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The Preparation and Structural Study of PVA: NH4I Nano Composite Polymer Electrolyte System

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Abstract:

The composite polymer electrolyte system based on Polyvinyl alcohol (PVA) doped with Ammonium Iodide [NH_4I] with different weight percent ratios have been prepared by solution cast technique which is further sonicated by UV Sonicator to disperse the nanoparticles in the solution. Structural properties were studied by X-ray diffraction (XRD) technique which confirms the polycrystalline nature of thin film with a preferred orientation along (002) plane. The complex formation of salt with the polymer was confirmed by Fourier transform infrared (FTIR) Spectroscopy. Hence from FTIR spectroscopy and XRD the interaction between PVA and Ammonium iodide [NH_4I] and their complex formation have been confirmed. Hence, Material can be used for different applications like Electrochemical Devices, Sensors, Fuel Cell and Dye sensitised Solar Cell.

Keywords: Polymer Composite, UV Sonicator, XRD

Introduction:

Solid-state ionics (SSI) gained much importance in recent past. It encompasses many scientific branches from fundamental studies in Physics and Chemistry to practical applications in technologies. The fundamental studies are diverted to understand the mass transport processes in crystalline, amorphous, polymers and composite solid electrolytes, which are either inorganic or organic solids. The technological applications include fuel cells, gas sensors, batteries, super capacitors, electrochromic display devices, high temperature electrolysers, gas separation membranes,etc.[1] when charged carries are transported under the influence of external electric field. Solid materials conduct electricity either by electrons or ions. There are some solids wherein both the electrons and the ions take part in conduction, however. Noteworthy, ionic conduction is altogether different than that from electronic. Electric charge transfer accompanies the mass transport in former case. An ideal ionic conductor should have negligible electronic conductivity. Mixed conductors, on the other hand, are the solids, in which electrons as well as ions are freely mobile and both contribute to electrical conduction.[2]

The solid electrolytes are ionic conductors in which cations or anions can move if vacancies or interstitial lattice sites are available in appropriate proportion. In other words, ion mobility is possible because of disorders/defects in the lattice. The conduction mechanism can be different depending on structural disorders or defects present..Pure polymers often exhibit poor electrical conductivity. However, they can be made ion conducting by complexing/dissolving suitable ionic salts into them.[3-5] Certain Nanofiller composite polymer electrolytes being used associated with well-suited electrodes which has practical significance in several advanced types of power sources including hybrid electric vehicles. The emerging nanoscale

techniques has various application potential of nanostructured inorganic and organic materials which enhances the efficiencies of batteries. [6-8]

In this work, We prepared Solid polymer electrolytes based on polyvinyl alcohol (PVA) complexed with Ammonium iodide [NH_4I] powder at different weight percent ratios and characterized by using XRD and FTIR spectroscopic analysis. The structural properties of the polymer electrolyte films was confirmed by XRD. The complex formation of the salt with the polymer was confirmed by Fourier transform infrared (FTIR) spectroscopy.

Materials and Method:

Poly(vinyl alcohol) (PVA), with a degree of hydrolysis more than 99% and average molecular weight of 146000, was procured from Aldrich, USA with dopant Ammonium Iodide[NH_4I] powder. Polyvinyl alcohol which is a semi crystalline and biodegradable polymer has very important applications due to the role of OH group and hydrogen bonds.[9] Ammonium iodide (NH4I) is primarily used as a solid electrolyte in the development of proton-conducting polymer electrolytes, due to its high ionic conductivity and ability to facilitate proton transport within the polymer matrix. .[9-12] NH_4I can be easily incorporated into various polymers through solution casting techniques, creating stable polymer electrolyte systems.[12-14]

First of all, PVA was dissolved in Deionized water to which (NH_4I) was added in different wt% along with continue stirring (4 hours) to obtain homogeneous viscous solution. These homogenous viscous solutions were casted in a glass Petri dish and left to dry for a week to remove any residual solvent. These polymer films were cut into circular pieces for further characterization.

Results and Discussion:

1. **X-ray Diffraction**

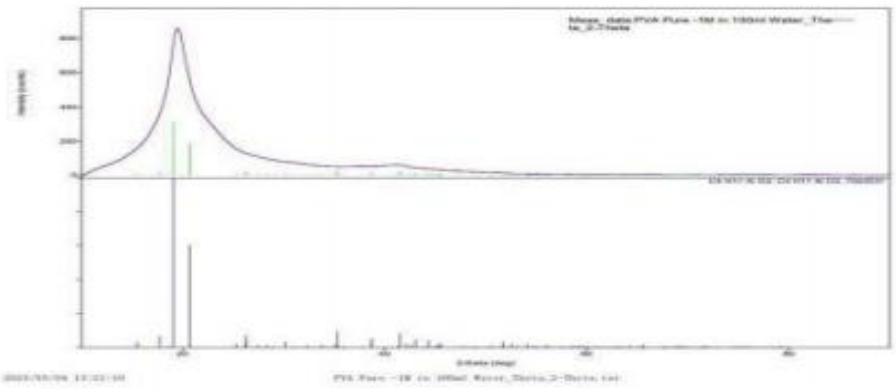

Fig. 1: X-ray Diffraction of Pure PVA

The XRD pattern of pure PVA shows the most intense diffraction peak is usually observed at 2θ = 15.52 and wavelength 79.78, which corresponds to the Monoclinic structure in fig.1.1.

