Development of bio-lubricant from *Jatropha curcas* oils

M.T.S. Syaima, M.I.M. Zamratul, I.M. Noor, Rifdi, W.M.W.T

Abstract— The main advantages of bio-lubricant are its renewability and biodegradability. Utilization of bio-lubricant as substitute to fossil-based lubricant is an alternative to solve the world's crude oil depletion. In this paper, bio-lubricant was synthesized from *Jatropha curcas* oil using bioprocess method (Polipazyme^{TM}). The produced *Jatropha curcas* based oils were then modified by the addition of glycerin and graphite. The properties of the modified bio-lubricant such as viscosity, lubricity and flash point were then evaluated and compared with commercial diesel and petrol lubricants. Overall, it was found that the properties of the *Jatropha curcas* based oils (both unmodified and modified) did not meet the characteristics of the commercial lubricants. Finally, it is recommended that the *Jatropha curcas* based oils may be further enhanced by the addition of other additives such as glycols or olefin copolymers to produce bio-lubricants, which complements the SAE standard.

Keywords—Bio-lubricant, *Jatropha curcas*, Polipazyme^{TM}, Glycerin, Graphite

I. Introduction

LUBRICANTS (motor oils) consumed worldwide are commonly originated from petroleum, coals or natural (Abdullah and Salimon, 2011; Ozioko, 2012) gases. However, these sources are infinite and keep depleting due to high fuel consumption over the world (Mirghani, et al., 2012). This situation has raised interests among ambitious researchers and scientists on finding the renewable green materials for lubricants as replacements to the fossil (Chauhan and Chibber, 2013; Jain and Suhane, 2012). Bio-lubricant is derived from natural resources. Compared to the conventional lubricants, bio-lubricant is more preferable due to its rapid biodegradability and low environmental toxicity. The major advantage of bio-lubricant is its high viscosity index, which enables its viscosity to stay virtually stable at constant temperature unlike mineral oil (Jeffrey, 2007). *Jatropha curcas* oil (JCO or JO) is one of the vegetable oils, which has recently gained an interest due to its non-edible characteristics (Arbain, 2009).

According to Mofijur et al. (2012), JO produces more oil (> 60%) compared to soybean, linseed and palm kernel which only yields 18.35%, 33.33% and 44.6% of oils, respectively.

M.T.S. Syaima, M.I.M. Zamratul, I.M. Noor , Rifdi, W.M.W.T are with Gyrus Tech Sdn Bhd, Suite 1A, Level 5, Universiti of Malaya Research Management Centre (UMRC), 50603, Kuala Lumpur Malaysia.

(Corresponding Author) Saidatul Syaima Mat Tari, Department of Chemical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia, (Tel.: +60379676879; Fax: +60379675319; E-mail address: syaima_s@yahoo.com)

Based on these findings, in this work, we conducted an extraction of bio-lubricant from *Jatropha curcas* oils. Being synthesized from biological resources made it an environmentally friendly product. It is a promising alternative to have bio-based lubricants due to their specific functional attributes such as high viscosity index, high lubricity, high flash point, very low volatility and biodegradability. With the development of this bio-lubricant to replace part of the petroleum-based lubricant, the depletion of the world's crude oil can be alleviated.

II. Experiments

A. Materials

Jatropha curcas oil (JCO) used in this study was obtained from Trades Wings Resources Sdn Bhd. Malaysia. Lipase enzyme (Polipazyme^{TM}) was produced at Department of Chemical Engineering, University of Malaya. All the fine chemicals used in the experiment (oleic acid, phenolphthalein, acetate acid, sodium hydroxide, diethyl ether, 2-propanol, glycerin), and calibration buffer solutions (pH 4.0, pH 7.0 and pH 10.0) were obtained from Fisher Scientific (M) Sdn. Bhd. Commercial lubricants were QUARTZ 5000 SM 15W50 (diesel) and Castrol GTX M-Tec 10W-30 (petrol).

