18650 Cylindrical Cells Capable of Zero-Volt Storage and Dead Bus Events

Space Power Workshop
April 26-29, 2022

Cellec Technologies Inc.

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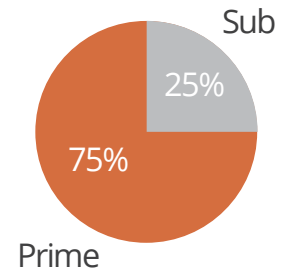
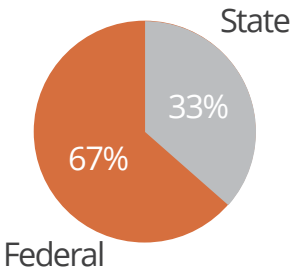
Cellec is a lithium-ion battery research and manufacturing company. We support the defense sector and advantage national security with our patented approach to achieving 0-volt stability in lithium ion cells. Since our incorporation in 2016 we have leveraged several innovate state and federal programs and are working toward creating clean and sustainable energy solutions. We are located in the heart of Rochester, NY in the historic Rochester Federal Savings Bank, and have access to advanced manufacturing facilities at the Battery Prototyping Center at Rochester Institute of Technology.

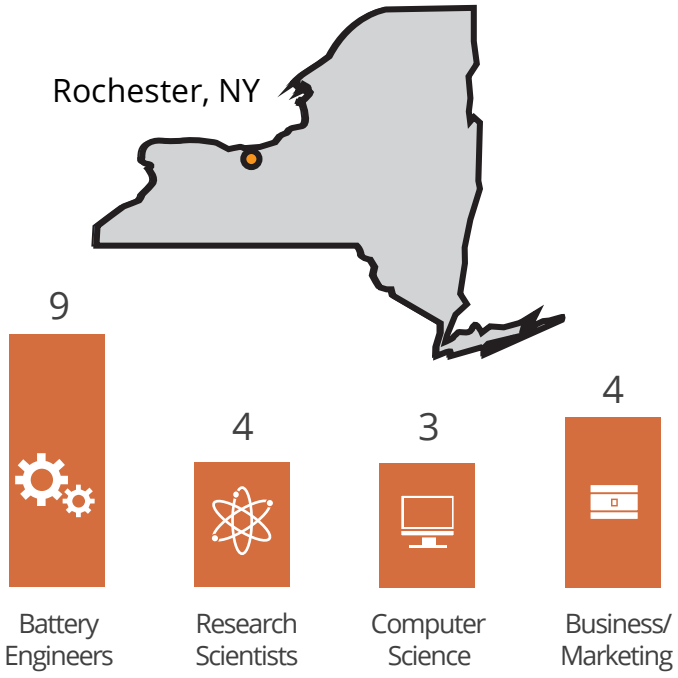
"Approved for public release; distribution is unlimited. Public Affairs release approval #_____".

