Preparation & Optical Studies on Zinc Oxide: Poly Vinyl Alcohol (PVA) Composite

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Abstract— Optical properties of pure Polyvinyl alcohol (PVA) and ZnO doped composite films have been investigated. The composite samples of various concentrations were prepared by the well known solution casting method. The characterization of films were carried out using UV-VIS spectroscopy and Refractive index. The UV-VIS result shows that the absorbance of the samples is greatly affected by variation of concentration of zinc oxide (ZnO) particles. The optical band energy gap of pure and composite samples have calculated and reported. The refractive index result shows the variation in refractive index with wavelengths and with different concentrations of ZnO.

Key words: Zinc Oxide, Poly Vinyl Alcohol (PVA), Optical properties

I. INTRODUCTION

Nowadays need and demand for polymers has been increased a lot due to their scientific and technological applications. Physical and chemical properties of polymer which is required to specific application can be obtained by adding or doping metal salts[1]. While doping, the properties that change depends upon the chemical properties of the dopant and how it interacts with the host polymers. So here while doping, as a result of chemical interaction, the dopant induces structural defects within the polymer and chemical properties of a polymeric material. Poly vinyl alcohol (PVA) is one of the most important polymers with a very high dielectric strength, good charge storage capacity and dopant dependent electrical and optical properties. PVA is well-known for its optical clarity and good mechanical processing.PVA was first prepared in 1924 by Hermann and Haehnel by hydrolyzing polyvinyl acetate in ethanol with potassium hydroxide [2]. PVA has Chemical formula (C2H4O)x and density between 1. 91-1. 31 g/cm3.PVA is easily soluble in water therefore; it also has many applications in polymer engineering technology and other fields [2-3]. Zinc Oxide (ZnO) is an n-type wideband gap semiconductor with high optical transparency in the visible range. The various physical and chemical techniques like in situ methods, solvent casting, melt processing, chemical precipitation method, sol–gel methods have been employed to design and fabricate to obtain the desired architecture of PVA/ZnO composites [4-6]. Doping ZnO in PVA enhances various properties of PVA. Combining Zinc Oxide and POLY VINYL ALCOHOL gives improved electrical, mechanical and optical properties. This is a nontoxic, biodegradable nanocomposite which is environmentally friendly and can be used for food stuff packaging [7]. The three properties which control the interaction of electromagnetic radiation with matter are the specific conductivity, electric conductive capacity and the magnetic inductive capacity. These properties are related to the refractive index and the absorption index of the system [8].

The aim of the paper is to understand the effect of ZnO doping on the absorption properties of PVA.

II. EXPERIMENTAL DETAILS

A. Materials

PVA that has been used in the study was purchased from Thomas Baker Chemicals Ltd., Mumbai and ZnO from Merck Specialities Private Ltd., Mumbai. Purest forms of the chemicals were used. All the samples of PVA and ZnO composite films were prepared by solvent casting method. Distilled water was used for the preparation process.

B. Preparation

Pure PVA film and PVA/ZnO composite films were made for the present study by solvent casting method. For pure PVA film 2g of PVA was weighed and a solution of same which was made in 30 ml of distilled water was kept in magnetic stirrer to obtain clear solution. Then for the composite film different percentages of PVA(1.996, 1.992, 1.998, 1.984, 1.960) and corresponding ZnO (0.2, 0.4, 0.6, 0.8, 1.2) were measured accurately and the same was mixed with 25 ml of distilled water. The solution thus prepared for the different ratios of PVA and ZnO also kept in magnetic stirrer until clear and homogeneous solution was obtained. The solutions were casted on a flat glass plate separately and kept in the oven which was maintained at 600 C temperatures to obtain the film. Films were obtained when the solvents get evaporated. The films were kept in air tight bags for further characterization.

C. Characterizations

1) UV-Visible Spectroscopy

UV-Visible absorption spectroscopic study helps in understanding the electronic structure and band gap of the material. Absorption in the near ultraviolet region arises from electronic transitions associated within the sample. The UV–Vis absorption spectra of PVA/ZnO composite film has been recorded using Shimadzu UV-1800 UV-Visible spectrophotometer taken in the wavelength range190–1100 nm. The boundaries starting point λos of absorption edge zone is determined by straight-line extrapolation and wavelength direction intersection from UV–Vis absorption spectra. The band gap energy of catalysts is calculated by following equations [6]:

\[ E_g=1239.8/\lambda_{OS} \text{ eV} \]

where \( \lambda \) is wavelength in nm and energy band gap is in eV.

2) Refractive Index

The Refractive indices of pure PVA and composite films were calculated. The refractive index is one of the most important optical property for an optical material as it plays a very important role in optical communication and designing of the optical devices. It is related to the electronic polarization of ions and also the local field inside that optical material [9]. The refractive indices of films of pure
PVA and composite films incorporated with ZnO in different concentrations were carried out. For measuring the refractive indices of samples the Abbe's Refractometer has been used. The Refractometer was first calibrated by measuring refractive index for water using a monochromatic light source that is a sodium light source (589 nm) which illuminates the sample which is kept between the prisms [10]

### III. RESULT & DISCUSSION

#### A. UV-Visible spectroscopy

The optical characterization of films was carried out by UV-Vis spectroscopy. An absorption Spectra was obtained by UV-Vis spectroscopy in the range of 185–300 nm. PVA has very limited UV absorbance and absorbance in the uv region is enhanced with the addition of ZnO due to its high energy gap. ZnO particles not only absorb UV light but also scatter visible light. The sharp absorbance edge was observed between range 190-200 nm. It is observed that band gap is decreased due to blending with ZnO.

![Fig. 1: Absorbance spectra of Pure PVA and ZnO incorporated PVA composite samples](image1)

![Fig. 2: Energy band gap for PVA and PVA/ZnO blend films](image2)

#### B. Refractive Index

In this current paper the refractive indices of pure PVA and PVA composite films incorporated with ZnO were measured by spectroscopic measurements. The effect of doping ZnO in various concentrations on the refractive index was carried out. The refractive index of PVA film was decreased after doping and it also decreased as the wavelength was increased which is represented in Fig. 1.

![Fig. 3: Variation in Energy Band Gap with Doping Concentration of ZnO](image3)

![Fig. 4: Variation in Refractive index with wavelength for Pure PVA, and other ZnO incorporated blends](image4)

### IV. CONCLUSION

In the present study the optical characterization of films was carried out by UV-Vis spectroscopy and refractometer. The UV-VIS studies confirm that doping of ZnO enhances the absorbance of PVA. The energy band gap is calculated and is decreasing with the doping of ZnO. This confirms the disorder within the ZnO doped PVA film. The refractive index study reveals that the refractive index is decreasing with increasing wavelengths and increasing with increasing concentration.

### REFERENCES