Studying the spectral properties of thin films of rhodamine (6G) dyes doped polymer (PMMA) dissolved in chloroform

Ali H. Al-Hamdani[1], Rafah Abdul Hadi[2], Rajaa Nader[2]

[1]Department of Laser and Optoelectronics Engineering, University of Technology

[2]Department of Physics, College of Science for Women, University of Baghdad

E-mail: ali- alhamdani2003@yahoo.com

Abstract

In the present work, poly methyl methacrylate (PMMA) doped with Rhodamine 6G was prepared. The spectral properties (absorption and fluorescence) of the films were studied at different concentrations ($1x10^{-5}$, $2x10^{-5}$, $5x10^{-5}$, $7x10^{-5}$, and $1x10^{-4}$mol/l). The investigated samples were made in the form of thin films. This was achieved by dissolving a certain weight of PMMA in a fixed volume of chloroform, composite films was with thickness (25.8µm) at room temperature. The achieved results were pointed out that absorption and fluorescence spectra have taken a wide spectral rang so when increased the concentration each peak shift toward along wavelength. The quantum efficiency of the films were calculated as follows (98%,89%,84%,83% and 76%) for the above concentrations respectively. It has been noticed that the quantum efficiency decreases as the concentrations increases.

Key words
Rhodamind, Rhodamind 6G , Absorpence, Fluorescence.

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دراسة الخصائص الطيفية للاغشية الرقيقة لصبغة الرودامين (6ج) المطعمة ببوليمر مثيل ميثا اكرليت المذابة في الكلوروفورم

علي هادي الحمداني[1]، رفاه عبد الهادي[2]، رجاء نادر[2]

[1]قسم هندسة الليزر والالكترونيات البصرية، الجامعة التكنولوجية

[2]قسم الفيزياء، كلية العلوم للبنات، جامعة بغداد

الخلاصة

في هذا البحث تمت دراسة بولي مثيل ميثا اكرليت (PMMA) المطعم بصبغة الرودامين (6G). وتمت دراسة الخصائص الطيفية (الامتصاص والفلورة) لأغشية صبغة الرودامين (6G) المطعمة ببوليمرمثيل ميثا اكرليت وبتراكيز مختلفة (,$1x10^{-5}$ $2x10^{-5}$,$5x10^{-5}$,$7x10^{-5}$and $1x10^{-4}$mol/litter). حضرت النماذج التي تمت دراستها كأغشية رقيقة وذلك من خلال أذابة وزن معين من (PMMA) في حجم ثابت من الكلوروفورم وبسمك (25.8 µm) وبدرجة حرارة الغرفة.
النتائج المنجزة تشير الى ان لهذه الاغشية طيفيا امتصاص وفلورة يمتد الى منطقة طيفية واسعة اذ بزيادة التركيز تنزاح القمم نحوالاطوال الموجية الطويلة.وتم حساب الكفاءة الكمية لأغشية صبغة الرودامين(6G) المطعمة وللتراكيز (98% and 89%، 84%، 83% ،76%) على التوالي وقد لوحظ نقصان في الكفاءة الكمية مع زيادة التركيز.

Introduction

Organic dyes have various applications in many scientific branches due to their high fluorescence quantum yield and broad gain bandwidth [1]. The wide bandwidth makes them suitable for tunable ultrafast pulse generation [2]. The use of a synthetic polymer host presents advantages as these materials show much better compatibility with organic laser dyes, are amenable to inexpensive fabrication techniques, are good optical transparency at both the pump and lasing wavelengths, and resistance to pump laser radiation [3,4]. Polymethylmethacrylate (PMMA) is the most frequently used host for laser dye due to its excellent optical transparency in the visible region and its relatively high laser damage resistances [5,6]. Some fluorescent dyes are used in dye lasers as active media [7]. The fluorescence quantum yield is an intrinsic property of a fluorophore and is important for the characterization of novel fluorescent probes. The fluorescence quantum yields the ratio of photons absorbed to photons emitted through fluorescence. The effect of solvent on the absorption and fluorescence characteristics of organic compounds has been a subject of interesting investigation.

In 2006 Raida studied the spectroscopic characteristics and manufacturing of an active polymeric laser medium [8]. In 2007, Thipperudrappa et al. studied the solvent effects on the absorption and fluorescence spectra of some laser dyes and estimated the ground and excited-state dipole moments [9]. In 2009 Isra Hadi studied the effect of the solvent and concentration on the absorption and the fluorescence spectrum of coumarin-dyes[10].

