Final Project Report for the Energy Transition Program (WE Spark)











Electrolyte Additive for Aqueous Zinc-Ion Batteries

1 | Group Members and Contributions

Name: Lojain Aseeri

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Performed coin cell assembly, conducted electrochemical testing (GCD), carried out material characterization (XRD, SEM), analyzed data, integrated literature insights, and prepared poster and report.

2 | Project Mentor

Prof. Guanjie He (University College London)

Co-mentor: Peiming Chen (University College London)

3 | Project Objectives and Goals

- Investigate the role of electrolyte additives in suppressing dendrite growth and mitigating side reactions at the Zn anode.
- Study Zn^{2+} solvation shell structure modification by organic additives to improve reversibility and electrochemical stability.
- Fabricate Zn||Zn and Zn||Ti coin cells and evaluate their electrochemical behavior through GCD and CV.
- The Characterization of material (data analysis mostly):
  1. Understand and draw the GCD & CE curve.
  2. Plot the curves from the XRD of the cycled anode.
  3. Mark the SEM images of the cycled anode.

4 | Current Progress and Milestones Achieved

- Successfully fabricated Zn||Zn symmetric and Zn||Ti half cells.
- Conducted electrochemical evaluation of baseline $ZnSO_4$ electrolyte vs. $ZnSO_4$ with organic additive (cellobiose).
- Performed XRD analysis, showing enhanced crystallinity with additive.
- Obtained SEM images, revealing smoother morphology and reduced dendrite growth.
- Conducted soaking test, where Zn in additive-containing electrolyte showed reduced corrosion and passivation.

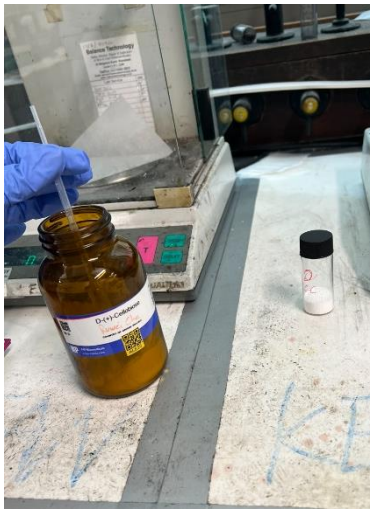
5 | Methodology and Approach

1. Cell Assembly: Zn||Zn symmetric cells for reversibility studies; Zn||Ti half cells for Coulombic efficiency evaluation.

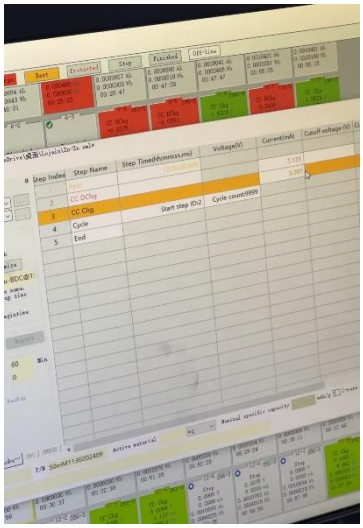
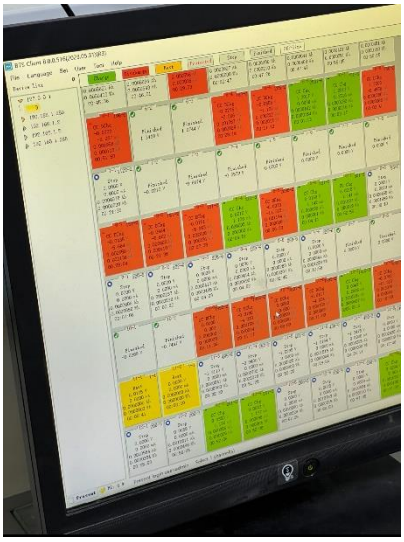




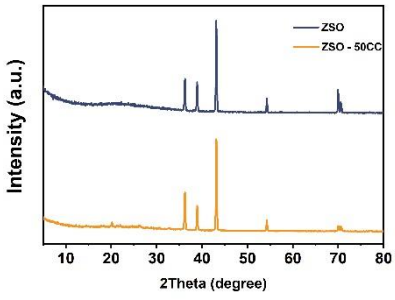

2. Electrolyte Preparation:
   - Control: 2M $ZnSO_4$ aqueous solution.
   - Modified: 2M $ZnSO_4$ + 50 mM cellobiose additive.

