Spectral Properties of Rodamine B dissolved in Chloroform

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Abstract: *The spectral properties (absorption and fluorescence) of Rhodamine B dye have   been studied. This type of dye belong to the Xanthenes family and it was dissolved in chloroform with different concentrations $(3\times10^{-5}, 8\times10^{-5}, 8\times10^{-4}, 5\times10^{-4}, 2\times10^{-4}$ and 2×10^{-3} mole/liter) at room temperature. The achieved results have been pointed out there are a blue shift in the absorption spectra and red shift in the fluorescence spectra as the concentration increased. The quantum efficiency of the dissolved RB in chloroform were (53%, 58%, 67%, 76%, 78% and 89%) for the above concentrations respectively.It has been noticed that the quantum efficiency decreased as a function of concentration.There is a good consistency of the behavior of the fluorescence and absorption spectra with Beer.*
Keywords: *Fluorescence, Absorbance, Rhodamine B, Quantum efficiency .*

I.   Introduction:

Laser dyes can usually be used for a much wider range of wavelengths. The wide bandwidth makes them particularly suitable for tunable lasers and pulsed lasers. Moreover, the dye can be replaced by another type in order to generate different wavelengths with the same laser, although this usually requires replacing other optical components in the laser as well. Dye lasers were independently discovered by P. P. Sorokin and F. P. Schäfer (and colleagues) in 1966[1,2].In addition to the usual liquid state, dye lasers are also available as solid state dye lasers (SSDL). SSDL use dye-doped organic matrices as gain medium[3-10].

Many studies focued on **Xanthenes family** which Rodamine B belong to them because of there higher gain [11,12] and their properties differ with many parameters (like,different solvents, different concentrations,..). The chemical structure of RhodamineBisshown in Figure (1)
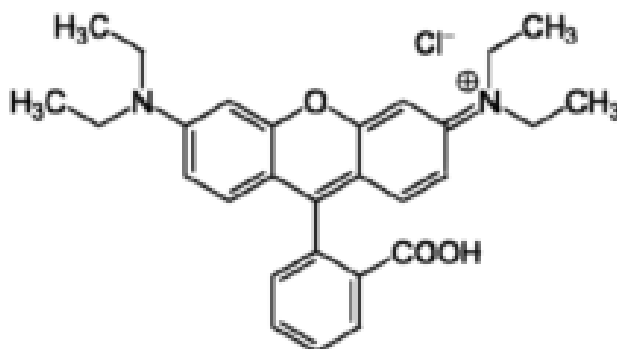

Figure 1: Chemical structure of Rhodamine B [13].

Theoretical Consideration

The spectrum of the molecular   fluorescence   F (ύ)   gives   the relative fluorescence intensity at wave-number (ύ), this is related to the quantum efficiency by the following equation ,[14].

$$q_{fm} = \int_{0}^{\infty} F(\upsilon')d\upsilon'$$

---------- (1)

In order to evaluate absolute quantum efficiency, we have to consider both the radiative and non-radiative processes   taking   place   in   the   medium,   therefore

$$q_{fm} = \frac{K_{fm}}{K_{fm} + \Sigma K_d} = \frac{K_{fm}}{K_{fm} + K_{IC} + K_{ISC}}$$

----------(2)

Since $K_{fm} = 1/ \tau fm$ and $\tau_f = 1 / K_{fm} + \Sigma K_d$

Therefore

$$q_{fm} = \frac{\tau_f}{\tau_{fm}} = \int_0^\infty F(\upsilon') \quad d\upsilon' \qquad \text{----- (3)}$$

Also

$$q_{FM} = \frac{\text{Number of quanta emitted}}{\text{Number of quanta absorbed}}$$

where

$\square_{fm}$:-The radiation life time can be calculated using relation as follow

$$\frac{1}{\tau_{FM}} = 2.88 * 10^{-9} n^2 (v'^2) \int \varepsilon('v) dv'. \quad ----(4)$$

Where

n:refractive index of a medium

$\square$: wave number at the maximum absorption

$\square \square (\square')d' \square$The area under the absorption spectrum curve as a function of the wavenumber,[15].
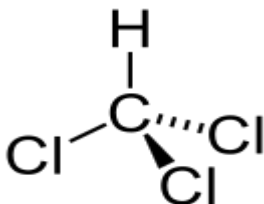
Experimental Work:
The materials used in search
The molecular formula of the RB is $C_{28}H_{31}N_2O_3Cl$ and processed by the company (HIMEDIA) India .This character belongs to the Xanthenes family and the molecular weight is 479.02 gm/mol.
The solvent :(Chloroform)
Chloroform is the organic compound with formula $CHCl_3$. The colorless, sweet-smelling, dense liquid is a trihalomethane, and.The physical properties as showen in the table.

