Optimization of New Proton Exchange Membrane (PEM) Technology

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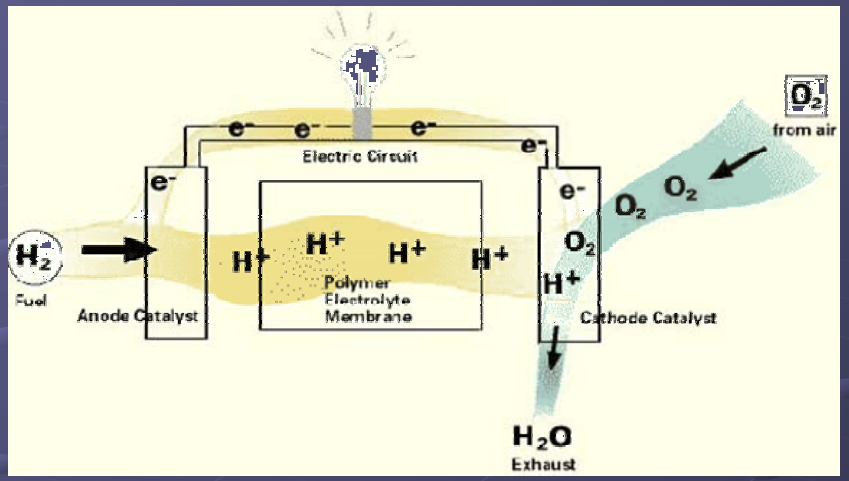
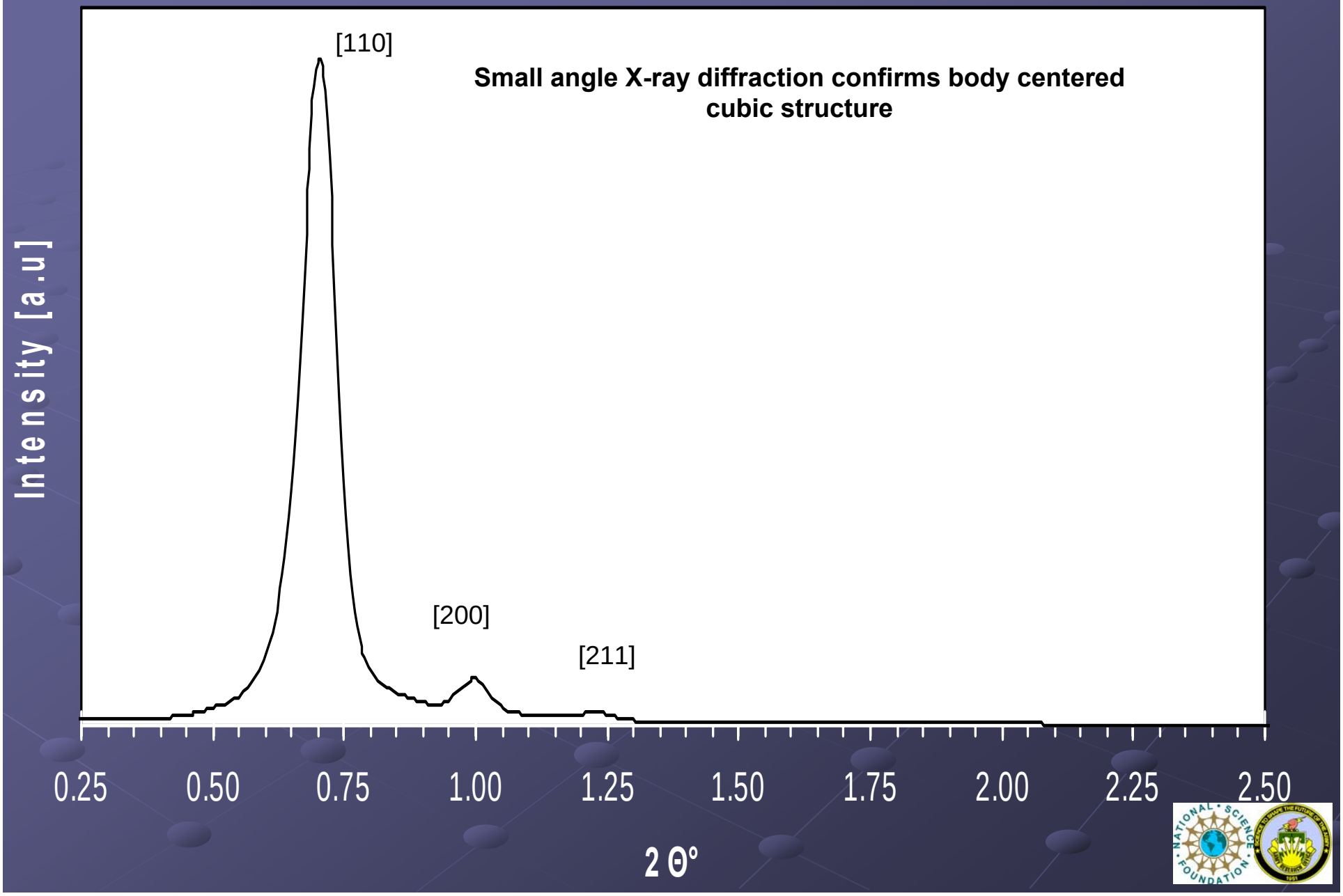
Motivation

