Structural, thermal, dielectric and modulus studies on magnesium-doped tamarind seed polysaccharide based biopolymer electrolytes

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We report the X-ray diffraction (XRD) profile, differential scanning calorimetry (DSC) plots and measurements of ionic conductivity, dielectric parameters and electric modulus parameters for different compositions of magnesium chloride ($MgCl_2$)-doped tamarind seed polysaccharide (TSP) biopolymer electrolyte films. Different compositions of the biopolymer and dopant salt were used in the ratios of TSP : $MgCl_2$ (90 : 10, 80 : 20, 70 : 30 and 60 : 40 wt.%). The XRD and DSC plots confirmed the highest amorphous nature for the optimum composition TSP : $MgCl_2$ (70 : 30 wt.%). AC impedance spectroscopy was used to determine the ionic conductivities of the prepared films. For TSP : $MgCl_2$ (70 : 30 wt.%), a maximum conductivity of 1.27×10^{-5} S cm^{-1} was reported at 303 K and 2.09×10^{-5} S cm^{-1} at 363 K. The values of the dielectric constant and dielectric loss were higher at lower frequencies and gradually declined with the frequency for all the films. The highest values of the dielectric constant and dielectric loss for the composition TSP : $MgCl_2$ (70 : 30 wt.%) were reported to be 3.87×10^4 and 2.08×10^5 respectively. Studies of the electric modulus spectra revealed the relaxation process that occurs in biopolymer electrolyte systems.

Keywords: Biopolymers, biopolymer electrolyte, electric modulus, impedance, tamarind seed polysaccharide, storage devices.

mainly two types of electrolytes: liquid and solid. Owing to their high ionic conductivity and fast ion transport, liquid electrolytes are commonly used in Li-ion batteries[2]. Solid electrolytes have also been explored as alternatives to liquid electrolytes in solid-state batteries because they offer advantages, such as safety, a wider range of operating temperatures, high-energy density, etc.[3]. Among the various types of electrolytes explored, polymer electrolytes are gaining significant attention as better replacements for liquid electrolytes in Li-ion batteries, offering safety, flexibility and higher energy densities. The incorporation of specific groups known as functional group (e.g. amides, esters) polymers has found several applications, one such application being the enhancement of conductivity[4]. A polymer electrolyte systems have been developed to achieve enhanced ionic conductivities along with a few desirable properties. Polymer electrolytes are also used in fuel cells, solar cells and supercapacitors, demonstrating their potential applications in energy storage technologies. Recent advances in the design of these materials have resulted in enhanced ionic conductivities for practical applications. These also offer safety compared to liquid electrolytes, thereby solving the problem of dendrite formation, to a great extent. Polymers also offer intrinsic flexibility, which enables the design of lightweight devices.

Although synthetic polymer electrolytes (SPEs) have