44th Leeds-Lyon Symposium on Tribology - September 4-6, 2017, Lyon, France

LOCAL OCCUPANCY OF VISCOELASTIC INTERFACES: A NEW RHEOLOGICAL PERSPECTIVE ON ANTIWEAR TRIBOFILMS

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KEYWORDS
Viscoelasticity; Rheology; Tribochemistry

ABSTRACT
The ultra-thin tribofilms generated from zinc dialkyldithiophosphate (ZDDP) and ashless dialkyldithiophosphate (DDP) have long been considered as rigid interfaces that act as a mechanical barrier [1], which helps protect the metal surface from severe wear. Although some studies suggested that these tribofilms can also behave as a viscous polymer [2] or a molten glass [3], no evidence was provided to confirm these proposed antiwear mechanisms. Using the Atomic Force Microscope (AFM), this study shows for the first time that ZDDP and DDP tribofilms work as viscoelastic interfaces, which under shear can flow and spread through the contact area. This can be easily observed in Fig. 1, which shows the structure evolution of a mature ZDDP tribofilm after sheared at different contact pressures. The results show that the tribofilm coverage changes as a function of time and contact pressure. The coverage evolves from an area of 5 um x 5 um under 2.1 GPa to an area about 7 um x 7 um under 4.5 GPa.

The remarkable rheological properties of the antiwear tribofilms of ZDDP and DDP have great implications in our understanding on how they provide their antiwear protection. Our initial results suggest that the rheological properties of these tribofilms enable them to maintain local order on the nanoscale through the motion, rearrangement and local reconfiguration of single and multiple patches at the interface. Eventually, these isolated patches coalesce to form elongated streaks in the direction of shear. The flowability of the tribofilm along with the local occupancy of its pads and their interaction with their nearest neighbors can affect the shape, growth and ultimately the tenacity and removal of the tribofilm.

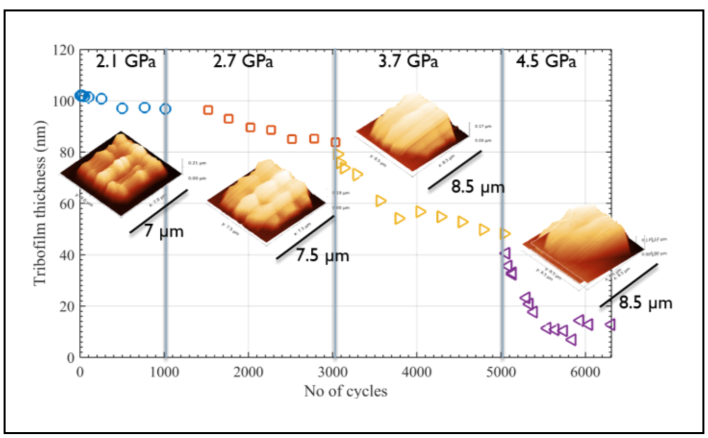

Fig.1 Evolution of the ZDDP tribofilm structure after sheared at different contact pressures

ACKNOWLEDGMENTS
The authors would like to express their grateful acknowledgment to the financial support of Marie Curie Initial Training Networks (ITN) - FUTURE-BET project, grant no. 317334.

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