High-voltage Electrolyte Design for Sodium-ion Batteries

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Introduction

Sodium-ion batteries (SIBs) have emerged as a promising alternative to lithium-ion batteries (LIBs) due to the abundant availability and low cost of sodium resources. The SIBs bring an opportunity for achieving high Coulombic efficiency for the Na-ion battery anode but also create more challenges for the cathode due to its high potential. Therefore, achieving high energy density and long cycle life in SIBs remains a significant challenge, primarily due to the limitations of conventional electrolytes in supporting high-voltage SIBs.

High-voltage electrolytes are crucial in unlocking the full energy potential of SIBs. The electrolytes should withstand high operating voltages and also maintain good electrochemical/thermal stabilities to accommodate both anode and cathode materials. Innovations in electrolyte chemistry, including novel solvents, salts, and additives, are essential for enhancing the electrochemical performance and safety of SIBs.

Objectives and Methodology

- ❑ Develop electrolytes enabling HC||NMC622 full cells to achieve long-cycle performance.
- ❑ Understand the correlation between electrolyte composition, electrode (HC, NMC622) interphases (SEI, CEI), electrochemical operation window, and electrochemical performance
- ❑ Propose electrolyte design principles for SIBs.

M1 Electrolyte Electrochemical Stability Test

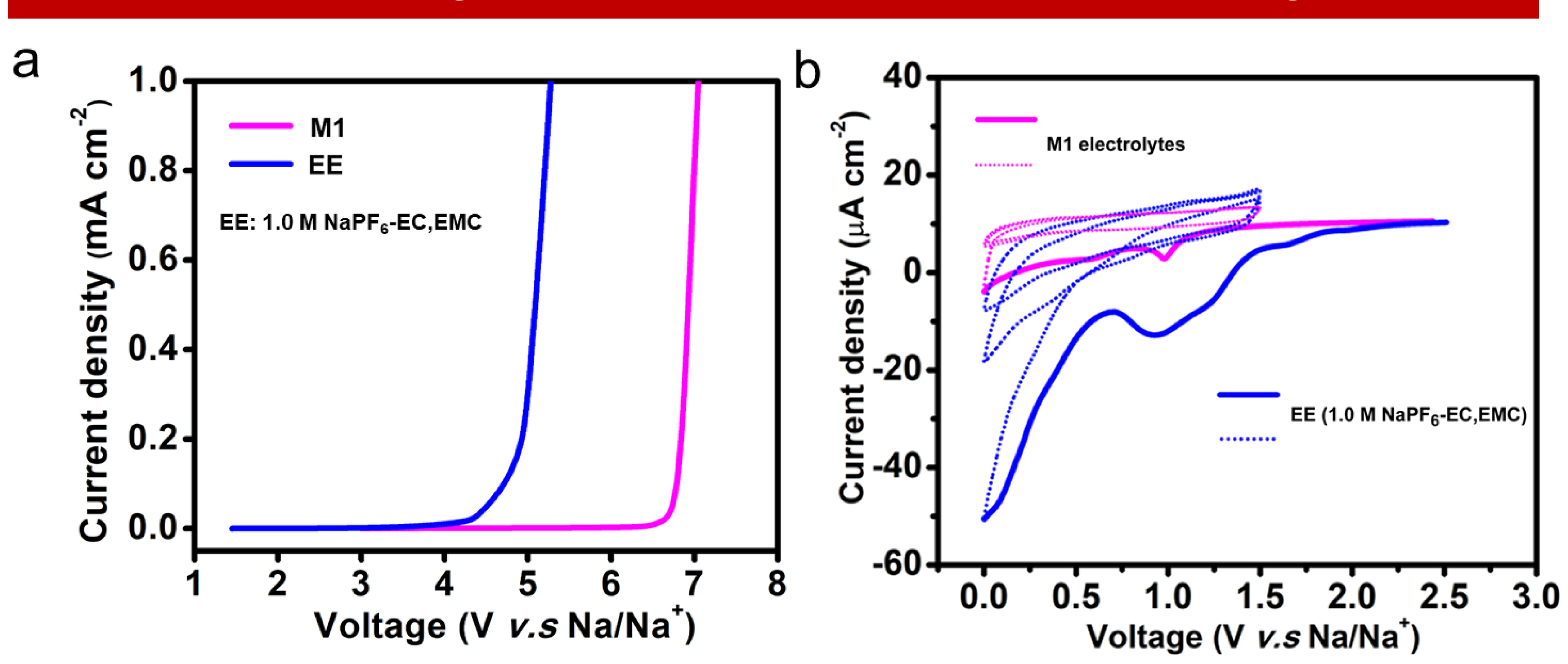

Figure 1. Electrochemical stability of the designed electrolyte I (M1) and commercial electrolyte (EE). LSV (**a**) and CV (**b**) scans in Na||Al half cells at a scan rate of 0.5 mV s^{-1}.

