Chapter 5
Preparation and Spectral Characteristics of CdS-Au and CdS-TiO$_2$ Nanocomposites

Abstract

In this chapter, CdS based nanocomposites are studied in the context of nonlinear optical applications. In the first section of this chapter, optical properties of CdS:Au nanocomposite particles and films are investigated. Properties of CdS:TiO$_2$ nanocomposite particles are optically studied in the second section.
5.1 Introduction

In recent years, fabrication of nanoscale composites comprising surface modified metals semiconductors and metal–semiconductor is a thrust area of research to obtain tailored materials with tunable electronic and photonic properties [1-4]. In the case of semiconductors, conduction and valence bands are separated by a well-defined bandgap, but metal nanoclusters possess close lying bands and electrons are free to move. The surface plasmon absorption band of a metal cluster is dependent on both the cluster size and chemical environment [5, 6]. Nano particles embedded in polymer matrices have got much importance in the area of nanophotonics due to their photonic applications such as luminescence tuning [7], band gap engineering [8], optical nonlinearity [9]etc. Nonlinear optical properties of nanocomposites can be very important in high speed communication network as all optical switching, wavelength manipulation and signal processing [10-12]. A large enhancement of the nonlinear optical property in the semiconductor nanoparticles is predicted by theoretical considerations that are based on the quantum confinement effects of the carriers in those materials [13, 14].

Among II-VI semiconductors, CdS is a mostly studied material. Large third-order nonlinearities of CdS nanocrystallites embedded in polymer films have been reported [15-19]. There are a number of reports on optical properties of nanocomposite consisting of CdS and other materials. Enhanced optical nonlinearities of Au/CdS core/shell QDs have also been reported [20]. But the optical properties of nanocomposites in which CdS as base material is not well-studied. It is well-known that noble metal nanoparticles possess absorption called surface plasmon resonance in the visible region. Out of various metal nanoparticles, gold and silver are well studied materials. In this work, Au is selected for the preparation of nanocomposites with CdS. With the view of
combining plasmonic and excitonic effect, clubbing of CdS and Au nanoparticles is the main objective of this study.

TiO$_2$ is recently getting much attention due to its nanocomposites are exhibiting high optical nonlinearity [21-23]. Litty et.al reported that enhanced nonlinearity of ZnO due to the doping of TiO$_2$ [24]. So influence of TiO$_2$ on nonlinear optical property of CdS was taken up in the present study. The first section of this chapter, the preparation of CdS:Au nanoparticles is discussed. Thus prepared Au coated CdS nanoparticles are dispersed in a polymer matrix and cast into homogeneous transparent film. Subsequently we characterized the linear absorption and fluorescence properties of the composites. The nonlinear optical properties of the composite films were also measured through Z-scan technique. In the second section, optical properties of CdS:TiO$_2$ PVA nanocomposite structures have been reported.

5.1.1 Experimental

The linear optical absorption spectrum was measured at room temperature using a spectrophotometer (JascoV-570 UV/VIS/IR). Transmission electron microscopy (TEM) of CdS and CdS: Au nanoparticles were performed on a JOEL 2100 HRTEM machine for size measurement. The fluorescence emission from the same is recorded using a Cary Eclipse fluorescence spectrophotometer (Varian). Nonlinear optical measurement was carried out by Z-scan measurement.

5.2 Optical properties of CdS and CdS:Au nanocomposites

5.2.1 Preparation

CdS nanoparticles were prepared by chemical bath technique from Cd(CH$_3$COO)$_2$, using thiourea and NH$_4$OH [25, 26]. All the chemicals were of GR (Guaranteed reagent) grade from Merck Ltd. CdS nanoparticles were
prepared by mixing aqueous solutions of cadmium acetate (concentration 0.1 M) and thiourea (0.15 M). The pH of the mixture was kept at 10.5 by adding NH₄OH. The mixture was heated to 70°C and stirred for 1.5 hours. The color of the solution changed to yellow and precipitation occurred.

