Materials Oral Abstract

Advances in Suppressing the Polysulfide Shuttle in Lithium-Sulfur Batteries

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The shuttling of polysulfides in a lithium-sulfur battery is a major technical issue limiting the electrical performance and cycle life. This "polysulfide shuttle" causes self-discharge, low charging efficiencies, and irreversible capacity losses. Suppressing the polysulfide shuttle will bring us closer to realizing a rechargeable battery that has two to three times the energy density of today's lithium-ion batteries.

Recently, we have demonstrated a novel approach to suppressing the polysulfide shuttle with a *"mixed conduction membrane"* (MCM). MCM is a thin non-porous lithium-ion conducting barrier that simply restricts the soluble polysulfides to the positive electrode. MCM is unique in that it can transport lithium ions with facility while blocking polysulfide transport. Lithium-ion conduction occurs through the MCM by electrochemical intercalation or insertion reactions and concomitant solid-state diffusion, exactly as in the cathode of a lithium-ion battery. Because of the rapidity of lithium ion transport in the MCM, the internal resistance of the battery is not higher than that of a conventional lithium-sulfur battery. The use of MCM opens up a new avenue for the improvement of the performance and longevity of high-energy lithium-sulfur cells.

We have confirmed the suppression of polysulfide transport by direct measurement of the shuttle currents. The effect of MCM is comparable to that of using lithium nitrate additives, but the MCM membrane is expected to offer an extended benefit during cycling, as the MCM is not consumed in the cell unlike lithium nitrate. The internal resistance of the cell is largely unaffected by the presence of the MCM barrier. The MCM layer is easy to fabricate and can be incorporated readily using state-of-art manufacturing methods used in lithium ion cells. We also expect other benefits such as the ability to resist formation of electronic shorts resulting from dendrite formation that have not been investigated here.

In addition to describing the new results with MCM, we will describe the criteria for the selection of materials for MCMs and demonstrate the effectiveness of this novel MCM layer by proving the suppression of shuttling of polysulfides, demonstration of improved capacity retention during repeated cycling, and the preservation of rate capability and impedance of the lithium-sulfur battery.

Speaker Biography:

Prof. Sri Narayan has been on the Faculty in the Department of Chemistry at the University of Southern California (USC), since the year 2010. In the last six years, under the sponsorship of ARPA-E, Prof. Narayan and his team at USC have made notable innovations in the area of robust iron-based batteries, inexpensive aqueous organic redox flow batteries and long-life lithium sulfur batteries.

Prior to this faculty appointment he was the Group Head of the Electrochemical Technologies Group at the NASA-Jet Propulsion Laboratory. During his 20-year tenure at the NASA-Jet Propulsion Laboratory, he pioneered the development of the Liquid-Fed Direct Methanol Fuel Cell that led to its commercialization. Prof. Narayan is the recipient of the NASA-JPL Exceptional Achievement Award (1996) and NASA-JPL Explorer Award (2009), was elected as the Fellow of the Electrochemical Society (2012), and was recently recognized with the Phi Kappa Phi USC Faculty Award (2015) for his contributions to field of sustainable energy storage.