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Electrical Transport Properties of [Succinonitrile–Poly(Ethylene Oxide)]–LiX–$Co(bpy)_3(TFSI)_2$–$Co(bpy)_3(TFSI)_3$ Solid Redox Mediators, Where X = TFSI or Triflate

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Abstract. A fast ion-conducting solid redox mediator (electrolyte) is a basic requirement for all-solid-state dye-sensitized solar cells. In the present paper, we have reported electrical transport properties of [(1−*x*)SN–*x*PEO]–LiX–$Co(bpy)_3(TFSI)_2$–$Co(bpy)_3(TFSI)_3$ solid electrolytes, where SN stands for a plastic crystal, succinonitrile, PEO for a high-molecular-weight polymeric matrix, poly(ethylene oxide), and X for an anion either TFSI (radius 0.7 nm) or triflate (radius 0.44 nm). The composition, x = 0, 0.5, and 1 in weight fraction yields SN, SN–PEO blend, and PEO-based electrolytes. The plasticizing property of the SN helps to lower the high crystallinity of the PEO. $Co(bpy)_3(TFSI)_2$, and $Co(bpy)_3(TFSI)_3$ provide redox species. The results were compared with those of acetonitrile (ACN)-based liquid electrolytes. In comparison to the liquid electrolytes (electrical conductivity, $\sigma_{25°C}$ ~1.7×10^{-2} S cm^{-1}) the solid ones with TFSI$^-$ ions exhibited $\sigma_{25°C}$ of 2.1×10^{-3} for $x = 0$, 7.2×10^{-4} for $x = 0.5$, and 9.7×10^{-7} S cm^{-1} for $x = 1$. The triflate ions-based solid electrolytes had lower $\sigma_{25°C}$-values, such as 1.5×10^{-3} for $x = 0$, 3.1×10^{-4} for $x = 0.5$, and 6.3×10^{-7} S cm^{-1} for $x = 1$ The electrolytes with x = 0 and 1 had Arrhenius-type behavior akin to those of liquid electrolytes; however, the activation energy values were quite high. In contrast, the blend-based electrolytes ($x = 0.5$) had Vogel−Tamman−Fulcher-type behavior and the pseudo-activation energy was less than those of the liquid electrolytes. The differential scanning calorimetry revealed the arrest of the amorphous phase for the blend-based electrolytes because of the SN–PEO–ionic salt interactions. The blend-based electrolytes were thermally stable up to 125 °C, making them superior to the liquid electrolytes for the device application.

Keywords: Dye-Sensitized Solar Cells, Redox Mediators, Plastic Crystal, Solid Polymer Electrolyte, Electrical Conductivity.