# Synthesis and characterization of zinc doped tin oxide nanoparticles by co-precipitation method

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***Abstract: Zinc doped tin oxide nanoparticles were prepared by co-precipitation method and collected samples were calcinated at 400°C. Structural, morphological and optical properties of nanoparticles were characterized using XRD, FESEM and UV-Visible absorption spectroscopy. XRD pattern reveals that the particles exist as orthorhombic structure and crystallite size was found around 23.9 nm. The presence of functional groups and formation of Zn doped tin oxide compound were verified by FTIR study. The morphology of prepared sample was characterized by FESEM.***

***Keywords:***
***Co-precipitation method***
***Tin oxide***
***Morphology***

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1.Introduction

Metal oxide nanomaterial has received a great attention in various industrial area because of their unique properties such as electrical, optical and magnetic properties. Especially tin oxide nanoparticle has attracted in many fields due their excellent applications, which leads to produce various semiconducting materials like gas sensors, photovoltaic devices, optoelectronic devices and solar cell etc[1-7]. There are different methods available to prepare metal oxide nanoparticles such as sol–gel method[8], hydrothermal method[9], precipitation method[10] etc. Among these methods tin oxide nanoparticles are synthesized by simple precipitation method due to its simplicity and low cost[11].

In this present work, Zn doped tin oxide nanoparticles were prepared by co-precipitation method. Zn doped tin oxide nanoparticles has an important factor in production of semiconducting materials, because of their high electrical conductivity property[12]. Optical, structural and morphological properties of Zn doped tin oxide nanoparticles were analyzed by UV-Visible, XRD and FESEM studies. The presence of varies functional groups and formation of Zn-SnO compound were absorbed by FTIR.

2.Experimental details

2.1.Materials

All of the chemicals used in this work were analytical grade reagents and used without further purification. Tin chloride (SnCl2), Zinc chloride (ZnCL2), and sodium hydroxide (NaOH) were purchased from Merck Company. Deionized water was used to prepare all solutions.

2.2. Preparation of zinc doped tin oxide nanoparticles

3.79 gm of tin chloride (SnCl2) was dissolved in 100ml of de-ionized water .The solution was continuously stirred for one hour and 1.36 gm of zinc chloride (ZnCl2) was dissolved in 100 ml of de-ionized water and stirred for one hour. The fully dissolved zinc chloride ($ZnCl_2$) solution was added into the tin chloride solution and mixture was continuously stirred for an hour. Then 0.4 gm of NaOH was dissolved in 20ml of de-ionized water by continuous stirring. The NaOH solution was added drop by drop in the mixture, until the pH value reaches at 11. The colour of solution changed to pure white and precipitation was formed at the bottom of the beaker. Then solution was washed thrice with water and then with acetone. The precipitated powder was dried in an oven at 100°C. The collected samples were grinded and calcinated under 400°C for 5 hours.

2.3. Characterizations

FTIR characterization is analyzed in the spectral range from 400-4000cm-1 using shimadzu Fourier transform infrared spectrometer. The powder XRD pattern was carried out by Enraf Nonius CAD4-F diffractometer with the CuKa (λ=1.540AÅ) radiation. UV-Visible absorption spectra were recorded at room temperature using a Varian Carey UV-Visible spectrophotometer from 200 nm to 1200 nm. The Field Emission Scanning Electron Microscopy characterization was taken out by FESEM quanta 20 spectrophotometer.

3. Results and discussion

3.1. Optical analysis

Figure1. shows UV-Visible absorption spectrum of Zn doped tin oxide nanoparticles. UV/Visible absorption spectrum of sample was recorded in an airtight environment at room temperature with a wavelength range of 200 to 1000 nm. The absorbed SPR peak was maximum at 284 nm and absorption edge was shifted towards shorter wavelength (blue shift). The strong and sharp absorbed peak indicates that particles size was uniform and distributed well. In order to determine the band gap energy value of zinc doped tin oxide nanoparticles was calculated from simple energy wave equation is given by,

$E=hc/\lambda$

Where h is the Planck's constant, c is the light velocity and λ is the wavelength of absorbed peak. The calculated band gap energy value of zinc doped tin oxide nanoparticles was 4.4 eV.

