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The hydrothermal synthesis and gas sensing properties of ellipse-like Fe_2O_3

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Abstract

Fe_2O_3 particles were successfully synthesized by hydrothermal method. The morphology and gas sensing properties were investigated. The results shows that the diameter of the minor axis and major axis of ellipse-like Fe_2O_3 is about 800 nm and 500 nm, respectively. The sensor based on Fe_2O_3 particles exhibits an good response of about 48.2 to 1000 ppm triethylamine at optimum operating temperature of 400oC. The response time is 21 s , showing fast response to triethylamine.

Keywords

Fe_2O_3; hydrothermal method; gas sensing properties.

1. Introduction

As one of the main gas sensing matrix materials, n-type Fe_2O_3 gas sensing material is often used to detect combustible and toxic gases because of its non-toxic, low cost and good stability [1-6]. At present, many methods such as hydrothermal method [7], co-precipitation method [8], sol-gel method [9] and micro-emulsion method [10] have been adopted to prepared Fe_2O_3. In this experiment, Fe_2O_3 elliptical particles were prepared by hydrothermal method and their gas sensing properties were investigated.

2. Experimental Section

2.1 Chemicals and reagents

$FeCl_3$ $6H_2O$, ethanol, acetone, triethylamine and benzene were purchased from Tianjin Tianli Chemical Reagent Co., Ltd. Octylamine ($C_8H_{19}N$) were purchased fromTianjin kwangfu Fine Chemical Industry Research Institute. All chemicals were analytical grade and without further purification process. All solutions were prepared with deionized water.

2.2 Preparation of Fe2O3 particles

2 mmol $FeCl_3$ $6H_2O$ was dissolved in 20 mL deionized water to form a clear light yellow solution (solution A), and then 1 mmol $C_8H_{19}N$ was was dissolved in 20 mL n-butanol to form a clear solution (solution B). Then solution B was added into solution A and stirred for 20 minutes. The mixed solution was transferred into 50 mL Teflon-lined stainless steel autoclave and heated at 200^{o}C for 24 hours. After natural cooling, the precipitate was filtered and washed with deionized water and anhydrous ethanol for many times. Finally, the product was dried at 80^{o}C for 12 hours to obtain the reddish brown sample.

2.3 Fabrication and measurement of gas sensor

Fe_2O_3 particles were mixed with terpineol to form a paste. The paste was coated onto a ceramic tube with a pair of gold electrodes to and dried at 80^{o}C for 2 h. Then the sensor was annealed at 500^{o}C for 2 h in air. Finally, a Ni-Cr alloy coil was inserted and fixed into the ceramic tubes for controlling the

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operating temperature. The gas responses were defined S = Ra/Rg for reducing gas, where Ra is the resistance of sensor in gas, Ra is the resistance in test gases.

3. Results and discussion

3.1 Morphology analysis of sample

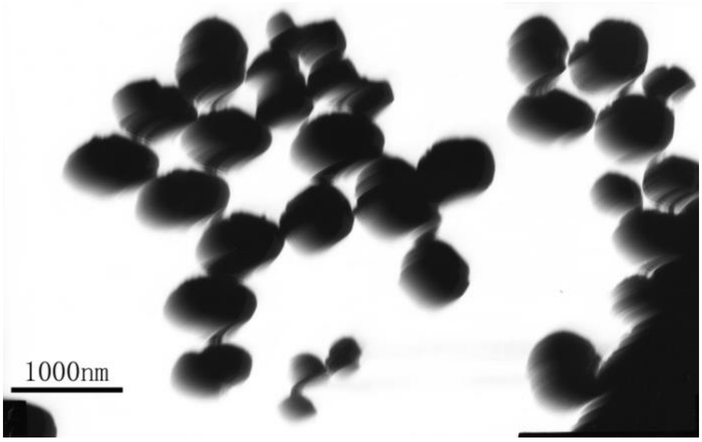

Fig. 1 TEM photographs of Fe_2O_3 particles

Fig. 1 shows the TEM micrograph of the Fe_2O_3 sample. It can be seen that the particles are elliptical. The diameter of the minor axis and major axis is about 800 nm and 500 nm, respectively.

