In-Situ Adsorption of Friction Modifier Additives: A Combined QCM-D and CLSM Study

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Understanding the adsorption mechanisms of friction modifier additives is a widely studied topic and of high interest for the development of future lubricants. Being able to observe the adsorption in-situ in the lubricant as function of temperature or tribological stressing is particularly helpful. For this reason we developed a combined quartz crystal microbalance with dissipation (QCM-D) and confocal laser scanning microscopy (CLSM) setup that allow to determine the adsorbed mass and visualize the additive molecules by fluorescence. Experiments using an organic friction modifier showed that the additive forms droplets that adsorb on the iron oxide surface.

Keywords (from 3 to 5 max): Friction modifier, In-situ, QCM-D, UHV microtribometer.

1. Introduction

It is known that different types of surface-affine additives (i.e. antiwear/anti-corrosion/ anti-friction) can have very different adsorption behaviour on surfaces (e.g. [1,2]). This is why the investigation of additive adsorption is an ongoing research topic of high interest. QCM-D, providing information about the mass and the conformational changes of adsorbed material, has been shown to be a useful tool to study the formation of the adsorption of additives. While the measurement of the adsorbed mass is relatively straightforward, the determination of the film thickness and structure relies on various simple or complex models to fit the QCM-D data [3]. Therefore, especially in the biosciences, several approaches have been tested to combine QCM-D with other techniques such as AFM or optical methods [3]. In our study, we have adapted these approaches to the study of additives and we present an *in-situ* study of the adsorption of selected additives. The found adsorption results are also compared to tribo-experiments in order to answer the question whether synergistic effects in adsorption also lead to synergistic effects in wear reduction.

2. Methods

We designed a novel QCM-D experiment and combined the QCM-D technique with fluorescent imaging of the additive adsorption using a 3D confocal laser scanning microscope (CLSM) see figure 1. For this reason a QCM quartz crystal was mounted in a flow cell. The crystal was coated with an Fe_2O_3 film in order to mimic a technical surface. The lubricant is heated and pumped into the cell using a peristaltic pump. The friction modifier that was used, fluoresces without extra labelling of the molecules and therefore here these experiments are restricted to the adsorption of a single additive.
Additionally, we performed friction studies using gas phase adsorption of the pure additive using a home-built UHV vacuum microtribometer.

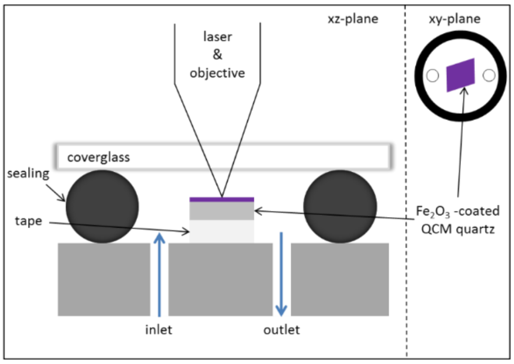

Figure 1: Schematic of the combined QCM-D and CLSM setup.

3. Results and discussion

In the present experiments, the adsorbed mass of the friction modifier is very low and suggests that the film formed on the surface is less than a full monolayer. Using CLSM images, we find that the friction modifier forms droplets in the oil, which adsorb and coalesce on the surface. The calculated mass of the adsorbed droplet correlates reasonably well with mass found by QCM-D.
Also, the deposition of the pure additive in the UHV chamber shows the formation of droplets on pure iron surfaces that grow with the deposition time and lead to a friction reduction. Future experiments under tribological stressing will discussed in the outlook of the talk.

4. References

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