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SNL Energy Storage Technology and Systems – Energy Storage Safety
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Materials Characterization of Abused Cells

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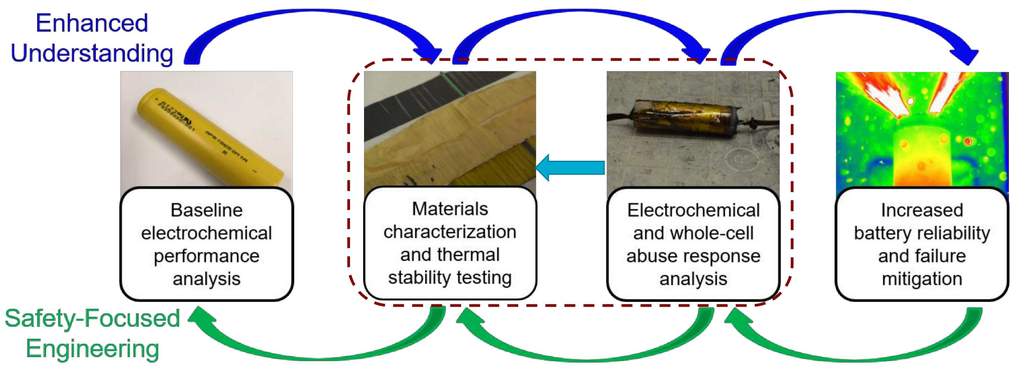
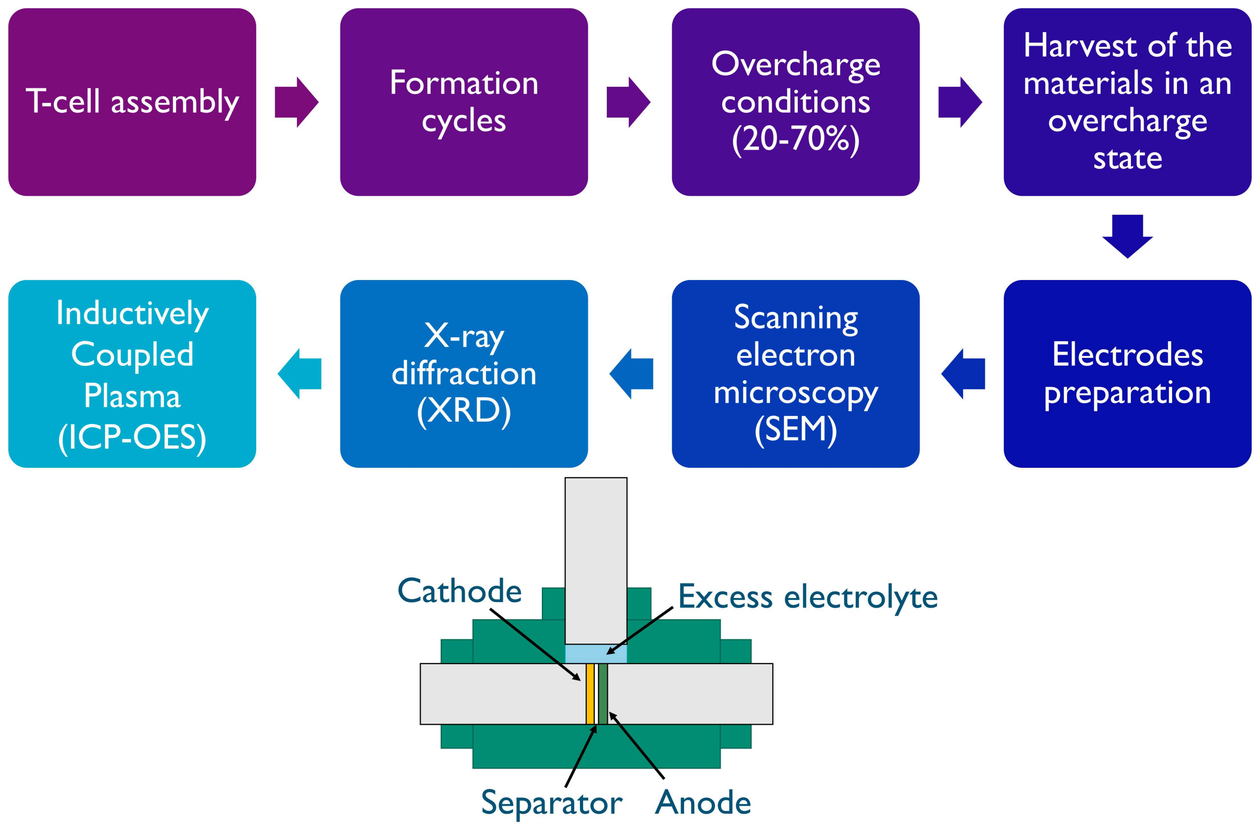
Introduction

