Telluride Alloying Stabilizes Manganese Anodes for Aqueous Mn-Ion Batteries

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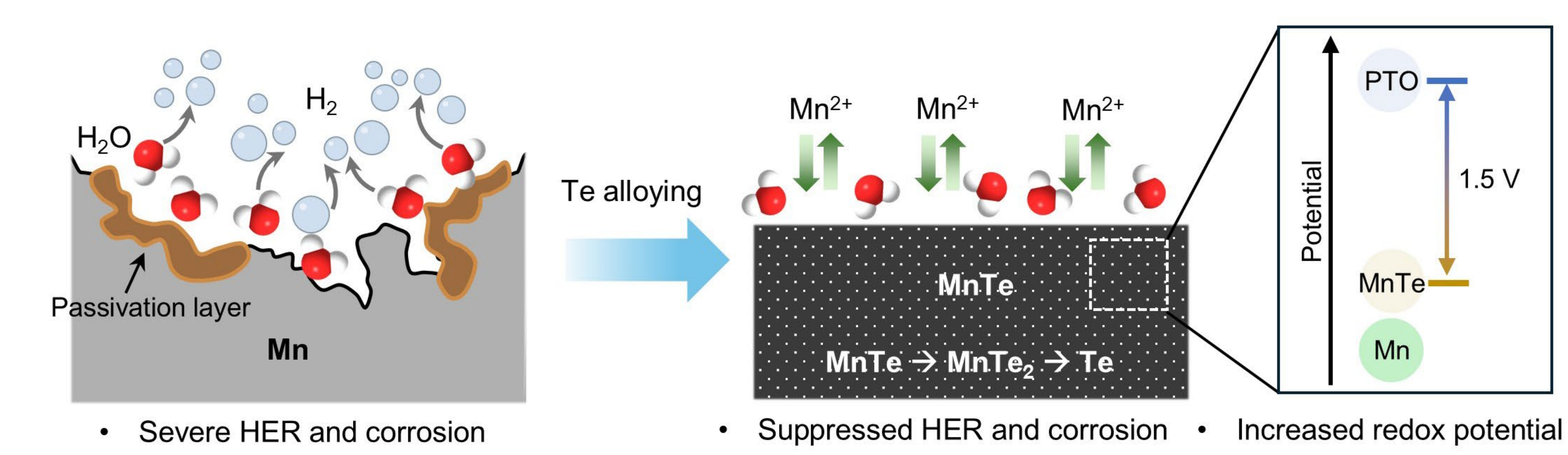
Problem

- Manganese (Mn) metal is a promising low-cost anode because of its low redox potential of **−1.19 V vs. SHE**, high theoretical gravimetric capacity of **976 mAh g^{-1}**, and high volumetric capacity of **7250 mAh cm^{-3}**.
- These values exceed those of Zn metal, 820 mAh g^{-1} and 5858 mAh cm^{-3}, highlighting the potential of Mn for high-energy aqueous batteries.
- **However, the highly negative Mn redox potential makes Mn thermodynamically unstable in aqueous electrolytes, causing spontaneous corrosion and hydrogen evolution reaction (HER).**
- These parasitic reactions lead to gas generation, surface passivation, large polarization, low Coulombic efficiency, and poor cycling stability.
- Therefore, stabilizing Mn redox chemistry in water is essential for safe, reliable, and cost-effective Mn-based energy storage.