- Fuel cells
  - Environment
  - Efficiency [$$]
- Current Technology
  - Currently Nafion ® is desired PEM.
  - Nafion ® membranes dehydrate and lose proton conductivity at temperatures > 80° C
  - High levels of CO in the hydrogen feed poison the platinum catalyst on anode
  - Operating temperatures >120 ° C lead to better CO tolerance



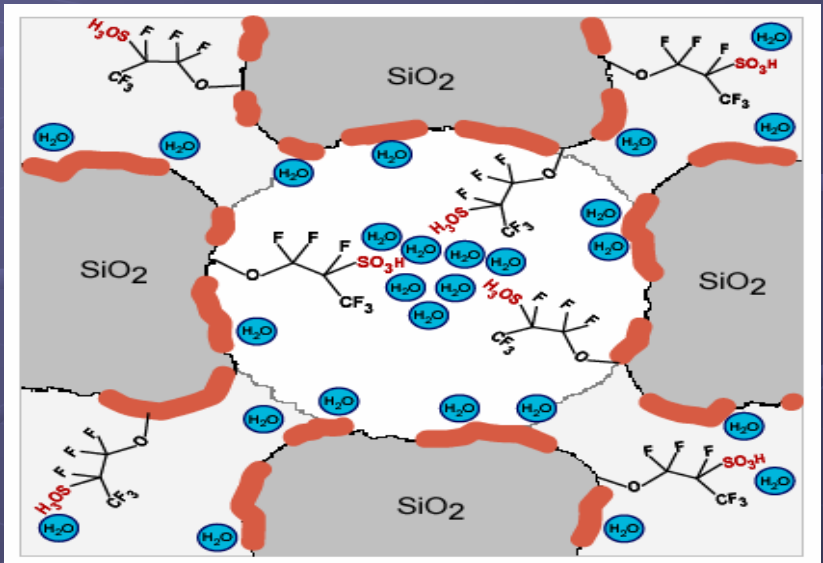
http://www.doc.ic.ac.uk/~mpj01/ise2grp/energystorage_report/img2.gif

