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# Impact of Ytterbium Ion on Substantial Effects of Biodegradable Equal Mixture of Polymer Blend of PVA and PVP

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**Abstract-** A biodegradable solid polymer blend films of PVA (50)/ PVP (50) filled with  $\text{Yb}(\text{NO}_3)_2$  were prepared by solution casting technique. The degree of amorphosity of the polymer blend composites was increased by the incorporation of filler into the polymer blend matrix. The decrease in the optical energy gap values was observed with the addition of filler which is illustrated by UV-Vis studies, indicating the interaction of filler with polymer blend matrix. With the temperature increase, the value of dielectric constant was found to increase depicting the more polar nature of polymer matrix. The tangent loss spectra of the samples showed a broad peak which confirms the presence of relaxing dipoles in the polymer composites.

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**Abstract-** A biodegradable solid polymer blend films of PVA (50)/ PVP (50) filled with  $\text{Yb}(\text{NO}_3)_2$  were prepared by solution casting technique. The degree of amorphosity of the polymer blend composites was increased by the incorporation of filler into the polymer blend matrix. The decrease in the optical energy gap values was observed with the addition of filler which is illustrated by UV-Vis studies, indicating the interaction of filler with polymer blend matrix. With the temperature increase, the value of dielectric constant was found to increase depicting the more polar nature of polymer matrix. The tangent loss spectra of the samples showed a broad peak which confirms the presence of relaxing dipoles in the polymer composites.

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## I. INTRODUCTION

The polymer blending technology turned out to be a brilliant means for modifying a polymer compound for specific uses/multifunctional device applications, often at much lower fabrication costs than the currently available material. Very often precise properties are achieved by blending crystalline and amorphous polymers. Crystalline polymers have outstanding chemical resistance, better mechanical properties, low viscosity whereas amorphous polymers provide good dimensional stability.<sup>[1]</sup> Solution blending is one of the simple blending techniques which have control over the physical properties of the miscibility compositional regime.

Poly (vinyl acetate) (PVA) is a semi-crystalline, water soluble, nontoxic synthetic polymer which has the highest application in polymer industry. PVA exhibits interesting physical properties due to the presence of OH groups which are responsible for hydrogen bond formation with other polymers.<sup>[2]</sup> Poly (vinyl piperidine) (PVP) is a low toxic amorphous vinyl polymer having outstanding physiological compatibility. PVP is soluble in water and most organic solvents.<sup>[3]</sup> The two polymers have polar side groups; PVA contains a hydroxyl proton

and PVP containing piperidine ring, which has a proton-accepting carbonyl group.<sup>[4]</sup> It is therefore expected that a hydrogen bonding interaction occurs between PVA and PVP.<sup>[5]</sup>

The superiority of polymeric materials is due to the aspects of their tremendous versatility and the amazing degree of tailoring to bring them closer to the novel applications. Polymers in combination with transition metal/ rare earth metal salts give complexes which find applications in high energy electrochemical devices. Dielectric properties of polymers play a dynamic role in device applications such as high performance capacitors, electrical cable insulation, electronic packaging to medical equipment, etc.<sup>[6]</sup>

Rare earth ions filled polymer blend composites are extensively investigated because of their useful applications. The intention of this work is to explain the possibilities of fabrication of new polymer composites containing rare earth ions to make them useful in technological applications. Rare earth metal ion  $\text{Yb}^{2+}$  has shown a significant effect on the crystallinity of the host matrix. Also, Optical, Mechanical and the Dielectric properties of pristine PVA (50)/ PVP (50) polymer blend films are improved with the addition of  $\text{Yb}^{2+}$  metal ions.

