# Transition metal-embedded MWCNT carbon paste sensors: Innovative platforms for pharmaceutical analysis

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Electroanalysis, finds widespread application in determining electroactive species, notably pharmaceuticals, due to its versatile and potent analytical performances. Electroanalytical methods offer several advantages, including simple operation, high sensitivity, low cost, and rapid response. The pivotal aspect of electroanalytical methodologies is the working electrode, where the analyte's redox reaction occurs. Thus, the careful selection of electrode material is a crucial step in ensuring the efficacy and accuracy of the sensing process. Moreover, enhancing the performance of electroanalytical methods often involves employing modifiers.

One prevalent approach in modern electroanalysis involves utilizing a carbon paste electrode as the sensing element. This method relies on carbon material, specifically graphite powder mixed with a suitable binder (pasting liquid). The preparation of the paste is straightforward, and these sensors offer the advantage of easy modification by incorporating the modifier during the mixture preparation. This practice is extensively employed in detecting organic analytes in electroanalysis.

To enhance sensor performance, scientists employ hybrid materials, which combine different types of substances. One notable example is the combination of carbon nanotubes (CNTs) with metal (nano)particles. CNTs exhibit remarkable tensile strength, excellent electrical conductivity, large surface area, and high chemical stability. Depending on their structure, CNTs exist as single-walled carbon nanotubes (SWCNTs) or multi-walled carbon nanotubes (MWCNTs). Incorporating CNTs as modifiers improves electron transfer rates, thereby enhancing the sensitivity and selectivity of the modified sensor. Various nanoparticles, particularly those of transition metals, possess a high surface-to-volume ratio and high surface energy, rendering their surface atoms highly active and demonstrating catalytic activity (1).

Several hybrid materials have been synthesized and employed as carbon paste sensors for detecting compounds such as ibuprofen and estradiol. For ibuprofen determination, a modifier composed of MWCNTs-supported Ni electrocatalyst was applied, resulting in the construction of Ni-MWCNTs-CPE. Under optimized conditions, this sensor exhibited a linear range of 25-500 µmol/L and a LOD value of 0.13 µmol/L (2). Similarly, for estradiol determination, functionalized MWCNTs with immobilized Fe electrocatalysts (Fe/f-MWCNTs) were utilized to create Fe/f-MWCNTs-CPE. This sensor demonstrated the capability to detect estradiol in a concentration range of 0.25 to 20 µmol/L, with a detection limit of 0.02 µmol/L. The prepared sensor proved directly applicable for estradiol determination in water, urine samples, and pharmaceutical formulations of estradiol. These studies underscore the enhanced performance of modified carbon paste-based sensors using hybrid material-based modifiers that combine the benefits of carbon nanotubes with transition metals such as Ni and Fe.

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References

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