


The silver suspension effect on the spectral properties of Rhodamine B dyes

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ABSTRACT

In this paper, the effect of adding silver nanoparticles to a solution of Rh B dye dissolved in ethyl alcohol with a molar concentration ($1 \times 10^{-5} \text{M}$) on the spectral properties (absorption and fluorescence) was studied. The results showed an increase in the absorbance peaks and suppression of the fluorescence peaks by adding silver nanoparticles. The results showed an improvement in the absorption peaks with an increase in the added weights and suppression of fluorescence. The phenomenon of damping at the apex of fluorescence is caused by the collision mechanism, by the increase in optical path length, and by the contribution of binary molecules and chromosomal clusters.

Keywords: “Rhodamine dye, doping, silver particles, absorbance, fluorescence, optical switches”.

1. Introduction

Rhodamine B (Rh.B) dye is one type of xanathene family derivatives, which is represent a core of such group of dyes, and tends to be fluorescent [1].

Rh.B is a triphenylmethane dye, appears to be red-violet color, 479.02 g/mole molecular weight, molecular formula ($\text{C}_{28}\text{H}_{31}\text{ClN}_2\text{O}_3$), and figure (1) shows a molecular structure [2].

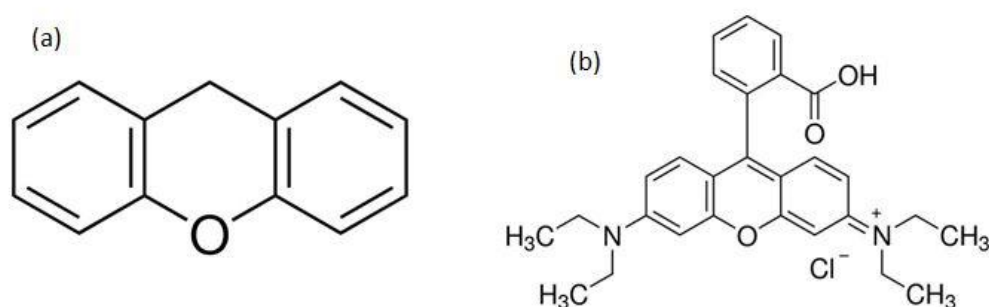


Figure 1. The molecular structure of Xanthine's (a), and (b) Rh B dye [3].

In addition to dye sensitized solar cells as a prospective technical development in the field of solar cells, Fluorescence microscopy, flow cytometry, and fluorescence correlation spectroscopy are just a few of the biotechnology applications that use Rh. B dyes.[4].

Organic dyes are well-known for fluorescence applications, such as active medium in liquid type lasers and a photonic switch (Q-switching), which is defined as an optical medium that absorbs a specific wavelength of the pumping source for a specified period and changes its spectral properties and characteristics based on its interaction with wavelength falling on it.[5].

Silver is a chemical element with the symbol Ag (derived from the Greek word meaning "shiny" or "white"). A soft white metal, it exhibits the highest thermal, electrical and reflective conductivity among any other metal. Silver is found in the Earth's crust in the form of a pure and free element ("original silver"), as an alloy with other metals, and in minerals such as argentite. Most silver is made as a by-product of refining gold, lead, copper, and zinc [6]. Appliances, such as air conditioners or refrigerators, have a nano-silver coating on their interior surfaces for an anti-bacterial and anti-fungal effect. When the air moves, the painted surfaces interact with silver ions that can resist any aerobic bacteria, which in turn prevents the respiration of bacteria, negatively affects the cellular metabolism of bacteria and prevents cell growth [7].

Many investigations have been made about different types of death. Barzan et al. explored the effect of concentration on the absorption and fluorescence properties of Rhodamine 6G dye. [8], the effect of solvent type on the structural properties of Rhodamine 6G was investigated by Chapman et al. [9], Ali et al. They are a group of scientists who developed a revolutionary method for [10], Ali et al. They are a group of researchers who have collaborated on a variety of initiatives. [11], Zampini et al. Study of the photophysical properties of dyed silica particles. [12]. Dyes are very useful in a variety of applications, including active liquid media in tunable lasers[13], and a fast negative Q-Switching element (saturable absorber) in solid-state lasers [14]. Peggett. He synthesized Rhodamine derivatives and demonstrated their usefulness as fluorescent sensors. [3], Al-Arab et al. generating a random laser using a fluorescein dye moistened with TiO₂ nanoparticles [15]. They also studied a theoretical model to study the photophysical properties of laser-saturated Ag nanoparticles using fluorescein dye [16]. The present work focuses on the synthesis of Rh. B dye and the study of the effect of doping with silver particles on the photophysical properties (absorption and fluorescence).

