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B K-edge XANES analysis of tribofilms formed on metal surfaces by CVTF containing boron additive

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1 Introduction

Belt-drive continuously variable transmissions (CVTs) have attracted attention because they enable greater fuel efficiency than conventional automatic transmissions (ATs). Belt-drive CVT fluids (belt-drive CVTFs) must have not only the same physical properties as ATs, such as low temperature fluidity and high oxidation stability, but also ensure a high coefficient of friction between the belt and pulleys in the transmission system to convey forces efficiently [1]. In a previous study, it was found that adding boron additives to CVTFs increased their friction coefficients. However, the mechanism of this increase has not been sufficiently clarified. What is understood is that the additives in CVTFs react with metal surfaces to form tribofilms that directly affect the friction coefficient.

In this paper, we discuss the relationship between the chemistry of the boron species in the tribofilms and the friction coefficient when boron additives are added to CVTFs.

2 Experiment

A block-on-ring friction tester [2] was used to prepare tribofilms and measure the friction coefficients of four test fluids. The test fluids were prepared by adding different boron additives to the same base oil. The friction coefficients of the test fluids are shown in Fig. 1. The tribofilms were then subjected to XANES measurement.

B K-edge XANES measurements were carried out at BL-7A. The samples were placed under vacuum and the spectra were collected in the fluorescence yield mode.

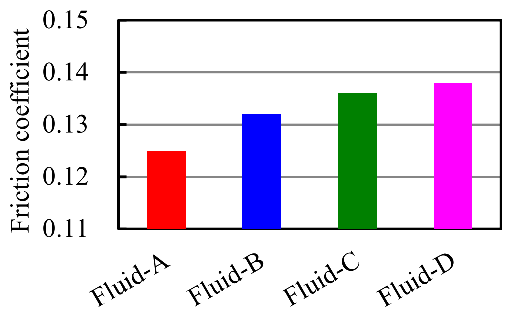

Fig. 1: Friction coefficients of test fluids.

3 Results and Discussion

Figure 2 show the B K-edge XANES spectra of the tribofilms obtained with the four test fluids. A sharp main peak was observed at around 194 eV and two broad peaks were also observed at around 198 eV and 203 eV in the XANES spectra of all tribofilms. The spectra were normalized to the sharp main peak at around 194 eV. The sharp peak at around 194 eV and the broad peak at around 203 eV indicate the presence of boron species with trigonal planar geometry, while the broad peak at around 198 eV is associated with a tetrahedral geometry. [3]. The spectra indicate that all tribofilms contain boron species with both trigonal and tetrahedral geometries.

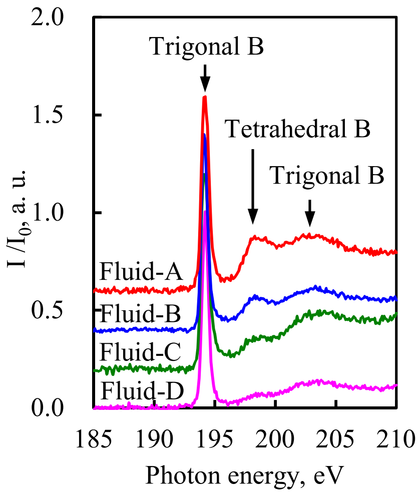

Fig. 2: B K-edge XANES spectra of the tribofilms

The heights of the tetrahedral boron peaks varied significantly among the test fluids. We thus focused on the tetrahedral boron peak at around 198 eV in order to elucidate the chemistry of the boron species in the tribofilms. The height of the tetrahedral boron peak was taken to be a measure of the proportion of boron species with a tetrahedral geometry in the tribofilm.

The relationship between the friction coefficient and the height of the tetrahedral boron peak for four different tribofilms is shown in Fig. 3. Figure 3 shows that the height of the tetrahedral boron peak decreased as the friction coefficient of the tribofilm increased.

This suggests that tribofilms with higher friction coefficients have a lower concentration of tetrahedral boron species, or a higher concentration of trigonal boron species.

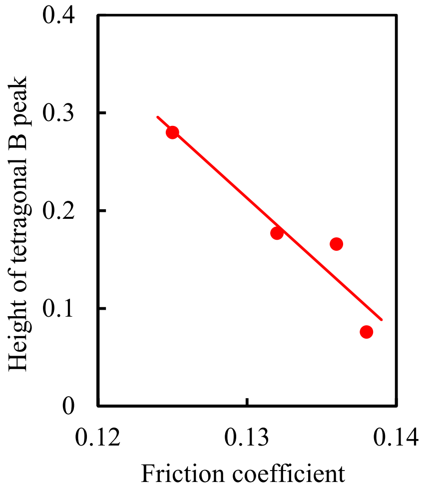

Fig. 3: Relationship between the friction coefficient and the height of tetrahedral B peak in the B K-edge XANES of tribofilms

References
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