M2 electrolyte Electrochemical Stability Test

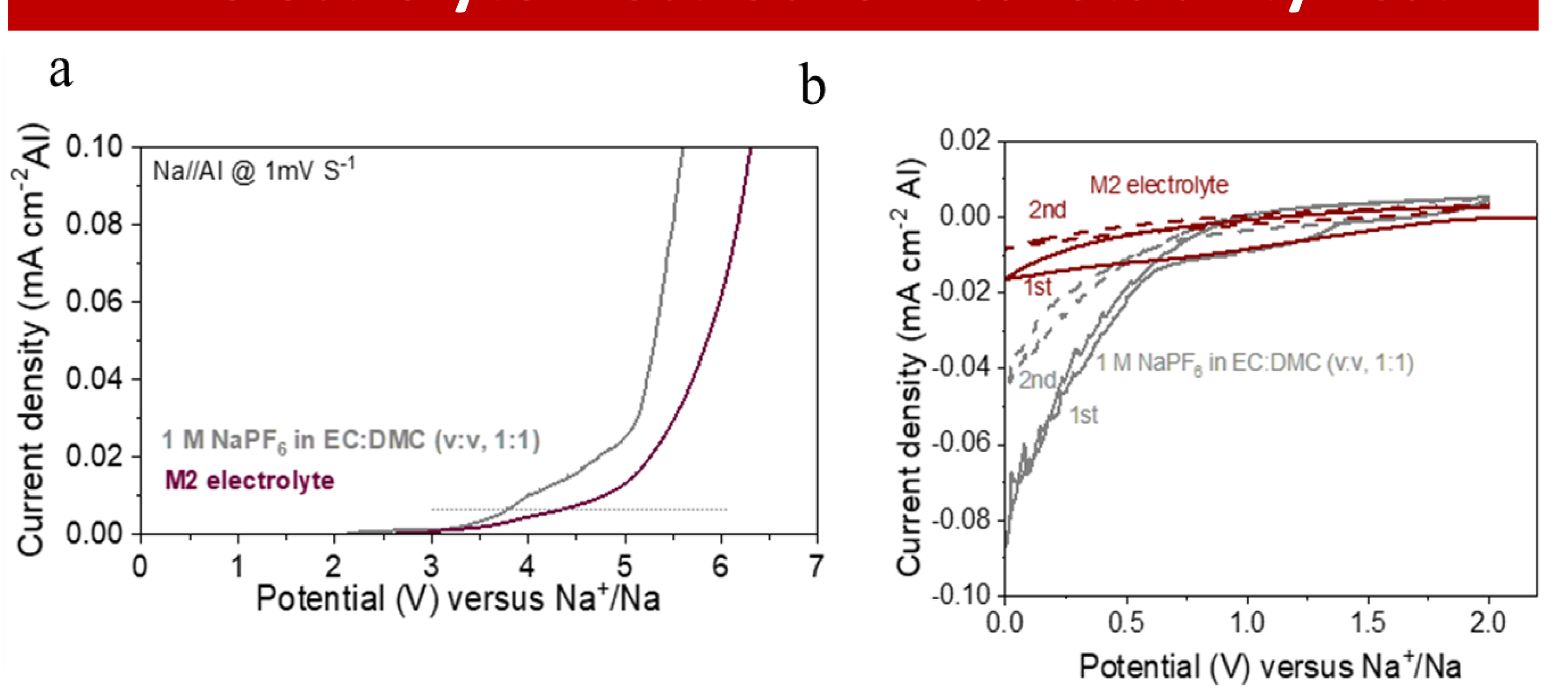

Figure 2. **Electrochemical stability of the designed electrolyte II (M2) and commercial electrolyte**. (**a**) LSV of M2 and commercial electrolyte. (**b**) CV of M2 and commercial electrolyte.

