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MoS_2 graphene fiber based gas sensing devices

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ABSTRACT

A facile method is developed to synthesize a fiber-like reduced graphene oxided (rGO)/molybdenum disulfide (MoS_2) composites through a wet-spinning and a hydrothermal method. In the presence of Dodecyl dimethyl benzyl ammonium chloride, graphene provides a substrate for nucleation of MoS_2. In this composite, MoS_2 nanosheets can be anchored onto the surface of graphene through both physical adsorption and electron transfer by hydrothermal method. This process inhibits both graphene and MoS_2 layers from stacking together. The gas sensing properties are evaluated in an intelligent gas sensing analysis system. It is demonstrated that the obtained composite fiber devices show an excellent sensitivity and selectivity to NO_2 and NH_3 than the individual components in different light illumination conditions and the proper proportion of components was detected.

1. Introduction

Nanomaterials have attracted much attention in gas sensing devices owing to their improvement in surface-to-volume ratio characteristics [1–3]. In particular, graphene-based gas sensors have recently attracted intensive attention, mainly due to the atomically thin-layered 2D structure and excellent electrical properties of graphene sheets [4–7]. To absorb the structural merits and overcome the zero-band-gap shortage of graphene, other graphene-like 2D layered semiconducting materials with appropriate band gap such as molybdenum disulfide (MoS_2) [8,9], hexagonal boron nitride (h-BN) [10,11] and tungsten diselenide (WSe_2) [12,13] have inspired scientists to research on.

As a typical graphene-liked 2D layered n-type semiconductor, MoS_2 is composed of three atom layers (S–Mo–S) and stacked through van der Waals force (vdW). What is more, when the numbers of MoS_2 layers is reduced, the indirect band gap becomes direct and wide high luminescence efficiency [14,15]. Other works have shown that the thin-film transistor (TFT) based on few layers MoS_2 film exhibited a high sensitivity to NO, NO_2 and NH_3. While, the low conductivities of MoS_2 usually limit its performances [16,17]. Blending it with graphene nanosheets to form hybrid architectures can improve their electrochemical, catalytic and sensing behaviors [18,19]. However, there are few recent reports on their potential as an effective gas sensor [20].

Recently, flexible and wearable devices with excellent performance, even under high tensile strain or large deformation, have attracted increasing attention because of their multifunctional applications, including supercapacitors [21,22], polymer solar cells [23,24] and organic light emitting diode (OLED) [25]. The fiber form of devices assembled by carbon nanotubes [26] or graphene [27,28] is a new structural in relative areas and is more advantageous compared to traditional film or sheet-type devices due to their lower weight, flexibility and compactness in practical applications. However, graphene fiber-based gas sensors are rarely reported.

Accordingly, we reported a facile way to produce reduced graphene oxided (rGO)/MoS_2 (G/M) fibers for gas sensing. The present work contains two steps: (1) a wet-spinning method to obtain a template (2) a hydrothermal for the synthesis of layered G/M composites. In addition, we employed a cationic surfactant Dodecyl dimethyl benzyl ammonium chloride (DDBAC) for better adsorption and nucleation of MoS_2 on graphene substrate. The sensing properties of G/M fibers were evaluated with NO_2, NH_3, humidity and other organics. The main reason for the outstanding performance is that MoS_2 has a good selectivity and sensibility and graphene provides a skeleton and a reinforcement in electronic conductivities. This undoubtedly opens up new possibilities for flexible and wearable devices for various environmental sensing applications.

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