Comparison Between Beta and Gamma Irradiation on Optical Energy Gap of Crystal Violet Doped Polystyrene Films

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ABSTRACT

In this work, crystal violet doped polystyrene polymer films with different doping ratio has been prepared by casting method and synthesized optical energy gap by measuring the absorption spectrum for all samples by using UV-Visible spectrophotometer. The effect of Beta and Gamma irradiation on the optical energy gap are studied. The optical energy gap will change; decreased when effect gamma ray Comparison with effect of Beta ray. Polystyrene showed that is very sensitive to crystal violet dye and radiation.

Keywords: Optical Properties, Dye-Doped Polymer, Beta Irradiation, Gamma Ray, Crystal Violet, Polystyrene.

INTRODUCTION

The radiation processing of materials by Beta and Gamma ray on several kinds of plastics and dye doped polymer are widely used for routine dosimeter. This is done by measuring the absorbed energy by weight unit of the product, Tanaka et al (1984), Nam (1989). Polystyrene (Ps) is a synthetic aromatic polymer made from the monomer styrene, liquid petrochemical as shown in fig.(1).Polystyrene's chemical formula is $(C_8H_8)_n$; it contains the chemical elements carbon and hydrogen. Polystyrene can be rigid or foamed. General feature of polystyrene is clear, hard and brittle. It is a very inexpensive resin per unit weight. It is a rather poor barrier to oxygen and Water vapor and has relatively low melting point Kuopfter (1984). Polystyrene is one of the most widely used plastics. Polystyrene can be naturally transparent, but can be colour with colorants. As a Thermoplastic Polymer, Polystyrene is in a solid (glassy) state at room temperature but flows if heated above about 100 °C, its glass transition temperature, Maul et al (2007). Crystal violet or Gentian violetor Methyl violet (2B)is a triphenyltmethane dye as shown in fig. (2). The dye is used as a histological stain and in Gram's Method of classifying bacteria. Crystal violet has antibacterial, antifungal, and anthelmintic properties and was formerly important as a topical antiseptic.

The medical use of the dye has been largely superseded by more modern drugs, although it is still listed by the World Health Organization. When dissolved in water the dye has a blue-violet color with an absorbance maximum at 590 nm and an extinction coefficient of 87,000 M⁻¹cm⁻¹, Adams *et al* (1914), Mahasin (2012).



Fig.(1): Structure of Polystyrene



Fig. (2) Structure of crystal violet

particles are Beta high-energy. hiahspeed electrons or positrons emitted by certain types of radioactive nuclei such as potassium-40. The beta particles emitted are a form of ionizing radiation also known as beta rays, Balashov et al (1997). When positrons from a radioactive source (energy of few hundreds of keV) penetrate a solid they slow down to thermal energies by inelastic collisions within a psec(10⁻¹²s). In molecular solids (e.g polymers) a high fraction of positrons forms Polystyrene (PS), the formation probability and annihilation characteristics of Ps in these solids depend on their chemical and physical properties. The ability of the positron to form a variety of electronic states in molecular solids(Free positron and Ps, positron and Ps bound to vacancies and voids), positron annihilation lifetime yields unique information regarding the polymer properties under study, Eldrup (1995).

When radiation interact with material; beta has the medium penetrating power and the medium ionizing power, and gamma ray has more penetrating in material. There are more researchers studied the radiation effect on polymers such as Abdullah (2006) studied the effect of Gamma radiation on the energy gap of glassy polymers (PC, PS, PMMA) and the effect of adding Anthracene to these polymers. The results showed that energy gap will change depending on gamma dose. Also, Bhat et al (2007) found there is gradual change in the color of PVA with methyl red films when irradiated with Gamma ray In the dose range 10-55 KGy. Rashid (2010) studied the effect of Beta rays on optical properties of PMMA polymer. Al-Kadhemy et al (2012) studied the effect of Gamma ray with dose range (50-200) rad step 50 on FTIR spectrum of crystal violet doped PS films, the results showed that 150 and 200 rad will affect on the structure of polymer and dye. Al- Kadhemy et al (2013) calculated optical energy gap of crystal

violet doped PS films before and after irradiation with 200 rad Gamma ray.

In present work, we aim to compare the effect of Beta and Gamma rays on optical energy gap for crystal violet doped PS films. And the effect of changing doping ratio of dye solution added to polymer.

Experimental Work: Polymer presents some important advantages as they usually show good compatibility with organic dyes and excellent optical homogeneity. Then polymer polystyrene will obviously induce structural absorption changes and good transparency and good solubility with this dye Paul et al (1978) . Crystal violet (CV) has chemical C₂₄H₂₇N₃HCl formula with molecular weiaht M_w=393.95gm/ mol. Both dye and polymer are soluble by the solvent chloroform (CHCl₃).

The dye solution with concentration 0.5×10^4 mol/liter is prepared according to the method mentioned by Adams, and Rosenstein (1914). The dye doped polymer films are prepared by casting method. Certain amount of polymer PS powder 1 gm were dissolved in 10 ml of solvent chloroform. The different ratio of dye solution (5, 10, 35, 40)ml were added to polymer solution and mixed very well. The mixture poured in glass Petri dish with 10 cm diameter and left to dry for 24hr at room temperature about 25°C to get homogeneous films.

