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AREA: Synthesis and characterization of catalysts and adsorbents

Synthesis and characterization of the photocatalyst bismuth vanadate ($BiVO_4$)

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Abstract

Bismuth vanadate ($BiVO_4$) is an n-type semiconductor that has generated particular interest due to its properties. Its narrow band gap allows it to efficiently absorb sunlight in the visible spectrum, as well as being corrosion-resistant, non-toxic, low-cost to produce and acting as an excellent photocatalyst in the degradation of organics when exposed to visible light. This semiconductor has three distinct crystalline forms: monoclinic scheelite, tetragonal zircon and tetragonal scheelite. Among these, the monoclinic scheelite form of $BiVO_4$, which has a band gap of 2.4 eV, stands out for its high photocatalytic activity under visible light irradiation [3]. The method of synthesizing $BiVO_4$ plays a fundamental role in the material's properties, affecting factors such as nanoparticle size, types of crystalline structure, morphology and specific surface area [2]. The hydrothermal synthesis process is widely applied in various industries due to its low cost and effectiveness in developing materials. The aim of this work is to synthesize and characterize $BiVO_4$ using hydrothermal synthesis. The synthesis of $BiVO_4$ was carried out and the material obtained was characterized by X-ray diffraction (XRD), X-ray fluorescence (XRF) and UV-Vis diffuse reflectance spectroscopy (DRS). The precursors used in the experiment included $Bi(NO_3)_3.5H_2O$ and NH_4VO_3. The first step in the process was to prepare the NaOH and HNO_3 solutions at 2 mol L^{-1}. Next, the $Bi(NO_3)_3$ and NH_4VO_3 compounds were diluted in their respective solutions. After careful stirring and ultrasonic treatment, the pH of the mixture was adjusted to 5.5. This adjustment was followed by autoclaving at 140°C for 6 hours, ensuring homogenization and complete reaction of the components. Afterwards, the resulting mixture was washed with ethyl alcohol, centrifuged and then dried at 60°C. Finally, the sample was calcined in two stages, at 200°C and 400°C, for a period of 2 hours each, ensuring the proper formation of the desired products. Firstly, XRD data reveals that $BiVO_4$ crystallized in the monoclinic scheelite phase. It can be seen that the diffractograms of samples calcined at temperatures of 200 and 400 °C match the standard for monoclinic $BiVO_4$ (JCPDS No. 14-0688). These diffractograms show clear, well-defined peaks, reflecting the achievement of monoclinic $BiVO_4$ with a high level of purity and crystallinity [1]. XRF data of $BiVO_4$ calcined at 400°C indicated a predominance of bismuth (78.9%) and vanadium (19.4%), among other elements such as silicon and aluminum. ERD analysis revealed that the material shows optical absorption in the ultraviolet and visible regions, with an absorption band of 2.5 eV. This indicates responsiveness to visible light. The results indicated that the use of the hydrothermal synthesis method made it possible to obtain the $BiVO_4$ compound in a monoclinic structure. XRD analysis validated the formation of the monoclinic phase of $BiVO_4$ under all the conditions investigated. In addition, XRF analysis confirmed the presence of elements including bismuth, vanadium and oxygen in the sample.

Keywords: Spectroscopy, characterization, hydrothermal.

References

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