Materials and Methods

PMMA (poly methyl methacrylate) used in this study was reported to have chemical formula $(C_5O_2H_8)_n$ and molecular weight of 84000 $gm.mol^{-1}$. The laser dye that is used belongs to xanthene family with chemical formula $C_{28}H_{31}N_2O_3Cl$ and molecular weight of 479.02 gm mol^{-1}, which an appearance of pale red crystalline powder. Composite films (thickness = 25.8 µm) of PMMA doped with Rhodamine 6G were prepared by using solution of constant concentration in chloroform.

The absorption spectra were recorded by using a UV – VIS spectrophotometer (Metertech, SP 8001). Spectrofluorometer (Model F96PR) was used for recording the emission spectra of R6G doped in PMMA.

Experimental Work

A- Solutions preparation

Solutions of different concentration of R6G in chloroform solvent were prepared. The powder is weighted using an electronic balance type (mettler AE 166) German – mode having a sensitivity four digits. Different concentrations were prepared according to the following equation:

$$W = \frac{M_W \times V \times C}{1000} \quad (1)$$

where

W weight of the dissolved dye (gm)

M_w molecular weight of the dye (gm/mol)

V the volume of the solvent (ml)

C the dye concentration (mol/ℓ)

The prepared solution were diluted according to the following equation

$$C_1 V_1 = C_2 V_2 \quad (2)$$

where

C_1 Primary concentration

C_2 New concentration

V_1 The volume before dilution

V_2 The volume after dilution

Their concentration were prepared for R6G are (1×10^{-5}, 2×10^{-5}, 5×10^{-5}, 7×10^{-5} and 1×10^{-4}) mol/ℓ.

B – Preparation of thin – film

Dye doped polymer films were fabricated by dry method. The solution of the polymer is prepared by dissolving the required amount of polymer. A required amount of dye solution was added to polymer solution.

Measuring of quantum efficiency (q_{fm})

Quantum efficiency defining as the ratio between the number of quanta emitted and the number of quanta absorbed [12]:

$q_{fm=}$ number of quanta emitted / number of quanta absorbed (3)

For rhodamine 6G dissolved in methanol the dependence of the fluorescence quantum efficiency and the fluorescence lifetime on concentration was studied.

Results and Discussion

The absorption and fluorescence spectra of R(6G) in PMMA with different Concentration (1×10^{-5}, 2×10^{-5}, 5×10^{-5}, 7×10^{-5} and 1×10^{-4}) mol/ℓ respectively are shown in Fig.1. From these figures we can observed that (R6G) absorption spectrum and the fluorescence spectrum shifted to shorts wavelength. (red shift) with increasing the concentration.

Table 1 shows the absorption, fluorescence peaks, and the quantum efficiency of the dye doped in PMMA. The quantum efficiency decreased as the dye concentrations was increased because of decrease the probability of non-radiative transition (Inter System Crossing (I.S.C) and Internal Conversion (I.C).

Table 1: Absorption and fluorescence peaks and the quantum efficiency of R6G.

C mole/litter	$_{abs}\lambda$ (nm)	$_{fluo}\lambda$ (nm)	Quantum Efficiency q_{fm}
1×10^{-5}	532	595	98%
2×10^{-5}	531.9	600	89%
5×10^{-5}	531.9	610	84%
7×10^{-5}	533.9	583	83%
1×10^{-4}	533	612	76%

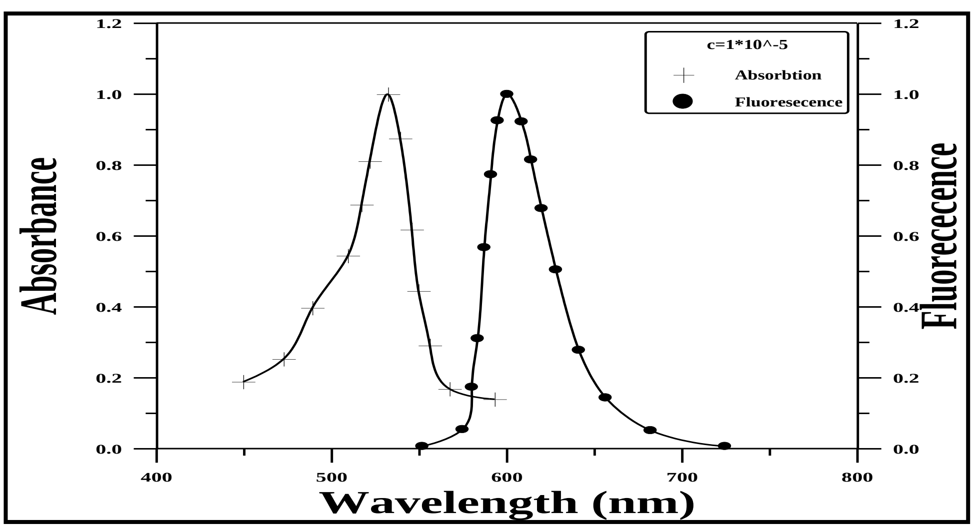

Fig.1: The absorption and fluorescence spectrum of R6G dye doped PMMA for concentration 1×10^{-5} mol/ ℓ at thickness (25.8µm).

