Nano-Tailored Optical Properties of Iodine Doped Poly (Methyl Methacrylate) Composites

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Abstract— Iodine Doped Poly (Methyl Methacrylate) composites have been prepared and characterized. From optical 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 PMMA varies nonlinearly with the doping concentration. The dispersion did not follow Cauchy's equation.

Key words: Refractive Index, Polymers

I. Introduction

Organic polymers are extensively used in optical applications like lenses, optical waveguides and nonlinear optical devices. The physical parameter which plays a key role in the system design of the devices is the refractive index of the material. In the development of optical polymers, it is often required to have polymers with refractive indices within a certain range. One possible application of nanocrystals would be in nano tuned refractive index materials. In this present work, the preparation of nanoparticles is described by a solvent evaporation technique. The formation of nanoparticles is normally observed by a blue shift in the optical absorption spectra [1-2]. In the present work, the absorption coefficient, energy band gap, refractive index were determined, and the effect of Iodine doping concentration on some of its optical properties was studied.

II. Experimental Details

Different samples were obtained by dissolving, Poly(Methyl Methacrylate) (PMMA) in benzene and taking different percentages of Iodine - 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 study over a wavelength range of 390 to 630 nm using a Systronics spectrophotometer, Model 106, which offers a spectral bandwidth of 5nm over the entire range. 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 PMMA are found to be strongly affected by Iodine used as dopant. The optical absorption study was done over a wavelength range of 390 to 630 nm for Iodine doped Poly (Methyl Methacrylate). Fig. 1 shows the absorption spectra of the prepared samples. The absorption increases as the iodine percentage increases. It is very clear that high absorbance is observed at the lower wavelength region of spectrum. 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 increased with increasing dopant concentration. The variation of the optical energy gap may reflect the role of Iodine in modifying the electronic structure of the PMMA matrix due to appearance of various polaronic and defect levels [3, 4].

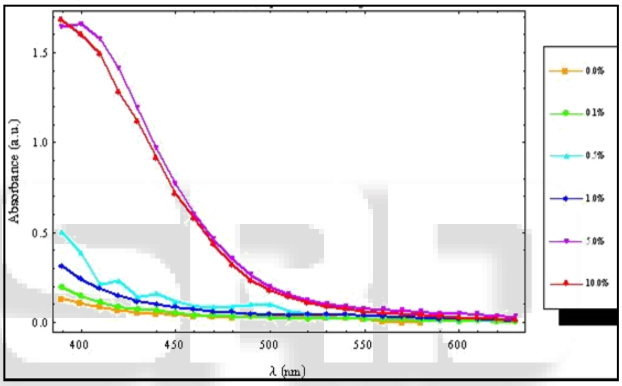

Fig. 1: Absorption Spectra of Pristine PMMA and Iodine Doped PMMA Samples

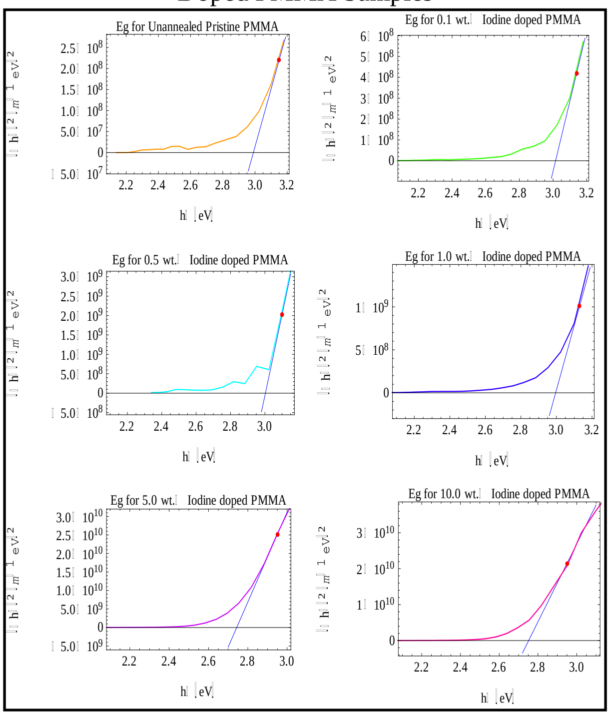

Fig. 2: Tauc Plots for Pristine and Iodine Doped PMMA Samples

Iodine doped PMMA by weight %	Eg (eV)
0.0 wt.%	2.99
0.1 wt.%	3.02
0.5 wt.%	3.01
1.0 wt.%	3.00
5.0 wt.%	2.74
10.0 wt.%	2.75

Table 1: Optical Energy Band Gap Obtained for Different Samples.

