Solvent co-exfoliated graphene/MoS_2 nanocomposite for photoactivated VOCs gas detection

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Abstract

Graphene has been demonstrated as a potential gas sensor material by many researches [1,2]. However, the strong binding energy between graphene and analyte molecules leads to an inefficient desorption and subsequently a poor reliability on sensing performance. Besides, the lack of semiconducting property of graphene also disables the modulation of the transport characteristics through light irradiation or gate bias tuning to enhance the sensing performance. Compositing graphene with other two-dimensional (2D) layered materials brings in new or tailored properties, and offers the possibility to overcome the abovementioned shortcomings of graphene as sensor material. It is reported that compositing graphene with MoS_2 provides ultrahigh photogain and excellent photoresponsivity [3,4]. The light induced electron-hole pairs would be greatly helpful for gas adsorption and desorption since the separation of electron-hole pairs increases the carrier concentration on the surface of sensor material. However, up to now, there is no report concerning this photoactivated gas sensing performance of graphene-MoS_2 nanocomposite yet.

In this study, we developed a cost-economical, time-saving and efficient ultrasound-assisted solvent method to exfoliate graphene and MoS_2 simultaneously in a proper solvents mixture. The Hansen Solubility Parameter strategy basing on the theory of surface energy equilibration was applied to predict and optimize the composition of solvents mixture. A ternary-solvent system was used to minimize the difference of surface energy between solvents mixture and solutes. We demonstrated that the addition of solvent species provided an extra dimension to tune the surface energy of solvents mixture, and enabled us to brew the best solvents mixture for exfoliation process. Impressively, graphene-MoS_2 hybrid structure was observed after heat treating co-exfoliated graphene-MoS_2 solution, which was due to the restacking effect. The graphene-MoS_2 nanocomposite was drop-casted on the sensor substrates, as shown in Fig.1 (a), and tested with various volatile organic compounds (VOCs) gases, including ethanol, methanol, benzene, and toluene, at room temperature with visible light irradiation. The experimental results revealed that the nanocomposite sensor exhibited n-type sensing response towards reducing VOCs gases, as shown in Fig. 1 (b). The sensing performance of nanocomposite sensor surpassed both graphene-based and MoS_2-based sensor owing to the synergetic effect. Remarkably, the sensing property of nanocomposite sensor underwent degradation when the visible light irradiation was removed.

References

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Figures

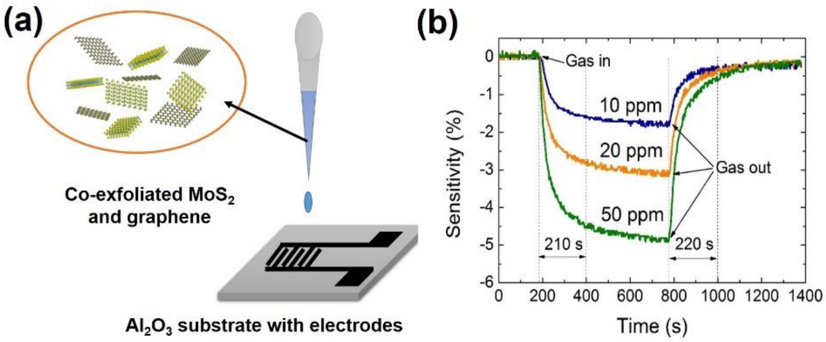

Fig. 1 (a) The fabrication process of graphene-MoS_2 nanocomposite sensor. (b) The typical sensing response of graphene-MoS_2 nanocomposite sensor towards methanol gas with different concentrations at room temperature with visible light irradiation.