Business Mix



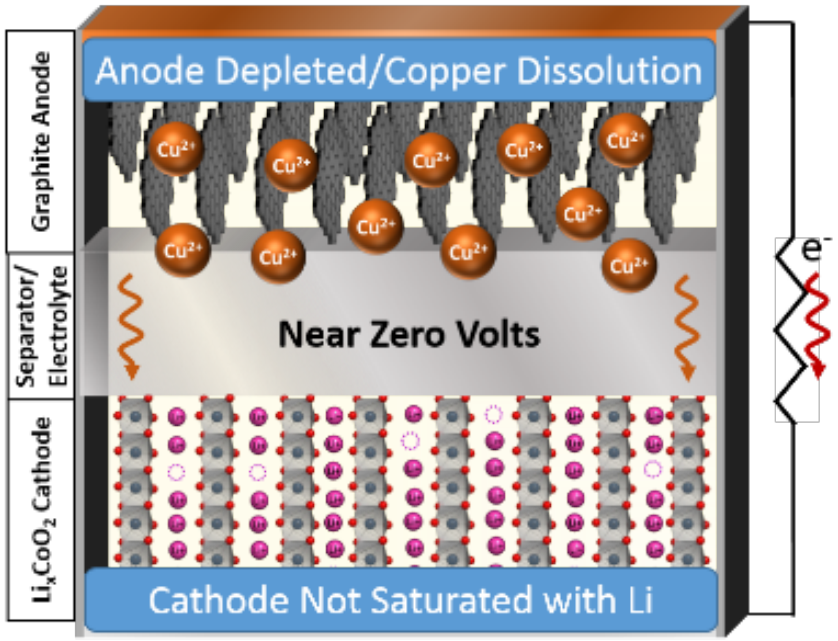


Diversity of Backgrounds

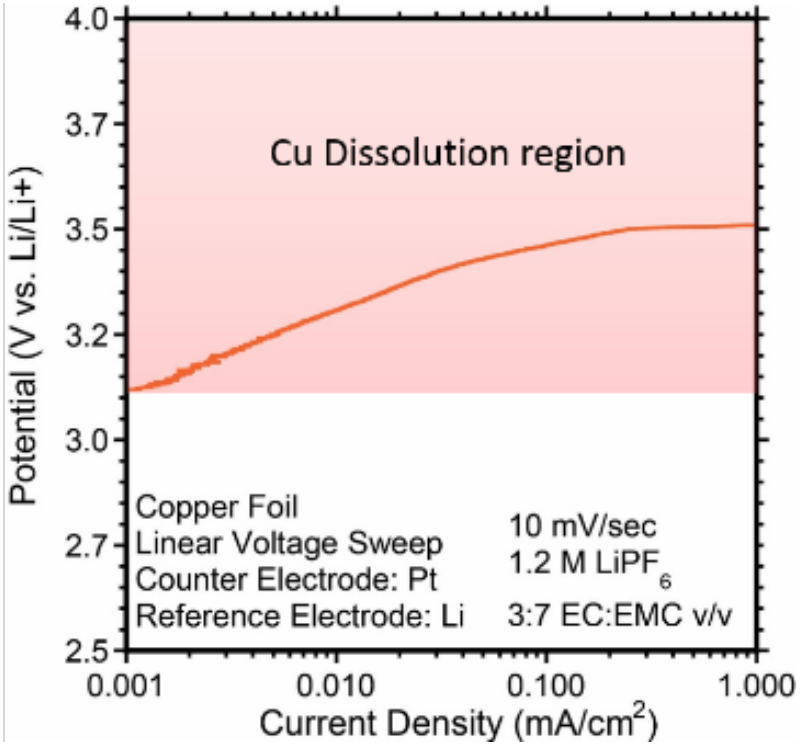


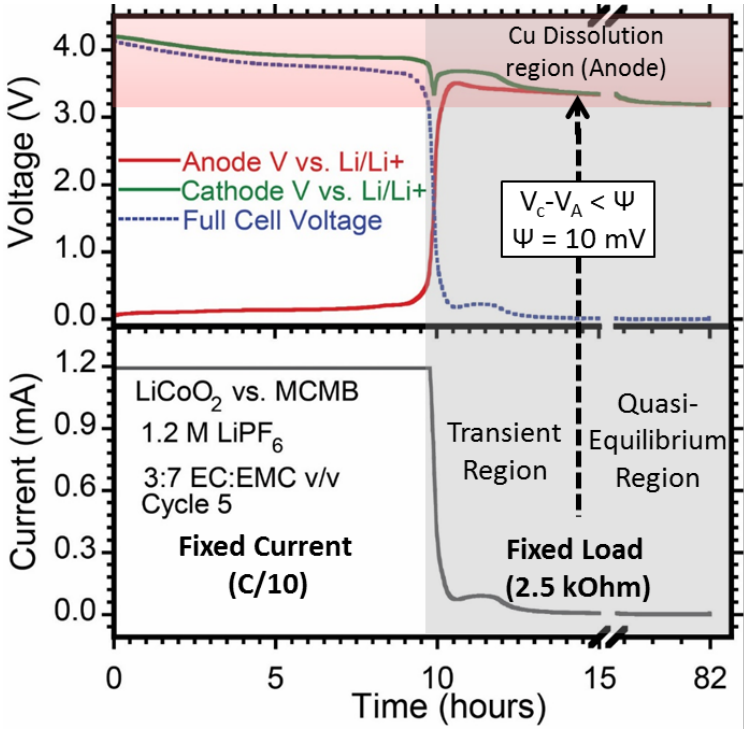
Incorporated in 2016 | 13 Programs | 20 Employees | 5 Patents

