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ANTI-OXIDATION ADDITIVES IN PALM OIL LUBRICANT TOWARDS A SUSTAINABLE LUBRICATION APPROACH

Ojaomo, K.E. [1,2,*], Syahrullail Samion [1], Mohd Zamri Yusop [1] and Fazila Mohd Zawawi [1]
[1] Faculty of Mechanical Engineering, Universiti Teknologi Malaysia,
81310 UTM Johor Bahru, Johor, Malaysia.
[2] Department of Mechanical Engineering, The Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria.
[*] Corresponding author: ebenezer@graduate.utm.my

ABSTRACT
Bio lubricants are bio-based compounds which offer renewable and biodegradable replacement for petroleum derived lubricants because of the latter's toxicity to environmental balance. They are derivative from plant and animal, agricultural wastes, edible and non-edible sources such as nuts etc. Lubricants are very essential in sustaining the techno-economic life of equipment and machines. Its potency for reducing friction and wear is regarded as agelong. Apart from vibration due to misalignment of machine components, a major cause of wear and vanish in machine operations is inadequate or lack of lubrication. Although bio lubricants application appears promising, their commercial deployment is quite limited in relation to the mineral oils. However, research in this field is continuously rising to improve their properties with the aim of overcoming the current limitations of poor oxidation stability, low temperature flow challenges, volatility at high temperature, low flash point, low viscosity index etc. and enhancing large scale production. This paper examines the anti-oxidating effect of tert-butylhydroquinone TBHQ in palm oil lubricants. The result showed oxidation onset temperature OOT was shifted from 180℃ to 220℃ due to inclusion of 0.3wt% of TBHQ

KEYWORD
Bio lubricant, additives, TBHQ, friction and wear, surface tribology, antioxidant, anti-wear.

INTRODUCTION

Surface degradation is regarded as one of the major causes of machine failure next to obsoletion due to aging unethical handling (Zhu et al., 2019). Surface degradation include mechanical wear during operation, corrosion due to harsh environmental influence(Ahmed et al., 2020). Figure 1 showed the tribological effect of lubrication on the materials surfaces. The surface degradation of the unlubricated material as seen under an optical microscope had a wider wear scar and much coefficient of friction COF in comparison with the lubricated surface (Aiman et al., 2022). This underscores the enormous contribution of lubricant to machine efficiency and maintenance. Over the years, various lubricants have been applied to mitigate the consequences of equipment degradation towards a longer lifespan. Improper selection or formulation of lubricants have been demonstrated to cause vibration, noise and misalignment resulting in great losses and wastes(Ali et al., 2022; Li et al., 2022; Wang et al., 2022). Research on bio lubricants have grown rapidly in the recent two decades as well. Even though remarkable progress has been made, studies on fortifying the properties of potential vegetable oils candidates with additives are still increasingly evolving.

Although, conventional mineral base stock lubricants have been well developed and used in different services, they are seriously confronted with environmental challenges (Padgurskas et al., 2013)(Singh et al., 2020). Due to their toxicity, poor biodegradability and disposal challenges, these mineral-based lubricants formulations, which account for the largest volume of application for conventional lubricants are environmentally precarious. For instance, due to engine exhaust emissions and evaporation that take place while using conventional lubricants, they contribute to environmental contamination (Wen et al., 2019). At the end of the machine operation, safe disposal of spent lubricants becomes a challenge due to slow degradability and are noxious to human health, fauna, and flora (Gul et al., 2021). Against this backdrop, formulation of eco-friendly lubricant with good lubricity to solve the issue of high friction and wear becomes important.

