High Efficiency Lithium Sulfur Batteries

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In this work, we examined several parameters in the Li-S technology with a focus on mitigating the issue of shuttle reactions and hence improving the capacity and efficiency of Li-sulfur cells. The sulfur cathode in the current Li-S battery offers superior theoretical capacity (1672 mAh g^{-1}) compared to all Li-ion battery cathodes (300 mAh g^{-1} maximum). Moreover, a Li-S battery has the advantages of using an abundant, nontoxic and low-cost cathode material, as well as having a wide operating temperature range.[1,2,3,4] Despite these advantages, the dissolution of lithium polysulfides and their shuttle reactions, and thus a low coulombic efficiency prevent the development of practical Li-S batteries (Figure 1a).

To solve these problems, we pursued several approaches. First, we studied the impact of improving the electronic conductivity of the sulfur electrodes by adding increasing ratios of carbon and carbon with increasing surface areas into Li-S cell electrodes. The impact of impregnating sulfur into carbon pores over simple mixing was also studied. We next investigated the inclusion of nano-sized TiO_2 particles having a large specific surface area into the electrodes in order to contain the dissolution of sulfur. In this case, some improvements in capacity retention and cycle life were observed. To further enhance capacity and coulombic efficiency, $LiNO_3$, a reported shuttle inhibitor, was added to the electrolyte and the impact and mechanism were studied (Figure 1b). It was concluded that $LiNO_3$ was effective as a 'consuming' type, rather than a catalyst type, of electrolyte additive. Unlike what was believed by some researchers, the efficiency improvement by adding $LiNO_3$ may not be directly resulted by forming a protective layer on the surface of Li anode in a Li-S cell. Rather, it may be the continuous reactions between LiNO3 and dissolved polysulfides that compensated the shuttle mechanism and enhanced the efficiency.

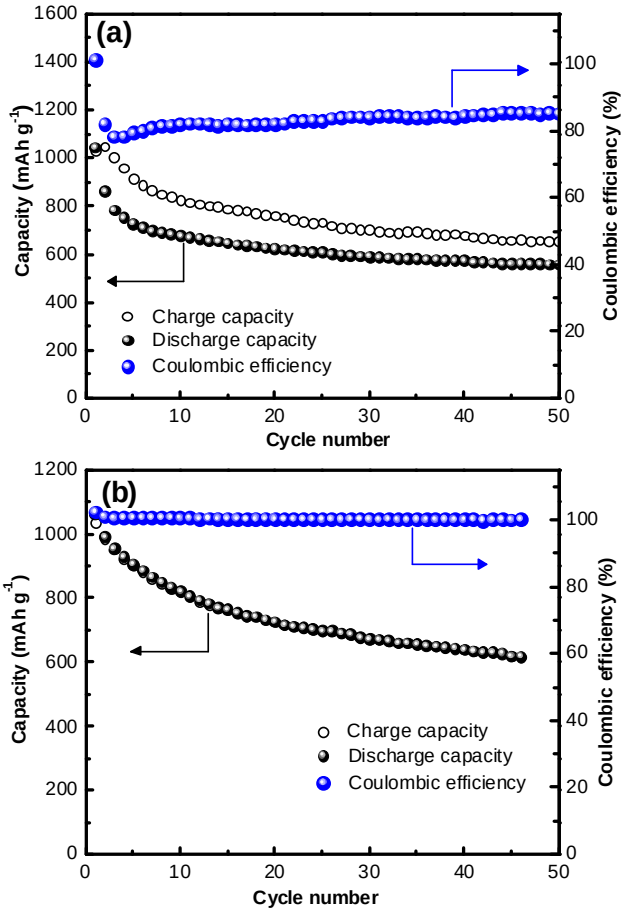

Figure 1: Capacity and coulombic efficiency vs. cycle number at C/10 for a Li-S cell containing (a) 1M LiTFSI in DME/DOL (v/v=1/1) electrolyte; (b) 1M LiTFSI and 0.5M LiNO3 in DME electrolyte.

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