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EHL contact: *ex* and *in-situ* studies by Brillouin spectroscopy WTC 2021, Lyon

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A Brillouin Light Scattering approach method is used to predict the lubricant behavior under extreme condition of pressure and understand the process behind friction. First, an *ex-situ* study is performed to provide information about the pressure dependence of longitudinal modulus and sound velocities using Diamond Anvil Cell DAC system. The signature of the lubricant glass transition is found at pressures equivalent to those encountered in mechanical contacts. Then, a ball-disc tribometer is coupled with a Brillouin spectrometer to probe *in situ* the lubricant mechanical properties inside the contact and to highlight the influence of shear on the lubricant glass transition.

Keywords : tribology, spectroscopy, glass transition, friction plateau

1. Introduction

In industrial application, a wise use of lubricant is needed to optimize friction inside gears or ball bearing system. Extreme conditions of pressure, overcoming few GPa, and high shear stress are applied to the lubricant, which makes difficult any experimental characterization of the lubricant. Under such high pressures, we expect the lubricant to experience a phase transition, which is assumed in literature to originate the friction plateau. Yet, it has never been directly proven in a mechanical contact. We propose to compare the local lubricant physical properties by using Brillouin spectroscopy technique and compare to the macroscopic plateau from friction measurement in a tribometre. Considering two main parameters, pressure and shear in this system, we approach this study with experimental setup that allow to uncorrelated those parameters. The first part, done in a DAC, provides the pressure and temperature contribution to the glass transition in condition close to those found in a mechanical contact. The second by coupling a tribometre and the spectrometer to understand the contribution of the shear on the lubricant physical properties inside the confined contact.

2. Methods

Using a ball on disc tribometer, we are able to study the evolution of friction of a thin film (~ 100 nm) of model lubricants (benzyl benzoate and squalane denoted respectively BB and SQ) regarding the change of loads and different conditions of shear. Under high loads (pressure > 1 GPa), friction measured exhibits a plateau regime associated in literature to the lubricant Limiting Shear Stress (LSS) [1].

On the other side, the lubricant physical properties are probed by Brillouin spectroscopy (BLS). The position and the full width at half maximum (FWHM) evolution of the inelastic peaks on the spectra respectively reflect the elastic and viscous contributions of the lubricant behaviour respectively.

In the first step of this work, we perform BLS measurements on the lubricants at rest in a diamond anvil cell. Spectra are recorded over a wide range of pressures and three different temperatures. This set of data lead to characterize, among others, the glass transition of the lubricants. Furthermore, these data are compared to friction curves recorded at the same pressure and temperature range.

In a second part, we take into account the confinement and the shear experienced in a contact by coupling the spectrometer set up to the tribometer. Spectra and friction curves are recorded simultaneously.

Due to the dynamic nature of the friction tests, a Virtual Image Phase Array (VIPA) spectroscope based on a single pass etalon interferometer combine with Rayleigh suppressor will help to overcome experimental challenges of low signal output and follow the dynamic evolution of mechanical properties of the lubricant.

3. Discussion

The uncoupled set of data lead to make a strong correlation between the nominal glass transition of lubricants (at rest) and the onset of the friction plateau on macroscopic friction curves.

Furthermore, the BLS technique turns out to be a powerful tool to derive the lubricant visco-elastic properties by fitting the measured spectra with models from literature [2].

Coupling the BLS setup to the tribometer is still in progress. Measurements will soon be performed under the range of thermodynamic conditions already explored at rest. In a first step, measurements in pure rolling condition will enable to probe the effect of confinement on the lubricant behaviour. Then, the influence of shear will be studied in sliding conditions. These results will improve our understanding of the underling physical processes triggering the friction plateau.

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4. References

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