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Molten NaI-$AlCl_3$ Catholytes for Use in a Sodium Battery

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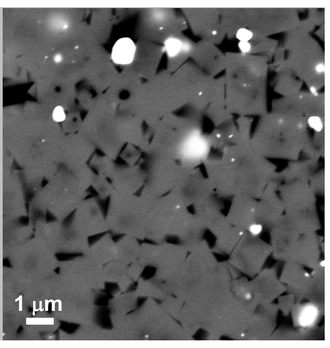


Molten sodium batteries promise a safe, scalable solution to grid scale energy storage. Our previous long term 3000 h tests[1] on NaI-based catholytes suggested possible precipitation of solid NaI. To better understand this potential problem, we synthesized a wide range of NaI-$AlCl_3$ salts and performed extensive thermal characterization, coupled with electrochemical analysis to better understand the phase stabilities of this molten salt system.

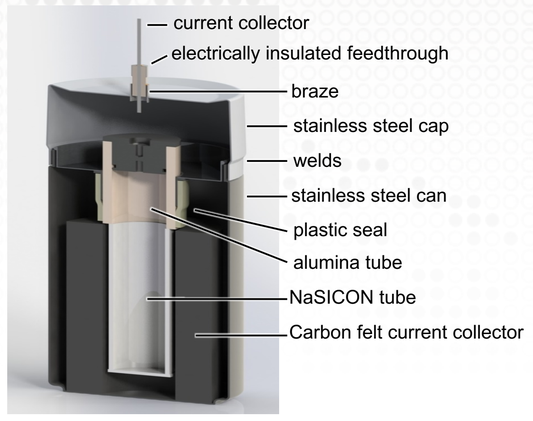
Battery reactions upon charging:

Anode: $Na^+ + e^- \rightarrow Na$

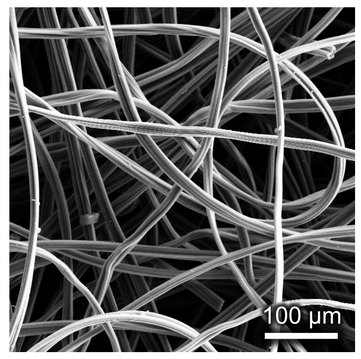
Cathode: $3I^- \rightarrow I_3^- + 2e^-$

As the battery is charged, Na^+ concentration decreases in the catholyte.

Schematic of a NaI Battery

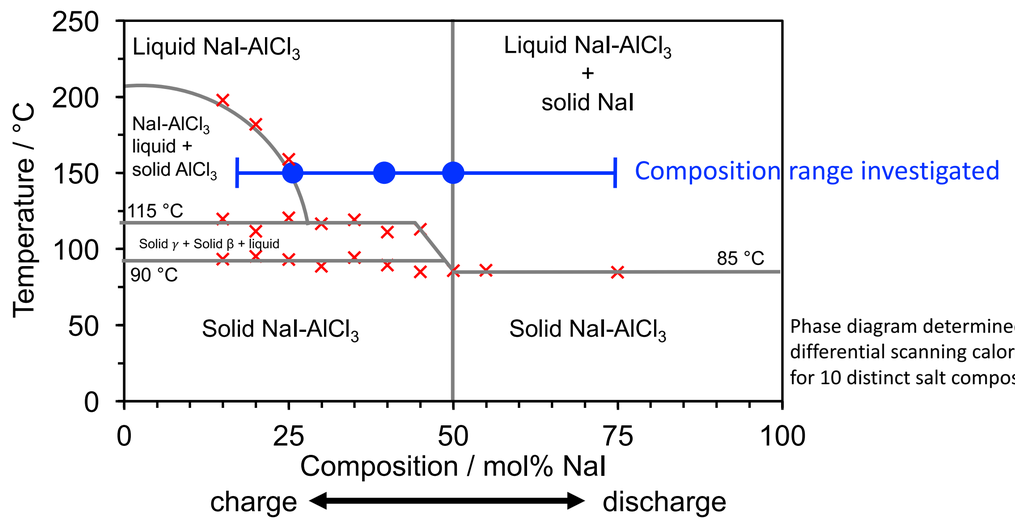


Carbon Felt Current Collector



Use a single carbon fiber from carbon felt to characterize electrochemical performance

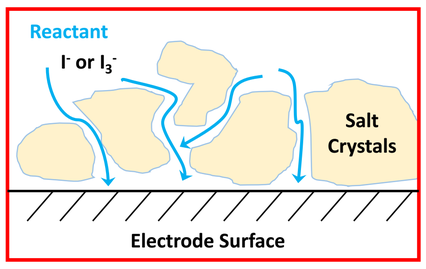
Preliminary Phase Diagram of NaI-$AlCl_3$ Catholyte



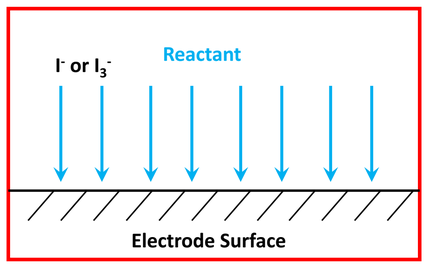
Phase diagram determined by differential scanning calorimetry for 10 distinct salt compositions.