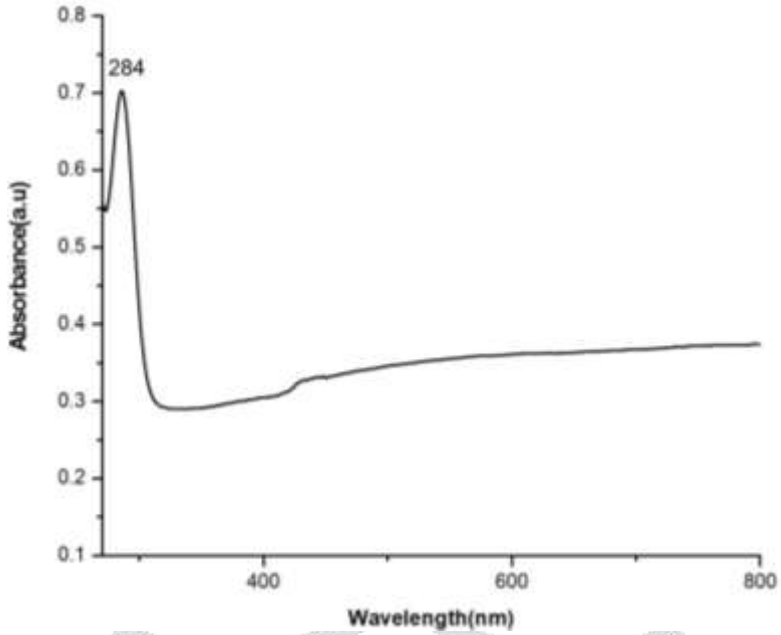


Fig 1.UV-Visible absorption spectrum of zinc doped tin oxide nanoparticles calcinated at 400 °C

3.2. Functional groups analysis

Figure 2. shows FTIR spectrum in the range of 400-4000cm-1 of zinc doped tin oxide nanoparticles calcinated at 400°C. The presence of various chemical functional groups and the formation of zinc doped tin oxide nanoparticles were also verified by FTIR spectrum. The broad band appears at 3410 cm-1 was assigned to stretching mode of OH vibration and this indicates that water absorbed on metal oxide surface[13-14]. The peaks absorbed at 1567cm-1 represents H-O-H bending vibration of particles. The peaks appear at 1408cm-1 was assigned to N-H stretching mode of vibration because of deformation and decomposition of ammonia from ammonium hydroxide [16]. The peak absorbed at 1023cm-1 corresponds to CH2 stretching mode of vibration. The peaks appear at 672 and 569cm-1 were assigned to Zn-SnO vibration mode and these absorbed peaks clear that Zn was successfully doped with tin oxide nanoparticles.