0-Volt Storage Tolerance with Anode Pre-lithiation



Crompton and Landi, Energy Environ. Sci., 2016,**9**, 2219-2239

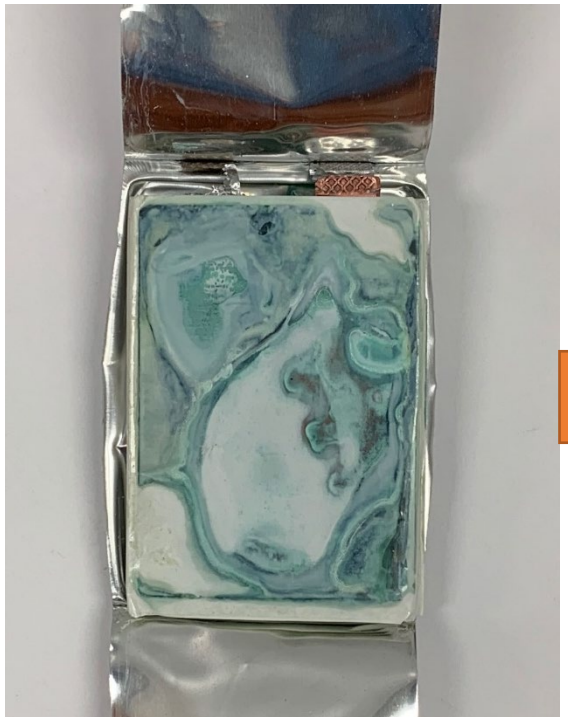




Schematic of $LiCoO_2$/MCMB cell function in the near zero volt condition. Orange arrows represent copper ion flow. Red arrow represents electron flow through external circuit. Linear sweep voltammogram of copper foil. Red shaded region represents assigned potential range in which copper dissolution and solid electrolyte interphase layer damage occurs.

Destructive Physical Analysis

No RLE Treatment



Visible Copper Dissolution

DPA Post Zero-Volt Storage

Zero-Volt Tolerant Cell

No Visible Copper Dissolution

Applications of 0-Volt Technology

Safety

A major thrust of Cellec Technologies is building 0-Volt stable cells, highlighting safety at the core of this technology. A cell with 0-Volt stability is capable of long-term storage at a low state of charge, creating possibilities for safe aircraft transport, assembly into battery packs, and recovery from dead-bus events.

Dead Bus Events

0-Volt technology allows for cell use in applications where infrequent power demands are common. Storing in and recovering from zero volts allows for safer long-term storage and use in longer duration missions.

Lower Maintenance

With the capability to recover from 0-volt events, this cell design requires less maintenance than conventional cell designs which need to be stored at higher voltages.

Storage and Shipping

Novel 0-Volt technology provides safe shipping and long-term storage capability for lithium ion cells which is beneficial for infrequent-use applications and for end-use applications that necessitate air-shipping.

Safer Pack Assembly

Discharging Li^+ cells to 0-volts prior to assembly into series and parallel battery packs reduces the electrical and thermal hazards to workers and infrastructure. Electrical shocks and arcing cannot occur without stored energy in the cells.

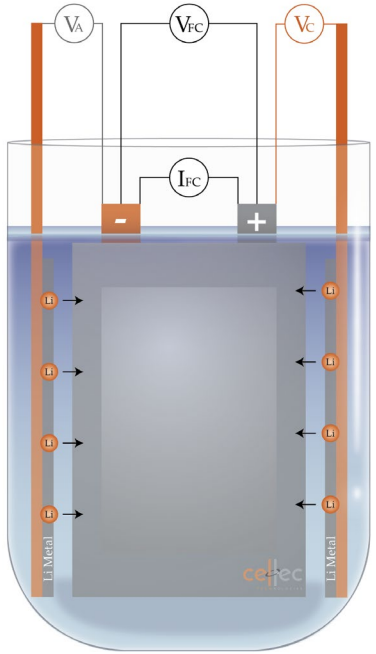
Deferred Payloads

0-volt stable cells have increased shelf stability for deferred or delayed use in applications, where multiple units will be deployed over the course of calendar year(s). 0-volt stable cells can be stored in safe conditions until time of deployment.

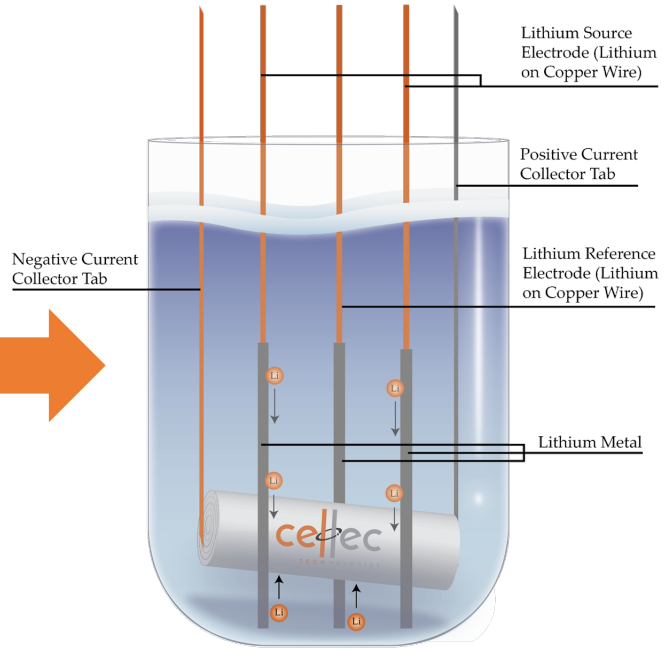
Reversible Lithium Excess Method For Cylindrical Cells

Cellec Technologies has recently developed bath lithiation techniques to enable zero-volt stability in 18650 cylindrical cells in multiple cathode and anode chemistries for aerospace applications.

