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Synthesis and Structural Exploration of $NaFe_{1-\gamma}Cr_{\gamma}(MoO_4)_2$ ($0 \le y \le 1$): A New Class of Molybdate Electrode Materials for Next-Gen Sodium-Ion Batteries

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The rapid advancement of embedded systems in electric, hybrid, and satellite vehicles, along with the widespread adoption of portable electronics (smartphones) and the development of renewable energy sources (such as wind and solar), has led to a substantial increase in global demand for high energy density storage systems, particularly lithium-ion batteries.

However, the increasing cost of lithium, linked to its scarcity and uneven global distribution, presents a major challenge to the scalability and sustainability of current battery technologies. This has intensified interest in sodium-ion batteries, which rely on sodium, a more abundant, low-cost, and environmentally benign element.

Despite sodium's chemical similarity to lithium, its larger ionic radius and slightly higher redox potential necessitate the development of new electrode materials tailored to its specific electrochemical behavior. To address this challenge, the present study investigates a family of sodium molybdate-based materials with the general composition $NaFe_{1-\gamma}Cr_{\gamma}(MoO_4)_2$ ($0 \le y \le 1$), chosen for their favorable redox characteristics, structural adaptability, and ecological compatibility. A series of compositions with varying chromium-to-iron ratios is synthesized to explore their impact on material stability and potential electrochemical performance.

Comprehensive characterization is conducted through X-ray diffraction (XRD), infrared (IR) spectroscopy, and scanning electron microscopy (SEM), with crystallographic data refined via the Rietveld method. This integrative approach provides insight into how chromium substitution influences the structural framework and suitability of these compounds as a novel anode materials for rechargeable sodium ion batteries in next-generation.

Keywords: Sodium-ion batteries, Electrode materials, Molybdates, Chromium substitution, Structural analysis, XRD, IR, SEM, Rietveld refinement.