SODIUM-ION BATTERY R&D INSIGHTS:

Capacity, Degradation, and Beyond

acculon™ energy

Acculon's ongoing research and development efforts are focused on our versatile battery system architecture, which accommodates a range of applications and is tailored for diverse cell form factors and chemistries, including sodium-ion cells. We're actively involved in exploring various commercially available sodium-ion batteries entering the market so that we can bring safe, optimized battery products to a variety of market segments across the electrification landscape. This entails transforming data into comprehensive insights to design and manufacture modules and packs capable of meeting the demands of both low and high-voltage applications for all of our OEM customers.

Today, we delve into some pivotal areas of investigation regarding Sodium-ion Batteries (SiBs), beginning with capacity and degradation, and then moving on to environmental and thermal testing.

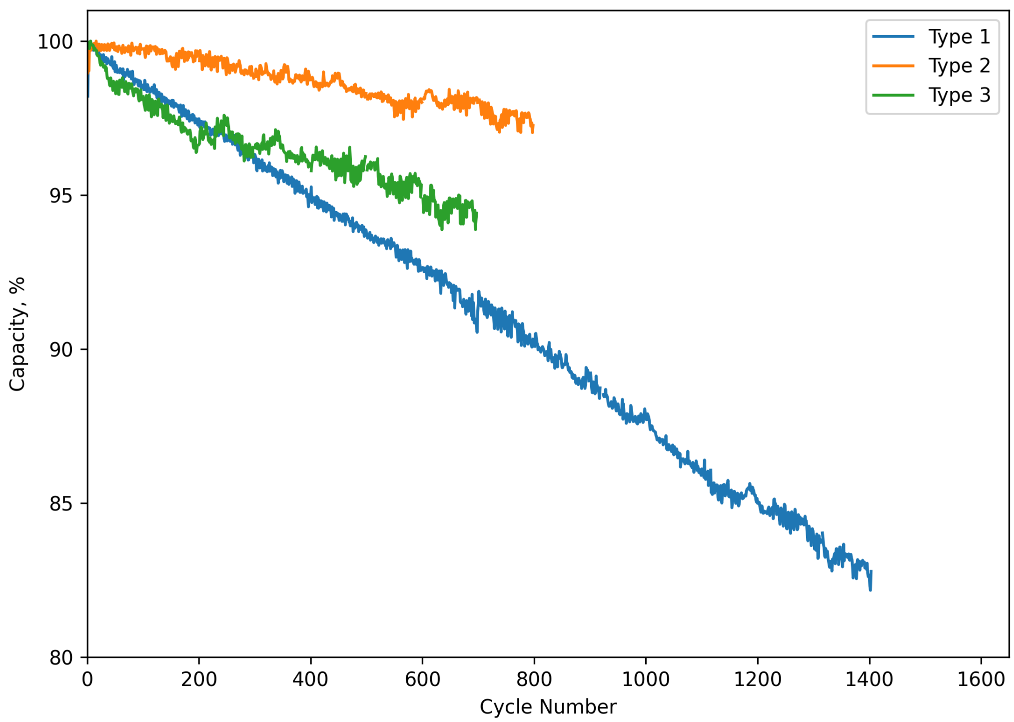
In terms of capacity and degradation: grasping these concepts is crucial as they significantly influence the performance and longevity of energy storage systems. **Capacity**, defining a battery's charge storage capability, fundamentally impacts the duration of device operation before necessitating a recharge. It directly shapes battery usability and efficiency across diverse applications. Conversely, **degradation** refers to the gradual decline in a battery's capacity over time, affecting its lifespan and thereby influencing the suitability of a battery technology for specific applications. Next, we will discuss other characteristics that make this cell chemistry an exciting addition to the energy storage industry.

Capacity

We have conducted a thorough assessment of various commercially available sodium-ion cells to gain valuable insights into their performance, aimed at mitigating risks associated with future battery programs utilizing these cells. **Our analysis revealed that the initial volumetric and gravimetric capacities across all available cells in the market are remarkably similar, indicative of the current technological landscape.** This similarity stems from the utilization of oxide-based cathode and amorphous carbon anode materials in the sourced cells, resulting in a strong correlation observed in both volumetric and gravimetric energy densities. The average energy density values for the four different tested form factors stand at 120kWh/kg and 250 Wh/l.

