Preparation and Characterization of PVA-NiO Composite

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Abstract: Polyvinyl Alcohol – Nickel Oxide composite have been prepared by solution cast technique with different filler concentrations (0.25, 0.5) wt%. The obtained films have the thickness of the order of 50 μm. X-Ray diffraction confirms the retention of NiO nanoparticles in PVA polymer matrix. In optical study the absorption spectra of the UV radiation were studied in the wavelength range 200-800 nm and the results were analyzed in terms of absorption formula for non-crystalline materials. The decrease in the optical band gap with concentrations suggests creation of new levels in the band gap.

INTRODUCTION

Industrial applications of polymers are introduced on a large scale. In industry majority of the plastic products are made from petroleum-based synthetic polymers that do not degrade in a land. Polymers that are produced from sugars, natural fibres, renewable forest resources, poly(lactic acid) and protein-nanoparticle composites are of prime importance in industries [1] There are many more opportunities for industrial applications provided by polymers like packing of prepared materials. Including all this water treatment, paper processing, mineral sequestering, textile processing, personal care products, pharmaceuticals, drug delivery, petroleum production, enhanced oil recovery, coatings and inks additives and sensors also are the applications of polymers [2]. In the present work we are taking Polyvinyl alcohol (PVA) which is a poly hydroxy polymer and one of the largest, synthetic, water-soluble polymer produced in the world based on volume. Doping is basically done for producing the original polymer with little or non-degradation of the polymer backbone [3]. Also the technique of doping metal nanoparticles to organic polymer modifies the properties and modes of applications in polymers. NiO is one of the oxide having wide band gap semiconductor with the absorption edge in the near UV–visible regionand it exhibit functional properties and offer promising candidature for many applications [4]. In present work, we have prepared PVA-NiO thin films having differentconcentrations of the dopant by using solution cast method. The structural properties of films were studied by using X-ray diffraction (XRD), absorbance of the films has been recorded by using UV-Vis spectroscopy.

EXPERIMENTAL

Nickel chloride hexahydrate($Nicl_2.6H_2O$), Sodium Hydroxide (NaOH), Polyvinyl alcohol(PVA) were used a raw material to get mother solution by using solution cast technique. Sol-gel technique was used to fabricate nickel oxide nanoparticles. For this sodium hydroxide solution was added drop wise to the nickel chloride solution to get precipitation. The desired solution was stirred continuously for 2 hours to get gel. After drying the powder was subjected to calcination at 290^0c in a muffle furnace to get black powder. In the second part the different concentrations of the nanoparticles were added in the polymer solution and stirred continuously by maintaining temperature up to 90^0C until the nanoparticle dispersed completely in the PVA solution to get the polymer composite. Then known volume of viscous PVA–NiO solution was poured onto a leveled clean glass plate and left to dry at room temperature for about 48 h [5].

XRD STUDY

To investigate the nanostructure and crystallinity of pure and NiO doped PVA composites, the X-ray diffraction analysis has been performed as shown in Fig. 1. For pure PVA a characteristic peak for an orthorhombic lattice indicate its semi crystalline nature, which arises due to strong intermolecular and intermolecular hydrogen bonding between the molecular chain of PVA[6-9] . In the graph a broad peak was noticed at 2θ~20° that can be granted to the Vander Wall distance of 5A°. A hexagonal ordering of the molecular chains appeared in the form of hump at about 2θ~42°. The pattern of 0.25 and 0.5 wt% NiO-PVA films exhibit low intensity (2 0 0) and (2 2 2) diffraction peaks indicates that NiO is successfully incorporated into polymer matrix.

