Novel Non-Flammable and Self-Regenerative High-Performance Hydrogel Electrolyte with Anti-Freeze Properties and Intrinsic Redox Activity for Energy Storage Applications

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Introduction

- Hydrogel electrolytes are essential components of a plethora of functional devices due to their flexibility and high electronic and ionic conductivity.
- Hydrogel Electrolytes suffer from poor water retention (dehydration) during operation.
- The overall performance of the hydrogels-based devices is severely declined as a result of conductivity fading of the hydrogel with poor self-regeneration.
- To this end, the rational tailoring of hydrogel electrolytes with high conductivity, self-regeneration, non-flammability, anti-freezing ability, stability, and intrinsic redox activity is necessary to enable the fabrication of highly durable devices.
- Herein, we demonstrate the design and synthesis of highly ionic conductive LiBr@PVA-based electrolytes. Upon the use of the synthesized hydrogel electrolytes in supercapacitor devices, they revealed intrinsic redox activity with outstanding water retention capability and self-regeneration characteristics.

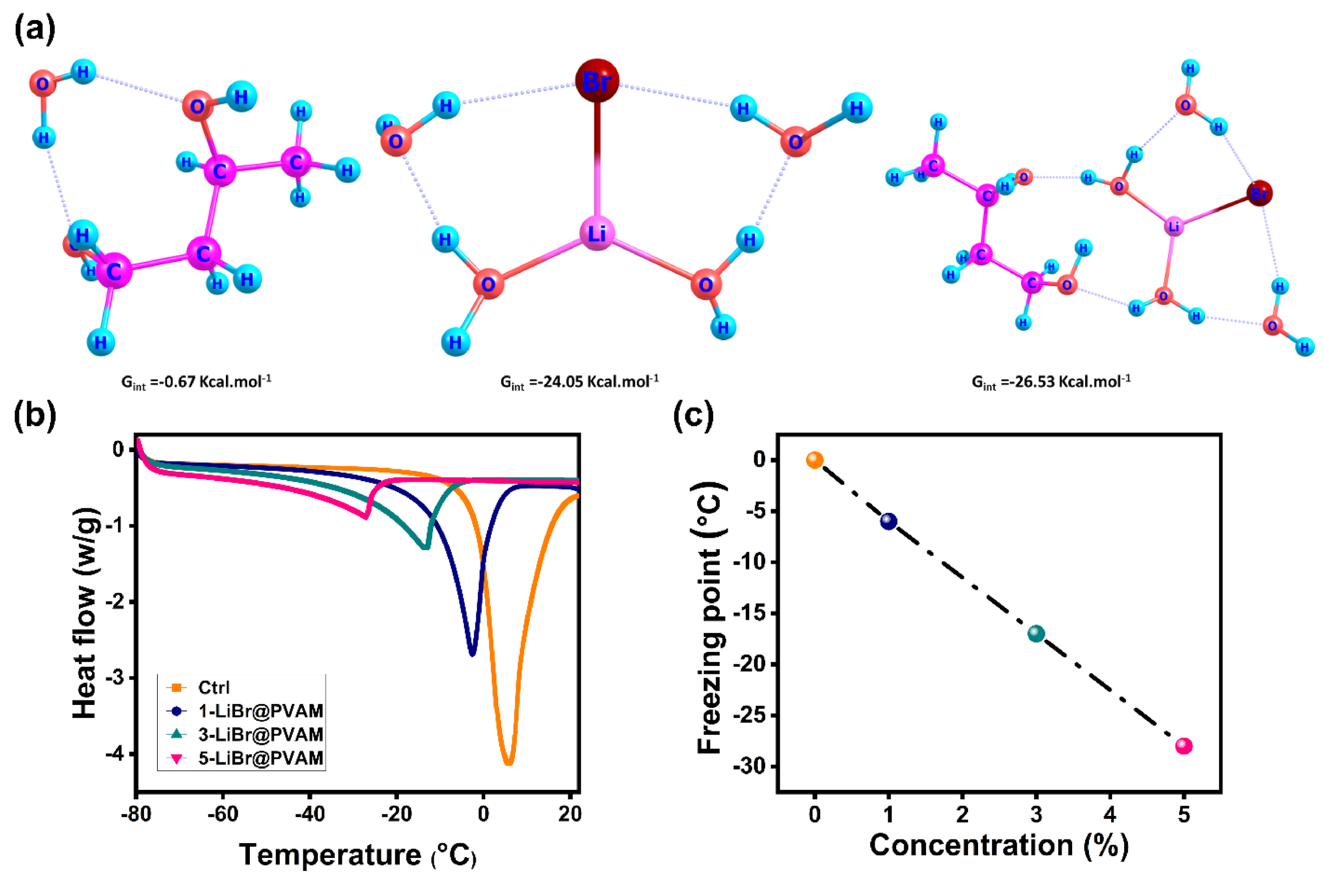
Why This Work ?

