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Structural Analysis of Traction Oil under Static High Pressure

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Introduction

The microscopic structure of lubricants has received much attention recently because of its great influence on the tribological properties of the sliding surface under lubrication conditions. As is well known, the structure of a conventional lubricating oil transforms into a quasi-solid structure under high pressure, as occurs in continuously variable transmission mechanics, for example. Past studies have focused mainly on the macro-characteristics of lubricants under high pressure, such as their viscosity and bulk modulus. Nevertheless, some studies have revealed that the tribological properties largely depend on the molecular structure of the oil. Several simulation studies using molecular dynamics techniques have investigated the molecular structure of lubricating oil under high pressure. Such studies indicate the obvious growing attention being paid to the microscopic behavior of lubricating oils.

X-ray diffraction (XRD) is traditionally used for obtaining information about the microscopic structure of materials, even amorphous and liquid ones. We have now used XRD to analyze the structure of lubricating oils, focusing especially on their microscopic behavior under static high pressure generated by a cubic multi-anvil press.

Sample Oil

We used a pure base oil DM2H of the traction oil TDF32 (produced by Idemitsu Kosan, Co., Ltd.) as a sample oil for the analysis.

The sample cell configuration is shown in Figure 1. We used a NaCl plate for the pressure calibration.

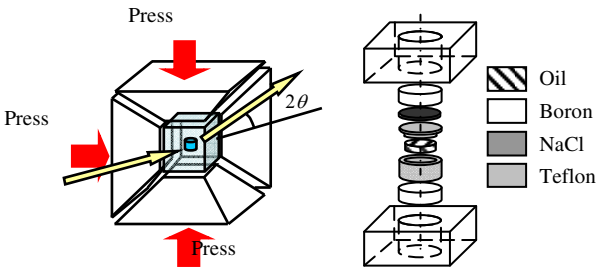

Fig. 1 Cubic multi-anvil apparatus and sample cell

Experimental Procedure and Results

We used synchrotron radiation X-rays to analyze the structure because they have high brightness and a wide energy range. In addition, using them enabled us to quickly obtain accurate intensity profiles compared to using X-rays in common laboratories. In particular, we investigated the microscopic structure of the traction oil at atmospheric pressure and their microscopic behavior under high pressure. A X-ray diffractometer with a cubic multi-anvil press 'MAX80' at NE-5C in PF-AR was used for the analysis.

The obtained intensity profiles at $2\theta = 5°$ are shown in Figure 2. The profiles have no sharp peaks, meaning that the intensity profiles came from the oil. We can see that the atomic distance became shorter with increasing in the pressure from the peak shift around E = 25-30 keV. The change in the pair distribution functions with the increase in pressure is shown in Figure 3.

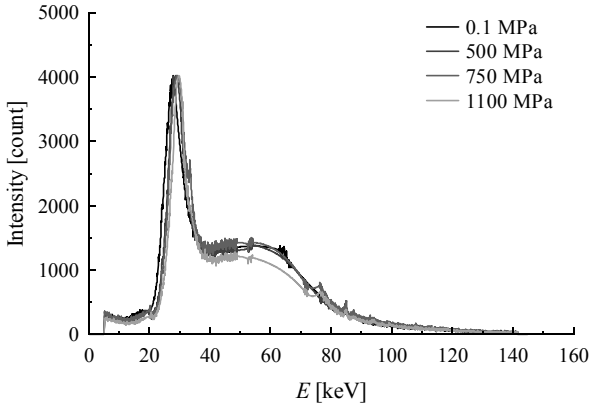

Fig. 2 Scattering intensity profiles at $2\theta = 5°$

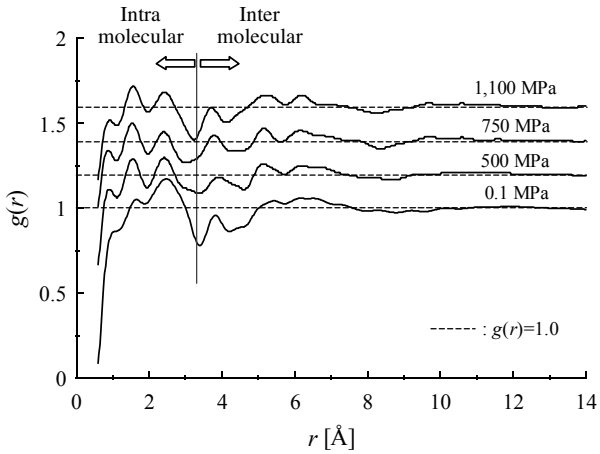

Fig. 3 Pair distribution functions with increase in pressure

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