Effect of Nano filler on ionic conductivity of Solid Polymer Electrolytes

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Abstract: Due to its numerous uses in sensors, cell phones, and other electronic devices, as well as their light weight and high conductivity, solid polymer electrolyte batteries have recently grown in significance and utilisation. The research on these polymer electrolytes has drawn a lot of interest, opening up a new avenue for the study of battery development. Now is the time for scientists to examine solid polymer electrolyte batteries that are environmentally benign. Some attempts to develop such batteries that used sodium and potassium ions in polymer sheets for ionic conductivity were successful. The conductivity of PVP: CH_3COOK and PVP: CH_3COONa are examined in this review work in connection to the effects of nanofiller Al_2O_3. The produced film PVP:CH_3COOK:Al_2O_3 (80:20:1%) has a maximum ionic conductivity of 2.02×10^{-3} S/cm. Solid polymer batteries have been created using the suggested weight percent ratios of polymer films, and the discharge properties of the cell have been investigated. We are discussing structural and morphological studies of polymer films with Al_2O_3 nanofiller added to improve ionic conductivity.

Keywords: Polymer films, Ionic conductivity, Transport properties, Discharge parameters.

INTRODUCTION

Battery demand has skyrocketed, as has the battery's evolution and history. This is due to the fact that billions of people carry electric and electronic devices. Cell phones, laptops, and digital cameras are examples. Batteries convert chemical energy into electrical energy. The anode and cathode of a battery form an electrical circuit that powers an electronic device. Batteries should be safely disposed of once the electrical circuit is exhausted, but millions are thrown away every year. Batteries may seem harmless, but they can harm the environment. These include Mercury, Cadmium, Lithium, and Lead. Depleted batteries end up in landfills where they decay and leak. Chemicals leach from batteries and contaminate groundwater and surface water. Batteries pollute our aquatic ecosystems, which support thousands of aquatic plants and animals. This means we could be ingesting dangerous metals when we drink tap water. Undesirably unstable Lithium Batteries can smoulder for years in landfills. This causes breathing problems and contributes to global warming. The vaporised form of improperly exposed batteries also pollutes lakes and streams as rain. Lead and strong corrosive acids found in batteries can cause eye and skin burns. Batteries contain toxic metals such as nickel and cadmium, which are known human carcinogens. Any substance, radiation, or radionuclide that causes cancer is a carcinogen. When these agents mix with our air and water, we risk cancer. It has been linked to severe medical issues such as developmental & neurological damage and congenital disabilities. The Mysterious disease in Eluru town in the month of December 2020 in Andhra Pradesh, India, is the best example of the hazardous effects of battery waste. The Indian Council of Medical Research (ICMR), New Delhi report says that lead, nickel and cadmium contaminants are ten times more than the permissible level in water resources of Eluru town. We have answered these problems by making environmentally friendly batteries. In this review article we are discussing the possible attempts made in developing environmental friendly batteries. This article discusses environmentally friendly batteries made with solid polymer electrolyte films like PVP-CH_3COONa, PVP-CH_3COOK, were prepared with wt% ratios using the solution cast technique. The obtained films are characterized by measuring their ionic conductivity. Al_2O_3 nanoparticles are doped into the solid polymer electrolyte films to improve ionic conductivity further. PVP, Polyvinylpyrrolidone with linear formula $(C_6H_9NO)_n$ is a water soluble host polymer and is commonly used binder in many pharmaceutical tablets[1]. Potassium acetate (CH_3COOK) is commonly used in processed foods as a preservative and acidity regulator. Sodium acetate (CH_3COONa) is used as the carbon source for culturing bacteria and is commonly used in potato chips. Aluminium (III) oxide Al_2O_3 is the common ingredient in sunscreen and is sometimes used in cosmetics. These compounds are environmental friendly, water soliable and does not cause any hazardous effects on living things.