M1 Electrolyte Full Batteries Test

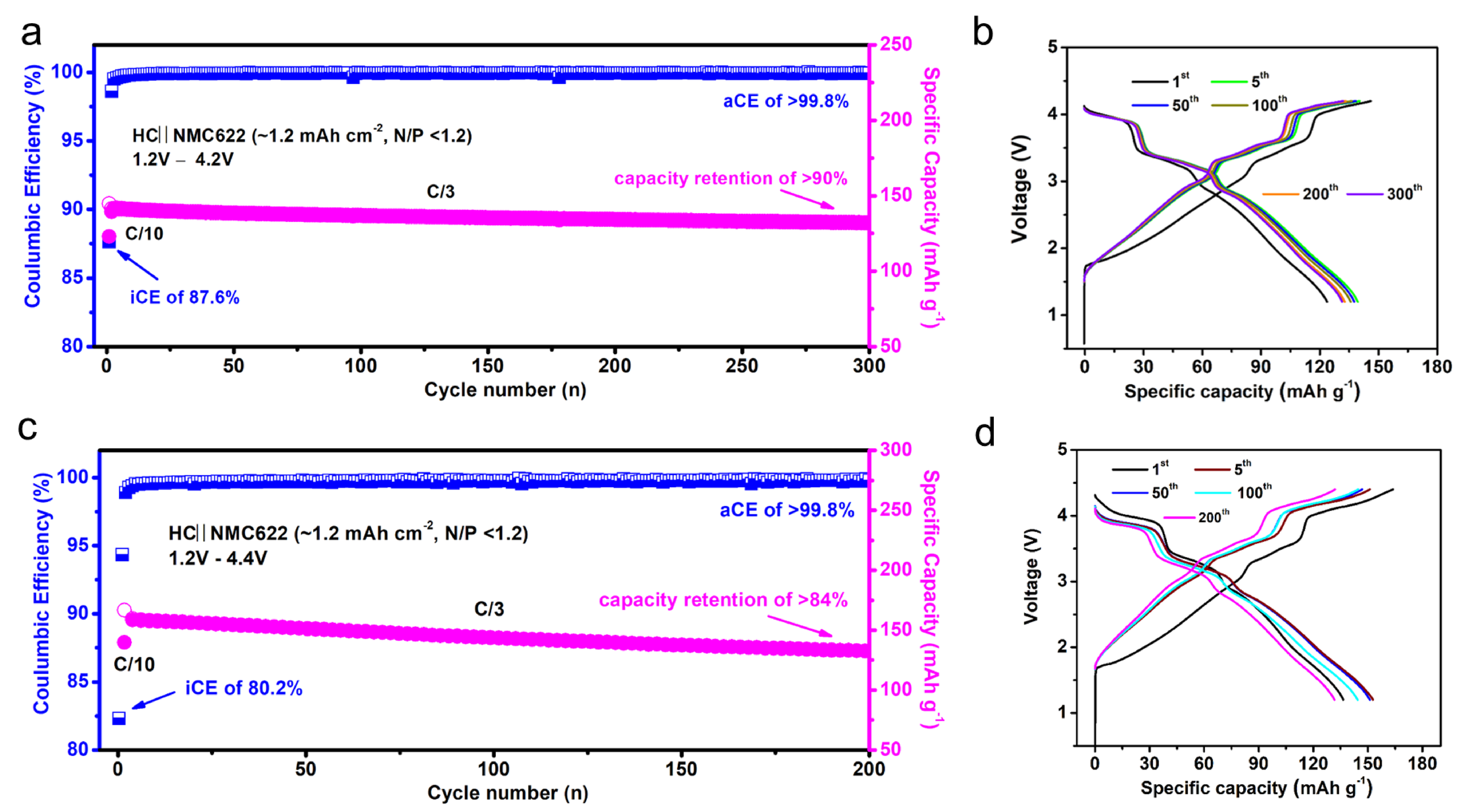

Figure 3. (**a**) Cycle performance and (**b**) voltage profiles of the HC||NMC622 full cells (1.2 mAh cm^{-2}, N/P < 1.2) in M1 electrolyte with a cut-off voltage range of 1.2-4.2V at C/3 (formation cycle at C/10). (**c**) Cycle performance and (**d**) voltage profiles of the HC||NMC622 full cells (1.2 mAh cm^{-2}, N/P < 1.2) in M1 electrolyte with a cut-off voltage range of 1.2-4.4V at C/3 (formation cycle at C/10).