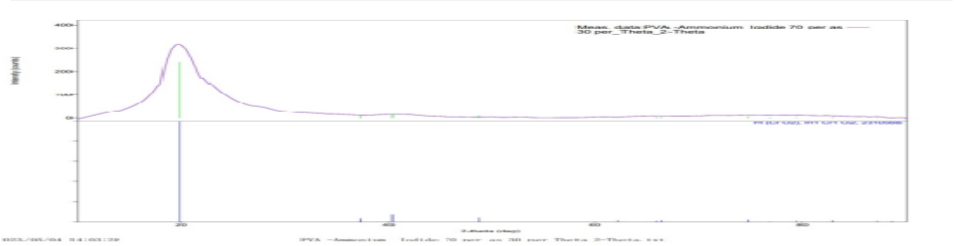

Fig. 1.2 X-ray Diffraction of PVA(70%) +NH4I(30%)

XRD spectra of pure PVA and NH_4I/PVA composite electrolyte polymeric films. As can be seen, and appearance for the peak around 2θ =19.86 and wavelength this 97.73 signifying semi- crystalline comportment in the character film is presented. Values of parameter a= 4.7870 b=4.7870 c= 4.7870 and angle α= 36.300β=36.300γ= 36.30 having volume =34.405 This values are very well matched with standard values. From this angles and parameter we say this structure of monoclinic structure.

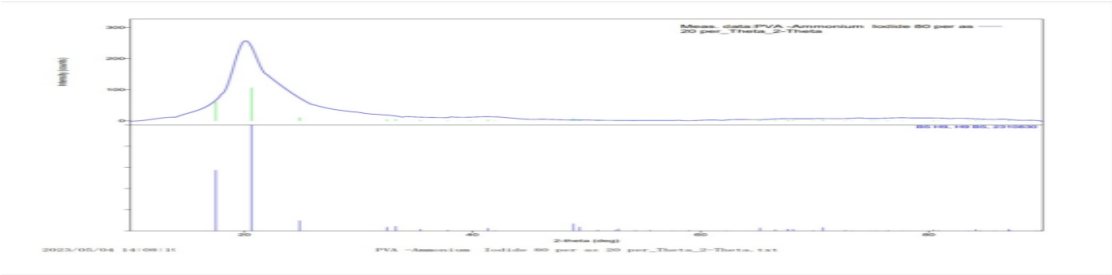

Fig. 1.3 X-ray Diffraction of PVA (80%) +NH_4I(20%)

XRD spectra of pure PVA and NH_4I:PVA composite electrolyte polymeric films. As can be seen, and appears for the peak around 2θ =17.50 and wavelength is 99.06 signifying semicrystalline comportment in the character film is presented. Values of parameter a= 7.1600 b=7.1600 c= 5.3800 and angle α= 90.000 β=90.000 γ= 90.000 having volume =332.997 This values are very well matched with standard values. From this angles and parameter we say this structure is of monoclinic structure.

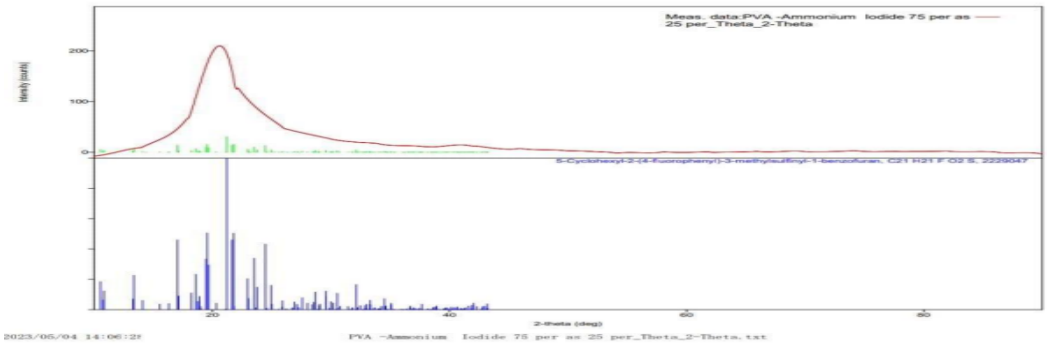

Fig. 1.4 X-ray Diffraction of PVA (75%) +NH_4I(25%)

XRD spectra of pure PVA and NH_4I/PVA composite electrolyte polymeric films. As can be seen, and appears for the peak around 2θ =9.43 and wavelength is 43.22 signifying semi- crystalline comportment in the character film is presented. Values of parameter a= 16.4070 b=11.3751 c=18.7490and angleα= 90.000β=90.000γ= 90.000 having volume =332.997. This values are very well matched with standard values.