2. Materials and methods:

Rh B dye solution was made at a concentration of (1×10^{-5} M) by simply dissolving the dye powder in high purity ethanol (0.999) and stirring the solution for 20 min at room temperature to each sample, after which we added silver nanoparticles with weights (0.002g, 0.004 g, 0.006 g, 0.008 g) followed to the solution and stirred until it was homogeneous and the color of the solution changed, and it reached two hours for each sample.

In order to examine the as-prepared samples, each sample was packed into a dark glass tube, absorbance was tested with (UV/VIS Lasany) and then we checked for fluorescence with a spectrophotometer (SHIMATDZU RF-5301pc). The wavelength

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of the maximum absorption peak was used as the wavelength of the pumping source in the fluorescence experiment and we also examined (FTIR) by Fourier transform infrared spectroscopy (BIOTECH ENGINEERING MANAGEMENT) to measure the amount of infrared radiation reflected or transmitted through the samples.

3. Results and discussion:

In order to verify the prepared Rh.B dye solutions, the Fourier Transform absorption in the infra-red region (FTIR) spectra were measured as shown in figure (2), the figure reveals the band observed at 3670 cm^{-1} is due to the OH group absorption in alcohol. The broad-band at 3317.5 cm^{-1} is assigned to OH-stretching of carboxylic acids, while the adsorption band at $2977\&2970\text{ cm}^{-1}$ are assigned to C-H asymmetric and symmetric stretching vibration respectively.

The band at 1485 cm^{-1} is due to C-H band in alkane, and the bands at $1319\text{ \& }1273\text{ cm}^{-1}$ are attributed to C-N stretch in aromatic amine.

The sharp band at 1041 cm^{-1} , due to C-O stretch in ether. The observed band at 879 cm^{-1} is assigned to aromatic ring, and the bands at $605\text{ \& }651\text{ cm}^{-1}$ is due to C-Cl stretch in halo-compounds.

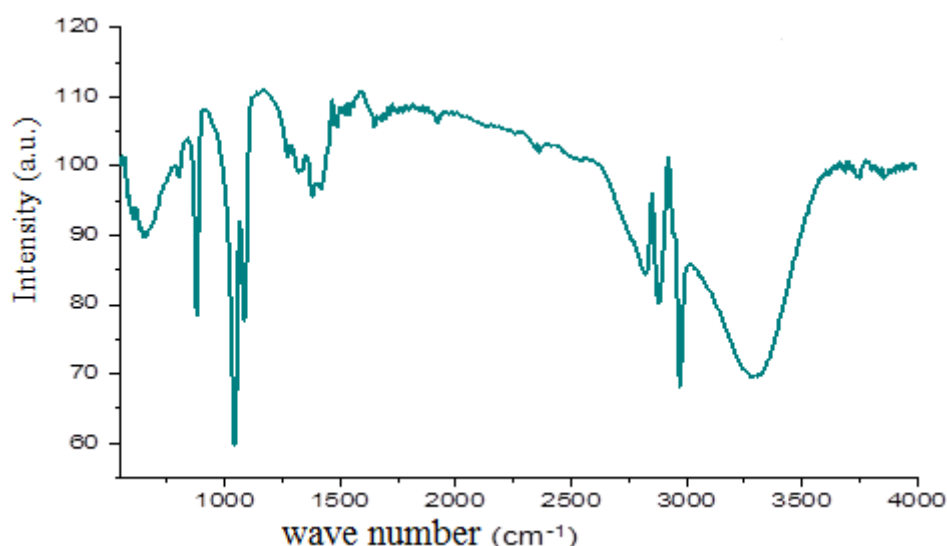


Figure 2. The FTIR Spectrum of the solution for Rh.B and silver nanoparticle

In order to examine the silver powder particle size, the surface topography of the sample powder prepared for AFM 3-dimensional images are obtained by scanning the sample surface with ($1\mu\text{m}\times 1\mu\text{m}$) area, and 100 nm height. The result data (figure 3) show that the r.m.s roughness value equal to (0.931) nm, that leads to the estimated silver grain size around (50-100) nm.

