

In-situ observation of additive concentration and molecular interaction in EHL contact using micro-FTIR

K. Takiwatari¹, Y. Hoshi², H. Nanao², S. Mori^{2*}

¹) Department of Chemical Engineering, Ichinoseki National College of Technology, Takanashi, Hagisho, Ichinoseki-shi, Iwate, 021-8511, Japan.

²) Department of Chemistry and Bioengineering, Faculty of Engineering, Iwate University, 4-3-5, Ueda, Morioka-shi, Iwate, 020-8551, Japan.

*Corresponding author for mori@iwate-u.ac.jp

1. Introduction

Lubricant is a mixture of additives and base oils, and chemical composition is expected to be changed during lubrication process. Therefore, in situ observation of lubrication process has been applied.

In this study, we investigated the additive concentration under EHL condition by means of in-situ observation with Micro-Fourier transform infrared spectrometer (micro-FTIR)¹⁻³. The effect of a hydrostatic pressure and lubricating parameters was also discussed using diamond-anvil cell (DAC).

2. Experiment

Poly- α -olefin (PAO) and polyphenyl ether (5P4E), polybutylene glycol (PBG), polypropylene glycol (PPG) were used as a base oil, and oleic acid (OA) and methyl oleate (OM) were dissolved in each base oil at a concentration of 10wt%, respectively.

In order to obtain IR spectra of oil film in EHL contact, in-situ observation with micro-FTIR was employed. The experimental apparatus consists of micro-FTIR and ball on disk-type lubrication-tester. Hertzian contact is formed by point contact between a steel ball and IR transparent disk made of calcium fluoride. In addition, IR spectra of oils were measured on the pressure range from 0.1MPa to 4GPa and temperature up to 200°C using DAC with a thermal cell.

3. Results and discussion

The concentration of the additive was estimated from IR spectra measured by in-situ observation. It was found that the concentration was depended on the base oil. In the case of OA in PAO (OA/PAO) and OM in PAO (OM/PAO) and PBG (OM/PBG), PPG (OM/PPG), the additive concentration in EHL contact decreased (Fig. 1). On the other hand, it did not change in the case of OA in PBG (OA/PBG) and PPG (OA/PPG), and 5P4E used as base oil (OA/5P4E, OM/5P4E). The results indicate that OA and OM were not introduced into the Hertzian contact region because of weak interaction with base oil, which was confirmed from IR spectra. The IR peak of C=O stretching mode of OA in PAO indicated to be a dimer and was shifted to lower wavenumber at the Hertzian contact region. This result reveals that stabilization of the hydrogen bonding of the dimer under high pressure.

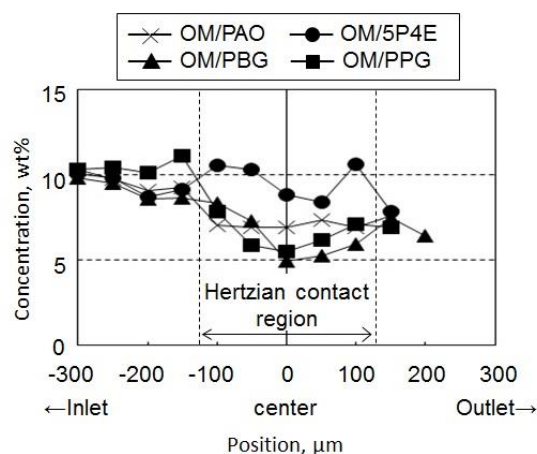


Fig.1 Concentration of methyl oleate in EHL contact (Load: 10N, SRR: 0, Entrainment speed: 0.13m/s)

4. Summary

The concentration and molecular interaction of oleic acid and methyl oleate in various base oils was investigated. The following summaries can be drawn.

1. The additive concentration in EHL contact was dependent on the base oils. These results imply that molecular interaction affect the additive concentration.
2. The behavior of molecular interaction in EHL contact was affected by the structure of molecular interaction and dynamic condition.

5. References

- [1] Sato, S., Takiwatari, K., Daming, D., Komoriya, T., Nanao, H. and Mori, S., "In-situ observation of EHL film with urea grease by micro FT-IR spectroscopy," Proc. Int. Tribol. Conf., Hiroshima 2011, 2011, B2-09.
- [2] Takahashi, M., Takiwatari, K., Nanao, H., Shimotomai, N. and Mori, S., "In-situ observation of EHL film formed from O/W emulsion by micro FT-IR spectroscopy," Proc. Int. Tribol. Conf., Hiroshima 2011, 2011, P10-02.
- [3] Hoshi, Y., Shimotomai, N., Sato, M. and Mori, S., "Change of concentration of additives under EHL condition", J. Jap. Soc. Tribol., 44, 9, 1999, 736-743.(in Japanese)