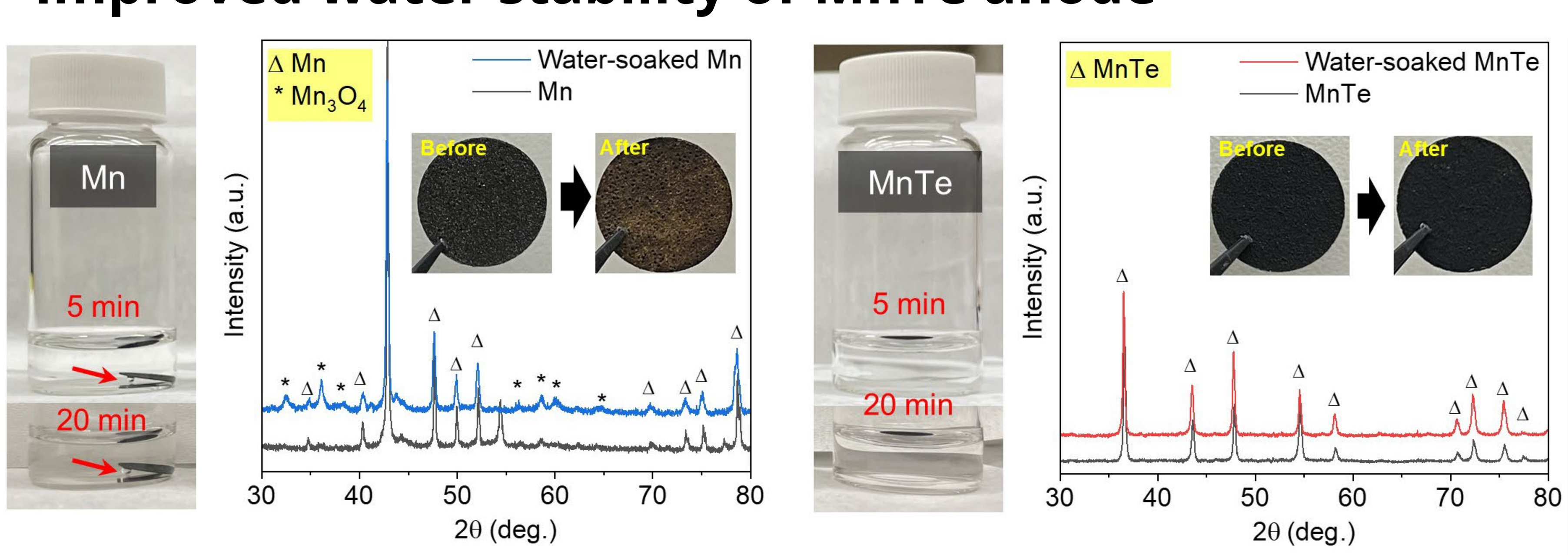
Approach & Concept

- **Te alloying regulates Mn redox chemistry and suppresses hydrogen evolution**

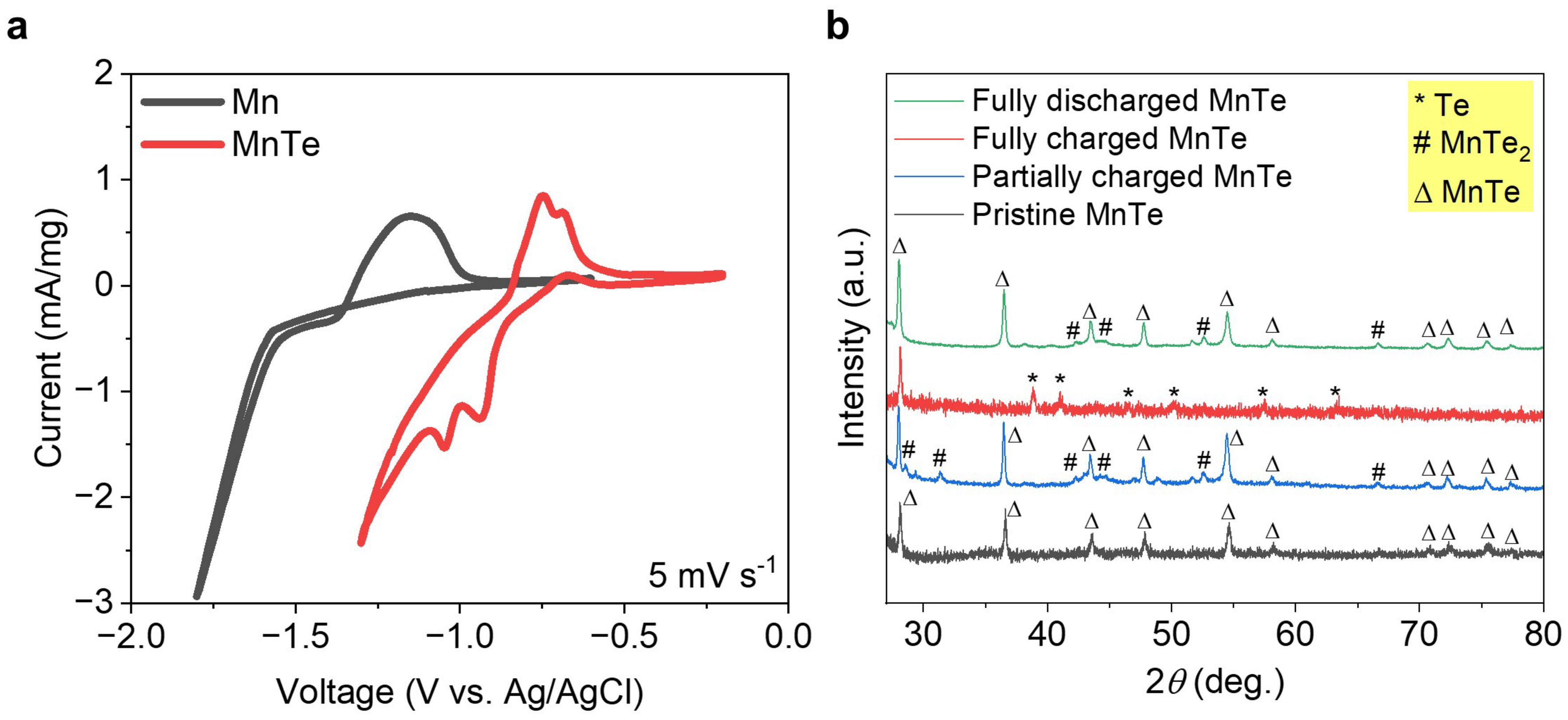


