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Tribological behaviour of trihexyltetradecyl phosphonium bis (2,4,4-trimethylpentyl) phosphinate with ZDDP interaction

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ABSTRACT – Iinvestigations on the potential use of ionic liquids (ILs) as additives in lubricants have increased in the recent past. Low miscibility of ILs in the non-polar oils is a major obstacle in maintaining an optimum lubrication performance. This article focuses on the use of Trihexyltetradecyl phosphonium bis (2,4,4-trimethylpentyl) phosphinate as an additive in mineral base oil. Wear rate was estimated for different concentrations of IL at constant load and temperature. Coefficient of friction was found to be least in 3% when compared to 5% and 1% by volume concentration. This was further validated by the SEM and AFM analysis carried out. ZDDP was blended with the IL and the additive interaction was also studied.

1. INTRODUCTION

Piston ring - cylinder surface system undergoes through various lubrication regimes. The effectiveness of lubrication at the interface depends on the ability of the lubricant to sustain the severity of this environment. The reduction in the properties of the conventional engine oils after prolonged use due to depletion of existing additives has inspired many researchers to find alternates. In recent years the potential of ionic liquids (ILs) as an additive in lubricants to reduce the wear rate by resolving additive depletion is being explored. Ionic liquids (ILs) are room temperature molten salts that have been shown to offer many advantages. Recent studies suggest that the addition of Phosphonium ILs as additive in the engine oil (after depletion of the already existing additive package) improved its friction and wear behaviour and ILs effectively contributed to the boundary film formation when already present additives (such as ZDDP) are substantially depleted in the case of used engine oil. The objective was to test the lubricant with Trihexyltetradecyl phosphonium bis(2,4,4-trimethylpentyl) phosphinate as an additive in different concentrations and its effect on the wear rate of the metal [1,2]

2. METHODOLOGY

Friction and wear tests were carried out on a reciprocating wear test with a ball on flat geometry. The samples of AISI 52100 steel of dimension 30×30×10 were prepared by machining using a wire electrical discharge machine followed by surface grinding to achieve similar surface roughness values. The test solution was prepared by mixing 1%, 3% and 5% of Trihexyltetradecyl phosphonium bis(2,4,4-trimethylpentyl) phosphinate in engine oil. In the machine, the upper specimen (ball) reciprocates on the lower specimen (flat). The operating parameters load, temperature and speed were kept constant at 50N, 100ºC and 600 rpm. The stroke length was kept at 15 mm. The sample was heated to the desired temperature and at steady-state condition the test was allowed to run for a time period of 120 min. The experiment was paused at specific intervals of 5,10,15,20,30,50,80 and 120 minutes to analyse the wear scar on the ball specimen. A replica method was adopted here. The wear scar impressions were taken on aluminium foils of 20 microns thick. The details of the method are described elsewhere [3].

Table 1 Test parameters.

Conc.	**Load (N)**	**Temperature (ºc)**	**Duration (min)**
1 %	50	100	120
3 %	50	100	120
5 %	50	100	120

Impressions on the aluminium foils aluminium were later measured under a high precision microscope. The diameters were taken in two perpendicular dimensions as shown in the Figure 1.

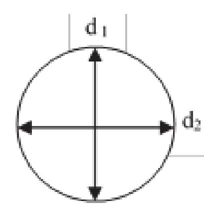

Figure 1 Wear scar dimensions on the ball in two perpendicular directions.

Average diameter was calculated. Wear rate was estimated using the appropriate formulae [4]. The test was repeated for each concentration with the same parameters to observe similar wear rate spread.

3. RESULTS AND DISCUSSION

The variation of coefficient of friction with respect to time is presented in the Figure 1. It may be observed from the Figure 2 that the coefficient of friction of when tested with different concentrations were found to decrease over a period of time. Sample 2 with a concentration of 3% IL in base oil was found to offer less coefficient of friction. The behaviour is more consistent when compared with other concentrations.

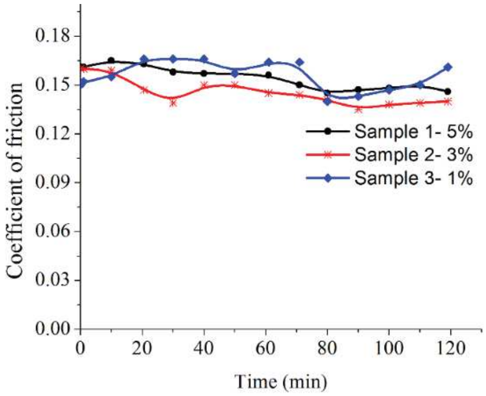

Figure 2 Variation of coefficient of friction with respect to time for different additive concentrations.

