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Platinum Nanoparticles Based Screen Printed Electrode for the Simultaneous Detection of Paracetamol and Ascorbic acid

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ABSTRACT

Platinum nanoparticles (PtNPs) modified screen-printed electrode (SPE) was fabricated via a simple electrochemical method for simultaneous detection of paracetamol and ascorbic acid. The formation of PtNPs was confirmed by scanning electron microscopy (SEM) as well as cyclic voltammetry (CV). The CV results obtained on PtNPs/SPE showed a sensitivity, reaching 629 $\mu AmM^{-1}cm^{-2}$, 311 $\mu A\ mM^{-1}cm^{-2}$ over a linear range of 30-1100 µM and exhibiting a detection limit of 0.52 µM and 0.42 µM for paracetamol and ascorbic acid respectively. The developed sensor allows to determine with high accuracy paracetamol and ascorbic acid in commercial pharmaceutical samples.

1. Introduction

Paracetamol (PA, acetaminophen), a widely used antipyretic and analgesic drug, is an effective and safe agent used worldwide to treat fever, arthralgia and neurodynia. However, it is reported that overdoses of PA lead to hepatic toxicity, in some cases associated with liver and kidney damage and even death [1]. Therefore, its detection in pharmaceutical formulations is vital.

Ascorbic acid (AA, Vitamin C) has various pharmacological and physiological functions in collagen synthesis, immune system and drug metabolism. In some formulations, AA and PA can be combined, as the presence of AA enhances the pharmacological effect of PA, and promotes the protective effect against PA hepatotoxicity [2]. Therefore, the simultaneous determination of PA and AA for quality control of pharmaceutical formulations is imperative.

The electroanalytical techniques have been used for the determination of PA and AA in pharmaceutical formulations since they offer low-cost, high sensitivity, relative simplicity and short analysis time without pre-treatment of the samples. In the past decade, nanomaterials have attracted vast concerns for the preparation of electrochemical sensors, in which metal nanoparticles including gold nanoparticles (AuNPs) [3], platinum nanoparticles (PtNPs) [4] and palladium nanoparticles (Pd-NPs) [5] have been researched more intensively for electrocatalytic oxidation of PA and AA. Attributed to their excellent conductivity and catalytic properties. Among these nanoparticles, PtNPs have attracted more attention due to their high reactivity, high electrocatalytic efficiency, chemical inertness and high selectivity.

For this purpose, platinum nanoparticles (PtNPs) was electrodeposited on the entire surface of the working electrode, applying a simple electrochemical treatment by CV. In order to confirm the presence of these nanoparticles on the surface of the SPE, we undertook their characterization by means of SEM (Figure 1). This figure shows a carbon surface perfectly covered with Pt nanoparticles. These particles are rather medium in size between 50 nm and 200 nm in diameter with a three-dimensional structure (3D). The 3D architecture of these nanoparticles results in a large surface area on which electrochemical reactions can take place, making the deposition of Pt nanoparticles a very attractive material for various applications.

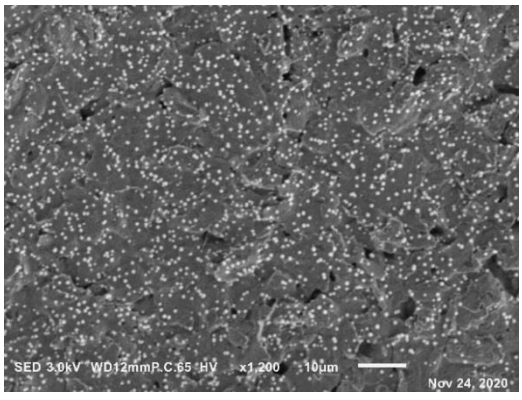

Figure 1 SEM photo of platinum nanoparticles prepared by CV.

To simulate the analyses in real environments, the simultaneous determination of paracetamol and ascorbic acid was performed. Figure 2 shows the cyclic

voltammograms recorded with the mixture of the two analytes at different concentrations. Easily exploitable curves are obtained, with clearly separated oxidation peaks of the two antioxidant species.

