide temperature ranges (Encinar et al., 2020).

Pour point

Palm oil pour point defined as the lowest temperature that makes the palm oil flow. The pour point in lubricant oils is a vital and very important factor. It is worth mentioning that the palm oil lubricants have a lower pour point than mineral oils. Pour point feature of palm oil provides smooth lubrication, especially in cold operating conditions (Ahmed et al., 2014).

Flash point

Palm oil flash point defined as lowest temperature that heats oil before it evaporates, then ignites. Fire point is the temperature at which biolubricant ignites and the ignition continues for 5 minutes even after the ignition source is removed. Ignition point and flash point provide the ability to resist fire in Palm oil. Palm oil have a higher flash point and Ignition point than conventional oils. Pour point feature of palm oil enables to start fires in case of oil leakage (Cecilia et al., 2020).

Oxidative stability

Palm oil are considered to have low oxidative stability due to the presence of an alkyl group in their molecules. Palm oil oxidize quickly and become viscose fluid and become thick, similar to polymer. Oxidative stability characteristic of palm oil can be improving by applying chemicals reaction’s or chemical modifications such as esterification reactions. (Loh et al., 2006). One of the factors affecting the increase in surface oxidation are:

- Exposure to high temperatures
- Exposure to water
- Surface type
- Exposure to air
- Exposure to high pressure.

Esterification process can be defined a chemical reaction by combaınıg between carboxylic acid (RCOOH) with alcohol (ROH) to produce ester (RCOOR) and water. The esterification process is commonly used because of its cheapness and simplicity, for example, the process of reducing the viscosity of Jatrava oils is carried out by reacting triglycerides with methyl alcohols in the presence of sodium hydroxide as catalysts for the reaction to produce glycerol and fatty acids as shown in Figure 2.

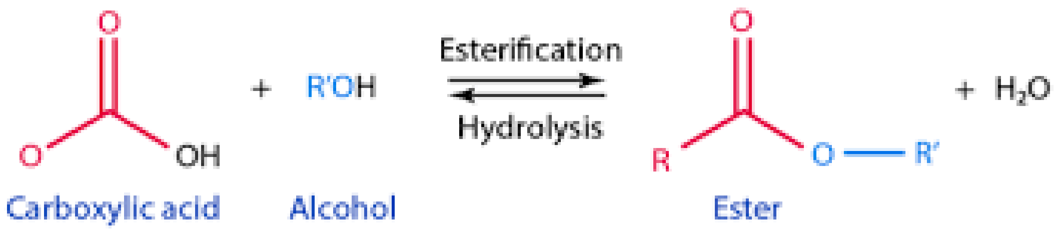


Figure 2. Esterification process

Table 2. Physicochemical properties of various biolubricants

Lubricants	Vicosity index	Viscosity 40C (cSt)	Pour point ()	Flash point ()
Palm oil	186	52.4	-5	300
Soybean oil	246	28.86	-9	325
Safflowr oil	180	45.6	-11	242
Rapeseed oil	180	45	-12	252
Sunflower oil	206	40	-12	250

3. Tribological behavior of palm oil in ic engines

Palm oil is one of the most widely commercially oils around the world. India and China have witnessed a significant growth in the production of palm oils. Production rate of palm oils around the world is 40%, and the amount of palm oil consumption around the world in 2021 is about 19.8 million tons, due to Its cheap price, high tribological performance. Palm oil consist of long chains of fatty acids. Rapid growth of the palm crop (the cultivation of one hectare of palm produces an amount of oil equivalent to ten times if another crop was planted such as rapeseed oils). High percentage of saturated fats is an important feature for calculating the turbological performance of palm oil. Palm oil is characterized by containing a large amount of saturated fatty acids, up to 50% of the rest of the other oils. Palm oils have several benefits as following:

- Low volatility
- High flash point
- Lower negative impact on the enviroment.

Physicochemical properties of palm oil

Active functional groups

Palm oils contain three guest groups:

- Ester groups (RCOOR) are common groups in palm oils that give it resistance to friction.
- Hydroxide (OH) groups cause the high viscose property, due to hydrogen bonds in palm oils.
- Carboxyl groups (RCOOH), which are groups found in the fatty acids of palm oils, work on the adhesion of oils to metal surfaces.

