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SNL Energy Storage Technology and Systems – Energy Storage Safety
Funded by Dr. Imre Gyuk
U.S. Department of Energy; Office of Electricity; Energy Storage Systems Program

Comparative Electrochemical Performance of Commercial 18650-Format Lithium-ion Cells

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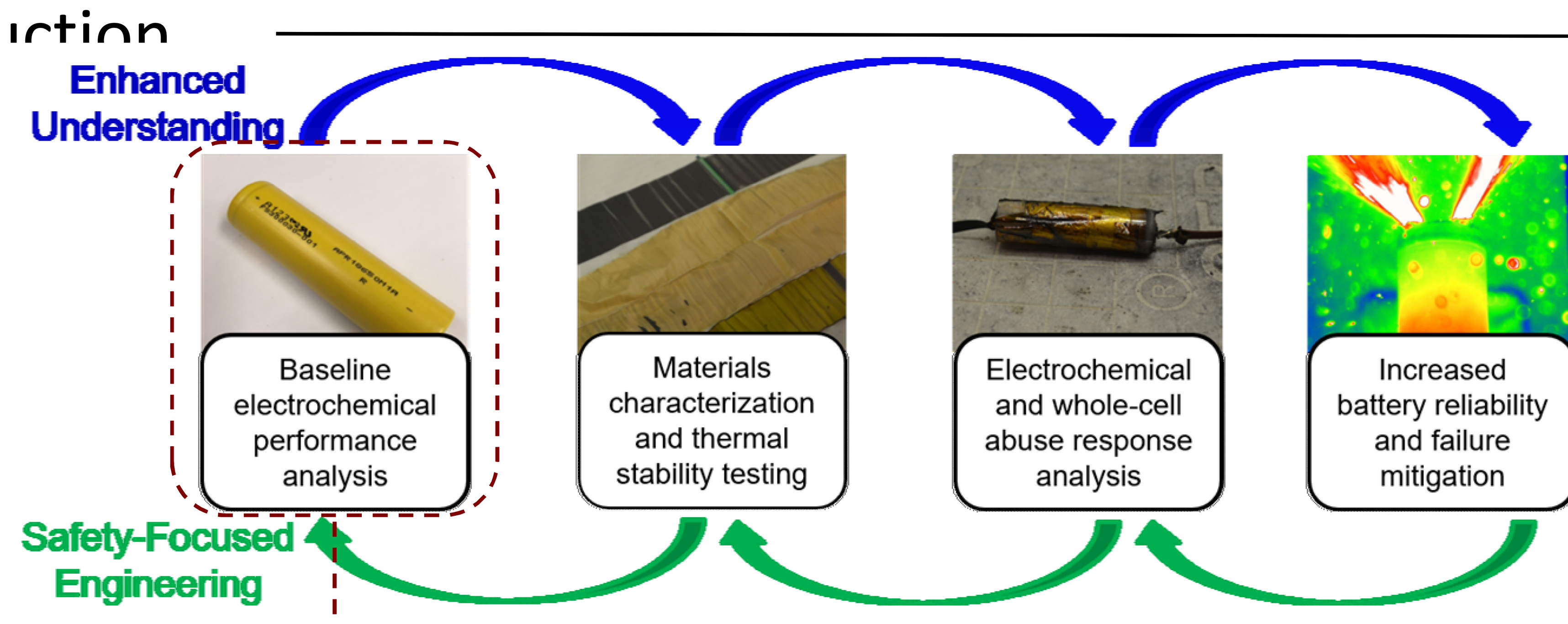
Introduction

