Experimental characterization of the effect of the electrolyte-to-sulfur ratio on the Li-S battery performance for different electrolyte systems

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Along with the increase in demand for electric vehicles recently, lithium-sulfur (Li-S) batteries have been a top research topic due to their high theoretical specific energy and energy density, which differ them from commercial batteries [1]. However, these batteries that are promising options for the future are still in the research phase because there are some crucial obstacles that must be overcome, such as the polysulfide shuttle mechanism, capacity fade, etc., resulting from the complex mechanisms in the batteries.

There are several solutions to deal with these problems. One of the best ways for this purpose is electrolyte design because the electrolyte-to-sulfur (E/S) ratio, which is a crucial cathode design parameter, plays a significant role in the performance of the Li-S batteries. An increase in the E/S ratio affects the voltage and the capacity of the cell positively while mitigating the system-level energy density and specific energy of the cell [2,3]. In this regard, comprehension of the effect of the electrolyte-to-sulfur ratio on battery performance might enable researchers to shed light on overcoming these problems.

In this study, the characterization of the effect of the E/S ratio on the Li-S battery performance for different electrolyte systems is experimentally studied. Previously in the literature, the most common electrolyte, which is 1M lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) in a mixture of 1,3-dioxolane (DOL) and 1,2-dimethoxyethane (DME) at a volume ratio of 1:1, was used in order to investigate the effect of the E/S ratio on battery performance [2,3]. Here, we investigated the impact of the E/S ratio for five different electrolyte systems; 1M LiTFSI or trifluoromethanesulfonate (LiTF) in triethylene glycol dimethyl ether (G3) and 1M LiTFSI, LiTF, or lithium perchlorate ($LiClO_4$) in sulfolane electrolytes were used in order to investigate the effect of the E/S ratios of 6, 9, 16, and 23 mL/g on Li-S battery performance.

As a result, it can be clearly seen in Figures 1a and 1b that in electrolytes with LiTFSI in Sulfolane or G3, the highest capacity is observed at an E/S ratio of 9 mL/g. On the other hand, for sulfolane with 1M $LiClO_4$, an E/S ratio of 6 mL/g has the highest capacity (Figure 1c). Also, the discharge capacity is high at an E/S ratio of 6 mL/g in G3 with LiTF, as seen in Figure 1d. It is concluded that unlike the LiTFSI in DOL:DME electrolyte system, Li-S cells with sulfolane or G3-based electrolyte systems achieve high discharge capacities at low E/S ratios. On the contrary, the capacity retention for all electrolytes is limited.

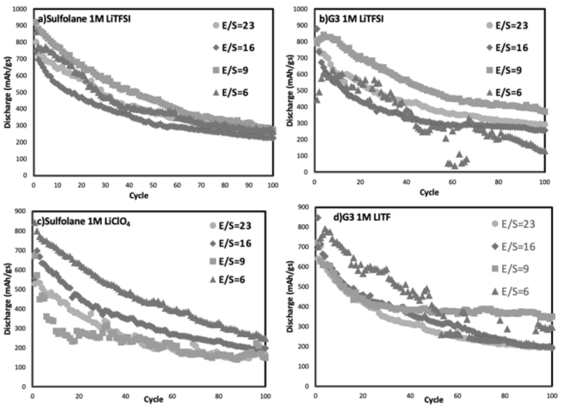

Figure 1. Effect of E/S ratio on the discharge capacity profiles of Li-S cells with a) 1M LiTFSI in Sulfolane, b) 1M LiTFSI in G3, c) 1M $LiClO_4$ in Sulfolane, and d) 1M LiTF in G3 electrolyte systems.

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