Neutron reflectometry of adsorbed additive layers on (a-C) DLC

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1. Introduction

Diamond-like carbon (DLC) coatings have proven to be very promissing in protecting the contact surfaces of mechanical systems due to their low friction, low wear and anti-adhesion properties. It is known that most carbon films are chemically very stable and, therefore, generally inert towards external species under static conditions. However, under dynamic sliding conditions, DLC surfaces may interact with counter faces and with the hydrogen or water molecules in their surroundings [1]. Tribochemical reactions of DLC surfaces were also confirmed in cases with relatively complex additives, like ZDDP and MoDTC [2]. On the other hand, only a few studies on the adsorption of simple polar organic molecules, such as alcohols, exist on DLC [3]. Since the adsorption of polar groups is one of the fundamental boundary-lubrication mechanisms that affect both the friction and wear on steel surfaces, we aimed to find out whether such molecules form adsorbed layers also on the DLC surfaces.

2. Experimental

We used neutron reflectometry to study the adsorbed additive layers on DLC, as this technique has been used successfully on metal surfaces [4]. Samples were silicon blocks, which were coated with a 40 nm thick a-C coating. The experiments with each block were performed in three steps; (1) a neutron reflectivity profile was obtained from the sample surface in air, (2) a reflectivity profile was obtained in base oil, and (3) a reflectivity profile was obtained in base oil mixed with 20 mmol/l of deuterated hexadecanol. The use of the deuterated additive was necessary to differentiate the neutron scattering length densities of the additive and PAO oil, which enabled the observation of adsorbed layers. The fitting of the data was performed using a Parratt theory.

3. Results

Fig.1 presents the reflectivity profiles obtained for the a-C coating during each step. The thickness of the coating was calculated from the fitting of the data of the first step, and was determined to be 40.5 nm. In the second step, when the coating was exposed to pure PAO oil, no shift of the reflectivity profile was observed, as expected. In the third step, when PAO with deuterated hexadecanol was used, the shift of fringes was observed. Fitting of the data revealed that a 0.4 nm thick layer of adsorbed additive was formed on the surface. The density of the layer was calculated to be more than 90 % of the density of the bulk hexadecanol.

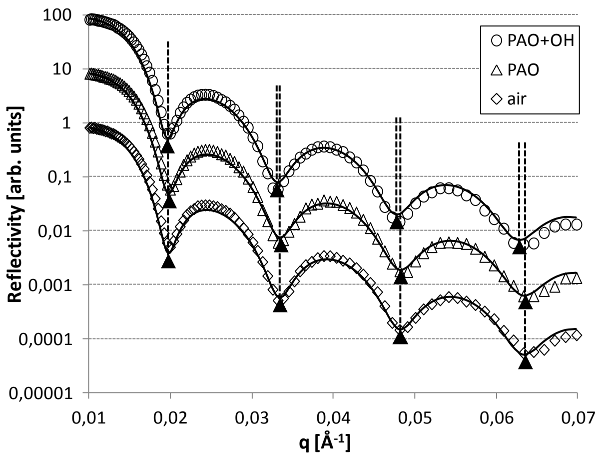

Fig.1 Neutron reflectometry profiles for a-C coating. Fitting of the data revealed a 0.4 nm thick layer of adsorbed hexadecanol (OH) molecules.

4. Conclusions

In this work neutron reflectometry was successfully used to study the adsorption of alcohol molecules on the DLC coating. The results revealed that hexadecanol adsorbs onto the surface of the a-C coating and forms a dense (90 %) 0.4 nm thick layer on it. This implies that alcohols can serve as potential boundary lubrication agents in the tribological DLC contacts.

5. References

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