



Effect of temperature reaction on chemically synthesized ZnO nanoparticles change in particle size

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ARTICLE INFO

Article history:

Received 20 February 2020

Received in revised form 21 August 2020

Accepted 2 September 2020

Available online 23 October 2020

Keywords:

ZnO nanoparticles

XRD

Scanning electron microscope

Fourier-transform infrared spectroscopy

Ultraviolet photo detectors

Photoluminescence

ABSTRACT

Previously ZnO nanostructures production such as Hydrothermal, Co-operation and Anodization were described. In this paper FTIR, XRD, scanning electron microscope processes are used for determining various characteristics of ZnO particles. It shows morphological changes of ZnO particles. We have presented the study of ZnO nanoparticles properties by using UV-Visible spectrophotometer, photoluminescence spectroscopy devices. It determines the properties of ZnO nanoparticles. We have described the effect of temperature reaction on chemically synthesized ZnO Nano particles based on change in Particle size. © 2019 Elsevier Ltd. All rights reserved.

Selection and Peer-review under responsibility of the scientific committee of the 2nd International Conference on Nanoscience and Nanotechnology.

1. Introduction

In the recent years, Zinc oxide nanostructures have more attraction based on the optical properties of crystallite size and morphology. Normally ZnO Nano particles are considered as a promising material for doing the high-performance of photonics applications. ZnO properties have excitonic binding energy, high efficiency wide gap, for making electro-optic applications with Lasers or high efficiency LEDs. ZnO nanostructures are to be used for developing the various applications by taking optical properties, physical properties for solar cells, gas sensors, optoelectronics, photochemical devices [1–4]. ZnO nanostructure has large surface area for applying the catalytic reaction process by taking large surface area with high catalytic activity [5]. Field emitter and gas sensors are functional material of Nano devices of ZnO [3–5]. Many methods were described for ZnO nanostructures production such as Hydrothermal, Co-operation and Anodization [6–16]. ZnO nanoparticles were also used as UV screeners by adding the polymer which was the absorption of UV radiation and to reduce the polymer photo degradation with the addition of OD-ZnO nanoparticles with surface modified organosilanes [12].

ZnO is an interesting material with various potential applications such as piezoelectric, sensors [2], UV lasers [3], piezoelectric [4], luminescent phosphor, photonic crystals [5] and photovoltaic [6]. Many authors have been conducted on optical and the electrical properties of ZnO. Sadhu et al. have been studied optical properties of ZnO by changing the particle size and shape. [7]. A plethora of ZnO nanostructures have already been synthesized and characterized in detail. Synthesis analysis of ZnO structures are having large volumes. But still It is a major challenging task with simple and economical wet chemical methods. In the present days, Advanced Oxidation process has been used for the conversion of pollutants into innocuous substances of waste water [17]. The process of oxygen as the oxidant and is processed under ambient conditions [18]. Investigation of Electrochemically assisted ZnO NPs for degrading the zno dyes [19]. In this regard, ZnO nanoparticles can be used as an inexpensive, effective, and non-toxic semiconductor photo catalyst for degrading the range of synthetic dyes [20].

The objective of the paper is to synthesize the ZnO nanostructures assemblies are formed by using wet chemical approach with the effect of temperature reaction. FTIR can be used for the detection of group and absorbed ZnO nanoparticles, ZnO nanostructures have been synthesized by using various investigation methods with the help of various microscopes.

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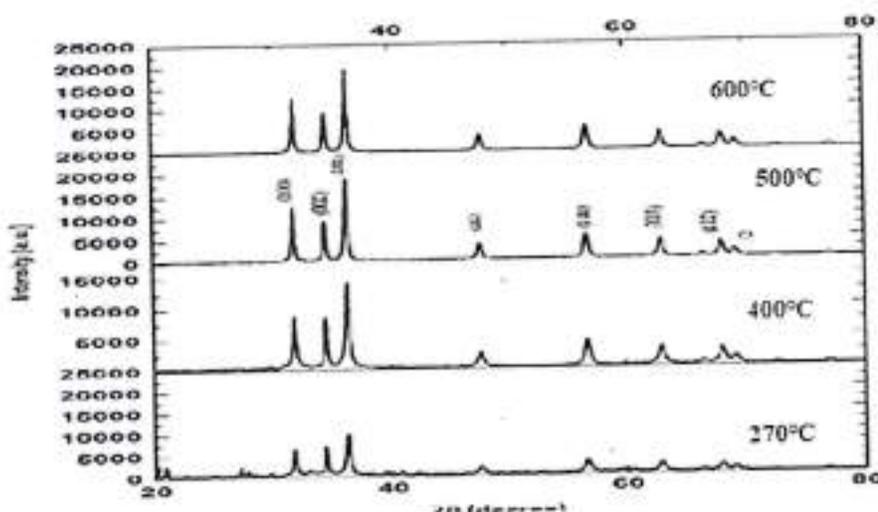