Degree of unsaturation

Degree of unsaturation refers to the number of bonds in the chains of carbon molecules. Palm oils contain two main types of fatty acids: palmic acid (16:0) / oleic acid (18:1) fatty acids. Several experiment studies on palm oil, counducted that (when the value of fatty acids is greater than 16, palm oil has good tribological properties). Palmitic acid 16:1 is one of the most abundant fatty acids in palm oils, and the proportion of molecules is greater than 16, so palm oils have good tribological properties.

Carbon chain length

In the palm oil struture the length of the carbon chains can be from 6 to 24. Many experiment studies on palm oil conducts that(if the carbon chains are 8 atoms, the oil has good tribological properties) .The length of the carbon chains in the fatty acids in palm oils is an important factor affecting several factors (viscosity, tribological properties, oxidative stability and pour points.

Mechanical efficiency

As can be seen in Figure 3 (a) the maximum value of mechanical efficiency of the internal combustion engine has been noted when the engine lubricates with 100% mineral oil, slight differences have been found when the engine lubricates with a blend lubrication of 75% mineral oil, and 25% palm oil. mechanical efficiency of the internal combustion engine is noted at 54% when the engine lubricates with 50% mineral oil, and, 50% palm oil. the rational reason for decreases in the mechanical efficiency at the start of operation is an increase in frictional power.

Brake thermal efficiency

As can be demonstrated in the Figure 3 (b) variation of brake thermal efficiency with load conditions of mineral oil with different percentages of palm oil, and, mineral oil. For mineral oil lubrication brake thermal efficiency values are close to palm oil, and, mineral oil blending in a wide range of operations. Maximum brake thermal efficiency is 33.8% for mineral oil lubrication, where 34.6% brake thermal efficiency values engines lubricating with 25% palm oil-75% mineral oil.

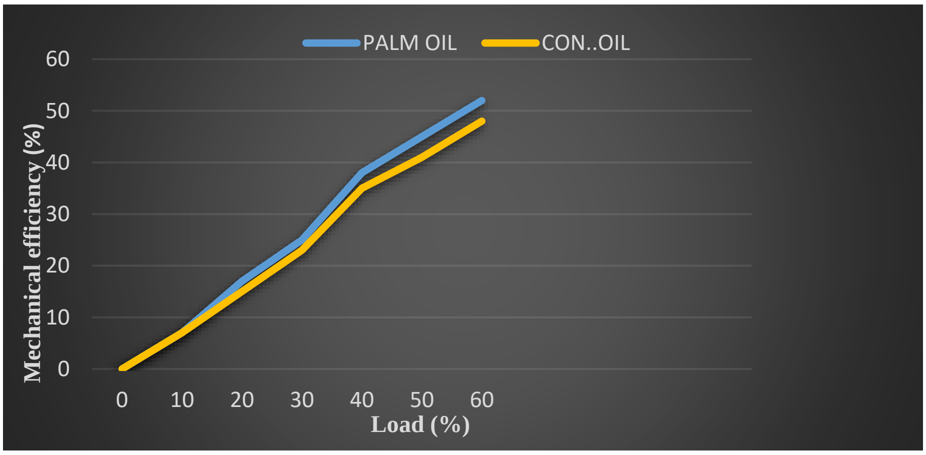
Brake specific fuel consumption BSFC

As can be seen in Figure 4 (a) Brake specific fuel consumption variation with engine load lubricated with mineral oil, and, blending of mineral oil-palm oil. The figure 4 (a) demonstrated no difference in the fuel consumption values when the engine lubricates with mineral oil or lubricated with the blending of mineral oil-palm oil.

CO emission

As can be demonstrated in Figure 4 (b) variation of CO harmful emission with engine load conditions of the engine lubricated with mineral oil, and, engine lubricated with different percentages of palm oil, and, mineral oil blending. at the start of the operation, there is a huge variation in CO emitting levels, but this huge variation in CO emitting levels goes to reducing when increasing the engine load, moreover, at full engine load with 50% palm oil-50% mineral oil, CO harmful emissions are very low levels.

a)



b)