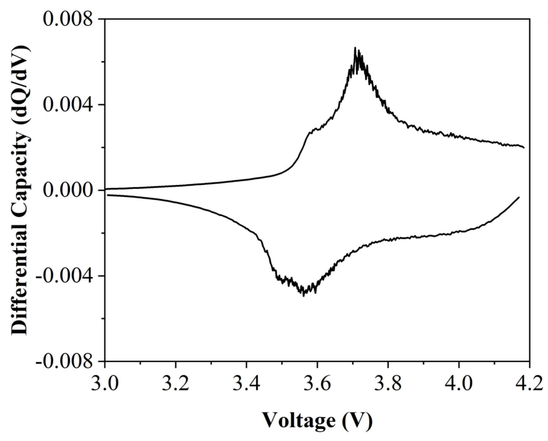
- Stationary energy storage systems (ESS) are increasingly deployed to maintain a robust and resilient grid.
- As system size increases, financial and safety issues become important topics.
- Holistic approach: electrochemistry, materials, and whole-cell abuse will fill knowledge gaps.
- The prevention of catastrophic failure requires detection of internal faults well before they have developed to the point of no return.
- Understanding the degradation mechanisms of the battery components during abusive conditions is essential to influence the development of new component designs that are more resilient to abusive conditions.



Methodology

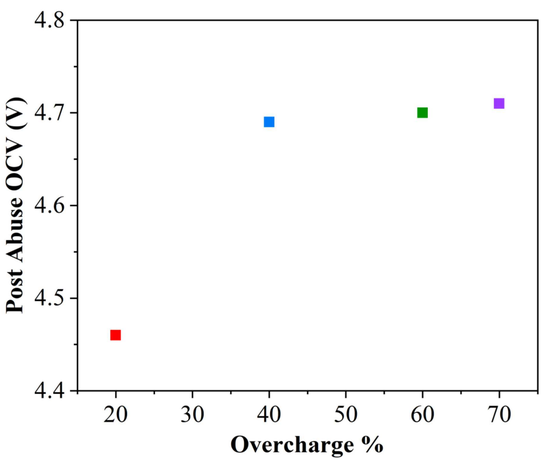


T-cells Conditioning



