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RESEARCH ARTICLE

Adsorption and Photocatalytic Degradation of Crystal Violet Dye by using Cadmium Sulfide in Aqueous Solutions

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Abstract

Chemical methods were used to synthesized cadmium sulfide thin films in a mixed phase which testing for wastewater treatment through the photocatalytic degradation. Specific region of light (UV) was used to remove the organic pollutant which commonly destroy the environmental such Crystal violet dye forming what we could it wastewaters. The testing solutions were degraded under visible-light irradiation using the CdS thin films. Structural studies of the CdS photocatalyst refer to the hexagonal and cubic phases with good crystallinity and uniformly and homogenous distributed over all the sites of support with less agglomerations. The morphology analysis mostly shown induces porosity, which mostly enhance intercalating dyes. The optical band-gap energy of sample within film was 2.35 eV, which explained the high photcatalytic behavior in the degradation of the non-biodegradable Crystal violet dye. As accepted the semiconductor/ UV-light were succeed to declaration of day which shows good acceptable results. The surprised was the efficiency of degradation or deceleration was rises very high as compare with the same conditions of reaction in room temperature in addition to increases with raises of concentration from 0.5 to 4 g/L.

Keywords: *Cadmium sulfide, Photcatalytic degradation, Adsorption, Crystal Violet dye* **.**

Introduction

The dyes were interred the live of human in every part and sections or levels starting from cosmetics, paint, until foods. The huge amount of excuse dyes the removed from huge number of factories which treatment with many materials in very large quantities. All the dyes mostly characterized by toxicity and can be converting to very high toxicity materials after espouse for many conditions in the environments [1]. Thus many attempts were focused on remove or at least reduce the risks of these materials.

The attempts may include physical or chemical techniques such chemical oxidation process [3], membrane filtration[2] and photocatalytic degradation[3] and adsorption [4-6]. There is another physio-chemical techniques which is Advanced oxidation processes (AOPs) such electro-chemical [7], ozonation [8], solar photoelectro-Fenton ,[9] photo-degradation [10], and photocatalysis [11]. The amazing behavior for all types of AOPs are heterogeneous catalytic photo reaction, able to mineralization the pollutant with high efficiency [12].Cadmium sulfide (CdS) is a classic II—VI group of semiconductor [13] that is able to activation with specific energy light [14]. CdS can be prepared using sol-gel, template method, hydrothermal/ solvothermal reactions micro emulsions and precipitation [15-20].

Experimental

Materials and Methods

Crystal violet (CV) from Merck/ Germany was used as pollutant in this work which behave the physicochemical properties that shown in Figure 1. Cadmium sulfide CdS with purities 99.99% was purchase from Sigma-Aldrich. 500 mg/L of CVs dye represent a stock solution and was prepared by dissolving 0.25 g of crystal violet dye (CV) in 0.5 L double distilled water.

Figure 1: the skim for absorbance and Formula of Crystal violet CVs

Methods

After preparation a series of concentrations at room temperature the natural PH was 6.20 that are depend in all experiments. The reaction mixture was carried out using 250 mL Pyrex glass reservoir which was equipped with cellophane cover to keep light inside vessel and this cover provided with hole to pass air. Pyrex glass beaker containing crystal violet dye sample (200 mL) and effect amount of catalyst CdS (0.5–4.0 g L^{-1}), with light intensity (1.74-10.4 mW cm^{-2}), and concentration of dye (10–60 mgL^{-1}) on the photo degradation efficiency was studied. Other experiments were done using concentrations of H_2O_2 and KIO_3 (10 mM). Light source was focused vertically without lens; the solutions were kept homogeneous by using a magnetic stirrer in the suspended colored solution dye. The percentage degradation efficiency PDE of CV dye with time t (min.) by photocatalytic reaction and apparent rate constant k (min^{-1}) from initial C_0 to photolyzed concentration C_t (mg/L) were calculated by:

$$PDE\,(\%) = 100 \times (C_0 - C_t)/C_0 \qquad (1)$$

$$\left(\frac{C_t}{C_0}\right) = e^{-kt} \qquad (2)$$

All the absorbance measurement were done at maximum wavelength at 590 nm by UV-Visible Spectrophotometer, model Cintra 5 UV-Visible.

