

Effect of Solvents on Size and Morphologies Of SnO Nanoparticles via Chemical Co-precipitation Method

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Abstract: Stannous oxide (SnO) is an important functional material which contributes to a wide range of applications. In present study, the SnO nanoparticles were synthesized using different solvents by chemical co-precipitation method. Different morphologies of SnO nanoparticles have been obtained by different solvents. The size of SnO nanoparticles was estimated by powder X-ray diffraction (PXRD) pattern and revealed that SnO crystallizes into tetragonal rutile phase. The chemical structural information of the synthesized nanoparticles was studied by Fourier transform infrared (FTIR) spectroscopy. The prominent UV emission peak was observed at 358 nm in the luminance spectra, studied by photoluminescence (PL) spectroscopy. The composition of the product SnO nanoparticles could be determined by X-ray photoelectron spectroscopy (XPS) and the binding energies of O 1s and Sn 3d_{3/2} have been found which are centered at 530 and 495 eV, respectively.

Keywords: Stannous oxide; semiconductor; nanoparticles; morphologies; co-precipitation

1. INTRODUCTION

Nanostructured materials have attracted great interest in both fundamental as well as applied research areas due to their outstanding physical and chemical properties and also promising applications in nanodevices [1]. A reduction in particle size to nanometer scale results in various interesting properties compared to the bulk properties. Stannous oxide (SnO) is one of the best p-type semiconductors found in literature for various applications. The naturally formed tin (Sn) vacancies causes the variable direct band gap in SnO, has attracted considerable attention owing to its specific functional characteristics and significance in a various technological applications such as coating substrate, catalyst, thin film transistors, etc.[2]. Variety of solution phase techniques like homogeneous co-precipitation [3], hydrothermal route [4], sol gel method [5], sol gel combustion [6], mechanical ball milling [7], and sonochemical method [8] have been employed to synthesis metal oxides. Among these, co-precipitation method is a simple and less expensive and requires simple instrumentation. A variety of SnO distinct morphologies have been successfully synthesized such as particle, platelet [9], flower [10], whiskers [11] and dendrites [12]. However, the implementation of nanostructure's preparation of SnO with well controlled size and morphology by chemical co-precipitation method is a great challenge for nanomaterials synthesis. Here, we report the size and morphological changes of SnO nanoparticles using different solvents. The properties of as-synthesized SnO nanoparticles were determined by using XRD, FTIR, SEM, PL and XPS.

2. EXPERIMENTAL DETAILS

In the synthesis process, all reagents of analytical grade (AR) were used without further purification. 0.36M of tin chloride (SnCl₂) was dissolved in different solvents such as de-ionized water, ethanol, ethylene glycol and propanol. Then, NaOH solution was added drop wise into the solution to maintain the pH of solution between 8-11. The resultant solution was stirred constantly for 60 minutes and then after vigorous stirring, white suspension was obtained. The product was centrifuged, filtered out and rinsed with alcohol and deionized water several times to remove soluble impurities if any in the

solution, and then dried at 60°C for 1h in air atmosphere, and finally the product was collected for characterization.

3. RESULTS AND DISCUSSION

3.1 Structural Analysis

The PXRD patterns of synthesized SnO nanoparticles using different solvents are shown in figure1. The diffraction peaks are well matched with the standard SnO reflections (JCPDS Card No. 06 – 0395).

