

## Lithium/Sulfur Gel Polymer Batteries with Nanostructured Sulfur/Carbon Composite Cathode

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### Introduction

Elemental sulfur is a promising cathode material for the next generation high-energy rechargeable lithium batteries with a high specific capacity of  $1672 \text{ mAh g}^{-1}$  and specific energy of  $2600 \text{ Wh kg}^{-1}$ . Along with this, sulfur is inexpensive, abundant and environmentally friendly [1]. However, Li/S batteries suffer from a 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 this study, we report on preparation of a S/C composite cathode by using a mesoporous carbon, ketjen black (KB) as a conducting additive and its use in a lithium polymer battery. 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

Sulfur was mixed with KB and heat treated at various temperatures from 150 to 300 °C in Ar atmosphere to prepare S/KB composite. PVDF-HFP/PMMA polymer matrix was prepared by phase inversion method. A gel polymer electrolyte (GPE) 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.

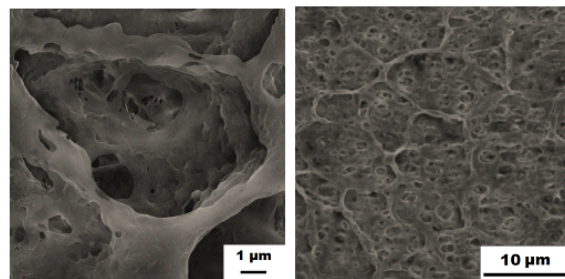
The S/KB composite and PVDF-HFP/PMMA polymer matrix were characterized by TG-DTA analysis, elemental analysis, SEM, XRD and BET. The electrochemical properties of the composite cathode were investigated in a lithium half-cell (coin-type CR2032) with PVDF-HFP/PMMA GPE by cyclic voltammetry (CV), galvanostatic cycling and AC impedance spectroscopy.

### Results and Discussion

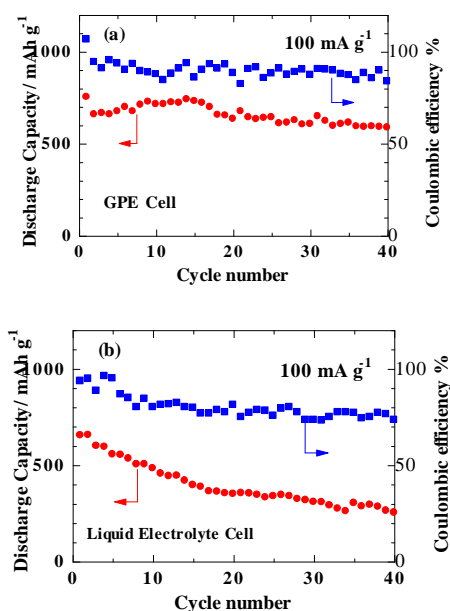
Fig. 1 presents the SEM photographs of PVDF-HFP/PMMA composite at different magnifications. It can be seen that the polymer matrix has highly porous structure, with the pore diameters from 0.1 to 1  $\mu\text{m}$ . The abundant porous structure increases the surface area of the matrix and could effectively enhance its absorption ability and improve the electrolyte retention.

The cyclability of the GPE cell is remarkably enhanced compared with the liquid electrolyte as shown in Fig. 2a and b, and the GPE cell retains about 80% of its initial capacity over 40 cycles, while the discharge capacity of the liquid electrolyte battery drastically fades upon cycling. Further development of this research will

be presented at the Meeting.



**Fig. 1** SEM images of PVDF-HFP/PMMA matrix at different magnifications.



**Fig. 2** Cyclability of (a) GPE and (b) liquid electrolyte cells at galvanostatic charge-discharge at a current density of  $100 \text{ mA g}^{-1}$ .

### References

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