

Influence of Zn and Fe Dopants on Structural and Morphological of Layered Cathode Materials NCA Synthesized *via* the Combustion Method

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Structured Abstract

Background: Lithium-ion batteries (LIBs) have been widely used in portable electronic devices and electric vehicles (EVs). Layered cathode materials, such as Nickel Cobalt Aluminium Oxide (NCA), are commonly applied in LIBs due to their high energy density and lower cost. However, NCA suffers from capacity fading and cation mixing, which can degrade battery performance. To address these issues, this study proposes doping NCA with Iron (Fe) and Zinc (Zn). The objective of this research is to determine whether the synthesis produces a pure, single-phase cathode material and to investigate how these dopants affect the material's structural, morphological, and elemental composition.

Methods: The combustion method began by weighing all the starting materials and dissolving them in deionized water. The solutions were then combined in a 1 L beaker and stirred for one hour to ensure uniform mixing. The mixture was then heated on a hot plate in stages: first at 200 °C for 30 minutes, followed by 300 °C for another 30 minutes, and finally at 400 °C until combustion occurred. After the combustion reaction, the resulting precursor was ground using a mortar and pestle. Lastly, the ground precursor was sintered and annealed in a high-temperature furnace to produce the final product.

Results: In this study, X-ray diffraction (XRD) results confirmed that the NCFe sample formed a single-phase layered α -NaFeO₂ structure with a hexagonal R-3m space group, while NCZn showed impurity peaks from secondary Co₃O₄ phases. NCFe recorded the highest Reference Intensity Ratio (RIR) of 0.93, indicating minimal cation disorder and better structural stability. Scanning Electron Microscopy (SEM) images showed NCFe had irregular particles but a more uniform morphology than NCZn. Energy-Dispersive X-ray (EDX) analysis confirmed that the elemental compositions of Ni, Co, Al, Zn, and Fe were close to the target stoichiometry and evenly distributed across particle surfaces. Overall, Fe-doping improved the structure and morphology of nickel-rich cathode materials.

Conclusion: In conclusion, the findings of this study indicated that Fe-doping significantly improved both the structural ordering and morphology of LiNi_{0.65}Co_{0.24}Mn_{0.1}Al_{0.01}O₂, making NCFe the most suitable dopant candidate for synthesizing nickel-rich cathode materials (NCA) using the combustion method.

Keywords: Lithium-ion battery, cathode materials, dopants, combustion

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