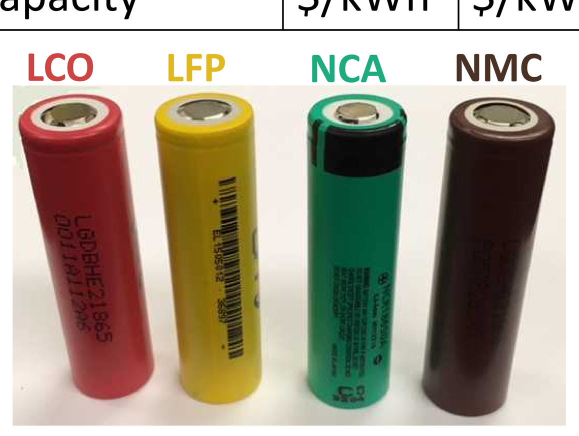
- Stationary energy storage systems (ESS) are increasingly deployed to maintain a robust and resilient grid
- As system size increases, financial and safety issues become important topics
- Holistic approach: electrochemistry, materials, and whole-cell abuse will fill knowledge gaps
- Electrochemical performance helps define safety and reliability
- Detailed studies on the electrochemical performance as a function of application conditions have been limited
- Cells have application-specific operation and performance characteristics

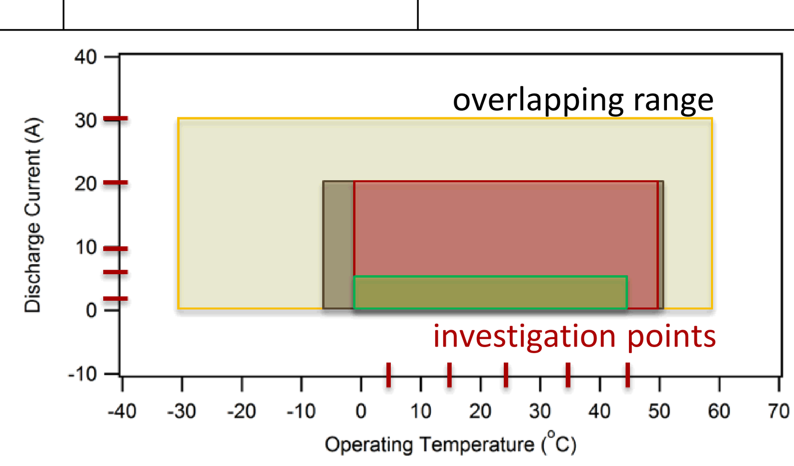


Cell Chemistry

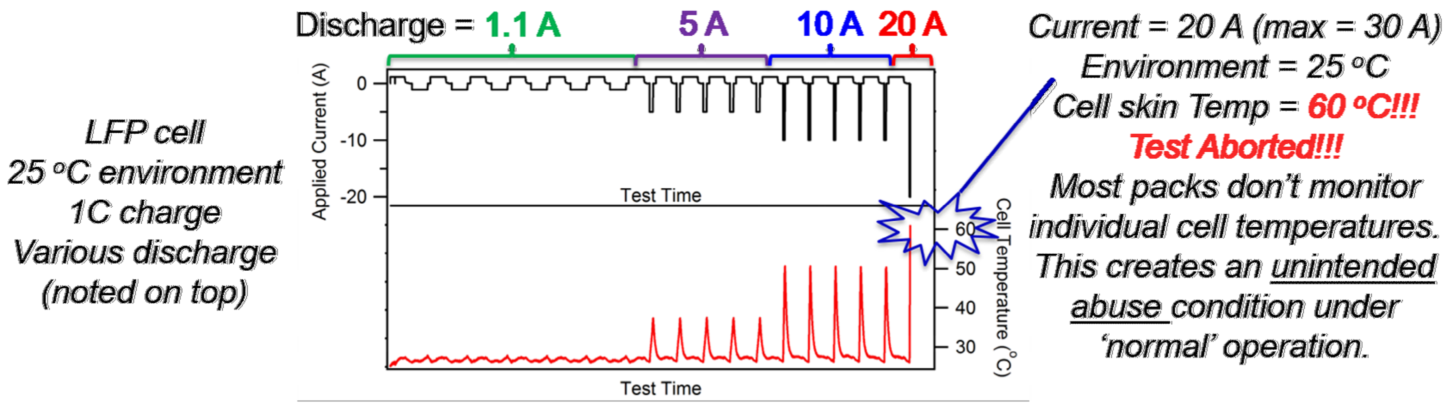
Manufacturer specifications often lack fidelity and parametric detail to ascertain the reliability and operational performance.

