

The Comparative Study of PVA Powder and Film Using D.C Glow Discharge Plasma

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Abstract: *The PVA powder and film was exposed to the DC glow discharge plasma for surface modification. The plasma treated and untreated PVA powder and film was analyzed by Fourier transform infrared spectroscopy, UV-Visible Spectrum, Scanning electron microscopy, X-ray diffraction. The various results obtained are functional group confirmation, particle size, amorphous nature and absorption range of treated powder and film was compared with untreated powder/ film.*

Keywords: PVA powder/film, DC glow discharge plasma

1. Introduction

PVA is an important polymer, exhibiting piezoelectric, pyroelectric and ferroelectric properties. The typical advantages of PVA are flexibility, formability and Low density. PVA is a rubbery synthetic polymer and it is prepared by polymerization of vinyl acetate monomer, also referred to as VAM. Glow discharge is a technique in polymerization which forms free electrons which gain energy from an electric field and then lose energy through collisions with neutral molecules in the gas phase. This leads to many chemically reactive species, which then leads to a plasma polymerization reaction [1]. The electric discharge process for plasma polymerization is the low temperature plasma method, because higher temperature cause degradation. These plasmas are formed by a direct current or radio frequency generator [2]. Glow discharge polymerization uses plasma sources to generate a gas discharge that provides energy to activate or fragment gaseous or liquid monomer, often containing a vinyl group, in order to initiate polymerization. Polymers formed from this technique are generally highly branched and highly cross-linked and adhere to solid surface well [3].

2. Methodology

Non – Thermal plasma was generated using a dc glow discharge chamber. Atmospheric air was used as a plasma forming gas. The discharge chamber was first thoroughly cleaned and air tightened. Air in the chamber was completely evacuated using vacuum pump. The required air pressure was allowed through needle valve and the pressure was measured by pirani gauge. The electrodes inside the chamber was fixed perpendicular to the axis and separated by a distance 6cm. The high potential is applied between two electrodes. After getting steady discharge plasma, the PVA powder and film surface was exposed perpendicular to the axis through Teflon stick. The discharge potential and base pressure were kept constant at 400v and 0.3mbar, respectively. The powder and film was treated, after the plasma treatment the treated powder and film was analyzed. The result of the treated powder and film was compared with that of the untreated powder and film. The typical processing parameters as shown in table (1).

Table 1: Typical Operating Parameters For Plasma Processing

Discharge potential	450v
Pressure	0.03mbar
Exposure time	10mins
Electrode separation	6cm
Samples	PVA powder and film

3. Result and Discussion

3.1 FTIR Analysis

The FTIR spectrum of the sample was obtained at room temperature by using FT-IR spectrometer in the range 4000-500 cm^{-1} for plasma treated and untreated PVA powder and film [4]. Figure 1 shows the FT-IR spectrum of plasma treated and untreated powder and film. C-H in plane bending vibration and C=O in plane bending occur in both treated and untreated PVA powder. C-H symmetric stretching in CH₃ vibration, CH₂ asymmetric deformation, CH₂ twisting, C-C stretching and C=O out of plane bending are occur in both treated and untreated PVA film. After plasma treatment of PVA powder and film some additional groups are present. C-H stretching, C=O stretching, CH₂ twisting and CH₃ wagging are present in PVA powder. C=O in plane bending and C-CH₂ in plane bending are present in PVA film [5].