The irradiation was done with Beta and gamma radiation by Sr^{90} and ^{60}CO source. The dose of Gamma ray is taken 200 rad. Absorption and transmission spectra were measured by UV-Visible spectrophotometer type(CARY 100 Conc. UV- Visible spectrophotometer) made in Japan. This operates in wavelength range of (200-1100) nm and with scanning speed of (1500) nm/min.

The thickness of films were measured by digital micrometer type Tesha (0.001)mm with accuracy range (0-150) mm made in Japan. The range of thickness for all samples between (0.096 -0.109) mm.

RESULTS AND DISCUSSION

Absorption spectra for pure PS polymer films are shown in fig.(3). There is strong absorption in 250nm and sudden decrease after these limits in the absorption values. These results are matched with Fraih (2010).

The behavior of absorption spectrum of crystal violet in chloroform solution with concentration 0.5×10^{-4} mol/liter is shown in fig.(4). It is broad band with maximum absorption at 589nm with intensity 3.367, and second peak at 550nm with intensity 2.314.The separation between two maximum bands about 39nm. This behavior of absorption spectrum is similar to that mentioned by Adams (1914) and Kaniappan and Latha (2011).



Fig. (3) Absorption spectrum of pure PS polymer films.



chloroform solution with concentration 0.5x10⁻⁴ mol/liter

The absorption spectra of crystal violet doped PS films with different doping ratio of dye solution (5, 10, 35, and 40)ml before and after Beta and Gamma (200 rad.) irradiation are shown in figs.(5.a, b, and c), respectively. There is two peaks at about (540- 600 nm) in absorption spectrum, that is shift toward long wavelengths compared with dye solution. Where the intensity of these bands increases with increasing the amount of doping ratio of crystal violet solution that add to CV-PS films, and with effect of Beta and Gamma irradiation, as shown in table (1).



Fig.(5)Absorption spectrum of Crystal Violet doped PS films in different doping ratio of dye solution a- before, and after (b- Beta irradiation c- Gamma irradiation).

The optical energy gap (E_g) is often necessary to develop the electronic band structure of film material. It is obtained by plotting $(\alpha hv)^{1/r}$ versus (hv) in the high absorption range followed by extrapolating the linear region of the plots to $(\alpha hv)=0$. Where α is absorption coefficient, which was calculated Chopra, and Kaur (1983).



Fig.(6) Energy gap for different ratio of crystal violet doped PS polymer a-5ml b- 40 ml









Fig.(7) Energy band gap after Beta irradiation for cv_ps with doping ratio(a)2ml(b)5ml(c) 10ml (d) 35ml (e) 40 ml





Fig.(8) Energy band gap after Gamma irradiation for cv_ps with doping ratio (a)5 ml (b) 40 ml

 $\alpha = 2.303 \text{ A/t}$ (1)

where A is the absorbance, andt is the thickness of film.

The type of transition determined from the value of r; which is taken r=1/2,3/2 for allowed and forbidden direct transition, respectively. And r=2, 1/3 for allowed and forbidden indirect transition, respectively Pankov (1915), Ayman (1997). The value of r for our work is 2for allowed direct transition. Figs. (6-8) and table (1) represent optical energy gap for CV-PS with different doping ratio before and after Beta and Gamma irradiation, respectively.

	Before Irradiation			After Beta Irradiation			After Gamma Irradiation		
Doping ratio of CV solution(ml)	λ _{max} (nm)	Absorbance	E _g (eV)	λ _{max} (nm)	Absorbance	E _g (eV)	λ _{max} (nm)	Absorbance	E _g (eV)
Crystal Violet in chloroform solution	550 589	2.314 3.367	2.1						
Pure PS			2.8			3.99			
5	540 597	0.279 0.282	1.8	535 595	0.339 0.336	3.97	540 600	0.299 0.301	1.79
10	540 598	0.624 0.647	1.88	540 595	0.505 0.519	3.85	540 600	0.676 0.677	1.79
35	540 597	1.298 1.263	1.81	550 595	2.177 2.247	3.2	550 600	1.619 1.748	1.85
40	540 598	1.298 1.328	1.9	545 595	1.601 1.641	3.1	550 600	2.46 2.515	1.68

 Table (1): Absorbance and maximum wavelength of absorption spectrum for all samples

Increasing doping ratio of crystal violet and irradiation with Gamma ray led to decrease the value of energy gap, whereas effect of Beta ray led to increase energy gap of polymer. So that PS is very sensitive to radiation and dyes. Radiation can affect the molecular weight in two ways. It can increase it by linking molecules together (cross linking) or it can decrease it, by inducing main chain degradation. Also, scission might occur in the main chain of the polymer and the fragments might link to the main chain of a polymer, Abdullah (2006), Ayman (1997).

CONCLUSION

rom this research it has been shown that crystal violet dye affect on optical energy gap of CV- PS films. Also, Gamma and Beta ray strongly influenced on the energy gap of these films that is affect on structure of these films.

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