Spectrophotometric Determination of Salbutamol by Oxidative Coupling Reaction with 1-Naphthylamine-4-Sulfonic Acid in the Presence of Potassium per Sulfate

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Abstract

Background: Oxidative coupling reactions are among the most important reactions that have wide applications in chemistry, and the oxidative coupling process involves the interaction of two or more organic substances in the presence of an oxidizing agent, where an oxidation process occurs for these substances forming intermediate compounds that interact with each other to form a colored product that can be determined by either spectrophotometric, polarographic, or various chromatographic methods and these reactions were used to quantify many different organic and inorganic compounds. In this article, the spectrophotometric determination of salbutamol was done by an oxidative coupling reaction with the reagent 1-Naphthylamine-4-sulfonic acid in the presence of potassium per sulfate. **Objective:** In this study, we developed a simple, rapid, sensitive, selective, and accurate UV-visible spectrophotometric method for analyzing salbutamol in pure drugs and pharmaceutical formulations. **Materials and Methods:** Based on oxidative reaction with 1-Naphthylamine-4-sulfonic acid at pH 11.24, form a yellow-orange colored product in alkaline medium has a maximum absorbance at 470 nm. The Beer's law is followed in the concentration range 5–23 μg/mL. **Results:** The product was stable for 60 min, molar absorptivity was found to be 0.8054×10^4 $L \cdot mol^{-1} \cdot cm^{-1}$, and sandal index was 0.0296 $\mu g \cdot cm^{-2}$ with a relative error (RE) of 0 to −0.79, and a relative standard deviation (RSD) of 0.54%–1.84%. Detection limit (DL) was 0.227 μg/mL, quantitative limit (QL) was 0.756μg/mL, correlation coefficient was 0.9998, and recovery was 99.51%, respectively. **Conclusion:** The method was found to be accurate and precise, as indicated by recovery studies which is up to 100% and relative standard deviation is not more than 2 that is good result. The proposed method has been successfully applied in the determination of preparations containing salbutamol.

Keywords: Oxidative coupling, pharmaceutical, salbutamol, spectrophotometer

Introduction

Salbutamol, 4-[2-(tert-butylamino)-1-hydroxyethyl]-2-(hydroxymethyl) phenol[1] is a white powder that is easily soluble in water; salbutamol is photosensitive, so it should be kept in a closed, opaque container.[2]

Salbutamol is generally used for acute episodes of bronchospasm caused by bronchial asthma and chronic bronchitis.[3] Salbutamol is still used and delivered as a racemic mixture [+, −].[4] Selective β_2-adrenoceptor stimulants promote smooth muscle relaxation by increasing intracellular cyclic adenosine monophosphate (cAMP); as a result, bronchial and uterine muscles relax, peripheral arteries widen, and heart rate increases.[5] When the β-2 adrenoreceptors are activated, ATPase channels open, allowing potassium to be transported from the extracellular to the intracellular area.[6] Salbutamol also has anti-inflammatory qualities that have yet to be proven clinically.[7] Because of the medicinal importance of the

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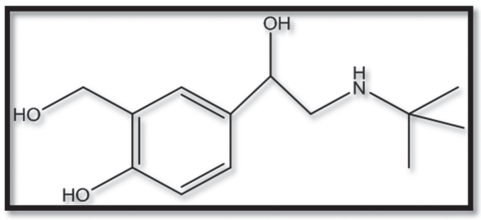
drug, it has been estimated by many different analytical methods, such as high-performance liquid chromatography technology HPLC,[8,9] spectroscopic methods,[10-14] flow-injection methods,[15,16] and electrolysis methods.[17,18] The aim of the present work is to find out a simple, sensitive, and specific spectrophotometric method and to determine its validation for the estimation of salbutamol from pharmaceutical formulations.



Chemical structure of salbutamol

Materials and Methods

Instrument

The UV-visible double beam (T92+ Spectrophotometer, China) with 1 cm matched quartz cells, Microprocessor pH meter 3310.

Materials

All chemicals used in this study were of a high degree of purity (Fluka, bdh, SDI).

