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Li-ion Battery Research and Development Capability for Stationary Energy Storage at PNNL

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Pacific Northwest National Laboratory

Support from DOE Office of Electricity Delivery & Energy Reliability Energy Storage Program

Electrical Energy Storage Applications and Technologies (EESAT) Conference
Portland, OR, Sept. 21-25, 2015

Project Overview

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Li-ion Battery Energy Storage Challenge

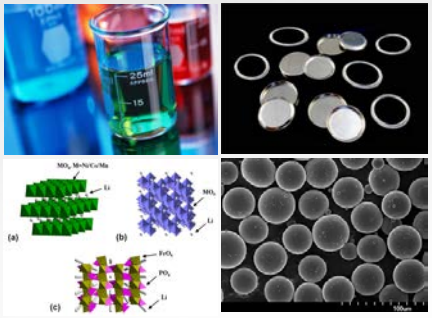
Li-ion battery is widely utilized for stationary application but more reliable, safe and cost effective battery chemistry is desired.

Program Objectives

- Fundamental understanding of application specific battery chemistries based on novel electrode materials and electrolytes.
- Understand reliability and limitation of various Li-ion battery chemistries.

Accomplishments

- Facile synthesis of high voltage $LiCoPO_4$ cathode and electrolyte optimization for stable cycling.
- Gassing analyses of $Li_4Ti_5O_{12}$ (LTO) anode with carbonate based electrolyte at elevated temperature.
- Demonstration of commercially relevant scale batteries (pouch cell) utilizing Advanced Battery Facility (ABF) at PNNL.



~1 mAh

1~5 Ah

~ MWh ESS Batteries

High Voltage $LiCoPO_4$ Cathode

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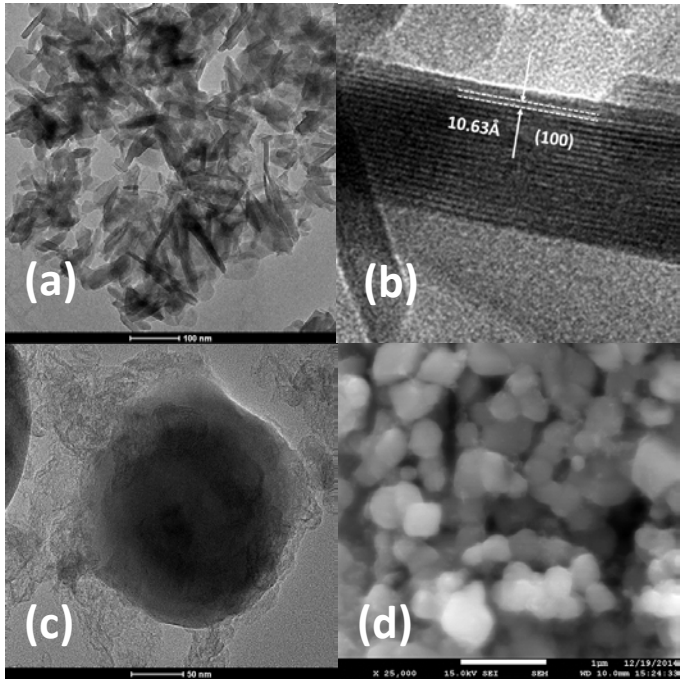
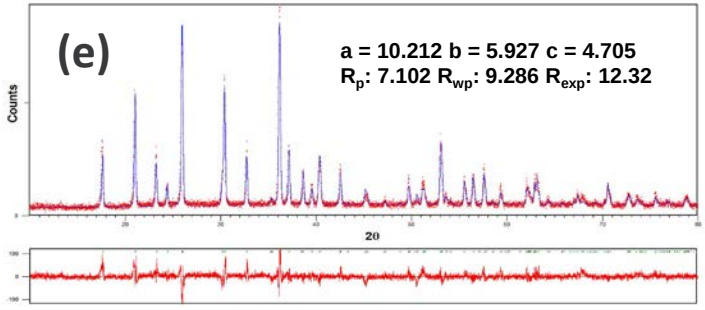




