

Effect of zinc dioctyl dithosphat concentrations on the friction coefficient of palm oil

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Keywords: Biolubricant; palm oil; friction coefficient

ABSTRACT – This paper investigates the friction coefficient and wear scar diameter of palm oil with addition of zinc dioctyl dithosphat (ZnDoDP) as an additive. Palm oil samples with addition of 0 to 3 wt.% ZnDoDP were prepared using ultrasonic homogenizer. The friction test was performed using a four-ball tester in accordance to ASTM D4172 and the balls were analyzed using portable microscope. The results revealed that the lowest friction coefficient and wear scar diameter was observed at 2 wt.% of ZnDoDP.

1. INTRODUCTION

A complex composition of microbial toxins contains in the mineral-based lubricant causing irritation or allergies if it is touched to human skin. Shashidhara and Jayaram [1] reported that about 80% of all occupational diseases from operators were due to skin contact with mineral-based cutting fluids. Furthermore, continuous demands of mineral based lubricant affect their mineral resources, which is will contribute to the depletion of their sources. Additionally, an increase of mineral-based lubricant demands also led to aggregate of their market prices. At the same time, it is harmful and polluting environment if it is not properly dispose due to their characteristic, which is a non-biodegradable [2]. This study introduces vegetable oil as an alternative based lubricant to substitute mineral-based lubricant. Nevertheless, based on the previous studies [3-6], it reveals that the drawbacks of vegetable-based lubricant, which is has lower tribological properties. Therefore, the aim of this study is to investigate the effect of ZnDoDP concentrations on the friction coefficient of vegetable oil using palm oil.

2. METHODOLOGY

In this study, a commercial cooking palm oil was used as a based lubricant with addition of ZDoDP at difference concentrations of 0 wt.%, 1 wt.%, 1.5 wt.%, 2 wt.%, 2.5 wt.% and 3 wt.%. The mixtures were carefully prepared using ultrasonic homogenizer so that the additives were uniformly distributed into the palm oil. The tribological test was performed using a four-ball tester according to the ASTM D4172, as shown in Figure 1. Three lower balls clamped together with one upper ball is held at the top in a chuck and pressed with a force 40kgf into the cavity that filled with the sample

lubricant formed by the three clamped balls for three-point contact. Table 1 shows the testing parameters and material properties of the ball bearing.

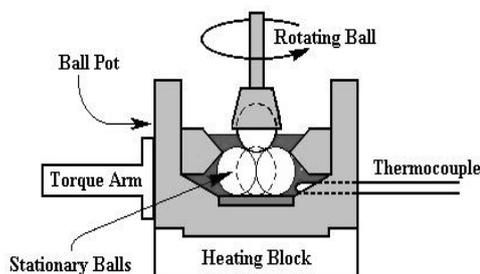


Figure 1 Schematic diagram of a four-ball tester

Table 1 Test parameters and ball bearing properties

Ball material	Carbon steel
Ball size	12.7mm
Ball hardness	64-66 HRC
Load	40kgf
Speed	1200 rpm
Temperature	75°C
Time	60 minutes

Lubricants are compared by using the average size of the scar diameters worn on the three lower clamped balls and friction coefficient. Friction coefficient (*COF*) was calculated based on Equation (1).

$$COF = \sqrt{6/3} \times \frac{\tau}{0.367 \times F} \quad (1)$$

Where, τ is the frictional torque and F is the applied load.

3. RESULTS AND DISCUSSION

3.1 Coefficient of friction

Figure 2 shows the friction coefficient of palm oil at different concentrations of ZDoDP. It reveals that friction coefficient decreases with increasing ZDoDP. However, after 2.5 wt.%, the value of friction coefficient slightly increased. The present finding suggests that ZnDoDP created a protective layer film between surface contact of the ball, hence, reducing the friction between the ball.

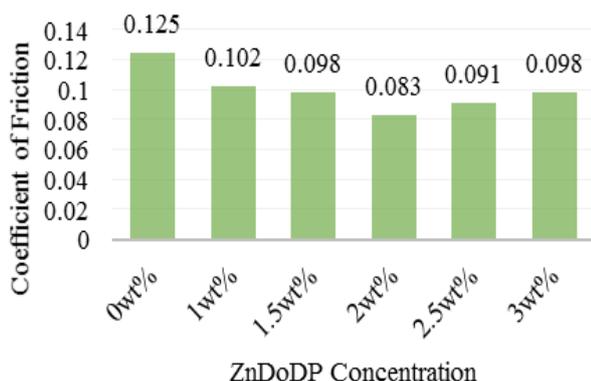


Figure 2 Effect of ZDoDP concentrations on the friction coefficient of palm oil.

This finding is consistent with the finding of Farhanah and Syahrulail [5], which stated that an additive contains phosphorus and sulphur that react with metallic surface, created protective layer at metallic surface that have low shear strength, hence reducing friction. However, increment of friction coefficient after 2.5 wt.% of concentrations is might be due to the multiple zinc molecule adsorp into the surface and led to increase the friction coefficient as the zinc molecule collide together. This is an agreement with Mahipal et al. [4], where friction coefficient increased as the zinc-dialkyl-dithio-phosphate (ZDDP) concentration excess more than 2wt%.

3.2 Wear scar diameter

Figure 3 shows a wear scar image on a ball bearing after tribological testing. Referring to Table 2, it can be seen that the result of wear scar diameter for different concentration of ZDoDP. It shows that with addition of ZDoDP into palm oil give positive feedback for the wear scar diameter. From 1 wt.% until 2 wt.% of ZDoDP, the result of wear scar diameter shows the decreasing of wear size. It can be suggested that ZDoDP create a thin protective film that act as a cushion between the surface contacts, hence reduce the stresses between the balls and reduce the wear [4,5]. However, an excessive addition of ZDoDP that more than 2 wt.% give a negative feedback which is an increases of wear size [4].

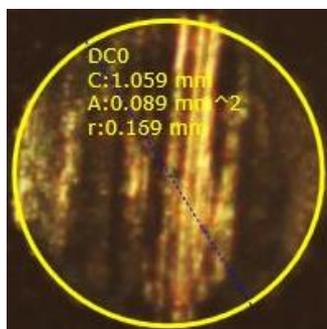


Figure 3 Wear scar image under portable microscope

Table 2 Wear scar diameter results

Concentration	Wear scar diameter (mm)
1	0.266
1.5	0.19
2	0.169
2.5	0.237
3	0.285

4. CONCLUSION

In conclusion, addition of ZDoDP into palm oil can reduce the friction coefficient properties. From this study, addition of 2 wt.% ZDoDP shows a great decrease of friction coefficient to 0.083. The newly found results would encourage further studies on green bio-lubricants.

ACKNOWLEDGEMENT

This project is supported by Ministry of Education Malaysia (grant number: RAGS/1/2015/TK03/FTK/03/B00116).

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