Advanced 4Ah 18650 Li-ion Cell with Zero-Volt Tolerance for Space Applications

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Image from nasa.gov

Outline

- Introduction
- Problems and factors in zero-volt situation
- Results
  - Zero-volt exposure at 20 ohms for multiple 7 days
  - Zero-volt on the shelf for >9 months
  - Negative volt exposure (up to -0.5V)
- Conclusion

American Lithium Energy is scaling commercial production of advanced silicon anode cells in the USA

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to meet the rapidly growing demand from Defense, Aerospace, and Commercial customers for onshore batteries



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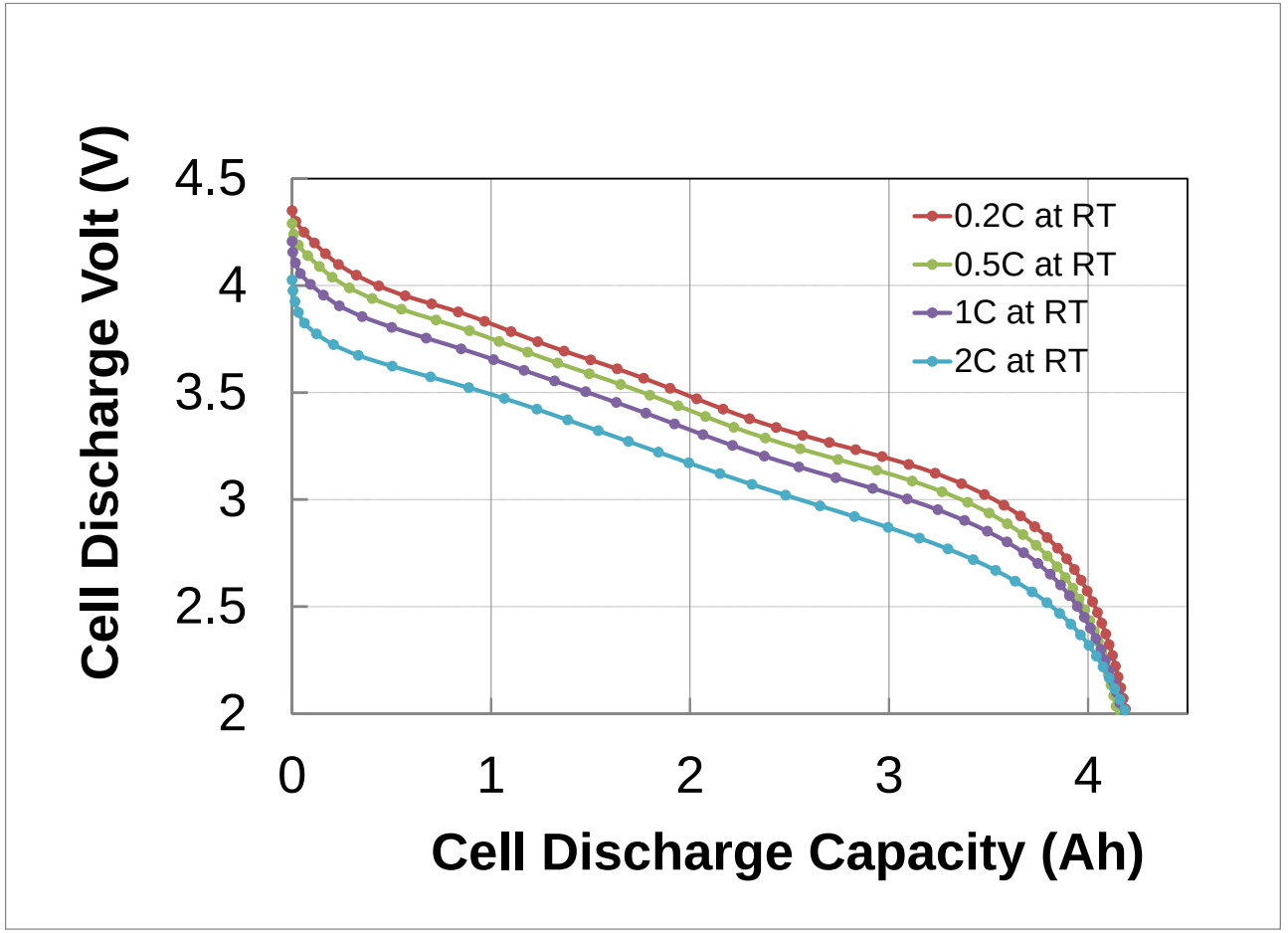
ALE 4Ah Nano Si 18650 Cells

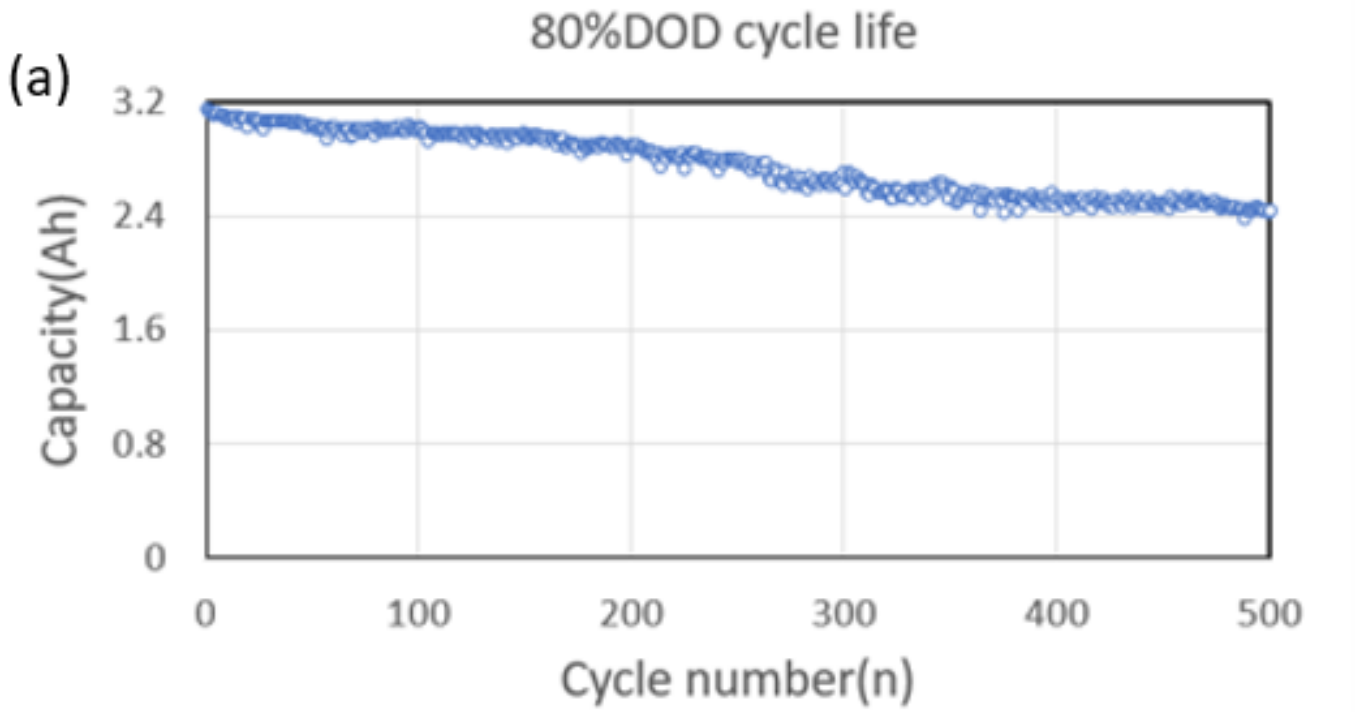
- High specific energy: up to 350 Wh/kg
- High power: Up to 700 W/Kg
- Excellent low temperature performance
  - -40C at C/5 and -57C at C/16
- Good cycle life
  - <2% energy loss after >6000 cycles at 20%DOD
  - Meet major UN 38.3 requirements
    - Pass impact, crush, overcharge and external short tests
- Good thermal stability
  - Pass 130°C (60 min.) hot box test

