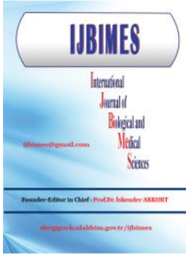
Copyright © IJBiMeS

Vol. 1-No.2 (2016) pp. 1-4

***I**nternational **J**ournal of*
***Bi**ological and **Me**dical **S**cience*
(IJBiMeS)

http://www.ijbimes.com



Research Article

Influence of Reaction Time on the Size of SnO_2 Nanospheres and Its Sensing Properties to VOC Gases [#]

Filiz BORAN[1]*, Sevil ÇETİNKAYA[2]

[1]Hitit University, Engineering Faculty, Chemical Engineering Department, 19030, Corum-Turkey
[2]Cumhuriyet University, Engineering Faculty, Chemical Engineering Department, 58030, Sivas-Turkey

* Corresponding Author : filizbektas@hitit.edu.tr

(First received 15 November 2016 and in final form 17 December 2016)
[#] Presented in "3rd International Conference on Computational and Experimental Science and Engineering (ICCESEN-2016)"

Keywords
Spherical nanoparticle
Tin oxide
VOC gases

Abstract: Tin Oxide (SnO_2) nanoparticles were synthesized using a simple hydrothermal technique at 100ºC reaction temperature in a Teflon lined autoclave without adding any surfactant. A systematic study has been conducted by varying the reaction time between 6 and 72 hours using Tin (II) Chloride hydrate as an inorganic precursor. The influence of reaction time on the morphology, distribution and crystallite size of SnO_2 nanoparticles were analysed by transmission electron microscopy (TEM), X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy. The microscopy studies showed that the morphology of SnO_2 nanoparticles are spherical and SnO_2 nanospheres have an average size of 21.7-34.4 nm at different reaction times. The best combination of size and morphology was obtained at 21.7 nm at 12 hours reaction time. The gas sensing properties of SnO_2 nanospheres to the vapors of various Volatile Organic Compounds (VOC), such as Ammonia, Ethanol, Methanol, Acetone, Chloroform and Toluene were also investigated by two probe resistivity unit in a closed vessel at room temperature. The response of SnO_2 nanospheres to Ammonia vapor at different concentrations (1000-5000 ppm) was measured and SnO_2 nanospheres are observed to have a good sensitivity (98%). These results indicate that SnO_2 nanospheres exhibit to be an important alternative material for the detection of ammonia present in the environment at room temperature.

1. Introduction

Volatile Organic Compounds (VOCs) as toxic compounds, especially ethanol, acetone, ammonia and methyl benzene, are extra harmful to human health. But, they have been widely used in various industries [1]. Nowadays, many semiconductive metal oxides such as SnO_2, WO_3, ZnO, TiO_2, In_2O_3, Fe_2O_3 etc. have been extensively studied for detection of VOCs [2, 3]. Among various metal oxide, tin oxide appears to be one of the most important material because of its high sensitivity to reduce, large surface area, wide-band-gap (Eg= 3,65 eV), dielectric constant, environmental friendliness and easy synthesis [4, 5]. Although there are many studies on synthesis process of SnO_2 nanoparticles, there is no report that focuses on the importance of reaction time to get the smallest particle of SnO_2 nanospheres. To alleviate this deficiency to the extent possible, the influences of reaction time on the size of SnO_2 nanospheres and its sensing properties to the VOCs gases are investigated in this study.

2. Experimental

$SnCl_2.2H_2O$ (2 g) was dissolved in deionized water and 4 ml ammonia solution (%26) was added to this under stirring at room temperature. After that, the solution was transferred into a 120 ml Teflon-lined autoclave and kept at 100 ºC for varying reaction time between 6 and 72 hours. After naturally cooling to room temperature, the sample was filtered, washed with distilled water and ethanol several times, and then dried at 60°C for 24 h. Finally, SnO_2 nanospheres were obtained by annealing the as-prepared precursor in a muffle furnace at 500°C for 2 h.

