INDUSTRIAL PILOT PROJECT

Demonstrating the electro-control of ionic liquid lubricants in biobased hybrid oils at metal interfaces via neutron reflectivity

THE INDUSTRIAL CHALLENGE

Nynas AB is a global leading supplier of naphthenic base oils for industrial lubrication and the automotive industry who are committed to the development of new sustainable lubricant strategies, including biobased oils. With the transition to the growing electrical mobility industry, lubricant technologies also face new challenges and demands, such as electrical compatibility and thermal management. Ionic liquids (ILs) are one potential e-lubricant solution, due to their inherent conductivity, high temperature stability, low vapour pressures and surface responsiveness to electric fields.

WHY USING A LARGE SCALE FACILITY

Over the past few years, efforts have been made to better understand how electric fields can be used to control IL boundary layers. At KTH, tribotronic test rigs have been developed in parallel to custom electrochemical atomic force microscope and quartz crystal microbalance instruments to probe IL lubricant systems. However, neutron reflectivity (NR) has proven to be the vital tool for providing both structural and compositional characterisation of these highly complex, buried surface layers.

HOW THE WORK WAS DONE

The interfacial electro-responsivity and structuring properties of a tribologically relevant IL, mixed at additive concentrations in both a bio-based oil and a hybrid naphthenic oil mixture, were investigated using an electrochemical NR cell at the SUPERADAM beamline at the Institut Laue-Langevin (ILL), France. Both NR and polarised NR measurements were conducted on thin films (200 Å) of noble (gold) and magnetically soft metal substrates with native passive oxide films (iron and steel), respectively. The preparation of the latter films was developed in collaboration with Koenigs Systems UG. To achieve enhanced scattering from the IL boundary layers, the scattering length density of the IL-oil mixtures was contrast matched to the metal interfaces. This was possible thanks to oil deuteration provided by ANSTO Deuteration Facility, Australia

THE RESULTS AND EXPECTED IMPACT

For the first time, the boundary layers of a tribologically relevant IL were detected and characterised at the interface between metal or a metal oxide and a biobased or hybrid oil at additive concentrations of IL. In addition, the boundary layer structure was found to be influenced by the bulk IL concentration, different applied electric potentials, as well as the choice of metal interface. Some of the initial results collected have already provided clear molecular rationale for observed tribotronic behaviours in ball-on-disc experiments on the same IL-biobased oil mixtures. It is anticipated that this demonstration of the formulation of IL e-lubricant additives in biobased oils, as well as exemplifying their electrical compatibility and performance, will contribute to the development of future lubricant strategies. Importantly, Nynas AB also gained valuable insight into how NR can be utilised as a powerful and versatile tool for the study of e-lubricants and gained substantial experience of experimental procedures involved.

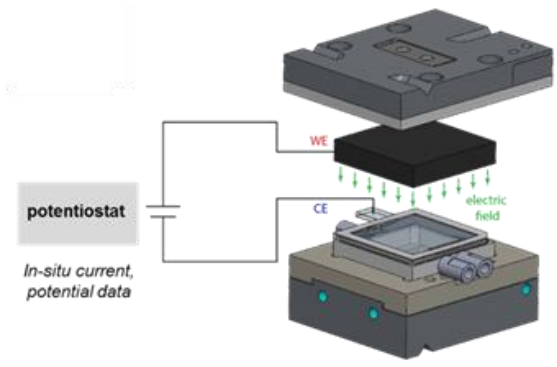

Figure. 1 Schematic of the custom-made electrochemical NR cell used in this work.

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