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Oleic acid/[EMIM] oleate as additives to [EMIM] $EtSO_4$ for the lubrication of a Si_3N_4 tribopair

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The aim of this investigation is to determine the lubrication mechanism of 1-ethyl-3-methyl imidazolium ethyl sulfate, [EMIM] $EtSO_4$ + 2 wt % of an equimolar ratio of oleic acid and [EMIM] oleate for the sliding of a Si_3N_4 tribopair. The results of the friction measurements are here presented together with small-area X-ray photoelectron spectroscopy (XPS) results. The tribological data combined with the XPS investigations allowed the growth of a tribofilm to be demonstrated in the presence of the blend.

Keywords: tribology, ionic liquids, additives, Si_3N_4, surface chemistry.

1. Introduction

Ionic liquids (ILs) have been extensively investigated in tribological studies as lubricants. The interaction between ILs and the sliding surface is suggested to be due to the formation of a stratified layer at the solid-liquid interface [1,2], which considerably reduces the coefficient of friction (CoF). In the present work [EMIM] $EtSO_4$ is used to lubricate a Si_3N_4 tribopair. The ceramic Si_3N_4 was selected for its tribological properties, such as high abrasive wear resistance. For this reason, it is widely used as an abrasive, for mechanical seals and various types of bearings.

2. Materials and Methods

The IL [EMIM] $EtSO_4$ was supplied by Sigma Aldrich, Darmstadt, Germany; the Si_3N_4 tribopairs were from Toshiba, Japan. An equimolar mixture of oleic acid and [EMIM] oleate (University of Pisa, UniPi, Italy) was blended with [EMIM] $EtSO_4$ to form a lubricant containing a total of 2 wt % additive. All pin-on-disc experiments were performed on a Bruker UMT-2 tribometer using mechanically polished tribopairs of Si_3N_4 at a relative humidity (RH) of 40-55% and at ambient temperature (25°C). In these conditions the water uptake (measured by weighting) was 7.9 (0.5) % for IL and 9.8 (0.8) % for the blend. The running in was carried out in water under an applied load of 4.5 N. The Stribeck curves were repeated one after the other in the same track. In order to investigate the transition from hydrodynamic- to mixed- and boundary lubrication regimes, ramp tests were performed, consisting of a sequence of steps in which the speed was gradually decreased from 200 mm/s to 0.1 mm/s. Small-area X-ray photoelectron spectra (XPS) were obtained on the Si_3N_4 disks following the mechanical polishing and on both counterparts after the mechanical tests.

3. Results

The presence of the additive results in a decrease of the CoF values from about 0.3 to 0.03 at low speeds, i.e. influencing the boundary lubrication behavior (Figure 1).

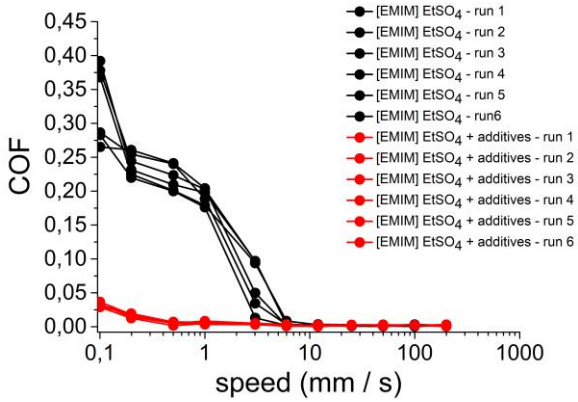

Figure 1: Stribeck curves of [EMIM]$EtSO_4$ and the additivated lubricant. Ramp test: decreasing sliding speed from 200 mm/s to 0.1 mm/s. Normal load 4.5 N. radius 8 mm.

XPS results did not show film formation on the surface of the tribopair analyzed after the Stribeck test in the presence of [EMIM] $EtSO_4$. In the presence of the blend a different shape of C1s and Si 2p signals comparing contact area and non-contact area was observed.

4. Discussion

The low CoF and the XPS results obtained with the [EMIM] $EtSO_4$ + 2 wt % of equimolar ratio of oleic acid / [EMIM] oleate blend suggest the formation of a tribofilm. In humid air and in the presence of the IL the mechanism is likely a smoothing of asperities.

5. References

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