ASSESSMENT OF THE IMPACT OF NANO FILLER ON THE IONIC CONDUCTIVITY OF SOLID POLYMER ELECTROLYTES

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Abstract:
Solid polymer electrolyte batteries have lately increased in relevance and usage due to their wide range of applications in sensors, mobile phones, and other electronic devices, as well as their light weight and high conductivity. The study of battery development has a new direction thanks to the popularity of the research on these polymer electrolytes. Now is the moment for scientists to explore solid polymer electrolyte batteries that are ecologically friendly. There have been some successful attempts to create batteries of this type that employ sodium and potassium ions in polymer sheets for ionic conductivity. This review study investigates the conductivity of PVP: CH3COOK and PVP: CH3COONa in relation to the impacts of nano filler Al2O3. 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

Both the history and demand for batteries have increased dramatically. This is because billions of people carry electronic and electric devices with them. Examples include digital cameras, computers, and cell phones. Chemical energy is transformed into electrical energy by batteries. An electrical circuit that powers an electronic device is created by the anode and cathode of a battery. When the electrical circuit has been used up, batteries should be carefully disposed of, yet millions are nonetheless discarded each year. Batteries may affect the environment even if they appear to be innocuous. They include lead, lithium, mercury, and cadmium. In landfills, depleted batteries deteriorate and leak. Batteries release chemicals that pollute both groundwater and surface water. Our aquatic habitats, which are home to countless of aquatic plants and animals are contaminated by batteries. This means we could be ingesting dangerous metals when we drink tap water. Undesirably unstable Lithium Batteries can shoulder 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	000

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 °C. The maximum conductivity for CH_3COOK SPE films without nano filler is observed as $2.31 x 10^{-5}$ Scm^{-1} at 100 °C for (80:20) wt%[2]. The maximum conductivity for CH_3COONa SPE films without nano filler is observed as $2.13 x 10^{-5}$ Scm^{-1} at 100 °C 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 $2.02 x 10^{-3}$ Scm^{-1} at 100 °C for (80:20) wt%[4]. The maximum conductivity for CH_3COONa SPE films without nano filler is observed as $2.13 x 10^{-5}$ Scm^{-1} at 100 °C 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.

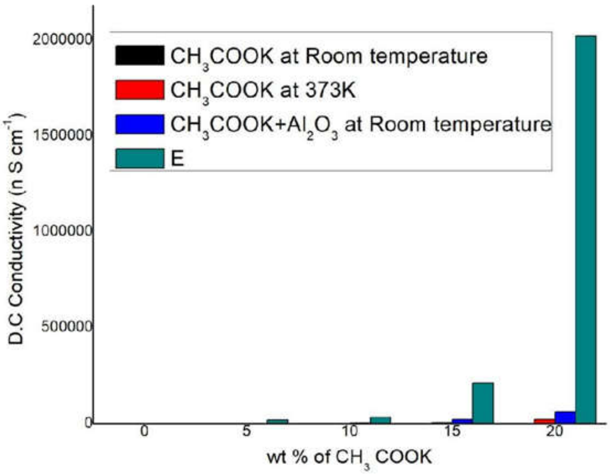

Fig.1 The variation of D.C. Ionic Conductivity of CH_3COOK Solid Polymer Electrolyte films with and without nano filler at room temperature and at 100 °C.

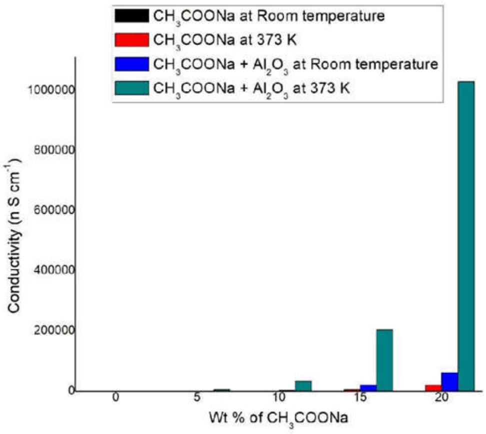

Fig.2 The variation of D.C. Ionic Conductivity of CH_3COONa Solid Polymer Electrolyte films with and Without nano filler at room temperature and at 100 °C.

CONCLUSION

With the addition of appropriate nano fillers, the polymer electrolyte films for sodium acetate and potassium acetate showed improved ionic conductivity, which is encouraging for the development of environmentally friendly batteries. We can create effective batteries to match our current demand if we pick the appropriate host polymer, organic salts that are less damaging to the environment, and the correct nano filler that is similar in size to the organic salt. Every battery has a specified life span, it should be noted. It should decay after the maximum amount of recharges. We can protect the environment, ecology, and our species from harmful battery materials if we exercise caution while selecting the fundamental battery components from the hazardous effects of pollution and toxicity of our natural resources.

REFERENCES

[1] V. Bühler, Berlin, Heidelberg, New York Springer. (2005).
[2] M.S. Kumar, M.C. Rao, Mater. Res. Express 5 (2018).
[3] M.S. Kumar, M.C. Rao, 080012 (2020).
[4] M.S. Kumar, M.C. Rao, Res. Rev. J. Phys. 8 (2019) 17–22.
[5] M.S. Kumar, M.C. Rao, Heliyon 5 (2019) e02727.
[6] M. Seshu Kumar, M.C. Rao, Mater. Today Proc. 5 (2018) 26405–26410.
[7] T.M. Bandhauer, S. Garimella, T.F. Fuller, J. Electrochem. Soc. 158 (2011) R1.