Overcoming the Challenges in High Energy Density Storage with Nanotechnology

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All of today's Li-ion energy storage devices (rechargeable batteries) work on the principle of reversible storage of electrons and Li-ions in bulk materials. Transport of these charge carriers is by intercalation chemistry, where little change occurs to the framework that hosts them during the redox cycling of the cell. This can provide high power, but limited energy storage capability. Li-S and Li-O_2 batteries, which operate on a different principle than conventional Li-ion batteries, represent promising new technologies that could meet the needs for high energy density storage. They require carefully designed nanomaterials in order to function. The presentation will compare and contrast the similarities and differences in the two systems based on our knowledge of the electrochemistry and materials science, and discuss the critical developments necessary in the future to bring them to the marketplace. For example, in both cases, nanoporous cathode materials are vital as hosts to provide electron transport pathways for redox, and to store either the sulfur and its discharge product Li_2S; or to store the discharge product, Li_2O_2. Deliberate design of conductive nano-frameworks can overcome some of the challenges presented by inherent cell chemistries. In the case of the Li-O_2 cell, high overpotential on charge along with poor cyclability - related to electrolyte decomposition and catalytically sensitive oxygen reactions – are critical challenges that also need to be solved. The mechanisms of the oxygen reduction reaction, and oxygen evolution reaction will be presented in the context of the intriguing electrochemical activity of transition metal oxide nano-catalysts.