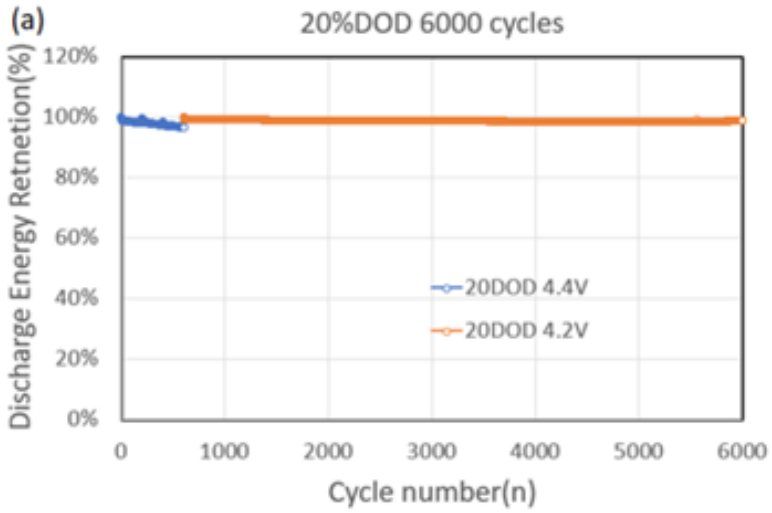
Cell Capacities at Different C Rates & at RT

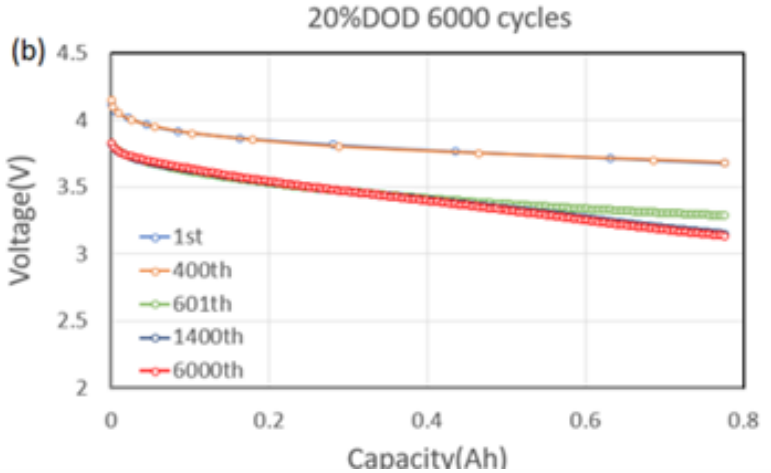


- The cell capacity at 2C rate is almost the same as that at C/5 rate
- The cell rate capability is good

Cycle Life: 20% and 80% DOD at RT







- The cycle life are very good at 20%DOD and 80%DOD
- The cell energy retention is about 98.6% after >6000 cycles at 20% DOD (18 months data)

