

A Non ionic surfactant on the surface modification of SnO₂ nanoparticles

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Abstract

Nanoscale SnO₂ particles have been synthesized by simple hydrothermal method using a non-ionic surfactant PEG abbreviated as Polyethylene glycol at different pH. The samples were characterized by X-Ray diffractometer, UV-Vis absorption spectrometer and Field emission scanning micrograph. The prepared SnO₂ nanoparticles appear to be in single crystalline tetragonal in phase with the diameter ranging from 30-55nm. The absorption spectra exhibited a blue shift due quantum confinement effect. The morphological changes with the variation in the pH values were studied.

Introduction

Nanomaterials have attracted a great interest due to their intriguing properties different from those corresponding to bulk state. The fabrication of nanostructured materials has been an active and challenging subject in material science and other fields [1]. Semiconductor nanoparticles have been extensively studied from both experimental and theoretical viewpoints, owing to their potential application in solar energy conservation, Photocatalysis and in the field of optoelectronics [2-5]. Metal oxide nanoparticles play an important role in the selective surface modification of various substrates in the form of coating. Tin oxide is a direct band gap n type semiconductor ($E_g=3.6\text{eV}$) and has been the most strategic material used in applications, gas sensing, transparent electrodes and liquid crystal displays etc. [6,7] thus a great deal of research work has been devoted to synthesis tin oxide nanoparticles. Recent studies have shown that many fundamental physical or chemical properties of semiconductor materials strongly depend on the size and morphology of the materials. Several physical and chemical synthetic methods are

available for the fabrication of this material including solgel [8] CVD [9], annealing precursor powder [10], thermal evaporation and microwave heating [11]. Mild methods focus on micelle technique, electrical deposition and hydrothermal method [12]. Recently it has been noted that polymers can be used to assist the formation of nanoscaled materials and one remarkable candidate is Polyethyleneglycol, which provides an inexpensive, stable, nontoxic reaction medium [13]. In this study the focus is laid on the simple and efficient hydrothermal method for the preparation of SnO₂ nanoparticles and the influence of a surfactant at different pH is studied.

Experimental procedure

SnO₂ nanopowders were successfully prepared by means of dissolving 0.02 mol of SnCl₂.2H₂O (A.R) in 50ml of water containing appropriate amount of NaOH. The reactants were stirred vigorously to obtain a clear solution, in which 0.02 mol of PEG was added. After stirring for 0.5 hrs, the reactants were put into Teflon-lined stainless steel autoclave of 100ml capacity. The sealed autoclave was maintained at 130°C for 24h, and cooled to room temperature naturally. A yellow precipitate was collected and washed with deionized water and absolute alcohol several times and then dried at 60°C for 3h. The obtained samples were then calcinated at 400°C for 2h. The prepared samples were subjected to different characterization. The crystalline structure of materials was analyzed by X-ray diffraction (XPRT PRO with CuK_α radiation $\lambda=1.5406\text{\AA}$) at scanning speed of 2°/min from 20° to 80°. The surface morphology was analyzed using Scanning electron micrograph (JEOL, JSM-67001). The absorption spectra were carried out in the range of 200 –2000nm by using SHIMDZU UV 310PC.

Results and Discussion

The phase purity and crystal structure of SnO₂ nanoparticles obtained are examined by XRD patterns as shown in the fig1 (a-c) The sharp diffraction peaks in the pattern can be indexed as 110, 101, 200, 211, 220, 002, 310, 112, 301, 202, 321 and are in agreement with the JCPDS 41-1445. The sharp intensity of the prepared sample's diffraction peaks relative to the background signal indicates that the resultant had high purity of SnO₂ rutile phase. The size of the particle estimated using Debye Scherer's formula was about 32, 44, 52nm for pH=2, 5, 7 respectively and are markedly less than previously reported value [14]. From the XRD pattern it is found that the peaks gradually sharpens with the increasing pH value indicating the increase in grain growth.

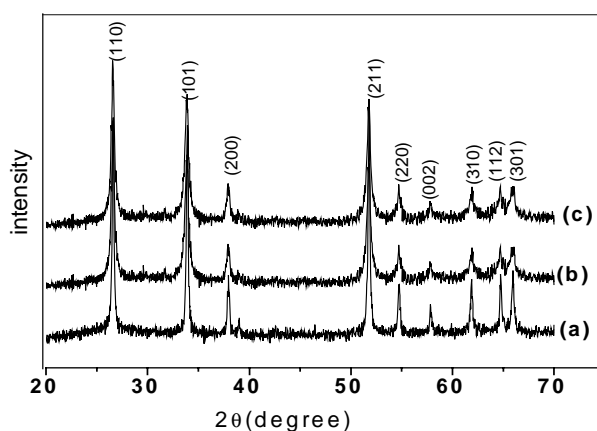


Figure 1(a-c): XRD pattern of prepared SnO₂ pattern using PEG at pH=2(a),pH=5(b),pH=7(c).