New PEM Material



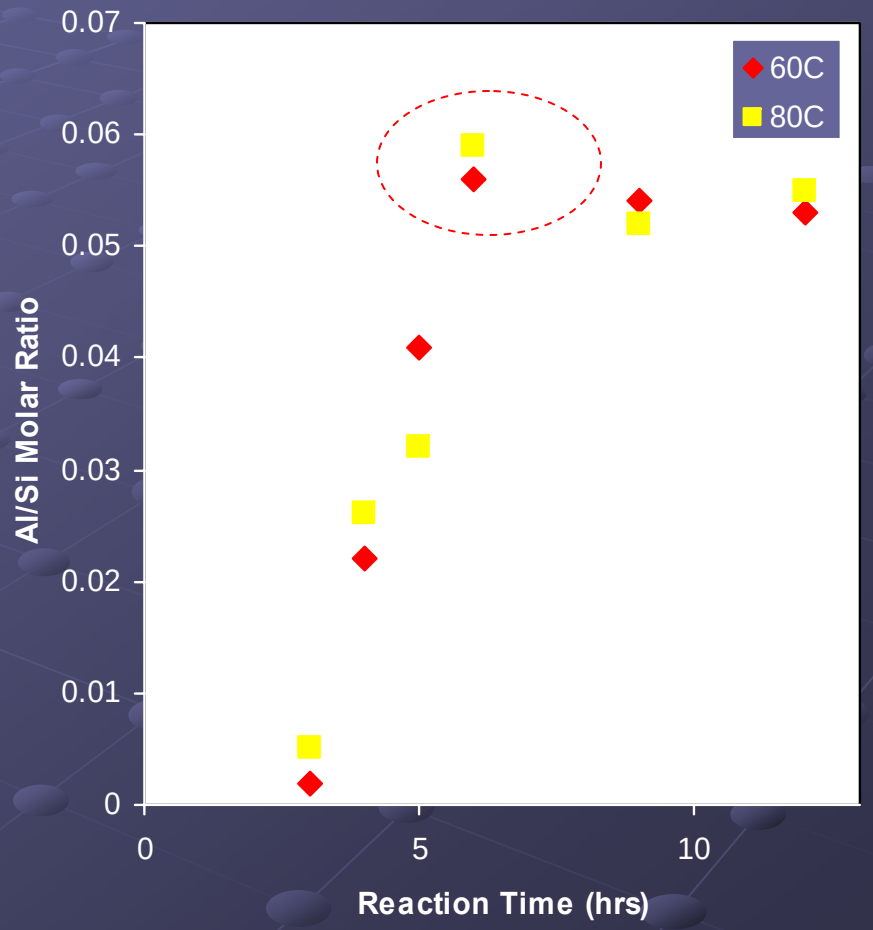
Approach

- Synthesize SBA-16 material
- Calcined mesoporous silica (8 nm)
- Aluminum will be grafted into each pore to allow for increased water retention by creating a charged pore surface
- Perflourinated sulfonic acid groups will be grafted to allow for proton conductivity



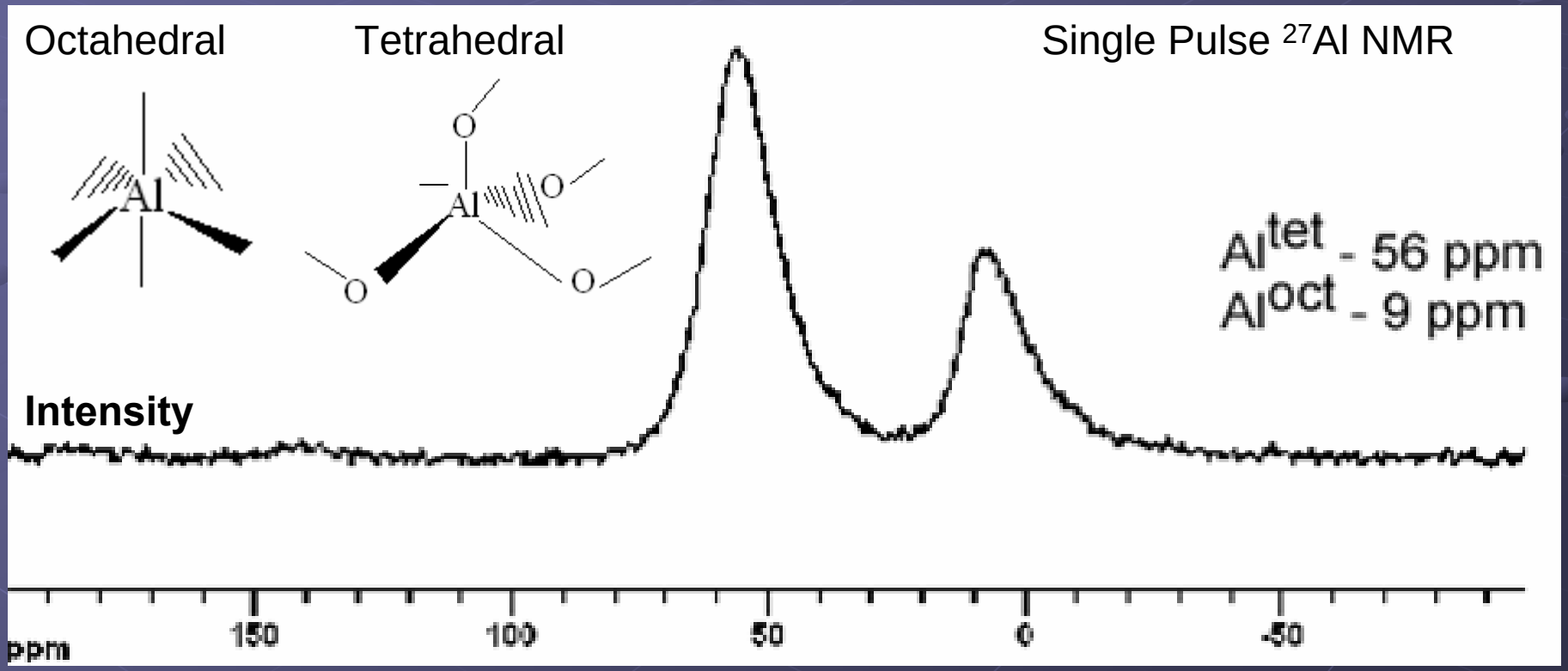
Optimization of Aluminum Grafting

- Reacted SBA-16 with sodium aluminate ($NaAl_2O_3$) at different temperatures and times
- Using elemental analysis we obtained molar ratios of Al/Si for each reaction condition
- Reaction time of 6 hrs yields highest Al/Si