Salbutamol standard solution 1000 µg/mL (4×10^{-3}M)

The solution was prepared by dissolving 0.1000 g of pure salbutamol powder in an amount of distilled water and then completing the volume to the mark in a 100 mL volumetric flask. A concentration of 250 µg/mL was prepared by taking 25 mL of the standard solution (1000 µg/mL) and diluting it in a volumetric bottle of 100 mL and completing the volume with the same solvent.

Potassium per sulfate solution (2×10^{-2}M)

This solution was prepared by dissolving 0.540 g of potassium per sulfate powder in distilled water in a volumetric flask of 100 mL and then completing the volume to the mark with the same solvent.

Sodium carbonate solution (1M)

This solution was prepared by dissolving 4 g of the substance in a little distilled water and completing the volume with the same solvent in a volumetric flask of 100 mL.

1-Naphthylamine-4-sulfonic acid solution (2×10^{-2}M)

This solution was prepared by dissolving 0.446 g of 1-Naphthylamine-4-sulfonic acid in a volume of distilled water and dilution in the volumetric flask to 100 mL with the same solvent.

Pharmaceutical preparations of salbutamol (Butalin)

Overall, 20 tablets of pharmaceutical preparation were ground (Butalin) and a representative sample with a weight of 1.213 g equivalent to 10 tablets was taken. Each pill contained 2 mg of the drug. After that, the 10 tablets was dissolved in distilled water in a volumetric flask of 100 mL; the solution was filtered; the sediment was washed several times with distilled water; and finally, the volume was completed to the mark with distilled water to obtain a solution at a concentration of 1000µg/mL. Then, 25 mL of the prepared solution was diluted by distilled water to the mark in a 100 mL volumetric flask to obtain a concentration of 250 µg/mL.

The general principle of the method

The principle behind the method is the coupling of the reagent 1-naphthylamine-4-sulfonic acid with the drug salbutamol and in the presence of the oxidizing agent potassium per sulfate in an alkaline medium, a solution with a yellowish-orange color was formed, which gave the highest wavelength at 470 nm versus the blank solution.

Preliminary study

It was observed that when salbutamol solution was mixed with the reagent solution 1-Naphthylamine-4-sulfonic acid in the presence of potassium per sulfate with sodium carbonate and shaking a little, formed yellow-orange product. Therefore, the optimal conditions for the coupling reaction were studied to obtain the best possible results in order to develop a simple and sensitive spectrophotometric method for the determination of salbutamol.

Study of optimal conditions

Subsequent experiments were carried out using 1 mL of the oxidizing agent solution potassium per sulfate, 2 mL of the used reagent 1-Naphthylamine-4-sulfonic acid solution, 2 mL of the standard salbutamol solution with a concentration of 250 µg/mL, and 1 mL of sodium carbonate solution in a final volume of 25 mL. The absorption of the solutions at different wavelengths was measured against blank solution.

Results

Choosing the best coupling reagent

Overall, 2 mL of each of the used reagent solutions was taken at a concentration of 2×10^{-2}M, 1 mL of the oxidizing agent solution potassium per sulfate with a concentration of 2×10^{-2}M, 2 mL of salbutamol solution, and 250 mg/mL and 1 mL of the sodium carbonate solution with a concentration of 1M; the results are indicated in Table 1. We notice that the 1-Naphthylamine-4-sulfonic acid reagent gave the highest absorbance of the component's colored product at 470 nm against the blank solution: The blank

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solution did not show any absorption at this wavelength, so this reagent was chosen in the subsequent experiments.

Effect of the coupling reagent volume

A study was conducted to stabilize the optimal amount of the reagent solution 1-Naphthylamine-4-sulfonic acid of 2×10^{-2}M, which gives the maximum absorption of the colored product, as increasing volumes (1.3–3 mL) were added from the reagent solution 2×10^{-2}M, 1 mL of the oxidizing agent solution potassium per sulfate 2×10^{-2}M, 2 mL of the salbutamol solution 250μg/mL, and 1 mL of sodium carbonate 1M, where the results indicate that 2 mL of the volume used is the optimal volume of the reagent as this volume was used in the subsequent experiments; the results are shown in Table 2.

