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Simple Thermal decompose method of CdS nanoferriteparticles for Enhanced Biological Applications

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Abstract

In this work, cadmium sulfide nanoferriteparticles by using a new Cd-octanoate complex via a simple and fast method like thermal decompose method. The synthesized nanoferriteparticles were characterized by using X-ray diffraction pattern, Scanning Electron Microscopy, Fourier Transform Infrared Spectroscopy and Spectroscopic Techniques. These techniques were used to investigate the CdS surface purity. CdS nanoferriteparticles were dispersed in the solution as single entities. It showed very good resistance against oxidation for months according to their polymer shell. Finally, the optical properties of the product were obtained from photoluminescence (PL) spectroscopy.

Keywords

CdS; nanocomposites; semiconductors; octanoate; thermal decompose; nanoferriteparticles

Introduction

The term 'nano' is derived from Greek word "nano" which mean very small or dwarf. One nanometer is equal to one billionth of a meter, 10-9 m [1]. The term nanostructure condensed matter structure having a minimum dimension approximately between 1nm (10A°) to 100nm (1000A°). Nanotechnology is the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale [2]. II–VI binary compound semiconductors have drawn considerable interest due to their interesting electronic and optical properties. They play significant roles in both basic science and application fields. It has been fine accepted that size and morphology of nanomaterials are vital issues for their application and great efforts have been devoted to achieve size and morphological controllable syntheses of semiconductor nanocrystals [3]. Cadmium sulfide (CdS), a direct band gap material with Eg of 2.42 eV at room temperature, has vital applications in the optoelectronic devices [4-6]. And it receives a wide range of research notice since of their unique properties and their wide variety of potential applications. For illustration, potential applications for laser light-emitting diodes, solar cells, non-linear optical, optoelectronic and electronic devices are in discussion [6-11].

Owing to their small size, these nanoferriteparticles reveal properties remarkably different from their bulk counterparts of the same chemical composition. Cadmium sulfide is a chemical compound that has the formula CdS. It is yellow in color and is a semiconductor of electricity. It exists as two different polymorphs, hexagonal greenockite and cubic hawleyite. The most important applications of Cadmium Sulfide are as a pigment. Cadmium Sulfide is also used in the production of solar cells where it is used as a buffer layer in the manufacture of CIGS (Copper -Indium-Gallium-Selenide) solar cells. In this technique, the organic surfactant, such as polyethylene glycol (PEG), coated on the surface of the nanoferriteparticles, plays key roles in determining not only the size but also the shape of the products throughout the synthetic procedures; and the attained nanoferriteparticles are comparatively steady and can be re-dispersed in nonpolar solvents simply.

Properties of Cadmium Sulfide

Property	**Value**
Physical state and appearance	Solid. (Solid powder.)
Molecular Weight	144.46 g/mole
Color	Yellow or brown
Melting Point Sublimes	(980°C or 1796°F)