Results and Discussion

The Effect of Cadmium Sulfide Mass on Photo Catalytic Degradation of Crystal Violet Dye

The effect of mass of Cadmium sulfide on photcatalytic degradation of Crystal violet, was studied using 40 ppm of Crystal violet dye, flow rate of air 10ml/min, room temperature 298 K. Figure 2 shows different loaded mass of CdS have been tested by the photo catalytic degradation processes of CV dye. The experiments shows increases then decreased the photcatalytic efficiency gradually with change of masses CdS until reach to 0.5 gm/100cm^3. This may be attributed to the light absorption will be limited only to the first layers of Crystal violet dye and the other layers of solution do not receive light photons. Moreover at CdS loading a light scattering will attained, this lead to decrease the photon intensity [21] [22]. The mass of CdS 0.5 gm/100cm^3 gives the best PED% which is equal to 46.2% as reported Figure 3.

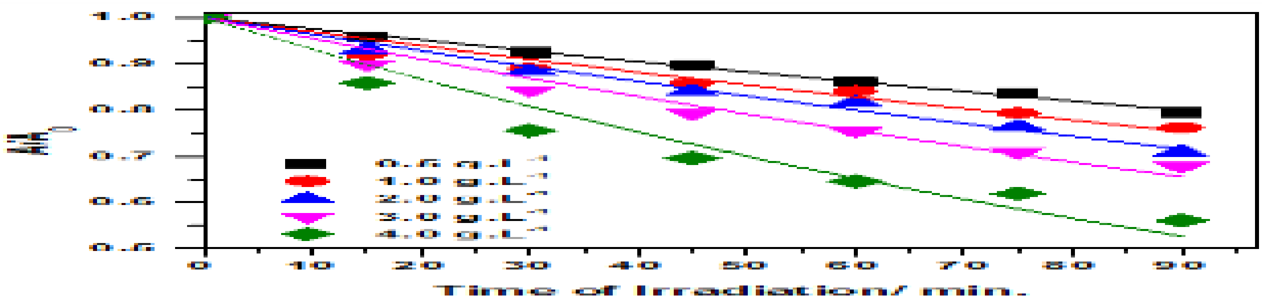

Figure.2: The effect of CdS masses on Photcatalytic degradation of CV dye

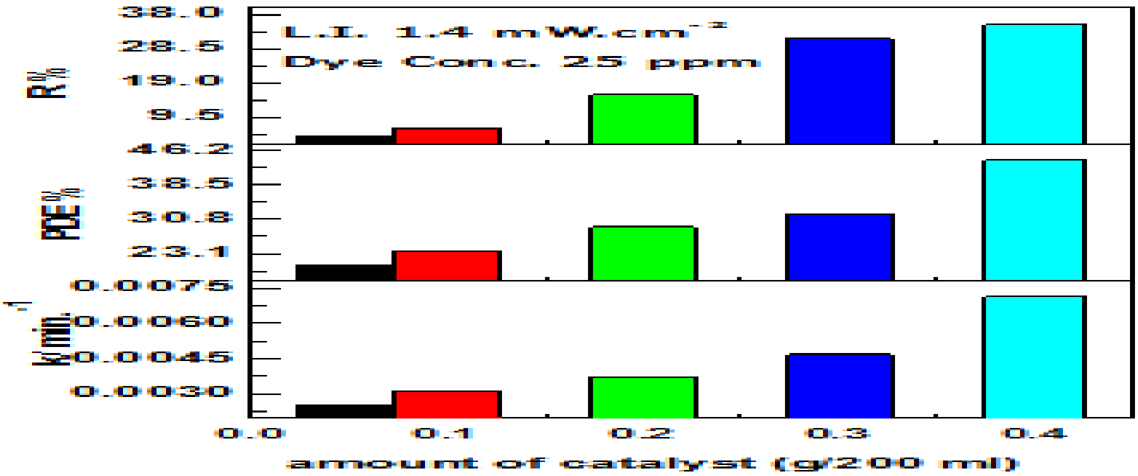

Figure.3: the change of Photocatalytic Degradation Efficiency with irradiation time of different types of CdS

The Effect of Initial Crystal Violet Dye Concentration on Photo Catalytic Degradation Processes

Figure 4, shows the influence of concentration dye were done by A serious of value from 10-60 ppm of CVs with 0.5 g/ 100 cm^3 of CdS with the UV- light intensity equal to1.4 mW/cm^2, at room temperature 298 K . The_observed results shows gradually reduce in photcatalytic degradation with the increasing of initial Crystal violet dye concentration. This activity may relate to 10ppm which was the ideal concentration to cover the active site and the best absorption of light on the surface of the CdS particles. The physical behavior of mixture suppose that the higher concentration of CV dye may prevent the penetration of light towards the CdS particles [23] [22]. The concentration of Crystal violet dye 10ppm gives the optimum photcatalytic degradation efficiency which is equal to78% as plotted in Figure 5.

