Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2011, 2 (3):295-301

ISSN: 0976-8610
CODEN (USA): AASRFC

Synthesis and Application of CdS nanocrystaline thin films

Yogesh V. Marathe and V. S. Shrivastava*

Nano-Chemistry Research Laboratory, G.T.P. College, Nandurbar, (M.S.) India

---

ABSTRACT

In present investigation CdS nanocrystaline thin films were deposited on glass substrate by using two different methods i.e. sol gel and spray pyrolysis. Optical charecterisation of prepared nanocrystaline films was performed by UV Visible spectroscopy. Optical characterization indicates that film deposited by sol gel has band gap 3.25 and spray deposited film shows band gap 2.87eV. Prepared thin films then applied to the photocatalytic experiment of reduction of Cr (VI) from aqueous solution. Various process parameters have been studied in order to optimise efficient photocatalytic reduction of Cr (VI).

Keywords: CdS, Sol gel, Spray pyrolysis, Photocatalytic.

INTRODUCTION

Extensive use of chromium containing compounds in industrial processes releases chromium result in contaminnatrion of surface water , sub surface water and soil. Waste waters resulting from metal plating , textile ,pulp and paper , leather tanning ,metal finishing ,pigment , and dyes , photography ,wood preserving and metalergical industries contain heavy metals particularly chromium in higher concentration [1] Though chromium is essential nutrient for plant and animal, however accumulated higher concentrationit causes a serious disorders and deseases and it can ultimately become lethal [2]. ISO and WHO fixed ,considering the toxicity ,The maximum tollerence limit for total chromium for public water supply and for bathing ghats ,at 0.05 mg/L [3]. The applicfation of activated corbon for for the removal of chromium and other heavy metals ,colours , odour and taste ,other organic acids by adsorption process from the industrial wasrewater is common practice.In industrial wastewater chromium is mostly found in two forms one is hexavalent and and the other is trivalent whereas the hezxavalent form is more common and hazardous to biological activities.[3] At higher concentrations all compounds of chromium are toxic.Exposure of human beings tonchrome bearing dust for longer period will cause skin irritation and corrosion of skin,ulser formation ,liver damage ,respiratory trac infection,nausea, vomiting,severe diarrhea, [1].Considerable work was done on the removal of chromium from wastewater by different methods like chemical precipitation,electrochemical reduction ,ion exchange ,evaporation and concentration ,electrolysis and electroplating [4-6].These all methods are not economical,when the effluent contain chromium is very large quantities or resulting resulting from small scale industries. Several workers have also tried for water treatment of dyes by adsorption over low cost materials [7-9]. Each method has its own disadvantages for examples, the use of charcoal is technically easy but has high waste disposal cost while in filtration low molar mass dyes can pass through the filter system. Photocatalytic reduction and oxidation receives much attention due to ability of the photocatalytic technique to complete degrade organics and inorganic pollutants into water and CO_2 without generating any harmful byproducts. The technique has been widely employed for the photomineralisation of a large number of organics and inorganics.In photocatalytic degradation genaraly two forms of semiconductor catalyst used aone in powder form and another is solid supported material i.e. thin film. The use of powder catalyst ghas spme disadvantages like separation of catalyst after each run, non reusability,continuous stiring during the reaction etc. Therefore thin film photocatalysis attains more popularity than other techniques.

Several methods are reported for the preparation of CdS thin film such as electrodeposition,[10] Pulse lasor deposition[11], Physical vapor deposition [12], vaccum evaporation[13],close space sublimation [14] But all these methods have sophisticated requirement in order to precise temperature control, high pressure etc. Besides all above methods Sol gel and spray pyrolysis techniques simple, convenient and cheaper.

Hence in this research we have selected these two methods for the deposition of CdS thin film and applied in photocatalytic experiment for removal of dye.

MATERIAL AND METHODS

All reagents used are of analytical purity, $CdCl_2$ and Thiourea is used as precursor for Cd and S respectively and which were purchased from LOBA Chemie, Mumbai ,India, Polyethlylene glycol, Ethanol and Acetic acid was also purchased from LOBA ands used without further purification.