M2 Electrolyte Full Batteries Test

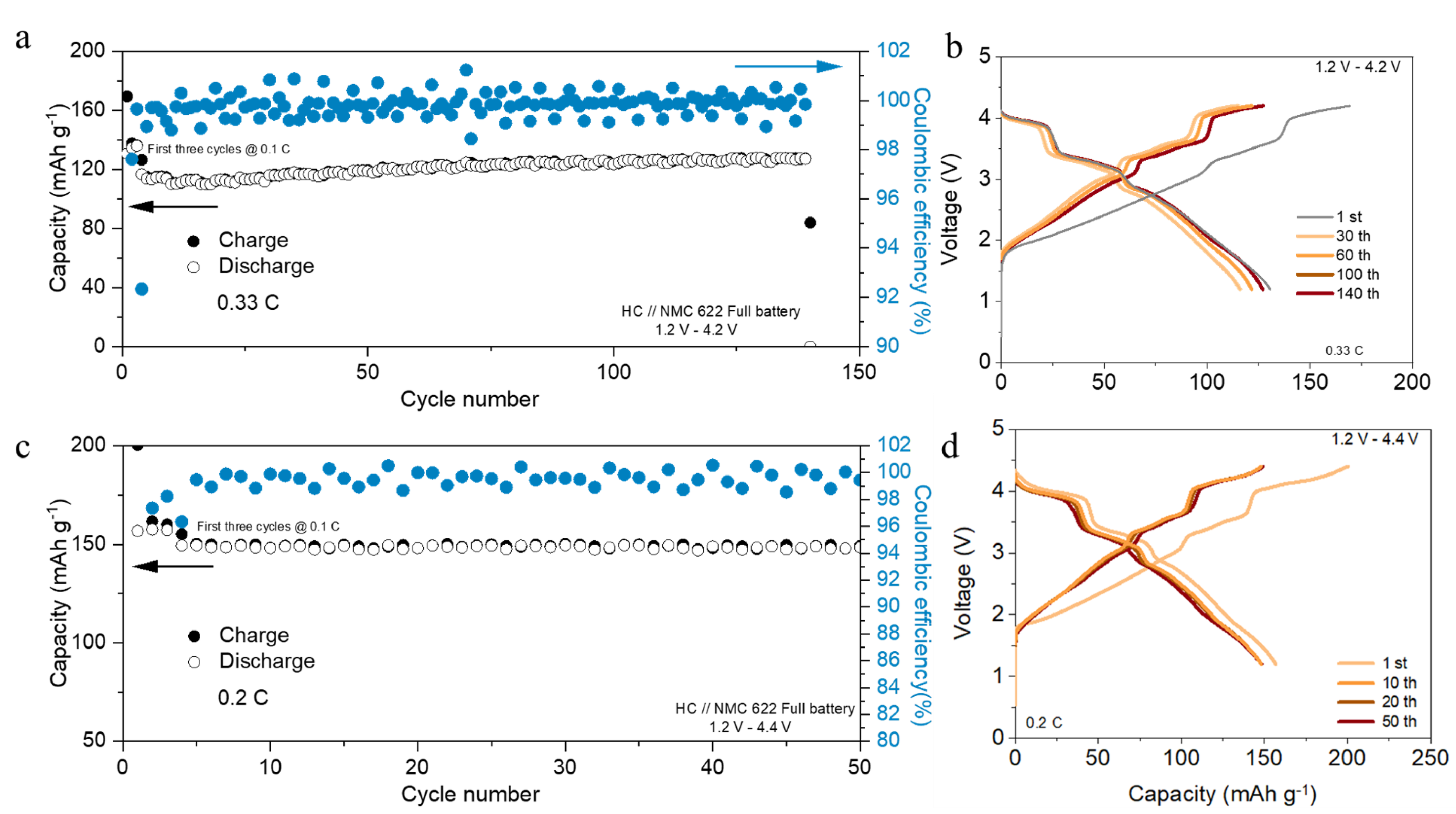

Figure 4. (**a**) Cycle performance and (**b**) voltage profiles of the HC||NMC622 full cells (1.2 mAh cm^{-2}, N/P < 1.2) in M2 electrolyte with a cut-off voltage range of 1.2-4.2V at C/3 (formation cycle at C/10). (**c**) Cycle performance and (**d**) voltage profiles of the HC||NMC622 full cells (1.2 mAh cm^{-2}, N/P < 1.2) in M2 electrolyte with a cut-off voltage range of 1.2-4.4V at C/5 (formation cycle at C/10).

Conclusion and Future Work

➢M1 electrolyte enables HC||NMC622 full cells to achieve 90% capacity at 300th with cut-off voltage of 4.2V; >84% at 200th with cut-off voltage of 4.4V, M2 electrolyte enables HC||NMC622 full cells to maintain their capacity after 150 cycles

➢Optimization of M1 and M2 electrolytes to further enhance HC||NMC622 pouch cell performance.

Acknowledgment

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