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Tribological behaviour of diblock Polymer Friction Modifier (PFM) under boundary lubrication regime in steel/steel contact

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The friction behavior of a diblock PIB-PEG PFM blended to PAO 4 base oil in steel/steel contact is investigated under severe lubrication conditions. Whatever the three tribometers used (MTM, Reciprocating and Rotative Ball-on-Flat tribometers), this PFM achieves a very low friction coefficient (μ ~ 0.040) only at 100°C. Better solubility of the polymer at higher temperature seems to be the key of this performance. Furthermore, physicochemical characterizations inside and outside of wear tracks by ToF-SIMS and AFM technics provide information on PFM organization on steel surface, that better highlight the action mechanism of the PFM inside the contact.

Keywords (from 3 to 5 max): tribology, boundary lubrication, PFM, physicochemical characterizations.

1. Introduction

Polymer Friction Modifier (PFM) are interesting alternatives to classical lubricant friction modifiers like Molybdenum Dithiocarbamates (MoDTC) as they are more relevant to current ecological issues. Their tribological performance remains to be clearly demonstrated and understood. Indeed, it has been reported in literature for PFM an excellent tribological behavior on MTM Tribometer tests whereas those performed on reciprocating tribometers are rare and lead to variable friction behaviors [1-2]. This work aims to investigate the friction reduction capabilities of a PIB-PEG copolymer blended to PAO 4 base oil in steel/steel contacts working under severe lubrication conditions and to clarify the action mechanism of the PFM in the contact.

2. Methods

A PFM (PIB-PEG copolymer) is blended into PAO 4 base oil in order to carry out tribological tests.

2.1. Tribological tests

The friction behavior of the PFM has been tested on three different tribometers: MTM, Reciprocating and Rotative Ball-on-Flat tribometers under severe test conditions. The standard friction test condition is 100°C, 1 GPa and 0.003m/s.

2.2. Physicochemical characterizations

After friction tests, ToF-SIMS and AFM analysis are performed inside and outside of wear tracks. Analyzed samples were chosen from those that achieved the low friction.

2.3. Results

Various friction coefficients are collected from tribological tests using these three tribometers mentioned above. ToF-SIMS profiling and AFM imaging inside and outside of wear tracks provide information on PFM organization on steel surface.

3. Discussion

Some tribological conditions lead to low friction coefficient (μ around 0.040) and others not (see fig 1). These low friction coefficients are observed on tests performed only at 100°C. We notice that temperature is the main parameter which is involved in the low friction achievement. Indeed, thanks to DLS experiments, it was shown that the solubility of the polymer is increased at high temperature (100°C in this case). Furthermore the various tribological conditions allows to conclude on the conditions necessary to obtain reproducible low friction. ToF-SIMS and AFM characterization show that molecules are always adsorbed on the surface when the low friction is achieved. Moreover, they reveal the PFM organization on the surface especially how the polymer is bonded to the steel surface.

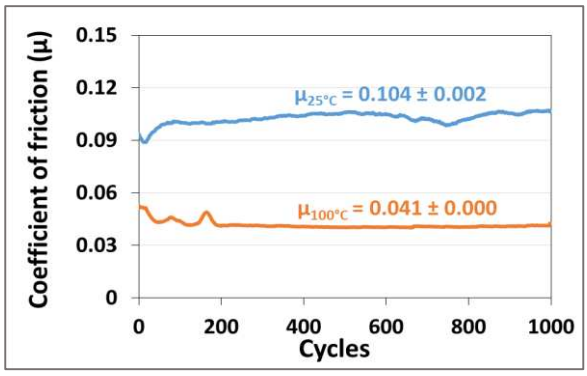

Figure 1: Friction curves of PAO 4 + PFM at 25°C (in blue) and 100°C (in orange). Tests are carry out on reciprocating tribometer (1 GPa, 0.003m/s) and values of friction coefficient (μ) are averaged between 400 and 1000 cycles.

4. References

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