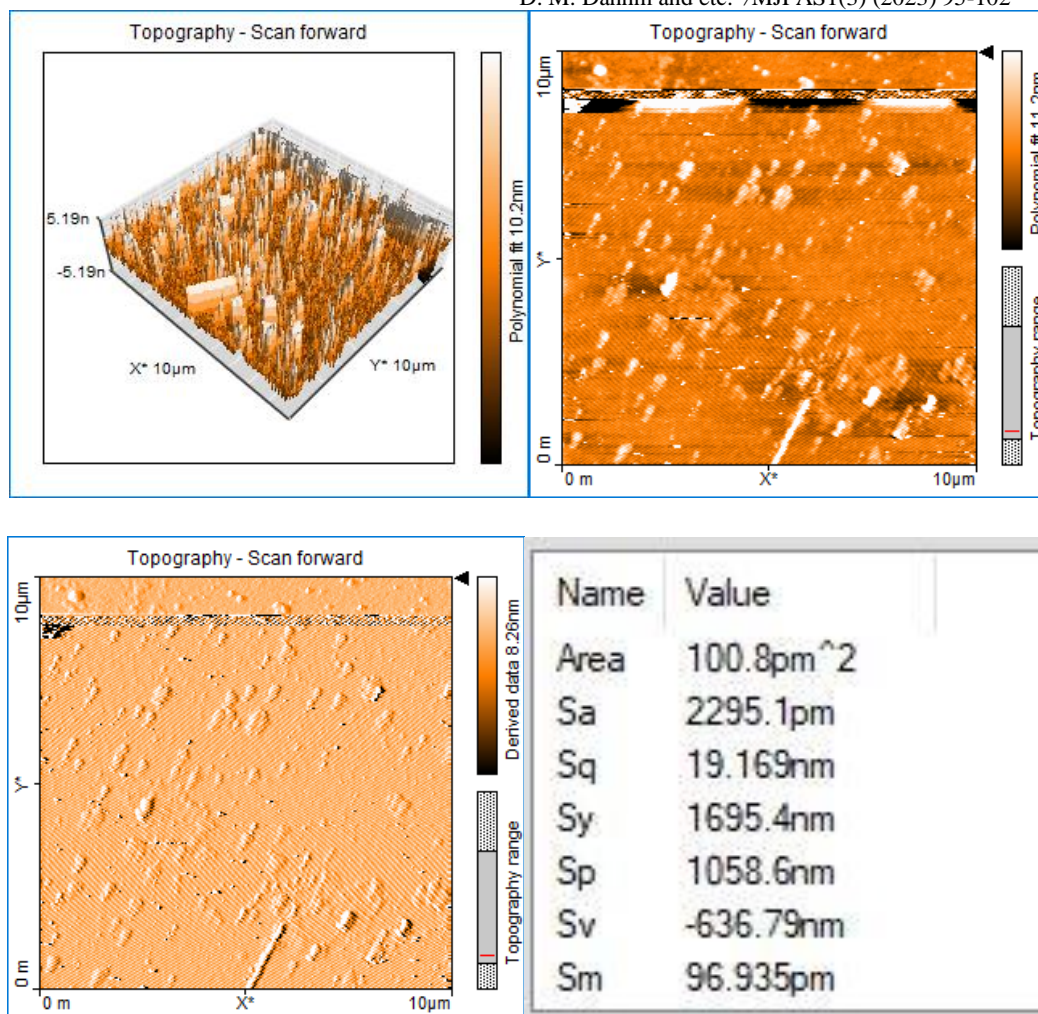


Figure 3. The AFM images of the nano-silver powder

The absorption and fluorescence spectra were varied at different weights, the synthesis of monomer and dimer, as well as the assembly of Rh.B dye particles with nanoparticles. Figure (2) depicts the optical absorption spectra of Rh.B solution at a concentration (1×10^{-5} M) and silver addition with different weights ($\text{Ag}_1=0.002\text{g}$, $\text{Ag}_2=0.004\text{g}$, $\text{Ag}_3=0.006\text{g}$, $\text{Ag}_4=0.008\text{g}$).

