

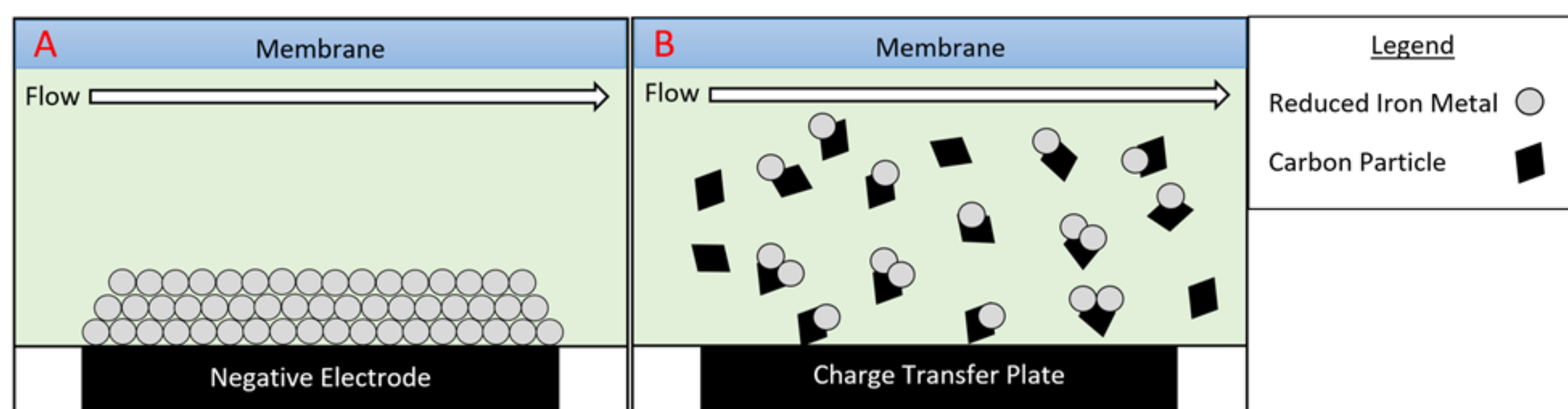
Approach and Objectives

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...

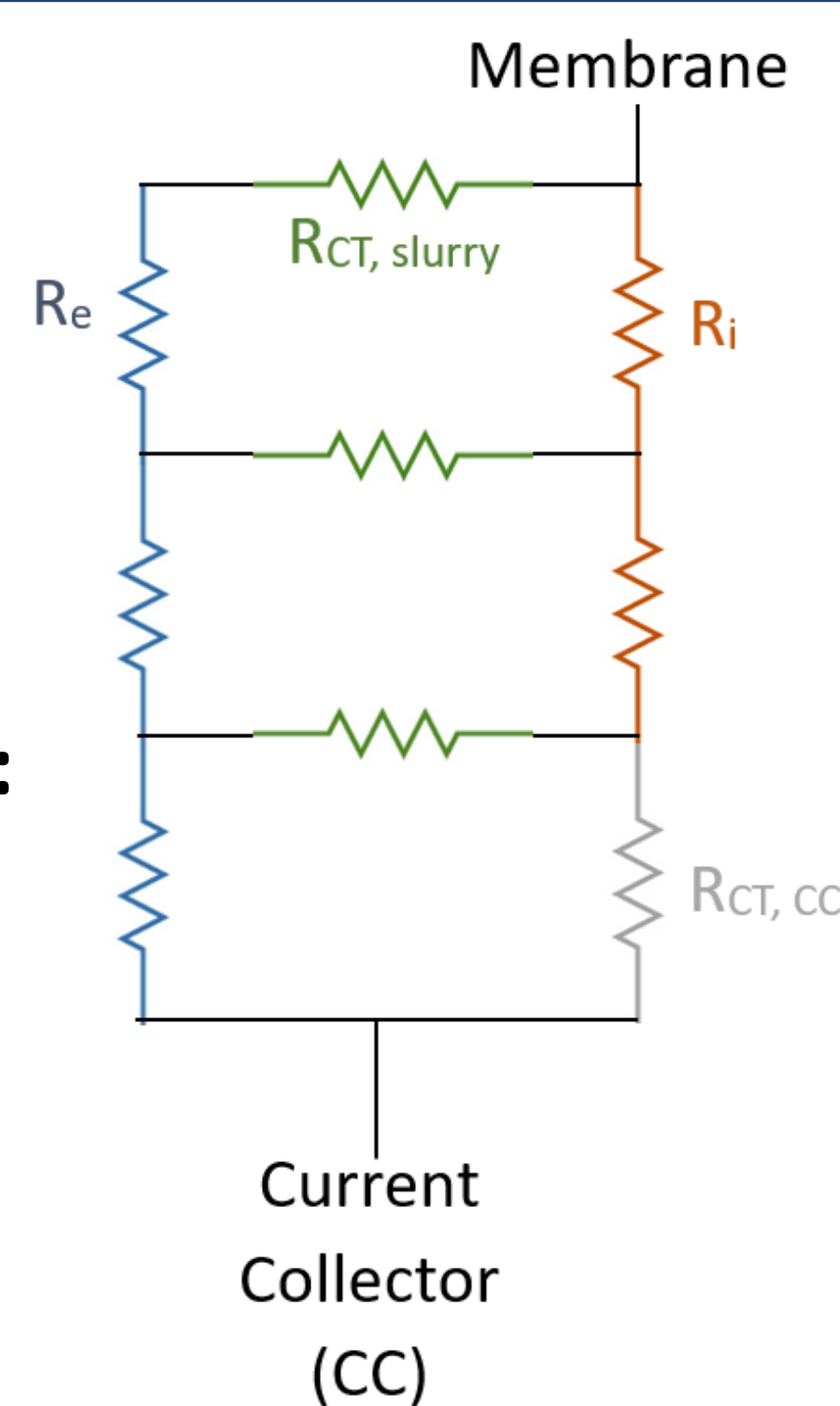
- Demonstrate a long duration (>10 hr) energy storage capability
 - based on earth abundant, low-cost materials
 - with independently scalable energy and power
 - safe, non-flammable battery chemistry
 - plated metal stored on dispersed carbon particles
 - minimal corrosion to allow for long duration 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

