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Synthesis and Spectral Characteristics of RhB and Rh6G Dyes and their Mixture in Solid Matrix

Lalruatpuia, Uzair Khan, K M S Dawngliana & S Rai*

Laser and Photonics Laboratory, Department of Physics, Mizoram University, Aizawl-796 004, Aizawl, India

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The absorption and fluorescence spectra of RhB dye and Rh6G in solvent and doped in silica glass with different concentrations have been carried out in the spectral range of 450-750 nm. The fluorescence spectra have been recorded with two excitation wavelength 370 and 450 nm. CdS nanoparticles (NPs) were prepared by sol-gel method in order to investigate their optical behaviors as efficient Förster resonance energy transfer (FRET). Pure RhB and RhB dye doped in Silica glass with different concentrations were tested as acceptor from the CdS nanoparticles. In this paper, we study FRET behavior of CdS NPs with RhB dye and energy transfer between RhB dye and Rh6G dye.

Keywords: CdS; Sol-gel; FRET; RhB dye; Rh6G dye; Silica glass

1 Introduction

Organic laser dyes within various hosts (liquid or solid) represent attractive materials for use in tunable laser applications because of their large fluorescent bandwidth. Liquid dye lasers require pumping of a dye solution through a resonator to maintain photo stability and hence suffer from where it problems (such as solvent and dye poisoning)[1-3]. Incorporating the laser dyes within host would solve many of these problems. In last few years many efforts have been performed to embedded dye molecules in silica glasses[4-5], with the aim to obtain solid state dye laser devices that could replace the liquid dye laser. Silica is prepared to its superior mechanical, thermal and optical properties. Rhodamine-B dye can be immobilized in silica host. The lack of photostability of the gain medium has been the major factor limiting the use of solid state lasers[6]. Embedding nanoparticle to solid host is for improving the optical property of dye. Forster resonance energy transfer (FRET)[7] is the energy transfer process occurring through the dipole-dipole interactions between an excited donor (D) molecule and an acceptor (A). CdS is a donor part which has the band gap energy 2.41eV[8], combined with RhB as acceptor. Forster energy transfer has great interest in science and has potential applications in the areas of luminescence tagging, imaging, medical diagnostics, multiplexing and most recently in bio-sensors[9-15].

*Corresponding authors: (Email: srai.rai677@gmail.com)

In this work we study the optical properties of CdS nanoparticle prepared by sol-gel process, doped with RhB in concentration range 10^{-6} to 10^{-3} mol.L^{-1} and also energy transfer between RhB dye and Rh6G dye for a concentration ($1x10^{-6}$ Rh6G and $1x10^{-5}$ RhB). The investigations provide the information about the interaction between CdS nanoparticle, RhB dye and Rh6G dye[16].

2 Experimental

2.1 Sample Preparation

RhB and Rh6G dye doped in silica glass was prepared by sol-gel method. Tetraethyl Ortho silicate (TEOS) is used as the main precursor in presence of distilled water to form SiO_2 network. For the preparation of sample the ratio of TEOS, H_2O, C_2H_5OH and HNO_3 is 1:5.5:3.5:0.1 respectively is maintained and stirred for two hours. RhB dye solution is prepared by mixing 50ml/20ml/10ml ethanol with RhB concentration 5×10^{-6} mol.L^{-1}, 1×10^{-5} mol.L^{-1}, 1×10^{-4} mol.L^{-1}, 1×10^{-3} mol.L^{-1}for different sample while for Rh6G the sample is maintained at 1×10^{-5} mol.L^{-1}, 1×10^{-4} mol.L^{-1} and 1×10^{-3} mol.L^{-1} concentrations, now small amount of dye solution is added during stirring position. Now the mixture is stirred for two hours to form sol. The sol is then left at room temperature for few days to form stiff gel in a plastic sealed container. Some pinholes are made for evaporation and left for three weeks to form solid glass sample.

For the preparation of CdS sample 2% thioacetamide, 2% $CdN_2O_6.4H_2O$ and 2ml ethanol solution mixed together and stirred for one hour, during stirring position, heat is produced by magnetic stirrer and three drops HNO_3 mixed with the solution to form yellow colour of CdS solution. This solution is used for optical studies.

2.2 Experimental Setup

Absorption and fluorescence spectra of the prepared sample were recorded by iHR320 imaging spectrometer (HORIBA). All optical measurements were recorded at room temperature. The excitation wavelengths were set at 370 and 450 nm of diode lasers.

3 Results and Discussion

3.1 Optical properties

3.1.1 Absorption spectra of pure RhB and RhB doped in silica glass at different concentration

The absorption spectra of RhB in liquid at different concentrations and RhB and RhB doped in silica glass are shown in Fig. 1(a,b). From Fig. 1(a) we observed the absorption peak at (a) 545 nm (b) 550 nm (c) 575 nm and (d) 593 nm for different concentrations of RhB. The absorption intensity is increased with increasing concentration of RhB in ethanol solution; The FWHM is increased with increasing the concentration of RhB. Again from Fig.1(b) the absorption spectra of RhB in silica host at 4 different concentrations observed at (a) 566 nm (b) 553 nm (c) 526 nm and (d) 571 nm for different concentrations of RhB. The absorption intensity is decreases with increasing concentration of RhB solution from 5×10^{-6} mol.L^{-1} to 1×10^{-4} mol.L^{-1} the intensity again increases at the concentration of 1×10^{-3} mol.L^{-1}of RhB in silica glass. From Table-1 the FWHM of RhB doped in silica glass is vary with concentration, at lower concentration 5×10^{-6} mol.L^{-1} the FWHM is 91.97 nm, it increases to 101.36 nm at 1×10^{-5} mol.L^{-1}, but it decreased at the concentration 1×10^{-4} mol.L^{-1}to 88.21 nm then increased at highest concentration of RhB at 1×10^{-3} mol.L^{-1} to 95.72 nm.

