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Electrochemical Performance of Screen Printed Sensors for Potentiometric Determination of Anticholinergic Oxybutynine Hydrochloride in Pharmaceutical Formulations and Biological Fluids

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NEW potentiometric sensitive and selective modified screen printed electrodes (MSPE) which based on phosphotungestic acid (PTA), sodium tetraphenyl borate (NaTPB), phosphomolybdic acid (PMA) or ammonium reineckate (RN) ion pairing agents for determination of oxybutynine hydrochloride (OBCH) were developed. The proposed electrodes have Nernstian slope values of 59.200.52±, 58.000.22± and 58.520.22± mV decade^{-1} for electrodes modified with 7.5, 17.5 and 7.5 mg of RN (electrode I), NaTPB (electrode II) and PTA (electrode III) ion pairing agents, respectively. It is found that the dynamic drug concentration range at 25 °C was 1.0x10^{-5} - 1.0x10^{-2} mole L^{-1} with detection limit (LOD) equal 1.0× 10^{-5} mol L^{-1} and limit of quantification (LOQ) equal 3.33×10^{-5} mol L^{-1}. The response of MSPEs was pH independent in the range 2.0-6.0. The investigated electrodes have fast response time of 10, 9 and 8 s for electrodes I, II and III, respectively. These electrodes have good Nernstian response in the temperature range 10–60 °C. The slope of the straight–line obtained represented the isothermal coefficient of MSPEs which were found to be 1.594 ×10^{-3}, 2.151×10^{-3} and 2.377×10^{-3} V/ for electrodes I, II and III, respectively. The small values of the isothermal coefficient indicated the high thermal stability of the electrodes. The MSPEs showed a relatively long life time of 36 days. Pure, biological fluids and pharmaceutical formulation of OBCH were quantified using calibration and standard addition methods and the obtained results agreed with that of the official HPLC method. Validation parameters were optimized according to ICH recommendations.

Keywords: MSPE, Ion pairing agents, Oxybutynine HCl, Pharmaceutical formulation, Biological fluids.

Introduction

Uripan belongs to the class of anticholinergic and antispasmodic substances. Structure of uripan, alpha-cyclohexyl-alpha-hydroxy-benzene acetic acid, 4-(diethylamino)-2-butynyl ester hydrochloride [1], was shown in Figure (1).

Oxybutynine hydrochloride exerts a direct antispasmodic effect on smooth muscle and inhibits the muscarinic action of acetylcholine on smooth muscle. Oxybutynine hydrochloride

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exhibits only one-fifth of the anticholinergic activity of atropine on the rabbit detrusor muscle, but four to ten times the antispasmodic activity. No blocking effects occur at skeletal neuromuscular junctions or autonomic ganglia (antinicotinic effects). So it can be used to treat damage to the brain neurons and birth defects in spinal tracks.

Oxybutynine hydrochloride relaxes bladder smooth muscle. In patients with conditions characterized by involuntary bladder contractions, cystometric studies have demonstrated that oxybutynine increases bladder (vesical) capacity, diminishes the frequency of uninhibited contractions of the detrusor muscle, and delays the initial desire to void. Oxybutynine thus decreases urgency and the frequency of both incontinent episodes and voluntary urination.

Also it can used to treat hyperhidrosis (excessive sweating) and it is found that people who treat with oxybutynine HCl reported greater improvements compared with those treated with placebo.

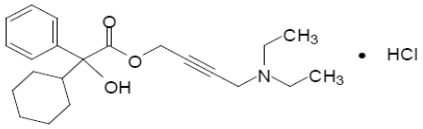

Figure 1. Chemical structure of OBCH drug.

Quantitative determination of OBCH revealed that few methods have been performed for its analysis such as polarography [2], spectrophotometry [3,4], HPLC [5] and polymeric matrix membrane [6]. Ion-selective electrodes (ISEs) are now widely used for the direct potentiometric determination of ion concentrations in different samples. Their advantages are simple design, low cost, adequate selectivity, low detection limit, high accuracy, wide concentration range and applicability to coloured and turbid solutions.

