Journal of Materials Science and Chemical Engineering, 2016, 4, 25-29
Published Online May 2016 in SciRes. http://www.scirp.org/journal/msce
http://dx.doi.org/10.4236/msce.2016.45004

Microwave Synthesis and Photocatalytic Properties of $CeVO_4/FeVO_4$ Nanocomposites

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Received 13 April 2016; accepted 24 May 2016; published 27 May 2016

Abstract

In this paper, $CeVO_4/FeVO_4$ nanocomposites were prepared by direct feeding microwave synthesis method with nine water iron nitrate ($Fe(NO_3)_3 \cdot 9H_2O$), cerium nitrate hexahydrate ($Ce(NO_3)_3 \cdot 6H_2O$) and ammonium metavanadate (NH_4VO_3) as raw material and Sodium Dodecyl Sulfate (SDS) as surfactant. Then X-Ray Diffractometer (XRD) and Scanning Electron Microscopy (SEM) were used to observe the $CeVO_4/FeVO_4$ nanocomposites. SEM image showed that the as-prepared $CeVO_4/FeVO_4$ nanocomposites calcined at 773 Kis formated of small particles aggregation irregular sheet structure. We studied the photocatalytic activity of the as-prepared samples by using degradation of methyl orange in visible light. The results showed that the photocatalytic activity of $CeVO_4/FeVO_4$ nanocomposites were very well. It found that when the catalyst calcined at 773 K was 0.10 g, and 0.5 mL hydrogen peroxide joined as well as, pH was 2.0, the degradation ratio of catalyst for methylene orange of 100 mL 5 mg/L reached 98.63% in 40 min.

Keywords

$CeVO_4/FeVO_4$ Nanocomposites, Microwave Synthesis, Photocatalytic, Methyl Orange

1. Introduction

Environmental pollution, energy crisis and population growth are the three major challenges facing humanity in the 21st century. In recent years, the photocatalytic applications in environmental protection have been paid more and more people's attention.

Many researchers are already visible in the synthesis and catalytic vanadate complex aspects of exploration. These photocatalysts due to a relatively narrow band gap, and visible light photocatalytic activity are widespread

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How to cite this paper: Chen, S., Yang, S.B., Fan, D.J. and Liao, X.H. (2016) Microwave Synthesis and Photocatalytic Properties of $CeVO_4/FeVO_4$ Nanocomposites. *Journal of Materials Science and Chemical Engineering*, **4**, 25-29.
http://dx.doi.org/10.4236/msce.2016.45004

concern. Monoclinic phase vanadate semiconductor photocatalyst material with a narrow band gap in the visible region can exhibit high photochemical activity, and is a promising class of applications highly active photocatalyst material [1]-[8].

In this article, $CeVO_4/FeVO_4$ complexes are prepared by the method of liquid-phase microwave synthesis, small particle size uniform, the catalytic effect is good. The results show that in 100 mL, 5 mg/L of methyl orange solution, adding $CeVO_4/FeVO_4$ 0.1 g nanocomposites by 773 K thermostatic heat 2 h after adding 0.5 mL H_2O_2, adjust to pH 2.0, at this time, the degradation rate reaches 98.63%. So, the as-prepared photocatalyst has good photocatalytic performance.

2. The Experiment

2.1. Instruments and Reagents

Microwave oven with 650 W (Sanle general electric corp. Nanjing, China) with refluxing system was used. Powder X-Ray Diffraction (XRD) was used to characterize the sample. Data were collected on a Shimadzu XRD-6100 X-ray diffractometer (Cu Kα radiation, λ = 0.15418 nm). The morphology and size were determined by SEM. The SEM images were recorded on a Quanta 200 FEG field emission scanning electron microscope. Ultraviolet-visible diffuse reflectance spectrum was carried out on a UV-2600 UV—visible spectrophotometer. Lambda10 UV-vis spectrometer (Perkin-Elme Corp, USA) was used for monitoring the absorption spectra of photo-de-gradation of methyl orange.

All the reagents used were of analytical purity. Doubly distilled water was used throughout the experiments.

2.2. Direct Feeding Microwave Synthesis of $CeVO_4/FeVO_4$ Nanocomposites

At a molar ratio of 1:1, weighed by calculating the required 2.17 g $Ce(NO_3)_3{\cdot}6H_2O$, 1.01 g $Fe(NO_3)_3{\cdot}9H_2O$, was dissolved in 50 mL 1 mol/L HNO_3 solution, dispersed and dissolved with ultrasonic waves, mixed uniform for *A* solution. Weigh 1.17 g NH_4VO_3 was dissolved in 10 mL containing 1 mol/L of $NH_3{\cdot}H_2O$, add deionized water to 50 mL, 1.0 g SDS was added to the solution to the dispersion, the dispersion was dissolved by ultrasonic mixing, for *B* solution. The *A*, *B* two solutions were mixed rapidly transferred into 250 mL round bottom flask, fitted with reflux apparatus, with 40% power (total power constant, 30s work cycle, the work 12 s, stop 18 s) microwave irradiation 20 min, allowed to cool to room temperature, pour the supernatant liquid by centrifugation, washed three times with distilled water, dehydrated with acetone once, 60˚C vacuum drying 4 h, and then placed in a muffle furnace and heated treated 2 h at different temperatures. Products collected for characterization and photocatalytic experiments.

