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Optical and Luminescence Study of PVP/PPO Membranes

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Abstract: In the present work, Polyvinyl pyrrolidone/polyphenylene oxide (PVP/PPO) membranes have been synthesized by using spin coating technique. Optical and luminescence properties of membranes were studied by using optical absorption and florescence spectroscopic techniques. Two excitonic bands under the absorption edge have been observed in these samples. The optical absorption edge has been observed to shift towards higher wavelength side upon addition of PPO in the PVP matrix. A photoluminescence spectra in visible region (at ~500 nm) was observed to be enhanced in immiscible blend (50/50) composition with that for PVP polymer. Improved luminescence in visible region indicates the modification in structure-property relationship in PVP/PPO blend, which is required for its application in designing optical devices.

Keywords: Polymer matrix; Blend; Optical absorption spectroscopy; Florescence spectroscopy.

1 Introduction

Polymer blending is the simplest, most well-known technique in polymer engineering for creating new solid materials with more enhanced properties than homopolymers [1]**.** The formation of polyblends can be of two types; one in which there is a homogeneous mixing of components and in second, the mixed phases segregate to form phase separated blends. Multiphase polymer blends have attracted considerable scientific and industrial interest because of their importance in modern polymer industry [2]. Phase immiscibility has become a key factor in polymeric systems to explore the attractive features of each component in technological applications [3]. Spectroscopic studies have generally been used to elucidate structure-property relationship for wide variety of systems to understand their miscibility behavior as reported in literature [4-7]. Formation of highly miscible and homogeneous PVP/PVA blends have been ascribed to electrostatic interactions of polar carbonyl group (C=O) of PVP and hydroxyl group of PVA [4-5]. It means that, the functional group interaction results in the formation of miscible bends while non-availability interacting functional groups result in limited miscibility in the blends. Structure and properties of polyvinyl alcohol (PVA) have also been observed to improve with the effect of polyethylene oxide (PEO) blending [7].

In the present work, blending of thermally stable polyphenylene oxide (PPO) and thermally labile poly vinylpyrrolidone (PVP) polymers is studied by using optical and luminescence spectroscopic techniques. Non-availability of functional group in PPO limits interactions to weak Van der Waals type and its higher concentrations yields immiscibility with the formation of self-aggregates due to PPO component [8]. Therefore, present work report a systematic study of optical properties for PVP/PPO polymer blend system.

2 Experimental Details

Films of PVP blended with PPO in various compositions of (100/0), (50/50) and (0/100) in (wt %) were prepared by spin coating technique. Polymer PVP (Aldrich) and PPO (Aldrich) were used as purchased. Chloroform (Ranbaxy) as solvent is used for preparing polymer blend with the continuous stirring for about 3 h at room temperature. The polymer films were prepared by using spinning speed at 3500 rpm for 10s for evenly spreading the solution and then dried in air. These films were taken for optical absorption measurements using a UV-VIS spectrophotometer (UV160A, Shimadzu, Japan) and a photoluminescence emission spectra by using the fluorescence spectrophotometer (Lambda 45, Perkin Elmer, USA).

3 Results and Discussion

3.1 Optical Absorption and Luminescence Spectroscopy

The analysis of the optical properties such as optical absorption and a photoluminescence of the polymer

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systems are most vital tools for elaborating their electronic behavior are the most vital tools used. The study of absorption spectrum is a simple to know the processes of electron excitation from a lower energy state to higher energy state [9]. Optical absorption spectra for PVP/PPO films on quartz substrate are shown in the figure 1.

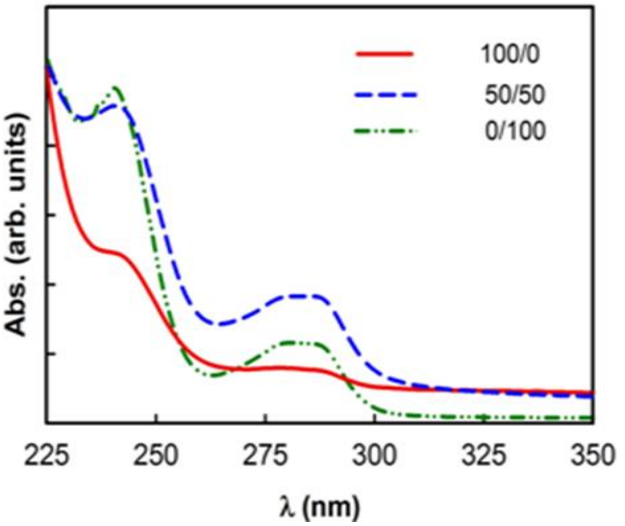

Figure 1. Optical absorption spectra for the PVP/PPO polymer films.

It has been observed that optical absorption edge shifts towards larger wavelength (lower energy) along with the increase in intensity and full width at half maximum for excitonic bands with the increase in the PPO content in PVP/PPO blend films. The absorption edge at 232.8 nm, accompanied with the shoulder peak at 246.2 nm and deconvolution of broad peak gives two peaks at 280.3 nm and 294.1 nm respectively for PVP films. Similarly, absorption edge at 256.8 nm following the shoulder peaks at 240.2 nm and one broad peak centered at 278.6 nm and 288.3 nm respectively has been observed for PPO films. These sub-gap absorption maxima can be ascribed due to the electronic transitions between different vibronic levels near to the band edges. Near the fundamental absorption edge, the absorption varies with the energy as: $(\alpha h\nu)^n = B\ (h\nu - E_g)$

Where E_g is the optical gap, n describes type of transition, i.e. n = ½, 2 for indirect band gap and direct band gaps respectively, and B is the constant, inverse of which tells about tailing parameter. Figure 2 shows variation of $(\alpha h\nu)^{1/2}$ and $(\alpha h\nu)^2$ versus incident photon energy hν for indirect and direct band gap respectively for the PVP/PPO polymer films and are summarized in Table 1.

