Refractive Index and Spectroscopic Studies on RhodamineB Doped Polystyrene Composites

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Abstract— RhodamineB doped Polystyrene matrixes have been prepared and characterized. From UV-VIS absorption studies, absorption coefficient and optical energy band gap have been found out using Tauc plot. Refractive index measurements were done at 390, 535, 590, 635 nm wavelengths, revealed that refractive index of the Polystyrene varies nonlinearly with the doping concentration. The dispersion did not follow Cauchy's equation.

Key words: Refractive Index, Polymers

I. Introduction

Polymers are emerging as an important class of materials, which offers challenging opportunities for both fundamental research and new technological applications. Polymer thin film coatings on solid substrates are of high technological importance due to their increasing potential of applications in electronics, sensors etc. These coatings are commonly used to optically match the refractive index of lenses and minimize reflections in optical components [1,2]. Polystyrene has attracted the attention of scientists for its interesting features and its superior physical and chemical properties, such as its good processability, rigidity, low water absorbability, transparency as well as its low cost which makes it required in many applications in industry [3, 4]. In the present work, the absorption coefficient, energy band gap, refractive index was determined, and the effect of RhodamineB doping concentration on some of its optical properties was studied.

II. Experimental Details

Different samples were obtained by dissolving, Polystyrene (PS) in benzene and taking different percentages of RhodamineB - as dopant -by weight, ranging from 0.1 % to 10.0%. Thin films were obtained by evaporating the solutions on glass substrates. The thin films were peeled off the substrate and were analysed by optical absorption studies using a Systronics UV-VIS spectrophotometer, - a microcontroller- based instrument - with a wavelength range of 200nm to 900nm. It offers a spectral bandwidth of 2nm over the entire range. The optical absorption study was done over a wavelength range of 200 to 900nm for RhodamineB doped polystyrene (PS). Refractive index measurements - at 390, 535, 590, 635 nm wavelengths - were done by using Abbe's refractometer. The analysis of data from the refractive index studies and absorption studies was done by using Mathematica software.

III. Result and Discussion

A. Optical Absorption Studies

The obtained optical parameters of PS are found to be strongly affected by RhodamineB used as dopant. The optical absorption study was done over a wavelength range of 200 to 900nm for RhodamineB doped polystyrene. Fig. 1 shows the absorption spectra of the prepared samples. The absorption increases as the RhodamineB percentage increases. The sharp peaks are observed at wavelength 561nm for almost all the doped samples.

Fig. 2 shows the dependence of $(\alpha h\nu)^2$ on the photon energy ($h\nu$). The optical energy gap was estimated from the extrapolation of the linear portion of the graph to the photon energy axis. It is observed that the Eg slightly decreased with increasing dopant concentration. The variation of the optical energy gap may reflect the role of RhodamineB in modifying the electronic structure of the PS matrix due to appearance of various polaronic and defect levels [5, 6].

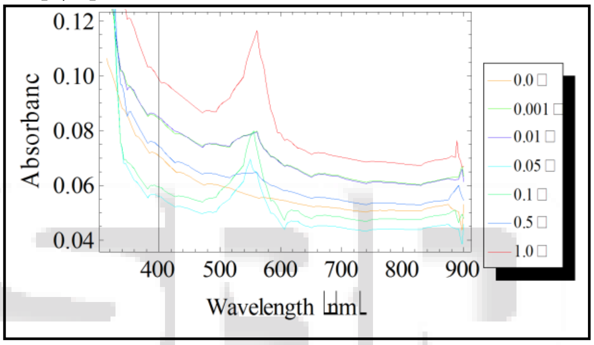

Fig. 1: Absorption Spectra of Pristine PS and RhodamineB doped PS samples

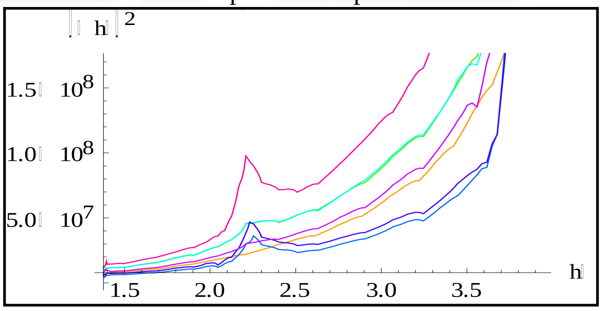

Fig. 2: Tauc plots for Pristine and RhodamineB doped PS samples

RhodamineB Doped PS by weight %	Eg (eV)
0.0%	3.2523
0.001%	3.1995
0.01%	3.1281
0.05%	2.9002
0.1%	2.5387
0.5%	2.4666
1.0%	2.4155

Table 1: Optical Energy Band Gap obtained for different samples.

