NEUTRON REFLECTION CHARACTERISATION OF IONIC LIQUID ADDITIVE ADSORPTION AT STEEL/WATER INTERFACE FOR WATER-BASED LUBRICATION

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KEYWORDS
Lubricant additives; NanoTribology; Hydrodynamic Lubrication, Neutron Reflection

ABSTRACT
As a kind of novel and promising high-performance lubrication, water-based lubricants have the advantages including high thermal conductivity, good cooling performance, low price and particularly low tendency to pollute. However, poor dispersion and dissolution stability, low reactivity and high corrosiveness inhibit the widespread usage of the water-based lubricants. To resolve these problems, ionic liquids (ILs) have been developed as a new additive with good friction-reducing and antiwear properties [1]. As reported by open literatures, the tribological properties of the ionic liquids is strongly related to the nanostructure of their adsorbed layer [2]. However, how the nanostructures determine the tribological properties of the ionic liquids remains inconclusive. In this work, we have established neutron reflection method to characterize the obtain the nano-structural features of adsorbed layers of several novel ionic liquid additives at the stainless-steel/water interface. Compared to traditional additives, the novel ionic liquid additives adopted a much thicker adsorbed layer, which prompted their lubrication performance under high pressure.

The critical micellization concentrations (CMCs) for the four additives were determined by surface tension measurements as shown by Figure 1AB. Apart from OGT, the CMC values for DEHP, LGT and LGAT are found to be 10 mM. The decreased contact angle measurement manifests that adsorption of DEHP onto the stainless steel, indicating the formation of a protective film on the surface (Figure 1C).

The inner and finer structure of adsorbed DEHP on the stainless steel was studied by Neutron reflection (NR) using a stainless steel coated silicon block. As shown by Figure 1DE, the silicon block is firstly covered by 28±1 Å SiO_2 and then 176±1 Å stainless steel. A layer of porous iron oxide (Fe_3O_4) with a thickness of 21±1 Å is formed on the steel surface. The head groups of DEHP can adsorb onto the Fe_3O_4 layer and occupy around 26% volume. The absorbed DEHP is composed of one dense layer and one thicker but looser layer, with a solvent volume fraction of 68±4% and 33±4%, respectively. Figure 1F illustrates the layer thickness and scattering length density (SLD).

Our results clearly indicate the feasibility and unique advantage of NR in determining the structures of the adsorbed lubricant additives onto stainless steel surface at atomic scale. Compared to traditional additives, the adsorbed layers of our designed novel ionic liquid additives are a much thicker, which benefit for their lubrication performance under high pressure conditions.

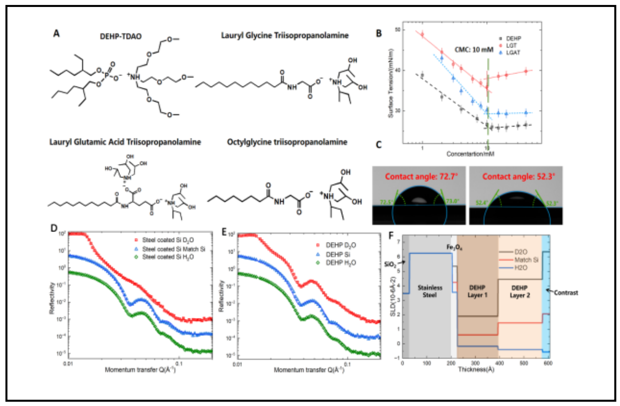

Fig.1 (A) Molecular structures of four designed ILs additives (B) Surface tension measurements of four designed ILs. n its (C) The contact angles of pure water (left) and the 2 mM DEHP (right) on the stainless steel. (D) The neutron reflection profiles of the stainless steel coated silicon block and (E) with 2 mM DEHP absorbed on the surface. (F) The scattering length densities (SLDs) of different layers.

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