0.1g of CdS nanoparticles were added to the Au Stock solution (0.4mM). After stirring around 1 1/2 hour, the resultant CdS nanoparticles are filtered and washed. Thus formed CdS:Au nanoparticles are then dried and used for further optical studies.

5.3 Results and Discussion

Figure 5.1 shows photographs of (a) CdS:Au and (b) CdS nanoparticles dispersed in the PVA matrix.

![Figure 5.1: CdS:Au and CdS nanoparticles are embedded in PVA matrix](image)

Figure 5.2 (a) and Figure 5.2(b) presents TEM images for CdS:Au and CdS nanoparticles. From TEM images, it is clear that CdS:Au nanoparticles are of the order of 5nm. Average size of CdS nanoparticles are of 4nm. This increase in size of CdS:Au nanocomposite particles indicates the narrow coating of Au.
Figure 5.3 shows represents the energy dispersive X-ray (EDS) spectrum of CdS:Au nanocomposite particles.

Figure 5.3: Energy dispersive X-ray spectrum of CdS:Au nanocomposite particles

It shows the atomic percentage of elements involved in formation. The EDS analysis shows that the percentage of atoms of Cd and S elements are roughly of the same percentage (34% and 27%). This indicates that the material
retain the stoichiometry without much change. The percentage of Au is only 0.55%. So it is indicative of the fact that gold forms only a coating on the CdS nanoparticles. Cu and Si percentage may be ignored as their presence are expected due to the method of preparation and characterization. The part of O comes from surface oxides.

Figure 5.4 shows the transmission electron microscopy (TEM) elemental maps of CdS: Au nanocomposite particles. In addition to aggregation/agglomeration of the nanocomposite particles [27], the elemental maps clearly illustrate the binding of CdS nanoparticles to gold nanoparticles to
form CdS:Au nanocomposite particles. This clearly indicates the presence of Au on CdS nanoparticles.

5.4 Optical absorption studies on CdS and CdS:Au nanoparticles

0.001g of CdS nanoparticles and CdS:Au nanoparticles are dispersed in 10ml of 4wt%PVA solution. Figure 5.5 shows the absorption spectra of the nanoparticles. The absorption spectra show the onset absorption edges of CdS:Au nanoparticles and CdS nanoparticles and are almost at 485nm and 479nm. But the tail of the absorption edge of CdS:Au is red-shifted compared to that of CdS nanoparticles. The absorption spectrum of gold nanoparticles prepared at 0.4mM is shown in Figure 5.6.

![Absorption Spectra](image)

Figure 5.5: Optical absorption spectra of CdS and CdS:Au nanoparticles in PVA solution
5.4.1 Fluorescence studies on CdS and CdS:Au nanoparticles

0.001g of CdS and CdS:Au nanoparticles are dispersed in 10ml of 4wt% PVA solution and emission spectra are taken. Figure 5.7 shows the fluorescence spectrum of CdS and CdS:Au nanoparticles in PVA aqueous solution under the excitation of 386nm. Figure 5.8 shows the excitation spectrum of CdS nanoparticles. It shows a maximum at 386nm and this wavelength is used for fluorescence excitation. From the emission spectra it is clear that emission intensity of CdS:Au nanoparticles is almost the same as that of CdS nanoparticles. This indicates that the plasmonic absorption of Au does not play any part due to the small amount of Au nanoparticles present in the CdS:Au nanoparticles. So the expected change in the emission intensity of CdS nanoparticles in the CdS:Au nanocomposite particles is not observed.
Figure 5.7: Fluorescence spectrum of CdS and CdS:Au nanoparticles in PVA matrix

Figure 5.8: A typical excitation spectra of CdS nanoparticles in PVA matrix
5.5 Optical properties of CdS:Au and CdS PVA nanocomposite thin films

