Candlenut Oil as Base Oil for Bio Lubricants: Experiment to Improve of Low Temperature Properties with Additive Pourpoint Depressant (PPD)

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Abstrak-- *Penelitian ini menyelidiki Minyak kemiri berpotensi menjadi bio-pelumas, menggantikan ketergantungan pada minyak mineral dan bahan baku yang dapat dimakan, jika penggunaan minyak nabati yang dapat dimakan untuk produksi bio-pelumas sulit karena permintaan makanan, yang telah meningkat tajam. Sifat aliran suhu rendah minyak nabati sangat buruk, dan ini membatasi penggunaannya pada suhu operasi rendah terutama sebagai cairan otomotif dan industri, menambahkan aditif PPD telah diadopsi untuk meningkatkan sifat minyak nabati. Metode preparasi sampel dilakukan dengan mengaduk minyak kemiri dan aditif PPD pada kemudi magnetik selama 60 menit. Ada 6 sampel dengan konsentrasi massa aditif PPD yang berbeda yang terbuat dari 0 hingga 0,05% PPD (b / b). Pengujian Viskositas Kinematik & Pourpoint dilakukan pada masing-masing sampel, hasil penelitian menunjukkan bahwa dampak pencampuran aditif PPD menyebabkan nilai Viscosity Kinematic meningkat secara bertahap sebesar ±0,022 mm^2/s dan dari pengujian nilai pourpoint konsentrasi massa aditif optimum sebesar 0,03% PPD (w/w) dengan nilai pourpoint -37°C, ini menunjukkan bahwa konsentrasi% PPD (w/w) tidak berbanding lurus dengan nilai pourpoint minyak kemiri.*

Kata kunci: *Bio-pelumas, Minyak kemiri, Depresan titik tuang, Viskositas Kinematik*

Abstract-- *This study investigated Candlenut oil has the potential to become a bio-lubricant, replacing the dependence on mineral oil and edible feedstocks, if use of edible vegetable oils for bio-lubricant production is difficult owing to the demand for food, which has increased sharply. The low temperature flow property of vegetable oils is extremely poor, and this limits their use at low operating temperatures especially as automotive and industrial fluids, adding additive PPD have been adopted to improve the properties of vegetable oils. Sample preparation method is carried out by stirring Candlenut oil and PPD additives on magnetic steering for 60 minutes. There were 6 samples with different mass concentrations of PPD additives made from 0 to 0.05 % PPD (w/w). Kinematic Viscosity & Pourpoint testing was carried out on each sample, the findings showed that the impact of mixing PPD additives caused the Viscosity Kinematic value to increase gradually by ±0.022 mm^2/s and from testing the pourpoint value of the optimum additive mass concentration of 0.03 % PPD (w/w) with a pourpoint value of -37 ° C, this showed that the concentration of % PPD (w/w) was not directly proportional to the pourpoint value of Candlenut oil.*

Keywords: *Bio-lubricant, Candlenut oil, Pour-point depressant, Viscosity Kinematic*

1. INTRODUCTION

Vegetable oils have a number of inherent qualities that give them advantages over petroleum oils as the feedstock for lubricants. Based on the fact that vegetable oils are derived from a renewable resource, they avoid the upstream pollution associated with petroleum extraction and refining in terms of usage [1].

Aleurites moluccana (L.) Willd., also known as candlenut, is one of the world's great domesticated multipurpose trees. It is native to the Indo-Malaysia region and was introduced throughout the Pacific islands in ancient times. In Indonesia, it has long been grown for both subsistence and commercial purposes, sustaining people's everyday lives, especially in the eastern part of the country. The species can be used for various purposes; the seeds provide material for lighting, cooking and pharmaceuticals, and the trunk is used for timber. The main A. moluccana cultivation areas in Indonesia are in the provinces of North Sumatra, West Sumatra, South Sumatra, Bengkulu, Lampung, West Java, West Kalimantan, South Kalimantan, East Kalimantan, Bali, South Sulawesi, Maluku, and East Nusa Tenggara. The total cultivation area of A. moluccana in Indonesia has been reported to be 205.532 ha [2].

In this paper, emphasis is placed on the prospects of the second-generation feedstock (candlenut oil) as a sustainable alternative bio-lubricants. This paper aims to highlight the potential of candlenut oil for bio-lubricants production, replacing the dependence on mineral oil and edible feedstocks, if use of edible vegetable oils for bio-lubricant production is difficult owing to the demand for food, which has increased sharply.

