UNIVERSITI TEKNOLOGI MARA

SYNTHESIS OF GOLD NANOPARTICLES EMBEDDED GRAPHENE OXIDE FOR FIBRE OPTIC GAS SENSOR APPLICATIONS

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ABSTRACT

In this work, graphene oxide (GO) was successfully synthesized with the optimization formulation obtained using 1g of graphite, 3g of potassium permanganate ($KMnO_4$), 25 mL of sulfuric acid (H_2SO_4), 5 mL of hydrogen peroxide (H_2O_2) with 20°C of reaction temperatures and 3 hours of reaction time. The AuNPs were successfully synthesized with the optimum condition using 0.254 mM of gold chloride ($HAuCl_4$) and 40 mM of trisodium citrate (NaCt). The composite structure of AuNPs embedded to GO (GO-AuNPs) was performed by direct mixing of GO solution to AuNPs solution at various volume ratios (1:05, 1:1, 1:2.5, 1:5, 1:7.5, 1:10 and 1:15). Then, fabrication of GO, AuNPs, and composite GO-AuNPs (at various volume ratios) encapsulated optical fibre probes was performed via dipping process for 24 hours with the aid of vortex mixing. The detection using indoor air exposed the highest light intensity signal on the fibre optic sensor generated from the GO-AuNPs-based sensor at a volume ratio of 1:5 and 1:10. For spectral analysis, the highest CO_2 detection was detected by fibre optic sensors with GO-AuNPs (1:5) as a coating material with 62.7% signal improvement from uncoated sensor probe, 26.4% higher than the signal from GO-coated and 33.9% better than AuNPs-coated sensor. The highest N_2 detection was obtained by the sensor fabricated of GO-AuNPs (1:10) with the signal enhancement of 59.8% from uncoated probe sensors. In the sensitivity analysis which represents the ratio of a change in output intensity to a change in gas concentration, the results of GO-AuNPs (1:5)-based sensor demonstrated excellent sensitivity enhancement to CO_2 detection (28.02% at 25 L/min) and GO-AuNPs (1:10)-based sensor demonstrated high sensitivity to N_2 (12.4% at 25 L/min). The signal also proved that the composite (GO-AuNPs) coating probe provides 6 times higher signal than single-element coating (GO or AuNPs). Based on the stability analysis, GO-AuNPs (1:5) sensors, and GO-AuNPs (1:10) sensors were found to be very stable against CO_2 and N_2. From the selectivity analysis, the results show that GO-AuNPs (1:5), GO-AuNPs (1:10) and AuNPs-based sensors have a high selectivity for CO_2. Meanwhile, GO-based sensors are the most sensitive to N_2 gas, which is supported by the results of selectivity analysis. In summary, the CO_2 and N_2 detection signal from the uncoated probe was really low while all coated probes generated a higher signal, hence proving that the composite (GO-AuNPs) coating materials are very useful in enhancing the signal of the gas detection. This newly integrated configuration of the sensing platform should help in developing versatile optical fibre-based sensors, thus creating enormous sensor application possibilities, especially for gas sensor applications.

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TABLE OF CONTENTS