Enabling Long Duration Metal Hybrid Redox Flow Batteries

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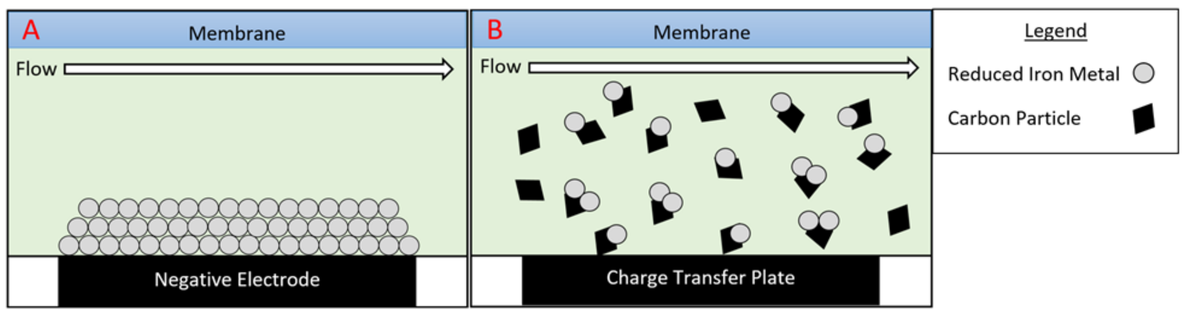
Approach and Objectives

Approach:

- **Negative Couples Based on Iron and Zinc Plating/Stripping**
- **Carbon Slurry Electrodes to De-couple Energy and Power**

Objectives:

- **Improve our understanding of carbon slurry flow behavior**
- **Demonstrate an advanced slurry flow battery**
- **Develop additives and understand their mechanistic behavior for suppressing hydrogen evolution on Zn and Fe**



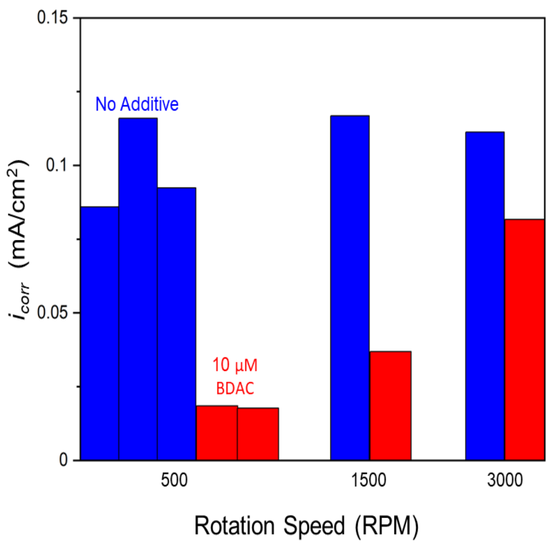
Impact on the DOE Energy Storage Mission

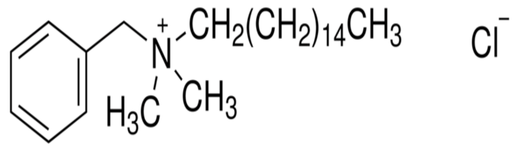
If successful, this program will…

- **Demonstrate a long duration (>10 hr) energy storage capability**
  - **based on earth abundant, low-cost materials**
  - **with independently scalable energy and power**
  - **safe, non-flammable battery chemistry**
  - **plated metal stored on dispersed carbon particles**
  - **minimal corrosion to allow for long duration storage**
- **Improve grid resilience**
- **Enhance the adoption of renewable energy generation**
- **Provide energy solutions for disenfranchised communities**
- **Educate the next generation of engineers and scientists in electrochemical energy storage technologies**

Additives for Zinc Plating

Zinc hybrid flow batteries have exceptional energy density. However, preventing zinc dendrites and zinc corrosion are active areas of research

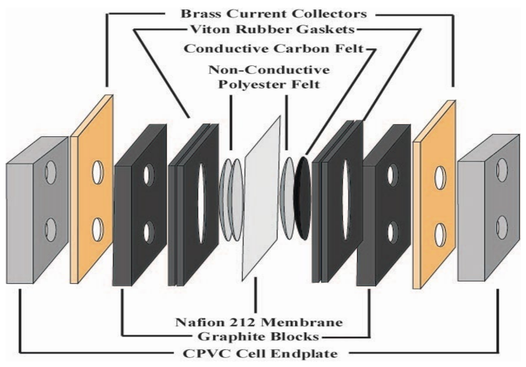


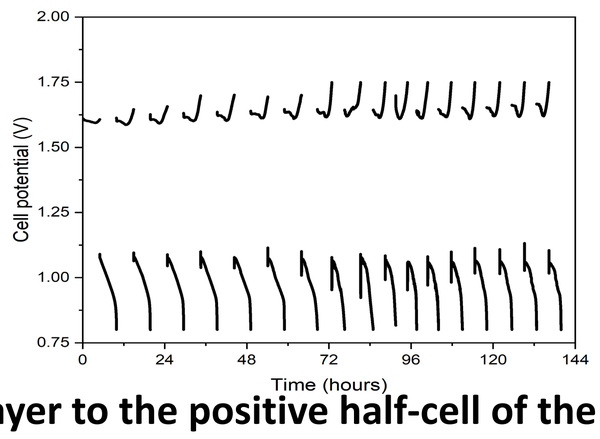


Benzyldimethylhexadecylammonium Chloride (BDAC)

