

# Studies on Discharge Capabilities of ALE 4Ah Li-ion 18650 Cylindrical Cells at Extremely Cold Temperature $-57^{\circ}\text{C}$

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# Outline

- Introduction
- Problems and factors in extremely cold temperatures
- Results
  - Performance down to  $-57^{\circ}\text{C}$
  - Stability after the low temperature down to  $-65^{\circ}\text{C}$
- Conclusion

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

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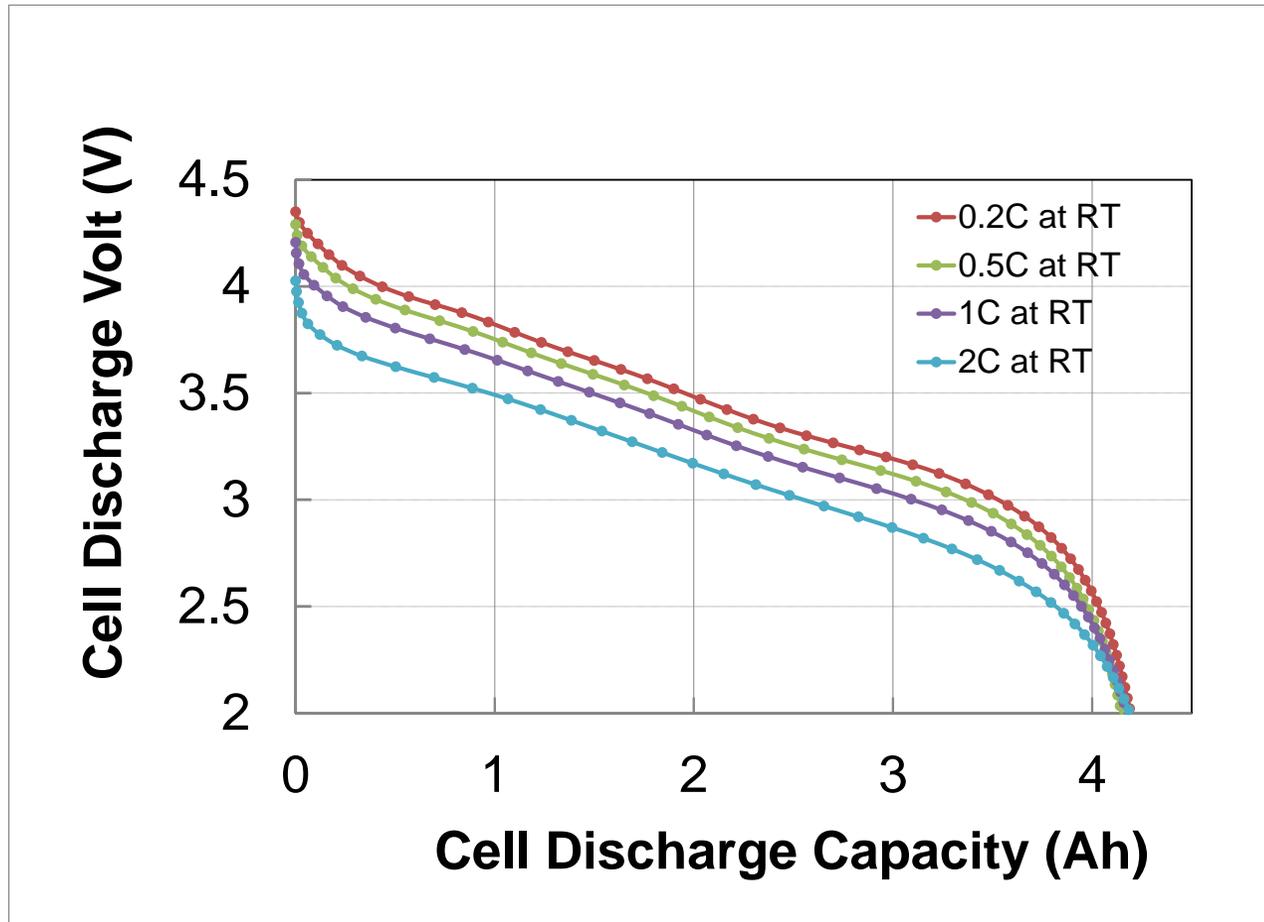
to meet the rapidly growing demand from Defense, Aerospace, and Commercial customers for onshore batteries



