Nucleation Study on Dendrite Suppressing Lithium-Sodium Electrolyte for Lithium Batteries

Johanna K. Stark, Paul A. Kohl
School of Chemical & Biomolecular Engineering
Georgia Institute of Technology
311 Ferst Dr NW, Atlanta GA 30332-0100

High energy density batteries are desired for smaller, lighter mobile devices. A lithium metal anode is an intriguing possibility because it represents the maximum achievable energy density for a lithium-based battery, 3861 mAh/g instead of 329 mAh/g for commercial graphite anodes. A major deterrent is that lithium metal electrodeposits into long whiskers that can short circuit the battery.

Ionic liquids are of interest not only because of their near-zero vapor pressure, but also because they allow for the co-deposition of other metals such as sodium and potassium. Reduction of alkali metals other than lithium has not been shown for organic electrolytes. The co-deposition of lithium and sodium from quaternary ammonium butyltrimethylammonium bis(trifluoromethansulfonyl)imide (QA-TFSI) has been shown to mitigate lithium dendrite growth [1], [2]. Our modified electrolyte allowed lithium to deposit in beads on the surface rather than as dendrites. Lithium dendrites likely grow due to certain crystal faces being more electrochemically active than others. Sodium may deposit preferentially on these sites, resulting in a dimpled morphology that blocks dendrite growth.

A detailed study on the nucleation and early morphology has been completed. In QA-TFSI, lithium dendrites appear immediately upon nucleation. Addition of a small amount of sodium changed the nucleation geometry of the deposited metal to a rounded beads, rather than cylindrical dendrites. Analysis of current-time transients showed significant deviations from conventional geometry based growth models due to the effect of the solid electrolyte interface (SEI) layer. The model was adapted to better explain the behavior observed from electrochemical, SEM, and SIMS data.

References

[1] J. K. Stark, Y. Ding, and P. A. Kohl, “Dendrite-Free Electrodeposition and Reoxidation of Lithium-Sodium Alloy for Metal-Anode Battery,” *Journal of The Electrochemical Society*, vol. 158, no. 10, pp. A1100–A1105, 2011.

[2] J. K. Stark and P. A. Kohl, “Nucleation of Electrodeposited Lithium Metal: Dendritic Growth and the Effect of Co-deposited Sodium,” *Journal of The Electrochemical Society*, 2013 (under review).