PEG assisted SnO₂ nanocrystals shows optical, electronic, optoelectronic properties distinct from bulk materials. Nanosized semiconductor particles generally exhibit threshold energy in the optical absorption measurements, due to the size specific band gap structures [15]. The optical absorption spectra of samples obtained with three different values of pH are shown in the Fig 2. Considering the blue shift of the absorption position from the bulk SnO₂, the absorption onsets of the present samples can be assigned to the direct transition of electron in SnO₂ nanocrystals [15]. The absorption edge for samples prepared at pH=2 showed a prominent blue shift compared to other two samples.

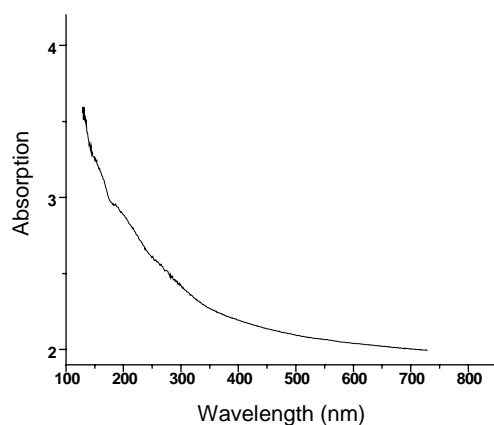


Figure 2: Absorption Spectra of synthesized SnO₂ using PEG at pH=2

The morphology of the samples is shown in SEM images presented in Fig.3. There is a remarkable change in the morphology with the variation of growth condition such as pH and type of precursors etc. The synthesizing procedure followed is similar to that used by E.Shen.et.al, where SnCl₄ was used to obtain SnO₂ nanoparticles of size 50nm,as against in this study SnCl₂ is used to obtain SnO₂ particles of size 32nm.These reveal that type of precursor has a notable effects on the

size and morphology. pH values have a great influence in determining the morphology, at pH=2 the particles exhibited a spherical shape which modified into cauliflower like for pH=5 then a triangular shape for pH=7. The growth mechanism can be attributed to the fact that, PEG being a non-ionic surfactant SnO₂ formation is not possible by electrostatic interaction, and the formation can be attributed to weak Vanderwall's interaction [16].

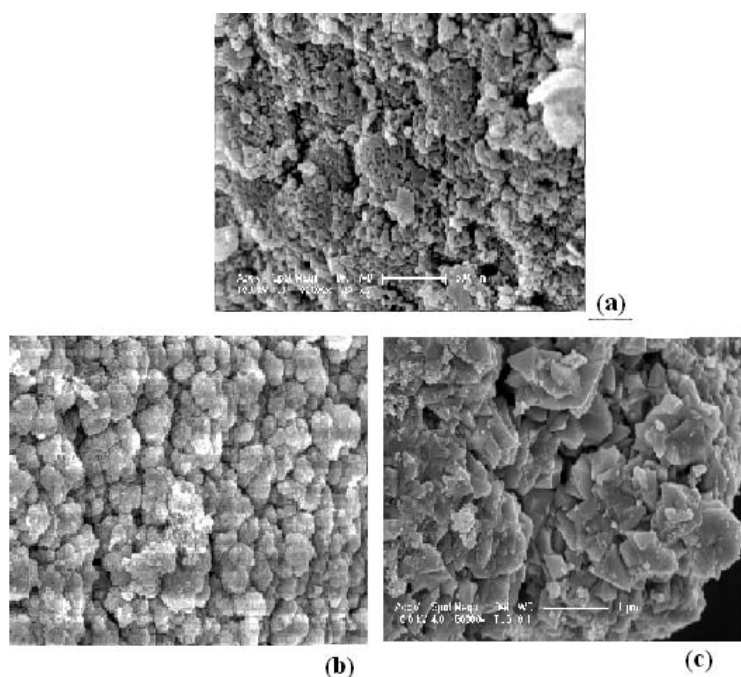


Figure 3(a-c): SEM images of SnO₂ using PEG at pH=2(a),pH=5(b),pH=7(c).

Conclusion

SnO₂ nanoparticles having particles ranging from 32-52 nm were productively synthesized by a simple hydrothermal method. XRD results show that the nanoparticles were single crystalline SnO₂ with rutile structure. The obtained particle size were lesser than the previously reported values. SEM images exhibit distinct morphologies for different pH. The absorption edge showed a prominent blue shift. This convenient synthesis strategy can be applied as general approach for the preparation of other metal oxides nanoparticles and nanorods.

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