Figure (4) shows that the intensity of the absorption peak increases with the increase of silver added weights due to the increase in the absorption cross section. The solution shows an absorption peak around 543 nm due to the absorption of the monomer corresponding to the So-S1 electron transition, and a shoulder around 580 nm due to the presence of the diodes [17]. On the other hand, the molar concentration of dye solution (Ag_2) shows a complete binary process. Rh. B Dye occurs at (Ag_3 , Ag_4) dye concentrations, when the absorption peak at 544 nm fades away.

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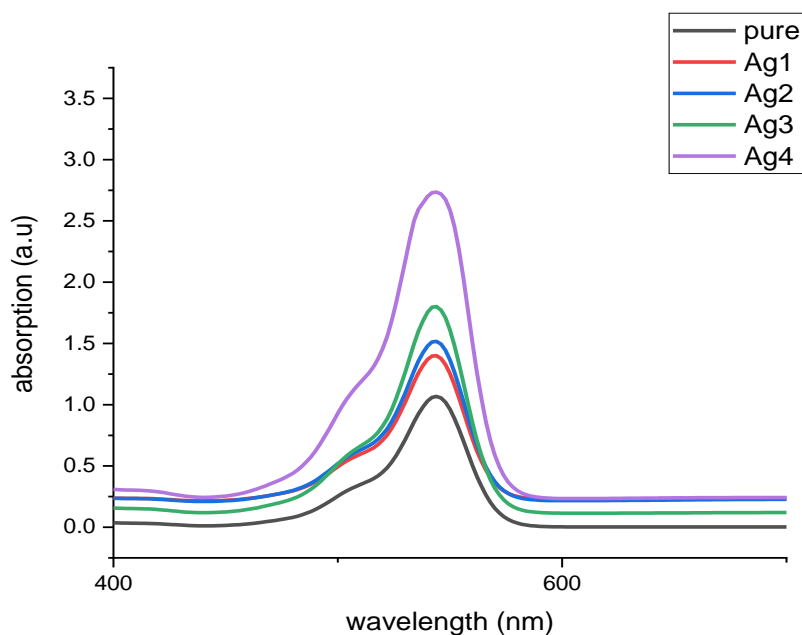


Figure 4. Absorption spectra of Rh.B solutions with silver.

The energy band gaps of Rh. B were determined using optical absorption spectra taking advantage of the following relationship [18]:

$$\alpha h\nu = A(h\nu - E_g)^2 \quad (1)$$

Where: α denotes the absorption coefficient, h is Planck's constant, ν is frequency, A is a transition probability dependent constant, E_g is the energy band-gap and the gradient (n) depends on the type of transformation, (E.g. indicates the energy distance between absorption and fluorescence peaks).

The following figures also indicate the graph $(\alpha h\nu)^2$ as a function of $(h\nu)$ where the energy bandgap was obtained by extracting it from the straight line of the curve $(\alpha h\nu)^2$ against $h\nu$ to intercept the horizontal axis, where it was found to be equal to ($E_g = 4.54$ eV) of the solution before doping and after adding the nanoparticles, it was found that it is equal to ($E_g = 6.28$ eV) as shown in Figure (5).

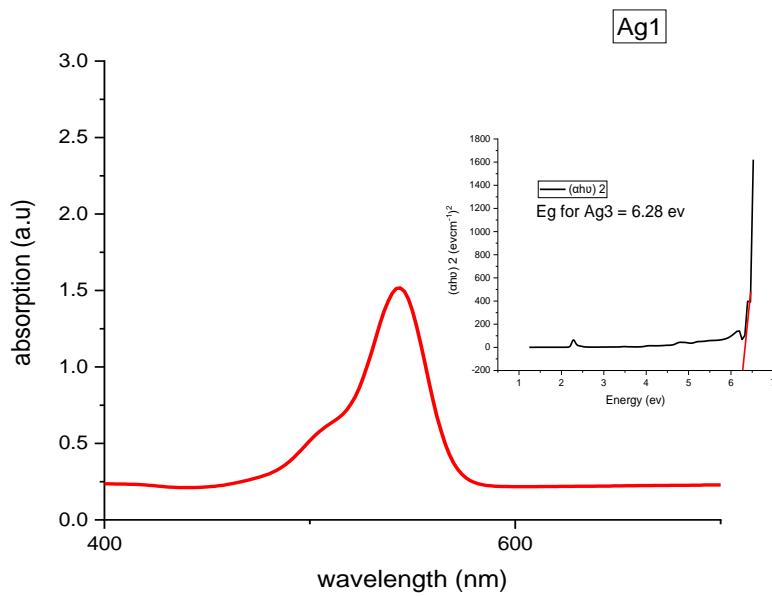


Figure 5. The Energy gap calculation from the absorption spectra.