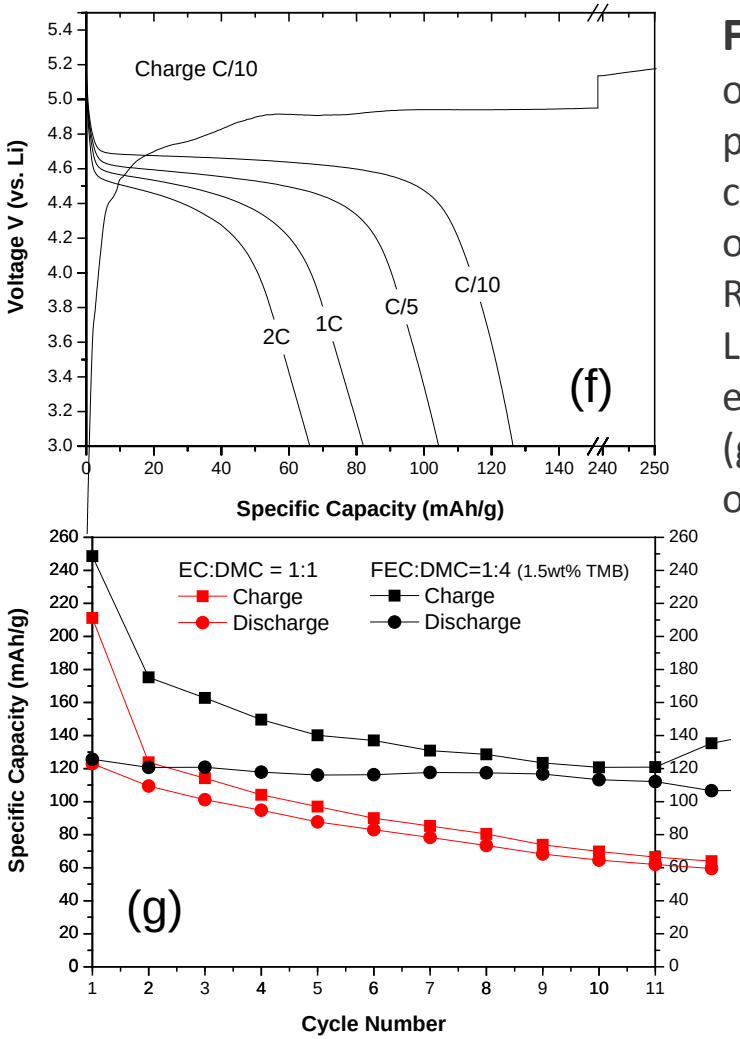
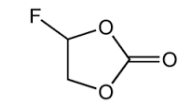
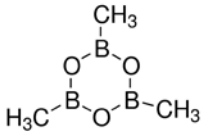


Figure 1. TEM images of (a,b) $CoHPO_4 \cdot H_2O$ precursor, (c) $LiCoPO_4$/C cathode, (d) SEM image of $LiCoPO_4$/C cathode, (e) Rietveld refinement of $LiCoPO_4$ XRD pattern, (f) electrochemical rate and (g) cycling performance of $LiCoPO_4$/C at 25°C.



FEC



TMB

$Li_4Ti_5O_{12}$ Gassing at High Temperature

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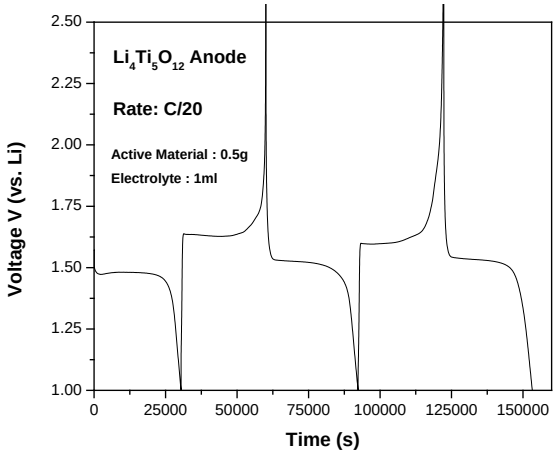

