



# Study of Optical Limiting of Ratio Mixing(3:1) Two Dyes for Rhodamine B and Methyl Violet 10B

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## Abstract

RB and MV, two organic laser dyes, were prepared in an ethanol solvent using mixing ratios (3:1) and varying concentrations ( $2 \times 10^{-6}$ ,  $4 \times 10^{-6}$ ,  $6 \times 10^{-6}$ , and  $8 \times 10^{-6}$ ) M of the two dyes, Rhodamine B and Methyl violet (10B). A study of the UV-VIS spectra of varied concentrations of each dye dissolved in absolute ethanol solvent, and then the absorption and transmission spectra of all samples were conducted. Fluorescence spectroscopy was used to examine the spectrum optical characteristics of all the manufactured samples. The findings indicated that for the same wavelength, when concentrations rose, absorbance rose as well. Transmittance showed the exact opposite connection. The nonlinear refractive index ( $n_2$ ) and nonlinear absorption coefficient ( $\beta$ ) of prepared samples were determined using the Z-Scan method in both Close and Open aperture. For these tests, a diode pump solid state laser with a wavelength and power of 457 nm was used (84 mW).

According to the findings, the refractive index increased while the nonlinear absorption coefficient decreased with increasing concentrations of the material.

The optical limiter is used to protect the human eye from the high powers of the laser.

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**Key Words:** Optical Limiting, Nonlinear Refractive Index, Organic Laser Dyes.

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## Introduction

Solvent-dissolved or solid-integrated dye lasers use organic solvents and dye molecules. However, the liquid and solid phases of dyes have had a considerable influence as laser media, even though dyes have been proved to laser in solid, liquid or gas phase (Brackmann U et al, 2000). To safeguard the human eye and sensors, dye doped polymers are employed in the same domains as other current photonic technologies such as fiber optics and optical amplifiers (Doğan M et al, 2003). Synthetic polymer Polyvinyl Alcohol (PVA) has been widely used since the early 1930s for many industrial, commercial, medicinal, and food applications because of its multiple features, including as its ease of manufacture, low cost, and dielectric nature (Dehghani Z et al, 2015). When it comes to science, nanotechnology has been a big accomplishment. It allows materials with unique dimensions and

structures to be created. Physical and chemical characteristics of materials are affected by changes in surface atoms (Fadhel H et al, 2020).

## The Used Materials

Materials utilized in this project include:

### 1. Rhodamine B Organic Laser Dye

It is a xanthine dye known as Rhodamine B. It is one of the most frequently used spectroscopic variables. Lasers and thermochemistry use Rhodamines amino forms of xanthine as fluorescence labels and probes for a broad range of applications (biological and non-biological) (Jassim M et al, 2017).

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**2. Methyl Violet 10B Organic Laser Dye**

Methyl violet 10B has six methyl groups. Pyocyanin, or crystal violet, has C<sub>25</sub>H<sub>30</sub>ClN<sub>3</sub> molecular formula (López F et al, 1990).

**3. Polymer**

Chemical formula (C<sub>2</sub>H<sub>4</sub>O<sub>x</sub>)<sub>x</sub>, which originates from the hydrolysis of Polyvinyl Acetate (PVA), is readily degraded by living beings (Limpan N et al, 2012).

**4. Silver Nanoparticles (Ag NPs)**

Laboratory Reagent LTD provided silver nanoparticles with a surface area of more than 40 m<sup>2</sup>/g and a particle size of between 1 and 100 nm (Mauro F et al, 1999).

**Solutions Preparation**

Each organic laser dye was dissolved in (ethanol) solution at a concentration of 10<sup>-3</sup> M. Using an electronic balance type (BL 210 S, Germany) with a four-digit sensitivity, the powder was measured. The following equation was used to create various concentrations (Petrov D et al, 1996):

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

Where, Weight of the dissolved substance (g), molecular weight (g/mol), volume (mL) of the solvent, and concentration (C) are all measured in

grams per liter (M). Equation was used to dilute the obtained solutions (Slafa I et al, 2013).

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

Where: C<sub>1</sub>: Primary concentration, C<sub>2</sub>: New concentration. V<sub>1</sub>: The volume before dilution and V<sub>2</sub>: The volume after dilution.