5.5.1 Linear optical properties of CdS:Au PVA nanocomposite films

For studying the nonlinear optical properties of the nanocomposites in optical limiting application, CdS and CdS:Au nanoparticles have to be embedded in film form. Firstly these nanoparticles are embedded in PVA matrix. The procedure is described as follows. 0.006 g of CdS and CdS: Au nanoparticles are added to 10ml of 10 wt % PVA aqueous solution by stirring and followed by ultra-sonication for 6hrs until uniform dispersion is achieved. The resultant viscous solution is drop casted and kept for a day to dry out to form thin films. Thus formed CdS and CdS:Au PVA composite films are optically characterized using Spectrophotometer. The optical absorption spectra of these films are shown in Figure 5.9. From the absorption spectra it is clear that Au coated CdS leads to a red shift in the onset of absorption edge. Considering the absorption spectrum of CdS:Au PVA nanocomposite films, it is observed that there is no distinct plasmonic absorption peak of Au but it’s merged with the absorption spectrum of CdS nanoparticles leading to a red-shift of absorption tail for the CdS:Au PVA nanocomposite compared to the CdS PVA nanocomposite. Band gap is measured to be 2.40 eV and 2.35eV for CdS and CdS:Au PVA nanocomposite films respectively. The thickness of the films is measured to be 55micrometer.

Figure 5.9: Optical absorption spectra of CdS and CdS:Au PVA nanocomposite films

Figure 5.10: Optical band gap plot of CdS PVA and CdS:Au PVA nanocomposite films

Band gap of CdS:Au PVA film is reduced compared to the band gap of CdS PVA thin film. This is due to the influence of plasmonic peak of Au which extends the tail to higher wavelength resulting in a red-shift for absorption tail of CdS:Au PVA nanocomposite film.
5.5.2 Nonlinear optical studies on CdS PVA and CdS:Au PVA thin films

Nonlinear optical studies of CdS:Au PVA and CdS PVA thin films were carried out using Z-scan experiment. Figure 5.11 gives open aperture Z-scan traces of CdS PVA and CdS:Au PVA nanocomposite films at a typical fluence of 43MW/cm². Figure 5.12-5.13 yield the open aperture Z-scan traces of CdS:Au PVA and CdS PVA nanocomposite films for different input intensities.

![Open aperture Z-scan traces of CdS PVA and CdS:Au PVA nanocomposite films at an input intensity of 43MW/cm²](image)

Figure 5.11: Open aperture Z- scan traces of CdS PVA and CdS:Au PVA nanocomposite films at an input intensity of 43MW/cm²

The open-aperture curve exhibits a normalized transmittance valley, indicating the presence of reverse saturable absorption in these nanoparticles. The nonlinear absorption coefficient is obtained by fitting the experimental open aperture data using equation (2.2),

$$ T(z, S = 1) = \sum_{m=0}^{\infty} \frac{[-g(z, 0)]^m}{(m + 1)^{3/2}} $$  

......(2.2)
Figure 5.12: Open aperture data at different input intensities of CdS:Au PVA nanocomposite films

Figure 5.13: Open aperture traces at different intensities of CdS PVA composite film

The solid curves in Figure 5.11-5.13 are the theoretical fit to the experimental data. The open-aperture Z-scan scheme was used to measure $\beta$. 

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Generally, optical response of nanoparticles consists of absorption, refraction and scattering. In this case, scattering does not play any significant role as the size of these nanoparticles is much less and can be neglected. In order to explain the optical nonlinearity of these nanocomposite films, the system can be considered as a two band system. As the excitation wavelength is 532nm, which is in the range of the band gap of these nanoparticles, we can consider that the nonlinear absorption is mainly contributed by an excited-state absorption or free carrier absorption process, in which electrons in the valence band are excited to intermediate energy states because of the linear absorption tail. Thus a large number of free carriers are generated by one-photon excitation under a 532nm laser pulse. Subsequently, the free carriers thus formed could further absorb another photon and get excited to a higher conduction-band level, resulting in a transient absorption. In this process, we suggest that the lower level of conduction band may act as an intermediate state to generate the reverse saturable absorption. CdS:Au nanocomposite film is having high nonlinear absorption compared to CdS PVA film. This is due to the overall effect of plasmonic and excitonic contribution in the case of CdS:Au PVA nanocomposite films.

