

Boron Doped Carbon Felt Electrode on Stabilizing Cycle Life of Soluble Lead Redox Flow Battery



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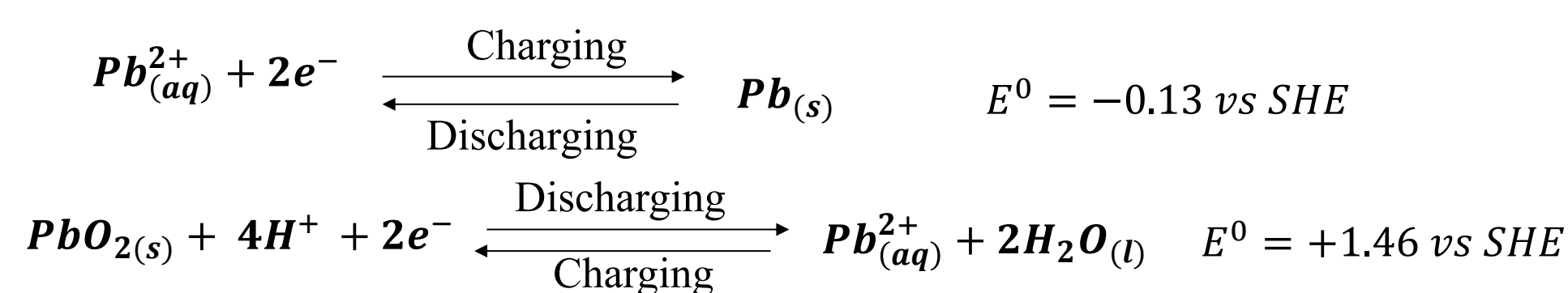
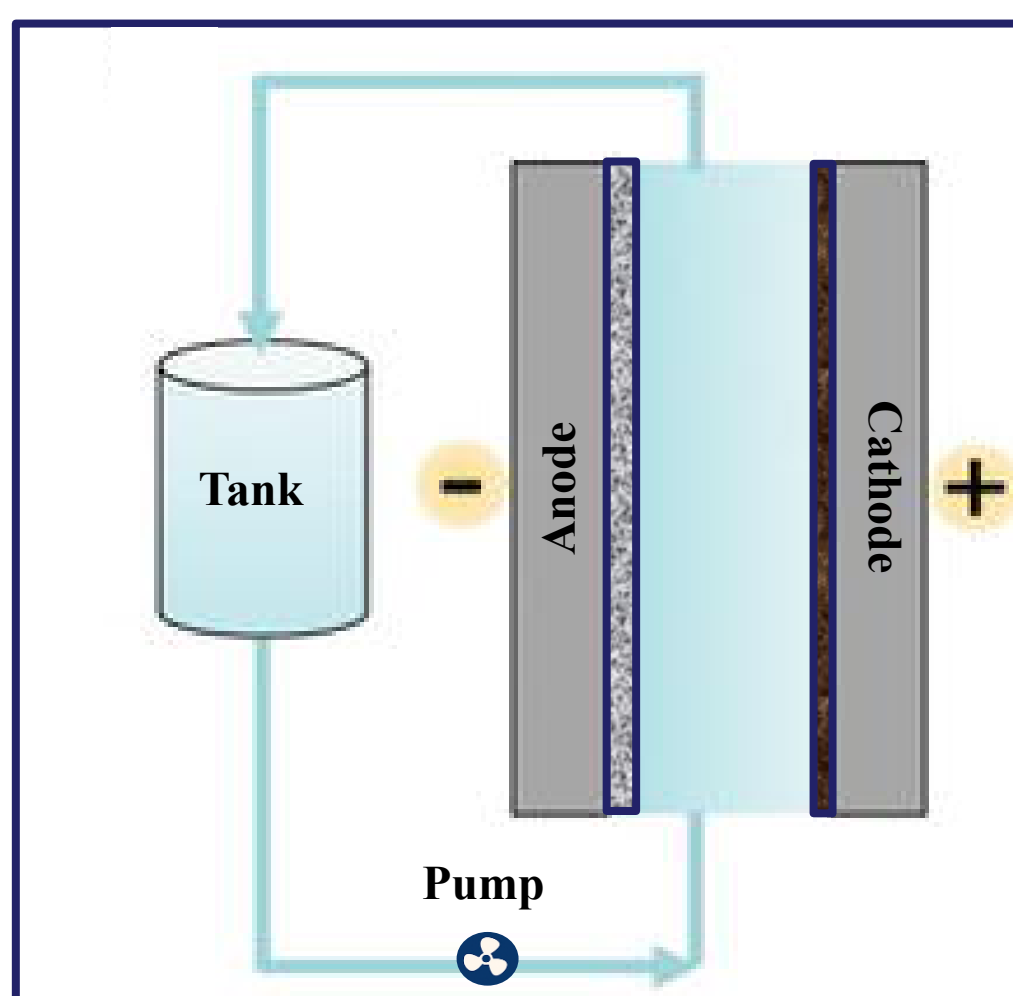
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Introduction