Properties	
Molecular formula	$CHCl_3$
Molar mass	119.38 g mol^{-1}
Appearance	Colorless liquid
Density	1.483 g/cm^3
Melting point	-63.5 °C, 210 K, -82 °F
Boiling point	61.2 °C, 334 K, 142 °F
Refractive index	1.4459

Chloroform Structure, [16].

Instrument used in work:
-Fluorescence spectrum was measured by a (Spectrofluorometer SL174) by the processor (Elico)
-Absorption spectrum was measured by a (SP-8001.UV-visible spectrophotometer) by the processor (Metertechlnc)

The preparation of dye solution withdifferent concentration was taken place by dissolving an appropriate amount of dyepowder in agiven volume of solvent used, according to the relationship:

$$W = \frac{M_W VC}{1000} \qquad \text{------ (5)}$$

Where
W: Weight of the dissolved dye (gm)
Mw: Molecular weight of the dye (gm/mol)
V: The volume of the solvent (ml)
C: The dye concentration (mol/l)

The prepared solutions were diluted   according to the following equation:-
C1 V1=C2 V2

Where:
C1: primary concentration
C2: new concentration
V1: the volume before dilution
V2: the volume after dilution

II.   Results and Discussion

During the study of the spectral properties of theRhodamine Bdissolved in   the   chloroformsolvent thefollowing results can be deduced.Figures(2- 7) show the absorption and fluorescence spectra of the solution with differentconcentration $(3\times10^{-5}, 8\times10^{-5}, 8\times10^{-4}, 5\times10^{-4} ,2\times10^{-4}$ and 2×10^{-3}mol/liter) respectively.The maximum wavelength of the fluorescence and absorption spectra was shown to be depend on the concentration of the dye solution, as shown the figures.Table (1) shows the absorption , fluorescence peaks, and the quantum efficiency of the dye and StokeShift.At dilute of dye, 3 x 10^{-5}mol/litre, the quantum efficiency appears high while the maximum wavelength shift (Stoke Shift) is 132nm, the quantum yield of the dye solution decrease as the dye concentration increase,show theFigure (8) .Increasing the concentration of the dye solution resulted in red shifting of the fluorescence wavelength to higher wavelengths.

III.   Conclusion

From the observed results of studying the fluorescence and absorption spectra of Rhodamine B dye dissolved in chloroform one can conclude the following:-
1.   The increase in dye concentration showed an increase in relative intensity for both spectra, which is in agreement with Beer – Lambrt law.
2.   The Stock's shift for fluorescence spectrum of the RB dye dissolved in chloroform is toward the longer wavelength (low energy) as the concentration increased.
3.   It must be noted that quantum yield of the dye solution decrease as the dye concentration increase.
4.   As the dye concentration increase the interference region between the fluorescence and absorption spectra have been increased which produced a decrease in Stock's shift.

