Effects of Nanopore Size on the Interactions of Lipid Bilayers with Mesoporous Silica Particles

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Lipid bilayers immobilized on a variety of synthetic surfaces have applications in the field of sensing, separations and small molecule discovery. When immobilized on a porous platform, the bilayer provides a mechanism to screen small molecules and encapsulate proteins within the pore volume. On average, bilayers are only a few nano-meters thick, making their interaction with nano-meter diameter pores of great importance to their intended use. Mesoporous silica provides a unique immobilization platform due to its tunable properties such as pore sizes, morphologies and surface functionality. This research addresses a current challenge in the study of the interactions of lipid bilayers with nano-meter scale pores, the limited approaches to link the tunable pore properties of mesoporous silica with the visualization techniques to characterize the lipid bilayers. Within our laboratory, hydrothermal aging of porous particles during synthesis has proven to be a very effective technique to tailor pore diameters on the 3-15 nano-meter scale, which also spans the scale of bilayer thickness. Additionally, our spherical particle synthesis results in large (7.5 μm) particle diameters, which are amenable to visual confirmation and bilayer localization using confocal scanning laser microscopy.

This investigation examines the effect of pore size on the surface and interior properties of supported and tethered lipid bilayers on mesoporous silica particles. Particles are synthesized using hydrothermal aging which provides nano-meter control over pore diameter between 3 and 15 nm. The lipid dipalmitoylphosphatidylcholine (DPPC) was chosen for its biological relevancy and well understood bilayer properties, which when formed are approximately 5 nm thick. Lipid silane 13-(chlorodimethylsilylmethyl)heptacosane is used as covalent tether of the membrane to the inorganic support, and the properties of supported and tethered bilayers are compared. Nanoporous particles are synthesized with particle diameters on the micron scale for visual characterization and bilayer localization is confirmed using confocal scanning laser microscopy. The diffusivity of lipids within the particle is determined at the surface and in the interior of the particle using Fluorescence Recovery After Photobleaching (FRAP). Size based nano-pore inclusion and exclusion on bilayer diffusivity both on the surface of and within porous particles is investigated.T Membrane fluidity is also evaluate as a function of surface density of the tethered lipid silane.