3.2 Gas sensing performance analysis

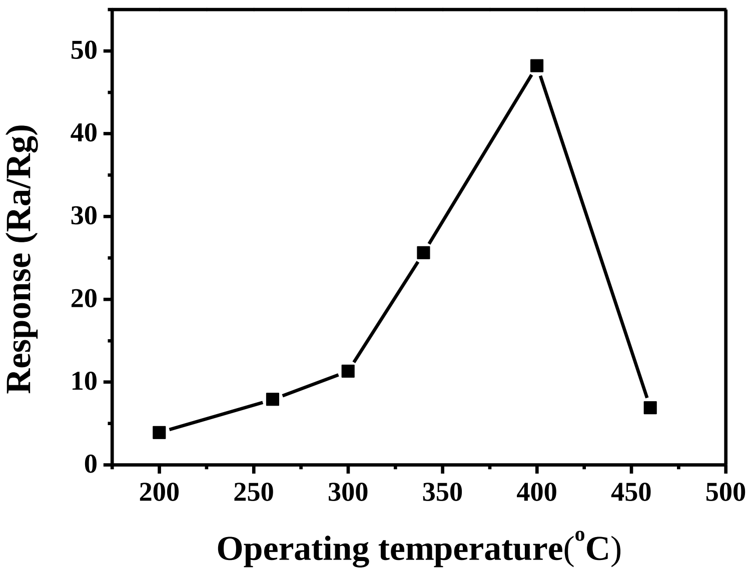

Fig.2 Responses of the Fe_2O_3 sensor to 1000 ppm triethylamine at different temperature

The responses of the Fe_2O_3 sensor to 1000 ppm triethylamine at different operating temperature are showed in Fig. 2. The result shows that the response to triethylamine continuously increases below 400°C, and then decreases. It is obvious that the sensor possesses highest response of 48.2 to 1000 ppm triethylamine at 400°C. Therefore, 400°C is the optimum operating temperature and is used for further sensing tests.

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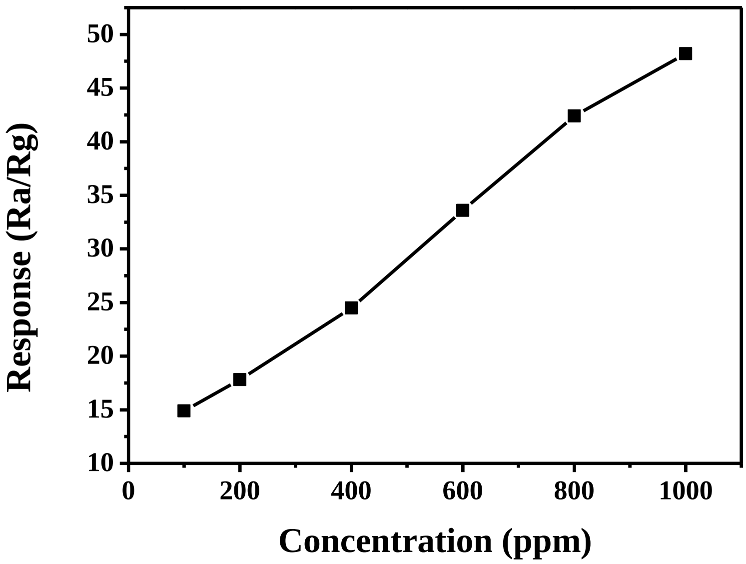

Fig. 3 Responses of the Fe_2O_3 sensor to different concentration triethylamine at 400°C

Fig. 3 depicts the gas response of Fe_2O_3 sensor to different concentration triethylamine at 400°C. Linear relationship between response and concentration can be seen in Fig. 3.

