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EFFECT OF BANANA PEELS AS AN ADDITIVE ON THE TRIBOLOGICAL PROPORTIES OF PARAFFIN OIL

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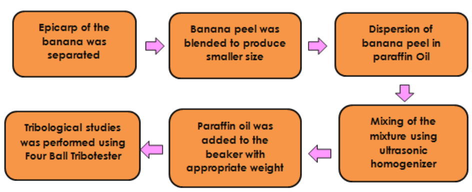
Graphical abstract



Abstract

In this preliminary studies, friction and wear properties of banana peel as a natural additive in paraffin oil was performed and evaluate using four-ball tester. Inverted microscope then was used to measure the wear scar diameter on ball bearing. Coefficient of friction, μ and wear significantly reduced at high load, temperature and speed. At 100 °C, the load of 500 and 1000 N, the COF values reduces from 0.1163 to 0.1012 and 0.1235 to 0.1174 respectively. At the same condition, WSD was found to decrease from 4.81 x 10^{-4} mm^3 to 2.33 x 10^{-4} mm^3 and 4.99 x 10^{-4} mm^3 to 2.75 x 10^{-4} mm^3 at 500 and 1000 rpm respectively.

Keywords: Banana peel; paraffin oil; friction and wear

Abstrak

Dalam kajian awal ini, sifat geseran dan kehausan kulit pisang yang digunakan sebagai bahan tambahan semulajadi di dalam minyak parafintelah diuji dan dinilai dengan menggunakan penguji empat bola. Mikroskop digunakan untuk mengukur diameter kesan kehausan pada bola pengalas. Pekali kehausan, μ dan kadar kehausan signifikan berkurang pada beban, suhu dan kelajuan yang tinggi. Pada suhu 100 °C, beban 500 and 1000 N, nilai μ berkurangan dari 0.1163 ke 0.1012 dan 0.1235 ke 0.1174. Pada keadaan yang sama, kadar kehausan berkurangan dari 4.81 x 10-4 mm3 to 2.33 x 10-4 mm3 dan 4.99 x 10-4 mm3 to 2.75 x 10-4 mm3 at 500 and 1000 rpm. Keputusan ini menunjukkan campuran kulit pisang di dalam minyak parafin mununjukkan sifat tribologi yang baik.

Kata kunci: Kulit pisang; minyak parafin; geseran dan kehausan

1.0 INTRODUCTION

Various types of lubricants are available all over the world including mineral oils, synthetic oils, re-refined oils, and vegetable oils. Most of the lubricants which are available in the market are based on mineral oil derived from petroleum oil which is not adaptable with the environment due to the toxicity and non-biodegradability [1, 2].

Unknown petroleum reserve and the increasing consumption, which made concern to use petroleum based lubricant thus, to find the alternative lubricant to meet the future demand is an important issue [3]. Therefore, vegetable oil can be played a vital role to substitute the petroleum lubricant as it possesses numerous advantage over base lubricant like renewability, environmentally friendly, biodegradability, less toxicity and so on [4,5].

Banana skin has been often referred as slipping tools by the literature [6]. Previous study had showed that coefficient of frictions under epicarp of banana skin; on the floor material is much lower to the value of common materials and similar to the well lubricated surface. During their study, they found that, lubricating effect of banana skin is contributed by existence of follicular gel which sized about a few micro meters [6].

In this work, friction and wear properties of banana peel as a natural additive in paraffin oil was performed and evaluate using four-ball tester.

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In this work, friction and wear properties of banana peel as a natural additive in paraffin oil was performed and evaluate using four-ball tester.

2.0 EXPERIMENTAL

2.1 Sample Preparation

An epicarp of Cavendish banana skin was measured and blended together with paraffin oil using ultrasonic homogenizer. The ultrasonic homogenizer was used to mix the paraffin oil with 20% of banana peel for an hour. The mixture then was being refined using food grade cloth filter.