Advantages of SLRFB:

- Electroactive materials are externally stored. Highly scalable.
- Excellent safety, recyclability, high cycle life
- Low-cost active materials



Bottleneck

- Pb dendrite on the anode
- Oxygen evolution at the cathode while charging,
- Partial reversibility of PbO₂ at the cathode due to sluggish kinetics of Pb²⁺/PbO₂ redox couple.
- Low areal capacity and limited lifespan (100-200 cycles).

Methodology

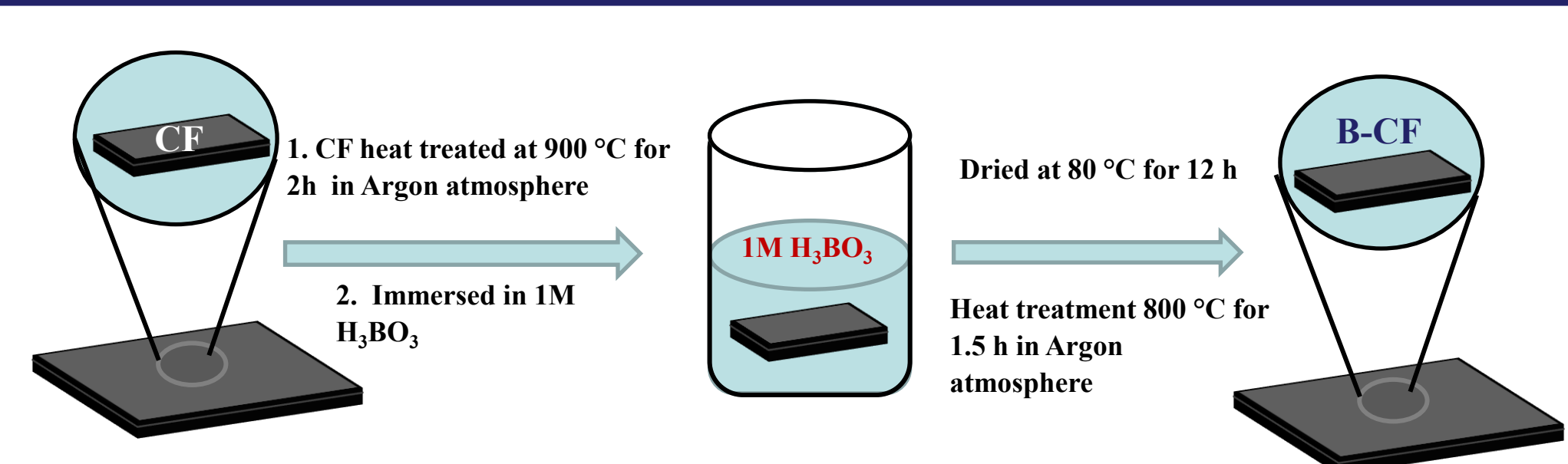


Fig. 1 Preparation scheme of B-CF

Results (Physicochemical study)