Battery	LCO	LFP	NCA	NMC
[redacted]				
Capacity	2.5 Ah	1.1 Ah	2.9 Ah	3.0 Ah
[redacted]				
Max Discharge Current	20 A	30 A	6 A	20 A
[redacted]				
Energy Density	533.3 Wh/L	212.1 Wh/L	569.7 Wh/L	612.1 Wh/L
[redacted]				
Cost per Capacity	852.3 $/kWh	2842.8 $/kWh	835.1 $/kWh	594.0 $/kWh



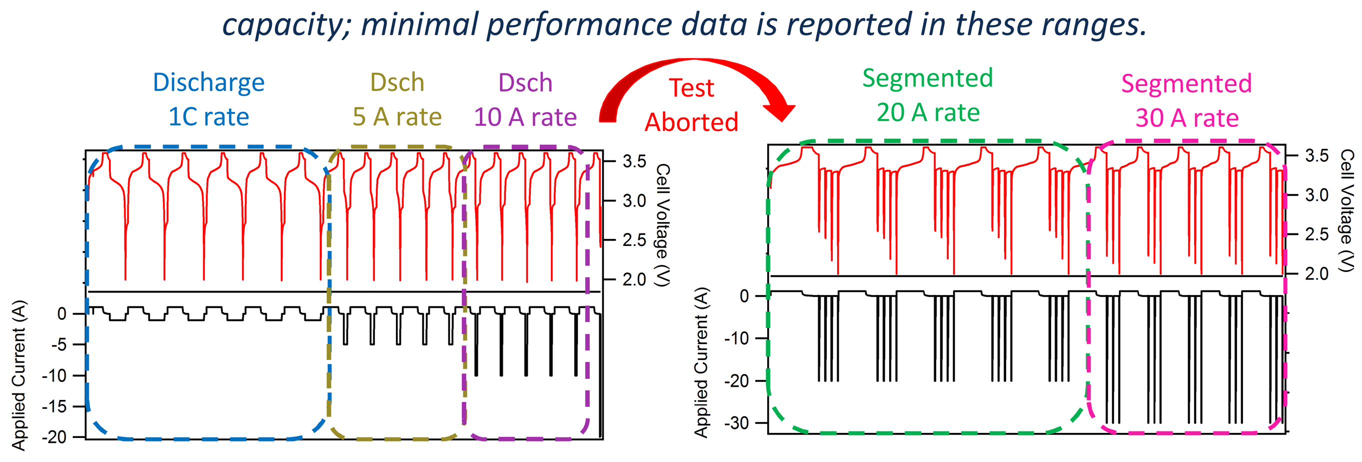


Compounding conditions such as discharge current and temperature can interact to create an unintended abuse condition (i.e. self-heating to abuse temperature).