Specific Gravity	4.82 g/cm3
Solubility	Insoluble in hot and cold water

Experiment

Materials

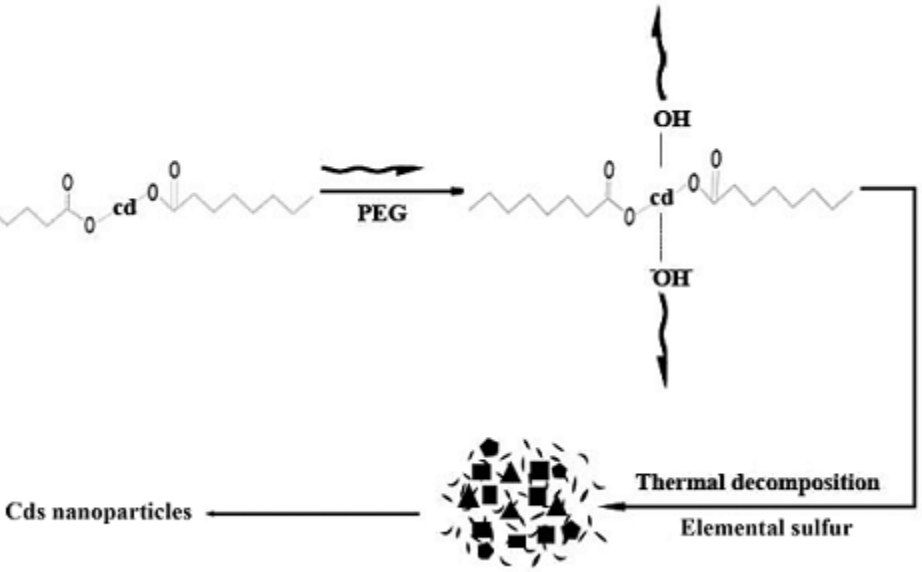
The chemical reagents used in this experiment such as polyethylene glycol, elemental sulfur (99.95 %) and complete ethanol were of analytical grade and were used. The precursor complex, [bis (octanoate) cadmium(II)], was prepared in accordance with the method explained in[12]. The distilled water used in this work. In this present paper, we report on the synthesis of CdS nanoferriteparticles by thermal decomposition of [bis(octanoate)cadmium(II)], in the presence of PEG. PEG was used as together the medium and the stabilizing reagents.

Characterization Studied

X-ray diffraction patterns were taken by a Rigaku D-max C III, X-ray diffractometer using Ni-filtered Cu-Kα radiation. Fourier transform infrared spectra were studied on Shimadzu Varian 4300 spectrophotometer in KBr pellets. Scanning electron microscopy images were attained on Philips XL-30 ESEM equipped with an energy-dispersive X-ray spectroscopy. Room temperature photoluminescence was studied on an F-4500 fluorescence spectrophotometer. Transmission electron microscope images were obtained on a Philips EM208S TEM with an accelerating voltage of 110 kV.

Synthesis of CdS nanoferriteparticles

CdS nanoferriteparticles were prepared in a three-neck flask under argon atmosphere. In a distinctive synthesis procedure, the $[Cd(oct)_2]$–PEG complex was prepared by reaction of 0.5 g of $[Cd(oct)_2]$ and 8 ml of PEG. The mixed solution was taken into the flask beneath stirring and then 0.28 g sulfur was added to the solution. The assortment was heated up to 160 °C approximately 100 minutes. The colour of the solution modified from green to black. The black solution was cooled at room temperature. The nanoferriteparticles were splitted upon the addition of excess ethanol and centrifuged. The samples were washed with ethanol and dichloromethane, finally dried in vacuum oven at room temperature. Scheme 1 shows the schematic diagram of CdS nanoferriteparticles preparation.



Scheme 1 Schematic of CdS nanoferriteparticles preparation

Results and discussions

XRD patterns of the as-synthesized particles is shown in ***Figure 1***. It is dependable with the spectrum of CdS. The reflections of CdS can be indexed fine to hexagonal CdS (space group: P63mc; JCPDS No.06-0314). The crystallite sizes of the as-synthesized CdS, Dc, was calculated from the major diffraction peaks of the base of (110) using the Scherrer formula:

$Dc = K \lambda / \beta \cos \theta$;

where K is a constant (ca. 0.9) (33); λ is the X-ray wavelength used in XRD (1.5418 Å); β is the Bragg angle; θ is the pure diffraction broadening of a peak at half-height, that is, broadening due to the crystallite dimensions. The diameter of the nanoferriteparticles calculated by the Scherrer formula is 35 nm.

The morphological studies examined by SEM and TEM analysis as shown in ***Figure 2***. The size of particles by SEM was about 34 nm to 41 nm. The main reason for decreasing the particle size of CdS nanostructure is the presence of PEG and octanoate that act as surfactant agent. In actuality they cap the nanoferriteparticle surfaces and avoid from aggregation.