Li+ Pouch Cell



Li+ 18650 Cylindrical Cell

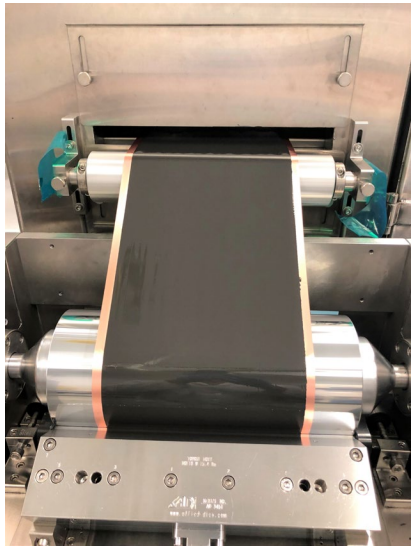


Examples of Cylindrical Cell Chemistries

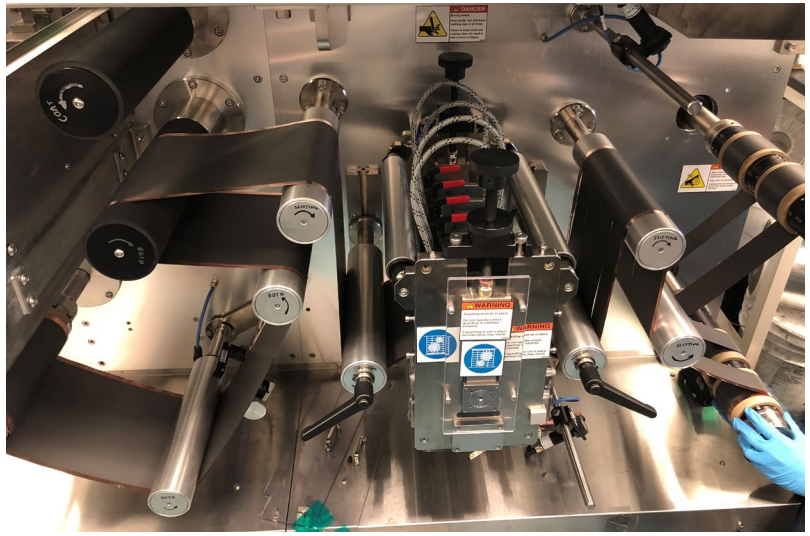
NCA LCO NMC

18650 Electrode Processing

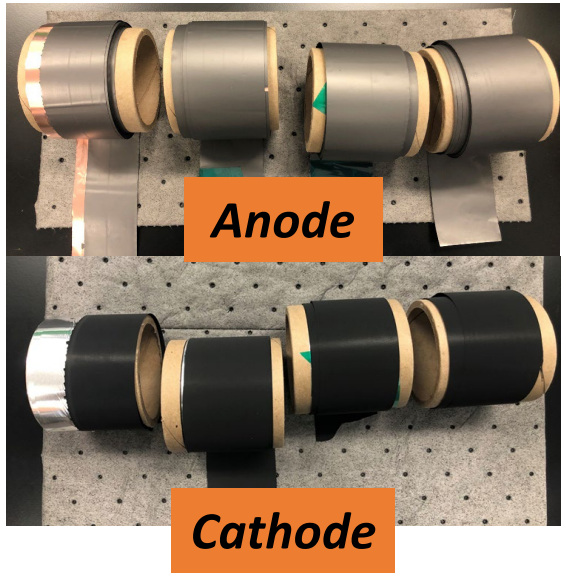
R2R Coating



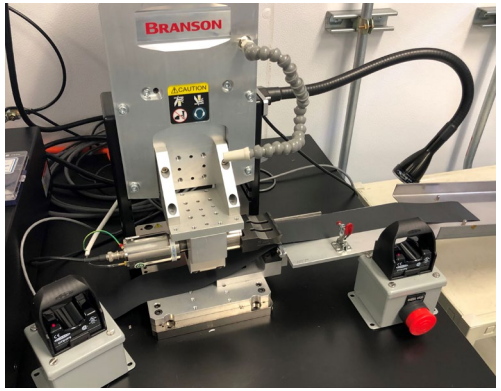
Anode Slitting Process Overview



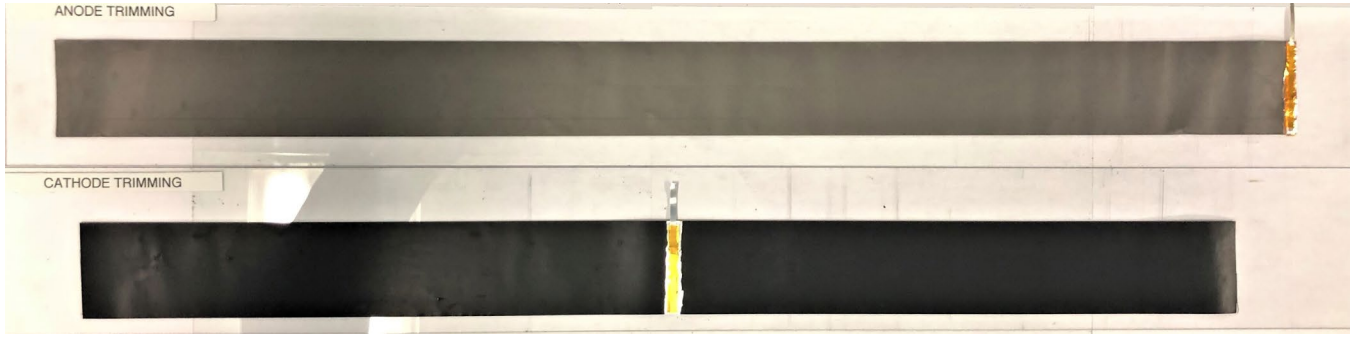
18650 Slit Rolls



Branson Ultrasonic Welder