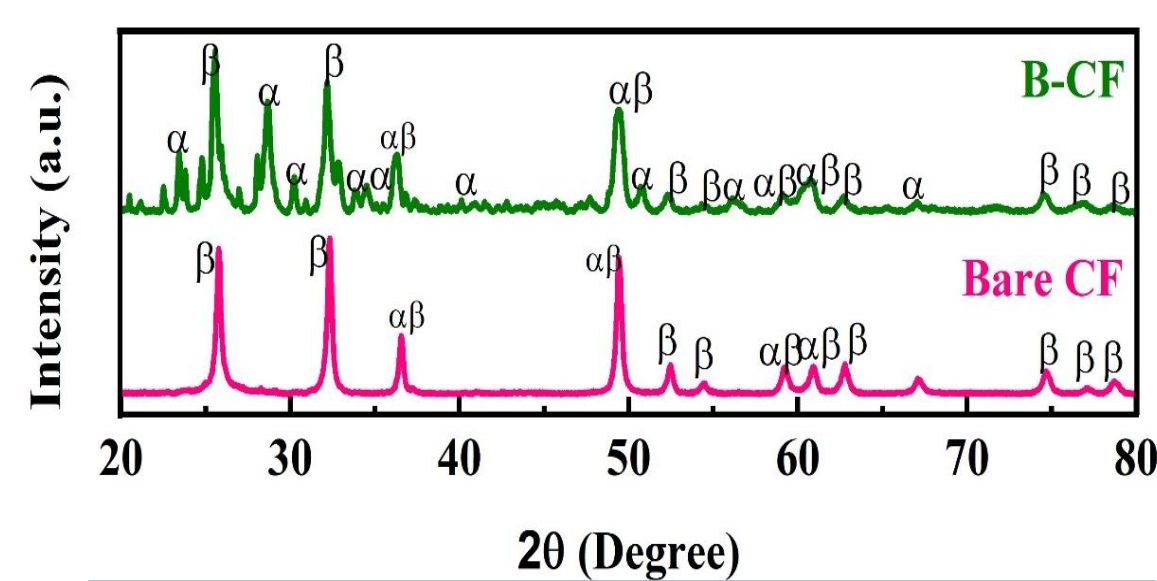


Fig. 2 XRD patterns of PbO₂ films deposited on the electrode

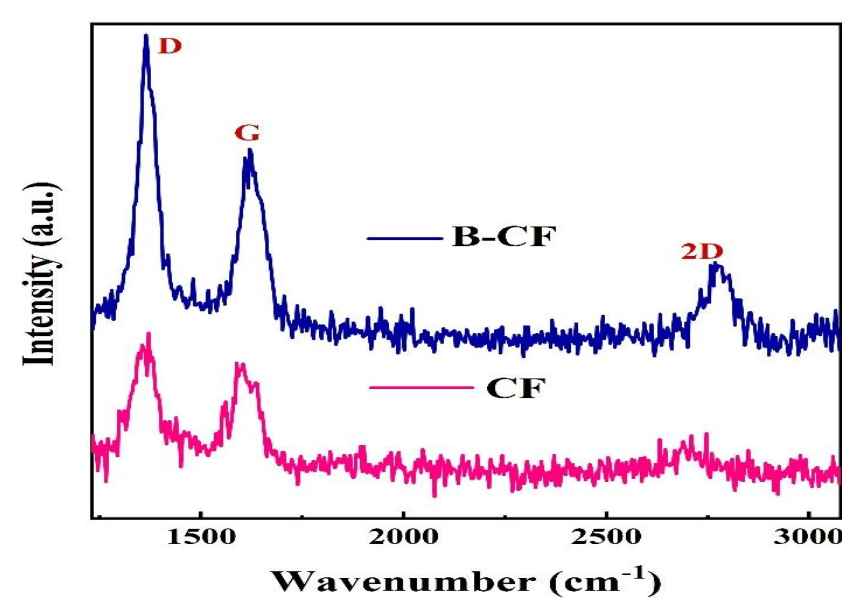


Fig. 3 Raman spectra of CF and B-CF samples.

