

Synthesis and Characterization of a Molecularly Imprinted Polymer for Diclofenac Sodium Using (2-vinylpyridine and 2-hydroxyethyl metha acrylate) as the Complexing Monomer

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Abstract:

Four electrodes were synthesized based on molecularly imprinted polymers (MIPs). Two MIPs were prepared by using the diclofenac sodium (DFS) as the template, 2-hydroxy ethyl metha acrylate(2-HEMA) and 2-vinyl pyridine(2-VP) as monomers as well as divinyl benzene and benzoyl peroxide as cross linker and initiator respectively. The same composition used for prepared non-imprinted polymers (NIPs) but without the template (diclofenac sodium). To prepared the membranes electrodes used different plasticizers in PVC matrix such as: tris(2-ethyl hexyl) phosphate (TEHP), tri butyl phosphate (TBP), bis(2-ethyl hexyl) adipate (BEHA) and tritoyl phosphate (TTP). The characteristics studied the slop, detection limit, life time and linearity range of DFS–MIPs electrodes. The results were obtained from selectivity measurements on amino acids showed good response as well as pharmaceuticals analysis.

Keywords: Molecularly imprinted electrodes, Diclofenac sodium, potentiometric method, (2-HEMA), (2-VP) monomers.

Introduction:

Diclofenac sodium has the structure, 2-[(2,6-dichlorophenyl)amino] benzene acetic acid sodium salt Fig.1 , which belongs to the group of non-steroidal anti-inflammatory drug (NSAID). That is widely used for the treatment of analgesic, rheumatoid arthritis, osteoarthritis and ankylosing spondylitis (1). It is used as an suitable on the treatment to chronic diseases like arthritis and pain after surgical operations. It facilitate pain and reduces inflammation (2). Water crystallizes diclofenac sodium which have melting point from 283 - 285 °C which dissolved at room temperature in deionized water, acetone ,methanol, acetonitrile, cyclohexane, HCl, and phosphate buffer(3).

According to review, diclofenac sodium was determination by several methods such as HPLC(4), spectrophotometry(5), thin layer chromatography (6), GC-Mass(7) and spectroscopic methods (8).

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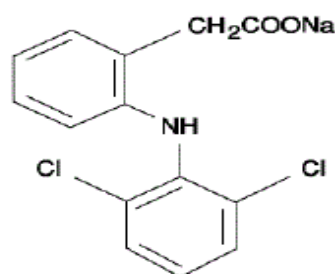


Figure 1. Chemical structure of the sodium diclofenac

An extensive literature survey revealed that there were several HPLC methods for the determination of diclofenac in blood plasma, whereas there was little other work disclosed only for the quantitative determination of diclofenac sodium in pharmaceutical formulation samples.

Selective electrodes were used as a technique for determination of di duo to several, rapid, easy preparation, fast response time, selectivity, wide linearity and low cost. For above characteristics that led to used sensors for the determination of ionic species, and the list of available electrodes has been grown largely over the past years(9-18). PVC membrane electrodes are one of the types of

potentiometric sensors which were widely used and have different application in analysis of ionic species (19).

Molecularly imprinted polymers (MIPs) were used for drugs as formation a complex between the analyte and a functional monomer with presence of a cross-linking agent and initiator. Several reports described the use of MIPs as ionophores in ion selective electrodes for a variety of drugs and chemicals such as ibuprofen (20), warfarin (21), phenytoin (22) and metronidazole benzoate (23). In this work were prepared MIP by using 4-vinyl pyridine (4-VP) and 2-hydroxy metha acrylate (2-HMA) as a monomers, divinyl benzene (DVB) as a cross-linker for polymerization with plasticizers tris (ethyl hexyl) phosphate (TEHP), tri butyl phosphate (TBP), bis(2-ethyl hexyl) adipate (BEHA), and tritoyl phosphate (TTP).

Materials and Methods:

Preparation of MIP and NIP

For the preparation of diclofenac sodium molecularly imprinted polymer (DFS-MIP), 0.5 mmol (0.1590g) from DFS dissolved in methanol (CH_3OH), then mixed with 2 mmol (0.2102 g) 2-vinylpyridine (2-VP), 4.61 mmol (0.6g) 2-hydroxy ethyl metha acrylate (2-HEMA) as the monomer which dissolved in $3\pm$ mL chloroform (CHCl_3), was after that added (1.3g) divinyl benzene to the solution as the cross linker, followed that added (0.05g) benzoyl peroxide (BPO) as the initiator which also dissolved in $3\pm$ mL chloroform. For obtaining a homogeneous solution, the mixture was stirred for 5 minutes. N_2 passes for 30 minutes on the mixture to remove oxygen from solution. After that the solution was placed in a water path at 65°C . when the reaction completed the molecularly imprinted polymer became hardened. After the polymerization process, the polymer were dried and crashed to obtain a polymer particles. These particles was sonicated in $\text{CH}_3\text{OH}/\text{CH}_3\text{COOH}$ (18:2, v/v) to remove the template from MIP. The particles size was between (53 – 100 μm). The preparation of non-molecularly imprinted polymer using the same substances and conditions that formed MIP but without diclofenac sodium (template).

