Friction-Reducing Performance of Polymethacrylate (PMA)-Based Additives Having Multiple Adsorption Sites

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1. INTRODUCTION

Organic polymers such as polymethacrylate (PMA) have been widely used in engine oils as viscosity index improvers to prevent a decrease in oil viscosity with increased in oil temperature. Previous studies by the authors have reported that the functionalized PMA caused multiple adsorptions by a number of the functional groups [1,2]. In the case of functionalized PMA, a film, adsorbed at multiple-points by the polymers, prevented a drastic increase in friction with increasing oil temperature, whereas this increase in friction was not prevented by conventional oiliness additives having a single polar group. Although a load-bearing function was easily lost just after molecules were desorbed in the case of the oiliness additives, the adsorbed film from the polymer maintained the load-bearing function under high temperature condition by enhancing the number of the adsorption sites. However, there are still limitations to fully understanding of the friction-reducing mechanism of the multiple-point adsorbed film from the PMA under severe conditions such as high temperature and low speed. This study addresses the limitations described above by conducting friction measurements with elevated temperature and with varying sliding speed respectively, by using several types of PMA-based additives having different functional groups, molecular weight, and chemical structures.

2. EXPERIMENTAL PROCEDURE

Two kinds of friction measurements were conducted by using a laboratory-made 3balls-on-disk tribometer. One of the measurements was conducted with varying sliding speed at constant temperature, and the other was carried out with elevated temperature at constant speed. Several kinds of the PMA-based additives having different functional groups, concentration of the functional groups, and molecular weight were used as sample additives. In addition, low-molecular organic additives having a single polar group such as alkyl carboxylic acid and alkyl alcohol were also introduced as references. Dielectric relaxation measurements were carried out to elucidate the relationship between the polarity of the base oil and the multiple adsorption performance of the polymers.

3. RESULTS AND DISCUSSION

Figure 1 shows plots of coefficients of friction against sliding speed, obtained from the friction measurement at varying speed with four kinds of the PMA-formulated oils and an additive-free base oil (PAO). All of the functionalized PMA (PMA-OH, PMA-N, PMA-COOH) showed lower coefficients of friction than non-functionalized PMA and PAO. In addition, speed dependence of friction was observed in case of PMA-COOH and -OH. This suggests that friction-reducing performance of the PMA was attributed not only to reduction in desorption probability of the molecules from rubbed surfaces by multiple-point adsorption but also the adsorption ability of the functional groups.

Fig. 1 Plots of friction coefficients against sliding speed with varying speed (upper) from 50 mm/s to 5 mm/s (bottom) from 5 mm/s to 50 mm/s

REFERENCES