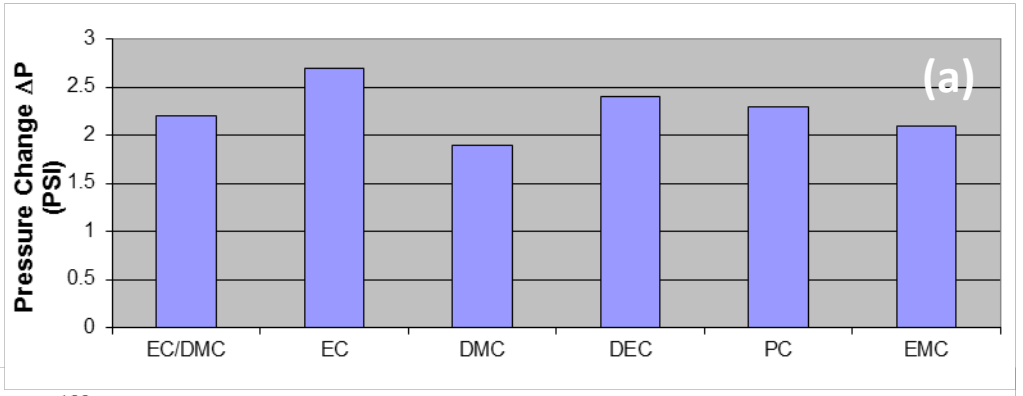

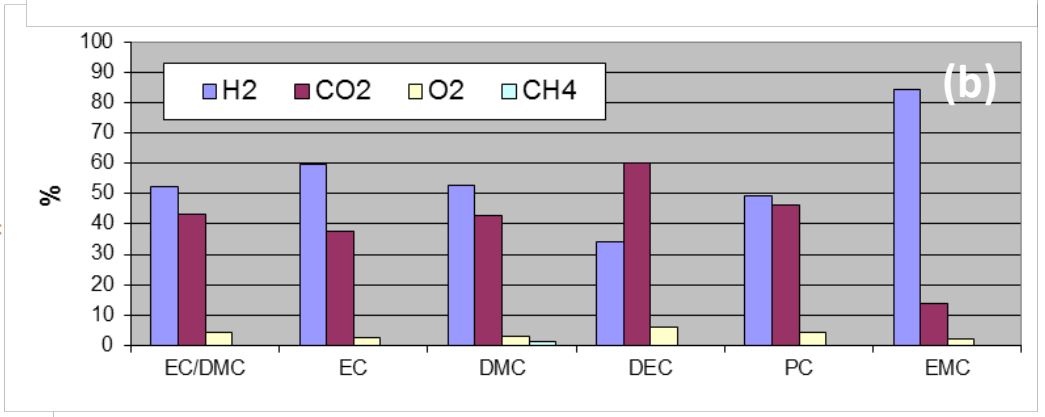

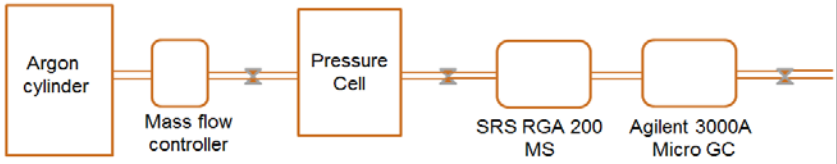

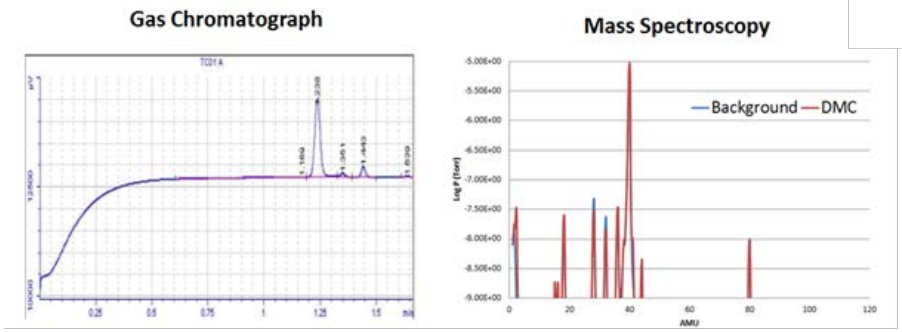

Figure 2. (a) Pressure build up and (b) gas species generated when using electrolyte containing 1M $LiPF_6$ salt with various carbonate based solvents at charged state for two weeks at 55°C. (1atm = 14.69 psi)