Conclusions

The study of the Rhodamine 6G dye solutions in the chloroform solvent and the same dye doped in polymer PMMA with increase concentration one could conclude the following: shifted the fluorescence spectrum of Rhodamine 6G dye solution in the chloroform solvent and polymeric thin film, in the same solvent toward the longer wavelength (red shift). Increase in the relative intensity of the absorption and fluorescence spectrum for Rhodamine 6G dye solution and the polymeric thin film. Decrease the fluorescence life time as compared with radiative life time of dye solution and polymeric thin film. Decrease quantum efficiency of dye solutions and polymeric thin film. Decrease the overlap between the absorption spectrum and the fluorescence of polymeric thin film due to increase of stokes shift, compare with dye solution, so it's better to use polymeric thin film because of reduce self-absorption process. The quantum efficiency of the dye solution decreases as the dye concentration increases at (1X10^{-5} mol/l) which quantum efficiency equal %98 while at (1x10^{-4}mol/l) equal 76%.

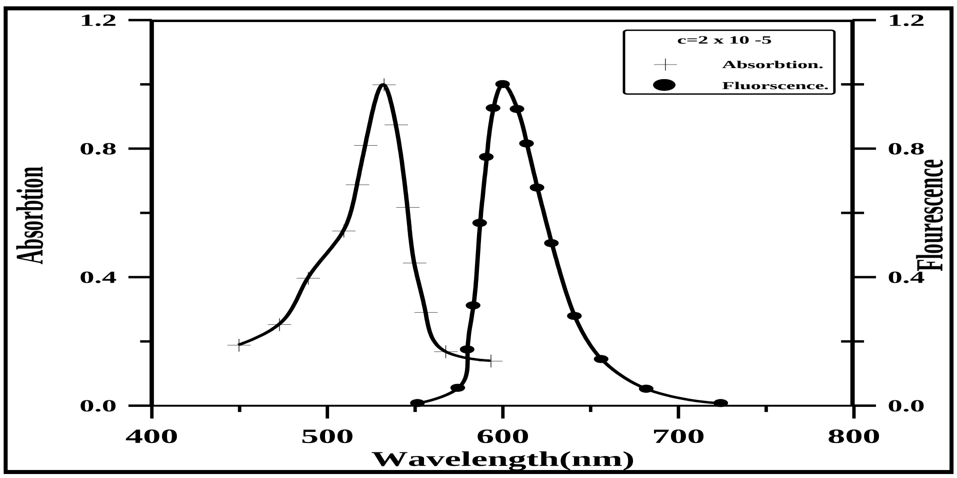

Fig. 2: The absorption and fluorescence spectrum of R6G dye doped PMMA for concentration 2×10^{-5} mol/ℓ at thickness (25.8µm).

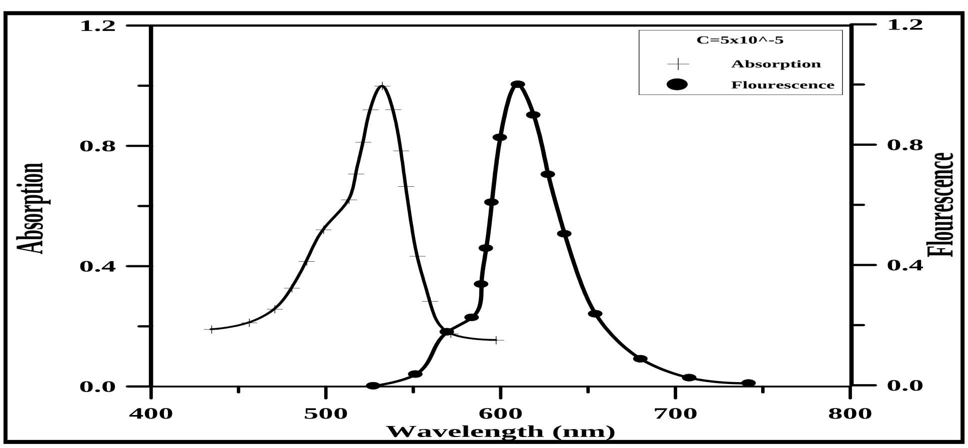

Fig.3: The absorption and fluorescence spectrum of R6G dye doped PMMA for concentration 5×10^{-5} mol/ℓ at thickness (25.8µm).