Table1 shows the estimated value of the optical band gap energy of Pristine Polystyrene and Rhodamine B doped Polystyrene. It is observed that the Eg slightly decreased with increasing dopant concentration.

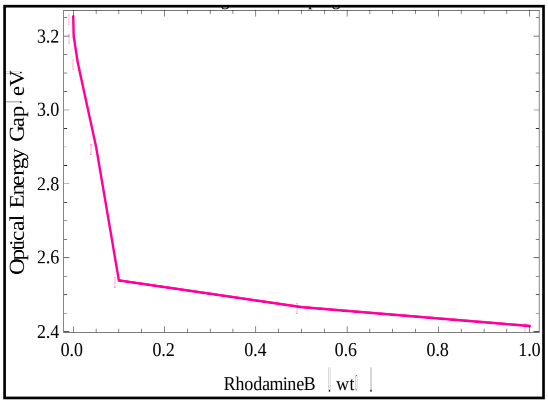

Fig. 3: Variation of optical energy gap Eg of PS with doping percentage of RhodamineB at different wavelengths.

Figure 3 shows the variation of optical energy gap Eg of PS with doping percentage of RhodamineB at different wavelengths. At low doping concentration ranging from 0.001% to 0.1% by weight percentage, the Eg value drastically decreases with increasing doping concentration of RhodamineB in PS matrix. From 0.1% to 1.0% doping concentration of Rhodamine B in PS matrix, the optical energy bad gap Eg value is almost constant.

B. *Refractive Index Studies*

Refractive index measurements - at 390, 535, 590, 635 nm wavelengths - were done by an Abbe's refractometer with an accuracy of +0.001. The above wavelengths were provided by introducing Schott filters of desired wavelength in the path of light through cold light source. The analysis of data from the refractive index studies was done by using Mathematica. The variation of refractive index of RhodamineB doped PS samples and the dependence on the doping concentration and annealing temperature has been discussed in this section.

1) *Doping Dependence*

Fig. 4 illustrates the variation of refractive index of unannealed RhodamineB doped PS samples by weight % at different wavelengths. It is observed from the figure that with doping concentration, the refractive index increases initially at a faster rate showing non linear behaviour at low doping concentration but slows down to exhibit linear variation at high doping concentration. From these Figures it is also evident that at lower wavelengths the refractive index is higher and at higher wavelengths the refractive index is found to be smaller. It is found that at highest doping wt%, dye molecules segregate to the surface breaking the bonds of the PS matrix as well as simultaneously forming new bonds, thereby modifying the overall refractive index [7].

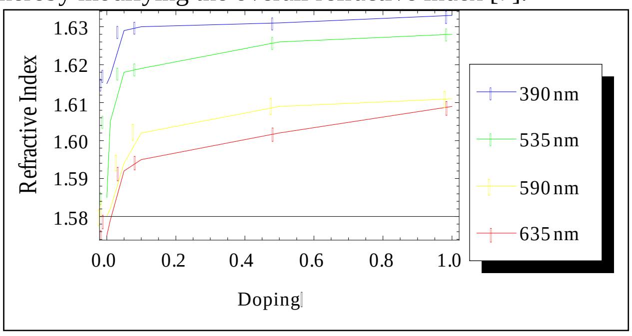

Fig. 4: Variation of refractive index of PS with doping percentage of RhodamineB at different wavelengths.

2) *Wavelength Dependence*

The frequency or wavelength variation of refractive index is called dispersion. Dispersion is an important property for optical design (i.e., correction of chromatic aberration) and in the transmission of information (i.e., pulse spreading). The refractive index shows a general decreasing trend with increasing wavelength shown in Fig. 5.

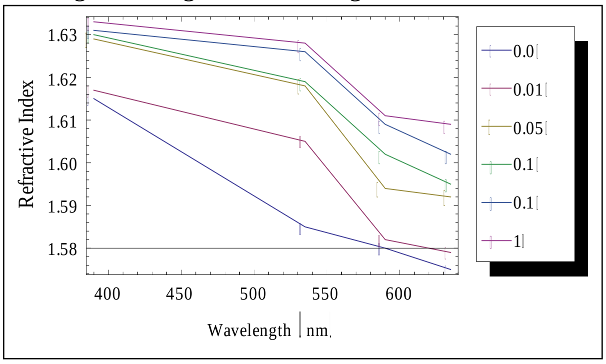

Fig. 5: Dispersion plots RhodamineB doped PS for different doping concentration.

IV. CONCLUSION

Polymeric materials are currently being investigated to both widen the physical properties and reduce the capital requirements in the production of photonic crystals. The refractive index of a material is the most important property of any optical system that uses refraction. It is used to calculate the focusing power of lenses, and the dispersive power of prisms [7].

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