Quantifying the Promise of Beyond Lithium-Ion Technologies

Kevin Gallagher[a,*], Tom Greszler[b,*], Steven Goebel[b,*], Mark Mathias[b,*], Venkat Srinivasan[c,*]

[*] *Joint Center for Energy Storage Research*
[a] *Argonne National Laboratory, Lemont, IL USA;*
[b] *General Motors Company, Pontiac, MI USA;*
[c] *Lawrence Berkeley National Laboratory, Berkeley, CA USA;*

The Joint Center for Energy Storage Research (JCESR) is a U.S. Department of Energy – Office of Science funded Batteries and Energy Storage Hub. JCESR seeks to deliver transportation and grid prototypes with demonstrated performance projected to greatly exceed current technologies. In order to achieve this goal, JCESR is focused on chemistries that are "beyond lithium-ion" and hold potentially great reward for those able to overcome the non-trivial obstacles. Researchers world-wide are also focused on trying to identify a new battery chemistry with significantly higher energy density and lower cost. As existing resources to support these efforts are finite, decisions have to be made regarding what chemistries hold the greatest promise. Additionally, a transfer function that projects bench-scale research results to real world pack level values is missing from much development work.

To better understand the promise of new, exciting technologies, we go beyond the back of the envelope. Techno-economic modeling is used within JCESR to complete system analyses of pack level energy density and cost based on materials level transport and kinetic parameters. Through this approach, discoveries made at the bench-scale can be translated to pack level values and likewise pack level goals may be communicated as materials level properties (e.g., D, κ, i_0). This effort thus provides researchers with a better understanding of the chemistry/materials performance levels required to make a significant improvement in mass, volume, and/or cost in the resulting battery system.

The lithium–oxygen (Li–O_2) chemistry is the first system to be analyzed in detail within JCESR. This work builds upon previous efforts to go both deeper and broader to understand the entire design space of the chemistry. The basis of the cell and pack model is the lithium ion battery performance and cost model (BatPaC) that is a freely available bottom up design and cost model.[1,2] This framework is integrated with and expands on the earlier results of Greszler et al to map the entire design space for the complete energy storage system.[3]

Figure 1 (top) presents a schematic of a layer within the cell of a nonaqueous lithium metal (Li) / lithium peroxide (Li_2O_2) cell couple. The thickness of the electrodes and size of the flow channels are designed based upon the battery power and energy requirements as well as the transport and charge transfer values assumed for the parameters. Figure 1 (bottom) displays polarization curves for three different parameter sets. A range of assumed performances allows us to determine the energy density and cost of the entire design space and then determine the most probable outcomes.

In this presentation, we will compare techno-economic modeling results of potential Li-oxygen systems with current and projected Li-ion systems in the context of automotive application.

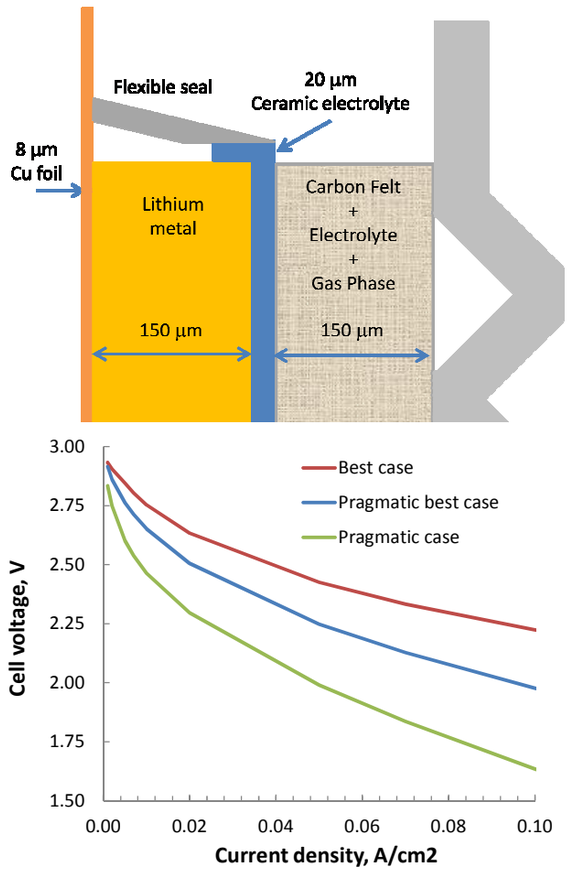

Figure 1. (top) Schematic of Li-Li_2O_2 layer within cell (bottom) polarization curves for Li-Li_2O_2 cells with varying performance levels

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References

1.) P.A. Nelson, K. G. Gallagher, I. Bloom, and D. W. Dees, "Modeling the Performance and Cost of Lithium-Ion Batteries for Electric Vehicles," Second Addition, Chemical Sciences and Engineering Division, Argonne National Laboratory, ANL-12/55, Argonne, IL USA (2013).

2.) BatPaC (Battery Performance and Cost) Software, P.A. Nelson, K.G. Gallagher, and I. Bloom, (2012). available from http://www.cse.anl.gov/BatPaC/

3.) T. Greszler, M. Mathias, W. Gu, S. Goebel, D. Masten, and B. Lakshmanan "Li-Air and Li-Sulfur in an Automotive System Context" *Beyond Lithium Ion V*, Berkeley, CA USA, June 5-7 (2012).