2.3. Photocatalytic Experiment of $CeVO_4/FeVO_4$ Nanocomposites

Preparation of 100 mL concentration 5 mg/L of methyl orange solution with dilute nitric acid pH was adjusted to 2.0 by adding a certain amount of $CeVO_4/FeVO_4$ nanocomposites and 0.5 mL of hydrogen peroxide, and uniformly dispersed ultrasonically in full under dark conditions adsorption, placed under visible light photocatalytic degradation experiments carried out. Sampling every 10 min, the supernatant after centrifugation taken by UV—Vis absorbance spectroscopy and observe the color change of the solution until the solution is completely faded or color does not change until the absorbance. Finally, according to the change in absorbance to calculate the degradation rate of the solution, the calculation formula is as follows:

$$D_t\% = \frac{(A_0 - A_t)}{A_0} \times 100\%$$

In this equation: D_t for methyl orange solution in the presence of catalyst through degradation under visible light irradiation time rate after *t*, A_0 as the catalyst without the absorbance of methyl orange solution when irradiated with visible light, A_t as catalyst by the absorbance of the methyl orange solution under visible light irradiation time after *t*.

3. Results and Discussion

Figure 1 is a XRD pattern of the sample. As can be seen, the larger the heat treatment temperature on the sample crystal. When the calcination temperature is increased to 773 k when, XRD diffraction peaks of the sample

sharp, crystal has a very complete explanation.

Figure 2 is a scanning electron micrograph of the sample prepared, it can be seen, most of the catalyst prepared in irregular sheet structure, these sheets are formed by a number of fine particles aggregated.

Figure 3 is a sample of UV—visible diffuse reflectance spectroscopy, can clearly be seen, $CeVO_4/FeVO_4$ nanocomposites in the visible range has a strong absorption, is a good light-responsive photocatalyst.

Figure 4 shows the photocatalytic degradation of methyl orange curve. After adding 0.1 g at 773 k fired $CeVO_4/FeVO_4$ nanocomposites in 100 mL 5 mg/L methyl orange solution, placed in sunlight degrades, it can be seen only in the 40 min, methyl orange solution the degradation rate of 98.63%, good degradation effect. Well, the photocatalytic performance specifications prepared catalyst.

We also studied the influence factors of the photocatalytic performance, such as heat treatment temperature of the catalyst, the dosage of the catalyst. The results showed the best photocatalytic effect, when the heat treatment temperature is 773 K, the dosage of the catalyst is 1.0 g/L.

4. Conclusions

In this paper, through direct feeding microwave prepared $CeVO_4/FeVO_4$ nanocomposites, SEM display 773 K

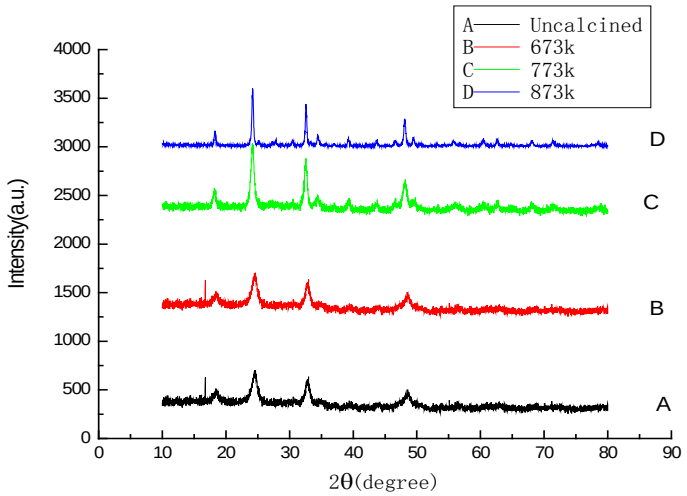

Figure 1. XRD pattern of as-prepared sample.

