Optical Properties of Laser Dye Rhodamine B Doped Polymethylmethacrylate- Polycarbonate Films

Farah Jawad Kadhum Al-Nuaimi

Al-Mustansiriyah Univ.- College of Science- Physics Dept.

Abstract

Films of pure polymethylmethacrylate (PMMA) doped Polycarbonate (PC) and laser dye Rhodamine B (RhB) doped PMMA-PC have been prepared using casting method at room temperature. Optical properties were investigated for different doping ratio of dye solution by using spectrophotometric measurement of absorption, transmission in the wavelength range (200-900) nm. The optical constants and energy gap (E_g) calculated for these films.

Key words: Polymethylmethacrylate, Polycarbonate, RhodamineB, Optical Properties, Dye doped polymer.

الخصائص البصرية لأغشية بولي مثيل ميثا أكريليت- بولي كاربونيت المطعمة بالصبغة الليزرية رودامين B

فرح جواد كاظم النعيمي

الجامعة المستنصرية- كلية العلوم- قسم الفيزياء

الخلاصة

حضرت اغشية البولي مثيل ميثاكريلات المشوبة ببولي كاربونيت النقية واغشية بولي مثيل ميثا اكريليت-بولي كاربونيت المطعمة بالصبغة الليزرية رودامين B بطريقة الصب بدرجة حرارة الغرفة. بحثت الخصائص البصرية لنسب تطعيم مختلفة لمحلول الصبغة للاغشية باستخدام جهاز المطياف للامتصاص والنفاذية للمدى (٢٠٠-٩٠٠)نانومتر. وحسبت الخصائص البصرية والثوابت البصرية وفجوة الطاقة للاغشية .

1- Introduction

Polymethylmethacrylate PMMA has been widely used due to optical properties and physical characteristics[1,2],which is in good insulator ,good rigidity, transparency, good tensile strength and hardness, thermal stability, quick response could be used in optical communication[3], good chemical resistance and high resistance to weathering[4].Its chemical structure illustrated in fig. (1)[5].

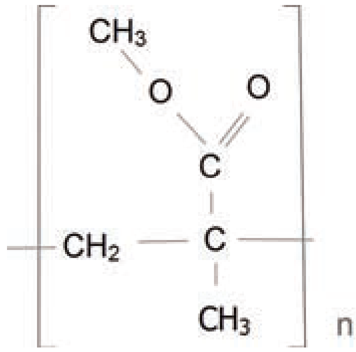


Fig.(1) Chemical structure of PMMA[5]

Polycarbonate(PC) is a type of polyester; it is an amorphous thermoplastic with very low water absorption [6].Due to structure of PC, as shown in fig.(2), this material has high melt viscosity and resistance to high temperatures.[7].

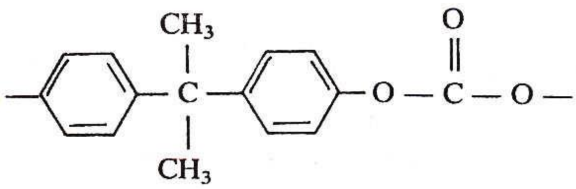


Fig.(2) Chemical structure of PC [7]

The polymer PC is: one of the most dimensionally stable thermoplastics, very good optical properties and transparency, excellent electrical insulators over a wide range of humidity and temperature conditions, attacked by alkaline solutions and hydrocarbon solvents, may be used extensively in electrical and electronic applications and outdoor lighting and glazing [8-9].

Rhodamine B is an interesting molecule with spectral luminescence properties that makes it useful as a biomarker and important for studies of biological systems and sensors [10].Also, a sensing probe is used for detection of heavy metals. It's chemical structure illustrated in fig.(3)[11].

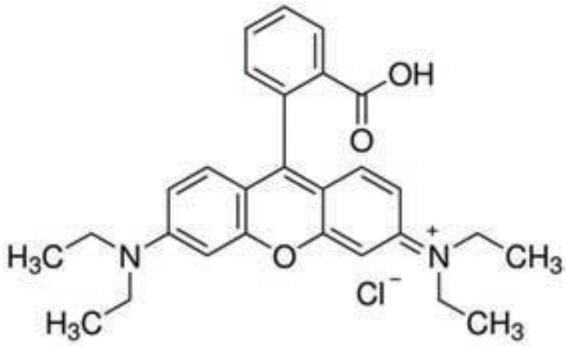


Fig.(3) Chemical structure of RhB[11]

Many researchers studied the optical properties of PMMA and PC films with different doping materials; such as Deshmukh et al [12], Ismail et al [13] and Tagreed [14]. This work aims to study the effect of adding different ratio of Rhodamine B dye solution on optical properties of PMMA-PC films.

