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Comparative Study of Electrolytes in All-Iron Redox Flow Batteries: Enhancing Efficiency and Affordability for Sustainable Energy Storage Systems

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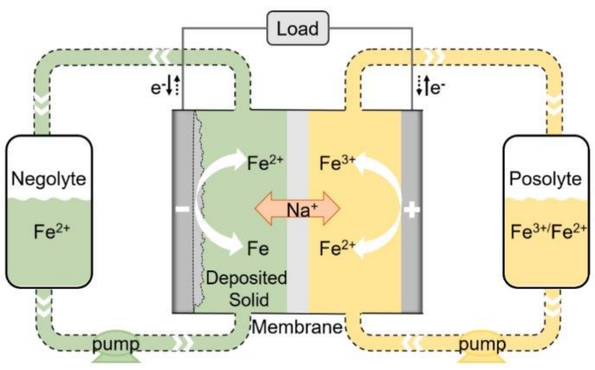
Abstract

All-Iron Redox Flow Batteries (AIFBs) offer a scalable and cost-effective solution for grid-scale energy storage. They are seen as promising alternatives to vanadium-based systems, which face cost and supply challenges. A key issue for AIFBs is dendrite formation on the anode side. The optimisation of electrolytes in AIFBs is focused on decreasing hydrogen generation side reactions and reducing dendrite formation to improve the battery efficiency [1],[2]. All-soluble AIFBs with iron-based organic complexes, such as Fe-gluconate and Fe-(BIS-TRIS), have shown remarkable advantages, such as high stability, high Coulombic/energy efficiency and low capital cost without forming precipitation[3],[4]. This poster presents recent advances and initial electrochemistry test results of cost-effective and high-performance electrolytes utilised for all-soluble AIFBs.

All-Iron Redox Flow Battery

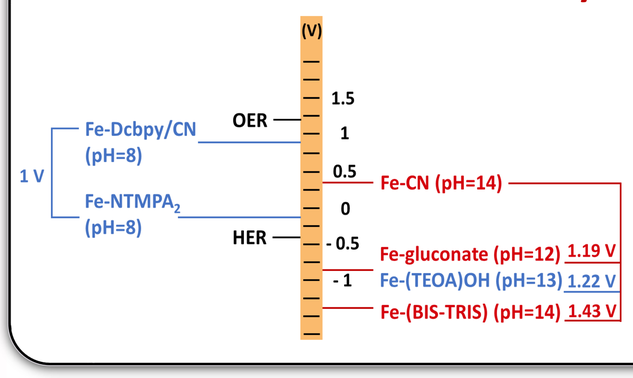


Traditional all-iron redox flow battery [5]

All-iron redox flow battery:

- ✓ **Advantages:** Low chemical toxicity and material costs
- x **Disadvantages:** Side reaction of hydrogen evolution and solid Fe deposition
- ▶ Electrolyte study could tackle disadvantages

Selected Redox Pairs for electrolyte study



Fe-(BIS-TRIS) based AIFBs

Reaction: $Fe[(BIS\text{-}TRIS)]^{2-} \leftrightarrow Fe[(BIS\text{-}TRIS)]^{-} + e^{-}$

Coulombic efficiency: 99.8%

Energy efficiency: 73.2%

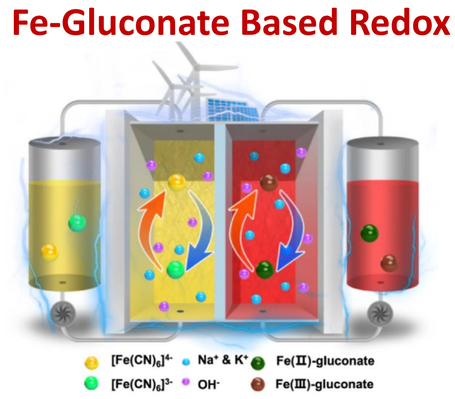
Fe-gluconate based AIFBs

Reaction: Fe^{2+}-gluconate $\leftrightarrow$ Fe^{3+}-gluconate + e^{-}

Coulombic efficiency: 99%

Energy efficiency: 83%[3-7]