The wear rate of the steel ball was estimated considering the wear scar diameters measured at various intervals [4].

Variation of wear rate with respect to time is presented in Figure 3. The wear rate was found to be lower for 3% solution by volume till 60 minutes and later an increase was observed.

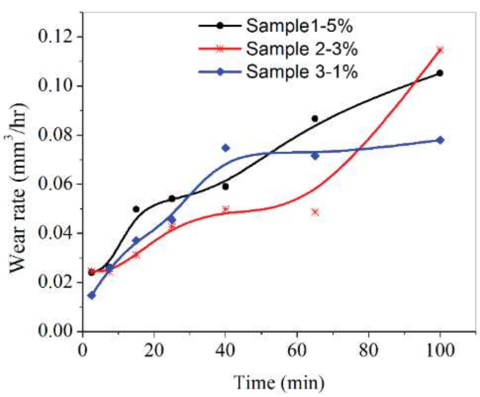

Figure 3 Variation of wear rate with respect to time for different additive concentrations.

Sample with a concentration of 3% IL in base oil was found to offer less friction over a longer period, when compared with other concentration the coefficient of friction remains more consistent. Figure 4 presents the results of the AFM and SEM analysis carried out. The surface was found to be unaffected during the wear process. This may be attributed to the formation of the boundary film as seen in the AFM.

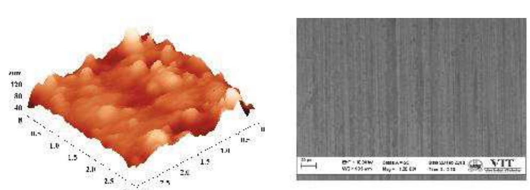

Figure 4 AFM and SEM images of the sample tested with 3 % concentration of IL.

Figures 5 and 6 present the variation of coefficient of friction and wear rate when tested with blends of engine oil and additive at various concentrations. In these also the performance was found to be better with 3 % IL concentration.

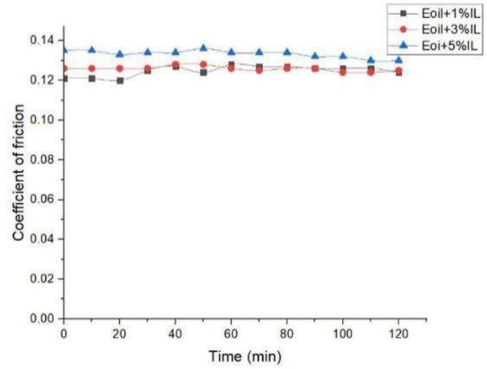

Figure 5 Variation of coefficient of friction with respect to time for different additive concentration in engine oil.

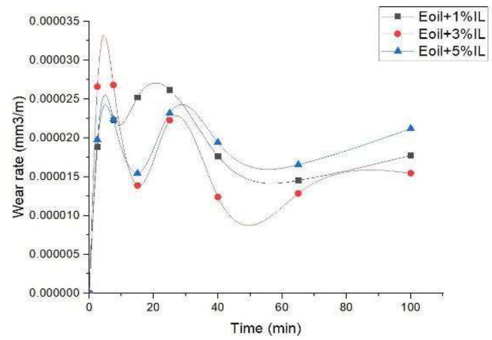

Figure 6. Variation of wear rate with respect to time for different additive concentrations in engine oil.

4. CONCLUSION

The results observed from the work carried out concludes that addition of Trihexyltetradecyl phosphonium bis (2,4,4-trimethylpentyl) phosphinate at 3% by volume shows least wear rate and coefficient of friction compared to 1% and 5% concentration solution. SEM and AFM studies conducted validated this behaviour.

5. REFERENCES

[1] Anand, M., Hadfield, M., Viesca, J. L., Thomas, B., Battez, A. H., & Austen, S. (2015). Ionic liquids as tribological performance improving additive for in-service and used fully-formulated diesel engine lubricants. *Wear*, *334*, 67-74.

[2] Bermúdez, M. D., Jiménez, A. E., Sanes, J., & Carrión, F. J. (2009). Ionic liquids as advanced lubricant fluids. *Molecules*, *14*(8), 2888-2908.

[3] P. M. Anil & Rajamohan, V. (2017). Influence of surface roughness and ZDDP additive on the friction and wear of reciprocating sliding surfaces at high contact pressures. *Industrial Lubrication and Tribology*, *69*(5), 738-749.

[4] Winer, W. O., & Peterson, M. B. (Eds.). (1980). *Wear control handbook*. American society of Mechanical Engineers.