

Hydrogel Electrolytes in Zinc-Ion Batteries: Patent Analysis and Future Prospects for Wearable and Flexible Electronics

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INTRODUCTION & AIM

- Hydrogel electrolytes (HEs) represent a transformative advancement for zinc-ion batteries (ZIBs), particularly in wearable and flexible electronics.
- These electrolytes are especially suited for small form factor ZIBs due to their flexibility, lightweight properties, and reduced leakage risks, but emerging trends suggest potential scalability for large-scale energy storage applications.
- Compared to state-of-the-art aqueous electrolytes, HEs offer significant advantages, including a reduction in side reactions, an increase in energy density, and enhanced compatibility with flexible substrates.

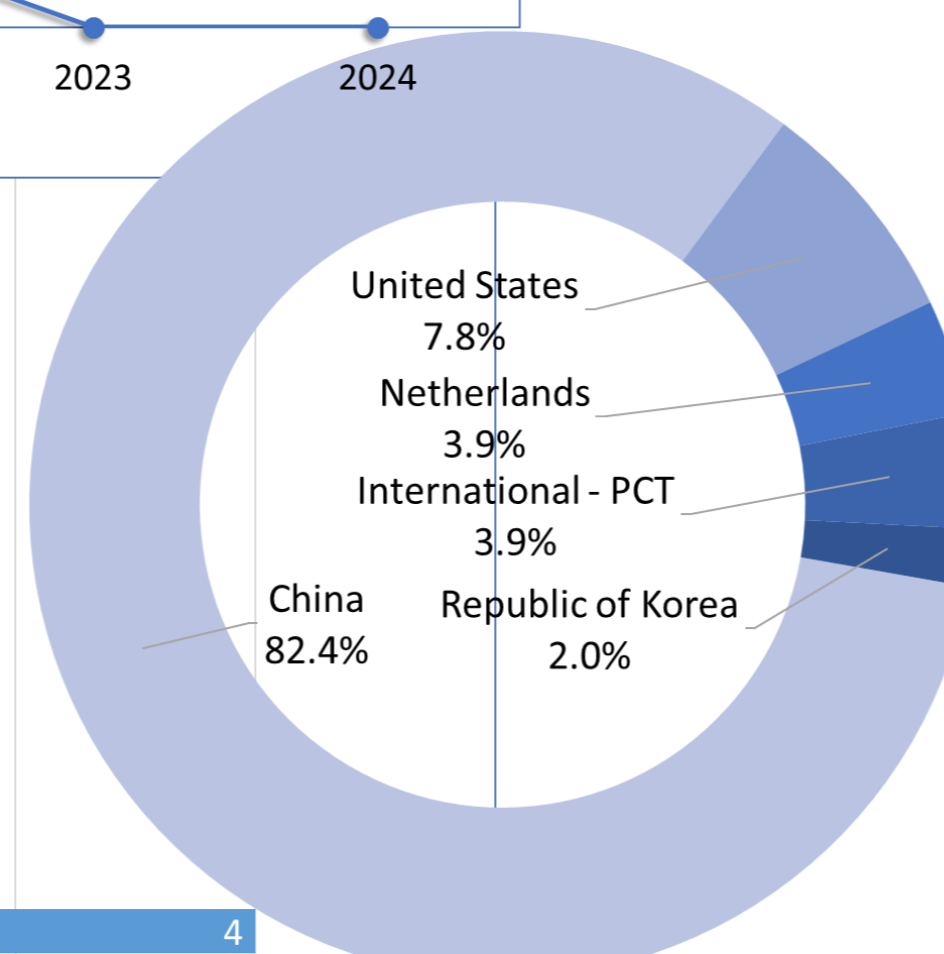
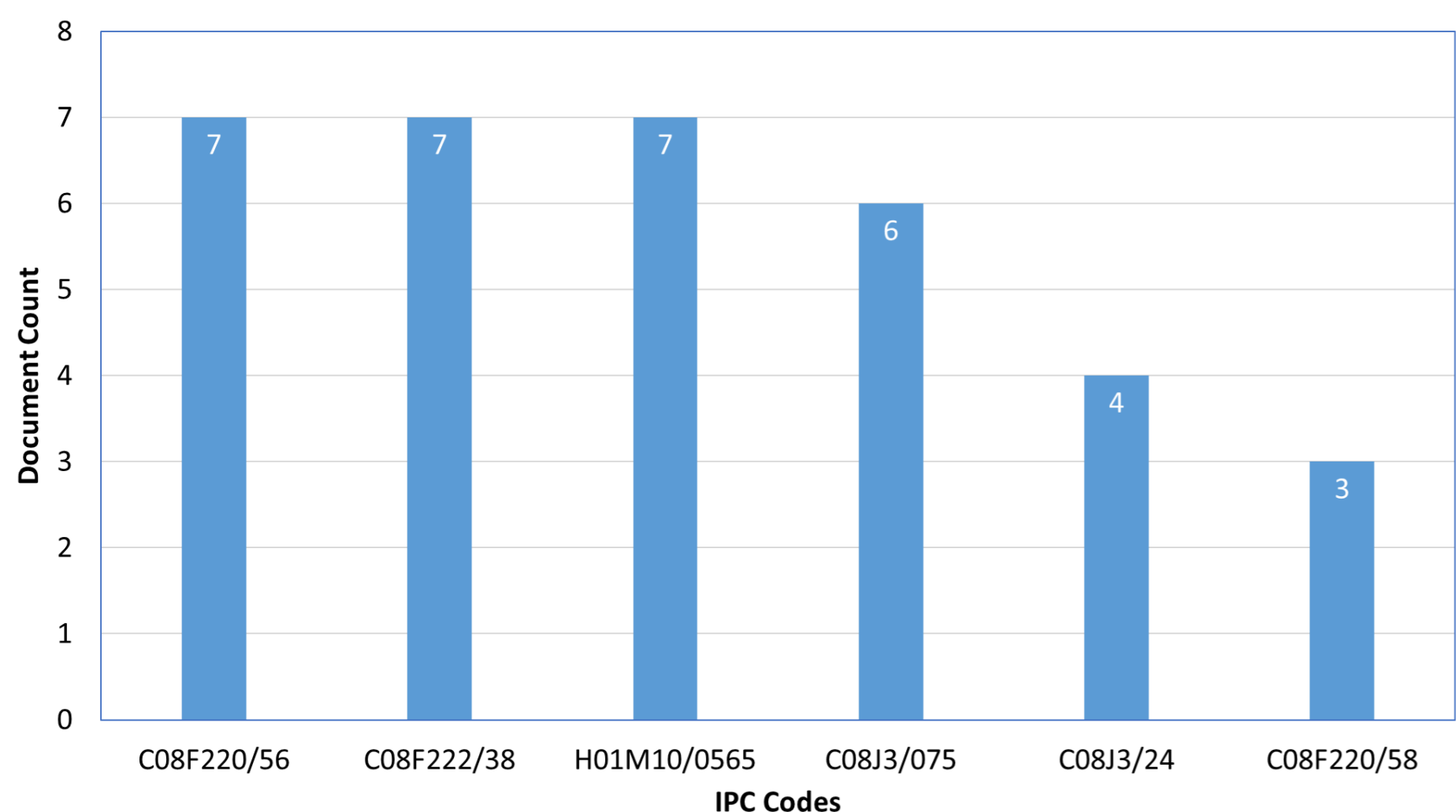
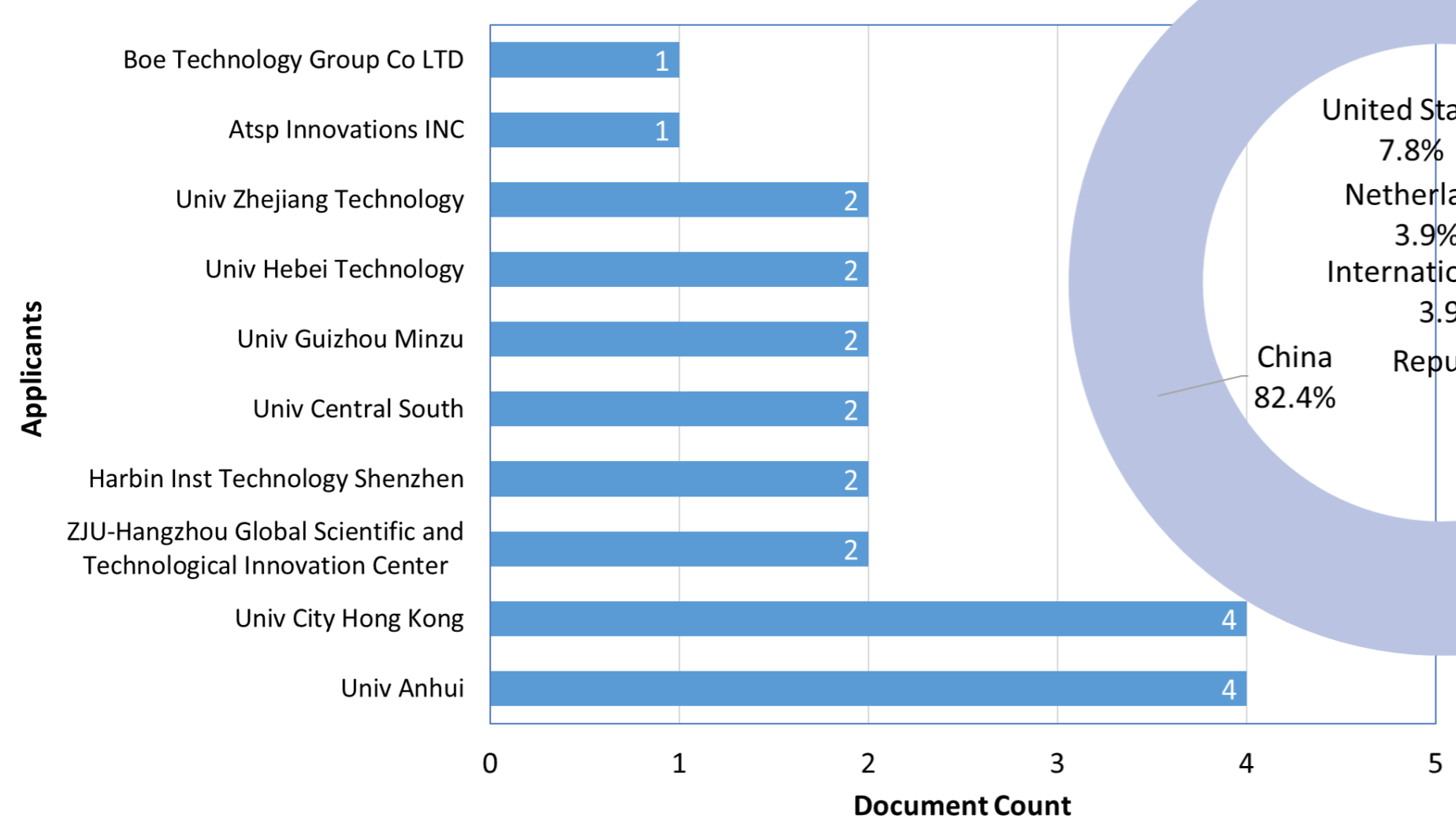
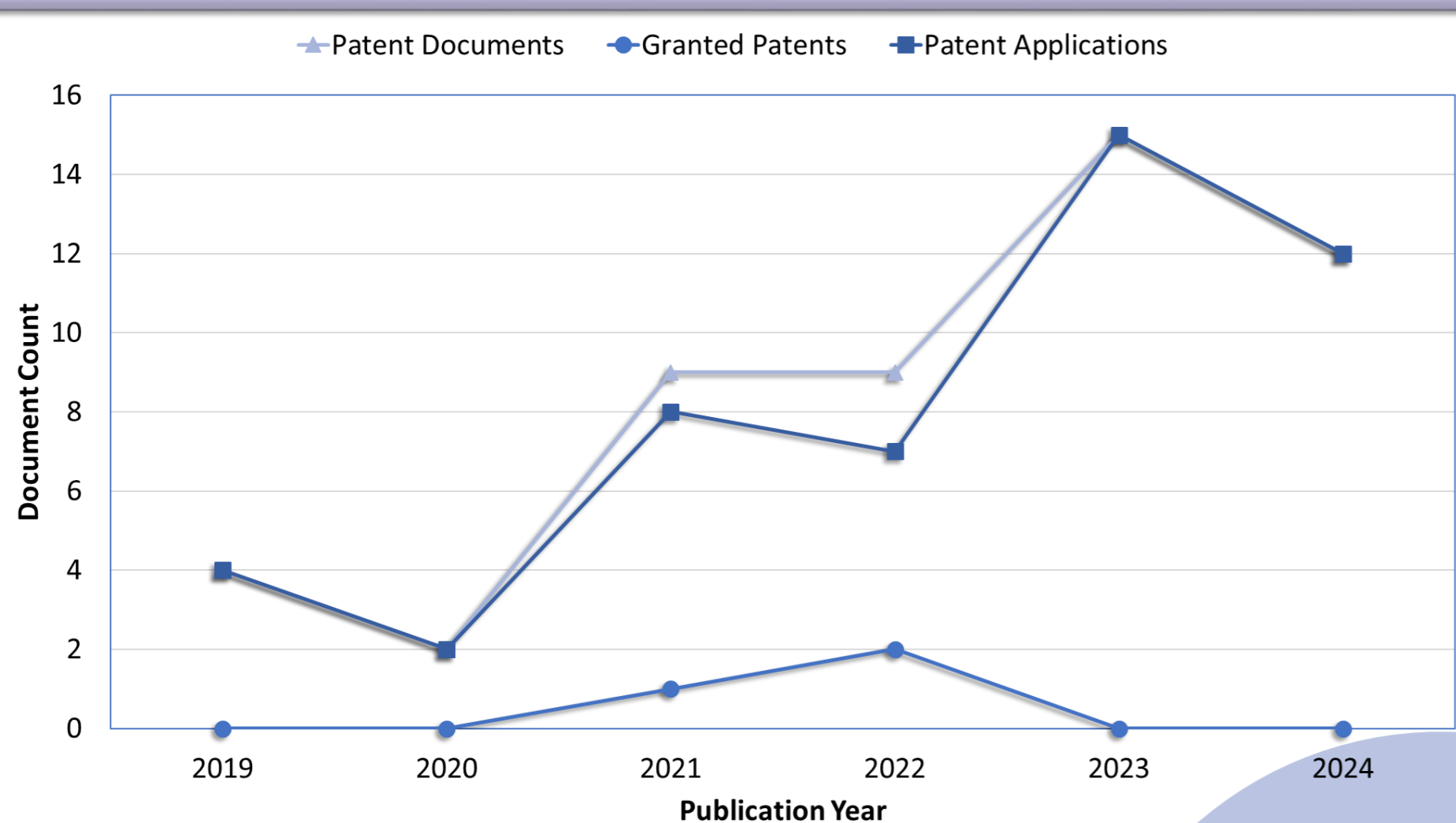
INTRODUCTION & AIM

