Sol-Gel Preparation of Tio$_2$-Cds Composite Material for Photocatalytic Application

Raja A., Rajasekaran P., Selvakumar K., Asath Bahadur S., Swaminathan M.

Abstract-The TiO_2 and CdS nanoparticles were synthesized using sol gel method. TiO_2-CdS nanocomposite was synthesized by ultra-sonication method. The SEM image reveals the spherical shaped pure TiO_2 and pure CdS nanoparticle and was uniformly mixed in the TiO_2-CdS nanocomposite. The photocatalytic result reveals that MB dye removal was observed to be higher in the TiO_2-CdS nanocomposite as compared with pure TiO_2 nanoparticle for 90 minutes of visible light irradiation.

Keywords— Methyle Blue; Degradation; nanoparticles.

I. INTRODUCTION

Photocatalytic decomposition of organic compounds in waste products is a sturdy green technique for environmental purification, which provides medium gaps in water and stimulates an advanced antioxidant function. TiO_2 is the most popular oxide semiconductors in this way is used in this way due to its distinctive properties such as hyphetic and stable, non-toxicity, and abundant use efficiency, and cost efficiency [1]. However, TiO_2 is a relatively large group and the wavelength is about 380 nm. The Absorption efficiency is small in practical applications for TiO_2 photocatalysis. On the other hand, rapid reassembly of photodic electron-hole pairs in TiO_2 particles achieves a lower rate of electrons or holes that intermediate semiconductor/fluid, where photo catalyzed degradation. Significantly, the TiO_2 is a common candidate for photo ionization of the TiO_2 Play station using the Brightness Radiation [2-4]. The photo generated electrons do not run from CB and the holes are still present in Cds particles, with the extent of TiO_2 photo response expanded by efficiency, stability long-term separation and TiO_2 as excellent active material under visible region. Specifically, a dimensional (1D) composite have a variety of attractive objects in the aspect of photocatalytic degeneration of organic molecules due to the low level of condenser and large-scale surface area [5]. This job, easy and straight forward path adapted to the highly controlled CdS nanoparticles combined with simple hydrothermal method [6-7].

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II. EXPERIMENTAL DETAILS

A. Synthesis of TiO_2 by sol- gel method

3 M of titanium (IV) butoxide was dissolved in 10 ml of alcohol and to mix to using ultrasonication method. The above mixture was added 5 ml of water with stirrer for 2h. The PH was maintained at 7, the solution was filtered and washed with alcohol and kept at 100 ºC for 12h, the material heated at 100ºC for 12h. 1:1 molar ratio of $CdCl_2$ and Na_2S, the precursor was dissolved in deionised water with sirring 30 min. Na_2S solution was slowly added into $CdCl_2$ solution under constant stirring in ice bath [8]. The preparation was washed with water for several times to become PH normal. The obtained powder was kept at 100 ºC for 2h.

B. *Synthesis of TiO_2 -CdS nanocomposite*

In the typical process of sonication of TiO_2-CdS nanocomposite, 1 mg of TiO_2 was dispersed in 50 ml H_2O and ultrasonicated for 30 min, then predetermined amount of CdS was added into TiO_2 solution followed by sonication for 1hr. The solution was filtered and the solid product was dried in oven to 2hrs at 100ºC. Finally the TiO_2-CdS nanocomposite was obtained.

C. Photocatalytic activities

The photocatalytic studies were performed at room temperature for the degradation of methylene blue dyes. Initial solution and irradiated solution was examined using UV-Vis spectrophotometer for degradation. The photocatalytic activities of TiO_2-CdS nanocomposite and pure TiO_2 nanoparticle photocatalysts were evaluated by monitoring the photo degradation of MB aqueous solution under visible light. A 10 mg of TiO_2-CdS and pure TiO_2 was added into 50 mL of a MB aqueous solution. The solution was stirred at dark room to the adsorption desorption of the dye molecules. Under magnetic stirring, the mixed solution was irradiated by visible light source. Samples were then taken every 30 min for analysis of the dye degradations.