Fig. 1. (a) XRD patterns of ZnO nanoparticles.

Table 1
XRD Estimate particle Size and lattice constant of ZnO nanoparticles.

ZnO Sample	2 Theta (deg)	D (Å)	FWHM (deg)	Grain Size (nm)	Lattice Parameters 600°C	
					a'	c'
ZnO 270 °C	31.7920	2.8121	0.3885	31.71	3.24	5.20
	34.4380	2.60021	0.3021			
	36.2779	2.47206	0.3920			
	47.4566	1.90610	0.3904			
ZnO 400 °C	31.8442	2.8080	0.4102	38.35	3.24	5.20
	34.8444	2.6084	0.3337			
	36.3272	2.4720	0.4238			
	51.850	2.2806	0.3936			
ZnO 500 °C	34.5063	2.5984	0.2952	39.281	3.24	5.19
	36.3177	2.4702	0.4920			
	31.7942	2.8122	0.3446			
	34.4443	2.6016	0.3078			
ZnO 600 °C	36.2783	2.4742	0.3611	38.73	3.24	5.20
	47.7489	1.90480	0.2952			

2. Material and method

In these experiments Zinc acetate, sol-gel method, sodium hydroxide were used by chemical precipitation. Distil water is used for the solution of distil water which is obtained from Merck (Mumbai) India.

3. Results and discussion

3.1. Chemically synthesis of ZnO

Zinc acetate and Sodium-hydroxide solution was added slowly in the ratio of 1:2. It provides stirring process for four hours. It was filtered and washed distil water. Molar ratio is 1:2. Precipitation has dry at oven at 100 °C. The precipitate was dry in an oven at 100 °C and ground to fine powder using agate mortar and pestle. Powder was calcined at various temperatures such as 270 °C, 400 °C, 500 °C and 600 °C With respect to calcined temperature, changes at O-H bond.

3.2. Characterization

3.2.1. Structural investigation

X-ray diffraction data are recorded by over in the range of 20–80 using miniflex II diffract meter of X-ray. The following figure

shows the XRD pattern. Standard JCPDs data card no 76-0704 can be used to determine the hexagonal crystal structure.

ZnO Nano particles have hexagonal crystal structure which have been designated were

(100.5), (002.5), (101.01), (102.02), (110.01), (103.02), (200.01), (112.01) and (201.02) at $2\theta = 31.792, 34.438, 36.2779, 47.5488, 56.613, 62.858, 66.3966, 67.957$ and 69.0791 respectively.

Debye Scherer's equation (1) is used for the estimation of the average grain size of the samples with the help of full width at half maxima.

Calcinations temperatures of samples are used for increasing the average crystalline size. Crystalline size is obtained. A significant increase in crystalline size is obtained for the sample claimed at 37 °C room temperature 40 °C, 50 °C and 60 °C

$$D = \frac{0.94\lambda}{\beta \cos\theta} \quad (1)$$

where

D – represents size of the crystalline (nm)

λ – Incident wavelength X – ray (nm)

β – Maximum full width.

θ – Represents the diffraction angle.