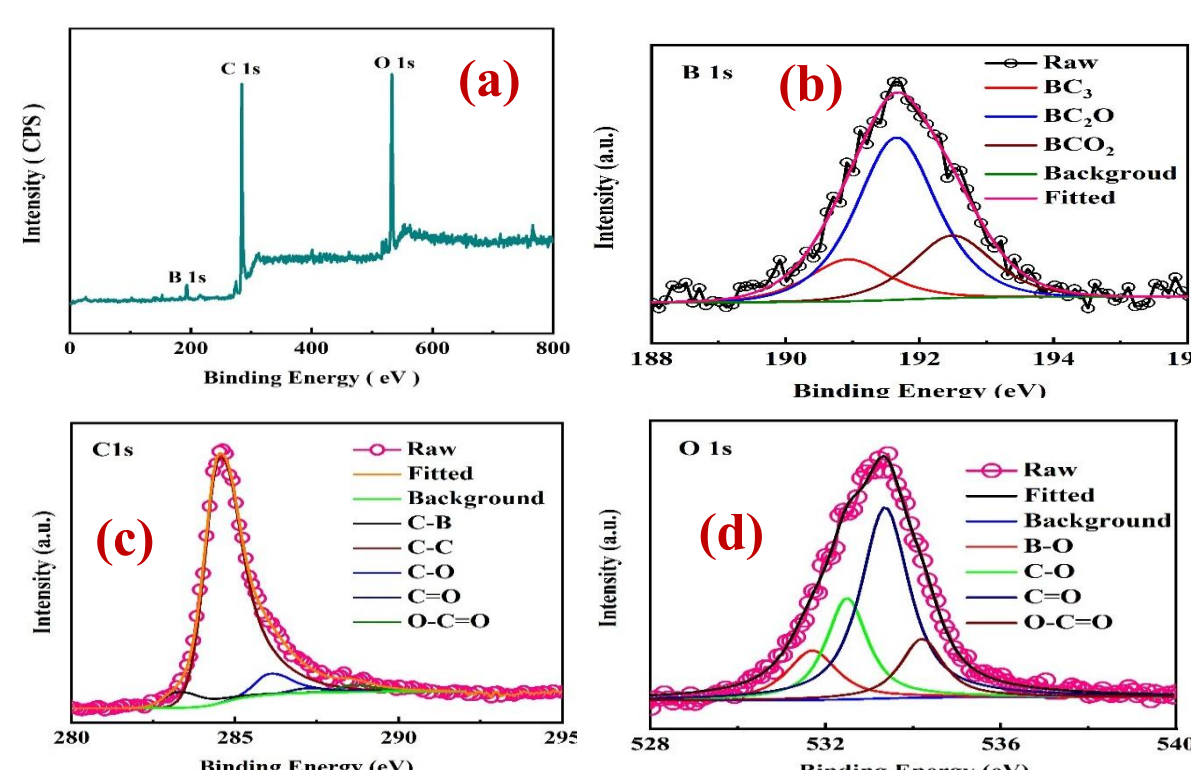


Fig. 4 (a) XPS survey spectra and high-resolution deconvoluted spectra of (b) B 1s, (c) C 1s, and (d) O 1s of B-CF.

