

Electrochemical Performance of Lithium Gel Polymer Battery with Sulfur/Carbon Cathode

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Introduction

Elemental sulfur (S) is a very attractive alternative to the cathode material used in lithium-ion batteries due to its low cost, high theoretical capacity of 1672 mAh g^{-1} and specific energy of 2600 Wh kg^{-1} , abundance and environmental friendliness [1]. However, Li/S batteries suffer from the low level of cathode material utilization and poor cycle life, which is essentially due to the insulating nature of S and solubility of reductive polysulfides in liquid organic electrolyte [2].

In the present work, we used a mesoporous carbon, ketjen black (KB), as a conducting additive to prepare a S/C composite cathode. A gel polymer electrolyte was prepared by trapping a solution of lithium bistrifluoromethane-sulfonamide (LiTFSI) in tetraethylene glycol dimethyl ether electrolyte in a poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP)/poly(methylmethacrylate) (PMMA) polymer matrix prepared by phase inversion using a combination acetone/water as solvent/non-solvent. The electrochemical and structural properties of this GPE and its electrochemical performance as an electrolyte for a Li/S cell with a S/KB cathode have been investigated.

Experimental

Figure 1 and Figure 2 showed the schematic of the S/KB composite and PVDF-HFP/PMMA polymer matrix preparation, respectively.

The S/KB composite and PVDF-HFP/PMMA polymer matrix were characterized using TG-DTA analysis, chemical analysis, XRD, BET and SEM. The composite cathode electrode was prepared by mixing S/KB composite with conductive carbon and PVDF binder and coating this mixture on nickel foam. The electrochemical properties of the composite cathode were investigated in a lithium half cell (coin-type CR2025) with PVDF-HFP/PMMA base gel polymer electrolyte by cyclic voltammetry (CV), galvanostatic cycling and AC impedance spectroscopy.

Results and Discussion

Figure 3 shows the XRD spectra of the starting components used to prepare the composite cathode, S and KB, the S/KB composite, pure PVDF-HFP, PMMA and PVDF-HFP/PMMA composite polymer matrix. It can be seen that the characteristic peaks of S disappear when the carbon composites were prepared via ball-milling and heat treatment. The sublimed sulfur precipitates in a highly crystallized form when cooled to the ambient temperature. However, the S/KB composite does not show the peaks of S in XRD spectra. It could be an indication of trapping S into the internal pores of KB. The X-ray diffraction pattern reveals clearly that PVDF-HFP/PMMA composite is less crystalline than pure PVDF-HFP and PMMA. The polymer matrix crystallinity

decrease is favorable for the ionic conductivity enhancement of the polymer electrolyte.

Further development of this research will be presented at the Meeting.

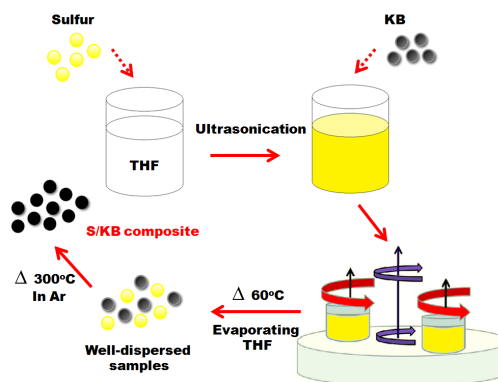


Fig. 1 Schematic of the S/KB composite preparation.

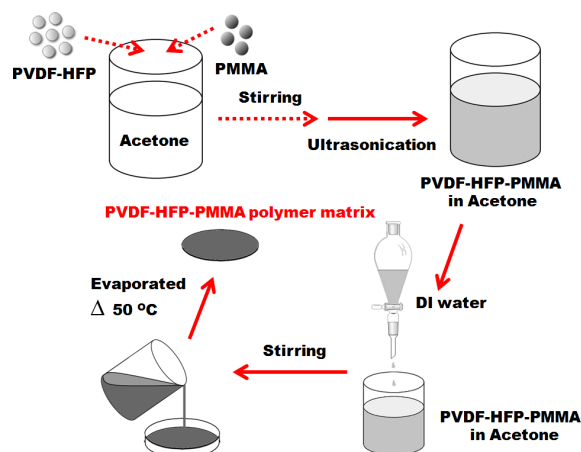


Fig. 2 Schematic of the PVDF-HFP/PMMA polymer matrix preparation.

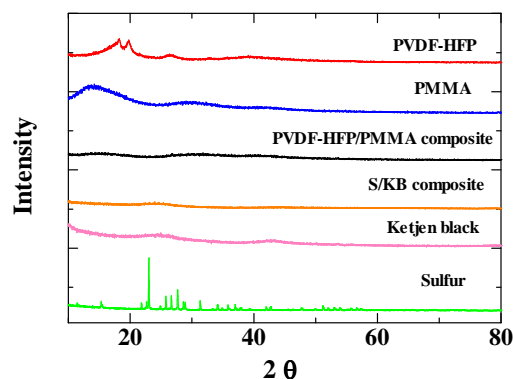


Fig. 3 XRD patterns of sulfur, KB, S/KB composite, PVDF-HFP, PMMA and PVDF-HFP/PMMA composite.

References

1. R.P. Tischer, *The sulfur electrode*, Academic Press, New York, 1983.
2. R.D. Rauh, K.M. Abraham, G.F. Pearson, J.K. Surprenant, S.B. Brummer, *J. Electrochem. Soc.* 126 (1979) 523-527.

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