From Table 5.1, it is clear that the nonlinear optical absorption coefficient is decreased with the increase in input intensity.

The decrease in the nonlinear optical absorption coefficient is due to the saturation behavior which is typical of two photon absorption, excited state absorption etc. due to the third order optical nonlinearity.
Table 5-1: Nonlinear optical absorption coefficient at different laser intensities

<table>
<thead>
<tr>
<th>Input intensity (GW/cm²)</th>
<th>Nonlinear optical absorption coefficient (β) x10⁻⁶ (cm/W)</th>
<th>Cds PVA film</th>
<th>Cds:Au PVA film</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.043</td>
<td>2.71</td>
<td>6.28</td>
<td></td>
</tr>
<tr>
<td>0.119</td>
<td>2.73</td>
<td>2.87</td>
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<tr>
<td>0.188</td>
<td>1.74</td>
<td>1.82</td>
<td></td>
</tr>
<tr>
<td>0.477</td>
<td>0.724</td>
<td>0.741</td>
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</tr>
</tbody>
</table>

Figure 5.14: Closed aperture Z-scan data of Cds and Cds:Au PVA nanocomposites

Figure 5.14(a) and (b) shows the closed aperture Z-scan plot of Cds PVA and Cds:Au PVA thin films at input fluence of 119MW/cm². The closed-aperture curves have shape corresponding to a positive value of the nonlinear refractive index n² and it is the self-focusing nonlinearity. By dividing the normalized closed-aperture transmittance by the corresponding normalized open aperture data, we can retrieve the phase distortion created due to the change in refractive index. It is observed that the valley–peak of the closed-aperture Z-scan distance comes within the range of Δz = 1.7z₀, and thus confirming the third-
order optical nonlinearity. The nonlinear phase change (Δφ), can be obtained by the best theoretical fit of experimental data using the equation (2.4).

\[ T(x, \Delta \varphi) = 1 - \frac{4 \Delta \varphi x}{(x^2 + 9)(x^2 + 1)} \]  

(2.4)

where \( \Delta \varphi = 2\pi \frac{\Delta n_{\text{eff}}}{\lambda} \) and \( x = z/z_0 \). \( \Delta n \) is related to the nonlinear refraction coefficient \( \gamma \) through the relation, \( \Delta n = \gamma I(t) \). The calculated values of nonlinear optical parameters are shown in the table 5.2.

It is clear from table 5.2 that the formation CdS:Au PVA nanocomposites causes an increase in nonlinear absorption as well as nonlinear refraction property compared to CdS PVA nanocomposites.

**Table 5-2: Nonlinear optical absorption and refraction**

<table>
<thead>
<tr>
<th>Sample</th>
<th>β (cm/W) x10^-6</th>
<th>γ(cm^2/W) x10^-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>CdS:Au PVA film</td>
<td>6.28</td>
<td>4.86</td>
</tr>
<tr>
<td>CdS PVA film</td>
<td>2.71</td>
<td>3.72</td>
</tr>
</tbody>
</table>

Yin et al. [28] reported the value of nonlinear refractive index for bulk CdS to be \(-5.3 \times 10^{-13} \text{cm}^2/\text{W}\) at 532nm. Even though the weight percentage (0.03% wt) of CdS and CdS:Au nanoparticles in the composite films is small, the magnitude of nonlinear refraction is much higher than (100 times) that of the reported value of bulk CdS material. Recently Du et al. [29] measured optical nonlinearity of 2-17% wt CdS/PS nanocomposite particles and observed a maximum nonlinear refraction coefficient of \(-3 \times 10^{-13} \text{cm}^2/\text{W}\) at 532nm. Very recently Jing et al. [30] investigated third-order nonlinear optical properties of 18.2% wt of CdS/PVP nanocomposite films using Z-scan technique and obtained large nonlinear optical refraction and nonlinear absorption coefficient values of \(-1.65 \times 10^{-11} \text{cm}^2/\text{W}\) and \(-4.25 \times 10^{-7} \text{cm}/\text{W}\) respectively at 532nm. This result confirms our values on
nonlinear optical coefficients of CdS:Au PVA and CdS PVA nanocomposite films. Hence these samples can show promising applications for optical devices in photonics.