EXPERIMENTAL

Inorganic materials such as sodium acetate (CH_3COONa, CH_3COOK, and $Mg(OTf)_2$) with a purity of 98 percent, polyvinyl pyrrolidone (PVP) with a molecular weight of 36,000 g/mol, and aluminium oxide (Al_2O_3) with a purity of 99 percent were purchased from Sigma Aldrich chemicals in India. NCP films were made by mixing the right amount of inorganic salt with the right amount of nanofiller in the host PVP polymer. All of the compounds were mixed in wt percent ratios of (95:5), (90:10), (85:15), and (85:15), respectively (80:20) for pure salt. For nano filler the compounds were mixed in wt percent ratios of (95:5:1), (90:10:1), (85:15:1), and (85:15:1), respectively (80:20:1). As a solvent, triple distilled water was used. For thorough dissolution, the chemicals were placed in a conical flask and stirred continuously for 24 hours. The solution was then placed into polypropylene petridishes and let to evaporate for 48 hours in a hot air oven at 60 degrees Celsius. At various wt percent ratios, PVP-CH_3COOK[2], PVP-CH_3COONa[3], PVP-$CH_3COOK:Al_2O_3$[4] and PVP-$CH_3COONa:Al_2O_3$[5] electrolyte films were made. Finally, until further characterization, the produced films were stored in a vacuum desiccator to remove any moisture traces.

RESULTS AND DISCUSSION

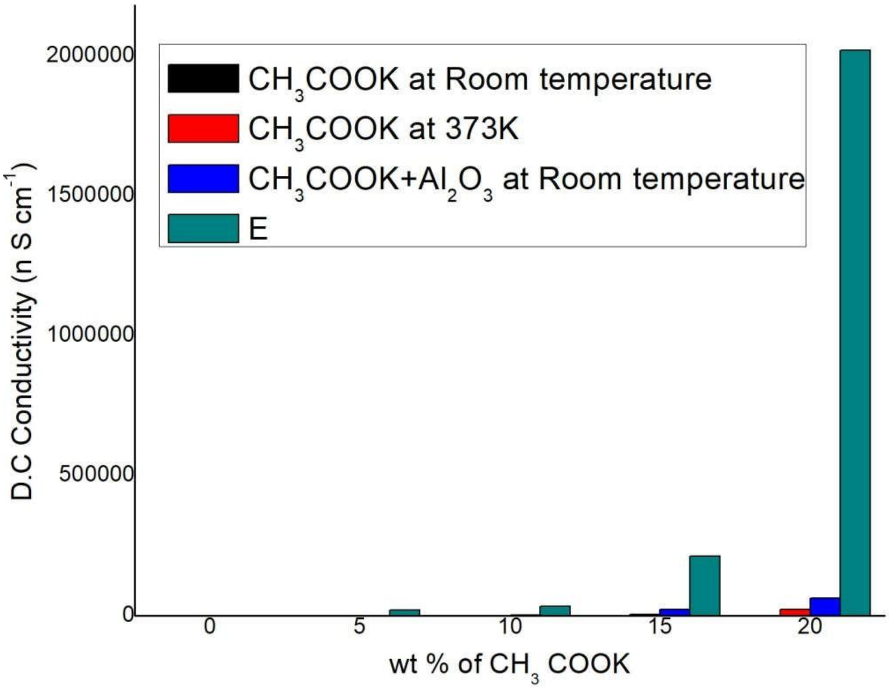
S. No	solid polymer electrolyte film with wt% of CH_3COOK	Conductivity ($nScm^{-1}$)		Conductivity with nano filler ($nScm^{-1}$)	
		At Room temperature	at 373 K	At Room temperature	at 373 K
1	0	1.02	11.3	1.02	11.3
2	5	31.2	310	42.1	21000
3	10	40.5	415	3010	35200
4	15	121	5100	23100	213000
5	20	625	23100	63500	2020000

Table 1. D.C Ionic Conductivity of PVP:CH_3COOK + Al_2O_3 NCP films

S. No	solid polymer electrolyte film with wt% of CH_3COONa	Conductivity ($nScm^{-1}$)		Conductivity with nano filler ($nScm^{-1}$)	
		At Room temperature	at 373 K	At Room temperature	at 373 K
1	0	1.02	11.3	1.02	11.3
2	5	31.1	306	41.1	5220
3	10	40.7	411	3010	33100
4	15	120	5130	21200	205000
5	20	621	21300	62200	1030000

