



Photocatalytic activity of CdTe quantum Dots encapsulated in zeolite Y



Rongfang Wang^{a,b}, Bin Li^{a,*}, Lihui Dong^{a,*}, Feiyue Zhang^a, Minguang Fan^a, Liya Zhou^a

^a School of Chemistry and Chemical Engineering, Guangxi University, Nanning 530004, China

^b College of Chemistry and Material, Yulin Normal University, Yulin 537000, China

ARTICLE INFO

Article history:

Received 26 April 2014

Accepted 20 July 2014

Available online 30 July 2014

Keywords:

Semiconductor

Nanocomposites

FTIR

CdTe/Y

Photocatalytic activity

ABSTRACT

A series of CdTe/Y nanocomposites was prepared by introducing Cd²⁺ into zeolite Y and then adding TeO₂ and NaBH₄. X-ray diffraction and Fourier-transform infrared spectroscopy analysis showed that the framework structure of zeolite Y was not destroyed and that CdTe quantum dots were successfully introduced into zeolite Y. Ultraviolet–visible diffused reflectance spectroscopy demonstrated that the absorption spectra of CdTe/Y evidently red shifted compared with zeolite Y. The effect of the initial Cd²⁺ concentration was systematically investigated. The photocatalytic activities of CdTe/Y were also measured by the photocatalytic degradation of methyl blue. Results indicated that CdTe/Y had high catalytic performance and that photocatalytic activity increased with increased Cd²⁺ concentration.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Semiconductor quantum dots (QDs) have gained significant attention in the past two decades because of their unique optical properties. Among these QDs, CdTe QDs have been extensively studied [1–4]. The absorption spectra of QDs blue shift relative to the bulk when the semiconductor particle dimensions are reduced. These materials can be synthesized in different systems prepared in solution [5–8], polymers [9], or glasses [10]. However, the sizes of semiconductor QDs are not uniform in these systems.

Zeolite Y is an aluminosilicate material composed of SiO₂ and Al₂O₃ with the general formula M_x[(AlO₂)_x(SiO₂)_y]_{3n}H₂O. The uniform void spaces (often called cages or channels) of zeolites enable them to be better media than colloidal solution for controlling aggregation. Thus, zeolites are used as hosts for generating very small QDs, organizing them into regular arrays, and enhancing their stability [11]. Since the 1980s, semiconductor QDs encapsulated inside zeolites have been extensively studied [12–16]. Henglein [17] as well as Wang and Herron et al. [18,19] reported the preparation, structure, and optical properties of semiconductor QDs in zeolites. However, the practical application of QDs in zeolite has not yet been fully explored despite the great potential.

To the best of our knowledge, reports on the synthesis of CdTe in zeolite are limited. In this work, a novel method of synthesizing CdTe inside zeolites was established. CdTe QDs and zeolite were expected to complement each other with their own advantages.

The photocatalytic activities of the CdTe/Y nanocomposites were also measured by the photocatalytic degradation of methyl blue.

2. Materials and method

CdTe/Y nanocomposites were synthesized by a novel approach. About 3 g of zeolite Na-Y was added to 100 mL of CdCl₂ solution in a 40 °C water bath under magnetic stirring for 2 h, the Cd-Y was obtained. Subsequently, 0.3 mL of thioglycolic acid was injected into the Cd-Y solution, followed by the addition of NaOH solution until pH 8.0 was reached. Under stirring, TeO₂ and NaBH₄ were added to the original solution. The resulting mixture was heated to 100 °C and then refluxed for 2 h. Cd-Y and CdTe/Y were then collected by filtration, extensively washed with distilled water, and dried to a powder. Finally, all samples were calcined at 300 °C for 2 h in flowing air.

To characterize the specimens, Fourier-transform infrared (FT-IR) spectra were obtained using a Bruker/Vector 22 FT-IR Spectrometer Vector. X-ray diffraction (XRD) patterns were performed using a Rigaku/Dmax-2600-pc diffractometer with Ni-filtered Cu K α radiation ($\lambda=0.15418$ nm). Ultraviolet–visible diffuse reflection spectrum (UV–vis DRS) profiles were recorded from 200 nm to 800 nm with BaSO₄ as a reference. All measurements were carried out at room temperature.