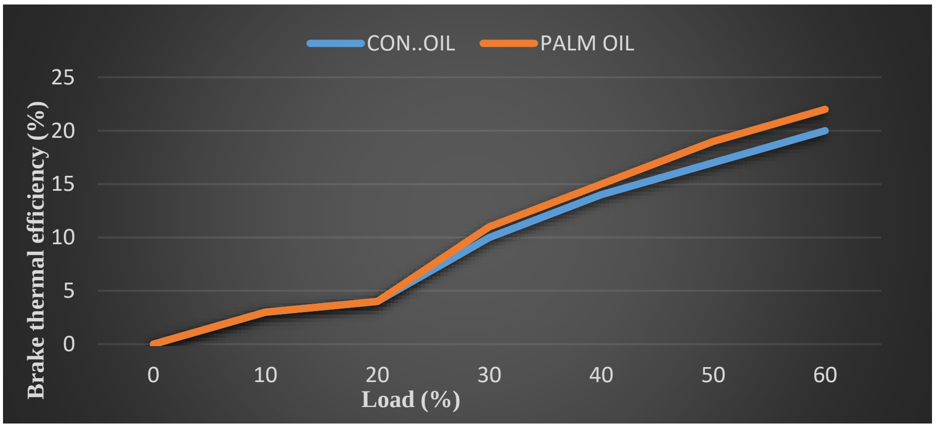
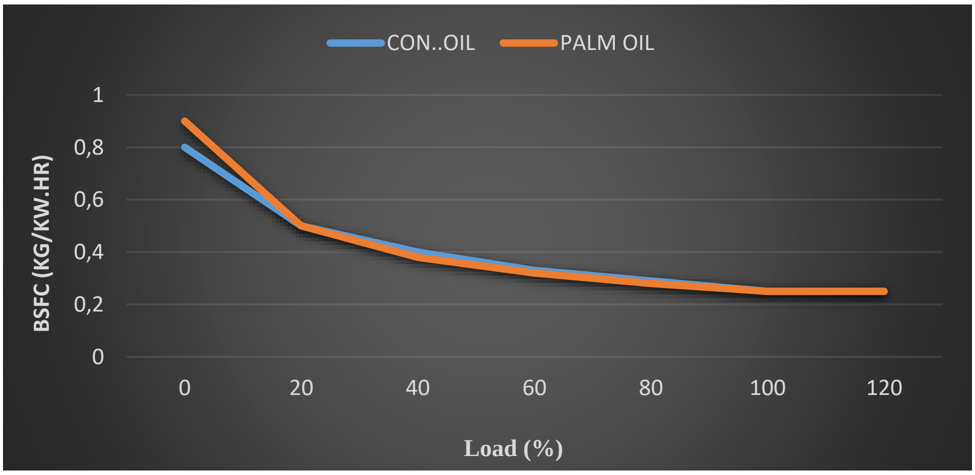


Figure 3. Comparison between conventional oil and palm oil a) mechanical efficiency variation with engine load, b) brake thermal efficiency

a)



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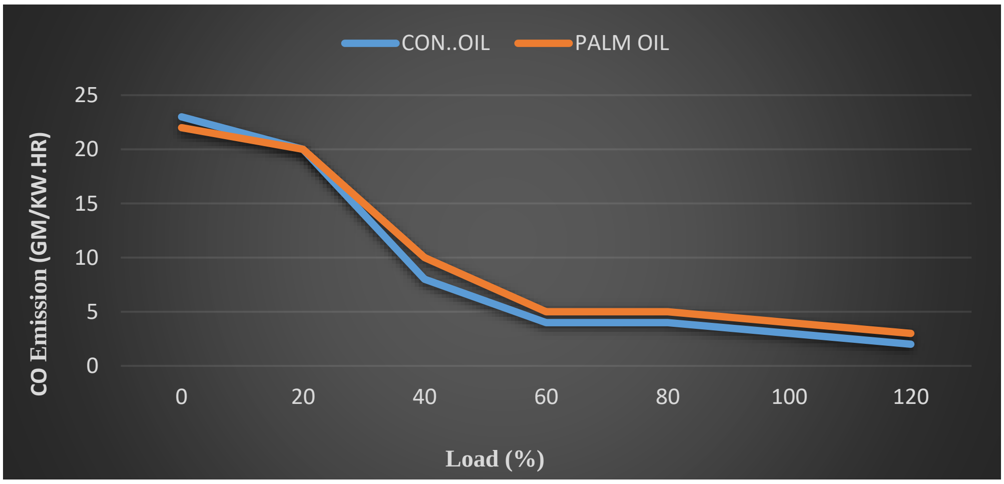

