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Poly(ethylene oxide carbonates) solid polymer electrolytes for lithium batteries

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Abstract

Poly(ethylene oxide) (PEO) is the gold standard matrix for polymer electrolytes used in actual all-solid lithium batteries. However, PEO solid polymer electrolytes show some limitations; such as relatively low ionic conductivity and lithium transference number resulting in the actual polymer-lithium batteries operating at 70 °C. In the last years, polycarbonates (PC) have been presented as an alternative polymer matrix with superior ionic conductivity for solid batteries which may work at room temperature. In this article we systematically investigated the properties of new polymers which combine varying composition of both ethylene oxide and carbonate groups. A series of poly(ethylene oxide carbonates) (PEO-PCs) have been synthesized by polycondensation between different ethylene oxide diols and dimethyl carbonate. As a result, eight new PEO-PCs with number of ethylene oxide units ranging from 2 to 45 between carbonate groups were synthesized and characterized in terms of physico-chemical properties (T_m and T_g). These PEO_{2-45}-PC were formulated as solid polymer electrolytes (SPE) by adding different amounts of bis(trifluoromethane) sulfonimide lithium salt. The effect of the SPE composition (ethylene oxide/carbonate ratio, salt content) on the ionic conductivity and thermal properties (glass transition temperature and melting temperature) was investigated. The optimum SPEs showing the lowest glass transition temperature led to highest ionic conductivity value of $3.7 \cdot 10^{-5}$ S cm^{-1} at room temperature. FTIR spectra revealed the coordination between the carbonate groups in the polymer chain and the lithium salt. ^{7}Li-^{19}F NMR analysis T_1 relaxation and diffusion coefficients measurements indicated local dynamics that correlates with the general conductivity behaviour.

Graphical abstract