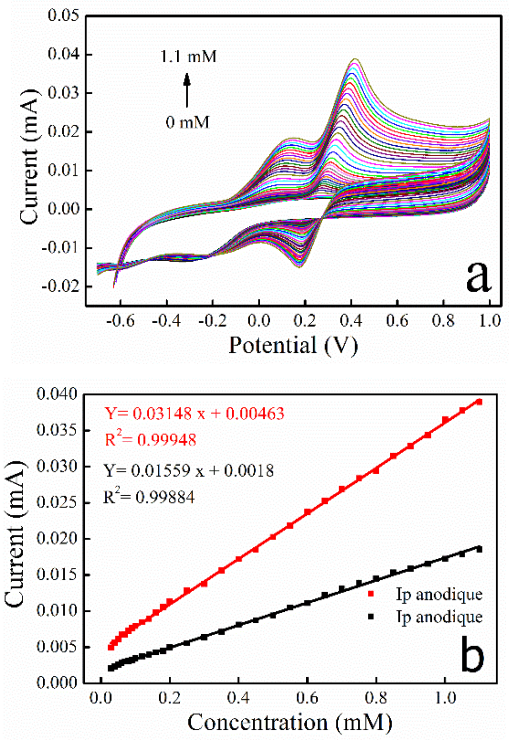

Figure 2 (a) Voltamgrams obtained on PtNPs/SPE at different concentrations of ascorbic acid and paracetamol, scanning speed 50 mV/s, (b) Dependence of the anodic peaks of the electrooxidation of AA and PA as a function of the concentration of AA and PA obtained on PtNPs/SPE.

As illustrated in Figure 2a, the cyclic voltammetry responses show that the simultaneous detection of paracetamol and ascorbic acid is strongly dependent on concentration and that the intensity of the oxidation peaks of both analytes increases steadily with increasing concentration. After processing the set of curves the evolution of the current intensity of the two peaks is plotted as a function of the concentration of each of the two drug substances.

Figure 2b shows the calibration curves obtained. Linearity was validated for both drug substances in the concentration range from 30 µM to 1.1 mM. The equations obtained are respectively:

$$I_p(mA)_{AA} = 0.01559\,C(mM) - 0.0018 \quad (1)$$

$$I_p(mA)_{PA} = 0.0314\,C(mM) - 0.00463 \quad (2)$$

With a sensitivity of 629 µA. $mM^{-1}.cm^{-2}$, 311 µA. $mM^{-1}.cm^{-2}$ and a limit of detection of 0.52 µM, 0.42 µM for paracetamol and ascorbic acid, respectively. The catalytic activity of the platinum electrode and the reliability of the electrochemical analysis technique were tested for the detection and determination of ascorbic acid and paracetamol in commercial pharmaceutical samples such as Vitamin C Efferalgan tablets and Vitamin C Dofebril tablets (Table 1).

Table 1 Analytical results of commercial pharmaceutical samples.

Drug	Drug substance	Content in tablets (mmol/l)	Content analysed by CV (mmol/l)	Recovery rate
Vitamin C Efferalgan	AA	3.3	2.97	90.0 %
	PA	6.6	6.22	94,24 %
Vitamin C Dofebril	AA	3.3	3.18	96,63 %
	PA	6.6	6.42	97,27 %

From the results indicated in this table, it can be seen that the amount of AA and PA determined by CV on the platinum electrode in the commercial pharmaceutical samples is slightly lower than the amount indicated on their boxes. This is probably due to the non-dissolution of these substances during sample preparation.

2. Conclusion

The results obtained concerning the development of a voltammetric microsensor based on platinum nanoparticles supported on a screen-printed electrode for the simultaneous determination of PA and AA demonstrate once again the very beneficial contribution of modified electrodes in the field of electroanalysis. The PtNPs/SPE showed low detection limit, wide linear range, high sensitivity for the simultaneous determination of PA and AA. Furthermore, these Pt nanoparticles based sensor exhibit practical analytical utility for thesimultaneous determination of PA and AA in commercial pharmaceutical samples with excellent recoveries.

3. References

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