B. Bio-lubricant production

The development process of bio-lubricant was carried out using bioprocess method (Polipazyme^{TM}). The reaction took place in a beaker, which was immersed in a temperature controlled water bath and were maintained at the desired stirring speed using a motor-driven laboratory impeller stirrer.

C. Additive modification

The produced *Jatropha curcas* based bio-lubricant was modified by the introduction of additives i) 20% glycerin and ii) 20% glycerin + 10% graphite. This blend (oils and additives) were then mixed evenly. In case (ii), the solution was left for 1-2 days to allow graphite particles to settle. After that, these particles were separated from the mixture by using a separator funnel.

D. Analysis and characterization

The properties of the bio-lubricant (without and with additive(s)) were measured. All the testing was based on ASTM standards (NTUT, 2008). The viscosity was tested using a Brookfield Viscometer and the coefficient of friction (CoF) i.e. lubricity index was obtained using Fann EP/ Lubricity Tester 20015. On the other hand, flash point was found using Pensky-Martens Closed Cup Tester. Comparison was made between the newly developed bio-lubricant with the commercial lubricants: QUARTZ 5000 SM 15W50 (diesel) and Castrol GTX M-Tec 10W-30 (petrol).

III. RESULTS AND DISCUSSION

Figure 1 showed the bio-lubricant solution with (a) and without (b) graphite. The top layer of fluid in Figure 1(a) is the clear modified oil using graphite. As it can be seen in this figure, the graphite was settled as sediment at the bottom of the glass funnel, while the product (top layer) is clear and vivid. Meanwhile, the bio-lubricant solution without graphite, which is presented in Figure 1(b), appears to be quite cloudy due to the presence of some impurities. The purpose of adding graphite is to dissolve and remove all the soluble substance in bio-lubricant, thus producing clear oils with no impurities. This is an advantage for a bio-lubricant product as it will prevent corrosion or erosion of car engine parts, particularly the piston.

Fig. 1 Bio-lubricant solution (a) with graphite (b) without graphite

Table I summarizes the viscosity, flash point and lubricity index values for all samples namely pure *Jatropha curcas* oil, un-modified *Jatropha curcas* based bio-lubricant, modified *Jatropha curcas* based bio-lubricant (20% glycerin), modified *Jatropha curcas* based bio-lubricant (20% glycerin and 10% graphite) and commercial diesel and petrol lubricants (QUARTZ 5000 SM 15W50 and Castrol GTX M-Tec 10W-30).

From the results, pure Jatropha curcas oils and all the bio-lubricants (un-modified and modified) presented lower viscosity and flash point compared to the commercial lubricants. However, the modified Jatropha curcas bio-lubricant based oils have improved viscosities compared to the original oils, with the increment of about threefold. This enhancement might be attributed to the high viscosity characteristics of glycerin. However, the improvement of viscosity has not reached the yardstick of standard lubricant and therefore, further modification is required prior to commercialization. Thus, it is suggested that instead of glycerin and graphite, olefins copolymers or glycols, which have been known to have high viscosities, may be utilized as viscosity modifier (Ravishankar & Nass, 2010). The same trend was also obtained for lubricity, where the original Jatropha curcas oil and its derivatives (un-modified and modified) portray a lower coefficient of friction (CoF) than the commercial lubricating oils. This signifies that, all of them pursue an enhanced resistance towards friction, thus possess a better lubricity thus has an excellent quality as bio-lubricant.

TABLE I
CHARACTERISTICS OF LUBRICANTS

Substances	Viscosity (cP) (@70°C, 76 rpm)	Flash Point (°C)	CoF
Pure *Jatropha curcas*	11.66	118	10
Bio-lubricants			
Original Base Oil	1.27	28	8.0
+ 20% Glycerin	3.53	26	7.5
+ 20% Glycerin + 10% Graphite	3.52	28	8.0
Commercial lubricants			
Castrol GTX M-Tec 10W-30 (Petrol)	24.14	190	12
QUARTZ 5000 SM 15W50 (Diesel)	38.82	198	11

