A NEW ORGANIC–INORGANIC NANOCOMPOSITE REDUCED GRAPHENE OXIDE FOR EFFICIENT NO_2 SENSING

Masoud Khaleghiabbasabadi <masoud.khaleghiabbasabadi@tul.cz> Daniele Silvestri, Stanisław Wacławek

This study introduces a NO_2 sensor based on a Fe_3O_4@rGO-N-(piperidine-4-SO_3H) nanocomposite, designed for efficient detection of nitrogen dioxide in polluted air. The sensor was synthesized and characterized using techniques such as EDX, FTIR, TGA, Raman spectroscopy, and SEM. To optimize performance, sensors were fabricated with different weight percentages (1, 5, 10, and 15 weight percent) of the nanocomposite. Sensitivity and response time were evaluated across NO_2 concentrations ranging from 2.5 to 50 ppm. The results revealed that the sensor exhibited maximum efficiency at concentrations above 5 ppm with at least 15 weight percentage of the nanocomposite, proving its environmental monitoring potential.

Keywords: Toxic gas detection, Nanosensor, Reduced graphene oxide, Nanocomposite, Nitrogen dioxide (NO_2)

INTRODUCTION

Nitrogen oxide gases (NO_x), including nitric oxide (NO) and nitrogen dioxide (NO_2), contribute to the formation of harmful nitrous and nitric acids, posing serious threats to both human health and the environment. These gases are major contributors to photochemical smog and acid rain [1]. Primarily generated through fuel combustion in stationary and mobile sources, NO_x emissions remain a significant air pollution concern, prompting stringent control measures [1]. The combustion of fossil fuels such as coal, oil, and natural gas across power generation, transportation, and industrial activities releases pollutants including NO_x, sulfur dioxide (SO_2), and carbon monoxide (CO), further exacerbating air quality issues [1]. This underscores the urgent need for reliable and durable NO_x sensors capable of real-time monitoring to support public health and safety initiatives [1]. Nanomaterials have become increasingly important in scientific and industrial domains due to their unique chemical and physical characteristics. Among them, carbon-based nanostructures have emerged as promising materials in environmental and energy-related applications [1]. Their use in gas sensing has grown rapidly, thanks to their high sensitivity and adaptability for detecting gases such as NO_2 [1]. Graphene derivatives like graphene oxide (GO) and reduced graphene oxide (rGO) are particularly well-suited for gas sensor applications due to their large surface area, which enhances gas adsorption and detection sensitivity.

METHODOLOGY

The nanosensor was fabricated using a combination of electrodeposition and deposition methods. Initially, a gold layer approximately 300 nm thick was electrodeposited onto an alumina substrate using the conventional sputtering technique. Next, 0.2 g of the synthesized Fe_3O_4@rGO-N-(piperidine-4-SO_3H) nanocomposite was dispersed in 3 mL of ethanol via ultrasonication and then applied to the gold-coated alumina using a spin-coating machine. After deposition, the substrate was connected using silver paste, placed in a container, and subsequently heated for 2 hours and dried at 100 °C.

RESULT

The structural properties of the Fe_3O_4@rGO-N-(piperidine-4-SO_3H) were characterized using a range of analytical methods, including energy-dispersive X-ray spectroscopy (EDX), elemental analysis, scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). The combined use of these techniques allowed for a thorough and detailed investigation of the synthesized Fe_3O_4@rGO-N-(piperidine-4-SO_3H) nanocomposite, providing clear and comprehensive insight into its chemical structure. Fig. 1. demonstrates the Sensitivity for different samples of Fe_3O_4@rGO-N-(piperidine-4-SO_3H) in several NO_2 concentrations (2.5 and 50 ppm). The gas-sensing performance of Fe_3O_4@rGO-N-(piperidine-4-SO_3H) nanosensor reveals that sensitivity is influenced by both the NO_2 gas concentration and the density of active sites on the sensor surface. The sensitivity of sensors with varying nanocomposite loadings (1–20 Weight percent) was evaluated across a range of NO_2 concentrations (2.5–50 ppm). Notably, increasing the nanocomposite content from 10 to 15 Weight percent resulted in a marked improvement in sensor sensitivity.

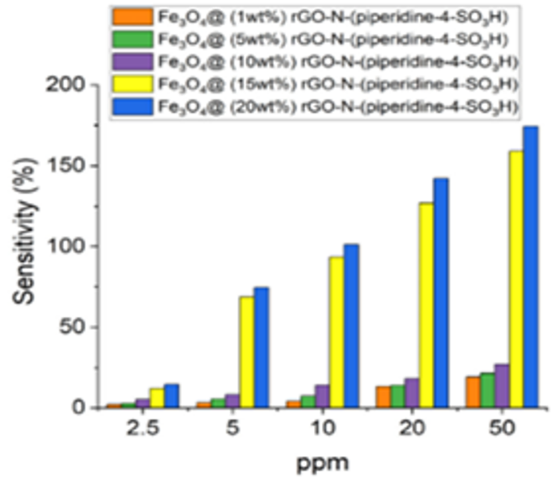

Figure 1: Sensitivity for different samples of Fe_3O_4@rGO-N-(piperidine-4-SO_3H) in several NO_2 concentrations (2.5 and 50 ppm.

CONCLUSIONS

This study outlines the synthesis, analysis, and application of the Fe_3O_4@rGO-N-(piperidine-4-SO_3H) nanocomposite for selective and sensitive NO_2 gas detection. Experimental results show peak performance at NO_2 concentrations above 5 ppm with at least 15 weight percent graphene-based material. At concentrations over 10 ppm, the sensor achieves sensitivity above 100 percent and a response time under 100 seconds. The study confirms that functionalizing graphene oxide with piperidine sulfonic acid significantly boosts its gas-sensing efficiency, making it a promising candidate for advanced NO_2 detection.

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