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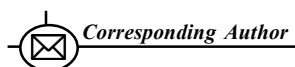
# Environmental Science

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## Current Research Paper

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### Photocatalytical Elimination Of Alizarin Red By Chitosan-CdS Composite Nanoparticles



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#### ABSTRACT

Chitosan-CdS composite nanoparticles were prepared by reverse micro-emulsion reactions. The alizarin red was degraded rapidly by chitosan-CdS composite nanoparticles in a short time. 98.1% of the alizarin red disappeared at 30min when the concentration is 20mg/L. The absorption peak became weak rapidly and disappeared finally at maximum absorption wavelength 261nm during the photocatalytical elimination process of alizarin red, and the new absorption peaks appeared at 223nm and 228nm respectively, which showed new products formed. The elimination of alizarin red was pH-dependent, more efficient at acidic condition than at neutral and alkaline. The photocatalytical elimination efficiency of chitosan-CdS composite nanoparticles was increased by 24.2% and 28.4% respectively at 2min and 30min compared with common CdS. The hypothetical mechanism of photocatalysis was put forward preliminarily: The primary step was the sorption of chitosan-CdS composite nanoparticles, which stimulated the photocatalytical elimination of alizarin red.

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#### KEYWORDS

Chitosan-CdS composite  
 nanoparticles;  
 Photocatalytical elimination;  
 Alizarin red;  
 Mechanism.

#### INTRODUCTION

Photocatalytical degradation of organic pollutants by semiconductor is receiving increasing inter-

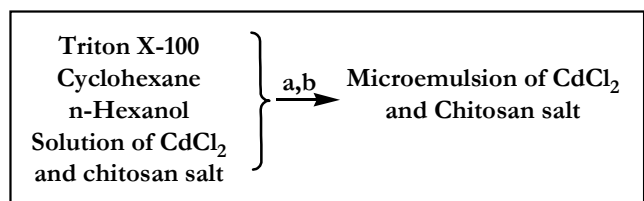
ests. Among the semiconductors, cadmium sulphide (CdS) is one of the most active photocatalyst, which can absorb light in the visible part of the energy spectrum and therefore may be driven efficiently by so-

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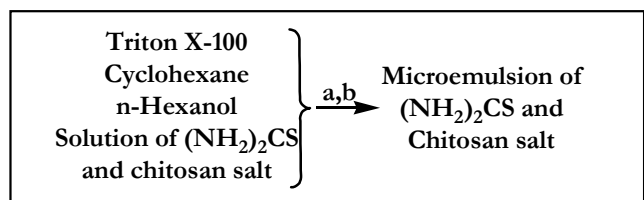
lar energy<sup>[1]</sup>. According to the report of literature<sup>[2]</sup>, high photostable CdS nanoparticles modified with alkyl group were prepared by an improved microemulsion technique using hexanethiol ( $C_6H_{13}SH$ ) as co-surfactant. The surface-modified layer should not be oxidized in the photocatalytic process, moreover, an enhancement of the photocatalytic activity has been clearly observed to photodegrade 4-chlorophenol under UV light. Chitosan has been widely used in the treatment of wastewaters<sup>[3,4]</sup> and reported to prevent the coagulation of inorganic nanoparticles<sup>[5]</sup>. Here, we present photocatalytic elimination of alizarin red, one model substance for complex aromatic compounds, by CdS nanoparticles modified with chitosan (chitosan-CdS).

### EXPERIMENTAL

#### Preparation of microemulsion of $CdCl_2$ and chitosan salt



#### Preparation of microemulsion of $(NH_2)_2CS$ and chitosan salt



#### Preparation of chitosan-CdS composite nanoparticles

a) Mixed in a definite proportion; b) Stirring; c) Addition of NaOH solution at  $60^\circ C$ ; d) Incubation at  $30^\circ C$  for 24h; e) Centrifugation; f) Washing with EtOH and  $H_2O$ ; g) Freeze-dry