2.2 Equipment

DUCOM TR 30 L - Four-ball tribotester machine was used with standard test method. This machine is simple to use for testing friction and wear of lubricating oils. Three balls are located in a (Figure 1) cup below a fourth ball which is connected to a rotating shaft via a chuck. Different loads are applied to the balls by weights on load lever. The frictional torque exerted on the three lower balls can be measured by a calibrated arm, which is connected to the spring of a friction recording device.

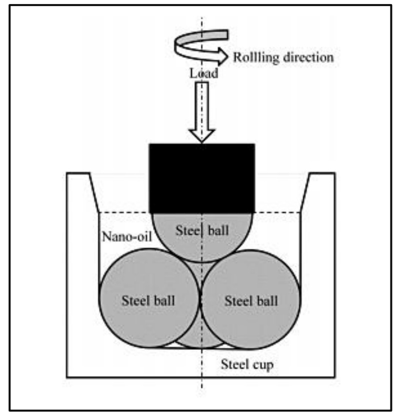

Figure 1 Schematic diagram of the four-ball tribotester

2.3 Ball Bearing Material

Carbon-chrome steel (SKF bearing) ball bearing with average surface roughness (Ra) of 0.022 µm and 12.7 mm in diameter was used as tested ball material. Mechanical properties of the tested ball as provided by the manufacturer are listed in Table 1.

Table 1: The mechanical properties of the tested ball provided by the manufacturer.

Properties	Carbon-chrome steel, EN-31
Hardness (H), HRC	62
Density (ρ), g/cm^3	7.81
surface roughness (Ra)	0.022

2.4 Test Procedures

At the beginning of the experiment, paraffin oil + 20% of banana peel sample was placed on the erected plate where three balls are held position into a cup with the clamping ring and assembly secured by tightening the locknut. The fourth ball is then fitted on the upper balls chuck. Mounting disks are placed between the thrust bearing and the cup. The desired loads of 60, 250 and 500 N were then placed on the load lever to be tested at temperature of 27, 80, 100 °C and speed of 500 and 1000 rpm.

2.5 Friction Evaluation and Determination of Coefficient of Friction, μ

Data gathered by the TR 30 L four Ball Tester is then used to determine the COF, μ using Equation 1.

$$\mu = \frac{T\sqrt{6}}{3Wr} \quad (1)$$

Where

μ : Coefficient of friction

T : Frictional torque in kg/mm

W : Applied load in kg

r : Distance from the center of the contact surface on the lower balls to the axis of rotation, which is 3.67 mm

2.6 Wear Test

The wear measurements reported as volume loss in cubic millimeters according to ASTM standard test method. Wear scar diameters, d were first measured using Axiovert 200-M inverted microscopes 3. Wear volume losses, V of the ball bearing with radius R as illustrated in Figure 2 then was determined using Equation 2.

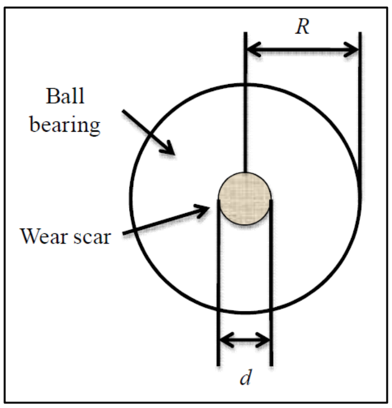

Figure 2: Ball bearing with wear scar

$$V = \frac{\pi(d)^4}{64(R)} \qquad (2)$$

Where

d : Wear scar diameter in mm

R : Ball bearing in mm

2.7 Kinematic Viscosity

Kinematic viscosity can be obtained by dividing the absolute viscosity of a fluid with the fluid mass density as per Equation 3.

$$v = \frac{\mu}{p} \qquad (3)$$

Where

v : Kinematic viscosity

μ : Dynamic viscosity

ρ : The density of the fluid

3.0 RESULTS AND DISCUSSION

3.1 Stability of the Mixture

Blended paraffin oil with 20% banana peel does not experience any change in term of its colour and there is no sediment appears after five days observation as shown in Figure 3a. The stability of the mixtures of oils before and after the experimental procedures was observed and analyses shown in Figure 3b. Based on the criteria of lubricant, visibility and clearity of the oil is one of the parameter should be considered.

