High-Performance Carbon Monoxide Gas Sensing Using a 2D WS_2@PEDOT:PSS Organic–Inorganic Hybrid Composite

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Abstract

Continuous and reliable monitoring of carbon monoxide (CO) at room temperature is crucial due to its high toxicity and stringent exposure limits, particularly for portable and low-power environmental sensing applications [1]. However, most commercially available and metal oxide-based CO sensors require elevated operating temperatures, resulting in high power consumption, complex circuitry, and limited suitability for continuous real-time monitoring [2]. To address these limitations, a novel organic-inorganic p-n junction nanocomposite comprising tungsten disulfide nanosheets (WS_2 NSs) and poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) is developed for ultra-sensitive room-temperature CO gas sensing, with mechanistic insights obtained through in situ Raman spectroscopy. The hybrid nanocomposite is synthesised via ultrasonic exfoliation of WS2 followed by uniform dispersion within the PEDOT:PSS matrix, forming an efficient p-n heterojunction. A chemiresistive sensor fabricated using this composite exhibits an outstanding linear response (R^2 = 0.9969) over a wide CO concentration range of 1-600 ppm, with a sensitivity of 0.91 μA/ppm at room temperature. At 25 ppm CO, the sensor demonstrates excellent repeatability along with rapid response and recovery times. *In situ* Raman analysis reveals that CO exposure modulates the carrier concentration at the WS_2@PEDOT:PSS interface, leading to reduced depletion layer thickness and enhanced interfacial charge transport. The proposed sensing platform offers a promising pathway toward energy-efficient, room-temperature CO sensors suitable for practical environmental monitoring.

Keywords: Gas sensors, Tungsten Disulfide (WS_2), Heterojunction, *In situ* Raman.

Reference

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[2] Kaushik, A., *et al.*, **Chemical Reviews**, **115(11)** (2015) 4571–4606.

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