Table(1): Absorption and Fluorescence peaks and the Quantum efficiency of RB

Concentration mole/Liter	$\square_{a\,bs.}$ **max** **nm**	$\square_{flu.}$**max** **nm**	**Stoke** **Shift** **Nm**	**Quantum Efficiency** **q$_{fm}$**
8×10^{-5}	553.82	597	44.82	89%
3×10^{-5}	552.48	608	56.48	78%
8×10^{-4}	541.84	640	98.16	76%
5×10^{-4}	548.56	647	98.44	67%
2×10^{-4}	551.44	645	93.5	58%
$2x10^{-3}$	515.69	647	132	53%
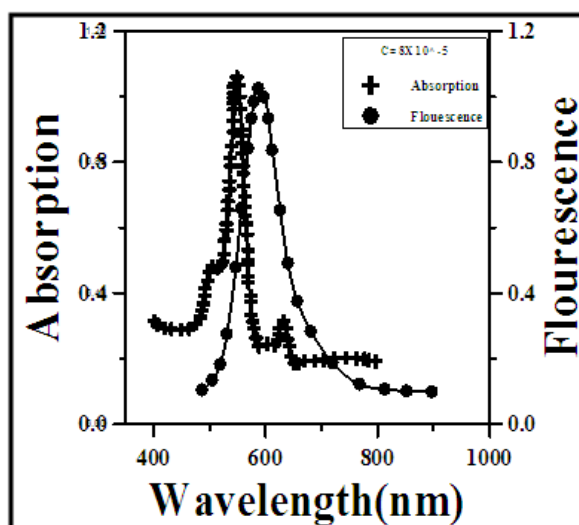
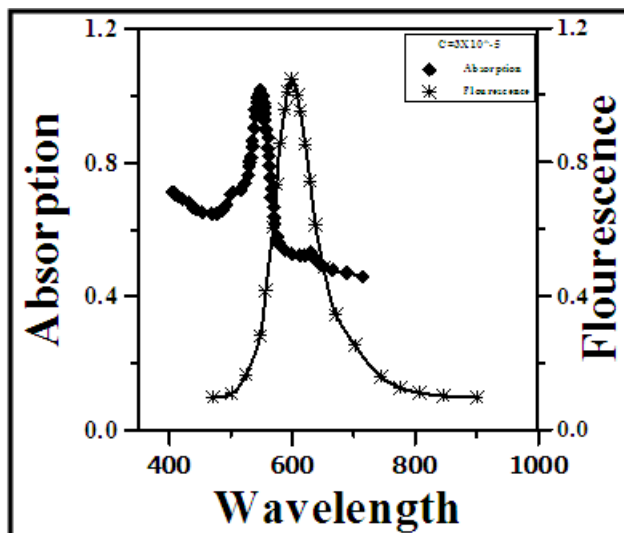**Figure (2)** The absorption and Fluorescence spectrum of RB dye concentration 8×10-5mol/L.

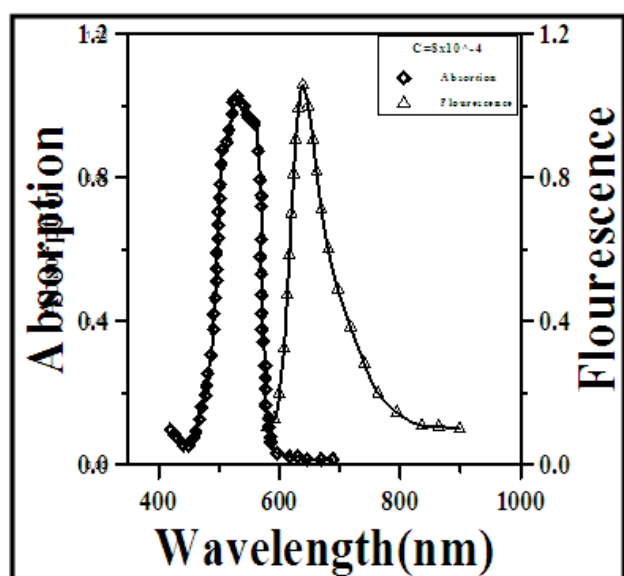**Figure (3)** The absorption and Fluorescence spectrum of RBdye for concentration 3×10-5mol/L

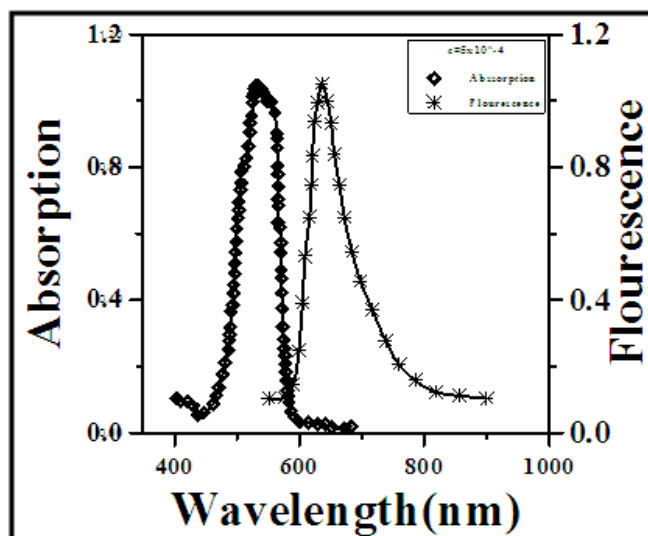**Figure (4)** The absorption and Fluorescence spectrum of RB dye for concentration 8×10-4mol/L