The SnO_2 nanospheres were examined by using powder X-ray diffraction (XRD) performed on a Rigaku DMAX

IIIC diffractometer with a Cu Kα radiation (1.541871 Ao). Fourier transform infrared (FTIR) spectroscopy was carried out on a Mattson 1000 model FTIR spectrometer in the range of 400-4000 cm^{-1}. The morphology of the synthesized samples was observed by transmission electron microscopy (TEM, FEI Tecnai G2 Spirit Biotwin). The gas sensing measurement was performed by subjecting the synthesized sample pellet to the VOCs vapours in a glass closed test chamber using two probe technique with a Thurlby electrometer. The synthesized sample pellet was pre-prepared by keeping it under 7 t pressure for 3 min. The gas sensitivity is defined as shown in equation 1.

$$\%S = \frac{(\rho a - \rho v)}{\rho a} \times 100 \qquad (1)$$

Here, ρa and ρv are the electrical resistivity of the pellet in air and target VOC vapour, respectively [4].

3. Result and Discussion

3.1. Characterization

X-ray diffraction patterns of SnO_2 nanospheres synthesized at different reaction times are presented in Fig. 1. All the synthesized samples can be indexed to SnO_2 rutile structure without observable impurity peaks. The observed narrow and strong peaks in all the samples indicate the good crystallinity.

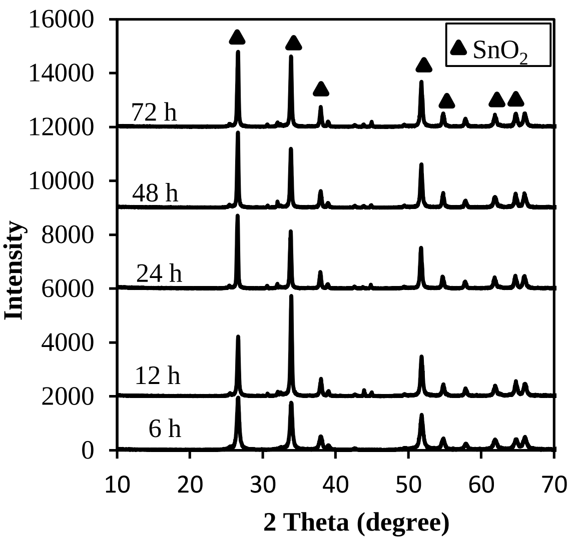


Figure 1. *XRD patterns of SnO_2 nanospheres synthesized at different reaction times.*

The XRD patterns exhibited that the peaks at 2θ 26.6°, 33.9° and 51.9° are associated with (110), (101) and (211) reflection planes of the tetragonal SnO_2 [5]. The characteristics peaks of SnO_2 at around 37.9°, 54.7°, 61.9° and 65.9° corresponding to the (200), (220), (310), and (301) planes respectively were observed [6].

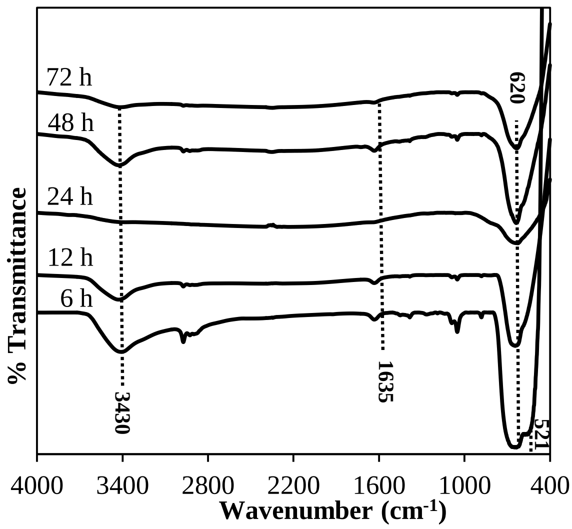


Figure 2. *FT-IR spectrum of SnO_2 nanospheres synthesized at different reaction times.*

Fig. 2 shows the FTIR spectrum of as synthesized SnO_2 nanospheres at different reaction times. The FTIR signals have been attributed to stretching vibration of O-H bending (3430 cm^{-1}, 1635 cm^{-1}), O-Sn-O (620 cm^{-1}) and Sn-OH (521 cm^{-1}). The peak at 521 cm^{-1} disappeared after 12 h due to the transformation of all $Sn(OH)_4$ to SnO_2 [6, 7]. According to these results, we can say that the most appropriate reaction time is 12 hours to form SnO_2.

