Creating a Nafion thin-film with a surface water layer in order to increase the accuracy of Neutron Reflectometry studies of lipid bilayers

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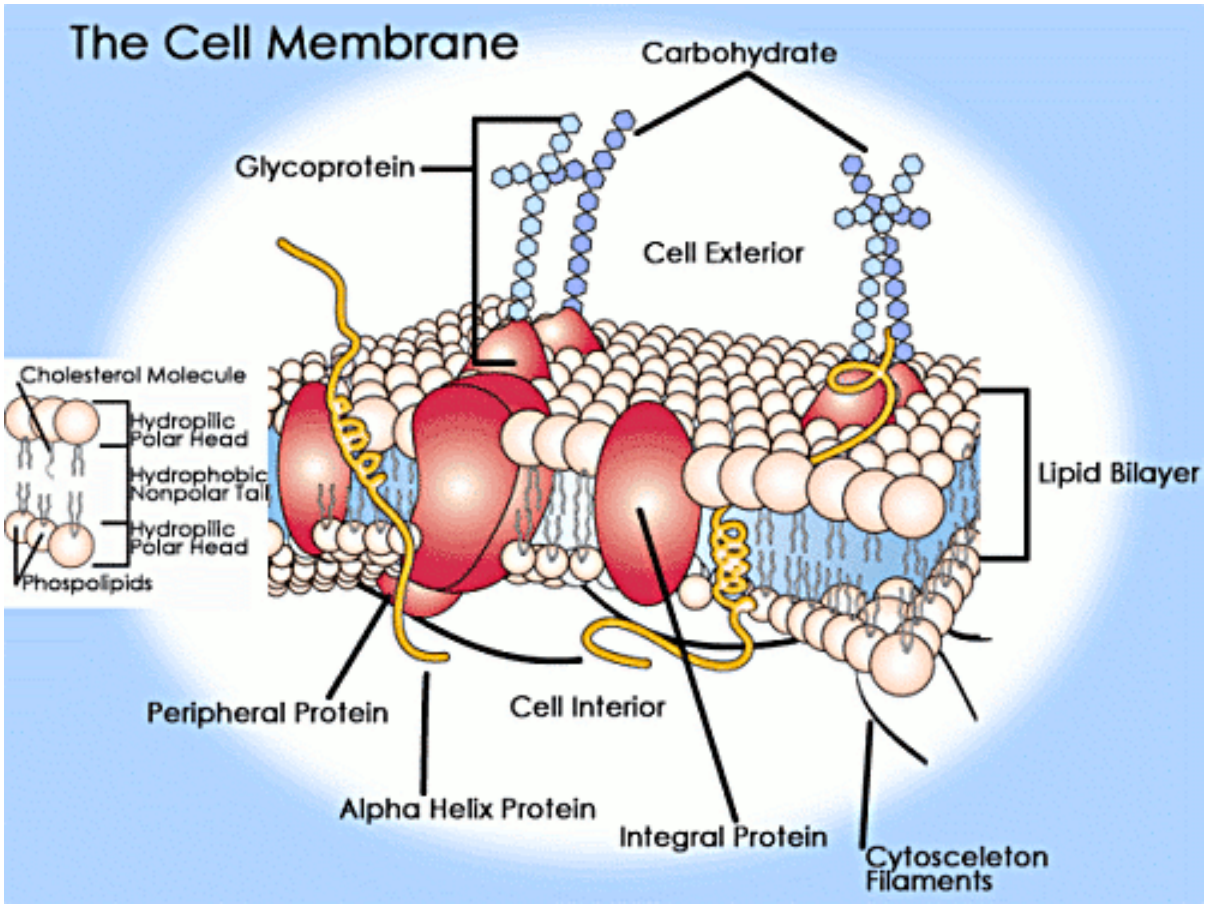
Background Information

- So what is a lipid bilayer?

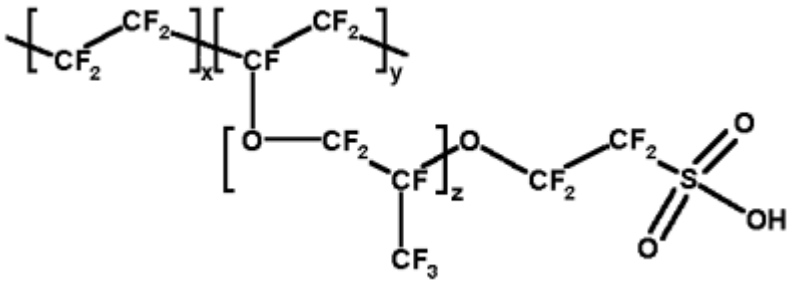


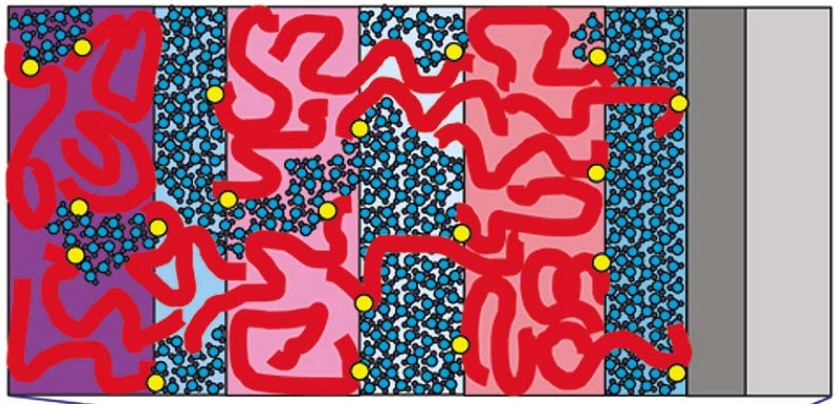
http://www.sparknotes.com/biology/cellstructure/cellmembranes/section2.rhtml