In the present work, modified screen printed (MSPE) electrodes have been constructed and their performance characteristics were studied. The electrodes are based on the interaction of the ion pairing agent like (Na^+TPB^-) with the oxybutynine HCl drug [Ox^+] to form the ion-pair which utilized electrodes such as : content of ion pairing agent, plasticizer, pH, temperature, selectivity, life time...etc. The electrodes were used successfully as sensors for determination of OBCH in pure form, pharmaceutical preparations and biological fluids (serum and urine). Method validation parameters were studied. The method was precise and accurate as indicated from the percent recovery, standard and relative standard deviation values.

Experimental

Reagent and solution

All chemicals and reagents used were of anylatical reagent grade. In all experiments, bidistilled water was used. o-Nitrophenyloctylether (o-NPOE) was supplied from Fluka while dioctylphthalate (DOP), dibutylphthalate (DBP) and dioctyl sebecate (DOS) were supplied from BHD. Tricresylphosphate (TCP), polyvinylchloride (PVC with relative high molecular weight) and graphite powder were supplied from Aldrich. Sodium tetraphenylborate (NaTBP), ammonium reineckate (RN; $[NH_4](Cr(NH_3)_2(SCN)_4).H_2O]$), phosphotungstic acid (PTA; $H_3[PW_{12}O_{40}]$) and phosphomolybdic acid (PMA; $H_3[PMo_{12}O_{40}]$) were purchased from Aldrich (USA).

Lactose, fructose, maltose, sucrose, starch, $CoCl_2.6H_2O$, $NiCl_2.6H_2O$, $MnCl_2.4H_2O$, NaCl, $CrCl_3.6H_2O$ and $CuCl_2 2H_2O$ were used as interfering materials and they were purchased from El-Nasr Company, Egypt. Uripan tablets were produced by ADWIA Pharmaceutical Company (5 mg OBCH per tablet), El-Obour City, Cairo, Egypt.

NaTPB solution (1.0×10^{-2} mol L^{-1}) was prepared by dissolving an accurate weighed amount of it in warm water, adjusted to pH 9 by adding sodium hydroxide and completed to the desired volume with distilled water. The resulting solution was standardized potentiometrically against standard (1.0×10^{-2} mol L^{-1}) oxybutynine HCl solution.

Aqueous solutions of PTA, PMA and RN were prepared using the analytical grade chemicals and the exact concentrations of these solutions were determined by the appropriate recommended methods [7] and lower concentrated solutions were prepared by the appropriate dilutions.

1.0×10^{-3} mol L^{-1} Standard solution each of lactose, fructose, maltose, sucrose, starch, $CoCl_2.6H_2O$, $NiCl_2.6H_2O$, $MnCl_2.4H_2O$, NaCl, $CuCl_2.2H_2O$, $CrCl_3.6H_2O$ was prepared by

dissolving the proper weights into 100 mL bidistilled water. All solutions must be protected from light by keeping them in dark-colored quickfit bottles during the whole work.

Stock OBCH solution (1.0×10^{-2} mol L^{-1}) was prepared by dissolving the proper weight of the drug (394 mg) into smaller amount of bidistilled water then stirring till the drug completely dissolved. The resulting solution was then made up to 100 mL with bidistilled water in a measuring flask.

To prepare 1.0×10^{-2} mol L^{-1} of Uripan (pharmaceutical preparation), 39 of tablets were taken and ground them well, dissolved in smaller amount of distilled water with stirring then filtered to get rid of insoluble materials and transferred quantitatively to 100 mL volumetric flask. Then content was estimated via potentiometry using the proposed electrodes. The method was repeated several times to check the accuracy and reproducibility of the proposed method.

For determination of OBCH in biological fluids, a series of human serum and urine samples from healthy donors were used. Aliquots of urine or serum samples were transferred into small separating funnels, spiked with a definite concentration of OBCH, then the content was determined using the proposed potentiometric sensors.