Figure 4. Comparison between conventional oil and palm oil a) Brake specific fuel consumption varation with engine load, b) CO emmission

4. Conclutıons

This study reviews the physicochemical properties of Palm oil and summarized the chemical modifications of the Palm oil and sheds light on the tribological behavior of palm oil as a lubricant in internal combustion engines and its function to reduce the friction between the moving parts. Lubrication process plays an important role for cools warm parts and reject unwanted heat. Through investigation of several studies on biolubrications, it was found palm oil is one of the most commonly used oils in lubricating oil in internal combustion engines. Palm oil are cheapest bio-lubricants, available all year round, have high Tribological properties and, It accounts for about 40 % of biolubricants production. Palm oil can be used as an alternative to traditional oils because it has good effects on the environment as it contributes to reducing harmful emissions from oils derived from fossil fuels. Moreover, Tribological performance of palm oils is affected by physicochemical properties. Enhance the Tribological performance of palm oils affected by physicochemical properties such as oil viscosity, flash point, oxidative stability. Studies have been observed that adding nanoparticles to palm oil effectively contributes to the development of the Tribological performance of palm oil, also, reducing the coefficient of friction and reducing surface wear rates. Studies have been observed that the mechanical efficiency of internal combustion engines increases when using palm oils. Studies have been obtained braking efficiency of internal combustion engines is at its highest when using palm oil as a lubricant. Studies have been noted that fuel consumption is at the lowest when using palm oil as a lubricant compared to conventional lubricants.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

Reference

Ahmed, D.I., Kasolang, S., Dwyer-Joyce, R.S., Sainan, K.I., Roselina, N.N., 2014. Formulation and physico-chemical characteristics of biolubricant. *Journal Tribologi*, 3(1): 1-10.

Ali, I., Kucherova, A., Memetov, N., Pasko, T., Ovchinnikov, K., Pershin, V., Tkachev, A., 2019. Advances in carbon nanomaterials as lubricants modifiers. *Journal of Molecular Liquids*, 279: 251-266.

Azman, S.S.N., Zulkifli, N.W. M., Masjuki, H., Gulzar, M., Zahid, R., 2016. Study of tribological properties of lubricating oil blend added with graphene nanoplatelets. *Journal of Materials Research*, 31(13): 1932-1938.

Bajaj, D.S., Jahagirdar, D.R., 2018. Experimental investigation on usage of cotton seed oil as a lubricant to substitute mineral oil. *In Proceedings of TRIBOINDIA-2018 An International Conference on Tribology*.

Cecilia, J.A., Ballesteros Plata, D., Alves Saboya, R.M., Tavares de Luna, F.M., Cavalcante Jr, C.L., Rodríguez-Castellón, E., 2020. An overview of the biolubricant production process: Challenges and future perspectives. *Processes*, 8(3): 257.

Cho, D.H., Wang, L., Kim, J.S., Lee, G.H., Kim, E.S., Lee, S., Lee, C., 2013. Effect of surface morphology on friction of graphene on various substrates. *Nanoscale*, 5(7): 3063-3069.

Choopanya, P., Yang, Z., 2016. An effective mesh strategy for CFD modelling of polymer electrolyte membrane fuel cells. *International Journal of Hydrogen Energy*, 41(15): 6445-6456.

Chou, R., Battez, A.H., Cabello, J.J., Viesca, J.L., Osorio, A., Sagastume, A., 2010. Tribological behavior of polyalphaolefin with the addition of nickel nanoparticles. *Tribology International*, 43(12): 2327-2332.

Chowdary, K., Kotia, A., Lakshmanan, V., Elsheikh, A.H., Ali, M.K.A., 2021. A review of the tribological and thermophysical mechanisms of bio-lubricants based nanomaterials in automotive applications. *Journal of Molecular Liquids*, 339: 116717.

De Wijn, A.S., 2016. Nanoscience: Flexible graphene strengthens friction. *Nature*, 539(7630): 502–503.

Encinar, J.M., Nogales, S., González, J.F., 2020. Biodiesel and biolubricant production from different vegetable oils through transesterification. *Engineering Reports*, 2(12): e12190.

Garcés, R., Martínez-Force, E., Salas, J.J., 2011. Vegetable oil basestocks for lubricants. *Grasas y aceites*, 62(1): 21-28.

