Case Study

Optimizing Battery Cycle Life Prediction with LQMs

NOVONIX™

SANDBOXAQ

Partner
Novonix
https://www.novonixgroup.com

Industry
Battery Industry

Organization Size
150-200

Products & Services
NOVONIX provides advanced, high-performance materials, equipment, and services for the global lithium-ion battery industry.

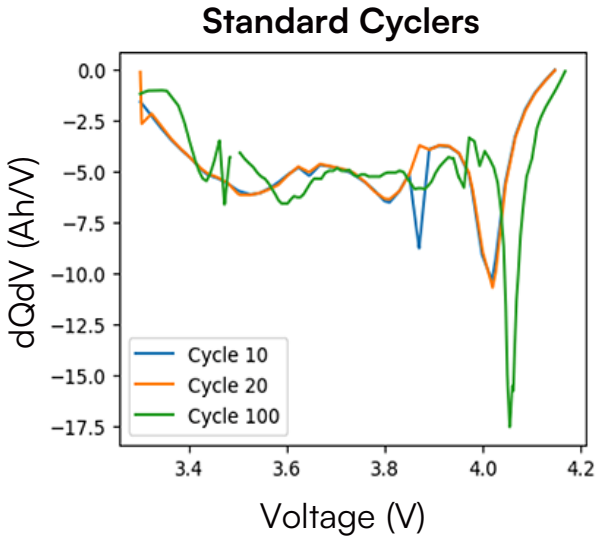
Country
Canada and USA

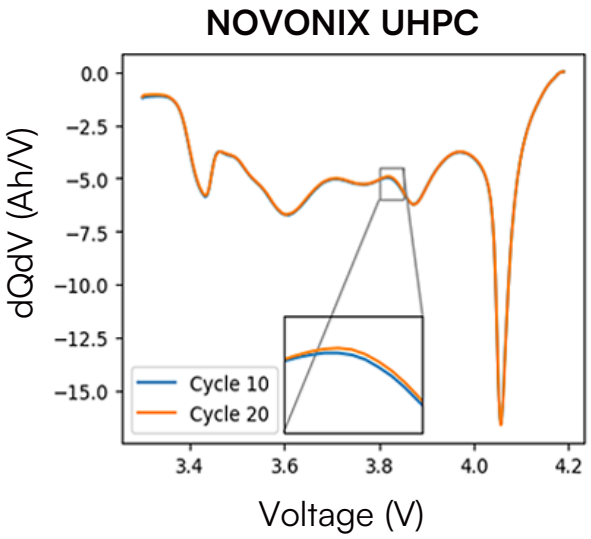
CHALLENGE

Predicting the cycle life of battery cells, particularly lithium-ion, is inherently difficult due to the limited availability of high-quality, large-scale datasets and the lack of generalizable feature sets that can accurately model cell degradation. Traditional approaches struggle to capture the nuanced interactions between different cell parameters across thousands of cycles, particularly when those features may not apply across different chemistries or manufacturers. NOVONIX, a leading battery materials and technology company, sought to accelerate their battery development via predicting battery cycle life with SandboxAQ's next-generation large quantitative model (LQM) approaches.

SOLUTION

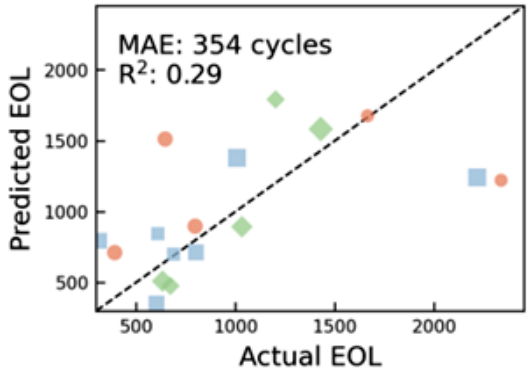
Robust and generalizable lifecycle prediction models require advanced featurization techniques to accurately predict end-of-life (EOL) for a variety of cell chemistries and cycling conditions. **SandboxAQ** utilized a comprehensive dataset constructed in collaboration with NOVONIX, featuring early-cycle **Ultra High Precision Coulometry (UHPC)** measurements. These high-precision cyclers allowed us to capture minute charge-losses and efficiency variations across early cycles, providing our models with a more nuanced understanding of underlying degradation mechanisms. By tracking subtle changes early in the cycling process, our LQMs revealed valuable insights into the electrochemical processes that drive long-term cell degradation. This enabled the development of more interpretable and robust models for predicting EOL across a wide range of chemistries.



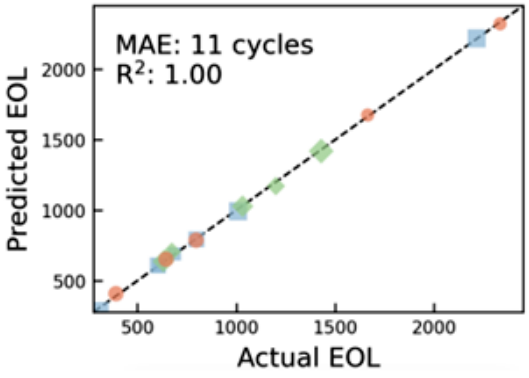


RESULTS

SandboxAQ's LQM, leveraging features derived from NOVONIX's UHPC cyclers, demonstrated unprecedented accuracy. These features are obtained from both high-resolution cycle metrics and raw data traces which traditional cell cyclers are not capable of reliably measuring due to limitations in the precision of standard equipment. The experimentally-observed EOL was predicted within a **mean absolute error (MAE) of 11 cycles** using just 40 cycles of UHPC data. For a dataset of diverse NMC-based cells spanning three manufacturers, the UHPC-based model showcased a **35x increase in accuracy** compared to traditional capacity-based models using features from standard cyclers. This dataset contained distinct electrode compositions, with a variety of high Ni-based cathodes and either graphite or silicon-graphite composite electrodes, highlighting the synergy of high precision instrumentation with state of the art modeling approaches for robust and generalizable cycle life prediction. Moreover, with only 2 cycles of UHPC data, SandboxAQ's LQM predicted the number of cycles for a cell to reach EOL with a **MAE of 50 cycles**, representing a **50x faster time-to-prediction** compared to traditional models requiring 100 cycles of data. Applying this methodology to battery cycling would save companies like NOVONIX thousands of hours in testing, a **1000x speedup** in battery development.



Standard modeling approaches applied to commercial NMC cells



Standard modeling with NOVONIX UHPC measurements