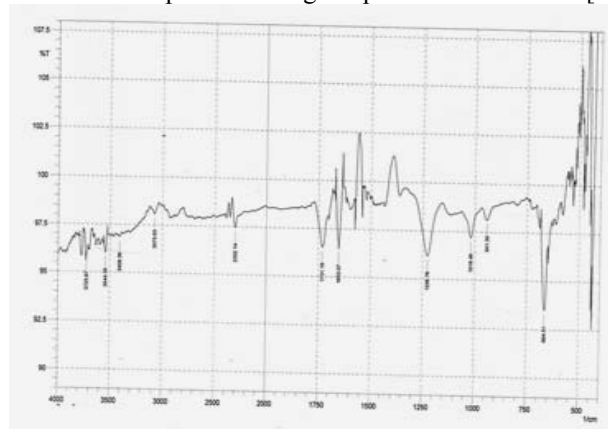


Figure 1: (a) FTIR Spectrum for untreated PVA Powder

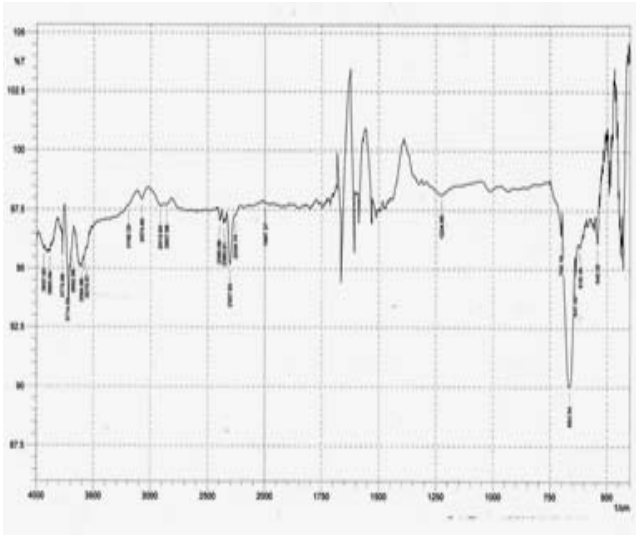


Figure 1: (b) FTIR Spectrum for plasma treated PVA Powder

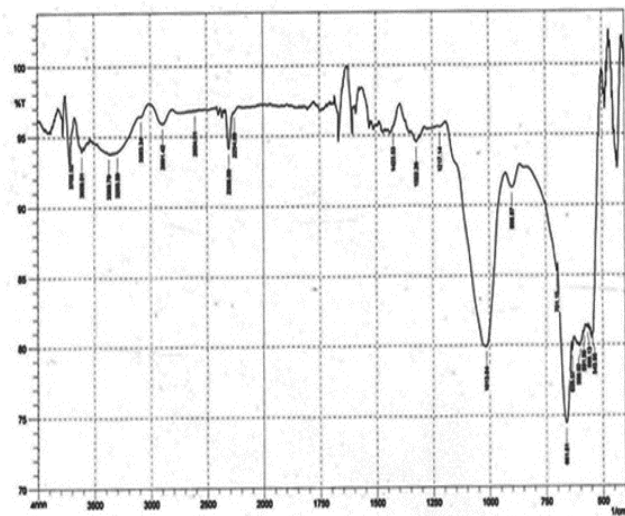


Figure 1 (c): FTIR Spectrum for untreated PVA Film

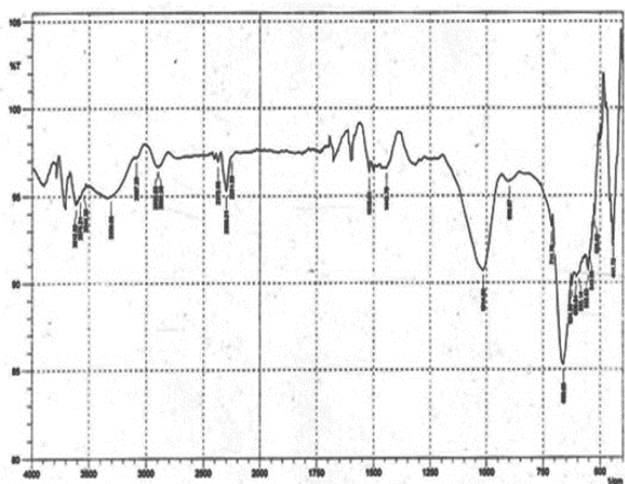


Figure 1: (d) FTIR Spectrum for plasma treated PVA film

3.2 SEM Analysis

Figure 2 shows the various magnifications of Field Emission Scanning Microscope images of untreated and plasma treated PVA powder. Large numbers of micro sphere particles have been observed with the size range from 53 to 375 μm for untreated PVA powder. The distribution of

particles is not uniform. This might be indicates the smooth surface of PVA powder [6]. It can be noticed that there was no pores have been observed from untreated sample, whereas porous structure was observed in some particles of plasma treated sample and also the distribution of particles are low. This result shows that the plasma treatment increase the porous structure and decrease the distribution of PVA molecules when compared to the untreated sample.

