Tata Institute of Fundamental Research

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Internal Webinar

Effective Approaches to Enhance Ionic Conduction in Solid Polymer Electrolytes for Rechargeable Na-ion Batteries

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In recent years there is a huge demand for the development of large scale energy storage systems (ESSs) for application in portable electronic devices and hybrid electric vehicles.[1] Considering the cost, safety and wide spread availability of sodium resources the solid-state sodium-ion batteries (SIBs) have garnered significant research interest alternative to solid state Li-ion batteries (LIBs). Moreover, Na has a very negative redox potential (-2.71 V vs SHE) and a small electrochemical equivalent (0.86 gA h^{-1}) which makes it most advantageous element for battery application after Li.[2] Besides, these features compared with liquid electrolytes solid-state electrolyte (SSE) possess the leak free state, wide electrochemical window, high thermal stability over wide temperature ranges, ease of handling, fabrication, modularity and reliability in various electrochemical devices.[3,4] Despite these significant advantages SSE have relatively poor room temperature ionic conductivity (10^{-5} to 10^{-7} S cm^{-1}) and unstable interface between the SSE and electrode which blocks their practical application. Thus, the pre-requisites for SPEs is expected to satisfy to be used in Na-ion batteries are as follow: (1) the electrolyte's conductivity should be high enough (>10^{-3} S cm^{-1}) to minimize the iR drop across the cell, (2) it should be capable of maintaining this level of conductivity over a wide temperature range (~0 to 60 ^{o}C), (3) it should not undergo phase separation at low or high temperatures and (4) it should be chemically stable over the operational potential window of the Na-ion battery. For example R. Murugan et al. designed lithium garnet composite polymer electrolyte membrane (GCPEM) based on complexation of PEO with lithium perchlorate ($LiClO_4$) and lithium garnet oxide $Li_{6.28}$ $Al_{0.24}$ $La_3Zr_2O_{12}$ (Al-LLZO) by employing solution casting method which showed the Li^+-conductivity of 4.40×10^{-4} S cm^{-1} at room temperature and electrochemically stable up to 4.5 V.[5] Therefore, it is necessary to provide promising directions to design SSEs that can meet both bulk and interfacial conductivities for commercial solid state Na-ion batteries.

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