A Fast-Rechargeable Zinc-Air Flow Battery System with High Power Density and High Energy Efficiency for Long Duration Energy Storage

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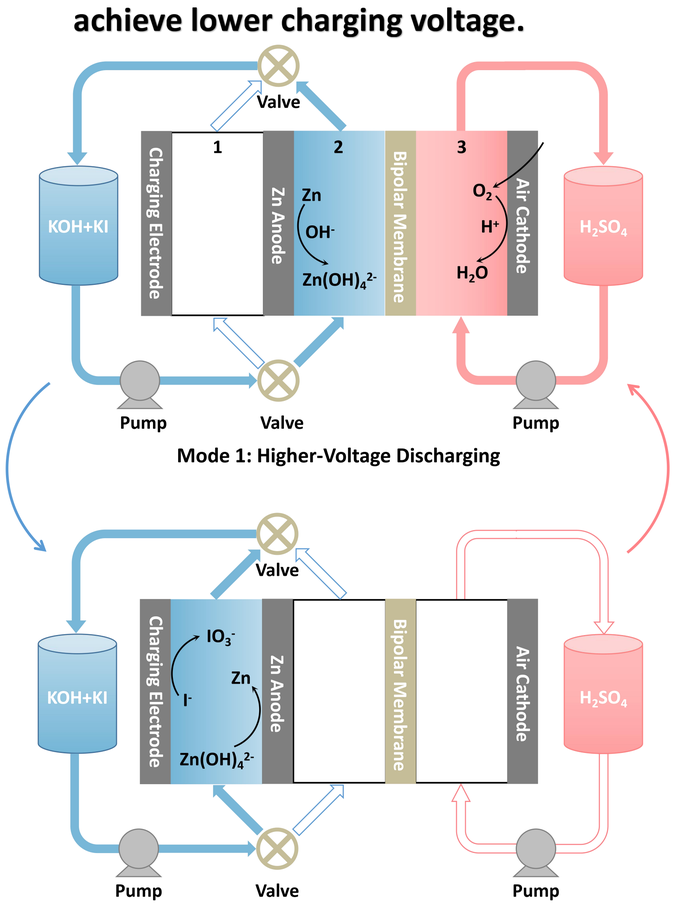
1. Introduction

To achieve long-duration energy storage (LDES), a technological and economical battery technology is imperative. Herein, we demonstrate an all-around zinc-air flow battery (ZAFB), where a decoupled acid-alkaline electrolyte elevates the discharge voltage to ~1.8 V, and a reaction modifier KI lowers the charging voltage to ~1.8 V. This ZAFB exhibits a long discharge duration of over 4 hours, a high power density of 178 mW cm^{-2} (about 76% higher than conventional ZAFB), and unprecedented energy efficiency of nearly 100%. Moreover, the ZAFB demonstrates outstanding fast charging ability, mitigated zinc dendrite growth and parasitic hydrogen evolution, enhanced cathode protection, and good resistance to environmental disturbance. This all-around ZAFB will not only become a very promising option for LDES but also promote the development of other LDES systems.

2. Design Motivation

1. Decoupled acid/alkaline electrolytes endow ZAFB higher discharge voltage.

2. The oxidation of KI with faster kinetics and lower oxidation potential can substitute the sluggish OER process and achieve lower charging voltage.

