Synergistic Ce-NiCoO2 Wrapped in Biomass-Derived N-CQDs for High-Performance Seawater-Activated Batteries

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The rising cost and scarcity of conventional battery materials have accelerated the search for sustainable energy storage systems capable of operating in extreme environments. Seawater-activated batteries (SWBs) generate energy instantly upon contact with seawater, offering long shelf life and high safety for maritime, military, and emergency applications. However, their performance is limited by the poor conductivity and instability of traditional anodes. This study develops a novel anode of cerium-doped nickel cobalt oxide (Ce–NiCoO2) encapsulated in biomass-derived nitrogen-doped carbon quantum dots (N-CQDs). The Ce–NiCoO2/N-CQDs hybrid was synthesized via a controlled hydrothermal method. Cerium, cobalt, and nickel salts were used as precursors, with Ce doping levels of 0%, 3%, 5%, and 10% and a 50:50 Co:Ni ratio, followed by calcination. Melon skin-derived N-CQDs were prepared hydrothermally using polyetherimide as the nitrogen source, enabling uniform encapsulation and improved interfacial contact. SEM showed optimized Ce doping thinned the flower-like nanosheets, increasing electroactive surface area. Cyclic Voltammetry identified 5% Ce–NiCoO2/NCQD as optimal, enhancing areal capacitance by ~119% over undoped NiCoO2/NCQD. EIS confirmed reduced charge-transfer resistance. By integrating materials innovation with green chemistry, this work presents a potential sustainable strategy for high-performance seawater battery anodes, transforming biomass waste into advanced materials for next-generation energy storage.

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