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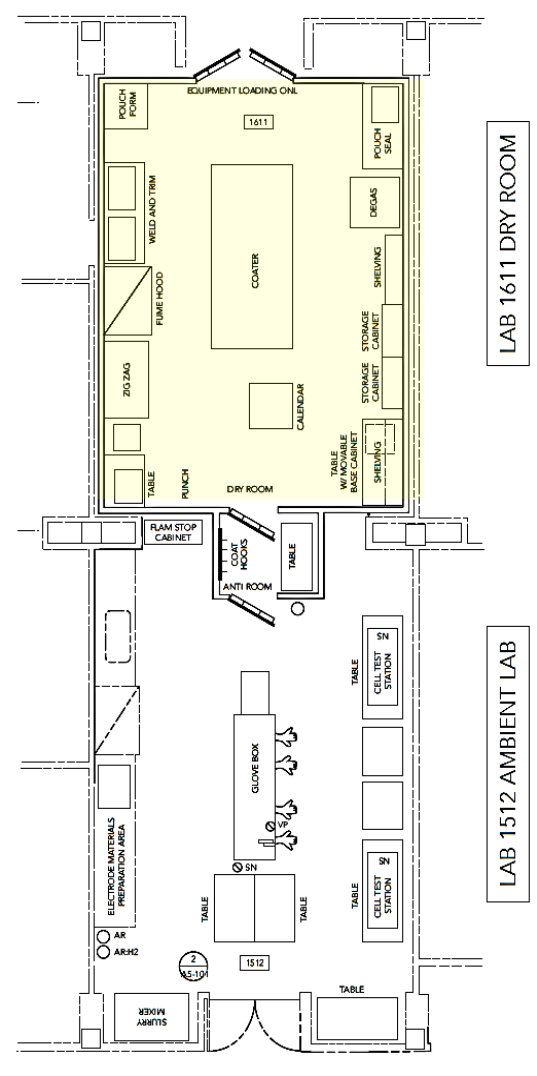
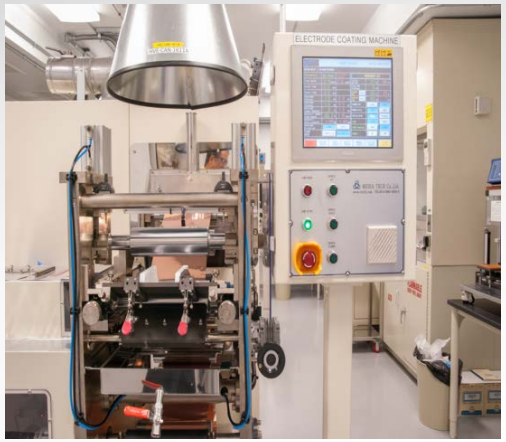
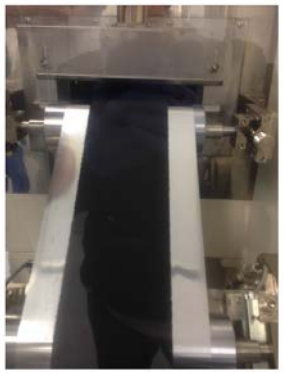


Mixes Electrode Material Slurry (1~5kg)



Roll width: 250mm
Coating width: 150mm
Coating thickness: 10~300µm

Calendering



During coating process

Dried electrode coating (double-side)

Very uniform and smooth electrode

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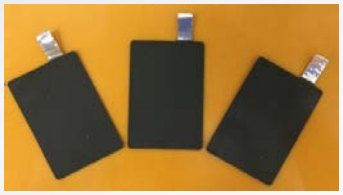
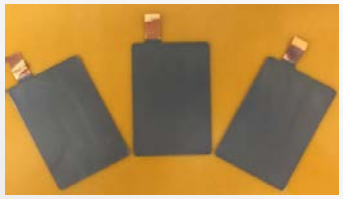
Electrode Punching

