Electrodeposition for Low-Cost, Water-Based Electrode Manufacturing

Vehicles Technology Office
2019 Annual Merit Review

Project ID: BAT263

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ORNL - David Wood III
Navitas – Mike Wixom, Pu Zhang

Overview

Timeline

- Project start date: January 1st, 2016
- Project end date: June 30th, 2019
- 90% complete

Barriers

- High material processing cost
- High manufacturing cost
- Toxic material exposure

Budget

- Total project funding:$3,999,034
  - DOE share: $1,399,275
  - FFRDC: $1,600,000
  - Contractor share: $999,759
- Project is fully funded.
- Funding for FY 2017: $762,346
- Funding for FY 2018: $826,415

Collaborating Partners

- Metokote (now PPG)
  - Role: Roll-to-roll eCoat design and installation
  - Project lead: Dennis Siefer
- Navitas System
  - Role: Full-cell build and testing
  - Project lead: Mike Wixom
- Oak Ridge National Lab
  - Role: Electrode processing and anode support
  - Project lead: David Wood III
- Argonne National Lab
  - Role: CAD synthesis
  - Project lead: Greg Krumdick

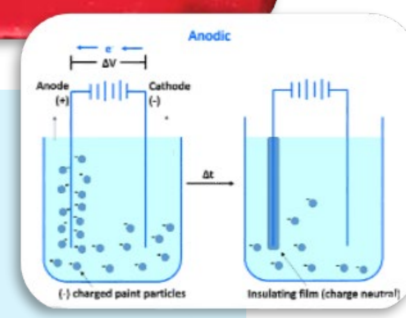
Relevance

Overall Objectives

- Reduce electrode manufacturing cost using electrocoat processing.
- Improve the environmental friendliness with water-based battery processing.

Objectives this Period

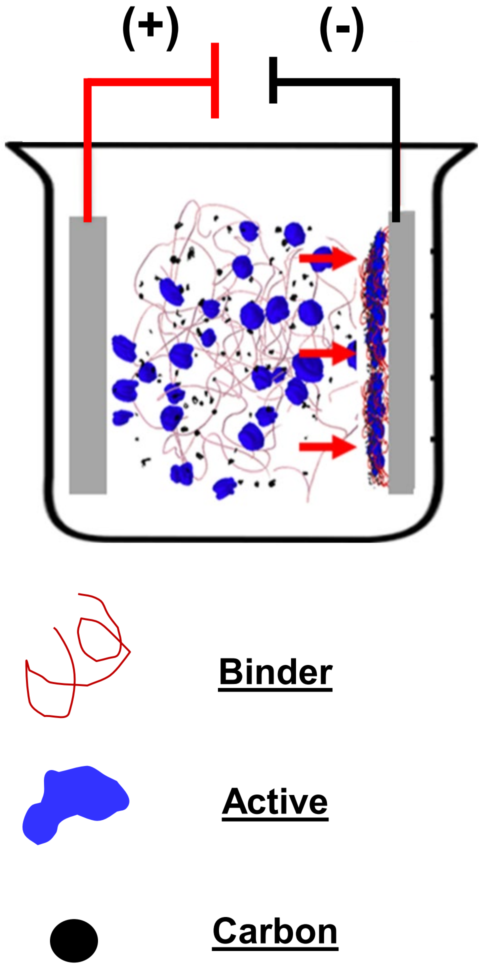
- Design and install R2R eCoat pilot process
- Compare R2R plot application to benchtop eCoat performance
- Modify process design and electrode formulation to optimize.
- Validate full-cell, pouch cell battery performance.