![Figure 5.15: Optical limiting curves of CdS:Au PVA and CdS PVA nanocomposite films](image)

From Figure 5.15, it is clear that for CdS:Au PVA nanocomposite films are having low limiting threshold (34 MW/cm²) compared to CdS PVA thin films (41 MW/cm²).

5.6 Optical properties of CdS and CdS:TiO₂ nanocomposites

CdS:TiO₂ nanoparticles are prepared by chemical bath technique from Cd(CH₃COO)₂, using thiourea and NH₄OH and TiO₂ colloidal nanoparticle solution [15-17]. All the chemicals were of GR (Guaranteed reagent) grade from Merck Ltd. TiO₂ colloidal nanoparticles are prepared by hydrolyzing titanium isopropoxide (1.4% volume) TiO₂ nanoparticle and then thermally decomposed to TiO₂ colloidal nanoparticles as described in section 3 of chapter 3. CdS:TiO₂ nanoparticles are prepared by mixing aqueous solutions of cadmium acetate
(concentration 0.1 M) and thiourea (0.15 M). Then 2ml of TiO$_2$ colloidal nanoparticles is added to the mixture. The pH of the mixture was kept at 10.5 by adding NH$_4$OH. The mixture was heated to 70 $^\circ$C and stirred for 1.5 hours. The color of the solution changed to bright yellow and precipitation occurred indicating the formation of CdS:TiO$_2$ nanoparticles. The particles are filtered, washed and then dried in vacuum oven and used for further studies. Figure 5.16 shows the photographs of CdS:TiO$_2$ and CdS nanoparticles. It clearly indicates that the colour of CdS:TiO$_2$ is brighter yellowish compared to the colour of CdS nanoparticles.

5.6.1 Results and Discussion

0.001g of CdS and CdS:TiO$_2$ nanoparticles are dispersed in 10ml of 4%wt PVA aqueous solution. Figure 5.16 photographs of CdS:TiO$_2$ and CdS PVA nanocomposites. Brighter yellow for CdS:TiO$_2$ nanocomposite compared to the yellowish CdS nanoparticles indicate the influence of TiO$_2$ nanoparticles in the CdS:TiO$_2$ PVA nanocomposite particles.

![Figure 5.16: Photographs of (a) CdS:TiO$_2$ PVA and (b) CdS PVA nanocomposites](image)
Figure 5.17 presents HRTEM images for CdS:TiO$_2$ and CdS nanoparticles. From HR TEM image (fringes), CdS:TiO$_2$ nanoparticles are of the order of 4nm. Average size of CdS nanoparticles are of 4nm. It is not able to identify d-spacing of CdS and TiO$_2$ from this image. So EDS analysis was carried out to find out the presence of TiO$_2$. 

![HR TEM image of CdS:TiO$_2$ nanocomposite particles](image)

Figure 5.17: HR TEM image of CdS:TiO$_2$ nanocomposite particles

![Energy dispersive X-ray spectrum of CdS:TiO$_2$ nanocomposite nanoparticles](image)

Figure 5.18: Energy dispersive X-ray spectrum of CdS:TiO$_2$ nanocomposite nanoparticles
Figure 5.18 shows represents the energy dispersive X-ray (EDS) spectrum of CdS:Au nanocomposite particles.

