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A FACILE AND ECONOMICAL METHOD FOR MASS PRODUCTION OF ZnO NANOPOWDER

H. IDRISS[a,b*], S. A. MOUSSA[a,c], A. S. ALAAMER[a], M. A. AL-RAJHI[a]
[a]*Committee of Radiation and Environmental Pollution Protection (CREPP), Department of Physics, College of Science, Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia.*
[b]*Sudan Atomic Energy Commission.*
[c]*Biophysics Group, Biochemistry Department, Genetic Engineering and Biotechnology Division, National Research Centre, Dokki, Giza, Egypt.*

In this work, a simple, facile and economical solid state method was used to produce ZnO nanopowder. The method is based on the thermal decomposition of zinc acetate dehydrate at 900 °C for one hour. The ZnO nanopowder studied by means of X-ray diffraction(XRD), Fourier transform infrared spectroscopy(FT-IR), Fluorescence spectrometer and scanning electron Microscopy(SEM). The result obtained revealed that the synthesized ZnO nanopowder was wurtzite type with a crystallite size of 54.79 nm.

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Keywords: ZnO nanopowder, XRD, SEM, FT-IR, crystallite size, fluorescence spectra

1. Introduction

In recent years, the interest in the use of nanoparticles has been increasing owing to their novel features [5,11]. The fast development of nanoparticles usage in all areas encourages tangible profits in fields covering microelectronics, agriculture, aerospace engineering, pharmaceutical, healthcare, chemical applications, and environmental processing [14]. It is well documented in the literature semiconductor nanoparticles is a good material for prospective applications because of its wide band gap, ease of fabrication, low visible absorption, high radiation resistance and cheap [25]. Among many metal oxide, nano-zinc oxide has a large specific area and high surface energy and used widely in nanocomposites because of the unique efficiency in the dispersion of nano-range interfaces and interactions [6]. Zinc oxide nanoparticles is one of the most attractive nanomaterials and used on a large scale in many applications in the industry, environmental, medicine, because of availability, cheap, no health and environmental risk compared to the others nanomaterials. On the other hand, ZnO nanoparticles has abroad applications in solar cells [4], gas sensors [22], photocatalytic, antibacterial, electrical and optical devices [13], electrostatic dissipative coatings [1], degradation of environmental pollutants [23, 21]. Toxicity assessment of ZnO NPs has been studied by many researchers [15, 19]. Numerous methods have been employed in ZnO nanoparticles synthesis including sol-gel, chemical vapour deposition and electrochemical methods and sonochemical methods [24, 2]. Thermal decomposition is a simple, inexpensive and effective method for synthesis of nanomaterials. In this work we present solid state method to fabricate ZnO nanopowder.

2. Experimental

Synthesis of ZnO nanopowder

Zinc acetate dehydrate [Zn $(CH3COO)_{22}$ H_2O] 99 ,99% purity was purchased from Panreac (Spain) and used as a precursor to prepare ZnO nanopowder without further purification.

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[*] Corresponding author: hjoidriss@gmail.com

10 g of zinc acetate dehydrate was placed into the ceramic crucible and calcined at 900 °C for 1 hour in muffle furnace in air. Finally, ZnO nanopowder was obtained.

Instrumentation

The crystal structure of ZnO nanopowder was performed using Rigaku Ultima IV high-resolution XRD equipped with Cu-Kα radiation (λ = 1.5418 A°). fluorescence spectra were measured using Perkin Elmer LS-55 fluorescence spectrometer. The surface morphology of ZnO of nanopowder have been studied using scanning electron microscope. Fourier transform infrared spectroscopy (Model: Nicolet 6700) was used for chemical bonding determination.

3. Result and discussion

XRD analysis

The structure of ZnO nanopowder was investigated using X-rays diffraction patterns. The findings are displayed in Fig.1, and shown broad peaks at position (32.08, 34.73, 36.54, 47.90, 56.88, 63.19 ,68.12 and 69.29 deg. as 2 theta). Indeed, these peaks are identified as (100), (002), (101), (102), (110), (103), (200), (112) and (201) plans of hexagonal wurtzite structure of ZnO. The average crystallite size (D) was calculated using the Scherer's equation [17].

$$\mathrm{D} = \frac{0.9\,\lambda}{\beta cos\theta} \tag{1}$$

Where λ the wavelength of Cu Kα radiation is, β is the full width half maxima (FWHM) of the diffraction peak and θ is the Bragg peak angle. From the Scherer's formula the average crystallite size was found to be of 54.79 nm. It obviously shows the presence of nano-sized particles in the samples.

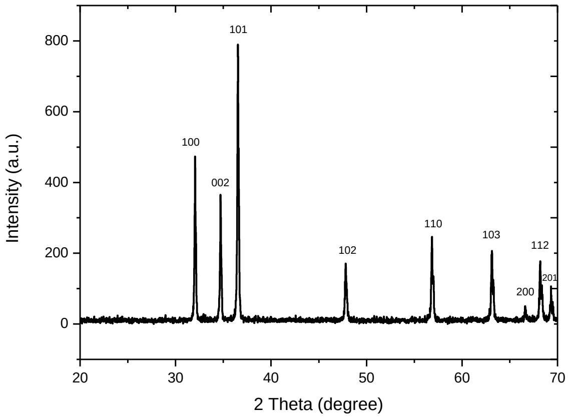

Fig. 1. XRD patterns of ZnO nanopowder synthesized by thermal decomposition method.

The scanning electron microscopy (SEM)

SEM is one of the hopeful methods for the topography analyzing of the samples and it provides valuable information about the growth mechanism, shape and size of the nanoparticles. The surface morphology of ZnO nanopowder at different magnifications is shown in Fig .2. SEM images show that ZnO nanopowder has non uniform shape. However, the images prove the synthesis of ZnO nanoparticles.

