Lithium Dendrite Suppression via Alkali and Alkaline Earth Cation Additives

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A lithium metal anode is an intriguing possibility for secondary batteries because it represents the maximum achievable energy density for a lithium-based anode, 3861 mAh/g instead of 329 mAh/g for commercial graphite anodes. However, the formation of lithium dendrites is one factor preventing the implementation of lithium metal anode batteries because their growth can short-circuit the battery and lead undesired thermal effects.

Recently, we have shown that sodium will codeposit with lithium from ionic liquids to form a nondendritic deposits [1, 2]. Alkali metal ions can affect the morphology of deposited lithium. This study presents the mechanism of lithium dendrite formation and a survey of the effects of alkali and alkaline earthmetal ions on the morphology of lithium metal deposited from a quaternary ammonium ionic liquid, butyltrimethylammonium bis(trifluoromethansulfonyl)amide (QA-TFSI). Metals discussed will include sodium, potassium, magnesium and calcium.

A detailed study on the nucleation and early morphology will be presented for the sodium case. 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.