Apparatus

Laboratory potential measurements were performed using HANNA pH/mV meter model 211 (Romania). Silver-silver chloride double junction reference electrode (Metrohm 6.0222.100) in conjugation with different drug ion selective electrodes was used.

Electrodes preparation

Modified screen printed electrodes preparation

SPEs were printed as arrays of six couples consisting of the working electrode (5×35 mm). A polyvinyl chloride flexible sheet (0.2 mm) was used as a substrate which was not affected by the curing temperature or the ink solvent and easily cutted by scissors. The indicator electrodes were prepared depending on the method of preparation, SPEs [8-10] were heterogeneous electrodes having a composite structure since the printing ink matrix colligates different phases (carbon powder, plasticizer, modifier) polymeric binder which was PVC dissolved in proper organic solvent (50 mL acetone and 50 mL cyclohexanone) after printing and curing carbon tracks were deposited on the substrate with a final composition 30.55% carbon, 18.33% plasticizer, 51.92% PVC and 0.18% ion pairing agent (NaTPB, PTA, PMA, RN). They were printed and cured at 60 ºC for 2 hrs. The prepared electrodes were stored at 4 ºC in refrigerator and can be used directly.

Results and Discussion

Electrochemical behavior of OBCH with utilized electrodes

To obtain the electrochemical behavior, calibration was carried out by immersing the electrodes in conjunction with the double junction Ag/AgCl reference electrode in solutions of OBCH in the concentration range of 1.0×10^{-7}–1.0×10^{-2} mol L^{-1}. They were allowed to equilibrate by stirring and then recording the e.m.f. readings. The electrodes showed a linear response over the concentration range 1.0×10^{-5} - 1.0×10^{-2} mol L^{-1}. Different MSPEs were prepared with different types and content of ion pairing agents of RN, NaTPB, PTA and plasticized with TCP. It was clear from Table 1 that SPEs modified with 7.5, 17. 5 and 7.5 mg of RN (electrode I), NaTPB (electrode II) and PTA (electrode III) ion pairing agents showed the best Nernstian slope of 59.200.52±, 58.000.22± and 58.520.22± mV $decade^{-1}$, respectively.

Effect of plasticizer

Plasticizers are considered to have an important role in the behaviour of MSPEs. They have a lot of advantages like improvment the ionic mobility, enhancement the solubility of the sensing material and lower the overall bulk resistance of the electrode due to their polarity characteristics. They improve mechanical connection of the individual electroactive carbon particles into a uniform compact mixture [11,12].

It is found that the electrode plasticized with TCP is the best one as it gives the highest Nernstian slope (59.5 ± 0.20 mV $decade^{-1}$) in comparison with the other plasticizers where their slope‘s values were 63.500.5±, 48.91 ± 0.2, 65.50 ± 1.5 and 27.20 ± 1.4 mV $decade^{-1}$ for DBP, DOP, o-NPOE and DOS plasticizers, respectively.

The plasticizer molecules diffuse into the

polymer and weaken the polymer–polymer interactions (van der Waals' forces) according to the Lubricating Theory of plasticization [13].The plasticizer molecules reduce polymer–polymer interactive forces and prevent the formation of a rigid network as they act as shields. This lowers the PVC Tg and allows the polymer chains to move rapidly past each other, resulting in increased flexibility, softness, and elongation. The mechanistic explanation of plasticization considers the interactions of the plasticizer with the PVC resin macromolecules. It assumes that the plasticizer molecules are not permanently bound to the PVC resin molecules but are free to self-associate and to associate with the polymer molecules at certain sites such as amorphous sites. As these interactions are weak, there is a dynamic exchange process whereby, as one plasticizer molecule becomes attached at a site or center, it is readily dislodged and replaced by another. Different plasticizers yield different plasticization effects because of the differences in the strengths of the plasticizer–polymer and plasticizer–plasticizer interactions. At low plasticizer levels, the plasticizer–PVC interactions are the dominant interactions, while at high plasticizer concentrations plasticizer–plasticizer interactions can become more significant. The polar portion of the molecule must be able to bind reversibly with the PVC polymer, thus softening the PVC, while the non-polar portion of the molecule allows the PVC interaction to be controlled so it is not so powerful a solvator as to destroy the PVC crystallinity. Plasticizers have a strong affinity for PVC polymers, but do not undergo a chemical reaction that causes bonding, or grafting, to the polymer [13].