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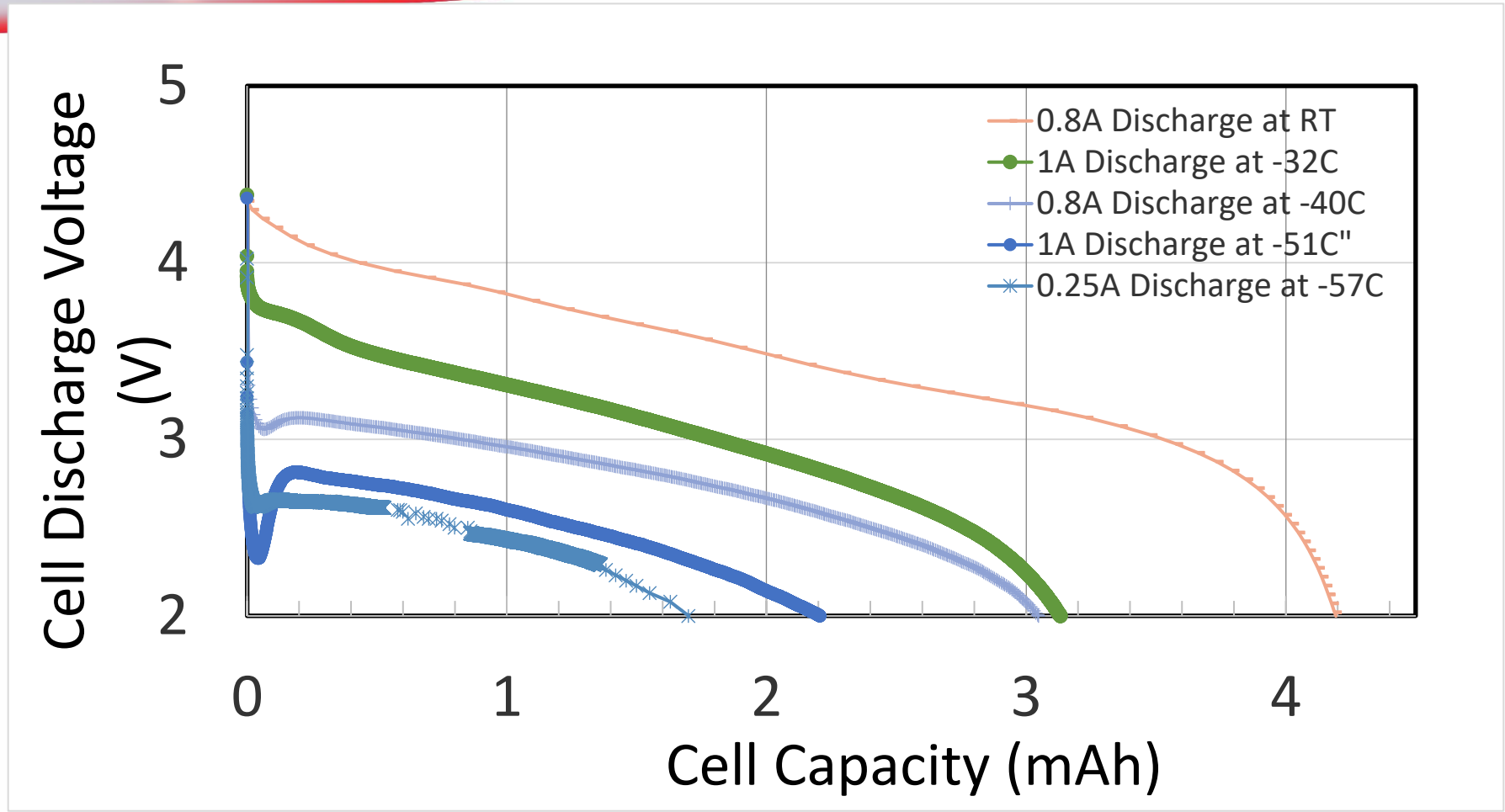
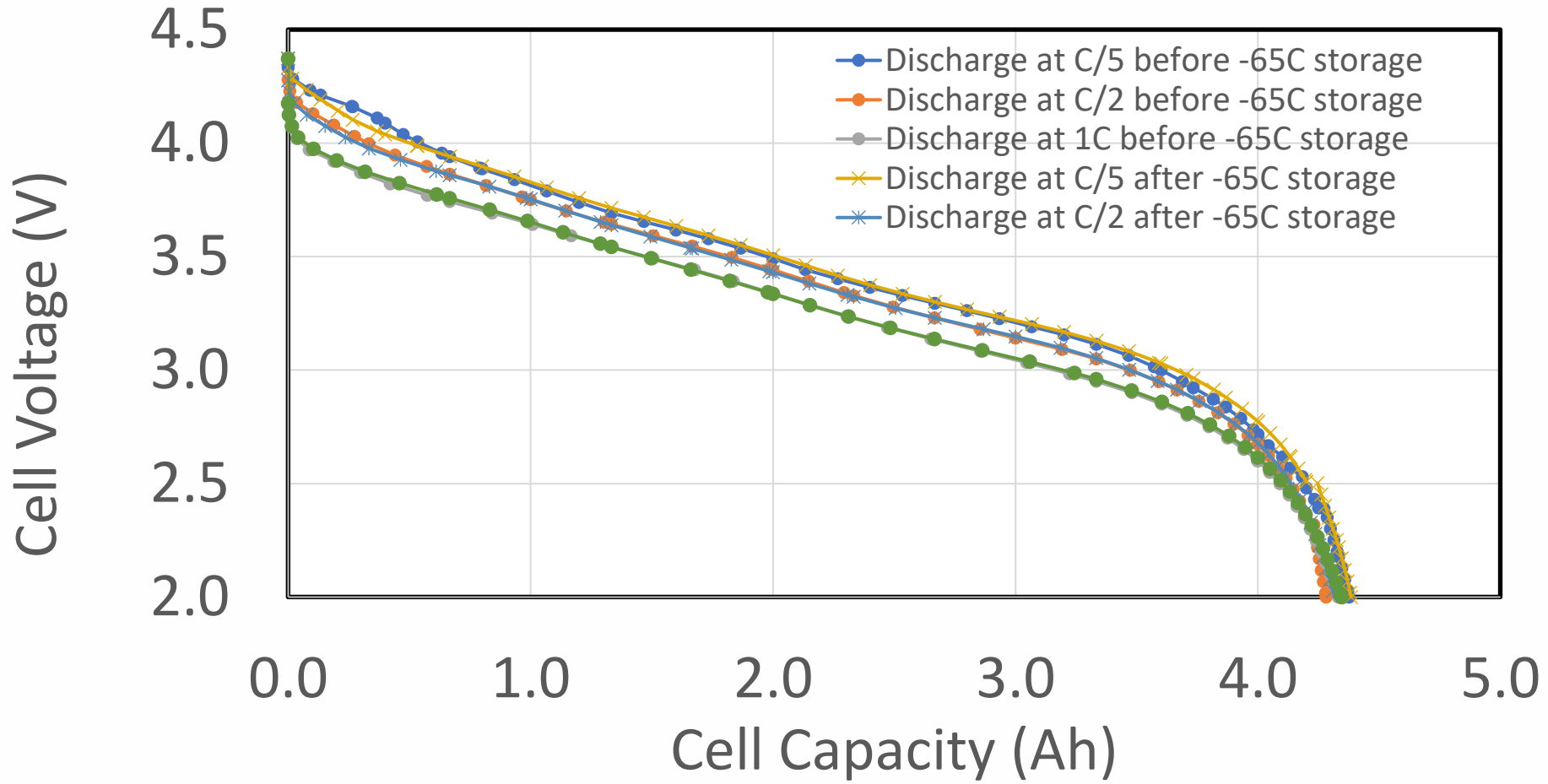
Cell Discharge Capacities at Low Temperatures



- The cell can deliver >3Ah at -40°C and C/5 rate, and about 1.8Ah capacity at -57°C and at C/16 rate, respectively

Cell Capacities Before and After Storage Test at -65°C



- The cell was cooled down to -65°C and hold there for 3 hrs before it warmed up naturally
- There is no capacity loss after the low temperature treatment