There are two major problems associated with vegetable oils as functional fluids offer low resistance to thermal oxidative stability and poor low-temperature properties [3] [4] [5]. Cloudiness and solidification become apparent in vegetable oil at low temperatures upon prolonged exposure to low temperature (–10 to 0°C) [6]. Pour point is the lowest temperature at which oil flows or pours. Pour point is an important factor. Vegetable oil-based bio-lubricants have lower pour points than mineral oils, thus providing excellent lubrication for cold starts [5].

In the industry one major characteristic of the low-temperature properties of lubricating fluids is pour point. This test method covers the determination of pour point of petroleum products by an automatic apparatus that applies a slightly positive air pressure onto the specimen surface while the specimen is being cooled, ASTM technique D 6749 [7].

This study presents a systematic approach to increase the pour point of vegetable oil (candlenut oil) blending using PPD additives with a magnetic stirrer for 60 minutes, 6 samples were made with mass concentrations of different PPD additives 0 to 0.05% PPD (w/w). Furthermore, ASTM D445 [8] Kinematic Viscosity testing is carried out on each sample, while pour point measurements are used to study low temperature properties with ASTM D 6749 Pour Point testing.

2. METHODS

In order to use vegetable oils as lubricants, several approaches have been adopted to improve the properties of vegetable oils. Genetic modification, additive treatment, transesterification, epoxidation, chemical modification, structural modification, and/or biotechnology are some of the techniques that have been employed. These methods improve the performance and stability of vegetable oils for their direct applications [6].

2.1. Materials

Candlenut Oil Properties in Table 1 with composition Oleum Aleurites Moluccana 100% produced by PT. Darjeeling Sembrani Aroma (Bandung, Indonesia) , additive VISCOPLEX PPD Properties in Table 2 produced by Evonik Oil Additives Asia-Pacific, Pte. Ltd (Singapore), with over 70 years of experience in developing highly innovative, low-temperature polyalkyl methacrylate (PAMA) technology [9].

Table 1. Candlenut Oil Properties

Properties	Method	Value
Viscosity at 100℃	*ASTM D 445*	7,161 mm^2/s
Density at 15℃	*ASTM D 4052*	0.92 g/cm^3
Flash Point	*ASTM D 92*	312 ℃
Pour Point	*ASTM D 6749*	-20 ℃
Color	-	Yellow

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Table 2. Additive PPD Properties

Properties	Method	Value
Viscosity at 100℃	*ASTM D 445*	100 mm^2/s
Density at 15℃	*ASTM D 4052*	0.90 g/cm^3
Flash Point	*ASTM D 3278*	>120 ℃
Physical State	-	Liquid
Color	-	Yellow

2.2 Sample preparation method

Bio lubricants preparation in Figure 1, Candlenut oil blending using PPD additives with a magnetic stirrer for 60 minutes, 6 samples were made with mass concentrations of different PPD additives 0 to 0.05% PPD (w/w) in Table 3. Digital scales machine from Mettler Toledo and Stirring machine from Cole-Parmer.

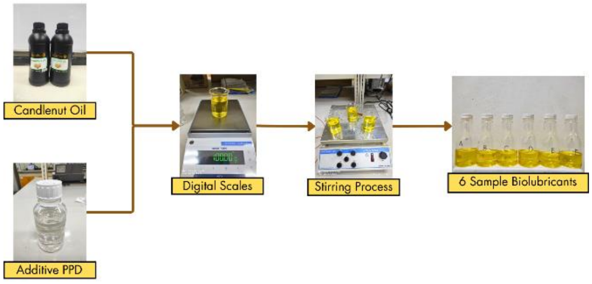

Figure 1. Bio-lubricant preparation

Table 3. Composition each sample

Sample	Additive Pourpoint Depressant (g)	Candlenut oil (g)
A	*0*	100
B	*0.01*	99.9
C	*0.02*	99.8
D	*0.03*	99.7
E	*0.04*	99.6
F	*0.05*	99.5

2.3 Pour point depressants determination

At a certain lower temperature, the flow ability of the oil is totally ceased. The temperature is known as pour point for lube oils. Several options are available to counteract the problems which include the use of chemical additive treatment [10] [11], known as pour point depressant (PPD). Certain high molecular weight polymers function by inhibiting the formation of a wax crystal structure that would prevent oil flow at low temperatures. Two general types of pour point depressants are used.