Neutron Reflectometry Studies of Biological Membranes

- Neutron Reflectometry can be used to determine the structure of biological membranes.
- In order to hydrate the biological membrane, water reservoirs are typically used.
- Water produces interference by scattering neutrons meant to be scattered by the membrane.
- By reducing the amount of water required to secure and hydrate the membrane, Neutron Reflectometry scans will reveal more accurate structures.

Nafion





- The first ionomer created DuPont.
- Consists of perfluorovinyl ether groups terminated with sulfonate groups onto a teflon backbone.
- Is frequently used as a PEM in fuel cells.

Introduction

- We will prepare several different concentrations of Nafion in an ethanol solution and deposit each onto a silicon wafer.
- We will use X-Ray Reflectometry to determine the structure of these films.
- We will create a graph representing the relationship between Nafion concentration and Nafion thickness.

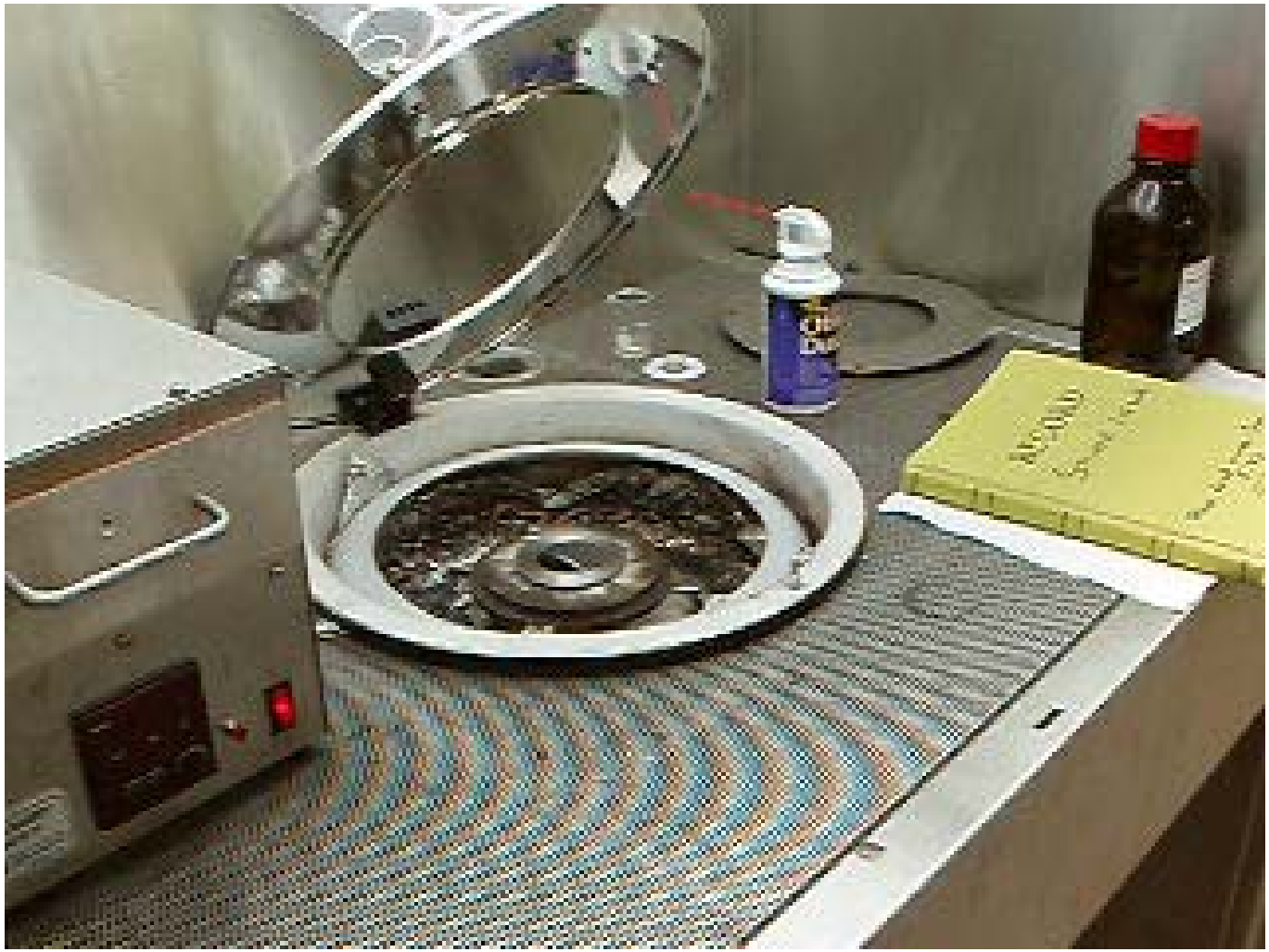
Goals

- To create a thin-film with a surface layer of water to hold down and hydrate a biological membrane.
- This thin layer will provide less interference at higher incident angles, and allow for more accurate Neutron Reflectometry scans.

