Tribological Properties of Nanodiamond-Dispersed Lubricants

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Nanodiamonds (NDs) were added in lubricants and their tribological properties were investigated using Mini Traction Machine. NDs were modified with carboxylic acid derivatives and well-dispersed in ester oil. Ester oil with NDs showed lower friction coefficient at the boundary lubrication regime compared with base oil. Furthermore, once slid with ND-dispersed oil, low friction was kept when the same specimens were slid with the base oil, indicating that NDs changed the surface properties of the test specimens. Surface analyses showed that carbon layer existed on the surface. It was indicated that low friction coefficients were achieved by ND-derived film.

Keywords (from 3 to 5 max): nano particle, diamond, dispersion, ester, friction

1. Introduction

Nanoparticles attract much attention as novel lubricant additives these days, and their several tribological effects have been reported [1]. However, it is important to improve dispersion stability for applying nanoparticles to lubricating oils. In this study, nanodiamonds (NDs) were modified with organic compounds to stably disperse in lubricating oils [2], and the tribological behaviours of oils with organo-modified NDs were investigated.

2. Experimental

Ester oil (VG3) was used as base oil. NDs modified with carboxylic acid derivatives were added in ester oil so that the concentration was 0.01 mass%. Mini Traction Machine was used to investigate the tribological properties of ND-dispersed oils. Stribeck charts were obtained after running-in process. (load: 20N, temperature: 100 °C, slide roll ratio: 100%)

3. Results and Discussion

NDs modified with carboxylic acid derivatives were dispersed well in the ester oil for more than a week after stirring, while NDs without modification added in the ester oil settled soon after stirring.
Stribeck charts of the ester oil without and with NDs are shown in Figure 1. Compared with the ester oil without NDs, the ester oil with NDs modified with carboxylic acid derivatives tended to decrease friction coefficient at the boundary lubrication regime. To clarify the mechanism of lowered friction coefficient, the same test was carried out with the ester oil itself using the test specimen previously slid with the ND-dispersed oil. As the result, friction coefficient still stayed low, suggesting that NDs changed the surface properties.
The surfaces of the specimens were analysed by X-ray photoelectron spectroscopy (XPS). Compared with the specimen slid with ester oil, carbon double bonds and a thicker carbon layer were detected in the case of the specimen slid with ND-dispersed oil, indicating the existence of ND-derived films including sp2 carbon (Figure 2). Based on these chemical analyses of the sliding surfaces, we suggest that the tribological properties of ND-dispersed oil is achieved by the protective film derived from NDs.

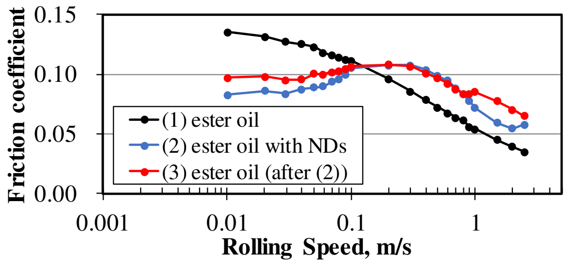

Figure 1: Stribeck charts of the oils

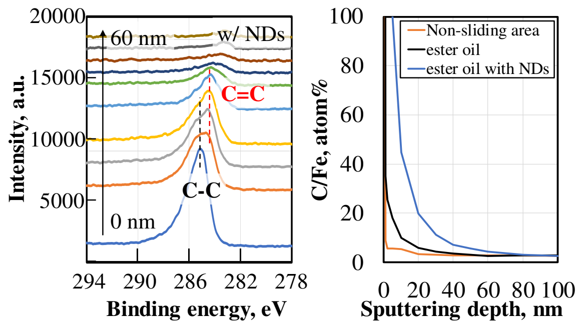

Figure 2: XPS depth profiles of the specimens

4. Acknowledgements

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5. References

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