Abstract

The present work attempted to uncover the structural modification and physical parameters in alkali sulfate based solid electrolytes that have been prepared by slow evaporation method of an aqueous solution containing M_2CO_3: H_2SO_4: H_3PO_4 (M=Cs, K and NH_4) systems with mole ratio 2: 1: 1, respectively. The work extended to replace potassium hydroxide (KOH) alkaline electrolyte solution in Nickel metal hydride battery by alkali sulfate based solid electrolytes and study the electrochemical properties of the battery. Furthermore, the work extended to synthesis hybrid from alkali sulfate based solid electrolyte (inorganic compounds) with one of the organic compounds, PMMA, to benefit from the electrical and mechanical properties of them, respectively.

Characterizations of the investigated samples have been done using X-ray diffraction, Infrared transmittance spectra, energy dispersive spectroscopy (EDAX), nuclear magnetic resonance (NMR) and differential scanning calorimeter (DSC). X–ray diffraction study showed that the samples are orthorhombic crystals. EDAX spectroscopy illustrated that ammonium sulfate is the only compound which the partial replacement of sulfur by phosphorus could be permitted. Nuclear magnetic resonance illustrated that alkali sulfates were incorporated by protons into a crystalline structure, especially, cesium sulfate. The DSC of the investigated samples showed different peaks characterizing the phase transitions.

The dc electrical conductivity of alkali sulfate based solid electrolyte samples was studied in a temperature range 273 - 470 K. The activation energies of conduction in the activated parts have been found.

The total conductivity of alkali sulfate based solid electrolytes was studied in the frequency range 500 Hz-1MHz and in the temperature range 273-470 K. The behavior of conductivity frequency dependence was found to be divided into two regions; one is observed at low frequency (dc conductivity) while the other appears at relatively higher frequency range. In general, this behavior obeys the relation, $\sigma_{tot} = \sigma_{dc} + A\omega^{s}$. The values of the power (s) of all samples have been found in the range 0.4 to 1.3.

The frequency and temperature dependence of the dielectric permittivity $\varepsilon`$ and dielectric loss $\varepsilon``$ of alkali sulfate based solid electrolyte were studied. The general behavior shows an anomalous behavior in $\varepsilon`$ and $\varepsilon``$ at the transition temperatures. The values of $\varepsilon`$ and $\varepsilon``$ show a decreasing behavior as the frequency is increased. The bulk conductivity σ_b and relaxation time τ have been obtained by means of the complex impedance technique.

The total conductivity of PMMA / alkali sulfate based solid electrolyte composites was studied in the frequency range 500 Hz-1MHz and in the temperature range 273-373 K. The behavior of conductivity frequency dependence seemed to be divided into two regions for all samples that contain high concentration of alkali sulfate based solid electrolyte. In general this behavior obeys the relation, $\sigma_{tot} = \sigma_{dc} + A\omega^{s}$, while for all samples that contain low concentration of alkali sulfate based solid

electrolyte, the relation of frequency dependent conductivity can be reduced to $\sigma_{tot} = A\omega^{s}$.

The total conductivity of PMMA / alkali sulfate based solid electrolyte composites is studied as a function of the alkali sulfate solid electrolyte concentration. It is noticed that the conductivity increases with increasing alkali sulfate based solid electrolyte concentration. The general behavior can be understood in terms of the percolation phenomena and breathing polymer chain model.

The frequency and temperature dependence of the dielectric permittivity $\varepsilon`$ and dielectric loss $\varepsilon``$ of PMMA / alkali sulfate based solid electrolyte composites were studied. The general behavior shows anomalous behavior in $\varepsilon`$ and $\varepsilon``$ at the transition temperatures of the solid electrolyte. The values of $\varepsilon`$ and $\varepsilon``$ showed a decreasing behavior as the frequency and PMMA concentration were increased. The bulk conductivity σ_b and the relaxation time τ have been obtained by means of the complex impedance technique.

Rechargeable nickel metal hydride battery have been fabricated with the configuration Mg_2Ni // alkali sulfate based solid electrolyte // $Ni(OH)_2$. Cesium sulfate based solid electrolyte has been chosen as the best due to its good electrochemical characteristics. A maximum cell voltage of 1.2 V is obtained at full charge. The discharge characteristics have been improved with increasing the cycles of charging.