Electrochemical properties of sulfone-based electrolytes for rechargeable lithium-sulfur batteries

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Lithium-sulfur (Li-S) battery is an interesting technology because it has very high specific energy density (2500 Wh/kg) caused by high theoretical capacity of elemental sulfur. Moreover, an abundant sulfur obtained by a common by-product of the petroleum refining process facilitates a competitive price for making of Li-S batteries.[1] Despite these advantages, the practical application for Li-S batteries are limited by two major problems: (i) a low intrinsic conductivity of sulfur and (ii) loss of active material because of solubility of the intermediate products.[2] Generally, poor conductivity can be resolved effectively by dispersing sulfur into an electronically conductive agents, for example, carbon phase materials and polymers. These conducting materials can improve the electron transport properties in the electrode. The formation of soluble polysulfides, on the other hands, which has not yet be solved, was attempted to be controlled or suppressed by various solvents and additives. The polysulfides can diffuse to lithium anode and be reduced to short-chain polysulfides. Also those soluble species can move back to sulfur cathode where they are re-oxidized into long-chain polysulfides. This process produces an internal shuttle reaction that results in low energy efficiency. In order to alleviate the formation of polysulfides, it is important to find a suitable electrolyte composition. Many studies for Li-S batteries have been accomplished by specific solvent mixtures and appeared dramatically different electrochemical behavior. It is expected to be especially true for the Li-S batteries system due to the presumably different solubility of polysulfides. The electrolyte for Li-S batteries can be categorized by several solvent groups. One group involves organic carbonates including ethylene carbonate (EC), propylene carbonate (PC), and diethyl carbonate (DEC). Another group includes ethers, such as 1,3-dioxolane (DOL), 1,2-dimethoxyethane (DME), and tetra-(ethylene glycol) dimethyl ether (TEGDME). Another possible solvent, there are limited reports on the use of sulfones (ex. ethyl methyl sulfone (EMS) and tetra methylene sulfone (TMS)). Several researchers have conducted comparative studies of specific solvent mixtures in Li-S batteries, including TEGDME/DOL, DME/DOL, and DME/DG/DOL. However, there is a lack of systematic comparison of the effects of sulfone-based electrolyte systems on the electrochemical performance of sulfur cathode.

In this study, we employed sulfone-based electrolytes and evaluated their performances in Li-S batteries. Conventional sulfone-based electrolytes were first investigated but clearly turn out to be unusable in Li-S batteries.

Acknowledgement

This work was supported by the Next Generation Military Battery Research Center program of The Defense Acquisition Program Administration and Agency for Defense Development.

References

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