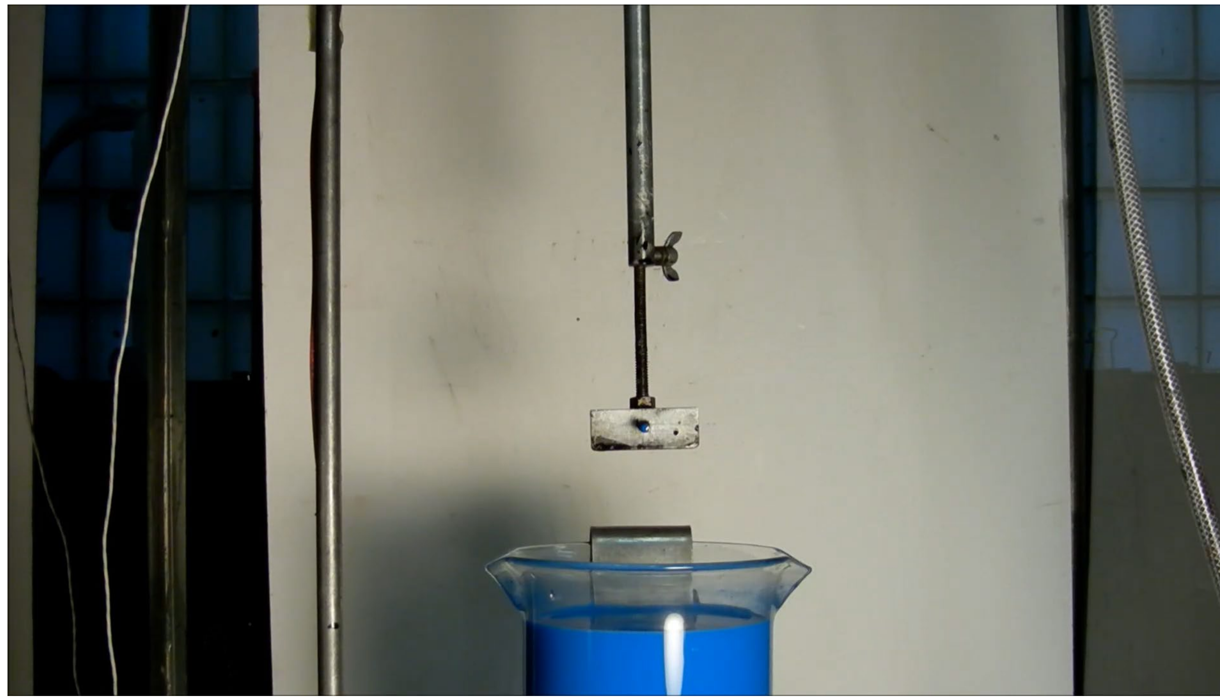


Impact

- Successful production of electrocoated cathodes to:
  - Reduce cell manufacturing cost.
  - Enable waterborne manufacturing.
  - Eliminate the need for using toxic solvents.
  - Facilitate automotive OEM and consumer acceptance of electric vehicles.
  - Allow for the creation of the next generation of US-based advanced battery manufacturing.

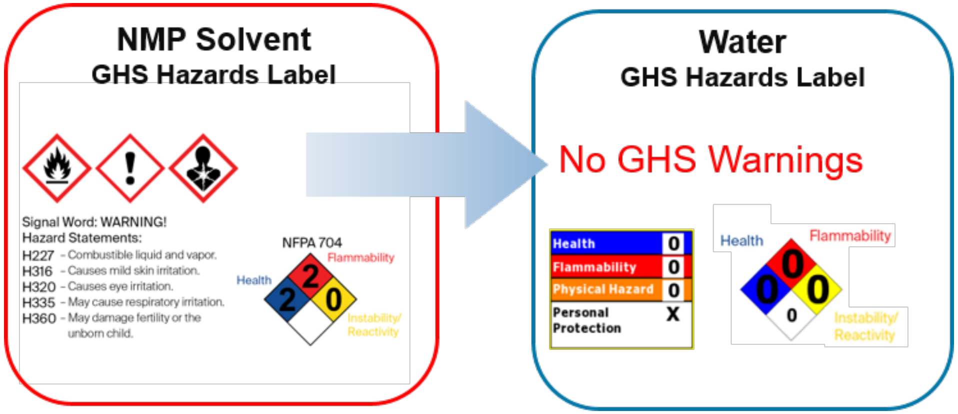
Approach: Electrodeposition for Water-Based Battery Electrode Manufacturing





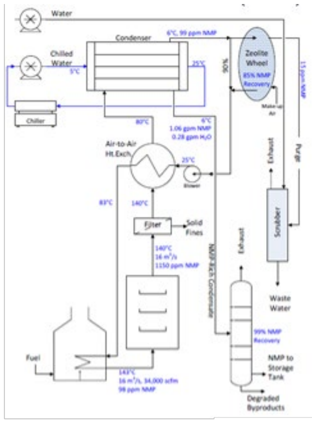
Approach: Use Electrocoat to Overcome Current Process Barriers