During this study, four quantities of each of Rhodamine B dye and Methyl violet 10 B dye were used to produce mixing of these two pigments (2 mL of Rhodamine B mixing with 1 mL of Methyl violet 10 B) to prepare mixing at a ratio of 3:1.

**Result and Discussion**

**1. Absorbance Spectra of Mixture Rhodamine B and Methyl Violet 10B**

**Organic Laser Dyes**

At varied concentrations (2x10<sup>-6</sup>, 4x10<sup>-6</sup>, 6x10<sup>-6</sup>, 8x10<sup>-6</sup> M), the absorbance spectra of the combination of them (3:1) as solution were recorded in the 400-700 nm range as shown in Figure (1). A photon is emitted (radiative relaxation) or energy is transferred to another particle when this occurs. As the energy of atoms increases, the number of collisions between atoms increases, which in turn causes an increase in the amount of energy produced by the electrons that collide. Increasing the material's ability to absorb. Electron relaxation occurs when an excited electron returns to a lower energy state. Beer- Lambert law is well-agreed upon (Tripathi R et al, 2018).

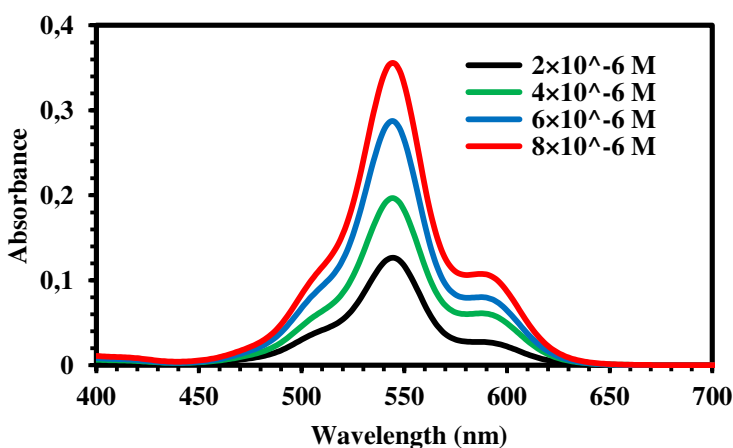


Figure 1. The absorbance spectra for mixing of (RB+MV) organic laser dyes with ratio (3:1) at different concentrations

**2. Fluorescence Spectra of mixture Rhodamine B and Methyl Violet 10B Organic Laser Dyes**

Figure 2 shows the fluorescence intensity of combining Rhodamine B with Methyl Violet 10B organic laser dye at various concentrations (2x10<sup>-6</sup>,

4x10<sup>-6</sup>, 6x10<sup>-6</sup>, and 8x10<sup>-6</sup> M). According to sources (Venugopal S et al, 2002), fluorescence intensity grows linearly with increasing concentrations, as it does in the absorption spectra. Once an excited state is reached, the molecule comes back to its



original state by heat or vibrations. This is known as fluorescence.

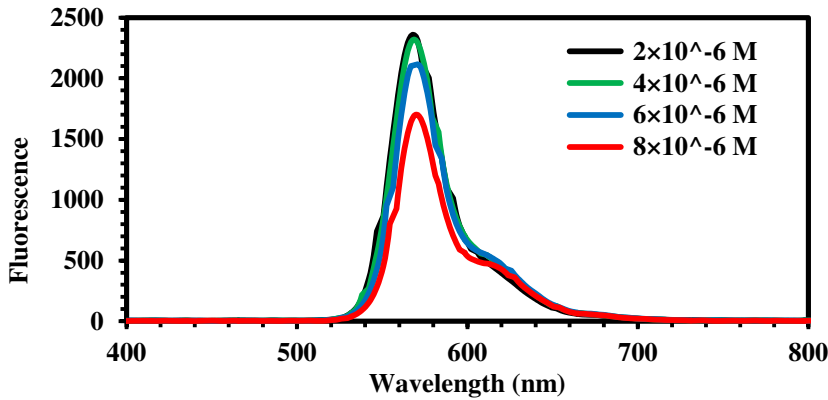


Figure 2. Fluorescence spectra for mixing of two organic dyes (Rhodamine B and Methyl Violet 10B) organic laser dyes with ratio (3:1) at different concentrations

**3. Nonlinear Refractive Index**

Nonlinear refractive index of combination Rhodamine B and Methyl Violet 10B (RB and MV) organic laser dyes f with ratios (3:1) at various

concentrations ( $2 \times 10^{-6}$ ,  $4 \times 10^{-6}$ ,  $6 \times 10^{-6}$ , and  $8 \times 10^{-6}$  M) was determined by closed-aperture Z-Scan method. Nonlinear refractive index grew as concentration rose, as indicated in the Table (1).

