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Synthesis and Characterization of ZnO Nanoparticles by Co-Precipitation Method

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Abstract

Zinc oxide powders have been synthesized by a co-precipitation method using zinc acetate dehydrate and methanol as the reactants. A number of process parameters such as reaction temperature, solution basicity or pH and heating time are the main factors affecting the morphology and physical properties of the ZnO nanostructures The synthesized particles were characterized to study their microstructural properties by scanning electron microscopy and the presence of the functional group the Fourier Transform-Infrared spectroscopy (FT-IR) has been carried out and analysed.

Keywords: Nanoparticles; Zinc oxide; Spectroscopy; Co-precipitation method

Introduction

Today, Nanotechnology (NT) is operating in various fields of science *via* its operation for materials and devices using different techniques at nanometer scale nano particles are a part of nanomaterials that are defined as a single particle 1 nm-100 nm in diameter. From last few years, nanoparticles have been a common material for the development of new cutting edge application in communication, energy storage, sensing, data storage, optics, transmission, environmental protection, cosmetics, biology and medicine due to their important optical, electrical and magnetic properties. In perticuler the unique properties and utility nanoparticles also arise from a variety attributes including the similar size of nanoparticles and biomolecules such as proteins and polynucleicacids [1]. Additionally, nanoparticles can be fashioned with a wide range of metal and semiconductor core material that impart useful properties such as fluorescence and magnetic behavior [2]. Moreover, unlike their bulk counterpart nanoparticles have reduced size associated with high surface/volume ratios that increase as the nanoparticles size decreases. As the particle size decrease to some extent a large number of constituting atoms can be found around surface of the particle which makes the particles highly reactive with prominent physical properties. Nanoparticle of particular material show unique material properties, hence manipulation and control of the material properties mechanistic means is needed. In addition, synthesis of nanoparticle having uniform shape and size easy synthetic routes is the main issue in nanoparticle growth. For the past decade scientists have been involved in the development of new synthetic routes enabling the precise control of the morphology and size of the nanoparticles. In addition, nanoparticle synthesis can be possible *via* liquid (chemical method), solid and gaseous media [3].

Nanostructure have received much attention because of their novel properties, which differ from those of bulk materials [4,5]. Control of dimension and morphology of material has aroused the interest of researchers in the design of functional device due to the optical and electronic properties of nanometer and micrometer sized material which determine their application, can be adapted by varying their size and shape [6]. Zinc Oxide (ZnO), a versatile semiconductor material has been attracting attention because of the commercial demand for optoelectronic devices operating at the blue and violet regions [7]. ZnO is quartzite type semiconductor with band gap energy of 3.37 eV and it has very large excitation binding energy (60 meV) at room temperature [8]. Recently special attention has been devoted to the morphology as ZnO can from different nanostructure [9-11]. Thermal stability irradiation resistance and flexibility to form different nanostructure are the advantages that expedite its potential wide application in photo detectors, surface acoustic wave device, ultraviolet nano-laser, varistors, solar cell, gas sensor, biosensor, ceramics, field emission, and nano-generator [12-21].

Materials and Methods

Experimental work

ZnO nanoparticles were synthesized using chemical precipitation method. In a typical synthesis 13 g of zinc acetate dehydrate $Zn(CHOO)_2.2H_2O$ was dissolved in 0.6 M methanol solution under the continuous stirring. The mixed solution was stirred with a magnetic stirrer at 80°C for 2 hour to form a transparent solution. Then the pH was adjusted with ammonia between 9 and 11. After adjusting the pH by using the pH meter. Then the solution was dried at 100°C for 1 hour and then the temperature was increased up to 150°C until the precipitate occurred. The white precipitate formed after the evaporation was filtered washed with methanol 3-4 times. Then the dried at room temperature. Then after the power sample are grind using the pastle and mortar to get homogenious particles. After drying the powder sample was heated in an oven at 500°C temperature. Achieved by the oven after 3 hours. Then the temperature kept constant at 500°C for 3 hrs. After heating for 3 hrs the further was cooled to room temperature. Then after the powder sample are grind using pestle and mortar to get homogenious particles.

Figure 1 shows the experimental figures of the ZnO nanoparticles synthesized by the co-precipitation method.

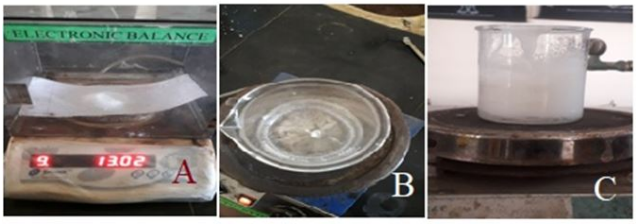

Figure 1: A) Weighing; B) Stirring and; C) White precipitation.

Basic diagram prepared nanoparticles

The block diagram shows the overall process done to produce the Zinc Oxide (ZnO) nanoparticles by co-precipitation method precursor materials are zinc acetate dissolved in 0.6 M methanol. We already discussed the overall process earlier. Then the obtained sample materials were characterized by the SEM and FTIR spectroscopy (Figure 2).

