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One-pot hydrothermal synthesis and characterization of FeS_2 (pyrite)/graphene nanocomposite

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HIGHLIGHTS

- ▶ FeS_2 (pyrite)/graphene nanocomposite was synthesized by a hydrothermal method.
- ▶ Uniform distribution of FeS_2 nanoparticles on graphene sheets is achieved.
- ▶ Gelatin plays a decisive role in the preparation of FeS_2/graphene nanocomposite.
- ▶ High performance photocurrent response for FeS_2/graphene nanocomposite.

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ABSTRACT

This work reports on the investigation of temperature, reaction time, pH, concentration of graphene oxide (GO) and the effect of gelatin on the synthesis of pyrite structured FeS_2 nanoparticles assembled on graphene nanosheets using a facile 'one-pot' hydrothermal method. The results of X-ray diffraction, Fourier transform infrared spectroscopy, Raman spectroscopy and electron microscopy confirmed the simultaneous formation of pyrite structured FeS_2 and the reduction of GO, yielding a nanocomposite of the materials, through the hydrothermal process. The systematic investigation shows that the nanocomposite, comprising a uniform distribution of nanoparticles on the surface of the graphene sheets, is easily synthesized, providing that certain reaction criteria are achieved. The condition warrants that the reaction is carried out in the presence of gelatin with a concentration of 1.5 wt.%/v in a pH of 11 at 200 °C for 24 h. Photocurrent response of the samples showed that the nanocomposite with the GO concentration of 1 mg/mL produced the highest photocurrent value of about 1.01 μA, which is about 2.6 times higher than that obtained by the pure FeS_2.

1. Introduction

Graphene, a one-atom-thick planar sheet of sp^2-bonded carbon atoms, has attracted tremendous attention due to its unique electronic, mechanical, thermal, and optical properties [1–4]. These unique properties hold great promise for potential applications in many advanced technologies such as nanoelectronics, sensors, capacitors and composites [5–8]. At present, graphene sheets are prepared by a variety of techniques, including chemical vapor deposition, micromechanical exfoliation of graphite, epitaxial growth, and thermal or chemical reduction of graphite oxide [1,9–12]. Among these methods, chemical reduction of exfoliated graphite oxide is an efficient approach in obtaining graphene sheets in bulk. Although graphene oxide (GO) has been reduced using reductants like hydrazine, $NaBH_4$, and hydroquinone, some researchers have shown that GO can be reduced by green methods such as hydrothermal [13] and natural reductants like gelatin [14] and sugar [15].

Graphene's high electrical conductivity, large surface-to-volume ratio, and excellent chemical tolerance make it a distinguishable matrix for nanocomposites. Therefore, nanocrystal-decorated graphene composites have been the focus of research in recent years for their multifunctional abilities [16,17]. Functionalization of the intriguing two-dimensional nanosheets is expected to not only enhance the performance of graphene and nanocrystals, but also to display additional novel functionalities resulting from the interaction between the materials. Several examples, including copper(II) oxide [18], molybdenum sulfide [19] and titanium dioxide [20] nanoparticles assembled on graphene sheets, show

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