TEM images of SnO_2 nanospheres synthesized at different reaction times are presented in Fig. 3. The microscopy studies showed that the morphology of SnO_2 nanoparticles are spherical and the crystallite size of the five synthesized samples at different reaction times (6, 12, 24, 48, 72 hours) were 22 nm, 21.7 nm, 34.35 nm, 28.35 nm, 25.37 nm respectively. While at 6 and 24 hours reaction time, the SnO_2 nanoparticles agglomeration are more dominant, the particles show better distribution for reaction time at 12, 48 and 72 hours. The best combination of size and morphology was obtained at 21.7 nm at 12 hours reaction time.

3.2. Gas sensing properties

The response of SnO_2 nanospheres synthesized at 12 hours for saturated ammonia, ethanol, methanol, acetone, chloroform and toluene at room temperature is 98, 26, 28, 30, 47 and 57%, respectively (Fig. 4). In the results, the sample exhibits a remarkably high response to NH_3. Figure 5 shows the gas response towards various concentrations of NH_3 in the range of 1000-5000 ppm and the response is about 14, 25, 32 and 39%, respectively.

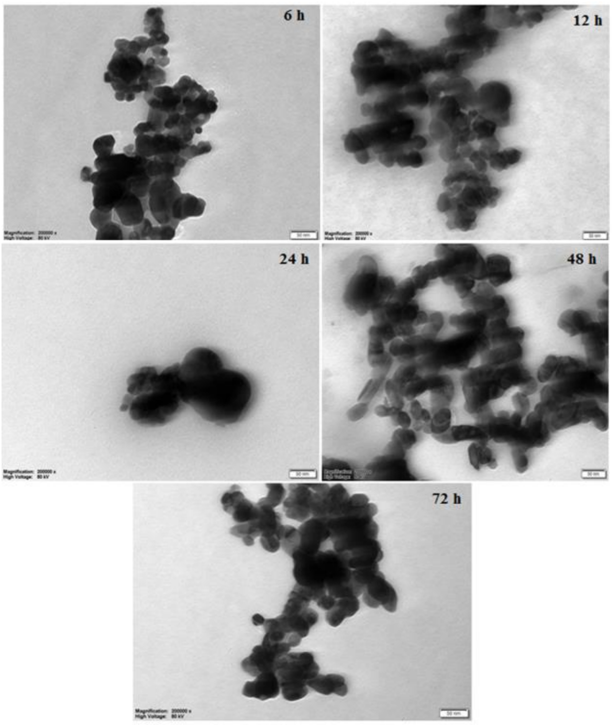


Figure 3. *TEM image of SnO_2 nanospheres synthesized at different reaction times [Scala Bar: 50 nm].*

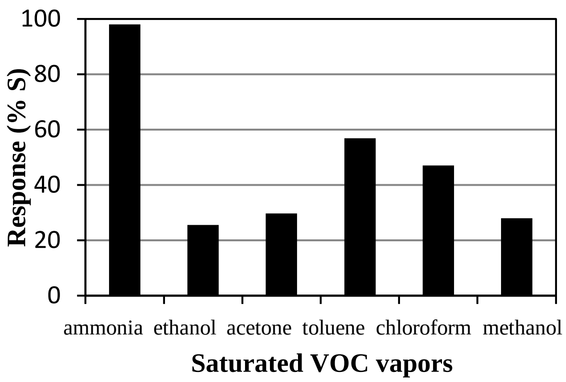


Figure 4. *Gas sensing properties of SnO_2 nanospheres synthesized at 12 hours to various VOCs saturated vapours at*

