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Tribological properties of halogen-free ionic liquids against sintered ceramics

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1. Introduction

Ionic liquids (ILs) are expected to be used as new high-performance lubricants due to their low volatility and thermal stability. In general, it is known that their lubricity depend on whether they have halogen in their molecule structures. Halogen containing ILs exhibit excellent lubricity for metals; however at the same time, corrosive damage occurs on worn surfaces [1]. In addition, halogen-containing ionic liquids generate toxic gas including halide during sliding phase. On the other hands, halogen-free ILs can prevent such corrosive phenomena, however, the lubricity is very inferior compared with halogen-containing ILs.

In the previous study [2], the tribological properties of halogen-free ILs against various hard materials were investigated, and it was reported the change of sliding materials can improve the lubricity of halogen-free ionic liquids. The lubricity of the combinations of sintered ceramics and halogen-free ILs exhibited good lubricity.

In this study, the tribological properties and their mechanisms were investigated.

2. Experimental conditions

The tribological properties of sintered ceramics, Al_2O_3, Si_3N_4 and SiC, were evaluated using a ball-on-disk reciprocating sliding tester. The physical properties of ceramics disks are shown in Table 1. The ball specimen was 10mm in diameter and made of AISI52100 (HRC 60). In this study, two kinds of halogen-free ionic liquids, [EMIM][DCN] and [BMIM][TCC], and PAO were adopted as lubricants. These viscosities are 7.62mPa·s, 11.13mPa·s and 8.55mPa·s at 50˚C respectively. The test conditions are shown in Table 2.

3. Results and discussions

Figure 1 shows the friction and wear properties of ceramics using all lubricants. Al_2O_3 and Si_3N_4 lubricated with both ionic liquids and SiC lubricated with [BMIM][TCC] showed lower friction coefficient than that with PAO. In addition, the wear scar of the disk was not observed because the wear was too small. The friction behaviour of each ceramic lubricated with [BMIM] [TCC] and [EMIM] [DCN] are shown in Fig. 2. When [BMIM] [TCC] was used, few differences were observed between the friction behaviour of ceramics. On the other hand, when [EMIM] [DCN] was used, a remarkable difference was observed between the friction behaviour of SiC and the others. Though SiC had the smoothest surface of all ceramics, its friction coefficient showed the highest value. It is supposed that the differences of these tribological properties were due to the chemical effects rather than the physical effects such as the surface roughness.

4. References

[1] Y. Kondo et.al.,: " Lubricity and corrosiveness of ionic liquids for steel-on-steel sliding Contacts", *Proc. of IMech E., Part J,* 226(11) (2012) 991-1006

[2] Y. Kondo et.al.,: "Study on Tribological property of Halogen-free Ionic Liquids for Hard Materials", *Proc. of JAST Tribo. Conf. Tokyo*(2012) 373-374

Table 1 Physical properties of ceramics

Material	Roughness [μm]	Hardness [GPa]
Al_2O_3	0.253	18
Si_3N_4	0.109	14
SiC	0.020	22

Table 2 Test conditions

Frequency [Hz]	50
Amplitude [mm]	1
Lubricant [μl]	30
Temperature [ºC]	50
Load [N]	50
Time [min]	60

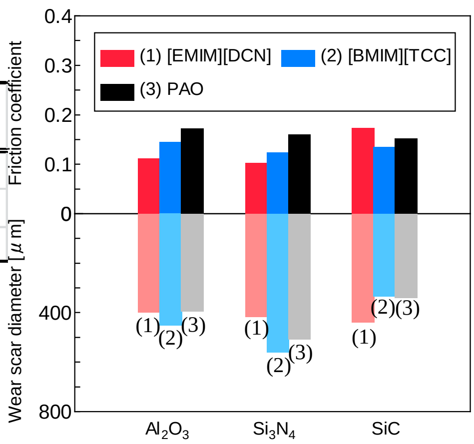

Fig. 1 Friction and wear properties of ceramics using all lubricants

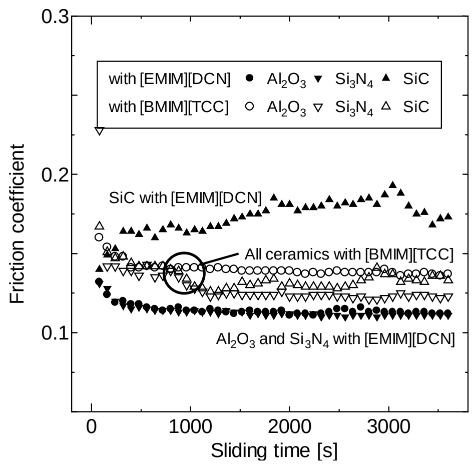

Fig. 2 Friction behavior of ceramics using ionic liquids