Instruments:

Ion analyzer used in this work (WTW model, Germany), a pH meter (WTW model pH 720, Germany), and a saturated calomel electrode (Gallenkamp, USA). The electrode diclofenac sodium-MIP used was constructed in the laboratory and all potentiometric measurements were made at room temperature. The diclofenac sodium-MIP electrode combined with Ag-AgCl electrode and the

reference electrode was 0.1 M internal solution of diclofenac sodium. The PVC tube (1-2 cm long) was flattened and polished by putting it on a glass plate and soaking with THF. The membrane was cut similar to the external diameter of the PVC tubing and pasted on the polished end. The other direction of the PVC tubing was then linked to the electrode body. To make the electrodes more sensitive were by soaking in 0.1 M diclofenac sodium solution for at least 2 hours before the use of the electrodes.

Materials and chemicals:

1. Diclofenac sodium standard obtained from industries of pharmaceuticals (IRAQ-SDI -Samara). Cata flam tablet 50 mg from (Novartis pharma AG, Basle, Switzerland), Voldic-K tablet 50 mg from (Pharma International CO. Amman –Jordan) and OPIFENAC-25 tablet 50 mg (Ajanta Pharma, India) were purchased from local pharmacies.
2. Plasticizers, Tris (2-ethyl hexyl) phosphate (TEHP) (97.0% purity), tri-butyl phosphate (TBP) (99.0% purity), Bis(2-ethyl hexyl) adipate (BEHA) (99% purity) and Tritoyl phosphate (TTP) (94% purity) were purchased from Fluka AG. Other chemicals and reagents materials were obtained from Fluka, BDH and Sigma Aldrich.

Preparing of Standard solutions

1. For preparing standard solution of 0.1 M diclofenac sodium by dissolving 0.159 g of standard diclofenac sodium in the methanol and completed to 100 mL in the volumetric flask. The other solutions were prepared in 100 mL at the ranged from 10^{-6} – 10^{-1} M in the same procedure.
2. The stock standard solution of 5×10^{-3} M, 5×10^{-4} M phospho molybdic acid was prepared by dissolving 0.912g, 0.091g respectively in distilled water and completed to 100 mL.
3. All amino acids 0.1 M stock solution prepared at ranged from (10×10^{-6} - 10×10^{-1}) M which present the interfering ions such; asparagine, arginine, glycine, tryptophan, were prepared and diluted to 100 mL.

Synthesis of membrane molecularly imprinted polymers electrode

Diclofenac sodium membrane was immobilized into the PVC tube as portrayed by Thomas and Moody(24). DFS-MIP of (0.04g) was mixed with different of plasticizers (0.8g) used in this work such as: TEHP (electrode A1), TBP (electrode A2), BEHA (electrode B1) and TTP (electrode B2). Then added (0.34g) of PVC powder was scattered on $7\pm$ mL of tetrahydrofuran with stirring until a clear viscous solution was acquired. Then the solutions mixed with stirring until the mixture were became homogeneous. The mixture was casted into a glass ring (30-35 mm diameter) and unwind on a glass plate and a ribbon of filter was placed on top of the

glass. The solvent was then allowed to evaporate according to room temperature more than 24 hours at least. The thickness of the membrane obtained was different of membrane to other's, the thickness was about (0.4 -0.7) mm. That size of membrane was adequate to prepare electrodes.

Scanning Electron Microscope SEM

The morphology of MIP and NIP membranes with and without conditioning has assessed by scanning electron microscope [JSM-6390A] (Tokyo,japan) for MIP1 is shown in Figure. 2. Fig. 2a shows a numerous pores on the surface which made it a suitable sorbent because of the well-defined binding sites on the imprinted polymer. In addition, the image shows that the diameters of MIP1 are uniform in sizes and shapes (regular spherical). Fig. 2b shows that the MIP1 is bound to the holes of MIP1, indicating that the MIP1 can be used as a selective sensor for diclofenac sodium template in the solution. The differences between the SEM images of MIP and NIP in terms of size and surface morphology of the polymeric particles are clearly can be observed.