- Solid State Electrolyte
- Water Retention
- Safety Considerations
- Redox Activity
- Anti freezing Properties
- Patent

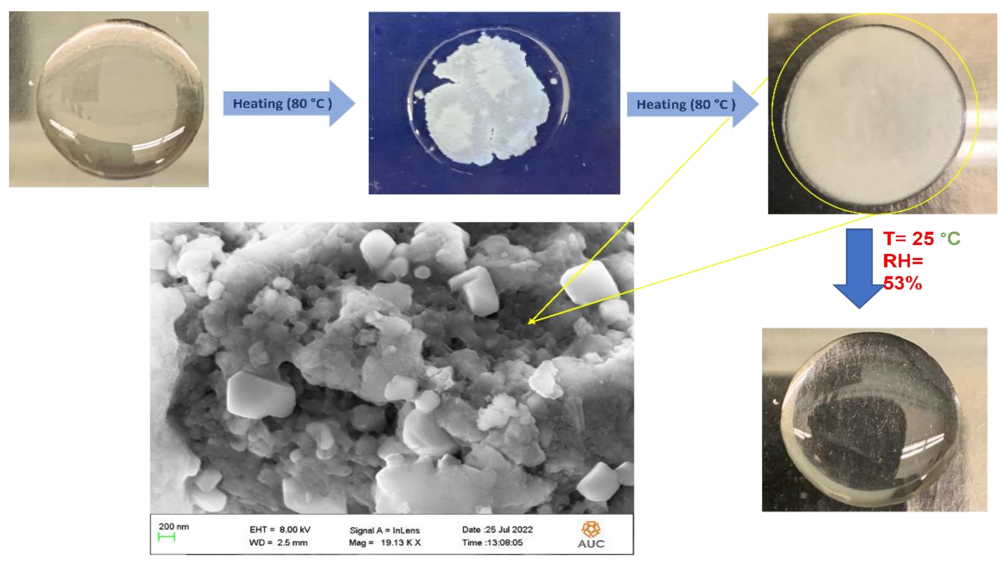
This Work Achievements

- Published JMCA, RSC IF=15
- Filed as USUS Provisional Patent no. 1633/15 PROV
- 6 Citations in just 6 months