It shows the atomic percentage of elements involved in formation. The EDS analysis shows that the percentage of atoms of Cd and S elements are roughly of the same percentage (50% and 42%). This indicates that the material retain the stoichiometry without much change. The percentage of Ti is only 5%. So it is indicative of the fact that TiO$_2$ is doped into the CdS nanoparticles. Cu and Si percentage may be ignored as their presence are expected due to the method of preparation and characterization.

Figure 5.19 is the TEM image where elemental maps are observable. Figure 5.20 shows the transmission electron microscopy (TEM) elemental maps of CdS:TiO$_2$ nanocomposite particles. In addition to aggregation/agglomeration of the nanocomposite particles [16], the elemental maps clearly illustrate the binding of CdS nanoparticles to TiO$_2$ nanoparticles to form CdS:TiO$_2$ nanocomposite particles. This clearly indicates the presence of TiO$_2$ on CdS nanoparticles.

![ TEM image showing where the elemental maps were obtained](image)

Figure 5.19: TEM image showing where the elemental maps were obtained
Figure 5.20: (a) TEM/Cd La1 (b) TEM/S Ka1 map (c) TEM/Ti Ka1 map and TEM/O Ka1 map

Figure 5.21 is the absorption spectra of these nanocomposite particles in PVA solution. The absorption spectra show the onset absorption edges of CdS:TiO$_2$ nanoparticles and CdS nanoparticles at 479nm and 475nm indicating a red-shift. It is clear from spectra that the tail of the absorption edge of CdS:TiO$_2$ red-shifted compared to that of CdS nanoparticles.
A typical absorption spectrum of TiO$_2$ colloidal nanoparticles prepared is shown in Figure 5.22.
Fluorescence spectra of CdS and CdS:TiO$_2$ nanocomposite particles are shown in Figure 5.23. There is an increase in emission intensity around 530nm for CdS:TiO$_2$ nanocomposite particles compared to CdS nanoparticles.

5.7 Optical properties of CdS and CdS:TiO$_2$ nanocomposite films

5.7.1 Optical absorption studies

For studying the nonlinear optical properties for optical limiting application, CdS and CdS:TiO$_2$ nanoparticles have to be embedded in film form. Firstly these nanoparticles are embedded in PVA matrix. The procedure is described as follows. 0.006 g of CdS and CdS:TiO$_2$ nanoparticles are added to 10ml of 10 wt % PVA aqueous solution by stirring and followed by ultrasonication for 6hrs until uniformly dispersed. The resultant viscous solution is drop casted and kept for a day to dry out to form thin films. Thus formed CdS and CdS:TiO$_2$ PVA composite films are optically characterized by a Spectrophotometer JASCO570 UV\VIS\IR. The optical absorption spectra of these films are shown in Figure 5.24. From the absorption spectra it is clear that
in the case of CdS:TiO₂, there is a red shift for the onset absorption edge. Band gap is measured to be 2.40 eV and 2.24 eV for CdS and CdS:TiO₂ respectively from Figure. 5.25.

![Absorption Spectra](image)

**Figure 5.24:** Absorption spectra of CdS PVA and CdS:TiO₂ PVA nanocomposite films

![Optical Band Gap Plot](image)

**Figure 5.25:** Optical band gap plot of CdS PVA and CdS:TiO₂ PVA nanocomposite films

### 5.7.2 Nonlinear optical studies on CdS PVA and CdS:TiO₂ PVA thin films

Figure 5.26 gives open aperture Z-scan traces of CdS PVA and CdS:TiO₂ PVA nanocomposite films at a typical fluence of 43MW/cm².
Figure 5.26: Open aperture Z-scan traces of CdS PVA and CdS:TiO$_2$ PVA nanocomposite films

Figure 5.27 yields the open aperture Z-scan traces of the CdS:TiO$_2$ PVA nanocomposite films at different input intensities.