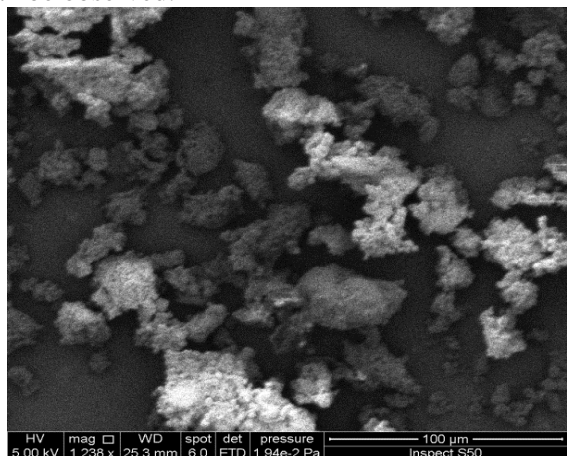


Figure 2a. SEM for the MIP1 before washing

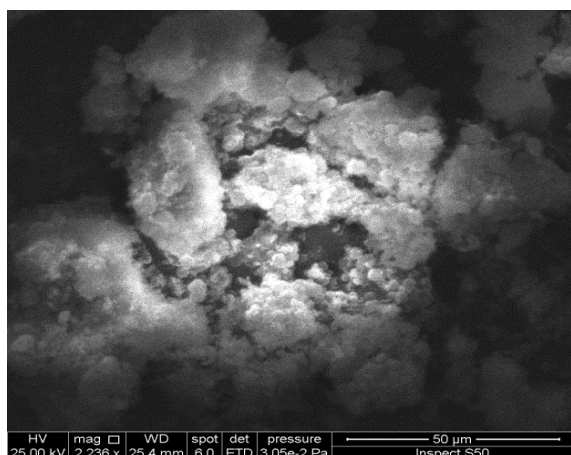


Figure 2b. SEM for MIP1 after washing

The morphology of the prepared membrane using the DFS-MIP1 before washing is shown in figure 2a and after washing is shown in Fig 2b.

Figure 2a (before washing) reveals that the particles of the complex are formed in a regular spherical shape with an average of about 200 μm in diameter. On the other hand, Fig 2b (after washing) shows that the formed particles look like a colloidal particles growing in a solution. This might take place due to a presence of excess of DFS that forms ionic atmosphere surrounding the complex and create the formation of electric double layers.

Construction of ion-selective electrodes

The building of the electrode body and the immobilization were achieved as portrayed by Mahajan et al.(25). Diclofenac sodium solution (0.1) M was filled in the glass tube as an internal solution. Preferred immersing. The membrane in standard solution of (0.1) M of diclofenac sodium for at least two hours before measurements which represents stipulations of membrane electrode.

Preparation of Pharmaceutical Samples

To obtain the powder of tablets pharmaceutical samples using pestle and mortar to grinding the tablets then take a suitable weight for preparation in 100 mL of solutions. Used appropriate amount of methanol (CH₃OH) for dissolved pharmaceutical samples as well as using the magnetic stirrer for more than 30 minutes. After that filtered the solution by using 0.07μm cellulose filter paper for preparing and obtained the concentrations of 5 x10⁻³ M and 5 x10⁻⁴ M diclofenac sodium.

Results and Discussion:

The largest group of potentiometric sensors is represented by ion selective electrodes (ISEs). The signal is generated by the charge separation at the interface between the membrane and the solution, due to the selective partitioning of ionic species between these two phases (26). A line diagram of the ISE cell can be represented by the Fig (3).

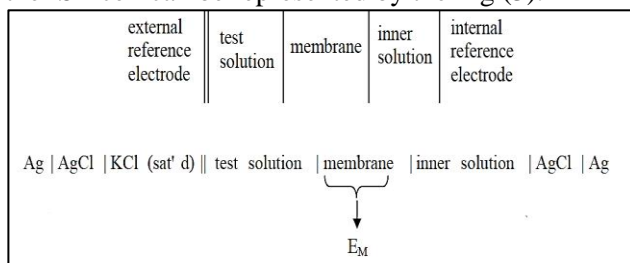


Figure 3. A line diagram of the ISE cell.

And the potential of (ISE) cell is given by the equation: (6)

$$E_{\text{cell}} = (E_m - E_{\text{ref}}) + E_j$$

Where:

E_m = is the membrane potential.

A plasticizer is an important component in an ISE membrane. The plasticizer acts as a membrane solvent, affecting membrane selectivity through both extraction of ions into the organic phase and influencing their complexation with the ionophore. Synthesis molecularly imprinted polymers by using the diclofenac sodium as template, 2-vinyl pyridine or 2-hydroxy metha acrylate as monomers, divinyl benzene as cross linker and benzoyl peroxide as initiator. Used four plasticizers for preparations

electrodes based on PVC membranes. These plasticizers such as: tris(2-ethyl hexyl) phosphate (TEHP), tri butyl phosphate (TBP), bis(2-ethyl hexyl)adipate (BEHA) and tritoyl phosphate (TTP). The nernstain slopes for all electrodes bases on DFS-MIP1 (A1, A2 membranes) and DFS-MIP2 (B1, B2 membranes) were obtained, linearity range, correlation coefficients, detection limit (M) and life time (day) respectively are shown in the table1 and Fig 4.

Table 1. Characteristics of the diclofenac sodium-MIP electrode based on different functional monomers and plasticizers.

