Spectral Characteristics of Rhodamine B Dye in Different Solvents (Methanol, Water, and Acetone)

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Abstract
This study examined the impact of concentration fluctuation on the absorption spectra of laser dye Rhodamine B in methanol, water, and acetone at ambient temperature concentrations of 10^{-5}, 10^{-6}, and 10^{-7} M. Numerous factors were assessed, including absorbance, wavenumber, and molar absorption coefficient. The findings demonstrated that different solvent types and concentrations alter the absorption peak's wavelength and strength.

Keywords: Rhodamine B; Spectral characteristics; Absorption; Solvent effect
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1. Introduction

Kamlet and Taft linear solvation energy correlations allow for an investigation of the solvatochromic properties of Coumarin dyes as well as the solvent/solute hydrogen bonding interactions. The environment of the dissolved dye plays an important role in its photophysical activity. Absorption spectra of Coumarin dyes in solutions have been obtained [1]. An investigation into the absorption and fluorescence spectra at constant molar concentrations (FIF) of Rhodamine B was submitted at room temperature as regard to ethanol, methanol and their associated mixture [2] to be realised and to understand the spectroscopic characteristics of optical emission of dye Rhodamine 6G (R6G) [2]. Here we explore the effects of solvent and concentration. Eight different organic solvents are in investigated at constant dye concentration. The slight changes in the fluorescence spectra are observed only for different solvents [3]. The influence of differential solvents on the fluorescence and absorbance spectrum of Rhodamine 3GO dye with room temperature and constant concentration were studied. The fluorescence spectra is move to the long wavelength (red shift) and decreasing absorption were shown by this data [4]. Concentration Dependent Investigation of Optical Absorption and Fluorescence Spectra of Rhodamine 6G Dye Solution. The influence of increasing dye concentration on the position of the absorption and fluorescence peaks is examined. As a result, it quenches the fluorescence intensity and increases its absorbance [5]. Various concentrations of Rhodamine B dye were produced in solvent water at room temperature. The optical linear properties: the transmission, absorption spectrum, the linear coefficient of absorption and the linear index of refraction [6] al so for a mixture of Rhodamine B (RB) and Fluorescein Sodium (Na Fl) organic laser dyes were determined at different concentrations in ethanol solvent [7]. The linear optical properties of Rhodamine B in water, a well-studied organic dye with laser applications as given in the fluorescence spectra and absorption spectra, are important for use in more modern applications. Fluorescence and absorption spectra of the dye were calculated [8]. Rhodamine 6G (Rh6G) dye photophysical properties in vary solvents at room temperature have been studied. Additionally, to portray the influence of concentration and solvent on its absorption and fluorescence of the dye [9]. Fluorescence and optical absorption spectra oscillated by Rhodamine B dye molar concentration. Results indicated an increase in absorption intensity along with a decrease of fluorescence intensity [10]. This work sought to determine the influence of concentration on fluorescence and the Eosin dye absorption spectra obtained from solutions at different concentrations. These include absorptions wavelength and fluorescence in the UV-Vis [11].

2. Theoretical part

The relationship between the intensity of the incident ray (I_0) and the intensity of the intensity of transmitted light ray (I) can be expressed by the following formula [12]:

$$I = I_0 e^{-\varepsilon c x} \quad (1)$$

where ε is the absorption coefficient, c is the molar concentration, and x is the path length or sample thickness

3. Experimental Part

Rhodamine B is a chemical compound $C_{28}H_{31}ClN_2O_3$ and molecular weight 479.02 g/mol. Rhodamine dyes fluoresce and can thus be detected easily by fluorometers.

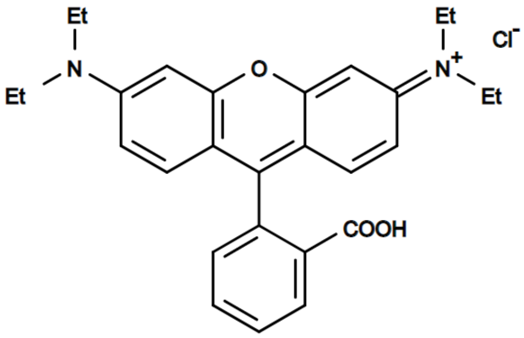

Fig (1) Chemical structure of Rhodamine B dye

The material is weighted according to the following relation:

$$W = \frac{M \times M_W \times V}{1000} \quad (2)$$

where W is the weight of material in (g), M_W is the molecular weight (g/mol), M is the molar concentration (mol/L), and V is the volume of solvent used to dissolve the material in (mL)

The following equation was used to dilute the produced solutions:

$$M_1V_1 = M_2V_2 \quad (3)$$

where M_1 is the primary concentration, M_2 is the new concentration, V_1 is the volume of solution before dilution, and V_2 is the volume of solution after dilution

4. Results and Discussion

The absorption spectra of Rhodamine B dye were monitored in different solvents, namely methanol, water, and acetone at concentrations 1×10^{-5}, 1×10^{-6}, 1×10^{-7} at room temperature. Figures (2), (3), and (4) illustrate the absorption spectra of Rhodamine B dissolved in three different solvents (methanol, water and acetone). We observe some changes in the wavelength of the absorption peak of Rhodamine B in methanol at 540, 550 and 552 nm, in water 553, 554 and 555 nm, and in acetone 530, 535 and 537 nm for the three concentrations as shown in table (1). We observe a shift in absorption peaks towards shorter wavelengths. Laser dye solutions should ideally be prepared in very dilute formulations to obtain the lowest possible overlap area between spectral beams.

