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Synthesis and morphology characterization of SnO_2 nanoparticles by hydrothermal method

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ABSTRACT: Nanoparticles are widely used in different applications such as cancer cell treatment and antibacterial agents. SnO_2 nanoparticles were synthesized successfully by hydrothermal method and subsequent calcination using Tin (II) chloride- dihydrate, Sodium hydroxide, in presence of Hexadecyltrimethylammoniumn bromide (CTAB) as Surfactant. These nanoparticles were characterized by using Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM). XRD pattern showed that all diffraction peaks were assigned to the pure tetragonal phase of SnO_2 and SEM image of pure SnO_2 showed that the nanoparticles are homogeneous with uniform particle size. In this research SnO2 nanoparticles were successfully synthesized.

Keywords: *Hydrothermal method; Metal oxides; Morphology; Particle size; SnO_2 nanoparticles; Synthesis*

INTRODUCTION

During the last decade, developing and understanding of nanometric particles have been become interesting field of science (Prodan, *et al.*, 2013). It is well known that the performance of materials is greatly influenced by the morphological and structural features including size, shape, specific surface area, and porosity (Li, *et al.*, 2008). Inorganic metal oxides (ZnO ,Fe_2O_3, TiO_2, SnO_2, CuO etc.) are the most common minerals on the Earth and their nanostructure are very important due to their special shapes, compositions, and chemical and physical properties (Zhai, *et al.*, 2009, Anandan, *et al.*, 2010, Zhou, *et al.*, 2010). Nowadays Metal oxides (MOs) have been used in the structure of solar cells, sensors and fuel cells (Jan, *et al.*, 2014, Noguera, 1996, Baumer, *et al.*, 1997). Nanostructures of MOs can indicate unique physical and chemical properties based on their size, high aspect ratio and edge effect and due to these properties, MOs have engrossed variety of applications such as lithium ion batteries, fuel cells, field effect transistor, solar cells, magnetic storage devices, biosensors, cancer cell treatment and antibacterial agents (Baumer, *et al.*, 1997, Baek & An, 2011). In recent years, considerable efforts have been devoted to fabricating various SnO_2 nanostructures, including nanowires (Chen, *et al.*, 2012), nanoparticles (Van de Krol, *et al.*, 2008), nanobelts (Liu, *et al.*, 2013), nanorods (Zhang, *et al.*, 2012), hollow nanostructures (Zhou, *et al.*, 2013), mesoporous

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solids (Zhang, *et al.*, 2013), and porous nanostructures (Guo, *et al.*, 2013). Different methods have been used to synthesize nanoparticles like sol gel method (Adnan, *et al.*, 2010), hydrothermal method (Farrukh, *et al.*, 2010), surfactant assisted method (Farrukh, *et al.*, 2012), deposition-precipitation method (Yazid, *et al.*, 2011) and wet-oxidation method (Saron, *et al.*, 2012). In the present investigation, SnO_2 nanoparticles have been synthesized by a simple hydrothermal method and their structural and morphology properties were studied.

EXPERIMENTAL

Materials

Hexadecyltrimethylammonium bromide (CTAB), Sodium hydroxide (NaOH), Tin (II) chloride-dihydrate ($SnCl_2.2H_2O$), ethanol were procured from Merck, Germany. All the chemicals were used as received without any further purification.

Synthesis of SnO_2

1.8 g hexadecyltrimethylammonium bromide and 1.2 g $SnCl_2.2H_2o$ were dissolved into 15 ml distilled water at the same time,0.58 g NaOH was dissolved into 15 ml distilled water, then these two solutions were mixed, the mixed solution was stirred for 30 min at 25°C. Afterwards, the clear solution was heated at 130°C for 24H in autoclave and then cooled down to room temperature .the precipitate was washed with distilled water and ethanol several times and then was dried at 60°C for 2h. Finally SnO_2 was calcined at 600°C for 3h.

