Development of SWCNT/TiO_2 Gas Sensor for Enhanced Formaldehyde Detection in Composite Wood Material

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In industries such as wood composites, household materials, paper, and textiles, the need for efficient formaldehyde detection is paramount. Traditional methods often lack the simplicity, speed, and sensitivity required for accurate detection. This research focuses on developing a nanotechnology-based gas sensor utilizing Single-Walled Carbon Nanotubes (SWCNT) and Titanium Dioxide (TiO_2) for enhanced formaldehyde detection in wood products. The research addresses the challenge of effectively detecting formaldehyde gas in wood composites using advanced nanotechnology. By employing SWCNT/TiO_2-based gas sensors, the study aims to overcome the limitations of conventional detection methods. The objective is to create a sensor that is both highly sensitive and capable of rapid, accurate and safe formaldehyde detection in various wood products. The Interdigitated Electrode (IDE) pattern was meticulously designed using AutoCAD software, ensuring a gap of 500 µm between finger electrodes. Fabrication of the IDE was carried out using conventional lithography processes. TiO_2 nanoparticles were synthesized via the sol-gel method, and SWCNT was deposited on the TiO_2 surface to develop the gas sensor. Surface morphologies of bare TiO2/AlIDE and SWCNT/TiO_2/AlIDE were characterized using Field Emission Scanning Electron Microscopy (FESEM) and Atomic Force Microscopy (AFM). Electrical measurements including gas response characteristics and chronoamperometry were performed using a potentiostat/galvanostat. Real-time detection was validated using various composite wood products such as block board, particle board, merbau, and HDF. The sensor exhibited high sensitivity, detecting formaldehyde concentrations as low as 0.86 ppm in block board, 0.73 ppm in particle board, 0.40 ppm in merbau, and 0.4 ppm in HDF within a 10-minute timeframe. Repeated data confirmed the sensor's repeatability and effectiveness, offering a viable alternative to conventional desiccator methods for formaldehyde emission testing in composite wood products. The utilization of SWCNT/TiO_2-based gas sensors represents a significant advancement in formaldehyde detection technology for wood products. The sensor's high sensitivity and rapid response make it suitable for real-time monitoring of formaldehyde emissions. By replacing outdated methods with nanotechnology-based solutions, this research contributes to the enhancement of safety and quality standards in industries reliant on wood composites.

Keywords: Formaldehyde, IDE Sensor, SWCNT, TiO_2