Synthesis and characterization of poly (vinyl alcohol) based aluminum-ion conducting solid-polymer electrolytes

M.H. Viduranga, M. Kajani, J.H.T.B. Jayamaha, V. Jathushan and K. Vignarooban*
Department of Physics, Faculty of Science, University of Jaffna, Jaffna 40000, Sri Lanka
* vigna@univ.jfn.ac.lk

Abstract

The R&D works on so-called '*batteries beyond lithium-ion*' took an exponential growth in recent days due to the overwhelming demand for secondary batteries; particularly for portable electronic and automotive applications. Inevitably, designing a suitable electrolyte with sufficient ambient temperature ionic conductivity is a major challenge faced by the material research community in the field of non-lithium based secondary battery chemistries. To the best of our knowledge, reports on solid-polymer electrolytes (SPEs) for aluminum-ion batteries (AIBs) are lacking in the literature. In this work, an attempt has been made to synthesize and characterize Al^{3+} conducting SPEs based on poly (vinyl alcohol) (PVA) host polymer for potential applications in secondary AIBs. These SPEs were synthesized by using standard solvent-casting technique with DI water as the solvent. Among several SPE compositions studied in this work, the composition $PVA_{20}Al_2(SO_4)_3$ showed highest ambient temperature ionic conductivity of 5.6 x 10^{-6} S cm^{-1}. DC polarization studies done under an applied DC voltage of 1 V for the SS/SPE/SS configuration confirmed dominant ionic conducting nature of these electrolytes with an ionic transference number (t_{ion}) of 0.99. The conductivity vs inverse temperature variation exhibited Arrhenius behavior and the estimated activation energies systematically decreased with ionic conductivity. The highest conducting composition mentioned above showed lowest activation energy of 0.48 eV. The triply-charged nature of aluminum-ions contributes for the reasonably good ambient temperature ionic conductivity value observed in the best conducting composition.

Keywords: Aluminum-ion batteries; Al $^{3+}$ ion conductors; Poly (vinyl alcohol); Solid-polymer electrolytes; Activation energy

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