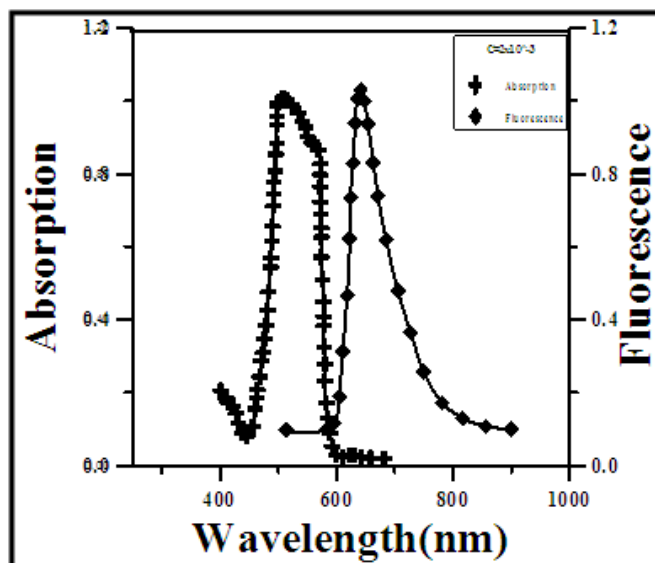**Figure (5)** The absorption and Fluorescence spectrum of RB dye for concentration 5×10-4mol/L

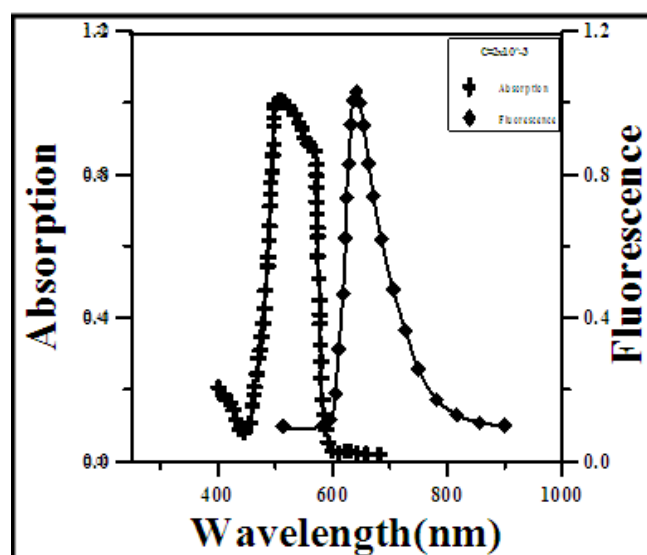**Figure (6)** The absorption and Fluorescence spectrum of RBdye for concentration 2×10-4mol/L

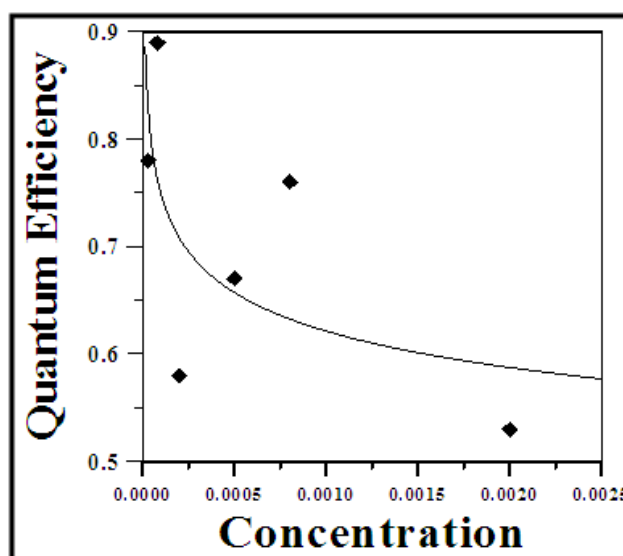**Figure (7)** The absorption and Fluorescence spectrum of RBdye for concentration 2×10-3mol/L

Figure (8) The relation between Quantum Efficiency and the Concentration of RhB dye

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