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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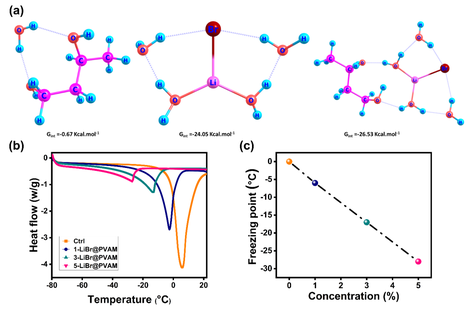
Introduction

Hydrogel electrolytes are essential components of a plethora of functional devices due to their flexibility and high electronic and ionic conductivity. However, they suffer from poor water retention (dehydration) during operation. Consequently, 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. The mechanism of regeneration and water retention is thoroughly investigated. Also, the devices showed improved self-discharge potential (SDP) rate compared to those previously reported using polymeric electrolytes with redox additives. Moreover, the synthesized LiBr@PVA-based electrolytes exhibited high anti-freezing properties with stable electrochemical performance before and after regeneration. Our study provides a universal method to fabricate large-scale hydrogel electrolytes with unique properties and opens the doors to fabricate high-performance solid state devices.

Why This Work ?

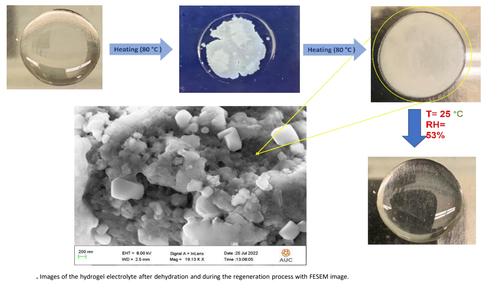
- Solid State Electrolyte
- Water Retention
- Safety Considerations
- Redox Activity
- Anti freezing Properties
- Patent

Water Retention Measurements

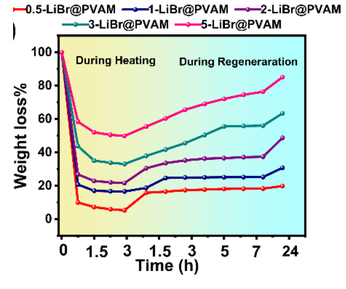


Water Regeneration Measurements

This photo depicts the regeneration Properties of the hydrogel



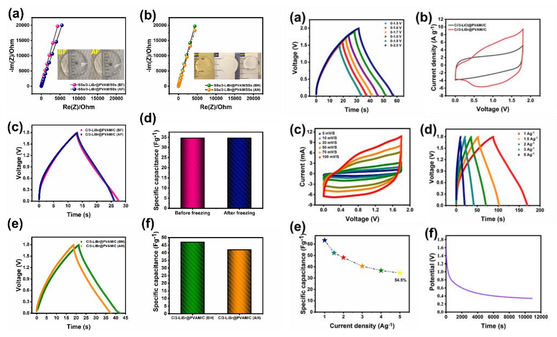
. Images of the hydrogel electrolyte after dehydration and during the regeneration process with FESEM image.



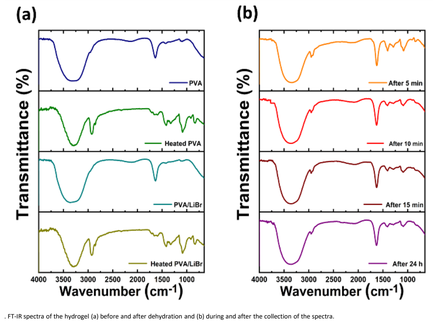
Highlighted Electrochemical Results

Moreover, 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.

Electrochemical Measurements Before and after regeneration



FTIR Characterization



. FT-IR spectra of the hydrogel (a) before and after dehydration and (b) during and after the collection of the spectra.

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.

Highlighted Achievements from This Work

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