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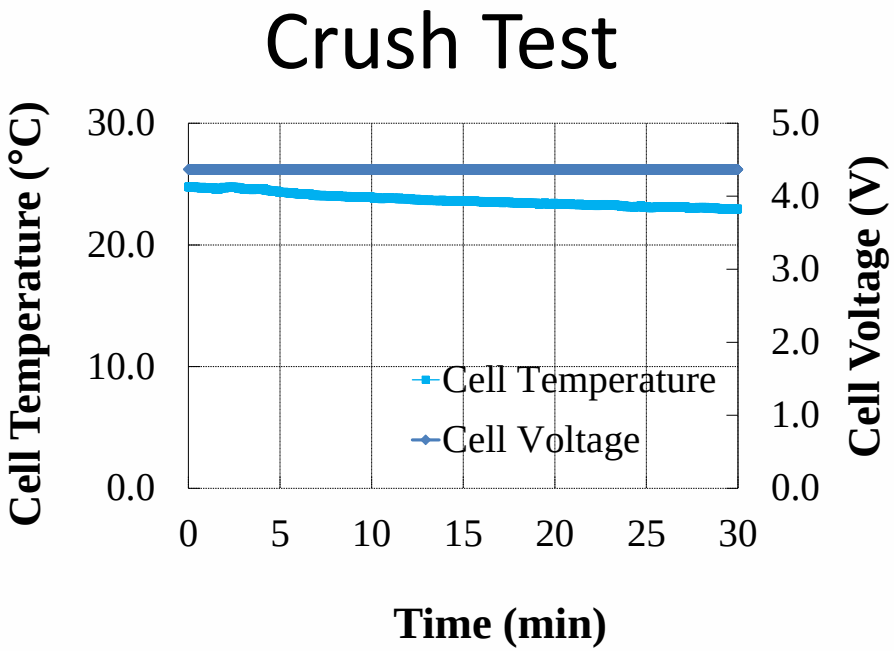
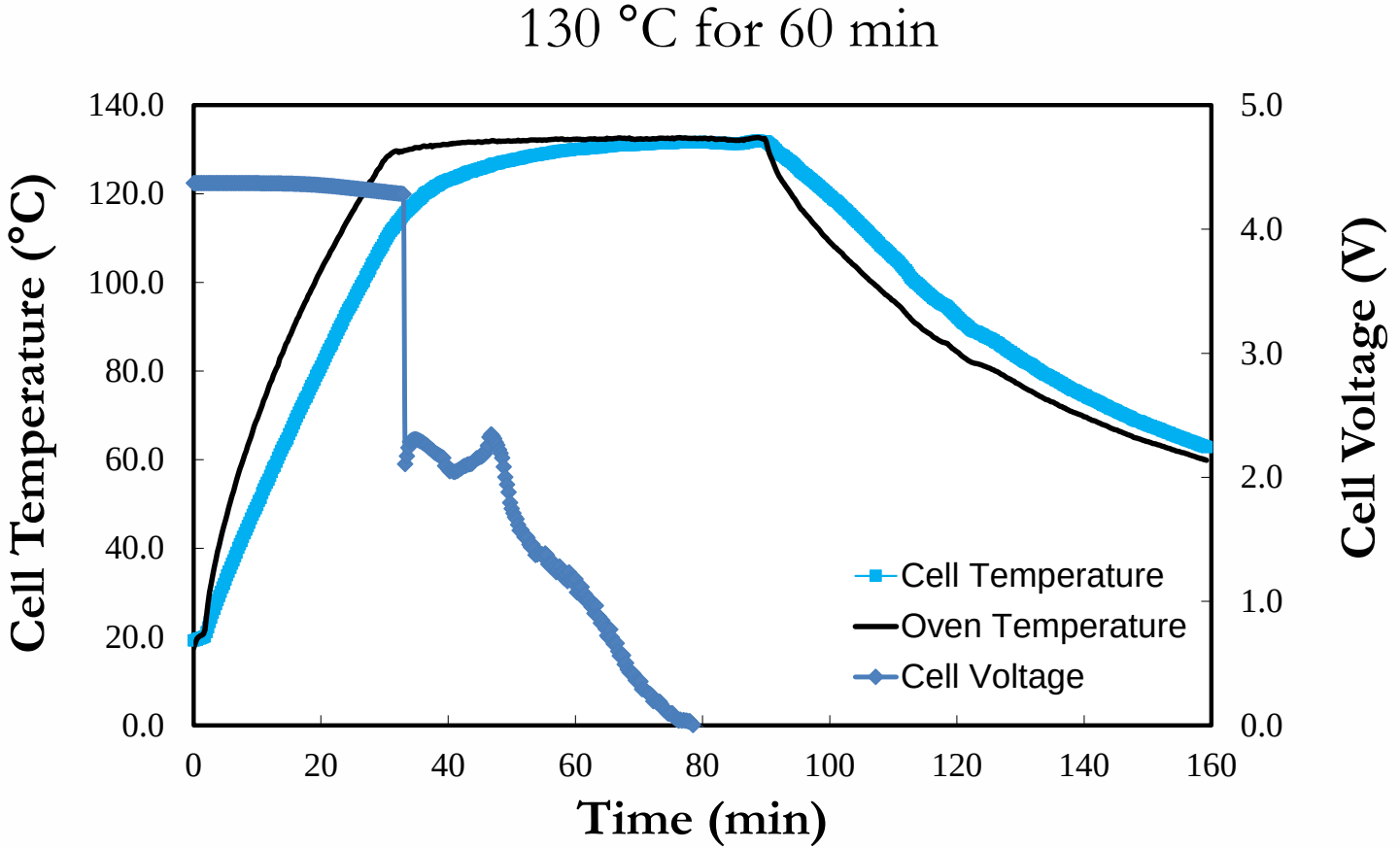
ALE 4Ah Nano 18650 Cells