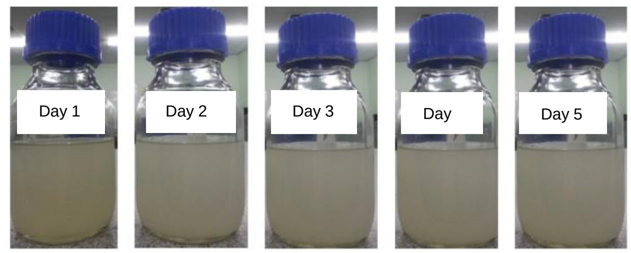

Figure 3a: Observation of Paraffin oil with 20% Banana peel in five (5) days

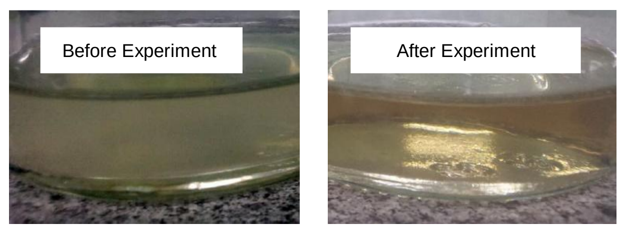

Figure 3b: Paraffin oil with 20% Banana peel before and after the experimental procedures

3.2 Kinematic Viscosity

Dynamic viscosity of 20% banana peel blended with paraffin oil was performed using Brookfield viscometer at 40 °C and 100 °C with the speed of 20 rpm. Dispersion of banana peel in paraffin oil was believe to increase it viscosity as the kinematic viscosity increased from 30.0 to 38.4 at 40 °C and from 17.5 to 32.2 at 100 °C. Paraffin oil which was blended with 20% of BP was exhibited the VI values of 696.969 compared to VI paraffin oil which values of 572.603. According to ASTM, the viscosity index is an arbitrary number indicating the effect of change of temperature on the kinematic viscosity of oil. A high viscosity index signifies a relatively small change of kinematic viscosity with temperature (ASTM Data Series Publication DS 39b). As shown in table 1, paraffin oil with 20% of BP has a high VI compared to paraffin oil. High VI index indicates that, its capability to retain viscose at high temperature. As for that reason, it should possess favorable of high temperature characteristics and highly desirable property in view of their use as lubricants. The viscometric property of paraffin oil blended with 20%

BP in comparison with paraffin oil was tabulated in Table 2.

Table 2: Viscometric properties of paraffin oil with 20% at speed of 20 rpm

Properties		Paraffin oil + 20% BP	Paraffin oil
Kinematic Viscosity, cSt (mm^2/s)	40 °C	38.4	30.0
	100 °C	32.3	17.5
Viscosity Index (VI)		696.969	572.603

3.3 Coefficinet of Friction (COF) Analysis

Coefficient of friction (COF) analysis of Paraffin oil and Paraffin oil + 20% banana peel was performed and analysis using DUCOM 30 L –Four Ball Tester. The coefficient of friction versus applied loads on four-ball testing is shown in Figure 4a and 4b. At 100 °C, the load of 500 and 1000 N, the COF values reduces from 0.1163 to 0.1012 and 0.1235 to 0.1174 respectively. The coefficient of friction of the bio-lubricant is largely depends on the mixing ratios of the vegetable oil and the mineral oil [2].

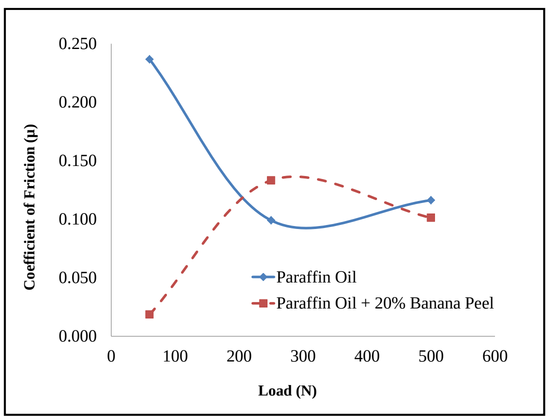

Figure 4a: Coefficient of friction (µ) vs. Load of Paraffin Oil and Paraffin Oil + 20% Banana Peel at 500 rpm

