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The Effect Of Mixing Two Organic Dyes On The Optical Linear Properties

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Abstract. Organic laser dyes Rhodamine B (RB) and Aniline Blue (AB) have linear optical properties were determined at different concentrations (2×10^{-5}, 4×10^{-5}, 6×10^{-5}, and 8×10^{-5},M)at room temperature with an ethanol solvent. The absorbance intensity range shifts toward the longer wavelengths (red shift) with respect to the AB dye, while the absorbance intensity shifts towards the shorter wavelengths (blue shift) with respect to the RB dye. Organic laser dyes have a wavelength range of 520-690 nm. As compared to individual laser dyes, the findings show that a mixture of laser dyes is an efficient optical material. It can be used as a cavity laser resonator.

Keywords: Aniline Blue, methanol solvent, Organic laser dye, linear optical characteristics.

Introduction

The organic compounds are defined as hydrocarbons and their derivatives. They can be subdivided into saturated and unsaturated compounds[1]. Laser dyes are organic compounds with laser properties. Organic laser dyes are compounds that exhibit absorption from the ultraviolet to the near infrared, especially it exhibit strong absorption in the visible portion of the spectrum[2]. Laser dyes are complicated molecules with multiple ring structures that produce a broad range of absorption and emission spectra. Because of their chemically identical structures, laser dyes can be divided into different groups. Common xamples are the coumarins, xanthenes and pyrromethenes[3,4]. laser dyes must be mixed by varying donor/acceptor concentration via fluorescence resonance energy transfer (FRET) from the excited donor molecule(D) to the acceptor molecule(A). FRET provides structural information of a complex medium.[14-34] It has wide applications in the field of physics, chemistry and biology[5].Energy transfer happened when the energy transfer from donor to accepter.The condition for this mechanism is when there is an overlap between fluorescence of the donor and absorption of the accepter. The goal of energy transfer was to improve the efficiency and broadband the tunable spectral range of dye lasers[6].

Materials Used

The organic dye RB(Loba Chemie, Mumbai, India), belonging to methyl family, is an important histological and bacterial stain and is used for coloring textiles and leather. Its scientific name is (Tetraethylrodamine) with molecular formula ($C_{28}H_{31}N_2OCl$) [7]. An Aniline Blue(AB)organic dyewith molecular formula ($C_{32}H_{25}N_3O_9S_3Na_2$) ,as illustrated in Fig.1.