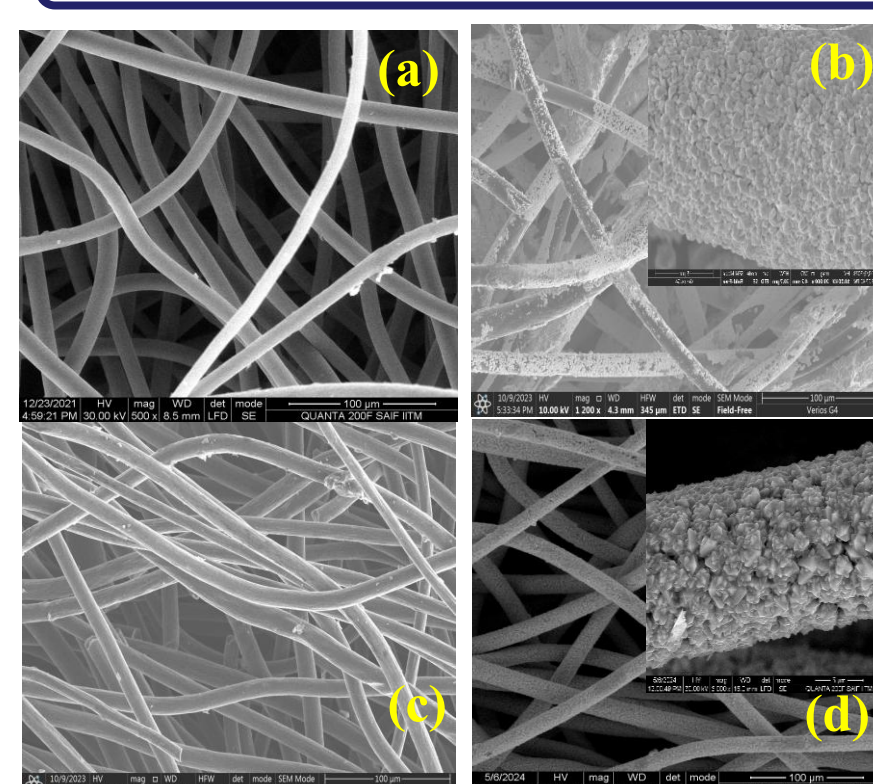


Fig. 5 Surface morphology of (a) bare CF, (b) B-CF, (c) PbO₂ deposited on bare CF, and (d) PbO₂ deposited on B-CF

Results (Electrochemical Study)

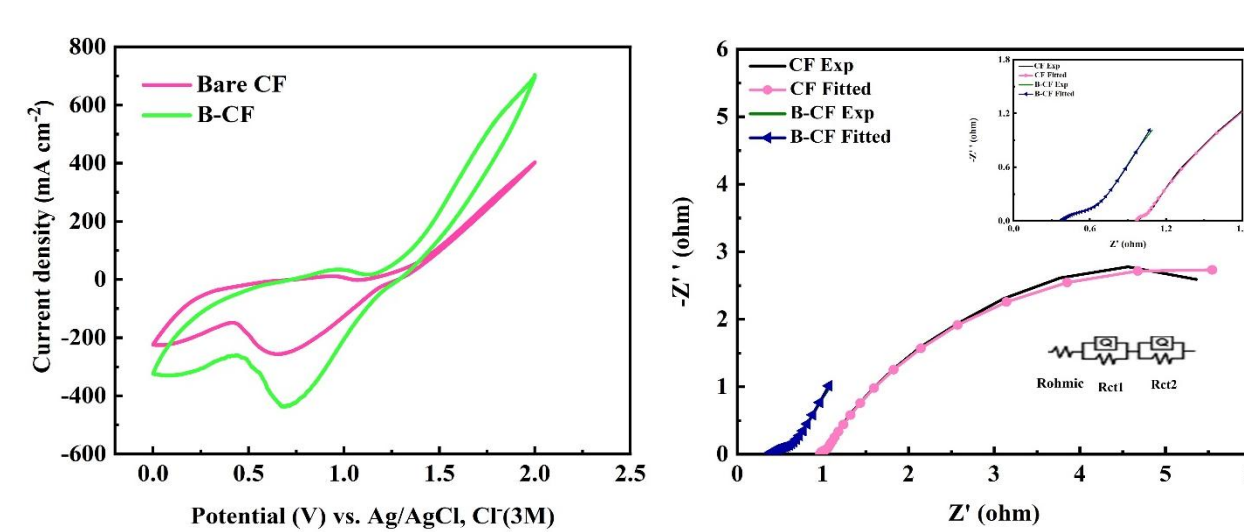


Fig. 6 (a) CVs of Pb²⁺/PbO₂ redox couple recorded at a scan rate of 2 mV s⁻¹ (b) Nyquist plot of the positive electrodes side).