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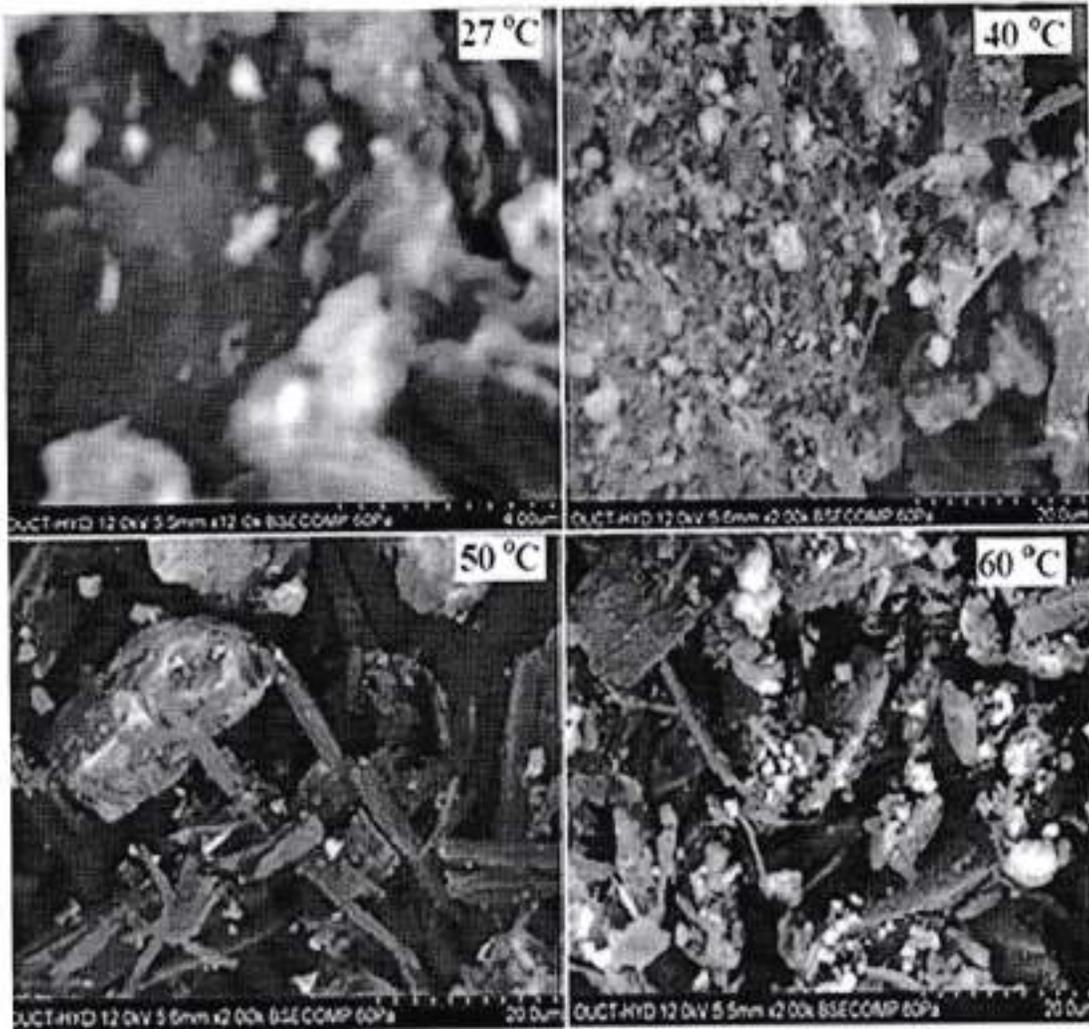


Fig. 3.1. SEM shows ZnO samples 27 °C to 60 °C samples.

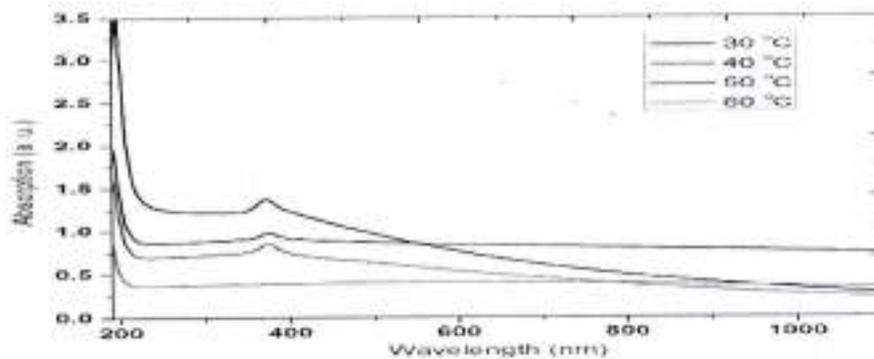


Figure 3.20 Optical absorption spectra of ZnO nano particles prepared at different Reaction Temperatures.

