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Ultra-Sensitive Formic Acid Gas Sensor Based on Zn-doped SnO_2 Nanoparticles Prepared by Flame Spray Pyrolysis

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Abstract

Volatile Organic Acids (VOA) are organic compounds with acidic properties. The most common organic acids are the carboxylic-based acids, including formic acid, acetic acid, lactic acid and propionic acid. Specifically, formic acid detection is an effective carrier for hydrogen production widely used in many applications including medicine, pesticide, organic synthesis, and tannery industry [1, 2]. Although the leakage in formic acid processing could not be detected at the very first time, it may affect seriously damage both in human body and factory. Hence, it is interesting to produce the effective sensing materials for the rapid formic detection. In this present study, flame-spray-made Zn-doped SnO_2 nanoparticles with 0.1−1 wt% Zn contents (Fig.1) were systematically studied for formic detection. The particle and sensing film properties were characterized by X-ray diffraction, nitrogen adsorption, electron microscopy, energy dispersive X-ray spectroscopy and X-ray photoelectron spectroscopy. The sensing films were tested towards 50−1000 ppm formic acid at operating temperatures ranging from 200 to 400°C in dry air. Gas-sensing results demonstrated that the SnO_2 sensing film with the optimal Zn content of 0.2 wt% exhibited a very high response of ~46400 toward 1000 ppm formic acid with short response time within second at the optimal operating temperature of 350°C (Fig.2). Therefore, the Zn-doped SnO_2 sensors are promising for ultra-sensitive detections of formic acid and may be useful for industrial and biomedical applications.

Keywords: Zn, SnO_2, Flame spray pyrolysis, Formic acid, VOA sensor.

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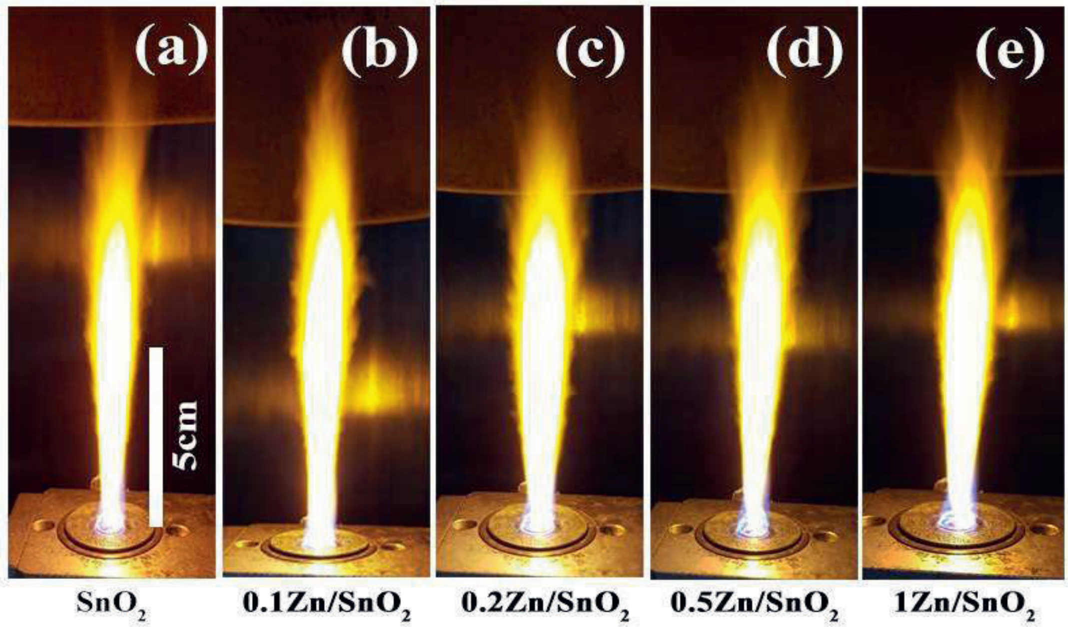

Fig. 1. Spray flame of (a) pure SnO_2, (b-e) 0.1 -1 wt% Zn/SnO_2 nanoparticles using 5 mL/min of liquid precursor feed rate and dispersed by O_2 (5 L/min) at 1.5 bar pressure drop across the nozzle tip.

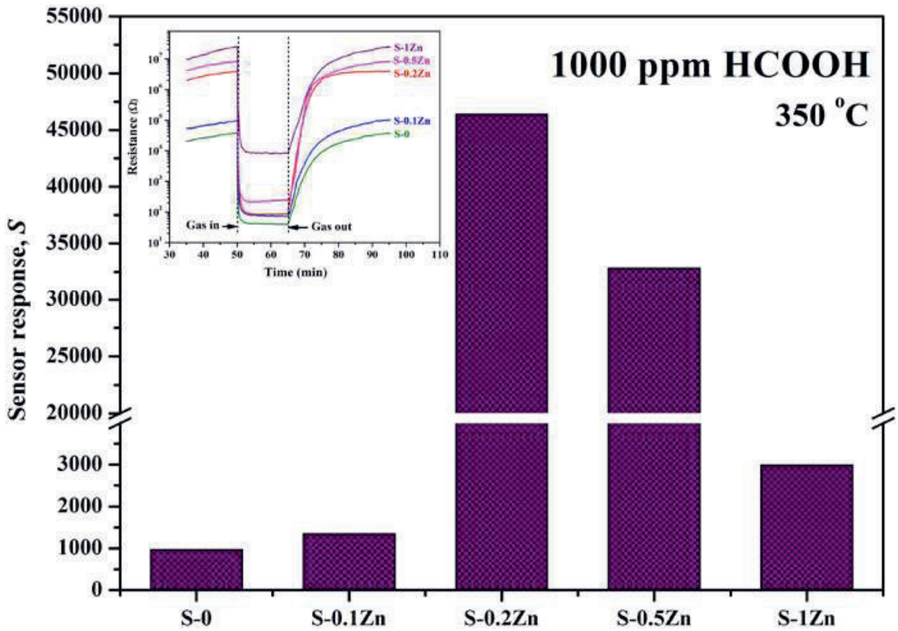

Fig. 2. The histograms of typical sensor response with corresponding change in resistance (inset) of undoped SnO_2 (S-0), and 0.1–1 wt% Zn-doped SnO_2 sensors (S-0.1Zn to S-1Zn) towards 1000 ppm HCOOH at optimal operating temperatures of 350˚C in dry air.

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