Adsorption of Surfactants at the Solid-Liquid Interface: Effect of Surface Topological Variations

Adsorption of surfactants at the solid-liquid interface is key to many applications, including the removal of particulates from laundry or hard surfaces, the removal of oil from underground, deinking of plastics and the separation of minerals, e.g. copper and lead from other species. Our group has studied in detail the effect of topological variations on surfactant adsorption using both experimental and molecular dynamic (MD) simulations. On a surface that is not molecularly smooth but where variations in topology are random, we have shown that with an increase in variation, the amount of surfactant adsorption decreases on a total surface area basis, and, in some cases, even on a nominal surface area basis (e.g. the surface area assuming the surface is molecularly smooth). Two types of controlled topological variations have been explored by our group, the bottom of trenches with varying trench widths, and on top of pillars with varying pillar size. The bottom of the trenches and the tops of the pillars were molecular smooth. In both cases, changes in morphology were determined using force measurements with an AFM probe. In the trench case, we were only able to measure the center of the trench and the thickness of the surfactant layer was identical within experimental error to the thickness adsorbed on a surface with no topological variation while the amount of surfactant adsorbed, as measured by forces, was less. In the pillar case, the thickness was higher near the edge of the pillar and decayed exponentially with distance from the edge with a decay-length constant of ~10 nm while the amount adsorbed was less near the edge and increased exponentially with a slightly larger decay-length constant. These decay length constants are much larger than expected given the ~2 nm size of a surfactant molecule and are also much larger than MD simulations. Surfactant driven by entropy and known to be highly cooperative, and these large decay constants are a manifestation of the cooperativity of surfactant adsorption.

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