Fig. 3.2. Optical absorption spectra of ZnO nano particles prepared at different reaction temperatures.

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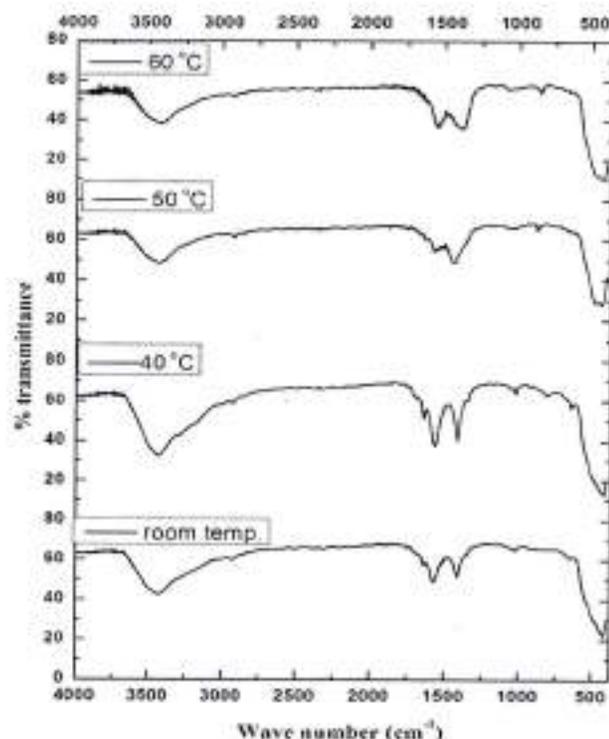


Fig. 2. (b). FTIR pattern of ZnO nanoparticles samples.

The range of grain size from 22 nm to 52 nm depends upon the growth of particles. It influences the grain size particles of ZnO nanoparticles [Fig. 1; Table 1].

3.2.2. FTIR

FTIR can be used for the detection of group and absorbed ZnO nanoparticles. FTIR spectra of ZnO Nano powder was in the range of 400 to 3600/cm with chemical precipitation of sol-gel techniques. Inter hydrogen bond is stretched of the centered peak of 3478/cm. Existence of water molecules and hydroxyl group. These results were matched with these observations.

The two weak bond at 2922 and 2857 /cm in the modes of C-H stretching phase. The bending vibration of O-C-O species are near at 2228 cm^{-1} by group structure. The weak bend at 647–831 cm^{-1} is appearing in IR spectrum of annealed (60 °C) compound. It indicates the presence of stretching and bending vibration of the intercalated C-O species. ZnO formation indicates the peak characteristics around 437/cm which becomes stronger. It gives vibrational frequencies of 564/cm due to presence of ZnO particles. It is absent in 27 °C ZnO. The following figure shows the vibrational frequency of ZnO 467 /cm is also shifted (Fig. 2; Table 2).

Table 2
FTIR various function groups in ZnO Nanoparticles.

Vibrational band	Samples ZnO 270 °C Freq.cm ⁻¹	Samples ZnO 400 °C Freq.cm ⁻¹	Samples ZnO 500 °C Freq.cm ⁻¹	Samples ZnO 600 °C Freq.cm ⁻¹
Zn-O	437	421	476	452
Zn-O	482	489	488	489
Zn-O	673	648	669	663
Zn-O	829.42	835	881	881.30
C-C	1020.38	1018	1020	1020
C=O	1410.11	1411.94	1440.87	1440.87
C=O	1572.04	1581.66	1580.11	1586.33
CO ₂	2341.66	2346.61	2326.11	2359.02
C-H	2961.76	2961.76	2926.11	2926.11
O-H	3431.48	3439.19	3448.84	3531.78

3.2.3. Scanning electron microscopy (SEM)

Electron Microscope images (SEM) are shown in Fig. 3.1. ZnO sample is synthesized at room temperature which represents the homogenous porous cloudiest microstructure.