Eliminate Toxic Solvent Exposure Costs



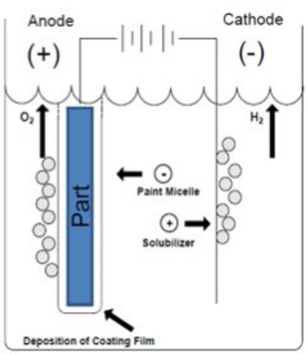
Integrated with other VTO W/B Projects at ORNL

Eliminate Costly Toxic Solvent Recovery



NMP Recovery Process
Shabbir Ahmed, ANL
2015 VTO AMR ES228

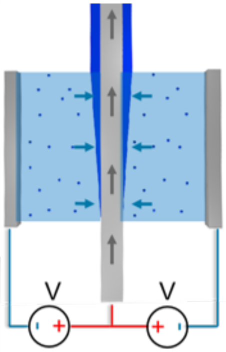
Lower Drying Costs



Wet Film going into oven:

- High solids
- Low solvent
- Low VOC
- No LEL limitation

Eliminate 2-Coat / 2-Cure Coating Process



- ***Simultaneously*** coat both sides
- One pass through oven
- Deposition controls uniformity
- Particle assembly controls porosity

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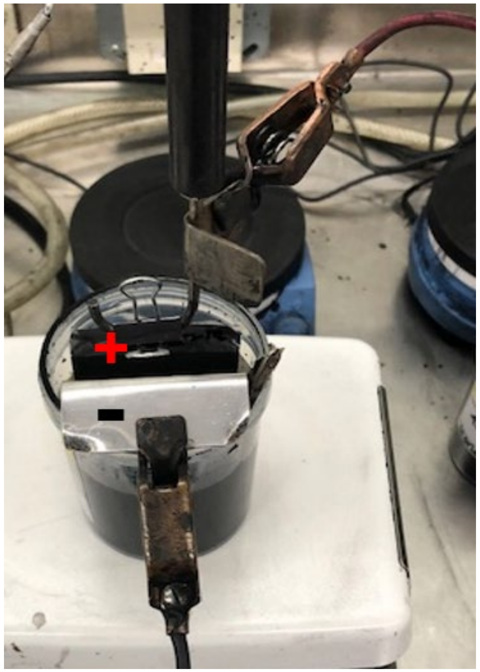
Advancing Electrodeposition from the Benchtop to a Continuous Roll-to-Roll Pilot Scale Coating System

Benchtop



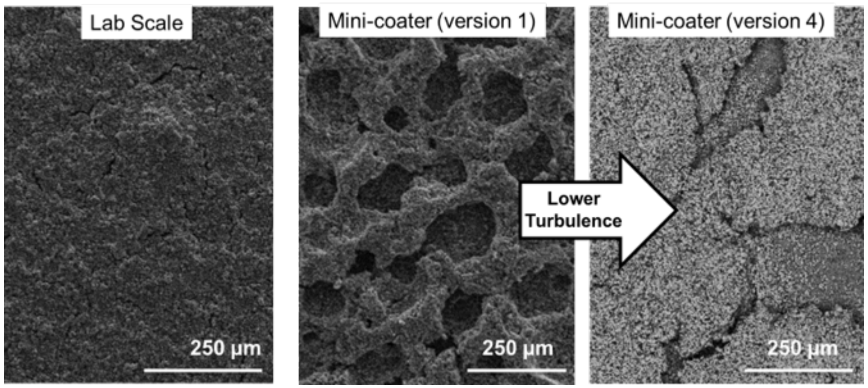
Challenges

- **Pilot Coater Design**
- **Pilot Coater Reformulation**
- **Electrode Coating Quality**
- **Cell Performance**

