



## Differential Pulse Voltammetry Technique for the Determination of Imipramine, Dopamine and Norepinephrine Using a Hydroquinone Derivative Multi-wall Carbon Nano-tube Carbon Paste Electrode

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### ABSTRACT

In this study, a synthetic para dihydroxy benzene derivative was used for electro-catalytic determination of chemical and biological species. The modified electrode was fabricated using graphite powder, multi-wall carbon nano tubes and the synthetic compound. The analytes including imipramine, dopamine and norepinephrine were quantified. The kinetic parameters were calculated. Based on the obtained results, the modified electrode shifted the electro-catalytic oxidation potential about 490 mV for imipramine. Analytical parameters including the limit of detection and linear dynamic range were determined using differential pulse voltammetry technique. Simultaneous determination of imipramine, norepinephrine and dopamine along with the individual determination of imipramine were studied. The method applied in urine sample with satisfactory results.

**Keywords:** Differential Pulse Voltammetry, Imipramine, Dopamine, Norepinephrine, Multi-wall Carbon Nanotubes

### INTRODUCTION

Imipramine (IM), the first tricyclic antidepressant that was introduced in last decade of

1950s by *Ciba*, is used for the treatment of enuresis and deep depression. The powerful antidepressant properties of imipramine have made it favorable in the treatment of treatment-resistant depression<sup>1</sup>.

Dopamine (DOP), a neurotransmitter of the catecholamine, has important roles in the human brain and body. The released dopamine by nerve cells sends signals to other nerve cells. The dopamine distinct system has a major role in reward-motivated behavior. The major type of reward increases the level of dopamine in the brain<sup>2,3</sup>. Norepinephrine (NE) is a catecholamine with multiple roles including those as a hormone and a neurotransmitter. The actions of norepinephrine carried by binding to the adrenergic receptors and used in those with severe hypotension<sup>4</sup>. The mechanism of imipramine's medicinal action is including the blockading of both dopamine and norepinephrine reuptake. Therefore, the level of dopamine and norepinephrine is affected by taking the imipramine.

Several reports have been found for chromatographic<sup>5</sup> and electrochemical determination of imipramine<sup>6,7</sup>, affinity chromatography-mass spectrometry<sup>8</sup> and electrochemical methods for the determination of dopamine<sup>9-12</sup> and gas chromatography-mass spectrometry<sup>13</sup> and electrochemical techniques for quantitative determination of norepinephrine<sup>14-17</sup> individually

and in the presence of other co-existing species. Regarding to the imipramine mechanism action, simultaneous determination of imipramine, dopamine and norepinephrine in bio-fluids can be attractive for clinical researchers.

In this report, the authors introduced a new modified electrode for quantitation of imipramine individually and in presence of two co-existing species by use of the fabricated electrode.

## EXPERIMENTAL

### Materials and methods

All of the electrochemical experiments done by use of a Sama 500 potentiostat-galvanostat and use of three-electrode cell: the modified electrode as working electrode, a graphite electrode as an auxiliary electrode, and saturated calomel electrode as reference electrode. The obtained data was storage and processed using a personal computer. The pH measurements were done by use of Metrohm 781 pH/mV meter.

### Instrumentation

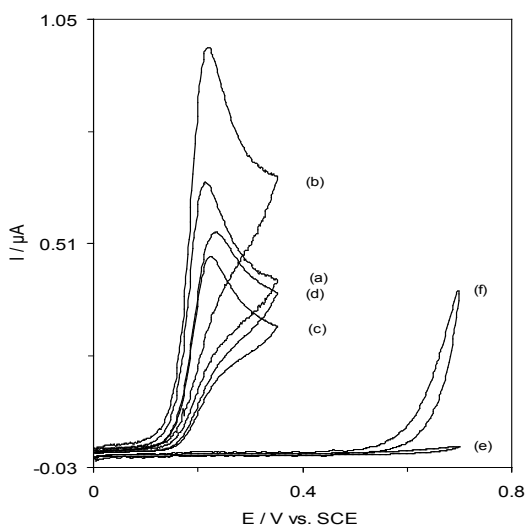
The analytical grade of Imipramine, dopamine, and norepinephrine were prepared from Sigma and the other chemical reagents purchased from Merck. The multi-wall carbon nanotube (MWCNT; purity of >95%, length of 5–20  $\mu\text{m}$  and diameter of 10–20 nm) was prepared from Plasma Chem. The paraffin oil and graphite powder were used for preparing the carbon paste. The synthesis of modifier, 4-Hydroxy-2-(triphenylphosphonio) phenolate (HTP), was done based on Ref.<sup>18</sup>.

### The preparation of electrode

50.0 mg of graphite powder, 0.5 mg of HTP and 1.0 mg of MWCNT weighed accurately and thoroughly mixed. Then, appropriate amount of paraffin oil added to obtain the carbon paste and fabricated into a Teflon rod electrode characterized with internal diameter 2 mm and 5 mm deep with a spatula. Other unmodified carbon paste electrode prepared in the same way without adding the modifier.

### Sample preparation procedure

Human urine sample were collected from person who had not taken the drugs. The collected



**Fig. 1: The recorded cyclic voltammograms of (a) HTP-MWCNT-CPE, (c) HTP-CPE and (e) MWCNT-CPE in supporting electrolyte and the sweep rate was  $25 \text{ mV s}^{-1}$ . The corresponding cyclic voltammograms of (b) as (a), (d) as (c) and (f) as (e) were recorded in the presence of  $0.1 \text{ mmol/L}$  of IM.**

sample diluted with appropriate amount of supporting electrolyte (phosphate buffer solution 0.15 mol/L at pH 7.0).