3.1.2 Emission spectra of pure RhB at different concentrations and RhB doped in silica glass

The emission spectra of Pure RhB and RhB doped in silica glass with different concentrations are shown in Fig. 2(a,b). The emission peak observed in Fig.2 at (a) 571 nm with intensity 18551 (a.u), (b) 575 nm with intensity 39545 (a.u), (c) 590 nm with intensity

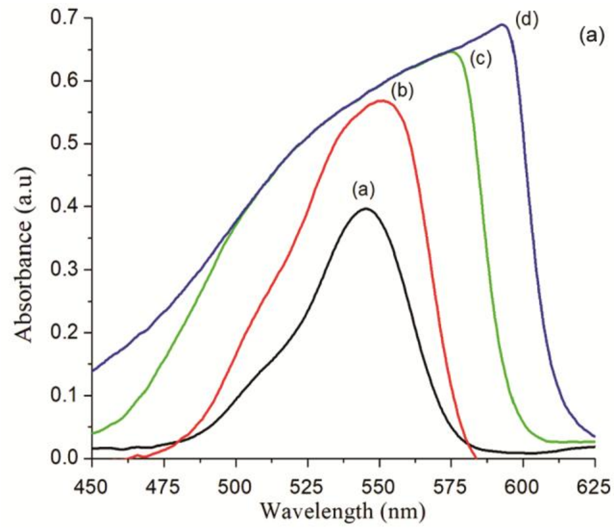

Fig. 1 – (a) a; Absorption spectra of RhB in ethanol with different concentrations at (a) 5×10^{-6} mol.L^{-1}(b) 1×10^{-5} mol.L^{-1} (c) 1×10^{-4} mol.L^{-1} (d) 1×10^{-3} mol.L^{-1}.

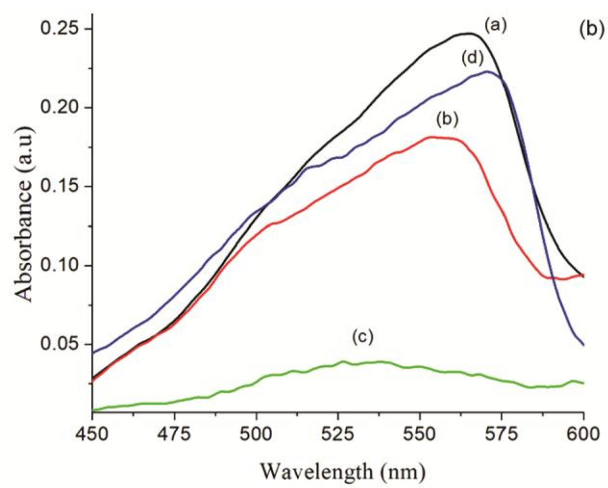

Fig. 1 – (b) Absorption spectra of RhB doped in Silica glass with different concentrations at (a) 5×10^{-6} mol.L^{-1}RhB,(b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB (d) 1×10^{-3} mol.L^{-1} RhB in ethanol solvent.

Table1 — Absorption of RhB in liquid and silica glass

Concentration (M/L)	(5×10^{-6})		(1×10^{-5})		(1×10^{-4})		(1×10^{-3})	
RhB in two different host	liquid	in silica glass	liquid	silica glass	liquid	silica glass	liquid	silica glass
Wavelength (nm)	545	566	550	553	575	526	593	571
Absorbance	0.397	0.247	0.569	0.183	0.647	0.042	0.689	0.224
FWHM (nm)	41.29	91.97	54.43	101.36	91.97	88.21	106.99	95.72

25756 (a.u) and (d) 611 nm with intensity 33486 (a.u). So the intensity of emission spectra of RhB increases with the concentration from 5×10^{-6} mol.L^{-1} to 1×10^{-5} mol.L^{-1} and intensity becomes maximum at 1×10^{-5} mol.L^{-1}and then again decreases when we further increase the concentration at 1×10^{-4} mol.L^{-1} and increased at highest concentration of 1×10^{-3} mol.L^{-1}of RhB to 33486 (a.u) as shown in Table-2. Similarly, in Fig. 2(b) the emission peak observed at (a) 586 nm with intensity 20450 (a.u), (b) 593 nm with intensity 34692 (a.u), (c) 571 nm with intensity 6701 (a.u) and (d) 604 nm with intensity 14674 (a.u). Here intensity become maximum at concentration 1×10^{-5} mol.L^{-1}and for again increase the concentration intensity becomes minimum at 1×10^{-4} mol.L^{-1}and again increases with increasing to maximum concentration.

