Prospects of Palm-based Oil as a Biolubricant

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INTRODUCTION

A lubricant is a substance used to reduce surface friction and wear between interacting surfaces, to dissipate heat, prevent corrosion and transfer of power. In general, a good lubricant should have a high viscosity index, high flash and fire points (higher than the operating temperature of the machine), high oiliness, and high resistance towards oxidation and corrosion. Besides that, volatility loss and deposit of carbon should be kept low for industrial and machinery lubrication.

Biolubricants are generally considered as lubricants with high biodegradability as well as low toxicity and are environmental friendly, which can be derived from edible oils (*e.g.* palm, soyabean, sunflower, rapeseed and coconut oils), non-edible oils (*e.g.* castor, neem, jatropa and polanga) (Kumar and Sharma, 2011), and even waste cooking oil (Alotaibi and Yousif, 2016; Li and Wang, 2015; Wang *et al*., 2014).

The global biolubricant market is forecast to reach a value of USD 2.60 billion by 2020 (Anon., 2016), driven by growth of the automotive sector and industrial production, environmental and hazard issues over mineral-based lubricants, as well as regulatory support towards the use of sustainable materials. With this in mind, extensive studies are being directed towards the exploration of renewable, non-toxic materials as feedstock for lubricant production.

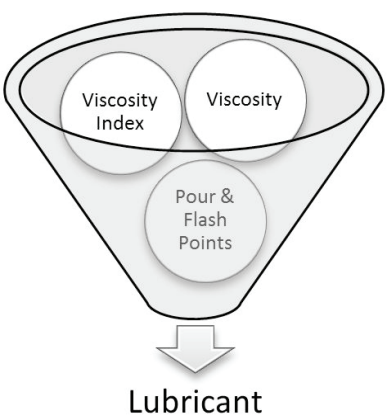

Figure 1. Important properties of lubricants.

ADVANTAGES AND DISADVANTAGES OF BIOLUBRICANTS

In recent years, increasing awareness about environmental issues and global climate change has shifted the attention of using petroleum-based materials towards more biodegradable and renewable materials. At the same time, stringent regulations by the government have accelerated the adoption of bio-based lubricants.

High biodegradability (Luna *et al.*, 2015; Siti Afida *et al*., 2015), alongside low toxicity and availability of palm-based oils, has made them a lucrative candidate as an alternative for lubricant feedstock (*Figure 2*). The excellent

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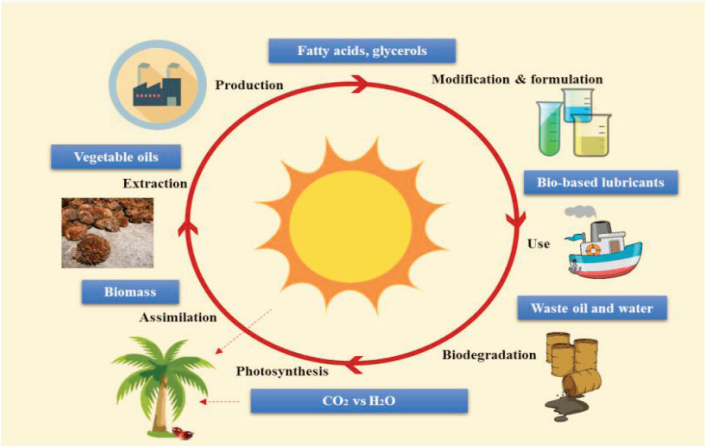
lubricity properties of palm-based oils are due to the ester configuration in the triacylglyceride molecule. In general, some of the lubricant properties of vegetable oils are more superior compared with mineral oil, characteristics such as high viscosity index, high flash point, high lubricity and low evaporation loss.

In the early 1990s, several patents were filed for lubricant formulations using palm olein (Cox *et al*., 1994; Dobbin and Wood, 1993), showing the great interest in palm oil as a renewable and 'green' feedstock for lubricants. Palm olein has moderate thermal oxidative stability, and a cold-temperature behaviour attributed to the balanced chemical composition of saturated and unsaturated fatty acids in palm olein.

Nevertheless, palm-based oil encounters similar limitations as other vegetable oils. These include poor thermal, oxidative and hydrolytic stability due to the presence of several active sites, *i.e.* the double bond and β-hydrogen in the triacylglyceride molecule. Consequently, the application of palm-based oil as a lubricant is restricted to lubricants with low thermal requirement.

These disadvantages, however, can be overcome through modification of the triacylglyceride structure. Chemical modification such as by epoxidation, transesterification (Zulkifli *et al.*, 2016; Kania *et al*., 2015; Yunus and Idris, 2003) and esterification has been carried out to enhance the lubricity properties and to overcome the limitations of the oil (Erhan *et al*., 2006; Erhan and Asadauskas, 2000).



Source: Reillustrated from Mobarak *et al*. (2014).

Figure 2. Life cycle of bio-based lubricants.

