SYNTHESIS, STRUCTURAL AND CHARACTERIZATION OF CADMIUM OXIDE NANOPARTICLES BY MICROWAVE IRRADIATION METHOD

D. SWATHI [1], K. NISHANTHI [1,*]

[1] Post Graduate and Research Department of Physics Kamban College of Arts and Science For Women, Thenmathur, Tiruvannamalai-606 603 (Affiliated to Thiruvalluvar University, Vellore), Tamilnadu, India.

ABSTRACT

Cadmium oxide nanoparticle have been synthesized by microwave irradiation method and their morphology, structure, and optical properties of cadmium oxide nanostructures have been thoroughly investigated. The XRD results revealed that the CdO nanoparticles are crystalline with a cubic phase. Photoluminescence study was carried out to find the emission peak of CdO. The present method produces CdO nanoparticles with a relatively lower band gap energy (4.49 eV), which could be used as a photocatalyst..

Keywords: Powder XRD; UV and Bandgap.

1. INTRODUCTION

Transparent conducting oxide (TCO) nanoparticles have fascinated countless attention over past two decades owed to their unusual size-dependent physical and chemical properties.TCO nanoparticles have unique properties arising from the nanoscale range such as electrical, electronic, magnetic, optical and chemical properties. It is owed to the quantum confinement effect and large surface to volume ratio of atom. TCOs are typically classified as n-type and p-type in which the n-type TCO semiconductor micro/nanostructures are playing important role in the constructionof next generation nanoscale optoelectronic devices such as electronic devices, photovoltaic devices, catalysts, sensors, phototransistor, photodiode, transparent electrodes, liquid crystal displays, bio- imaging. CdO is a promising II–VI n-type semiconducting compound and one of the TCOs with a direct band gap of 2.5 eV. It has high electrical conductivity combined with high optical transmittance in the visible region of the solar spectrum and high reflectance in the infrared region. Rare earth doped II-VI n-type materials have attractive attention in optoelectronic applications.

2. EXPERIMENTAL PROCEDURE

2.1. MATERIAL SYNTHESIS

Cadmium chloride, Cerium chloride, and ammonia (Merck) were used for the synthesis of Ce doped CdO nanoparticles. All chemical reagents used were analytical grade and double distilled water was used as solvent. A 0.1M solution of cadmium chloride was dissolved in double distilled water and stirred at room temperature. Cerium chloride as a dopant source was added in suitable amount in the starting solution. The doping concentration was varied at 5wt% of Ce. The pH of the solutions were maintained at 8 by adding the ammonia drop wise and stirred continuously. White precipitate was formed which was filtered and washed repeatedly with double distilled water and then ethanol. Then the precipitate was irradiated for 5 minutes with microwave at the frequency of 2.45GHZ. The irradiated sample is annealed at 400˚C in the muffle furnace for 2 hours in order to remove the residues present in the material.

2.2. CHARACTERIZATION

The resulting powders were analyzed by X-ray diffraction (XRD) using a Bruker AXS D8 Advance instrument diffractometer with monochromatic CuKα1 wavelength of 1.5406 Å. The Fourier transform infraredspectra (FT-IR) of the samples were recorded by using a Nicolet 5DX FTIR spectrometer. The ultraviolet (UV) spectrum of the ZrO2 samples was recorded on a Perkin Elmer UV-visible DRS spectrophotometer. Photoluminescence spectral studies was carried out for the sample CdO using spectrofluorometer fluor-log FL3-11.

3. RESULTS AND DISCUSSION

3.1. X-RAY DIFFRACTION (XRD)

Figure 1, The recorded XRD patterns of the pure and Ce doped CdO are shown in the cubic phase with a preferred orientation along (111) plane at diffraction angle (2θ) 33.1°. The additional planes occurred are (200), (220), (311) and (222) and the corresponding 2θ values 38.3°, 55.4°, perfectly matched with the JCPDS card no. 05-0640.The crystallite sizes were found to be 18.72 nm,

