

Microporous PVdF Electrolytes for Lithium/Sulfur Batteries

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Rechargeable lithium batteries based on solid polymer electrolytes have been developed for new demanding applications, such as electric vehicles and portable electronic goods. They need higher energy densities and power storage. A battery system based on the lithium and elemental sulfur has a theoretical capacity of 1672 mAh/g of sulfur and a theoretical specific energy of 2600 Wh/kg. The lithium/sulfur system can therefore be used as inexpensive high energy density rechargeable batteries.

The lithium/sulfur batteries using liquid electrolytes showed many problems, particularly the loss of active sulfur in the form of a soluble product. Therefore, solid polymer electrolytes are of practical importance for the lithium/sulfur battery. Recently, gel-type polymer electrolytes are attractive at the sight of practical applications because they usually possess high ion conductivities of $> 10^{-3}$ S/cm at room temperature. However, these polymer electrolytes exhibit low mechanical strength and loss of liquid electrolyte from highly swollen gel polymer. In the case of using elemental sulfur as a cathode material, the loss of electrolyte is serious drawbacks because the sulfur can react with organic electrolytes.

In this work microporous PVdF electrolytes have been prepared and applied to the lithium/sulfur cells. The microporous PVdF electrolyte were prepared by dissolving commercially available P(VdF-co-HFP) (Kynar 2801) and di-n-butyl phthalate (DBP) in acetone and casting the solution on glass plate. The cast film was dried in air and then residual nonsolvent, DBP, was extracted with ethyl ether or methanol. The extracted PVdF film was further dried in vacuum at 60 °C and soaked in liquid electrolyte solution containing lithium salts at 25 °C for 24h in argon filled glove box. Lithium salts are LiCF₃SO₃, LiBF₄, and LiPF₆, and PC/EC and TG/EC(v/v, 1/1) were used as organic solvents. The sulfur electrodes were prepared by mixing sulfur, carbon, PEO, and LiCF₃SO₃ in acetonitrile.

The sulfur electrode and polymer electrolyte were well characterized using SEM, XRD, and DSC. The dried polymer film was appeared to be microporous and can take up the liquid electrolytes. The ion conductivity depends on the porosity of the polymer film and then the uptake amount of electrolytes as shown in Fig.1. The initial discharge capacities accordingly depend on the uptake amount of electrolytes as shown in Fig.2. In this work we have obtained high discharge capacities per active sulfur, and thoroughly investigated the effect of the content of DBP, composition of electrolyte solutions, and lithium salt on the ionic conductivity of PVdF electrolytes and then initial discharge capacity.

Fig.1. Ionic conductivities vs. uptake of electrolytes.

Fig.2. Initial capacities vs. uptake of electrolytes.

References

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