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Estimation of the distribution of MoS_2 on sliding surface by AFM/Raman combined Analysis

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Engine lubricants undergoes various chemical and physical changes during its lifetime, which can result in reduced lubricant performance and affect fuel economy. The efficiency of engine lubricants is determined by additives in the lubricant. Molybdenum dithiocarbamate (MoDTC) is a friction modifier that has been used in automotive engines. MoDTC shows friction reduction effect by forming MoS_2 on the sliding surface. However, the relationship between friction properties and MoS_2 coverage on sliding surfaces has not been investigated.

In this study, commercial engine oil (SAE 0W-20) was used as lubricant. The degraded oils was prepared by NOx gas bubbling assuming a gasoline engine. The SRV tribotester was used to evaluate the friction properties of the degraded oils. Chemical state of sliding surface were analyzed by Raman spectroscopy. In addition, the surface morphology of the sliding surface was observed using AFM.

As a result of friction properties evaluate using SRV tribotester, friction coefficient of new oil and 8 hours degraded oil was 0.04 to 0.05. On the other hand, friction coefficient of the 16-hour and 24-hour degraded oil increased to 0.16. From these results, it is expected that additives in the oil have been degraded.

Fig.1 shows the results of AFM and Raman spectroscopy. These images were obtained by combining the surface topography from AFM and the MoS_2 distribution from Raman spectroscopy by binarization. In the sliding surfaces obtained from the 0- and 8-hour degraded oil, MoS_2 was found to be concentrated in the projecting parts. In the 0-hour and 8-hour degraded oils, MoDTC remains in the oil, meaning that MoDTC reacts to form MoS_2 at the sliding surface projecting parts.

Figure 2 shows MoS_2 area ratio of each sliding sufaces. Comparison of MoS_2 coverage between samples showed that over the entire measurement area, the coverage was 30% for sliding surfaces obtained from new oil(0-hour) and about 10% for 8-hour degraded oil. However, the friction coefficients of these two oils are almost the same. Therefore, we focused our analysis on the projecting part of the sliding surface and found that the coverage of MoS_2 in the two samples was 30-35%. On the other hand, the sliding surfaces obtained from 16- and 24-hour degraded oil had very low amounts of MoS_2, so the coverage was less than 1% even in the projecting parts.

Therefore, to obtain low friction under the conditions of this study, a MoS_2 coverage of 30% is required at the projecting parts of the sliding surface.

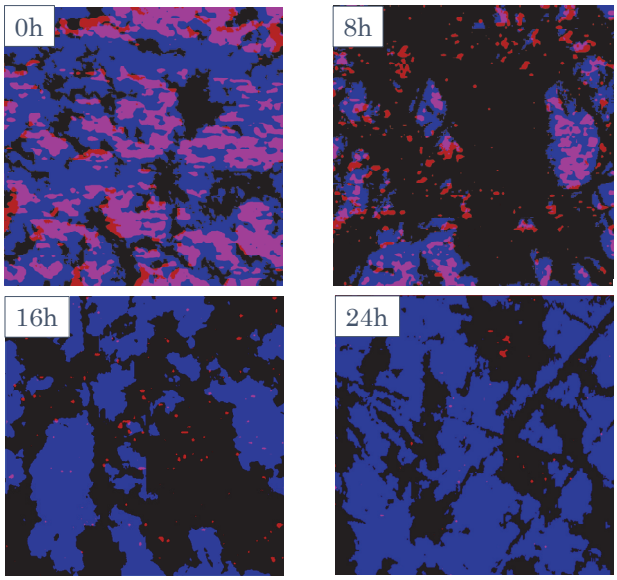

Fig.1 Combined images of AFM and Rman spectroscopy (Scan area:40x40μm)

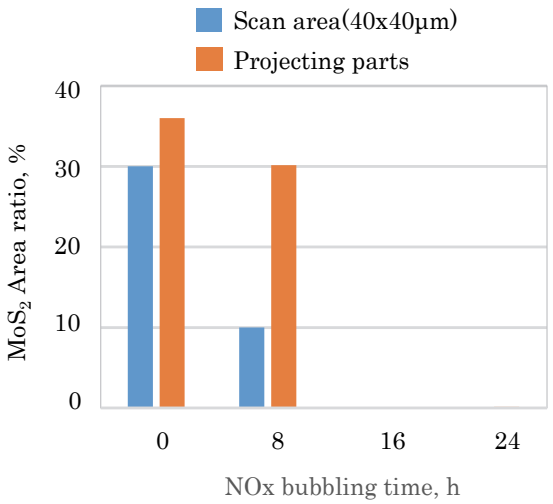

Fig.2 MoS_2 area ratio of each sliding surface