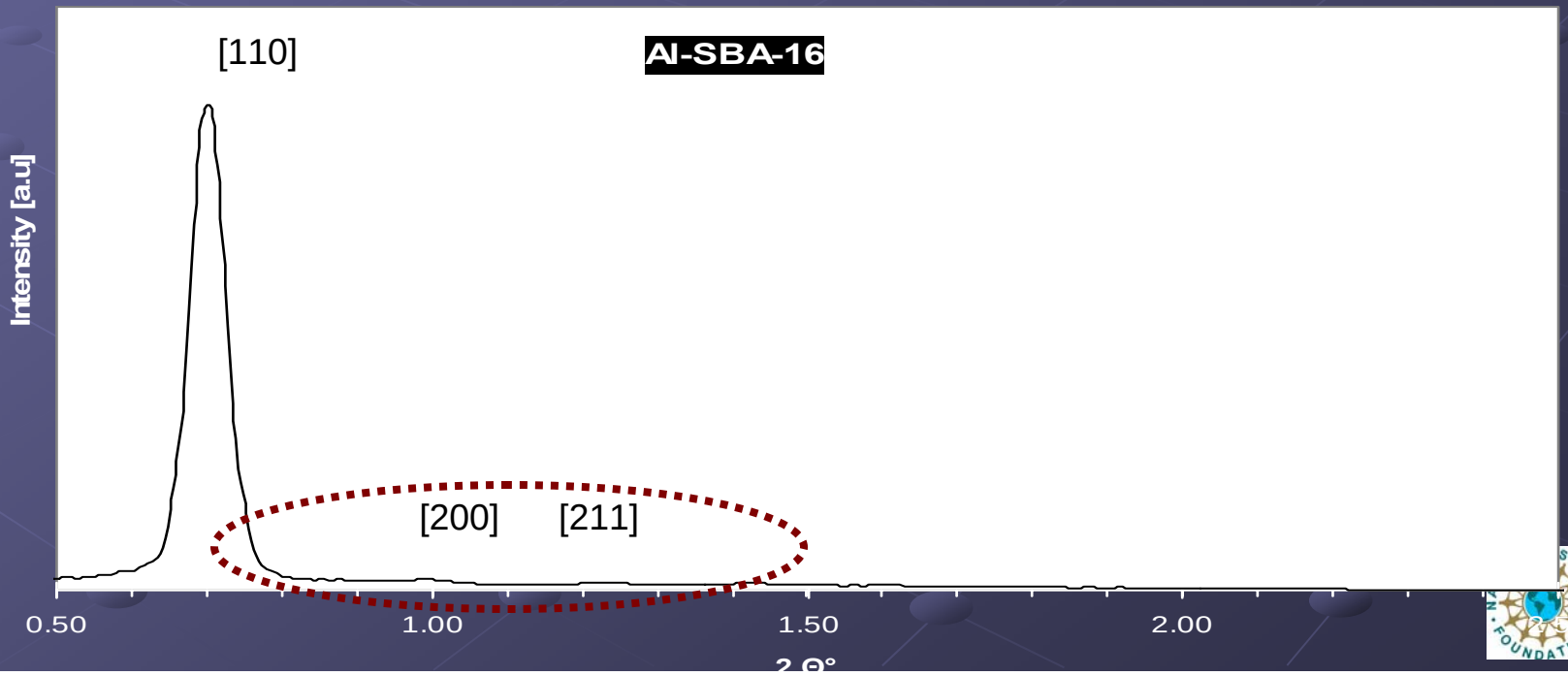
^{27}Al Nuclear Magnetic Resonance (NMR)

- Used to determine nature of aluminum present in SBA-16
- Gives quantitative information about percentage of tetrahedral and octahedral aluminum

