In-situ studies of the competitive adsorption of lubricant additives

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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. [1–3]). The interactions can be synergistic or antagonistic in character and influences the near-surface chemistry of the sliding surfaces and therefore also the tribological performance of the system. For wear protection additives, it is for instance known that phosphor and sulfur containing layers are formed under tribological conditions (e.g. [4,5]). In this presentation we will give an overview on an ongoing study of the adsorption of selected additives using novel in-situ approaches. The found correlations are also compared to tribological experiments in order to answer the question whether synergistic effects in adsorption also lead to synergistic effects in wear reduction.

2. Results

In an initial study, ZDTP and DTP were tested in combination with two different friction modifiers, a GMO and an organic friction modifier (OFM). As base oils mineral oil and PAO were used.
The adsorption behavior was studied via quartz crystal microbalance with dissipation (QCM-D) using Fe_2O_3 coated quartz crystals. The technique gives information on the amount of adsorbed additive (mass) as well as on the rigidity of the adsorbed layer (dissipation). The wear performance was tested in a ball-on-three disk tribometer. White light interferometry (WLI) was used to determine the wear volume and XPS depth profiles of the tribofilms were acquired on selected systems. From the correlation of QCM-D and wear data we are able to conclude that initially adsorbed films that are viscoelastic lead to a third body formation during a tribo experiment which is more pronounced and thereby wear can be reduced (Figure 1). However, the results cannot provide information on the morphology of these films. Therefore, in a subsequent experiment we combined the QCM-D technique with fluorescent imaging of the additive adsorption using a 3D confocal laser scanning microscope (CLSM).

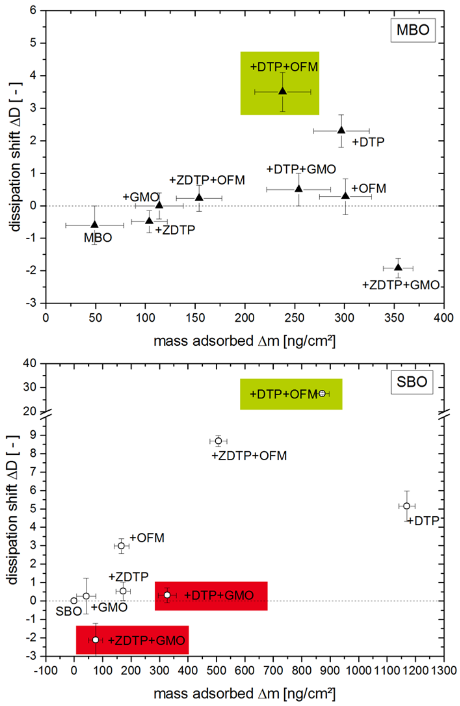

Fig. 1. Disssipation and adsorbed masses for two base oils. The green boxes indicate a synergistic effect in terms of wear; the red box indicates an antagonistic effect. The error bars are the standard deviation for three measurements.

Presently, these experiments are restricted to the adsorption of a single additive (i.e. a friction modifier). Surprisingly, we find that the friction modifier forms droplets in the oil which adsorb on the surface and there do not form a closed film. The calculated mass of the adsorbed droplet correlates reasonably well with mass found by QCM-D.

References

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