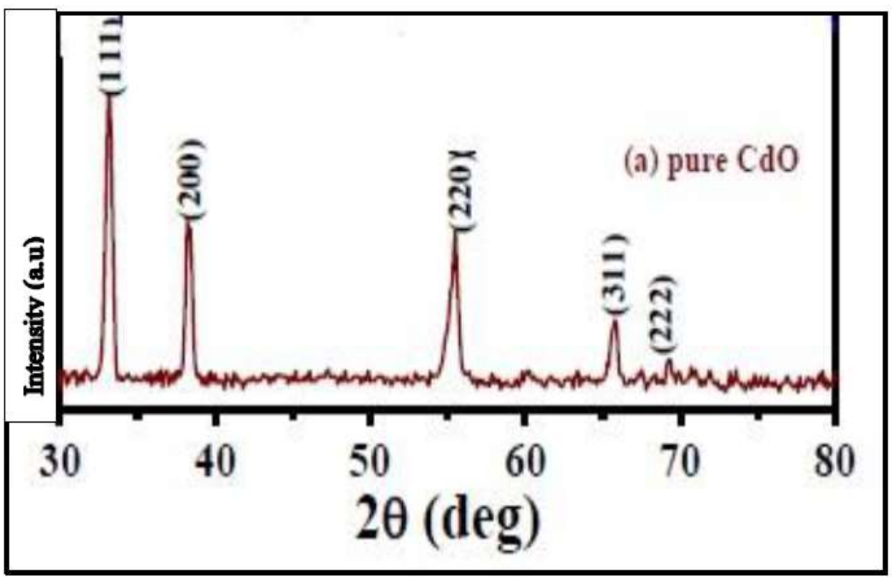

Figure 1. XRD patterns of Cadmium oxide nanoparticles

The reflections correspond to the characteristic planes (111), (220), (202), (131), (132) and (141). The average crystalline size of the crystallites was evaluated using the Scherrer's formula. The average particle size of ZrO2 is estimated to be around 14 nm for sample B.

3.2. Fourier Transform Infrared (FTIR) Analysis

The formation of ZrO2 functional group from the CADMIUM hydroxyl group was also confirmed from FT-IR analysis. The FT-IR spectrum of ZrO2 nanostructures of sample Figure 2.

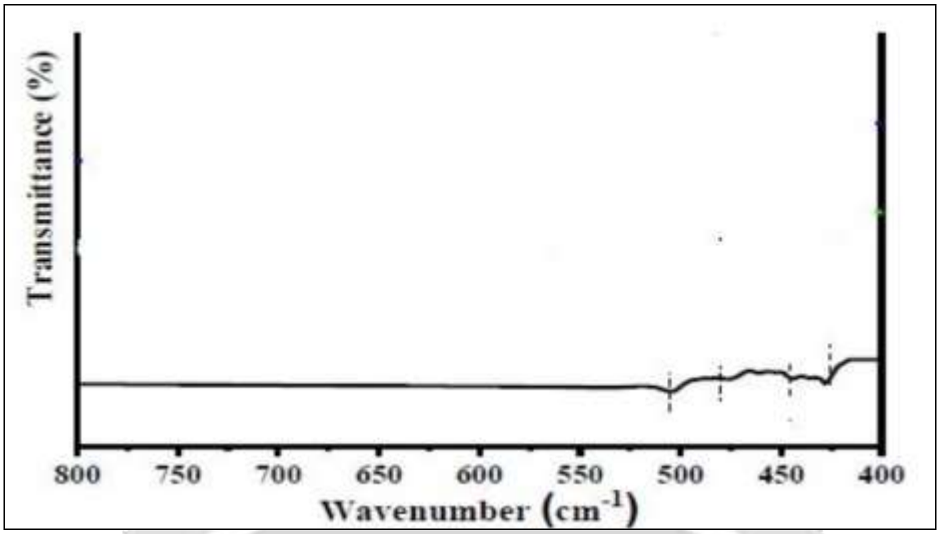

Figure 2. FT-IR spectra of Cadmium oxide nanoparticles

The observed peaks at 505 cm-1 clearly indicate the formation of Cd-O phase and metallic bonds.

3.3. UV-Visible – Diffused Reflectance Spectroscopy (DRS)

Among the optical methods, UV–vis diffuse reflectance spectroscopy is one of the most employed (no Effect of T). The theory which makes possible to use DR spectra was proposed by Kubelka and Munk. Applicable to sample showing scattering. DRS takes advantage of the enhanced scattering phenomenon in powder materials. DRS technique does not require a powder sample to be dispersed in any liquid medium, so the material is not contaminated or consumed. The reflecting power is also a function of the absorbing power of a substance. Only the part of the beam that is scattered within a sample and returned to the surface is considered to be diffuse reflection. Dilution of sample (by KBr etc) is important to minimize specular reflection (interference). The nanomaterial Cadmium oxide samples were subjected to UV–vis diffuse reflectance spectroscopy (in the range 200-900 nm) to determine the wavelength and their optical band gap energy by using their data. From the figure 3.3. the reflectance peak was observed at 257 nm.

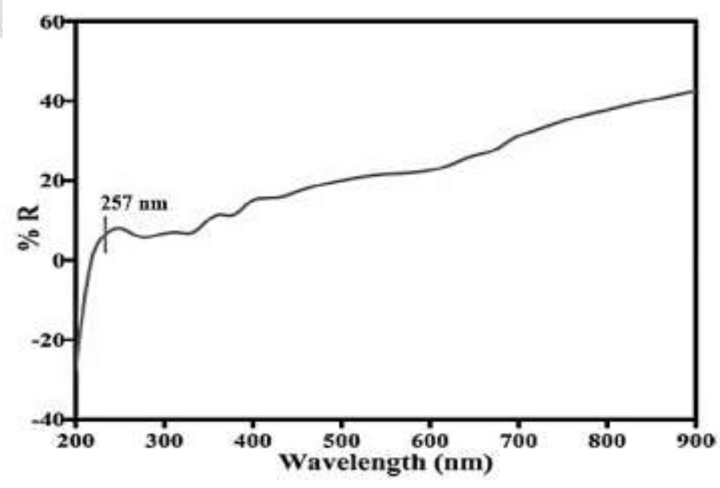

Figure 3. UV-Vis diffused reflectance spectra of Cadmium oxide samples

T he bandgap value is obtained from the Kubelka- Munk formula which can be expressed by thefollowing relation [4,5].

$$K = \frac{(1-R)^2}{2R}$$

Where K is the reflectance transformed according to Kubelka Munk and R was the reflectance (%). The reflectance accepts onset peaks were located at 276 nm, corresponding to the band gap of 4.49 eV respectively [6].