- This study explores the trends in patent activities for HEs used in ZIBs, emphasizing their applications in eco-efficient and sustainable energy solutions.

METHOD

- Data Source:** Patent data from international databases.
- Analysis Framework:**
 - Distribution of patent documents by publication year to identify trends.
 - Classification of applicants.
 - Geographic distribution by jurisdiction.
 - International Patent Classification (IPC) analysis to map innovation areas.

RESULTS & DISCUSSION



- This study analyzes 51 patent documents, including 48 applications and 3 granted patents, focusing on the formulation and application of HEs in ZIBs.
- IPC data reveal that:
 - 14% of the patents pertain to HEs based on copolymers derived from compounds with unsaturated aliphatic radicals containing amides, such as acrylamide and methacrylamide.
 - Similarly, 14% emphasize electrolytes solely composed of polymeric materials.
 - Processes for treating macromolecular substances, such as hydrogels, constitute 12% of the patents, while 8% target crosslinking processes like vulcanization of macromolecules.
 - Patents involving copolymers with oxygenated carbonamido radicals account for 6%, underscoring diverse approaches to material synthesis and optimization.
- China leads this innovation landscape, with Anhui University and the City University of Hong Kong emerging as primary contributors.

CONCLUSION

- Patent classification data also indicate that many patents target technologies aligned with greenhouse gas mitigation, such as viscoelastic HEs for energy storage.
- These findings underscore the promising future of HEs in ZIBs, supported by active research and development efforts focused on eco-efficiency, high capacity, and sustainability.