Choosing the best oxidizing agent

Several experiments were carried out to find the best oxidizing agent to form the colored product. Solutions of several oxidizing agents were used with a concentration of 2×10^{-2}M, each with a volume of 1 mL; 2 mL of the reagent solution 1-Naphthylamine-4-sulfonic acid and 1 mL of the sodium carbonate solution were added to a concentration of 2×10^{-2}M in a volumetric flask with a capacity of 25 mL. Then, the absorbance for each sample was measured against the blank solution. It was noted that the best oxidizing agent was potassium per sulfate, which gave the highest absorbance for the colored product formed at the wavelength of 470 nm. The results are shown in Table 3.

Table 1: Effect of coupling reagent type

Reagent (2×10^{-2}M)	Variable	Absorbance	λmax
1-Naphthylamine-4-sulfonic acid	SB	0.604	470
	BW	0.092	415
1,5-Diaminonaphthalene	SB	0.472	535
	BW	0.080	442
4-aminobenzenesulfonic acid	SB	0.412	490
	BW	0.073	430
p-aminophenol	SB	0.320	510
	BW	0.062	400

Table 2: Effect of the coupling reagent volume

mL of reagent (2×10^{-2}M)	Absorbance	
	BW	SB
1.3	0.106	0.486
1.5	0.118	0.493
1.8	0.125	0.521
2	0.097	0.604
2.3	0.120	0.582
2.5	0.132	0.547
2.8	0.144	0.475
3	0.154	0.410

Effect of the oxidizing agent volume

This study was conducted to select the best volume of the oxidizing agent solution with a concentration of 2×10^{-2}M, as different volumes (2–0.2) mL were used; it was found that 1 mL of potassium per sulfate solution is the best, which was used in subsequent experiments, and the results are shown in Table 4.

Choosing the best base to use for coupling

Overall, 1 mL of different types of bases (strong and weak) with a concentration of 1M was used and its effect on the absorption of the colored product formed was studied; the results are shown in Table 5.

From the table just cited, we note that sodium carbonate (Na2CO3) gave the highest absorption of the colored product formed and therefore it was chosen in the subsequent experiments.

Effect of the amount of base used

Where different quantities of the base used were added of sodium carbonate of (0.2-2 mL) 1M to find out the optimum amount, which gives the highest absorption of the colored product formed, it was found that 1 mL gives the best absorption (pH value was 11.24), therefore, a volume of 1 mL was used in subsequent experiments. The results are shown in Table 6.

Table 3: Choosing the best oxidizing agent

Oxidizing agent (2×10^{-2}M)	Absorbance		λmax (nm)
	Blank	Sample	
Potassium per sulfate	0.088	0.604	470
Potassium iodate	0.073	0.443	425
Ammonium per sulfate	0.052	0.290	456
Ammonium ferric sulfate	0.040	0.120	510

Table 4: Effect of the oxidizing agent volume

mL of $K_2S_2O_8$ (2×10^{-2}M)	Absorbance	
	BW	SB
0.2	0.086	0.340
0.4	0.080	0.454
0.6	0.074	0.482
0.8	0.065	0.571
1	0.090	0.604
1.2	0.081	0.543
1.4	0.075	0.490
1.6	0.064	0.478
1.8	0.060	0.382
2	0.054	0.327

Table 5: Choosing the best base to be used for coupling

Base solution, 1M	Na_2CO_3	NaOH	KOH	$Ca(OH)_2$
Absorbance	0.604	0.525	0.467	0.370

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Effect of sequence of additions

The sequence of addition of the solutions used sometimes has an effect on the absorption of the colored product. Therefore, a number of experiments were conducted with a different sequence of additions, noting that all the volumes and concentrations of the substances used were the same in all cases. It was noted from the results obtained in Table 7 that the order (VI) gives the highest absorption of the colored product formed; this indicates that the reagent is first oxidized and then combined with the drug, so it has been adopted in subsequent experiments. Oxidizing agent solution potassium per sulfate (O), reagent solution (R), salbutamol solution (S), and base solution (B).