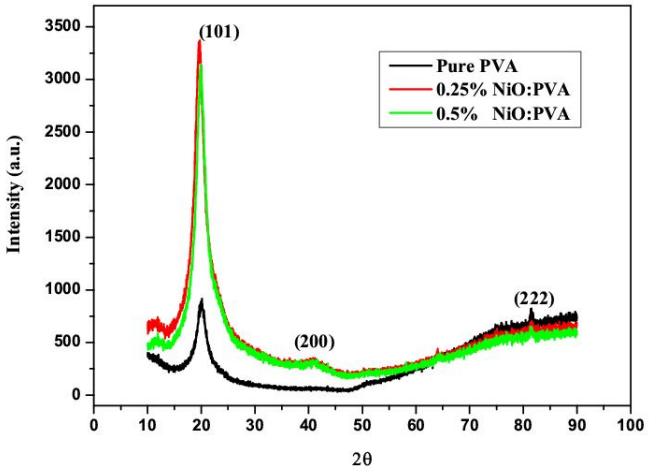

FIGURE 1. XRD spectra of NiO:PVA films

OPTICAL STUDY

Optical measurements done for both absorbance as well as transmittance (see Fig. 2). The results reveal that the pure PVA is less absorptive for UV radiation. Even a small increase in filler concentrations (0.5 wt%) leads to increase in absorbance up to 20%. Further a small shift in the absorbance edge towards the longer wavelength region with increase in NiO concentrations clearly indicates the interaction between the filler particles and PVA matrix, which leads to open the path to obtain the new structure for NiO:PVA composites. On the other hand the transmittance was also found to be consistent with absorbance which is low in the UV region and increase drastically in the visible region. As expected the transmittance is found to be decreased (from 95% to 89%) with increased filler concentrations. The results are in good agreement with XRD results where we obtained deteriorated crystalline microstructure, which enhances the optical scattering, hence decreased transparency.

The Tauc's relation [4] have been used to calculate bandgap

$$(\alpha h\nu)^{\frac{1}{p}} = A(h\nu - Eg) \tag{1}$$

The plotted results show (See Fig. 3) that band gap is decreased with increase in doping concentrations. It can be noted that for pure PVA band gap comes out to about 3.82 eV and after doping 0.5 wt% the band gap value decreases to 3.6 eV. This suggests that the involvement of the Ni in the polymer matrix results in the formation of localized levels within the band gap, which construct new paths for electrons and hence facilitates the electronic transitions from valance band to the conduction band [10,11].

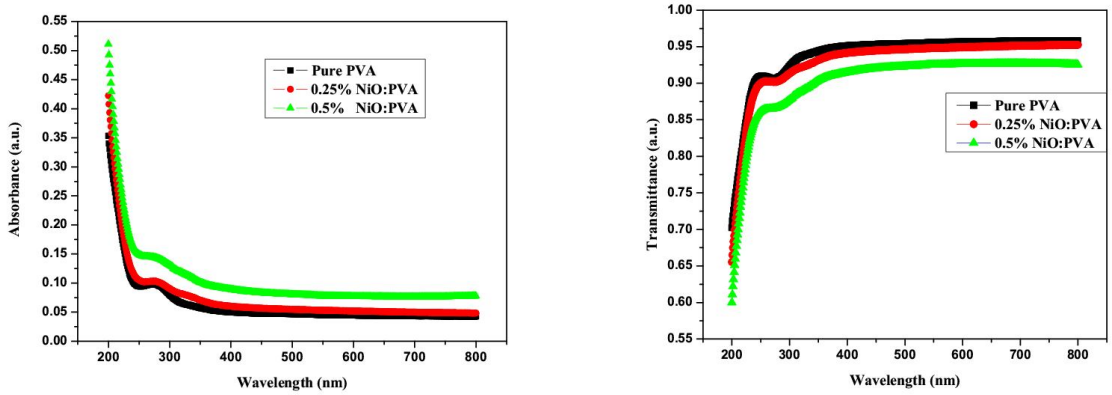

FIGURE 2. a) Absorptionspectra and b) Transmittance spectraNiO:PVA films.

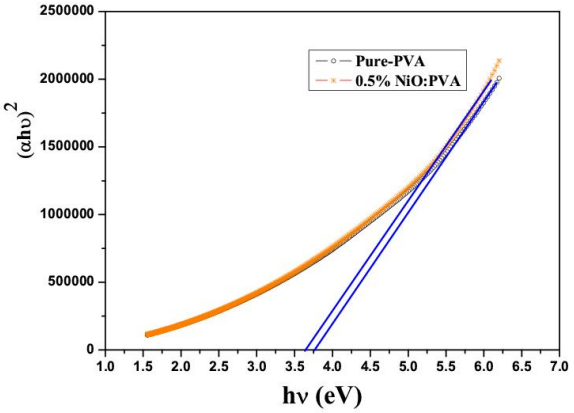

FIGURE 3. Optical bandgap of NiO:PVA films.

CONCLUSION

Composites of NiO:PVA containing 0.25 and 0.5 wt% of NiO have been obtained by solution cast technique; the effect of different filler concentrations on crystallinity and optical properties was studied. The XRD results revels that the NiO nanoparticles were completely dispersed in PVA matrix. Transmittance spectra makes it clear that even a small amount of Ni can strongly affect transparency, as low transparency of about 89% was shown by 0.5 wt% NiO doped PVA. A clear shift in the optical band towards high energy value with increase in filler concentration was observed, which indicates that an appropriate amount could be right enough to tune the properties.

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