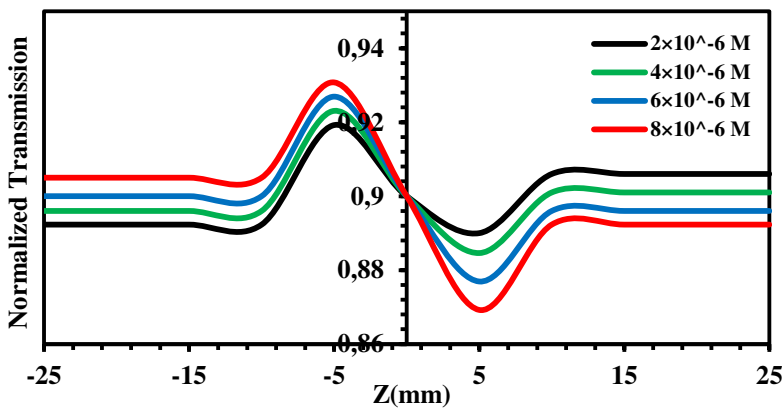


Figure 3. Closed-aperture Z-Scan data for different concentrations of mixing (RB+MV) organic laser dyes in (Ethanol) Solvent at Ratio (3:1)

**4. Nonlinear Absorption Coefficient**

Mixture Rhodamine B and Methyl Violet 10B (RB and MV) organic laser dyes (RB and MV) with ratios of 3:1 at varied concentrations ( $2 \times 10^{-6}$ ,  $4 \times 10^{-6}$ ,

$6 \times 10^{-6}$ , and  $8 \times 10^{-6}$ ) M. Nonlinear absorption coefficient dropped as concentration increased, according to the Table provided in the findings (1).



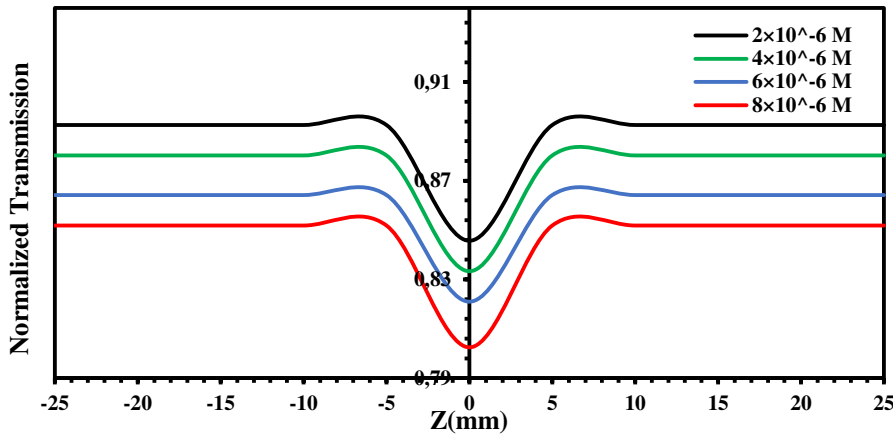


Figure 4. Open-aperture Z-Scan data for different concentrations for mixing of (RB+MV) organic laser dyes at ratio (3:1)

Table 1. Linear and nonlinear optical parameters for different concentrations for Mixture of Rhodamine B and Methyl Violet 10B at 3:1 and their thin films at  $\lambda=457\text{nm}$

