

## SYNTHESIS AND CHARACTERIZATIONS OF CdS NANORODS BY THE SOLVOTHERMAL PROCESS WITH PVA AS MATRIX

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In the present work, a study on the synthesis and characterizations of CdS nanorods is reported. The CdS nanorods were prepared by the solvothermal method in polyvinyl alcohol (PVA) matrix. The structure and surface morphology of obtained CdS nanorods with average diameter about 10~30nm were characterized by powder X-ray diffraction (XRD) and transmission electron microscopy (TEM). The quantum-confined effect of the CdS nanorods was confirmed by the ultraviolet-visible (UV-vis) spectrum. Photoluminescence (PL) determination showed the CdS nanorods have good optical property.

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### 1. Introduction

In the last decade, there have been great interests in II-VI group semiconductor nanomaterials because of their novel properties originating from quantum confinement effect [1-3]. They are important inorganic materials for a variety of applications including solar cells, optical filters, signal memory devices, photoconductors, infrared imaging devices, sensors and light-emitting materials [4-7]. Various synthetic schemes have been developed for size- and shape-controlled synthesis of metal sulfide nanomaterials, such as solid-state reaction, sol-gel process, sonochemistry, microwave radiation, hydrothermal, solvothermal and others [8-13].

Recently, many efforts have been devoted to the synthesis of 1D nanostructure of chalcogenide semiconductors because of their useful properties and technological importance [14-16]. For example, Dalvand et al. have been successfully synthesized CdS nanowires with different aspect ratios by the solvothermal method in different solvents [17]; Phuruangrat and co-workers have been prepared CdS multipod nanostructure under aminothermal process [18]. The present study is aimed to synthesize nanorods of CdS by the solvothermal method and investigate their optical properties by UV-vis adsorption and photoluminescence (PL) spectroscopy. X-ray diffraction (XRD) and transmission electron microscopy (TEM) have also been carried out to study the structure and morphology of the CdS nanorods.

### 2. Experimental

CdS nanorods were prepared by the solvothermal process using polyvinyl alcohol (PVA) as a stabilizer. The detailed preparation procedure is as follows. 1.1g CdCl<sub>2</sub>·2.5H<sub>2</sub>O was dissolved in 30mL 6wt% solutions of PVA in which 0.5mL 3-mercaptopropionic acid and 30mL butyl amine were subsequently added. The mixed solution was kept under N<sub>2</sub> atmosphere for 0.5h with continuous magnetic stirring. Then 0.57g thiourea was added into as-prepared solution with vigorous stirring, which was transferred into a Teflon liner autoclave. Close it tightly and heat it in an oven up to 180°C for 10d, and finally cool it down to room temperature. The collected

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solid-state yellow products centrifuged at 10,000rpm were washed with deionized water and absolute ethanol alternately, and then dried in a vacuum at 60°C for 24h.

Powder X-ray diffraction (XRD) was carried out on a Bruker D8 Advance X-ray diffractometer using Cu  $K_{\alpha}$  radiation with the scanning 2-theta angle ranging from 10 to 70 degree; TEM study were performed at JEOL JEL-2010 transmission electron microscopy; The optical properties of CdS nanorods were characterized at Shimadzu UV-2550 and Hitachi F7000 spectrophotometer respectively.

### 3. Results and discussion

The XRD pattern of CdS nanorods is shown in Fig. 1. The peaks in figure are identified to originate from (100), (002), (101), (102), (110), (103), (112) and (203) planes of hexagonal wurtzite phase of CdS(JCPDS No. 41-1049), the (101) diffraction peaks are strong and narrow which may be ascribed to the preferential growth of CdS nanocrystals.

