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Elucidating Molecular Transport through Membranes in Flow Batteries

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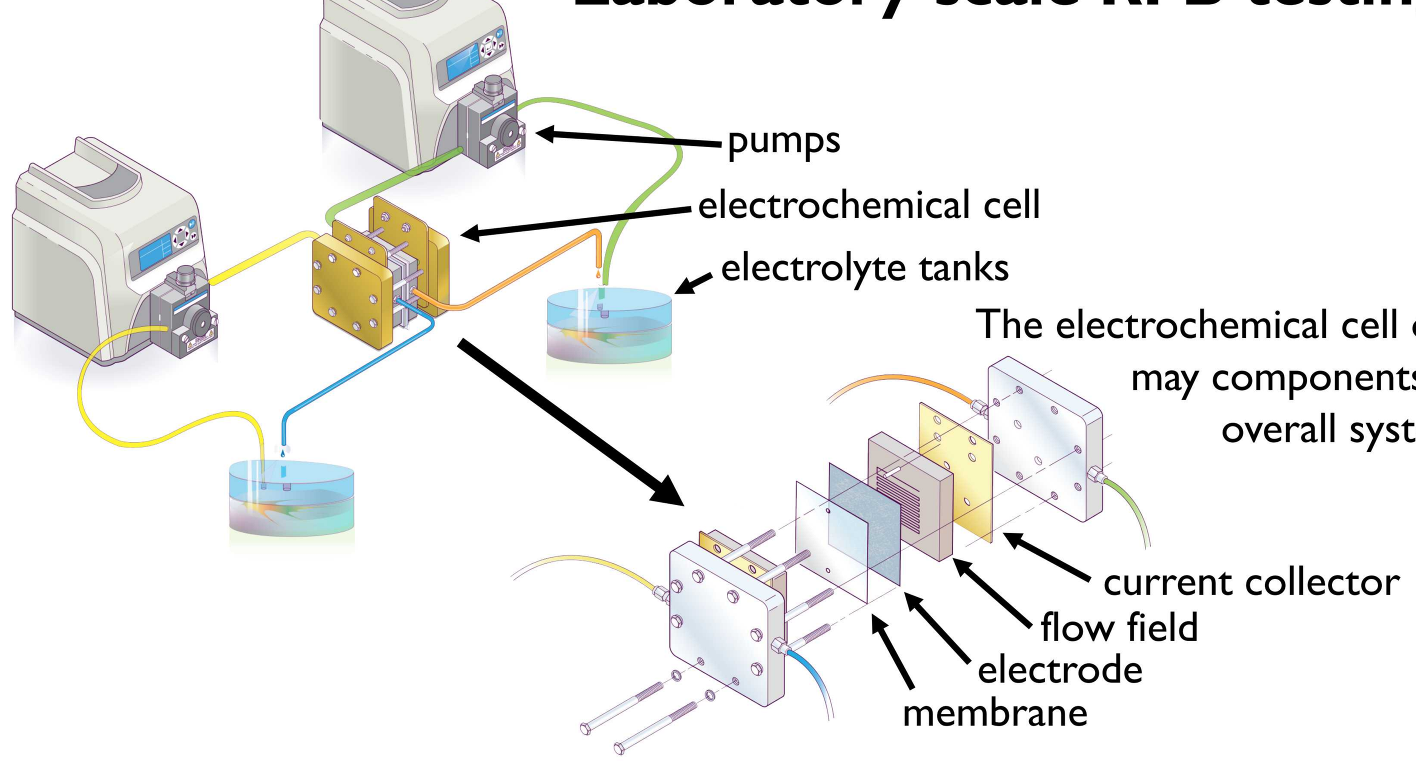
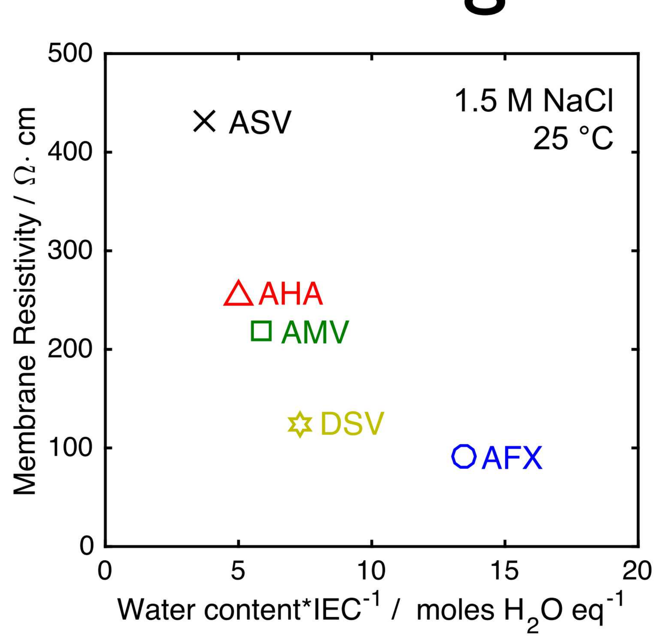
Redox flow batteries (RFBs) offer a readily scalable solution to grid scale energy storage. Understanding ion transport through RFBs enables design of more efficient, longer-lasting RFBs. Here we leveraged previously explored concepts of ion crossover in RFBs to identify key membrane properties in aqueous systems and use this knowledge to improve a higher voltage nonaqueous system.