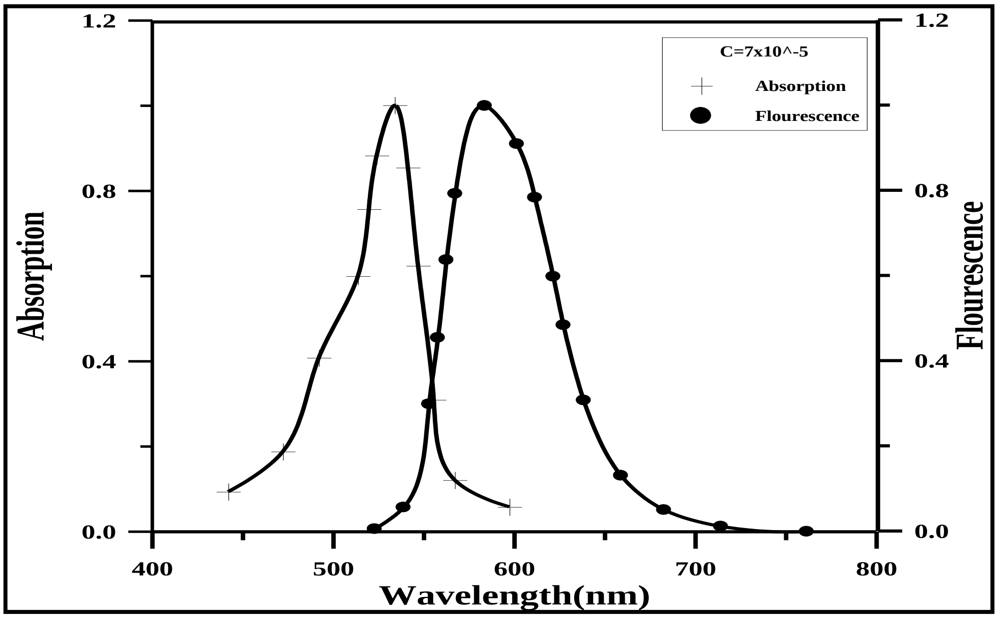

Fig.4: The absorption and fluorescence spectrum of R6G dye doped PMMA for concentration 7×10^{-5} mol/ ℓ at thickness (25.8μm).

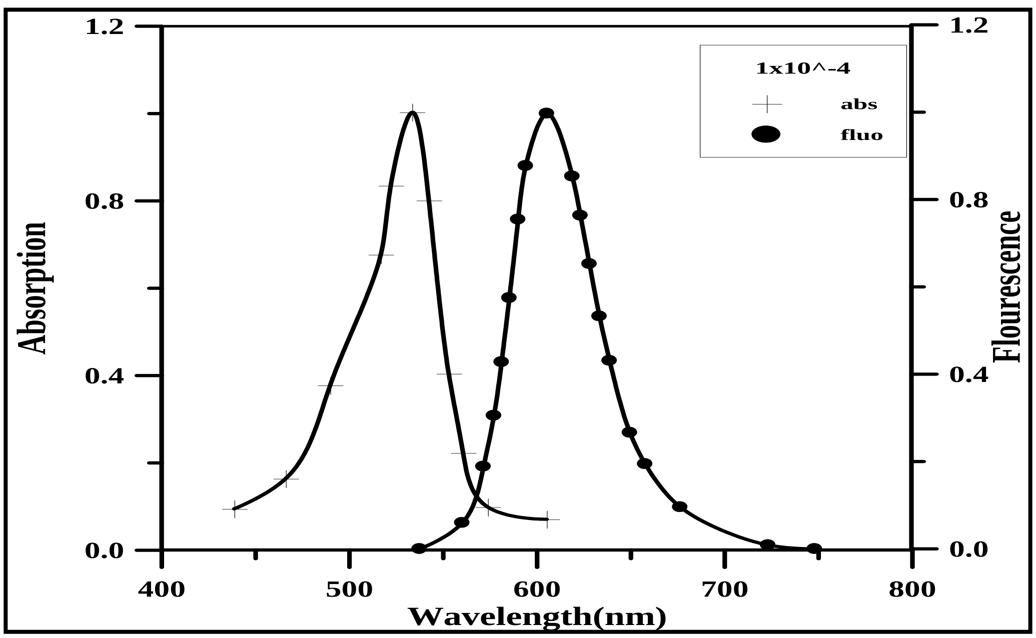

Fig.5: The absorption and fluorescence spectrum of R6G dye doped PMMA for concentration 1×10^{-4} mol/ℓ at thickness (25.8μm).

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