Effect of Aging on Mechanical, Electrochemical and Thermal Properties of Lithium Ion Cell Components

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Mechanical, electrochemical and thermal properties of aged and fresh lithium ion cell components are compared in this poster. 40Ah NMC/Graphite-based pouch cells were cycled under four different test conditions including different end-of-charge voltages (4.1 and 4.2V), C-rates (1C and 2C) and ambient temperatures (25 and 45^{o}C). The cells were cycled over a period of several months, until 80% of the nameplate capacity was attained. Cell components were obtained from destructive physical analysis (DPA) of the cells before and after cycling.

Electrochemical Testing: Half-cells were fabricated from the electrodes harvested from fresh cells as well as those obtained from the aged cells. Measurement of the EIS on the half-cells shows a growth in the electrochemical impedance of the anode, consistent with previously reported observations on aging mechanisms of lithium ion cells. The separator and cathode suffered relatively insignificant changes to their electrical responses compared to the anode.

Mechanical Testing: Mechanical tests, including compression test, tensile test and indentation test, were conducted on the cell components to investigate differences in the mechanical performance. Comparison of the fresh and aged cells components showed that cycling the cells has different degrees of deterioration on the different cell components. Compression tests indicated a drop in elastic properties of the cell components proportional to the severity of the aging condition; whereas, tensile tests showed quite a bit of variability owing to the large sample size requirement. This is reasonable, given the non-uniform degradation observed within the cells during the DPA.

Thermal Testing: Thermal conductivities of the cell components as well as the interfacial thermal impedance between the electrodes and the separator were measured using a custom-designed test fixture that minimizes the contact thermal impedance between the test samples and the test fixture. Results indicate a change in the thermal budget of the cells with aging. For instance, for cells cycled at the 1C discharge rate to 4.1V at 25oC, at the beginning of life, the thermal impedance was dominated by the bulk impedance at the cathode. With aging, the interface between the anode and the separator is likely to accumulate majority of the heat generated, due to a significant decrease in thermal conductivity across this interface.

These properties were integrated into constitutive models for the material response to evaluate impact of aging on safety of lithium ion cells.

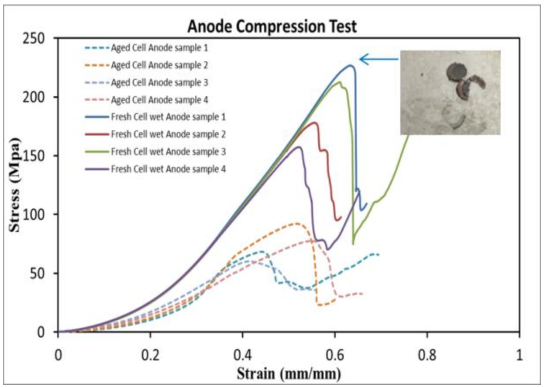

Fig. 1 Comparison of mechanical response of fresh versus aged cell components

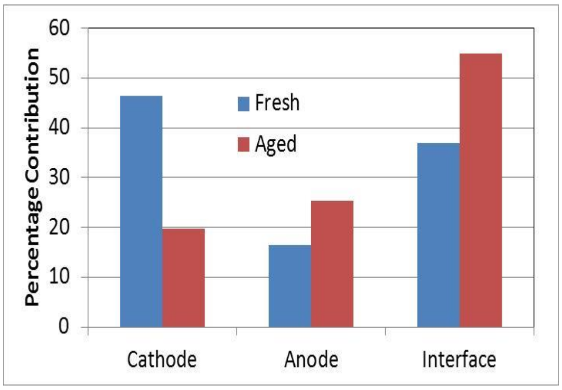

Fig. 2 Comparison of contributions from cell components as well as the interface to the thermal impedance in fresh versus aged cells