The photocatalytic activity of the as-prepared photocatalysts was estimated by the degradation of methyl blue under UV light. Approximately 0.05 g of the sample was added to 150 mL of 16 mg/L methyl blue solution. The sample suspension was stirred for 30 min in the dark before the photocatalytic reaction to reach adsorption equilibrium. The suspension was then illuminated by

* Corresponding authors. Tel./fax: +86 771 3234993.

E-mail address: binli@gxu.edu.cn (B. Li).

UV light under magnetic stirring. Exactly 2 mL of the above solution was withdrawn at the same time intervals. Subsequently, the aqueous samples were centrifuged to remove any suspended solid catalyst particles before analysis. The degradation rate of a sample was calculated by the following equation:

$$\text{Degradation rate (\%)} = \frac{(A_0 - A)}{A_0} \times 100\%$$

where A_0 is the initial absorbance of the dyes and A is the absorbance after irradiation at various time intervals.

3. Results and discussion

The XRD patterns of the Na-Y, Cd-Y, and CdTe/Y samples are shown in Fig. 1A. For Cd-Y and CdTe/Y, only the diffraction peaks associated with Na-Y mixed oxide were detected, indicating that CdTe was highly dispersed in zeolite Y. The inset in Fig. 1A shows the amplification of the corresponding XRD patterns at $2\theta = 23^\circ$ to 24° . Moreover, the diffraction peak of Cd-Y and CdTe/Y evidently blue shifted at $2\theta = 23.64^\circ$ to 23.62° compared with Na-Y. This result confirmed that CdTe QDs were successfully encapsulated in zeolite Y. The FT-IR spectra of Na-Y, Cd-Y, and CdTe/Y are shown in

Fig. 1B. These spectra did not show any SH group (2560 cm^{-1}) but showed the expected OH groups (3587 cm^{-1}). The FT-IR spectra of Cd-Y and CdTe/Y were similar to those of Na-Y. This result indicated that the framework structure of zeolite Y was not destroyed and that CdTe QDs were successfully introduced into zeolite Y.

The effect of CdTe on the BET surface area of the as-prepared composite samples was also investigated. The BET surface area of Na-Y and CdTe/Y was 900.407 and $243.257\text{ m}^2\text{ g}^{-1}$, respectively. Compared to Na-Y, CdTe/Y nanocomposite samples show lower BET surface area, indicated that CdTe QDs were dispersed in channels of zeolite Y.

The optical property can also be determined from UV–vis diffuse reflectance measurements. The absorbance of zeolite Y was low (< 0.2), as shown in Fig. 2. However, the absorbance peak of CdTe/Y was about 0.4, which corresponded to transition from the valance band to the conduction band. The spectral edges of CdTe in zeolite Y evidently red shifted compared with zeolite Y. Moreover, the band gap energy (E_g) of CdTe/Y was calculated by Tauc's formula: $\alpha h\nu = A(h\nu - E_g)^n$, where α is the absorption coefficient, $h\nu$ is the photon energy, A is a constant, and n depends