Fig. 7 Comparison of 1st GCD cycle (a), (b) capacity plot of Bare CF and B-CF, (c) charge/discharge profile, and (d) efficiency and capacity

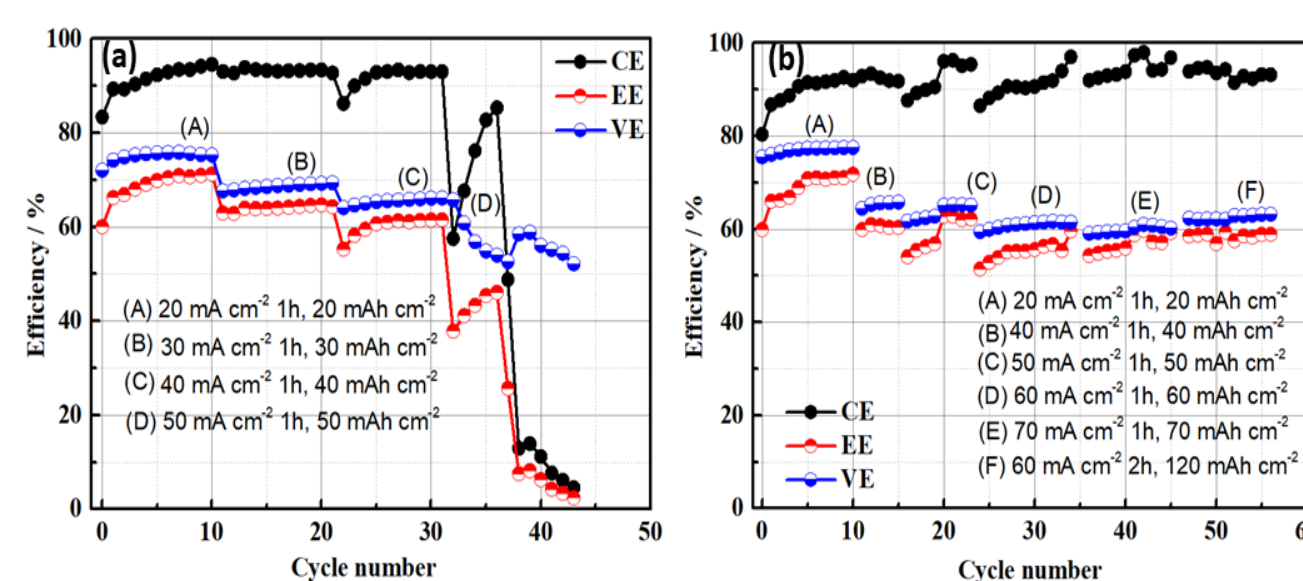
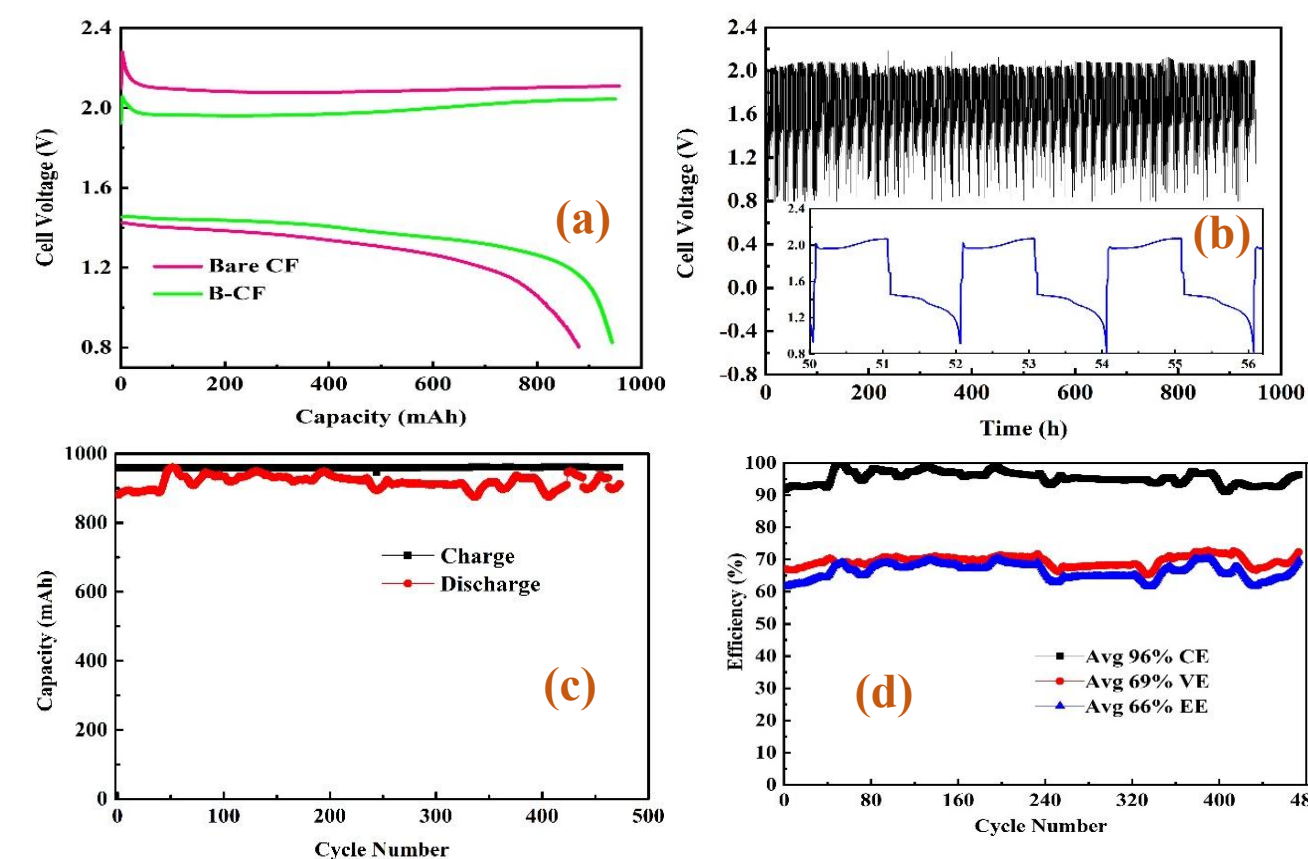