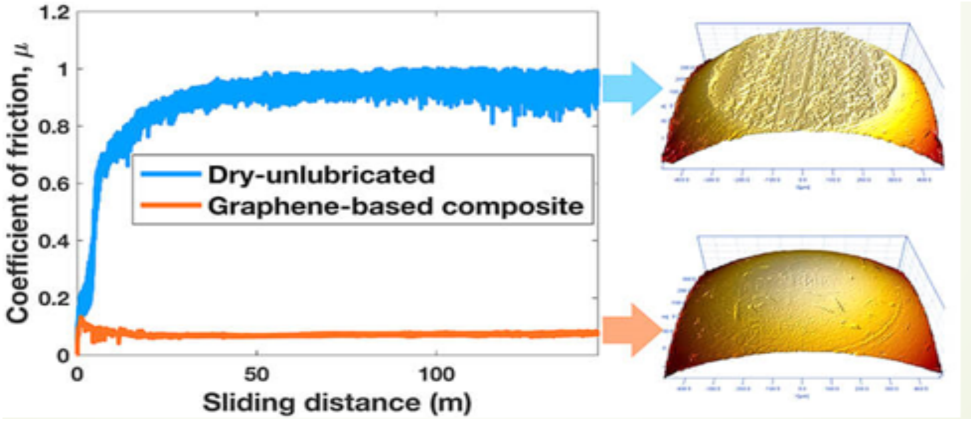

Figure 1. lubricant is a veritable tool to reducing surface degradation

Even though majority of bio-based oils had various traits, several of them demonstrate comparable behaviour. On the positive side, they typically have high levels of lubricity, viscosity index, and flash point; on the minus side, they were prone to oxidation and had poor low-temperature properties., numerous research has been carried out to address these drawbacks, and most of the outcomes were found to be encouraging (Farfan-Cabrera et al., 2020). Strategies that can be used to enhance their qualities, including changing the molecules' structures, adding advantageous additives, combining with nano-based compounds, and more (Kurre & Yadav, 2023; Yahayaa et al., 2019). These inventions were all made in accordance with the requirements of the applications. In this study, PO based lubricants limited oxidative stability will be examined for improved sliding operations by adding Tert-butylhydroquinone TBHQ for oxidation stability improvement. Poor oxidation stability is a limitation for most potential bio lubricants vegetable oil candidates

MATERIAL AND METHODOLOGY

PO was mixed with 0.3wt% of TBHQ using desktop homogenizer ASTM D6185 and agitated at the speed of 15000rpm for 30 minutes. Differential scanning calorimetry DSC ASTM D3418 was also used to conduct the oxidation test while linear tribometer was used for tribological tests. The effect of TBHQ on the oxidation onset temperature OOT of PO was determined using differential scanning calorimetry (DSC) measurements of base lubricant and with inclusion of anti-oxidant TBHQ. (Darminesh et al., 2017) It was performed with a Q-100 TA instrument, using 5mg samples sealed in hermetic aluminum pans. Cooling and heating rates of 10 ^{o}C/min were applied to all samples, flow rate of 50mL/min.which is an optimum rate that has advantage of being fast with greater data repeatability according to previous presentation (Zulhanafi & Syahrullail, 2019). The temperature window selected ranged from 25 up to 350 ^{o}C. The oxidation stability was judged based on the temperature at which degradation sets in (OOT).The dropping value of pressure in the pressure vessels indicates that an amount of oxygen has been absorbed into the oil. This is a starting point where the oil starts to oxidate. Linear tribometer was used to examine the tribological behaviour with an aluminuim plate and steel ball tribopair using PO as lubricant.

RESULT AND DISCUSSION

The mixing with TBHQ was miscible with PO without residues. This indicated homogeneity with the anti-oxidant. Figure 2 showed that the OOT of palm oil was enhanced by the inclusion of TBHQ in PO sample. Thus, the OOT increased from 180 ^{o}C to 220 ^{o}C. This observation is in concurrence with opinion that TBHQ can improve oxidation resistance for palm oil (Hassan et al., 2016) (Sapawe et al., 2016). Similarly Figure 3 shows the COF values against different loads and temperature of the lubricant. The COF values show a range of values with correlation to the properties of the tribo-pair used.

