Effect of Aging on the Mechanical Properties of Li-Ion Cell Components - A Preliminary Look

Lei Cao, Chao Zhang, Shriram Santhanagopalan, Ahmad Pesaran
Transportation and Hydrogen Systems Center, National Renewable Energy Laboratory

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Background – CAEBAT 1 & 2

- DOE/VTO/ES initiated the Computer Aided Engineering for Batteries in 2010
- CAEBAT had a strong focus on building electrochemical-thermal models that simulate the performance of lithium-ion batteries.
- Since the start of CAEBAT-2 projects in FY14, our emphasis has been on safety aspects – mechanical deformation in particular

A. Pesaran, et al., DOE AMR 2013
Current Work

Interaction of Mechanical/Electrical/Thermal effects

Propagation phenomena under crush

Displacement from crush response of a multi-layer stack

Sphere Indentation on a single Representative Sandwich model

Indentation deformed shape


Santhanagopalan et al. 228th ECS Meeting, 2015
Experimental

Fresh NMC/Graphite 40Ah Cell

Over 3000 1C/1C cycles at 45°C
25% capacity loss
Typical Constitutive Properties of Battery Components

❖ Tensile properties of electrodes

Cross-section of anode (Pesaran et al. AMR 2015)

- Electrodes are composites of metallic foil (alumina or copper) and active material
- Active materials are porous composites
- Good bonding under uniaxial tensile load
- Brittle fracture behavior of active layers leading to earlier failure of current collector
Aging Effect  Stress-strain curves

A relatively lower and significant variation of failure strain due to aging, indicates the presence of localized damages, for example, microcracking.
Mechanical Property Changes of Battery Components (2)

- **Aging Effect on Thickness**

  An increase of thickness for electrodes due to aging

  ![Fresh cathode](image1)
  ![Aged cathode](image2)
  ![Fresh anode](image3)
  ![Aged anode](image4)

  ![Graph showing thickness comparison](chart)

  Add number type of aging for reminder
There is a decrease of tensile modulus due to aging, indicating the change of chemical composition or microstructure for electrodes and separator.
SEM For Cathode

What is the actual scale?

Fresh cathode 1000 x

Fresh cathode 10,000 x

Aged cathode 1000 x

Aged cathode 10,000 x
SEM For Anode Matrix

Fresh anode
1000 x

Aged anode
1000 x

Aged anode

Fresh anode
10,000 x

Aged anode
10000 x

Aged anode
10000 x

What is the difference between these 2?
Compressive properties of electrodes/separator

- A customized procedure is developed to measure the compressive properties of the thin porous layers.
- A piece-wised model is utilized to describe the through-thickness stress-strain responses for active materials and separator.
Concluding Remarks.

• What did you learn?
• What was the Effect of Aging on the Mechanical Properties of Li-Ion Cell Components?
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