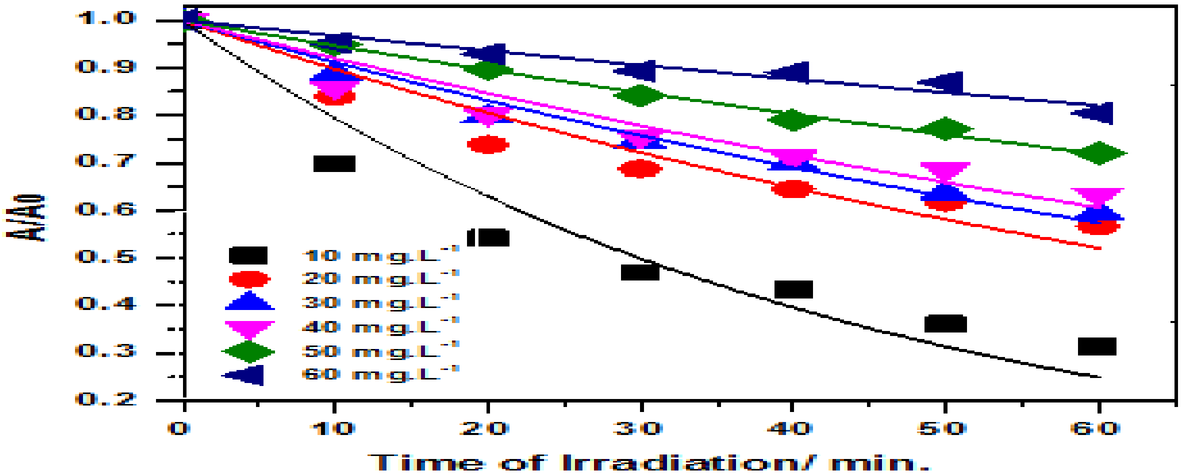

Fig.4: Photo catalytic degradation of CV dye at different initial concentration by CdS

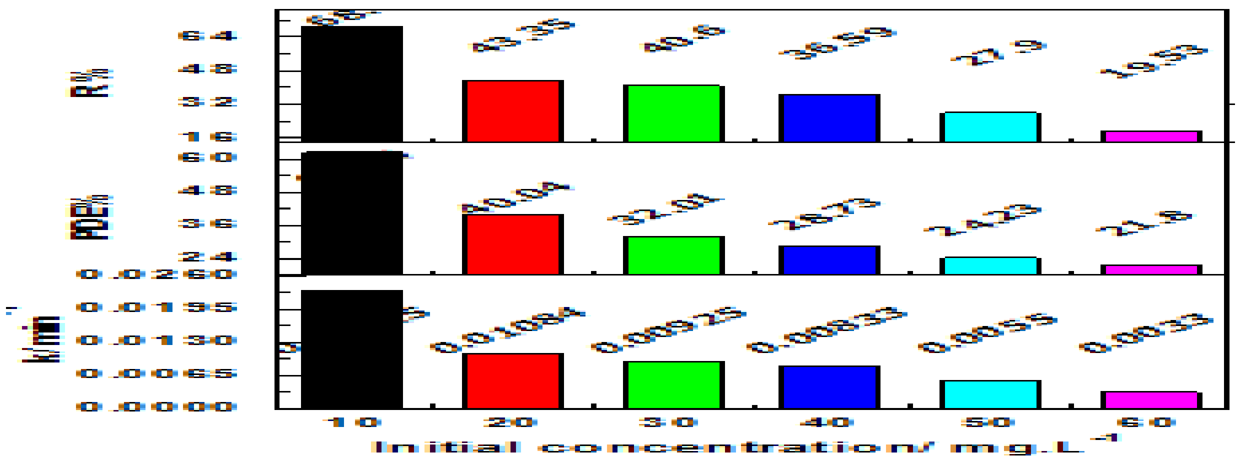

Fig. 5: Effect of C_0 with a) k, b) PED% c) R% on the photo catalytic degradation of CV dye by CdS