Fig. 8 Rate capability and efficiencies comparison plot of SLRFB cells employing (a) bare CF and (b) B-CF electrode at various current densities and capacity

Fig. 9 Cell Voltage vs Capacity plot at 20,40,50,60,70 mA cm⁻² current

Conclusion

- The cycle life of the SLRFB is extended with a B-CF electrode from 130 to 480 @ 40 mA cm⁻².
- The highest Capacity 957 mAh (area specific capacity 40 mAh cm⁻²) has been achieved with good cyclability (>500 cycles) with Boron Doped CF electrode.
- B-CF electrode reaches the maximum areal capacity of 120 mAh.
- This is the best value reported in the literature as of now.

Acknowledgment

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References

- Jaiswal, N.; Khan, H.; Ramanujam, K. The Combined Impact of Trimethyloctadecylammonium Chloride and Sodium Fluoride on Cycle Life and Energy Efficiency of Soluble Lead-Acid Flow Battery. *Journal of Energy Storage* 2022, 54, 105243. <https://doi.org/10.1016/j.est.2022.105243>.
- Jiang, H. R.; Shyy, W.; Zeng, L.; Zhang, R. H.; Zhao, T. S. Highly Efficient and Ultra-Stable Boron-Doped Graphite Felt Electrodes for Vanadium Redox Flow Batteries. *Journal of Materials Chemistry A* 2018, 6 (27), 13244–13253. <https://doi.org/10.1039/c8ta03388a>.