Effect of time

The time required to complete the reaction was studied by taking a series of volumetric flask with a capacity of 25 mL containing 2 mL of salbutamol solution at a concentration of 250 μg/mL. Next, 2 mL of the reagent solution of 1-Naphthylamine-4-sulfonic acid with a concentration of 2×10^{-2}M was added to it. Then, 1 mL from the oxidizing agent solution potassium per sulfate at a concentration of 2×10^{-2}M was added. Next, 1 mL of sodium carbonate solution was added. The solutions were left for different periods of time after which they were diluted with distilled water to the mark. Then, the absorbance of the solutions was measured at the wavelength of 470 nm against their blank solutions. The results are shown in Table 8.

We note from the table cited earlier that 5 min was sufficient to complete the oxidation and conjugation process, so it was adopted in the subsequent experiments.

Table 6: Effect of quantity of the base used

mL of Na_2CO_3, 1M	Absorbance		pH
	BW	SB	
0.2	0.175	0.385	7.58
0.4	0.181	0.431	8.22
0.6	0.183	0.468	9.12
0.8	0.184	0.565	10.42
1	0.186	0.601	11.24
1.2	0.172	0.580	11.43
1.4	0.166	0.568	11.71
1.6	0.158	0.531	12.01
1.8	0.154	0.497	12.21
2	0.147	0.456	12.60

Table 7: Effect of sequence of additions

Order number	Order of addition	Absorbance	
		BW	SB
I	S + R + O + B	0.052	0.428
II	B + O + S + R	0.070	0.474
III	R + B + O + D	0.082	0.562
VI	O + R + S + B	0.092	0.604

Table 8: The effect of changing time

Time/min	2	5	10	15	20
Absorbance	0.592	0.602	0.597	0.590	0.584

Effect of temperature

The effect of temperatures (10°C–60°C) on the oxidative coupling reaction has been studied using the optimal conditions obtained from previous experiments. We note in this study that the absorbance reached its maximum at a temperature of 25°C. Therefore, the laboratory temperature was used in subsequent experiments and the results are shown in Table 9.

The reaction product's stability

This study was carried out by taking three different volumes (1, 1.5, and 2 mL) of salbutamol solution with a concentration of 250 μg/mL, representing concentrations (10, 15, 20 μg/mL) and adding 1 mL of solution potassium per sulfate with a concentration of 2×10^{-2}M. Then, 2 mL of 1-Naphthylamine-4-sulfonic acid reagent solution was added with a concentration of 2×10^{-2}M. Next, 1 mL of sodium carbonate solution 1M in a volumetric flask of 25 mL was added. The volume was completed to the mark with distilled water. The absorption value of the formed colored product remains stable for at least 60 min, which is sufficient time to complete many of the measurements. The results are shown in Table 10.

Ultimate absorption spectrum

After reaching the optimum conditions, 1 mL of oxidizing agent potassium per sulfate solution of 2×10^{-2}M 2 mL of reagent solution of 1-Naphthylamine-4-sulfonic acid of 2×10^{-2}M, 2 mL of salbutamol solution of 250 μg/mL and 1 mL of sodium carbonate 1M at room temperature and leave the solution for 5 min for the completion and stability of the reaction and complete the volume to the mark in a 25 mL volumetric flask with distilled water, then final absorption spectrum of the product was measured yellow orange against the blank solution, it was found that it gives the highest absorption at the wavelength of 470 nm while the blank solution did

Table 9: The effect of changing temperature

Temperature (°C)	10	15	20	25	30	35	40	45	50	55	60
Absorbance	0.342	0.439	0.584	0.610	0.603	0.600	0.502	0.490	0.382	0.293	0.158

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not give any absorption in this region. The results are shown in Figure 1.

The optimal conditions for the determination of salbutamol are summarized in Table 11.