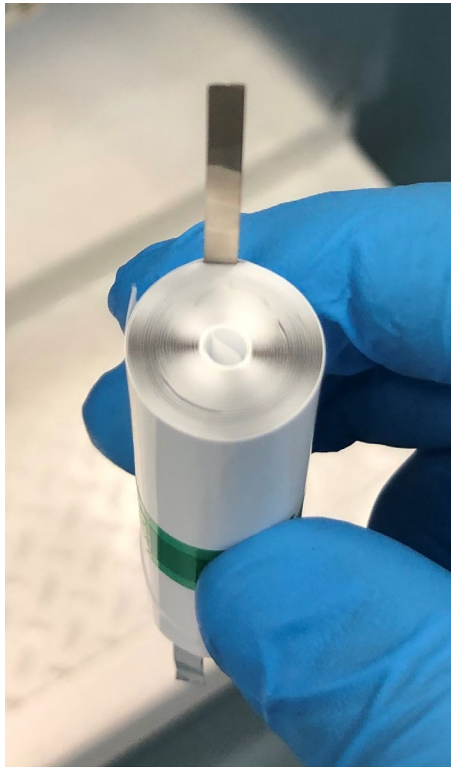
Electrode Tab Cleaning and Preparation



18650 Cell Fabrication

SOLITH Cell Winding Machine

Aligned Layers



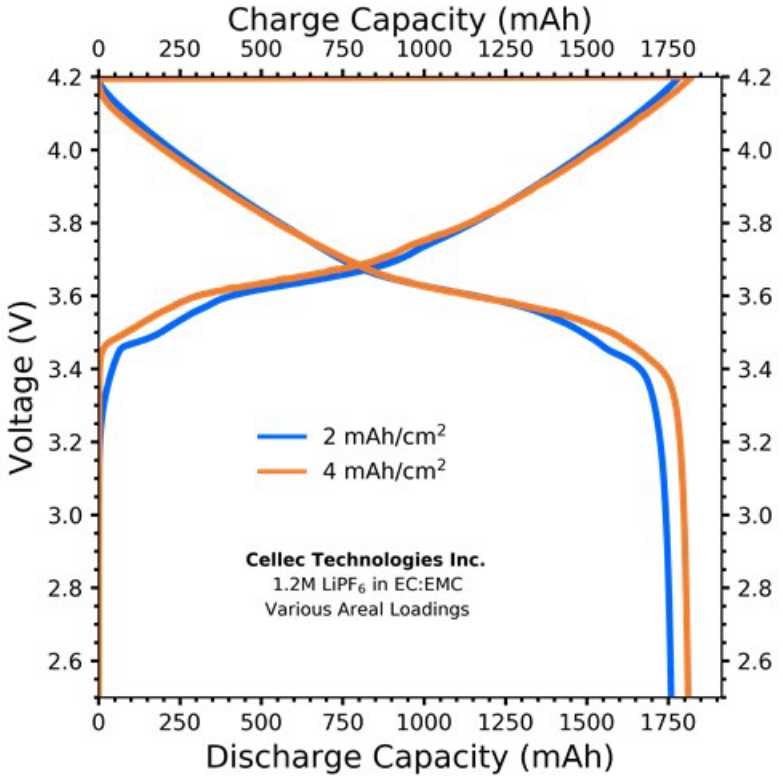
18650 Cells Post Crimping

PVC Wrapped 18650 Cells

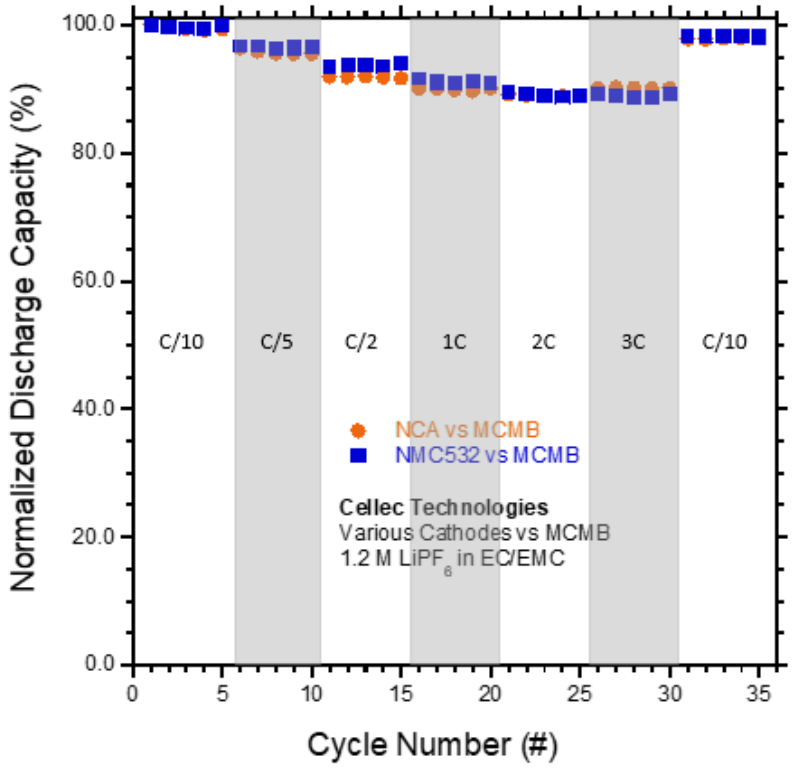
SOLITH Cell Winding Machine combines anode, cathode and separator layers to form a "jelly-roll" with each electrode tab facing outward from separate ends