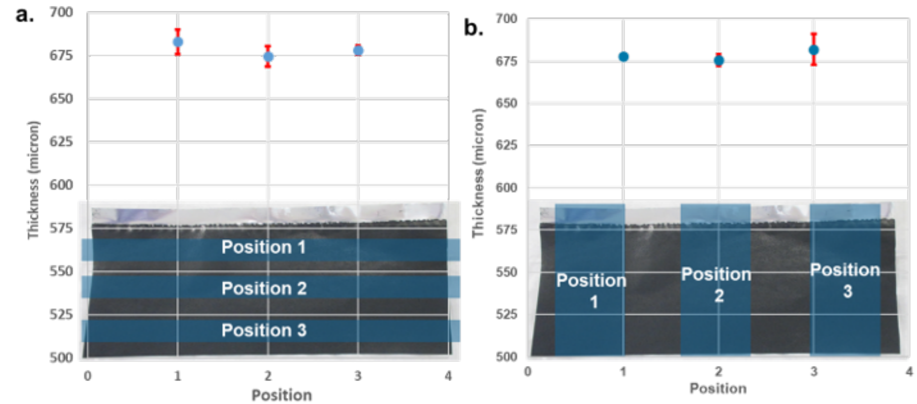
Pilot System

Challenges Transitioning from Benchtop to Roll-to-Roll Pilot Coating

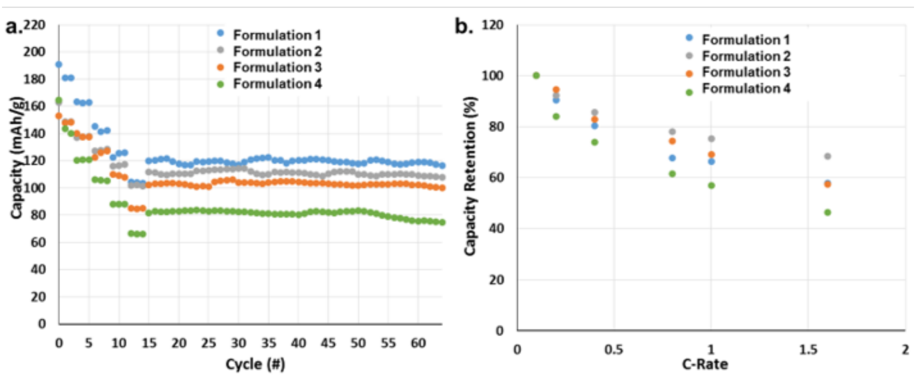
Turbulence



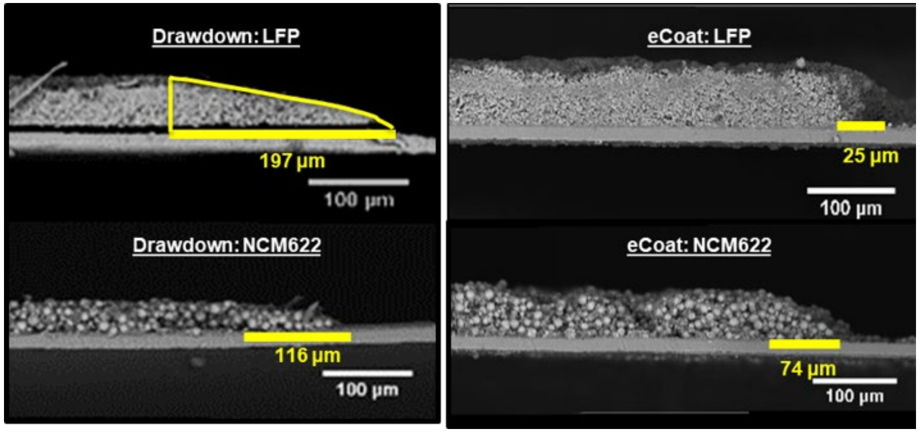
Bath Uniformity



Formulation Chemistry

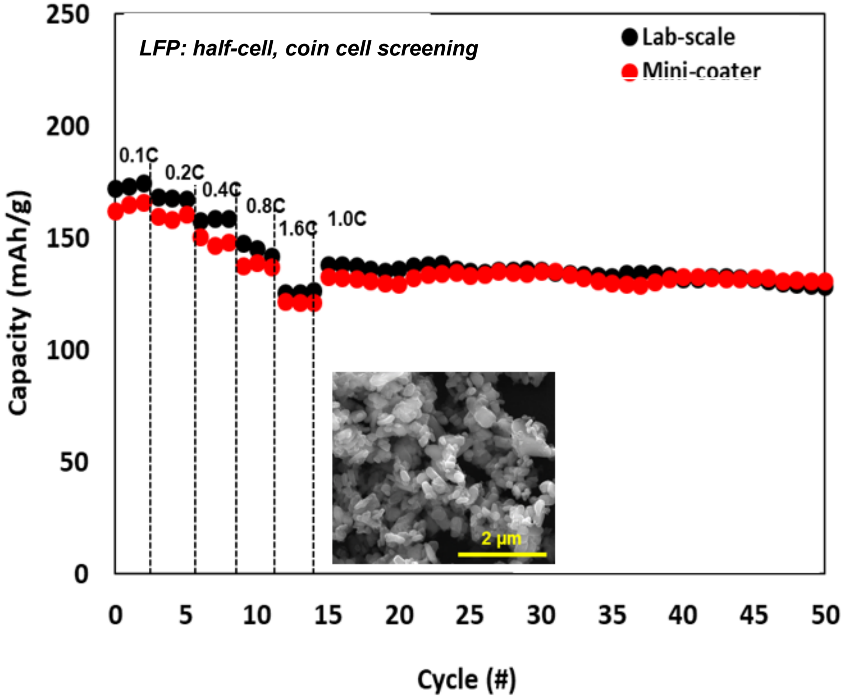