Laboratory-scale RFB testing



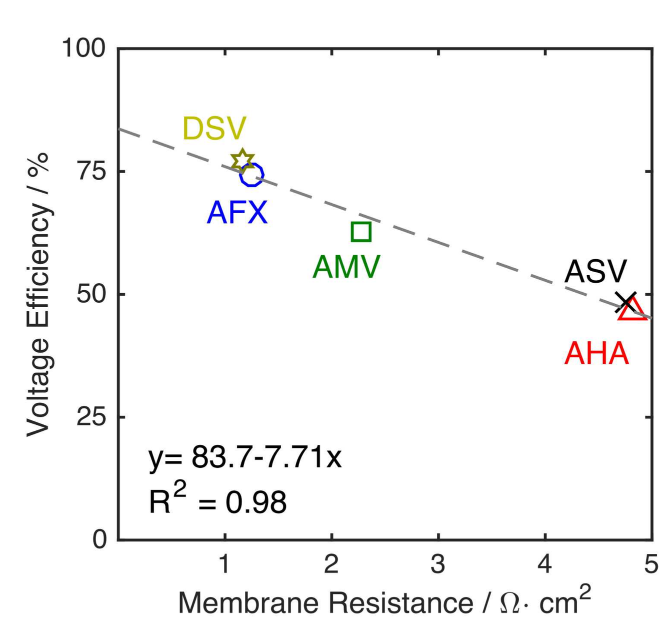
The electrochemical cell of a RFB contains may components, each integral to overall system performance.

Membranes for Aqueous Soluble Organic Flow Batteries



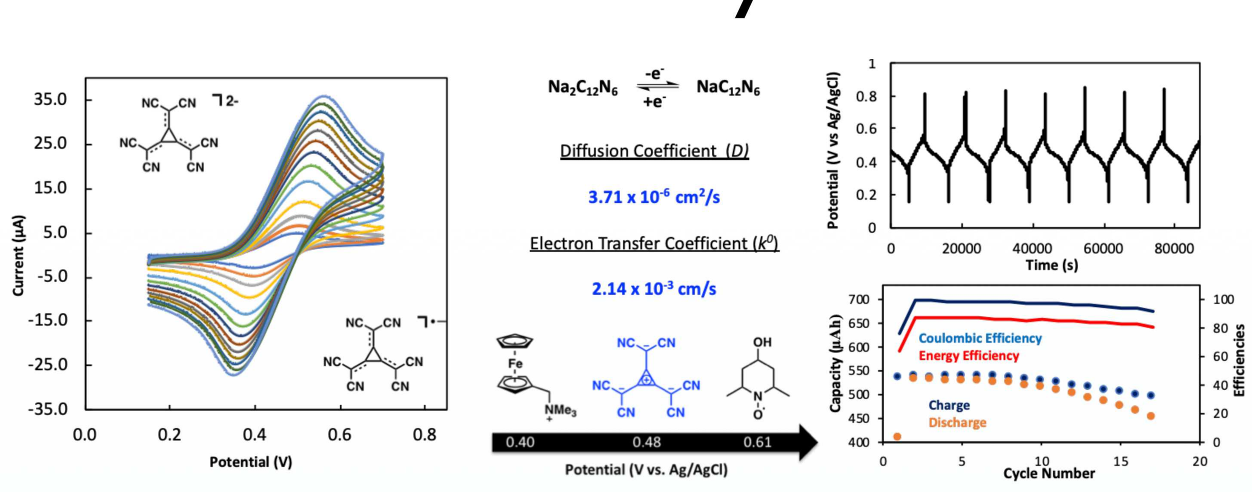
Across several commercial membrane chemistries we observe a systematic trend that membrane resistivity is controlled by the ratio of membrane water content to ion exchange content (IEC).