Abuse Tolerance: Meet Major UN 38.03 Requirements

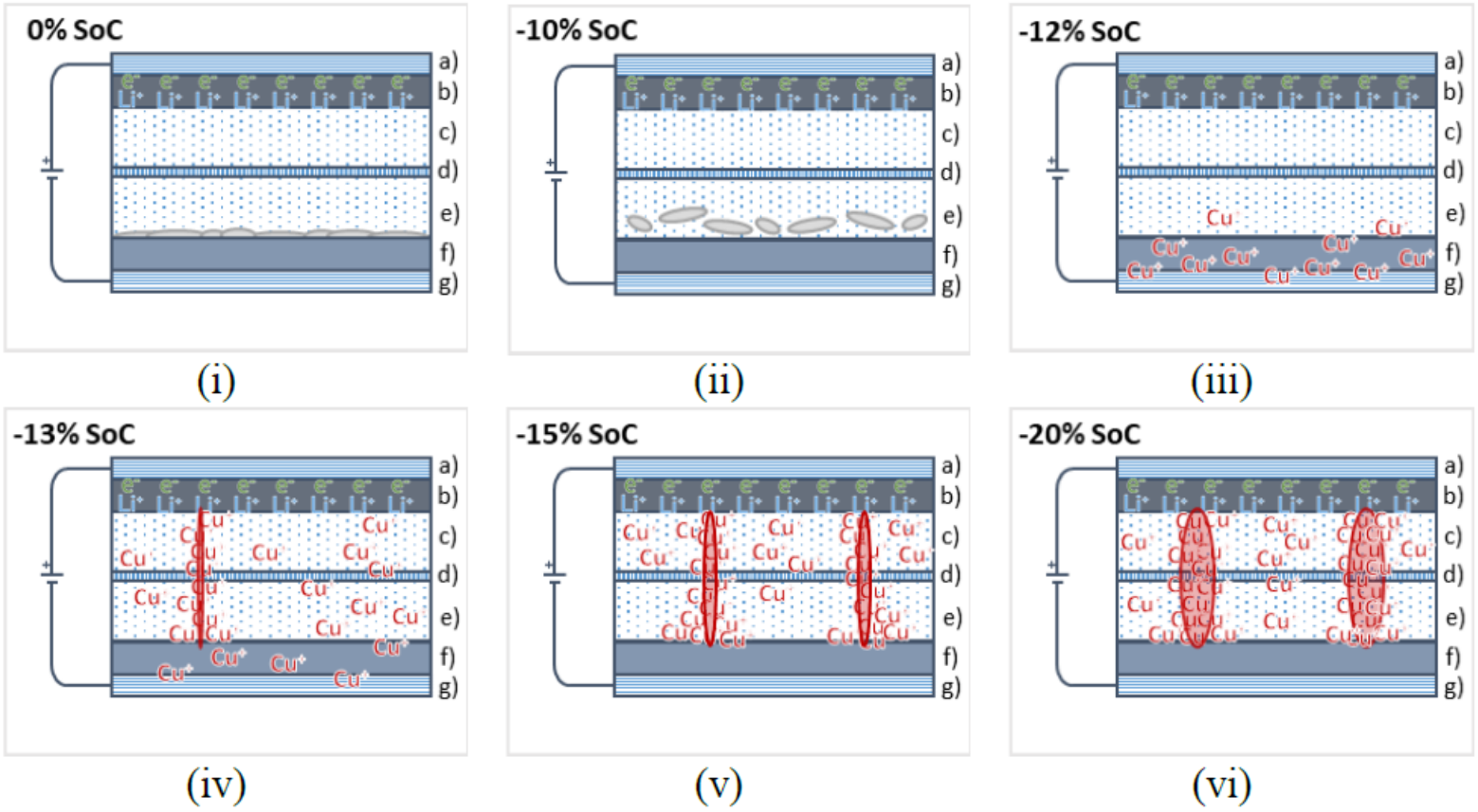






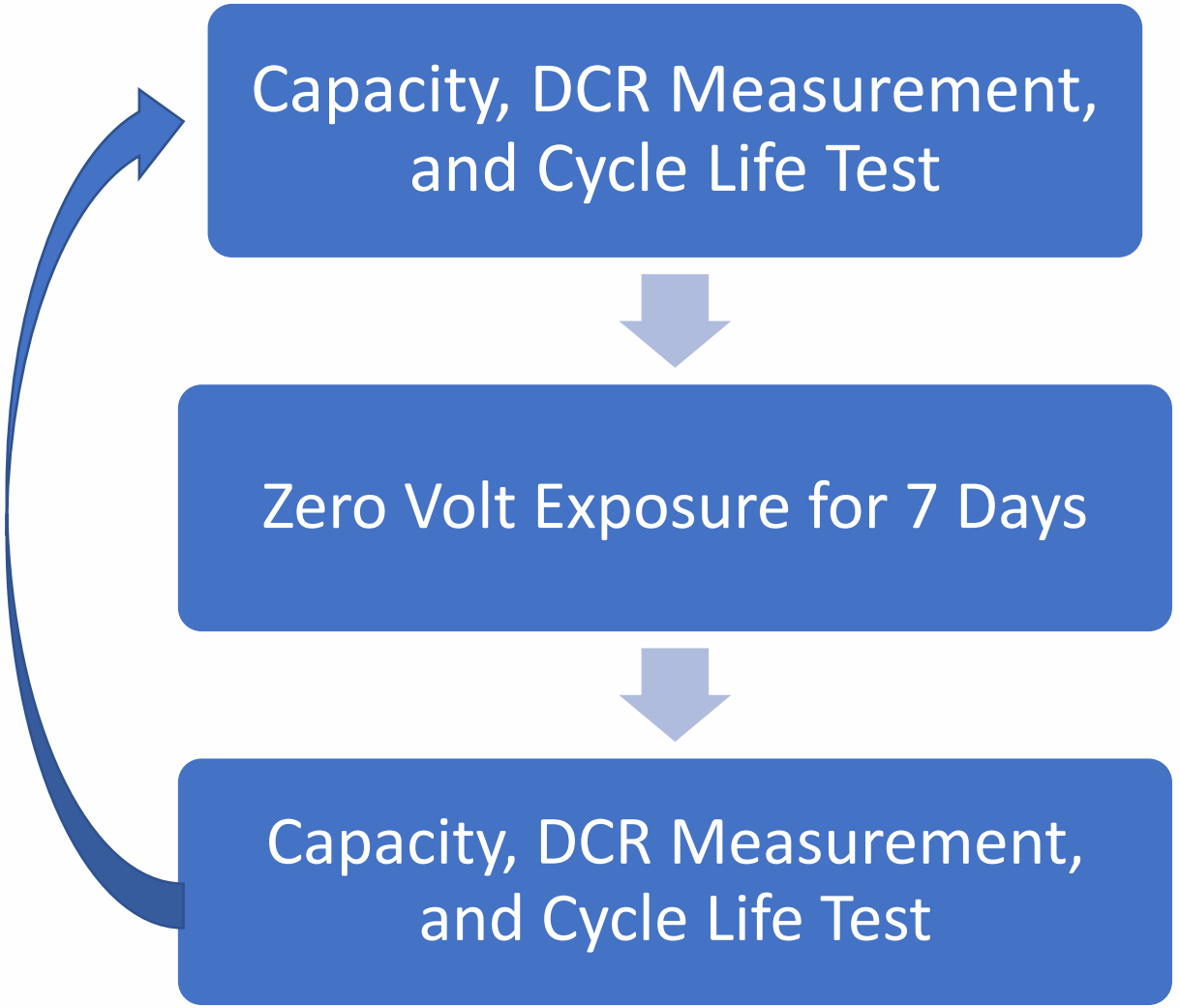
- No fire or explosion in impact, crush, external short and 130°C hot box tests