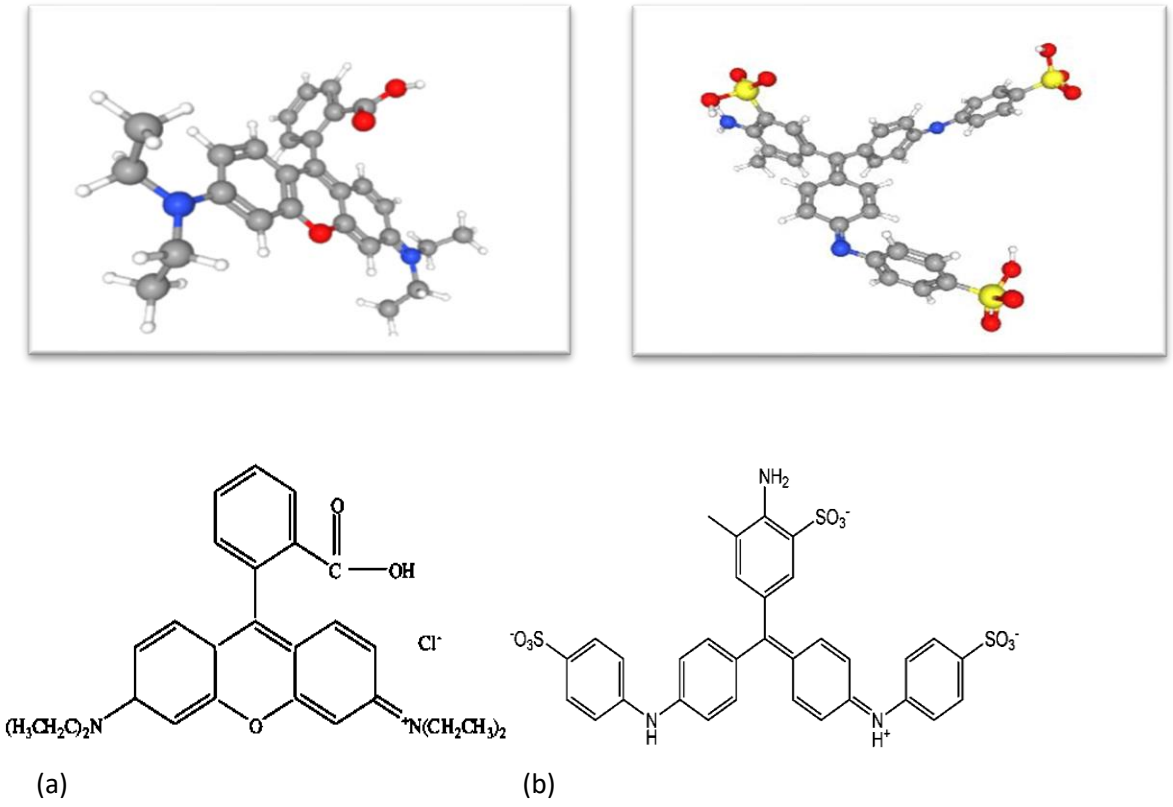

Fig.1a- Molecular Structure of RB dye, b- Molecular Structure of AB dye[8]

Theoretical Part

The transition of electrons from ground state to excited state orbital is essential for spectroscopy. If molecules absorb light, they can be excited from the lowest vibrational level of the ground singlet state S_{00} to higher vibrational levels of the S_{1n} state within a very short time (10^{-11}s), the Diagram of energy level of molecule organic dyes showe in Fig. 2 [9].

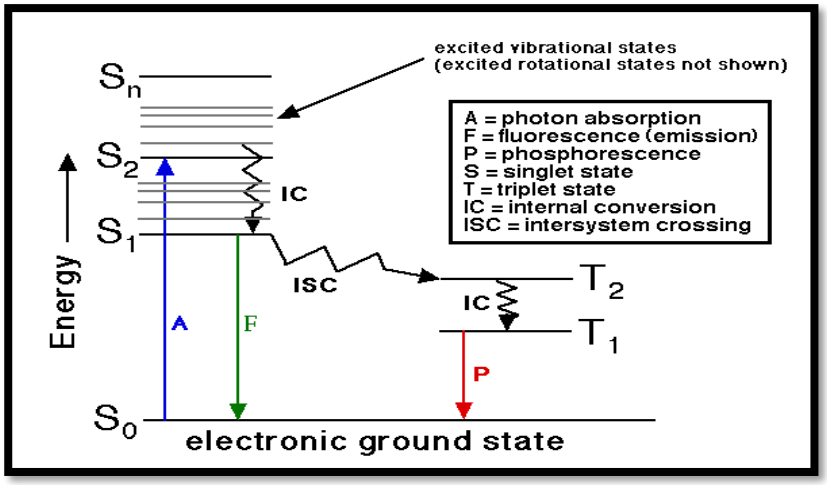

Fig. 2 Jablonski energy diagram[3]

The likelihood of absorbed photon is directly proportional to the absorbed molecules in the sample concentration and thickness of the model (the length of the optical path), according to Beer-Lambert law, which is the empirical relationship linking the light absorbance characteristics of the material that reflects light through it. The law states that the number of absorbent in the substance particles is directly proportional to the absorbed radiation part passing through. If passed in a particular solution, the amount of light absorbed is exponential function of the concentration, as in the equation[10]:

$I=I_o e^{-C\varepsilon L}$(1)

The equation can be written as follows [11]:

$\ln I_o / I = C\varepsilon L = A$ (2)

Where :

A: The absorbance, C : Concentration of the sample, ε : The molar.

Absorptivity and L: The path-length of the light through the sample. The absorption coefficient is defined as the rate of decrease in the emission of radiation energy per unit of distance in the direction of wave propagation within the medium. The absorption coefficient is determined by the photon's energy (hv) as well as the properties of matter. [12]. According to the Beer-Lambert law , the absorption coefficient is:

$2.303\ A = \alpha_o L$ (3)

$\alpha_o = 2.303\ A / L$ (4)

Where:

α_o: Linear absorption coefficient (cm^{-1}).