4. Conclusions

The SnO_2 nanospheres were successfully synthesized through controlling reaction time. The results showed that the reaction time has effect on size and morphology of SnO_2 during the hydrothermal synthesis and the best combination of size and morphology was obtained at 21.7 nm at 12 hours reaction time. Sensing properties of SnO_2 nanospheres exhibit the desirable sensing characteristics towards NH_3 at room temperature. The study showed that SnO_2 nanospheres are promising sensing material for an ammonia vapour sensor.

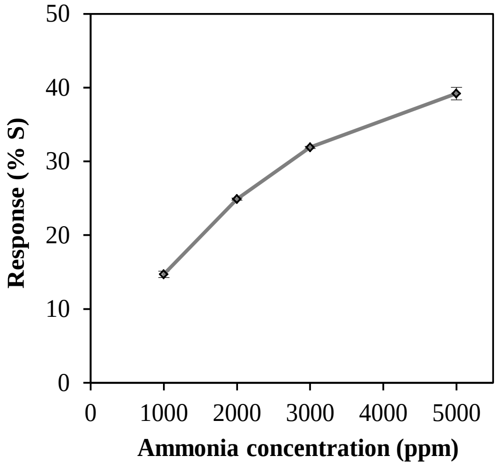


Figure 5. *Gas sensing response towards 1000-5000 ppm of NH_3 at 25ºC of SnO_2 nanospheres synthesized at 12 hours*

Acknowledgements

This work was supported by Cumhuriyet University Scientific Research Project (CUBAP), project numbered as M601.

References

[1] S. Liang, J. Zhu, J. Ding, H. Bi, P. Yao, Q. Han, X. Wang "Deposition of cocoon-like ZnO on graphene sheets for improving gas-sensing properties to ethanol" Applied Surface Science. 357 (2015) 1593–1600. DOI:10.1016/j.apsusc.2015.10.033

[2] B. Shouli, L. Dianqing, H. Dongmei, L. Ruixian, C. Aifan, C.C. Liu "Preparation, characterization of WO_3–SnO_2 nanocomposites and their sensing properties for NO2" Sensors and Actuators B: Chemical. 150 (2010) 749-755. DOI:10.1016/j.snb.2010.08.007

[3] J. Huang, Y. Kang, T. Yang, Y. Wang, S. Wang "Preparation of polythiophene/WO_3 organic-inorganic hybrids and their gas sensing properties for NO_2 detection at low temperature" Journal of Natural Gas Chemistry. 20 (2011) 403–407. DOI:10.1016/S1003-9953(10)60196-X

[4] S. B. Kondawar, S. P. Agrawal, S. H. Nimkar, H. J. Sharm, P. T. Patil "Conductive polyaniline-tin oxide nanocomposites for ammonia sensor" Adv. Mat. Lett. 3-5 (2012) 393-398. DOI:10.5185/amlett.2012.6361

[5] M. A. Farrukh, B-T. Heng, R. Adnan "Surfactant-controlled aqueous synthesis of SnO_2 nanoparticles via the hydrothermal and conventional heating methods" Turk J Chem. 34 (2010) 537 – 550. DOI:10.3906/kim-1001-466

[6] G.E. Patil, D.D. Kajale, V.B. Gaikwad, G.H. Jain "Preparation and characterization of SnO_2 nanoparticles by hydrothermal route" International Nano Letters. 2-17 (2012) 46-51. DOI:10.1186/2228-5326-2-17

[7] R. Adnan, N. A. Razana, I. A. Rahman and M. A. Farrukh "Synthesis and Characterization of High Surface Area Tin Oxide Nanoparticles via the Sol-Gel Method as a Catalyst for the Hydrogenation of Styrene" Journal of the Chinese Chemical Society. 57 (2010) 222-229. DOI:10.1002/jccs.201000034