Results

- **Improved water stability of MnTe anode**

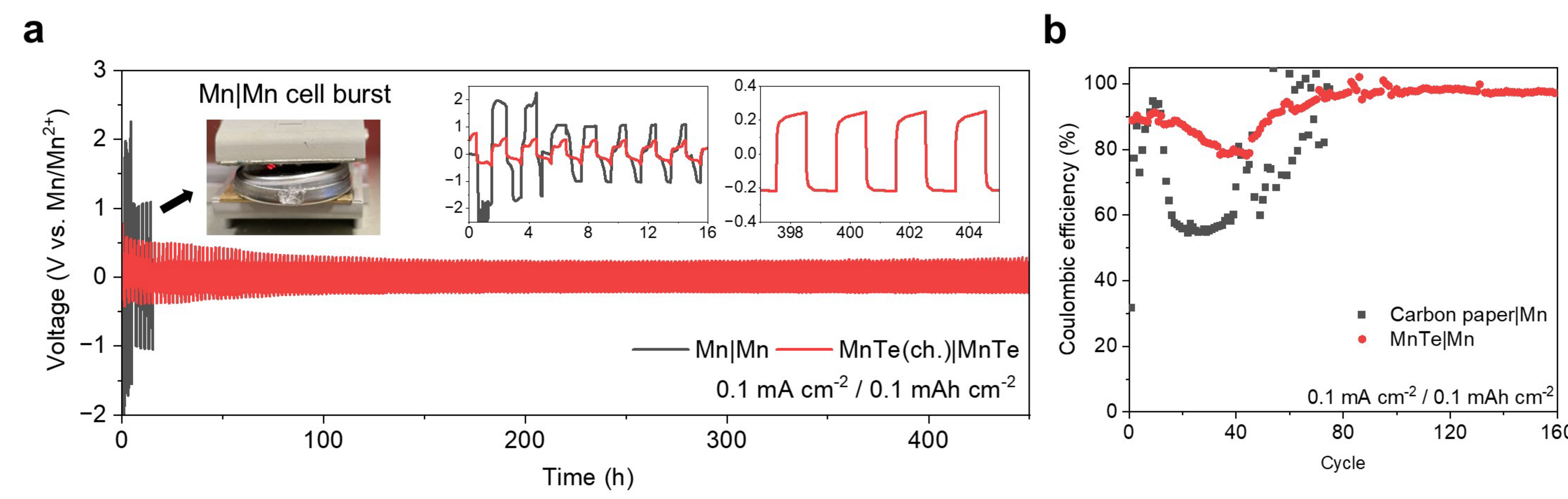


- **Electrochemical Mn-ion redox behavior and phase evolution of MnTe electrodes.**