# ALE 4Ah Nano Si 18650 Cells

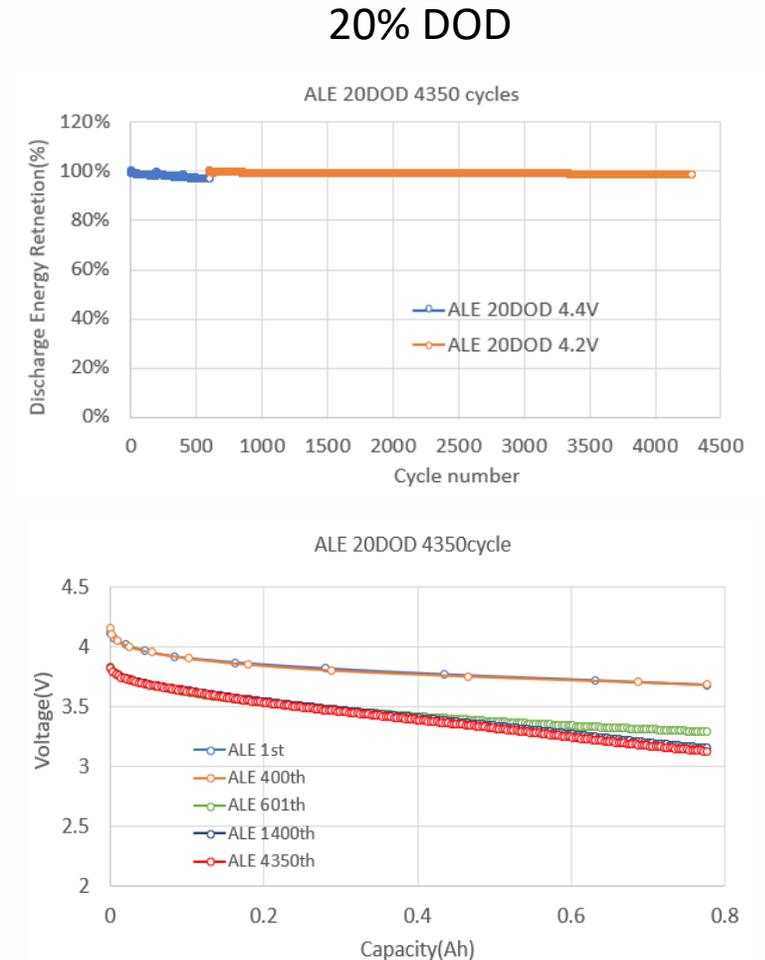
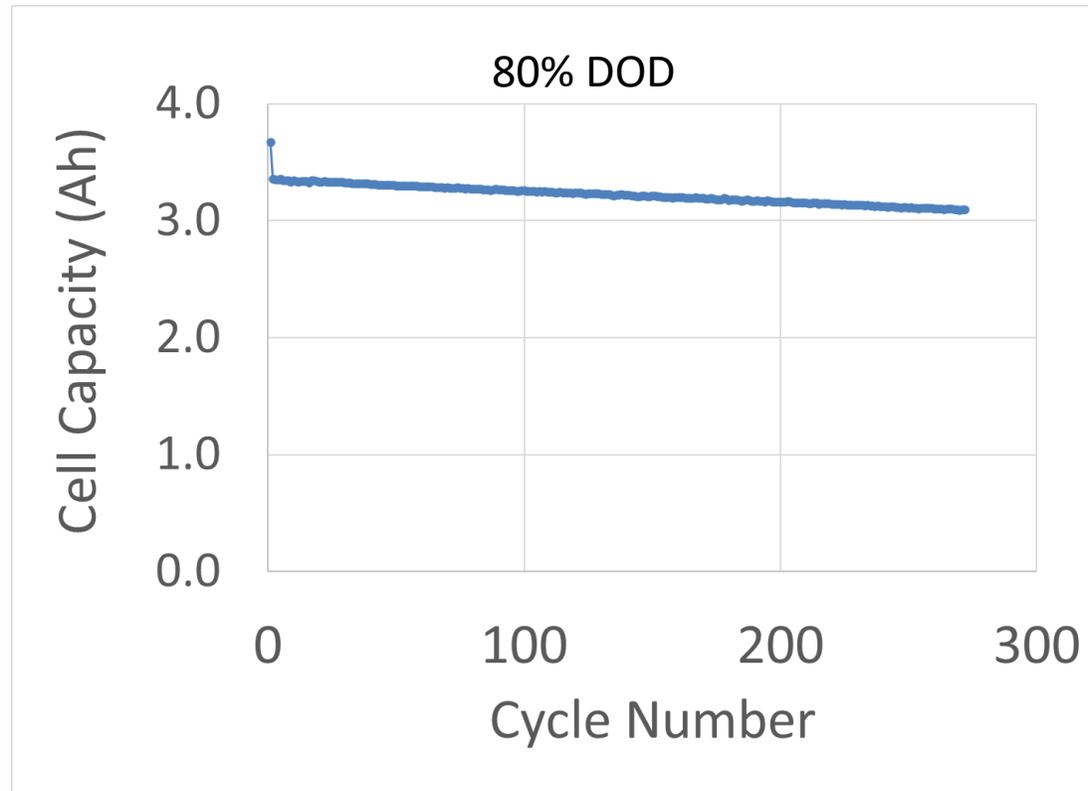
- High specific energy: up to 350 Wh/kg
- High power: Up to 700 W/Kg
- Excellent low temperature performance
- Good cycle life
- Meet major UN 38.3 requirement
  - Pass impact, crush, overcharge tests per UN 38.3 standard
- Good thermal stability
  - Pass 130°C (30 min.) hot box test

