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Research Article

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CdS Nanoparticles: Green Synthesis Method and Capping Agent's Effect on its Crystallite Size

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ABSTRACT

Now days, the study of CdS nanoparticles is very important because of its dependent properties like electric, catalytic and optical properties. CdS nanoparticles in nature has II-VI group semiconductor with a wide band gap. In this manuscript, author used green synthetic method for the CdS nanoparticle production which is simple, convenient, economic and environmental benign using glucose/starch as capping agent. Synthesised CdS nanoparticles were characterized by using X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Spectroscopy (TEM), Fourier Transform Infra-Red (FTIR) and UV-Visible Spectroscopy.

Keywords: CdS nanoparticles; Green synthesis; Spectral analysis; Starch; Glucose

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INTRODUCTION

Nanoparticles are of great importance because of their unique physical, thermodynamic and chemical properties, which are different from bulk materials [1]. Semiconductor nanoparticles also have crucial role due to size dependent optical, luminescence and electrical properties and have several applications in many research areas. Nanostructure sulfides have been studied extensively with a view to establish a relationship among size, structure and optical properties [2]. Currently, many workers have focused on cadmium sulphide because of several important properties [3-5]. Size dependant properties are exhibited by CdS nanoparticles because of high surface to volume ratio. It also possessed high photosensitivity which enables them useful for optoelectronic devices and various other biological applications and because of these applications various part of plants are used in the bulk production of CdS nanoparticles [6-9].

Various methods of the synthesis are used by researchers for CdS with or without using capping agents but may have some demerits like long reaction time, low product yield, tedious workup, toxicity and environmental issues [10-12]. In the present manuscript, green chemistry principles are used to overcome the problems reported earlier for the CdS production. Herein, we used chemical co-precipitation method using cadmium nitrate and sodium sulfide for CdS NPs. Glucose/starch as a capping agents as well as concentration effect of the capping agents were also studied.

MATERIAL AND METHODS

All the chemicals and reagents used in the present study were of analytical grade and used without further purification. The obtained nanoparticles were examined by a Bruker D 8 X-ray diffractometer with Cu K radiation (Lambda = 1.54A°) and the operating voltage and current were maintained at 40kV and 250mA, Scanning electron microscopy (F Model JEOL JSM 5600) with energy dispersive X-ray diffraction (EDX) photometer, IR spectra of the sample were recorded using Bruker, Germany (Model: Verlex 70) FTIR, transmission electron microscopy with EDX at 200kV and UV-Visible spectra were recorded on Perkin Elmer double beam UV-Visible spectrophotometer (Model: Lambda 950, USA) .

Synthesis of cadmium sulphide nanoparticles by using glucose and starch as a capping agent

A simple chemical co-precipitation method was followed for the synthesis of CdS nanoparticles. We utilized cadmium nitrate ($Cd (NO_3)_2$ as a source of cadmium ion and sodium sulphide (Na_2S) as a source of sulphide ion and glucose/starch is used as a capping agent. Cadmium nitrate (2.36 gm) is dissolved in 100 ml distilled water, sodium sulphide (0.78 gm) was dissolved in 100 ml of water, then sodium sulphide solution was added drop wise to cadmium nitrate solution and stirred continuously, an orange colour solution is obtained. The solution is stirred on magnetic stirrer for 16 hours at 500 rpm. Add 1.8 gm glucose/9 gm starch is taken and mix it to 100 ml water. Divide the orange solution in three equal parts and 10 ml glucose/starch in each solution drop wise. The sample is then heated and then put it to oven for 7 hours at 100 ºC. Filter the precipitates and dried in oven for 70ºC for 6 hours.

Flow chart of method (Figure 1)

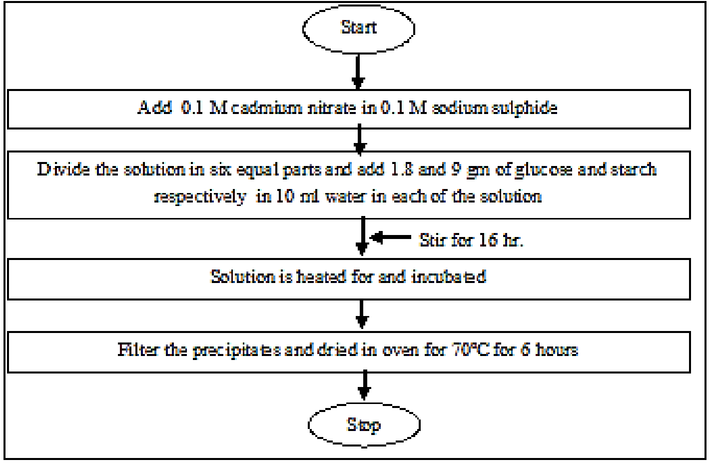


Figure 1: Flow chart for CdS nanoparticle using glucose /starch as a capping agent