Gul, M., Masjuki, H.H., Kalam, M.A., Zulkifli, N.W.M., Mujtaba, M. A., 2020. A review: role of fatty acids composition in characterizing potential feedstock for sustainable green lubricants by advance transesterification process and its global as well as Pakistani prospective. *BioEnergy research*, 13: 1-22.

Gulzar, M., Masjuki, H.H., Kalam, M.A., Varman, M., Zulkifli, N. W. M., Mufti, R.A., Zahid, R., 2016. Tribological performance of nanoparticles as lubricating oil additives. *Journal of Nanoparticle Research*, 18: 1-25.

Haigh, K. F., Saha, B., Vladisavljević, G. T., Reynolds, J. C., 2012. Kinetics of the pre-treatment of used cooking oil using Novozyme 435 for biodiesel production. *Procedia Engineering*, 42: 1106-1113.

Hussein, R. Z., Attia, N. K., Fouad, M. K., ElSheltawy, S. T., 2021. Experimental investigation and process simulation of biolubricant production from waste cooking oil. *Biomass and Bioenergy*, 144: 105850.

Jia, X., Huang, J., Li, Y., Yang, J., Song, H., 2019. Monodisperse Cu nanoparticles@ MoS2 nanosheets as a lubricant additive for improved tribological properties. *Applied surface science*, 494: 430-439.

Gara, L.L., Zou, Q., 2013. Friction and wear characteristics of oil-based ZnO nanofluids. *Tribology Transactions*, 56(2): 236-244.

Loh, S. K., Chew, S. M., Choo, Y. M., 2006. Oxidative stability and storage behavior of fatty acid methyl esters derived from used palm oil. *Journal of the American Oil Chemists' Society*, 83: 947-952.

Menkiti, M. C., Ocheje, O., Agu, C. M., 2017. Production of environmentally adapted lubricant basestock from jatropha curcas specie seed oil. *International Journal of Industrial Chemistry*, 8: 133-144.

Mofijur, M., Masjuki, H. H., Kalam, M. A., Shahabuddin, M., Hazrat, M. A., Liaquat, A. M., 2012. Palm oil methyl ester and its emulsions effect on lubricant performance and engine components wear. *Energy Procedia*, 14: 1748-1753.

Mokarian, M., Ameri, E., 2022. The effect of Mg (OH) 2 nanoparticles on the rheological behavior of base engine oil SN500 HVI and providing a predictive new correlation of nanofluid viscosity. *Arabian Journal of Chemistry*, 15(6): 103767.

Nafchi, F. M., Afshari, E., Baniasadi, E., Javani, N., 2019. A parametric study of polymer membrane electrolyser performance, energy and exergy analyses. *International Journal of Hydrogen Energy*, 44(34): 18662-18670.

Narayana Sarma, R., Vinu, R., 2022. Current status and future prospects of biolubricants: properties and applications. *Lubricants*, 10(4): 70.

Ren, B., Gao, L., Li, M., Zhang, S., Ran, X., 2020. Tribological properties and anti-wear mechanism of ZnO@ graphene core-shell nanoparticles as lubricant additives. *Tribology International*, 144: 106114.

Wu, Y.Y., Tsui, W.C., Liu, T.C., 2007. Experimental analysis of tribological properties of lubricating oils with nanoparticle additives. *Wear*, 262(7-8): 819-825.

Yang, J., Chen, Y., Xu, P., Li, Y., Jia, X., Song, H., 2019. Fabrication of compressible and underwater superoleophobic carbon/g-C3N4 aerogel for wastewater purification. *Materials Letters*, 254: 210-213.

Yunus, R., Rasheed, H. S., Zulkifli, N. W. M., 2020. Wear and friction behavior of semi synthetic engine oil blended with palm oil/TMP ester and nano glass powder additive. *Jurnal Tribologi*, 26: 16-36.

Zhang, Y., Tang, H., Ji, X., Li, C., Chen, L., Zhang, D., Zhang, H., 2013. Synthesis of reduced graphene oxide/Cu nanoparticle composites and their tribological properties. *RSC Advances*, 3(48): 26086-26093.

Zheng, D., Wu, Y. P., Li, Z. Y., Cai, Z. B., 2017. Tribological properties of WS 2/graphene nanocomposites as lubricating oil additives. *Rsc Advances*, 7(23): 14060-14068.

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