Characterization

The sample was characterized through Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

The infrared spectra of prepared SnO_2 are shown in Fig. 1. The broad adsorption band at 3439 cm^{-1} is referred to the stretching frequency of the O-H group, a

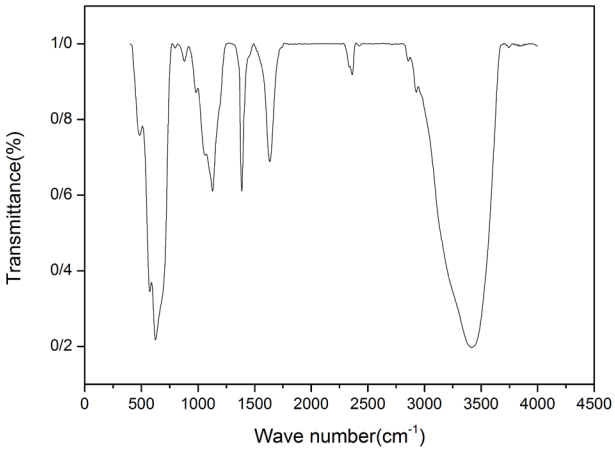

Fig. 1. Fourier transforms infrared spectra of SnO_2

band at 2921 cm^{-1} is attributed to C-H stretching vibration and 1640 cm^{-1} is due to O-H groups of moisture in sample. Peaks in rang of 1000-1600 cm^{-1} are evidence of the C-C and C-H vibration band. A strong absorption band at 624 cm^{-1} and a band at 564 cm^{-1} are assigned to Sn-O and Sn-O-Sn vibration, respectively which are confirmed that the SnO_2 nanoparticles were formed.

The XRD pattern of SnO_2 nanoparticles is displayed in Fig. 2. Eleven characteristic peaks of SnO_2 nanoparticles including: 26.6o (110), 33.9 o (011), 38.9o (020), 51.8o (121), 54.8o (220), 58.8o (002), 61.92o (130), 64.79o (112), 66.0o (031), 71.82o (230), 78.76o (231). These peaks have proper accordance with JCPDS (PDF No. 41-1445) data which explain the tetragonal phase of SnO2 and no impure peaks are found. According to Scherrer equation (1), in which λ is the X-ray wavelength, B is the line broadening at half the

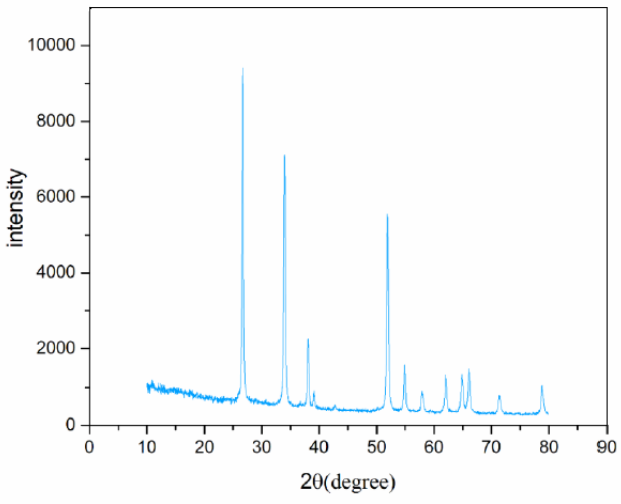

Fig. 2. XRD pattern of SnO_2 nanoparticles

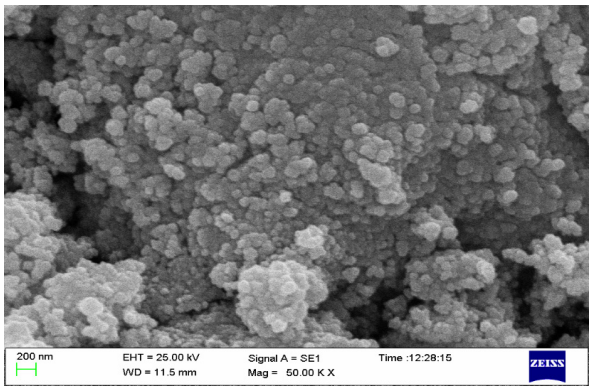

Fig. 3. Scanning electron microscopy of SnO_2

maximum intensity (FWHM), after subtracting the instrumental line broadening, in radians (this quantity is also sometimes denoted as Δ(2θ)) and θ is the Bragg angle (in degrees), crystallite size of nanoparticles was 58.7 nm.

$$D = \frac{0.9\lambda}{B\cos\theta B} \quad (1)$$

Fig. 3 represents the SEM image of pure SnO_2. It suggests that the obtained nanostructure exhibits shaped morphology and the nanoparticles are homogenous with uniform particle size. According to ImageJ software, average particle size was calculated less than 50 nm.

CONCLUSIONS

In this paper SnO_2 nanoparticle was synthesized by hydrothermal method and subsequent calcination. Characterization tests exhibited that synthesized nanoparticles have homogenous structure with uniform size. This nanoparticle can be used for different applications such as drug delivery, heavy metals removal, gas adsorption and etc.

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