Task 3 – Cylindrical Cell Rate Studies

Charge/Discharge Voltage Curves



Rate Capability



Discharge Capacity Recovery

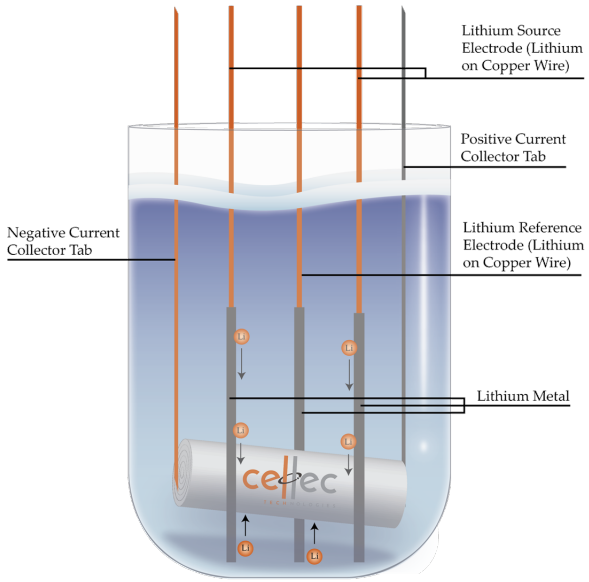
Cathode Active Material	*Initial Discharge Capacity (mAh)*	*Final Discharge Capacity (mAh)*
NMC 532	1736.9	1719.8
NCA	1791.5	1705.0

Full cells with MCMB anodes maintain rate capability with high capacity retention in baseline cells.