Controlling Current Distribution in Slurry-RFB's

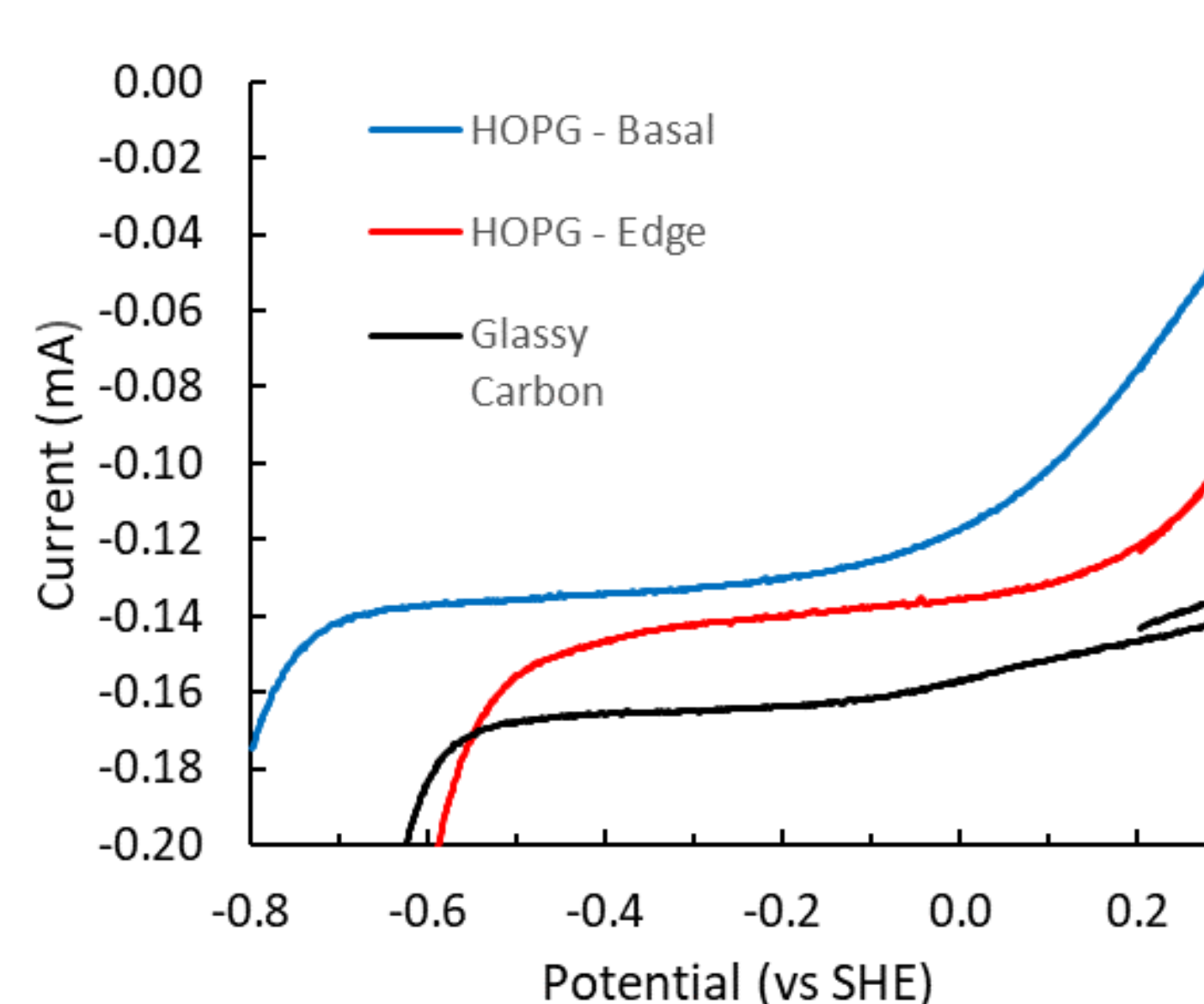
To decouple power and storage capacity in hybrid RFB, the metal deposition current must be on the slurry, rather than on the current collector.