The linear refraction index of sample (n_o) is the ratio between the light speed in the vacuum to the light speed in the medium, which is calculated as in the following equation [13]:

$$n_\circ = \left(\frac{4R}{(1-R)^2} - K^2\right)^{\frac{1}{2}} - \left(\frac{R+1}{R-1}\right) \quad (5)$$

Where:

n_o: Linear refraction index (without units).

R: The reflectance.

K:

Extinction coefficient.

Results and Discussion

Four concentrations of Rhodamine B (RB) dye, Aniline blue (AB) (2×10^{-5}, 4×10^{-5}, 6×10^{-5}, and 8×10^{-5}) M were prepared after dissolving them in ethanol solvent . After that, the dye was mixed with 1: 1 volumetric ratios for each concentration, and then the absorption spectra were measured using the UV-Vis spectrometer. The results of the measurements were as shown in Fig. 3, Fig. 4 and Fig.5, it is noticed from the figures that increasing the concentration leads to an increase. The absorbance of the two dyes and their mixture and this is in line with Beer-Lambert law. In addition, it is noticed that there is an increase in the range of wavelengths of the mixture compared with the absorbance curve for each dye separately, and this is a good factor for making the laser dye in dye lasers. From the results of the absorption spectra, the transmittance spectra of the two dyes and their mixture were recorded as shown in Fig. 6, Fig. 7 and Fig. 8. After obtaining the results of the absorption and transmittance spectra, the linear absorption coefficients (α_o) and linear refraction (n_o) were calculated for all the prepared models using the two relationships (4) and (5), as shown in Table 1. Where the table shows the most important optical properties of the dyes used in this study and their mixtures, and it is noted from the table that increasing the concentration leads to an increase in the two linear absorption (α_o) and refraction (n_o) coefficients as well as an increase in their values of the mixture compared with the two dyes separately,this was due to the energy transfer from the donor dye (RB)to the acceptor dye (AB), thus obtaining a mixture of two organic pigments can be used as a medium effective laser with a wide range of wavelengths in dye lasers.

Table 1 Values of linear optical properties for pure and mixture dyes at different concentrations.

Dyes	Concentration M	λ_{max} (nm)	A	T	α_o (cm^{-1})	n_o
RB	2×10^{-5}		0.339	0.458	0.782	1.525
	4×10^{-5}		0.538	0.291	1.238	1.769
	6×10^{-5}		0.667	0.215	1.535	1.919
	8×10^{-5}		0.682	0.208	1.570	2.347
AB	2×10^{-5}					
	4×10^{-5}					
	6×10^{-5}					
	8×10^{-5}					
Mixture of (RB+AB)	2×10^{-5}					
	4×10^{-5}					
	6×10^{-5}					
	8×10^{-5}					