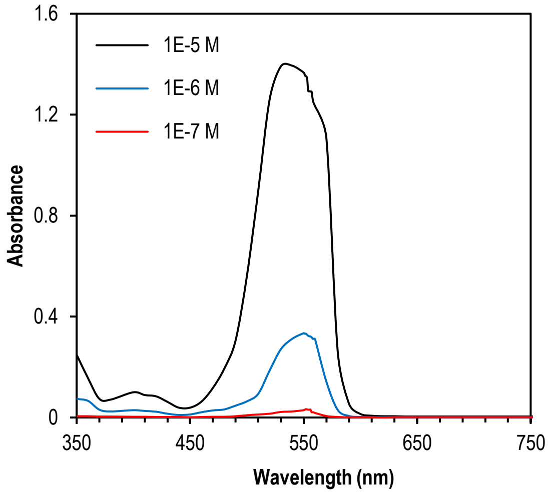

Fig (2) Absorption spectra of Rhodamine B dye dissolved in methanol at molar concentrations of 1×10^{-5}, 1×10^{-6}, and 1×10^{-7}

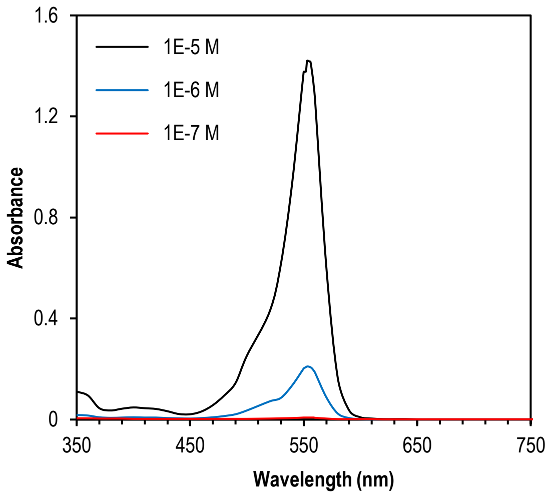

Figure (3) Absorption spectra of Rhodamine B dye dissolved in water at molar concentrations of 1×10^{-5}, 1×10^{-6}, and 1×10^{-7}

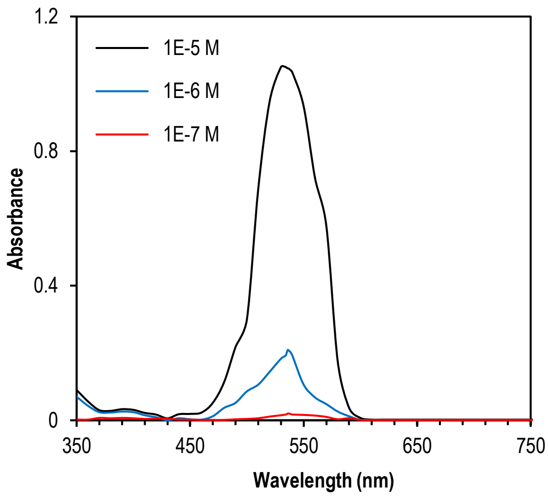

Figure (4) Absorption spectra of Rhodamine B dye dissolved in acetone at molar concentrations of 1×10^{-5}, 1×10^{-6}, and 1×10^{-7}

5. Conclusion

Increasing the concentration of the laser dye solution causes both an increase in the spectrum range and a shift of the absorption peak towards longer wavelengths (known as the "Red Shift"), which is caused by a rise in the disturbance field between the molecules. The increase in the absorption intensity of the dye with increasing concentration is attributed to the increased number of molecules, which in turn increases the probability of absorption within the concentration limits used. This is consistent with Beer-Lambert's law. The molar absorption coefficient (ε) increases with decreasing concentration in water, while in methanol and acetone it decreases only at a concentration of 10^{-7}.

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Table (1) The wavelengths and wavenumbers of the peaks of the absorption spectra of Rhodomine B dye in different solvents

Solvent	Molar Concentration	Maximum wavelength $\lambda_{max.}$ (nm)	$\bar{\nu}(cm^{-1})$	Molar absorptivity (ε) ($L.mol^{-1}.cm^{-1}$)
Methanol	1×10^{-5}	540	18518.5	1.394×10^{5}
	1×10^{-6}	550	18181.8	3.34×10^{5}
	1×10^{-7}	552	18115.9	3.3×10^{5}
Water	1×10^{-5}	553	18083.1	1.42×10^{5}
	1×10^{-6}	554	18050.5	2.1×10^{5}
	1×10^{-7}	555	18018.0	8.0×10^{5}
Acetone	1×10^{-5}	530	18867.9	1.05×10^{5}
	1×10^{-6}	535	18115.9	2.0×10^{5}
	1×10^{-7}	537	18050.5	2.0×10^{5}