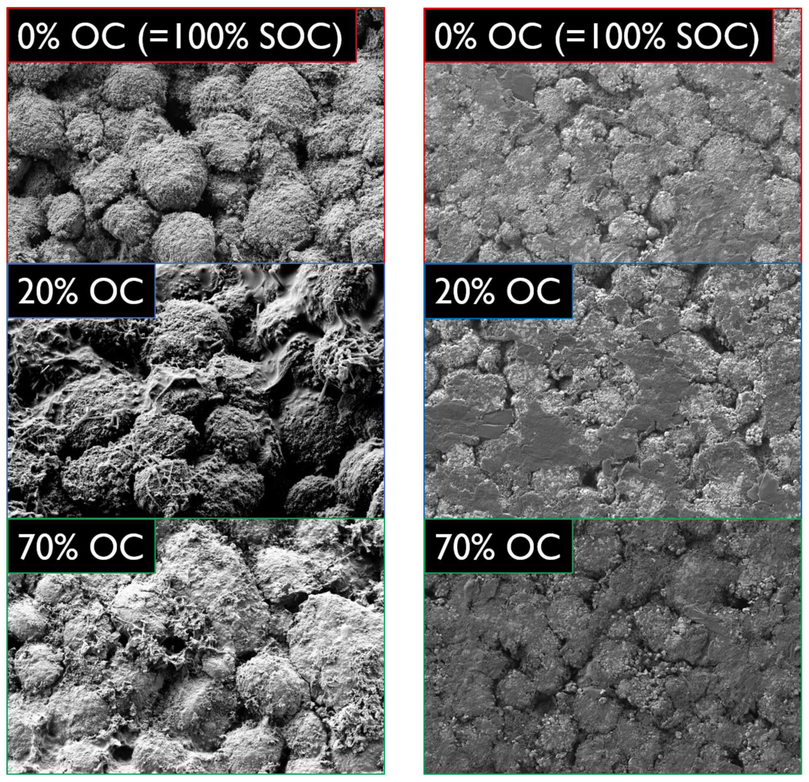
The T-cells were subjected to formation cycles to create a strong passivation layer on the surface of the anode.

After formation, T-cells were subjected to different levels of overcharge from 20% to 70% to assess the materials changes caused by strenuous conditions.



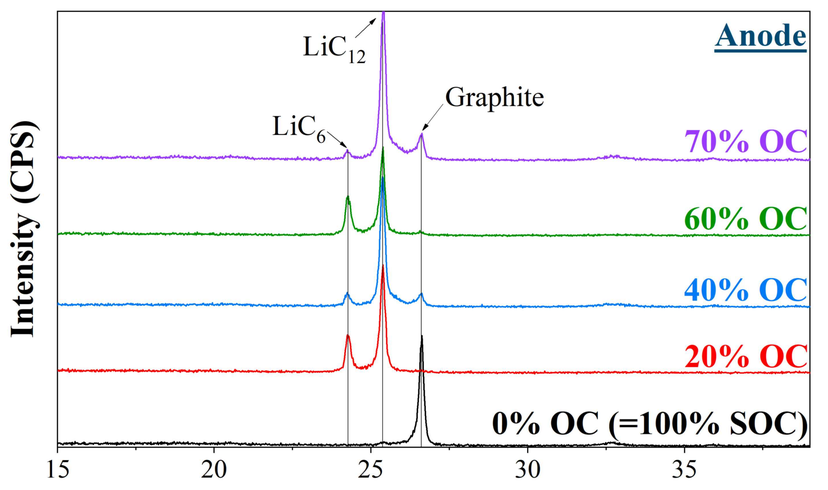
The measured voltage tapered off after 40% OC, indicative of saturation of the anode and its inability to accept more charge.

SEM

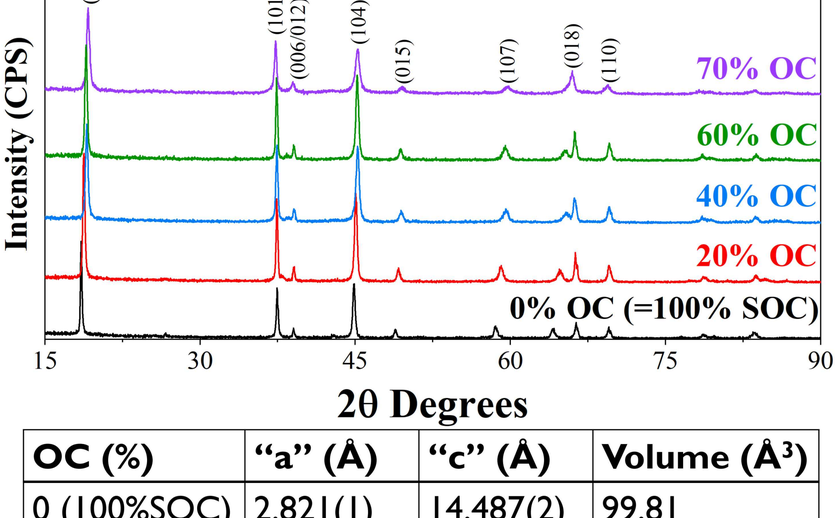


Anodes: SEM revealed the presence of dendrites and the deformation of the mesocarbon microbeads for higher levels of overcharge.
Cathodes: At higher OC levels, the agglomeration of particles exhibited deformation.