Flash point was also tested for all oils, including the unprocessed *Jatropha curcas* oil, which has not been undergone to hydrolysis and esterification. The unprocessed *Jatropha curcas* oil and *Jatropha curcas* bio-lubricant (un-modified) oil have a higher flash point than *Jatropha curcas* bio-lubricant (modified) oil. However, the unprocessed *Jatropha curcas* oil cannot be used directly for lubrication purpose because the main constituent of non-edible *Jatropha curcas* oil is a triglyceride (Srivastava & Prasad, 2000). Since triglycerides are esters of three fatty acids and one glycerol, which contains substantial amount of oxygen in its structure (Srivastava & Prasad, 2000), the application of the unprocessed *Jatropha curcas* oil as lubricant could cause the corrosion of parts in car engines , degradation of the metal parts, and eventually block the piston and cause piston fatigue.

IV. CONCLUSION

Renewable, biodegradable and environmentally friendly bio-lubricant has been produced from non-edible *Jatropha curcas* oil which has high viscosity index, high lubricity, high flash point, and a very low volatility. Addition of graphite as modifier has been proved to remove most of the impurities and dissolved substances in the based oil and successfully make the based oil cleaner and clearer. Nevertheless, the flash point of the modified *Jatropha curcas* bio-lubricant was too low and did not meet the characteristics of the commercial lubricants. Therefore, it was recommended to further improve the *Jatropha curcas* based bio-lubricant by adding other additives such as glycols and olefins copolymers in order to achieve bio-lubricant, which meets the characteristics of commercial SAE bio-lubricant. The suggested additives should have high viscosity and high flash point to modify the physical and chemical properties of the based oil in order to produce desirable bio-lubricant.

ACKNOWLEDGMENT

This work was supported financially by the University of Malaya Research Grant Program (RP016/2012-D), UM/MOHE High Impact Research Grant (H-16001-00-D000052) also strength support from the Energy Center of Mechanical Engineering Department.

REFERENCES

[1] Abdullah, B.M. and Salimon, J. (2011). Optimization of process parameters for diesters biolubricant using D-optimal design. World Academy of Sciences, Engineering and Technology, 56: 773 -781.

[2] Ozioko, F.U. (2012). Extraction and characterization of soybean oil based bio-lubricant. AU Journal of Technology 15(4): 260-264.

[3] Mirghani, M.E.S., Kabbashi, N.A., Qudsieh, I.Y., and Ibrahim, I. (2012). Fabrication of Nahar seed oil for biolubricant production. Malaysian International Conference on Trends in Bioprocess Engineering, held on 3-5 July 2012, in Universiti Malaysia Perlis, Malaysia.

[4] Chauhan, P.S. and Chibber, V.K. (2013). Non edible oil as potential sources for bio-lubricant production and future prospects in India: A Review. Indian Journal of Applied Research 3(5): 1-4.

[5] Jain, A.K. and Suhane, A. (2012). Research approach and prospects of non-edible vegetable oil as a potential resource for biolubricant – A Review. Advanced Engineering and Applied Sciences, 1(1) 23-32.

[6] Jeffrey, S. M. (2007). Bio Lubricants Manual

[7] Arbain, N. H., Salimon, J. (2009). Synthesis And Characterization Of Ester Trimethylolpropane Based Jatropha Curcas Oil As Biolubricant Base Stocks. Journal of Science and Technology.

[8] Mofijur, M., Masjuki, H. H., Kalam, M. A., Hazrat, M. A., Liaquat, A. M., Shahabuddin, M., & Varman, M. (2012). Prospects of biodiesel from Jatropha in Malaysia. Renewable and Sustainable Energy Reviews, 16(7), 5007-5020. doi: 10.1016/j.rser.2012.05.010 http://dx.doi.org/10.1016/j.rser.2012.05.010

[9] Ravishankar, P. S., & Nass, K. A. (2010). US Patent No. WO 2010/016847 A1. The Patent Cooperation Treaty (PCT)