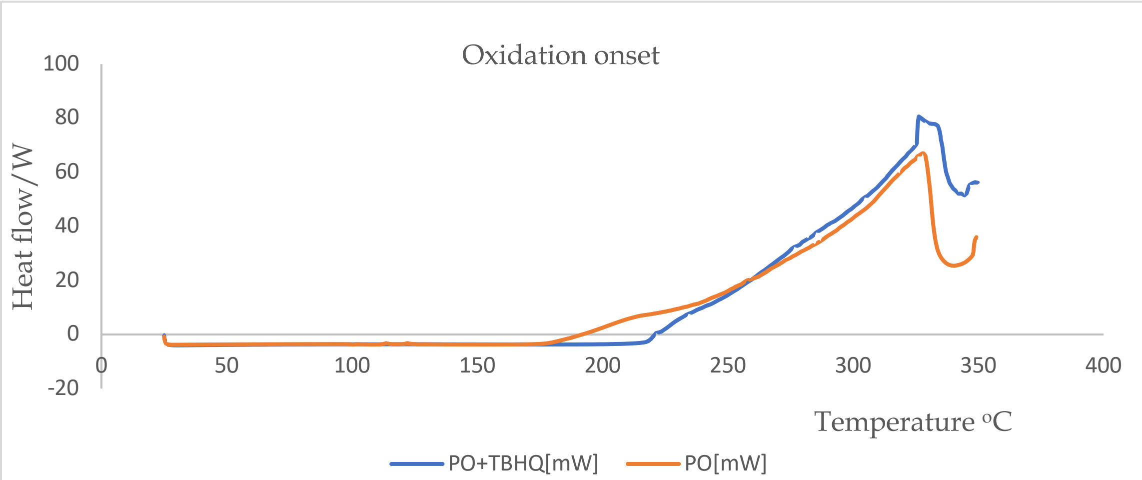

Figure 2. DSC oxidation test of PO with TBHQ antioxidant

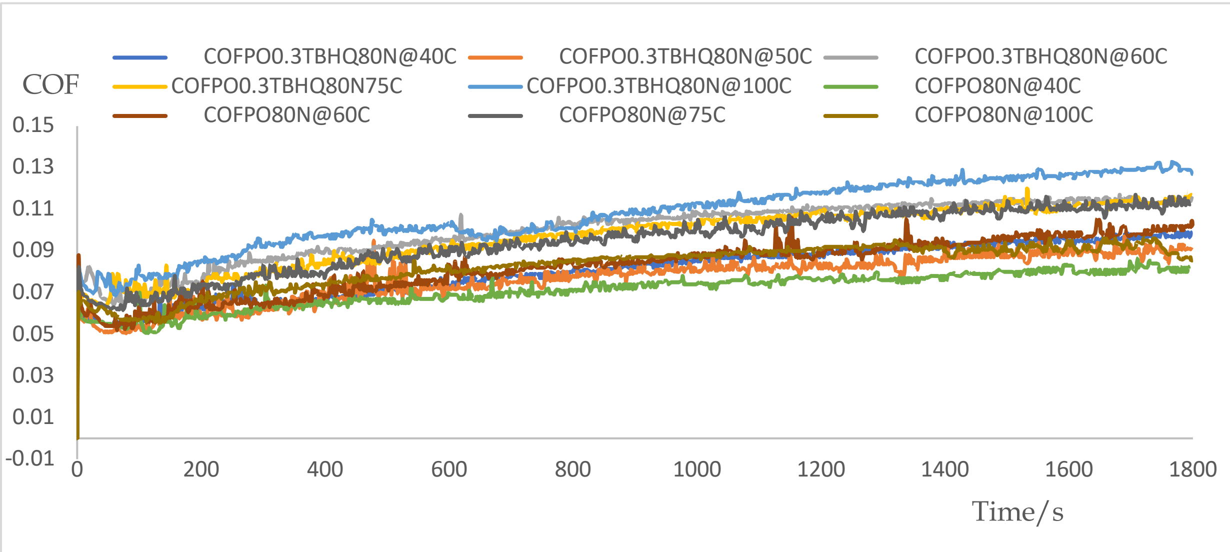

Figure 3. Tribological tests of PO with anti-oxidant

CONCLUSION

Further research on vegetable oils points to a sustainable direction in the field of tribology. Therefore, more additives and modifications to improve their performance for future applications are important due to non-renewability of the conventional mineral lubricants which may soon go into depletion.

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REFERENCES

Ahmed, A., Shah, A. N., Azam, A., Uddin, G. M., Ali, M. S., Hassan, S., Ahmed, H., & Aslam, T. (2020). Environment-friendly novel fuel additives: Investigation of the effects of graphite nanoparticles on performance and regulated gaseous emissions of CI engine. Energy Conversion and Management, 211(March), 112748. https://doi.org/10.1016/j.enconman.2020.112748

Aiman, M. A., Ramlee, N. A., Mohamad Azmi, M. A., & Tuan Sabri, T. N. A. (2022). Preparation, thermal degradation, and rheology studies for polylactic acid (PLA) and palm stearin (PS) blend: A review. Materials Today: Proceedings, 63, S222–S230. r.2022.02.420

Ali, Z. A. A. A., Takhakh, A. M., & Al-Waily, M. (2022). A review of use of nanoparticle additives in lubricants to improve its tribological properties. Materials Today: Proceedings, 52, 1442–1450.