2- Experimental work

2-1 Materials used

Rhodamine B (RhB) used as laser dye in this work to be doped with polymethyl-methacrylate (PMMA) and polycarbonite (PC) as host materials. The chemical formula of RhB is $C_{28}H_{31}N_2O_3Cl$, and molecular weight is 479.02 g/mole [15].

The polymer PMMA with molecular weight 200000g/mole has chemical formula $(C_5O_2H_8)_n$ made in Barcelona Espana.

Dichloromethane (CH_2Cl_2), with molecular weight (84.93) g/mole and density (1.323) g/cm^3, used as solvent for dye and polymers.

2-2 Preparation of Films

The concentration of Rhodamine B solution is 1×10^{-5}mole/liter [16]. The volume ratio of this dye solution is (5, 10, 15, 20, and 25) ml will add to polymer blend films. The films were prepared by casting method. All materials dissolved in dichloromethane at room temperature and put on magnetic stirrer for (30min) then pour the solution in clean glass petri dish and left to dry to get homogeneous films then take the measurements for all films by UV-Visible spectrophotometer type (70-80 UV- Visible spectrophotometer) in the wavelength range (200-900)nm.

3- Results and Discussions

The absorbance (A) may be defined as the ratio between absorbed light intensity (I) by material and the incident intensity of light (I_o) [17]. Fig.(4) shows the absorption spectra for RhB-PMMA-PC films for all doping ratio. The absorption spectrum for PC+PMMA shows two peaks at wavelengths (300, and 350) nm with intensity (1.799, 0.961), respectively. Whereas the absorption wavelength of Rhodamine B at (555) nm. Increasing doping ratio of RhB solution led to increase the intensity of peaks of both PMMA-PC and RhB due to increase the number of dye molecules that formed aggregates (such as dimmers and trimers) which decrease the role of polymer [18], as shown in table (1).

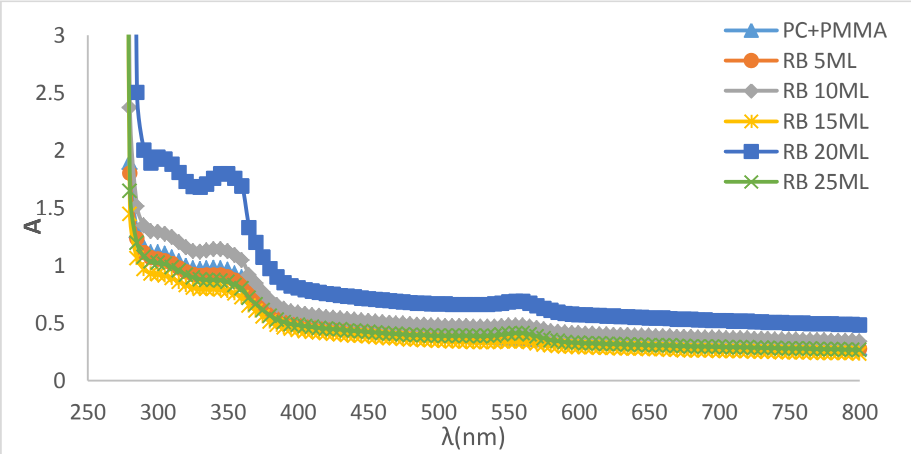


Fig. (4) Absorption spectrum for Rhodamine B-PMMA-PC films with different doping ratio of RhB solution

Table (1) Absorption Parameters

Doping ratio mole /liter	PC+PMMA		RhB	
	λ_{abs}.(nm)	I_{abs}.	λ_{abs}.(nm)	I_{abs}.
PC+PMMA	300 350	1.115 0.961	-	-
5ml	300 350	1.058 0.903	555	0.382
10ml	300 350	1.289 1.124	555	0.48
15ml	300 350	0.924 0.778	555	0.341
20ml	300 350	1.94 1.799	555	0.692
25ml	300 350	1.023 0.857	555	0.412

The transmission spectrum is reciprocal to absorption spectrum as shown in fig.(5). So that, increasing doping ratio led to decrease in transmission spectra.