TABLE 1. Effect of types and content of ion pairing agents on MSPEs performance.

Ion pairing agents	**MSPE**		
	Content , mg	Slope (mV decade^{-1})	R^2
NaTPB	*5*	*26.501.09±*	*0.996*
	10	67.50 ± 2.10	0.998
	17.5	**58.000.22±**	**0.998**
	20	30.800.40±	0.997
PMA	2.5	67.002.30±	0.997
	5	77.000.50±	0.997
	7.5	72.902.20±	0.997
	10	70.00 0.70±	0.996
RN	5	76.000.80±	0.999
	7.5	**59.200.52±**	**0.999**
	10	44.900.88±	0.996
	15	45.401.90±	0.998
PTA	5	48.501.50±	0.999
	7.5	**58.520.22±**	**0.999**
	10	66.70 1.92	0.998
	15	47.000.44±	0.998

The pH effect

The effect of pH on the performance of electrodes was studied over the pH range of 2–9 by immersing electrodes in 1.0×10^{-3} and 1.0×10^{-5} mol L^{-1} of OBCH solutions. It is clear from Figure (2) that the electrodes have stable potential readings (independed on the pH readings) in the pH range 2.0-6.0. The change at higher pHs could be the result of hydroxide precipitate formation, while in the low pH range, competitive proton binding is probably behind the decreased potential values [14].

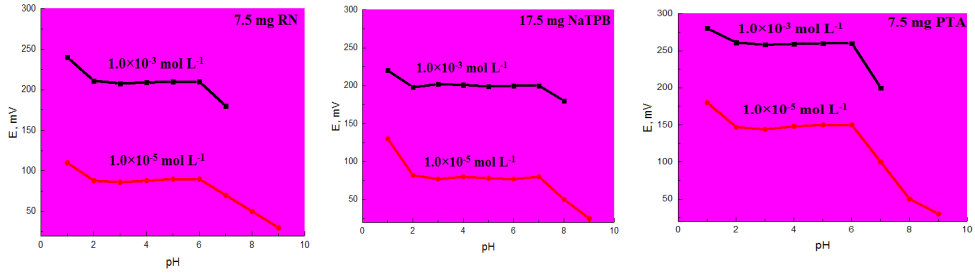

Figure 2. Effect of pH on performance of MSPEs (Electrodes I-III).

Life time

The performance of the modified potentiometric sensors was studied where the electrodes (I – III) were calibrated on different days. Figure (3) showed that life time of the MSPEs were 36 days for electrode I and 30 days for both electrodes (II and III). These electrodes surface don't needed to be refreshed by scratch and rinsed in distilled water to remove memory effect.

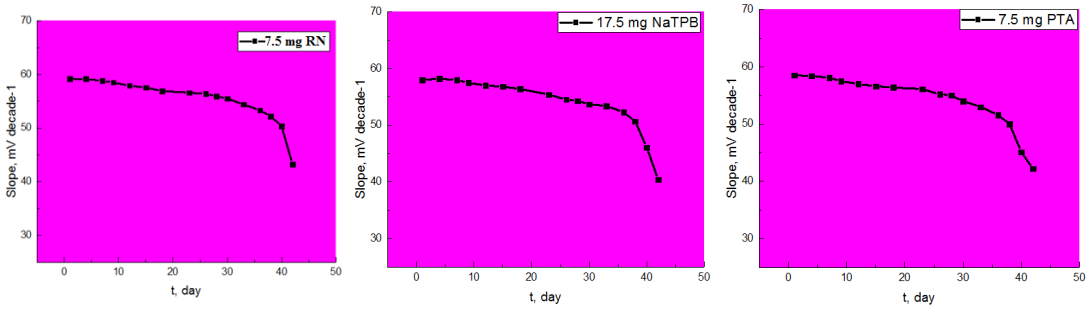

Figure 3. Effect of life time on the performance of some MSPEs.