In turn, the membrane resistance is linearly related to the flow battery voltage efficiency, even after 100 cycles



L.J. Small, H.D. Pratt, T.M. Anderson. *J. Electrochem. Soc.* **166** A2536-A2542 (2019).

University Collaborators

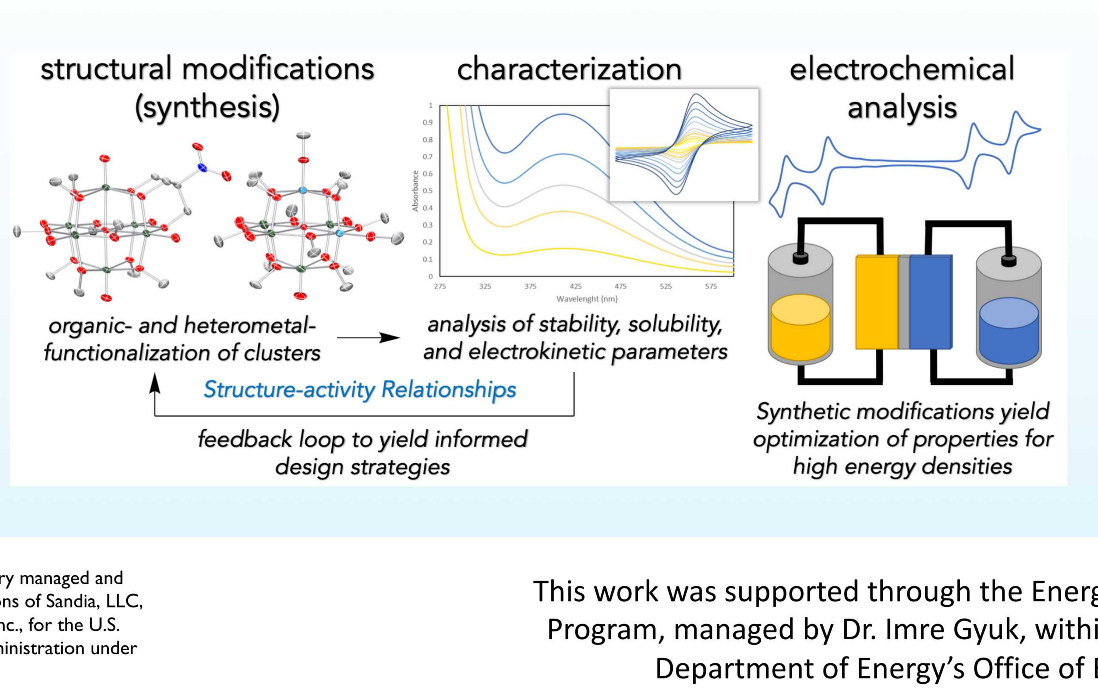


Radialene Radicals for Active Species in RFBs

Prof. Christopher Bejger
UNC Charlotte

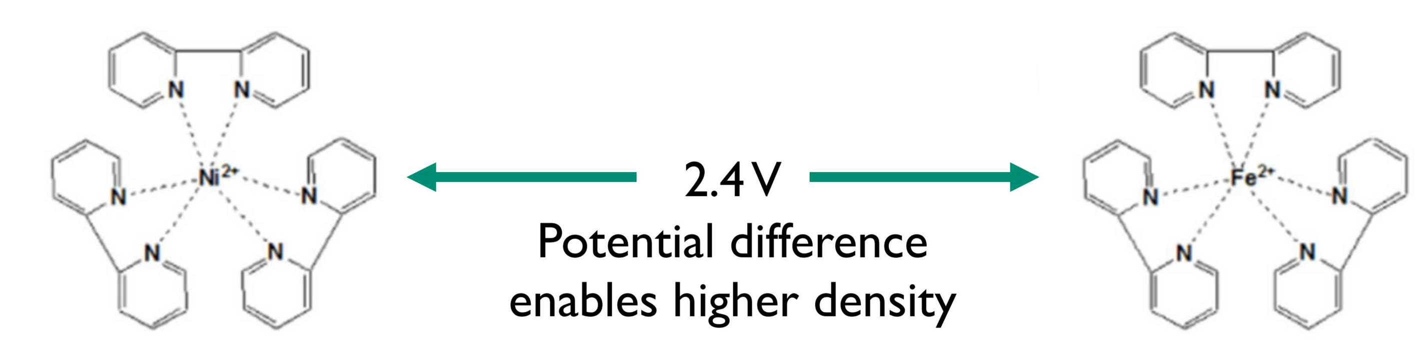
Metal-oxide Clusters as Charge Carriers for RFBs