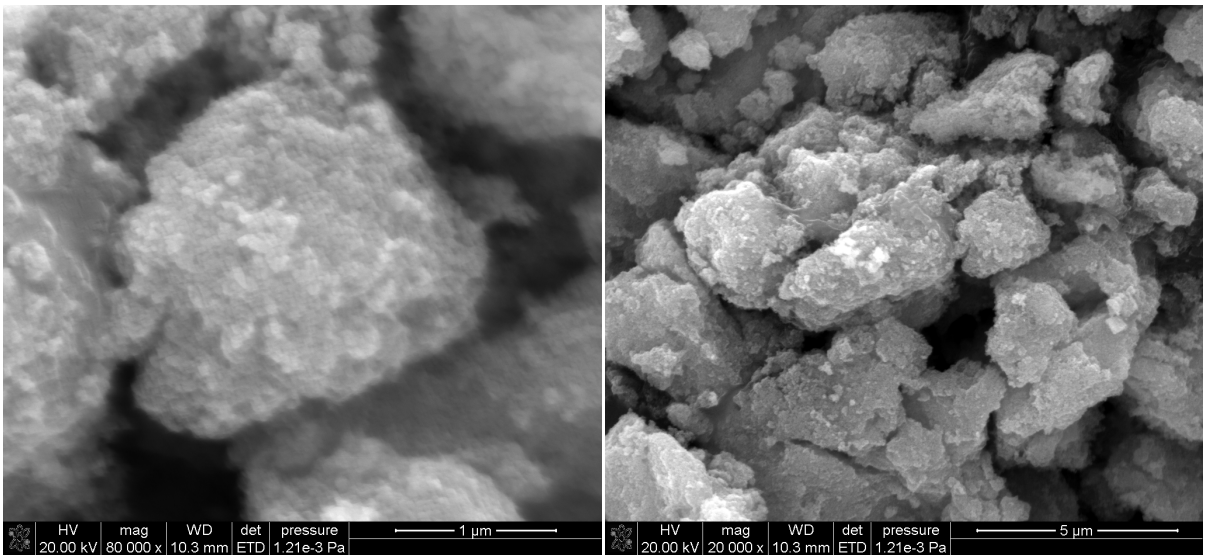

Figure 2. SEM image of as-prepared sample.

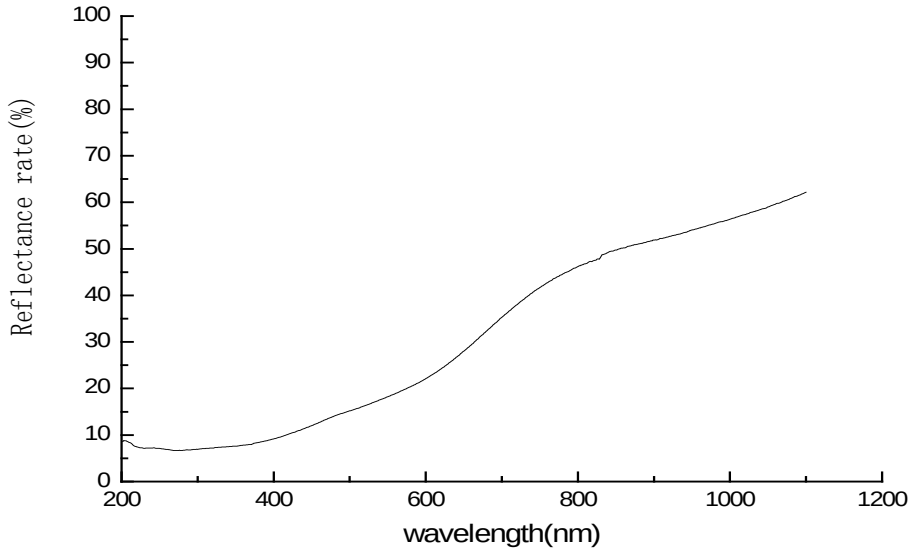

Figure 3. UV-Vis diffuse reflectance spectrum of $CeVO_4/FeVO_4$ nanocomposite.

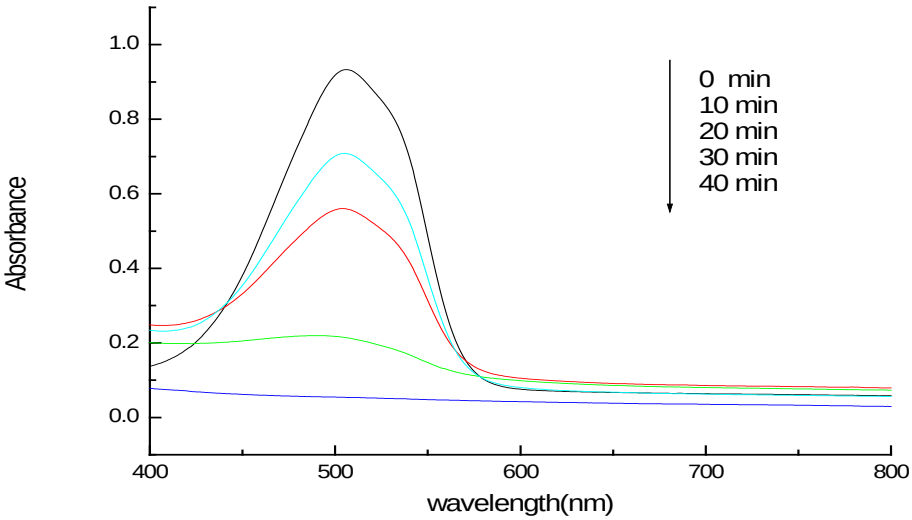

Figure 4. UV-Vis absorption spectra of photo-degradation of methyl orange.

heat treatment of 2 h samples showed irregular flake structure, these layers by some small particles aggregated to form.

The results showed that the $CeVO_4/FeVO_4$ nanocomposite microwave synthesis had excellent photocatalytic performance. In the 100 mL, 5 mg/L methyl orange solution, adding catalyst 0.1 g, adjusted pH to 2, with 0.5 mL H_2O_2, in the sunlight degradation, the degradation rate could reach 98.63% within 40 min.

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