Approved working method and calibration curve

After fixing the optimal conditions for the method, the standard curve was prepared as follows:

In a series of volumetric flask of 25 mL, different volumes (0.5-2.5 mL) were taken from a solution of salbutamol with a concentration of 250 µg/mL representing (5-25 µg/mL), added 2 mL of the reagent solution 1-Naphthylamine-4-sulfonic acid of 2 × 10-2M, then add 1 mL of oxidizing agent solution, potassium per sulfate of 2×10^{-2}M, and add 1 mL of sodium carbonate 1M, leave the solution for 5 min to complete the reaction and stabilize, then complete the volume to the point of the mark with distilled water, then measured of absorption of the solutions at wavelength 470 nm versus the blank solution. The results indicated in Figure 2 and Table 12 that the calibration curve follows Beer's law in the range of (5-23 µg/mL), and a deflection occurs at concentration 25 µg/mL, the value of the molar absorption coefficient of the method 0.8054×10^4 $L.mol^{-1}.cm^{-1}$, and Sandell's sensitivity was 0.0296 $\mu g.cm^{-2}$, the value of the correlation coefficient is 0.9998.

Accuracy and compatibility

The accuracy and compatibility of the proposed method for estimating SB was calculated under the optimal conditions described in the working method, by calculating the recovery (Rec%) and the RSD% for three different concentrations of SB (5, 15, and 25 µg/mL). By taking an average of six readings for each of them, the recovery rate was 99.51% and the RSD (1.84%–0.54%), meaning that the method is of high accuracy and has good agreement. The results obtained in Table 13 show that the method has good accuracy and compatibility.

Detection limit

The detection limit of this method was calculated at the wavelength of 470 nm, by measuring the absorption of the lowest concentration (5 µg/mL) taken from the calibration curve's average six readings under the same conditions; the results are shown in Table 14.

Table 10: The reaction product's stability

µg/mL of SB	Absorbance standing time						
	5	10	20	30	40	50	60
10	0.218	0.234	0.268	0.276	0.277	0.278	0.277
15	0.452	0.469	0.470	0.472	0.471	0.472	0.472
20	0.633	0.64	0.644	0.646	0.647	0.648	0.647

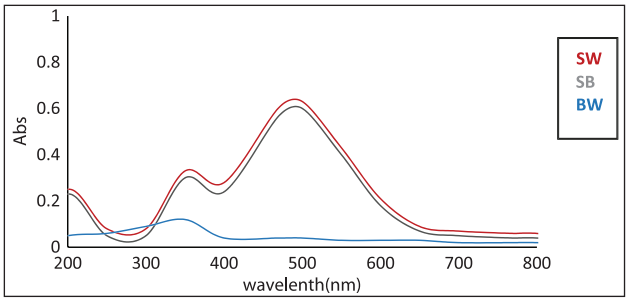

Figure 1: Final absorption spectrum for the determination of salbutamol by reaction with 1-Naphthylamine-4-sulfonic acid in the presence of oxidizing agent potassium per sulfate. BW: It represents the absorption spectrum of the blank solution versus distilled water. SB: It represents the absorption spectrum of the product formed versus the blank solution. SW: It represents the absorption spectrum of the product formed versus distilled water

Table 11: Summary of optimum condition

Experimental condition	
λmax	470 nm
Amount of 2×10^{-2}M potassium per sulfate	1 mL
Amount of 2×10^{-2}M 1-Naphthylamine-4-sulfonic acid	2 mL
Sodium carbonate	1 mL
Temperature	25°C
Solvent	Water

Table 12: Effect of the concentration of SB on the absorbance values

Volume (mL) of SB	Concentration of SB (µg/mL)	Absorbance
0.5	5	0.110
0.7	7	0.152
1	10	0.236
1.3	13	0.318
1.5	15	0.367
1.7	17	0.410
2	20	0.491
2.3	23	0.574
2.5	25	0.632