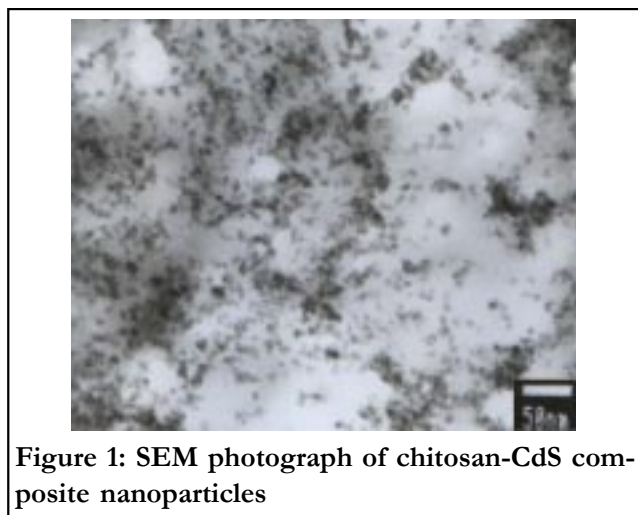
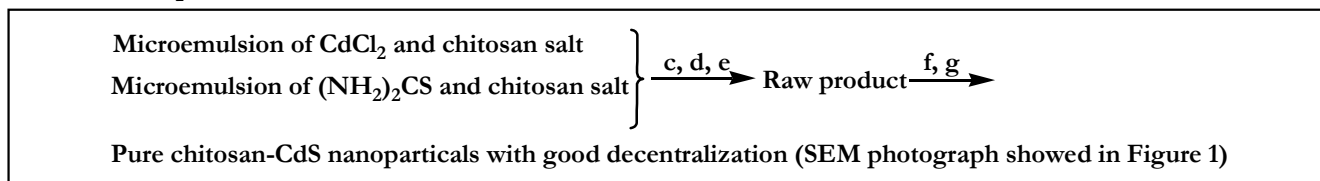


Figure 1: SEM photograph of chitosan-CdS composite nanoparticles

### Methods

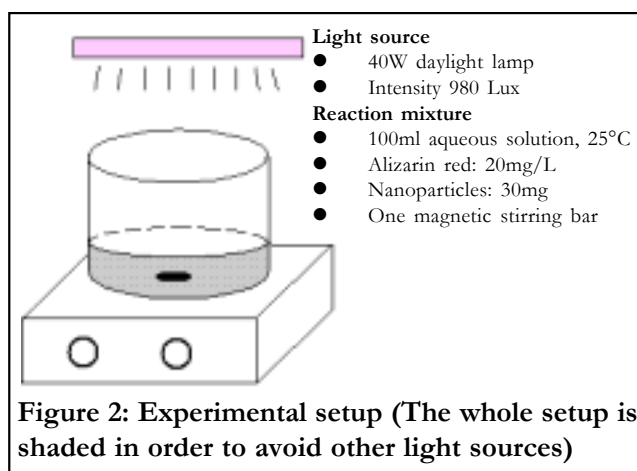


Figure 2: Experimental setup (The whole setup is shaded in order to avoid other light sources)

### RESULTS AND DISCUSSION

#### The influence of illumination and dark reaction on decolor of alizarin red

The results (Figure 3) showed chitosan-CdS composite nanoparticles have the effect of photocatalytic elimination and sorption on alizarin red, and the latter accelerated photocatalytic elimination at a great degree. In dark reaction, the efficiency of adsorption reached 41.9% and 64.0% respectively at 2min and 30min. In daylight lamp, the efficiency of elimination reached 54.8% and 98.1% respectively at 2min and 30min.

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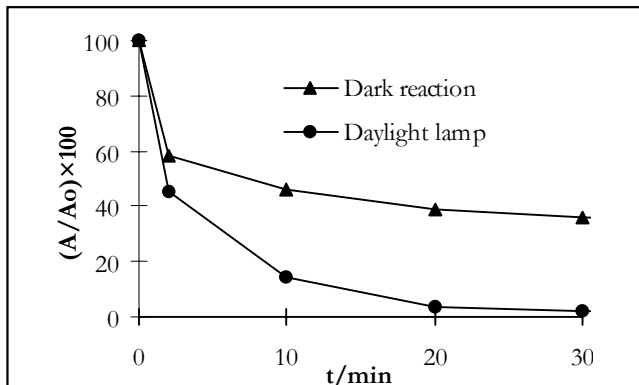