Edge Profile Control



Cathode Active Particle Size Influences Deposition Selectivity

LFP-based electrodes



Film composition (via TGA):

92% Active

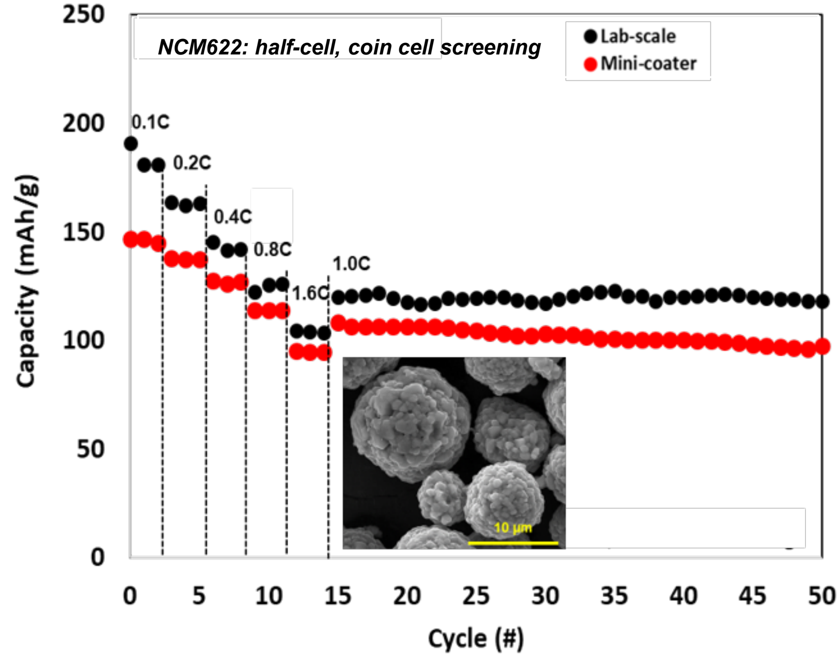
8% Carbon / Binder

Bath composition:

92% Active

8% Carbon / Binder

NCM-based electrodes



Film composition (via TGA):