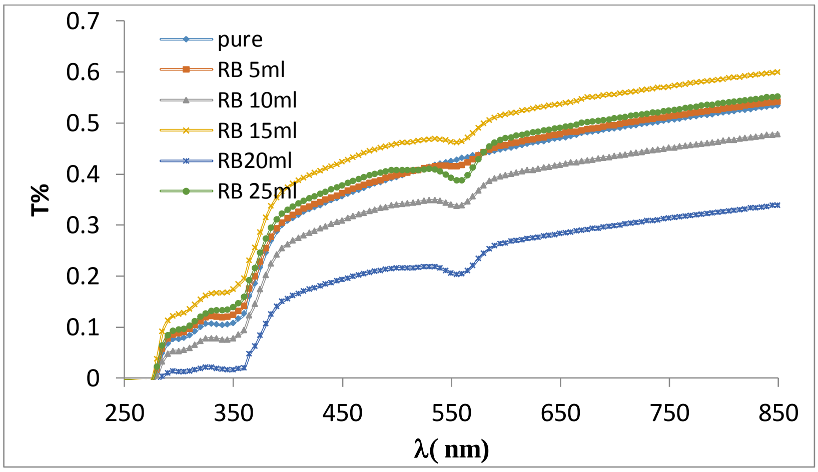


Fig.(5) Transmission spectrum for RhB-PMMA-PC films

The reflectance (R) may be calculated from eq.(1) [19]and demonstrated in fig.(6).

$$R+T+A=1 \quad (1)$$

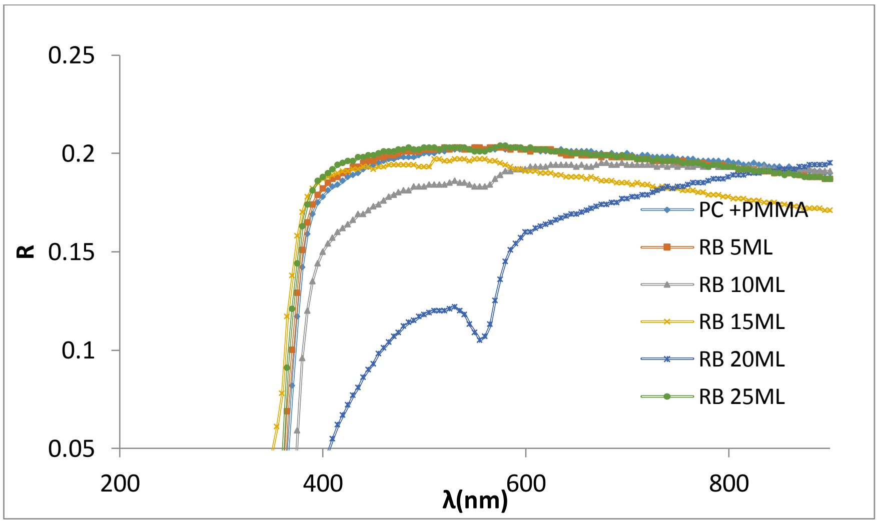


Fig.(6)Reflection spectrum for RhB-PMMA-PC films

Reflection spectrum is calculated from absorption and transmission spectra and depended on them, when doping ratio is increased, absorption increased and the reflectance be smaller. The best reflectance which be obtained from this work when the doping ratio is smaller than (25)ml due to its depending on(α),because increasing doping ratio of RhB solution led to increase the intensity of peaks of both PMMA- PC and RhB.
The absorption coefficient (α) can be calculated by [20]:

$$\alpha = 2.303A/x \quad (2)$$

Where (x) is a sample thickness.

The absorption coefficient (α) increased with increasing doping ratio as shown in fig.(7).

