Development of Advanced High Temperature Fuel Cell Membranes

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Objectives

- Develop a polymer electrolyte membrane (PEM) with stability at operating temperatures up to 150ºC
  - Synthesize aromatic polymers bearing flexible perfluorinated side chains with sulfonic acid end groups
  - Confirm polymer stability by thermal analysis
  - Provide polymers to Case Western Reserve University (CWRU) for evaluation

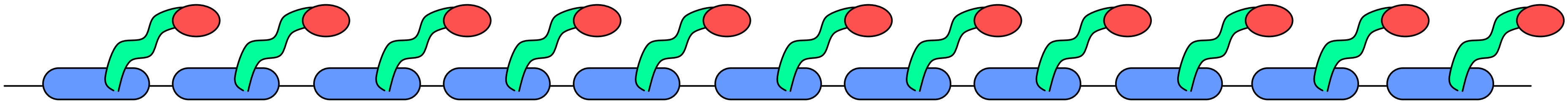
Budget

- Total funding: $85K

Technical Barriers and Targets

- DOE Technical Barriers for Fuel Cell Components
  - O. Stack Material and Manufacturing Cost
  - P. Durability
  - Q. Electrode Performance
  - R. Thermal and Water Management
- DOE Technical Target for Fuel Cell Stack System for 2010
  - Cost $35/kW
  - Durability >5000 hours

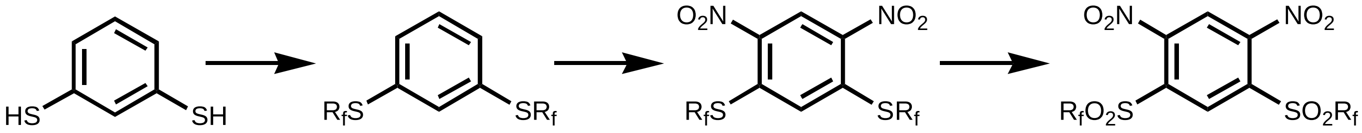
Approach

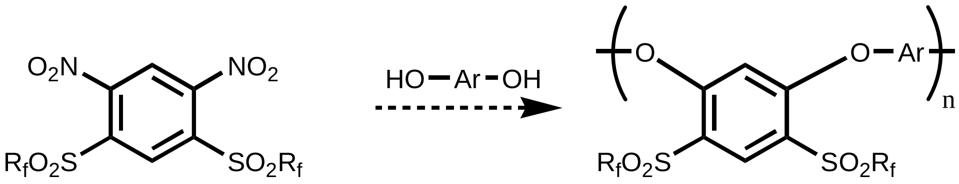


- Synthesis of new monomers
  - Aromatic repeat for rigid, stable backbone
  - Flexible perfluorinated spacer for aggregation and chemical stability; initial modeling shows 4-6 repeats ideal
  - Perfluoroalkyl sulfonic acid end groups for conductivity
- Polymer synthesis
  - Polyethers, polyetherketones, polyethersulfones, polycarbonates, polysulfides, polybenzimidazoles, and/or polybenzoxazoles for chemical and thermal stability
- Membrane characterization
  - Membranes will be supplied to Prof. Tom Zawodzinski at CWRU for characterization

First Approach

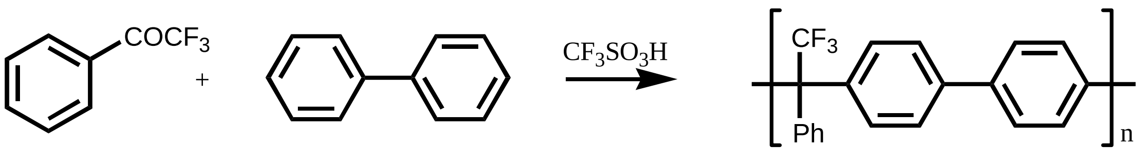
- Nucleophilic Polymerization.
  - Would give a high concentration of sulfonic acid groups.

