Article

Facile synthesis of Al_2O_3 and Fe_2O_3 via green chemistry for the potentiometric determination of Phenylephrine-HCl in pure form and pharmaceutical formulations

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Abstract

Phenylephrine (PHE) in its pure form and in pharmaceutical preparations can be determined using an easy-to-use, affordable, sensitive, and eco-friendly approach. The process is predicated on the synthesis of nano-iron oxide (Fe_2O_3) and nano-aluminum oxide (Al_2O_3) from the extract of the Melissa plant. The measurements were made between October 15, 2023, and January 15, 2024, at Tikrit University's College of Science, Department of Chemistry. This study's primary goal is to ascertain how much the electrical potential changes when copper wire is used instead of aluminum. There were four electrodes produced (I, II, III, IV). In a variety of PHE concentrations, the electrodes responded to the chemical appropriately ($1x10^{-2}$_$1x10^{-8}$) mol/L. Concerning the electrodes (II, IV), concerning the electrodes (II, IV), Regarding the electrodes (I, III), their response fell within the concentration range ($1x10^{-2}$_$1x10^{-6}$) mol/L. This range of concentrations showed a linear relationship. Table No. (1) displays the detection limit and quantitative limit values, both of which were good. The poles (I, II, III, IV) have Nernst inclinations of (54.0, 54.4, 57.571, 57.179) mv/decade, respectively. These values are in close proximity to the Nernst value for the single-charged ion, which is (59.15 mv/decade) over the number of degrees. For the electrodes that we made (I, II, III, IV), the pH (2_8) and the correlation coefficient (R) are, respectively, (0.9997, 0.9997, 0.9999, and 0.9998). The suggested approach was confirmed and contrasted with the approved approach. We were successful in this. The goal of the experiment is to produce nanomaterials from environmentally friendly sources. These methods have gained popularity due to their simplicity, affordability, and lack of environmental hazard. Additionally, when drugs are bound to nano-oxides, the outcomes are more favorable.

Keywords: green synthesis, phenylephrine, potential determination, nano aluminum oxide, nano iron oxide, dried lemon balm plant

Introduction

As electro-analytical sensors that can respond selectively to the chemicals to be examined through their chemical interactions, selective electrodes are classified as part of the automated categorization (1). It primarily relies on the transport of ions between the semi-permeable membrane and the electrolyte solution. The voltage produced at either end of the barrier membrane is then measured between two solutions that differ in the amount of the relevant ion (2). The volt meter or an acid function measuring device (pH meter) is used to link the ion-selective electrode to a reference electrode. The voltage of the ion-selective electrode is dependent on the logarithm of the activity of the ion to be measured studied according to the Nernist equation (5,4,3). It is believed that scientist Eisenman was the first to prepare a liquid membrane. In order to analyze the transport of potassium ions in the cow's heart's mitochondria, he relied on coronary ether in preparation, a cyclic chemical that comprises several heterogeneous elements, such as oxygen with nitrogen or sulfate (6). Scientist Qstwald made the discovery of ion-selective electrodes in 1890 (7). Solid electrodes are a different kind of electrode that were discovered in the 1960s by scientists Rokosing and Rungor (8). A member of the phenethylamine class, phenylephrine is a selective alpha-adrenergic receptor agonist medication. It is a medication made from the basic reaction of hydrogen chloride and phenylephrine in equal molar quantities. (9) Scientific name for 3-[1-hydroxy-2-(methylamino)ethyl]phenol-CH3

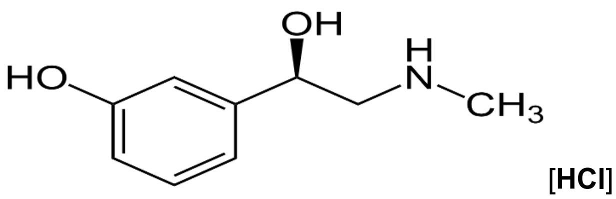


Figure (1) : Structural formula of phenylphrene

It is an odorless, white, crystalline powder that dissolves readily in water and has a variety of applications. For example, it can be used as eye drops to dilate the pupil, which enhances vision by passing through the retina (10) or as a blood pressure booster to raise blood pressure in ill patients who have low blood pressure. Blood (11). Its adverse effects include elevated blood pressure, which stimulates vascular baroreceptors and causes a sluggish heart rate (12). Prostate enlargement is increased by misuse, and repeated usage can cause blood vessel congestion (13).

