diamond

Oil

CASE STUDY

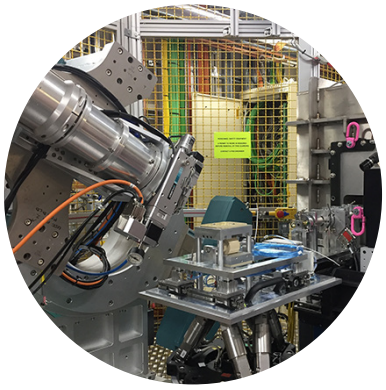
Studying solid-liquid interfaces under shear

Organic Friction Modifiers (OFMs) are surfactants included in engine oil formulations. They adsorb on metal surfaces, forming compact surface layers that act as protective coatings to reduce friction and wear occurring between mechanical engine parts.

The use of OFMs is associated with more energy efficient engines and a reduction in CO_2 emissions. The design of effective new formulations and novel OFMs relies on a detailed understanding of how OFMs self-assemble at interfaces and how their surface structure changes with tribological conditions.

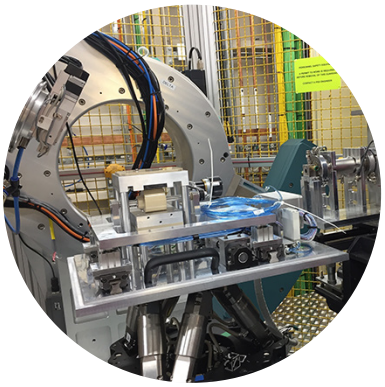
Infineum

The Challenge



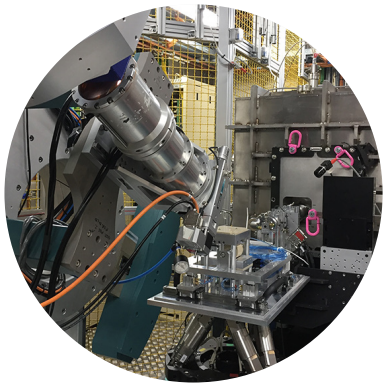
Recent tribological measurements have suggested that the compact surface layers may not be simple monolayers and in fact extend further into the bulk. Experimental studies of *in situ* friction reducing surface structures are very challenging as it requires a combination of a surface specific technique coupled with the harsh conditions applied within an engine where the probe does perturb the buried surface structure. Synchrotron specular X-ray and neutron reflectivity are ideally suited to these demands but a dedicated sample environment was needed to replicate the conditions inside the operating engine.

The Solution



A team from Infineum and the Universities of Cambridge and Kent worked with Diamond and STFC scientists to design and test a novel sample environment, a tribometer, designed to perform experiments replicating the conditions inside a working engine while simultaneously collecting surface specific structural information. The tribometer is compatible with I07 at Diamond along with neutron instruments at the ILL (France) and ISIS (UK) allowing the team to monitor different aspects of the surface chemistry. X-ray reflectivity (XRR) data was obtained from adsorption of glycerol monooleate (GMO) at the iron oxide – dodecane interface at different shear rates.

The Benefits



The combination of X-ray and neutron data provided a powerful probe of the buried surface structure of OFM layers at the iron oxide-dodecane under different tribological conditions, representing different friction conditions. This information is key to understanding structure at interfaces, necessary for developing design rules for the next generation of engine oil formulations. Due to the sensitivity of X-rays to a wide range of elements, it has also been suggested that the tribometer could be powerfully employed for studying surface-active compounds with greater electron densities under shear, such as inorganic friction modifiers.

"Curiosity drives science. Having a mindset which challenges and questions how things work is vital for creativity and hence innovation.

We've channelled curiosity while working with the Universities of Cambridge and Kent, ISIS and Diamond to not only determine how molecules behave, but also how we can make use of them to reduce friction.

This facilitates molecular-level design of new products which is only possible with the advanced methods available at ISIS and Diamond."

Professor Peter Dowding, Infineum Chief Scientist

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