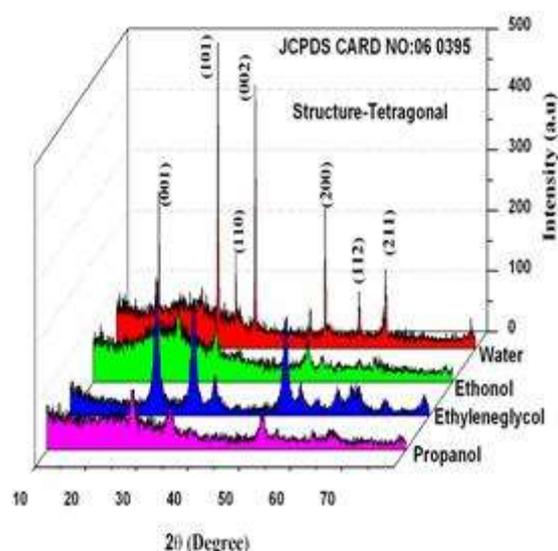


Figure 1. PXRD patterns of SnO nanoparticles

The X-ray pattern reveals that SnO nanoparticles are having tetragonal wurtzite structure and the obtained peaks are indexed to (001), (101), (110), (002), (200), (112) and (211) planes. The reduction in peak intensities and broad FWHM were observed for the samples synthesized in solvents of ethanol and propanol. The calculated values of grain size, dislocation density and strain are tabulated in table 1.

Table 1. Grain size and micro structural parameters of SnO nanoparticles

Sl. No	Solvent	Grain Size $D=0.9\lambda/\beta\cos\theta$ (nm)	Dislocation Density $\delta = 1/D^2$ (lines/m ²)	Micro Strain $\epsilon = \beta\cos\theta/4$ (lines ⁻² /m ⁴)
1.	Water	40.83	0.599 E+15	0.849 E-03
2.	Ethanol	13.61	5.3982E+15	2.547 E-03
3.	Ethylene Glycol	8.17	14.980E+15	4.243 E-03
4.	Propanol	6.81	21.584E+15	5.093 E-03

3.2 Functional Analysis

FTIR spectrum is a useful tool to understand the functional groups of any organic molecule. The FTIR spectra of SnO nanoparticles collected using different solvents are shown in Figure 2. Metal oxides generally give absorption band below 1000 cm⁻¹ arising from inter-atomic vibrations.

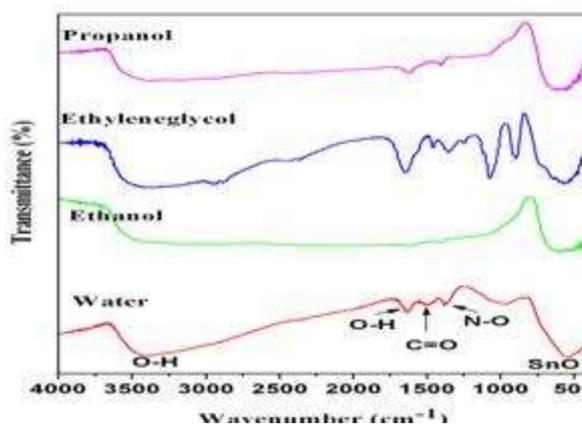


Figure 2. FTIR spectra of SnO nanoparticles

For all synthesized products, the absorption peaks are found at 3456 and 1618 cm⁻¹ are attributed mainly to the O-H stretching vibration of surface hydroxyl group or adsorbed water of the SnO nanoparticles [13]. The principal peak observed at 1586 cm⁻¹ corresponds to the strong asymmetric stretching of C=O bond. The presence of N-O is conformed from the peak observed at 1409 cm⁻¹. The absorption band at 515 cm⁻¹ is ascribed to the terminal oxygen vibration of SnO [14].

3.3 Morphological Analysis

Figure 3 shows the SEM micrograph of SnO using different solvents. The formation of plate like morphology is obtained using water as a solvent and it produces better morphology than the other solvents like ethanol, ethylene glycol and propanol. The formation of SnO nanoparticles are highly agglomerated for other solvents because of the formation of

smaller particles. But for the case of water solvent, the size becomes higher and it produces less agglomerated particles.