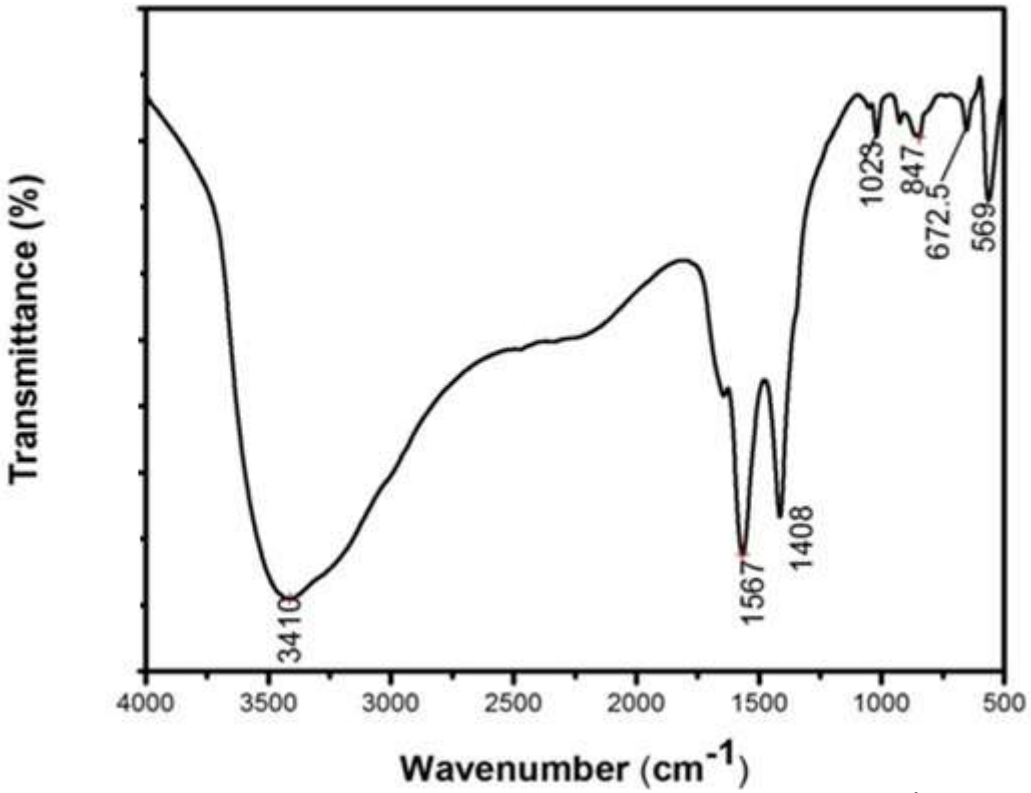


Fig 2.FTIR spectrum of zinc doped tin oxide nanoparticles calcinated at 400 °C

3.3. Structural analysis

Figure 3 shows XRD pattern of Zn doped tin oxide nanoparticles calcinated at 400°C by precipitation method. The observed pattern has several peaks at (020), (006), (023), (117), (028), (312), (043), and (315) at different diffraction angle (2θ) for zinc doped tin oxide nanoparticles. All the diffraction peaks were indexed to orthorhombic structure and perfectly matched with JCPDS (card no 78-1023) and lattice parameter a=4.737A°,b=5.708 A°, and c=15.865 A°. The peak correspond to lattice plane (023) was most prominent.

Normally average crystallite size of prepared samples depends on methods, concentration and calcination. Debye-Scherer formula was used to calculate the crystallite size of zinc doped tin oxide nanoparticles,

$$D=0.89\lambda/\beta\cos\theta$$

Where 0.89 is Scherer's constant, λ is the wavelength of X-rays, θ is the Bragg Diffraction angle and β is the full width at half maximum (FWHM) of the diffraction peak. The average crystallite size of the zinc doped SnO2 nanoparticles was found in the range of 23.9 nm.