## II. EXPERIMENTAL WORK

Poly vinyl acetate (PVA) and (PVP) Poly vinyl piperidine (PVP) were purchased from Aldrich. Double distilled water was taken as a general solvent for both polymers and filler particles. Initially, PVA (50)/ PVP (50) stock solution was prepared according to the procedure explained by H. M. Ragab. [7] The uniform and homogeneous solution mixture of known quantities of  $\text{Yb}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  (5, 15, and 25%) were added to the polymeric stock solution after ultrasonication at room temperature for 30 minutes. The mixture was stirred continuously for 6-8 hours and then kept for 24 hours to remove the bubbles. The mixture was then transferred into polypropylene plates and dried in the oven for four days at 50°C to make the sample completely free from solvent traces. [8]

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### III. RESULTS AND DISCUSSIONS

#### a) X-ray diffraction analysis

Fig. 1 represents XRD scans on pristine PVA (50)/ PVP (50) blend and PVA (50)/ PVP (50) blend filled with various concentrations of Yb(NO<sub>3</sub>)<sub>2</sub>. In the XRD scan on pristine PVA (50)/ PVP (50) blend the main peak centered at about  $2\theta = 19.430$  reveals the semi-crystalline nature of the blend which confirms with earlier reported data. This peak has been shifted slightly in PVA (50)/ PVP (50) matrix filled with 5% and 15% filler to 19.720 and 20.460 respectively. Also, the close observation of the scans suggests that there is a drop in peak intensity values in the case of 5% and 15% filler

mixed blend composites. The absence of sharp peaks confirms the amorphous nature of the polymer blend composites. This may be due to the interaction between the blend and the filler which results in the decrease in intermolecular interaction between the polymers blend chains.[9] This amorphous nature is responsible for ion diffusion in the matrix which can be obtained in the polymers that have flexible backbone.[10] But in the case of 25% filler concentration, the peak reappears at 19.430 and the peak intensity again increases. This shows that lower filler concentration of rare earth metal ions is more effective as a filler in creating an environment which is favorable for ion diffusion in the present chosen blend matrix.

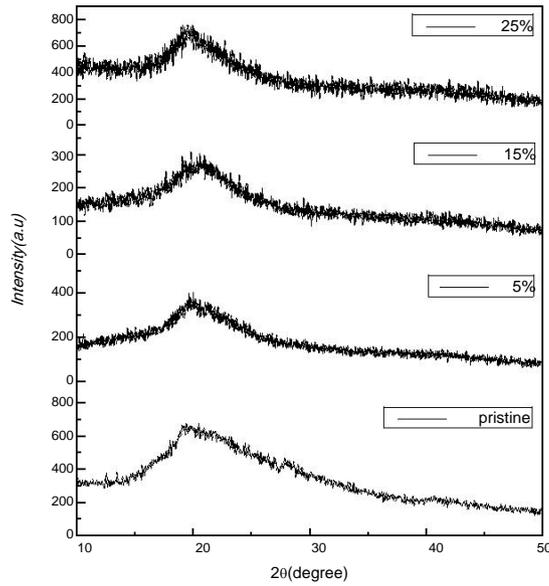


Figure 1: XRD scans on pristine PVA (50)/ PVP (50) and PVA (50)/ PVP (50) filled with filler

#### b) UV-Visible analysis

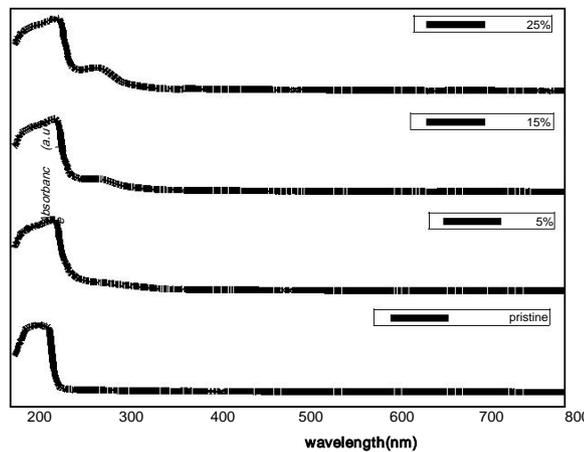


Figure 2: Absorbance vs Wavelength spectra of pristine PVA (50)/ PVP (50) and PVA (50)/ PVP (50) with filler