Effect of Addition of H_2O_2, KIO_3

The effect of H_2O_2, KIO_3 addition on the rate of 10 mM CV dye photcatalytic degradation was investigated at pH 5, mass of CdS 0.5 g/L^{-1}, light intensity (2.5 µens. sec^{-1}) and H_2O_2, KIO_3 concentrations (25 ppm). The experimental data could be analyzed kinaticaly to first order and represent in Fig. 6. Figure 7, refer to the influence of H_2O_2 additions which was succeeded to degradation the higher concentration of dye due to the free radicals ·OH when accelerated the photcatalytic degradation of CV dye [24]. The concentration of Crystal violet dye 25 ppm gives the maximum value of PED% which is equal to 94 .29 %. While The PED% with KIO_3 was shown 44.01% as compare in the condition without KIO_3 when shown 24.5 1% as represent in Figure 6 and 7. That is means the enhancement with H_2O_2 and KIO_3 were about four times and two times respectively as compare with the condition without them.

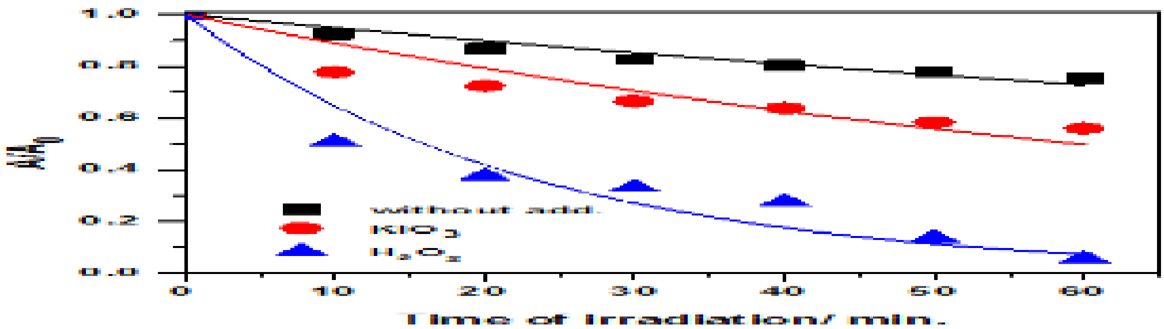

Fig6: Role of kinetic behaviors for degradation in the presence of H2O2 and KIO3

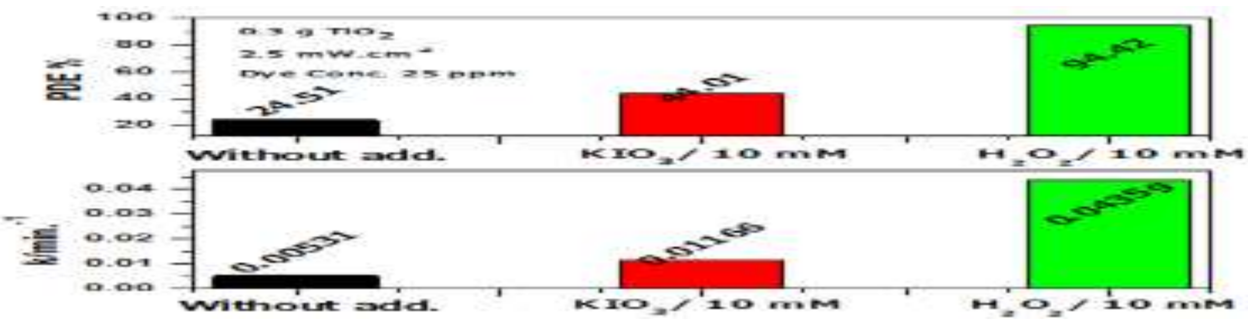

Fig7: Role of addition H2O2, KIO3 for enhancement removal of crystal violet dye

Light intensity and wavelength

The influence of Light intensity/ semiconductor towards the best activity was studied in this work at a given wavelength which mostly represents the critical parameter for electron-hole formation /recompilation [25, 26]. Experimentally many literatures supposed that the orientation of rate behave a square root which influence directly on the light intensity, others observed a linear relationship between the two variables [24, 27] .Figure 8 and 9 effect of change in light intensity with time from1.13 to 5.03 mW cm^{-2} respectively in the degradation of CV dye by photocatalytic reaction. The rate of degradation and photo degradation efficiency were increased for two suppose reason, firstly increasing UV light intensity due to more probability to excite the catalyst which means forming more charge carriers. The second may be related to high photon flux that recombination which increase more than low flux [28].

