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Highly Selective and Sensitive Detection of Xylene using Cr_2O_3-$ZnCr_2O_4$ Nano-heterostructures

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Abstract

The galvanic replacement reaction can be a promising synthetic method for preparing uniform and intimately mixed hetero-nanostructures. In this study, ZnO hollow spheres were synthesized by ultrasonic spray pyrolysis and subsequently converted into Cr_2O_3/$ZnCr_2O_4$ nanocomposite powders or phase-pure $ZnCr_2O_4$ powders via galvanic replacement reaction. Single-phase ZnO and Cr_2O_3 powders showed ethanol selectivity, whereas single-phase $ZnCr_2O_4$ showed no substantial response and selectivity to any specific gases. In contrast, the Cr_2O_3/$ZnCr_2O_4$ hetero-nanostructures showed significantly higher response to xylene than other interference gases. For example, the response to 5 ppm xylene is 69.2 at 275 °C which is 26.7 times higher than the response to 5 ppm ethanol. This result demonstrates that co-existence of Cr_2O_3 and $ZnCr_2O_4$ is needed for selective sensing of xylene. To investigate the effect of galvanic replacement reaction, coarse Cr_2O_3/$ZnCr_2O_4$ nanocomposite was prepared by solid state reaction. The sample showed relatively low response and selectivity to xylene. These results suggest that uniformly and intimately mixed Cr_2O_3 and $ZnCr_2O_4$ nano particles exhibit highly selective and sensitive sensing of xylene due to synergistic catalytic promotion and high chemiresistive variation of nanoparticles. The galvanic replacement reaction is a facile and effective synthetic route for preparing oxide hetero-nanostructures for high-performance gas sensor applications.

Key words: metal oxide gas sensor, $ZnCr_2O_4$, Cr_2O_3, Galvanic replacement, xylene