85% Active

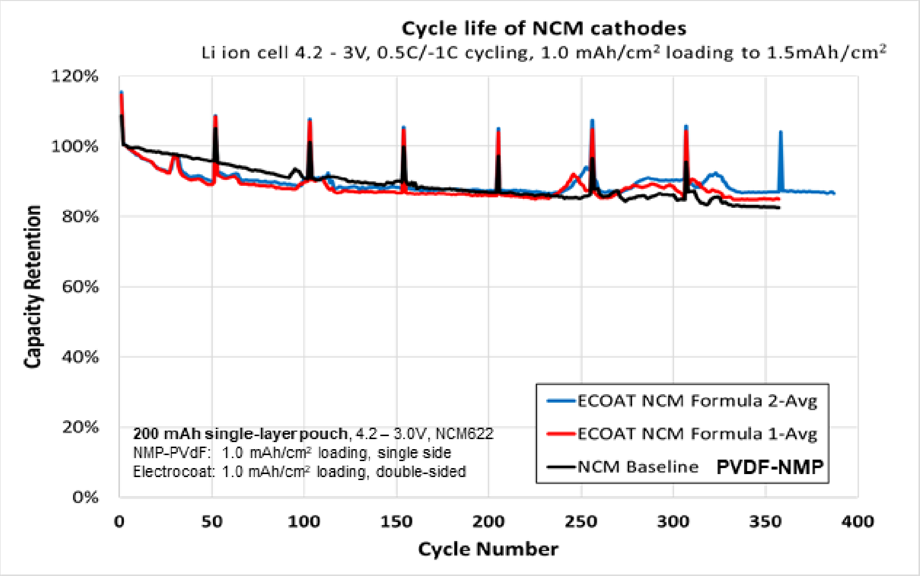
15% Carbon / Binder

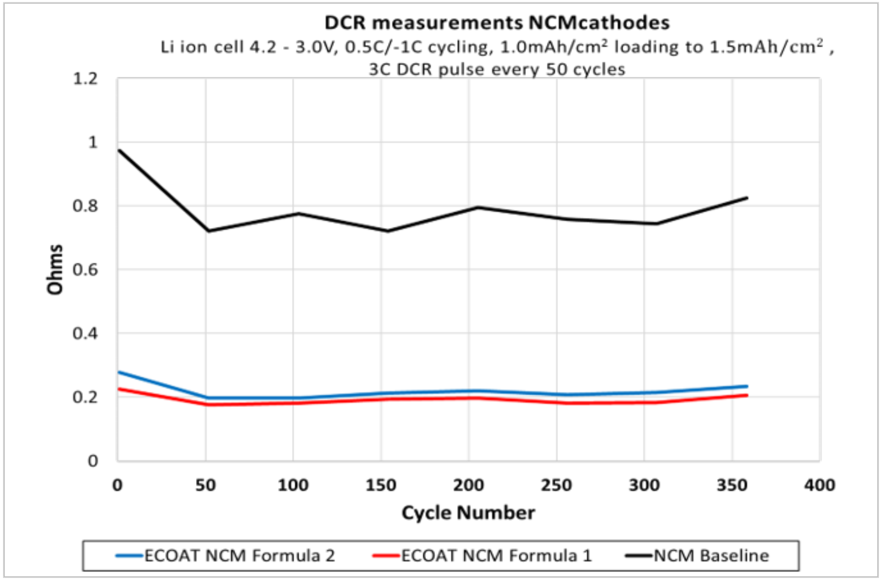
Bath composition:

92% Active

8% Carbon / Binder

Decreased Active Mass Loading Results in Lower Measured Gravimetric Capacities





Initial Discharge Capacities (mAh/g)

ECOAT NCM Formula 2: 138
ECOAT NCM Formula 1: 138
NCM Baseline: 171

NAVITAS SYSTEMS

PPG

Summary

- Bench scale - cathodes are coated with acceptable uniformity and energy density.
- Pilot coater differs from bench scale largely due to challenges from bath uniformity.
- Changes in process design and formulation chemistry can overcome challenges.
- Pilot scale mini-coater operational and cathode coated foil are being evaluated.

Proposed Future Research

- Pilot coater redesign
- eCoat for other battery components
- Improved downstream curing

Any proposed future work is subject to change based on funding levels

Technical Back-up Slides

Milestones

Date	Milestones and Go/No-go	Status
June 2017	**Milestone:** Formulation / application parameters are optimized sufficient to produce an electrode with an energy density of 2.5-3.0 mAh/cm^2	Complete
December 2017	**Milestone:** Pouch cells > 0.2 Ah are tested	Complete
July 2018	**Milestone:** Mini-coater is designed, built, and prepared for operation.	Complete
December 2017	**Milestone:** BatPac model updated and adjusted cost estimate obtained	Complete
December 2017	**Go/No-go:** Demonstrate ability to produce kg quantities of the active material.	Complete
December 2017	**Go/No-go:** Electrodes will either have reached a loading density of 2.0 mAh/cm^2 or a clear path to achieve metric that will be identified.	Complete
December 2018	**Milestone:** Electrodes are produced on the mini-coater that can be used for cell deliverables.	Complete
January 2018	**Milestone:** 12 baseline and 12 electrocoated cathodes will be evaluated in double layer pouch cells	Complete
May 2019	**Milestone:** 35 electrocoat and 12 baseline prismatic cells >1 Ah will be assembled and tested.18 optimized cells will be delivered to DOE for evaluation	On track
September 2019	**Milestone:** Root cause failure mechanisms identified	On track