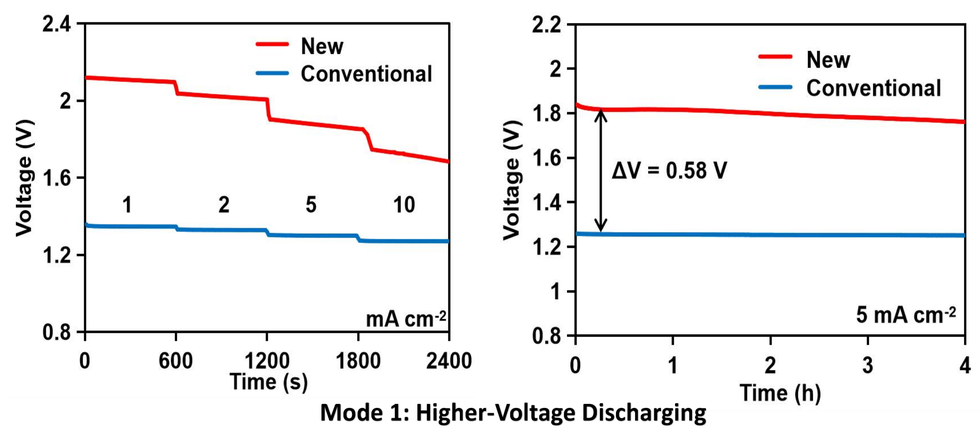


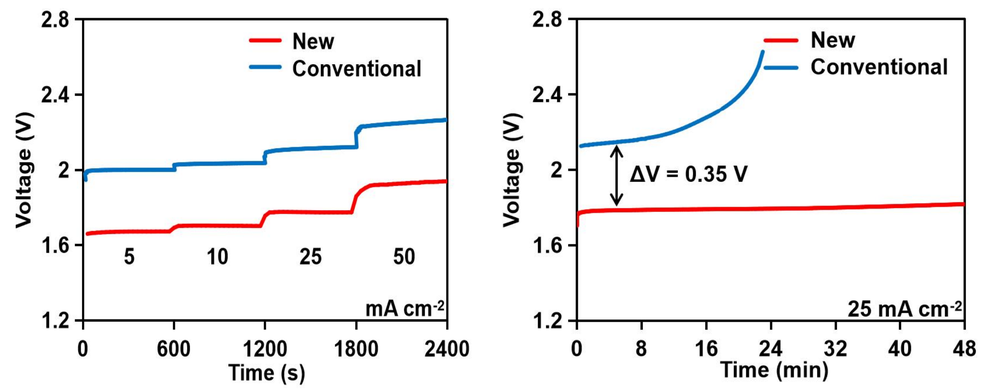
3. Battery Discharge/Charge

The discharge voltage of the novel ZAFB achieves over 2 V, further enhancing the battery power density.

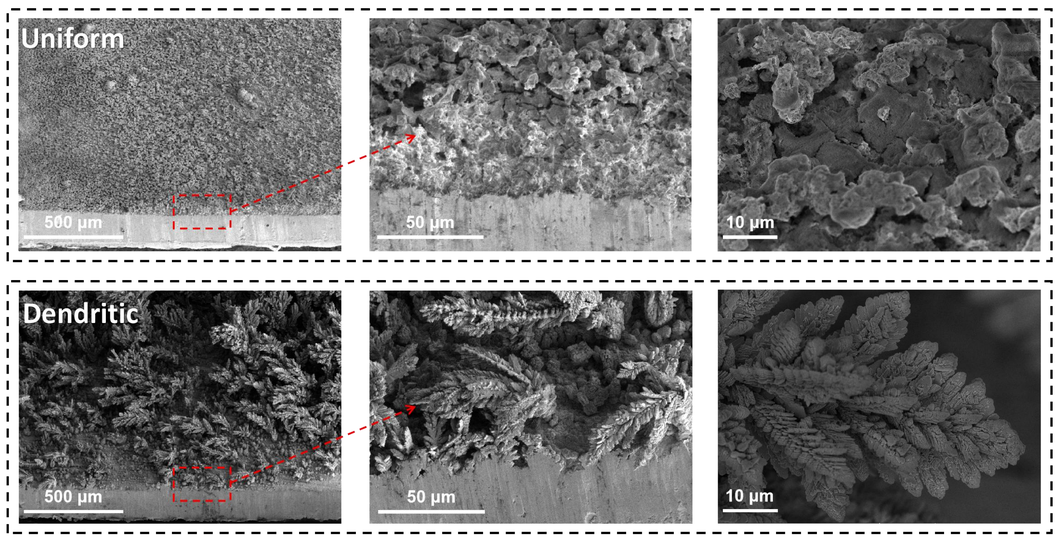
The charging voltage of the novel ZAFB decreases to 1.7 V, further increasing the battery energy efficiency.

The proposed novel ZAFB can realize 4-hour long duration energy storage and 5 times fast-charging ability.