Zero Volt Failure Schematics

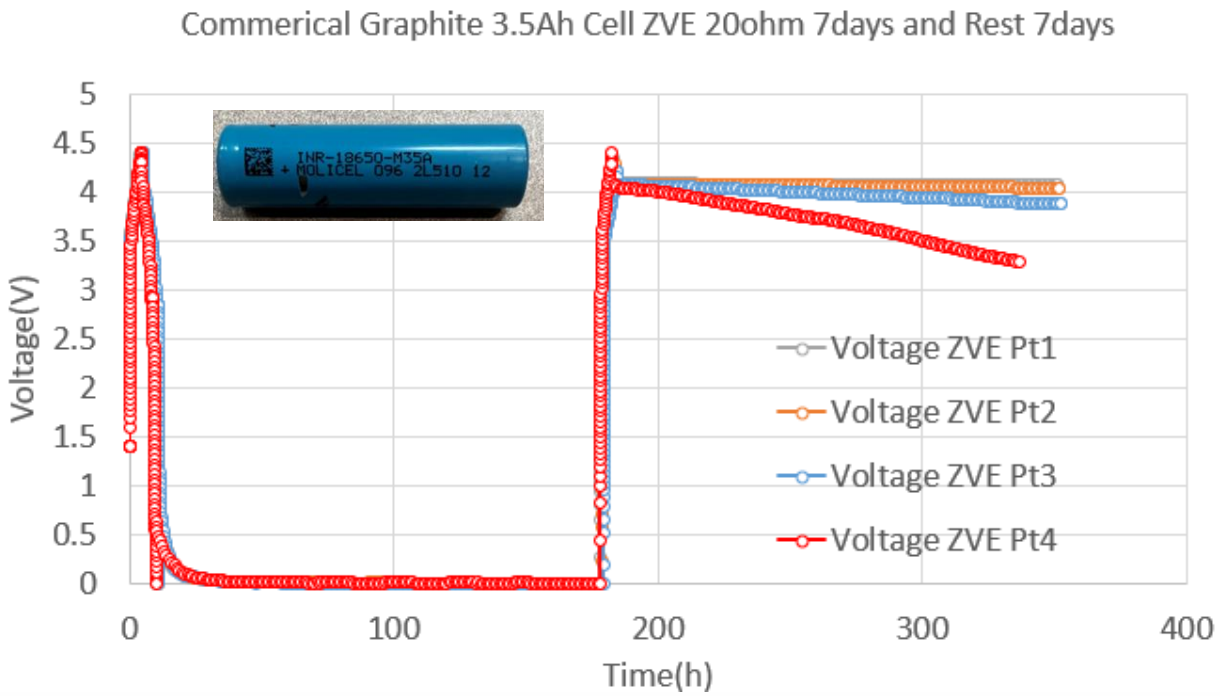


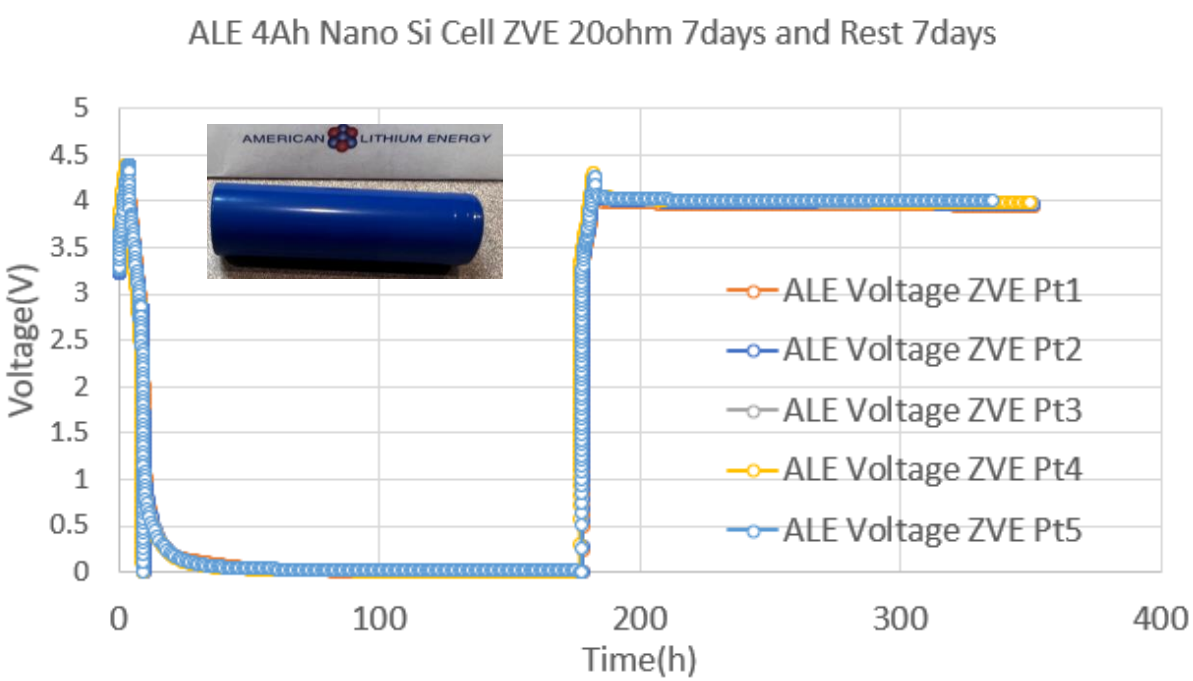
- Over discharge by 10% starts the decomposition of SEI layer
- Over discharge by 12% starts the Cu dissolution, and 13% by internal short