Membrane composition	DFS-MIP1 +TEHP (A1)	DFS-MIP1+TBP (A2)	DFS-MIP2 +BEHA (B1)	DFS-MIP2 +TTP (B2)
Slop (mV/decade)	18.5	21.98	22.04	17.33
Linearity range (M)	10^{-2} - 10^{-4}	10^{-1} - 10^{-5}	10^{-1} - 10^{-3}	10^{-3} - 10^{-6}
Correlation coefficient	0.9987	0.9962	0.9965	0.9941
Detection limit (M)	3×10^{-6}	2×10^{-6}	4×10^{-6}	6×10^{-6}
Life time (day)	46	14	11	8

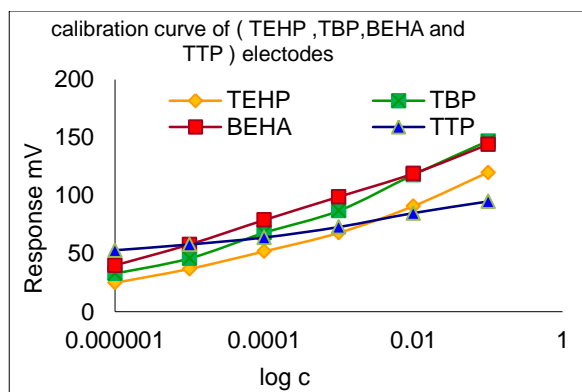


Figure 4. Calibration curve for DFS-MIP1 and DFS-MIP2 membranes electrodes.

Effect of pH on electrodes response

The study of pH affected DFS membranes electrodes by prepared various concentrations of DFS (5×10^{-3} , 5×10^{-4} and 5×10^{-5}). To measure the selective pH at ranged (1-11) by using the hydrochloric acid (0.1M, 1M) and/or ammonium hydroxide (0.1M, 1M) for pH studies. The results obtained by adding appropriate volume of HCl/NH₄OH as shown in Table (2) and Fig.(5,6).The change in potentials at differential pH values may be due to the composition of electrodes. This composition also effect on response and life time for electrodes.

Table 2. Working pH range for diclofenac sodium Selective electrode

Number and composition of MIPs	Membranes	Membrane composition	pH range		
			5×10^{-3}	5×10^{-4}	5×10^{-5}
MIP1	A1	DFS-MIP1 +TEHP	8-11	7.5-11	5-11
DFS+2-VP+DVB	A2	DFS-MIP1 +TBP	4.5-9	5-11	5-10.5
MIP2	B1	DFS-MIP2+BEHA	5.5-11	5.5-11	7.5-9.5
DFS+2-HEMA+DVB	B2	DFS-MIP2 +TTP	6.5-11	6.5-11	5.5-11

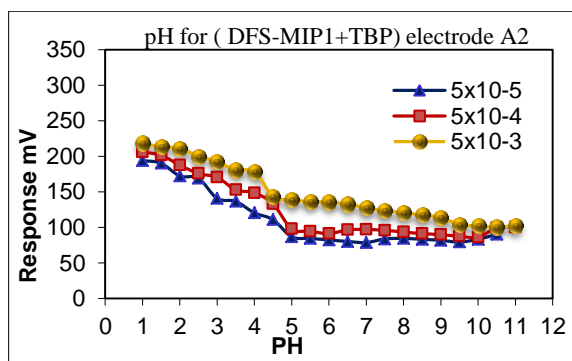
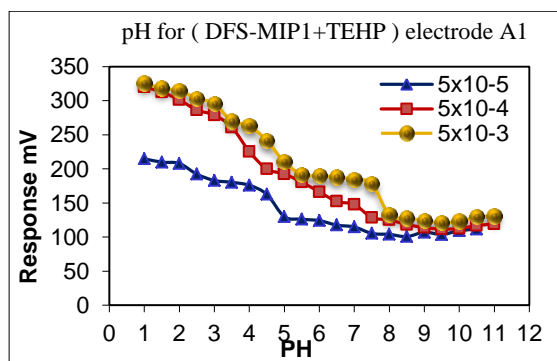


Figure 5. Effect of pH on the Diclofenac Sodium {DFS-MIP1 + TEHP (A1) and DFS-MIP1 +TBP (A2)} electrodes at concentration 5×10^{-3} , 5×10^{-4} and 5×10^{-5} .

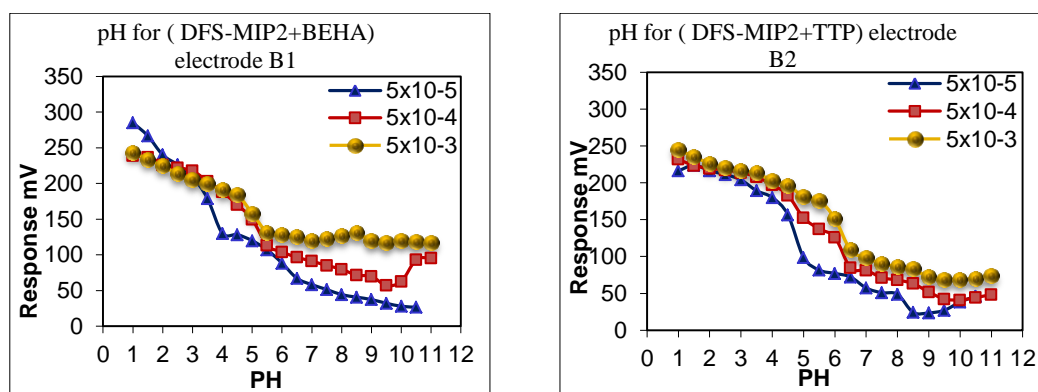


Figure 6. Effect of pH on the Diclofenac Sodium {DFS-MIP2 + BEHA (B1) and DFS-MIP2 +TTP (B2)} electrodes at concentration 5×10^{-3} , 5×10^{-4} and 5×10^{-5} .