Material	Concentration (Mol/L)	T	$(\alpha_0) \text{ cm}^{-1}$	$n_0$	$\Delta T_{P-V}$	$n_2 \times 10^{-11} (\text{cm}^2/\text{mW})$	T(z)	$\beta (\text{cm}/\text{mW}) \times 10^{-3}$
Mixture(RB+M V 10B)at (3:1)	$2 \times 10^{-6}$	0.75	0.45120	1.5452	0.048	9.7362	0.864	2.89
	$4 \times 10^{-6}$	0.63	0.65234	1.8606	0.053	12.742	0.851	2.85
	$6 \times 10^{-6}$	0.5410	0.86067	2.0730	0.065	15.399	0.827	2.80
	$8 \times 10^{-6}$	0.50	0.91836	2.1492	0.079	19.382	0.802	2.78

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5. Optical Limiting Behavior of Organic Dyes

Closing-aperture Z-Scan was used to investigate the optical limiting behavior of a combination of Rhodamine B and Methyl Violet 10B (RB and MV) chemical dyes with a ratio of 3:1 as solutions at concentrations of  $2 \times 10^{-6}$ ,  $4 \times 10^{-6}$ ,  $6 \times 10^{-6}$ , and  $8 \times 10^{-6}$  M. For each sample dissolved in (Ethanol), the optical limiting parameters at room temperature are shown in Figure (5).

Nonlinear refraction is responsible for the samples' excellent optical limiting performance. Initially, the output power increases as the input power increases, but at some point the sample begins

defocusing the beam, which results in a bigger portion of its cross-section being cut off by the aperture. Consequently, the photodetector's transmittance remained rather consistent, confirming (Wenhui Y et al, 2005). Whereas the optical power limiting threshold is inversely proportional to concentration, meaning that the optical limiting properties improve with increasing concentrations, the lower the threshold and amplitude of the optical limiting, the more suitable the sample is for optical limiting, as listed in Tables (2)



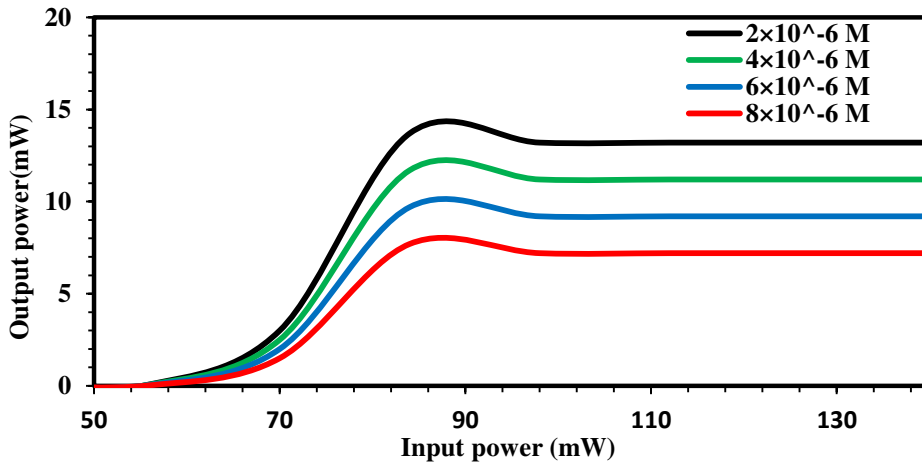


Figure 5. The optical limiting response for mixing of (RB+MV)organic laser dyes with ratio (3:1)at different concentrations in Ethanol solvent

Table 2. The optical limiting response of mixture of Rhodamine B and Methyl Violet 10B (RB and MV)organic laser dyes at different ratios as solutions at different concentrations

Material	Concentration (M)	Limiting Threshold (mw)	Limiting Amplitude (mw)
Mixture RB+MV at ratio 3:1	$2 \times 10^{-6}$	14.2	85
	$4 \times 10^{-6}$	12	85
	$6 \times 10^{-6}$	10	84.5
	$8 \times 10^{-6}$	7.9	84

**Conclusions**

Research found the linear refractive index ( $n_o$ ) increased with increasing concentration, the linear absorption coefficient ( $\alpha_o$ ) increased with increasing concentration, the nonlinear refractive index ( $n_2$ ) increased with increasing concentration, and the nonlinear absorption coefficient ( $\beta$ ) decreased with increasing concentration, where the lower the threshold and amplitude of the optical limit. The optical limiter is used to protect the human eye from the high powers of the laser, the more suitable the sample is to perform a test.

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