RESULTS AND DISCUSSION

Crystallite size of the synthesized nanoparticles were significantly influenced by the concentration of capping agents like glucose and starch were observed by using various techniques like XRD, SEM, TEM etc.

XRD analysis

XRD data were used to determine the lattice parameter, crystallite size and phase identification. Crystallite size was calculated by applying Debey-Sherrer's equation [13]

$$d = 0.9\lambda / \beta \, \mathrm{Cos}\theta$$

Where, d is the crystalline size, λ is the wavelength of the CuKα (1.54 Aº), θ is the angle between the incident beam and the reflecting lattice plane and β is the full width at half maxima (FWHM) of the diffraction peak (in radian). Interplanar spacing was calculated by applying formula: $d = \lambda/2 \sin \theta$ Where, θ is the angle between the incident beam and the reflection lattice planes and λ is the wavelength of the CuKα (1.54 Aº).

The XRD data for samples having different capping agents has been shown in Figure 2a and 2b. The presence of three peaks at 26.62, 42.62 and 51.86° confirmed the presence of cubic phase of CdS nanoparticles according to JCPDS file no. 10-454. Results showed that crystallite size of the CdS is in the nano scale and is in cubic phase.

1. XRD data (Glucose) for crystallite size (a) 2.9 nm, (b) 7.2 nm, (c) 6.5 nm
2. XRD data (Starch) for crystallite size (a) 3.1 nm, (b) 6.9 nm, (c) 5.8 nm

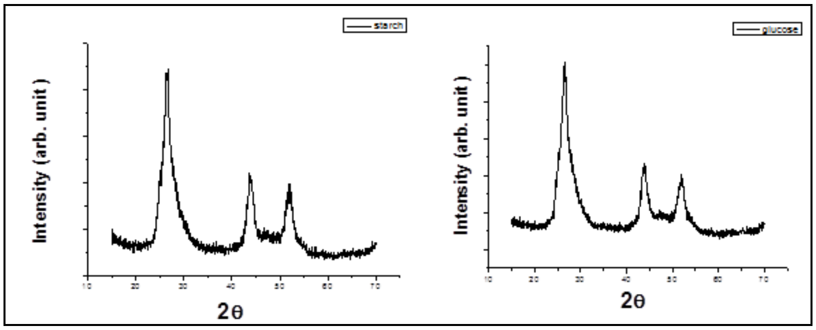


Figure 2: a: XRD of glucose doped CdS; b: XRD of starch doped CdS

SEM Measurement:

The SEM image of the CdS nanoparticles corresponding to the XRD pattern in Figure 2 it is clear that the prepared CdS nanoparticles have regular cubic shape and uniform size, with an average size of 20 nm and one can see some coalesced nanoparticles with a size of about 40 nm. (Figure 3a and 3b)