Selectivity coefficients

The influence of some inorganic cations and sugars on the electrodes was investigated by matched potential method (MPM) and separate solution method (SSM) (Table 2). The selectivity coefficients [15] values of the MSPEs reflect a very high selectivity of the proposed electrodes toward the OBCH over the interfering species. The inorganic cations do not interfere owing to the differences in ionic size, and consequently their mobilities and permeability. In the case of sugars, the high selectivity is mainly attributed to the difference in polarity and lipophilic character of their molecules relative to OBCH.

Effect of temperature

The effect of temperature on the performance of the potentiometric electrodes was evaluated from (10 – 60) °C and the isothermal coefficient (dE°/dT) will be determined for each electrode according to the following equation [16]:

$$E_{cell}° = E_{cell}° (25) + (dE° / dT) (t – 25)$$

It is obvious that the electrodes gave a good Nernstian response in the temperature range 10–60 °C. The slope of the straight–line obtained represented the isothermal coefficient of MSPEs which were found to be 1.594×10^{-3}, 2.151×10^{-3} and 2.377×10^{-3} V/ for electrodes I, II and III, respectively. The small values of isothermal coefficient indicated the high thermal stability of the electrodes.

Response time

The average time required for the electrode to reach a steady potential response within ±1 mV of the final equilibrium value. It is clear from Figure 4 that these electrodes have a fast response time which is 10, 9 and 8 s for electrodes I, II and III, respectively, which reflect the incorporation of best content of ion pairs and good solvent mediator.

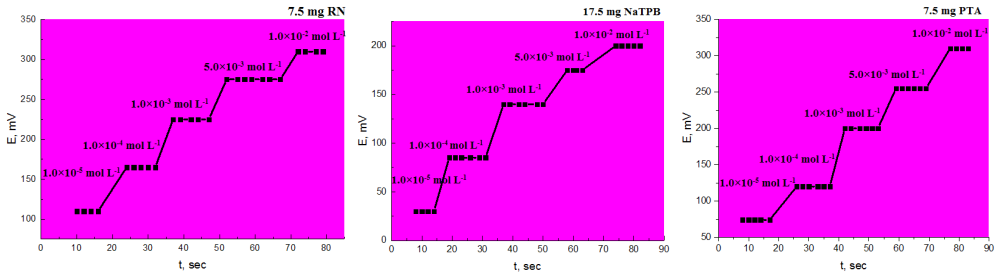

Figure 4. Dynamic responce time of the MSPEs (Electrodes I-III).

TABLE 2. Potentiometric selectivity coefficient values of OBCH using MSPEs (Electrodes I-III).

	$K^{pot}_{D,B}$ MSPEs					
Interfering Compound	Electrode I		Electrode II		Electrode III	
	SSM	MPM	SSM	MPM	SSM	MPM
Mn^{2+}	9.62×10^{-5}	----------	7.88×10^{-4}	----------	3.29×10^{-4}	----------
Ni^{2+}	4.06×10^{-4}	----------	8.53×10^{-4}	----------	3.42×10^{-4}	----------
Na^{+}	3.41×10^{-3}	----------	1.89×10^{-3}	----------	6.74×10^{-3}	----------
Cu^{2+}	2.66×10^{-5}	----------	1.27×10^{-3}	----------	6.21×10^{-4}	----------
Co^{2+}	3.42×10^{-5}	----------	5.30×10^{-4}	----------	5.99×10^{-5}	----------
Cr^{3+}	3.14×10^{-4}	----------	8.53×10^{-4}	----------	1.31×10^{-4}	----------
Fructose	----------	1.29×10^{-6}	----------	5.30×10^{-5}	----------	1.84×10^{-6}
Maltose	----------	1.51×10^{-6}	----------	4.01×10^{-5}	----------	1.24×10^{-6}
Sucrose	----------	2.23×10^{-6}	----------	3.16×10^{-5}	----------	2.24×10^{-6}
Starch	----------	5.28×10^{-7}	----------	5.29×10^{-5}	----------	2.07×10^{-6}
Lactose	----------	1.11×10^{-6}	----------	2.21×10^{-5}	----------	7.17×10^{-7}