III. RESULT AND DISCUSSION

A. X-Ray Diffraction studies

XRD patterns of the pure TiO_2, pure Cadmium sulfide and TiO_2-CdS are shown in Fig.1 (a-c). The crystallographic structures of three samples have been identified by the X-ray diffraction. From the (XRD) analysis, tetragonal anatase phase found to be in TiO_2 (JCPDS NO: 21-1272). Insert figure shows the pure TiO_2 peak at 2θ= 25.293, 48.052, 37.942, 53.966, 55.192, 62.75, 75.096, 68.865, and 70.307 its corresponding plane (101), (200), (004), (105), (211), (204), (215), (116), and (220) respectively, from the result, tetragonal structure of pure TiO_2 is confirmed. In the fig (b), from the (XRD) analysis, it is shown that the pure CdS nanoparticle has a very broad peak and there is a mixing phase of cubic and hexagonal phase in CdS nanoparticle. [Cubic (JCPDS NO: 75-1546) and hexagonal (JCPDS NO: 89-2944)] [9]. Insert figure shows the pure CdS cubic peak at 2θ= 26.526, 43.908, and 52.019. Its corresponding planes are (111), (220) and (311) respectively. It also shows another hexagonal peak at 2θ= 28.193, 24.81, 47.846, 36.653, 70.886 and 75.539. Its correspond plane are (101), (100), (103), (102), (211) and (105) respectively, from the result, the mixing phase of cubic and hexagonal structure of pure CdS is confirmed. TiO_2 has very broad peak at 2θ = 25.293 for TiO_2-CdS nanocomposite that peak indicates the presence of CdS in the TiO_2 composite, when the TiO_2 nanocomposite is compared with pure TiO_2, it has

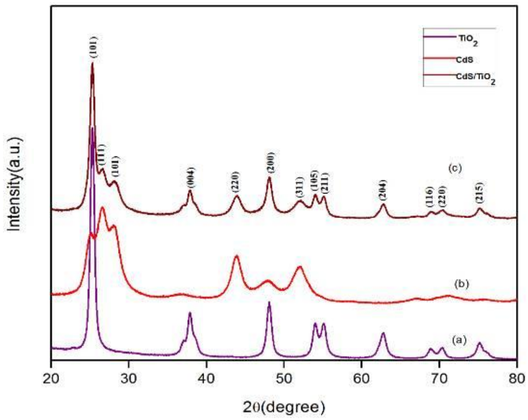

Fig.1. XRD pattern of (a) TiO_2 (b) CdS and (c) TiO_2-CdS

low intensity. Figure.1.(a-c) shows XRD pattern for TiO_2-CdS nanocomposite, pure TiO_2 and pure CdS respectively, the peak appears at 2θ= 25.2932, 26.526, 28.074, 37.942, 43.908, 48.052, 52.019, 53.966,55.192, 62.75, 68.865, 70.307 and 75.129 for both composite and TiO_2 and their corresponding plane are (101),(111), (101), (004), (220), (200), (311), (105), (211), (204), (116), (220) and (215) for respectively.

B. Morphological studies

Morphological analyses of the prepared TiO2 catalyst at various magnifications are shown in fig.2. From SEM image clearly depicted the spherical in shape and not uniform formation of spherical shape. As prepared nanoparticle size is to be measured at 72 nm. SEM image shows that TiO_2-CdS composite has aggregated and is spherical in shape. At a higher magnification, we can clearly see the uniform dispersion of CdS nanoparticle on TiO_2 nanocomposite.