2.2. Thin Film Preparation:

2.2.1) Sol-gel Method:

For the diposition of CdS thin film by sol gel dip coating method two solutions have been prepared 1: Polyethylene glycol was dissolved in ethanol and acetic acid was added to ethanoic solution under sttiring , which was continued for one and half hour.2: Cadmium chloride and thiourea were dissolved in ethanol under sttiring and the strring was for one hour . The prepared solution 2 was mixed to solution 1 and was sttired again for five hours to obtain the final sol for deposition of thin film. The dip coating coating technique was used to deposite thin film using above sol. After diposition annealing of the film is necessary in order to remove solvent and residuel organics and film destification . so the film have been post annealed in air at 150 ^{0}C.

2.2.2.) Spray pyrolysis:
CdS thin films were deposited onto glass substrates by spray pyrolysis method at 250 ^{0}C substrate temperature. 0.025M solutions of cadmium chloride hydrate and thiourea were used as starting materials. Glass microslides of the size 7.5 cm 2.5 cm were used as substrates. Prior to deposition these substrates were washed with water, then boiled in concentrated (2M) chromic acid and kept in distilled water for 24 h. Finally the substrates were ultrasonically cleaned in ultrasonic bath (SYSTRONICS) for 10 min. The temperature of substrate was controlled by an iron constantan thermocouple. The spray rate employed was 4 ml/min and kept constant throughout the experiment. Air was used as a carrier gas. After deposition, the film was allowed to cool at room temperature.

The Optical properties of thin films deposited by both methods have been studied by using double beam spectrophotometer (SYSTRONICS 2203).

2.3.) Photocatalytic Experiment:
2.3.1) Instrumentation:
The photocatalytic degradation was carried out in photocatalytic reactor, which consists of a cylindrical pyrex glass rector, a double walled quartz cooling water jacket and 400 W medium pressure Hg lamp with nominal wavelength range 220-1400 nm. The cooling water jacket was set up inside the reactor to maintain the temperature to be within range of 25-310C, preventing excessive heating of the reaction mixture. The reaction solution was stirred with magnetic stirrer at a constant speed to maintain well mixed during the experiment. The pH metric measurements were made on equiptronics digital pH meter (Model-E610) fitted with glass electrode which was previously standardized with buffer of known pH. The change of dye concentration was measured by by UV Visible spectrophotometer (SYSTRONICS 2203).

RESULT AND DISCUSSION

3.1) Optical Properties: The optical absorbance spectra of CdS thin films deposited by Sol gel and Spray pyrolysis are shown in Fig 1, from the spectrograph the absorption edge of sample found to occur in the range 450-550 nm the optical band gap Eg can be estimated from tauc plot

$$\alpha h\upsilon=A(h\upsilon-Eg)^{n}$$

Where Eg is the band gap corresponding to particular transition occurring in film, A is a constant, υ is transition frequency and the exponent n characterizes the nature of band transition. The graph between hυ vs.$(\alpha h\upsilon)^2$ plotted and shown in Fig 5 the extrapolation of straight line to $(\alpha h\upsilon)^2$ =0 axis gives the value of energy band gap of CdS thin film. The band gap of thin films observed to be 3.25 and 2.87 eV for sol gel and spray deposite film respectively.

3.2.) Photocatalytic Behavior:
Photocatalytic property of thin films were studied by applying both films in photocatalytic reduction of Cr (IV) from aqueous solution.Different process parameters have been studied in order to optimise efficient reduction of Cr (VI) from aqueous.

