Tribofilm Formation from Mixtures of Sulfur and Phosphorus-Type Extreme Pressure Agents

Mizuha Kawaguchi [1], Hironobu Matsueda [2], Kyosuke Arakawa [1], Hideki Sakai [1], Kenichi Sakai [1]

[1] Faculty of Science and Technology, Tokyo University of Science, Japan, [2] DIC Corporation

7225524@ed.tus.ac.jp

Lubricants are generally composed of base oils and additives. An extreme pressure (EP) agent is a lubricant additive that can form a tribofilm on a metal surface under sliding conditions at high temperatures and pressures. The tribofilm prevents wear of the metal surface. In this study, we focused on mixtures of sulfur (S) and phosphorus (P)-type EP agents. These mixtures provide a synergistic effect on friction reduction and antiwear performance, leading to their widespread use in various industrial applications. The main focus of this study is to elucidate reaction mechanisms of sulfur and phosphorus-type EP agents in terms of (i) adsorption of each component or their mixtures and (ii) composition of tribofilms formed by sliding.
n -dodecane was selected as a base oil. As a sulfur-type EP agent, 10,10'-trisulfanediyldistearic acid (COOH) was used. As a phosphorus-type EP agent, di(2-ethylhexyl)phosphate (di-P) was used. The adsorption/desorption of the EP agents on/from an iron oxide substrate was characterized using a quartz crystal microbalance with dissipation monitoring (QCM-D) technique. Friction coefficients were measured on a SPCC substrate by means of a ball-on-plate-type friction analyzer. After friction measurements, the surface composition of the SPCC substrate was analyzed by X-ray photoelectron spectroscopy (XPS).
In the COOH and di-P mixtures, friction coefficients increased during the initial stage of sliding and subsequently decreased to approximately 0.2 in the steady state. The initial increase in friction coefficients arises from adsorption of di-P on the SPCC substrate, whereas the subsequent decrease in friction coefficients reflects the predominant effect of COOH on the reactivity. XPS measurements revealed that, in the steady state, the tribofilm formed from COOH and di-P contained a larger quantity of sulfur than phosphorus. This supports higher adsorption capability and reactivity of COOH compared with those of di-P.