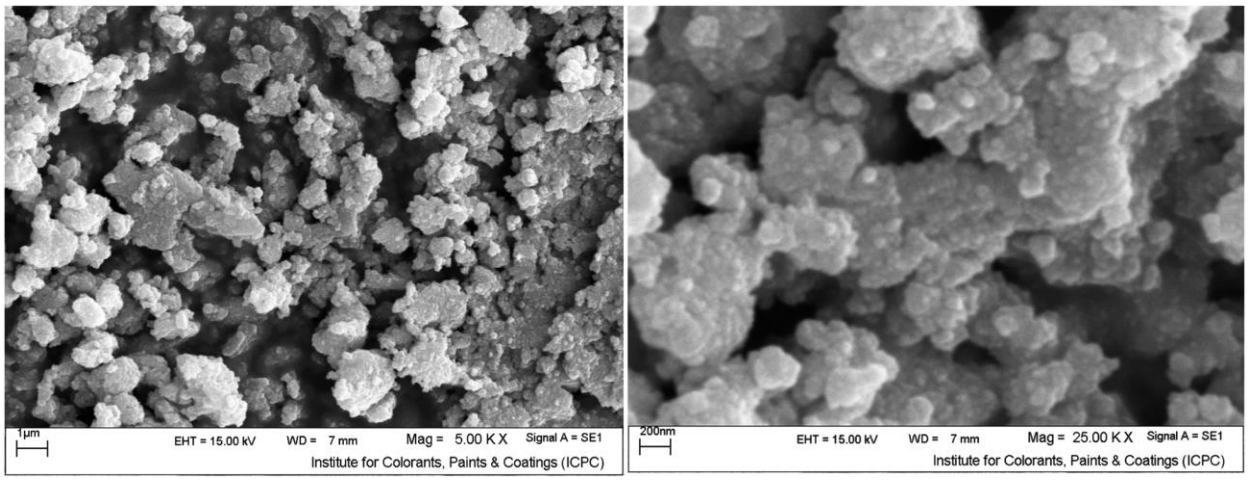


Figure 2 SEM image of CdS nanoferriteparticles

The TEM image of the product is given in ***Figure 3***. The size of the nanocrystals attained from the TEM is 32 nm.

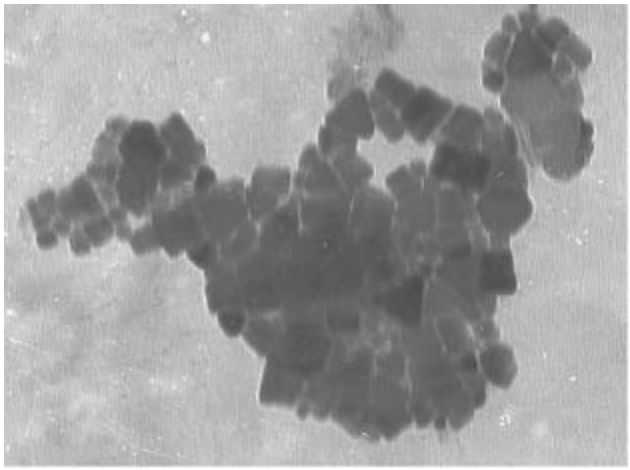


Figure 3 TEM image of CdS nanoferriteparticles

To examine whether the surface of the nanoferriteparticles was capped with organic surface the FT-IR of the as-synthesized particles was performed. Usually, ***Figure 4*** shows the FT-IR spectra of CdS nanoferriteparticles. The spectra of CdS nanoferriteparticles show weak stretch vibration at 1150 cm^{-1} attributing to the C–O stretching model of the PEG, two weak stretch vibrations at 2,920 and 2,885 cm^{-1} attributing to the C–H stretching models of the PEG carbon chain indicating PEG molecules are absorbed on the surface of nanoferriteparticles [13-16]. There was no evidence of free precursor, $[Cd(oct)_2]$, in the sample, so the PEG serves as the capping ligand that controls growth.

PL measurement was carried out at room temperature with wavelength of 392 nm (***Figure 5***). The PL spectrum consists of one strong peak at 395 nm that can be ascribed to a high-level ransition in CdS semiconductor crystallites.