Experimental

Sodium hydroxide (NaOH), hydrochloric acid (HCl), potassium aluminum sulfate (Kalum2.) ($AlKO_8S_2.18H_2O$), zinc acetate ($Zn(C_2H_3O_4)2$, hydrated iron chloride ($FeCl_3.6H_2O$), sodium tetraphenylborate (STPB), tetrahydrofuran (THF), tert-butyl phosphate (TBP), PVC, glucose, alpha-maltose, magnesium stearate, and methylcellulose .

Tools and devices

EUTECH INSTRUMENTS pH 700, Jenway-pH Meter 3310, Calomel Electrode Co.(Germany) No13-639-52 Fisher Scientific, Beschıckung/Loadıng –Model 100-800, Jenway Hot Plate With magnetic stirrer_Germany, Sartorius BL210 S AG GOTTINGEN.

Preparation of aluminum nanoparticles Al_2O_3NPS

Highly pure distilled water was used to prepare 100 mL of aqueous potassium aluminum sulphate at a concentration of 0.05 molar. After that, 60 mL of the solution was taken and 20 mL of Melissa extract was added, along with 0.5 grams of sodium hydroxide and 0.5 grams of zinc acetate. The mixture was then stirred for an hour. After adjusting the pH to 12, we dry the mixture for 45 minutes at 80°C. As a result, we will have aluminum nanoparticles that are somewhat yellow in color .

Preparation of Fe_2O_3NPS iron nanoparticles

A 100 milliliter aqueous solution of 0.01 molar (2.70g) iron chloride was made with ultra-pure distilled water. After that, the mixture was put in a beaker and heated to 70 degrees Celsius while being stirred constantly for 30 minutes. Next, we used a burette to add 40 cc of the Melissa extract drop by drop and adjusted the pH to 11. After 50 minutes of stirring the mixture, we thoroughly rinse the filtrate in distilled water to get rid of the salts, and then we dry it for 22 hours at 80°C. As a result, dark red iron nanoparticles will be produced (14,15).

Prepare the standard solution of phenylephrine hydrochloride (M0.01)

It is made by dissolving 0.2037 grams of the medication PHE powder in 100 milliliter volumetric flask with distilled water, then adding more distilled water to the required level. Following that, a dilution series of solutions ranging from (10^{-3}_10-^{8}) mol/L are created.

Ionic double preparation (PHE_STPB)

In a 50 mL beaker, 10 mL of the medication PHE at the same concentrations (2–10) are combined with 10 mL of the precipitating agent sodium tetraphenylborate to create the ionic double (PHE_STPB). A white precipitate starts to appear after a few minutes. We filter the mixture and let the filtrate dry after a full day. for seventy-two hours at laboratory temperature.

Membrane composition and electrode fabrication (I, II, III, IV).

In a 10 mL Beaker, 0.19 g of PVC were combined with 0.01 g of PHE_STPB, dissolved in 5 mL of THF, and thoroughly mixed with a glass stirrer to form the conventional PHE_STPB_ TBP coated copper wire film electrode (I) and the conventional DPH_STPB_ TBP coated aluminum wire film electrode (II). Next, 0.35 mL of the plasticizer TBP was added. Subsequently, two 5-cm-long wires were extracted, one made of copper and the other of aluminum. Following a thorough washing in distilled water and acetone, they were allowed to dry. They were put within a tube made of polyethylene. The wire was left with one end connected to the possible difference gadget. After repeatedly submerging the other end in the aforementioned mixture to create a thick coating, it was allowed to cure for a little while. minutes, and then carry out the procedure multiple times to create a thick layer of membrane. In order to create the copper wire membrane electrode coated with nanoparticles (PHE _STPB_ Fe_2O_3NPS _ Al_2O_3NPS _TBP) modified electrode (III) and the aluminum wire membrane electrode coated with nanoparticles (DPH _STPB_ Fe_2O_3NPS _ Al_2O3NPS _TBP) modified electrode (IV), 0.19 grams of PVC were combined with 0.01 grams of Ionic double (PHE_STPB) and 0.005 grams of each of nano-aluminum oxide Al_2O_3NPS and nano-iron oxide Fe_2O_3NPS, which were prepared using environmentally friendly methods in a 10 mL Beaker and dissolved in 5 mL of THF. The mixture was then thoroughly mixed using a glass stirrer. Finally, 0.35 mL of the plasticizer TBP was added. Subsequently, two 5-cm-long wires were extracted, one made of copper and the other of aluminum. Following a thorough washing in distilled water and acetone, they were allowed to dry. They were put within a tube made of polyethylene. The wire was left with one end connected to the possible difference gadget. After repeatedly submerging the other end in the aforementioned mixture to create a thick coating, it was allowed to cure for a little while. minutes, and then carry out the procedure multiple times to create a thick layer of membrane.