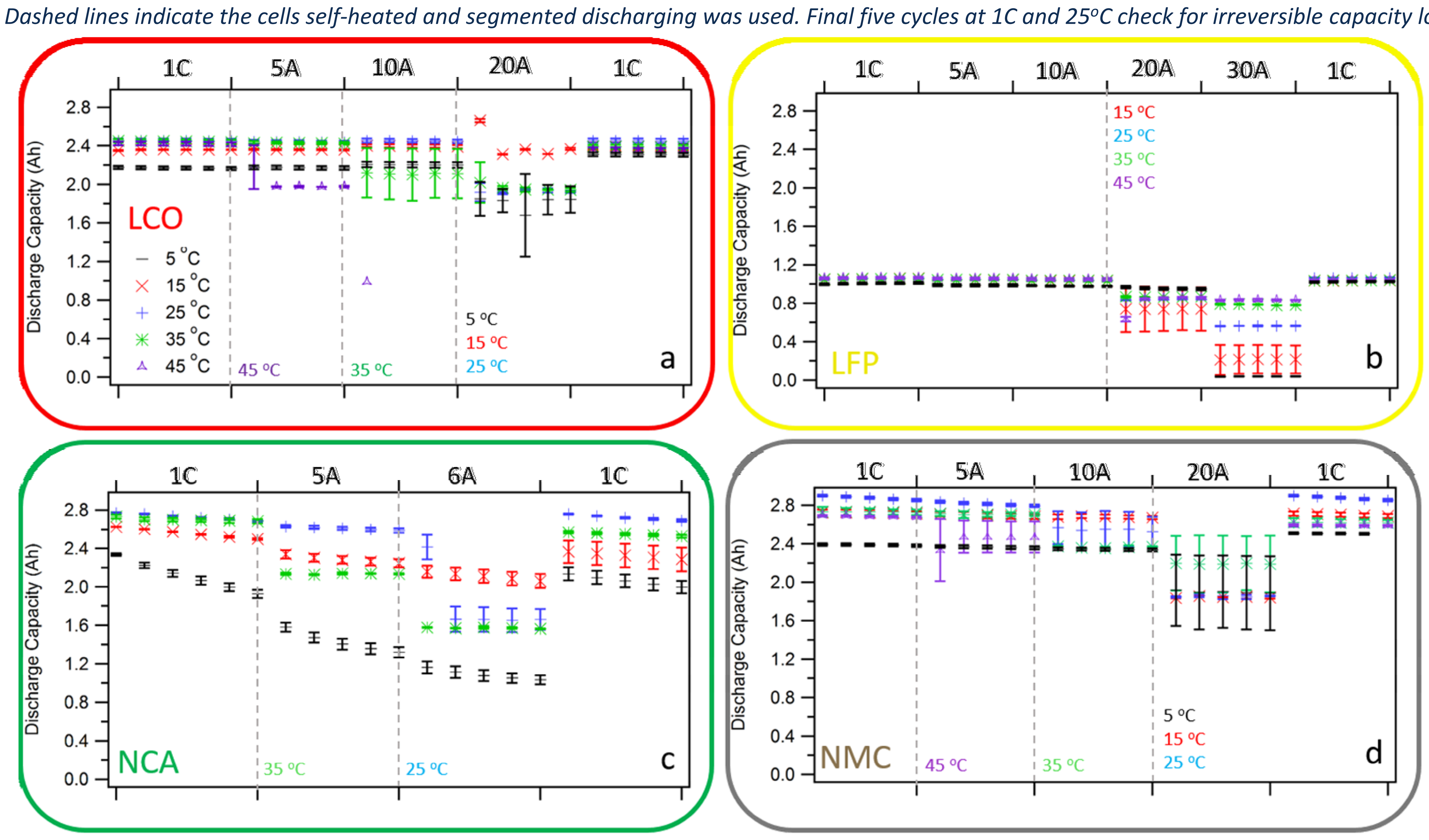
Test Procedure

Operation guidelines include temperature, maximum charging/discharging currents, and nominal capacity; minimal performance data is reported in these ranges.