Table 5-3: Nonlinear optical absorption coefficients

<table>
<thead>
<tr>
<th>sample</th>
<th>$\beta \times 10^6$(cm/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CdS:TiO$_2$ PVA film</td>
<td>8.23</td>
</tr>
<tr>
<td>CdS PVA film</td>
<td>2.71</td>
</tr>
</tbody>
</table>
Figure 5.27: Open aperture Z-scan traces of CdS:TiO$_2$ PVA nanocomposite films

Table 5-4: Nonlinear absorption coefficients at different input intensities

<table>
<thead>
<tr>
<th>Input intensities (MW/cm$^2$)</th>
<th>$\beta$ (cm/W) ($\times 10^{-6}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>8.23</td>
</tr>
<tr>
<td>119</td>
<td>3.20</td>
</tr>
<tr>
<td>188</td>
<td>1.95</td>
</tr>
<tr>
<td>477</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Very recently Jing et.al investigated third-order nonlinear optical properties of 18.2%wt of CdS/PVP nanocomposite films using Z-scan technique and obtained large nonlinear absorption coefficient value of $-4.25 \times 10^{-7}$cm/W at 532nm[30]. This result confirms our values on nonlinear optical coefficients of CdS:Au PVA and CdS PVA nanocomposite films. Hence these samples can show promising application for optical devices in photonics. These increased values can be attributed to contribution from excitonic and defect states and this is confirmed from the fluorescence studies. From fluorescence spectra...
(Figure 5.23), it is clear that the emission peak at 530nm is increased in respect of CdS:TiO$_2$ nanocomposite particles compared to CdS nanoparticles. This increase of emission intensity is due to the increase in the population of defect states which is acting as luminescent centers. So this will sensitively influence the nonlinear optical property of the material as well. The nonlinear absorption of CdS:TiO$_2$ PVA thin films is found to be more than three times that of CdS PVA thin films.

![Optical limiting curves for CdS PVA and CdS:TiO$_2$ PVA nanocomposite films](image)

**Figure 5.28:** Optical limiting curves for CdS PVA and CdS:TiO$_2$ PVA nanocomposite films

Figure 5.28 shows the optical limiting curves for CdS:TiO$_2$ PVA and CdS PVA nanocomposite films. The limiting threshold is reduced to a low value of 27MW/cm$^2$ in the case of CdS:TiO$_2$ PVA nanocomposite compared to the limiting threshold of CdS PVA nanocomposite (41MW/cm$^2$).
5.8 Conclusions

CdS: Au nanocomposite particles were prepared by mixing CdS nanoparticles with Au colloidal nanoparticles. Optical absorption study of these nanoparticles in PVA solution suggests that absorption tail was red shifted compared to CdS nanoparticles. TEM and EDS analysis suggested that the amount of Au nanoparticles present on CdS nanoparticles is very small. Fluorescence emission is unaffected indicating the presence of low level of Au nanoparticles. CdS: Au PVA and CdS PVA nanocomposite films were fabricated and optically characterized. The results showed a red-shift for CdS: Au PVA film for absorption tail compared to CdS PVA film. Nonlinear optical analysis showed a huge nonlinear optical absorption for CdS: Au PVA nanocomposite and CdS: PVA films. Also an enhancement in nonlinear optical absorption is found for CdS: Au PVA thin film compared to the CdS PVA thin film. This enhancement is due to the combined effect of plasmonic as well as excitonic contribution at high input intensity. Samples of CdS doped with TiO$_2$ were also prepared. Linear optical absorption spectra of these nanocomposite particles clearly indicated the influence of TiO$_2$ nanoparticles. TEM and EDS studies have confirmed the presence of TiO$_2$ on CdS nanoparticles. Fluorescence studies showed that there is an increase in emission peak around 532nm for CdS nanoparticles. Nonlinear optical analysis of CdS: TiO$_2$ PVA nanocomposite films indicated a large nonlinear optical absorption compared to that of CdS: PVA nanocomposite film. The values of nonlinear optical absorption suggests that these nanocomposite particles can be employed for optical limiting applications.
References