Application on pharmaceutical and official method

The designed sensors were utilized to determine OBCH in pharmaceutical preparations (Uripan tablet) using the potentiometric calibration and standard addition methods. The results obtained were compared to the official method [16-19] and the data obtained were summarized in Table (3). Statistical evaluation of the results of analysis of pure OBCH by the proposed electrodes and the official method showed that there is no significant difference between the proposed and reported methods as indicated from the F-test and t-test values.

Analytical applications in biological fluids

The proposed method was used to sense OBCH in urine and serum samples which collected from healthy volunteers. The urine and serum samples were spiked with standard solution of OBCH, then the proposed sensors (electrodes I-III) used to its determination. The recovery %, SD and RSD % were listed in Table (4) which gave an indication about the investigation in biological fluids and how the validated method could be adopted for determination of the drug.

Method validation

The analytical method [23-25] was validated according to the international conference for Harmonization (ICH) guidelines under the optimized experimental conditions: linearity, accuracy, precision, specificity, limit of detection (LOD) and limit of quantification (LOQ) were

achieved for standard OBCH solution. LOD is the lowest quantity of the investigated compound in sample that can be detected but not necessarily quantified with an acceptable uncertainty. It was the concentration of measured ion at the point of intersection between the extrapolated linear segment of the calibration curve representing the normal slope of electrode and horizontal line representing the voltage when the concentration has small changes and not produced any detectable change in the response. The LOD was 1.0×10^{-5} mol L^{-1} as shown in Table (6) which indicated that these sensors have high sensitivity and can be used for determination of low concentration OBCH drug. LOQ is the lowest amount of compound that can be measured in sample matrix at an acceptable level of accuracy and precision. It was found that LOQ is 3.33×10^{-5} mol L^{-1} as shown in Table (6) which indicated the high sensitivity of these electrodes.

Accuracy is important requirement of analytical methods. It is the clossness between the true or accepted reference value and the obtained value. As seen from Table (3), the high values of % recovery ensure the high accuracy of this method.

Precision is the measurement of how close results to each other. It usually expressed as standard or relative standard deviations of the replicated analysis. Inter and intra-day precisions were assessed using three concentrations from the OBCH drug and five replicates for each concentration. The relative standard deviation values were found to be small indicating the good repeatability and reproducibility of the proposed method (Table 5).

Linearity measures how well calibration plot of electrochemical potential versus concentration approximates a straight line. The standard calibration curve was obtained by using five concentration of OBCH standard. The linear relationship was obtained between negative logarithm [OBCH] and potential (mV) as shown in Table (6). The linear range for MSPE [21-22] was $1.0\times 10^{-5} - 1.0\times 10^{-2}$ mol L^{-1}.

Specificity was done by observing any interference from the common excipients of the pharmaceutical formulation. It was found that these components did not interfere with the result of proposed method, Table (2).

TABLE 3. Potentiometric determination of OBCH in Uripan tablets using MSPEs (Electrodes I-III).