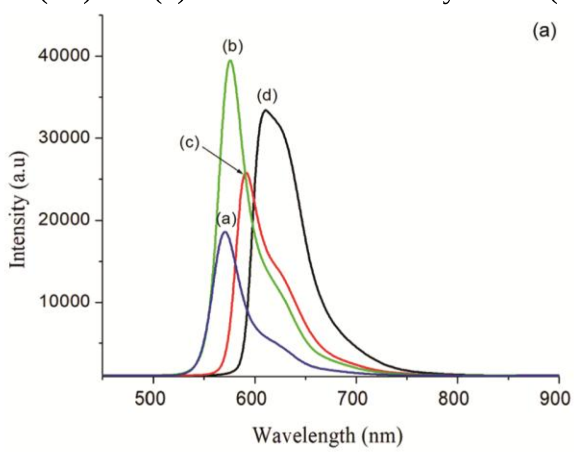

Fig. 2 − (a) Emission spectra of pure RhB at concentration of (a) 5×10^{-6} mol.L^{-1} RhB (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB (d) 1×10^{-3} mol.L^{-1} RhB in ethanol solvent.

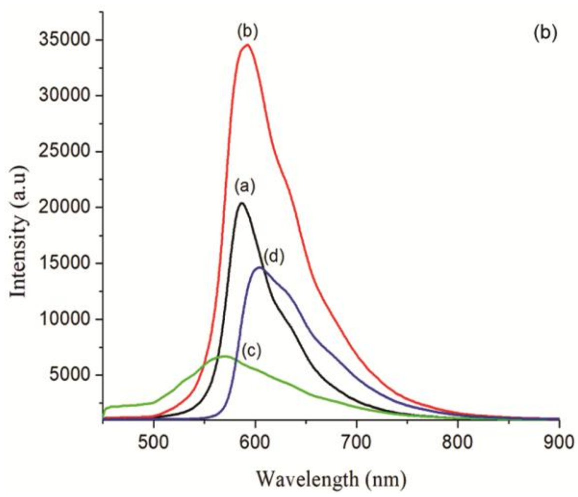

Fig. 2 − (b) Emission spectra of RhB doped in silica glass at (a) 5×10^{-6} mol.L^{-1} RhB, (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB and (d) 1×10^{-3} mol.L^{-1} RhB in ethanol solvent.

3.1.3 Absorption spectra of RhB dye doped in 2% CdS and RhB dye doped in 2% CdS co-doped with silica glass

Absorption spectra of RhB dye doped in 2% CdS and RhB dye doped in 2% CdS co-doped with silica glass at different concentrations is shown in Fig. 3(a,b). From Fig. 3(a), we observed the

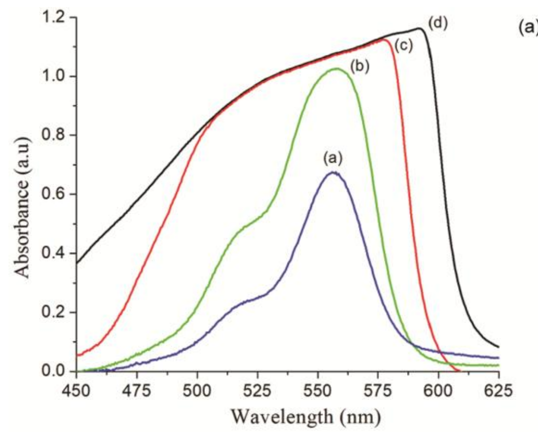

Fig. 3 − (a) Absorption spectra of RhB doped in 2%CdS with different concentrations at (a) 5×10^{-6} mol.L^{-1} RhB, (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB (d) 1×10^{-3} mol.L^{-1}RhB in ethanol solvent.

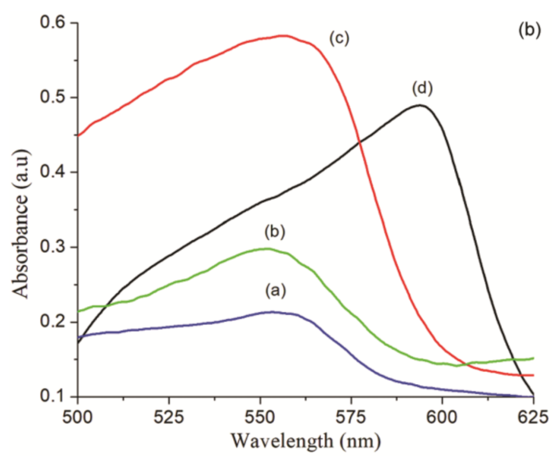

Fig. 3 − (b) Absorption spectra of RhB doped in 2%CdS and Silica glass with different concentrations at (a) 5×10^{-6} mol.L^{-1} RhB, (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB (d) 1×10^{-3} mol.L^{-1} RhB in ethanol solvent.

Table 2 — Emission of RhB in liquid and silica glass.

Concentration (m/L)	(5×10^{-6})		(1×10^{-5})		(1×10^{-4})		(1×10^{-3})	
RhB in two different host	liquid	silica glass	liquid	silica glass	liquid	silica glass	liquid	silica glass
Wavelength (nm)	571	586	575	593	590	571	611	604
Intensity (a.u)	18551	20450	39545	34692	25756	6701	33486	14674
FWHM (nm)	33.78	45.045	33.785	73.2	48.807	118.25	52.56	78.84

Table 3 — Absorption of RhB in liquid and silica glass with 2% CdS.