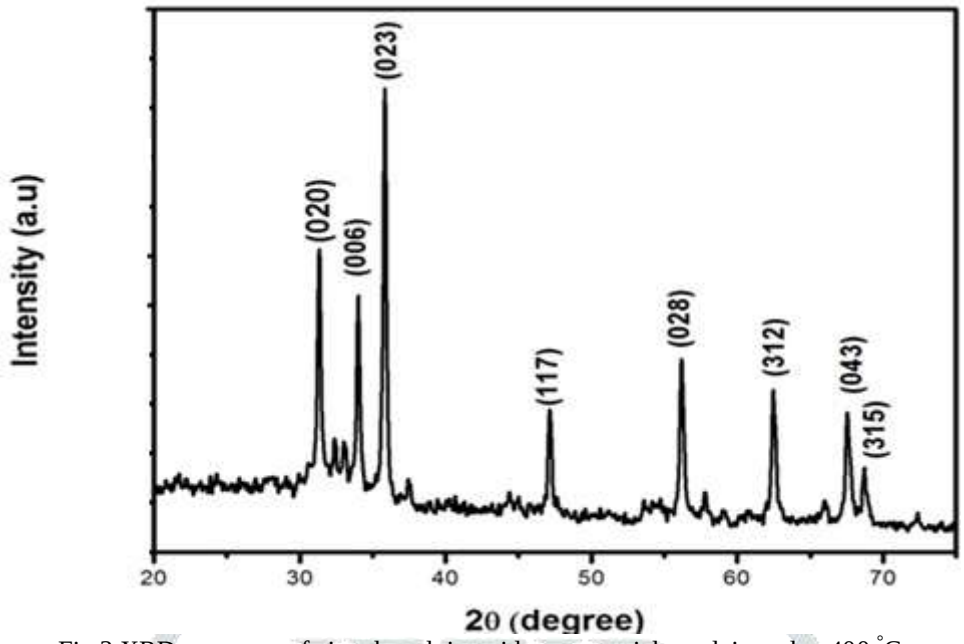


Fig 3.XRD spectrum of zinc doped tin oxide nanoparticles calcinated at 400 ˚C

3.4. Morphological analysis

Figure 4. shows FESEM image of zinc doped tin oxide nanoparticles was prepared and calcinated at 400°C. FESEM image of Zn doped tin oxide nanoparticles was recorded using FESEM quanta 20 spectrophotometer. FESEM image reveals that Zn doped tin oxide nanoparticles were mostly in spherical shape. The particles are in uniform size and homogenously distributed. Only few particles were non- uniform in shape. From this FESEM image, it confirms that the concentration of Zn dopant on metal oxide can change surface morphology of nanoparticles and also agglomeration of particles were controlled by increasing the concentration of Zn doping on metal oxide. The crystallite size and shape also depends on calcination temperature. The particles size was calculated by XRD data and the obtained value is 23.9 nm.

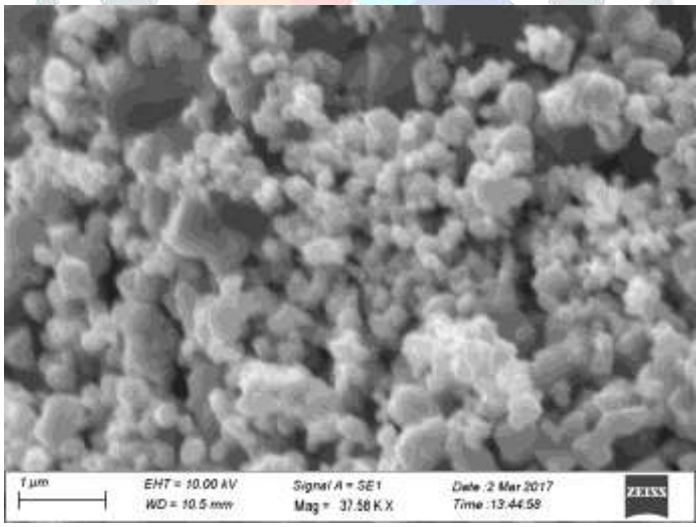


Fig 4. FESEM spectrum of zinc doped tin oxide nanoparticles calcinated at 400°C.

Conclusion

Zn-doped tin oxide nanoparticles were synthesized by co-precipitation method. XRD pattern reveals that Zn doped tin oxide nanoparticles was orthorhombic structure with crystallite size in the range 23.9nm. The UV-visible absorption spectrum indicates that SPR absorption peak is maximum at 284 nm and the band gap value is 4.4eV. The FESEM images of nanoparticles confirms the existence of very small size, particles are well distributed, spherical and extremely crystalline nature. The FTIR study confirms that Zn- SnO compound was formed successfully.

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