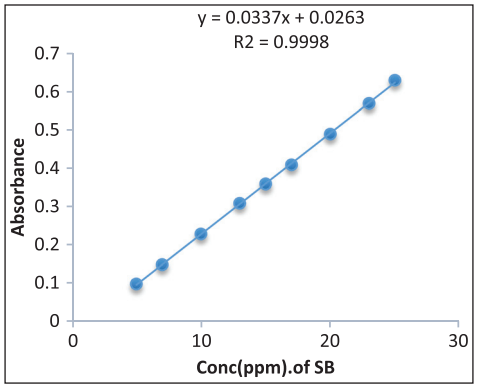

Figure 2: Calibration curve for the determination of salbutamol when it reacts with 1-Naphthylamine-4-sulfonic acid in the presence of oxidizing agent potassium per sulfate

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The nature of the product formed

To know the nature of the formed product and the ratio of the drug's binding ability to the reagent, continuous changes method (Job's method) and the molar ratio method were applied. In both methods, the concentration of each of salbutamol solution and the reagent solution is equal to which is 2×10^{-2} M. Different volumes of the drug solution (0.5-2.5 mL) were placed in a volumetric flask with a capacity of 25 mL; decreasing volumes of the reagent were added (1–9 mL); the rest of the additions were completed with the optimum volumes according to the method of work, and then they were diluted with distilled water to the mark limit; and finally, the absorption of these solutions was measured at a wavelength of 470 nm in comparison to their blank solutions. Figure 3 shows that the ratio is 1:1.

To ensure that the reaction ratio between the drug Salbutamol and the reagent is 1:1, the molar ratio method was used, where 2 mL of the drug solution was placed in a series of 25 mL volumetric flasks; the reagent solution was added in different sizes (0.3–3 mL); the rest of the additions were completed with the optimum volumes; the dilution was done with distilled water up to the mark; and the absorption of these solutions was measured at a wavelength of 470 nm against the blank solution for each of them. It was found that the molar ratio agrees with the method of continuous changes. Figure 4 confirms that the ratio is 1:1 between the salbutamol and the reagent 1-Naphthylamine-4-sulfonic acid.

Accordingly, the proposed equation will be as follows. The reagent first oxidizes and then reacts with salbutamol in an acidic medium.

Table 13: The accuracy and compatibility of the method

Concentration of SB (µg/mL)	Concentration of measured (µg/mL)	RE (%)	Recovery (%)	Average of recovery (%)	RSD (%)
5	5	0	100	99.51	1.84
15	15.1	−0.67	99.33		1.25
25	25.2	−0.79	99.21		0.54

Average of six determinations.