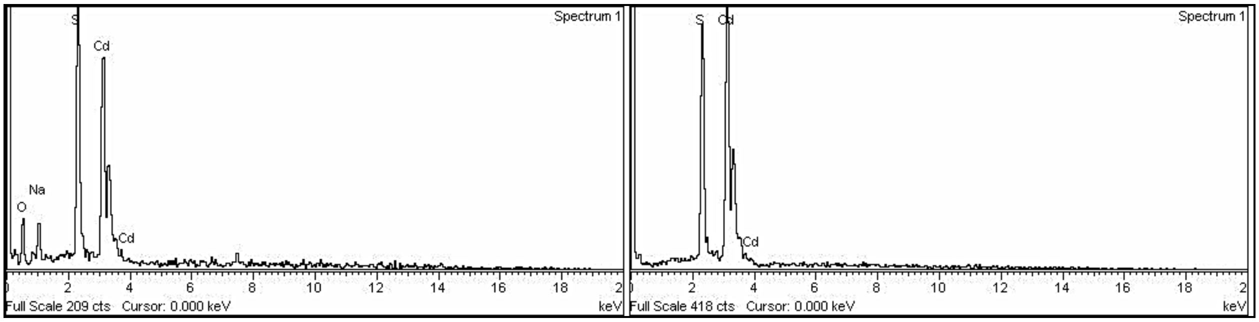


Figure 3: a: SEM image of glucose doped CdS; b: SEM image of starch doped CdS

TEM measurement

The TEM image of the CdS nanoparticles corresponding to the XRD pattern in Figure 2a and 2b, and SEM in Figure 3a and 3b, the particle size distribution was shown in Figure 4a and 4b from TEM, the average size appears to be around 20nm. These particles are single crystalline as revealed by the high resolution electron image. The particles are cubic in shape.

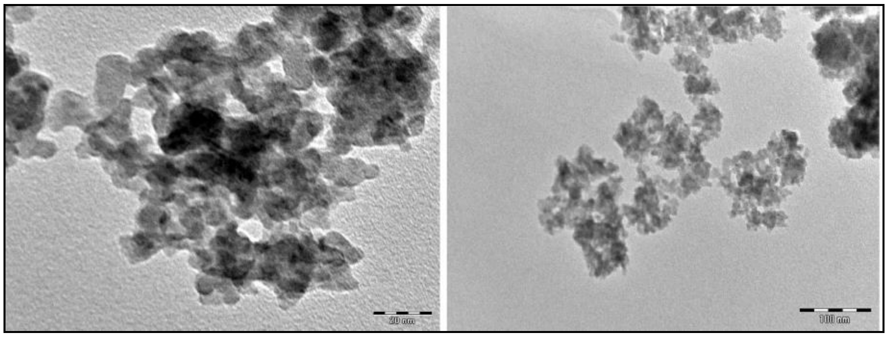
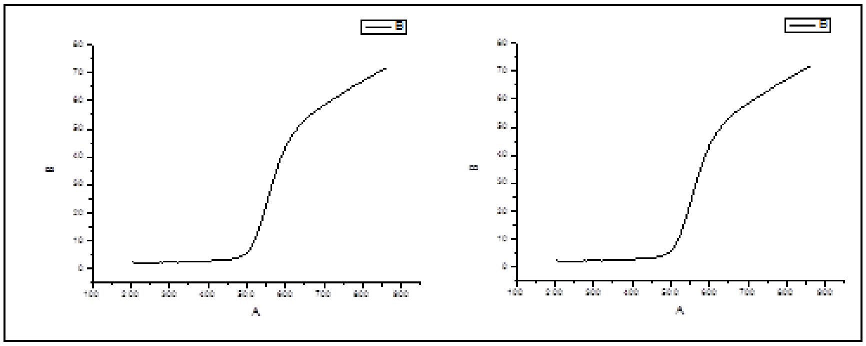


Figure 4: a: TEM image of glucose doped CdS; b: TEM image of starch doped CdS

UV-Visible spectrum

Characterization was confirmed by measuring the optical properties of CdS nanoparticle. An absorption spectrum was obtained by UV Visible spectroscopy in the range of 200 -600 nm. (Figure 5a and 5b) The UV-Visible spectrum of the synthesized nanoparticle is in accordance with the reported compounds. The absorption spectrum was shown λ_{max} at 480 nm by nanoparticle that confirmed a blue shift of about 50 nm as compared to bulk whose λ_{max} 530 nm.



[A= wavelength nm, B= Abs (%)]

Figure 5: a: UV-Vis spectrum of glucose doped CdS; b: UV-Vis spectrum of starch doped CdS

IR spectral studies

Further, characterization was confirmed by Fourier transformation Infrared spectrum of CdS nanoparticle. An absorption spectrum was obtained by IR spectrum in the range of 650-4000 cm^{-1}. The IR spectrum of the synthesized nanoparticle is in accordance with the reported compounds.

CONCLUSION

A simple, economic, green and eco-friendly method of CdS nanoparticle synthesis was developed by using glucose and starch as capping agents. The size of the glucose/starch capped nanoparticles are near about same as SEM and TEM data obtained of the nanoparticle size which is 20nm and starch is better capping agents as compared with glucose in crystallite size. This method is eco-friendly for commercial scale production as it does not involve the use of hazardous and toxic capping agents. Further, capping agent concentration has significant effect and can be seen in crystallite size as the concentration of the capping agent increases size of the crystallite decreases.

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