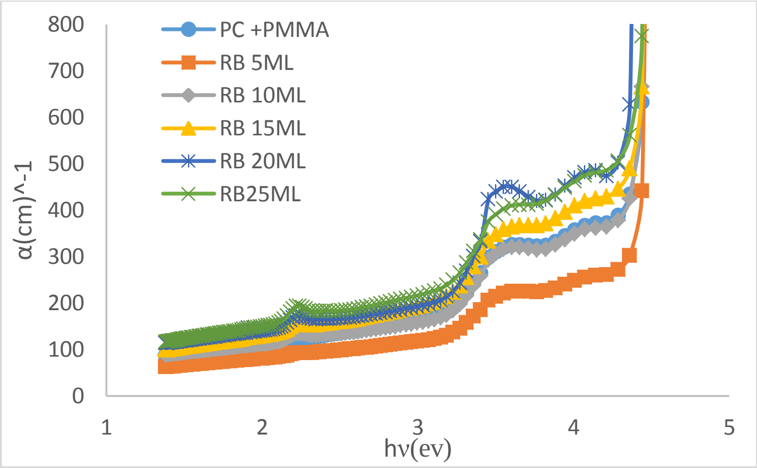


Fig.(7)Absorption coefficient for RhB-PMMA-PC films.

The energy gap increased with increasing doping ratio due to its depending on (α). Also, during polymer mixing, defect formation may occur, such as voids. Which give rise to desirable localized states in the band gab of the material [21], as shown in fig.(8) and table (2).

Table (2) Energy gap for RhB-PMMA-PC films

Doping ratio mole/liter	$(\alpha h\nu)^{1/2}$	
	PC+PMMA	(PC+PMMA) RhB
PC+PMMA	3 3.9	-
5ml	3 4.1	1.68
10ml	3 3.9	1.7
15ml	3 3.8	1.75
20ml	3 3.7	1.8
25ml	2.9 3.8	1.83

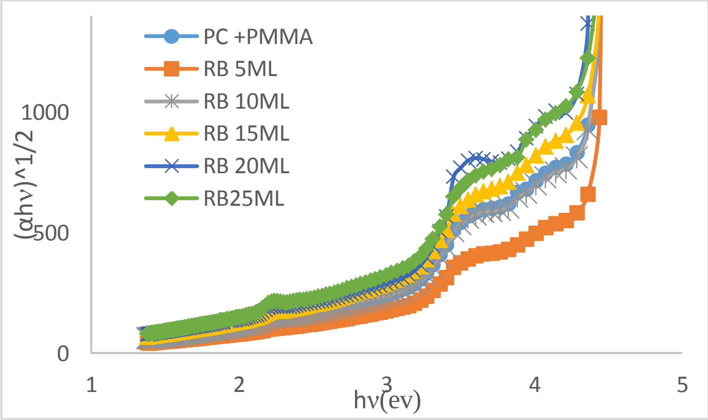


Fig.(8)Energy gap for RhB-PMMA-PC films

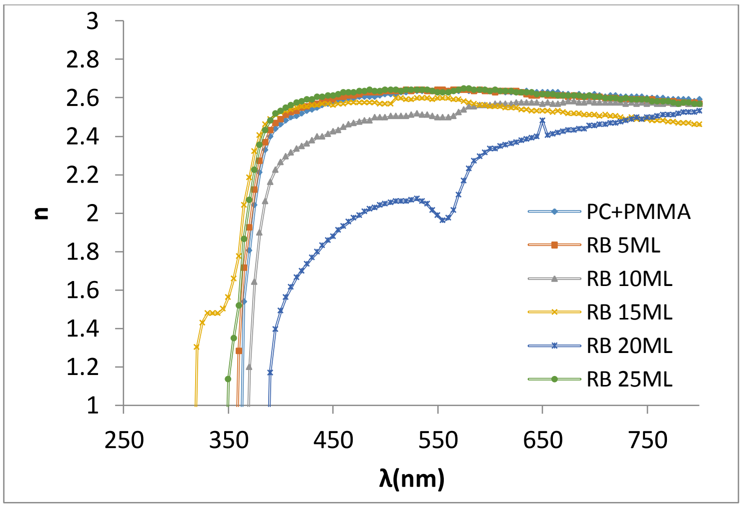
The extinction coefficient (k) can be calculated as follows [22] :

$$k=\alpha\lambda/4\pi \quad (3)$$

K depends on (α), as shown in fig.(9), increased with increasing doping ratio. The refractive index (n) calculated [22] from:

$$n=\frac{(1+\sqrt{R})}{(1-\sqrt{R})} \quad (4)$$

n is depending on reflectance (R), decreased with increasing in doping ratio as shown in fig.(9) .



