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Davisson-Germer Prize in Atomic or Surface Physics Lecture: Line 'Em All Up: Macromolecular Assembly at Liquid Interfaces

GERALDINE RICHMOND, Department of Chemistry, University of Oregon

Advances in our molecular level understanding of the ubiquitous fluid interface comprised of a hydrophobic fluid medium, and an aqueous solution of soluble ions and solutes has been slow until recently. This more recent upsurge in interest and progress comes from advances in both experimental and computational techniques as well as the increasingly important role that this interface is playing in such areas as green chemistry, nanoparticle synthesis, improved oil and mineral recovery and water purification. The presentation will focus on our most recent efforts in understanding (1) the molecular structure of the interface between two immiscible liquids, (2) the penetration of aqueous phase ions into the interfacial region and their effect on its properties, and (3) the structure and dynamics of the adsorption of surfactants, polymers and nanoparticles at this interface. To gain insights into these processes we use a combination of vibrational sum frequency spectroscopy, surface tension measurements using the pendant drop method, and molecular dynamics simulations. The results demonstrate that weak interactions between interfacial oil and water molecules create an interface that exhibits a high degree of molecular structuring and ordering, and with properties quite different than what is observed at the air-water interface. As a consequence of these interfacial oil-water interactions, the interface provides a unique environment for the adsorption and assembly of ions, polymers and nanoparticles that are drawn to its inner-most regions. Examples of our studies that provide new insights into the unique nature of adsorption, adsorption dynamics and macromolecular assembly at this interface will be provided.