1. FTIR (Fourier Transform Infrared Spectroscopy):

Generally, the infrared spectroscopy includes the region of electromagnetic spectrum of approximately from 0.78 to 1000 μm. The most useful segment of the infrared region of the spectrum is from 2 to 16 μm. The absorption bands, which occur in this region, are due to the fundamental molecular vibrations. Consequently, they lend themselves for identification, qualitative analysis and band assignment. In fact, the matter absorbs infrared radiations selectively with respect to the wavelength. The presence of broad absorption peaks in FTIR spectra for all the samples is evident. The broadening of absorption peaks in each spectrum is attributed to semicrystalline/partial amorphousness of complexes. The broadening of absorption peaks increases with increase in increase in dopant concentration. Obviously such broadening of absorption peak(s) indicates increased amorphous nature owing to doping.

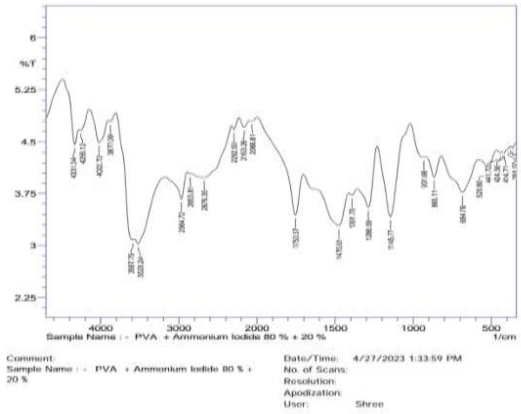

Fig. 2.1 Pure PVA

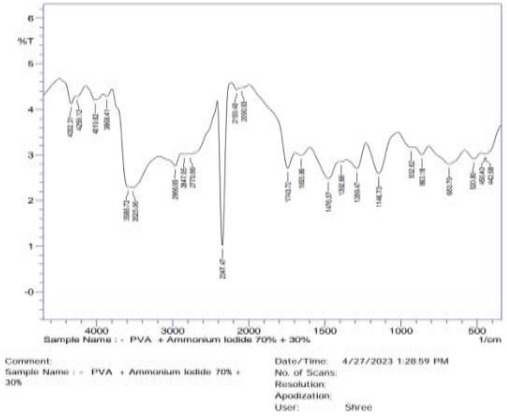

Fig. 2.2 70PVA:30 NH_4I

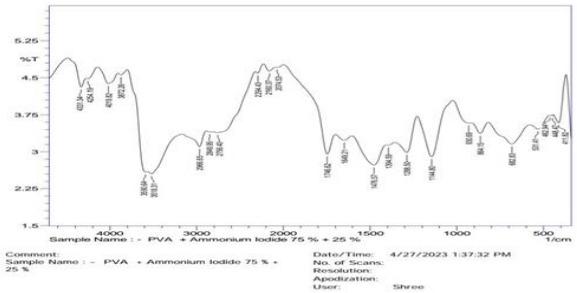

Fig. 2.3 75PVA:25NH_4I

PVA typically exhibits peaks in the FTIR spectrum at around 3200- 4000 cm^- 1 (O-H stretching), 2900 cm^-1 (C-H stretching), 1400- 1450 cm^- 1 (C-H bending), and 1100- 1300 cm^- 1 (C-O stretching). The presence of NH_4I may cause shifts or changes in the intensity of these peaks, indicating chemical interactions

between PVA and NH_4I. These peaks may become more pronounced or shift in position when NH_4I is added to PVA, indicating the formation of new chemical bonds or interactions.

Conclusion:

In this study the polymer thin films of pure PVA and doped with NH_4I are synthesized using Solution Cast technique. From x-ray diffraction it confirms polymerization of ploymer complex. From FTIR study it has been found that, the concentrations of NH_4I. (25%) increases the structural disorder. PVA before doping acts as an insulator and after doping it became semiconductor. The synthesis and characterization of PVA: NH_4I nanocomposites can lead to the development of new materials with improved properties for various applications. The physical and chemical properties of the nanocomposites can be tailored by adjusting the concentration of NH_4I nanoparticles. It is clear that PVA:NH_4I Nano composites can work in different applications like electronic, electrochemical devices as a Solid Electrolyte.

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