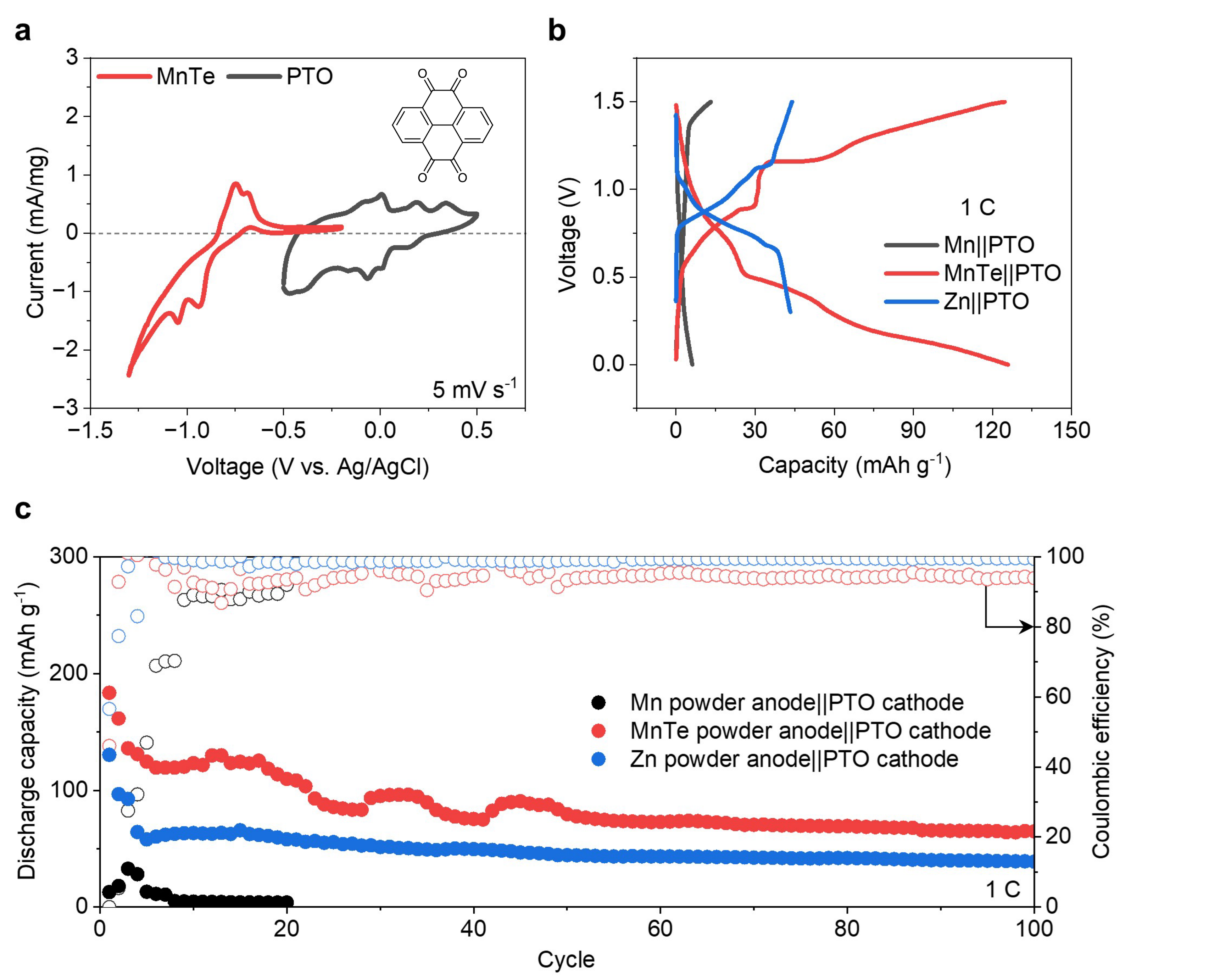
(a) CV curves of Mn|carbon paper (CP) and MnTe|CP cells. (b) Ex situ XRD patterns of MnTe electrodes at different electrochemical states.

- **Electrochemical performance of MnTe anodes**



(a) Symmetric cell cycling performance of Mn||Mn and MnTe||MnTe. (b) Coulombic efficiency of MnTe||Mn and carbon paper||Mn asymmetric cells at 0.1 mA cm^{-2} and 0.1 mAh cm^{-2}.

- **Full-cell electrochemical performance using MnTe anodes.**



(a) Cyclic voltammetry curves of MnTe anode and pyrene-4,5,9,10-tetraone (PTO) cathode measured versus Ag/AgCl. (b) Galvanostatic charge-discharge voltage profiles of Mn powder anode||PTO, MnTe powder anode||PTO, and Zn powder anode||PTO full cells at 1 C (1 C = 150 mA g^{-1}). (c) Long-term cycling performance and Coulombic efficiency of Mn powder anode||PTO and MnTe powder anode||PTO, and Zn powder anode||PTO full cells at 1 C.

Conclusions & Impact

- Te alloying converts unstable Mn metal chemistry into a phase-mediated Mn redox process with suppressed HER and improved full-cell stability. This alloy-mediated strategy provides a materials-level design principle for low-cost, earth-abundant battery systems relevant to reliable grid energy storage.

Future Directions

- Design Mn-compatible electrolytes and high-capacity cathodes for practical Mn-ion full cells. Translate Mn-based chemistry toward low-cost grid energy storage.

Acknowledgements & Reference

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- This work is currently under submission.

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