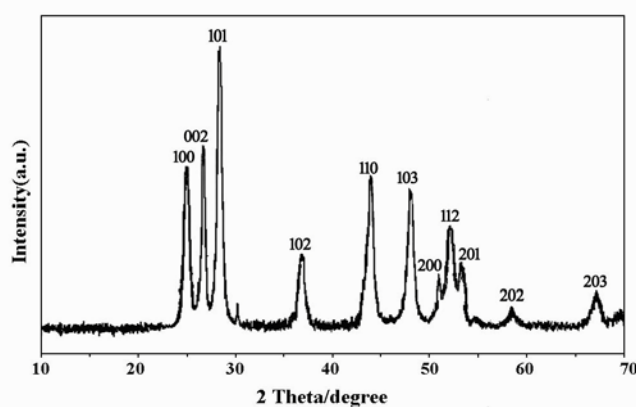


Fig. 1 X-ray diffraction (XRD) pattern of as prepared CdS nanorods.

The surface morphology and chemical composition of the prepared CdS nanorods were determined by transmission electron microscopy (TEM) and energy dispersive spectroscopy (EDS) respectively. Fig. 2A, B shows the TEM images of CdS nanorods prepared in the PVA matrix. The nanorods have nonuniform diameters in the range of 10 to 30nm and lengths of 160 to 250nm. The HRTEM image in Fig. 2C provides further insight into the crystalline structure of CdS nanorods. The image exhibits lattice fringes with d spacing of 0.314 nm nearly equal to that of (101) planes of hexagonal wurtzite phase of CdS crystallites, which is consistent with the results of XRD measurement.

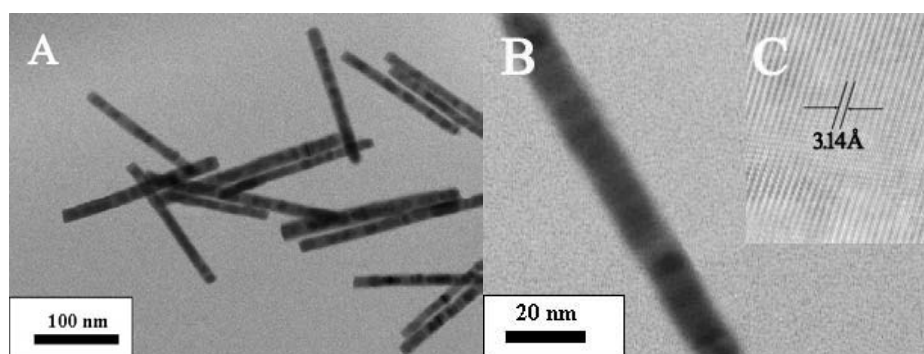


Fig. 2 TEM (A, B) and HRTEM (c) images of as prepared CdS nanorods.

The size distribution of CdS nanorods diameter was shown in Fig. 3, which is quite narrow with an average diameter of about 15nm. The EDS spectrum of the sample shown in Fig. 4

also showed the significant presence of only Cd and S with an atomic ratio (Cd/S) of nearly 1 in good agreement with the stoichiometric molar ratio of Cadmium (II) sulfide.

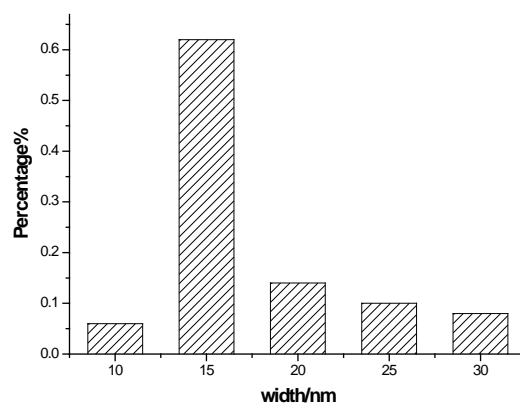


Fig. 3 The diameter size distribution of as prepared CdS nanorods

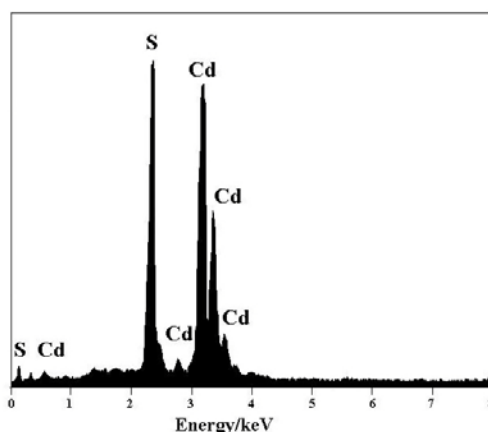


Fig. 4 EDS spectrum of as prepared CdS nanorods.