## RESULTS AND DISCUSSIONS

The electro-catalytic activity of synthesized modifier toward the oxidation of IM investigated by recording the cyclic voltammograms of modified and unmodified electrodes in presence and absence of IM. The cyclic voltammograms were shown in Figure 1 and discussed as follow: curves a and b show the cyclic voltammograms of modified electrode (HTP-MWCNT-CPE) in the absence and presence of 0.1 mmol/L of IM in supporting electrolyte at the sweep rate of 25 mV s<sup>-1</sup>, respectively. As it can be seen, the peak current was increased at the potential of 220 mV in the presence of IM that confirm the efficiency of the modifier for electro-catalytic oxidation of IM. Other cyclic voltammograms of unmodified electrodes (HTP-CPE and MWCNT-CPE) in the absence and in the presence of 0.1 mmol/l of IM also recorded at the same experimental conditions. A comparison of oxidation peak currents of IM at the unmodified electrodes (HTP-CPE and HTP-MWCNT-CPE) and related curves (curves d and b, respectively) confirm the efficiency of MWCNT by increasing 0.4 μA of anodic the peak current. Along with the increasing of the anodic peak current, the peak potential reducing near to 20 mV. This is an expected behavior for a case of electro-catalytic oxidation. The cyclic voltammograms of MWCNT-CPE that recorded that recorded at the same conditions (curves e and f, respectively) no signal obtained. Therefore, HTP-MWCNT-CPE can

be catalysed the electro-oxidation of IM and the use of MWCNT and HTP in a mixture improves the sensitivity of the modified electrode.

The cyclic voltammogram of 0.07 μmol/L of IM in supporting electrolyte at sweep rates 5 to 30 mV s<sup>-1</sup> with potential interval 5 mV s<sup>-1</sup> recorded. Using the obtained data of the cyclic voltammograms, the plot of the peak current against the square root of the sweep rate plotted. The shape of the plot confirms that the reaction is diffusion controlled and the suggested mechanism is an EC<sub>cat</sub> process.

By use of Andrieux and Saveant model, catalytic rate constants was obtained as  $(3.12 \pm 1.0) \times 10^{-3} \text{ cm s}^{-1}$ . Moreover, the total number of electrons was obtained  $n = 2.09 \approx 2.0$ . Considering the transfer coefficient of  $\alpha = 0.3$ , the rate limiting step contain one-electron transfer process and the mechanism of catalytic oxidation of IM is an E<sub>1</sub>C<sub>1</sub>.

### Chronoamperometric investigations

The catalytic oxidation of IM at modified electrode was also studied using chronoamperometry technique. Based on the recorded chronoamperograms, Cottrell equation and related calculations the diffusion coefficient (D) was obtained as  $7.9 \times 10^{-6} \text{ cm}^2 \text{ s}^{-1}$ .

### Differential pulse voltammetric investigations

Differential pulse voltammetry (DPV) technique used to determine the analytical parameters including linear dynamic range (LDR), limit of detection (LOD), individual and simultaneous determination of IM, and quantification of IM in

**Table 1. Determination of NE, IM, and DOP in urine sample using DPV technique.**

Sample (%)	Added (μmol/L)			Found* (μmol/L)			RSD (%)			Recovery		
	NE	IM	DOP	NE	IM	DOP	NE	IM	DOP	NE	IM	DOP
Urine	-	-	-	<DL	<DL	<DL	-	-	-	-	-	-
	40.0	30.0	200.0	39.6 ± 0.8	29.6 ± 0.6	201.8 ± 4.4	2.0	2.0	2.2	99.0	98.7	100.9
	60.0	50.0	300.0	60.9 ± 1.1	49.5 ± 0.9	298.8 ± 6.2	1.8	1.8	2.1	101.5	99.0	99.6
	80.0	70.0	400.0	79.4 ± 1.4	70.9 ± 1.2	404.8 ± 8.9	1.8	1.7	2.2	99.2	101.3	101.2

\* Mean ± standard deviation (n=3)

presence of NE, and DOP in urine sample. By the use of the technique, IM was determined in concentration range of 0.2–175.0  $\mu\text{mol/L}$  and the detection limit was obtained to be 0.036  $\mu\text{mol/L}$  of IM. Also, quantitative determination of IM in presence of IM, NE and DOP was investigated. The recorded DPVs was shown three anodic peaks at potentials of 74, 173 and 245 mV for oxidation of NE, IM, and DOP respectively at the surface of modified electrode. The calibration curves of NE, IM, and DOP with concentration ranges of 29.2–112.4  $\mu\text{mol/L}$  NE, 26.2–100.6  $\mu\text{mol/L}$  IM, and 178.0–680.7  $\mu\text{mol/L}$  DOP were obtained.

#### Applicability of the procedure in real sample analysis

Analytical applicability of the developed procedure studied in human urine sample for the determination of IM, NE, and DOP. Sample preparation carried out as discussed previously and different amounts of IM, DOP and NE spiked in real sample. Quantitative determination of them done using the developed procedure. The results summarized in Table 1. As it can be seen, the relative standard deviation and recovery varied in range 1.7 to 2.2% and 99.0 to 101.9% respectively. The

values confirm the efficiency of the procedure for the determination of IM individually and in presence of DOP and NE.

#### CONCLUSIONS

The introduced research illustrate the construction of a HTP-MWCNT-CPE as a modified electrode and its application for the quantitation of IM. The recorded cyclic voltammograms exhibit that the electrocatalytic oxidation of IM is improved. The kinetic parameters of the oxidation of IM at the introduced electrode have been determined as 0.3 and  $3.1 \times 10^{-3} \text{ cm s}^{-1}$ , respectively. The linear dynamic range for the determination of IM obtained as 0.2–175.0  $\mu\text{mol/l}$ . The analytical applicability of the electrode procedure was examined by the determination of IM, NE and DOP in human urine sample.

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