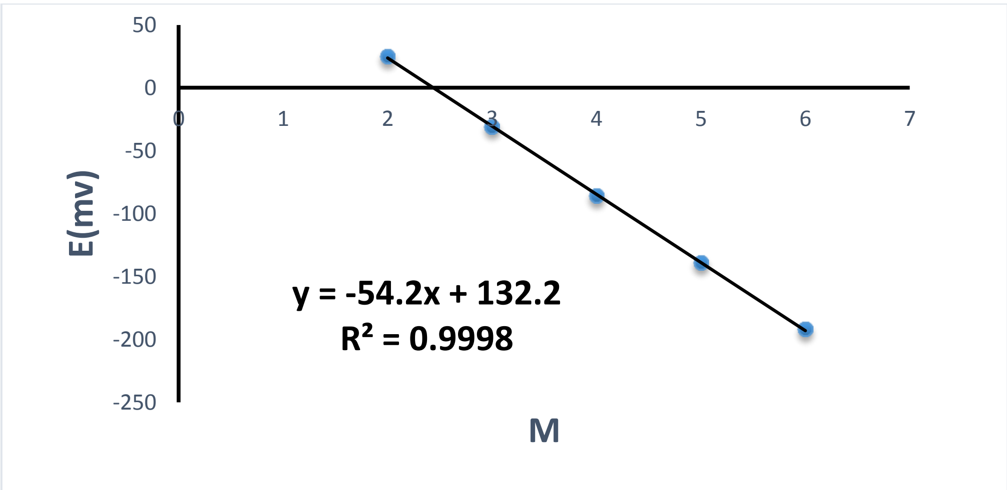
Calibration curve

Six readings were taken for each concentration of (25 mL) of a range of concentrations ranging from (10^{-2}_10^{-8}) mol/L of PHE solution using the constructed electrodes (I, II, III, IV) (the two nano-selective electrodes, and the two classic selective electrodes). with a series calomel reference electrode. At every measurement, the electrodes are washed with distilled water, dried with a tissue, and the curve is created in Excel (2013).

pH effect

Two solutions of sodium hydroxide (NaOH) and hydrochloric acid (HCl) at concentrations (0.1, 1, 0.01) are used to adjust the pH in order to determine the effect of the pH function on the drug PHE at a concentration of (10^{-2}, 10^{-4}) mol/L. After adjusting the pH value, the voltage is measured (mv) using manufactured electrodes (I, II, III, IV) in conjunction with the reference electrode. At every measurement, the electrodes are washed with distilled water, dried with a tissue, and the curve is plotted using Excel (2013).

Results and discussion



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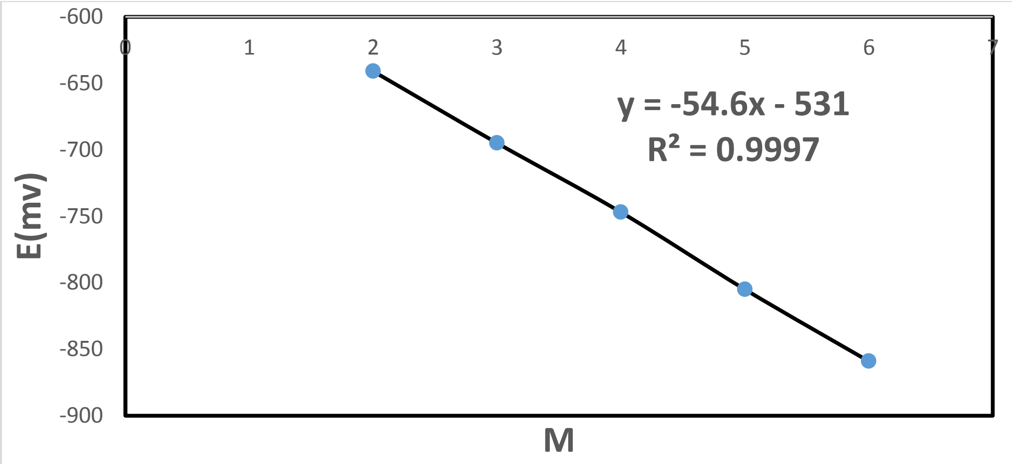

