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Modifications Required for Palm Oil to be Qualified as a Mechanical Lubricant

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ABSTRACT

Adaptation of apt chemical modifications and incorporation of suitable additives, especially, nano-additives, could improve the properties of bio-lubricants derived from palm oil. This makes it one of the best alternatives to mineral oil lubricants. Possible chemical modifications are hydrogenation, esterification/ transesterification, epoxidation and metathesis. Feasible additives and nano-additives available in the market for minimizing the drawbacks of palm oil as a lubricant are ionic liquids, phosphorus, sulphur, zinc dialkyl dithiophosphate, metal, metal oxides, metal sulphides, carbonates, borates, carbon materials, organic materials, hexagonal boron nitride, alumina, CaO, CuO, ZnO, TiO_2 and lanthanum borates. Few of them may not be environmental friendly. In line with market potentials and demand, it could be predicted that ROI of funding for the research and development of palm oil as a bio-lubricant may be significantly high. The study addresses tribological performance and properties, chemical modifications and formulation with additives of palm oil as a bio-lubricant.

KEYWORDS

Bio-Lubricant, Eco-Friendly, Lubricant, Mineral Oil, Palm Oil, Tribological

1. INTRODUCTION

Mineral oil has been extensively used for a long period in many applications, especially those related to engineering systems. It is a favourable selection for many applications due to the highly desirable technical properties and performance as a technical product. However, due to the uncertainty of the price and adverse effects such as environmental pollution and escalating cost, an alternative resource to mineral oil has been investigated by many researchers in the recent years (Cheng and Rosentrater, 2017).

One of the main usage of mineral oil, practised for many decades is its application as a lubricant. In recent years, there has been an increasing interest to reduce the dependency of mineral oil-based lubricating products. Once treated as solely desirable for edible and medicinal applications (Kangpanich et al., 2017; Chowtivannakul et al., 2016; Maimulyanti and Prihadi, 2016), bio-oils became rapidly popular in many other mechanical, electrical and thermal applications in the recent past. As environmental concerns cultivate, vegetable oil has become a good alternative source of reducing

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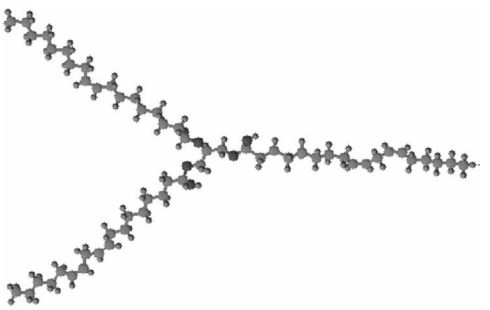
the dependence of the lubricating industry on mineral oil. Bio-oils have many benefits compared to that of mineral oil (Cheng et al., 2017; Syahrullail et al., 2011; Washington, 2011; Willing, 2001). It offers fewer impacts to the environment with respect to the renewability and biodegradability (Rahim and Talib, 2017; Washington, 2011). Other advantages of vegetable oils are; its wide availability as a renewable source and the ability to be harvested quite easily (Mba et al., 2015; Panchal et al., 2017). Historically, natural lubricants from vegetable oils have been used as a lubricant since the 17th century. Various vegetable oils such as olive, rapeseeds, castor beans, palm oil and wool grease were used significantly since early 19th century (Gawrilow, 2004). However, these vegetable oils, with their then quality, had limited stability and poor technical performance. Evolution of natural oils from vegetable started at the industrial revolution where the serious needs of inexpensive, stable lubricant in terms of performance such as thermal and oxidation were in high demand (Gawrilow, 2004). Consequently, there was a growing community in the technology sector that has recognized the importance of vegetable oils, especially in biodiesel and bio-lubricant applications, as an alternative to the mineral oil. The importance of such oil will soon be felt in machining processes based on cutting fluids (Travieso-Rodriguez et al., 2015) and lightweight vehicle manufacturing (Tang, 2017).

At present, many vegetable oils are used in industries which have been produced from groundnut, oil palm, soybean, rapeseed, and sunflower (Willing, 2001). Investigations in laboratory conditions show that vegetable oils with the addition of additives demonstrate excellent lubrication properties. This is due to the fact that a majority of vegetable oils consists of triglycerides and fatty acids. These structures offer qualities that are desired in lubricant-specifications and make vegetable oils become competitive with mineral oil in certain applications. Triglyceride is made up from three long chain fatty acids which are attached to the hydroxyl groups through ester linkages as shown in Figure 1 (Willing, 2001; Fox and Stachowiak, 2007).

The world largest oil palm cultivators in the world, Indonesia, Malaysia, and Thailand belongs to the South East Asian region. Due to many good qualities of palm oil, these countries have been conducting extensive research on investigating various applications of oil palm products, by-products and refuses (wastage and discards). Several of these research projects are focusing on the ability to develop oil palm related products as a potential bio-lubricant (Aiman and Syahrullail, 2017; Farhanah and Syahrullail, 2017; Rahim and Sasahara, 2017). Although there are several reviews on the lubrication-applications of bio-oils, published in the recent years, palm oil was only a peripheral focus of their scopes (Panchal et al., 2017). This paper has been developed to fill that vacuum in the literature which is a need at present. The discussion will focus on the tribological performance and properties, chemical modification and formulation with additives of palm oil as a bio-lubricant.

Figure 1. 3-D triglyceride molecule



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