Creation of the film

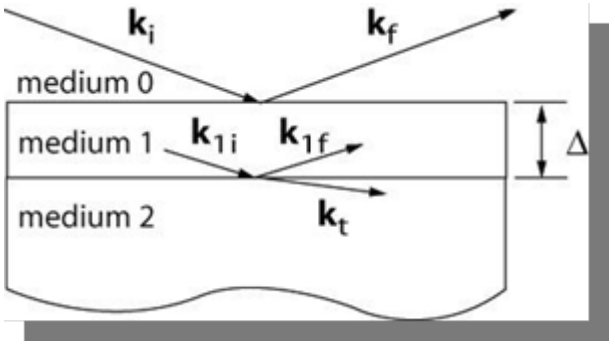
- We created 4 films of different Ethanol to Nafion concentrations:
  16:1, 32:1, 64:1, 128:1
- The experimental films were created by physical deposition.
- We used a spin coater, which uses centrifugal force to spread the Nafion solution.
- The thickness of the resulting film is dependent on spin rate, Nafion concentration, and on viscosity of the fluid.
- The sample is then annealed in a vacuum oven and placed in a desiccator.

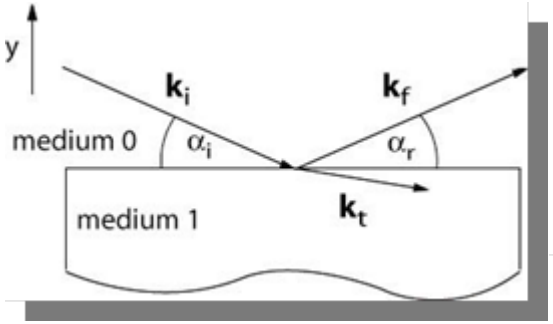
Spin Coat Video



Characterization of Samples

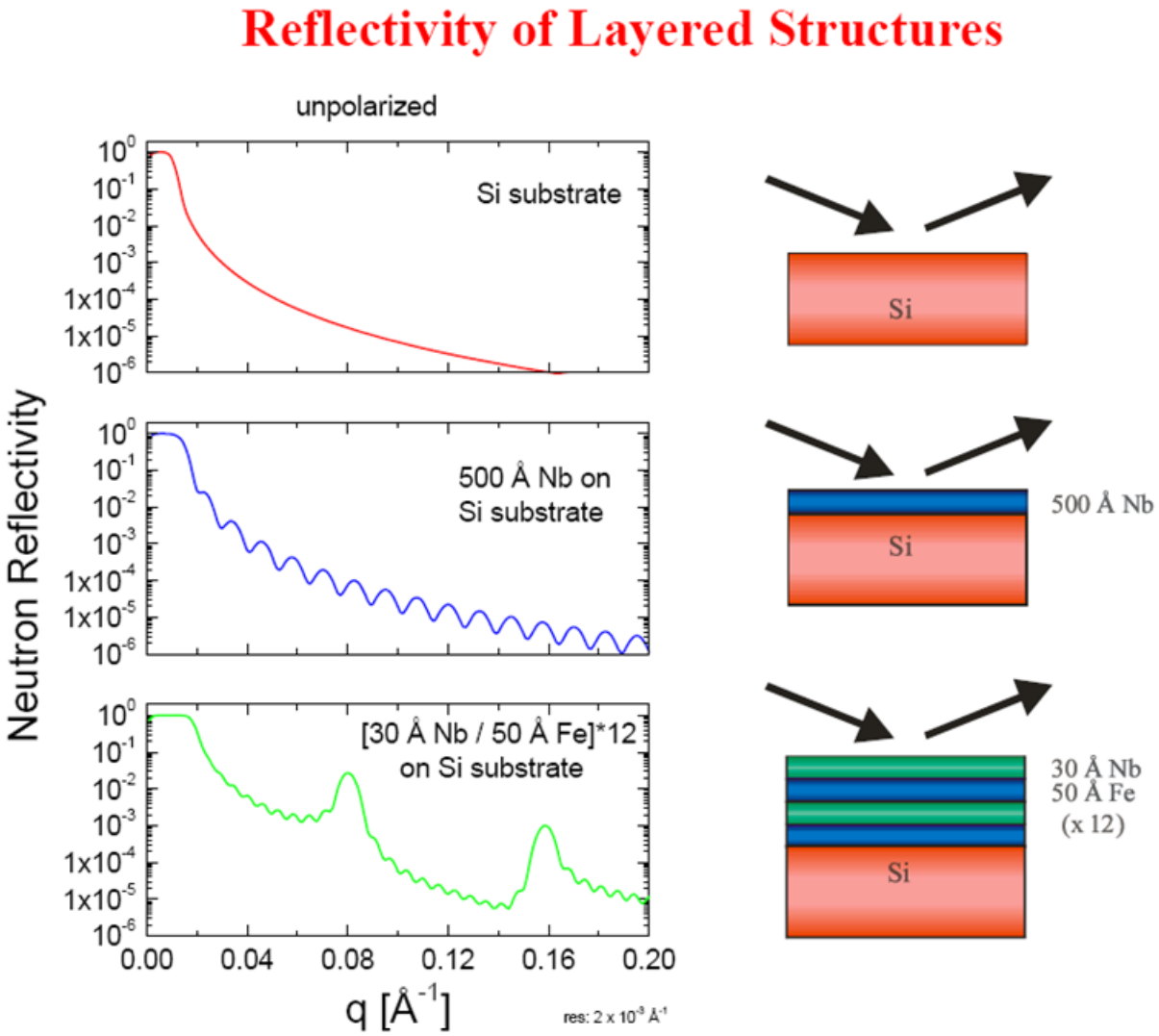
- X-Ray Reflectometry can be used to discern the thickness of each layer and its individual properties.
- By varying the angle of ejection of the X-Rays we can create a graph representing the depth profile of the sample.