Fig. 5 shows the UV–visible absorption spectrum of CdS nanorods synthesized in the PVA matrix. The adsorption peak position in the UV-vis spectrum was found at 465nm due to optically allowed transition of CdS between the electronic state in the conduction band and hole state in the valence band. The band gap of CdS nanorods are higher than that of bulk CdS (515nm), indicating a quantum size effect. Brus had derived Effective mass approximation formula to explain the blue shift. The Effective mass approximation formula is given as [19]:

$$\Delta E = \left( \frac{\hbar^2 \pi^2}{2R^2} \right) \cdot \left( \frac{1}{m_e} + \frac{1}{m_h} \right) - \frac{1.8e^2}{\epsilon R}$$

where  $\Delta E=0.16\text{eV}$  is the increase of the band gap energy,  $\epsilon$  is the relative dielectric constant,  $R$  is the radius of the particle and  $m_e = 0.19m_0$  and  $m_h = 0.8m_0$  are the effective masses of electrons and holes, respectively. Therefore, we speculate the prepared CdS nanostructures can be used as UV filters and special optical devices.

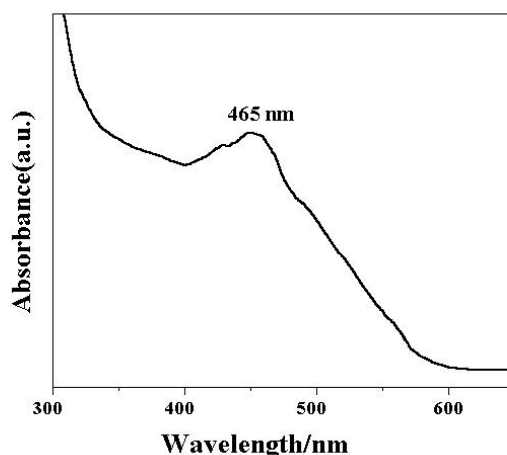


Fig. 5 UV-vis adsorption spectrum of as prepared CdS nanorods.

The Photoluminescence (PL) spectrum of CdS nanorods at the room temperature is shown in Fig. 6, which exhibits strong emission peaks centered around 520nm and 628nm. The peak at 520nm can be ascribed to emission resulted from the combination of electron and hole [20], and emission curve at 628nm can be assigned to emission from sulfur vacancies due to crystalline surface defects [21].

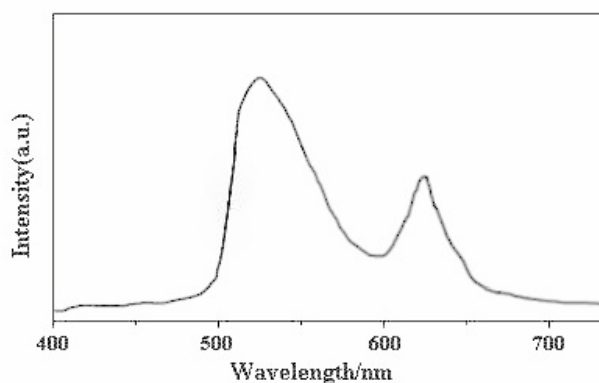


Fig. 6 Photoluminescence (PL) spectrum of as prepared CdS nanorods.

#### 4. Conclusion

In summary, CdS nanorods have been successfully prepared by a solvothermal process with polyvinyl alcohol (PVA) as directing agent and soft template. The synthesis process is very simple, effect and controllable. The obtained CdS nanorods with average diameter 10~30nm have a high degree of crystallinity. UV-visible absorption spectrum shows the strong blue shift in absorption edge compared to bulk materials. Photoluminescence spectrum of the sample at room temperature has observed two peaks centred around 520 nm and 628 nm assigned to band gap transitions and sulfur vacancy defects, indicating the products have good luminescence property.

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