Phospholipid Membrane Applications in Nanotechnology

INTRODUCTION

Interactions at the bio-nano interface have exciting potential in the next generation of technological advances. At the cellular level, lipid membranes, composed mainly of lipids and proteins, create the barrier at which interaction with the outside biological and non-biological world take place. Membranes exist not only as barriers, but are also key components of cellular activity. For example, they allow for creation of potential gradients, allowing for processes such as energy production to occur and also serve as sites for cellular target recognition.

Lipid membrane model systems have become popular for investigating biological membrane structure and function. These assemblies have the advantage of compositional and environmental control, allowing for investigation of membrane properties that can often be difficult to assess in cellular systems. Interaction of these assemblies with synthetic substrates has already exhibited potential in creating new bio-synthetic architectures as well as in providing information on cellular responses to the non-biological world.

Nanomaterials and nanostructured materials present a new challenge to bio-synthetic interactions. The size of nanomaterials allows potential for membrane uptake as well as interaction of individual nanoparticles with individual proteins or lipids, with both beneficial and harmful effects possible. Therefore, mechanistically understanding nanomaterials interactions with membranes is of vital importance. Likewise, nanostructured surfaces have exciting potential as templates for investigating membrane structure and function at a new level.

CINT CAPABILITIES

- Scanning probe microscopies- in situ AFM with Molecular Imaging Pico Plus microscope
- Optical Microscopy- Fluorescence Recovery After Photobleaching (FRAP)
- Ellipsometry- spectroscopic and imaging capabilities
- Membrane fragment and membrane protein isolation and purification, nanoparticle purification

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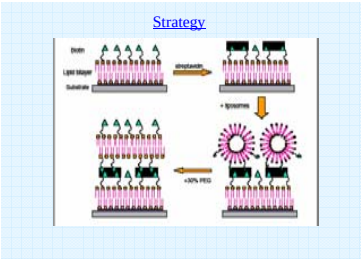
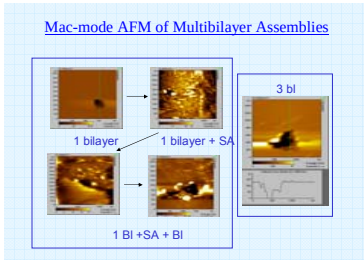
CONTROLLED ASSEMBLY OF PROTEIN-MEDIATED LIPID MULTI-BILAYERS

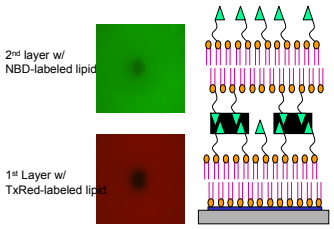
Multibilayer Formation using Biotin-streptavadin Conjugation

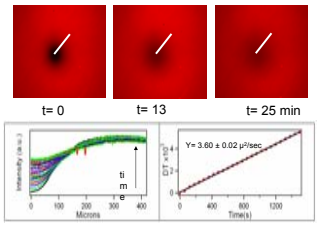




- Protein mediated creation of controlled multi-bilayer assemblies
  - ,liposomes contain a small percentage of biotinylated-PE lipid
  - Streptavidin used to link successive bilayers together

Fluidity of Individual Bilayers within Multi-bilayered Assembly





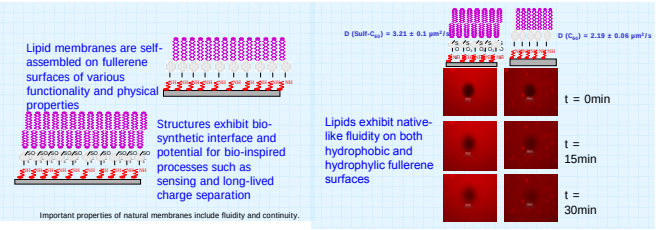
Biotin Concentration:	Layers:	Diffusion Coefficient (μ^2/sec):
none	TxRed	4.1 ± 0.1
0.20%	TxRed	3.5 ± 0.1
2%	TxRed	2.6 ± 0.1
20%	TxRed	1.33 ± 0.01

0.20%	TxRed	3.5 ± 0.1
	TxRed + SA	3.60 ± 0.02
	TxRed + SA + Unlabeled	3.8 ± 0.1
	unlabeled+ SA+ TxRed	1.9 ± 0.1

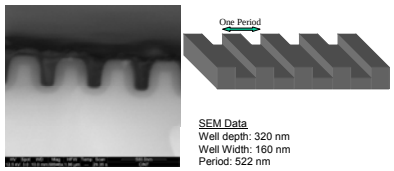
- Increased Biot-PE results in decrease in fluidity.
- Second bilayer in multi-bilayer assembly exhibits less fluidity

LIPID MEMBRANES ON NANOTRUCTURED SURFACES

Fluid Lipid membrane assemblies on Self-assembled Fullerene surfaces

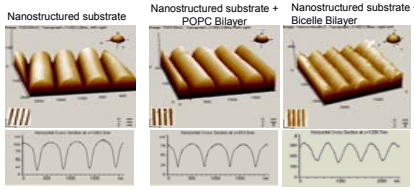


Lipid membrane assemblies on Nanostructured Surface

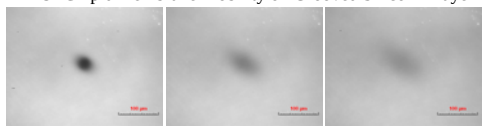


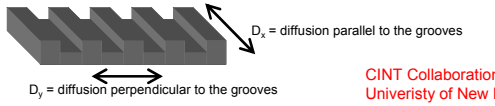
- Nanostructured surfaces similar in dimensions and contour to ruffled organelle membranes
- Fluid conforming bilayers formed with POPC- elliptical recovery
- Floating lipid bilayers formed with DPPC:DHPC bicelle bilayer
- Floating bilayers have potential use in membrane protein investigations

AFM of Grooved Silicon with Lipid Bilayer



POPC lipid membrane Mobility on Grooved Silicon Bilayer





CINT Collaboration with Dr. Gabriel Lopez, Univeristy of New Mexico