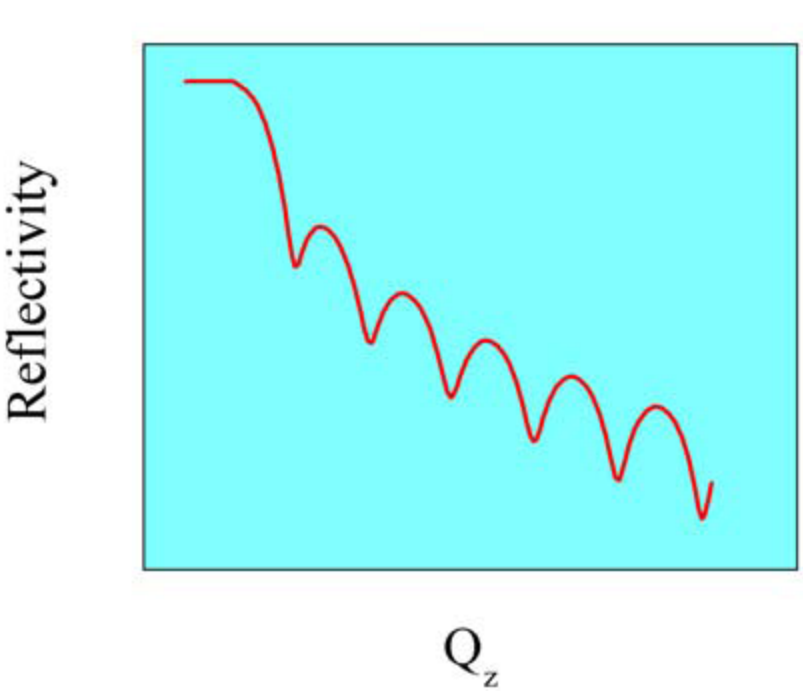


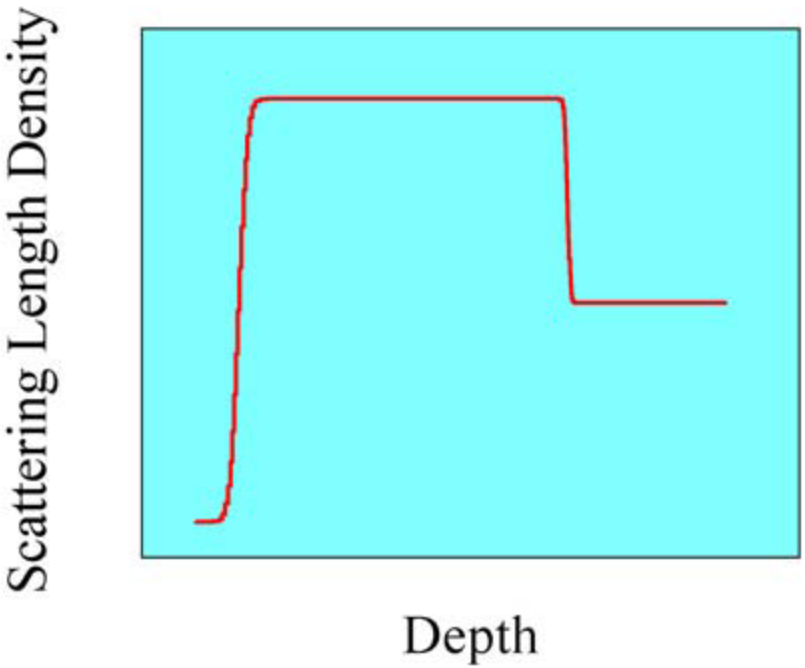
$$Q_z = \frac{4\pi}{\lambda} \sin \alpha_i$$

Characterization of Samples contd.



