Electron beam curing of acrylated polyurethanes and associated applications in Li-ion batteries

Zhijia Du[1], C. J. Janke[2], C. Daniel[1], Jianlin Li[1] and D. L. Wood III[1]

[1] Energy and Transportation Science Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA.

[2] Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA.

Email: duz1@ornl.gov

Li-ion batteries have been extensively studied for the last two decades for application in portable electronics, energy storage and electric vehicles. However, the latter two applications need a further increase in battery performance and reduction in packaging cost. It has been reported that electrode processing, especially the cathode, with conventional manufacturing methods accounts for considerably high cost in Li-ion batteries [1,2], which is due to the use of polyvinylidene fluoride (PVDF)/N-methylpyrrolidone (NMP) (the state-of-the-art binder/solvent system for electrode processing). NMP is expensive (bulk-quantity price of \$1.25 L^{-1} or more) and toxic and requires a costly solvent recovery process [2]. More efforts should be made, therefore, to develop aqueous binders for electrode materials to eliminate the use of NMP. In addition, composite electrodes used in conventional lithium-ion batteries are manufactured through a slurry coating process, where a significant amount of solvent is required [3]. It takes at least a few minutes for the solvent to evaporate. Given the high coating speeds necessary (up to 100 feet per minute) the drying zone is several hundred feet long, which occupies a large footprint in the battery manufacturing plant.

Here we propose manufacturing composite cathodes using electron beam (EB) curing of acrylated polyurethane as a novel binder in electrode formulations for Li-ion batteries, which eliminates the requirement of PVDF and NMP and allows the electrode to be cured instantly. Comparable performance from the EB processed electrodes to that of the conventionally processed electrodes has been observed. Such a novel processing approach presents an exciting new avenue for manufacturing research of high performance, low cost Li-ion batteries.

Acknowledgment: This research at Oak Ridge National Laboratory (ORNL), managed by UT Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725, was sponsored by the Office of Energy Efficiency and Renewable Energy Vehicle Technologies Office (VTO) Applied Battery Research (ABR) subprogram (Program Managers: Peter Faguy and David Howell).

References:

[1] J. Li, C. Daniel and D. L. Wood, J. Power Sources, 2011, 196, 2452.

[2] D. L. Wood, J. Li and C. Daniel, J. Power Sources, 2015, 275, 234.

[3] J. Li, B. Armstrong, J. Kiggans, C. Daniel, and D. L. Wood, J. Electrochemical Society, 2013, 160 (2), A201.