Zero Volt Stability Studies for 7 Days Repeatedly



Zero Volt Studies: 3.5Ah Commercial Moli 18650 cell and ALE 4Ah 18650 cell





- Very high self-discharging or internal short during rest for commercial 3.5Ah 18650 cell after 4 times of ZVE at 20ohm constant resistance discharging for 7 days
- Negligible self-discharging or no internal short during rest from ALE 4Ah 18650 cell after 5 times of ZVE at 20ohm constant resistance discharging for 7 days
- Zero Voltage Stability is good for ALE 4Ah 18650 Cell

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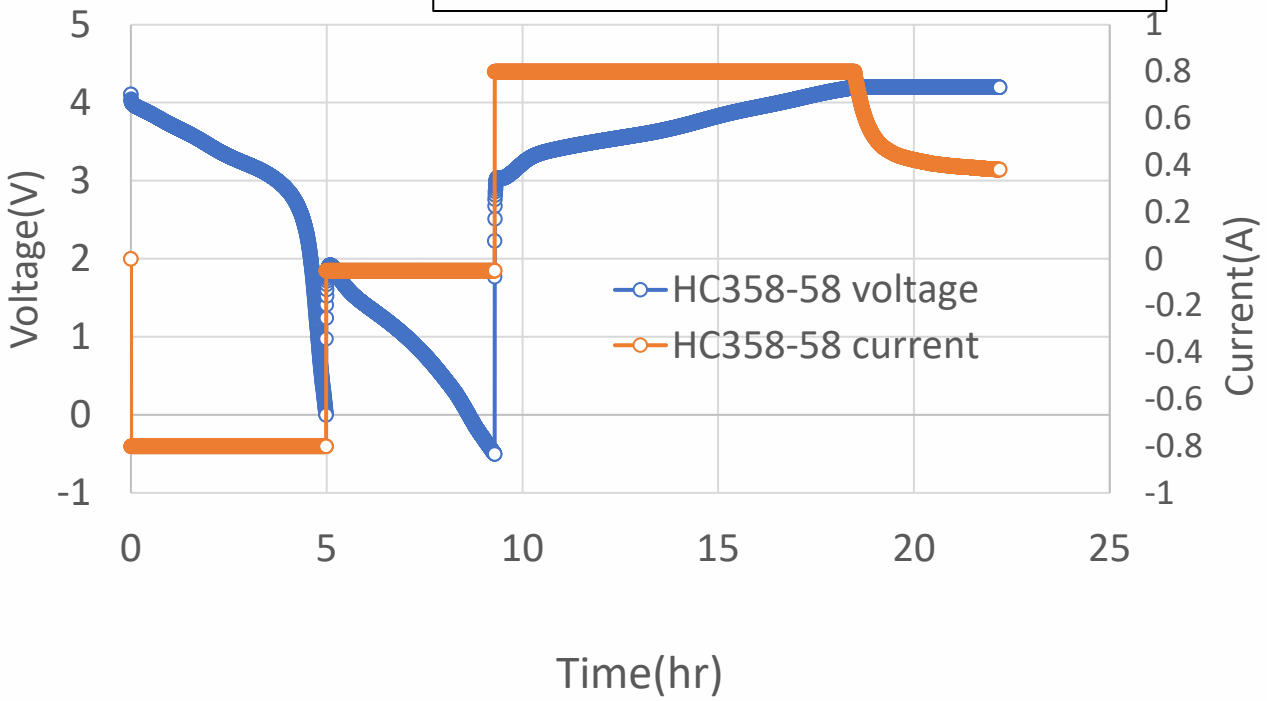
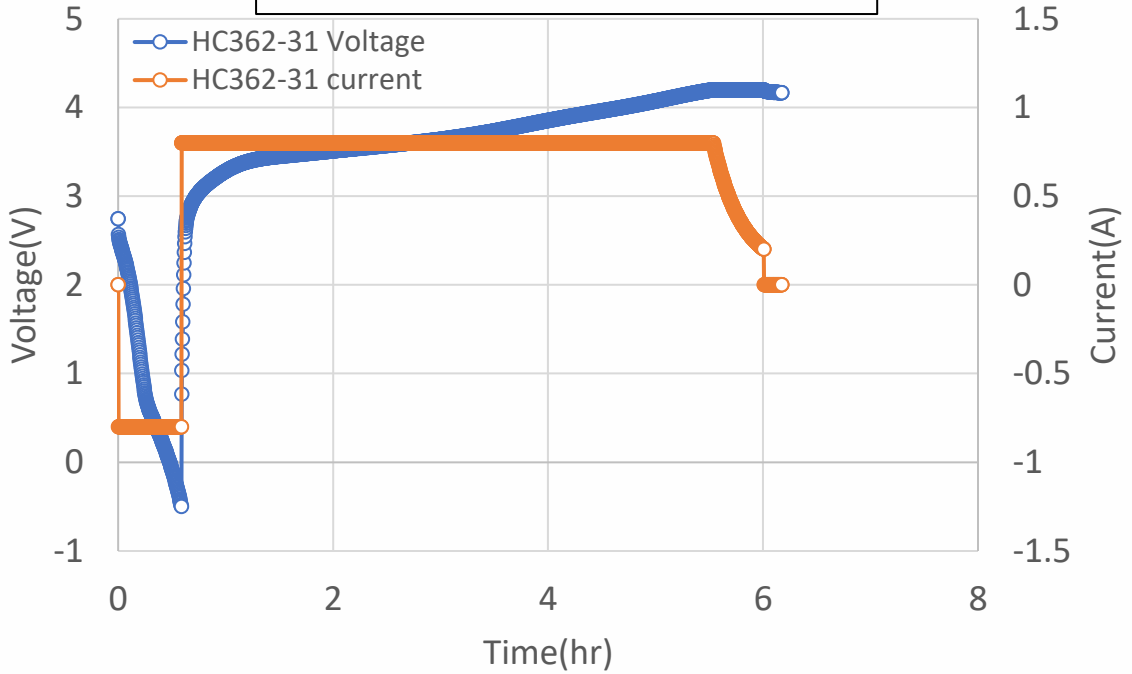
Negative Volt Exposure