Table 14: Detection limit

Concentration (µg/mL)	X	S	DL (µg/mL)	QL (µg/mL)
5	0.5883	0.008901	0.227	0.756

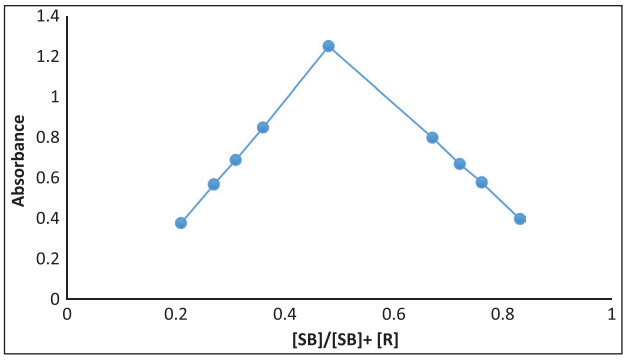
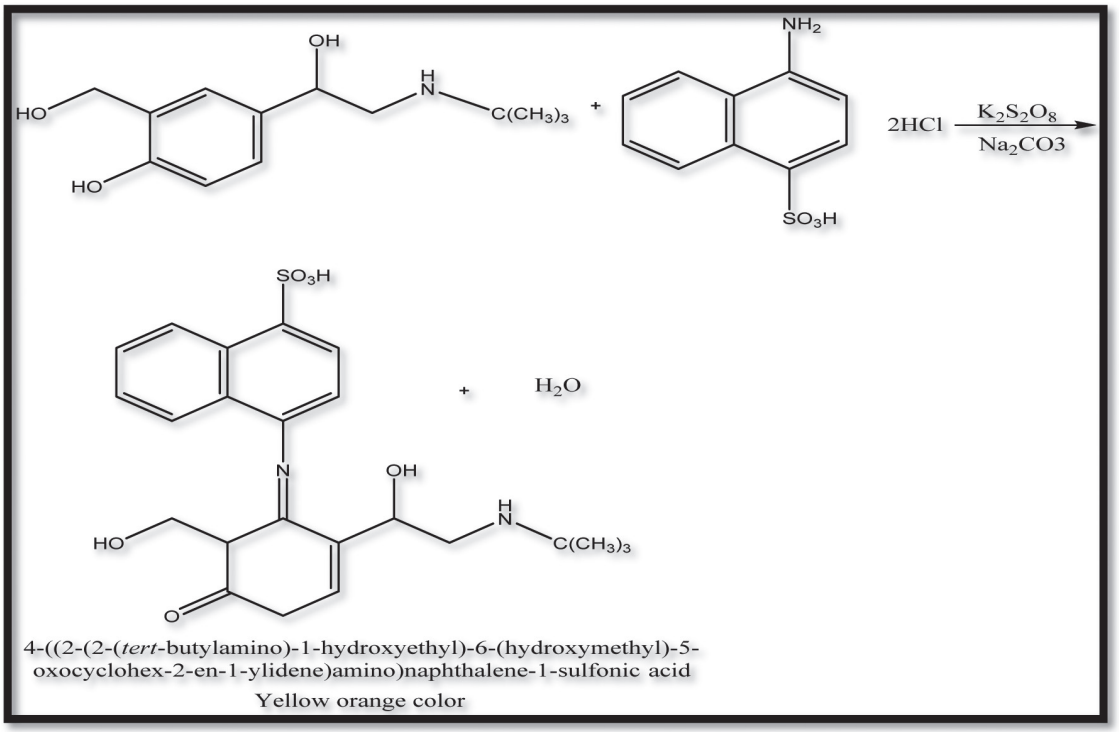


Figure 3: Job's method for the determination of salbutamol with the reagent 1-Naphthylamine-4-sulfonic acid in the presence of oxidizing agent potassium per sulfate



4-((2-(2-(*tert*-butylamino)-1-hydroxyethyl)-6-(hydroxymethyl)-5-oxocyclohex-2-en-1-ylidene)amino)naphthalene-1-sulfonic acid

Yellow orange color

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Applications

The method can be applied to the following pharmaceutical preparations (Butalin), and each tablet contains 2 mg of salbutamol.

The direct method

Three different concentrations of the preparation solutions (tablets) were taken (its preparation is indicated in section Pharmaceutical Preparations of Salbutamol (Butalin)), which were 5, 10, and 15 µg/mL and the same steps were followed when preparing the calibration curve; the absorption was measured at a wavelength 470 nm versus the blank solution; and the average of six was calculated. Measurements were calculated for each concentration, then the recall was calculated, and the results are shown in Table 15.

The results in above table show that the proposed method has succeeded in appreciation the pharmaceutical preparation that contains Salbutamol. The value of the average of recovery was 99.46%.

Standard additions method

To demonstrate the efficiency and accuracy of the addition method, the standard additive method was used to estimate salbutamol in pharmaceutical preparations. The method included adding fixed quantities (0.5, 1 mL) of pharmaceutical solutions at a concentration of 250 µg/mL, in two series of 25 mL volumetric flasks, and then adding increasing volumes (0.2, 0.4, 0.6, and 1 mL) of pure salbutamol standard solution at a concentration of 250 µg/mL. The solutions mentioned were treated with the same method used for the calibration curve, and then the absorbance of the solutions was measured against the blank solution at wavelength of 470 nm; the results are shown in Table 16 and Figure 5.