# 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

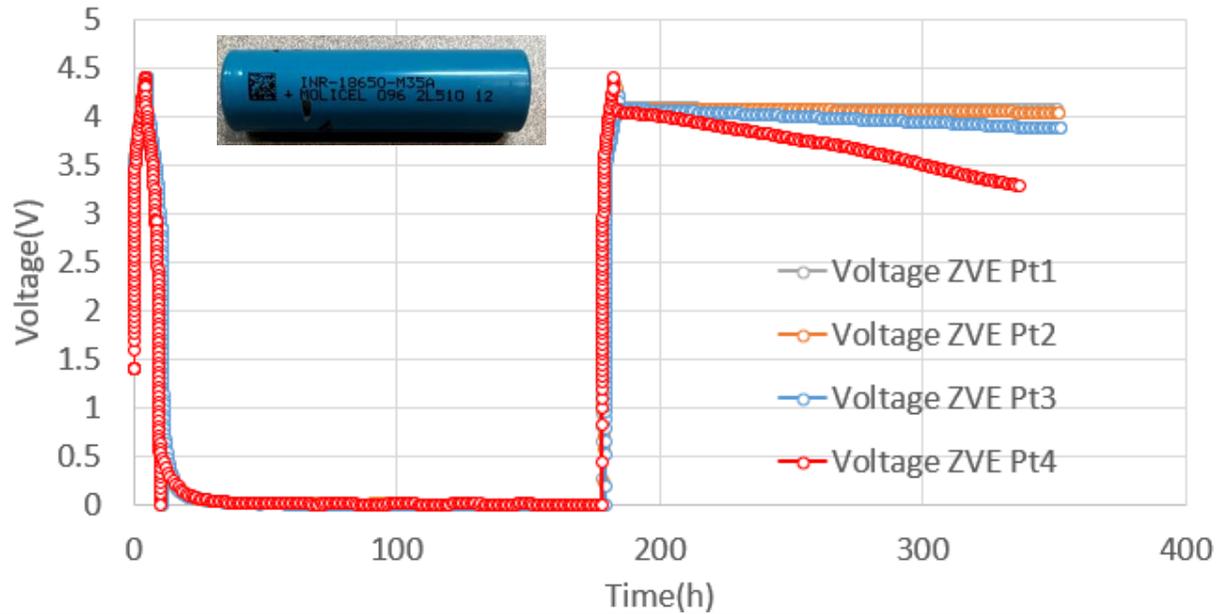
# Cycle Life: 20% and 80% DOD at RT



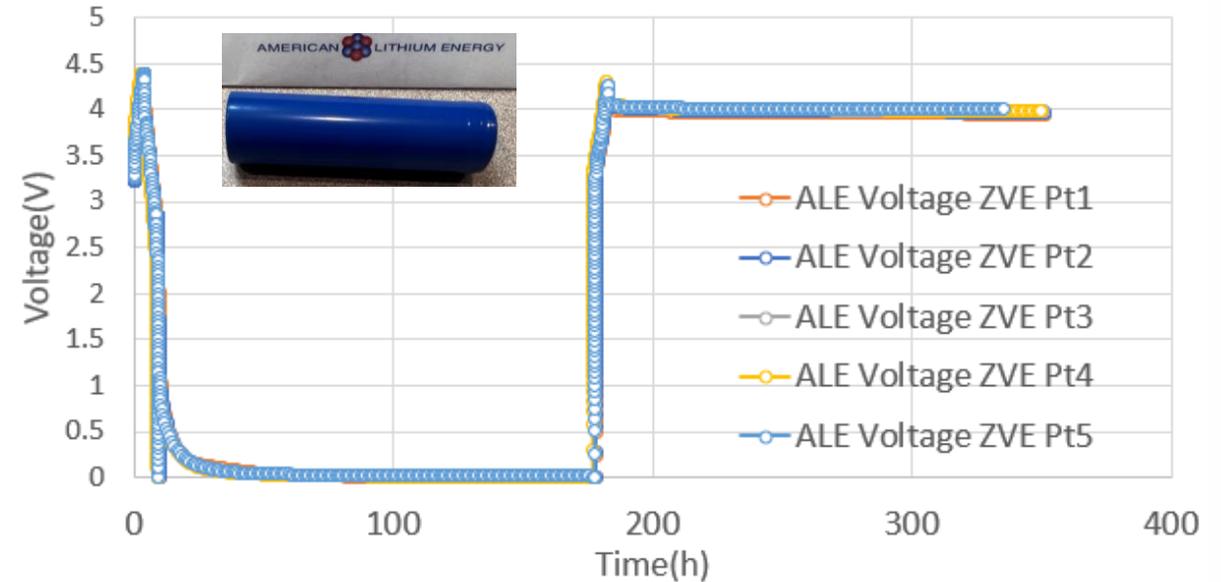
- The cycle life are very good at 20%DOD and 80%DOD
- The cell energy retention is about 98.6% after >4300 cycles at 20% DOD (18 months data)

# Zero Volt Stability

Commercial Graphite 3.5Ah Cell ZVE 20ohm 7days and Rest 7days



