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Preparation and Characterization of ZnO and $CdWO_4$ Nanopowders for Radiation Sensing

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ABSTRACT

Today, there is a great request for radiation detection in medical and industrial fields. Zinc oxide (ZnO) and cadmium tungstate (CWO) are two types of scintillator perspective due to their useful features such as high density, large Z, and efficient scintillation output. In this study, ZnO and CWO nanopowders were synthesized by the simple sol-gel method, and ZnO and CWO films were prepared by spin coating technique on glass substrates. Samples were characterized by X-ray diffraction, transmission electron microscopy, and X-ray induced luminescence measurements. XRD analysis showed that ZnO and CWO powders were well synthesized with wurtzite and monoclinic wolframite structures, respectively. It was observed that the particle diameters for ZnO and CWO nanopowders are 22 and 100 nm, respectively. The scintillation response of samples was measured using a 241Am alpha source. Compared to ZnO, CWO nanopowders showed prominent luminescence properties with higher radiation sensitivity for applications in fields of radiation detection.

1. Introduction

Scintillator materials have great applications in many fields, particularly in medical imaging devices. Searching for new scintillators with high efficiency and cost-effective fabrication methods has been an important topic among researchers. ZnO is a novel host semiconductor material that has attracted a lot of attention because of its potential application in various fields [1]. It can be said that ZnO in neutron generators and optical devices is very useful due to its optimal luminescence properties, wide band gap (3.26-3.28 eV), large exciton binding energy (60 meV), proper density (5.6 g/cm^3), and the ability to detect alpha particles. [2]. Cadmium tungstate (CWO), on the other hand, is a tungstate-based material that has unique characteristics such as high stopping power, high efficiency, high chemical stability, and short afterglow, which makes it one of the most useful scintillators. So far, ZnO and CWO nanoparticles have been synthesized by various methods such as reverse micelles [3], solvothermal [4], hydrothermal [5], solid-state metathetic reaction [6], and co-precipitation method [7]. It should be noted that most of the radiation detection applications are based on crystal growth of materials that using time-consuming, special, complex laboratory equipment and have their own problems such as cracking the crystal during or after pulling/growth. Moreover, a considerable part of ZnO and CWO scintillation applications are based on single crystals. However, the growth of these crystals is an expensive and elaborate route. As a result, new alternative methods are required for the production of polycrystalline powders and films [8, 9]. In this way, ZnO and CWO nanopowders are prepared through a simple method to produce scintillating powders that are more convenient and far easier than crystal growth.

2. Materials and method

ZnO and CWO nanoparticles were prepared according to the sol-gel method. First, a proper amount (1M) of zinc acetate dihydrate ($Zn(CH_3COO)_2.2H_2O$, Merck, 99.5% was dissolved in ethanol. TEA ($N(CH_2CH_3)_3$), Merck, 99.5% was used as a stabilizer. The molar ratio of TEA to zinc acetate was kept at 3:5. The solution was stirred at 60°C with a magnetic stirrer for 45 min to obtain a clear solution. After centrifugation, the precipitated material was dried for 24 h at 60 °C and calcined for 2 h at 700°C. In the next step for the synthesis of CWO powder, 5 g tungsten oxychloride ($WOCl_4$), Sigma- Aldrich, 98% was dissolved in 50 ml propanol. After stirring for 1 h, cadmium nitrate 98%

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