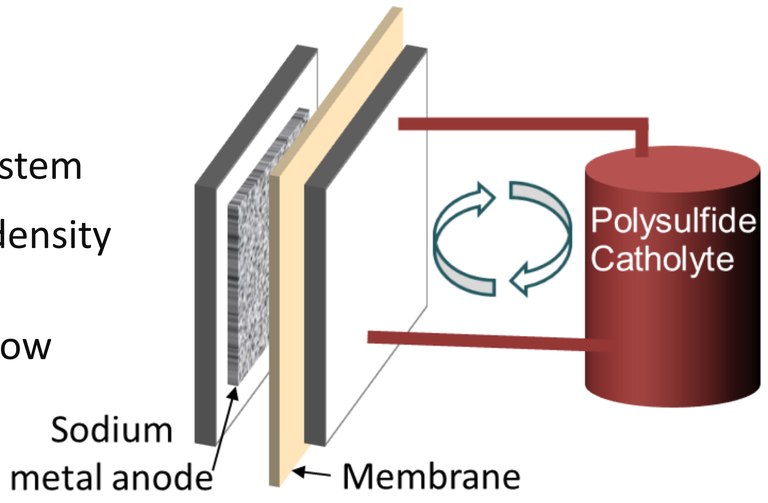
Design of Cost-Effective, Mechanically Robust Membranes for Sodium Polysulfide Hybrid Redox Flow Battery

Michelle Lehmann[1], Wenda Wu[1], Mohamed Kamaludeen[2] Tomonori Saito[1], and Guang Yang[1] (PI)
[1]Chemical Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830
[2]U.S. DOE Office of Electricity, Washington, DC 20585

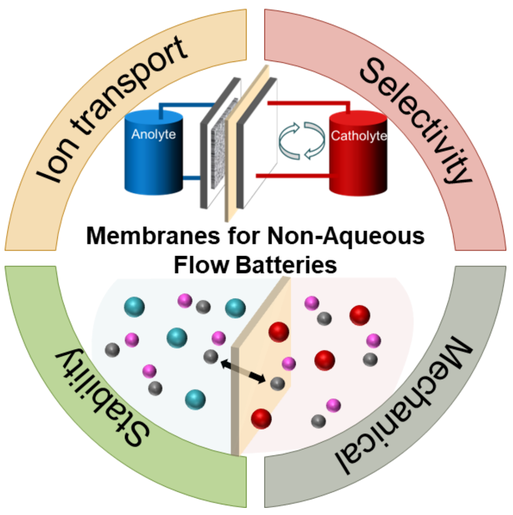
Introduction

Redox flow battery:
Na/Polysulfide Hybrid system

- High specific energy density
- Non-aqueous – high electrochemical window



- Low-cost high-performance membranes are still a major bottleneck in increasing TRL of non-aqueous RFBs

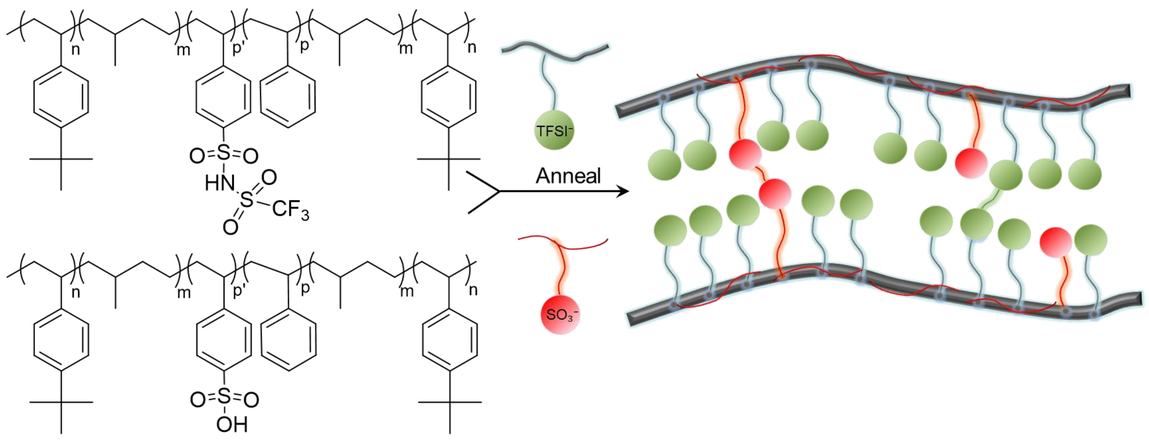


- ✓Thin (low resistance)
- ✓Low electrolyte uptake
- ✓Mechanically robust
- ✓High selectivity
- ✓High ionic conductivity
- ✓Excellent chemical and electrochemical stability

Our goal is to develop low-cost hydrocarbon-based membranes with improved selectivity, stability and Na^+ conductivity. Additionally, we aim to gain a greater understanding of the factors that influence crossover, uptake, and stability in non-aqueous systems.

