

Impact of Carbon Coating on Ni-rich, $\text{LiNi}_{0.8}\text{Mn}_{0.1}\text{Co}_{0.1}\text{O}_2$ (NMC811) Cathode Materials and Their Electrochemical Performance

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Structured Abstract

Background: The growing demand for efficient and sustainable energy storage has accelerated the development of advanced lithium-ion batteries (LIBs), especially for electric vehicles (EVs). Ni-rich cathode materials such as $\text{LiNi}_{0.8}\text{Mn}_{0.1}\text{Co}_{0.1}\text{O}_2$ (NMC811) offer high energy density and cost efficiency. However, issues like cation mixing, capacity fading, and poor long-term cycling stability remain critical limitations. Recent studies suggest that surface modifications—particularly carbon-based coatings—can significantly improve the electrochemical performance of Ni-rich cathodes. This study investigates the structural, morphological, and electrochemical effects of graphene coatings on NMC811 cathodes using two distinct methods: homogenizer dispersion and solid-state mixing.

Methods: Commercial NMC811 powder was coated with 1 wt% graphene using two approaches: (1) Homogenizer-assisted dispersion at 1500, 1700, and 2000 rpm (Plan A), and (2) Solid-state mixing with direct incorporation of graphene and Super P (Plan B). Structural analysis was performed using X-ray Diffraction (XRD), while surface morphology and elemental composition were studied using Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive X-ray Spectroscopy (EDX). Electrochemical performance was evaluated using a Wonatech battery tester over 30 charge-discharge cycles.

Results: All coated samples retained a pure layered structure without impurities. The RIR (003/104) value of the 2.0k rpm sample was 1.18, indicating reduced cation mixing and improved lithium-ion diffusion. FESEM-EDX analysis confirmed more uniform coating in the 2.0k rpm and solid-state samples. The homogenizer sample at 2.0k rpm showed the highest initial discharge capacity (252.48 mAh/g), improving 38.42% over pristine NMC811. However, it exhibited poor capacity retention (0.93% after 30 cycles). In contrast, the solid-state sample demonstrated better long-term stability, retaining 65.78% capacity despite lower initial output.

Conclusion: The results reveal that carbon coatings significantly influence the structural order, conductivity, and cycling performance of Ni-rich cathodes. While the homogenizer method boosts initial capacity, the solid-state method offers better durability. This study demonstrates the trade-off between energy density and stability and emphasizes the importance of optimizing carbon coating techniques for high-performance lithium-ion batteries.

Keywords: Graphene Coating, Lithium-ion Battery, Carbon Coating, Electrochemical Performance

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