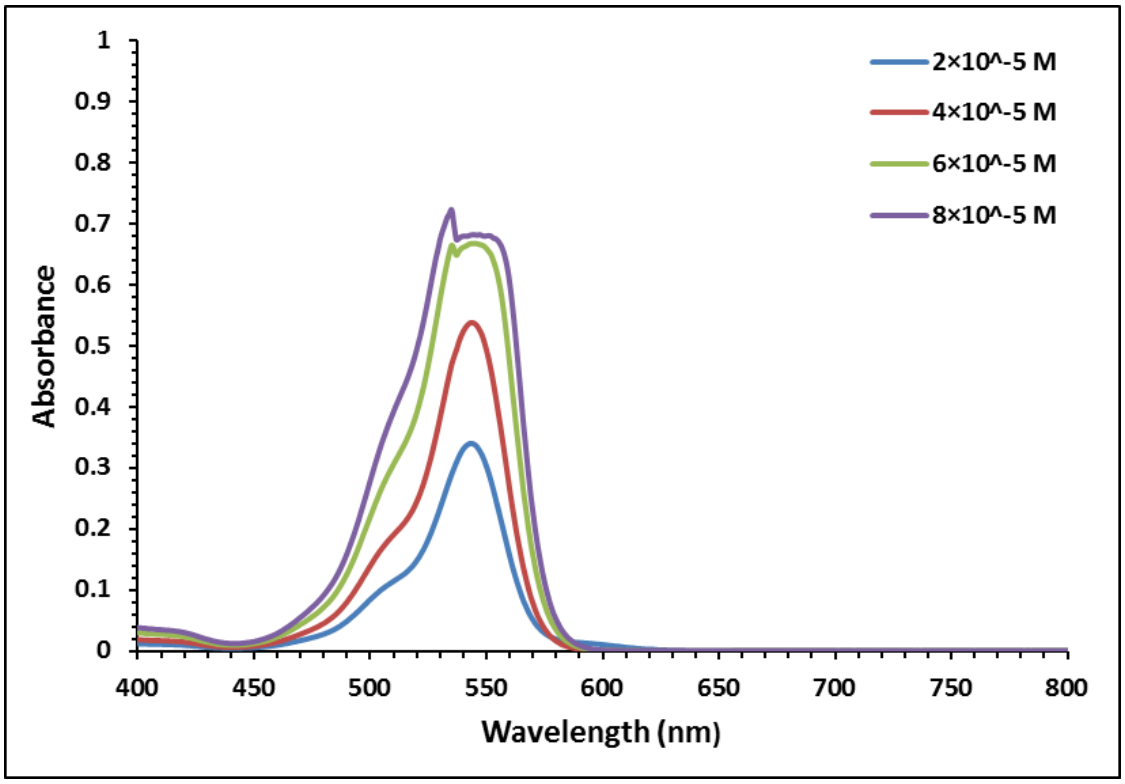

Fig. 3 Absorbance spectra for Rhodamine B (RB)dye at different concentrations in ethanol solvent.

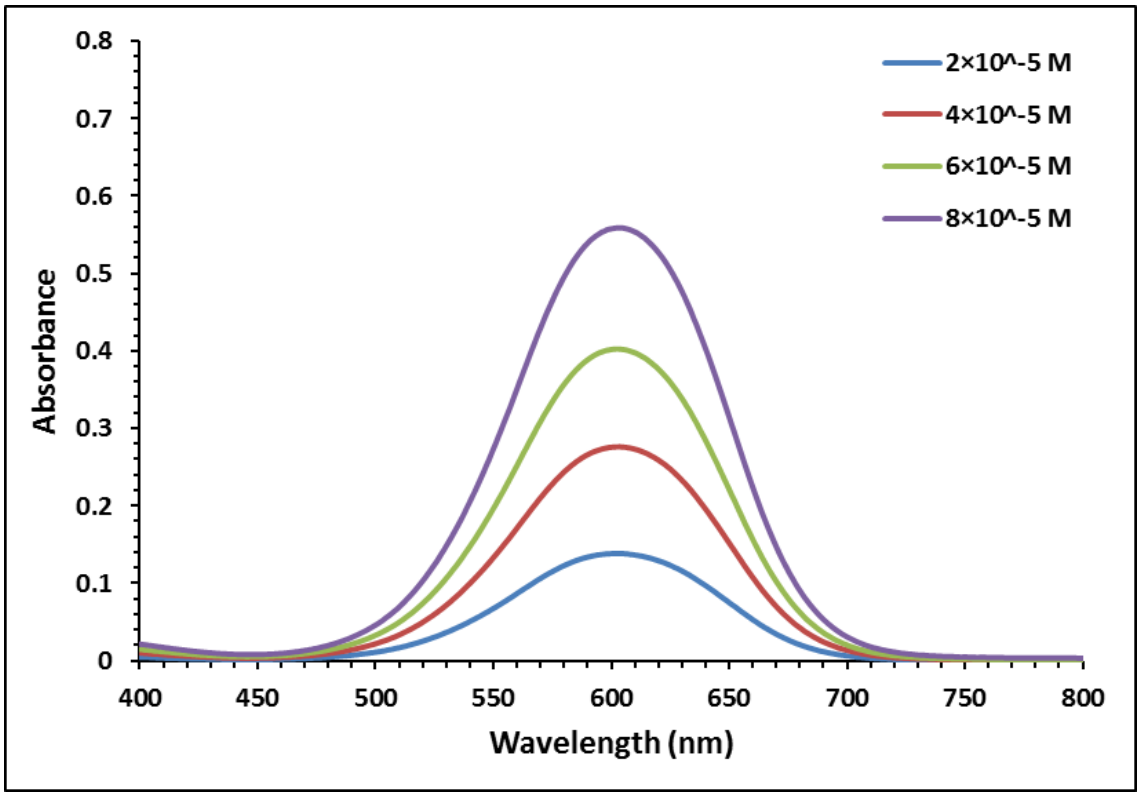

Fig. 4 Absorbance spectra of aniline blue (AB) dye at different concentrations in ethanol solvent.

