PEO-LiBETI Dry Polymer Electrolyte for EV Lithium Batteries

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In this work we report the characterization of a dry polymer electrolyte in terms of conductivity and stability of the interface with metallic lithium. The performance in conjunction with V_2O_5-based composite cathodes for EV batteries is also reported. The polymer electrolyte is based on high molecular weight PEO and a large anion lithium salt, $LiN(SO_2CF_2CF_3)_2$ (LiBETI).

Large counter-ion lithium salts are known to interfere with the crystallization process of the polymer chains (1), thereby promoting amorphous region and increasing the lithium transport in the polymer electrolyte. Such an effect has been experimentally verified by DSC measurements, which have shown the formation of a PEO-LiBETI complex (EO/Li = 6/1) with a sub-ambient melting temperature. Such a complex is present in all materials investigated with the exception of the $P(EO)_4$LiBETI material that DSC and XRD measurements have shown to be characterized by a different phase. As a result of the presence of a sub-ambient melting complex, $P(EO)_n$LiBETI polymer electrolytes (with n ranging from 8 to 50) show an ionic conductivity higher than 10^{-4} Scm^{-1} at 60°C already. They show the highest conductivity than any other dry, low molecular weight plasticizer-free, high molecular PEO-based electrolyte.

The interfacial properties of PEO-LiBETI polymer electrolytes with metallic lithium have been investigated in both rest condition and kinetic condition (current flow) on Li/ $P(EO)_n$LiBETI /Li cells in a temperature range from 60°C to 90°C. Figure 2 shows the evolution of the interfacial impedance of metallic lithium with several polymer electrolyte differing by salt concentrations, stored at 90°C for more than 120 days. As it can be seen from the figure, the impedance does not grow rapidly for any of the polymer electrolytes investigated. For the low-salt concentration ones, the interfacial resistance remain below 20 Ωcm^2 after more than 4 months of storage at 90°C.

PEO-LiBETI polymer electrolytes have been tested in full polymer batteries with V_2O_5-based composite cathodes at 90°C. Figure 3 shows the performance of two batteries discharged at several current densities ranging from 0.07 $mAcm^{-2}$ to 4.1 $mAcm^{-2}$ (i.e., from C/20 to 3C assuming 2 eq. of lithium as the theoretical capacity of V_2O_5). The cell was always recharged at the lowest current density (0.07 $mAcm^{-2}$) to assure the full recharge of the cells. The plots in Figure 3 show two well defined trends with the C rate, in which the delivered capacity is limited by the active material (< C/3) and by the electrolyte (> C/3), respectively. The results clearly shows the ability of the cell to deliver almost the full capacity at the C/3 rate that is the typical discharge time of EV applications. In the electrolyte limited region (> C/3), the cells were able to sustain 3C rate discharges corresponding to a power of 740 W per kilogram of active material.

Acknowledgements

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References

1. S. Lascaud, M. Perrier, A. Vallée, S. Besner, J. Prud'homme, and M. Armand, *Macromol.*, **27**, 7469 (1994).

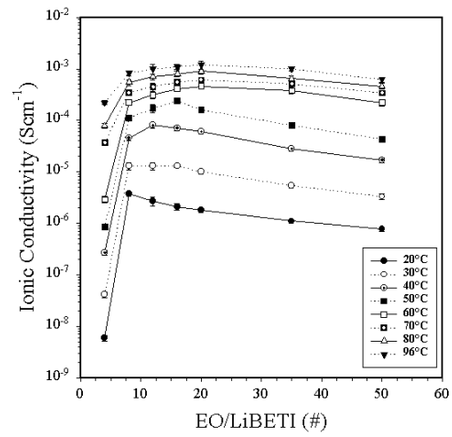

Figure 1. Ionic conductivity of $P(EO)_n$LiBETI polymer electrolyte as a function of the EO/Li ratio and temperature

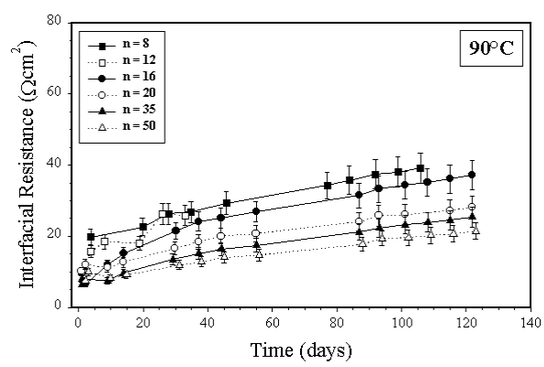

Figure 2. Evolution of the interfacial resistance of the Li/$P(EO)_n$LiBETI interface as a function of the EO/Li ratio, upon storage at 90°C.

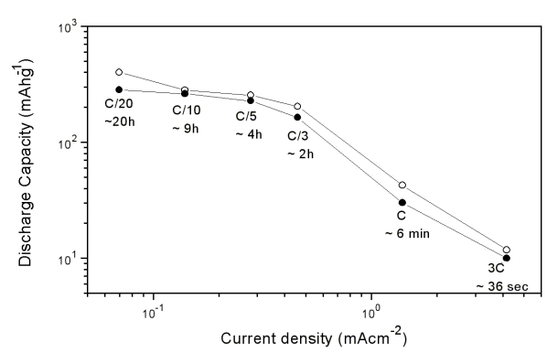

Figure 3. Discharge capacity vs. current density of two Li/$P(EO)_{20}$LiBETI/V_2O_5 cells held at 90°C. Cathode active material loading: 5 $mgcm^{-2}$. Pristine cathode composition: V_2O_5 (Pechiney) 60%, Carbon (Super P, MMM carbon) 10%, PEG (Carbowax, Union Carbide) 27%, PEO (Polyox, Union Carbide) 3%. Pristine electrolyte formulation: $P(EO)_{20}$ LiBETI.