3.4. Photoluminoscence spectrum of CdO nanoparticle

The photoluminescence (PL) spectra of microwave irradiated cadmium oxide are shown in Figure 3.4. From the figure, it is clearly evident that samples exhibited the emission peaks at 323 nm, 381 nm and 462 nm. Zaien and co-workers [9,10], reported that the emission peak of bulk CdO is 491 nm (2.5 eV). This red- -shift from 2.3 to 2.5 eV was caused by the formation of donor levels (the Fermi levels) near the conduction band of the CdO nanostructures. Moreover, it show the intensity of luminescent emission decreases with increase in the exposure of microwave irradiation time, and it is attributed to the decrease in oxygen vacancies as a function of microwave irradiation.

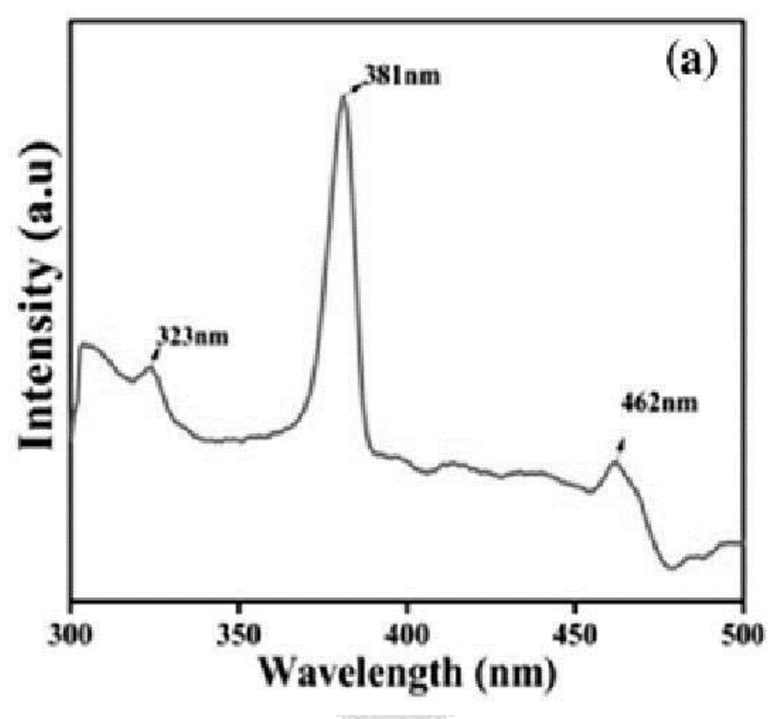

Figure 3.4. Photoluminescence spectrum of Cadmium Oxide nanomaterial

4.CONCLUSION

The morphology, structure and optical properties of cadmium oxide nanostructures synthesized by microwave irradiation have been investigated in detail. The XRD results exposed that the CdO nanoparticles possess crystalline nature with cubic phase. From the PL spectrum emission peaks at 323 nm, 381 nm and 462 nm show the intensity of luminescent emission decreases with increase in the exposure of microwave irradiation time. The CdO nanoparticles obtained by the present method are found to have relatively smaller band gap energy (4.49 eV), which is potentially to be used as a photocatalyst.

REFERENCES

[1]. A. K. Singh, Adv. Powder Technol. 21 (2010) 609-613.

[2]. N. C. S. Selvam, A. Manikandan, J. Colloid Interface Sci. 389 (2013) 91-98.

[3]. L. A. Perez-Maqueda and E. Matijevic, J. Mater. Res. 12 (1997) 3286-329.

[4]. S. Chen, Y. Yin, D. Wang, Y. Liu, X. Wang, J. Cryst. Growth 282 (2005) 498-505.

[5]. K. Campbell, D. Q. M. Craig and Tony McNally, Int. J. Pharm. 363 (2008) 126-131.

[6]. F. Kazemi, A. Saberi, S. Malek-Ahmadi, S. Sohrabi, Ceram. Silik. 55 (2011) 26-30.

[7]. J. Tauc, R. Grigorovici, and A. Vancu, Phys. Status Solidi B, 15 (1996) 627-637.

[8]. Wang, Chen, and Yang, J. Alloys. Compd. 488 (2009) 232-237.

[9]. M. Zaien, K. Omar, Z. Hasan, Int.J.Phys, Sci, 6,4176 (2011).

[10]. M. Tadjarodi, A. Imani, Mater. Lett, 65, 1025 (2011).