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RESEARCH ARTICLE

PREPARATION AND CHARACTERIZATION OF POLYVINYL ALCOHOL THIN FILMS FOR ORGANIC THIN FILM TRANSISTORS AND BIOMEDICAL APPLICATIONS

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ABSTRACT

Thin films of poly vinyl alcohol (PVA) were prepared on pre-cleaned glass substrates by Dip Coating Method. FTIR spectrum was used to identify the functional groups present in the prepared films. The vibrational peaks observed at 1260 cm^{-1} and 851 cm^{-1} are assigned to C–C stretching and CH rocking of PVA. The characteristic band appearing at 1432 cm^{-1} is assigned to C–H bend of CH_2 of PVA. The thickness of the prepared thin films were measured by using an electronic thickness measuring instrument (Tesatronic-TTD-20) and cross checked by gravimetric method. XRD spectra indicated the amorphous nature of the films. Surface morphology of the coated films was studied by scanning electron microscope (SEM). The surface revealed no pits and pin holes on the surface. The observed surface morphology indicated that these films could be used as dielectric layer in organic thin film transistors and as drug delivery system for wound healing.

Keywords: PVA, FTIR, XRD and SEM.

1. INTRODUCTION

In general, polymers are amorphous or polycrystalline substances, which have a great capacity of storing charges. Polyvinyl alcohol (PVA) is one of the promising representatives of polymeric materials and there are many proposals for its application in electronics, as well as packaging textile and food products due to its high clarity and excellent durability. In addition, PVA is used in the production of polarizing sheets (1,2). Due to the characteristics of easy preparation, excellent chemical resistance, good biodegradability and good mechanical properties, PVA has been used on many biomaterial applications (3). For example, PVA membranes have been used in the antioxidation, artificial pancreas, hemodialysis, and implantable biomaterials (4,5). The main purpose of this work is to study the morphological and structural properties of PVA films to identify the feasibility of using this PVA material for many other applications.

2. EXPERIMENTAL

The thin polymer film of polyvinyl alcohol (PVA) is deposited on pre-cleaned glass plate by Dip Coating method by isothermal immersion of a glass plate into the polymer solution of a suitable concentration held at a particular temperature for certain time. After bringing the solution to the required temperature the glass substrates, which has been cleaned well and held vertically above the solution inside the constant temperature bath by means of mechanical arrangement capable of slow and steady vertical moment are dipped inside the solution to deposit the films over the substrate. The substrates with deposited film were dried by keeping it inside the oven kept at 60^{0}C for 1 hr. The coated film thickness depends on i) nature of the substrate and solvent, ii) concentration and temperature of the solvent and iii) time for which the substrate is kept immersed in the solution. FTIR spectrums were used to identify the presence of the functional groups of the prepared films. The thickness of the coated films were measured by using an electronic thickness measuring instrument (Tesatronic-TTD-20) and cross checked by gravimetric method. The structural properties were investigated by using XRD and the morphology was studied by using Scanning Electron Micrographs (SEM). Pure PVA film of thickness 190 nm was used for FTIR, XRD and SEM analysis in the present investigation.

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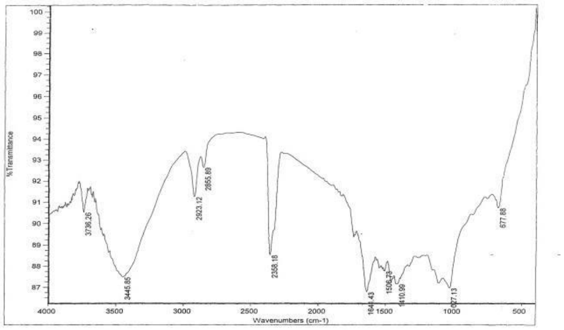
3. RESULTS AND DISCUSSION

The infrared spectrum of PVA thin film is shown in the figures 1. The spectrum of PVA film is found to be consistent with the previous reports in literatures for PVA film (6, 7, 8).



infrared spectrum of PVA thin films between 500 and 4000cm^{-1}

Fig. 1. FTIR spectrum of PVA film.

In general, the IR absorption bands of PVA are all quite broad and severally overlapped in 600-1500 cm^{-1} region. The O-H plane bending motion is coupled strongly with other molecular motions that involve frequencies in the range 600 - 1500 cm^{-1}. The bands at 677 cm^{-1} and 750cm^{-1} are assigned to out of plane O-H bending and γ(C-C) stretching vibration respectively. The band at about 1245 cm^{-1} results from wagging vibration of C-H. The band observed at around 1330 cm^{-1} result from wagging vibration of CH_2. The band at about 1410cm^{-1} is assigned to the symmetric bending mode $\gamma_\delta(CH_2)$. The bands at 1642 cm^{-1} and 1720 cm^{-1} of the carbonyl group are due to the absorption of the residual acetate groups due to the manufacture of PVA from hydrolysis of polyvinyl acetate. The absorption band obtained at about 2924 cm^{-1} result from stretching of CH_2 group. The relatively broad and intense absorption observed at around 3429 cm^{-1} indicates the presence of bonded O-H stretching vibration.

