Electrochemical and Mechanical Properties of Sodium-Ion Conducting Cross-Linked Polymer Gel Electrolyte

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doi: 10.20964/2017.11.56

Received: 27 July 2017 / Accepted: 6 September 2017 / Published: 12 October 2017

The free radical polymerization of cross-linked poly(methyl methacrylate) (PMMA) polymer gel electrolyte (PGE) for sodium-ion transport exhibits high ionic conductivity, good mechanical property and low cost. Appropriate amounts of sodium hexafluorophosphate (NaPF₆) were arbitrarily added into cross-linked PGEs in order to decrease the crystallinity of the polymer and to provide more charge carriers to facilitate ionic conductivity. The Shore A durometer test revealed that the NaPF₆ addition also enhanced the hardness of the cross-linked PGEs. The highest ionic conductivity obtained was $1.33 \times 10^{-3} \text{ S cm}^{-1}$ for the cross-linked PGE with 20 wt.% NaPF₆. Activation energies calculated based on Arrhenius behavior for cross-linked PGEs with 10 wt.%, 20 wt.% and 30 wt.% NaPF₆ additions were 0.13, 0.10 and 0.16 eV, respectively. The electrochemical window was from -2.5 V to 2.5 V and the transference numbers was ranging from 0.9 to 0.96. This work demonstrates that the adoption of cross-linking technique and NaPF₆ opens the door to facile synthesis of sodium ion conductive PGEs, in which the mechanical property and electrochemical behavior are easy to be tailored by simply tuning NaPF₆ additives. The enhancement of hardness and ionic conductivity of cross-linked PGEs enable their potential applications in advanced energy storage systems.

Keywords: Polymer gel electrolyte; Electrochemistry; Cross-linked poly(methyl methacrylate); Sodium hexafluorophosphate; Sodium ion conducting

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