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 by 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.

**Reflectivity of Layered Structures**

- Si substrate
- 500 Å Nb on Si substrate
- [30 Å Nb / 50 Å Fe]^{12} on Si substrate
Resulting Data

Reflectivity

$Q_z$

Scattering Length Density

Depth
Reflectivity Data

X-Ray Reflectivity of Nafion films at various concentrations

16:1
32:1
64:1
Depth Profile of Nafion film

- Nafion
- SiO₂
- Si
- Water

Scattering Length Density in 16pi Nb

Thickness (Angstroms)
Depth Profile of Nafion film
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.
## Final Results

<table>
<thead>
<tr>
<th>Ethanol:Nafion</th>
<th>Linear Fit</th>
<th>Exponential Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Layer</td>
<td>65.6:1</td>
<td>71.6:1</td>
</tr>
<tr>
<td>3-Layer</td>
<td>82.9:1</td>
<td>98.8:1</td>
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</tbody>
</table>
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

- Pynn's primer on neutron scattering
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