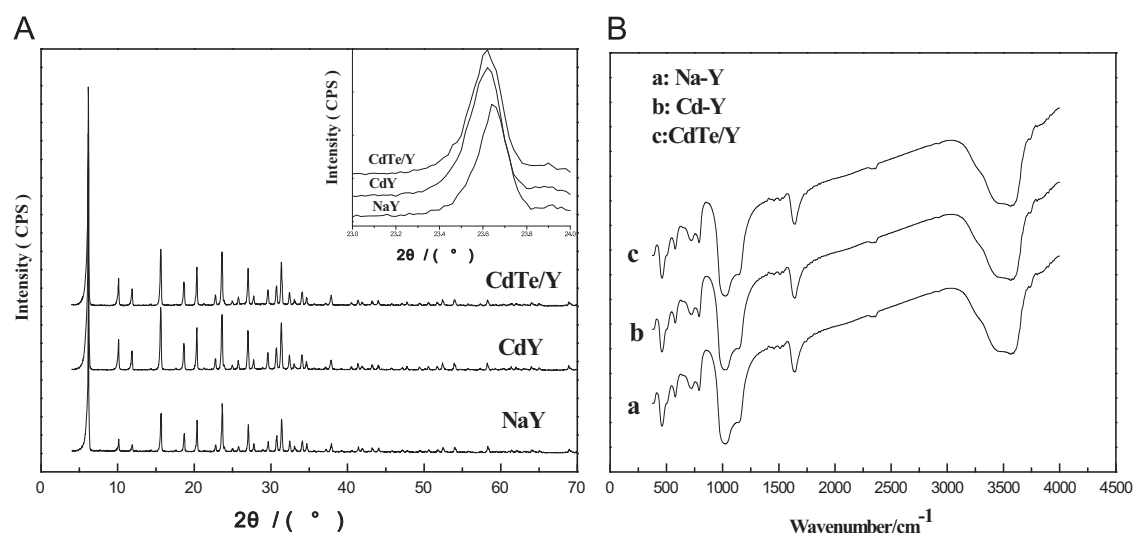


Fig. 1. XRD patterns (A) and the inset shows the amplification of corresponding XRD patterns from $2\theta = 23^\circ$ to 24° and IR spectra (B) of the Na-Y (a), Cd-Y (b) and CdTe/Y catalyst (c).

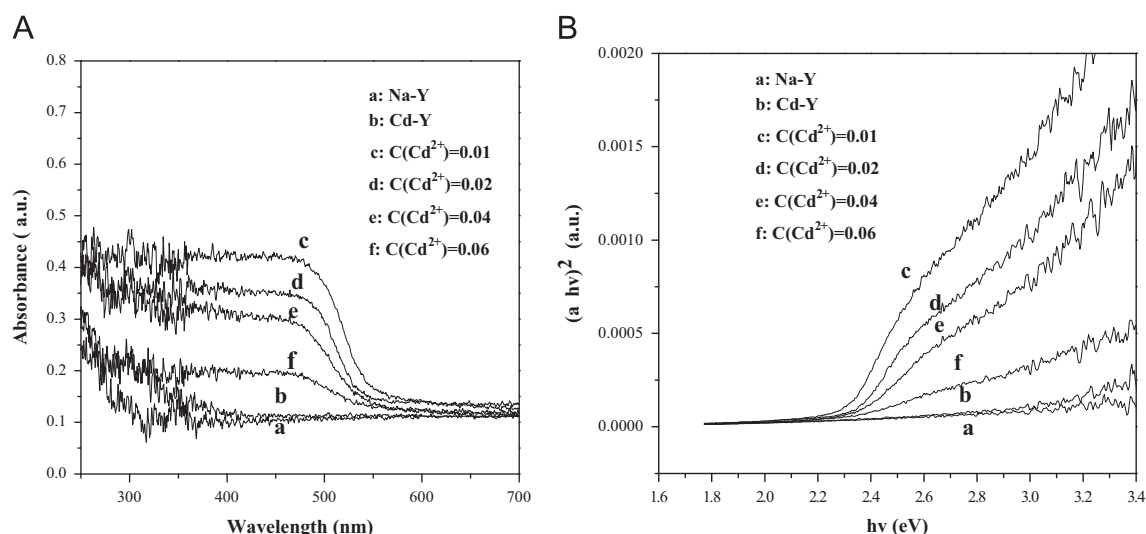


Fig. 2. Reflectance absorption spectra (A) of Na-Y, Cd-Y, and CdTe/Y samples and the direct band gap estimation (B) of samples.

Download English Version:

<https://daneshyari.com/en/article/1643377>

Download Persian Version:

<https://daneshyari.com/article/1643377>

[Daneshyari.com](https://daneshyari.com)