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Electrochemical sensor based on polypyrrole/triiron tetraoxide (PPY/Fe_3O_4) nanocomposite deposited from a deep eutectic solvent for voltammetric determination of procaine hydrochloride in pharmaceutical formulations

Idrees B. Qader [a,*], Hani K. Ismail [b,*], Hasan F. Alesary [c], Jalil H. Kareem [d], Yousif T. Maaroof [d], Stephen Barton [e]

[a] Pharmaceutical Chemistry Department, College of Pharmacy, Hawler Medical University, Erbil, Kurdistan Region, Iraq
[b] Department of Chemistry, Faculty of Science and Health, Koya University, Koya KOY45, Kurdistan Region-F.R., Iraq
[c] Department of Chemistry, College of Science, University of Kerbala, Karbala, Iraq
[d] Petroleum Technology Department, Erbil Technology College, Erbil Polytechnic University, Erbil, Kurdistan Region, Iraq
[e] School of Life Sciences, Pharmacy and Chemistry, Kingston University London, Kingston-Upon-Thames KT1 1LQ, Surrey, UK

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ABSTRACT

This investigation reports the electrochemical preparation of a polypyrrole/triiron tetraoxide (PPY/Fe_3O_4) nanocomposite from deep eutectic solvents (DESs), and their application as novel sensor electrodes to determine certain pharmaceutical formulations using cyclic voltammetry (CV). The modified polypyrrole/Fe_3O_4 nanocomposite was characterized using transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDAX), X-ray diffraction (XRD), and Fourier-transform infrared (FTIR) spectroscopy. These techniques confirmed the incorporation of Fe_3O_4 into the polypyrrole composite. Cyclic voltammetry and electrochemical impedance spectroscopy (EIS) indicated that PPY/Fe_3O_4 shows higher redox currents and greater electrical conductivity with procaine hydrochloride than other pharmaceutical formulations (ascorbic acid, diclofenac, losartan potassium, adiphenine hydrochloride, and metformin hydrochloride). Factors that could influence the determination of procaine hydrochloride, including pH, temperature, scan rate, concentration of drug, stability, and reproducibility, have all been optimized. Under optimal conditions, the calibration curve shows a linear relationship between oxidation peak current and procaine hydrochloride concentrations (between 0.005 and 0.3 mol/L), with an R^2 of 0.9943. The limit of detection (LOD) was 0.0024 mol/L and the limit of quantification (LOQ) was 0.0079 mol/L. The modified sensor (PPY/Fe_3O_4) constructed in this study was successfully used for the determination of procaine hydrochloride drug concentrations in a procaine-penicillin pharmaceutical product.

1. Introduction

Procaine hydrochloride (POR-HCl), with the international union of pure and applied chemistry nomenclature 2-diethylaminoethyl-4-aminobenzoate hydrochloride, is a white crystalline powder with an empirical formula of $C_{13}H_{20}N_2O_2$ and a melting point between 154 °C and 158 °C [1,2]. It was produced for the first time in 1905 and is commonly used as nerve block, acting as a local painkiller during minor surgical operations such as tooth extraction. This drug is also administered in combination with penicillin for the treatment of bacterial infections [3]. It is used as an alternative to cocaine due to its ease of preparation, ease of sterilization, and the fact that it is non-addictive. Its duration of action is shorter than cocaine and it is considerably less toxic [4,5]. Various technologies have been used to determine PRO-HCl such as fluorimetry [6], calorimetry [7], gas chromatography [8], high performance liquid chromatography, potentiometric titration, sequential injection analysis, electrophoresis, ion association titration atomic absorption, and spectrophotometry [4,9,10]. However, there are drawbacks with these technologies, such as bulky equipment, complex operation and processing, low sensitivity and selectivity, and high cost

* Corresponding authors.
E-mail addresses: idrees.qader@hmu.edu.krd (I.B. Qader), hani.khalil@koyauniversity.org (H.K. Ismail).

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