A Novel Lithium Substitution Induced Tunnel/Spinel Heterostructured Cathode Material for Advanced Sodium-Ion Batteries

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Introduction

The tunnel-type $Na_{0.44}MnO_2$ is one of the most promising candidates for advanced sodium-ion batteries, but its commercial application is hindered by poor cycling stability and low high-current capacity due to Jahn–Teller (JT) distortion. Herein, a Li-substituted, tunnel/spinel heterostructured cathode is successfully synthesized for addressing these limitations. In this work, the Li dopant acts as a pillar inhibiting unfavorable multiphase transformation, improving the structural reversibility, and Na storage performance of the cathode. Meanwhile, the tunnel/spinel heterostructure provides 3D Na^+ diffusion channels to effectively enhance the redox reaction kinetics. Therefore, the optimized $[Na_{0.396}Li_{0.044}][Mn_{0.97}Li_{0.03}]O_2$ composite delivers an excellent rate performance and cycle performance, demonstrating the potential of the cathode for practical applications.

Na half-cell performance

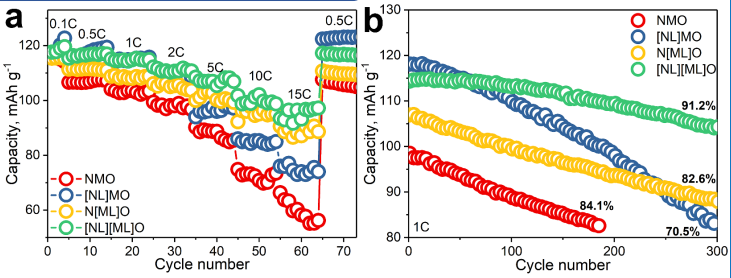

Figure 2. The electrochemical performance of prepared cathodes in coin-type half cells.

Discussion

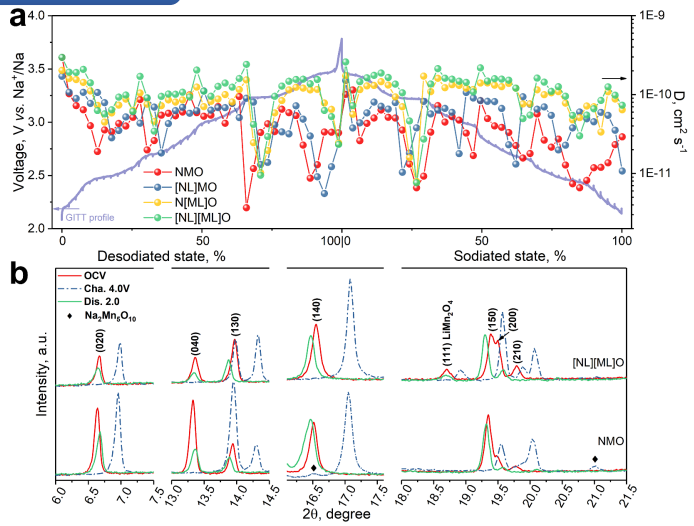

Figure 4. Electrode process kinetics and structural evolution of the as-prepared cathodes.

Synthesis and Characterization

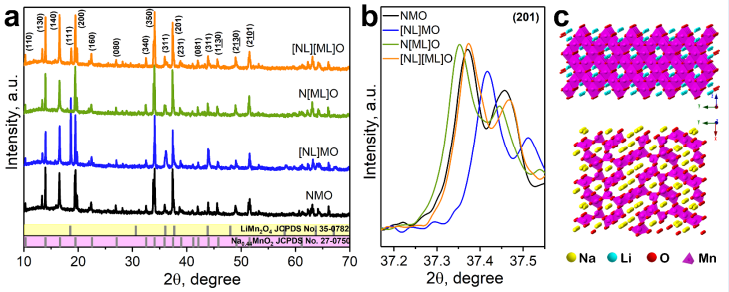

Figure 1. Material characterization of the as-synthesized materials.

Practicality

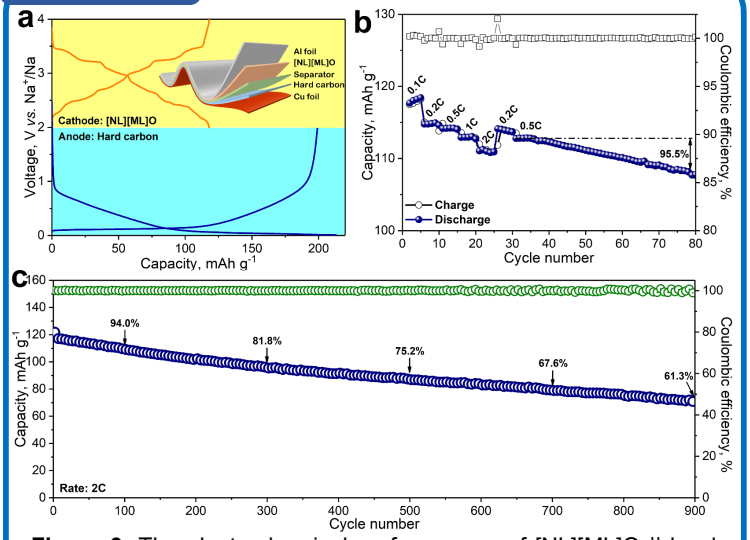

Figure 3. The electrochemical performances of [NL][ML]O || hard carbon full cells.

Conclusion

- **A tunnel/spinel heterostructured cathode was successfully synthesized for SIBs through Li substitution.**
- **The Li dopant acts as a pillar that mitigates structural degeneration and stabilizes the crystal lattice of the host material. And the tunnel/spinel heterostructure provides 3D Na^+ diffusion channels, effectively enhancing the redox reaction kinetics.**
- **[NL][ML]O composite delivers a reversible capacity of 119.6 mA h g^{-1} at 0.1 C with a high Coulombic efficiency of 99.8%. In addition, it demonstrates superior rate capability (15 C) and excellent cycling stability in Na-ion half(1200 cycles, 10C)/full(900 cycles, 2C) battery systems.**

References

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