Interference studies

For calculating the selectivity, coefficient measurement used separate solution method. Using the separate equation for this measurements according to the equation below.

$$\text{Log } K \text{ pot} = \frac{(E_B - E_A)}{(2.303RT/zF)} + (1 - z_A/z_B) \log a_A$$

EA, EB; zA, zB; and aA, represents the potentials, charge numbers, and activities for the primary A and interfering B ions, respectively at $a_A = a_B$.

The results obtained for selectivity coefficients of primary ion and interfering ions like amino acids used in this work. The selectivity coefficients depend on charges of both primary ion and interfering ions it also depends on concentration as well as the composition of electrodes (27).

All values for selectivity coefficients were listed in tables 3, 4, 5, 6 and figures (7, 8).

Table 3. Selectivity coefficients for (DFS –MIP1 +TEHP) electrode at different concentrations of Diclofenac sodium

Conc.(M)	Concentrations of Diclofenac Sodium (M): Concentrations of interference ions (M)							
	Interfering ions							
	Asparagine		Arginine		Glycine		Tryptophan	
	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$
10^{-1}	100.4	2.0932×10^{-4}	61.2	6.6925×10^{-7}	78	7.8518×10^{-6}	88.1	3.4504×10^{-5}
10^{-2}	88.2	5.7463×10^{-3}	71.4	4.8979×10^{-4}	73.7	6.8614×10^{-4}	85.4	6.2929×10^{-5}
10^{-3}	75.6	2.0268×10^{-2}	80.6	4.2177×10^{-2}	67.5	6.1832×10^{-3}	76.7	2.3814×10^{-2}
10^{-4}	73	1.6008×10^{-1}	76.3	2.5965×10^{-1}	61.2	2.8393×10^{-2}	70.1	1.0465×10^{-1}
10^{-5}	68.9	1.6244×10^{-1}	70.9	2.1777×10^{-1}	60.9	5.0288×10^{-2}	62.5	6.3578×10^{-2}
10^{-6}	73.1	5.8141×10^{-1}	68.7	3.0507×10^{-1}	59.3	7.6924×10^{-2}	63.6	1.4447×10^{-1}

Table 4. Selectivity coefficients for (DFS –MIP1 +TBP) electrode at different concentrations of Diclofenac sodium.

Conc.(M)	Concentrations of Diclofenac Sodium (M): Concentrations of interference ions (M)							
	Interfering ions							
	Asparagine		Arginine		Glycine		Tryptophan	
	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$	E_B (mV)	$K_{A,B}$
10^{-1}	106.4	1.6470×10^{-3}	109	2.3910×10^{-3}	71.9	3.1871×10^{-5}	82.6	5.4293×10^{-5}
10^{-2}	92.1	1.3169×10^{-2}	88.1	7.4214×10^{-3}	66.1	3.8398×10^{-4}	77.3	1.5776×10^{-3}
10^{-3}	81.6	9.6618×10^{-2}	81.4	9.3886×10^{-2}	58.3	4.7597×10^{-3}	74.5	3.4911×10^{-2}
10^{-4}	66.3	1.2687×10^{-1}	77.6	6.4117×10^{-1}	49.6	9.0267×10^{-3}	61.7	6.5605×10^{-2}
10^{-5}	61.1	1.6189×10^{-1}	71.9	7.6154×10^{-1}	46.4	4.9742×10^{-2}	59.2	1.2328×10^{-1}
10^{-6}	65.7	4.5450×10^{-1}	59.3	1.8156×10^{-1}	50.2	1.2014×10^{-1}	53.1	7.4641×10^{-2}

Table 5. Selectivity coefficients for (DFS –MIP2 +BEHA) electrode at different concentrations of Diclofenac sodium.

Conc.(M)	Concentrations of Diclofenac Sodium (M): Concentrations of interference ions (M)							
	Interfering ions							
	Asparagine		Arginine		Glycine		Tryptophan	
	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}
10 ⁻¹	143.5	7.4148×10 ⁻³	47.6	4.3410×10 ⁻⁶	79.3	4.6875×10 ⁻⁴	126.4	7.4048×10 ⁻⁴
10 ⁻²	123.1	1.4941×10 ⁻²	44.3	6.5838×10 ⁻⁴	72	3.9378×10 ⁻²	120.7	1.0813×10 ⁻²
10 ⁻³	112.7	8.1591×10 ⁻²	38.7	2.3448×10 ⁻³	64.8	1.1073×10 ⁻¹	101	1.6867×10 ⁻²
10 ⁻⁴	82.3	8.5993×10 ⁻³	48.1	6.7015×10 ⁻²	59.6	3.6629×10 ⁻¹	93.3	3.7854×10 ⁻²
10 ⁻⁵	72.9	1.3057×10 ⁻²	36	9.2744×10 ⁻²	47.5	5.0692×10 ⁻¹	80.5	3.6355×10 ⁻²
10 ⁻⁶	66	2.8144×10 ⁻²	21.9	1.6233×10 ⁻²	33	8.3635×10 ⁻²	76.7	1.1898×10 ⁻¹

Table 6. Selectivity coefficients for (DFS –MIP2 +TTP) electrode at different concentrations of Diclofenac Sodium.