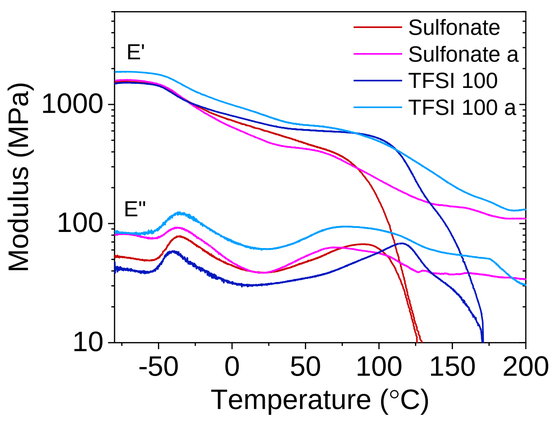
Nexar Pentablock Copolymer

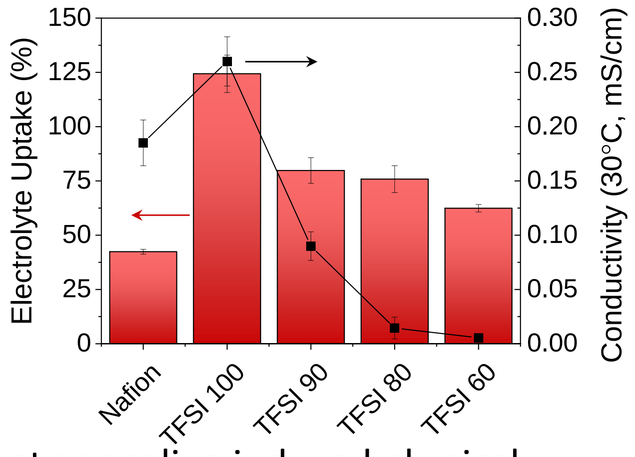
Method



- Sulfonate polymer is brittle with very low uptake
- TFSI polymer has too high electrolyte uptake
- Create blend of the two polymers to optimize membrane properties
- Anneal to induce crosslinking to further reduce uptake

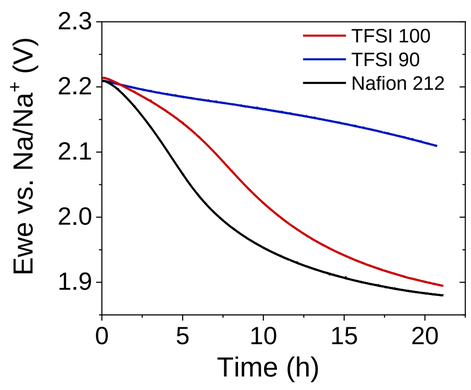
Thermal Properties and Conductivity



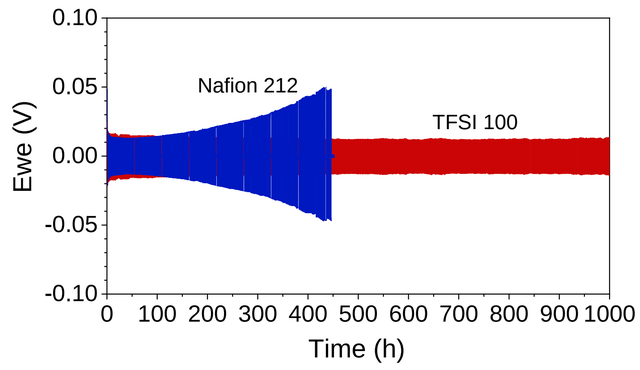


- DMA provides confirmation that annealing induced physical crosslinking
- Addition of sulfonate polymer to the TFSI version decreases uptake but also significantly reduces conductivity