Concentration (m/L)	(5×10^{-6})		(1×10^{-5})		(1×10^{-4})		(1×10^{-3})	
RhB and 2% CdS in two different host	liquid	in silica glass	liquid	in silica glass	liquid	in silica glass	liquid	in silica glass
Wavelength (nm)	555	555	558	552	577	556	591	593
Absorbance	0.674	0.214	1.026	0.3009	1.124	0.585	1.162	0.489
FWHM (nm)	36.384	93.84	51.039	90.238	98.539	110.09	122.29	81.94

absorption peak at (a) 555 nm (b) 558 nm (c) 577 nm and (d) 591 nm for different concentrations of RhB. The absorption spectrum intensity is increased with increasing concentration of RhB solution, which is shown in Table-3, similarly FWHM is increased with increasing the concentration of RhB. Again from Fig. 3(b) the absorption peak observe at (a) 555 nm (b) 552 nm (c) 556 nm and (d) 593 nm for different concentrations of RhB. The absorption spectrum intensity is increased with the concentration from 5×10^{-6} mol.L^{-1}to 1×10^{-4} mol.L^{-1}of RhB, but at highest concentration 1×10^{-3} mol.L^{-1}of RhB, intensity is decreased to 0.489 (a.u). From Table-3 the FWHM of RhB doped in 2% CdS co-doped with silica glass is vary with concentration, at lower concentration 5×10^{-6} mol.L^{-1}the FWHM is 93.84 nm, it decreases to 90.23 nm at 1×10^{-5} mol.L^{-1}, but it increased at the concentration 1×10^{-4} mol.L^{-1}to 110.09 nm then again decreased at highest concentration of RhB at 1×10^{-3} mol.L^{-1}to 81.94 nm.

3.1.4 Emission of RhB at different concentrations doped in 2% CdS and RhB doped in 2% CdS co-doped with silica glass

The emission spectra of RhB dye doped in 2% CdS at different concentration and RhB dye doped in 2% CdS co-doped with silica glass is shown in Fig. 4(a,b). From Fig. 4(a), the emission peak is observed at (a) 580 nm (b) 644 nm (c) 653 nm and (d) 669 nm, increasing the concentration of RhB the intensity is increases at concentration 5×10^{-6} mol.L^{-1} to 1×10^{-5} mol.L^{-1}. Then we again increase the RhB concentration to 1×10^{-4} mol.L^{-1}, intensity decreases for the highest concentration, intensity again decreases to 41378(a.u) is shown in Table-4. Again from Fig. 4(b), emission peak observe at (a) 600 nm (b) 606 nm (c) 622 nm, (d) 634 nm. The intensity variation is same as Fig. 4(a) which is shown in Table-4. The FWHM of Fig. 4(a) is also slightly increases with increasing concentration from 5×10^{-6} mol.L^{-1} to 1×10^{-5} mol.L^{-1}, if we again increase concentration 1×10^{-4} mol.L^{-1} the FWHM will be 45.047 nm and at highest concentration 1×10^{-3} mol.L^{-1} the FWHM will be maximum *i.e* 58.18 nm. Similarly, for Fig. 4(b) the FWHM decreased with increasing concentration from 5×10^{-6} mol.L^{-1} to 1×10^{-4} mol.L^{-1}and at highest concentration 1×10^{-3} mol.L^{-1} FWHM is increased to 95.724 nm.

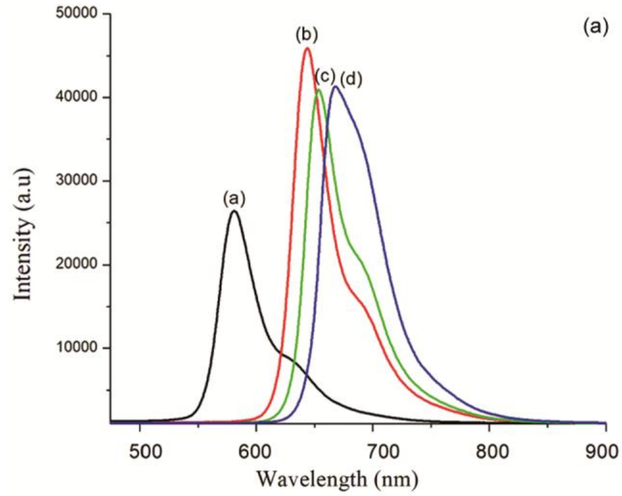

Fig. 4 − (a) Emission spectra of RhB doped in 2% CdS with different concentrations of (a) 5×10^{-6} mol.L^{-1}RhB (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1} RhB (d) 1×10^{-3} mol.L^{-1} in ethanol solvent.

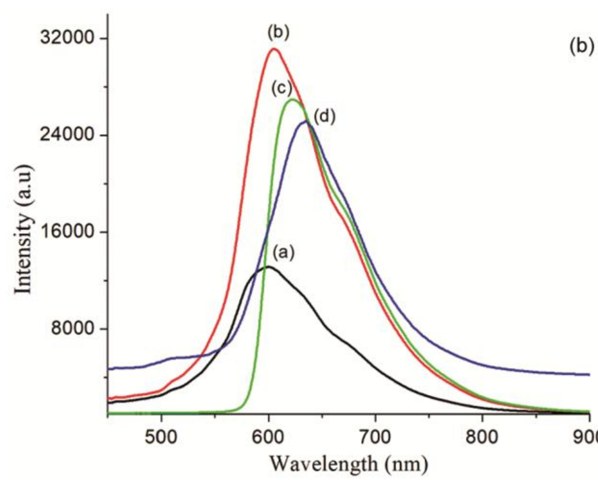

Fig. 4 − (b) Emission spectra of RhB doped in 2% CdS and silica glass with different concentrations of (a) 5×10^{-6} mol.L^{-1}RhB (b) 1×10^{-5} mol.L^{-1} RhB (c) 1×10^{-4} mol.L^{-1}RhB (d) 1×10^{-3} mol.L^{-1} in ethanol solvent.

