# Advancing Sodium-Ion Batteries through Electrode Doping and Optimized Electrolytes

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P2-type layered oxides ($Na_xTMO_2$) are promising cathode materials for sodium-ion batteries due to their cost-effectiveness, structural flexibility, and promising energy density. However, cycling to high voltages (>4.2 V) induces structural degradation, irreversible oxygen loss, and interfacial instability. These issues stem from irreversible anionic redox reactions, phase transitions, and Jahn–Teller distortion, all of which compromise capacity retention and safety [1].
To address these challenges, we employed a dual modification strategy: (1) Al doping at transition metal sites and (2) use of a low-concentration $NaPF_6$-based electrolyte. Al substitution, though electrochemically inactive, enhances structural integrity by suppressing $Mn^{3+}$-induced distortions and reducing TM migration, thereby stabilizing the oxygen redox process. Concurrently, low-concentration electrolytes limit interfacial side reactions and phase instability.
The optimized system demonstrated high initial capacities of 184/178 $mAh \cdot g^{-1}$ (discharge/charge) at 10 $mA \cdot g^{-1}$ between 2.0–4.6 V, with an electrode loading of 7 $mg \cdot cm^{-2}$ and 84% capacity retention after 100 cycles. These results highlight the synergistic role of bulk and interfacial modifications in enabling high-voltage, long-life sodium-ion batteries [2].

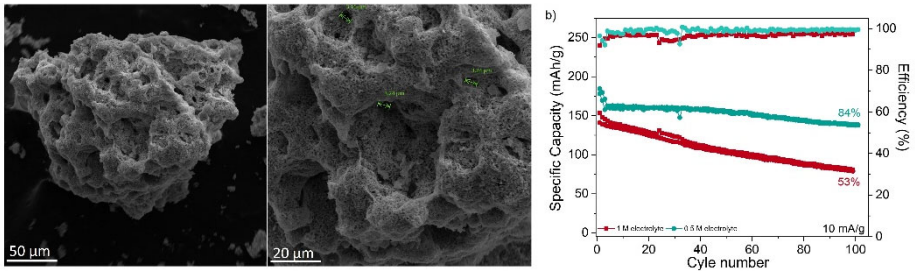


Figure 1: a) SEM images of synthesized material, b) cycling performances of P2-$Na_{0.67}Mn_{0.56}Ni_{0.11}Fe_{0.25}Al_{0.08}O_2$ with standard and low-concentration electrolytes at 10 $mA \cdot g^{-1}$ within the voltage range between 2.0-4.6 V (*vs.* $Na^+/Na$) [2].
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## References

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