Sandia National Laboratories

EXPLORING LOW-TEMPERATURE PERFORMANCE OF NA-ION CELLS TO SUPPORT NEW ESS APPLICATIONS

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PROJECT PROFILE

Topic: Safety & Reliability | Vertical: Safety & Reliability
Strategic Pathway: Grow
Project start and finish: FY25-FY26

PROBLEM

Na-ion batteries are expected to offer an alternative to Li-ion ESS that minimizes supply chain risks and enables improved operation at extreme temperatures (<10 °C & >40 °C). The latter would enable broader deployment of ESS to support the grid in harsh environments, however, this performance has not been independently validated.

APPROACH

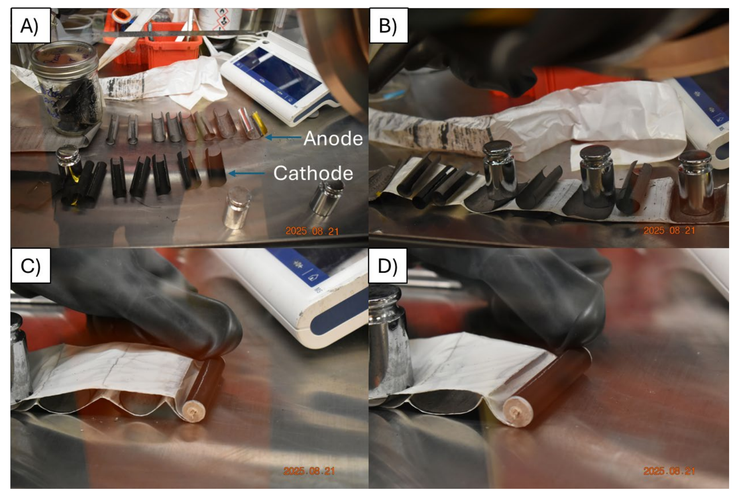
We performed cell-to-cell variance testing, long term cycling (within manufacturer's specifications), and teardown + materials characterization of two types of commercial 18650 Na-ion cells ($Na_xNi_yFe_zMn_{1-y-z}O_2$/hard carbon).

Teardown of a representative 15 °C cycled cell

A) Anode with white/grey coloring, suggesting Na plating

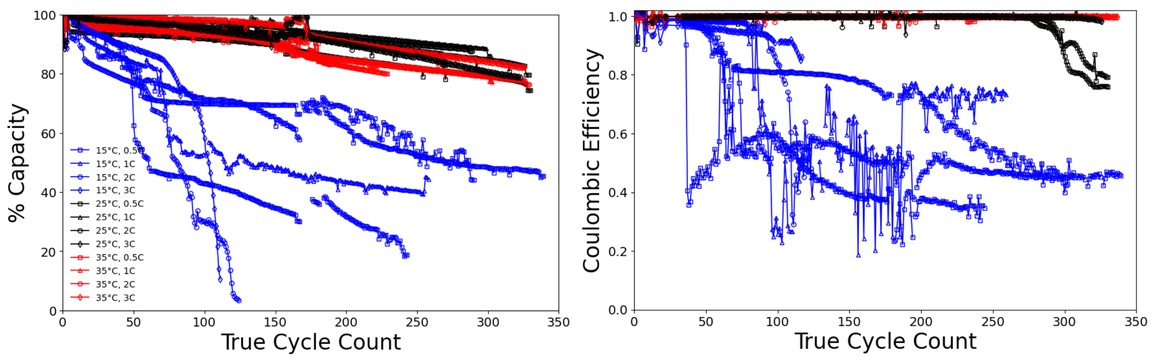
B) Portions of anode and cathode are completely segmented from the main jelly roll