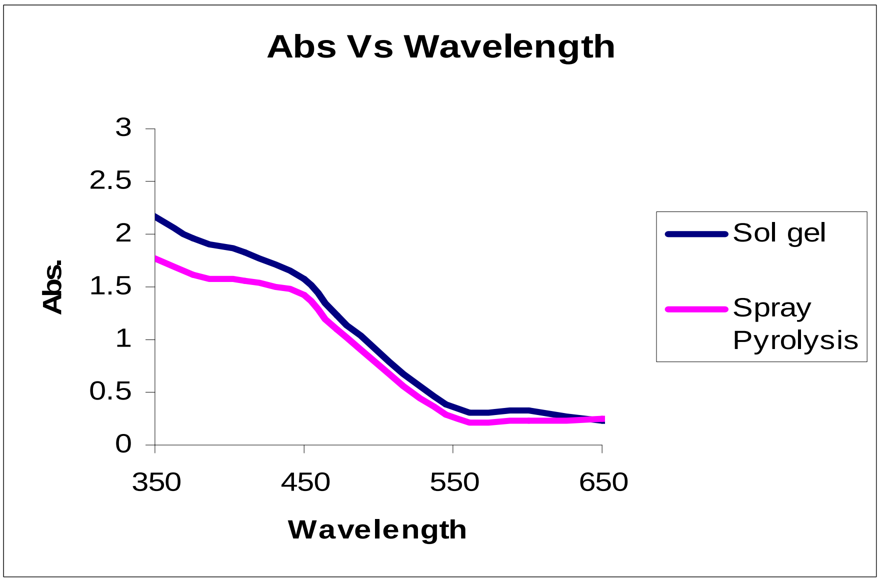


Fig.1. Optical absorbance spectra CdS thin films

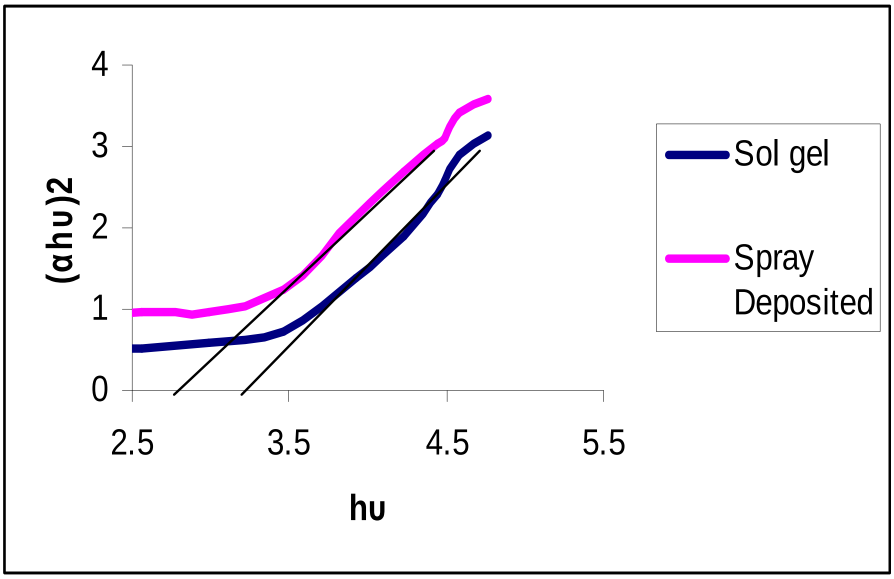


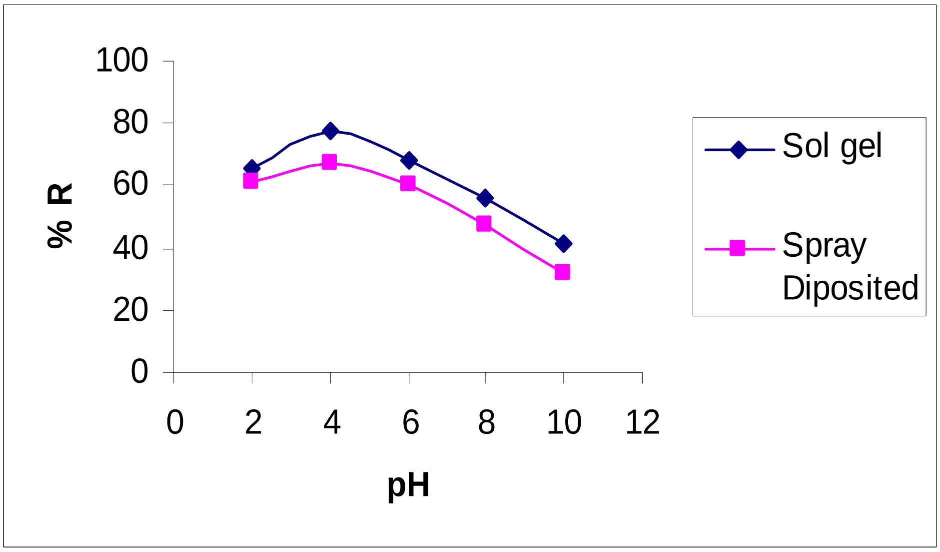
Fig 2.Energy band gap determination of CdS thin films from hυ vs. (α hυ)^2