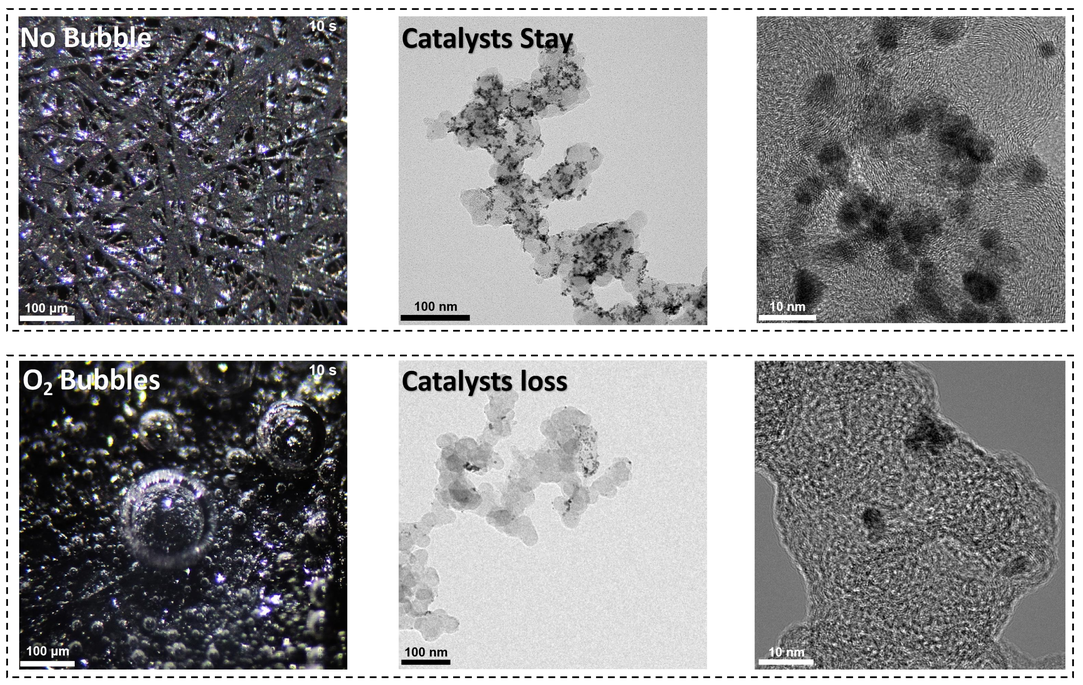


4. Alleviated Zinc Dendrite Growth



↑ Lower Charging Voltage ↓ Higher Charging Voltage

5. Alleviated Air Cathode Corrosion

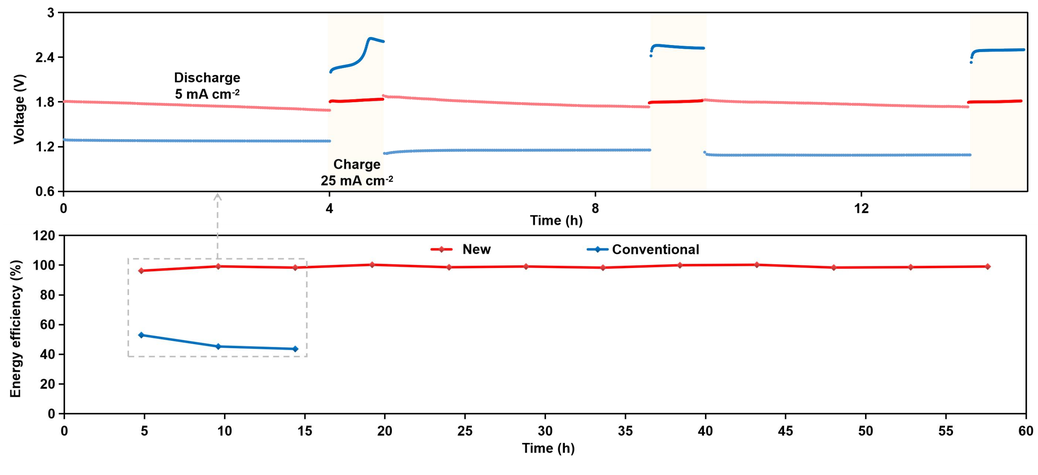


↑ Lower Charging Voltage ↓ Higher Charging Voltage

6. Battery Cycle Performance

The presented novel ZAFB can stably cycle for about 60 hours with 1.8 V high discharge voltage and near 100% energy efficiency.

The conventional ZAFB can only cycle for 3 times with 1.2 V discharge voltage and 50% energy efficiency.



7. Conclusion

By this novel configuration design, the critical issues in ZAFBs, including low power density, low energy efficiency, severe zinc dendrite growth and cathode degradation under fast charging, can all get improved. This work can elevate the compatibility of ZAFBs in long duration energy storage.

8. Acknowledgement

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