

SYNTHESIS OF ZINC SULFIDE AND ZINC-IRON SULFIDE NANOPARTICLES FROM ZINC(II) DITHIOCARBAMATE COMPLEXES AND THEIR UTILITY FOR PHOTOCATALYTIC DEGRADATION OF DYES

G. Gurumoorthy

Department of Chemistry, Bharath Institute of Higher Education and Research, Chennai

gurugovindchem@gmail.com

Abstract

Bis(N-(pyrrol-2-ylmethyl)-N-(2-phenylethyl)dithiocarbamato-S,S')zinc(II) (1) and bis(N-methylferrocenyl-N-(2-phenylethyl)dithiocarbamato-S,S')zinc(II) (2) have been synthesized. Complexes 1 and 2 have been used as precursors for the preparation of zinc sulfide and zinc-iron sulfide nanoparticles. Morphological characterization of nanoparticles was carried out using TEM. The nanoparticles are explored as photocatalysts to study the degradation of dyes using methylene blue and rhodamine-B in aqueous solution under UV irradiation. The zinc-iron sulfide works as an efficient photocatalyst for degradation of rhodamine-B

Key words: Zinc(II) dithiocarbamate; zinc sulfide; zinc-iron sulfide; nanoparticles; single source precursors

Introduction

A wide range of metal-dithiocarbamate complexes is known with examples finding use in applications as diverse as industry, agriculture, medicine and material science [1-3]. Metal sulfide nanoparticles have shown vital applications in many fields as an advanced materials such as IR detectors [6], photocopacitors for energy conversion and storage [4], sensors [5], photonic materials [6] and advanced optoelectronic devices [7]. In recent years, transition metal dithiocarbamate complexes have received a great deal of attention because of their importance as single source precursors for the preparation of metal sulfide nanoparticles [8,9]. The N-bound organic moieties in dithiocarbamate ligands in metal complexes affect the morphology and size of the metal sulfide nanoparticles [10,11]. The photocatalytic activity of the metal sulfide nanoparticles depends on the morphology and size of the nanoparticles [12]. The single source precursor for the preparation of metal sulfide nanoparticles [13].

Experimental

2.1. Materials and techniques

All reagents and solvents were commercially available high-grade materials (Merck/ Sd fine/Sigma aldrich) and used as received. SHIMADZU UV-1650 PC double beam UV-visible spectrophotometer was used for recording the electronic spectra of the complexes.

2.2. Photocatalytic experiments

The photocatalytic activity of cobalt sulfide and cobalt-iron sulfide was evaluated by degradation of aqueous solution of methylene blue and rhodamine-B. All the solutions were prepared using double distilled water. A typical photocatalytic experiments, 0.1 g of catalyst was added to 50 ml of an aqueous solution of rhodamine-B in the concentration of 1.0×10^{-4} M. The solution was maintained under darkness for 30 min to reach dye solution adsorption-desorption equilibrium. The solution with the suspended nano-photocatalyst was irradiated by UV light from mercury vapour lamp.

2.2.1 Preparation of complexes

bis(N-(pyrrol-2-ylmethyl)-N-(2-phenylethyl)dithiocarbamato-S,S')zinc(II) (1) and bis(N-methylferrocenyl-N-(2-phenylethyl)dithiocarbamato-S,S')zinc(II) (2) were prepared by general methods reported earlier [9].

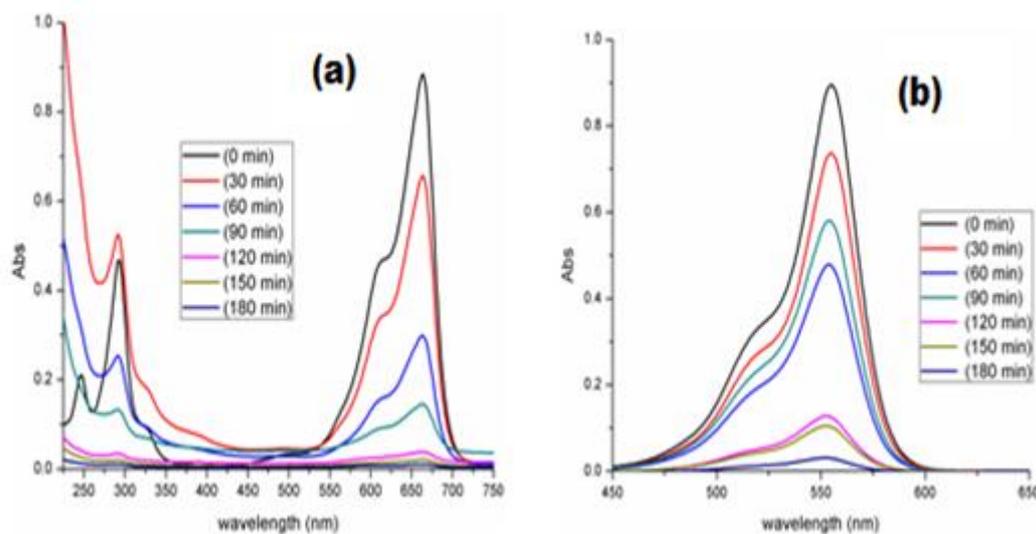
2.2.2. Preparation of zinc sulfide and zinc-iron sulfide