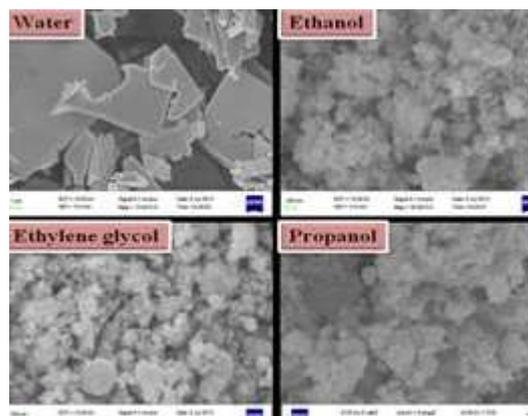


Figure 3. SEM images of SnO nanoparticles using different solvents

3.4 Photoluminescence studies

Figure 4 shows the room-temperature photoluminescence spectra collected by using an excitation wavelength of 325 nm. A strong UV emission peak located at 358nm (3.4 eV) corresponding to the near band-edge emission observed for all samples. The propanol mediated sample gives a very prominent UV emission. However, ethanol, ethylene glycol and water mediated samples show less intense UV emission peak comparable with the propanol mediated sample. Huan-Ming Xiong et al reported the surface state is regarded as a main factor that determines SnO visible luminescence, because SnO visible emission arises from its defects or vacancies which mainly located on the nanoparticles surface [15].

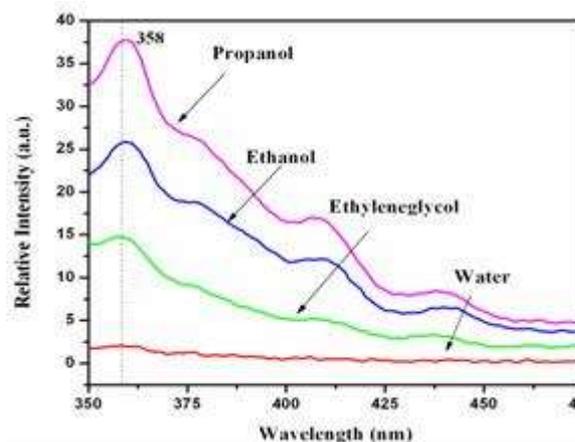


Figure 4. PL spectra of SnO nanoparticles

3.5 Compositional Analysis

Figure 5 shows the high resolution XPS spectra of as-synthesized nanoparticles. The dominant signals corresponding to Sn3d_{5/2}, Sn3d_{3/2} and O1s are found at 486.2, 495.4 and 530.7eV respectively. These values are matching well with the previous reports for SnO [16]. The O1s photoelectron peak is observed at 530.7 eV revealed that oxygen atoms are bonded to the Sn atoms.

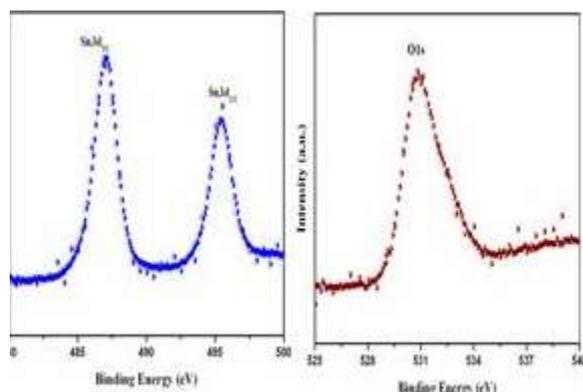


Figure 5. XPS spectra of SnO nanoparticles

4. CONCLUSION

Controllable size and different morphologies of SnO nanoparticles have been synthesised using different solvents by co-precipitation method. The size of the SnO nanoparticles has been estimated by PXRD. The chemical structural information of the product SnO has been studied by FTIR spectra. The different solvents give various morphologies studied by SEM analysis. The intensity of UV emission peaks are found to be varied with respect to the solvents used. The composition of the SnO nanoparticles has been determined by X-ray photoelectron spectroscopy (XPS).

5. REFERENCES

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