TRIBOLOGICAL PROPERTIES OF MALEIC DITHIOPHOSPHATE DERIVATIVES

S. Koyata *, K. Yagishita , K. Ishii
*koyata.saki@jxtg.com

Lubricants R&D Dept., Lubricants Company, JXTG Nippon Oil & Energy Corporation
8, Chidori-cho, Naka-ku, Yokohama 231-0815 JAPAN

KEYWORDS
Lubricant additives; Wear; Friction, EP/AW additives

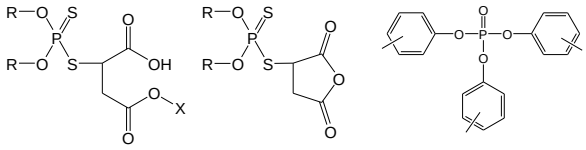
INTRODUCTION

Zinc dialkyl dithiophosphate (ZnDTP) has been widely used in hydraulic fluid as antiwear additive, but because of its poor stability at high temperature and in the presence of water, many additive technologies have been studied as replacements for ZnDTP.

One solution is to use a combination of phosphorus type antiwear additives and Sulfur type extreme pressure additives. In this study, with the aim of developing hydraulic fluids with improved antiwear and extreme pressure performance, tribological properties of a combination of maleic dithiophosphate derivatives (MDTPs) as a new sulfur-phosphorus type additives and tricresyl phosphate (TCP) were investigated. MDTPs contain polar groups, which should show good adsorption to metal surfaces.

EXPERIMENT

Chemical structures of additives in this investigation are illustrated in Fig. 1. Four kinds of MDTPs were used, each having polar groups with a different structure. API Gp.III VG32 is used as base oil. Formulations of test oils are presented in Table 1.



(a)MDTPs (b)MDTP-AM (c)TCP
（R:2ethylhexyl）

Fig.1 Chemical structures of additives

Table 1 Test oil formulations, mass%

Test Oil	TCP	MDTPs [-X]		MDTP-AM
A	0.5	H	0.015	-
B	0.5	CH3	0.016	-
C	0.5	C2H5	0.016	-
D	0.5	C3H7O2	0.017	-
E	0.5	-	-	0.015
F	0.5	-	-	-

Lubricating properties were measured using Block-on-ring tests according to ASTM D 2714.

RESULTS AND DISCUSSION

Figure 2 shows the wear scar width for each test oil used in this study. The wear scar width with TCP/MDTP-AM (OIL-E) is the widest among the test oils, and was about the same as that with TCP alone (OIL-F). OIL-A, -B, -C and -D all outperformed OIL-F, with OIL-A showing the best antiwear property. From the above, it was found that antiwear performance is greatly improved when MDTPs are used in combination with TCP. Further, with the exception of OIL-C, the antiwear properties improved with the increasing polarity of the MDTPs. We will look into why OIL-C was the exception to this trend in a future study.

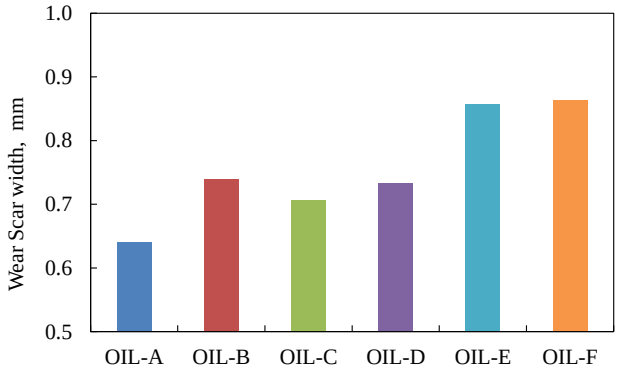


Fig.2 Wear scar width on block-on-ring test

The tribofilms formed on the block surfaces were analyzed by XPS to investigate the relationship between the tribofilms and antiwear properties. According to the XPS depth direction analyses, it is inferred that the sulfur-containing MDTPs readily adsorb and react with the metal surfaces, because the S/P ratios for the tribofilms formed TCP/MDTPs are higher at deeper areas in the film. These results suggest that when MDTPs having more than one carboxyl group are used in combination with TCP, it greatly aids in the formation of a tribofilm despite being added in a amount less than 1/20 that of TCP.