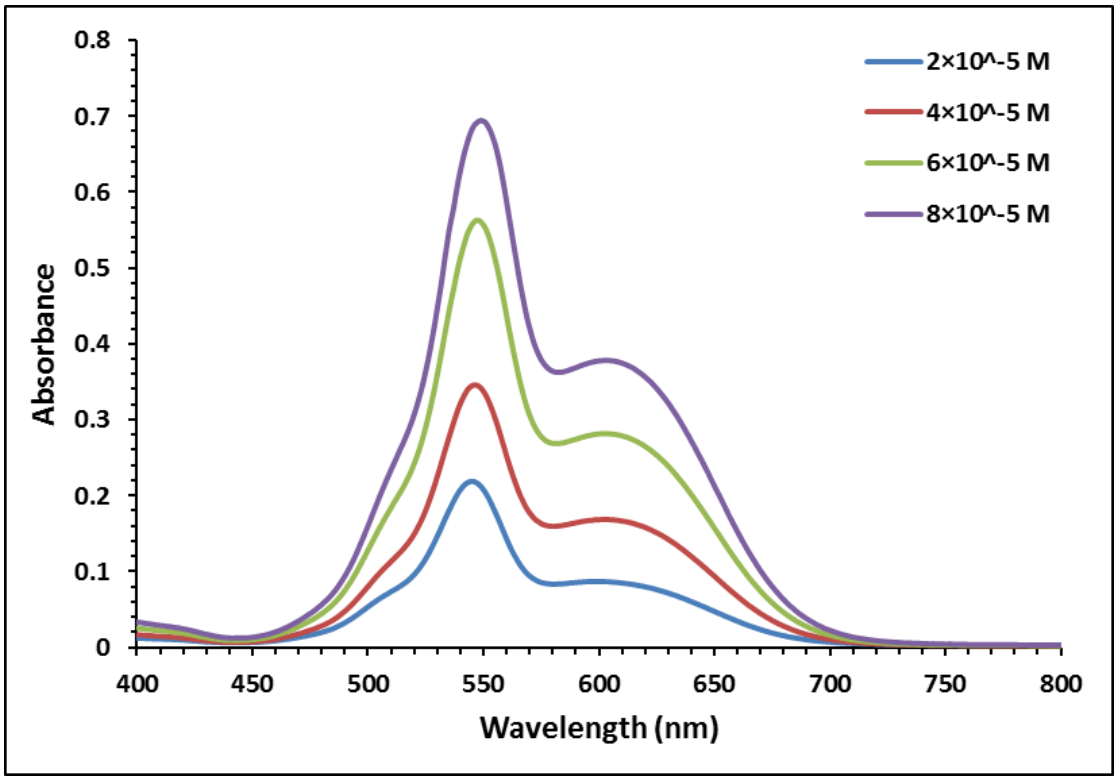

Fig. 5 Absorbance spectra of two mixture dyes (RB+AB) at different concentrations in ethanol solvent.