Electrolyte Composition Influences Electrochemical Behavior

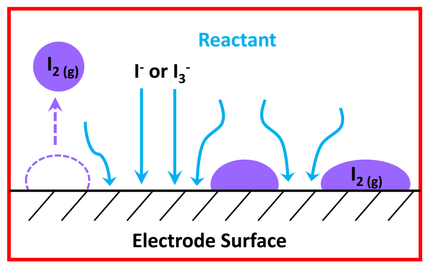
Low NaI Content:
Precipitation of $AlCl_3$ blocks electrode



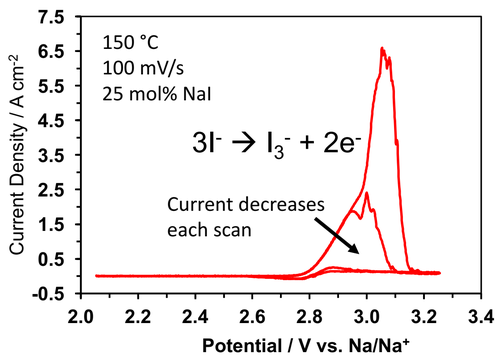
Mid NaI Content:
Ideal Behavior

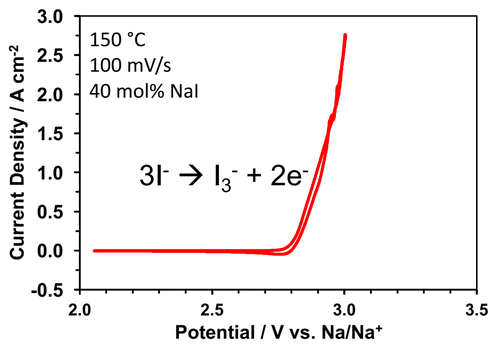


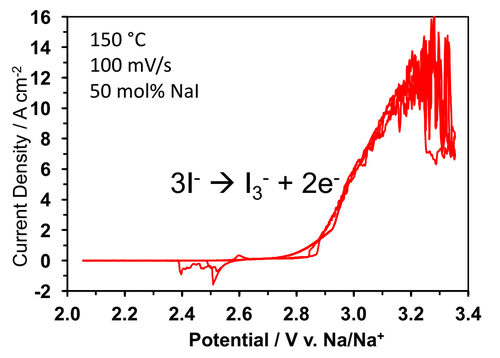
High NaI Content:
Iodine evolution causes irregular current spikes



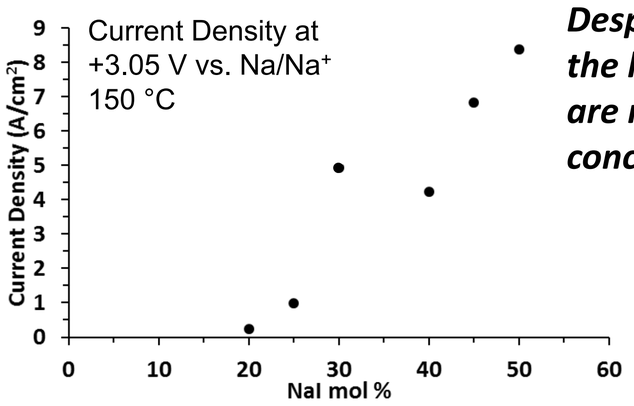
Characteristic Cyclic Voltammograms





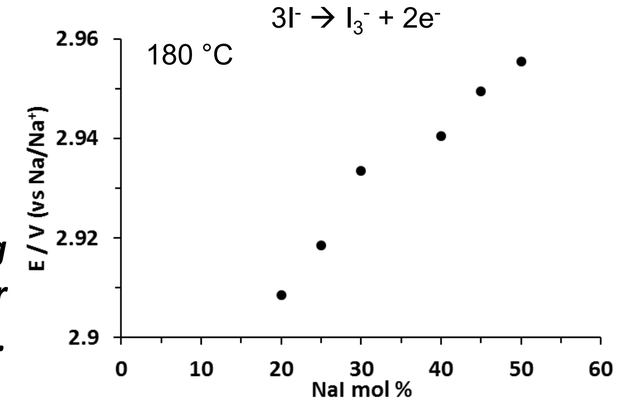


Relevance to Battery Performance



Despite, I_2 bubble formation, the highest current densities are reported at highest NaI concentrations.

Higher battery operating potentials seen at higher NaI concentrations.



[1] L.J. Small et al, *J. Power Sources*, 360 (2017) 569-574.

Optimal Performance Achieved Near NaI Solubility Limit

Acknowledgments
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