SOME TRIBOLOGICAL PROPERTIES OF AN IONIC LIQUID

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ABSTRACT
Some tribological properties of an ionic liquid were investigated by using a pin-on-disc friction and wear tester. Due to running-in, the coefficient of friction of the ionic liquid decreased with time to a very low value of 0.02 which suggests that the lubrication regime was hydrodynamic at the end of the tests. Anti-wear performance of the ionic liquid was substantially comparable to a paraffin-based oil.

INTRODUCTION
Ionic liquids have a number of excellent properties including negligible volatility, non-flammability, high thermal stability, broad liquid range, and controlled miscibility with organic compounds. Ionic liquids are considered to be promising lubricants in high temperature, vacuum and space environments [1].

In this study, some tribological properties of an ionic liquid were investigated by using a pin-on-disc friction and wear tester.

EXPERIMENTAL
An ionic liquid (IL), N,N-Diethyl-N-methyl-N-(2-methoxyethyl)ammonium bis(trifluoromethanesulfonfyl)imide was tested. A paraffin-based multi-purpose industrial oil (MO) was also tested as a reference. Properties of the lubricants and the structure of the ionic liquid are shown in Table 1 and Fig. 1, respectively.

| Table 1 Properties of the lubricants. |
|---------------------------------|-----|----------------|----------------|
| Pour point, degC | Density, g/cm³ | Viscosity, Pa.s (20 degC) |
| IL | N/A | 1.42 | 0.077 |
| MO | -13 | 0.9 | 0.070 |

As well as friction force, vertical displacement of the pin was measured. Experimental conditions are shown in Table 2. SUS440C pins with a tip radius of 50 mm and SUS440C discs with a diameter of 40 mm were used. Surface roughness Ra was below 0.2 µm. All tests were conducted in air at room temperature. The test duration was 120 minutes.

RESULTS
Fig. 2 shows the variation of the coefficient of friction with time. At the beginning of the tests, the system was operating in a mixed lubrication regime and the coefficient of friction of the ionic liquid was 0.039, 0.075 and 0.091 at the load of 2, 5 and 10 N, respectively. These values were virtually same as those of the paraffin-based oil. The coefficient of friction of the ionic liquid gradually decreased to a very low value of 0.02. On the other hand, the coefficient of friction of the paraffin-based oil at the end of the test was about 0.04 at the load of 10 N. The coefficient of friction of the paraffin-based oil decreased with load but was still higher than 0.02 of the ionic liquid.

Fig. 3 shows the variation of the pin displacement with time. Decrease in the pin displacement means that the pin approached the disc due to wear. The pin displacement of the paraffin-based oil was almost stable after the first 10 minutes. It
took a longer time for steady state to be reached in cases of the ionic liquid.

Fig. 2 Variation of the coefficient of friction with time.

Fig. 3 Variation of the pin displacement with time.

Fig. 4 Pin displacement and the coefficient of friction at the end of the test.

Fig. 5 Coefficient of friction versus speed.

Fig. 6 Pin displacement versus speed.

Low friction of the ionic liquid at the end of the tests suggests that the lubrication regime was largely hydrodynamic. This is confirmed by the relation between the coefficient of friction and the sliding speed, which was obtained after the wear tests. As shown in Fig. 5, the coefficient of friction of the ionic liquid reached a minimum near the speed in the wear tests (0.1 m/s), while the coefficient of friction of the paraffin-based oil reached a minimum at a larger speed than of the ionic liquid.

Fig. 6 shows the relation between the pin displacement (relative to the displacement at the speed of 0.01 m/s) and the speed. At the speed of 0.1 m/s, the pin displacement (a rough approximation of the film thickness) of the ionic liquid was larger than that of the paraffin-based oil. Low friction of the ionic liquid at the end of the tests probably resulted from larger film thickness as well as smaller surface roughness.

Very low friction due to running-in is often accompanied by excessive wear. Anti-wear performance of the ionic liquid was, however, substantially comparable to the paraffin-based oil.

REFERENCES