The bands at 660 cm^{-1} and 848 cm^{-1} are assigned to out of plane O-H bending and γ(C-C) stretching vibration and out of plane OH bending respectively. The band at about 1093 cm^{-1} is assigned to γ(C-O) stretching vibration of the ether groups. The band observed at 1332 cm^{-1} result from wagging vibration of CH_2. The band at about 1436 cm^{-1} is assigned to the symmetric bending mode $\gamma_\delta(CH_2)$. The bands at 1661 cm^{-1} and 1721 cm^{-1} of the carbonyl group are due to the absorption of the residual acetate groups due to the manufacture of PVA from hydrolysis of polyvinyl acetate (9). The relatively broad and intense absorption observed around 3380 cm^{-1} indicates the presence of bonded O-H stretching vibration (10).

Figures 2 shows the X-ray diffraction spectra of as grown PVA. The X-ray diffraction pattern indicates the large diffraction maxima that decrease at large diffraction angles.

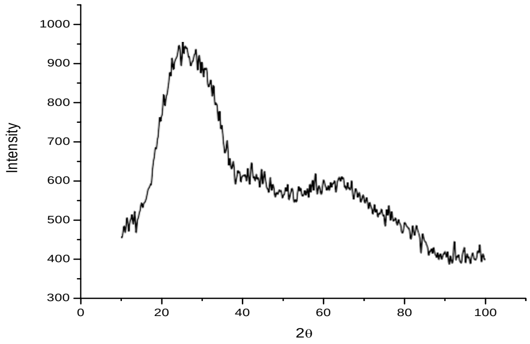


Fig.2. XRD spectrum of pure PVA film.

The first main maximum indicates the ordered packing of the polymer chains and the second maxima related to the effect of ordering inside the main chain. The diffraction of PVA film results from the strong intermolecular interaction between PVA chains through the intermolecular hydrogen bonding. The intensity of the diffraction peaks, the size of the diffraction peaks, and the size of the crystals are determined by the number of PVA chains packing together. The measurement revealed a broad pattern (characteristic of small particle size) for the as-prepared film. The absence of any intense peaks throughout the spectrum indicated the predominantly amorphous nature of the film.

The conclusive evidence of the occurrence of an amorphous state at the surface of the film is provided by SEM studies. The scanning electron micrographs of PVA film magnified to the order of 10000 is given in the Fig 3.

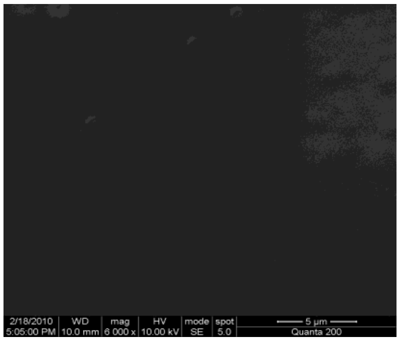


Fig. 3 SEM Micrographs of as grown PVA films.

The surface of the as grown PVA film appears to be very smooth and uniform. No pin holes and cracks are observed. The SEM figures again revealed the amorphous nature of the film. This amorphous nature agrees with the assumption made in the model of film growth proposed by Chandar Shekar *et al* (11). That is on dissolution, the entangled PVA chains open up and assume various poly dispersed conformations. As the substrate is immersed, the PVA chain segments closest to the substrate surface adsorb on suitable sites on the substrate. The PVA film grows initially by adsorption of the chain, which is indicated by the strong dependence of the initial growth rate of the film on the nature of the substrate. After the initial adsorption of the chain segment, the films started growing at the ends of the first chain. This process of layer by layer growth by relay-adsorption results in overlapping of the chains. The extent of random overlapping increases with increase of the number of chain segments adsorbed. Consequently the mode of growth yields an amorphous layer of PVA chains at a certain distance from the substrate.

4. CONCLUSION

Smooth and uniform thin films were prepared by a simple and cost effective Dip Coating method. The X-ray diffraction analysis indicated the amorphous nature of the films prepared. The broad humps obtained in the spectrum indicated the presence of crystallites of very low dimensions. The scanning electron micrograph indicated the amorphous nature. The obtained pinhole free, smooth, amorphous phase and uniform film surface implies the feasibility of utilizing these films as gate dielectric layer in organic thin film transistors and as drug delivery system for wound healing.

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