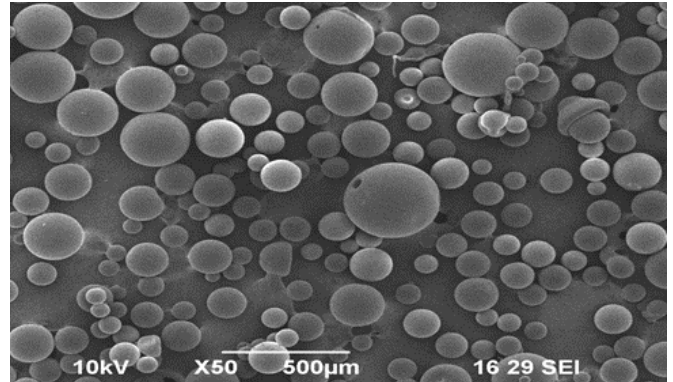


Figure 2: (a) SEM image of untreated PVA powder

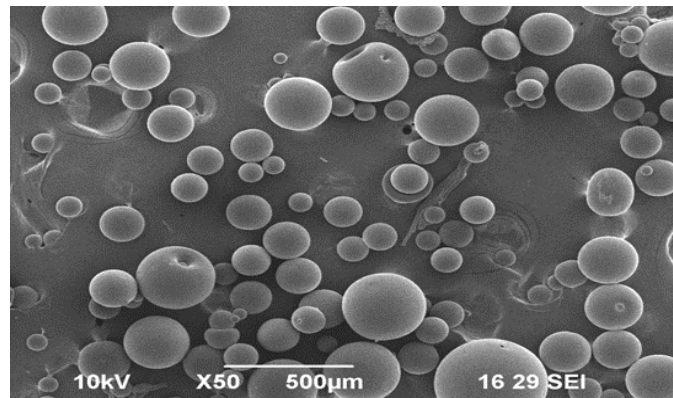


Figure 2 (b): SEM image of plasma treated PVA powder

3.2 XRD Analysis

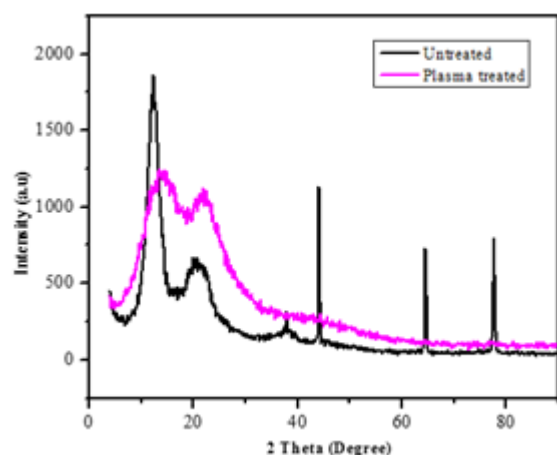


Figure 3 (a): XRD pattern of PVA powder

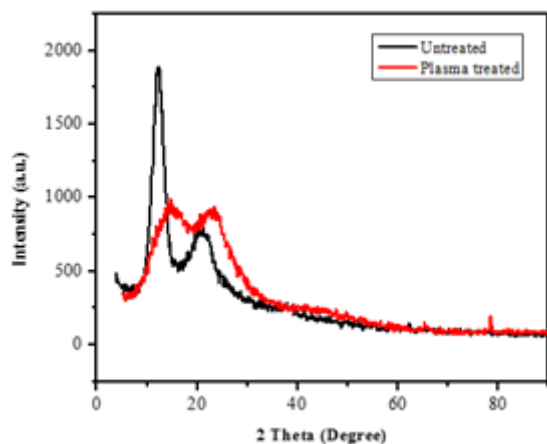


Figure 3(b): XRD pattern of PVA Film

The structure of the samples can be determined by X-Ray Diffraction technique. Figure 3 shows the XRD pattern of plasma treated and untreated PVA powder and film [4]. The sharp diffracted peaks have been observed from untreated PVA samples whereas the broader diffraction peaks obtained for plasma treated PVA samples. The decrease in the relative intensity of this diffraction peak with plasma treated PVA shows amorphous nature of the polymer [7]. Hodge et al established a correlation between the intensity of peak and the degree of crystallinity [8]. They have observed that the intensity of the peak in the XRD pattern of PVA decreases as the amorphous nature of PVA increases. The diffracted peaks of both powder and film are matched with the JCPDS card No. 49-2213.

3.3 UV –VIS Spectroscopic Analysis

The optical absorption spectrum of untreated and plasma treated PVA film were recorded in the range 200-1600 nm using UV-VIS-NIR Spectrometer. The Figure 4 shows that absorption against wavelength. The maximum absorption peaks occur at 280 nm and electronic transition changes from $n \rightarrow \sigma^*$ in untreated PVA film [9]. The redshift of absorption peak at 310 nm was observed in plasma treated sample, this is due to electronic transition of PVA molecules from $n \rightarrow \pi^*$. This result suggests that the absorption range was increased due to plasma treatment.

4. Conclusion

The PVA powder and film was exposed to D.C glow discharge plasma. The structural, morphological and optical properties have studied by X-ray Diffraction, Scanning Electron Microscope, Fourier Transform Infrared Spectroscopy and Ultraviolet Spectroscopy. These studies confirmed that the structural, optical properties of PVA samples are changed after plasma treatment. XRD result shows the amorphous nature of PVA sample was increased after plasma treatment. The particle size of 53 to 373 μm have been measured from SEM analysis. The plasma treatment creates some porous structure in the PVA molecules. The UV result suggested that the optical behavior of PVA sample was changed. The plasma treatment has changed the functional groups in PVA powder and film, it was confirmed by FTIR analysis. This study reveals that the plasma treatment affect the surface layers of the PVA

powder and film by nano level without affecting its bulk properties.

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