Figure 3: The influence of illumination and dark reaction on decolor of alizarin red

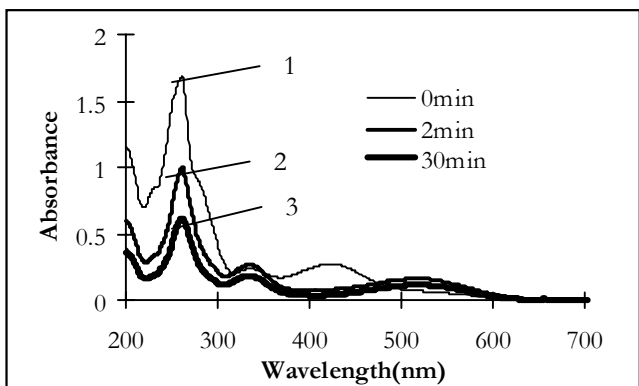


Figure 4: UV-Vis-spectra of the supernatant of the reaction mixture at reaction time of 0, 2, and 30min in dark reaction. Peak 1: 261nm; Peak 2: 261nm; Peak 3: 261nm

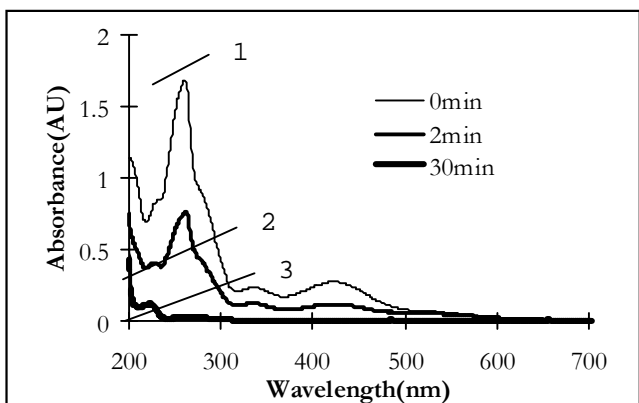


Figure 5: UV-Vis-spectra of the supernatant of the reaction mixture at reaction time of 0, 2, and 30min. Peak 1: 261 nm; Peak 2: 228 nm; Peak 3: 223nm

In dark reaction, UV-Vis-spectra (Figure 4) showed that alizarin red didn't disappear during adsorption.

In daylight lamp, UV-Vis-spectra (Figure 5) showed that alizarin red disappeared (Peak 1) dur-

ing the photocatalytical elimination and small amounts of new products formed (Peak 2 and 3).

### The influence of pH on the elimination of alizarin red

The elimination of alizarin red was pH-dependent, more efficient at acidic condition than at neutral and alkaline (Figure 6).

### The control experiments of chitosan-CdS composite nanoparticles and CdS

The results (Figure 7) showed chitosan-CdS composite nanoparticles were more efficient in eliminating alizarin red than CdS alone with the same dosage. At 2min and 30min, the efficiency of elimination reached 54.8% and 98.1% respectively for chitosan-CdS composite nanoparticles, however, the efficiency

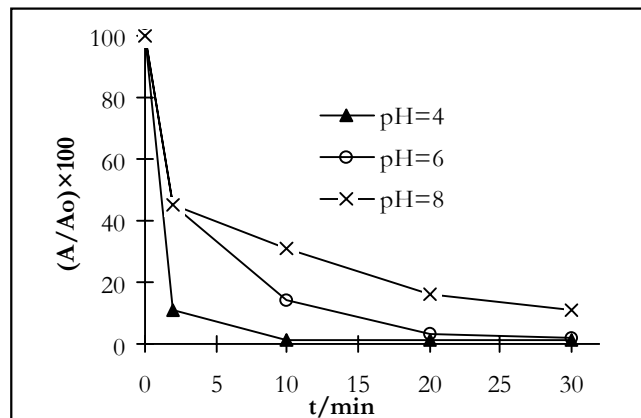


Figure 6: pH-dependence of the photocatalytical degradation of alizarin red by composite nanoparticles