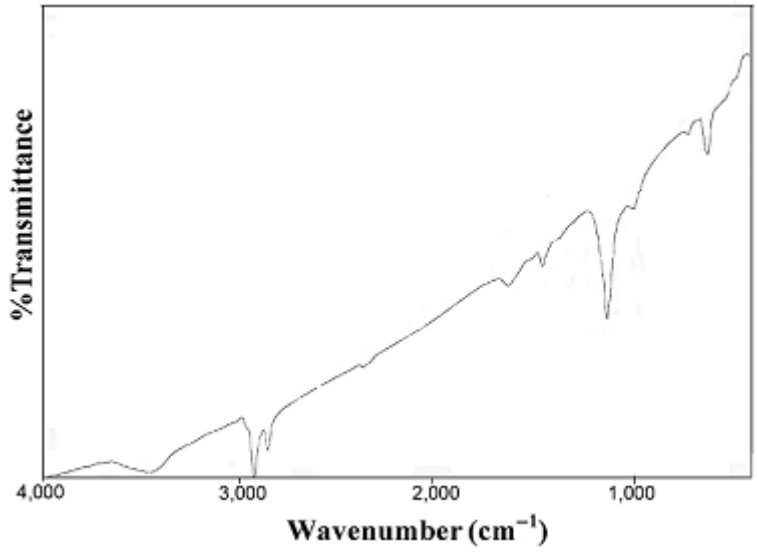


Figure 4 FT-IR spectra of CdS nanoferriteparticles

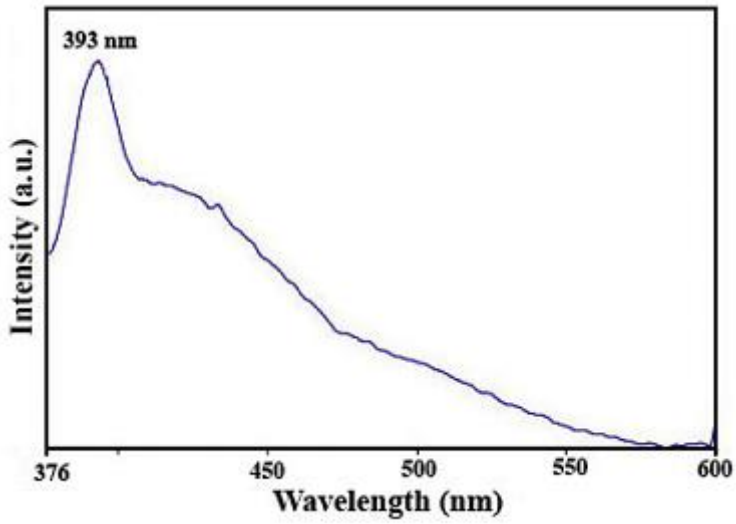


Figure 5 PL spectra of CdS nanoferriteparticles

Biological Applications of CdS nanoferriteparticles

The safe use in biomedicine of $Cd(oct)_2$]–PEG complex requires a detailed understanding of the biocompatibility and toxicity of particles in human beings. The biological characteristics and

physicochemical properties of CdS nanoferriteparticles entail new challenges regarding the management of potential adverse health effects following exposure. At certain concentrations, the synthesis of semiconductor nanoferriteparticles of $Cd(oct)_2$]–PEG complex to reduce their toxicity and improves their biocompatibility. This study successfully synthesized and characterized biocompatible cadmium sulfide nanoferriteparticles and showed that these particles are cytotoxic at high concentrations in HepG2 and HEK293 cells.

Conclusion

The CdS nanostructures with very minute nanoferriteparticles were prepared using a effortless thermal decomposition technique with a novel precursor. The octanoate complex and polyethylene glycol acted as surfactant and increased steric cause and then the nanoferriteparticles size decreases. The morphological analyses proved that the as-synthesized CdS was composed from extremely tiny nanoferriteparticles. FT-IR spectra showed that polyethylene glycol was capped on the nanoferriteparticles surface. The optical properties were attained from PL spectra. A strong peak was seen in 395 nm that can be attributed to recombination of excitons and/or shallowly trapped electron–hole pairs. These studies confirmed the effective cellular uptake and even distribution pattern of CdS-nanoferriteparticles in tissues. They were biocompatible with tissues from rodents. The $Cd(oct)_2$]–PEG complex used in this study can be potentially used in bio-imaging applications also.

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