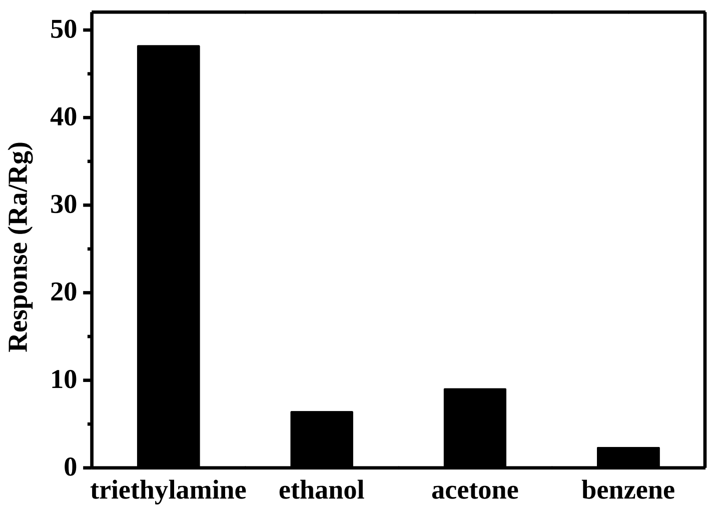

Fig. 4 Responses of the Fe_2O_3 sensor to different VOC gases at 400°C

Fig. 4 shows the responses of the sensor to different VOC gases of ethanol, acetone, triethylamine and benzene at 400°C. It can be seen that the response of Fe_2O_3 sensor to triethylamine is about 4 times that of other gases, which indicates the Fe_2O_3 sensor exhibits good selectivity to triethylamine.

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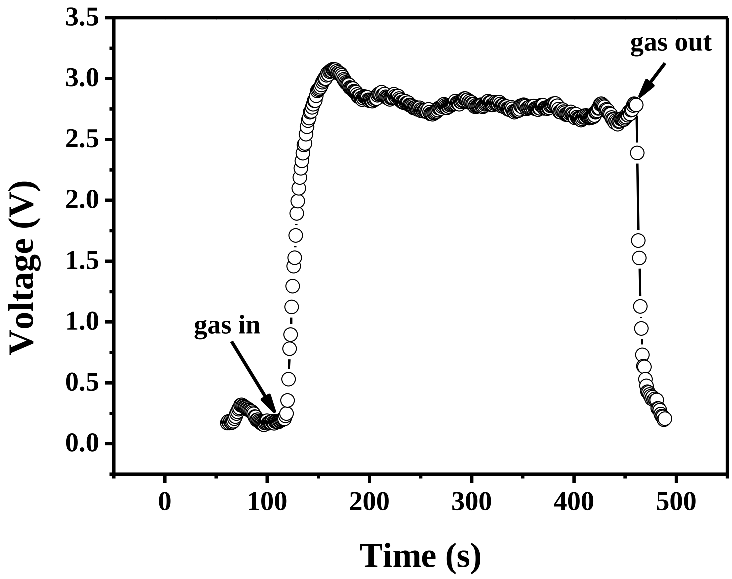

Fig.5 Response and recovery time of Fe_2O_3 sensor to 800 ppm triethylamine at 400°C

Fig.5 shows the response and recovery time of Fe_2O_3 sensor to 800 ppm triethylamine at 400°C. It can be seen that the response time of sensor to triethylamine is 21 s and the recovery time is 84 s at the optimum operating temperature of 400°C. The recovery time is much longer.

4. Conclusion

Ellipse-like Fe_2O_3 particles was successfully synthesized via hydrothermal method and its sensing properties were investigated. The sensor exhibits high response, good selectivity and fast response to triethylamine at 400°C. These results suggest that the sensor might have great potential to be used to detect triethylamine gas.

Acknowledgements

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