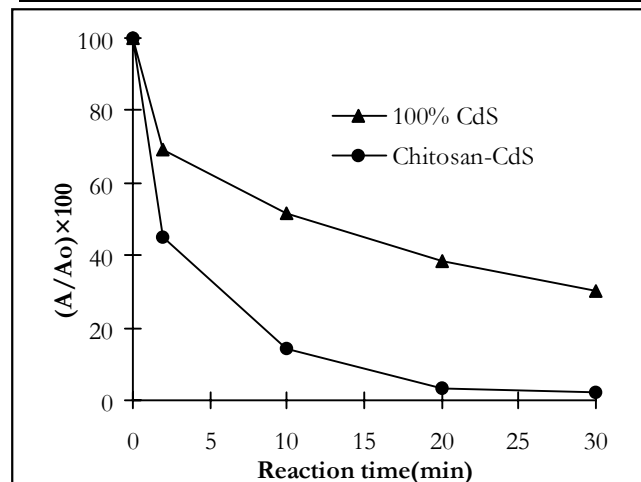


Figure 7: Absorption of the supernatant of the reaction mixture in the presence of CdS and chitosan-CdS composite nanoparticles

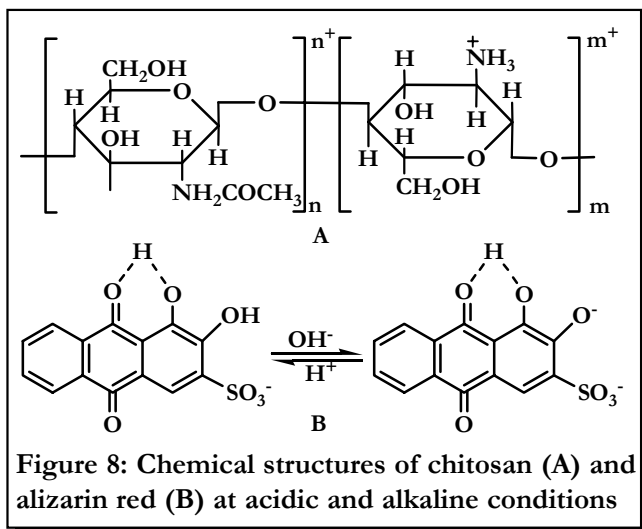
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only reached 30.6% and 69.7% respectively for CdS.

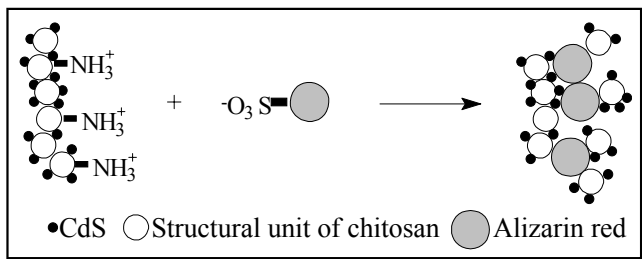
### Hypothetical mechanism of the photocatalysis

The chemical structures of chitosan and alizarin red are shown in figure 8.

1st Step: Adsorption of alizarin red on the composite nanoparticles by the chitosan constituent.



2nd Step: Formation of  $\bullet\text{OH}$  radicals by light.



3rd Step: Oxidation of alizarin red by  $\bullet\text{OH}$  radicals.



## CONCLUSIONS

- 1) Alizarin red was degraded rapidly by chitosan-CdS composite nanoparticles in a short time, and the new absorption peaks appeared at 223nm and 228nm respectively, which showed new products formed.
- 2) The elimination of alizarin red was pH-dependent, more efficient at acidic condition than at neutral and alkaline.
- 3) The chitosan-CdS composite nanoparticles had higher elimination degree than CdS alone.
- 4) The hypothetical mechanism of photocatalysis was put forward preliminarily: The primary step was the sorption of chitosan-CdS composite nanoparticles, which stimulated the elimination of alizarin red.

## ACKNOWLEDGEMENTS

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