Conc.(M)	Concentrations of Diclofenac Sodium (M): Concentrations of interference ions (M)							
	Interfering ions							
	Asparagine		Arginine		Glycine		Tryptophan	
	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}	E _B (mV)	K _{A,B}
10 ⁻¹	105.3	2.5865×10 ⁻⁴	70.6	2.1436×10 ⁻⁶	66.7	1.2508×10 ⁻⁶	54.8	2.4173×10 ⁻⁷
10 ⁻²	96.5	2.5022×10 ⁻²	68.9	5.5291×10 ⁻⁴	60.9	1.8312×10 ⁻⁴	56.5	9.9724×10 ⁻⁵
10 ⁻³	87.7	5.3488×10 ⁻²	65.1	2.3579×10 ⁻³	55.5	6.2610×10 ⁻⁴	60.1	1.1819×10 ⁻³
10 ⁻⁴	67.5	1.4008×10 ⁻²	64.7	9.5149×10 ⁻³	50.8	1.3950×10 ⁻³	71.7	2.5022×10 ⁻²
10 ⁻⁵	63.9	6.0568×10 ⁻²	50.4	9.3844×10 ⁻³	55.9	2.0060×10 ⁻²	69.1	1.2422×10 ⁻¹
10 ⁻⁶	58.4	1.1754×10 ⁻¹	48.1	2.8334×10 ⁻²	65.1	2.9656×10 ⁻¹	71.9	7.5862×10 ⁻¹

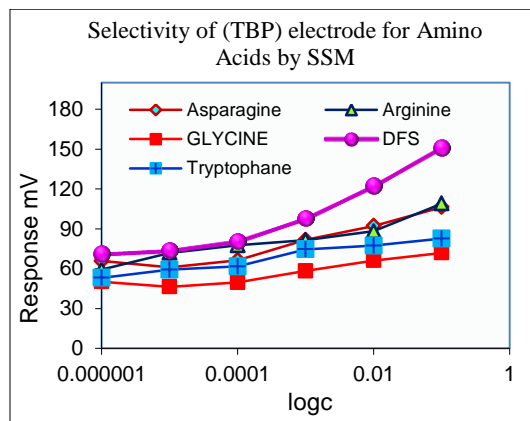
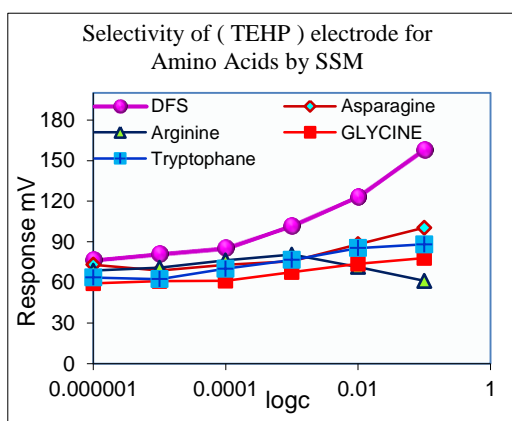


Figure 7. Selectivity of (DFS-MIP 1 + TEHP and DFS-MIP 1 + TBP) electrodes with amino acids via Separation Solution Method.

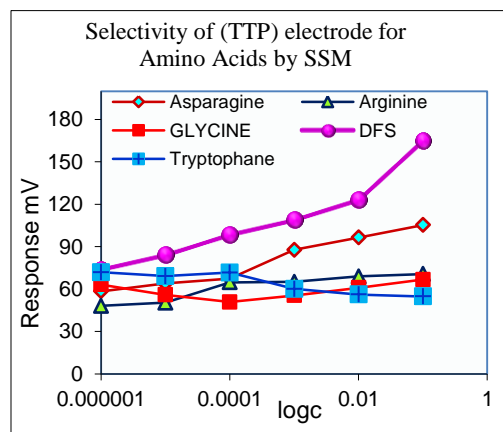
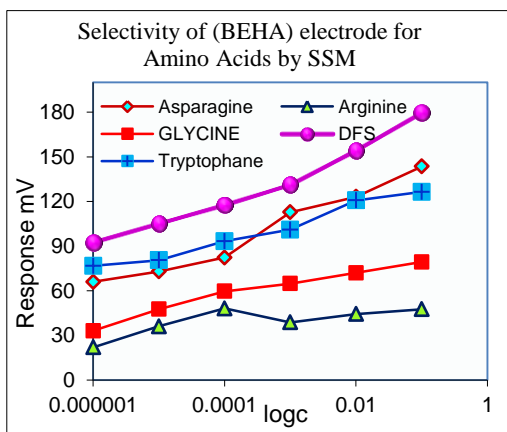


Figure 8. Selectivity of (DFS-MIP 2 + BEHA and DFS-MIP 2 + TTP) electrodes with amino acids via Separation Solution Method.