Electrode	OBCH	Calibration method in Uripan					Standard addition method				
	Taken	Found	Recovery	RSD	F-test	t-test	Found	Recovery	RSD	F-test	t-test
	mg mL-1	mg mL-1	(%)SD	%			mg mL-1	(%)SD	%		
I	3.939	3.904	99.11±0.070	1.79	0.41	0.69	3.879	98.48±0.030	1.01	2.25	0.07
	0.394	0.388	98.48±0.007	1.71	0.18	3.42	0.388	98.48±0.070	1.94	0.01	0.24
	0.197	0.198	100.5±0.003	1.39	-	-	0.193	97.97±0.003	1.69	-	-
II	3.939	3.919	99.49±0.041	1.05	1.20	1.90	3.988	101.2±0.098	2.46	0.21	2.20
	0.394	0.397	100.8±0.006	1.51	0.25	1.00	0.391	99.24±0.006	1.66	0.25	2.50
	0.197	0.199	101.1±0.003	1.62	-	-	0.194	98.48±0.002	1.03	-	-
III	3.939	3.905	99.14±0.068	1.74	0.44	0.74	3.899	98.98±0.045	1.17	1.00	0.84
	0.394	0.393	99.75±0.012	2.96	0.06	1.17	0.384	97.46±0.006	1.69	0.25	2.50
	0.197	0.199	101.1±0.003	1.62	-	-	0.192	97.48±0.002	1.04	-	-
Official	3.930	3.880	98.73±0.045	1.402.25							
Method [20]	1.871	1.840	98.50±0.001	3.07							
	0.393	0.400	101.78±0.003								

At n = 5, 95 %, F-test = 5.05, t-test = 2.571.

TABLE 4. Potentiometric determination of OBCH in biological fluids (urine and serum) using MSPEs.

Sample	Electrode	Taken mg mL^{-1}	Found mg mL^{-1}	Recovery (%) SD	RSD%
Urine	I	0.394	0.401	101.10.011	2.86
	II	0.394	0.391	99.490.002	0.83
	III	0.394	0.387	98.260.005	1.41
Serum	I	0.394	0.392	99.750.007	1.71
	II	0.394	0.382	97.200.009	2.45
	III	0.394	0.387	98.260.014	2.96

TABLE 5 . Evaluation of accuracy and precision (intra and inter-day) of MSPEs (Electrodes I-III).

Drug Form	Electrod Type	[OxHCl]	Intra –day			Inter-day		
		Taken mg mL^{-1}	Found mg mL^{-1}	Recovery (%)SD	RSD%	Found mg mL^{-1}	Recovery (%)SD	RSD%
Pure Form	I	3.939	3.874	98.35 ± 0.076	1.96	3.939	100.0 ± 0.107	2.72
		0.394	0.391	99.24 ± 0.006	1.53	0.384	97.46 ± 0.011	2.86
		0.197	0.199	101.1±0.046	2.34	0.194	99.48±0.019	0.98
	II	3.939	3.855	97.87 ± 0.101	2.61	3.840	97.49 ± 0.115	2.99
		0.394	0.394	100.0 ± 0.009	2.21	0.389	98.98 ± 0.003	0.84
		0.197	0.193	97.97±0.027	1.39	0.195	98.98±0.019	0.99
	III	3.939	3.919	99.49 ± 0.041	1.04	3.892	98.94 ± 0.061	1.65
		0.394	0.389	98.73 ± 0.004	1.21	0.388	98.48 ± 0.008	2.02
		0.197	0.194	98.48±0.031	1.59	0.195	98.98±0.027	1.40
Uriban	I	3.939	3.937	99.49±0.111	2.81	3.896	98.91±0.087	2.22
		0.394	0.391	99.24±0.006	1.47	0.385	97.72±0.006	1.49
		0.197	0.196	99.49±0.001	0.46	0.195	98.94±0.001	0.53
	II	3.939	3.888	98.70±0.097	2.51	3.891	98.78±0.097	2.49
		0.394	0.392	99.49±0.003	0.83	0.399	101.3±0.007	1.73
		0.197	0.198	100.5±0.003	1.41	0.201	102.1±0.003	1.39
	III	3.939	3.871	98.27±0.079	2.03	3.837	97.41±0.068	1.77
		0.394	0.386	97.97±0.009	2.45	0.387	98.22±0.008	2.14
		0.197	0.195	99.98±0.001	0.53	0.196	99.49±0.002	1.27

no. of replicates (n = 5).