3.1.5 Emission spectra of RhB at different concentrations doped in silica glass and RhB doped in 2% CdS co-doped with silica glass with ethanol solvent at the excitation wavelength, λ_{exc}=450 nm

The emission spectra of (5×10^{-6} mol.L^{-1}, 1×10^{-5} mol.L^{-1}, 1×10^{-4} mol.L^{-1} and 1×10^{-3} mol.L^{-1} of RhB)

Table 4 — Emission of RhB in liquid and silica glass with 2% CdS.

Concentration m/L	(5×10^{-6})		(1×10^{-5})		(1×10^{-4})		(1×10^{-3})	
RhB and 2% CdS in two different host	liquid	in silica glass	liquid	in silica glass	liquid	in silica glass	liquid	in silica glass
Wavelength (nm)	580	600	644	606	653	622	669	634
Intensity (a.u)	26552	13174	45938	31149	40986	27029	41378	25354
FWHM (nm)	37.53	106.99	37.548	105.108	45.047	91.97	58.18	95.724

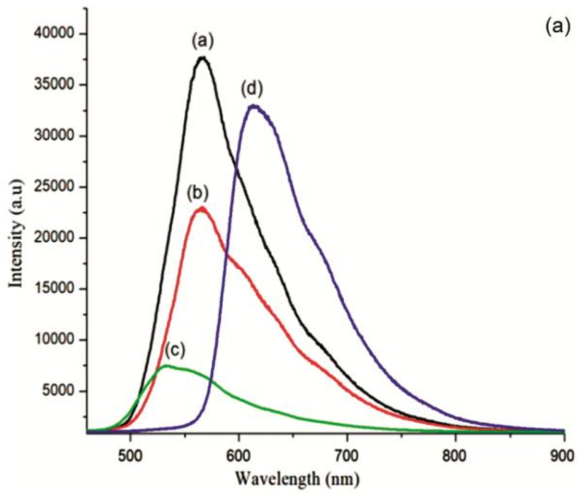

Fig. 5 — (a) Emission spectra of RhB in different concentrations with sol-gel glass in ethanol solvent. (a) 5×10^{-6}RhB doped in Silica glass. (b) 1×10^{-5}RhB doped in Silica glass (c) 1×10^{-4}RhB doped in Silica glass (d) 1×10^{-3}RhB doped in Silica glass.

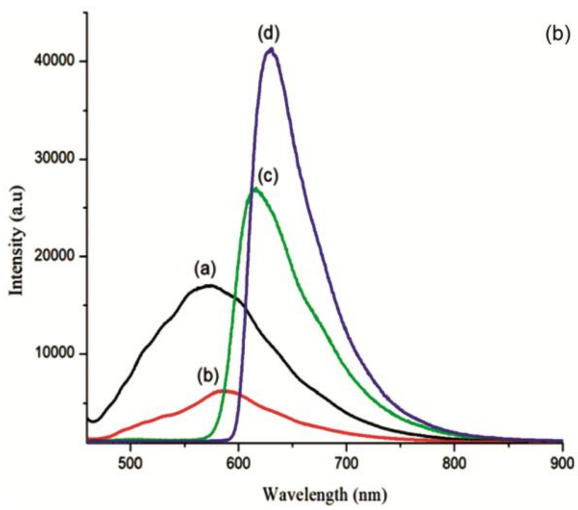

Fig. 5 — (b) Emission spectra of RhB in different concentrations with sol-gel glass in ethanol solvent. (a) 5×10^{-6}RhB doped in 2% CdS and Silica glass. (b) 1×10^{-5}RhB doped in 2%CdS and Silica glass (c) 1×10^{-4}RhB doped in 2% CdS and Silica glass (d) 1×10^{-3}RhB doped in 2% CdS and Silica glass.

doped in silica glass and co-doped in CdS with excitation wavelength 450 nm is shown in Fig. 5(a,b). The effect of dye concentration in Fig. 5(a) for RhB in silica glass as the concentration increases emission wavelength first decreases from 5×10^{-6} mol.L^{-1}to 1×10^{-5} mol.L^{-1}then increases up to higher concentration 1×10^{-3} mol.L^{-1}. So by increasing intensity first it come back to blue shift then goes to red shift. Similar condition occurs for Fig. 5(b) as the concentration increases from 5×10^{-6} mol.L^{-1} to 1×10^{-5} mol.L^{-1} the intensity decreases with blue shift and continue increase the concentration of RhB with 2% CdS to 1×10^{-3} mol.L^{-1} the emission intensity increases to 41306 (a.u) with red shift.

3.1.6 Spectral parameters of Rh-B in two different host materials with different concentrations at the excitation wavelength, λ_{exc}=450 nm

The absorption and fluorescence of the solid sample can give the quantum yield and lifetime of the RhB dye using the solvent as ethanol. We have used the standard value of τ_f=2.7ns[17]. The quantum yield of the samples is estimated from a known standard Φ_0[18] by comparing the absorption and emission spectra of the samples and those of the known standard values using the relation[19] is shown in Table-5.

Φ ——

Where h is the absorption peak height and S is the area under emission curve of the samples h_0 and S_0 are those of the known standard.