- Alkyl aromatic polymers adsorb on the wax crystals as they form, preventing them from growing and adhering to each other.
- (Polymethacrylates co-crystallize with wax to prevent crystal growth.

The additives do not entirely prevent wax crystal growth, but rather lower the temperature at which a rigid structure is formed [12].

Pour point are measured by following the ASTM D 6749 in Figure 2. After inserting the test jar containing the specimen into the automatic pour point apparatus and initiating the test program, the specimen is automatically heated to the designated temperature and then cooled at a controlled rate. At temperature intervals of 1 or 3°C, depending on the selection made by the user prior to the test, a slightly positive air pressure is gently applied onto the surface of the specimen which is contained in an air-tight test jar equipped with a communicating tube. Since one end of the communicating tube is inserted into the specimen while the other end is maintained at atmospheric pressure, a small amount of downward movement or deformation of the specimen surface, because of the application of air pressure, is observed by means of upward movement of the specimen in the communicating tube. This upward movement of the specimen is detected by a pressure sensor which is installed at the atmospheric end of the communicating tube. The lowest temperature at which deformation of the specimen is observed upon application of air pressure is recorded as the pour point, Test Method D 6749 [7].

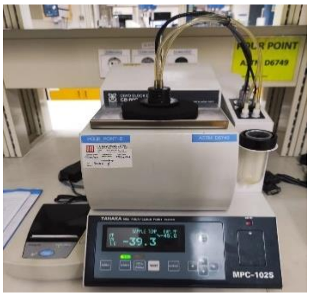

Figure 2. Tanaka MPC-102S

2.4 Kinematic Viscosity Determination

It is a measure of flowing characteristics of a fluid, caused by the force of gravity. Kinematic viscosity may be defined as the force per unit area required to maintain a unit velocity gradient (velocity difference of one unit in the liquid layer which are unit distance apart). Viscosity is the single most important property of lubricating oil, as it is the main determinant of the operating characteristic of lubricating oil. If the viscosity is too low then a liquid film cannot be maintained between two moving surfaces, which could result in high wear of parts [12]. Kinematic viscosity (v, mm2 /s) was measured with a Cannon-Fenske viscometer (Cannon Instrument) in Figure 3 at 100℃ according to ASTM D 445 [8].

Figure 3. Cannon Instrument Company (Cav 2000 series)

3. RESULT AND DISCUSSION

3.1 Viscosity Kinematic determination

Non-edible vegetable oil-based bio-lubricants are potential candidate for automotive applications in Figure 4 Lubrication requirements for a pick-up truck [5]. They have certain inherent technical properties which are enhanced than mineral oils like enhanced lubricity, high viscosity, good anti-wear property, high viscosity index, high ignition temperature, increased equipment service life, high load carrying ability, excellent coefficient of friction, low evaporation rates, low emission of metal traces into the atmosphere and rapid biodegradability [13]. On the negative side, vegetable oils in their natural form lack sufficient oxidative stability for lubricant application. Low oxidative stability indicates that oil will oxidize rapidly during use if untreated, becoming thick and polymerizing to a plastic-like consistency. Vegetable oils also have low-temperature limitations, unpleasant smell, poor compatibility with paints and sealants, flushing propensity because of low viscosity, and filter-clogging tendency [5].

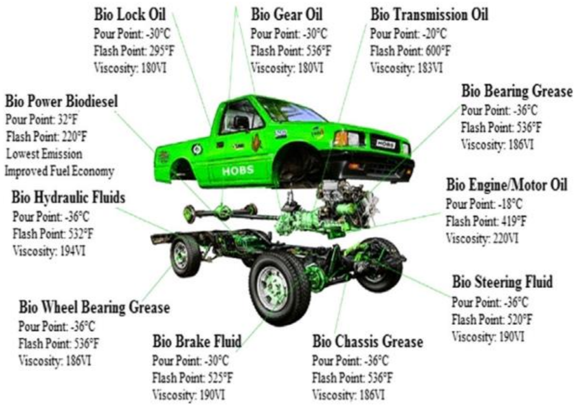

Figure 4. Lubrication requirements for a pick-up truck [5]

