Comb Shaped Anion Conductive Ionomer Films for Electrochemical Energy Storage Devices

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Introduction

US Energy Demand is predicted to increase 56% by 2040

Sustainable renewable energy is the optimum choice when there is an increase in energy due to the exponential use of information technology devices.

Membrane-based electrochemical devices have great potential

Overall Goal: Study the structure-property relationships of a series of comb shaped AEM and their applicability for electrochemical devices

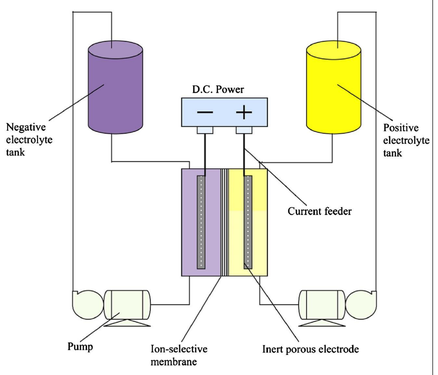
Examples: Vanadium Redox Flow Battery, Fuel cells etc.

Vanadium Redox Flow Battery (VRB)

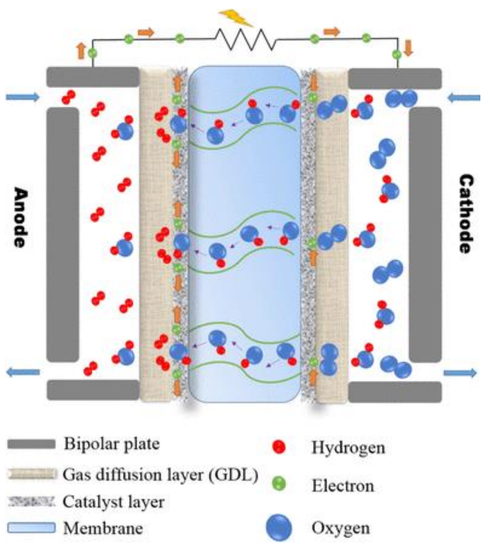
An electrochemical system which stores energy in two solutions comprising of different redox couples: V^{2+} and V^{3+}

Ion selective membrane commonly made from Nafion, a type of polymer with excellent chemical and thermochemical properties

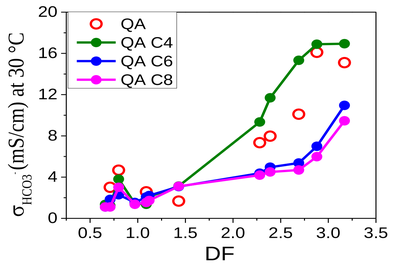
Drawbacks of Nafion: High cost, environmental drawbacks, only operate at 80 degrees Celsius [2]



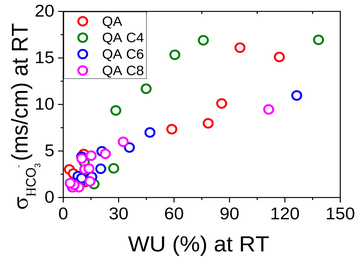
Anion Exchange Membrane Fuel Cell (AEM)



