

(1-x) Li_{1-y}Na_yM_{1-z}Ti_zO_{2x} LiM_{2-z}Ti_zO₄ Layered-Spinel nanoparticles as Promising dual positive electrode for Lithium-Ion Batteries and Sodium-Ion Batteries

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Abstract Text

The demand for high-capacity batteries is increasing rapidly with the upcoming energetic needs of an ever increasing population, especially in the transportation sector. Lithium-ion battery (LIB) has emerged as an attractive technology, however the main restriction is his low energy density¹. To make a post-transition possible the sodium-ion battery (SIB) are among the most promising alternatives due sodium is abundant, there are enormous availability and It's low cost². Besides, the electrochemical principles governing LIB and SIB batteries are quite similar³. Nevertheless, for both emerging alternatives it is necessary to find more suitable electrode materials. Therefore, nowadays, different electrode materials have been explored to increase the capacity of those batteries. Specially, the layered-spinel structure has been used to improve the initial specific capacity and stability electrode materials. The Na-layered structure cathode facilitates Li⁺-ion diffusion in the structure⁴. Besides the incorporation of Ti⁴⁺ in the LiMn₂O₄ spinel phase is performed with the purpose of improving its stability by averting the Jahn-Teller effect of the Mn³⁺ and decreasing Mn²⁺ dissolution towards the electrolyte during cycling since Ti-O provides a higher binding energy (662 kJ/mol) than for Mn-O (402 kJ/mol)¹.

The aim of this investigation is to estimate the optimal stoichiometry in the (1-x)Li_{1-y}Na_yM_{1-z}Ti_zO_{2x} LiM_{2-z}Ti_zO₄ layered-spinel by varying the concentration of Na⁺ and to assess the effects of the Na⁺ addition in the cycling stability of the active material. A facile sol-gel method is presented to develop new composite materials for LIB and SIB.

Analysis of XRD patterns confirmed the existence of a spinel layered composite where the peaks can be indexed to the cubic spinel structure (Fd $\bar{3}$ m) and layered structure (c2/c) for the (020) superlattice peak at 20.5^o. For LIB cycling was performed typically between 4.8 and 2.0V vs. Li|Li⁺ at a constant current of 29.0 mA g⁻¹, equivalent to 0.1 C-rate. The stoichiometry 0,5Li_{0,9}Na_{0,1}Mn_{0,4}Ni_{0,5}Ti_{0,1}O₂-0,5LiMn_{1,4}Ni_{0,5}Ti_{0,1}O₄ showed an initial specific capacity, ca. 141 mAhg⁻¹ but later it presented increasing of the specific capacity, ca. 180 mAh g⁻¹ at 15st cycling exhibiting 98% of its charge capacity after 30st cycles. Moreover, for SIB cycling was performed typically between 4.5 and 2.0V vs. Na|Na⁺ at a constant current of 12.0 mA g⁻¹, equivalent to 0.1 C-rate. In this case, the stoichiometry

$0.5\text{Li}_0\text{Na}_{1.0}\text{Mn}_{0.4}\text{Ni}_{0.5}\text{Ti}_{0.1}\text{O}_2$ - $0.5\text{LiMn}_{1.4}\text{Ni}_{0.5}\text{Ti}_{0.1}\text{O}_4$ showed an initial specific capacity, ca. 118 mAh g^{-1} .

Thus, by possessing interesting properties electrochemical we believe that these materials could be a potential electrode for the development of high-power rechargeable Li-ion batteries and Na-ion batteries.

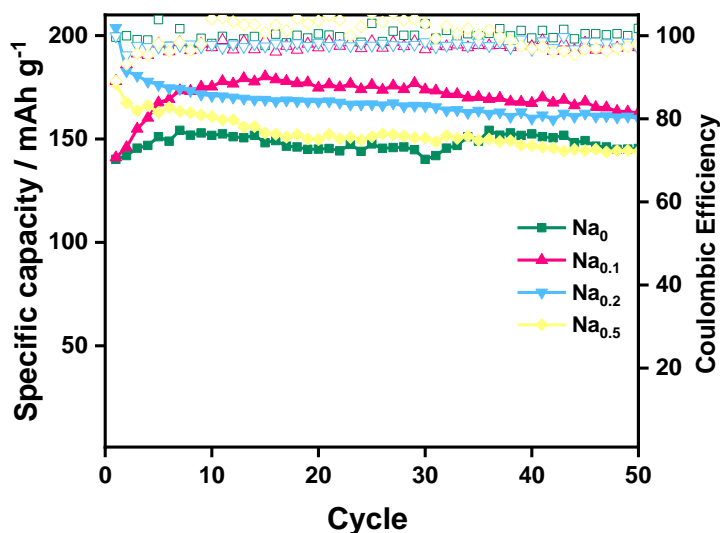


Figure 1. Discharge specific capacity of active material $0.5\text{Li}_{1-y}\text{Na}_y\text{Mn}_{0.4}\text{Ni}_{0.5}\text{Ti}_{0.1}\text{O}_2$ - $0.5\text{LiMn}_{1.8}\text{Ti}_{0.2}\text{O}_4$ [$y = 0; 0,1; 0,2, 0,5$] at a constant current of 23.9 mA g^{-1} (0.1C) between 4.9 and 2.0 V vs. $\text{Li}|\text{Li}^+$.

References

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