A large format and high performance aqueous rechargeable $LiFePO_4$/Zn battery for stationary energy storage

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Aqueous rechargeable lithium-ion batteries (ARLIB) have gained significant attention for various energy storage applications due to their inherent safety, low cost, and environmental friendliness compared to traditional non-aqueous battery systems. Here, $LiFePO_4$ (lithium iron phosphate) and Zn (zinc) materials were adopted as a positive and negative electrodes, respectively, for the large format ARLIB prototype. In particular, $LiFePO_4$ is known for its high thermal and chemical stability, theoretical capacity of 172 mAh/g, long cycle life, and excellent safety characteristics. Zinc, on the other hand, is abundant, low-cost, and has a high energy density. By utilizing an aqueous electrolyte, this battery chemistry aims to provide a safer and more sustainable alternative to traditional lithium-ion batteries. However, there are some challenges associated with developing high-performance ARLIBs, especially for stationary energy storage applications. Through continuous research and development, it is crucial to optimize the ARLIBs performance characteristics, such as energy density, power density, cycling stability, and calendar life. This can be achieved through material innovations, electrode modifications, and electrolyte advancements [1,2].

In this study, we aimed to design and develop a large format, high performance ARLIB prototype where following key problems were investigated and optimized: firstly, choosing the appropriate aqueous electrolyte composition is essential. It should provide good ionic conductivity while being stable over a wide voltage range. Various additives and salts were investigated to enhance the electrolyte's stability and reduce parasitic reactions on the Zn anode surface. Secondly is Zn dendrite passivation by adopting several scalable methods, such as magnetron sputtering and polymer layer coating. Thirdly is electrode design and engineering of the cathode and anode electrodes for maximizing performance. Strategies such as optimizing particle size, morphology, and coating technologies can enhance the overall electrochemical performance, including capacity, power, and cycling stability. Next step is the choice of separator that is critical for preventing the crossover of ions between the cathode and anode. High-performance separators with good ionic conductivity and mechanical strength are required to ensure efficient ion transport and prevent short circuits. Lastly, the battery's cell design, such as the arrangement of electrodes, current collectors, and packaging, is taken into account to facilitate efficient ion and electron transport, minimize internal resistance, and enable scalability for large-scale energy storage applications.

The present study provides insights into the importance of the extensive research and collaboration between academia and industry entities to address the technical challenges and optimize the performance and commercial viability of ARLIB batteries.

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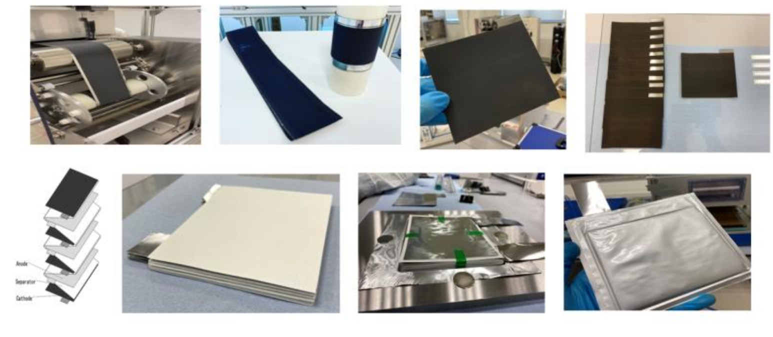

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