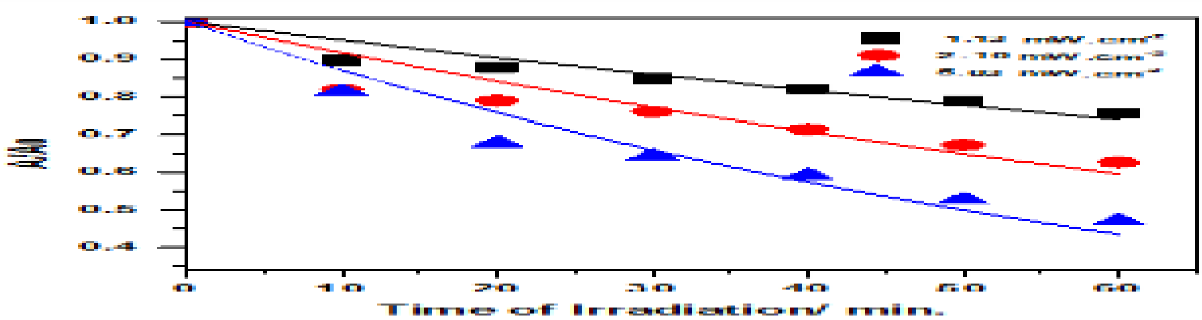

Fig.8: Photo catalytic degradation of CV dye by CdS at different light intensities

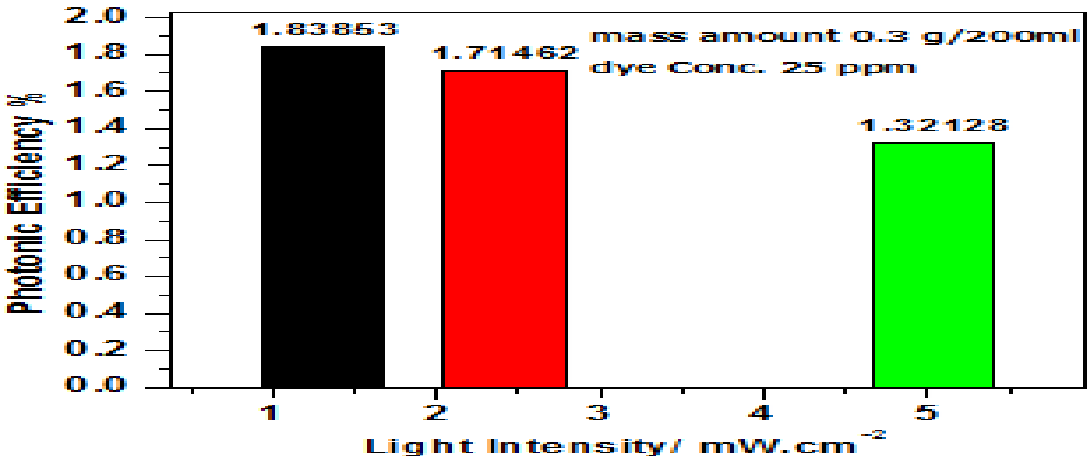

Fig. 9: Effect of light intensity on the photo catalytic degradation of CV dye by CdS

Conclusion

The Crystal Violet was removed by photoreaction with a CdS in aqueous solution under UV irradiation which behaved first order activity for the reaction. The parameters such the CdS concentration, light intensity and initial dye concentration affect the photo degradation effect. Efficiency of degradation mostly enhanced with the increase of loading catalyst which represent the surprised because that reverse effect when increase of initial dye concentration in our experiments. The effect of H2O2, KIO3 addition on the rate of photcatalytic degradation were regarded as a ideal parameter for enhancement removal with more than double value compare without additions.

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