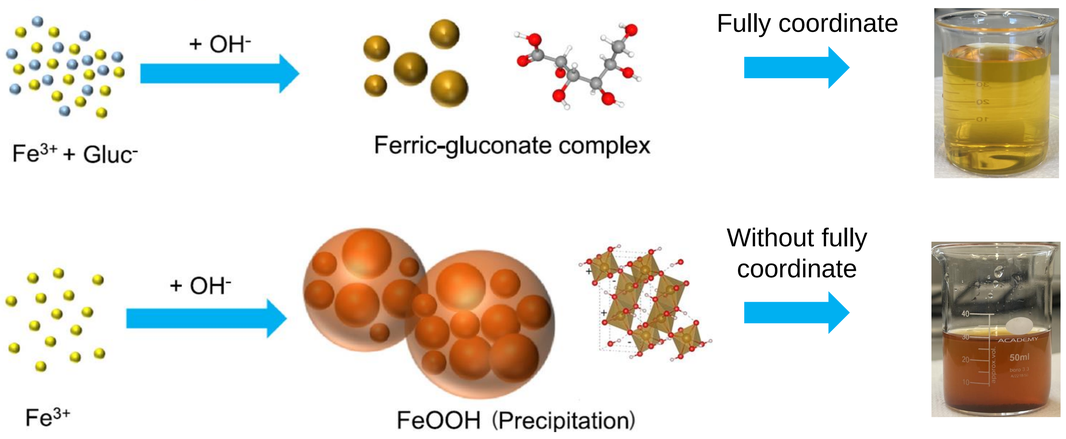
Fe-Gluconate Based Redox Flow Battery



All soluble redox couple: Stable all-soluble catholyte and anolyte without precipitation and hydrogen evolution

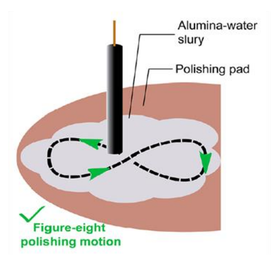
High-efficiency: High coulombic efficiency and energy efficiency

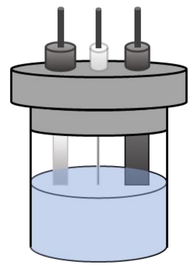
Low cost: Capital cost of £57.61/kWh based on a 10h system with a power of 9.9 kW[4]



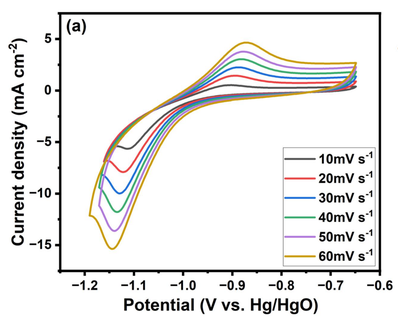
Methodology

Electrode polishing and cleaning[8] → Three-electrode system → Electrochemical test

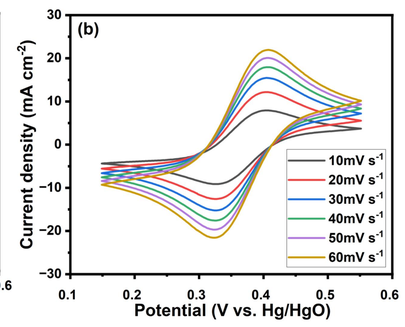




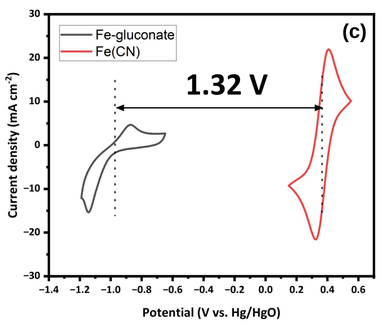
Electrochemistry Test Results



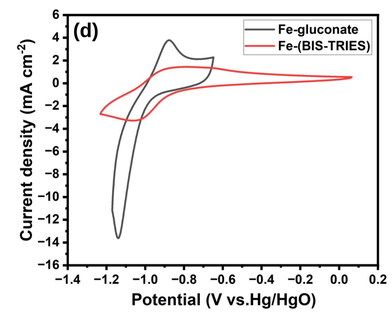
CVs of Fe-(gluconate) anolyte



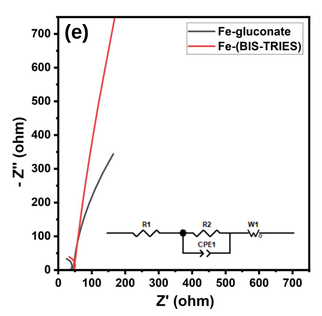
CVs of Fe(CN) catholyte



Cell potential obtained from CV test



Comparisons of CV between Fe-(gluconate) and Fe-(BIS-TRIS)



Comparisons of EIS between Fe-(gluconate) and Fe-(BIS-TRIS)

- Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) are used to analyse the electrochemical properties of electrolytes
- Fe-gluconate shows potential improvements in electrochemical activity compared to Fe-(BIS-TRIS)

Conclusion and Future Perspectives

This poster demonstrates recent advancements in the development of electrolyte studies in AIFBs. The utilisation of Fe-gluconate and Fe-(BIS-TRIS) as anode electrolytes has shown promising results in enhancing the efficiency of AIFBs. These all-soluble anolyte electrolytes also address key issues such as dendrite formation and hydrogen evolution in traditional AIFBs. Electrochemical tests indicate the potential for increased battery performance through electrolyte optimisation, paving the way for further research and development in the study of electrolytes for AIFBs.

References

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Acknowledgement

CASE Centre For Advanced Sustainable Energy

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