

Synthesis and sensing properties of SnS₂/rGO composite towards NO₂ gas at room temperature

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Summary:

In the present work, a SnS₂/rGO composite was prepared via mechanical mixing with different rGO proportions with the objective of sensing NO₂ at room temperature. The SnS₂/rGO 15% sample showed a high response and good selectivity at room temperature, with a 40% humidity level being determined as ideal for increasing the sensors' response.

Keywords: gas sensing, dichalcogenides, reduced graphene oxide

Background, Motivation and Objective

NO₂ gas is linked to increased mortality from respiratory and cardiovascular diseases¹; therefore, the development of efficient gas sensors is extremely important to monitor exposure. In this context, composites based on tin disulfide (SnS₂) and reduced graphene oxide (rGO) have been reported as excellent choices for NO₂ sensing, combining the strong chemical affinity between NO₂ and SnS₂ and the high electron conductivity of rGO₂.

Presently, we propose combining SnS₂ and rGO into a mechanically mixed composite for a NO₂ sensor that offers selective detection, high sensitivity, and operates effectively at room temperature.

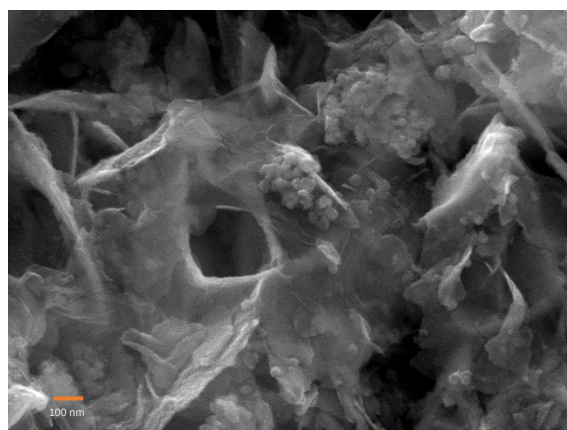
Description of the New Method or System

In this work, a mechanical mixing method was employed in order to form the SnS₂/rGO composite. This allows for the freedom to choose the appropriate synthetic route for each component, avoiding the formation of secondary phases while also enabling precise control of the components' characteristics before the composite is formed.

Results

The samples were prepared by mechanically mixing pre-synthesized rGO and SnS₂ in fixed proportions (15 wt% and 25 wt% rGO) to achieve a NO₂ sensor that is selective and operates at room temperature. In Figure 1, the scanning electron microscopy (SEM) image shows that the small SnS₂ particles are adhered underneath the rGO sheets in agglomerates.

Figure 1: SEM image of the SnS₂/rGO 15% sample.



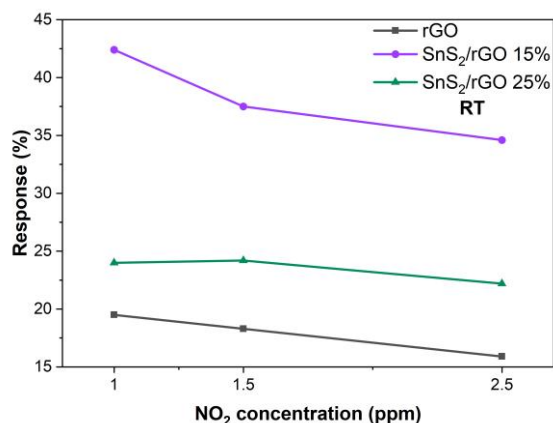
For the gas sensing measurements, the response was calculated as follows:

$$\text{Response (\%)} = ((R_a - R_g)/R_a) \times 100 \quad (1)$$

Figure 2 illustrates the relationship between the sensor response and NO₂ concentration.

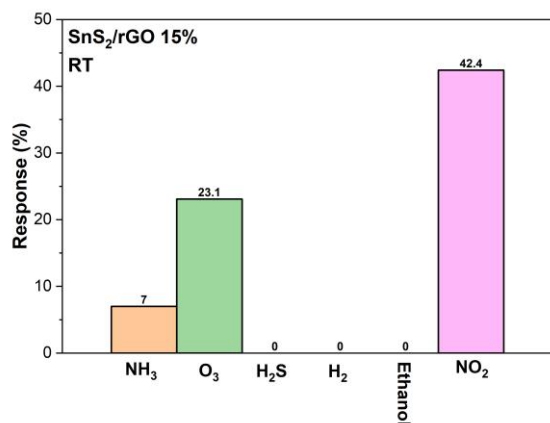
As can be observed, the composition containing 15 wt% rGO in SnS₂ exhibited two times higher response compared to the pure rGO sample and 1.7 times the response observed for the 25 wt% formulation at room temperature.

Figure 2: response $\times$ concentration data for the pure rGO, SnS₂/rGO 15%, and SnS₂/rGO 25%.



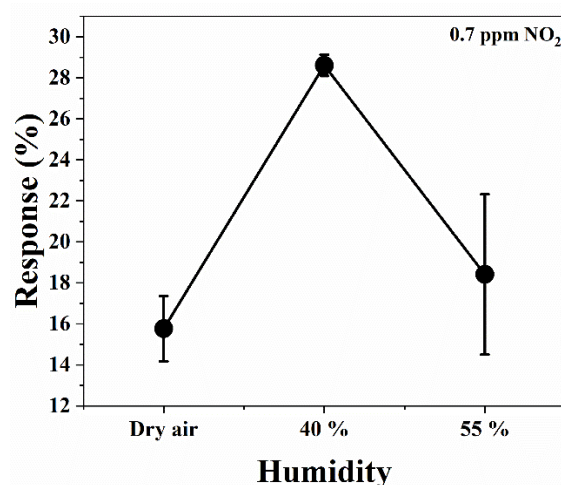
Since the SnS₂/rGO 15% presented the best characteristics among the evaluated samples, this sensor was chosen for the selectivity test. The selectivity test was performed using O₃, NH₃, H₂S, H₂, and ethanol gases, as displayed in Figure 3. It can be observed that although the SnS₂/rGO 15% composite shows some response to NH₃ and O₃, its response to NO₂ is much higher, indicating good selectivity towards NO₂. The sample did not show a significant response to H₂S, H₂, or ethanol.

Figure 3: selectivity test of the SnS₂/rGO 15% sample towards NH₃, O₃, H₂S, H₂, ethanol and NO₂ gases.



Furthermore, tests concerning the effect of humidity in the performance of the sensor were conducted. The results of the humidity test are displayed in Figure 4, where it can be seen that the sensor presents a higher response for a 40% humidity, and as the humidity increases, the response of the sensor tends to decrease.

Figure 4: variation of the response of the SnS₂/rGO 15% with varying humidity levels.



In conclusion, the mechanical mixing dispersion method was effective in forming a composite sensor based on SnS₂ and rGO that operates at room temperature and exhibits good selectivity for NO₂. The humidity plays a significant part in the detection of NO₂, with a 40% humidity level being determined as ideal for increasing the sensors' response.

References

- Chen, X., Qi, L., Li, S. & Duan, X. Long-term NO₂ exposure and mortality: A comprehensive meta-analysis. *Environmental Pollution* **341**, 122971 (2024).
- Cheng, M. *et al.* Highly sensitive sensors based on quasi-2D rGO/SnS₂ hybrid for rapid detection of NO₂ gas. *Sensors and Actuators B: Chemical* **291**, 216–225 (2019).