Resulting Data





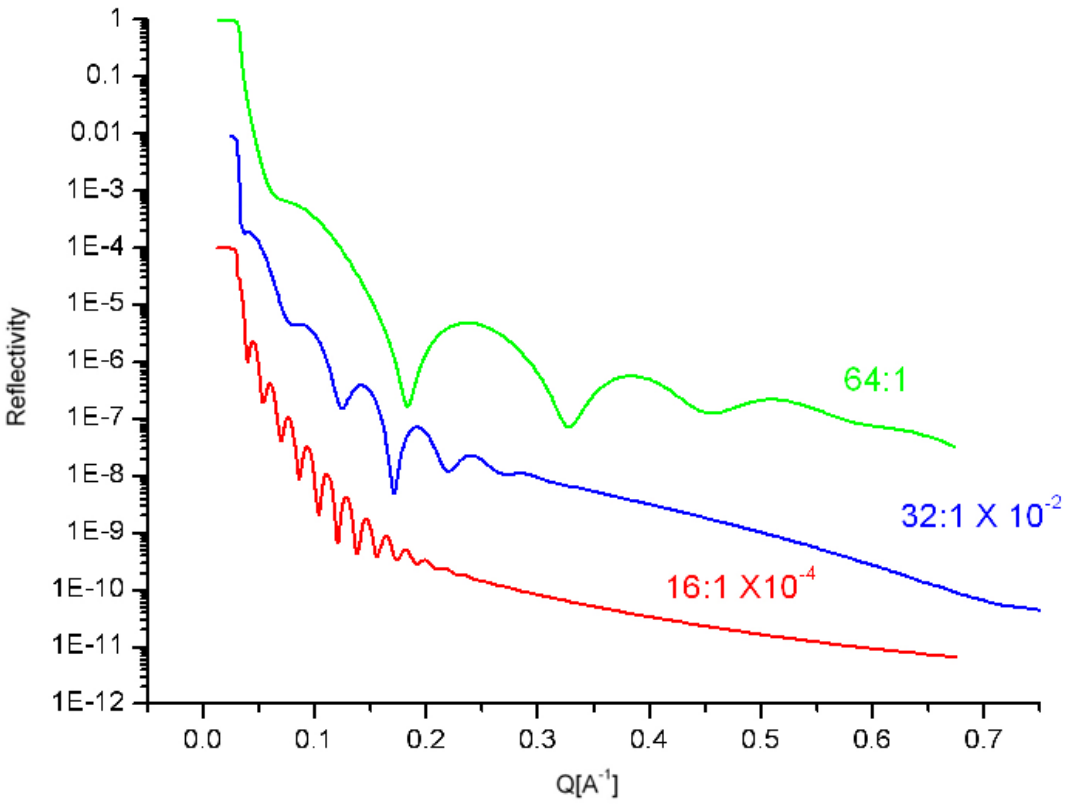
Reflectivity Data

X-Ray Reflectivity of Nafion films at various concentrations

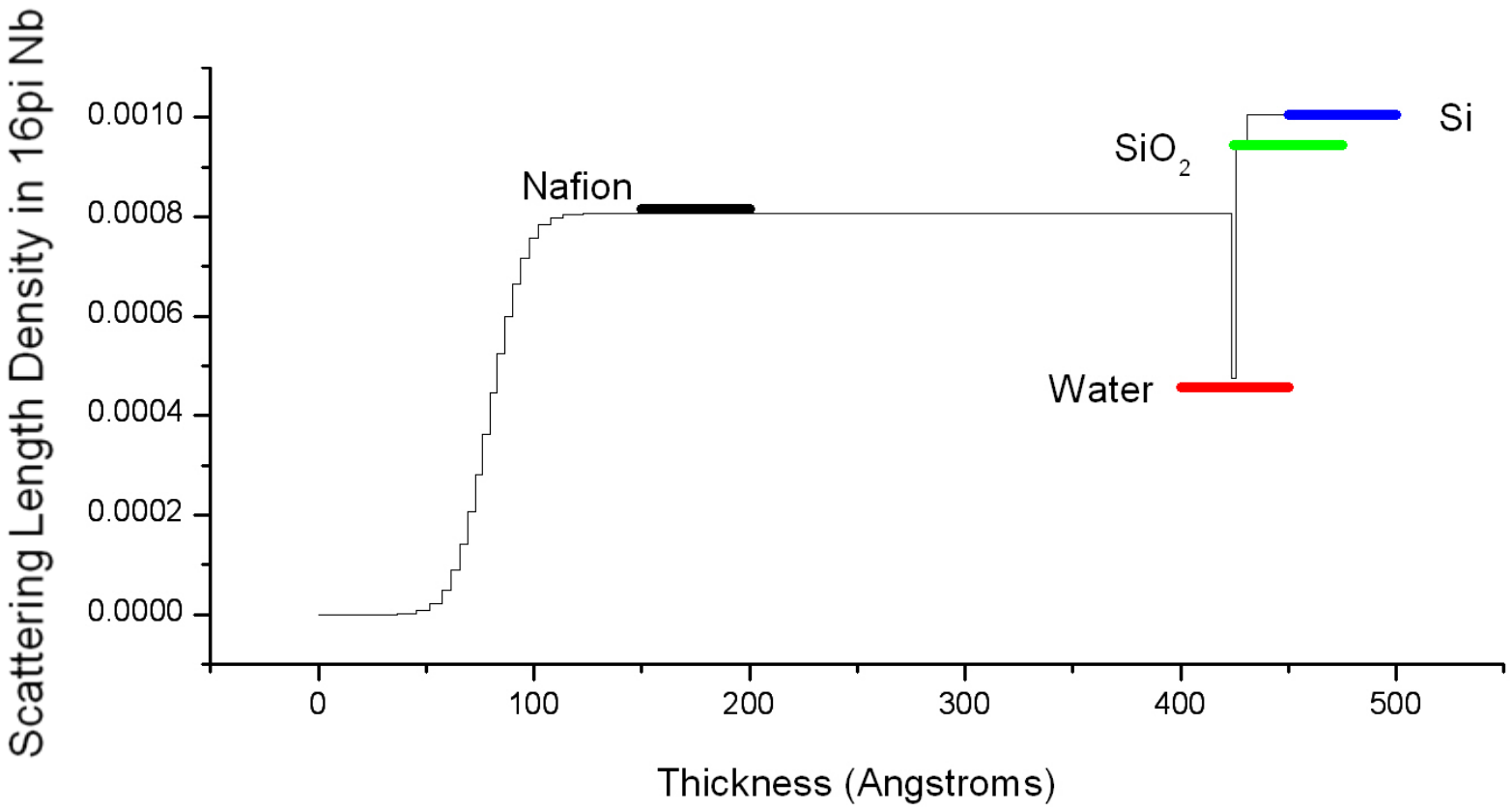
16:1

32:1

64:1

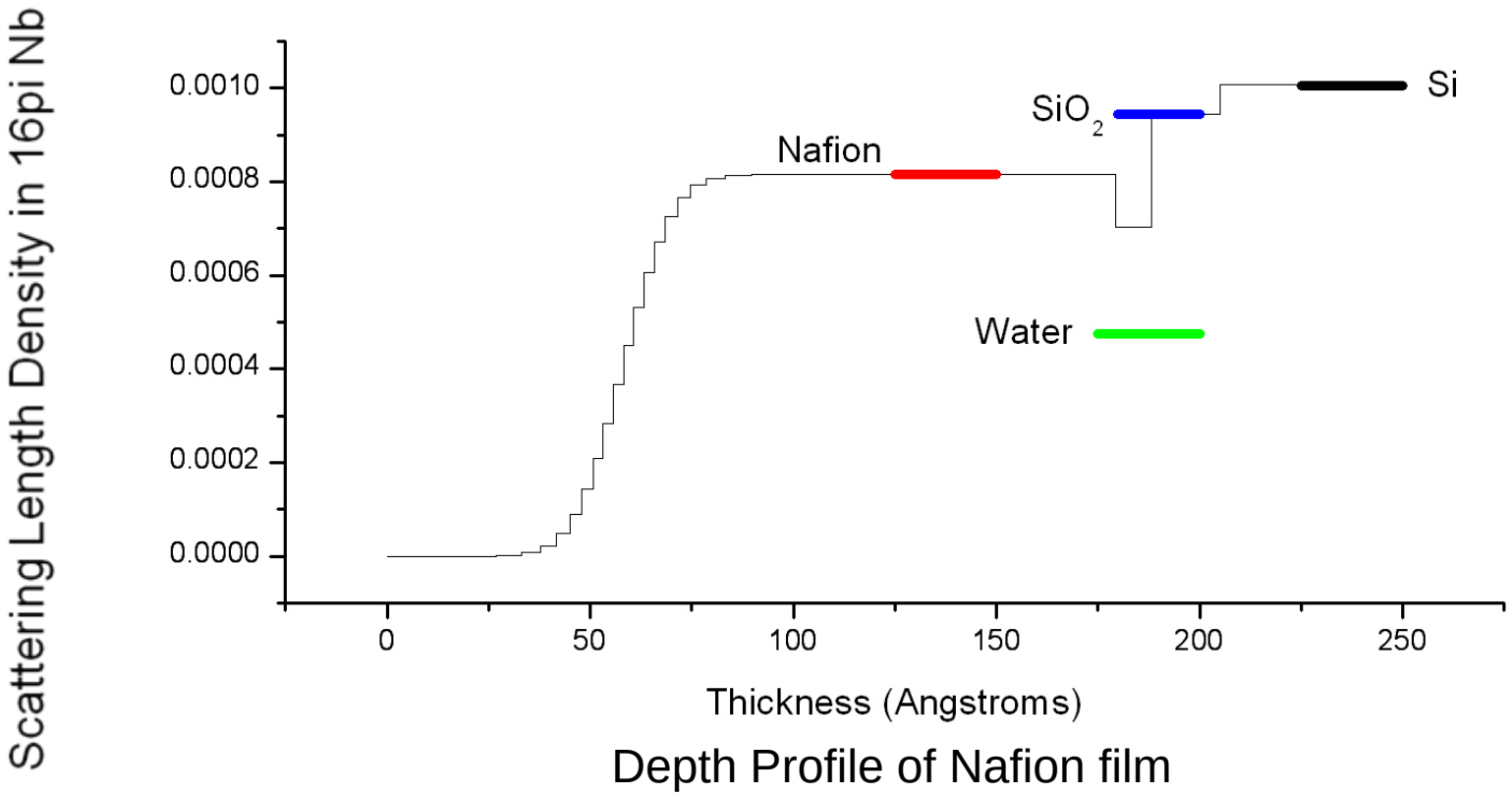


16:1

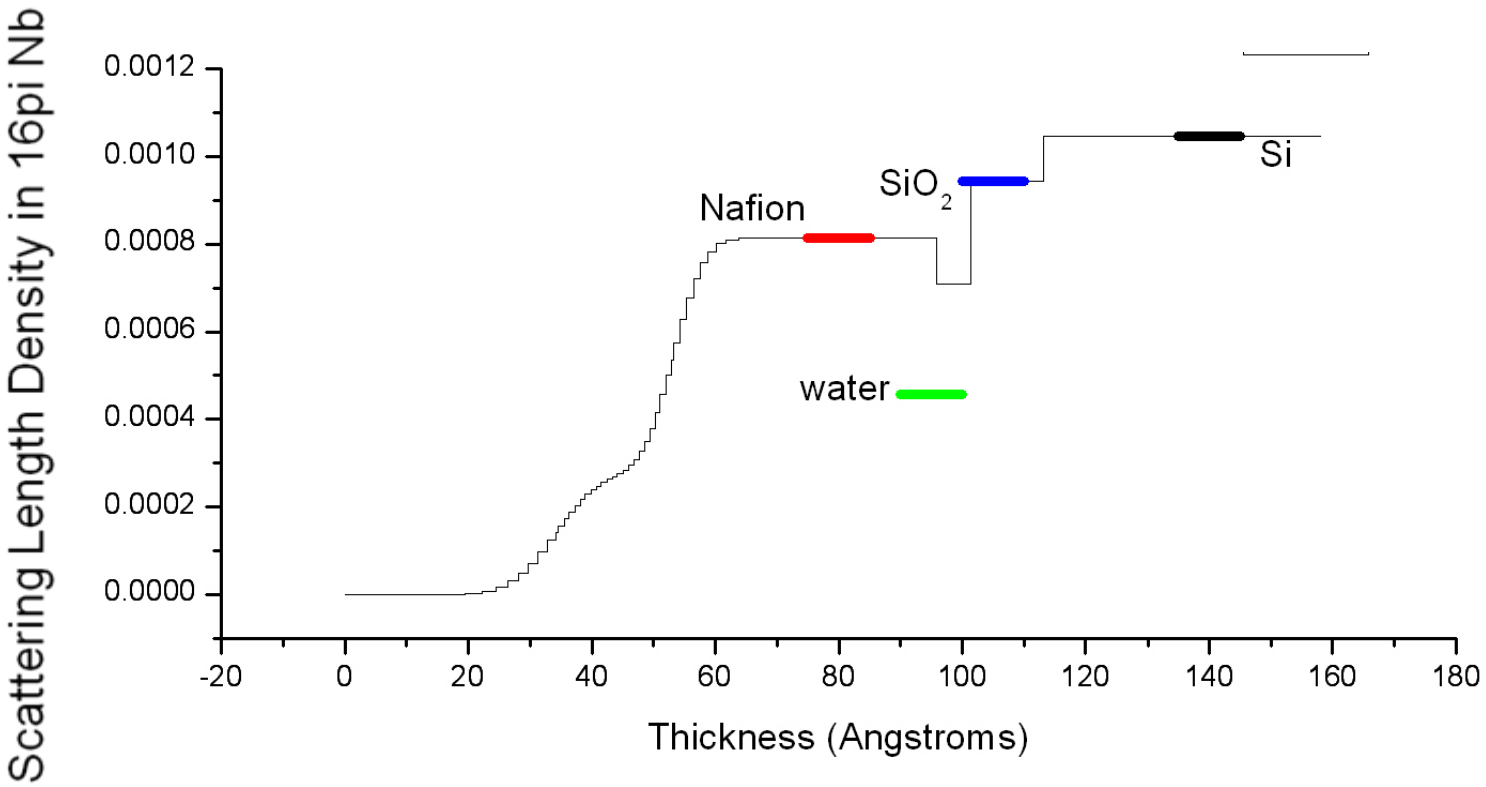


Depth Profile of Nafion film

32:1


Scattering Length Density in 16pi Nb
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0
50
100
150
200
250
Thickness (Angstroms)
Nafion
SiO2
Si
Water
Depth Profile of Nafion film

64:1



Depth Profile of Nafion film

128:1

- Provided low reflectivity data which was due to high reflectivity on the background scans.
- This can be attributed to either: the extremely thin nature of the film, or to unintended warping.
- The 128:1 data was not considered in the calibration curve.

Determining Nafion Thickness

- Each layer above the interface is a combination of Nafion and water.
- We can find the effective thickness of Nafion by determining the percent Nafion of each layer (from SLD), and then multiplying it by the thickness of the layer.

Calibration Curve

- Created two fit curves for the thickness/concentration data, one exponential and one linear.

