SAND2019-15113C

Title: Evaluating Safety Characteristics of Lithium-Ion Battery Systems Through Cascading Thermal Runaway Experiments and Modeling

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Abstract:

Safety implications of candidate energy storage technologies must be considered for responsible deployment at large scales. For lithium-ion batteries this includes the risk of thermal runaway and associated fires. The risk of thermal runaway is quite low for a single cell (~ 0.0001%), but the probability of a cell initiating thermal runaway can increase significantly in large installations with thousands of cells (~0.1%). If a single cell goes into thermal runaway within a module without adequate heat dissipation, adjacent cells may ignite and start a cascading thermal runaway event. Appropriate mitigation of this risk to energy storage equipment and personnel requires better understanding of the interplay between heat release and cooling during thermal runaway. To this end, we have designated propagation of thermal runaway in stacked pouch cells as a representative system to study experimentally and through computational modeling. Heat dissipation methods are experimentally investigated to limit cell-to-cell propagation of thermal runaway. A new thermodynamic framework is coupled with improved chemical rate expressions to model heat production during thermal runaway. Simplified versions of these computational tools are made available to the public to facilitate safety evaluations by organizations that design, manufacture, install, or purchase energy storage systems.

Acknowledgements:

This work was supported by the US Department of Energy Office of Electricity, Energy Storage Program. The authors wish to thank Dr. Imre Gyuk for his support of research advancing safety in stationary energy storage. Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government. Document Number: SAND2019-

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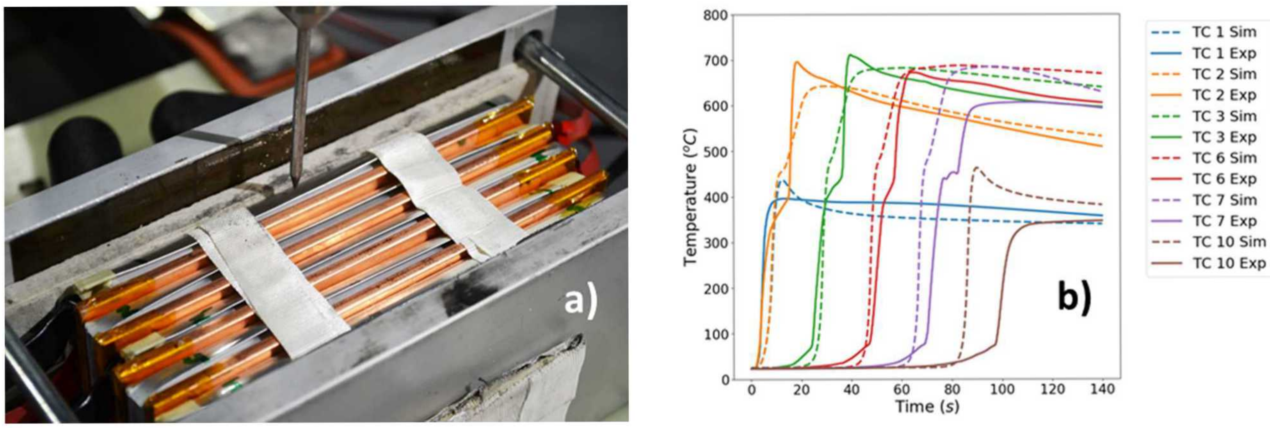

Figure 1: a) Experimental stack of five pouch cells, b) comparison of measured temperatures between cells (solid lines) to thermochemical model (dashed lines)

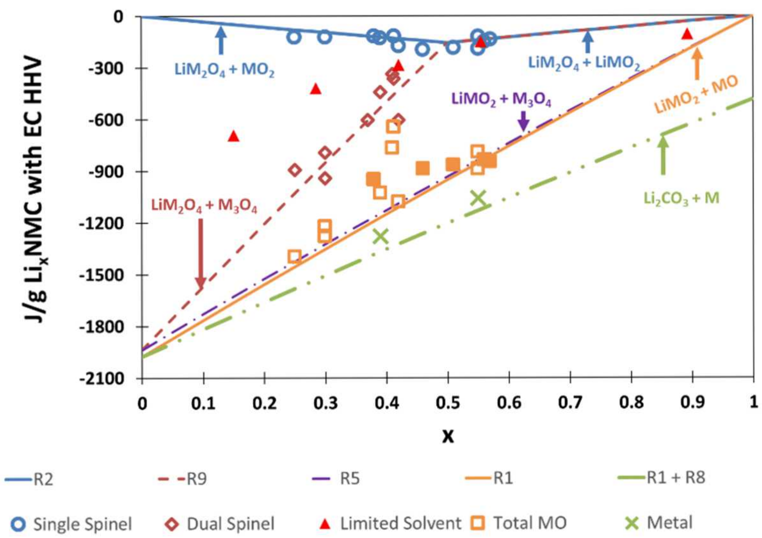

Figure 2: Measured heat from NMC (1:1:1) decomposition in solvent or electrolyte compared to ideal calculated phase changes with combustion of ethylene carbonate

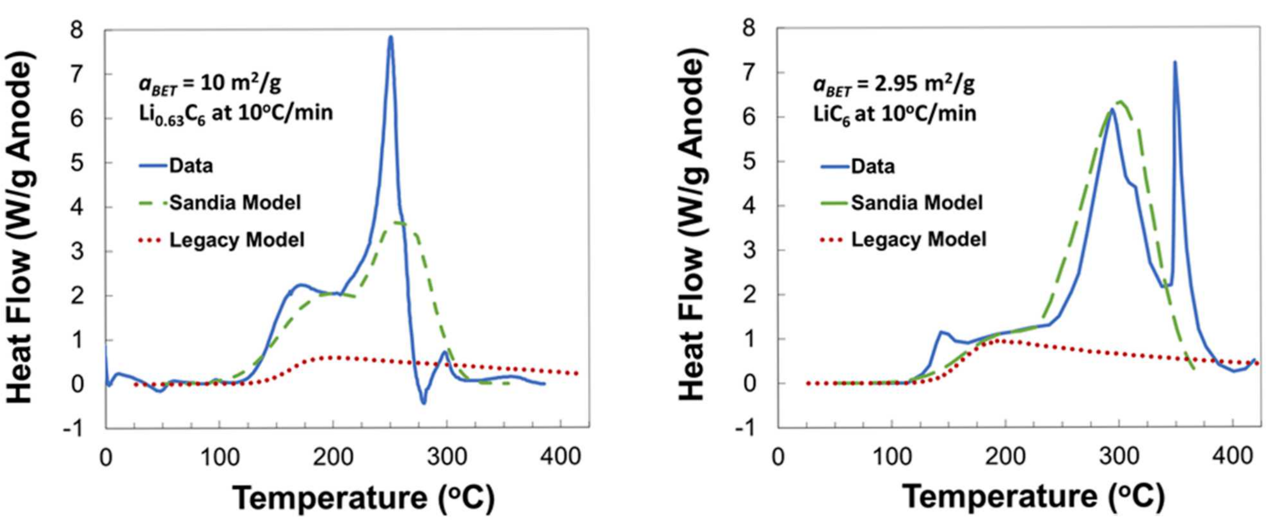

Figure 3: Comparison of models to measured heat release from two lithiated graphites with electrolyte