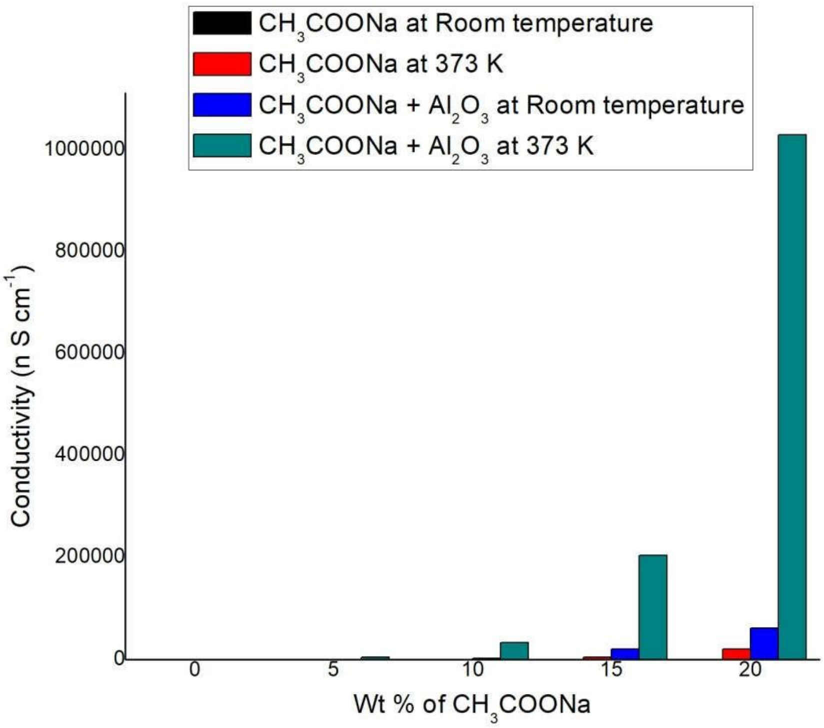
Table 2. D.C Ionic Conductivity of PVP:CH_3COONa + Al_2O_3 NCP films

The d.c. ionic conductivity of the prepared polymer films are listed in the table 1 and table 2. The conductivity of the polymer films for the both the salts is increasing with increasing of wt% of the salts. When compare both the salts CH_3COOK solid polymer electrolyte (SPE) films shows more conductivity than the CH_3COONa SPE films. The conductivity of the both films increases with increasing temperature. We report the conductivity at room temperature and at 100 ^oC. The maximum conductivity for CH_3COOK SPE films without nano filler is observed as $2.31x10^{-5}$ Scm^{-1} at 100 ^oC for (80:20) wt%[2]. The maximum conductivity for CH_3COONa SPE films without nano filler is observed as $2.13x10^{-5}$ Scm^{-1} at 100 ^oC for (80:20) wt%[6]. By adding the Al_2O_3 nano filler the conductivity of the both SPE films are increases from 100 times to 1000 times. The maximum conductivity for CH_3COOK SPE films with nano filler is observed as $2.02x10^{-3}$ Scm^{-1} at 100 ^oC for (80:20) wt%[4]. The maximum conductivity for CH_3COONa SPE films without nano filler is observed as $2.13x10^{-5}$ Scm^{-1} at 100 ^oC for (80:20) wt%[5]. Because of ions in the polymer matrix are retained, the conductivity of the films is enhanced, resulting in a reduction in the crystalline structure. [7]. The non porosity character of the films is one of the factors for the higher weight percent ratio. As a result, the film's glass transition diminishes, leading to a significant rise in ionic conductivity. Ionic conductivity can also be diminished by raising the salt concentration. [5]. This could be owing to the dissociation of ions and their carriers, causing a reduction in mobility. This demonstrates that the open exchange of sodium or potassium particles occurs in the host, resulting in greater ionic conductivity. In the graph following, the change in d.c ionic conductivity of the solid polymer electrolyte films with and without nano filler is demonstrated for both SPE films. We can see from the graphs that adding the appropriate nano filler to the organic salts results in a



fantastic boost in conductivity.

Fig.1 The variation of D.C. Ionic Conductivity of CH_3COOK Solid Polymer



Electrolyte films with and without nano filler at room temperature and at 100 ^{o}C.

Fig.2 The variation of D.C. Ionic Conductivity of CH_3COONa Solid Polymer Electrolyte films with and Without nano filler at room temperature and at 100 ^oC.

CONCLUSION

The results in the ionic conductivity of the polymer electrolyte films for both sodium acetate and potassium acetate with adding suitable nano fillers will give good hope for developing environmentally friendly batteries. If we choose the suitable host polymer, organic salts which are less harmful to the environment, and the proper nano filler which is similar in size to that of the organic salt, we can develop good batteries to meet our present demand. It should be noted that every battery has a specific life time. After its possible number of recharges, it should be decomposed. If we take precaution in choosing the basic battery materials, that they should be eco-friendly, then we can save the environment, ecology and our human kind from the hazardous effects of pollution and toxicity of our natural resources.

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