Prof. Ellen M. Matson
Univ. Rochester



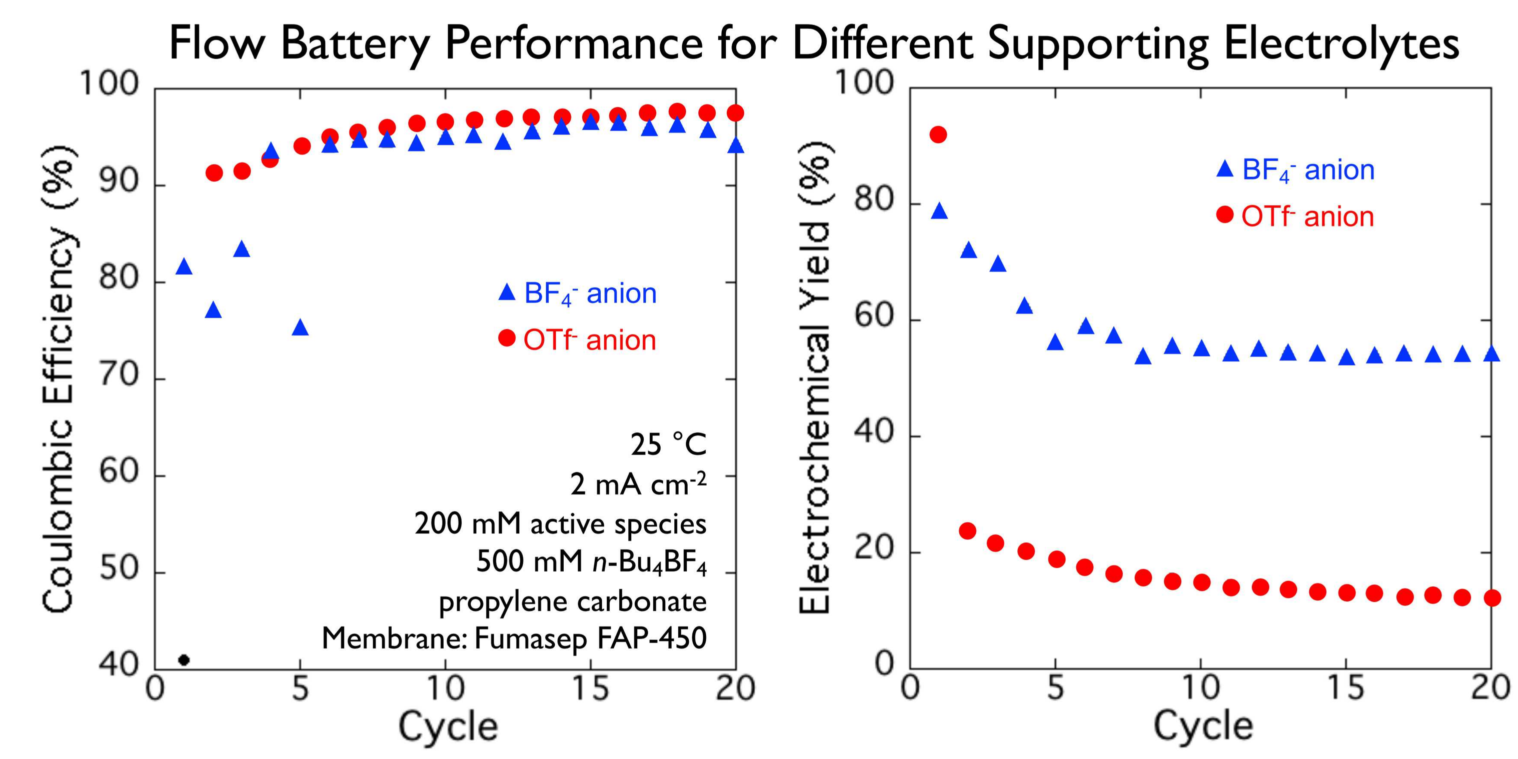
Nonaqueous Metal-Bipyridine Complexes

RFBs in nonaqueous solvents offer the advantage of higher operating potentials than aqueous systems, but are often hindered by solvent membrane-interactions. We investigated the effects of different solvents and salts on RFB performance, using a metal-bipyridine redox pair and Fumasep anion exchange membrane.