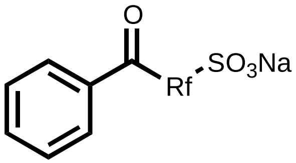


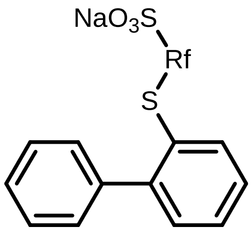


Next Approach

- Now concentrating on monomers for a Friedel-Crafts polymerization.
  - Gives a thermally stable polymer.
  - It is possible to modify either component.



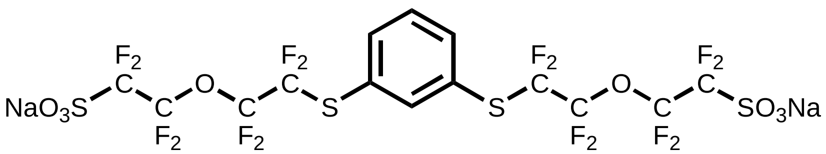




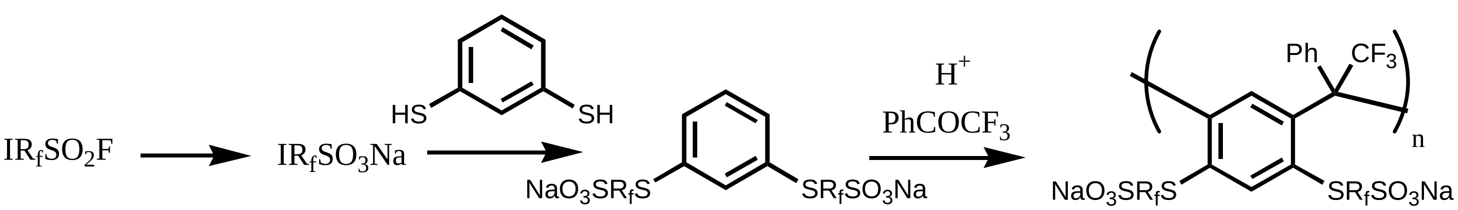
M. Zolotukhin, et al., *Chem. Comm.* 1030 (2004)

Technical Accomplishments/Progress

- Monomer synthesized.



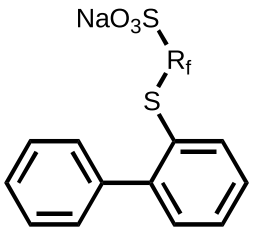
- Polymerization with trifluoroacetophenone gives a water soluble polymer.



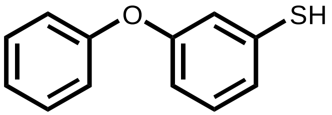
$R_f = CF_2CF_2OCF_2CF_2$

Progress

- Next monomer and a precursor to a third monomer synthesized.



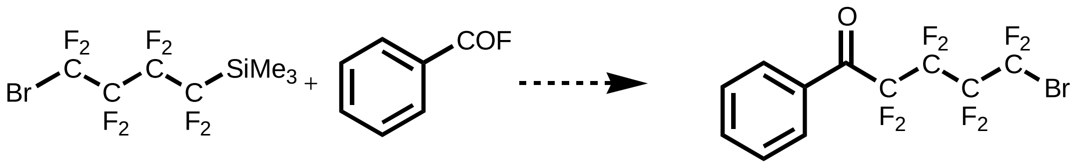
$R_f = CF_2CF_2OCF_2CF_2$



Technical Accomplishments/Progress

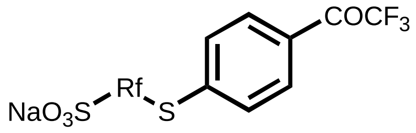
- Successfully differentiated the ends of a dibromoperfluoroalkane.

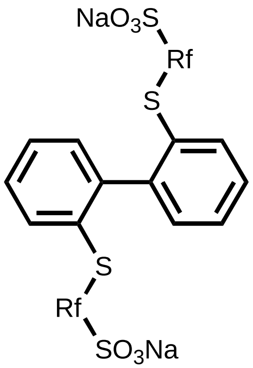
  - We will attempt to use it to synthesize a perfluorinated ketone.