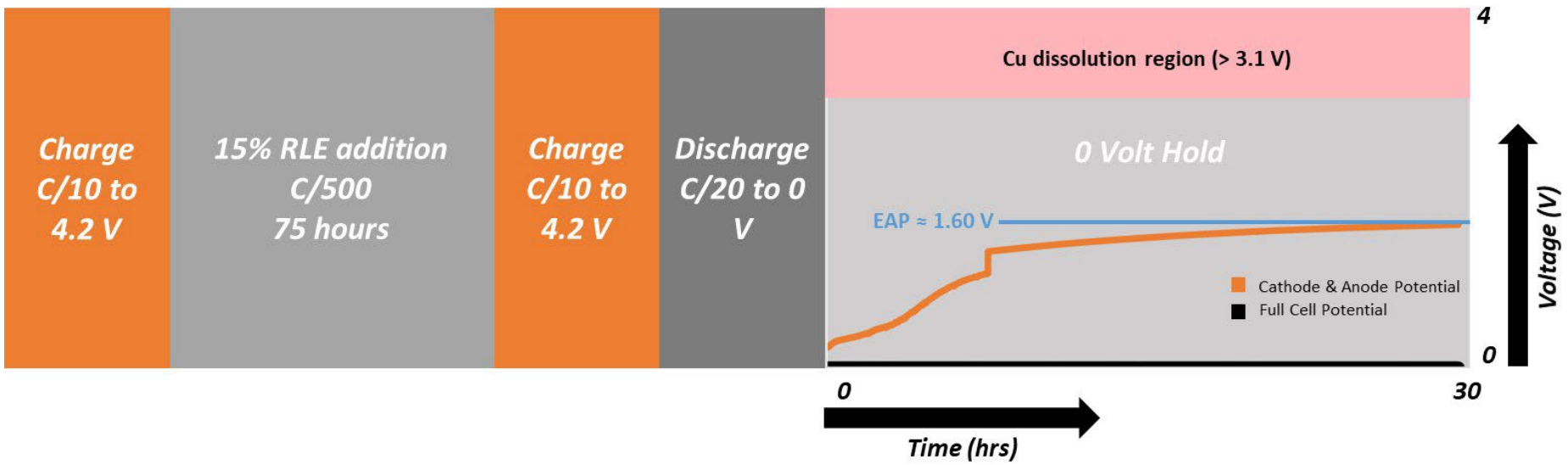
All cells underwent formation cycling (3 C/20 from 2.5 V to 4.2 V) before being put into rate study. Rate study schedule cycled cells from 2.5 V to 4.2 V for all varied C-rates. NMC 532 vs MCMB cell recovered to 99.1% of initial discharge capacity after completing rate study; NCA vs MCMB cell recovered to 97.8% of initial discharge capacity

Lithiation Bath Formation for 18650 Cells

Post-Formation Lithiation Bath



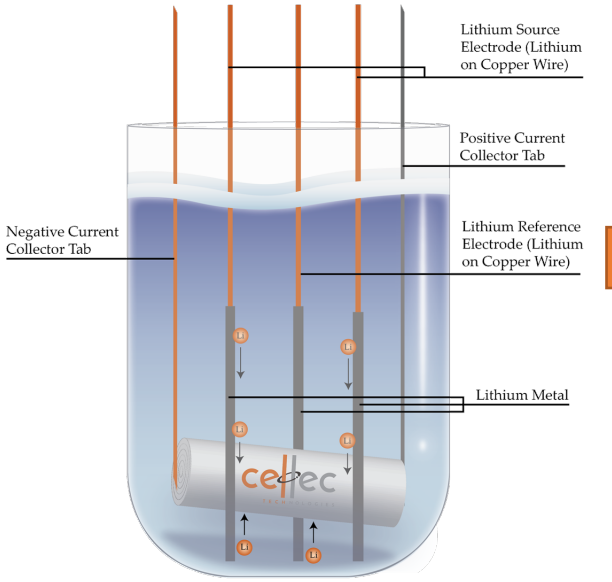
Lithiation and 0 Volt Hold Process Overview



Coulombic Efficiency during Formation cycles is similar in Bath lithiation cell when compared to prior results from the same materials cycled in cylindrical can. The formation cycle data and no visual changes observed in bath lithiation setup indicate cell setup is valid.

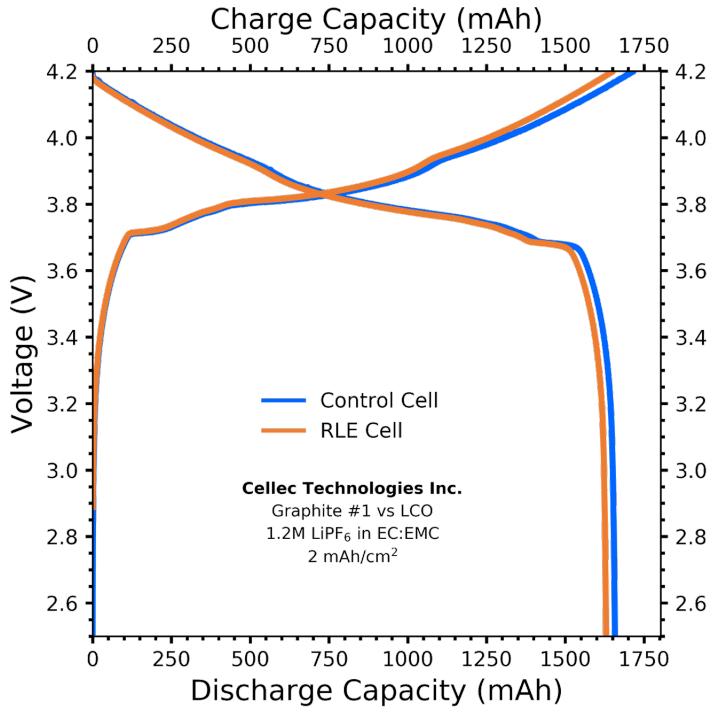
Lithiation Bath Formation and CE (%)