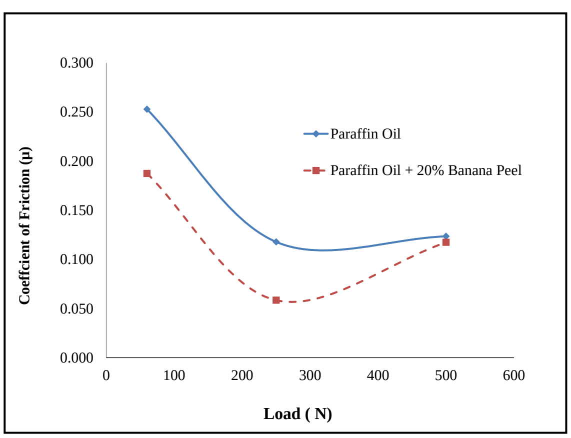

Figure 4b: Coefficient of friction (µ) vs. Load of Paraffin Oil and Paraffin Oil + 20% Banana Peel at 1000 rpm

3.4 Wear Analysis

Wear scar diameter of Paraffin oil and paraffin oil + 20% banana peel was analysis using inverted microscope and wear measurement reported as volume loss in cubic millimetres. Wear scar diameter of paraffin oil and paraffion oil + 20% banana peel with load of 500 N at 500 and 100 rpm was observed using inverted microscope and illustrated in figure 5a and 5b

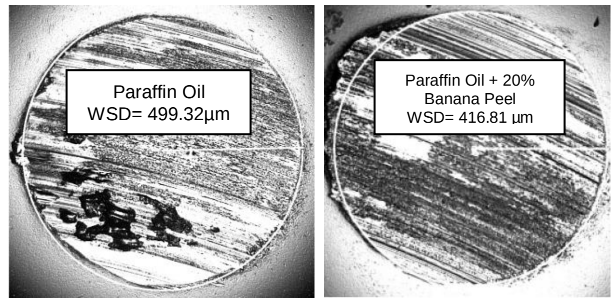

Figure 5a: Wear Scar diameter of paraffin oil and paraffin oil + 20% banana peel with load of 500 N at 500 rpm

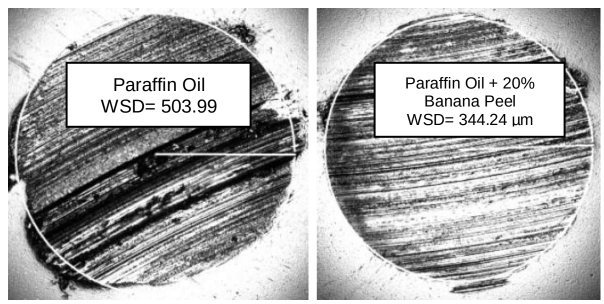

Figure 5b: Wear Scar diameter of paraffin oil and paraffin oil + 20% banana peel with load of 500 N at 1000 rpm

At same parameter, the wear of paraffin oil + 20% banana peel was decrease by 16.52% at 500 rpm. However, at 1000 rpm, the WSD was found to decrease by 31.89% as compared to paraffin oil (Figure 6a and 6b).

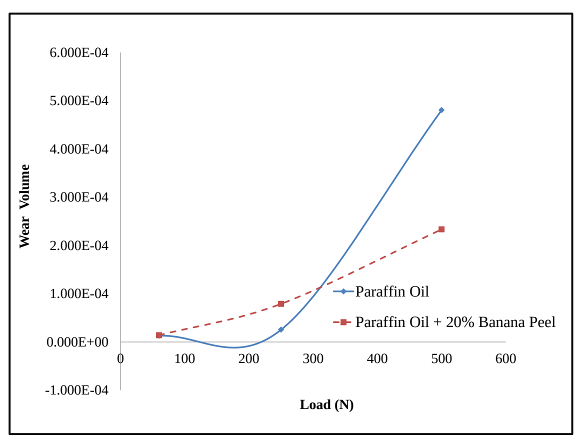

Figure 6a: Wear scar diameter of paraffin oil and paraffin oil + 20% banana peel at 500 rpm