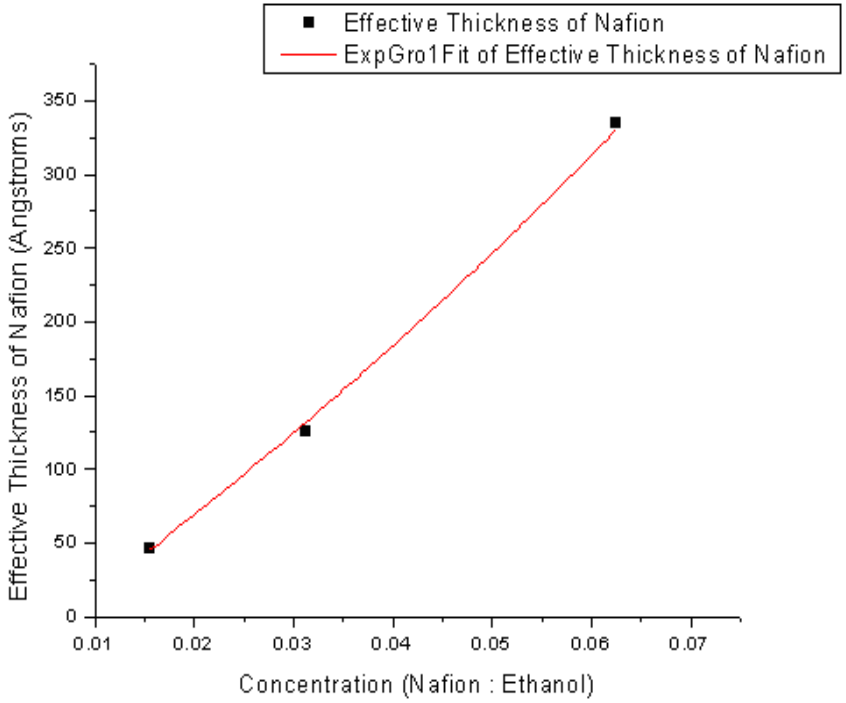


Fig 6

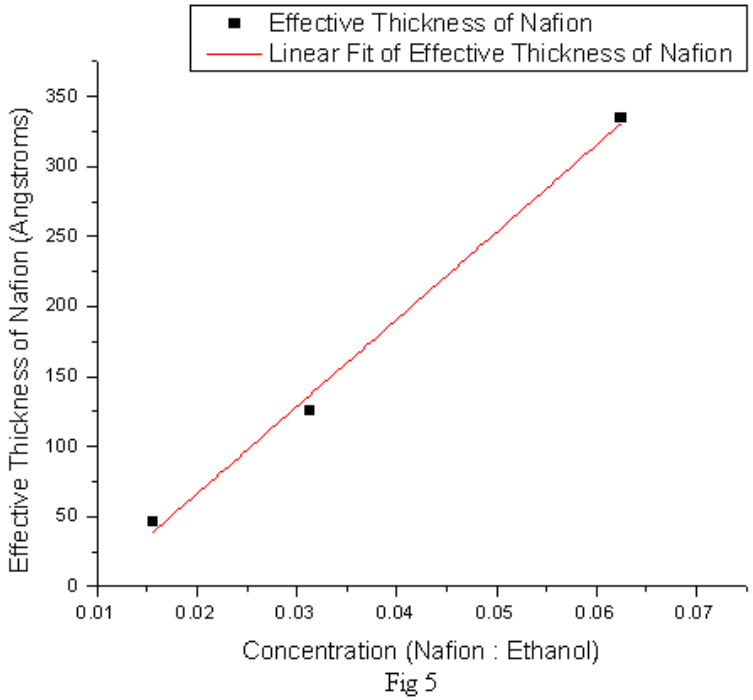


Fig 5

Final Results

Ethanol:Nafion	Linear Fit	Exponential Fit
5-Layer	65.6:1	71.6:1
3-Layer	82.9:1	98.8:1

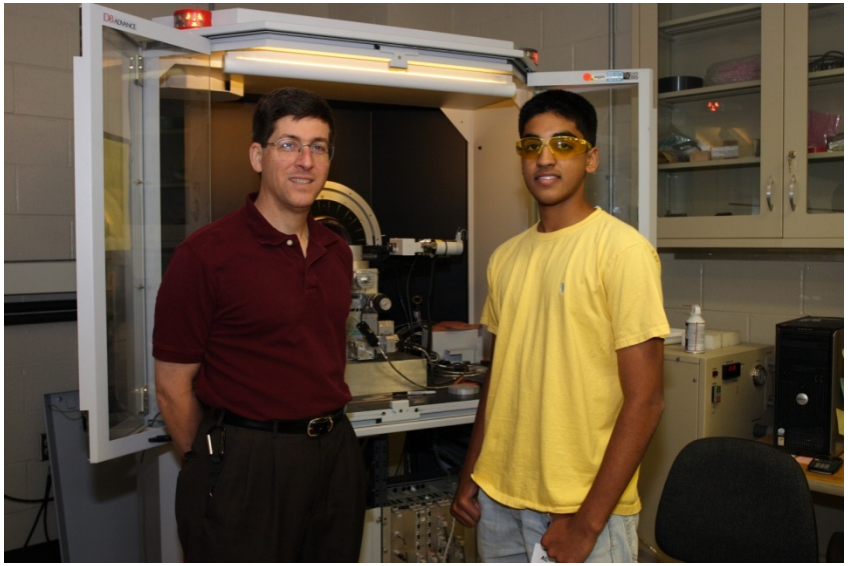
Future Research

- Ratios will be further tested to determine if desired water layer is accomplished.
- If one of the ratios yields the desired structure, the film can be used to secure and hydrate hybrid lipid membranes for more accurate neutron reflectometry scans.

References

- “Multilamellar Interface Structures in Nafion” Joseph A. Dura, et al., Macromolecules 2009 4769-4774
- Pynn's primer on neutron scattering

Acknowledgements



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