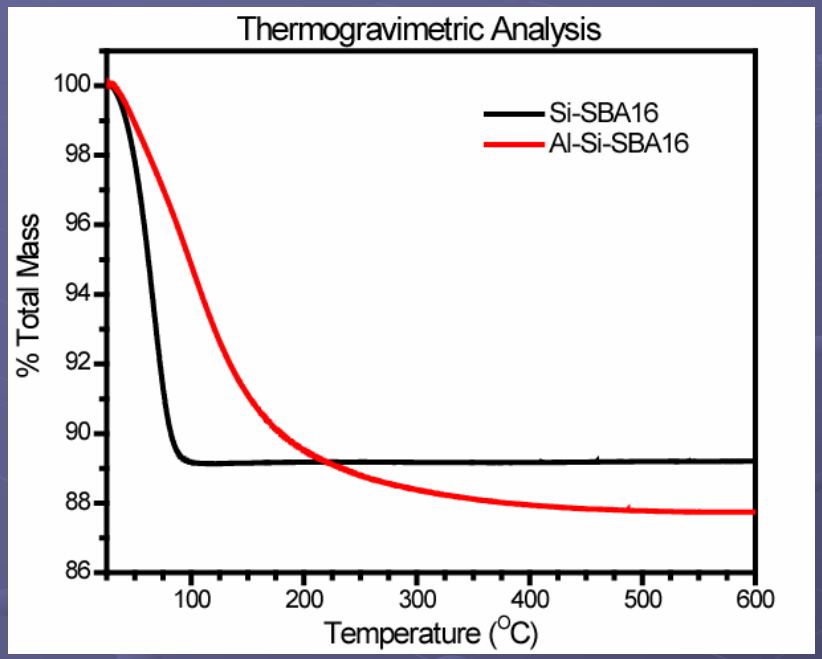


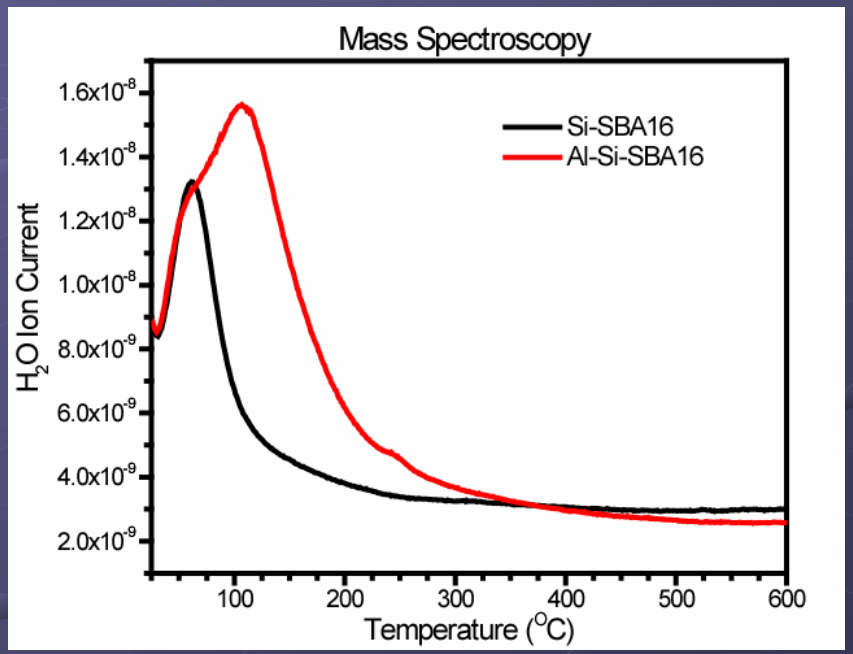
Challenges

- The reaction is producing tetrahedrally coordinated aluminum with high Al/Si molar ratios at 60°C and 6 hrs
- At these conditions the SBA-16 mesostructural ordering decreases slightly



Do the membranes retain water at high temperatures (> 80° C)?





- SBA-16 dehydrates completely at 80° C, similar to nafion
- Aluminum containing SBA-16 retains over 50% of its water at 110 °C, and doesn't completely dehydrate until about 250 °C
- These water retentions at temperatures greater then 110 °C are promising for high temperature fuel cells

Conclusions and Future Research

- Hypothesis of tetrahedral Al incorporation to improve water retention in SBA-16 is proven correct
- Optimum Aluminum grafting conditions are 60 °C for 6 hours
- Currently adjusting pH of the reaction solution to decrease damage of mesostructural order in SBA-16 materials
- Future work includes grafting sulfonic acid groups into these Al-SBA-16 materials and testing proton conductivity

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