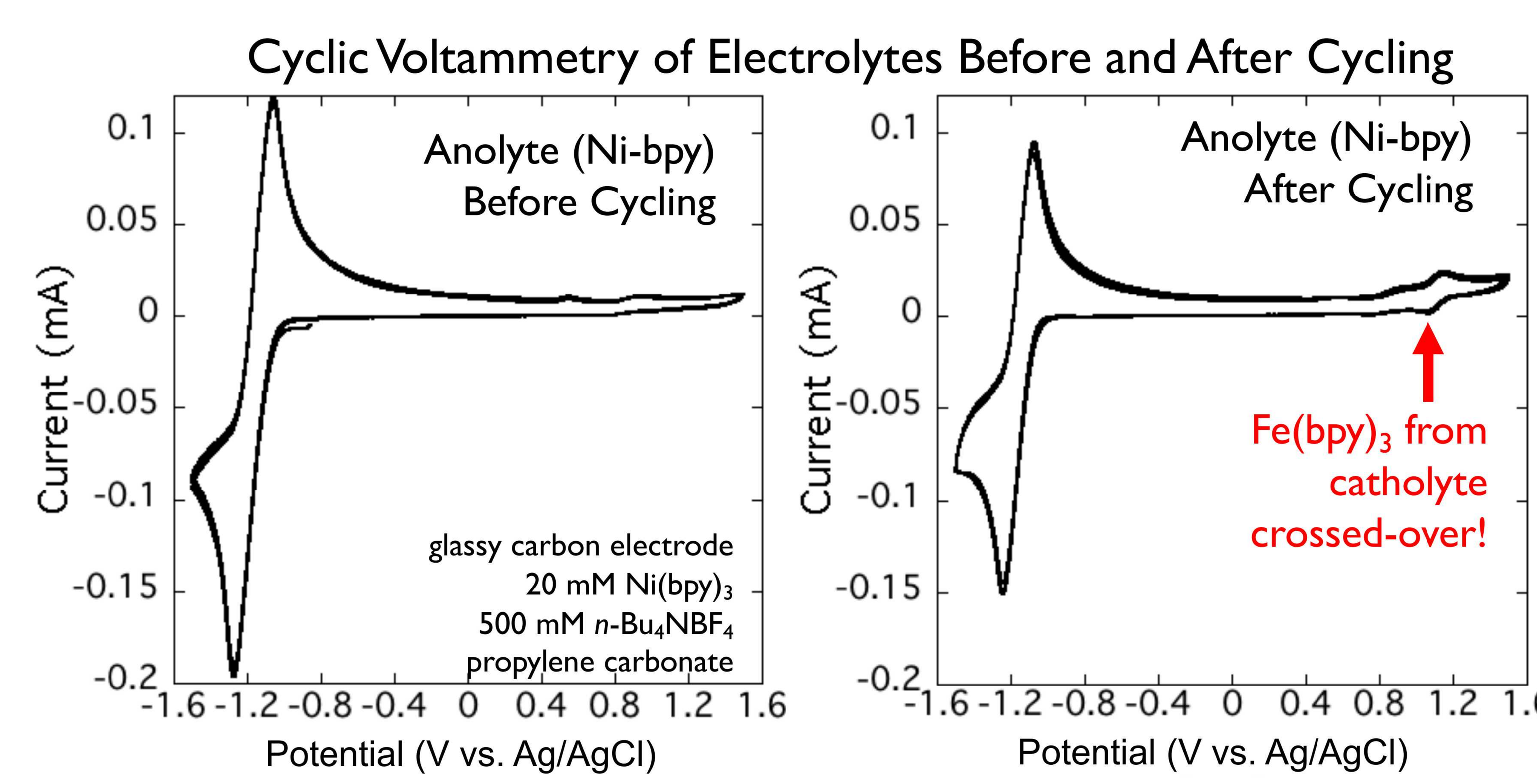


$Ni^0 \leftrightarrow Ni^{2+} + 2e^-$ $\quad$ $Fe^{2+} \leftrightarrow Fe^{3+} + e^-$

Junyoung Mun et al. *J. Electrochem. Soc.* **165** A215-A219 (2018).
Hudak et al. *J. Electrochem. Soc.* **162** A2188-A2194 (2015).



Use of triflate (OTf⁻) anion resulted in significant capacity loss vs. BF_4^- anion. Similarly, propylene carbonate performed better than acetonitrile.



Future Work

- How does cation vs. anion size influence bipyridine RFB performance?
    - Measure diffusion coefficients of bipyridine complex in different supporting salts
    - Membrane resistance / RFB voltage efficiency
    - Supporting salt solubility effects
- Identify, understand, and minimize capacity decay mechanisms in nonaqueous RFB
- Test new membranes from Cy Fujimoto (SNL) in aqueous and nonaqueous environments.

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