Adsorption of surfactants as friction modifiers and optimization of adaptive lubricants

ISIS Facility Development Studentship and Collaborative PhD project: School of Chemistry University of Bristol, ISIS Rutherford Appleton Lab and Infineum

Duration: 3.5 years from 28-09-21

Background

The aim of this project is to contribute towards reductions in CO₂ emissions and improvements in fuel economy for vehicle engines, through understanding of chemical and physical mechanisms by which chemical additives in lubrication oils act to reduce friction and wear. Tribology is defined as the science of interacting surfaces in relative motion, as found in vehicle engines, and hence these chemical additives are called tribology modifiers. These chemicals help reduce friction and wear, fuel costs and CO₂ emissions: for example, a single heavy-duty lorry covering 150,000 km per year, a mere 1% improvement in fuel economy though reduced friction/wear results in a saving on fuel costs of £435 and a reduction in 1.4 Mt of CO₂ per truck, per year. Hence, the project will impact on global warming through reduced CO₂ emissions, and improved fuel economy, with potential to reduce expenditure on fuel.

The proposal will develop sample cells, sample environment and neutron scattering techniques for studying structure and properties of buried organic layers adsorbed at interfaces between oils and metals. These experimental approaches will also exploit the principal advantages of neutron scattering, by using controlled deuteration of organic friction modifiers to contrast different individual components in these multi-component systems. The deliverables of this project will be: (1) an optimized tribometer for off-equilibrium neutron reflectivity (NR) studies; (2) a unique new cell for “equilibrium” adsorption studies using SANS, (3) direct control from the ISIS instrument computers of both rigs with manuals and experimental protocols; (4) new surfactants designed to act as adaptive lubricants (see below).

Form a chemical perspective, imagine the exciting possibilities offered by dialling up locally desired properties (stability, structure, viscosity, rheology, friction...). Such novel adaptive lubricants could respond to thermodynamic and environmental conditions. For example, if viscosity (controlled by additive self-assembly) could be made sufficiently shear-, pressure- and/or temperature-sensitive then lubricant properties could be locally optimized in specific engine regions (having themselves very different regimes of shear, T and P). Such rules can then be applied to other industrial sectors which utilise surfactants (e.g. personal care products, detergency, food, biomaterials).

This PhD links strongly with other collaborative Bristol-ISIS-Infineum PhD programmes: experimental tribometry and neutron reflection (Cambridge, Bristol), computer simulation (Edinburgh) and model polymer synthesis (Warwick), and cross-university collaborations will be developed. The student will join a team comprising over 20 research students and post-docs, ISIS facilities scientists and industrialists at Infineum, all offering a wide range of expertise and support from highly experienced staff.

Interested and suitably qualified candidates should make informal contact at with Professor Julian Eastoe Julian.eastoe@bris.ac.uk (http://orcid.org/0000-0001-5706-8792) before Friday 18 June 2021. The intended start date for the project is 29 Sept 2021. After contacting Professor Eastoe, you may then apply using the University of Bristol on-line application system.

Bristol supervisor: Professor Julian Eastoe (photo, right) who has supervised 44 PhD students. These students have all made successful careers in Industry, Academia and Facilities

ISIS Facility Supervisor: Dr Becky Welbourn

Industrial Supervisor at Infineum: Professor Peter Dowding who is Visiting Industrial Professor in Chemistry at Bristol.