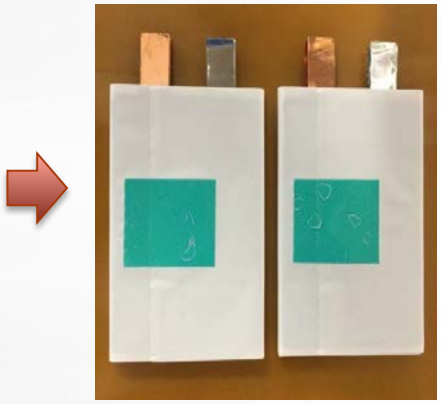
Zig-Zag Stacking of Cathode & Anode Electrodes with Separator

Multi-layer Electrode Tab Welding & Trimming

Pouch Formation







Dry cell

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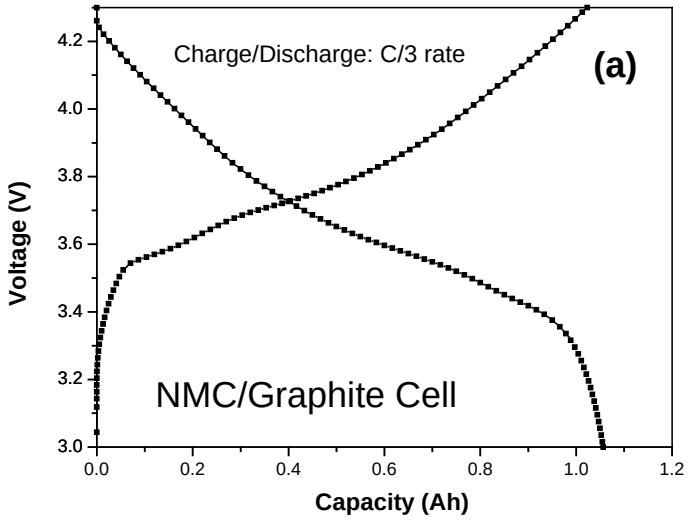
Side Sealing