C) Despite electrode cracking, the separator has remained intact

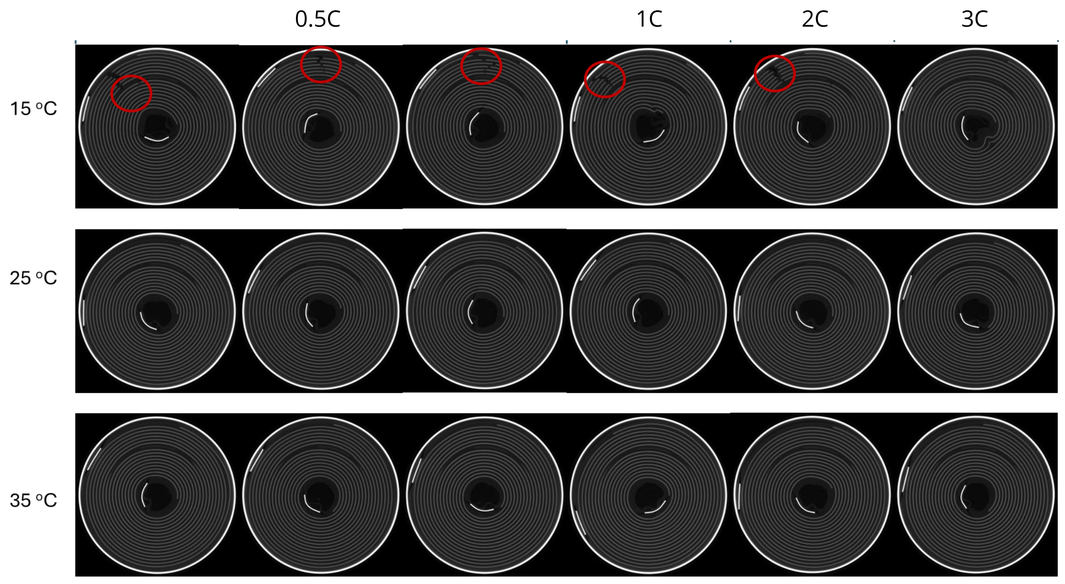


RESULTS

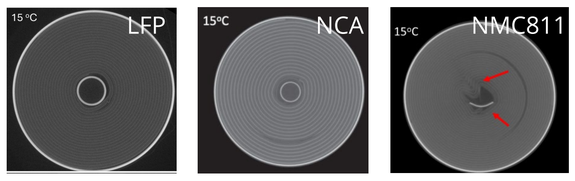
All cells cycled at 15 °C exhibited rapid capacity fade and lower coulombic efficiency than cells cycled at other temperatures.



Most cells cycled at 15 °C exhibited jelly roll cracking in post-cycling CT scans.



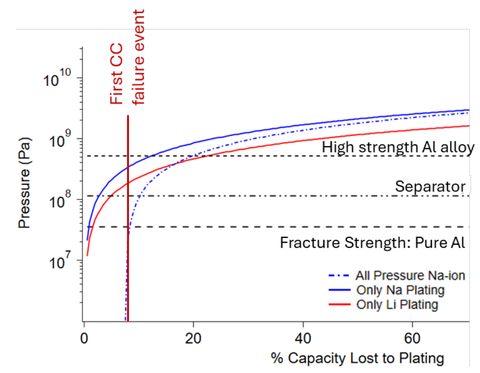
Previous cycling of 18650 LFP, NMC811, and NCA cells at 15 °C showed either no change or jelly roll deformation due to Li plating.



CONCLUSIONS & IMPACT

15 °C cycling of these Na-ion cells induced sufficient Na plating (teardown data) to crack the jelly roll (CT data), causing a sudden drop in capacity (cycling data). The low-temperature failure modes and mechanical behavior of Na vs. Li are different, with safety implications for Na-ion battery design.

Preliminary fracture model



These results provide critical early data that system developers can use to inform cell selection and testing for new low-temperature deployment environments.

FUTURE DIRECTIONS

We will expand our assessment of commercial Na-ion cell performance and safety, with an emphasis on the conditions where Na-ion is claimed to offer improvements over Li-ion:

- High-temperature stability (how does operating without active cooling impact degradation)
- Safety thresholds for fresh and aged cells (how do thermal runaway onset temperatures compare to Li-ion)

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