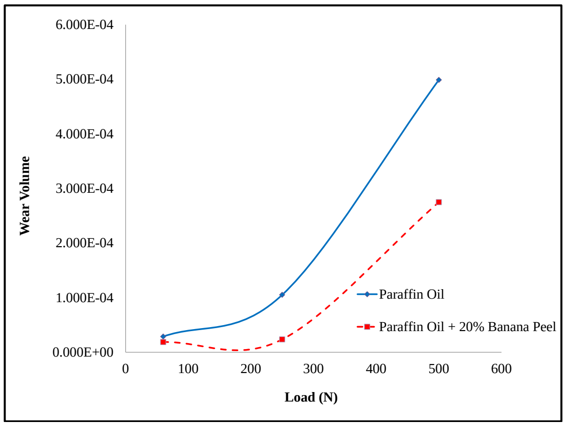

Figure 6b: Wear scar diameter of paraffin oil and paraffin oil + 20% banana peel at 1000 rpm

Wear volume losses for the test speed of 500 rpm and 1000 rpm was reduced at each normal load tested as refer to Figure 7. This suggest that banana peel effectively played a role of ball bearings by changing the sliding friction to rolling friction between the friction pair which result in reducing the contact area between the frictional surfaces. Furthermore, a smoother worn surface obtained due to the polishing effect of lubrication containing banana peel. This is in accordance with a significant reduction of wear volume losses. Reduction of wear volume losses at speed of 500 and 1000 rpm at 100°C was prove that 20% banana peel added to paraffin oil was believed to have additive effects. Abdollah *et al.*, [7] reveal that, additives successfully play the role of ball bearing and thus reducing wear properties.

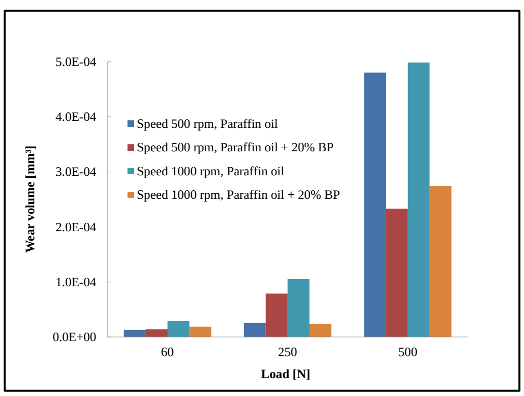

Figure 7 Wear volume (mm^3) plots against applied normal load of 60 N, 250 N and 500 N for wear volume.

This finding suggests that dispersion of 20 % banana peel in paraffin oil is suitable to be used at high temperature, loads and different speed. The result support the fact that the natural material shows a good high temperature properties and COF reduce when the load increased as the findings made by Quinchia *et al*. [8]. Mabuchi *et al*., [6] has discovered that the polysaccharide follicular gel on the banana peel generates lubricating ability and contributes to the friction reduction. Therefore, this study supports Mabuchi's discovery that the BP was able to reduce the COF. Abdullah *et al*., [7] stated that to some extent, this suggests that additive effectively played the role of ball bearings, where the sliding friction was changed into rolling friction between the friction pair, resulting in reducing the contact area between the frictional surfaces. Furthermore, a smoother worn surface was also obtained due to the polishing effect of lubrication. This is in accordance with a significant reduction of wear scar diameter [7].

4.0 CONCLUSION

The dispersion of BP in the paraffin oil is stable and smooth without any sedimentation problem. The kinematic viscosity of the mixture increased from 30.0 to 38.4 cSt for 40°C and from 17.5 to 32.3 cSt for 100°C temperature. Dispersion of banana peel in the paraffin oil has significantly reduced the COF and wear volume at 500 N load and 100°C. Our preliminary result shows that dispersion of banana peel in the paraffin oil shows good and promising tribological characteristic of lubricant. Further investigation should be carried out in future to enhance and reveal the properties of banana peel waste for biolubricant's application.

Acknowledgement

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