3.2.1) Effect of pH:

A series of experiments were conducted at different pH values ranging from 2 to 10, (Fig.3).The figure shows the change of concentration for the photocatalytic reduction only (i.e., the results shown are obtained after it was ascertained that an adsorption equilibrium has been attained and the lamp was turned on) and indicates that reduction rates increase with decreasing pH. Because $Cr_2O_7^{2-}$ ions are the predominant species at medium to low pH values, the reduction of Cr(VI) by Photogenerated electrons can be described as follow

$$Cr_2O_7^{2-} + 14H+ + 6e- +2Cr^{3+} + 7H_2O \qquad (1)$$

pH 4 was optimum pH observed.



ll

Fig.3. Effect of pH on percent removal of Cr (VI) by CdS thin films.

3.2.2.) Effect of Contact time:

Effect of contact time and concentration for the removal Cr (IV) from aqueous solution for CdS thin film. The experiments were carried out at room temperature, pH 4.0 and initial concentrations (60 mg /L) for different time intervals up to 180 min. Percentage of Cr (VI) removal increases with increasing in contact (fig.4).The percentage removal increases with increase in contact time and reaches equilibrium after 30 min. Therefore 30 min is optimum contact time for better Cr (VI) ion removal.

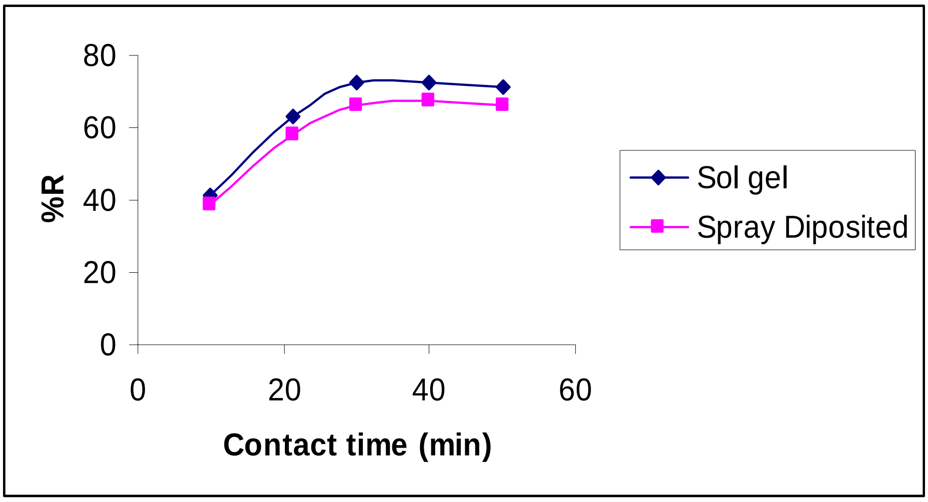


Fig.4. Effect of contact time on percent removal of Cr (VI) by CdS thin films.

3.2.3.) Effect of Initial concentration:

The rate of photodegradation of Pb(II) was studied by varying the metal ion concentration from 10 to 70 mg/L (Fig.5) because for fixed catalyst concentration active sites remains the same ,the number of substrate ions was accommodating the inter layer space increases so that the degradation decreases Moreover, the photodecomposition efficiency of Cr(VI) is much higher with thin film prepared by sol gel method than prepared by spray pyrolysis.

