Carbon-based cathodes for non-alkaline Zn-air batteries: structure-performance relations and stability

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Due to their high theoretical energy density, potentially low cost, and safety, rechargeable zinc-air batteries (ZABs) have been identified as a promising type of energy storage devices. However, research on ZABs has primarily focused on systems with strongly alkaline solutions, which have severe limitations. Anodes in these cells suffer from problems such as uneven plating-stripping of zinc, passivation by zinc oxide, or continuous corrosion in alkaline electrolytes. On the cathode side, irreversible uptake of carbon dioxide from ambient air leads to a decrease in conductivity and clogging of cathode pores with K_2CO_3.

One of the most promising ways to overcome the limitations of alkaline ZABs is switching to non-alkaline electrolytes. The electrolytes with near-neutral pH can substantially improve stability of Zn anodes and circumvent the problem with CO2 absorption from the air. Despite these advantages, non-alkaline ZABs are not well-studied, and the main issue with these batteries is poor kinetics of the oxygen reduction and evolution reactions. Therefore, the development of cathode scaffolds with high catalytic activity in near-neutral media is crucial for non-alkaline ZABs.

Our study focuses on carbon-based cathodes in non-alkaline ZABs that use aqueous solutions of zinc sulfate, acetate or triflate as electrolytes. We explore the relationships between the structure and performance of materials with varying morphology, specific surface area, wettability, graphitization degree and surface chemistry. Additionally, we evaluate the anodic stability of the cathodes using online electrochemical mass spectrometry (OEMS) in combination with Raman spectroscopy and X-ray photoelectron spectroscopy. Our findings offer insights for developing suitable cathodes with attractive morphological and structural characteristics for non-alkaline ZABs.

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