Degradation

We've observed notable discrepancies in the rate of capacity degradation among cells sourced from the market, despite adhering to a consistent cycling protocol. This protocol entails a 0.5 CCCV charge and a 0.5C CC discharge at 100% Depth of Discharge (DoD) under room temperature conditions.

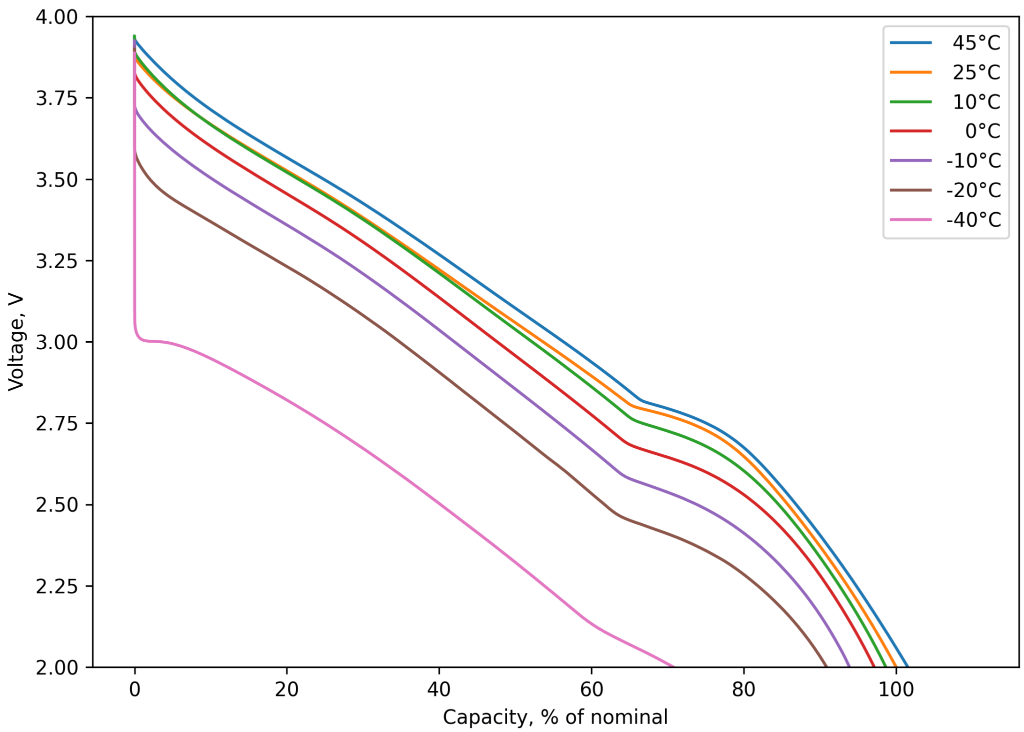


Among the various tested cell types, the degradation rates remain reasonably favorable, with the linear approximation projecting a range of 1600 to 6500 cycles required to reach 80% capacity, contingent upon the specific cell type. While acknowledging that the linear approximation may not provide the most precise estimation of long-term performance, it serves as a valid metric for comparative purposes until more comprehensive statistics are available and a thorough capacity retention test is conducted.

The degradation rate of batteries is heavily influenced by usage conditions, necessitating specific tests for each application to accurately forecast battery performance. Nonetheless, initial testing conducted at room temperature and a rate of 0.5C generally provides a solid representation across a broad spectrum of applications.

