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# Highly sensitive BTEX sensors based on hexagonal $WO_3$ nanosheets

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**Abstract :**
Hexagonal $WO_3$ (h-$WO_3$) nanosheets for selectively sensing BTEX (benzene, toluene, ethylbenzene, and xylol) were synthesized by a facile, low-cost and environmentally friendly hydrothermal method. The structure and morphology of the products were characterized by several techniques, such as powder X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), transmission electron microscopy (TEM), and high resolution transmission electron microscopy (HRTEM). The results showed that the as-prepared $WO_3$ are hexagonal nanosheets. Gas sensing tests of side-heating sensors exhibited that the h-$WO_3$ nanosheets(NS) had a much better response to BTEX rather than other VOCs such as ethanol, acetone, formaldehyde, methanol and ammonia. At the optimal working temperature of 320 ℃, the response value of the h-$WO_3$ nanosheets sensor to 50 ppm (parts per million ) BTEX was 8 times more than the other gases. Compared with h-$WO_3$ nanoparticles(NP) and nanorods(NR), the h-$WO_3$ nanosheets had the best selectivity and sensitivity for BTEX, which was 9 times more than h-$WO_3$ nanoparticles and nanorods.

**Key words:** h-$WO_3$ nanosheets, BTEX (benzene, toluene, ethylbenzene, and xylol), VOCs, gas sensor

**Results and Discussion**

Fig.1(a) demonstrates the XRD pattern of h-$WO_3$ NS. It can be seen from pattern that all the diffraction peaks were sharp and well indexed to the hexagonal phase $WO_3$(JCPDS: 33-1387, a=7.298Ǻ, b=7.298Ǻ). No peaks are observed from impurities and explaining the products with high crystallization through hydrothermal method.The XRD prtterns of h-$WO_3$ NP, h-$WO_3$ NR in Fig.1(b). It is quite clear that all the peaks were well indexed to the the hexagonal phase $WO_3$(JCPDS: 85-2460, a=7.324Ǻ, b=7.662Ǻ) and without any impurity, illustrating there is little effect for the phase of materials.

In Fig.2, the irregular h-$WO_3$ NS were obtained by hydrothermal method. A majority of h-$WO_3$ NS possess a size in the range from 300 to 500 nm

Fig. 3 shows the response of h-$WO_3$ NS based gas sensors to 50 ppm BTEX so as to confirm the optimum working temperature. It can be seen that the responses of sensors firstly increased when temperature up to 320 ℃ and afterwards declines when the temperature up to 350 ℃, which are attributed to against the gas molecules adsorbed on the surface when the temperature is over high. Therefore we select 320 ℃ as the optimum working temperature for further examining.

Fig.4 shows the responses to BTEX of the sensors based on different morphology $WO_3$ under the concentration of these gases was 50 ppm. It can be seen that the maximum response value of h-$WO_3$ NS sensor was 41 at 320 ℃. Compared with h-$WO_3$ NP and h-$WO_3$ NR, the h-$WO_3$ NS had the best selectivity and sensitivity for BTEX.

As shown in Fig.5, The responses of h-$WO_3$ NS sensors toward various gases (gas concentration is 50 ppm), obviously the response to BTEX was at least 8 times higher than the other gases, suggesting the h-$WO_3$ NS sensor had a good selectivity.

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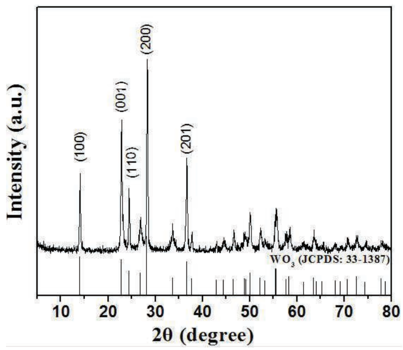
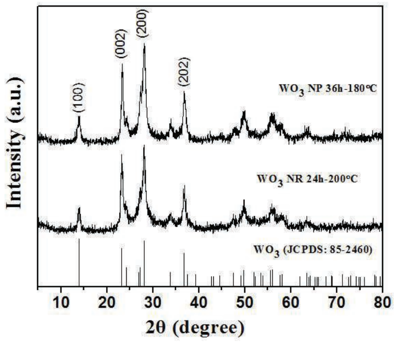



(a)




(b)

*Fig.1 XRD patterns of (a) h-$WO_3$ NS; (b) h-$WO_3$ NP and h-$WO_3$ NR*

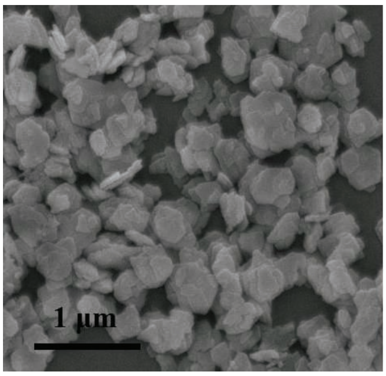



*Fig.2 The SEM image of h-$WO_3$ NS*

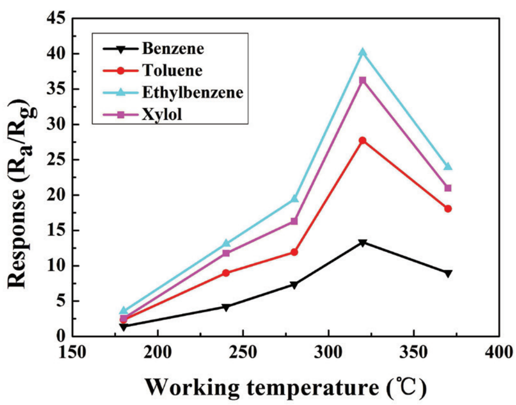



*Fig.3 The responses of h-$WO_3$ NS to 50 ppm BTEX under the different working temperature.*

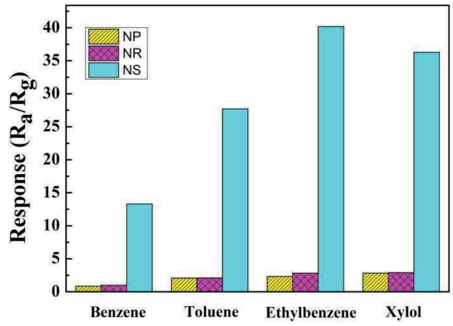



*Fig.4 Responses of the different morphology $WO_3$ sensors to BTEX*

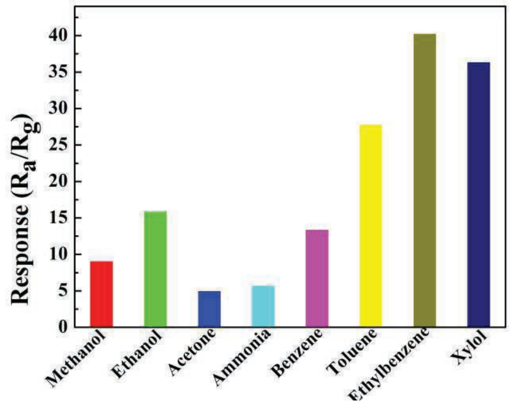



*Fig.5 Responses of the sensor based on h-$WO_3$ nanosheets to various gases*

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