Iron Based Flow Batteries for Low Cost Grid Level Energy Storage

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**Purpose**

Develop efficient, cost-effective grid level storage capability based on iron.

**Goals of this Effort:**
- Minimize Cost/Watt by increasing current density - Hardware Cost >> Electrolyte Cost
- Minimize Cost/Whr by increasing plating capacity
- Maximize Efficiency by minimizing current lost to hydrogen evolution

**Electrochemistry of the all-Iron system:**

Positive: \( \text{Fe}^{+2} \leftrightarrow \text{Fe}^{+3} + 0.77V \)

Negative: \( \text{Fe}^{+2} \leftrightarrow \text{Fe}^{0} - 0.44V \)

Cell: \( 3\text{Fe}^{+2} \leftrightarrow \text{Fe}^{0} + 2\text{Fe}^{+3} + 1.21V \)

**Impact on Iron Based Batteries on the DOE OE Energy Storage Mission**

Widespread grid level storage will require:
- Low Cost
  - All-Fe battery uses one low cost active element and inexpensive separators
- Environmental Acceptability
  - Mild pH, non-toxic electrolyte
- Geographic Flexibility
  - Iron is readily available from domestic sources

**Research Plan**

Year 1: COMPLETE
- Ligand Screening – demonstrated \([\text{Fe}^{+3}] >0.5M \ @ \text{pH}>2\)
- \(\text{H}_2\) evolution suppression – effect of pH, anions evaluated

Year 2: IN PROGRESS
- Effect of Ligands on Fe plating efficiency, morphology
- Separator studies – \(\text{Fe}^{+3}\), Ligand crossover

Year 3:
- Optimization of plating capacity, current density to maximize efficiency
- Scale up from 50 cm\(^2\) to 250 cm\(^2\)

**Recent Results**

- **Demonstrated**
  - Adherent, Stress-Free, Dendrite-Free Plating
  - Deposit Thickness
  - Shown is Equivalent to 75 mAh/cm\(^2\)
  - Deposits up to 150 mAh/cm\(^2\) have been made

- **Demonstrated**
  - Coulombic Efficiency >99% for Iron Plating
  - \(T = 60C\)

- **Measurement and model of Fe+3 crossover**
  - Room Temperature
  - Daramic Separator
  - Equivalent to 0.5% Capacity Loss in 24 hrs with Electrolyte Circulating

- **Measurement and model of Fe(II)/Fe(III) Overpotentials**
  - Negligible Kinetic Loss
  - Ohmic and Mass Transfer Overpotentials
  - Total Overpotential <20 mV @ 0.1 A/cm\(^2\)

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