Increasing the reaction temperature up to 50 °C. The microstructure consists of ZnO rods. SEM analysis clearly shows the ZnO samples. It represents Nano rod of crystalline size 62 nm to 84 nm.

3.2.4. UV-visible spectra for ZnO

Band gap are at 3.36 eV and 2.99 eV for ZnO. The small shift of band gap is attributed with ZnO. Annealing temperature is in the range of 27 °C to 60 °C. The longer wave length is shifted towards to 3.36 to 2.99 eV, which was the improvement for morphological and crystal nature of samples at higher temperature. The optical band gap E_g of ZnO was calculated by using the formula $E_g = hc/\lambda$. The crystallinity of ZnO improved when the temperature is increased from 27 °C to 60 °C. Conduction type of ZnO depends up on temperature. Fig. 3.2 shows the UV-visible absorption spectra of ZnO samples annealed at different temperatures (Table 3).

3.2.5. Photoluminescence

Synthesize the ZnO nanoparticles from precursors which are given in the below figures. Excitation emission at 362 nm which corresponds to UV emission. Nanoparticles spectra which are ranging from 430 nm to 563 nm provide emission of ZnO nanoparticles. The blue band peak at 460 nm corresponds to the weak blue-green band at 442 nm. The peak result from 516 nm to 562 nm result due to various defects of interstitial Zn. It shows acceptor presence and donor states of region in between valance and conduction bands. A sample is excited by xenon lamp of 320 nm wavelength with accompanying the narrow UV region. Smaller ZnO nanoparticles produces the strong visible by the presence of surface defect (Figs. 3.3 and 3.4).

4. Conclusions and future work

In this work we showed FTIR pattern of ZnO nanoparticles samples with FTIR various function groups in ZnO Nanoparticles. UV-visible absorption spectra of ZnO samples annealed at different level of temperatures are presented clearly in this paper. It shows the improvement for morphological and crystal nature of samples at higher temperature. Experimental results showed that scanning the images of ZnO samples at various temperatures. We have described the chemically synthesized of ZnO particles with respective temperature changes based on Particle sizes. In the future, we would like to extend this work for analysing Nano structures with respective various temperatures by taking number of samples.

Table 3
Energy Band Gap-Different ZnO samples.

Samples ZnO Temperature	Wavelength	Band gap
270 °C	372	3.36
400 °C	378	3.33
500 °C	386	3.30
600 °C	398	2.99

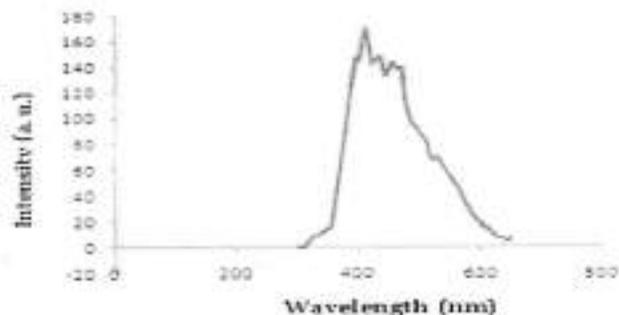


Fig. 3.3. PL spectra for emission sample ZnO 600 °C.

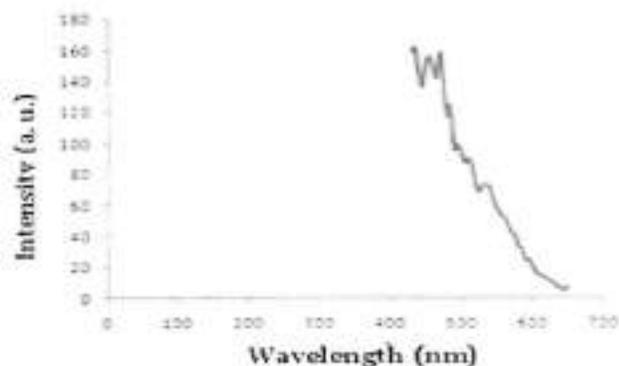


Fig. 3.4. PL spectra for emission sample ZnO 700 °C.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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