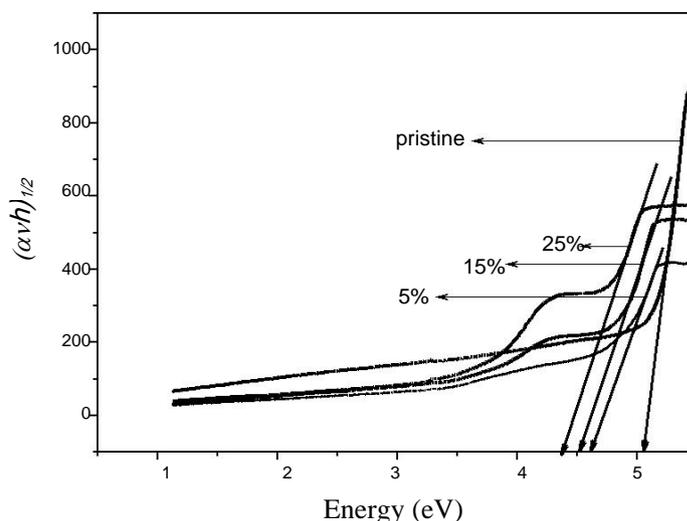


Figure 3: Plot of  $(\alpha hv)^{1/2}$  v/s  $(hv)$  for pristine PVA (50)/PVP (50)

The band structure of materials is well understood by subjecting the materials to UV-Vis analysis. Pristine blend showed absorption at 220nm. The filler mixed PVA (50)/ PVP (50) blend demonstrated high absorption probability above 220nm and below 250nm which is shown in Fig 2. This shows that there is a shift in the absorption wavelength compared to the pristine blend matrix. In the visible region, the samples were transparent. The absorption coefficient ( $\alpha$ ) is given by the relation,

$$\alpha hv = -B (hv-E_g)^r$$

Where,  $hv$ -incident photon energy,  $B$  –constant. Exponent  $r$  is found out from the slope of the linear part of the plot  $(\alpha hv)^{1/r}$  v/s  $hv$ .

Depending on the electronic transition that is taking place in the samples,  $r$  can take the value  $1/2$ ,  $3/2$ ,

2 and 3. From the optical absorption spectra recorded for the samples, best straight line fit is obtained for  $r = 2$ , which indicates that an indirect transition is allowed near the fundamental band edge [12, 13]. The values of the band gap energies are estimated from the extrapolation of the straight line part of the plot of  $(\alpha hv)^{1/2}$  v/s  $hv$  to the energy axis as the shown in Figure 3. The estimated values of the  $E_g$  are given in Table 1. It can be observed from the table that the  $E_g$  of the pristine PVA (50) /PVP (50) and Yb(NO<sub>3</sub>)<sub>2</sub> filled PVA (50) /PVP (50) polymer blend decreases with the increase in the concentration of filler. Also, the values recorded in the table justify the change in the behavior of polymer complexes tending towards semiconducting nature. This decrease in the energy band gap may be explained, that during polymer mixing, defects formation may occur, such as voids, which give rise to desirable localized states in the band gap of a material.[11, 12]

Table 1: Band gap energy ( $E_g$ ) for pristine PVA (50)/PVP (50) and filler incorporated PVA (50)/PVP (50) blend films

Samples	Pristine PVA(50)/PVP(50)	PVA(50)/PVP(50) +5% filler	PVA(50)/PVP(50) +15% filler	PVA(50)/PVP(50) +25% filler
Energy band gap (eV)	5.02	4.5	4.46	4.31

#### IV. CONCLUSIONS

Yb(NO<sub>3</sub>)<sub>2</sub> incorporated PVA (50)/ PVP (50) polymer blend films have been prepared using solution casting technique. X-ray diffraction scans have shown an increase in the amorphosity of composites which is a favorable condition for ion diffusion. Optical studies have confirmed the decrease in  $E_g$  with the increase of Yb(NO<sub>3</sub>)<sub>2</sub> making the material semiconducting in nature. All these significant results are obtained for 5% and 15%

filler concentration whereas higher concentration 25% is losing its role as effective filler. From the above investigations of physical properties, the results confirm that 15% is the optimized filler concentration showing significant improvement in many areas. Hence based on these results it could be recommended that this Ytterbium filled PVA (50)/ PVP (50) polymer composite films are found to be potential novel multifunctional materials for various optoelectronic and electro-mechanical devices.

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