Darminesh, S. P., Sidik, N. A. C., Najafi, G., Mamat, R., Ken, T. L., & Asako, Y. (2017). Recent development on biodegradable nanolubricant: A review. International Communications in Heat and Mass Transfer, 86(June), 159–165.

Farfan-Cabrera, L. I., Gallardo-Hernández, E. A., Gómez-Guarneros, M., Pérez-González, J., & Godínez-Salcedo, J. G. (2020). Alteration of lubricity of Jatropha oil used as bio-lubricant for engines due to thermal ageing. Renewable Energy, 149, 1197–1204.

Gul, M., Zulkifli, N. W. M., Kalam, M. A., Masjuki, H. H., Mujtaba, M. A., Yousuf, S., Bashir, M. N., Ahmed, W., Yusoff, M. N. A. M., Noor, S., & Ahmad, R. (2021). RSM and Artificial Neural Networking based production optimization of sustainable Cotton bio-lubricant and evaluation of its lubricity & tribological properties. Energy Reports, 7, 830–839.

Hassan, M., Ani, F. N., & Syahrullail, S. (2016). Tribological performance of refined, bleached and deodorised palm olein blends bio-lubricants. Journal of Oil Palm Research, 28(4), 510–519.

Kurre, S. K., & Yadav, J. (2023). A review on bio-based feedstock, synthesis, and chemical modification to enhance tribological properties of biolubricants. Industrial Crops and Products, 193(August 2022), 116122.

Li, H., Zhang, Y., Li, C., Zhou, Z., Nie, X., Chen, Y., Cao, H., Liu, B., Zhang, N., Said, Z., Debnath, S., Jamil, M., Ali, H. M., & Sharma, S. (2022). Extreme pressure and antiwear additives for lubricant: academic insights and perspectives. In International Journal of Advanced Manufacturing Technology (Vol. 120, Issues 1–2). Springer Science and Business Media Deutschland GmbH.

Padgurskas, J., Rukuiza, R., Prosyčevas, I., & Kreivaitis, R. (2013). Tribological properties of lubricant additives of Fe, Cu and Co nanoparticles. Tribology International, 60, 224–232.

Sapawe, N., Samion, S., Zulhanafi, P., Nor Azwadi, C. S., & Hanafi, M. F. (2016). Effect of Addition of Tertiary-Butyl Hydroquinone into Palm Oil to Reduce Wear and Friction Using Four-Ball Tribotester. Tribology Transactions, 59(5), 883–888.

Singh, Y., Sharma, A., Singh, N. K., & Chen, W. H. (2020). Development of bio-based lubricant from modified desert date oil (balanites aegyptiaca) with copper nanoparticles addition and their tribological analysis. In Fuel (Vol. 259).

Wang, X., Huang, J., & Guo, Z. (2022). Overview of the development of slippery surfaces: Lubricants from presence to absence. Advances in Colloid and Interface Science, 301(January), 102602.

Wen, C., Wang, H., Wang, L., Lou, Z., Sun, Z., & Zhou, Z. (2019). The reduction of waste lubricant oil distillate through the enhancement of organics degradation by ozonation with elevated temperature and stable pH for the zero discharge. Journal of Cleaner Production, 240, 118194.

Yahayaa, M. S., Raof, N. A., Ibrahim, Z., Ahmad, A., & Gomes, C. (2019). Modifications required for palm oil to be qualified as a mechanical lubricant. International Journal of Manufacturing, Materials, and Mechanical Engineering, 9(1), 50–66. https://doi.org/10.4018/IJMMME.2019010104

Zhu, T., Shipway, P. H., & Sun, W. (2019). The dependence of wear rate on wear scar size in fretting; the role of debris (third body) expulsion from the contact. Wear, 440–441.

Zulhanafi, P., & Syahrullail, S. (2019). The tribological performances of Super Olein as fluid lubricant using four-ball tribotester. In Tribology International (Vol. 130, pp. 85–93).