Tribological performance of some organic fluorine-containing compounds as lubricants

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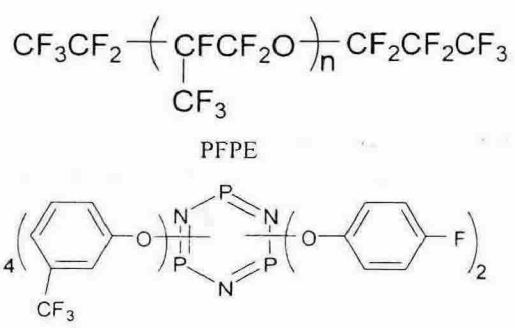
The friction and wear behaviors of fluorine-containing compounds such as perfluoropolyethers (PFPE), phosphazenes (X-1P), ionic liquids as lubricants for steel/seel, steel/ceramic, ceramic/ceramic were investigated using a SRV tester and a one-way reciprocating friction tester both in ball-on-disc configuration. It was found that the three fluorine-containing lubricants could reduce friction coefficient and wear volume effectively. The effectiveness of the three lubricants in reducing wear volume could be ranked as ionic liquids > X-1P > PFPE. Tests also showed that aryloxyphosphazene with polar substituent as a lubricant of steel/steel pair gave low wear, while aryloxyphosphazene with nonpolar group on the phenyl pendant led to high wear. The morphology and the tribo-chemical reaction of the worn surfaces were analyzed with a scanning electron microscope (SEM) and X-ray photoelectron spectroscope (XPS). XPS analyses illustrated the formation of iron fluoride in steel/steel system with the lubrication of both phosphazenes and ionic liquids.

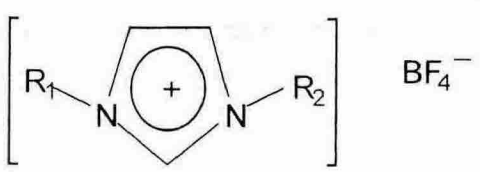
Kewwords: PFPE, phosphazenes (X-1P), ionic liquids, lubricity

Fig. 1 shows the molecular structures of the three to be tested F-containing lubricants.



PFPE

X-1P



L108: R_1= Me; R_2= n-octyl

Fig.1 Molecular structures of the lubricants

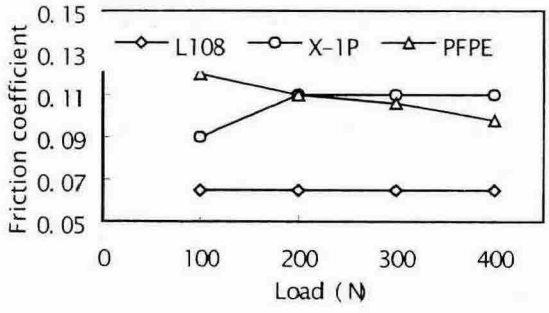


Fig.2 Friction coefficient as a function of load

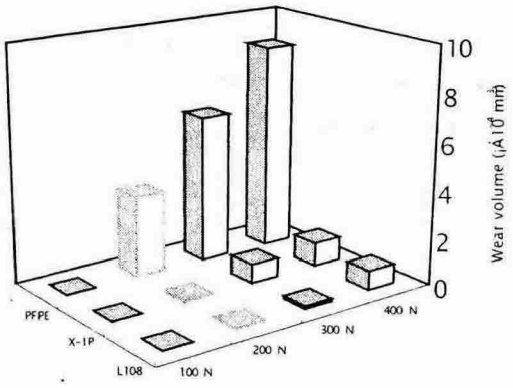


Fig.3 Wear volume as a function of Load

Under selected high loads, the friction coefficient and wear volume of Sialon/steel as a function of load are shown in **Fig.2** and **Fig.3**, respectively. Under relatively low loads the friction test results are presented in **Table 1**. It can be seen that all the three lubricants can significantly reduce the friction coefficient and wear volume of the sialon ceramics as compared with the case of dry sliding (wear volume 1.6×10^{-3} mm^3 and friction coefficient 0.64, respectively, under 100 N, for 10 min). Interestingly, the friction coefficient of sialon lubricated by L108 remained stable at 0.065 with load increasing from 0.5 N to 400 N, i.e. for both the high load and low load conditions. In addition, L108 exhibited the lowest wear volume under the high load condition, as compared with PFPE and X-1P. Besides, **Table 2** shows that low friction coefficient was also achieved for steel / SiO_2, steel / Si100, Si_3O_4 / SiO_2 and Si_3O_4 / Si100 with the lubrication of L108. Hence, L108 is a very promising and attractive lubricant for ceramics [1].

The friction coefficient of PFPE decreased with the increasing load, yet the wear volume is much higher than that of X-1P and L108. It seems that PFPE underwent degradation during sliding which resulted in the highest wear volume.

Table 1 Friction coefficient of sialon/steel lubricated with different oils under load 0.5~3 N.

Lubricant	PFPE	X-1P	L108
Friction coefficient	0.115	0.090	0.065

Table 2 Friction coefficient of different contact pair lubricated with L108, X-1P and PFPE (SRV test, 40 N load, 25 Hz frequency, 1mm amplitude)

Contact pair	Friction coefficient		
	L108	X-1P	PFPE
AISI 52100 ball / SiO_2 disc	0.060	0.110	0.132
Si_3N_4ball / SiO_2 disc	0.085	0.115	0.132
AISI 52100 ball / Si100disc	0.050	0.102	0.145
Si_3N_4ball / Si100 disc	0.050	0.098	0.155

The friction coefficient of Dy-sialon sliding against steel under the lubrication of PFPE, X-1P and L108 is much lower than under dry sliding. Either under low load or high load, L108 shows low friction coefficient and considerably decreased wear volume loss of the sialon. The wear volume loss of the sialon ceramic discs lubricated with various lubricants can be ranked as PFPE > X-1P > L108.

This work also proves that fluorine-containing ionic liquid compounds are a potential new type low vapor pressure good lubricity liquid lubricant.

ACKNOMLEDGEMENTS

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REFERENCES

[1] Ye, C., Liu, W, Chen Y. et al, Room-temperature ionic liquids: a novel versatile lubricant, Chem. Commun, pp. 2244-2245, 2001.