- **Strongly suppresses Zn corrosion in near neutral acidic electrolytes**
- **BDAC suppresses corrosion while not inhibiting Zn deposition/ stripping**

Zinc Hybrid Optimization with Non-Conductive Felt





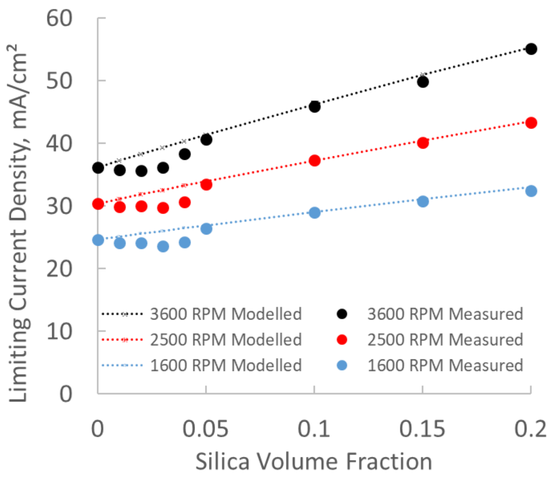
By adding a non-conductive felt layer to the positive half-cell of the Zinc-Iodine hybrid flow battery, this allowed:

- **Higher plating capacity**
- **Prevention of electrical shorts caused by dendrites**
- **4.8-hour charge/discharge cycles at 100 mA cm^{-2}**
  - **Substantially exceeds literature values**

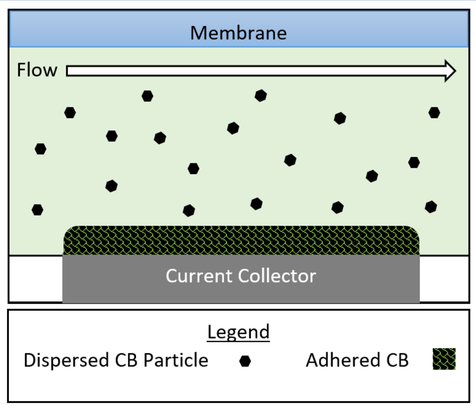
Mass Transfer Enhancement by Slurry Particles

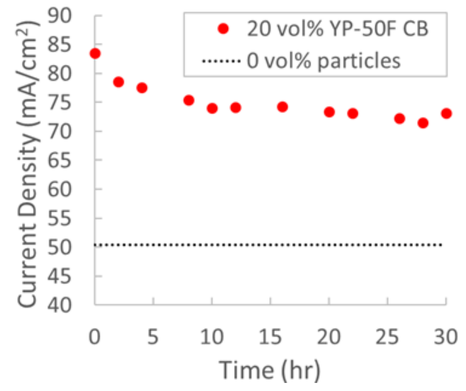
- **Ionic mass transfer is enhanced with increased slurry particle volume fraction in flowing electrolytes**
- **Additional shear regions between flowing particles creates enhanced convection**
- **A modified Levich Equation was developed to describe this enhanced transport in an RDE cell:**

$$i_l = 0.62nFC\omega^{1/2}\nu^{-1/6}(D + r^2\Phi\omega^m)^{2/3}$$



Accumulation of Adhered Slurry Particles





- **High surface area, low conductivity carbon black particles can adhere & accumulate on the graphite current collector over time**
- **This accumulated layer inhibits mass transfer**
- **This accumulation is undesirable in an actual flow battery, as it encourages metal deposition in the cell, limiting scalability**

Deliverables

1) **"Ionic Diffusion in Slurry Electrolytes for Redox Flow Batteries" submitted to J. Eletrochem. Soc.**
2) **"Considerations for Ionic Diffusion in Slurry Electrolytes for Redox Flow Batteries" Presented at the 243rd Electrochemical Society Meeting**
3) **"A Zinc-Iodine Hybrid Flow Battery with Enhanced Energy Storage Capacity" submitted to J. Power Sources**
4) **"Potential-Dependent BDAC Adsorption on Zinc Enabling 'Selective' Suppression of Zinc Corrosion for Energy Storage Applications" manuscript in preparation**

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