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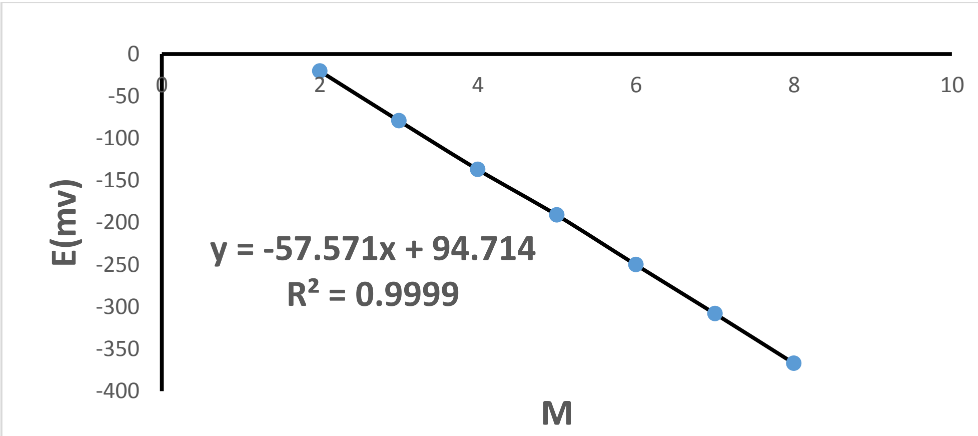

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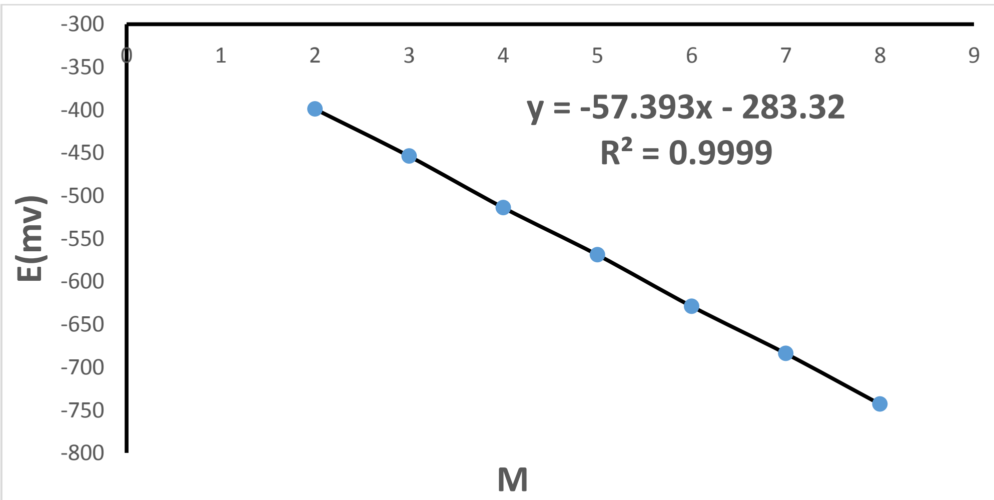
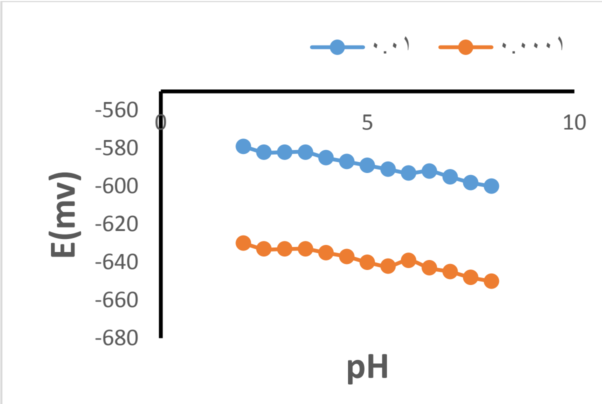


(d)

Figure (2) : (a) Calibration chart for conventional copper electrode (I) , (b) Calibration chart for conventional aluminum electrode (II) , (c) Calibration chart for copper nanoelectrode (III) , (d) Calibration chart for aluminum nanoelectrode (IV)

Table (1) shows the electrochemical response characteristics of the conventional copper and aluminum electrodes PHE_STPB_ TBP(I, II) and the nano-copper and aluminum electrodes PHE) _STPB_ (Fe2O3NPS _ Al2O3NPS _TBP (III, IV).

