Comparison of the electrochemical sensitivity of modified sensors based on screen-printed electrodes for real-time detection of anticancer medication

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Last decade, an intensive research effort has been performed in the field of analytical electrochemistry seeking designs of electrochemical biosensors capable of providing better analytical characteristics in terms of sensitivity, selectivity, reliability, ease of fabrication and use, and low cost, especially for pharmaceutical drugs' monitoring. The incorporation of nanomaterials into composite electrode matrices presents a useful strategy for the preparation of electrochemical biosensors with improved analytical performance. These devices exhibit the characteristics of the used nanomaterials and the advantages of composite electrodes, such as low background currents, great versatility due to the possibility of incorporation of different substances into the bulk of the electrode matrix, and easy surface regeneration.

Doxorubicin hydrochloride (DOX), a potent anticancer drug, is widely used in chemotherapy due to its high effectiveness against a broad spectrum of malignancies, including breast cancer, lymphomas, leukomas, and sarcomas. Doxorubicin's anticancer and antitumor main mechanism of action is related to the inhibition of DNA replication and transcription processes through intercalation between base pairs, thereby leading to cell death[1]. Despite its remarkable efficacy, Doxorubicin's clinical use raises one major concern regarding the correlation between its dose-dependent cardiotoxicity and the long-term health quality of cancer survivors. If not properly dosed, Doxorubicin can cause serious health hazards such as organ toxicity and drug resistance. Hence, to mitigate side effects during clinical trials, evaluate toxicity, and optimize therapeutic efficacy, it is crucial to monitor and regulate Doxorubicin's concentration in patients during and after cancer treatment.

The research in our work has been primarily focused on the development of screen-printed electrode (SPE)-based sensors and their application as electrochemical platforms for drug determination and monitoring, with a specific emphasis on their suitability for surface modification. Three commercially available types of screen-printed electrodes—graphene, carbon nanotubes, and polyaniline— were utilized as the electrochemical sensing component, which were subsequently modified with polymers. The polymeric modification, achieved by coating onto electrode surfaces, offers flexibility and introduces diverse functional groups that contribute to enhancing the reactivity of the materials[2]. Polyacrylic acid, polyvinylidene fluoride, and chitosan were used for polymer modification. All developed electrodes were tested using a solution of 0.002 mol/L DOX dissolved in 0.1 M phosphate-buffered saline with a pH of 6.8. Cyclic voltammetry and differential pulse voltammetry were used as electrochemical characterization techniques, to gather data regarding the electrochemical activity of all developed electrodes. The physical characterization of the electrodes was done using Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). All modified electrodes demonstrate a favourable electrochemical response to DOX and exhibit higher electrical conductivity compared to commercial ones. The obtained results from the characterization indicate that polymer-modified polyaniline electrodes exhibit excellent electrochemical conductivity and demonstrate the best overall electrochemical performance.

References

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