Hot-pressed, dry, nanocomposite, PEO-based electrolyte membranes. Ionic conductivity characterization and battery tests.

G. B. Appetecchi[1], F. Croce[1], J. Hassoun[1], M. Salomon[2], B. Scrosati[1]

[1]University of Rome " La Sapienza", P.le A. Moro 5, 00185 Roma, Italy
[2]MaxPower, Inc., Harleysville, PA 19438

Poly(ethylene oxide) (PEO)-based lithium electrolyte membranes appear the most suitable candidates as separators for reliable, lithium rechargeable polymer batteries[1]. Nevertheless, the PEO-LiX complexes perform well in terms of ionic conductivity only when the polymer is mainly in the amorphous state[2], i.e., when the mechanical properties of the polymer electrolytes are relatively poor.

In this work we report the results of the ionic conductivity characterization of PEO-based, nanocomposite, polymer electrolytes prepared by hot-pressing through a solvent-free procedure. Several $P(EO)_nLiCF_3SO_3$:filler electrolyte compositions were developed and characterized. In particular, the investigation was focused on the effect of the temperature, the PEO molecular weight, the EO/Li molar ratio, the nature and the content of filler. Nanoscale (< 7 nm) Al_2O_3 and SiO_2 were selected as ceramic fillers. Lithium polymer composite electrolytes, formed by a blend of poly(ethylene oxide) (PEO), $LiCF_3SO_3$ lithium salt and a selected, nano-particle ceramic filler, were prepared by hot-pressing through a solvent-free procedure. These dry, ionically conducting membranes were characterized in terms of ionic conductivity in the 30-105°C temperature range. The results, reported in Figure 1, demonstrate the favorable basic properties of these membrane, which show an ionic conductivity higher than 10^{-4} Scm^{-1} at 70°C, as well as high homogeneity and excellent mechanical properties.

The hot-pressed, composite PEO membrane were used as electrolyte separator in all-solid, lithium polymer cells by laminating a lithium foil anode, a selected hot-pressed, PEO electrolyte membrane and a $LiFePO_4$ composite cathode film prepared by hot-pressing through a completely dry, solvent-free procedure. Among the materials under development as cathode in lithium polymer batteries, the lithium iron phosphate, $LiFePO_4$, originally proposed by Goodenough[3], may regarded as very promising candidate due its capability to operate with a very flat voltage plateau. In addition, $LiFePO_4$ exhibits a large theoretical specific capacity (about 170 $mAhg^{-1}$), thermal stability and benefits of low cost and environmental compatibility. The performance of the polymer battery was evaluated at different current densities and temperatures. The results are shown in Figure 2.

Acknowledgment

This work has been carried out with the financial support of MaxPower, Inc., Harleysville, PA 19438 under US Army Contract DAAB07-01-C-D414.

References

1. C.A. Vincent and B. Scrosati, "*Modern Batteries. An Introduction to Electrochemical Power Sources*", 2nd ed. (Arnold, London, 1993).
2. F.M. Gray, "*Polymer Electrolytes*", Royal Society of Chemistry Monographs, Cambridge (1997).
3. A. K. Padhi, K. S. Nanjundaswamy, and J. B. Goodenough, J. Electrochem. Soc. 144 (1997) 118**.**

Fig. 1. Arrhenius plots of hot-pressed, nanocomposite, $P(EO)_nLiCF_3SO_3$: x% wt filler electrolyte membranes. Panels from A to D are referred, respectively, to a filler content as well as 5% wt Al_2O_3 (panel A), 5% wt SiO_2 (panel B), 10% wt Al_2O_3 (panel C), and 10% wt SiO_2 (panel D). Each panel reports the data for different PEO molecular weights and EO/Li molar ratios.

Fig. 2. Delivered capacity vs. temperature dependence for a Li / $PEO:LiCF_3SO_3:SiO_2$ / $LiFePO_4$ polymer battery at different current densities (see legend).