Temperature effect on the lubricity of ionic liquids

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The lubrication ability of ionic liquids has been widely investigated, and their outstanding performances have been acknowledged by many researchers. However, lubricity is closely dependent on operating conditions, namely temperature and moisture. In this study, we aim to compare the lubricity of a few commercially available ionic liquids at low and elevated temperatures. The results show that operation temperature has a significant effect on their performance. In most cases, higher temperature leads to diminished lubricity.

Keywords: ionic liquids, adsorption layer, tribo-film, friction, wear

1. Introduction

Since 2001, ionic liquids (ILs) have become one of the most intensively studied lubricants. Many various ILs have been studied for use as neat lubricants and/or lubricant additives. Among many advantages, ILs have been observed to have excellent lubricity and their properties have been summarized in several review papers. High thermal stability is often mentioned as an advantage of ILs. However, the most of published tribological tests were performed at an ambient temperature. With an increase in the operation temperature, the viscosity of the IL decreases, corrosiveness increases, and friction surface activity increases. The current study compared the lubricity of commercially available ionic liquids at low and elevated temperatures.

2. Materials and Methods

Three commercially available ionic liquids methyl-trioctylammonium bis(trifluoromethylsulfonyl)imide [N1888][NTf2], tributylmethylammonium bis(trifluoromethylsulfonyl)imide [N4441][NTf2], and trihexyltetradecylphosphonium bis(2,4,4-trimethylpentyl)phosphinate [P666(14)] [phosphinate] were used. Tribological tests of selected ILs were implemented using ball-on-plate reciprocating tribometer. For this test three friction pairs were selected: bearing steel–bearing steel (BS-BS), bearing steel–stainless steel (BS-SS), and bearing steel–aluminum alloy (BS-AL). The tribo-tests parameters were chosen to represent boundary lubrication conditions. They are as follows: load – 4 N, reciprocation frequency – 15 Hz, stoke length – 1 mm, test temperature 30 and 80 °C, test duration – 30 min. The friction surface morphology was analyzed using an optical microscope and SEM. The wear scars were measured using stylus profilometer Mahr GD-25 and the wear volume was calculated. EDS analysis was performed to investigate the wear trace composition.

3. Results and Discussion

The friction observed in the present study was closely related to temperature and friction pair materials (Figure 1). At the low temperature the friction was low and high differences between investigated friction pairs occur. In the high-temperature test, the friction was much higher and differences between friction pairs diminishes. Investigated ILs have substantially different wear reduction behavior on the different friction pairs and temperatures. In the BS-BS friction pair higher test temperature leads to increased worn surface abrasion. In the BS-SS friction pair, the higher test temperature caused double wear volume. The increase in temperature for the BS-AL friction pair leads to tribo-corrosion and extremely high wear. It was concluded that different wear mechanisms occur at different temperatures and friction pair materials. The observed tribo-films mostly consist of oxygen, sulfur, and fluorine. The amount of these substances is varying between the friction pairs and increases at the higher temperature.

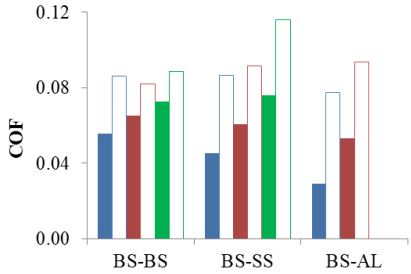

Figure 1: COF observed at different friction pairs and temperatures (30°C - filled, 80°C - empty) when lubricated with [N1888][NTf2] – blue, [N4441][NTf2] – read, [P666(14)] [phosphinate] - green

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5. References

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