Suppressing Li Dendrite Formation with Soft Coatings on Li-Ion Battery Anodes

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Li-dendrite formation on Li-ion battery anodes causes low Coulombic efficiency, accelerated electrolyte decomposition, and even penetration of the separator to trigger short circuit and thermal runaway. It is the major hurdle to the application of Li metal anodes and the main reason to the adoption of excessive graphite anode capacities in the state-of-the-art commercial Li-ion batteries. Engineering efforts to tackle with the problems arising from Li dendrite formation should ensure: (1) dendrite-free Li deposition for safety; (2) sustainable cycleability for long service life; (3) high stability under high current densities for fast charge-discharge applications; (4) simple processing and low cost for scalability; and (5) maintaining high volumetric energy density. In the case of Li metal anode, for instance, the areal capacity loadings are typically 2 mAh cm-2 or higher for practical applications. A 2 mAh cm^{-2} loading corresponds to a thickness of ~38 μm for a graphite active layer (assuming 95% graphite content and an electrode density of 1.5 g cm^{-3}) and of ~10 μm for metallic Li. The difference in the thickness marks an important limit for any surface modification layer on Li metal anodes in order to retain the intrinsic advantage of high volumetric energy and capacity densities of metallic Li anode. We present here the use of polymeric thin coatings of a few microns in successfully suppressing Li dendrite on either Li metal or graphite anodes. Operando microscopy analysis indicates redistributed of Li-ion diffusing across either high-polarity or polyeletrolyte surface layer on the anodes to mitigate dendrite formation upon Li plating. The designed soft coatings provide the double-benefits of dendrite suppression and reduced polysulfide shuttling for Li-S batteries and enables Li dendrite suppression upon under-potential lithiation during fast discharging for the common graphite anode.

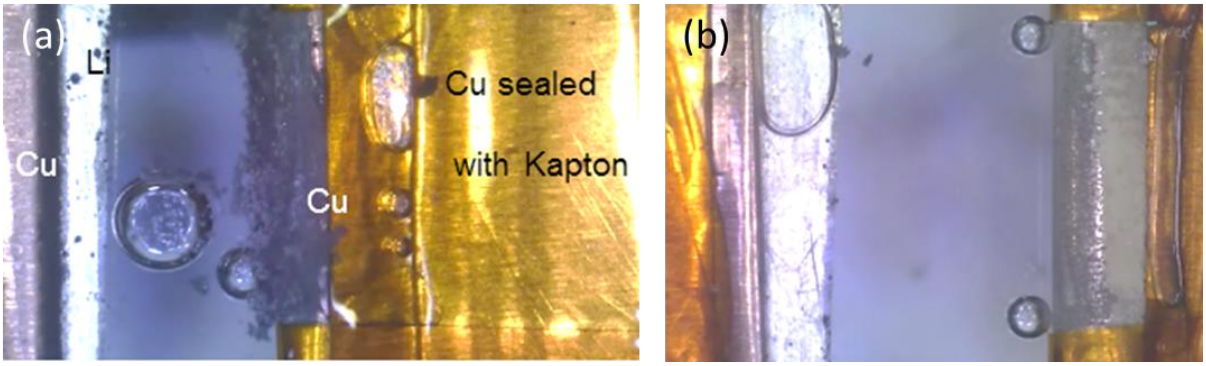

Figure 1.Operando microscopy observations of Li plating on (a) bare Cu and (b) polymer coated Cu current collectors.