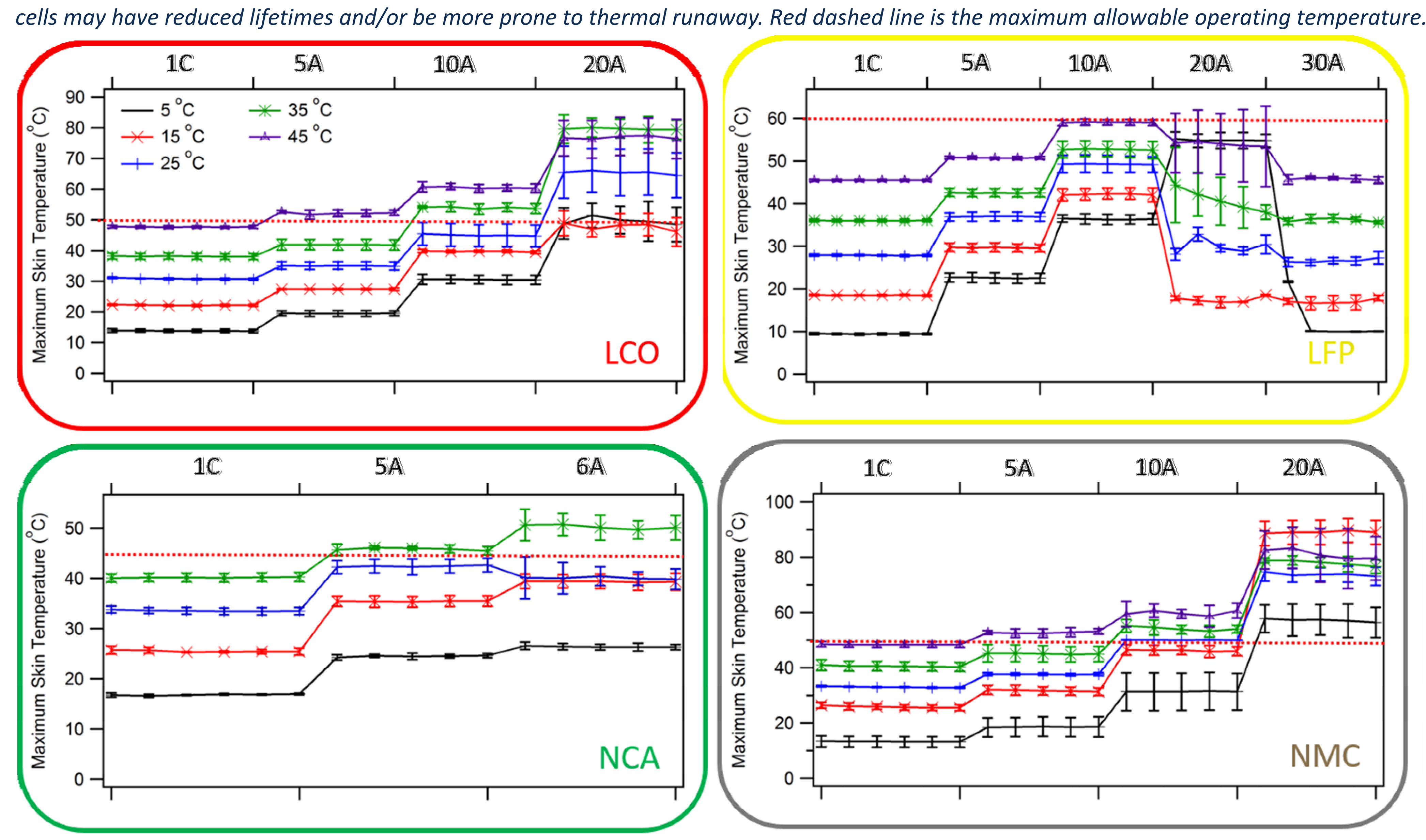


Performance

Environment temperature and discharge current have a profound effect on performance, most of which is reversible (exception: NCA and NMC). Dashed lines indicate the cells self-heated and segmented discharging was used. Final five cycles at 1C and 25°C check for irreversible capacity loss.



Significant self-heating occurs within normal operating conditions. Abuse temperatures leave cells in an unknown, potentially damaged state. These cells may have reduced lifetimes and/or be more prone to thermal runaway. Red dashed line is the maximum allowable operating temperature.



Conclusions

- Notable deviations in performance vs. chemistry, must consider application requirements
- Must carefully study compounding conditions to avoid unintended abuse conditions
- Some conditions caused irreversible capacity loss resulting in lifetime decay
- Without detailed performance data, safety and reliability is not fully understood

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