Session: Tools & modelling

An elastomeric model biofilm system for assessing the effect of physico-mechanical properties of marine biofilms on drag

Alexandra Jackson[1], Simon Dennington[1], Jennifer Longyear[3], Julian Wharton[1] and Paul Stoodley[1,2,4]

[1]National Centre for Advanced Tribology, Faculty of Engineering and Physical Sciences, Southampton University, United Kingdom

[2]National Biofilm Innovations Centre, School of Biological Sciences, Southampton University, United Kingdom

[3]AkzoNobel/International Paint Ltd., Stoneygate Lane, Gateshead, United Kingdom

[4]Departments of Microbial Infection and Immunity and Orthopaedics, The Ohio State University, OH, Columbus, USA

The physico-mechanical properties of biofilms are hypothesised to be significant in influencing marine drag yet are poorly understood. In part, this is owing to biofilm heterogeneity and viscoelasticity. This makes it difficult to apply standard test methods for studying biofilm physico-mechanics and complicates efforts to relate biofilm physical structure and mechanical properties to drag. To date, rigid and homogeneous structures have been used to study biofilm associated drag and although they might successfully simulate roughness, they do not account for material compliance. To address this, we have designed a synthetic model biofilm system where mechanical properties and surface geometry can be readily manipulated to study drag caused by compliant surfaces. Rigid sandpaper and elastomeric sandpaper replicas were used as the basis of the model and although the surface topography was homogeneous the mechanical properties were significantly different (P-value < 0.05). The elastomeric sandpaper replicas were exposed to a controlled hydrodynamic regime in a meso-scale marine biofilm flow cell (MBFC) and pressure drop measurements were taken to enable drag calculations. To quantify the mechanical properties of the replicas and to visualise deformation an Optical Coherence Tomograph (OCT) was used. Deformation of topographical features of the replicas surface allowed the estimation of shear modulus by measuring angles of deformation between OCT images using Fiji (ImageJ). The shear modulus of the elastomeric material, proposed as a marine biofilm model material, ranged from 79 Pa to 279 Pa which was within an order of magnitude of that reported previously for marine biofilms. On average, the elastomeric replicas generated up to a 52 % increase in drag when compared to the rigid counterparts of the same surface roughness. By utilising a fully synthetic tailored system the effects of geometry and mechanical properties on drag can be studied in isolation. OCT and MBFC used in conjunction allowed physico-mechanical properties and drag to be measured simultaneously, which further enables interactions between these properties and their effect on drag to be studied in more detail.