The current distribution for metal deposition in slurry electrodes is dependent on many factors:

- Slurry Electrode Electrical Conductivity
- Electrolyte Ionic Conductivity
- Deposition Kinetics on the Slurry
- Deposition Kinetics on the Current Collector



Varying Iron Deposition Onset Potentials per Surface



Iron deposition onset potentials per surface (vs. SHE):

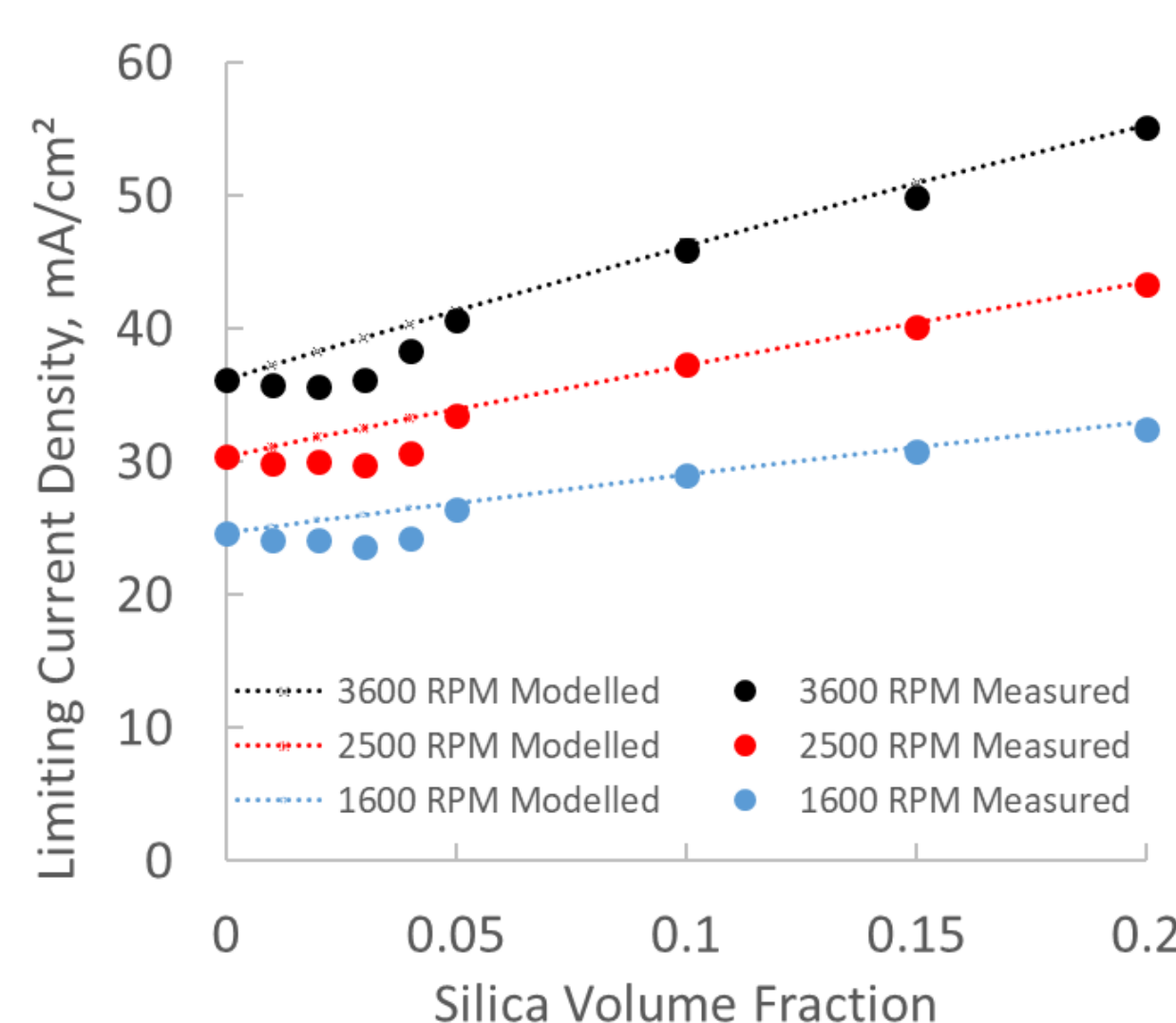
- Iron (lit.) -0.44V
- HOPG, Basal -0.71V
- HOPG, Edge -0.46V
- Glassy Carbon -0.56V