ALE 4Ah Nano Si Cell ZVE 20ohm 7days and Rest 7days

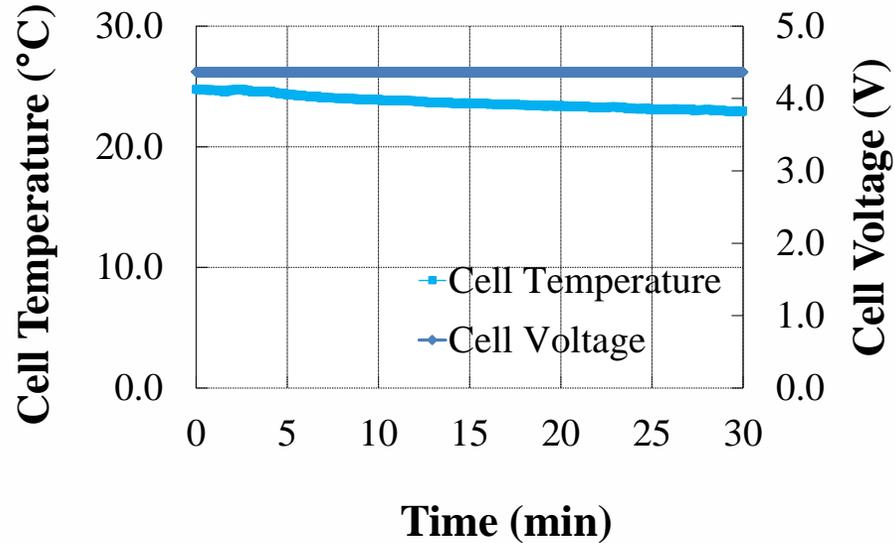


- Very high self-discharging during rest from commercial 3.5Ah 18650 cell after 4 times of ZVE at 20ohm constant resistance discharging for 7 days
- Negligible self-discharging during rest from ALE 4Ah Si cell after 5 times of ZVE at 20ohm constant resistance discharging for 7 days
- Zero Voltage Stability Confirmed