3.1.7 Absorption spectra of pure Rh6G and Rh6G doped in silica glass at different concentration

The absorption spectra of Rh6G dissolved in ethanol for three different concentrations and Rh6G doped in silica glass is shown in the Fig. 6(a,b). From this Fig. 6(a), we can notice that the typical absorption band of Rh6G is observed at (a) 531.5 nm (b) 533 nm and (c) 532 nm. The absorbance is increases with increasing the concentration of Rh6G in ethanol solution. From Table-6 the FWHM increases with the increasing concentration of Rh6G, therefore Red shift occurred for Fig. 6(a). Again from Fig. 6(b), the absorption spectra of Rh6G doped with silica at three different concentrations observed at (a) 525.48 nm (b) 501.57 nm (c) 525.48 nm. Additionally, absorption intensity increases with Rh6G concentration while FWHM decreases with increasing concentrations as mentioned in Table-6.

Table 5 — Spectral parameters of RhB doped in silica glass, where $\lambda_{a\,(max)}$ and $\lambda_{e\,(max)}$: absorption and emission maxima; ε is the molecular extinction coefficient; σ_a and σ_e: absorption and emission cross section; Φ_F fluorescence quantum yield.

Host	Concentration ML^{-1}	$\lambda_{a\,(max)}$ nm	$\lambda_{e\,(max)}$ nm	ε (10^3) $LM^{-1}cm^{-1}$	σ_a (10^{-16}) cm^2	σ_e (10^{-16}) cm^2	Φ_F
RhB in Sol-gel silica glass	5×10^{-6}	561.58	567.84	126.8	4.88	0.41	0.22
	1×10^{-5}	553.62	566.25	37.53	1.45	0.33	0.19
	1×10^{-4}	526.54	531.73	1.08	4.17	0.31	0.22
	1×10^{-3}	571.13	613.47	0.64	0.02	0.54	0.21
RhB doped in 2%CdS and Silica glass	5×10^{-6}	551.49	574.21	108.33	4.17	0.20	0.13
	1×10^{-5}	548.31	585.88	61.97	2.39	0.06	0.03
	1×10^{-4}	556.27	616.12	19.08	0.73	0.16	0.05
	1×10^{-3}	591.82	629.90	1.79	0.07	0.36	0.09

Table 6 — Absorption of Rh6G in liquid and silica glass.

Concentrations(M/L)	$1x10^{-5}$		$1x10^{-4}$		$1x10^{-3}$	
Rh6G in liquid and glass	liquid	Silica glass	liquid	Silica glass	liquid	Silica glass
Wavelength (nm)	531.5	525.48	533	501.57	532	525.48
Absorbance (a.u)	2.048	0.218	2.868	0.263	2.944	0.782
FWHM(nm)	32.5	150.37	120	118.72	132.5	106.78

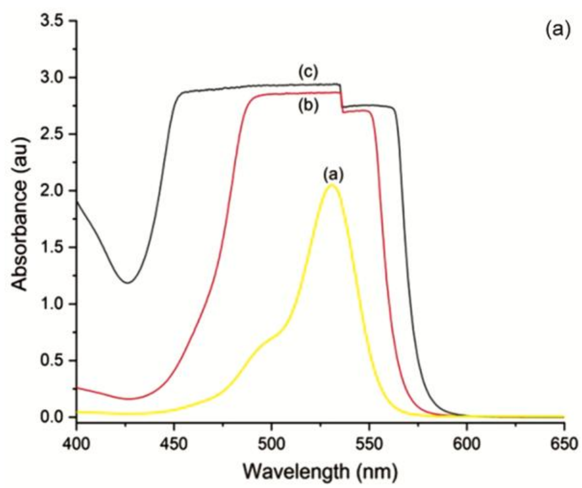

Fig. 6 — (a) Absorption spectra of Rh6G doped at concentrations (a)1×10^{-5} mol.L^{-1} Rh6G (b) 1×10^{-4} mol.L^{-1} Rh6G (c)1×10^{-3} mol.L^{-1} Rh6G in ethanol solvent.

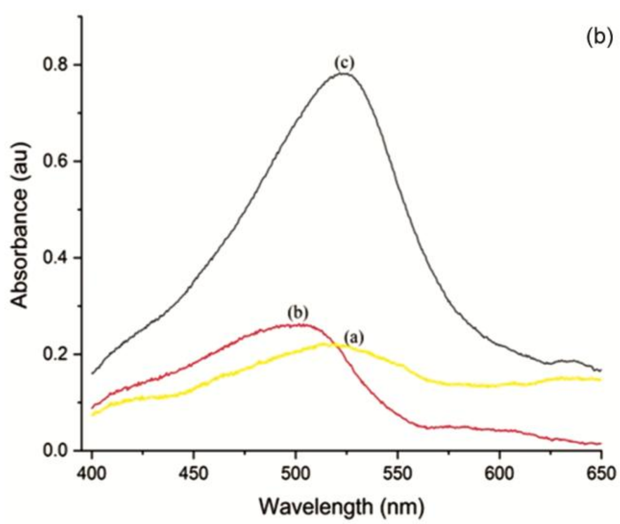

Fig. 6 — (b) Absorption spectra of Rh6G doped silica glass at (a)1×10^{-5} mol.L^{-1} Rh6G (b)1×10^{-4} mol.L^{-1} Rh6G (c)1×10^{-3} mol.L^{-1} Rh6G in ethanol solvent.

