

## HIGH RESOLUTION CHARACTERIZATION OF ZDDP TRIBOFILM ON CYLINDRICAL ROLLER BEARING BY X-RAY PHOTOELECTRON SPECTROSCOPY AND ATOM PROBE TOMOGRAPHY

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### KEYWORDS

*Lubricant additives; Tribofilms and 3rd bodies; Boundary lubrication; Atom Probe Tomography*

### ABSTRACT

For the purpose of decreasing wear and friction, zinc dialkyldithiophosphate (ZDDP) has been used in engine oil for several decades. In this study, ISO VG 100 mineral oil mixed with ZDDP was used in sliding tests on cylindrical roller bearings. Tribofilm formation could be observed after 2 hours sliding tests with normal load of 80 kN, working temperature of 80°C, and rotational speed of 20 rpm. X-ray photoelectron spectroscopy (XPS) and atom probe tomography (APT) were used for chemical analysis of the tribofilm. The results show that the ZDDP tribofilm consists of the common ZDDP elements along with iron oxides. Considerable amount of zinc and a small amount of sulfur were observed. In particular, an oxide interlayer with sulfur enrichment was found between the tribofilm and the steel substrate, which was characterized explicitly at the atomic scale by APT. The depth profile of the chemical composition was obtained and a tribofilm of approximately 40 nm thickness was identified by XPS. Finally,

the finding of sulfur enrichment supports the predictions according to the Hard and Soft Acids and Bases (HSAB) principle.

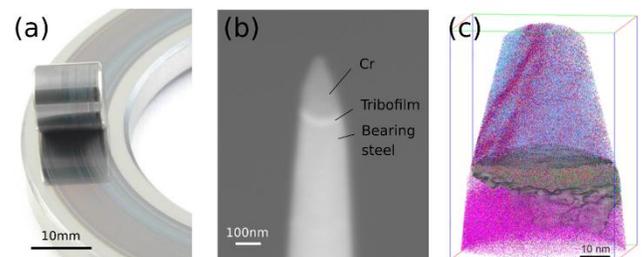


Fig.1 Overview of the atom probe sample preparation. (a) the wear track on the surface of a bearing ring, and (b) the shaped tip sample of the tribofilm for APT analysis; (c) the 3-D reconstruction of APT analysis.