Parameter	PHE _STPB_ TBP (I)	PHE _STPB _TBP (II)	PHE_STPB_TBP_ Al_2O_3NPS_ Fe_2O_3NPS(III)	PHE _STPB_ TBP_Al_2O_3NPS_ Fe_2O_3NPS(IV)
Slope (mV/decade)	54.2	54.6	57.571	57.393
Regression Equation	-54.2x+132.2	-54.6x-531	-57.57x+94.71	-57.39x-283.3
Linear range (M)	$(10^{-2}$ _ $10^{-6})$	$(10^{-2}$ _ $10^{-6})$	$(10^{-2}$ _ $10^{-8})$	$(10^{-2}$ _ $10^{-8})$
Correlation Coefficient(r)	0.9998	0.9997	0.9999	0.9999
Response time/s	10-35	15-40	5-33	5-37
Working PH range	2.5_3.5	2.5_3.5	2.5_3.5	2.5_3.5
Lifetime/day	24	19	36	30
Temperature C^o	25_30	25_30	25_30	25_30
LOD	$2.9x10^{-7}$	$2.9x10^{-7}$	$2.8x10^{-9}$	$3.1x10^{-9}$



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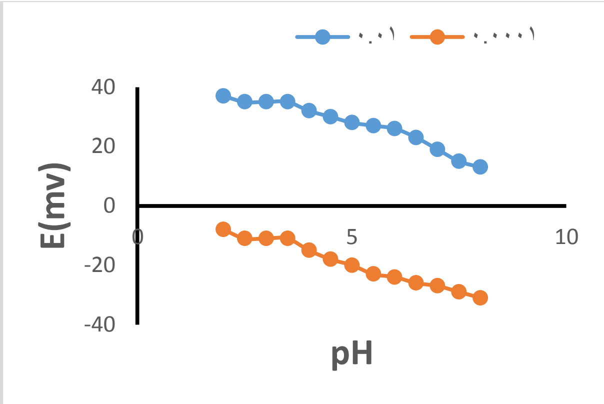

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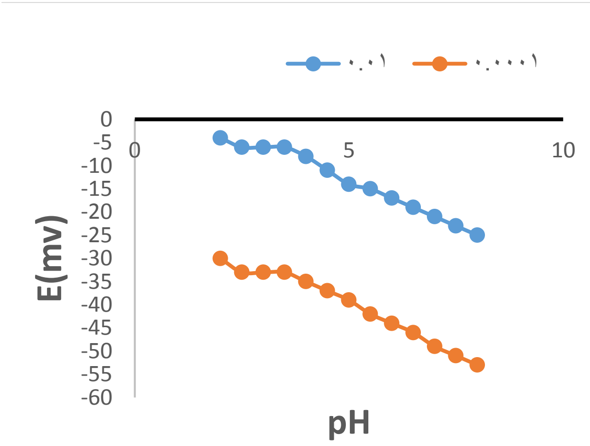

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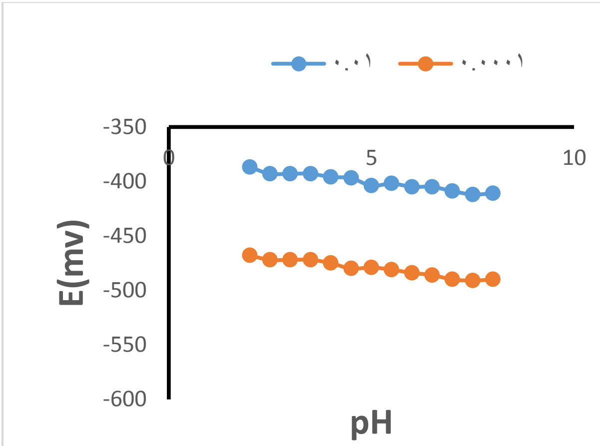

(d)

Figure (3) : (a) Effect of pH value on electrode II , (b) Effect of pH value on electrode I , (c) Effect of pH value on electrode III , (d) Effect of pH value on electrode IV

Table No. (2) shows the statistical treatment of the calibration curve for electrodes (I, III).

