Direct Observation of Pressure-induced Phase Transition Behavior of Lubricants and Their Lubrication Properties

Tomoaki Okano[1)*] and Nobuhide Tanino[1)]

[1)] Lubricant Research Laboratory, Idemitsu Kosan Co., Ltd., Japan.
*Corresponding author: tomoaki.okano.1000@idemitsu.com

The lubrication behavior and mechanism of lubricants under high-pressure condition are not yet well understood, the examples of such lubricants include Traction Drive Fluid(TDF), Metal Working Fluid(MWF) and more. It is well known that these properties are related with phase transition properties of lubricants but their process has not been clarified. In this study, we tried to clarify the process of phase transition behaviors of lubricants under high-pressure conditions and their lubricating properties. As a result, we have succeeded in the direct observation of phase transition behavior and clarified the difference of lubrication properties between glass phase transition and crystal phase transition.

Keywords: Lubricants, Phase Transition Behavior, High-Pressure, Direct Observation

1. Introduction

The consensus on lubrication under high-pressure conditions is that it is caused by fluid lubrication and the effect of additives like oiliness improvers and extreme-pressure agents. However, under high-pressure conditions such as Hertz contact caused by gears, bearings, and press processing like rolling rolls, phase transition behavior of lubricants from liquid to glass or crystal state may occur. This study aims to clarify the processes of phase transition behavior of lubricants under high-pressure conditions and the difference between types of phase transition behaviors.

2. Methods

2.1. Materials

We evaluated four types of chemicals, shown in Figure 1. DM2H is the base oil for TDF, while the rest are ester and alcohol compounds that are general additives for MWF. All additives except for DM2H are reagent grade. Esters and alcohols were dissolved into paraffinic base oil at the appropriate concentrations as oiliness agent.

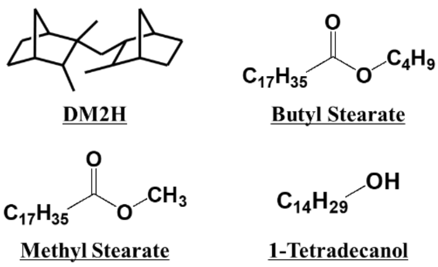

Figure 1: Chemical structure of samples.

2.2. Direct observation under high-pressure conditions.

We used improved High-pressure viscometer that was described previously [1]. All samples were tested under 30 °C (±2°C).

2.3. Evaluation of lubrication properties.

We used Mini Traction Machine (MTM) toevaluate lubricating properties using traction coefficient as index.

3. Results and discussions

3.1. Direct observation of phase transition behaviors.

Figure 2 shows the appearance of each lubricants in its respective transition pressures. Phase transition behavior was not observed for DM2H. On the other hand, the polar chemicals show crystallization under certain pressures. From these results, we have succeeded in the direct observation of pressure-induced phase transition behavior and we found that glass transition behavior like DM2H cannot be observed directly by optical microscope due to its amorphous state.

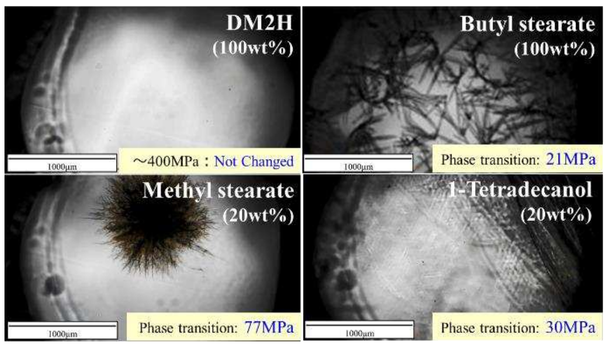

Figure 2: Appearance of phase transition behavior of each samples under pressures as indicated.
(Dilution samples are diluted with paraffinic base oil)

3.2. Lubrication properties of samples.

Table 1 shows the maximum traction coefficient (μ_{max}) of samples. From this result, glass phase transition like DM2H shows a higher value and crystal phase transition like butyl stearate shows a lower value.

Table 1: Maximum traction coefficient (μ_{max}) of samples

	DM2H	Butyl stearate
μ_{max} [-]	0.119	0.028

4. References

[1] N. Tanino. et al., “The influence of the phase transition of lubricants on press working,” 6th Asia International Conference on Tribology, 2018, 198-199.