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TOWARD COPPER SILVER ELECTROCHEMICAL NANOSENSOR FOR 1,3 – DINITROBENZENE

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INTRODUCTION & AIM

Nitroaromatic compounds, such as 1,3-dinitrobenzene (DNB), are widely used in the production of dyes, explosives, and pesticides. DNB is classified as a toxic and potentially carcinogenic substance, known for its harmful effects on the central nervous system. Owing to its stability in aqueous media and resistance to biodegradation, it tends to accumulate in ecosystems, which makes it a serious environmental threat. Conventional detection techniques, although effective, are often costly, time-consuming, and require complex instrumentation. Therefore, there is a strong need for sensitive, rapid, and low-cost electrochemical sensors for monitoring nitroaromatic pollutants. In this context, the present study aims to develop a simple CuAg/rGO nanocomposite for the modification of glassy carbon electrodes, enabling fast and reliable electrochemical detection of DNB in water, with a low detection limit in environmentally relevant concentration ranges and potential application in routine environmental monitoring.

MATERIALS AND METHODS

Graphene oxide was synthesized using a modified Hummer's method, while CuAg/rGO nanocomposites were obtained by adapting the procedure of R. Krishna et al. The resulting materials were characterized by SEM and TEM in order to confirm the morphology and distribution of metal nanoparticles on the graphene sheets. For electrode preparation, catalytic ink was prepared by dispersing 5 mg of CuAg/rGO in 980 µL of ethanol and 20 µL of Nafion (5 wt%), followed by sonication for 1 h to ensure a well-dispersed suspension. A volume of 67 µL of this suspension was drop-casted onto a glassy carbon electrode (GCE), resulting in a final loading of approximately 0.35 mg cm^{-2}, which represents an optimal balance between signal intensity and electrode resistance. The modified electrodes were dried at room temperature and subsequently used for the detection of DNB. Electrochemical measurements were performed by cyclic voltammetry in 0.1 M PBS solution, both in the absence and presence of 100 µM DNB, at a scan rate of 10 mV s^{-1}, including a pre-deposition step at 0.6 V for 150 s.

CHARACTERIZATION

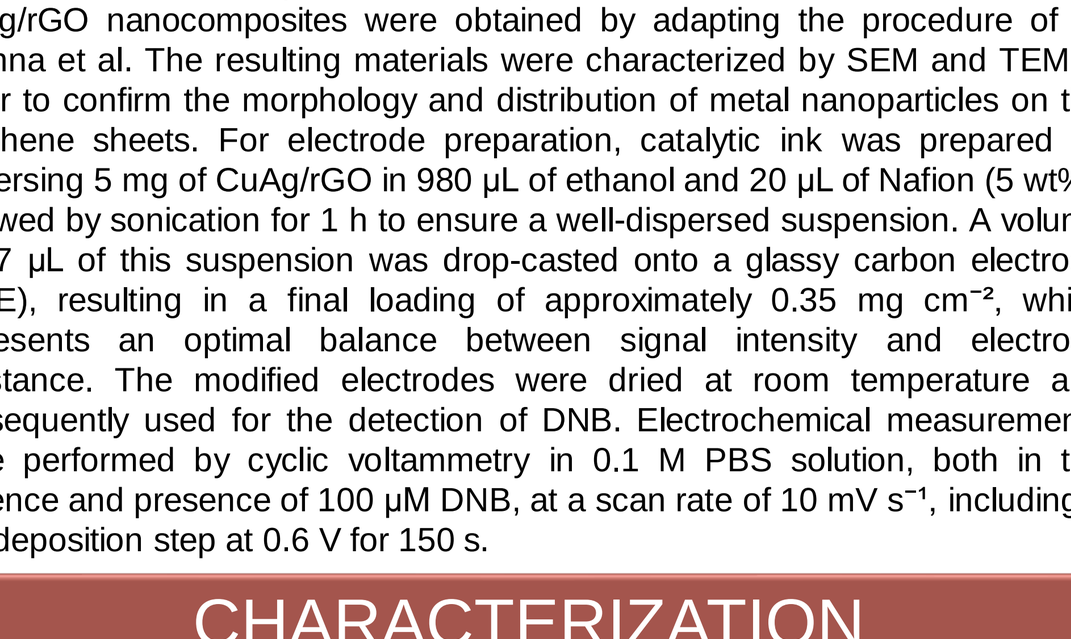

Figure 1. *SEM images (A) with the corresponding EDX spectra (B). TEM images (C) with distribution of particules (D).*

SEM analysis of the CuAg/rGO nanocomposite (Fig. 1A) showed a uniform morphology with nanoparticles evenly distributed across the graphene layers, while the EDX spectrum (Fig. 1B) confirmed the presence of copper and silver. TEM images (Fig. 1C) further revealed graphene oxide layers decorated with nanosized Cu and Ag particles, and particle size distribution analysis (Fig. 1D) indicated that most particles were in the 5–6 nm range with an average diameter of 5.4 nm, confirming homogeneous dispersion and good integration into the rGO structure.

RESULTS & DISCUSSION

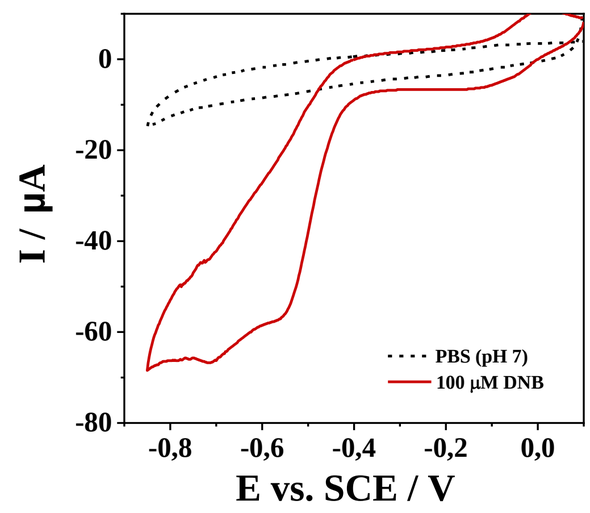

Figure 2. *Cyclic voltammograms of CuAg/rGO recorded in the absence and presence of 100 µM 1,3-dinitrobenzene in 0.1 M phosphate buffer (pH 7) saturated with N_2 at a scan rate of 10 mV s^{-1}.*

Cyclic voltammetry of the CuAg/rGO-modified electrode in the presence of DNB revealed two distinct reduction peaks, observed at –0.56 V and –0.68 V vs. SCE, which is in good agreement with literature data. The electrode showed a clear concentration-dependent increase in current response, confirming its efficiency in the electrochemical reduction of DNB. The calculated limit of detection was 2.21 µM, within a linear range of 0–50 µM. The appearance of two reduction peaks indicates a stepwise electron transfer mechanism during DNB reduction, consistent with the well-established electrochemical behavior of nitroaromatic compounds.

CONCLUSION

In summary, the CuAg/rGO-modified electrode exhibited excellent electrocatalytic performance toward the reduction of DNB, showing clear and reproducible signals with a low detection limit. These findings confirm that CuAg/rGO offers a simple, low-cost, and highly efficient sensing platform for rapid monitoring of nitroaromatic pollutants, with strong potential for practical use in routine environmental analysis.

ACKNOWLEDGEMENTS

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