Samples	**I**			**III**		
	Taken -Log conc. mol. L^{1-}	Found -Log conc. mol. L^{1-}	Recovery %	Taken -Log conc. mol. L^{1-}	Found -Log conc. mol. L^{1-}	Recovery %
Pure drug	6.0	5.981	99.69	8.0	8.02	100.25
	5.0	5.000	100.00	7.0	6.99	99.93
	4.0	4.025	100.63	6.0	5.99	99.79
	3.0	3.011	100.63	5.0	4.96	99.25
	2.0	1.977	98.89	4.0	4.02	100.62
				3.0	3.02	100.58
				2.0	1.99	99.63
%SE	0.302			0.225		
%RSD	0.676			0.552		

Table No. (3) shows the statistical treatment of the calibration curve for electrodes (II, IV).

Samples	II			IV		
Pure drug	Taken -Log conc. mol. L^{1-}	Found -Log conc. mol. L^{1-}	Recovery %	Taken -Log conc. mol. L^{1-}	Found -Log conc. mol. L^{1-}	Recovery %
	6.0 5.0 4.0 3.0 2.0	6.01 5.02 3.95 3.00 2.01	100.12 100.36 98.90 100.00 100.73	8.0 7.0 6.0 5.0 4.0 3.0 2.0	8.00 6.98 6.03 4.98 4.02 2.97 2.01	100.00 99.74 100.42 99.56 100.52 99.13 100.82
%SE %RSD	0.307 0.686			0.274 0.727		

Table No. (4) shows the values of K_(i,j)^pot for the manufactured electrodes (I, II, III, IV).

Selectivity coefficient $K_{i,j}^{pot}$				Ion Overlapping
Coated wire electrodes				
IV	II	III	I	
0.027	0.809	0.077	0.466	Glucose
0.017	0.348	0.084	0.577	Maltose
0.014	0.185	0.102	0.601	Cross Carmellose
0.040	0.177	0.091	0.528	Methyl Cellulose
0.008	0.170	0.052	0.485	Magnesium Setrate

The precipitating agent (STPB), which is stable and dissolves in organic solvents like tetrahydrofuran (THF) in the presence of other materials like polyvinyl chloride (PVC) and plasticizers like tert-butyl phosphate (TBP), is what formed the ionic double (PHE_STPB). It homogeneously dissociates the ionic double. The concentration range for the conventional selective electrodes is (10^{-2} _ 10^{-6}) mol/L, and for the nano-selective electrodes is (10^{-2} _ 10^{-8}) mol/L, according to the data in Table No. (1). The electrodes (I , II, III, and IV) had slope values of 54.2, 54.6, 57.57, and 57.39 (mV/decade), respectively. The reaction time ranges are as follows: electrode I (10^{-2} - 10^{-6}) mol/liter (10-35), electrode II (10^{-2} - 10^{-6}) mol/liter (15-40), and electrode III (10). electrode IV at the range of (10^{-2}_10^{-8}) mol/liter (5-37), and for electrode VIII at -2_10-8) mol/liter (5-33) respectively. For electrodes (I , II, III, and IV), the correlation coefficient values were found to be (0.9998, 0.9997, 0.9999, and 0.9999), respectively. 25 degrees Celsius is the ideal temperature for all electrodes to function at. The nano electrode has a longer lifespan than the traditional electrode. After investigating how pH affected the electrode's reaction, the optimal reading was discovered to be between 2.5 and 3.5. Increasing or reducing the PH beyond this range will affect the response of the electrode. The following figures illustrate this.

We can see from the data in the above table that the nanoelectrodes (III, IV) are more selective than the ions and conventional electrodes (I , II). Additionally, we observed that the selectivity coefficient values for all electrodes (I , II, III, and IV) are lower than the accurate value. This suggests that the additives do not interfere with the ion under study.

Structural properties of aluminum nanoparticles Al2O3NPs

Scanning electron microscope SEM

Aluminum particles imaged with a scanning electron microscope revealed reasonably regular nanograins with sizes ranging from 18 to 43 nanometers (see figure below). Additionally, the large number of black spots that show the compound's gaps also point to the sample's high porosity.