Na-polysulfide full cell

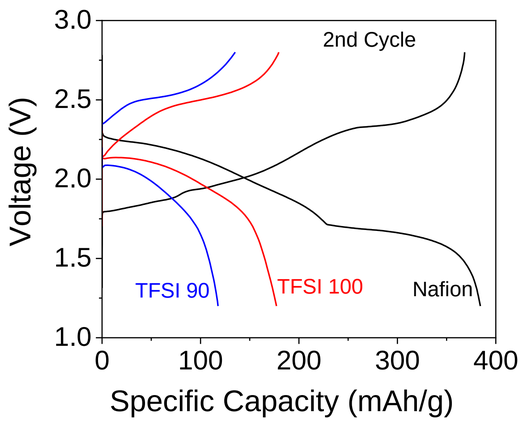


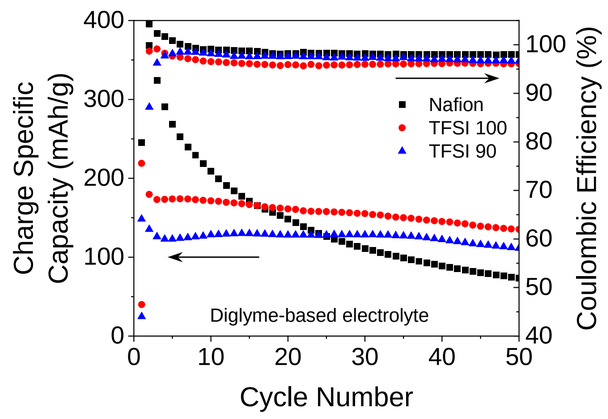
Na symmetric cell



Nexar hydrocarbon membranes

- Better selectivity for polysulfides compared to Nafion
- Improved electrochemical stability against Na metal





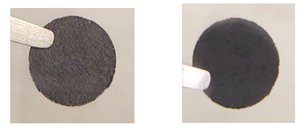
Nexar hydrocarbon membranes

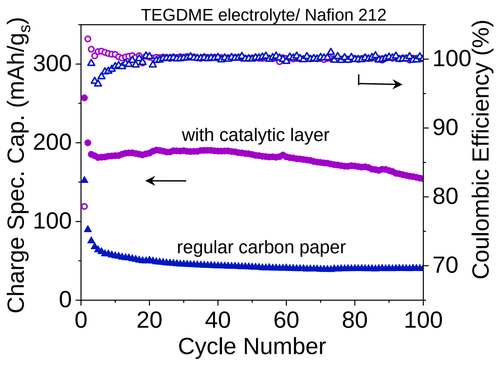
- Exhibit lower initial capacity than Nafion but significantly improved cycling stability
- The severe capacity decay is partly due to the absence of lower order polysulfides which can precipitate on Na metal

Conclusions/On-going Work

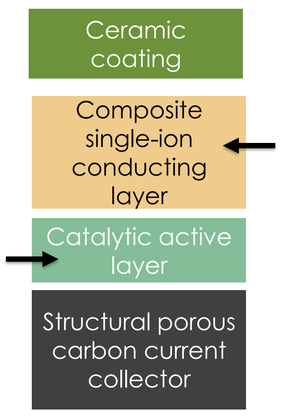
- TFSI moiety greatly enhances Na^+ conductivity, while sulfonate moiety appears to inhibit conductivity in Nexar-based membranes
- Membrane and solvent selection greatly influences long-term cycling stability

Addition of catalytic layer on carbon paper

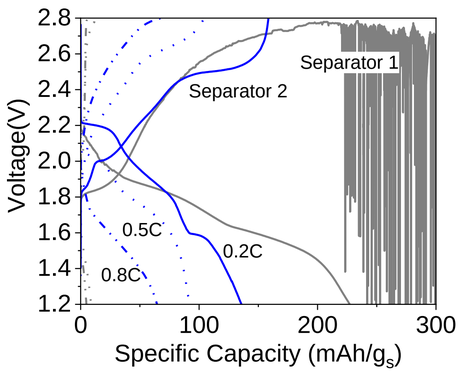


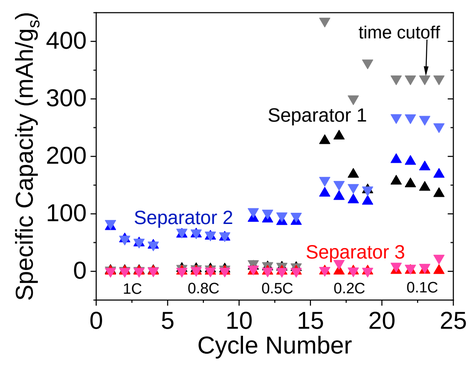


MEA



Screening of porous support layer





- Utilize commercially available, low-cost base polymers and supports
- Further develop composite/ layered cell for improved capacity

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Collaborators: Prof. David Mitlin (UT Austin) and Prof. Nian Liu (GIT)

References

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