4cq Lipid Assemblies in Bioengineering: Model Systems to Examine Bioaccumulation, Solvent Toxicity, and Membrane Compartmentalization

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Lipid-based colloidal assemblies can be used as model biological membranes to investigate bioaccumulation, cell destabilization, and compartmentalization of components such as solvents, solutes, surfactants, and nanoparticles in bulk fluid phases and at gas, liquid, and solid interfaces. These assemblies can take the form of spherical or cylindrical liposomes, micelles, planar bilayers, or monolayers; providing a diverse array of structural geometries and potential analytical techniques. However, there is a disconnect between the behavior of lipid bilayers and cell membranes, which are complex and dynamic barriers containing mixed lipids (cationic, anionic, and zwitterionic), cholesterol, surface enzymes, and protein channels. Multi-component lipid assemblies can be used to better mimic biological membranes. These assemblies can be used in bulk-phase and interfacial destabilization studies (e.g. adsorption, fusion, and disintegration), as demonstrated by the following projects.

(i) *Biological relevance and environmental impact of interacting nanomaterial-biomembrane systems* – While nanotechnology has the potential to revolutionize science and engineering, the biological and environmental fate of nanomaterials is unknown. The goal is to examine cell disruption by the interaction with, or insertion of, nanomaterials using biomimetic lipid assemblies. Preliminary spectroscopic work on liposome/alumina nanoparticle systems will be presented.

(ii) *Cellular structure-function relationships in non-aqueous media and at fluid interfaces* – Biomembranes can be significantly perturbed by the accumulation of non-aqueous solvents or by interacting with a fluid or solid interface; ultimately leading to cell inactivation or changes in metabolism. However, non-aqueous phases and biocatalyst immobilization have the potential to improve productivity and selectivity relative to aqueous systems. Under such conditions, destabilization of lipid assemblies will provide insight into cell stability, which is dependent on membrane integrity. Using fluorescence spectroscopy and dynamic interfacial tension measurements, we have previously shown that supercritical fluids can destabilize lipid bilayers in bulk aqueous phases [1, 2] and at fluid interfaces [3], respectively. From high-pressure biphasic incubations and UV-vis spectroscopy, we also identified a distinct relationship between *Clostridium thermocellum* activity and cell adsorption at the compressed propane interface [4].

Knowledge gained from these projects can be used to, for example, improve/tune biocatalytic selectivity, identify biocompatible solvents, and design hybrid biomaterials. Lipid interactions with fluid or solid interfaces, macromolecules, and small particles could also provide a framework for applying colloidal theory to complex biological systems.

[1] Bothun et al. Langmuir, 21 (2005) 530. [2] Bothun et al. submitted, Colloids & Surfaces A. [3] Bothun et al. submitted, Biomacromolecules. [4] Bothun et al. Biotechnol. Bioeng., 89 (2004) 32.