Investigating the influence of cell orientation, type of zinc electrode and electrolyte immobilization on the electrochemical performance of Ni-Zn battery cells

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The growing need for durable, environmentally friendly, and low-cost energy storage systems, characterized by high specific power, combined with the essential search for safe alternatives to Li-ion batteries, serves as the main factor for an ever-increasing number of research efforts devoted to rechargeable Ni-Zn power sources. Despite their safer nature and competitive power density and price, the rechargeable alkaline Ni-Zn battery system has not yet penetrated deeply into the market due to its tendency to gradually decrease in capacity over multiple charge and discharge cycles and its relatively limited cycle life The performance-limiting issues include passivation of the surface of the zinc electrode during discharge, electrode shape changes over repeated cycling, and formation of zinc dendrites during charge. These undesirable processes are primarily attributed to the gradual dissolution of zinc in the electrolyte, which mainly consists of an aqueous solution of potassium hydroxide. Therefore, the main challenge is to find suitable solutions for improving zinc electrode design, electrolyte composition and the development of innovative materials in order to achieve high resistance of zinc against dissolution, leading to an increase lifespan of the Ni-Zn batteries.

For successful operation of a nickel-zinc battery, it is necessary to know a number of important technological parameters - the composition and amount of the active mass of the electrodes, the volume and composition of the electrolyte, the types of separators, the geometric position of the element under test, etc. In this regard, the effect of the orientation of the nickel-zinc battery element on the initial capacity for two types of zinc anodes - pasted and electrochemically deposited over copper foam current collector was experimentally investigated. Additionally, the dependence of discharge/charge capacity during cycling of different types of Ni-Zn symmetric cells has been studied. The cells were assembled with an electrode package containing a commercially available sintered Ni cathode and Zn anode, prepared either by pasting zinc powder with AGAR binder or by zinc electroplating. The electrolyte utilized was potassium hydroxide, which was either immobilized within the pores of the active material or incorporated into a gel formulated from PVA with suitable additives. Phase composition and morphology analysis of the active mass before and after cycling by X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) were analysed.

The results obtained show that the cell assembled with the electroplated Zn anode, combined with the gel electrolyte possesses a slightly longer cycling life (up to 470 cycles) compared to that prepared by pasting, although the latter demonstrated a more stable capacity versus time.

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