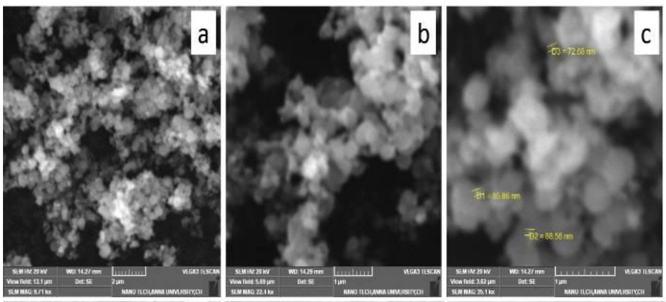

Fig.2. Morphological analysis

C. Thermogravimetric analysis (TGA)

Fig.3. (a) Shows pure TiO_2, the first weight loss occurs in the range of 30-100 °C for TiO_2 due to the water evaporation. The major weight loss was observed in the range of 200-520 °C due to the decomposition of some other inorganic functional group in the pure TiO_2. Fig 4.3. (c) shows thermal stability CdS, the first weight loss occurs at 100°C,the major weight loss was observed at 500°C-1000°C, due to the decompose of other inorganic compounds .

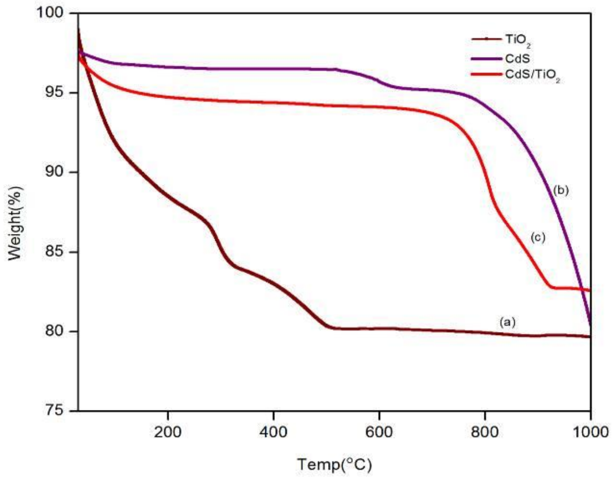

Fig.3. Thermo gravimetric analysis of TiO_2-CdS, CdS and TiO_2

Fig.3. shows thermal stability of TiO_2-CdS nanocomposite, the first weight loss occurs at 200°C, which is associated with water loss. After 600°C the TiO_2-CdS nanocomposite shows major weight loss as compared with TiO_2 and CdS. From the results that it could be observed that the TiO_2-CdS nanocomposite have higher thermal stability than pure TiO_2 and CdS, due to the presence of CdS in the nanocomposites. The TGA result proved that TiO_2-CdS nanocomposite was higher thermal stability compared with pure TiO_2 and CdS.

D. UV-Visible spectroscopic analysis

The UV-Vis absorbance spectrum of TiO_2-CdS photocatalyst is shown in fig.4. The photo responses of TiO_2-CdS catalyst are 479 nm as prepared TiO_2 catalyst corresponding absorbance peak at 353 nm and 497 nm for CdS catalyst, which reveals visible region [10].

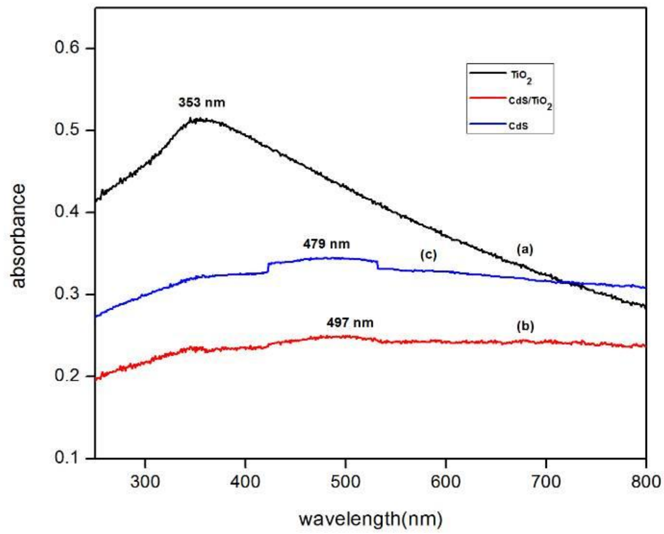

Fig.4. UV-Visible analysis of (a) pure TiO_2, (b) CdS and (c) TiO_2-CdS nanocomposite

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E. Photocatalytic degradation of MB dye

The photocatalytic efficiency of TiO_2-CdS nanocomposite and pure TiO_2were measured by UV spectroscopy. MB dye solution was irradiated with visible light, the sample was kept under Visible light source until reach the equilibrium.