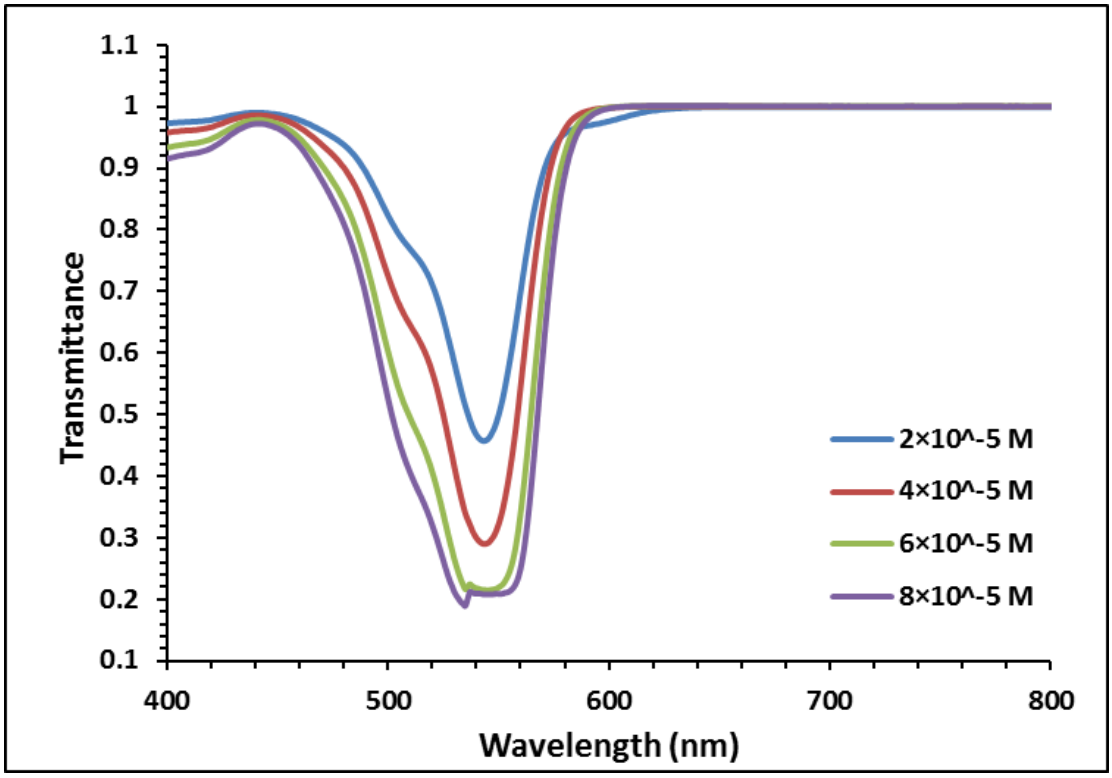

Fig.6 Transmittance spectra for Rhodamine B (RB) dye at different concentrations in ethanol solvent.