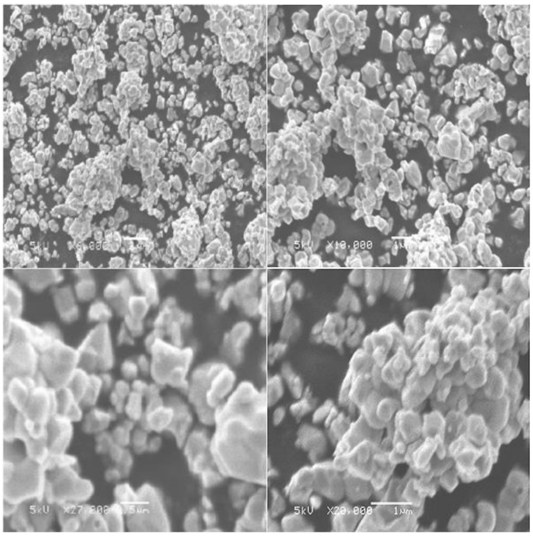

Fig. 2. SEM image of ZnO nanopowder at different magnifications.

Photoluminescence study

Fig. 3 displays photoluminescence spectra of ZnO nanopowder produced by thermal decomposition method at excitation wavelength of 325 nm. In PL spectrum, a number of emission bands, including band edge emission at 396 nm and violet emission 418 nm, blue emission 450 nm, blue-green emission 481 nm and green emission 531 nm were recorded. Band edge emission centered at around 396 nm is attributed to the recombination of excitons [18]. The origin of violet emission centered at 418 nm is ascribed to an electron transition from a shallow donor level of neutral zinc interstitials to the top level of the valence band [3]. A blue emission centered at 481 nm is due to a radiative transition of an electron from the shallow donor level of zinc interstitials to an acceptor level of neutral zinc vacancies [16]. Another blue emission was reported to appear at around 450, 468, 481, and 490 nm [20]. This emission may be related to surface defects of ZnO nanostructure or may be due to singly ionized zinc vacancies although the detailed mechanism for blue emission at 450 nm has been not clarified. The green emission at 531 nm are attributed to radiative transition from conduction band to the edge of the acceptor levels of oxygen antisites [9].

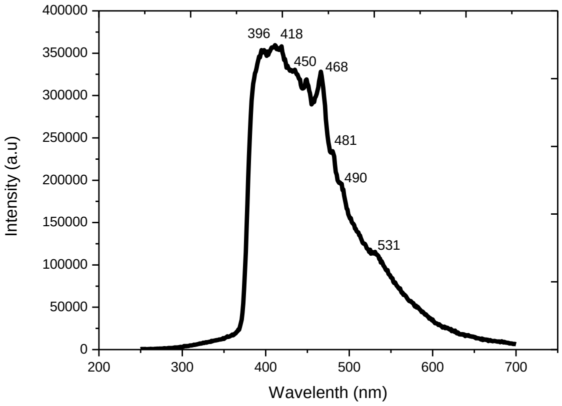

Fig. 3. Photoluminescence spectrum of ZnO nanopowder synthesized by thermal decomposition method

FTIR study

The vibrations and bending mode of the structure of ZnO nanopowder was studied by FTIR measurements at room temperature. The obtained spectra are depicted in Fig. 4. The broad absorption band at 3430 cm^{-1} can be assigned to the normal polymeric O-H stretching vibration of H_2O in ZnO lattices [10]. Other sharp peaks observed at 1633 cm^{-1} is attributed to H-O-H bending vibration, which in turn can be attributed to the small amount of H_2O in the ZnO nanocrystal [7]. The absorption band observed between 2355 cm^{-1} is due to the existence of CO_2 molecule in the air [12]. The vibration band at 442 cm^{-1} assigned to the stretching mode of pure ZnO [8].

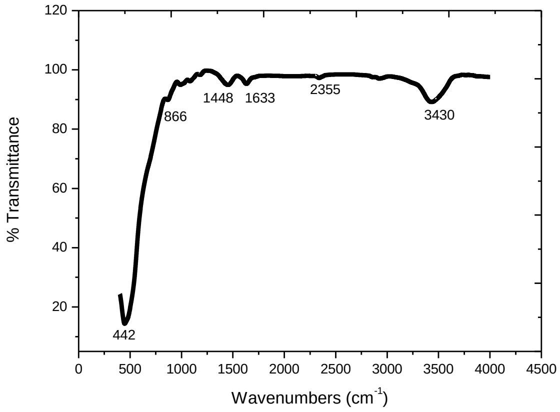

Fig. 4. FTIR spectrum of ZnO nanopowder synthesized by thermal decomposition method.

4. Conclusions

ZnO nanopowder has been prepared using simple, fast, cheap environmental safe synthesis method and was studied by XRD, SEM, FT-IR and photoluminescence spectroscopy. XRD and SEM studies confirmed the nanostructures. The average crystallite size of ZnO nanopowder was found to be of 54.79 nm. Numerous methods have been employed in ZnO nanoparticles synthesis including sol-gel, chemical vapor deposition and electrochemical methods etc. However, from an economic perspective, Thermal decomposition is less expensive and quick methods as well as the ability to produce large amounts of nanomaterials in a short time comping with other chemical methods. On the other hands, there are many challenges facing the nanomaterials which are the shape and size, to overcome these problems it is better to prepare nanomaterials by thermal decomposition and used on the spots to control size and shape change. Moreover, through this method can produce mass of nanomaterial in few time. These ZnO nanoparticles can be used in different filed such as biosensor, medical treatment, optoelectronic and environment remediation.

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