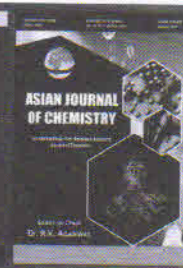


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## Enhanced Electrochemical Detection of Ambroxol Using AgNPs/MWCNT/Nafion/GCE Composite Sensor

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The development of the nanocomposite using AgNPs/MWCNT/Nafion/GCE in this study represents a significant advancement in the electrochemical detection of ambroxol, an important therapeutic agent in respiratory medicine. Silver nanoparticles (AgNPs) were green-synthesized using *Hyphaene thebaica* extract and integrated with functionalized multi-walled carbon nanotubes (MWCNTs) in a Nafion matrix to develop a highly sensitive electrochemical sensor for ambroxol. SEM, XRD and FTIR confirmed irregular, crystalline AgNPs strongly capped with phytochemicals, while acid-treated MWCNTs exhibited enhanced dispersibility due to surface carboxylation. The AgNPs/MWCNT/Nafion-modified glassy carbon electrode showed markedly improved electrocatalytic activity, enlarged electroactive surface area and irreversible, diffusion-controlled oxidation of ambroxol. The optimal sensing conditions were obtained at pH 4, 6  $\mu$ L modifier loading and a 4 min accumulation time. The sensor demonstrated a linear range of  $0.01-5 \times 10^{-5}$  M, a detection limit of  $6 \times 10^{-6}$  M, high selectivity and excellent reproducibility (RSD 3.6%). Application to spiked urine samples yielded an average recovery of 100.9%, validating its potential for pharmaceutical and clinical analysis.

**Keywords:** Silver nanoparticles, *Hyphaene thebaica*, Ambroxol, MWCNT, Electrochemical sensor.