TABLE 6. Comparison between response characteristics of MSPEs (Electrodes I-III).

	MSPEs		
Parameters	**I**	**II**	**III**
Slope (mV decade^{-1})	59.20± 0.52	58.00± 0.22	58.52± 0.32
Intercept	403.1	318.0	378.5
Correlation coefficient (r^2)	0.999	0.999	0.999
Linear range (mol L^{-1})	1.0×10^{-2}-1.0×10^{-5}	1.0×10^{-2}-1.0×10^{-5}	1.0×10^{-2}-1.0×10^{-5}
Detection limit (mol L^{-1})	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Quantification limit (mol L^{-1})	3.33×10^{-5}	3.33×10^{-5}	3.33×10^{-5}
Responce time, s	10.0	9.0	8.0
Working pH	2.0 - 6.0	2.0 - 6.0	2.0 - 6.0
Lifetime (day)	40	38	38
Isothermal coefficient (V/)	1.594×10^{-3}	2.151×10^{-3}	2.377×10^{-3}
Recovery %	97.46- 101.1	97.20- 102.1	97.41-101.1
SD	0.001- 0.111	0.003- 0.115	0.001-0.079
RSD %	0.43- 2.86	0.83- 2.99	0.53- 2.96

Conclusion

MSPEs have high sensitivity, high selectivity, fast response time and high stability over reasonable pH and temperature ranges. This method is valid and validation parameter as accuracy, precision ...etc, have a good agreement with the official method. These electrodes were precise and sensitive for determination of OBCH in pure and pharmaceutical samples by using calibration and standard addition method. MSPEs have advantage such as reproducibility of the preparation process, very simple, cheap and quick preparation.

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الأداء الكهروكيميائي لاقطاب الشاشة المطبوعة للتقدير الجهدى لهيدروكلوريد أوكسي بوتينين المضاد للكولين في التركيبات الصيدلانية والسوائل البيولوجية

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تم تتطويراقطاب ذات حساسيه عاليه من اقطاب الشاشه المطبوعه المعدله باستخدام عوامل الازدواج الايونى مثل (صوديوم تيترافينيل بورات, حمض فوسفوتنجستيك, حمض فوسفوموليبديك, رينيكات الامونيوم) لتقدير ماده الاوكسيبيوتينين هيدروكلوريد. وقد وجد ان الاقطاب المطبوعه والتي تحتوي على 7.5 مللي جرام من رينيكات الامونيوم, 17.5مللي جرام من صوديوم تيترافينيل بورات و 7.5 مللي جرام من حمض فوسفوتنجستيك. تعطي افضل ميل 59,20± 0,52 , 58,00 ±0,22 و58,52± 0,22 $mV\ decade^{-1}$ علي التوالي. ولذلك يمكن استخدام تلك الاقطاب لتقدير العقار محل الدراسة فى المدي المستقيم ($1.0x10^{-2}$-$1.0x10^{-5}$) مول لكل لتر وتتمتع بثبات حرارى من (10-60)درجه مئويه. وتم دراسه وقت الاستجابه ودرجه الحموضه ووجد ان استجابه الاقطاب لا تعتمد على درجه الحموضه فى المدى (6.0 – 2.0) اما وقت الاستجاب فكان يتراوح بين 8-10 ثوانى في درجه حراره الغرفه. . كما ان لاقطاب الشاشه المطبوعه ميزه طول المدى الزمنى للقطب. كما تم استخدام الاقطاب قيد الدراسه لتقدير عقار اوكسبيوتينين هيدروكلوريد فى شكله النقى, السوائل البيولوجيه والمستحضرات الصيدلانيه بطريقتى التقدير الجهدى و التقدير الجهدى والاضافه القياسيه واظهرت النتائج اتفاق جيد مع النتائج التى تم الحصول عليها باستخدام الطريقه المنشوره.