3.1.8 Emission spectra of pure Rh6G at different concentrations and Rh6G doped in silica glass

The emission spectra of Pure Rh6G and Rh6G doped in silica glass with different concentrations are shown in Fig. 7(a,b) .The emission peak observed in Fig. 7(a) at (a) 558 nm with intensity 1252(a.u), (b) 579 nm with intensity 2737(a.u), (c) 566.8 nm with intensity 4664 (a.u). So the intensity of emission spectra of Rh6G increases with the concentration from 1×10^{-3} mol.L^{-1} to 1×10^{-4} mol.$L^{-1}$and intensity becomes maximum at 1×10^{-4} mol.$L^{-1}$and then again decreases when we further increase the concentration at 1×10^{-5} mol.L^{-1}. From Table-7 the FWHM increases with increasing concentrations in solid and liquid samples. Again from Fig. 8(b) the emission peak observed at (a) 536.94 nm with intensity 14788 (a.u), (b) 555.53 nm with intensity 43493 (a.u), (c) 604.35 nm with intensity 43550 (a.u). Here intensity becomes maximum at concentration 1×10^{-3} mol.L^{-1} and the concentration intensity becomes minimum at 1×10^{-5} mol.L^{-1}.

3.1.9 Emission spectra of a mixture to fixed concentration of Rh6G dye and changing concentrations of RhB dye in silica matrix

Figure 9(a) shows the mechanism of transfer of energy from the Rh6G dye to RhB dye by mixing fixed concentration of Rh6G dye and changing concentrations of RhB dye, as it shows that the emission spectra are excited wavelength 450 nm. It can be seen that increase the emission spectrum of the acceptor when increasing the concentration of donor dye from 1% of $1x10^{-6}$ RhB to 1.5% of $1x10^{-6}$ RhB. It attains the maximum intensity at 1.5% of $1x10^{-6}$ RhB suggesting energy transfer when and intensity start decreases when increasing the concentrations. We

Table 7 — Emission of Rh6G in liquid and silica glass.

Concentrations(M/L)	$1x10^{-5}$		$x10^{-4}$		$1x10^{-3}$	
Rh6G in liquid and glass	liquid	Silica glass	liquid	Silica glass	liquid	Silica glass
Wavelength (nm)	558	536.94	566.8	555.53	579	604.35
Intensity (a.u)	1252	14788	4664	43493	2737	43550
FWHM(nm)	28.8	88.13	27	88.65	32.8	99.16

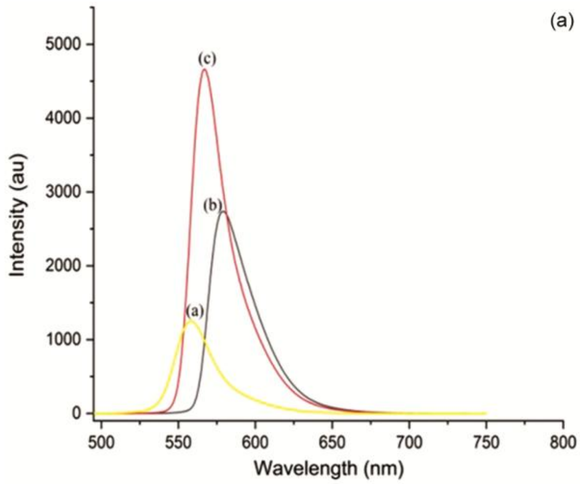

Fig. 7 — (a) Emission spectra of Rh6G doped at concentration (a) 1×10^{-5} mol.L^{-1} Rh6G (b) 1×10^{-3} mol.L^{-1} Rh6G and (c)1×10^{-4} mol.L^{-1} Rh6G in ethanol solvent.

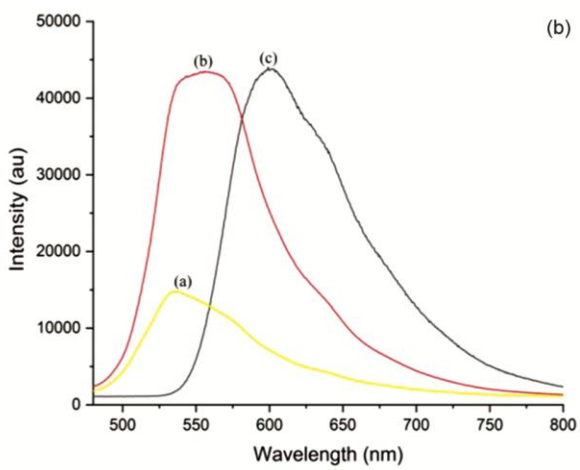

Fig. 7 — (b) Emission spectra of Rh6G doped silica glass at (a) 1×10^{-5} mol.L^{-1} Rh6G (b) 1×10^{-3} mol.L^{-1} Rh6G and (c)1×10^{-4} mol.L^{-1} Rh6G in ethanol solvent.

notice the very wide spectrum extends from 500 nm to 700 nm which is an ideal broad spectrum for the manufacture of lasers for midwife toning on a wide range of wavelengths[20-23].

3.1.10 Emission spectra of a mixture to fixed concentration of RhB dye and changing concentrations of Rh6G dye in silica matrix

Figure 9(a) shows the mechanism of transfer of energy from the RhB dye to Rh6G dye by mixing fixed concentration of RhB dye and changing

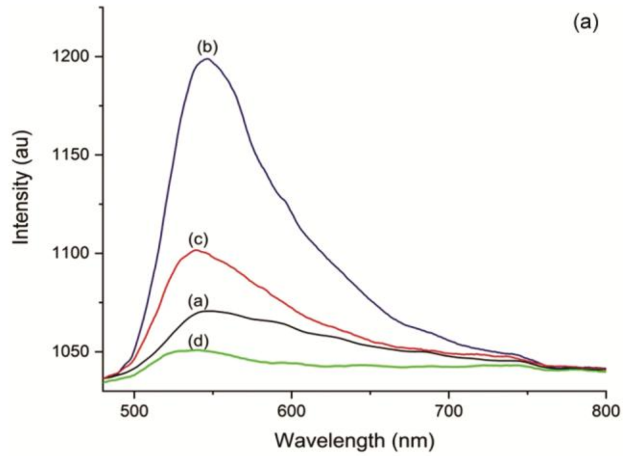

Fig. 8 — (a) Emission spectra of a mixture of 2% of $1x10^{-5}$ Rh6G with (a)1% of $1x10^{-6}$RhB (b) 1.5% of $1x10^{-6}$ RhB (c) 2% of $1x10^{-6}$ RhB (d)2.5% of $1x10^{-6}$ RhB with silica.