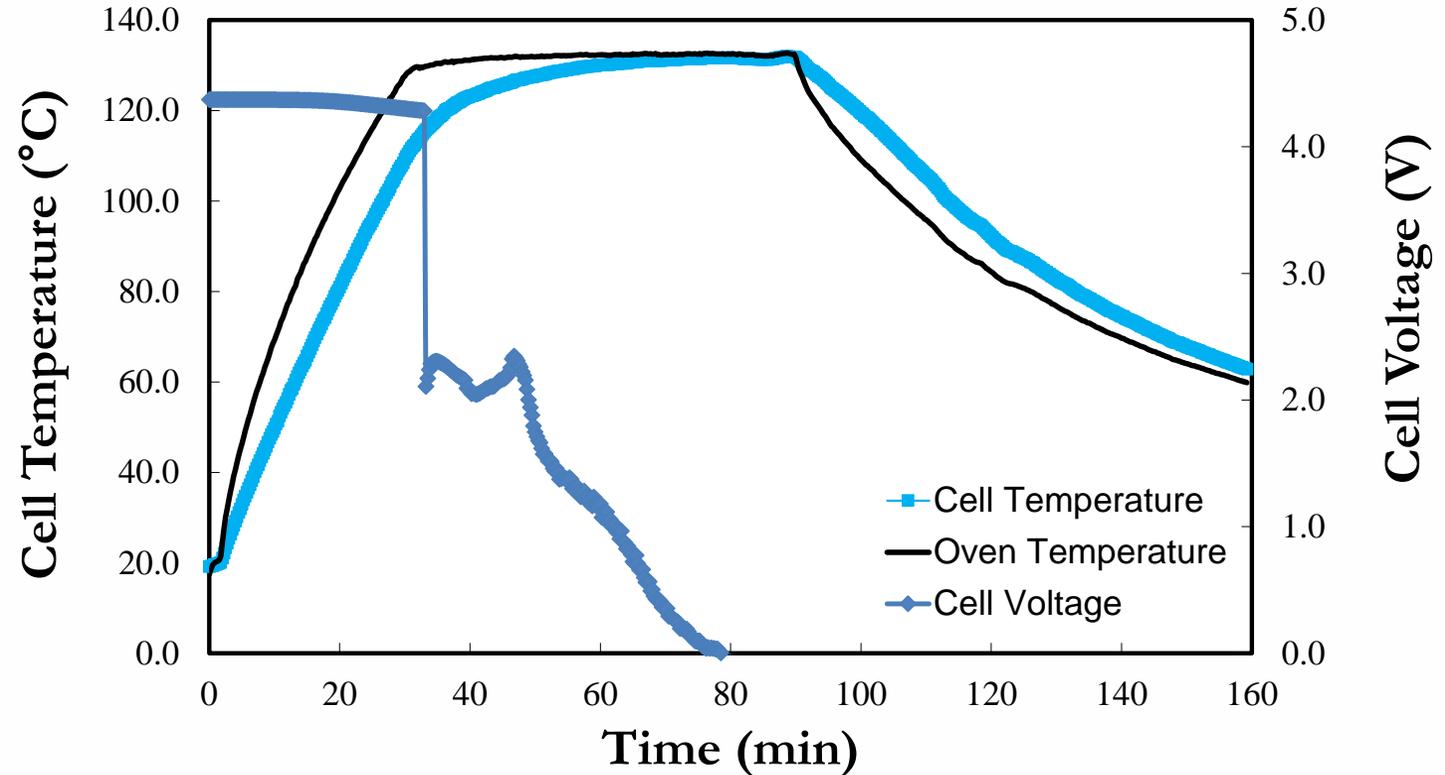
# ALE 4Ah Nano 18650 Cells

## Abuse Tolerance: Meet UN 38.03 Requirements

### Crush Test



130 °C for 60 min

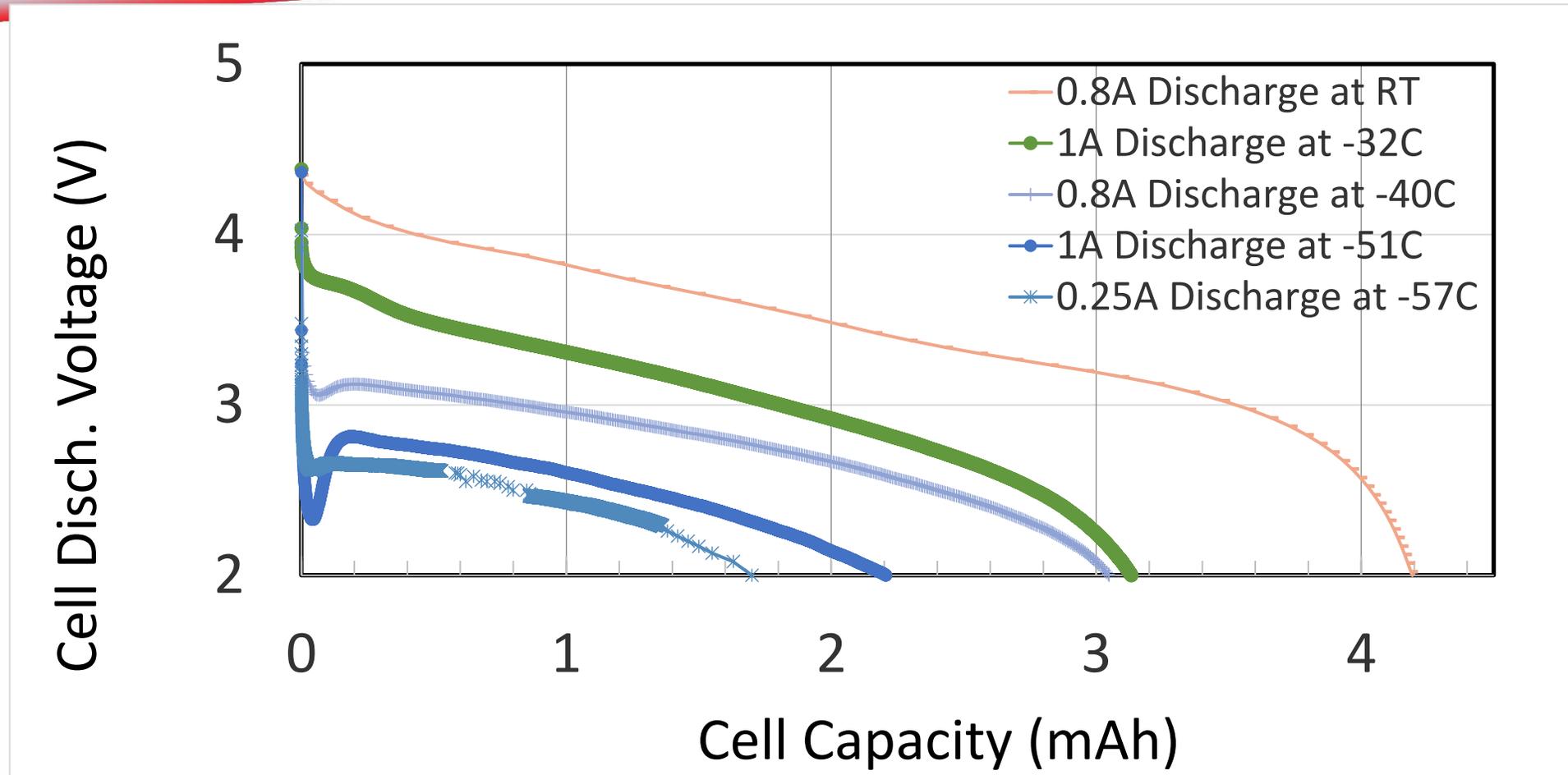


- No fire or explosion

# Problems and Factors at Low Temperatures

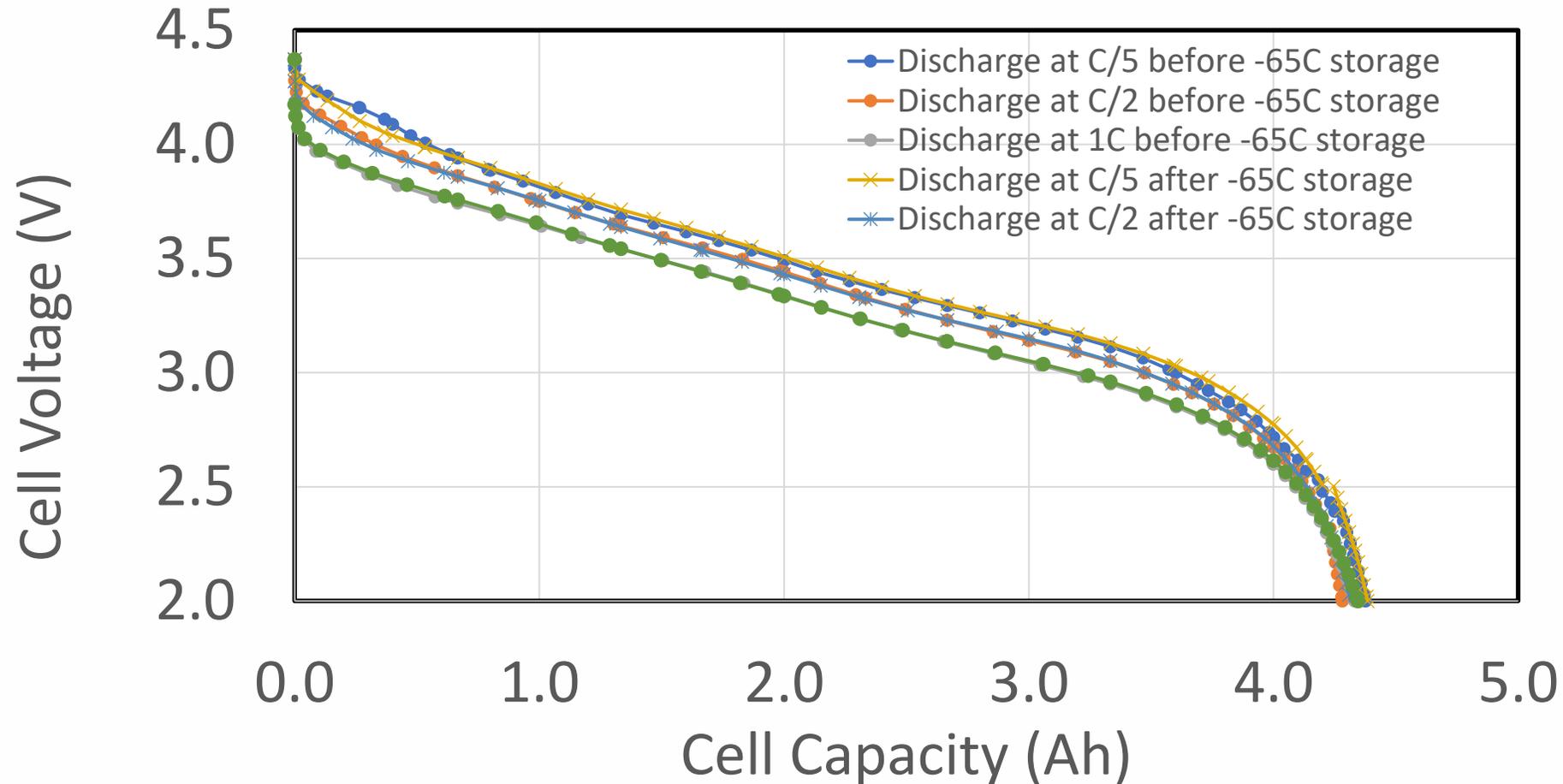
- Problems at Low Temperatures
  - Low power
  - Electrolyte freezing
  - High interfacial impedance
  - *Irreversible capacity loss after low temperature treatments*
- Key Factors in Low Temperatures
  - Poor lithium diffusion in electrolyte and active particles at low temperature
  - Poor conductivity in SEI layer
  - *Electrode cracks at the extremely cold temperature*

# 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

# Conclusion

- ALE 4Ah Si 18650 cell can deliver >3Ah capacity at -40°C and C/5, and 1.8Ah at -57°C and C/16
- ALE 4Ah Si 18650 cell is very stable after the storage down to -65°C, which is very beneficial to NASA application since the battery in space can be easily exposed to extremely cold temperature or environment