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Research paper

Synthesis, characterization and photocatalytic activity of CdS–montmorillonite nanocomposites

Horiya Boukhatem, Lila Djouadi, Nabil Abdelaziz, Hussein Khalaf *

Laboratory of Chemical Engineering (LGC), University Saad Dahlab of Blida, PO Box 270-09000, Blida, Algeria

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ABSTRACT

Nanocomposites based on cadmium sulfide (CdS) and Na-montmorillonite (Na^+-Mt) were prepared by a hydrothermal method using $Cd[NH_2CSNH_2]SO_4$ complex as precursor of CdS which was derived from cadmium sulfate and thiourea. These nanocomposites were characterized by X-ray diffraction (XRD), Fourier transform infrared spectra (FTIR) and X-fluorescence (XF). The nanocomposites consist of nanosized CdS pillars, which tend to increase in size as the amount of complex precursor increases. The CdS crystals have a hexagonal symmetry. The photocatalytic activity of the obtained CdS–Mt nanocomposites is improved significantly compared to that of the Mt and pure CdS. The resulting CdS–Mt nanocomposites could degrade methylene blue and rhodamine 6G under near UV–visible irradiation.

1. Introduction

The intercalation of guest molecules into layered minerals has attracted a great deal of attention. Among such minerals, montmorillonite (Mt) has been featured extensively because of its large surface area, swelling behavior and peculiar charge characteristics (Khaorapapong and Ogawa, 2007, 2008; Khaorapapong et al., 2001, 2008a, 2008b, 2009). The Mt has a layered structure and excellent hydrophilic and cation exchange properties. Its layer dimensions in length and width can be in hundreds of nanometers but its thickness is only 1 nm. The Mt layer consists of an octahedral sheet sandwiched between two opposing tetrahedral sheets (TOT), which is called a 2:1 phyllosilicate (Brigatti et al., 2006). These layers are stacked by weak dipolar or Van der Waals forces, and they have both surface and edge charges. The charges on edges are easily accessible to modification, but they do not accomplish much improvement in interlayer separation (Sengwa et al., 2009). The pillared Mt prepared through ion exchange reaction between Na^+-Mt and titanium polyoxocations which can exchange with the exchangeable cations (Na^+) in the interlayer space of Mt was studied extensively (Damardji et al., 2009; Perathoner and Centi, 2010; Pichat et al., 2005; Vicente et al., 2010). As a semiconducting material, besides its interesting optical properties, CdS is also interesting for its special photocatalytic activity. Cadmium sulfide (CdS) is a kind of semiconductor with a narrow band gap of 2.5 eV, and its valence electron can be easily evoked to a conduction band under visible light irradiation (Ru et al., 2009).

In this work, CdS–Mt nanocomposites were prepared via a hydrothermal route. In this method, an aqueous solution of thiourea and cadmium sulfate was added to a Mt aqueous dispersion, and the resulting dispersion was heated at 120 °C for 1 h. The obtained nanocomposites were characterized by X-ray diffraction (XRD), Fourier transform infrared (IRTF) and X-fluorescence (XF). The photocatalytic activity of these nanocomposites was tested by photocatalytic degradation of methylene blue (MB) and rhodamine 6G (R6G) under near UV–visible irradiation.

2. Experimental

2.1. Materials

The Na^+-Mt was prepared using bentonite from deposits of Maghnia in western Algeria. The cadmium sulfate ($CdSO_4$) and thiourea $CS(NH_2)_2$ were purchased from Panreac, Rhodamine 6G ($C_{28}H_{31}N_2O_3Cl$) was purchased from Sigma and methylene blue ($C_{16}H_{18}ClN_3S$) was supplied by Fluka Chemical. All reagents were used without further purification.

2.2. Preparation of CdS–Mt nanocomposites

CdS–Mt nanocomposites were prepared by applying the method described by Han et al. (2008) and Xiaoa et al. (2007) with some modifications. 1 g of Mt was dispersed into 100 ml of distilled water by stirring vigorously for 18 h to obtain 1.0% (mass) Mt dispersion. Controlled amounts of $CdSO_4$ and NH_2CSNH_2, at a molar ratio of 1:1,

* Corresponding author. Tel./fax: +213 25433631.
E-mail address: khussein_99@yahoo.com (H. Khalaf).

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