

Structural and Morphological Changes of NCTA Synthesized by Co-Precipitation at Different Annealing Temperatures

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Structured Abstract

Background: Lithium-ion batteries (LIBs) have remained popular since their introduction to the global market due to their high efficiency and energy density. This study focuses on synthesizing $\text{LiNi}_{0.69}\text{Co}_{0.2}\text{Ti}_{0.1}\text{Al}_{0.01}\text{O}_2$ (NCTA) using the co-precipitation method, with the aim of overcoming the challenge of achieving a pure, single-phase material essential for high-performance LIBs. One of the key challenges is cation mixing, particularly between lithium and nickel ions, which disrupts the structural integrity during charge-discharge cycling. Therefore, by controlling the synthesis parameters, especially the calcination temperature, it is possible to minimize impurities, reduce cation mixing, and optimize battery performance.

Methods: The synthesis process was carried out using the co-precipitation method, where all precursors were homogenized by continuous stirring for 4 hours. The resulting mixture was filtered and washed several times with deionized water to remove impurities. After filtration, the sample was dried overnight in an oven, pre-sintered at 480 °C for 5 hours, and then annealed at 870 °C and 920 °C for 15 hours. After annealing, the product was washed for 15 minutes and dried overnight in a vacuum oven. Finally, the obtained powder was characterized using X-Ray Diffraction (XRD) to analyze the crystal structure and Field Emission Scanning Electron Microscopy (FESEM) equipped with Energy Dispersive X-Ray Spectroscopy (EDX) to examine the morphology and elemental composition.

Results: The XRD patterns confirmed the formation of a pure, single-phase hexagonal layered α - NaFeO_2 structure within the $R\bar{3}m$ space group, with no detectable secondary phases. XRD analysis further revealed that the sample annealed at 870 °C exhibited a Reference Intensity Ratio (RIR) of 0.92 and the lowest degree of cation mixing, indicating improved crystallinity and enhanced structural stability. SEM images showed that all samples possessed a single-crystal structure, characterized by uniformly distributed spherical particles. Additionally, EDX spectra confirmed that the elemental distribution of Ni, Co, Ti, and Al closely aligned with the intended stoichiometry and was homogeneously distributed across the sample surfaces.

Conclusion: In conclusion, the findings of this study indicated that temperature 870 °C is the optimal annealing temperature for synthesizing $\text{LiNi}_{0.69}\text{Co}_{0.2}\text{Ti}_{0.1}\text{Al}_{0.01}\text{O}_2$ (NCTA) via the co-precipitation method.

Keywords: Lithium-ion batteries, cathode materials, temperatures, co-precipitation

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