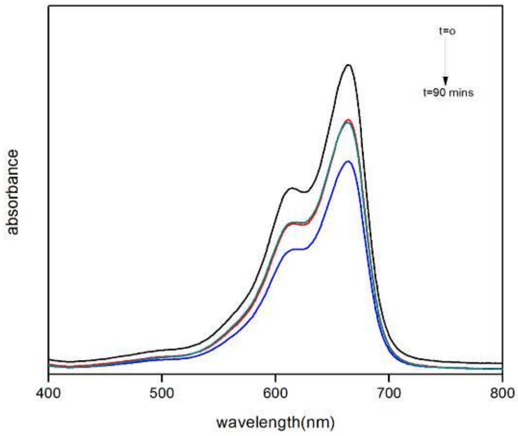

Fig.5 Degradation study of MB dye with pure TiO_2

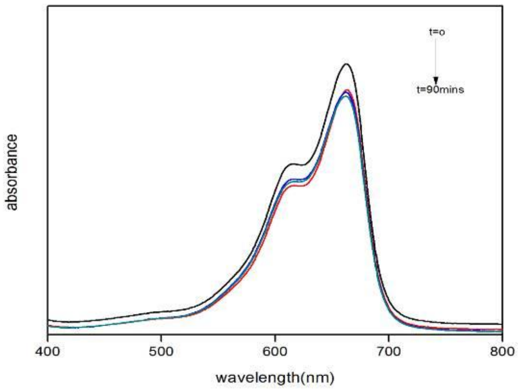

Fig.6. Degradation study of MB dye with TiO_2-CdS nanocomposites

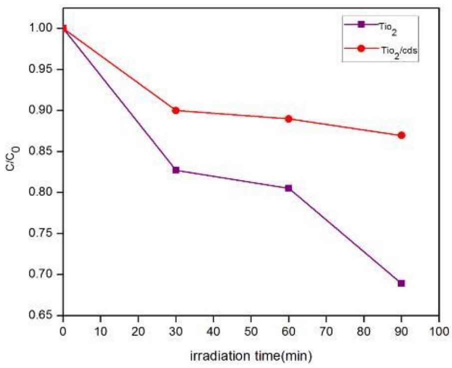

Fig.7. C/C_0 of TiO_2 and TiO_2-CdS nanocomposite with visible light irradiation

The Fig.5, Fig.6. and Fig.7. Show the photodegradation of TiO_2 and TiO_2-CdS nanocomposite respectively. From the figure, the result it could be observed that the photo degradation of MB dye was found to be higher in the TiO_2-CdS composite as compared with pure TiO_2, due to the presence TiO_2-CdS in the composite, which may be enhance the dye removal efficiency [11-13].

IV. CONCLUSION

The TiO_2 and CdS nanoparticles were synthesized using sol gel method. TiO_2-CdS nanocomposite was synthesized by ultra-sonication method. The XRD result shows the anatase structure and mixing phase of hexagonal and cubic for TiO_2 and CdS respectively. The SEM result reveals the spherical shaped pure TiO_2 and pure CdS nanoparticle. TGA result proved that TiO_2-CdS nanocomposite has higher thermal stability as compared with pure TiO_2 and CdS. The UV-Vis spectroscopy result shows that the absorption wavelength of 479 nm was observed for TiO_2-CdS nanocomposite. The photocatalytic result reveals that MB dye removal was observed to be higher in the TiO_2-CdS nanocomposite as compared with pure TiO_2 nanoparticle for 90 minutes under visible light irradiation. The TiO_2-CdS nanocomposite is excellent photocatalytic activity than pure TiO_2.

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