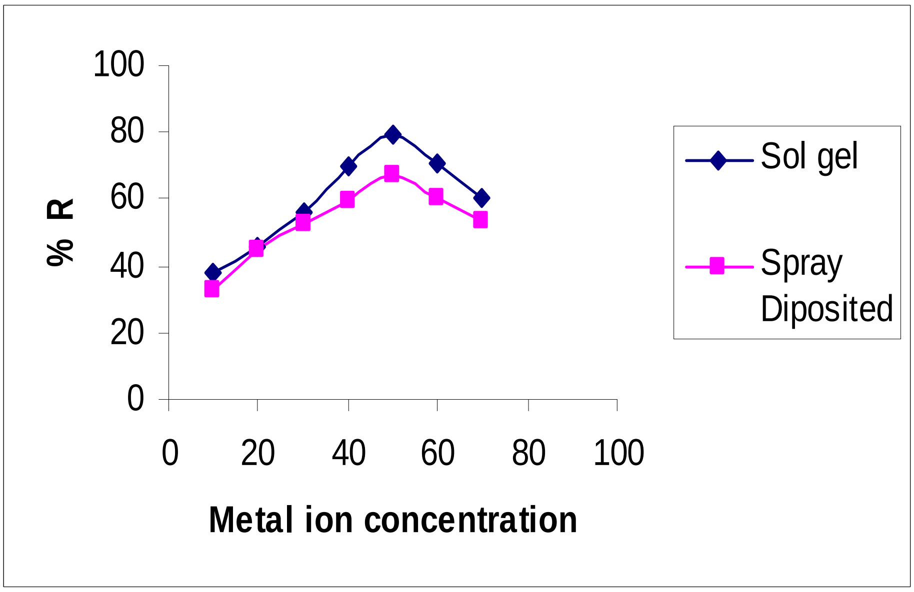


Fig.5. Effect of initial metal ion concenrration on percent removal of Cr (VI) by CdS thin films

CONCLUSION

CdS nanocrastaline thin film can be easily deposited by Sol gel and Spray pyrolysis technique.Optical study indicate that sol gel derived thin film shows higher band gap than that film deposited by spray pyrolysis.Hence sol gel derived thin film exhibit better photocatalytic property than spray deposited film. In reduction of Cr (VI) pH 4 , Contact time 30 min.,Initial metal ion concentration 40 ppm found to be optimum conditions for better metal ion reduction.Sol gel derive thin film shows better photocatalytic property than Spray deposited thin film it may be due to spray deposited film has smaller band gap due to which electron hole pair recombination rate is higher, hence decreases semiconducting property. Finding from this research one can get fundamental information of nanocrystaline CdS thin film preparation for other environmental pollution control applications.

Acknowledment
Authors are greatfully acknowledged to the UGC-Delhi for financial support by the grant No.F-38-67/2009 (SR) dated 19/12/2009.Authors are also thankful to the Principal G.T.P.College, Nandurbar for providing necessary laboratory facilities.

REFERENCES

[1] Narayana Nagesha and Krishnaiah Abburi *Indian J.Environ.Hlth*, **1989** 31 ,04,304.
[2] Shri Chand, V.K.Agrawal and Pavan Kumar *Indian J. Environ. Health*, **1994,** 36 (03),151.
[3] Rai AK and Surendra Kumar *Indian J. Environ.Health*, **1999,**41 , 01,65-73.
[4] Andopadhyay BA and Biswas MN Biswas *Indian J. Environ.Pollution*, **1998,**18 ,09, 662-671.

[5] Rangraj ,Bhanumati Arbindoo and Murugesan, *Indian J. Environ. Health*, **1999,** 41(01), 16-23.
[6] Charentanyarak L.,*Water Sup. Technol*., **1999,** 39 (10-11), 135.
[7] Wheatey AD, Smith, MD, Parr J., and Muhammad N. **1998** *Envirn.Tech*. ,19 1998,633.
[8] Muslehiddinoolu J., Uludao Y., Onder Ozbelge H. and Yilmaz L., *Talanta*, **1998,**46,1557.
[9] Croll BT, *J.Inst.water Envioron Mamt*, **1992**, 6(2),129.
[10] Gopal V. , .April GCand Schrodt VN, Sep *Purif.Technol*., **1998**,14,85.
[11] Pouzet JC, Bernede, Kelil A., Essaidis H., Benhida, *Thin Solid Films* , **1994,**15, 252.
[12] Birkmire RW, Mccandless BE. Hegedes SS ,*Solar Energy* ,**1992**, 13, 303.
[13] Ugwn EI,Ugwn and Onan DU, *Pacific Journal Sci.Tech*., **2007,**8,160
[14] Chu TL, Chu SS, *Int. J.Sol Energy* , **1992 ,**12, 121.