In the -0.56 to -0.46 V (vs. SHE) range, iron will deposit on a Graphite surface, but not on a Glassy Carbon surface.

By using a Glassy Carbon current collector, the metal deposition current may favor the slurry to an extreme degree within that potential range.

Mass Transfer Enhancement by Slurry Particles

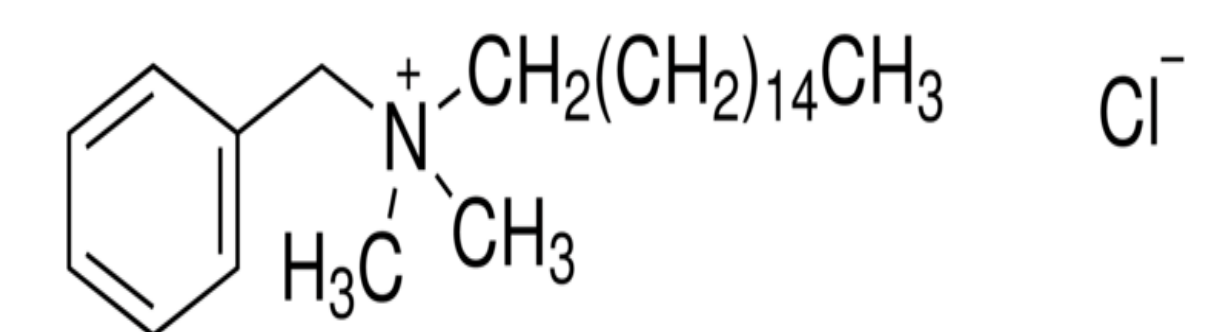
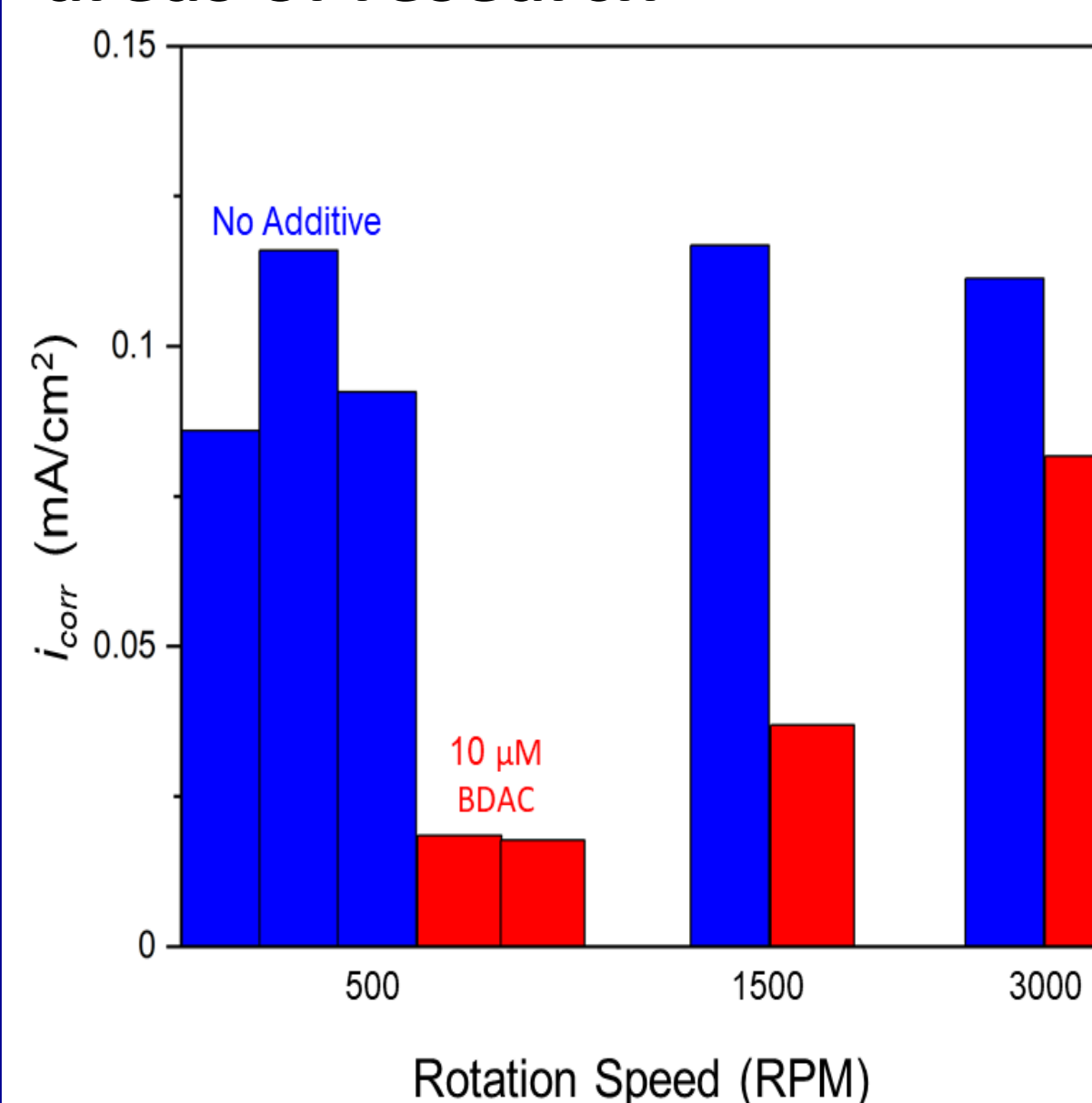
- Ionic mass transfer is enhanced with increased slurry particle volume fraction in flowing electrolytes
- Additional shear regions between flowing particles creates enhanced convection
- A modified Levich Equation was developed to describe this enhanced transport in an RDE cell:



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

Additives for Zinc Plating

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



Benzyltrimethylhexadecylammonium Chloride (BDAC)

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

Deliverables

- Published in 2023 in the Journal of the Electrochemical Society
 - "Ionic Diffusion in Slurry Electrolytes for Redox Flow Batteries"
 - "Potential-Dependent BDAC Adsorption on Zinc Enabling Selective Suppression of Zinc Corrosion for Energy Storage Applications"
- Presented at the 245th Meeting of the Electrochemical Society
 - "Controlling Current Distribution in Slurry Electrolytes for Redox Flow Batteries"
 - "Potential-Dependent BDAC Adsorption on Zinc Enabling 'Selective' Suppression of Zinc Corrosion for Energy Storage Applications"

Acknowledgements

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