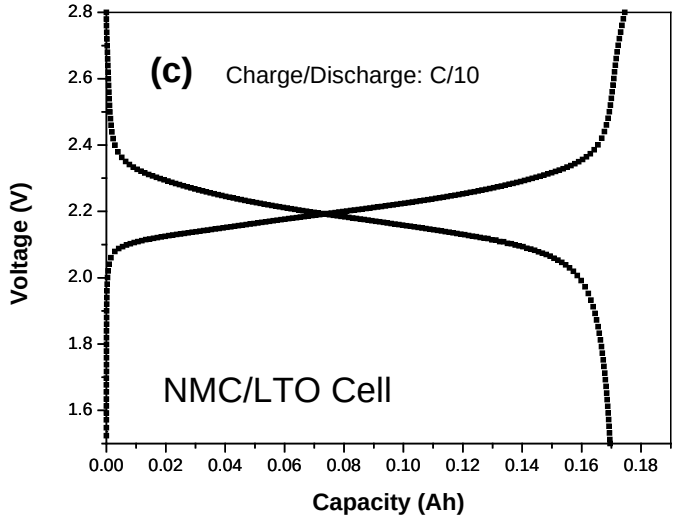
Electrolyte Injection

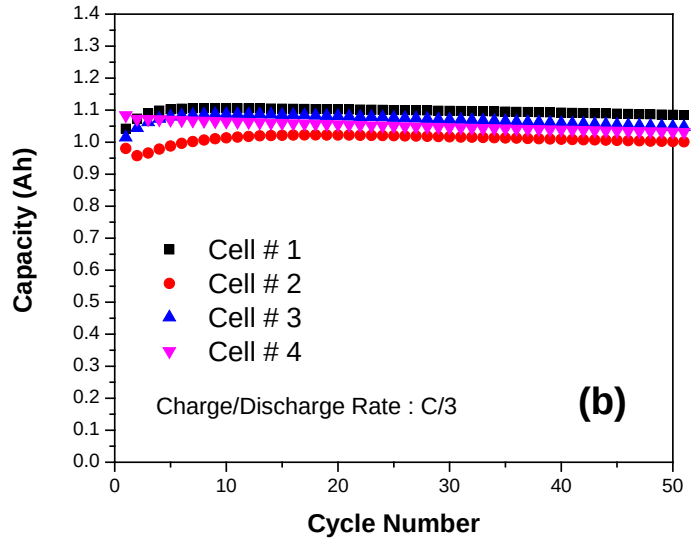
Formation Cycle, Degassing & Testing

Cell dimension:
40 mm x 60 mm

Pouch Cell Testing







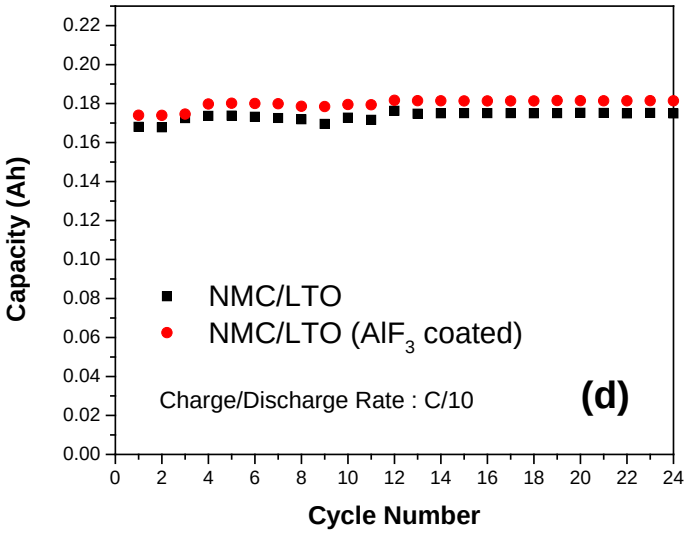


Figure 3. (a) Voltage profile, (b) cycling performance of NMC/Graphite pouch cell, (c) voltage profile, (d) cycling performance of NMC/LTO (AlF_3 coated) pouch cell at 25°C.

- NMC/Graphite Cell
  - Capacity: ~1Ah
  - 100% of theoretical capacity
  - Cathode/Anode: 10 layers each
- NMC/LTO Cell
  - Capacity: ~220mAh
  - 83% theoretical capacity of LTO
  - Cathode/Anode: 4 layers each

Summary

Electrode Material Development and Characterization

- Nanostructured $LiCoPO_4$/C cathode was synthesized using $CoHPO_4 \cdot H_2O$ nanoplate precursor obtained by simple precipitation route.
- $LiCoPO_4$/C cathode delivered up to 125mAh/g at C/10 and cycling stability have been improved by use of electrolyte containing FEC and TMB (1wt%) additives – Further electrolyte optimization is under investigation.
- Initial gassing analyses on the $Li_4Ti_5O_{12}$ (LTO) anode with carbonate electrolytes have been evaluated.

Pouch Cell Fabrication

- Conventional NMC/Graphite (~1Ah) and $Li_4Ti_5O_{12}$ (~220mAh) anode based pouch cells were successfully fabricated and tested.
- Study on the effect of AlF_3 coating on the LTO electrolyte gassing is under way.
- Pouch cell with various electrode material combinations including nanomaterials ($LiFePO_4$) is now feasible in our pouch cell line (ABF) at PNNL.

