

Flame-made Sb-doped SnO₂ Nanoparticulate Sensors for Acetic Acid Sensing

A. Sukee^{1,2}, A. Wisitsoraat^{3,4}, A. Tuantranont^{3,5}, S. Phanichphant³, C. Liewhiran^{1,3,6}

¹ *Department of Physics and Materials Science, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand*

² *Graduate School, Chiang Mai University, Chiang Mai 50200, Thailand*

³ *Center of Advanced Materials for Printed Electronics and Sensors, Materials Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand*

⁴ *Carbon-based Devices and Nanoelectronics Laboratory, National Electronics and Computer Technology Center, National Science and Technology Development Agency, Klong Luang, Pathumthani 12120, Thailand*

⁵ *Thailand Organic and Printed Electronics Innovation Center, National Electronics and Computer Technology Center, National Science and Technology Development Agency, Klong Luang, Pathumthani 12120, Thailand*

⁶ *Center of Excellence in Materials Science and Technology, Chiang Mai University, Chiang Mai 50200, Thailand*

Corresponding author's e-mail address: cliewhiran@gmail.com (C. Liewhiran)

Abstract:

Acetic acid (CH₃COOH) is one of the most important volatile organic acid (VOA) since it can be produced by fermentation and oxidation of natural carbohydrate. It is typically released from objectionable garbage or some spoiled food at ppm levels causing environmental pollution and danger to human health [1]. Hence, it is compelling to develop effective gas-sensing materials to detect the release of acetic acid [2-4]. In this work, Sb-doped SnO₂ were synthesized by flame spray pyrolysis in one step (Fig.1) and investigated for acetic acid detection. The as-prepared nanopowders were used to fabricate the sensing films by spin coating and tested towards 50-1000 ppm acetic acid at operating temperature from 150-350°C in dry air. All as-prepared nanopowders and fabricated sensing films were characterized by X-ray analysis, nitrogen adsorption and electron microscopy. From the electrical measurement results (Fig.2), the resistances of SnO₂ sensors decreases by 2-3 orders of magnitude with increasing Sb doping level from 0 to 2 wt% due to the Sb substitution at Sn lattice sites, which generates free electrons in conduction band of SnO₂, leading to a reduction in its electrical resistivity [3, 4]. From gas-sensing response, the 0.1 wt% Sb-doped SnO₂ sensing film exhibited a high response of ~73 toward 1000 ppm acetic acid at 300°C, which is more than one order of magnitude higher than that of undoped one. Therefore, flame-made 0.1 wt% Sb-doped SnO₂ sensor is a promising candidate for sensitive detection of acetic acid and may be beneficial in food science and environmental applications.

Key words: Flame spray pyrolysis, Sb doping, SnO₂, Acetic acid sensing.

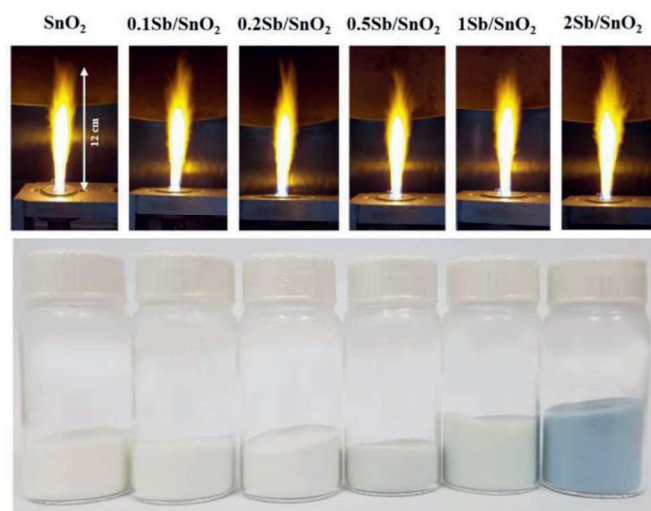


Fig. 1. The spray flame and as-prepared FSP-made nanopowders appearance of pure SnO_2 and 0.1-2 wt% Sb-doped SnO_2 nanoparticles. The flame appearance was all yellowish-orange and flame height was averaged of 12 cm.

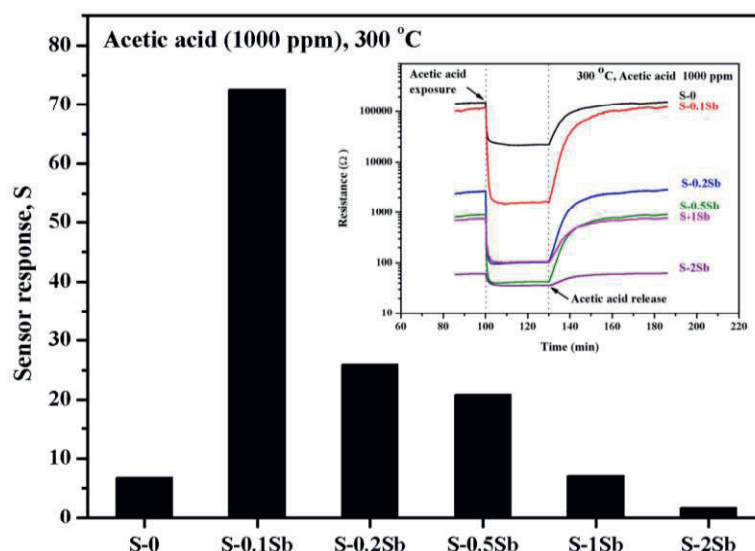


Fig. 2. The histograms of typical sensor response with corresponding a change in resistance (inset) of pure SnO_2 (S-0) and 0.1-2 wt% Sb/ SnO_2 sensors (S-0.1Sb to S-2Sb) towards 1000 ppm acetic acid at optimal operating temperature of 300 °C in dry air.

References

- [1] G. D. Nielsen, L. F. Hansen, B. A. Nexø, O. M. Poulsen, Indoor Air Guideline Levels for Formic, Acetic, Propionic and Butyric Acid, *Indoor Air* 5, 8-24 (1998); doi: 10.1111/j.1600-0668.1998.tb00028.x
- [2] C. Liewhiran, N. Tamaekong, A. Wisitsoraat, S. Phanichphant, Highly selective environmental sensors based on flame-spray-made SnO_2 nanoparticles, *Sensors and Actuators B: Chemical* 163, 51-60 (2012); doi: 10.1016/j.snb.2011.12.097
- [3] J. Rebholz, P. Bonanati, C. Jaeschke, M. Hübner, L. Mädler, U. Weimar, N. Barsan, Conduction mechanism in undoped and antimony doped SnO_2 based FSP gas sensors, *Sensors and Actuators B: Chemical* 188, 631-636 (2013); doi: 10.1016/j.snb.2013.07.063
- [4] W.X. Jin, S.Y. Ma, Z.Z. Tie, W.Q. Li, J. Luo, L. Cheng, X.L. Xu, T.T. Wang, X.H. Jiang, Y.Z. Mao, Synthesis of hierarchical SnO_2 nanoflowers with enhanced acetic acid gas sensing properties, *Applied Surface Science* 353, 71-78, (2015); doi: 10.1016/j.apsusc.2015.06.089