3.2 Kinematic Viscosity & Low temperature improvement using PPD

The low temperature flow property of vegetable oils is extremely poor, and this limits their use at low operating temperatures especially as automotive and industrial fluids. In Table 4 Improve pourpoint value of each sample after testing Kinematic viscosity and Pour point on 6 samples, it was obtained that the use of VISCOPLEX PPD additives in Candlenut oil caused the Kinematic Viscosity to increase gradually by ± 0.022 mm2/s in Figure 5. As for the pour point, Candlenut oil without PPD additives increased significantly from -20 to -33 after adding 0.01% PPD (w/w), then the increase began to be insignificant from -33 to -36 with 0.02% PPD (w/w), from -36 to -37 with 0.03% PPD (w/w) and did not increase if adding 0.04% &; 0.05% PPD (w/w) in Figure 6.

Table 4. Improve pourpoint value of each sample

Sample	*Pourpoint (℃)*	*Viscosity Kinematic 100 ℃ (mm2/s)*
A	-20	7.161
B	-33	7.184
C	-36	7.200
D	-37	7.230
E	-37	7.254
F	-37	7.276

3.2.1 Viscosity Kinematic increase gradually using PPD Additive

The gradual increase in Viscosity Kinematic occurs because Candlenut oil and PPD additives have different viscosity values. PPD additive viscosity is thicker than Candlenut oil viscosity, so the addition of PPD additive to Candlenut oil causes an increase in viscosity.

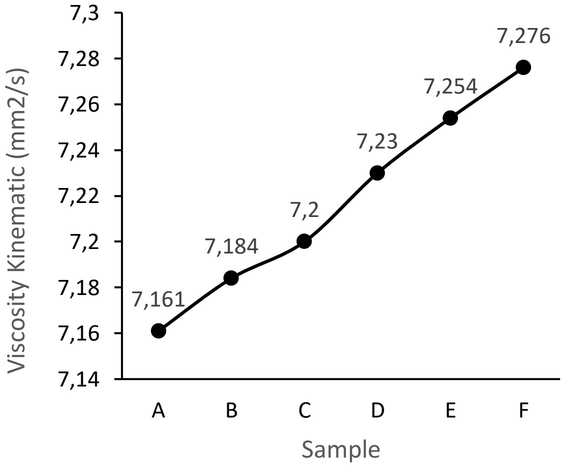

Figure 5. Graph of Viscosity Kinematic effect using PPD Additive

3.2.2 Pourpoint Value Improve using PPD Additive

From evaluating the Pourpoint value of the optimum Additive mass concentration of 0.03 % PPD (w/w) with a Pourpoint value of -37°C, this shows that the % PPD (w/w) concentration is not directly proportional to the pourpoint value of Candlenut oil.

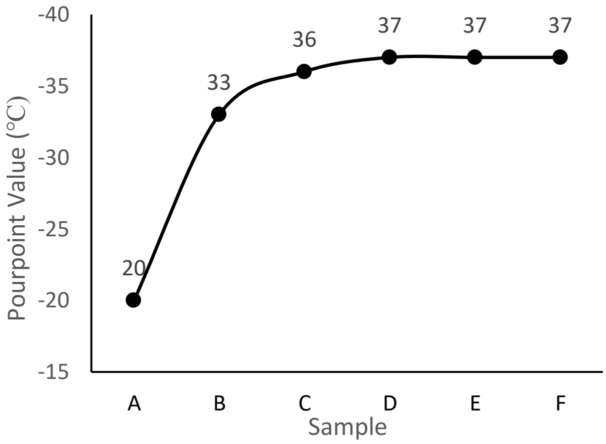

Figure 6. Graph of Pourpoint Value Improve

4. CONCLUSIONS

Candlenut oil has the potential to become a bio-lubricant, replacing the dependence on mineral oil and edible feedstocks, if use of edible vegetable oils for bio-lubricant production is difficult owing to the demand for food, which has increased sharply. The low temperature flow property of vegetable oils is extremely poor, and this limits their use at low operating temperatures especially as automotive and industrial fluids, adding additive PPD have been adopted to improve the properties of vegetable oils.

The findings showed that the impact of blending PPD additives in Candlenut oil caused the Kinematic Viscosity value to increase gradually by ± 0.022 mm2/s and from testing the pourpoint value of the optimum additive mass concentration of 0.03 % PPD (w/w) with a pourpoint value of -37 °C, this showed that the % PPD concentration (w/w) was not directly proportional to the pourpoint value of Candlenut oil.

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