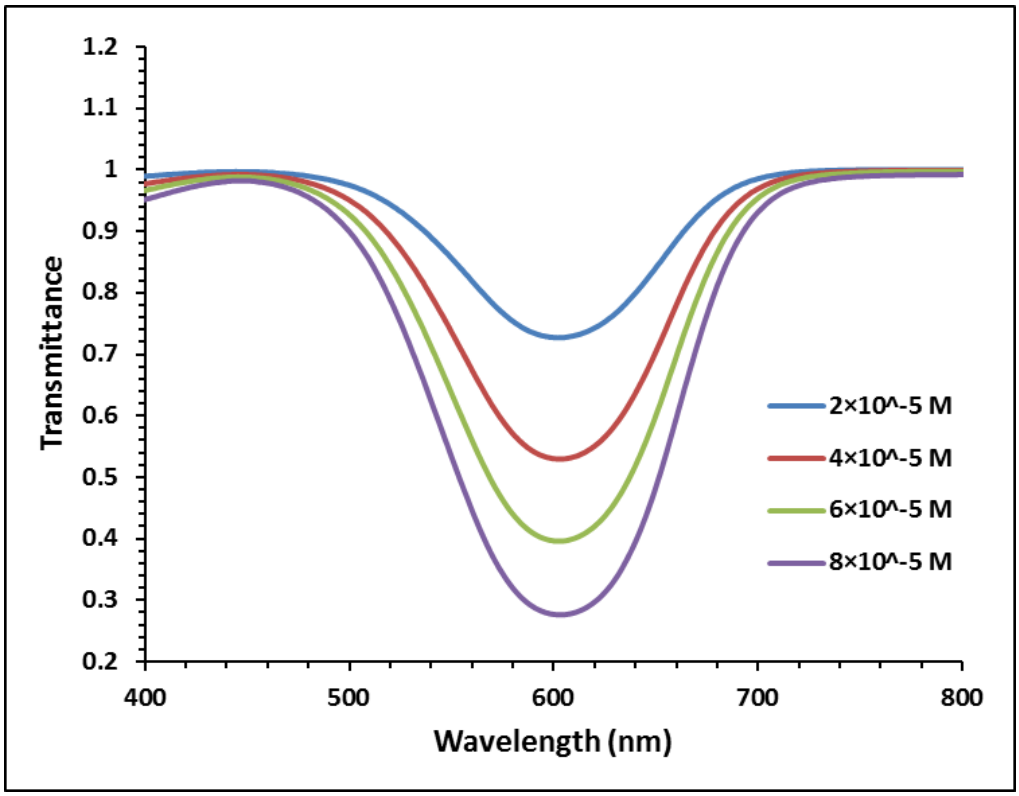

Fig. 7 Transmittance spectra of aniline blue (AB) dye at different concentrations in ethanol solvent.

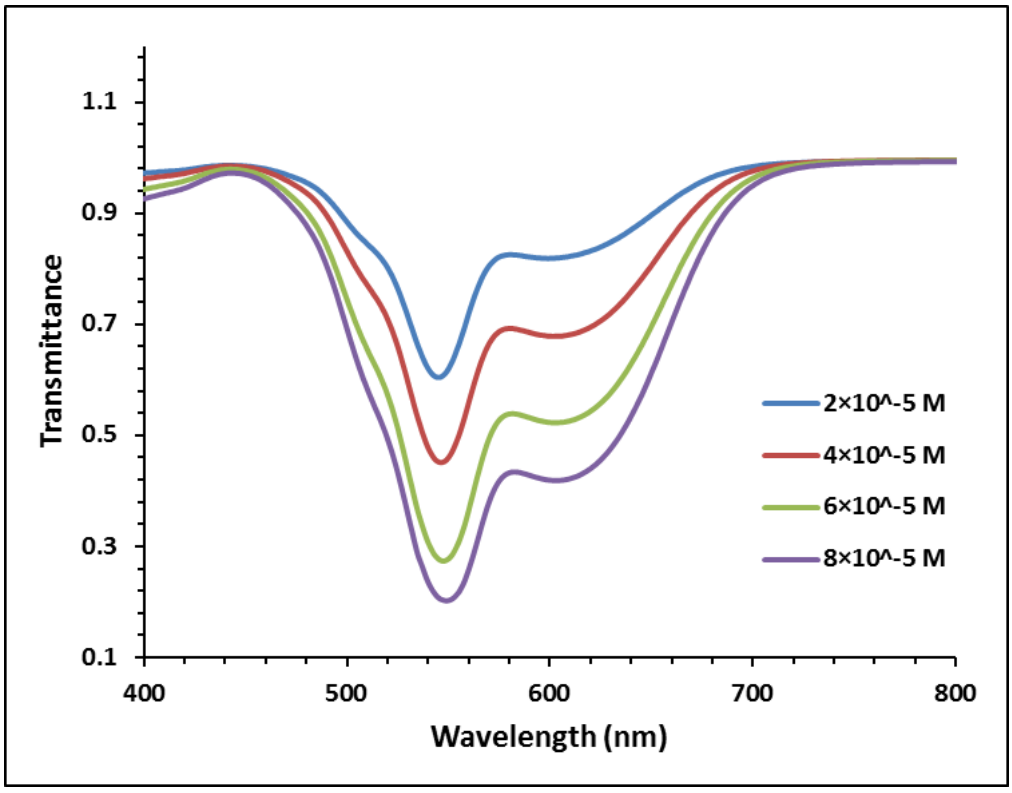

Fig. 8 Transmittance spectra of two mixture dyes (RB+AB) at different concentrations in ethanol solvent.

Conclusions

Dye mixing increases the coefficient of linear absorption and linear refractive index (LRF) and leads to a wide range of wavelengths due to energy transfer from the donor dye to the acceptor dye.

Dye mixing increases the coefficient of linear absorption and linear refractive index (LRF) and leads to a wide range of wavelengths due to energy transfer from the donor dye (RB) to the acceptor dye (AB).

Increasing the concentration leads to an increase in the absorption of each dye and their mixtures. We notice an expansion in the absorption spectrum of the mixture dye and this is important to work as an effective laser medium.

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