Potential of Palm Oil Waste for Biolubricant

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INTRODUCTION

Lubricants are comprised of two main components, *i.e.* base oil (70%-90%) and additives to modify/improve the base oil's properties. Most lubricant base oils are produced from non-renewable source such as mineral-based oil which can be divided into mineral and synthetic categories. It is a substance introduced between two moving surfaces to keep them apart and reduce friction, which ultimately reduces the heat generated. Lubricant also protects the surfaces from wear and corrosion, removes deposits and impurities, as well as transmit power.

Compelled by rapid industrialisation and growth of the automotive sector, demand for lubricants in various applications (*Figure 1*) is continuously increasing each year. The global market is forecasted to reach RM 166.59 billion by 2021 (Markets and Markets, 2016). However, owing to depleting petroleum resources, alternative sources for raw material are intensively being pursued. In addition, growing awareness of global climate change and environmental sustainability, supported by laws and regulations, the use of bio-based materials to make biolubricants are greatly encouraged.

Biolubricants are typically derived from plant or vegetable oil such as rapeseed, canola, sunflower, soyabean, coconut and palm oil. On top of their advantage as renewable resource and abundant supply, this type of oils is also biodegradable and non-toxic to both environment and human in contrast with mineral-based oils (Schiessler *et al.*, 2007; Ohlson, 1993). These properties are mainly critical for total loss applications such as two-stroke engine, chainsaw bars and chains, railroad flanges, cables, dust suppressants and marine lubricants as it was estimated that more than 50% of all lubricants used end up being released in the environment through evaporation, accidental spillages and leakages.

In the past decades, comprehensive

Figure 1. Various field of applications of lubricants.

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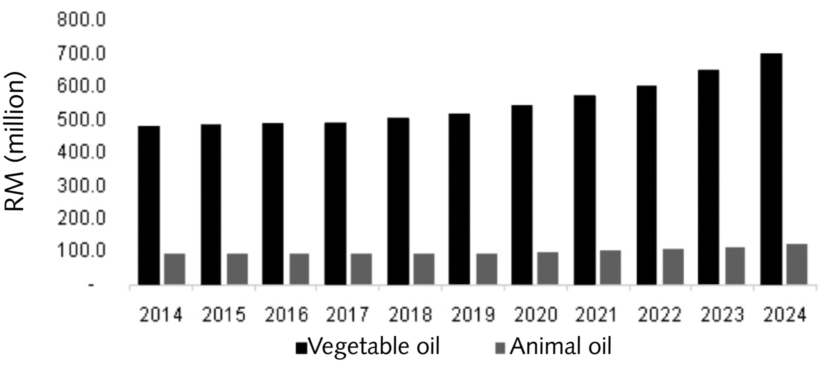

Source: Grand View Research (2016).

Figure 2. US biolubricants market revenue between 2014-2024.

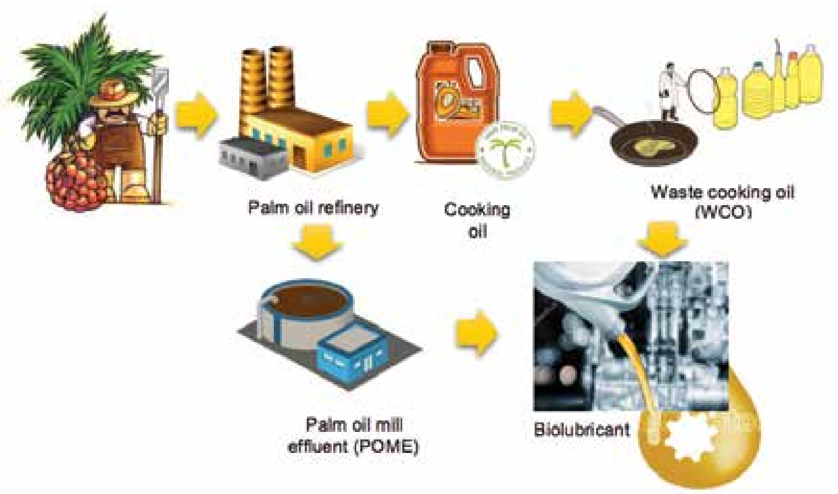

Figure 3. Biolube production from palm oil waste.

studies on the use of plant or vegetable oil as alternative resources have been carried out (Erhan and Adhvaryu, 2002). Enormous numbers of research groups all around the globe working on different type of oils coupled with technological innovations have witnessed over RM 2 billion of biolubricant market share in 2015 and is expected to significantly grow. The United Stated (US) biolubricant market revenue was projected to exceed RM 700 million by 2024 (*Figure 2*) (Grand View Research, 2016).

Palm oil, as the most traded oil, with over 38% of total global oils and fats produced, is a highly potential candidate as feedstock in the production of biolubricant (Noor Armylisas *et al*., 2016). Palm oil and its derivatives have been shown to exhibit some superior lubricity performance such as lower coefficient of friction and wear scar diameter, high viscosity index, high flash point, less hydrocarbon emission and lower volatility loss (Cheenkachorn and Fungtammasan, 2010; Mannekote and Kailas, 2011; Masjuki *et al*., 1999; Sharif *et al*., 2009; Ojolo *et al*., 2008; Azis *et al*., 2013; Usman *et al*., 2012; Mohamad *et al*., 2015). Poor cold flow properties, thermal and oxidative stability of palm oil can be tackled through several avenues such as modification of the structure, and/or with addition of chemical additives as well as blending with other oil (Hassan *et al*., 2016).