Table1 shows the estimated value of the optical band gap energy of Pristine Poly (Methyl Methacrylate) and Iodine doped Poly (Methyl Methacrylate). It is observed that the Eg slightly increased at low doping concentration.

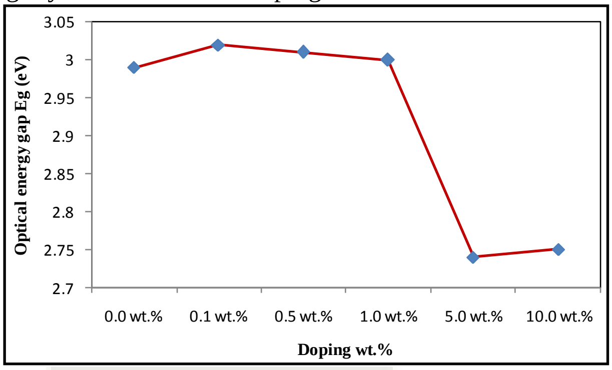

Fig. 3: Variation of optical energy gap Eg of PMMA with doping percentage of Iodine.

Figure 3 shows the variation of optical energy gap Eg of PMMA with doping percentage of Iodine. At low doping concentration ranging from 0.0% to 0.1% by weight percentage, the Eg value increases with increasing doping concentration of Iodine in PMMA matrix. From 0.1% to 1.0% doping concentration of iodine in PMMA matrix, the optical energy band gap Eg value is almost constant and drastically decreases from 1.0% to 5.0% doping level.

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 Iodine doped PMMA samples and the dependence on the doping concentration and wavelength has been discussed in this section.

a) Doping Dependence

Fig. 4 illustrates the variation of refractive index of unannealed Iodine doped PMMA 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 nonlinear 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.

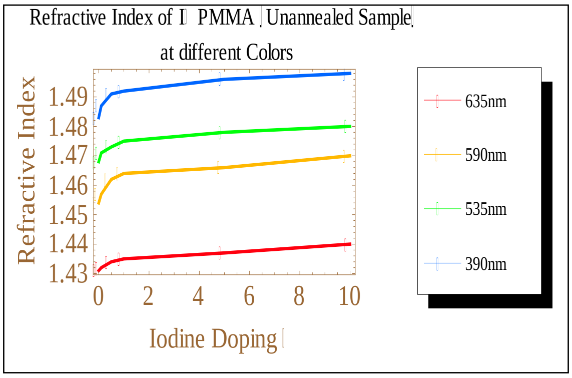

Fig. 4: Variation of Refractive Index of PMMA with Doping Percentage of Iodine at Different Wavelengths.

b) 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. Fig. 5 shows anomalous variation (©) of refractive index of unannealed PMMA with wavelength and compared with curves obtained from Cauchy's equation (ʃ); Sellemeier's equation (o); and modified Sellemeier's equation (ǀ).

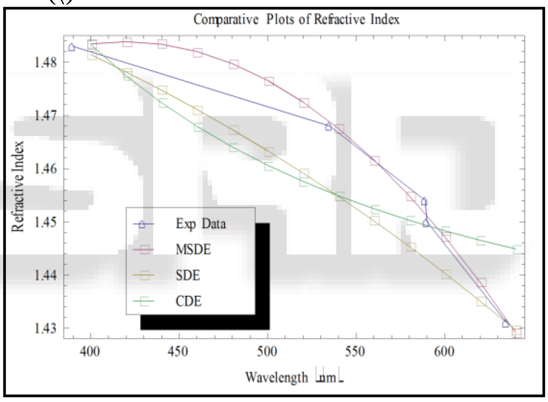

Fig. 5: Dispersion Plot of Iodine Doped PMMA.

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.

References

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