It has been observed that direct and indirect optical gaps increased with the increase in PPO concentration in spin coated PVP/PPO films. This shift in absorption band edge towards higher wavelengths and increase in optical gaps upon PPO addition in PVP/PPO blends can be ascribed due to the role of mixing with gradual phase transition for two component system. Fluorescence or photoluminescence (PL) spectroscopy is an analytic tool for measuring emission of light from a polymer molecule that is in an electronically excited state [10].

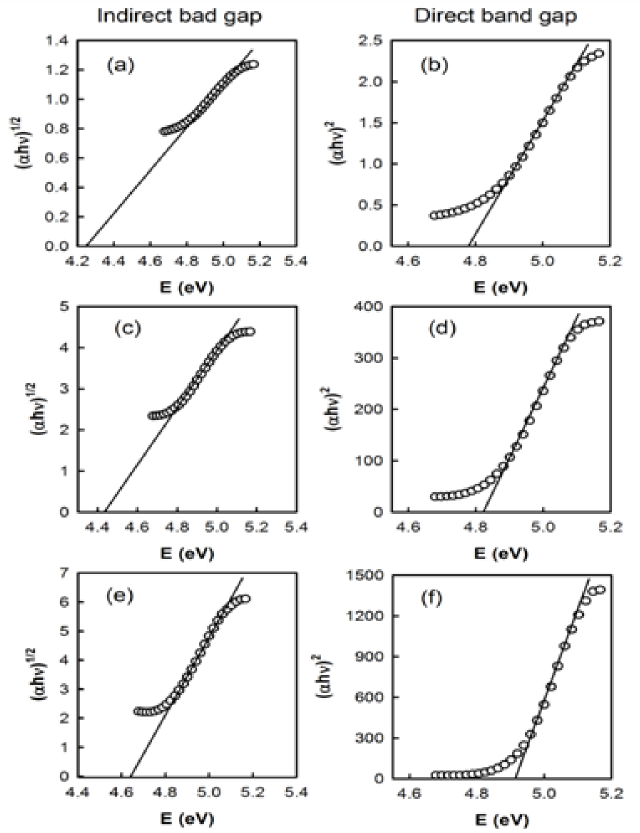

Figure 2. Variation of $(\alpha h\nu)^{1/2}$ and $(\alpha h\nu)^2$ versus photon energy (hν) for the indirect and direct optical gap for the PVP/PPO polymer films.

Figure 3 shows steady state fluorescence spectra at 250 nm excitation for PVP/PPO polyblends. Luminescence band at 480-530 nm has been observed for PVP, PPO and PVP/PPO films.

Intensity of a luminescence peak for PVP/PPO blend has been observed to increase as compared to pure PVP film (peak intensity at 501.2 nm). Improved luminescence in visible region indicates the modification in structure-property relationship in PVP/PPO blend, which is required for its application in designing luminescent devices. These phase separated PVP/PPO blends may provide an efficient route for efficient exciton separation or tailoring interfacial properties for low cost luminescent and photovoltaic devices.

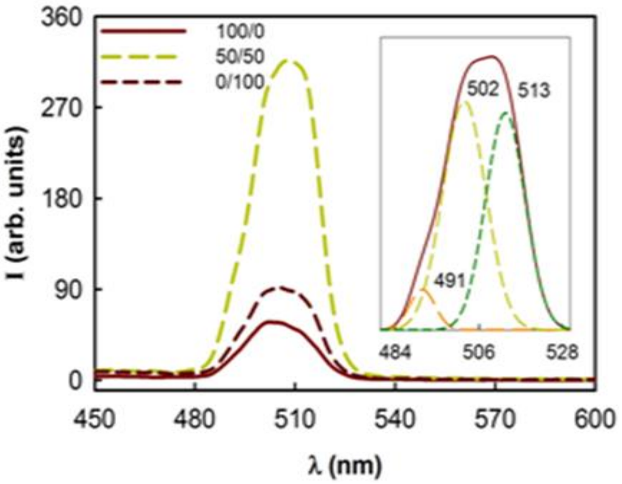

Figure 3. Fluorescence spectra of PVP/PPO films. The inset picture shows the deconvoluted spectra of the 50/50 polyblends

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Table1. Various optical parameters for the PVP/PPO system.

PVP:PPO (wt.%)	**E_O (eV)**	**Slope ($B^{1/2}$)**	**Excitonic peaks (±0.1nm)**		**Luminescence peaks (nm)**	
			1	**2**	**1**	**2**
100:0	4.11	1.22	284.3	294.8	501.2	513.3
50:50	4.39	6.47	278.1	288.6	502.2	512.9
0:100	4.62	12.40	278.6	288.3	499.9	511.9

4 Conclusions

Optical and luminescence properties of spin cast PVP/PPO polyblend are studied. Two excitonic bands under the absorption edge have been observed. Shift of absorption edge towards higher wavelength side upon addition of PPO in PVP matrix is also observed. Fluorescence spectra in visible region (at ~500 nm) are found to be enhanced in immiscible blend (50/50) composition with that for PVP polymer. Improved luminescence in visible region indicates the modification in structure-property relationship in PVP/PPO blend, which is essential for designing new low cost luminescent devices.

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