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The formation of tribo-chemical protective layer of bio-lubricant during friction test

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ABSTRACT – The aimed of this study is to investigate the formation of tribo-chemical protective layer of bio-lubricant from banana peel waste during friction test. The bio-lubricant is extracted from banana peel waste of Musa Aluminata Balbisiana (MBS). Tribological evaluation of MBS oil was conducted using pin-on-disc tribometer as per ASTM G 99 standard. In this study, bio-oil was used as a lubricating oil on sliding surface at varying loads and temperature. It was obobservinggthrough microscopic analysis that, the formation of tribo-chemical film which existed as protective layer on sliding surface thus preventing the contact between two surfaces.

1. INTRODUCTION

Banana skin has been often referred as slipping tools by the literature [1-3]. 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. Lubricating effect of banana skin is contributed by the existence of follicular gel, which is sized about a few micrometers [1]. Another study found that, percentages of extraction yields of bio oil from the peel waste of banana species were influenced by the existence of follicular gel [4]. The follicular gel was analyses using scanning electron microscopes and they concluded that, the polysaccharide follicular gel is a major key element in formation of oil [4,5]. Hamid et al., [2] investigated the effects of banana peel of Cavendish species as a natural additive in paraffin oil. The tribological properties of the specimens were evaluated using four-ball tester. The coefficient of friction, COF and wear significantly reduced at high load, temperature and speed.

The mechanism that affect the tribological performance of bio-lubricant is still limited. Hence, the objective of this paper is to to investigate the formation of tribo-chemical protective layer of bio-lubricant from banana peel waste during friction test.

2. METHODOLOGY

In this study, the tribological testing was performed according to the ASTM G99-05 standard under lubricated sliding conditions at different temperatures and applied load. A constant sliding speed and wear track diameter were applied along the experiments as shown in Table 1. The pin was heated using an external heat resource where a thermocouple was placed on the edge of the counterpart pin. Time was set according to the time of test that would be conducted. An infrared thermometer (Extech 42580) was used to measure the temperature. It was pointed at the specimen before the test began. Morphological characterization of the pin surface was carried out using Scanning Electron Microscopy (SEM). The electrons in the beam interact with the sample producing various signals that can be used to obtain information about the surface topography and composition (EDX). The surfaces of all the samples were coated with a thin film of platinum using Polaron SC 7640 Sputter in order to improve the conductivity and avoid electron-charging effects during analysis.

Table 1 Pin-on-disc test parameters**.**

Test Parameter	Value
Loads (N)	20, 40, 60, 80, 100
Temperatures (°C)	27, 40, 100
Sliding speed (RPM)	50
Sliding distances (m)	314
Sliding Times (minutes)	50

3. RESULTS AND DISCUSSION

A tribo-chemical reaction may occur between fatty acids composition in MBS oil with the disc surface, which may have resulted in the formation of metallic soap layer, and fluid protective layer that contributed to the favor of frictional reduction as shown in Figure 1. Pin was believed to exist as contacting surface while disc acts as opposing contacting surface. The higher magnitudes of COF at the beginning of sliding indicates that the lubrication regime occurred in the rubbing zone is boundary lubrication. Moreover, at this phase, the fluid protective film was fully developed with functioned to protect the contacted surface. At all the tested temperatures of the load of 80 N, it shows the greatest ability to retain its properties without the breakdown of the lubrication film. In this study, at higher load (80 N), the lubricating film thickness become thinner than some of the asperities present in the boundary lubrication. However, the asperities are covered by the long chain fatty acids and the ester of biolubricants, which are known as surface-active materials.

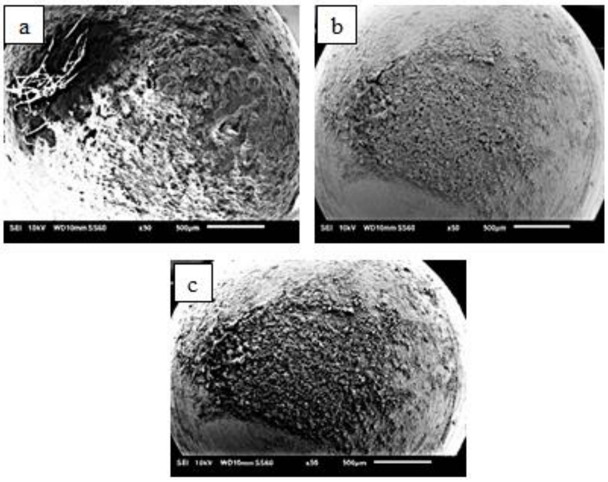

Figure 1 SEM micrograph of monolayer of tribo-chemical film at the hemisphere surface of the pins at (a) 27 ºC, (b) 40 ºC and (c) 100 ºC.

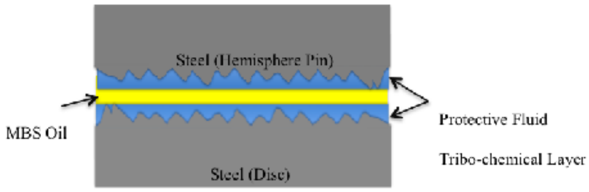

Figure 2 A schematic representation of tribo-chemical's film and its corresponding contact mechanism in pin on disc under lubrication of MBS oil.

The presence of adsorption of polar molecules such as long chain fatty acids and ester in bio-lubricants act as an efficient barrier for protective sliding surface contact and friction surface and lead to the reduction in COF. In addition, the existences polar group of esters also provides an affinity to metal surface and contributed to the formation of protective layer between metal surfaces. In other words, the polarity of the ester group creates a strong affinity to the metal by one end of the molecules and it's allowed a nonpolar hydrocarbon to extend out and provides a barrier between surfaces. Moreover, the presence of carbonyl group in MBS oil was believed to be chemically and physically adsorbed onto the steel or metal surface. The adsorption therefore provides a prevention of direct contact between frictional pairs due to the formation of orderly and closely packed molecular multi layers. A schematic representation of chemical adsorption of fatty acids molecules of MBS oil on surfaces during friction. Furthermore, fatty acids molecules which known as corrosive component, was believed can cause the corrosion and material removal of fractional pairs.

4. CONCLUSION

The investigation on tribological properties of MBS oil was successfully performed using pin on disc tribometer. The formation of tribo-chemical film was observed at the contact surface which acting as protective-layer during friction. The finding from this study might contribute to the sustainable development of the bio-lubricants fields.

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