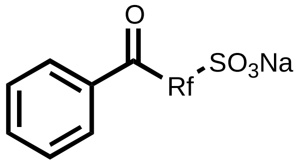


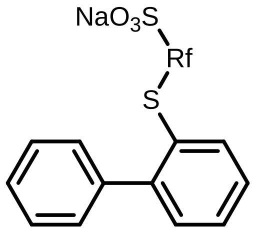
Future Plans

- Optimize polymerization.
- Incorporate other sulfonic acids.

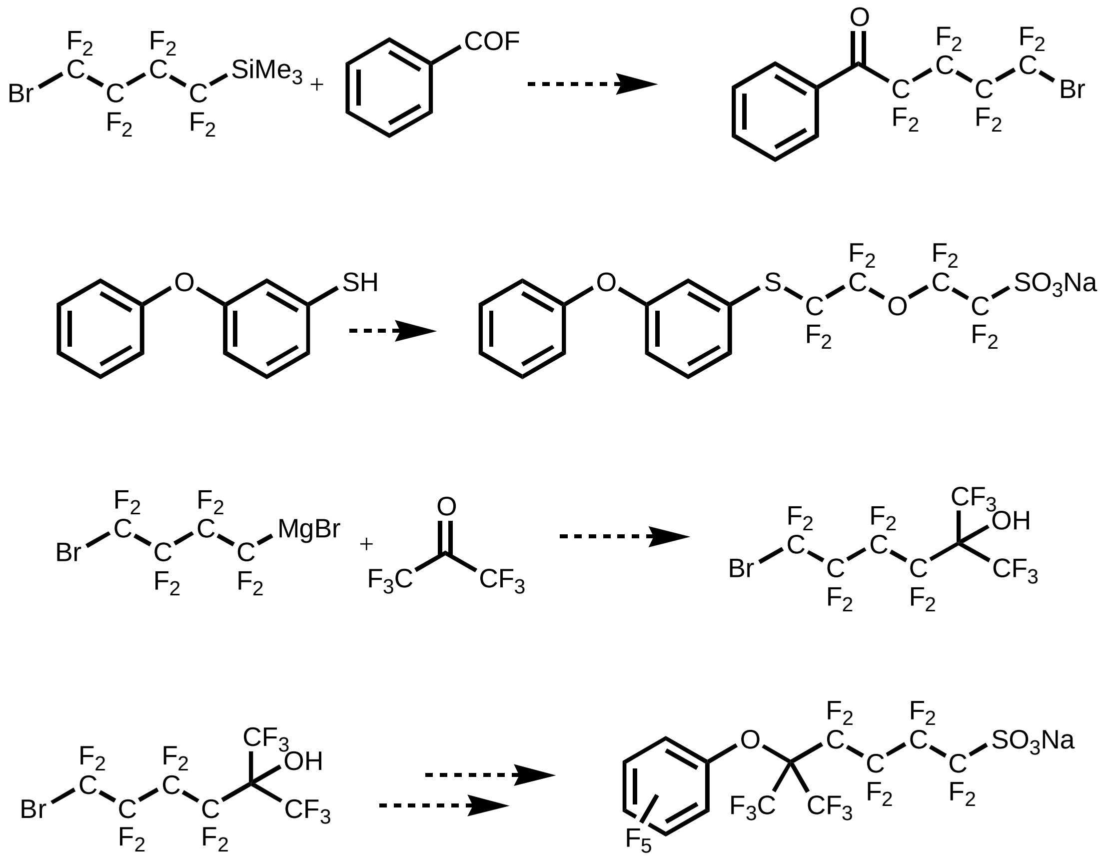








Synthetic Schemes



Interactions and Collaborations

- Membranes will be supplied to Prof. Tom Zawodzinski at CWRU for detailed characterization
- Researchers at China Lake will collaborate with the other program investigators whenever possible to maximize possibility for success

Future Work

- Monomer synthesis
- Polymer synthesis
- Membrane preparation
- Deliver membranes to CWRU for characterization

Acknowledgements

- Justine Debord
  - Post Doc.
- DOE Hydrogen Program

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