Abstract

ABSTRACT

Energy storage devices have a critical part to play in providing a cost-effective and dependable energy source. Batteries are our common storage solution, which is both reasonable and renewable to counteract climate change. The current batteries carry the risk of explosion or leakage due to their liquid electrolyte composition. But if replaced with a solid polymer and biopolymer electrolyte, their stability and battery safety can be improved. To this end, plant-sourced biomass is selectively chosen to form a solid bio-electrolyte, making the battery biodegradable and sustainable. Likewise, research for non-toxic, yet abundant materials resulted in these plant-based biomaterials. These materials comprise of agricultural wastes, plant by-products, and more. This study is focused on constructing a battery, an electrical storage device, utilizing a solid bio-electrolyte all derived from biodegradable sources, that is comprised of magnesium, lithium, and ammonium salts.

The first chapter concentrates on the various synthetic and biopolymer electrolytes utilized in energy storage systems and gives an understanding of the progress of different bio-degradable sources used to make strong electrolytes. Besides, this chapter provides a brief introduction to the benchmarks for bio-degradable materials to be used as electrolytes for battery applications. The second chapter delves into an extensive background analysis of the different liquid, gel, and solid electrolyte sources such as the synthetic and biopolymer electrolytes, biodegradable sources, and their composites that are used for the manufacture of different energy storage systems. Additionally, a review of the literature relevant to solid electrolytes and the current advances in the field of the present research is provided. The aim and scope of the present investigation along with the description and designation of the biomaterials used are explained in detail and tabulated.

The third chapter goes into detail about the chemical compounds and components that were used to produce a solid biopolymer membrane and bio-electrolyte, as well as the methods chosen for their preparation. It also describes the characterization techniques for these materials, such as Gas Chromatography-Mass Spectroscopy, Fourier Transmission-Infra Red Spectroscopy, X-Ray Diffraction Analysis, Differential Scanning Calorimetry, Linear Sweep Voltammetry, Electrochemical Impedance Spectroscopy, and Transference number measurement. This chapter also explains the preparation of all the bio-membranes

from their respective biomasses. This also illustrates the optimization of the biopolymer membranes from impedance plots. Furthermore, this chapter explains the method of constructing an ion-conducting battery from the prepared and optimized solid bio-electrolyte with magnesium, lithium, and ammonium salt as charge carriers.

In Chapter IV, the process of obtaining and extracting Corn-Silk biomass is discussed, as well as the preparation and characterization of a solid bio-membrane derived from the Corn-Silk extract. Polyvinyl alcohol (PVA) is infused into the extract to improve the amorphous nature of the membrane. Moreover, the use of $MgCl_2$, LiCl, and $HCOONH_4$ salts as ionic dopants is examined for the fabrication of Magnesium, Lithium, and Ammonium batteries. Fourier Transform Infrared (FTIR) analysis is then employed to evaluate the complex formation between the bio-membranes and the added salts. Thermal analysis is also performed to confirm the flexibility of the membrane. Finally, the prepared bio-membranes and the incorporated solid electrolytes are optimized by the AC Impedance technique.

In Chapter V, the collection and extraction of *Sargassum Muticum*, an aquatic vegetation, is explained. The bio-membrane and bio-electrolyte are prepared from the extracted seaweed and their characteristics are examined. FTIR technique reveals the complex formation between the extract, polyvinyl alcohol, and the added charge carrier. Differential scanning calorimetry (DSC) is used to study the thermal properties of the bio-electrolytes. Electrochemical impedance analysis is conducted to ascertain the ionic conductivity of the prepared bio-electrolytes and optimized for maximum efficiency. A battery that conducts primary ions is made with the bio-electrolyte membrane that has the most conductive capability and the open circuit voltage confirms the potential of this bio-membrane to be used as a reliable solid electrolyte in energy storage devices.

The sixth chapter examines the isolation and purification of Salmalia Malabarica gum and the creation of a solid bio-membrane from this exudate. Materials that come from natural sources have become increasingly popular due to their advantageous properties like biodegradability, biocompatibility, and sustainability, all of which are renewable. In addition, the development of bio-electrolyte for the fabrication of Magnesium, Lithium, and Ammonium batteries with $MgCl_2$, LiCl, and $HCOONH_4$ salts, which have an ionic conducting nature, is also established. Transfer Number Analysis is then conducted through Wagner's Polarization Technique and Evans's Polarization Technique, which evaluates the conductivity of the material.

The development of a bio-membrane based on Melezitose and magnesium salt incorporated bio-electrolyte is discussed in Chapter VII. The prepared bio-electrolyte is then characterized and analyzed in preparation for use in electrochemical devices. Based on AC Impedance analysis, Chapter VIII compares the ionic conductance of three biomass used for the preparation of bio-membranes. This chapter also discusses the efficiency of prepared bio-membranes from three different biomass and their bio-electrolytes based on their output circuit voltage, as well as the construction of magnesium, lithium, and ammonium ion conducting batteries.