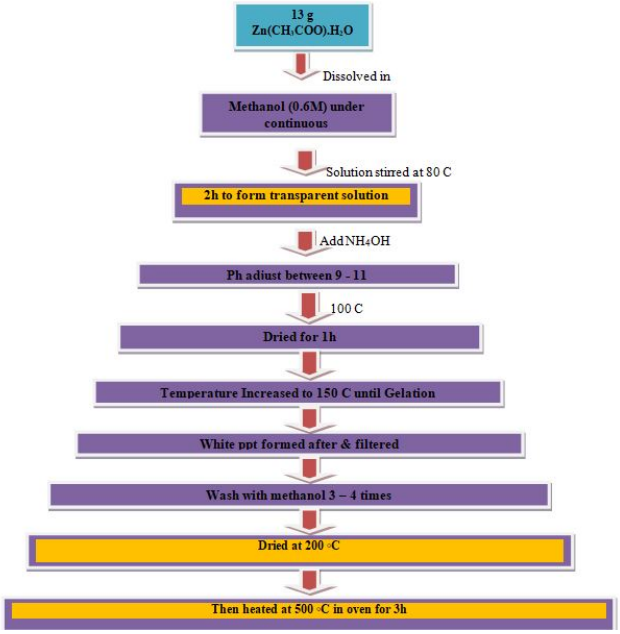

Figure 2: Block diagram of the ZnO nanoparticles synthesis.

Results and Discussion

Figure 3 shows the FTIR spectra of the ZnO nanoparticle sample. For the IR spectra, a series of absorption peaks from 400 cm^{-1} to 4000 cm^{-1} can be found. Metal oxides generally give absorption bands in fingerprint region *i.e.* below 1000 cm^{-1} arising from interatomic vibrations. The peak at 420 cm^{-1} is the characteristic absorption of Zn-O bond. To be more specific, a broad band at 3393 cm^{-1} is assigned to the O-H stretching mode of hydroxyl group. Peaks between 1680 cm^{-1} and 3000 cm^{-1} are due to C-H stretching vibration. The peaks observed at 1560 cm^{-1} and 1432 cm^{-1} are due to the asymmetrical and symmetrical stretching of the zinc carboxylate, respectively. Together this suggests that these FTIR identified impurities mainly exist near ZnO surfaces. This result is a good agreement with other works.

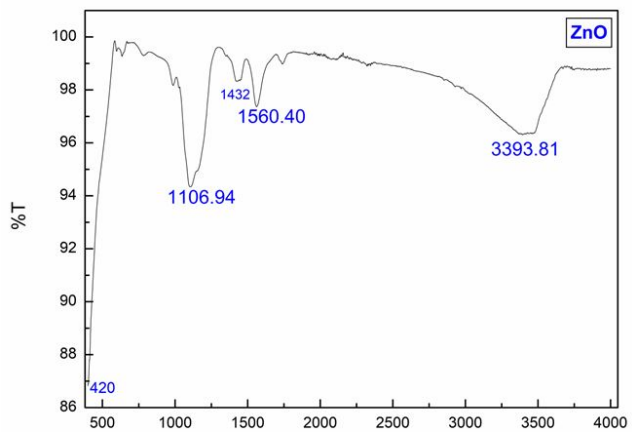

Figure 3: FTIR spectrum of ZnO nanoparticles.

The morphology of the prepared ZnO powder was investigated by Scanning Electron Microscopy (SEM). As shown in Figure 4, the average size of ZnO particles was estimated to be around 40 nm-50 nm. The SEM photograph shows that the powder ZnO NPs are spherical in nature and are agglomerates of nano-crystallitesand homogeneous. A similar result for SEM analysis was reported by Mirza, et al.

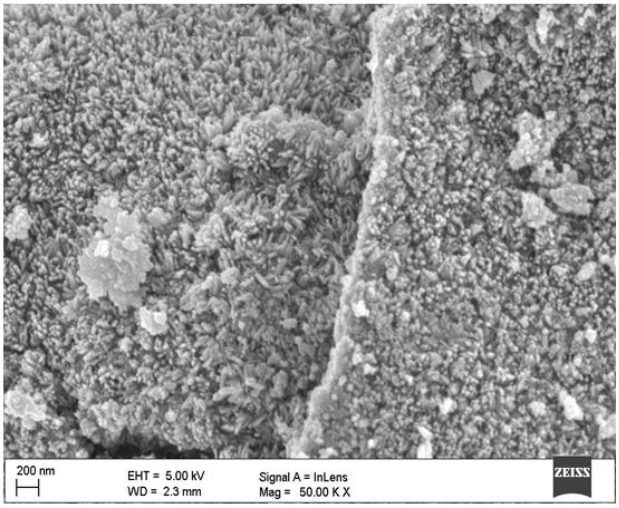

Figure 4: SEM image of ZnO nanoparticle.

Conclusion

Nano powder zinc oxide with less than 50 nm average gain size was synthesized by a co-precipitation method and the powder shapes were almost uniform. Films have been characterized using optical and structural measurement. For the FTIR spectra of series of absorption peaks from 4022 cm^{-1} to 4000 cm^{-1} can be found. FTIR identified impurities mainly exist near ZnO surface. The morphology of the prepared ZnO powder was investigated by SEM. The average size of ZnO particle was estimated to be around 40 nm-50 nm.

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