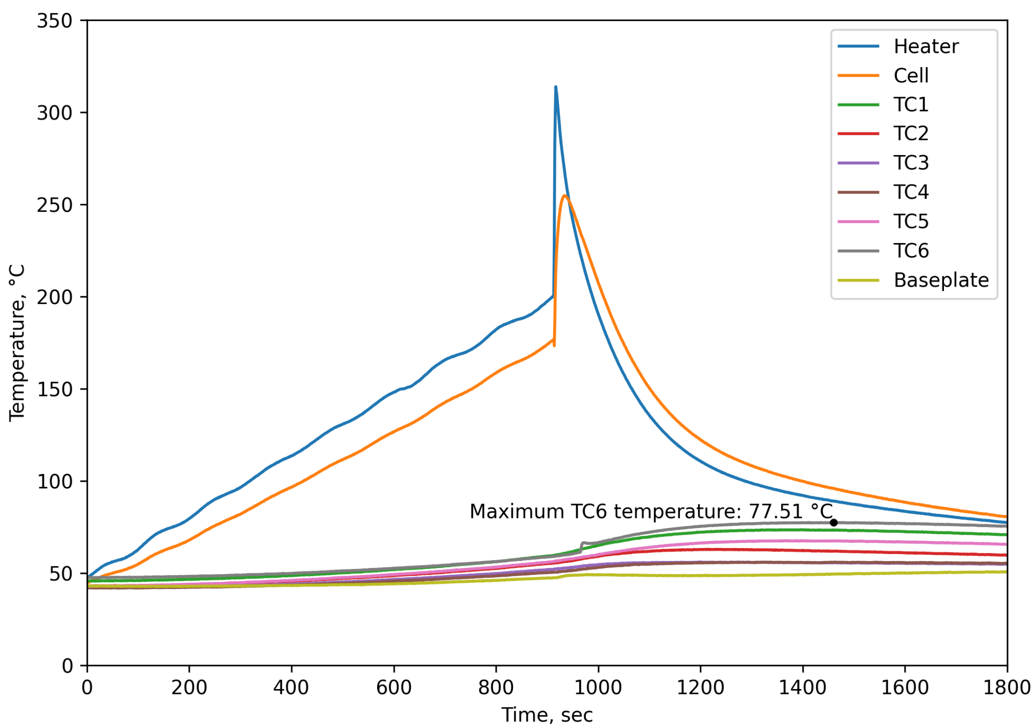
Cold Temperature Performance

The true differentiator of sodium batteries from most competitors is the cold temperature performance. **For applications that must perform optimally in extreme weather and climates, sodium-ion could be the top choice.** We conducted tests in our lab to evaluate the performance of sodium-ion batteries in extreme temperatures. We tested the batteries at a discharge rate of C/3 and various temperatures to confirm that they could provide most of their capacity without requiring any heaters at -20°C. Even at -40°C, the batteries could still provide 70% of their capacity.



Safety and Sustainability

Currently, Underwriters Laboratories (UL) and other regulatory and compliance agencies are updating safety standards to incorporate sodium batteries into the same guidelines that lithium batteries fall under. That said, **sodium-ion batteries are perceived as safer than their lithium-ion counterparts due to their lower energy density.** However, at the battery system level, sodium-ion is like other chemistries in that it is dependent on overall design strategies to ensure safety at the module and pack level, as all energy storage solutions carry a certain amount of risk. Combined with other thermal mitigation strategies such as the use of intumescent materials, for example, the safety profile of sodium is indeed promising. Acculon has conducted pre-certification, single-cell failure testing at the module level, which consisted of heating cells at different locations in the module to trigger thermal runaway. Below is a graph showing the maximum temperature of the center cell that was sent into thermal runaway with an attached heater, and it also shows the temperatures of surrounding cells before, during, and after the thermal event.



As shown, the maximum temperature of any cell surrounding the one sent into thermal runaway peaked at 77°C. It should be noted that similar results occurred when corner cells were sent into thermal runaway. In all of our thermal testing, no propagation occurred.

Another safety aspect of sodium-ion batteries is that they can be safely transported and stored in a fully discharged state (0V), and can even withstand forced reverse polarity over-discharge. All in all, sodium-ion cells have a promising safety profile.

Another bright spot for sodium-ion batteries is sustainability, which is at the heart of the electrification movement. The abundance of sodium creates a context for various sourcing options while also reducing the need for critical materials. Even so, we are not quite at the point yet of establishing reliable supply chains for this technology–but that day is coming quickly!

Conclusion

For a diverse range of applications, we at Acculon believe that sodium-ion batteries are a competitive alternative to other battery chemistries on the market, and are poised to accelerate the energy transition, pushing global markets toward significant sustainability strides as we move into the next generation of energy storage systems for electric industrial and commercial applications.

For more information about our advanced energy storage solutions or our battery technology insights, please visit our website at https://acculonenergy.com/.