

Microwave-Assisted Synthesis of CeVO_4 in the Mild Conditions, Characterization and Investigation of Luminescent Properties

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CeVO_4 (ICDD: 12-757) was synthesized by microwave-assisted method by using cerium sulphate and vanadium (V) oxide in an appropriate molar ratio. Characterizations were done by X-ray diffraction, Fourier transform infrared spectroscopy, ultraviolet spectrophotometry and thermogravimetric/differential thermal analysis. The material is crystallized in tetragonal system with unit cell parameters $a = 7.399 \text{ \AA}$ and $c = 6.496 \text{ \AA}$ and space group $I4_1/amd(141)$.

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1. Introduction

Most popular representatives of the group ABX_4 are the rare earth orthovanadates (REVO_4), have been intensively studied to investigate their physical and chemical properties since their crystal structures were determined [1, 2]. In general, these compounds display two crystallization types: tetragonal zircon and monoclinic monazite except for cerium orthovanadate, as a third polymorphic form as the boundary of zircon and monazite type [2, 3]. While the space group of zircon type crystals is $I4_1/amd$, the other is $I4_1/a$. In contrast, cerium orthovanadate included in the space group $I4_1/amd(141)$ [2].

Cerium orthovanadate was first synthesized via conventional solid-state ceramic method by Rao and Palanna in 1995 [3]. After four years, the same group investigated electrochemical properties of the material [4]. Since the 2000s, doping processes of cerium orthovanadate with rare earths, heavy metals and alkaline earths have been studied [5–13]. Currently, Ce-containing inorganic materials are interested in daily application such as scintillation area. These materials are leading fast and intense emission because of the rare earth's (Ce) strong electric-dipole [14]. Scintillator crystals are commonly used in medical and industrial applications and also detecting beams with high frequency in scientific researches. Above all properties or usage areas, the most striking one is being laser host. However, a lot of researches about known scintillator materials have been completed, there are still being studied to improve these materials [15].

In this paper, we tried to synthesize cerium orthovanadate via simpler and shorter microwave-assisted route and we achieved this. Also, by X-ray diffraction (XRD), Fourier transform infrared (FTIR), thermogravimetric/differential thermal analysis (TG/DTA), luminescent properties were investigated.

2. Experimental section

2.1. Microwave-assisted synthesis of cerium orthovanadate

Analytically pure ceric sulphate and vanadium (V) oxide were weighed an appropriate molar ratio and homogenized in an agate mortar. The mixture placed into a porcelain crucible to heat in microwave oven. After the material was exposed to microwave irradiation, it was took from the oven, and then homogenized again. The sample was heated at 700°C for 2 h for the best crystallization. Then, final product was ready to analyze.

2.2. XRD, FTIR, TG/DTA and SEM/EDX analyses

PANanalytical X'Pert PRO Diffractometer (XRD) with $\text{Cu } K_\alpha$ (1.5406 \AA , 45 kV, and 30 mA) radiation was used to solve structure of the product. FTIR spectrum was taken by a Perkin Elmer Spectrum 100 FTIR Spectrometer to support the functional groups. TG/DTA was carried out by Perkin Elmer Diamond TG/DTA. UV spectrum was taken by PG instruments, T80 UV-Visible spectrophotometer. Siemens V12 domestic microwave oven was used.

3. Results and discussion

Figure 1 shows X-ray powder diffraction pattern of the sample. When we compare the pattern to PDF

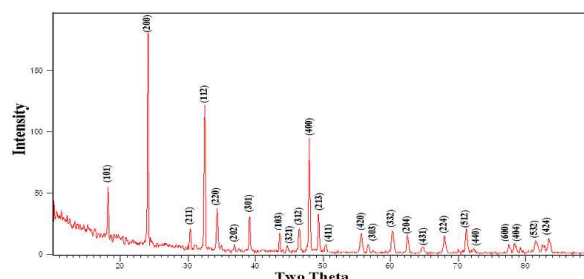
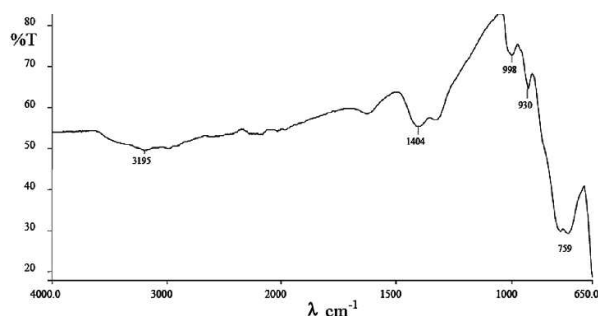
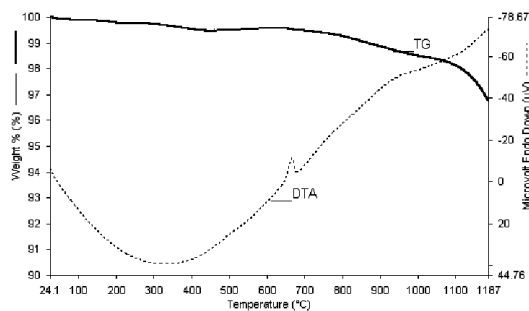
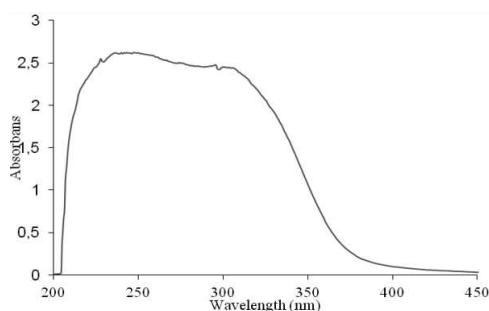


Fig. 1. Powder XRD pattern of CeVO_4 .

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Fig. 2. FTIR spectrum of CeVO₄.Fig. 3. TGA curve of pure CeVO₄.Fig. 4. Luminescent spectra of CeVO₄.

cards, we see that we obtained CeVO₄ (ICDD:12-757), crystallized in tetragonal system with unit cell parameters $a = 7.399 \text{ \AA}$ and $c = 6.496 \text{ \AA}$ and space group $I41/amd(141)$.

In Fig. 2, we can see the FTIR spectra of the product. The peak at 759 cm^{-1} belongs to V–O vibration frequency [15]. The strongest one is generally observed in the range $600\text{--}500 \text{ cm}^{-1}$, and it corresponds to stretching vibration of the metal at the tetrahedral site [16].

Thermal analysis results of CeVO₄ was given in Fig. 3. TG/DTA spectrum was taken in the temperature range of 24 to 1187°C . The graphics show that the sample is so stable due to not significant mass loss in this field.

Figure 4 shows the luminescent properties of the sample. The broad band around 240 nm corresponds to charge transfer (CT) band of VO₃ and VO₄ in this CeVO₄ system [17]. Ce³⁺ displays an intense $d\text{--}f$ emission which

can be tuned in the range 290–500 nm [18]. Also, this huge peak can be attributed to the $5d\text{--}2F_{5/2}$ and $5d\text{--}2F_{7/2}$ transition of Ce occupied different sites, but the exact mechanism is not yet understood [19].

4. Conclusions

CeVO₄, a scintillator material, exhibits extraordinary physical and chemical properties. We synthesized the material via microwave irradiation and low temperature crystallization. The material is crystallized in tetragonal system with unit cell parameters $a = 7.399 \text{ \AA}$ and $c = 6.496 \text{ \AA}$ and space group $I41/amd(141)$.

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