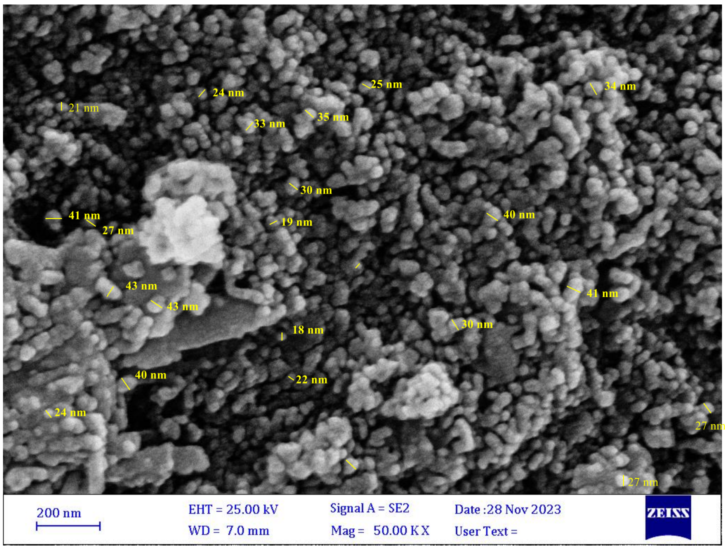

Figure (4): Scanning electron microscope (SEM) of aluminum nanoparticles

Structural properties of iron nanoparticles Fe2O3NPs

Scanning electron microscope SEM

Iron nanoparticles seen with a scanning electron microscope revealed folds and clusters along with certain nanograins with sizes varying from 36 to 81 nanometers. As seen in the figure below, the dark spots also point to the sample's high porosity.

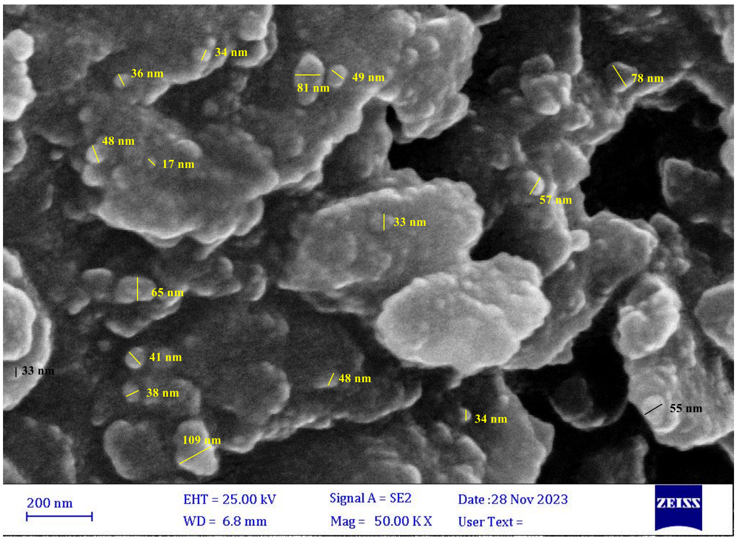

Figure (5): Scanning electron microscope (SEM) of iron nanoparticles

Conclusions

In this research, green chemistry methods were used because they are safe, cheap, easy to use, and not dangerous in terms of explosion. One area of chemistry that we looked at was electrochemistry. We made four sensitive wires, two of which were copper and two of which were aluminum. Two of the wires, copper (III) and aluminum (IV), were coated in nanoparticles of iron and aluminum (the nano-modified electrode), and the other two (I, II) stand for the conventional electrodes, which are coated wire electrodes used for testing drugs both in their pure form and in pharmaceutical formulations. This investigation shown that there is a difference between the two electrodes coated with nano-oxides and the two conventional electrodes for the drug (PHE) in terms of selectivity and sensitivity. Comparing the nanoelectrodes (III, IV) to the conventional electrodes (I, II), the results demonstrated that the latter had slower response times, worse selectivity and sensitivity, and less stable outcomes. This is because the nanoparticles in the electrical enhancement process have higher surface areas and volumes, which is why. smaller, which increases their sensitivity and selectivity. Because of these characteristics, we were able to analyze the medication (PHE) at low limits and in a wide concentration range. Because of the excellent physical and chemical characteristics of these particles, drug ions move quickly towards the coating, which accounts for the high sensitivity of the electrodes coated with nanoparticles. Electrodes coated with nanoparticles have been well relied upon for PHE drug detection in pharmaceutical compounds and research centers.

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