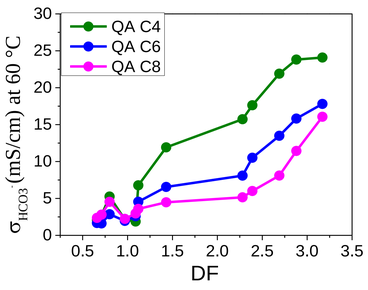
Results



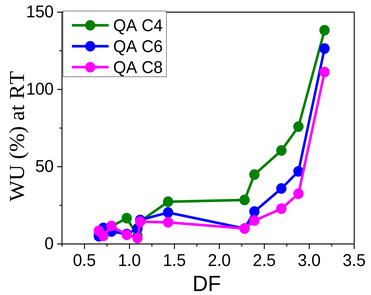
Conductivity at 30 degrees Celsius

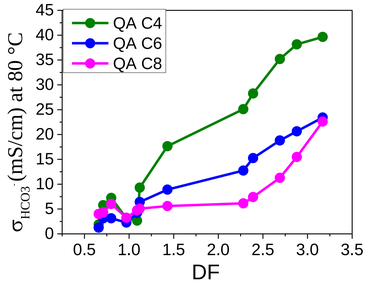


Conductivity vs WU

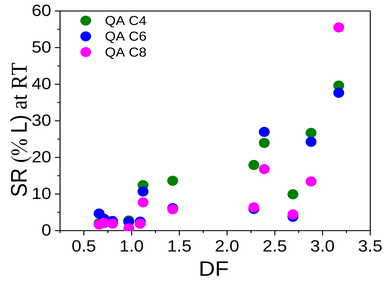


Conductivity at 60 degrees Celsius

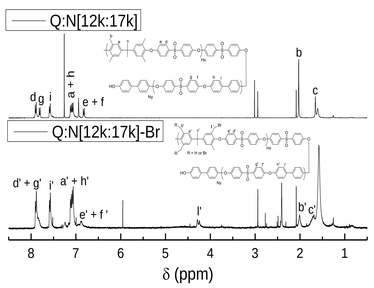




Conductivity at 80 degrees Celsius



Swelling Ratio



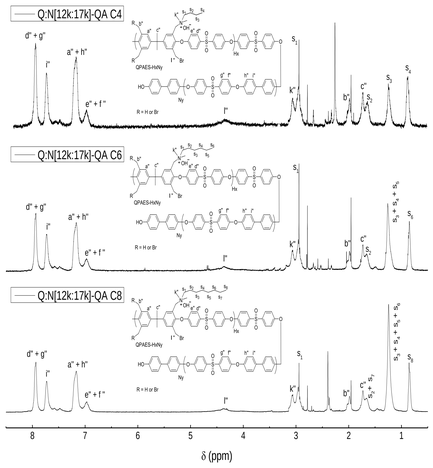
^{1}H NMR 12k-17k

^{1}H NMR 12k-17k-Brominated

^{1}H NMR 12k-17k C4 side chain

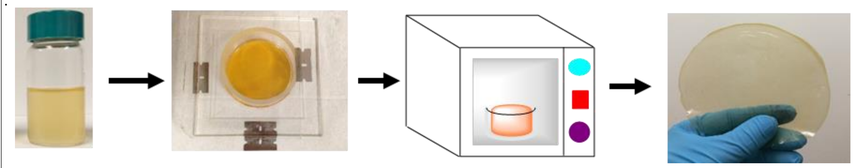
^{1}H NMR 12k-17k C6 side chain

^{1}H NMR 12k-17k C8 side chain



Film Fabrication

1) Dissolve 0.5 g brominated polymer in 15 mL Dimethylacetamide
2) Mix 1-2 mL of amine in a separate solution containing 5 mL DMAc
3) Add amine solution dropwise to brominated polymer solution
4) Cast film at 50 degrees Celsius in a high vacuum oven
5) Soak the film in 0.5 M NaOH solution for 48 hours
6) Rinse and soak in deionized water for 48 hours



DMAc/ QA chain + DMAc / H:N[x:y]

Casting on glass plate

Vacuum drying At 50 °C

H:N[x:y] - QA Cn Film

Conclusion

- A series of comb shaped AEM with varying side chain length was formed
- ^{1}H NMR was used to confirm the structure and measure the DF
- In general, conductivity, water uptake, and swelling increased with DF
- AEM with side chain exhibited much higher conductivity than QA AEMS
- A maximum conductivity of 40 mS/cm was observed at 80 ^{0}C AEM with different side chains showed increasing WU and SR with DF

Future Work

- Prepare AEM with C2, C10,C12,C16, and C18 side chains
- Explore structure-property relationships of AEMs with C2, C10, C12, C16, and C18 side chains
- Test different side chains on an actual fuel cell and VRB

References

1. Iojoiu et al.: *Mastering Sulfonation of Aromatic Polysulfones: Crucial for Membranes for Fuel Cell Application*
2. A. Parasuraman et al. *Review of material research and development for vanadium redox flow battery applications* Electrochimica Acta *101 (2013)*
3. J. Electrochem. Soc. **2015** vol. 162 no. 14 **F1504-F1539**

Acknowledgements

- Nebraska Center for Energy Sciences Research (NCESR)
- Dr. Chris Cornelius and C^2 lab

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