Center For Advanced Studies in Novel Surfactants (CASNS)

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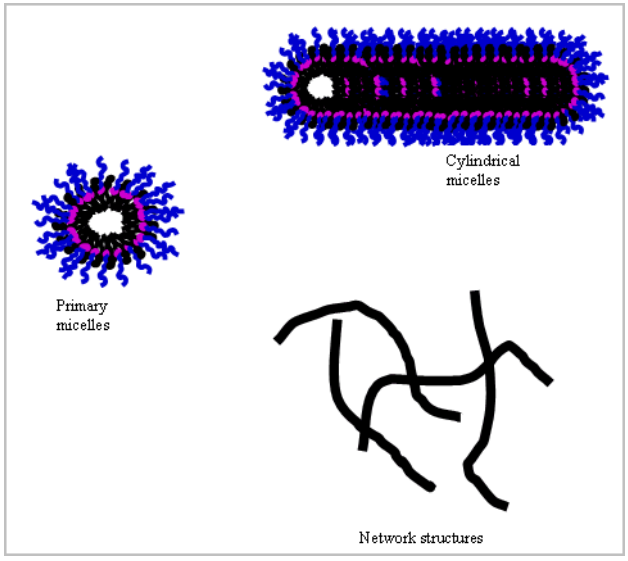
Coexistence of Nanostructures in Mixed Surfactant Solutions

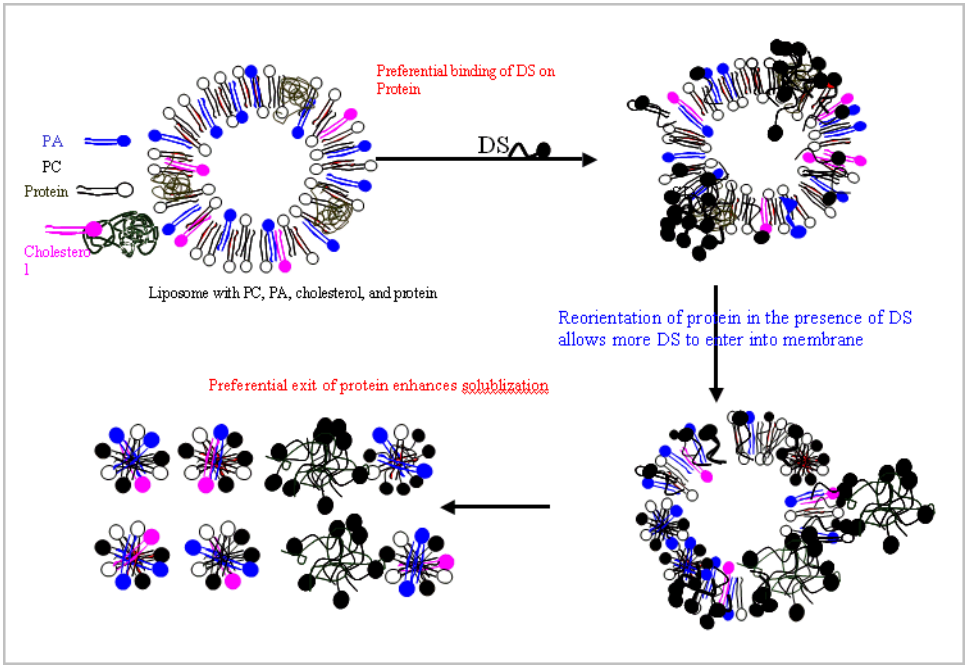


Analytical ultracentrifugation technique, is used for the first time to quantitatively determine speciation in surfactant mixtures and surfactant/protein mixtures in solutions. This technique is nondestructive and is particularly powerful for distinguishing the size and shape of various species in mixtures. Recent results have revealed coexistence of two types of micelles in polyethylene oxide solutions and its mixtures with sugar-based surfactant while only one micellar species is present in sugar-based surfactant solutions. Also, unlike ionic surfactants, the micellar growth of the nonionic sugar-based and polyethylene oxide surfactants are found to occur at a concentration immediately above the cmc. Both dynamic and equilibrium characteristics of nanoparticles, nanogels for drug-delivery, polymer-surfactant and surfactant/protein mixtures can be obtained using this technique. A number of industries, such as personal care, drugs, nano-technology, enhanced oil recovery and mineral processing, can produce next generation products using information on speciation, in terms of the type, size and shape of these supramolecular structures. For more information, contact Dr. P. Somasundaran, 212-854-2926; e-mail: ps24@columbia.edu.
Above: Nanostructures of micelles in the same aqueous surfactant solutions.