Calculation by Multiple Standard Addition Method (MSA):

The concentrations used for applied in this method (5×10^{-3} & 5×10^{-4}) for two solutions of diclofenac sodium for plotting the antilog E/S (Y-axis) against volume of standard diclofenac sodium (X-axis). Fig. (9, 10) represents the results of diclofenac sodium concentrations calculated via the electrodes based on DFS-MIP1+ TBP, DFS-MIP2+BEHA.

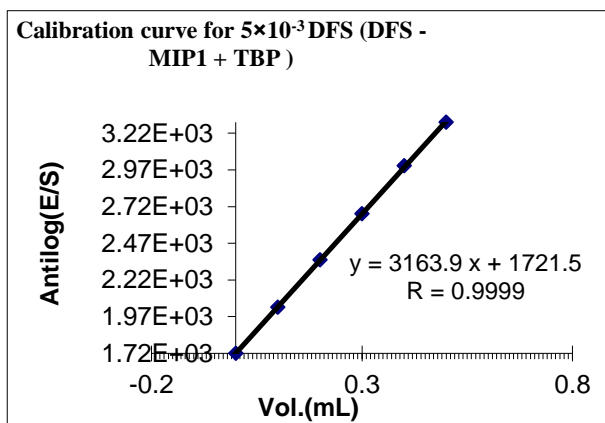


Figure 9. Antilog (E/S) against the volume of the added standard for the determination of Diclofenac Sodium solution (5×10^{-3}) by MSA using (DFS – MIP 1 + TBP) electrode.

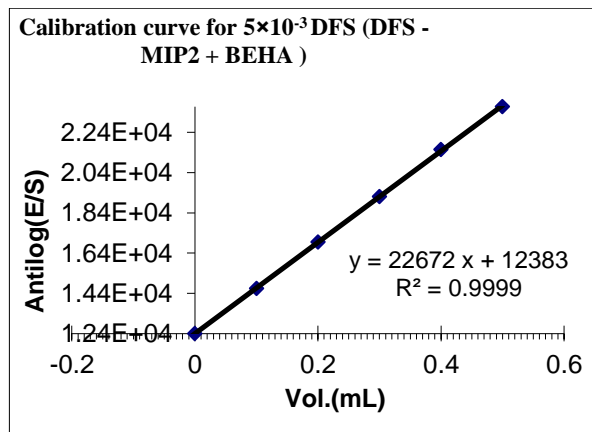


Figure 10. Antilog (E/S) against the volume of the added standard for the determination of Diclofenac Sodium solution (5×10^{-3}) by MSA using (DFS – MIP 2 + BEHA) electrode.

Applications of pharmaceuticals

Ion selective electrodes that based on molecularly imprinted polymers were used for determination of diclofenac sodium in pharmaceuticals. This ISEs measurements including: standard addition, direct, Gran plot and multiple standard addition method. Preparation solutions of diclofenac sodium at concentrations 5×10^{-3} and 5×10^{-4} M. The RE%, RC% and RSD% were calculated of diclofenac sodium in pharmaceuticals. The results obtained are represented in tables (9, 10, 11, and 12).

Table 9. Analysis of Diclofenac sodium samples by using ISE type (DFS-MIP1+TEHP)

Pharmaceutical	CataFlam (Novartis pharma AG, Basle, Switzerland)		
	DM	SAM	MSAM
Concentration M	5×10^{-3}		
Value founded	5.0673×10^{-3}	4.9483×10^{-3}	5.0636×10^{-3}
Recovery %	101.35	98.97	101.27
RE%	1.35	-1.03	1.27
RSD%	2.2707	1.12	–
Pharmaceutical	OPIFENAC-25 (Ajanta Pharma, India)		
Concentration M	5×10^{-3}		
Value founded	5.0852×10^{-3}	4.9937×10^{-3}	4.9248×10^{-3}
Recovery %	101.70	99.87	98.50
RE%	1.70	-0.13	-1.50
RSD%	1.8594	1.35	–
Pharmaceutical	Voldic-K (Pharma International CO . Amman –Jordan)		
Concentration M	5×10^{-3}		
Value founded	5.0728×10^{-3}	4.9385×10^{-3}	5.0946×10^{-3}
Recovery %	101.46	98.77	101.89
RE%	1.46	-1.23	1.89
RSD%	2.2403	1.14	–

Table 10. Analysis of Diclofenac sodium samples by using ISE type (DFS-MIP1 +TBP)

Pharmaceutical	CataFlam (Novartis pharma AG, Basle, Switzerland)		
	DM	SAM	MSAM
Concentration M		5×10⁻³	
Value founded	4.9468×10 ⁻³	4.8864×10 ⁻³	5.0415×10 ⁻³
Recovery %	98.94	97.73	100.83
RE%	-1.06	-2.27	0.83
RSD%	2.191	1.07	—
Pharmaceutical	OPIFENAC-25 (Ajanta Pharma, India)		
Concentration M		5×10⁻³	
Value founded	5.0739×10 ⁻³	4.9975×10 ⁻³	5.080×10 ⁻³
Recovery %	101.48	99.95	101.60
RE%	1.48	-0.05	1.60
RSD%	2.33	1.32	—
RSD%	1.721	1.37	—
Pharmaceutical	Voldic-K (Pharma International CO. Amman –Jordan)		
Concentration M		5×10⁻³	
Value founded	5.0926×10 ⁻³	4.9975×10 ⁻³	5.0562×10 ⁻³
Recovery %	101.85	99.95	101.12
RE%	1.85	-0.05	1.12
RSD%	1.72	2.01	—