0.5 g of **2** was mixed in 15 ml triethylenetetra amine in a round bottom flask and then the content of the flask was refluxed for 15 minutes. The black precipitate obtained was filtered off and washed with methanol. Similar procedure was adopted for the preparation of zinc-iron sulfide from **2**.

Results And Discussion

3.1. Photocatalytic activity of zinc sulfide and zinc-iron sulfide

To investigate the potentiality of the synthesized zinc sulfide and zinc-iron sulfide-1 nanoparticles as photocatalysts, the catalytic performances were examined by photodegradation of methylene blue and rhodamine-B. Figs.4 show the time dependent UV-vis spectral changes of methylene blue and rhodamine-B solutions in the presence of zinc sulfide and zinc-iron sulfide nanoparticles under UV light. The characteristic absorption peaks appeared at 662 nm and 554 nm for methylene blue and rhodamine-B solutions, respectively and gradually decreased with irradiation time. This indicates that the photodegradation of dyes is very fast upto 90 min. Negligible degradation was observed when the reaction was allowed to occur in the presence of UV light without any catalyst. It has been observed that 90 and 89 % degradation of methylene blue and rhodamine-B, respectively takes place at 180 min with zinc sulfide nanoparticles. When zinc-iron sulfide-1 is used under same conditions, 98 and 96 % of methylene blue and rhodamine-B degradation occurred, respectively. This shows that the zinc-iron sulfide-1 is a better photocatalyst than zinc sulfide.



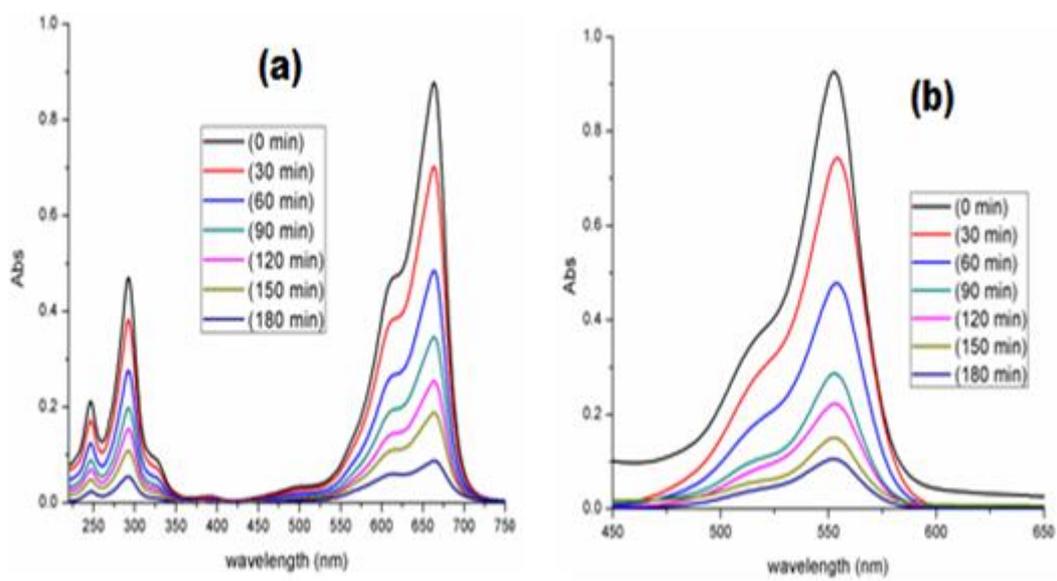


Fig.5. Time-dependent UV-Vis absorption spectra for degradation

- (a) methylene blue and (b) rhodamine-B using zinc sulfide and zinc-iron sulfide under ultraviolet light.

Conclusions

In this contribution two new zinc(II) dithiocarbamate complexes have been synthesized and characterized by spectroscopic techniques. These complexes have been exploited as single source precursors for the preparation of zinc sulfide and zinc-iron sulfide nanoparticles. Photocatalytic activities of both nanoparticles are evaluated by decolourization of methylene blue and rhodamine-B in aqueous solution under UV light irradiation. Zinc-iron sulfide is found in enhancing the rate of photodegradation of toxic dyes as compared to zinc sulfide. We expect this simple approach can be used for the synthesis of monometallic and bimetallic sulfide semiconductor nanoparticles with different morphologies, compositions and properties from single source precursors

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