Mechanisms of Interactions of Surfactants with Lipid Vesicles and Biomembranes

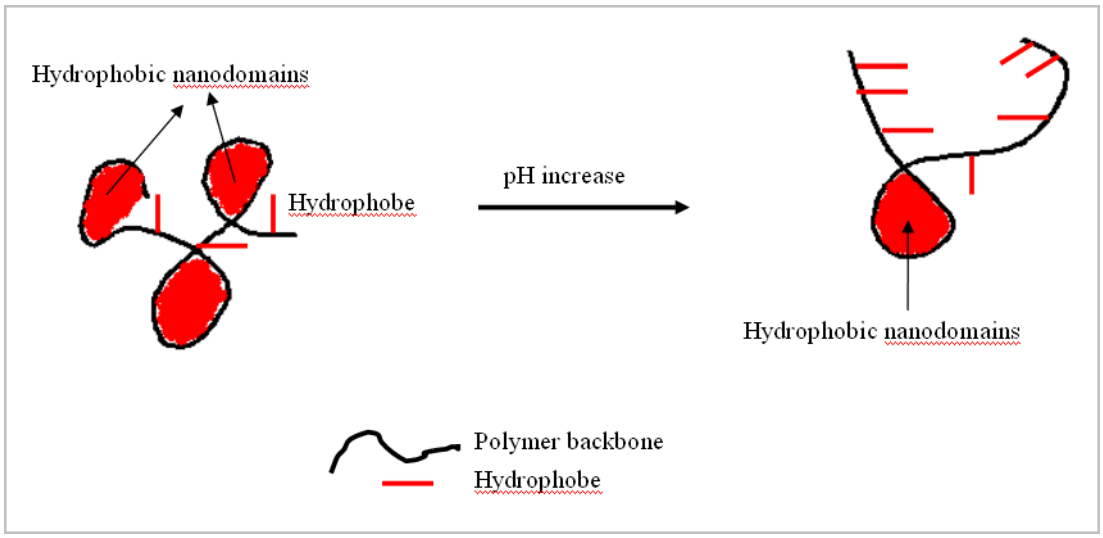
Our recent results on membrane-surfactant interactions with simpler biomembranes such as phosphatidic acid (PA) and phosphatidyl choline (PC) liposomes using electron spin resonance and fluorescence demonstrated for the first time in the history of liposome research that one of the liposome component, (PA) exits first upon interaction with the surfactant, dodecyl sulfate (DS) causing liposome disintegration. It was also discovered that while cholesterol made the liposome more resistant towards the surfactant, protein made the liposome more vulnerable. This has sig-

nificant implications in the formulation and use of consumer and drug products. It was also seen that protein undergoes structural reorientation in the presence of DS, with its preferential exit out of the liposome membrane, causing the liposome disintegration. The results on the mechanisms of surfactant interaction with biomembranes helps industry to develop formulation of efficient but mild personal care products.
Below: Conformational change of protein by dodecyl sulfate (DS) enhances the liposome solublization.



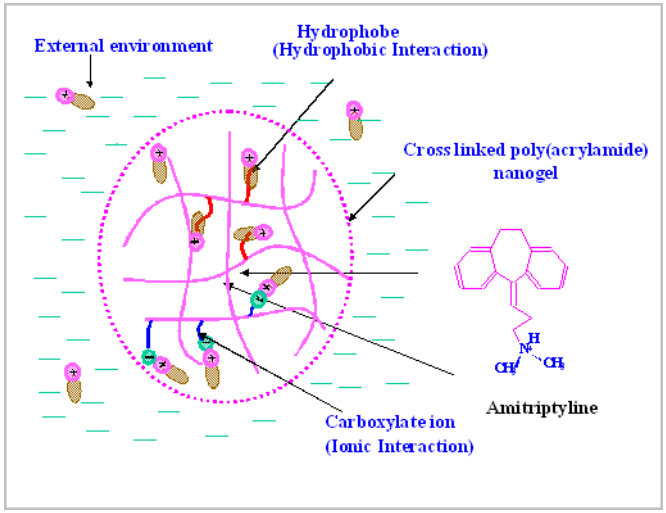
Conformational Behavior of Hydrophobically Modified Polymers