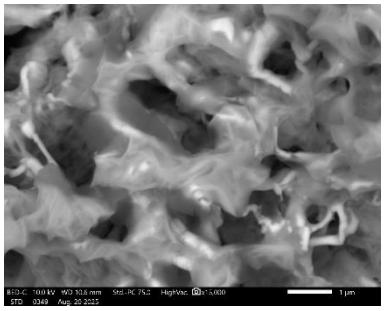



3. Electrochemical Testing:
    - GCD to evaluate reversibility and stability.
    - Coulombic efficiency and cycle life evaluation.

4. Characterization:
    - XRD: Analyzed structural changes and crystallinity.
    - SEM: Observed surface morphology post-cycling.
    - Soaking test: Visual check for corrosion/passivation.






6 | Preliminary Results and Findings

- Electrochemical performance: Cells with additive showed higher reversibility and Coulombic efficiency compared to control.
- XRD: Zn anodes cycled in additive-containing electrolyte exhibited sharper diffraction peaks, confirming improved crystallinity and absence of undesirable phases.
- SEM: Additive promoted uniform Zn deposition, with fewer dendritic structures and reduced by-product formation.

- Soaking tests: Zn samples in additive electrolyte displayed lower corrosion and thinner passivation layers.
- Literature-supported insights:
  - Additives adjust Zn^{2+} solvation environment by partially replacing water molecules, which reduces side reactions.
  - Hydroxyl-rich molecules (e.g., glucose, cellobiose) coordinate with Zn^{2+}, directing uniform nucleation and inhibiting dendrite growth.

7 | Challenges and Obstacles Encountered

- Performance differences were observed between the electrolyte and electrolyte's additive, but limited training time prevented further optimization to extend cycle life.
- Some materials and chemicals required for testing were delayed in delivery, restricting some planned experiments and atomization.
- The poster submission deadline coincided with a critical stage, as laboratory work and complete data collection were only finalized at the very end of the training period.

8 | Next Steps and Future Work

- Extend cycle testing to long-term stability studies.
- Explore a wider range of organic additives (glucose, cellobiose, polyols).
- Perform EIS to study charge transfer resistance and interfacial behavior.
- Apply in-situ techniques to observe Zn deposition.
- Optimize additive concentration for best balance between stability and conductivity.

9 | Resources and Tools Used

- Laboratory facilities of the Department of Chemistry at University College London (UCL).
- Coin cell assembly tools and electrochemical workstation.
- XRD, SEM, and GCD for material characterization.
- OriginLab Software for Data analysis and plotting of electrochemical/ characterization results.
- Literature: Glucose additive study and Zinc Anode Review.
- Microsoft PowerPoint and Word for poster preparation.

10 | Conclusion

This project demonstrated the effectiveness of electrolyte additives, such as cellobiose, in enhancing zinc anode performance by modifying the Zn^{2+} solvation shell. The additive suppressed dendrite growth, reduced corrosion, and improved overall reversibility. Experimental evidence from XRD and SEM confirmed these improvements, while literature studies on glucose provided additional validation of the solvation shell engineering mechanism. With further training, longer testing periods, and timely access to materials, even greater performance improvements could be achieved. Ultimately, this work highlights electrolyte engineering as a promising approach for developing safer, more efficient, and longer-lasting aqueous zinc-ion batteries.

11 | Acknowledgement

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12 | References

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2. Sun, P., Ma, L., Zhou, W., Qiu, M., Wang, Z., Chao, D., & Mai, W. (2021). Simultaneous regulation on solvation shell and electrode interface for dendrite-free Zn ion batteries achieved by a low-cost glucose additive. *Angewandte Chemie*, *133*(33), 18395-18403. https://doi.org/10.1002/anie.202105756