Post-Formation Lithiation Bath



Lithiation Bath

Charge/Discharge Voltage

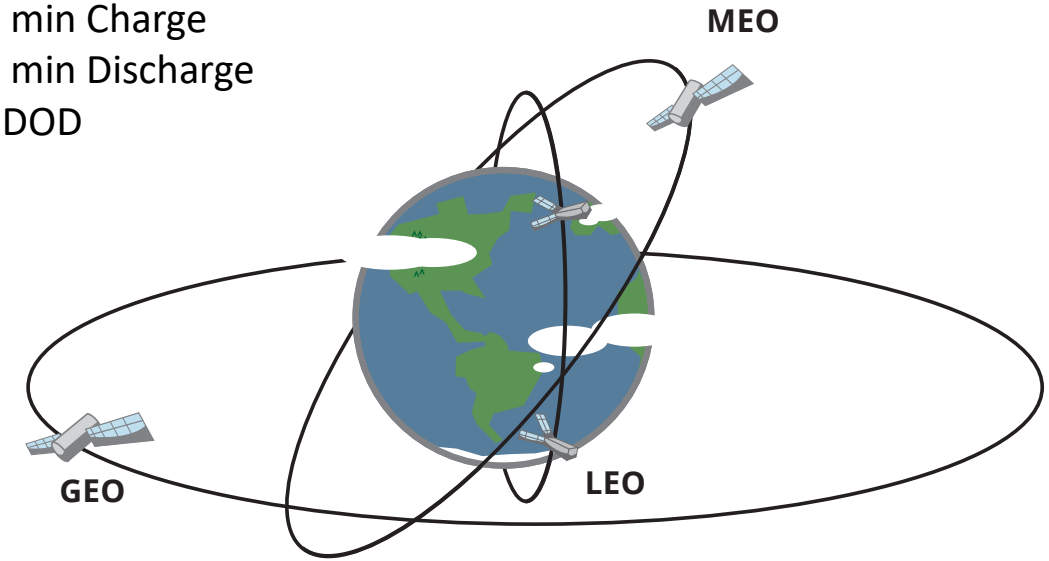


Cell charge/discharge voltage profiles are maintained following the RLE process on 18650 cylindrical cells using the bath lithiation process. The cells also have similar columbic efficiencies with continued cycling.

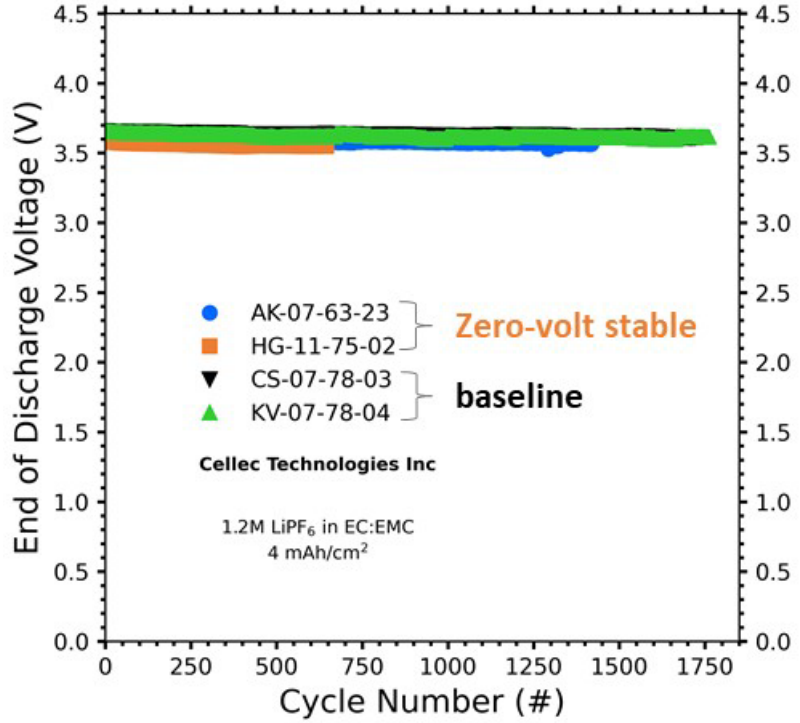
Task 10 - LEO Testing Baseline vs 0-Volt Cells

LEO Testing for 0-Volt Stable 3450 Cells

- 0-Volt stable cells were constructed and placed on resistors for long term storage
- RLE processed cells were held at zero-volt state-of-charge for 641 hours (~1 month)
- The cells were tested using a simulated LEO testing schedule
  - 90 min LEO Orbit
    - 60 min Charge
    - 30 min Discharge
  - 20-40% DOD



End of Discharge Voltage



Baseline cells (no RLE process) were prepared with NCA cathodes and graphite anodes for LEO testing analysis and show a >98% EoD retention after ~1700 cycles. 0-Volt stable cells had ~641 total hours at 0V with resistors after completing the RLE process.

Questions?