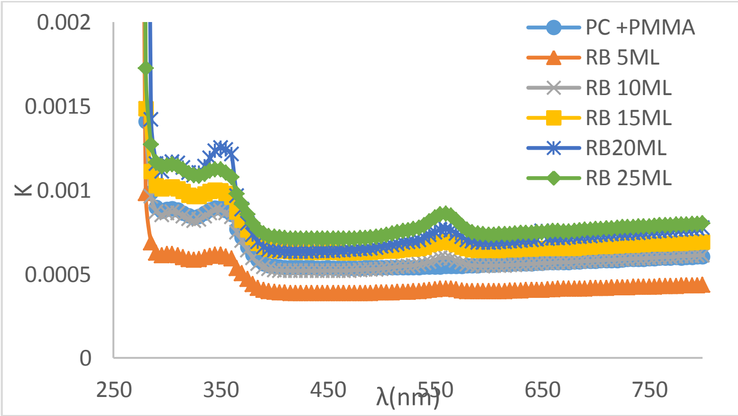


Fig.(9) Extinction coefficient and refractive index for RhB-PMMA-PC films.

Dielectric constant divided into two parts real and imaginary, which depends on the (n, k), respectively and shown in fig. (10)[23].

$\varepsilon = \varepsilon_r - i\varepsilon_i$, $\varepsilon_i = 2nk$, $\varepsilon_r = n^2 - k^2$ (5)

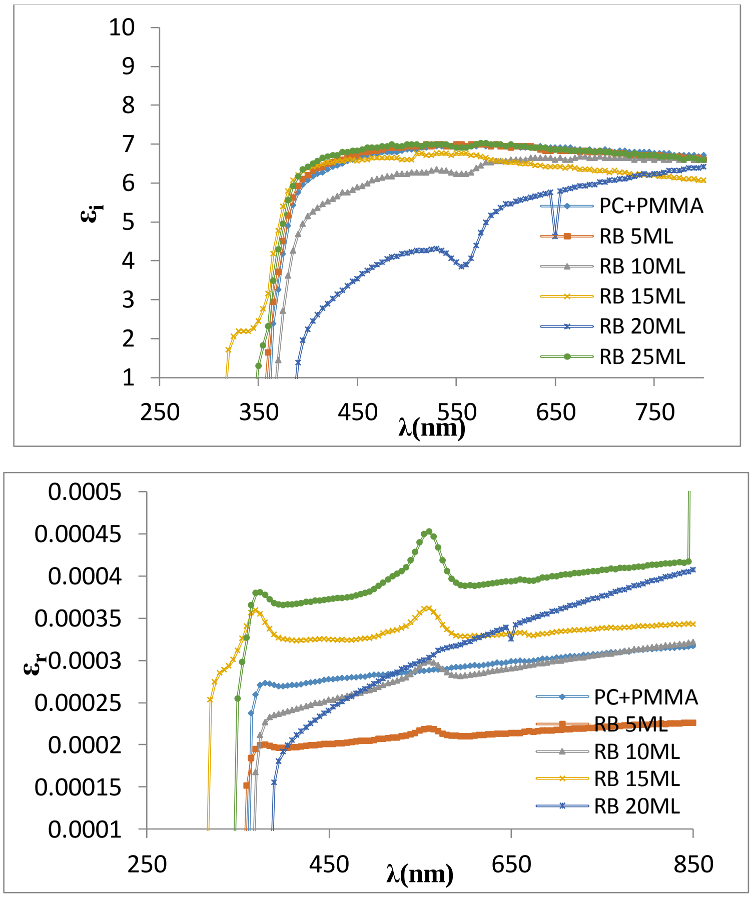


Fig.(10)Real and imaginary dielectric constant for RhB-PMMA-PC

4- Conclusion

It can be concluded that the addition of Rhodamine B laser dye effect on optical properties of PMMA- PC films. The best results in optical properties which be obtained from this work when the doping ratio is smaller than (25)ml due to its depending on(α),because of increasing doping ratio of RhB solution led to increase the intensity of peaks of both PMMA- PC and RhB. The energy gap for polymer blend changed with increasing doping ratio of RhB dye for allowed indirect transition.

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