Hydrophobically modified polymers have been tuned for nanodomains that can extract and deliver at will cosmetics/drugs/toxins by controlling pH, temperature or ionic strength of the system. These systems have the advantage that they have features of both the polymers and the surfactants. Due to the associative nature of the hydrophobic groups, hydrophobically modified polymers can form intramolecular nanodomains at all concentrations of the polymer and inter-molecular aggregates under different conditions. Thus, poly (maleic acid/octyl vinyl ether) forms hydrophobic nanodomains that can solubilize and release drugs, dirts etc. by change in pH, salinity or temperature. Changes in the size and structure of the nanodomains thus formed have important applications in rheology control, coating, delivery of actives and removal of overdose toxins. For more information, contact Dr. P. Somasundaran, 212-854-2926; e-mail: ps24@columbia.edu.

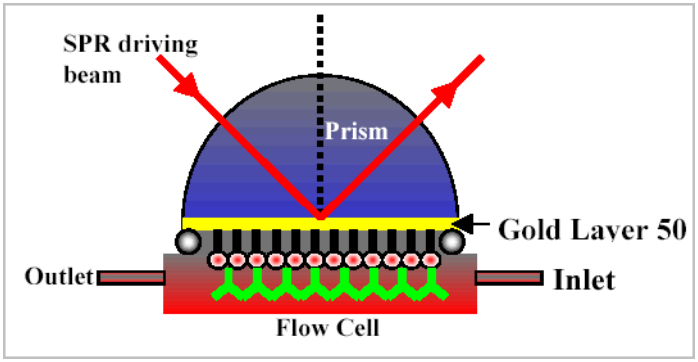


Novel Poly(acrylamide) Nanoparticles for Extraction and Release of Drug and Fragrance

Novel polyacrylamide nanogels (10-100nm) modified with functional hydrophobic and ionic groups, capable of almost complete removal of some overdose drugs have been produced by inverse microemulsion polymerization. Nanoparticles, in view of their a) submicron size, b) tendency to swell in different environments and c) ability to be functionalized show unique potential as drug and cosmetic carriers. Excessive use of amitriptyline is one of the major reasons for suicide in the United States. The hydrophobically modified and the ionic nanoparticles exhibited dramatic enhancement for amitriptyline and bupivacaine binding (80%) when compared to unmodified nanogels (18%). These hydrophobic and ionic interactions between the tested drug molecules and functional groups are represented in the following figure. The efficacy of these nanoparticles was excellent also for the extraction and release of vanillin, a flavoring ingredient for food materials and perfumes.



Interfacial Dynamics of Macromolecules using Surface Plasmon Resonance Spectroscopy



Understanding the short-term dynamics of interfacial processes is imperative in developing smart materials of the future. However none of the instruments allowed studying short term interactions in real time in situ. We developed a surface plasmon resonance spectroscope (adjacent figure) and applied it for the first time in studying the conformational dynamics of polymers and polymer surfactant interactions in millisecond time scales.

Surface plasmons (SP) are trapped surface modes existing at the interface between a metal and a dielectric with electromagnetic fields decaying exponentially in both media. The wavevectors of SPs are dependant on the refractive indices of the materials in the interfacial region an optical monitor of changes in the local environment. One of the most notable results, show the opening up of polymer (polyacrylic acid) matrix, during the binding of an oppositely charged surfactant (Dodecyltrimethylammonium Chloride). This result was contrary to normal expectations as charge neutralization is expected to increase the hydrophobicity of the layer causing the layer to collapse.