Table 11. Analysis of Diclofenac sodium samples by using ISE type (DFS-MIP2 +BEHA)

Pharmaceutical	CataFlam (Novartis pharma AG, Basle, Switzerland)		
	DM	SAM	MSAM
Concentration M		5×10⁻³	
Value founded	4.9493×10 ⁻³	5.1162×10 ⁻³	5.0101×10 ⁻³
Recovery %	98.94	102.32	101
RE%	-1.01	2.32	1
RSD%	1.23	1.62	—
Pharmaceutical	OPIFENAC-25 (Ajanta Pharma, India)		
Concentration M		5×10⁻³	
Value founded	4.9238×10 ⁻³	5.0645×10 ⁻³	5.0674×10 ⁻³
Recovery %	98.48	101.29	101.35
RE%	-1.52	1.29	1.35
RSD%	1.28	2.41	—
Pharmaceutical	Voldic-K (Pharma International CO. Amman –Jordan)		
Concentration M		5×10⁻³	
Value founded	4.9394×10 ⁻³	5.1730×10 ⁻³	5.0755×10 ⁻³
Recovery %	98.79	103.46	101.51
RE%	-1.21	3.46	1.51
RSD%	1.097	1.72	—

Table 12. Analysis of Diclofenac sodium samples by using ISE type (DFS-MIP2 +TTP)

Pharmaceutical	CataFlam (Novartis pharma AG, Basle, Switzerland)		
	DM	SAM	MSAM
Concentration M		5×10⁻³	
Value founded	5.0616×10 ⁻³	5.1643×10 ⁻³	5.0472×10 ⁻³
Recovery %	101.23	103.29	100.94
RE%	1.23	3.29	0.94
RSD%	1.86	2.26	—
Pharmaceutical	OPIFENAC-25 (Ajanta Pharma, India)		
Concentration M		5×10⁻³	
Value founded	5.0901×10 ⁻³	5.0266×10 ⁻³	5.0761×10 ⁻³
Recovery %	101.80	100.532	101.52
RE%	1.80	0.532	1.52
RSD%	2.022	2.2	—
Pharmaceutical	Voldic-K (Pharma International CO. Amman –Jordan)		
Concentration M		5×10⁻³	
Value founded	4.9348×10 ⁻³	5.2106×10 ⁻³	5.0542×10 ⁻³
Recovery %	98.70	104.21	101.08
RE%	-1.30	4.21	1.08
RSD%	2.035	2.54	—

Conclusion:

Diclofenac sodium membranes selective electrodes can be constructed by mixing with different plasticizers. These plasticizers TEHP, TBP, BEHA and TTP were used to prepare diclofenac sodium membranes electrodes based on PVC. The results obtained for all electrodes were excellent as well as applied on standard and pharmaceutical solutions. The aim of construction electrodes for used in determination diclofenac sodium in pharmaceuticals analysis.

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تخليق وتوصيف الطبعة البوليمرية الجزئية للدايكولوفيناك صوديوم باستخدام 2-فاينيل بيريدين و 2-هايدروكسي اثيل ميثا اكريليت كمونمرات معقدة

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الخلاصة:

تم تصنيع أربعة أقطاب كهربائية على أساس البوليمرات المطبوعة جزئياً. تم تحضير اثنين من الطبعة البوليمرية الجزئية بواسطة استخدام ديكولوفيناك الصوديوم كقالب، 2-هايدروكسي اثيل ميثا اكريليت و 2- فينيل بيريدين كمونمرات وكذلك دايفنيل بنزين والبنزويل بيروكسيد كرابط وبادئ للتفاعل على التوالي. لإعداد الأقطاب الغشائية لقد تم استخدام مواد بلاستيكية مختلفة في قالب بولي فاينيل كلورايد مثل: ترس (إيثيل هيكاسيل) فوسفات، ثلاثي بيوتيل فوسفات، بس (إيثيل هيكاسيل) أديبيت و تراي توليل فوسفات. الخصائص التي درست هي المنحدر، وحد الكشف، وعمر القطب والخطية لمجموعة من أقطاب الطبعة البوليمرية الجزئية لديكولوفيناك الصوديوم. أظهرت النتائج التي تم الحصول عليها من القياسات الانتقائية للأحماض الأمينية استجابة جيدة وكذلك تحليل الادوية الصيدلانية التجارية.

الكلمات المفتاحية: اقطاب الطبعة البوليمرية، دايكولوفيناك صوديوم، الطريقة المجهادية (بوتينشيومتريك)، مونمرات 2-هايدروكسي اثيل ميثا اكريليت، 2 - فينيل بيريدين.