PAN-based polymer electrolytes using porous membrane made by electrospinning

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Introduction

Polymer electrolyte using porous polymer matrix has been widely investigated for the electrochemical applications in lithium polymer battery. Phase inversion has been known to be method to prepare porous polymer matrix. But, this technique is very complicated.

Now, electrospinning is most effective method to prepare porous polymer matrix composed of fibers with diameters in the range from sub-micrometers down to nanometers.

In this study, we suggest the application of electrospun PAN matrix for a polymer electrolyte.

Results and Discussion

Porous polymer matrix is made by electrospinning using polyacrylonitrile, called PAN, (Polysciences, Mw = 150,000). Porous PAN matrix using electrospinning has high porosity, large surface area and three-dimensional structure with interconnected pores as shown Figure 1. Average fiber diameter is about 360nm and apparent porosity is about 80%. Therefore, porous PAN matrix is able to uptake and to retain electrolyte solutions.

PAN-based polymer electrolytes is prepared by immersion of porous PAN matrices into the EC/DMC (v/v, 1/1), EC/DEC (v/v, 1/1), and EC/DMC/DEC (v/v/v, 1/1/1) solutions with 1M $LiPF_6$, respectively.

The interaction between polymer and lithium ion or between ethylene carbonate and lithium ions are confirmed by FT-RAMAN shown Figure 2. When threshold at 2270 cm^{-1} is not shown in Figure 2 (a), interaction between lithium and C≡N groups in PAN does not existed. However, interactions between lithium ion and ethylene carbonate are confirmed that peak around 902 cm^{-1} is shown in Figure 2 (b). Therefore, electrolyte solution in pores is a major factor for the ionic conduction of polymer electrolytes.

Ionic conductivities of the polymer electrolytes were found to be as high as 10^{-3} S cm^{-1} at room temperature as shown in Figure 3.

Figure 4 shows the linear sweep voltammogram measured between 2.0 and 6.0 V. These polymer electrolytes show good oxidation stabilities up to 5.0V. Electrolyte solution is tightly trapped in the pores of porous PAN matrix.

Prototype cell using the polymer electrolyte with 1M $LiPF_6$-EC/DMC (1/1, v/v) shows good cycle property during 50 cycles.

Conclusion

Electrospun membrane shows a good polymer matrix of polymer electrolytes for lithium polymer battery with high performance.

Reference

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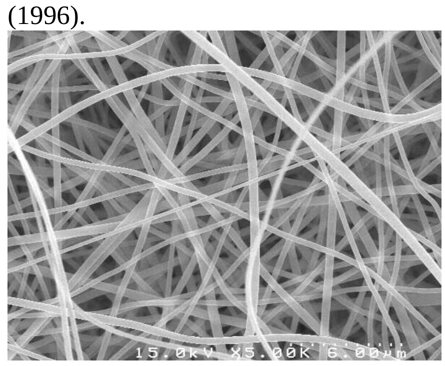
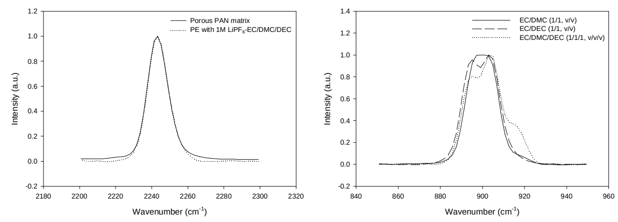


Figure 1. SEM image of the porous PAN matrix.



(a) (b)

Figure 2. FT-RAMAN spectra of polymer electrolytes.

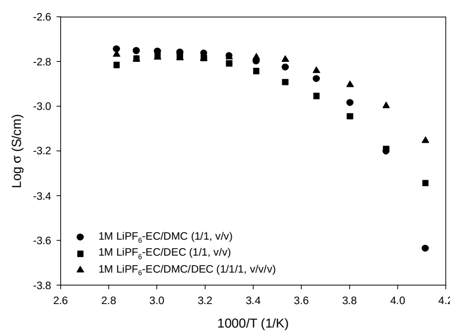


Figure 3. Ionic conductivities of PAN-based polymer electrolytes.

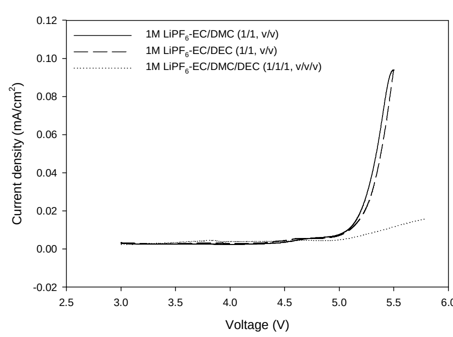


Figure 4. Linear sweep voltammograms of PAN-based polymer electrolytes.

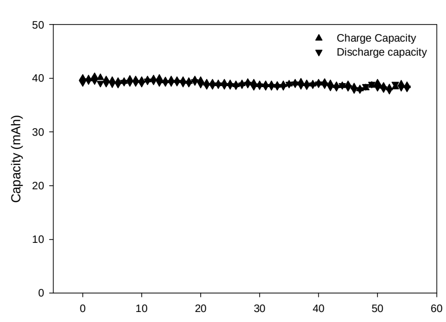


Figure 5. Cycling performance of prototype cell with PAN-based polymer electrolyte.