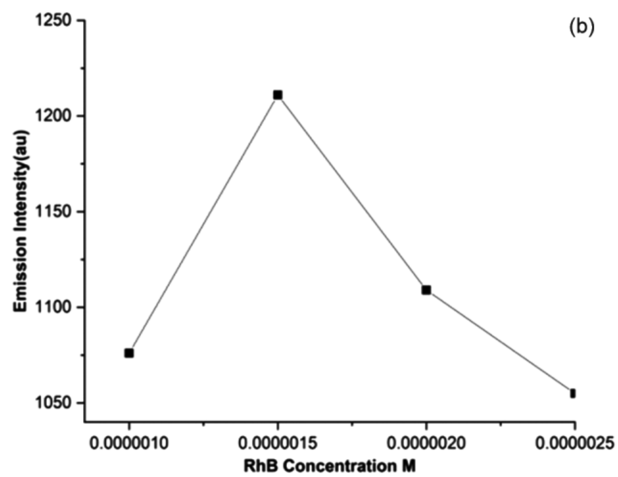

Fig. 8 — (b) Change the intensity of emission spectra of a mixture to fixed concentration of Rh6G dye and changing concentration of RhB dye.

concentrations of Rh6G dye, as it shows that the emission spectra are excited wavelength 450 nm. As seen from the Figure is that the intensity of emission spectra of the RhB dye increases by greater the amount of donor molecule which means increases the number of photons within the wavelength range of acceptor molecule. The merging of molecules from each other when increasing concentrations leads to they interact more and more coherently[24-30].

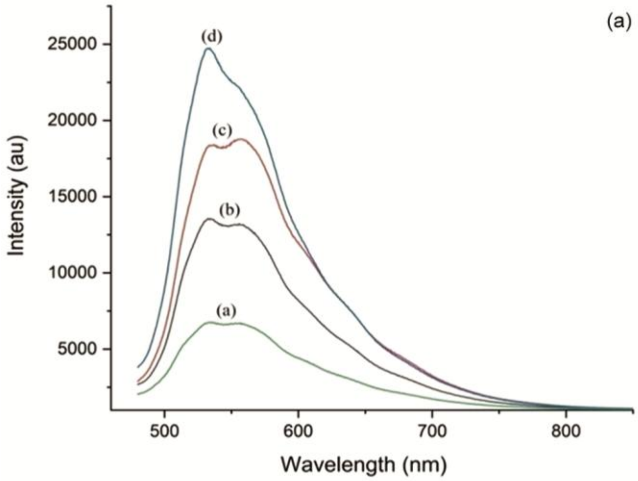

Fig. 9 — (a) Emission spectra of a mixture of 2% of $1x10^{-5}$ RhB with (a) 1% of $1x10^{-6}$ Rh6G (b)1.5% of $1x10^{-6}$Rh6G (c)2% of $1x10^{-6}$ Rh6G (d) 2.5% of $1x10^{-6}$ Rh6G with silica.

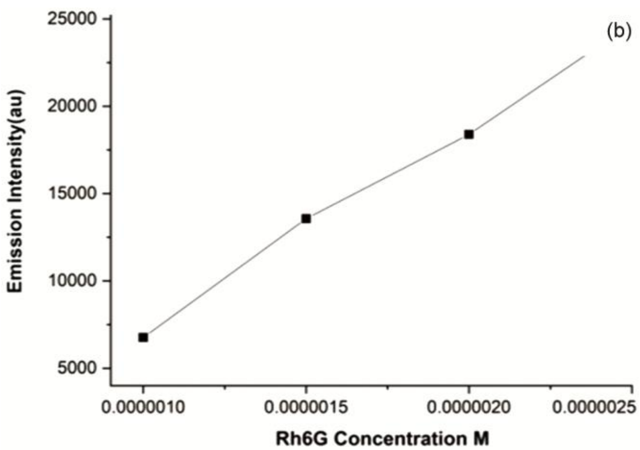

Fig. 9 — (b) Change the intensity of emission spectra of a mixture to fixed concentration of RhB dye and changing concentration of Rh6G dye.

4 Conclusions

We concluded from this study is that the absorption spectra for both dyes increases with increasing the concentrations whereas emission spectra first increases with increasing the concentration, attains maximum value and then decreases with further increasing the concentration for both solid and liquid phase. Furthermore, the transfer of energy from the donor 2% CdS nanoparticle to the acceptor RhB dye with different concentrations was from blue shift to red shift with increasing the concentration. Likewise, energy transfer between the donor RhG dye and donor RhB dye escalate with improving the donor concentration due to merging of molecules. Morever , while RhG dye and RhB dye interchange as acceptor and donor , energy transfer first increases with concentration of RhB, attains maximum value at 1.5% then gradually decreases with further increasing the concentrations.

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