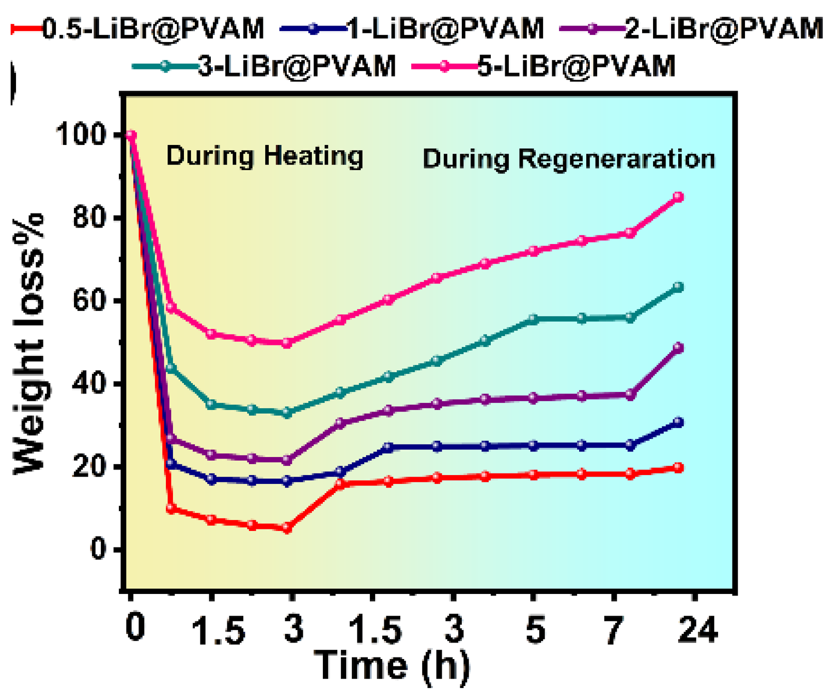
Water Retention Measurements



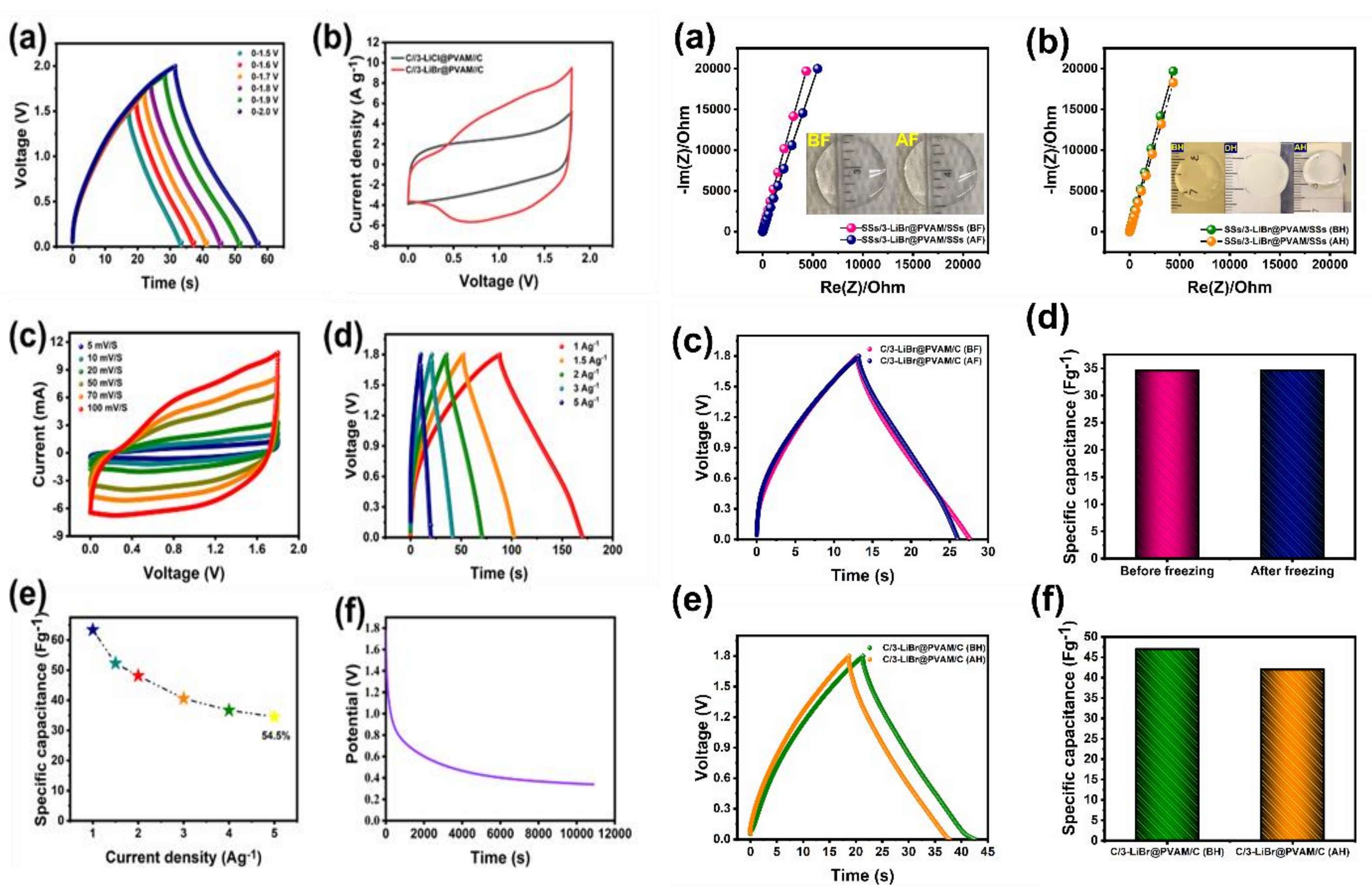
Water Regeneration Measurements



Images of the hydrogel electrolyte after dehydration and during the regeneration process with FESEM image.

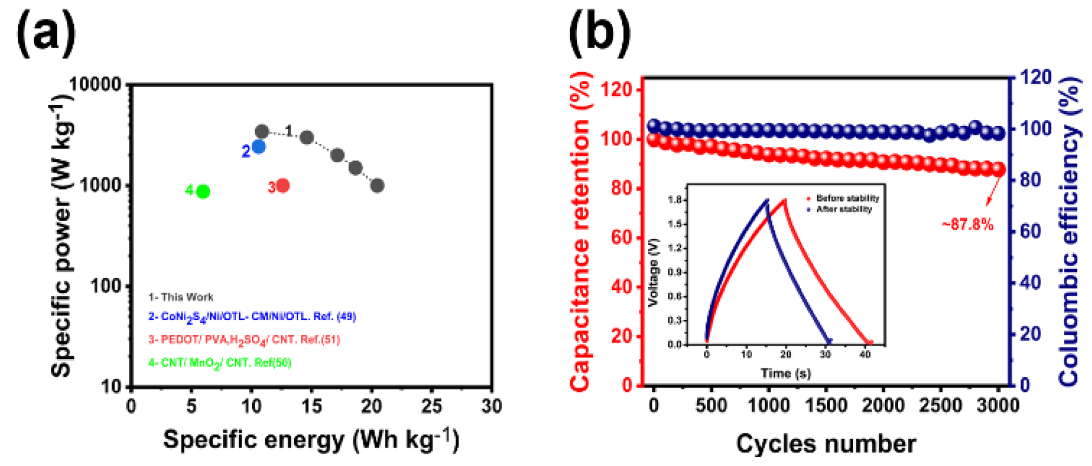


Highlighted Electrochemical Results



Electrochemical Results

- The hydrogel electrolyte showed higher ionic conductivity thank those reported in the literature.
- Upon testing the hydrogel as an electrolyte in supercapacitor devices, the fabricated C//3-LiBr@PVAM//C device showed high operating potential window of 1.8 V and took more than 10,800 s to drop from 1.8 V to 0.3 V during the self-discharge testing.
- In addition, the intrinsic redox properties of the electrolyte caused an increase in the specific capacitance, reaching 63.3 F/g.
- The fabricated device exhibited high specific capacitance compared to similar systems reported in the literature. The device can deliver high energy density of ~ 20.5 Wh/kg with a power density of 3430 W/kg.



Conclusion

We demonstrate a facile synthesis approach of novel hydrogel electrolytes based on LiBr@PVA and their utilization in energy storage devices. The electrolyte can regenerate more than 70% of its water content via absorption of water from the surrounding environment within 24 hours. The DFT calculations unraveled the reason behind the high-water retention ability of the fabricated hydrogel. Also, the DSC analysis revealed the anti-freezing properties of the hydrogel electrolyte, retaining its liquid state at − 30 °C. Moreover, the electrolyte is considered a completely non-flammable composite for use as a safe electrolyte for solid state devices.

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