- Procedure:
- Discharge to 0V at 0.8A
- Discharge 0.2Ah at 0.05A for 4h
- Charge to 4.2V at 0.8A



Procedure:
1. Discharge to -0.5V at 0.8A
2. Charge to 4.2V at 0.8A



- Both ZV cells have been discharged to -0.5V and recharged to 4.2V
- *No capacity decay*

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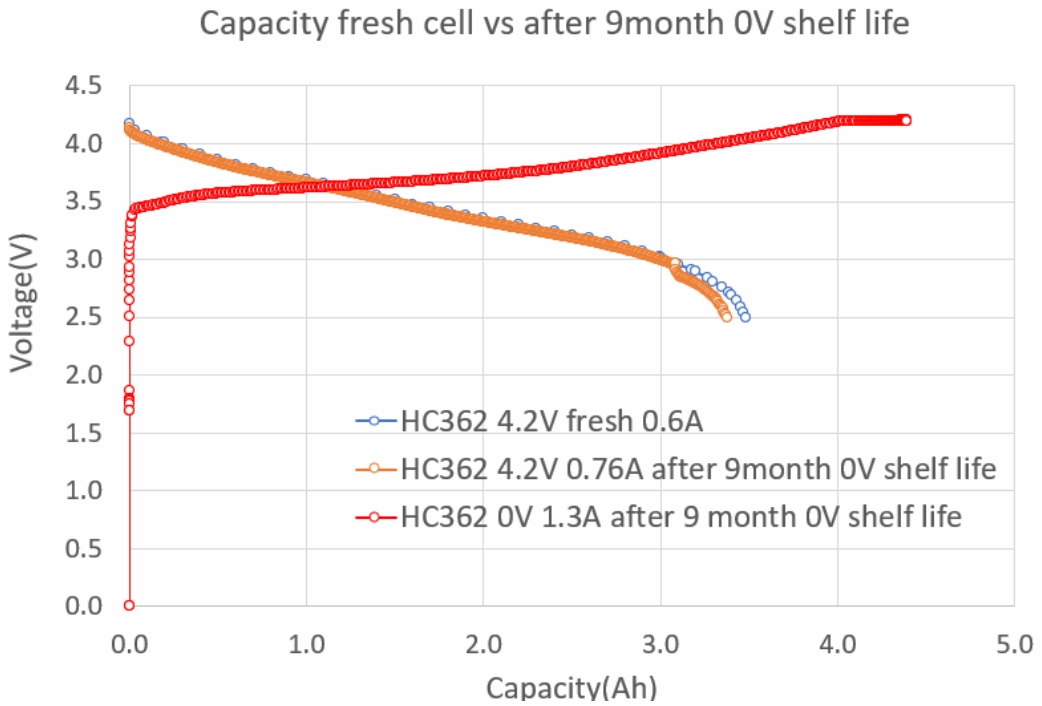
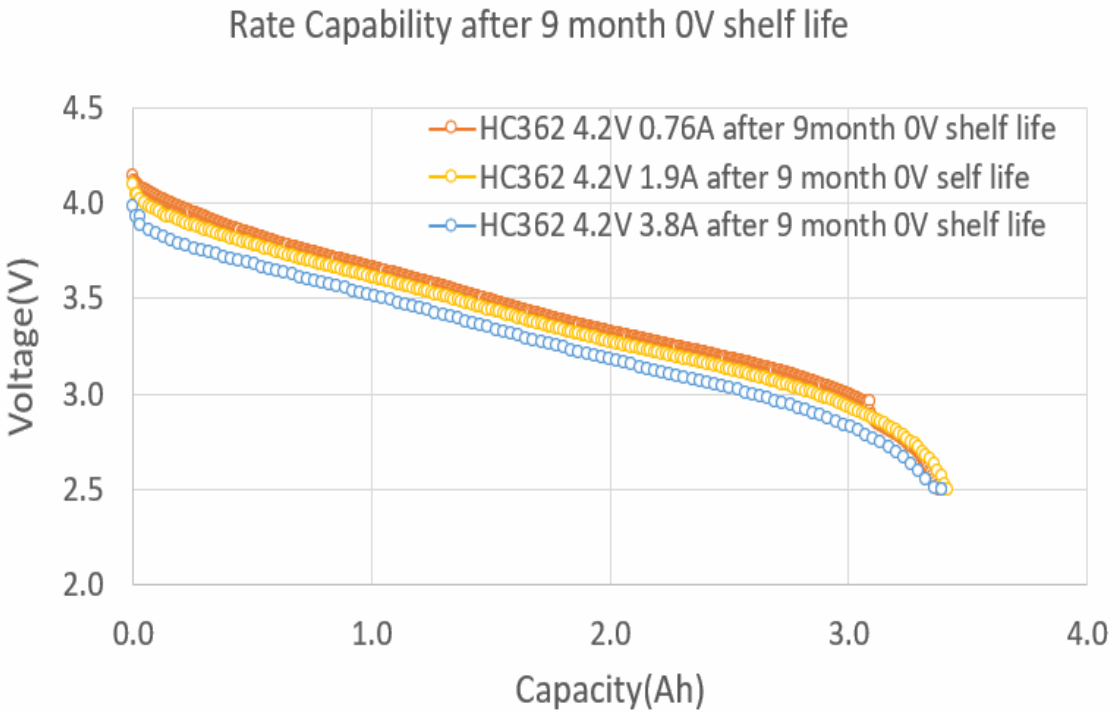
Zero Volt on the Shelf for Nine Months





- No capacity loss: Fresh cell with ZV design: the fresh capacity is 3.48Ah (4.2-2.5V), and 3.37Ah (4.2-2.5V) after charge from storage for 9 month at 0V, The 0.1Ah capacity loss is negligible, owing to higher discharge current.
- No power loss: The rate capability is quite good, the capacity is 3.37Ah (0.76A), and 3.41Ah (1.9A), and 3.39Ah (3.8A) after storage for 9 month at 0V.

Conclusion

- ALE 4Ah 18650 cell with zero volt technology is very stable at zero volt
  - No capacity or power loss after 5 times for seven days at zero volt
  - No energy and power loss at zero volt after nine months
- ALE 4Ah 18650 cell can deliver >3Ah capacity at -40°C and C/5, and 1.8Ah at -57°C and C/16
- ALE 4Ah 18650 cell is stable after the storage down to -65°C per our limited test, which is very beneficial to NASA application since the battery in space can be easily exposed to extremely cold temperature or environment