Acknowledgements

- Support from US DOE Office of Electricity Delivery & Energy Reliability - Dr. Imre Gyuk, Energy Storage Program Manager

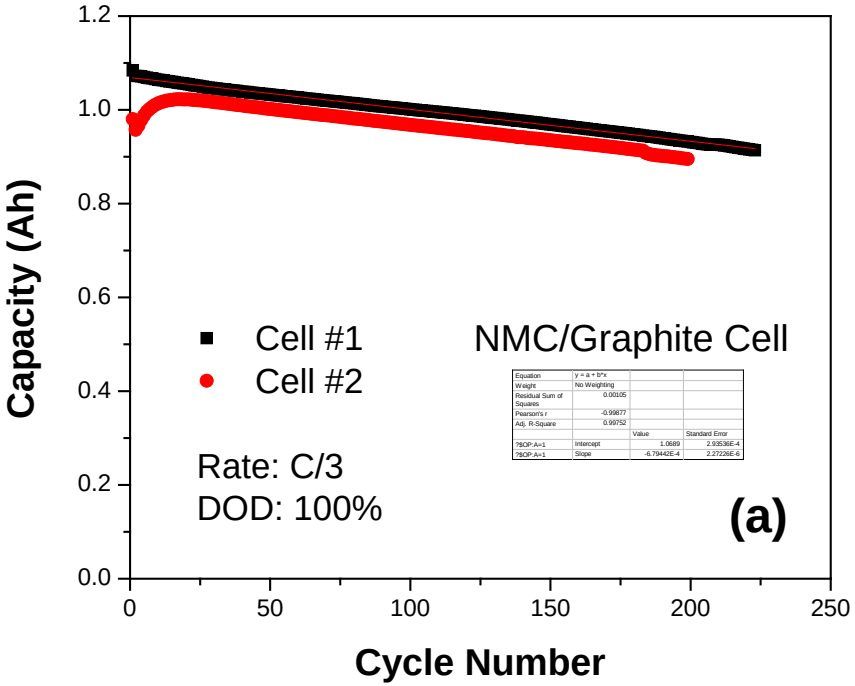
- **PNNL**

Samuel S. Cartmell
Qiuyan (Alan) Li
Sookyung Jeong
Xiaolin Li
Jie Xiao
Wesley A. Henderson

- **Polaris Battery Lab**

Doug Morris
Curtiss Renn

Additional Slides



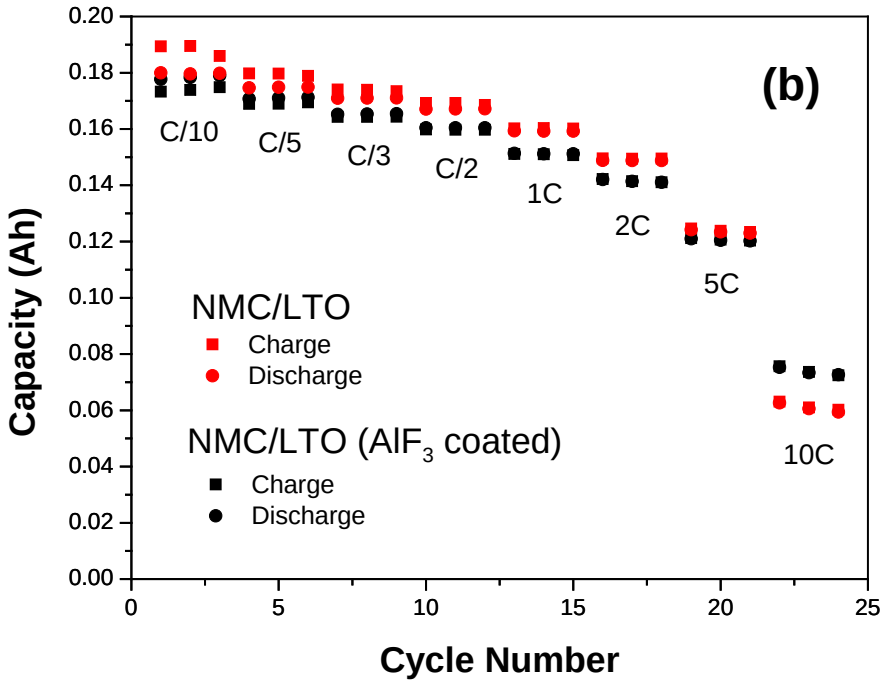


Figure 4. (a) long term cycling of NMC/Graphite cells and (b) NMC/LTO (AlF_3 coated) cells at various charge/discharge rates at 25°C.