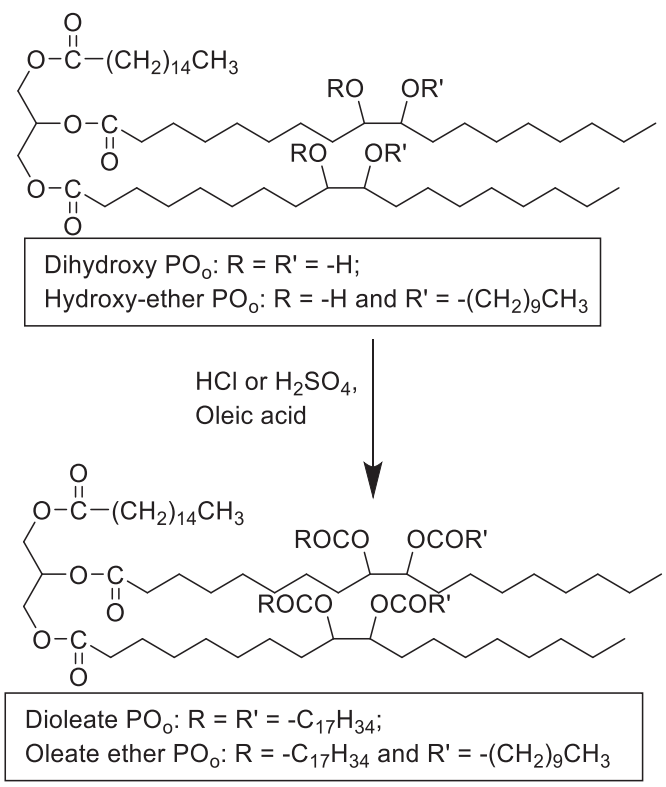


Figure 3. Esterification of palm olein (POo) to produce biolubricant basestock by Derawi and Salimon (2013).

One of the examples of modification of palm oil is the study by Derawi and Salimon (2013) in which they successfully produced hydrodynamic lubricant grades of ISO VG 460 and ISO VG 100 via epoxidation and esterification of palm olein (*Figure 3*).

APPLICATIONS OF PALM-BASED OIL AS A LUBRICANT

The transformation of palm oil into its derivatives via chemical modifications has proved

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to improve their tribological properties. Extensive studies have shown the promising potential of palm-based oils as lubricants in various applications (Loh and Choo, 2006a, 2006b; Yeong and Salmiah, 2005; Yeong *et al*., 2004a, 2004b), such as an insulating fluid in transformers (Junus, 2016; Azis *et al*., 2013; Usman *et al*., 2012), a hydraulic fluid for four-stroke engines (Mannekote and Kailas, 2011; Cheenkachorn and Fungtammasan, 2010; Cheenkachorn and Udornthep, 2006), a metal-working fluid (Lawal *et al*., 2012), and a drilling fluid (Kania *et al*., 2015; Habib *et al*., 2014). Abdelmalik demonstrated the use of palm kernel oil (PKO) as an insulating fluid (Abdelmalik, 2014; Abdelmalik *et al*., 2011).

Wan Nik *et al.* (2014) described the performance of palm oil which showed a shear thinning relationship between viscosity at low temperature and shear rate in a hydraulic system for marine applications. The use of palm oil derivatives such as palm oil methyl ester as lubricant additives has also been investigated to improve the performance of lubricant-based oil (Liew, 2015; Liew *et al*., 2014; Loh and Choo, 2012; Garcés *et al*., 2011).

CONCLUSION

Current research and development on the potential of palm-based oils as biolubricants is showing encouraging results. The inherent physicochemical properties of palm-based oils show the oils have potential as excellent lubricant materials and can be an alternative to mineral-based lubricants. The limitation of the palm-based oils can be removed with chemical modification to meet the specific requirements of the lubricants in different areas of application.

TABLE 1. SUMMARY OF ADVANTAGES AND DISADVANTAGES OF BIOLUBRICANTS

Advantage*	Disadvantage**
• High biodegradability • Less emission • Free of aromatics • Reduction of oil mist and vapor • Better skin compatibility • Similar or higher tool life • High viscosity index • Cost-saving	• Poor thermo-oxidative stability • Susceptible to hydrolytic breakdown • Poor cold flow behavior • Formation of emulsion in the presence of water • Poor corrosion protection

Source: * Salimon *et al*. (2012) ** Erhan *et al*. (2006).

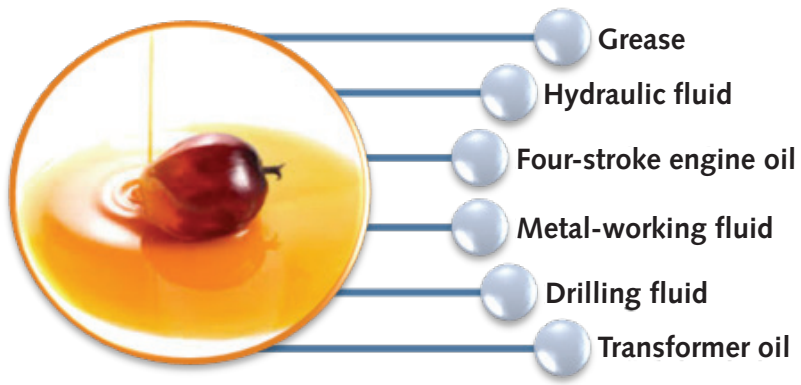

Figure 4. Potential applications of palm-based oils as lubricants.

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