Energy Density Limitation of Lithium-Sulfur Batteries

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Lithium-sulfur (Li-S) batteries are among the most promising candidates for the next generation rechargeable batteries due to their high energy density, low raw material cost and environmental friendliness. Although Li-S batteries possess a high theoretical cathode specific capacity of 1,672 mAh g^{-1}, the energy density of practical Li-S batteries is much smaller and depends on electrolyte/sulfur (E/S in mL g^{-1}) ratio. From previous works, successful operation of Li-S batteries under lean electrolyte conditions can be challenging, especially in the case when the solubility of lithium polysulfide (LiPS) sets an upper bound for polysulfide dissolution. Very recently, we have demonstrated that the E/S ratio of Li-S cells has a significant effect on both performance and theoretical energy density of Li-S batteries. Since the lower-bound for E/S ratio is restricted by the solubility of LiPS in the organic electrolyte, the theoretical energy density of Li-S batteries is significantly reduced. Experimentally, it was approved that when the LiPS concentration reached to the solubility limitation in the electrolyte, the reaction rate of reducing sulfur to LiPS in the cathode will reduce significantly. In this talk, we will discuss the relationship between theoretical specific energy and the solubility of LiPS in the electrolyte. The experiments were also proved that the solubility of LiPS could be the ultimate limitation to the energy density of Li-S batteries.

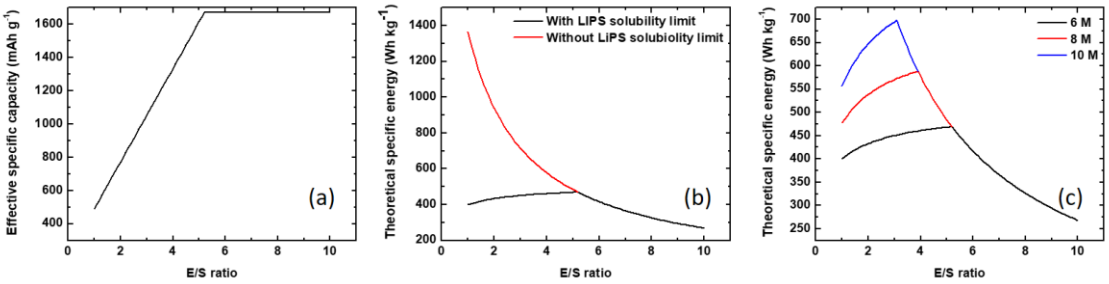

Fig. 1. (a) Effective specific capacity of a Li-S battery under different E/S ratios, (b) specific energy of a Li-S battery under different E/S ratios for with and without consideration of LiPS solubility; and (d) specific energy of a Li-S battery with different electrolytes having LiPS solubility of 6, 8, and 10 M/L.