Figure (6) shows the fluorescence emission spectra of the Rh.B solution with a dye concentration (1×10^{-5} M) and the fluorescence spectra of the dye solution with silver nanoparticles in weights ($Ag_1=0.002$ g, $Ag_2=0.004$ g, $Ag_3=0.006$ g, $Ag_4=0.008$ g). At 542 nm, the emission spectrum shows a relatively narrow bandwidth, indicating that the excitation of the dye solution occurs at this wavelength.

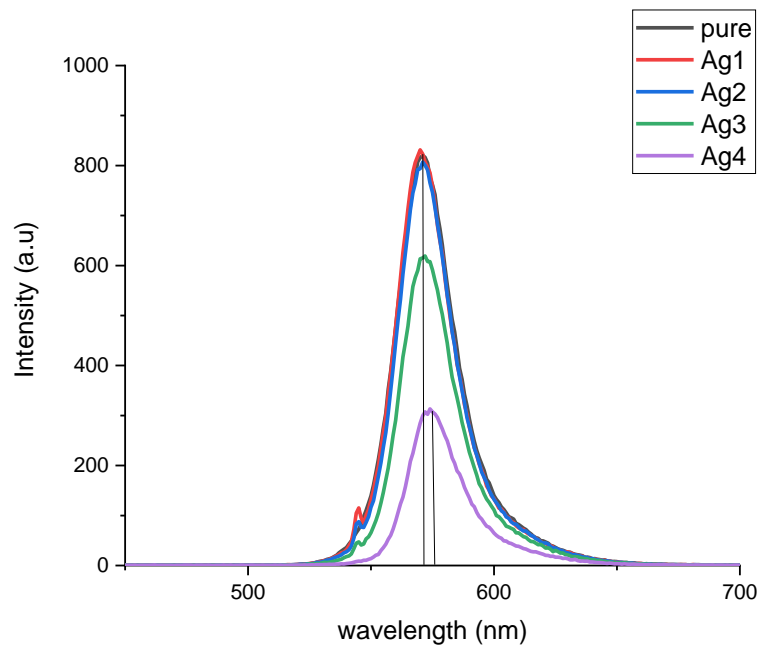


Figure 6. The fluorescence spectra of pure dye and with different weights of silver.

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Figure (6) shows the peak fluorescence wavelength and fluorescence intensity for pure Rh.B solution. The 10 μM dye concentration solution emits at a peak wavelength of about 570 nm, as shown in Figure 6, and the fluorescence peak wavelength shifts to red markedly with increasing weight of silver added especially in the sample (Ag_4) where the peak wavelength is 575 nm. A red spectral shift is detected due to spectral overlap between the fluorescence spectrum of Rh. B dye and the low energy tail of its absorption band, which leads to re-absorption effects [19]. As shown in Figure 5, the fluorescence intensity of the dye decreases drastically with increasing weights added for each sample, except for certain limits where the fluorescence intensity is strongly quenched due to the collision of the excited dye molecules with those in the ground state, as in the sample (Ag_1 , Ag_2) which causes aggregation processes and hypertrophy [20].

The results obtained for the absorption and fluorescence spectra can also be summarized in Table no.1

Table (1): Conclude the obtained results for absorbance and fluorescence.

Solution 1×10^{-5} (M)	Absorbency (a.u.)	Wavelength (nm)	fluorescence	Wavelength (nm)
pure	0.9	543	10	570
Ag1	1.3	544	242	570
Ag2	1.44	543	550	571
Ag3	1.7	544	870	571
Ag4	2.6	544	180	575

4. Conclusion

In this paper, the effect of adding silver nanoparticles to Rh. B dye for application in optical switch is comprehensively studied. Weights were taken ($\text{Ag}_1 = 0.002$ g, $\text{Ag}_2 = 0.004$ g, $\text{Ag}_3 = 0.006$ g, $\text{Ag}_4 = 0.008$ g). The absorption and flash spectra were studied, and it was found that with an increase in the weight of silver added, the absorption increased according to Beer-Lambert's law. As for fluorescence, it was suppressed by the numerous collisions between excited and ground state particles.

5. Acknowledgments:

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