XRD



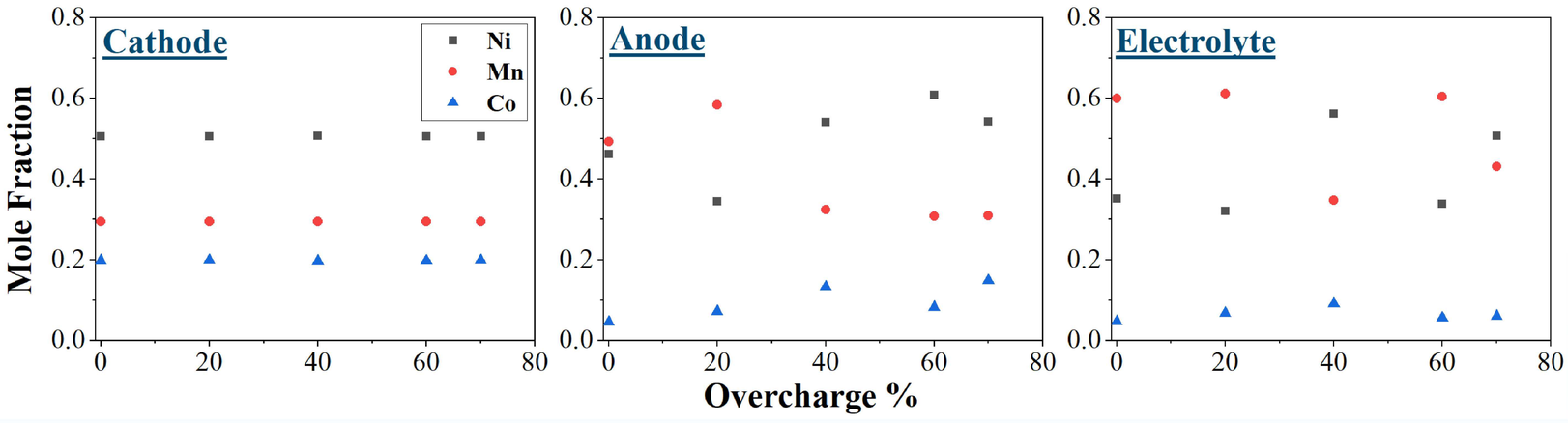
Anode: The reduction of the LiC_6 peak at 40% OC is likely a result of a redox reaction that happened at ~35% OC (2019 Peer Review).



OC (%)	"a" (Å)	"c" (Å)	Volume (Å^3)
0 (100%SOC)	2.821(1)	14.487(2)	99.81
20	2.822(1)	14.271(9)	98.42
40	2.827(1)	14.100(10)	97.57
60	2.825(2)	14.110(10)	97.50
70	2.837(2)	13.987(18)	97.48

Cathode: The unit cell volume decreased exponentially up to 40% OC. Afterward, the shrinkage of the lattice tapered off at ~97.5 Å^3, indicative of lithium depletion. Higher OC levels show significant peak broadening characteristic of increased strain in the lattice and/or reduction in crystallite size.

ICP-OES



Cathode: The mole fraction of the metals revealed an NMC composition of 5:3:2, which remained constant for all levels of overcharge. This is indicative of a uniform loss of transition metals as a result of overcharge conditions.
Anode & Electrolyte: Trace amounts of transition metals were identified in the anode and electrolyte. Mn exhibited preferential transport up to 20% OC; afterward, Ni dominates.

Conclusion

SEM, XRD, and ICP-OES analysis revealed critical points of failure during OC conditions. Both electrodes undergo significant changes after 40% OC, associated with Li depletion of the cathode and saturation of the anode. The ICP-OES confirmed preferential transport of Mn and Ni to the anode/electrolyte as a result of OC conditions.

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