In developing a commercial scale biolubricant, one must consider the raw materials and production cost. Vegetable oils which are reasonably priced can be used as an ingredient to prepare biolubricant. However, the development of vegetable oil-based biolubricant received a lot of criticism as this may cut short the supply of vegetable oils as an ingredient in food preparation and as supplement.

Thus, an alternative to vegetable oils are also being extensively investigated. In this article, we are going to highlight recent advancement in conversion of waste cooking oil (Alotaibi and Yousif, 2016) and palm oil mill effluent into biolubricant (*Figure 3*).

WASTE COOKING OIL (WCO) FOR BIOLUBRICANT

Cooking oil is used as daily ingredient in food preparation in frying, baking and other types of baking. A fast food business could generate as much as 15 litres of used cooking oil per day. Improper disposal of waste cooking oil (WCO) from household and restaurant – such as dumping dirty oil directly down sink drains – could lead to sewage blockage and damage. On environmental side, the oily substance could contaminate groundwater and coat unwitting plants and animals which eventually suffocate from oxygen. Besides that, emission of greenhouse gasses as a result of anaerobic decomposition of the oil could contribute to global climate change. Thus, proper disposal procedure of WCO recycling of this waste should be enforced by local authority.

In several countries such as United Kingdom and Hong Kong, and popular tourist attraction, Bali island of Indonesia, a systematic scheme has been introduced to collect and handle WCO from household, restaurant and hotels. Collected WCO will then be converted into carbon neutral electricity for homes and businesses as well as biodiesel. In Malaysia, several institute and local authorities including Universiti Putra Malaysia (UPM) have initiated campaign and starting a collection centre to encourage the nearby residents to keep and send the used oil to available collecting point. Herein, we are showing the potential of WCO to be used as biolubricant.

The conversion of WCO can be made in two-step process affording as high as 98% conversion via enzymatic route (Chowdury *et al*., 2014) or combined with chemical esterification (Chowdury *et al*., 2012). In comparison of Novozyme 435-catalysed (enzyme-catalysed) and Amberlyst 15-catalysed (chemical) esterification, Chowdury *et al*. proposed former route is more efficient at 60°C. This process was then further optimised for potential large scale production by employing surface response methodology (Chowdury *et al*., 2016).

Trimethylolpropane (TMP) ester derived from WCO via transesterification was shown to meet ISO VG32 requirement with enhanced oxidative stability in the presence of α-tocopherol, butylated hydroxyanisole and *tert*-butylhydroquinone as antioxidants (Wang *et al*., 2014). Transformation of WCO methyl ester into its corresponding epoxide improved its thermo-oxidative stability as compared to unmodified WCO methyl ester (Borugadda and Goud, 2016; Borugadda and Goud, 2014; Li and Wang, 2015).

PALM OIL MILL EFFLUENT (POME) FOR BIOLUBRICANT

As second largest oil palm producer in the world with production over 17 million tonnes in 2016, undoubtedly Malaysia would have hundreds of palm oil mill all over the country. Up to date, Malaysia has 453 palm oil mills with operating capacity of 111 million tonnes (Malaysian Oil Palm Statistics, 2017). Palm oil mill effluent (POME) sludge is the wastewater generated from the processing of fresh fruit bunch (FFB) which requires effective treatment before being discharged to water body.

The amount of POME produced is expected to increase over years with estimation of 0.50 to 0.75 t of POME generated for every tonne of FFB processed (Yacob *et al*., 2005). Huge amount of POME as by product from palm oil mills could cause environmental issue if not properly treated pior to disposal and has affected the mill operators due to its high treatment cost and difficulty to manage the waste attributed by large volume generated. This would lead to discharge of raw or partially treated POME as a far more cheaper and easier disposal method which eventually destroying the aquatic environment and crippled the water source for inhabitants nearby (Madaki and Seng, 2013). Thus, to divert this situation from getting worse, researches are being carried out to transform this waste into a valuable resources/feedstock (such as fermentation media, fertilisers and animal feed) or as another form of energy source (as an example methane captured during anaerobic process to run electricity, bioethanol and biohydrogen). Hence the use of POME as biolubricant is indeed one of the solution to be explored.

Syaima *et al.* (2015) has reported production of biolubricant from POME. Initially, POME was hydrolysed by lipase (Candida sp.) followed by catalyst free esterification with isopropanol. Viscosity and density of the resulting product were then evaluated and it was showed that the product has higher viscosity as compared to Euro 2 M and Euro 4 M. However, further study need to be conducted to evaluate the lubricity properties of POME-derived biolubricant.

CONCLUSION

A forementioned studies on conversion of WCO and POME into biolubricant are examples of fully optimised utilisation of palm oil waste into value added materials. This could be a small but bigger leap in minimising waste for a more sustainable world in the long run. Exploration of WCO and POME to be used as raw materials in development of biolubricant not only reduce the cost of starting materials but could reduce environmental pollution caused by improper disposal of these wastes. Moreover, unlike use of vegetable oil as feedstock, no competition for human food consumption would be encountered when WCO and POME are used as raw materials for biolubricant.

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