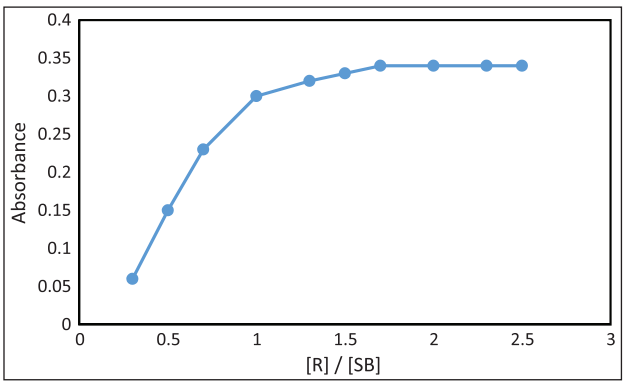

Figure 4: The molar ratio method shows that the ratio is 1:1 between salbutamol and the reagent 1-Naphthylamine-4-sulfonic acid

Table 15: The direct method

Concentration of SB (tablet) (µg/mL)	Concentration of measured (µg/mL)	RE (%)	Recovery (%)	Average of recovery (%)	RSD (%)
5	5.02	0.4	100.4	99.46	0.753
10	9.92	−0.8	99.20		0.542
15	14.82	−1.2	98.80		0.378

Table 16: Standard addition method for determination of SB in tablets

Amount taken (µg/mL)	Amount measured	Recovery (%)
5	4.92	98.40
10	9.85	98.50

Discussion

The ideal conditions of conjugation reagents, oxidizing agents, and media in which analytical reactions occur were investigated in the findings of this study. In order to acquire the best analytical results for the measurement of salbutamol, the influence of volumes, the effect of time, the sequence of additions, the suitable temperature, and product stability were investigated. The best reagent was discovered to be 1-Naphthylamine-4-sulfonic acid, which had the maximum absorbance at 470 nm when compared with the other reagents at concentrations of 2×10^{-2}M. It is also worth noting that the reagent's optimal volume is 2 mL, was chosen sodium carbonate 1M of volume 1 mL as the best medium for the reaction because it gave the highest absorbance as shown in Table 5, and the best oxidizing agent is potassium per as shown in Table 3 sulfate of concentration 2×10^{-2}M and volume 1 mL because it gave the highest absorbance. The best addition sequence number (IV) as in Table 7 because it give the highest absorbance, and the best temperature was 25°C because it gave a highest absorbance as shown in Table 9 .

Some physical variables of the proposed method were compared with some variables of spectroscopic methods in the literature used to estimate salbutamol, as the results show that the proposed method has good sensitivity and is not less in quality than other spectral methods.[10-14]

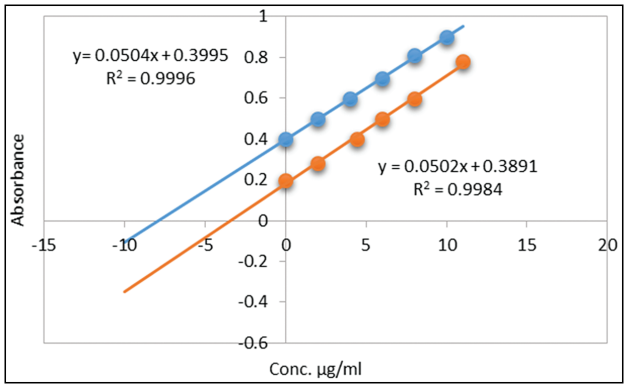

Figure 5: Standard addition curve for the determination of salbutamol in pharmaceutical tablets

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Because of their importance in pharmaceutical analysis, spectrophotometry technologies for drug determination have advanced significantly in recent years. Therefore, it is chosen in many studies because of its higher solubility in distilled water and HCl. Both the standard deviation and coefficient of variance were low enough. The accuracy of the approach was indicated by the percentage recovery range of 99%–101%. Salbutamol linearity within the concentration range of 10–250 g/mL was discovered using the proposed approach. The RSD% was determined to be less than 2, indicating that the procedure is highly reproducible.[12]

Conclusions

An easy, simple, and highly sensitive spectroscopic method has been developed for the determination of salbutamol based on the oxidative coupling reaction of the drug with the 1-Naphthylamine-4-sulfonic acid reagent in the presence of the oxidizing agent potassium per sulfate to form a colored product that is yellowish orange, stable, and soluble in water, gives the highest absorption at the wavelength of 470 nm, and obeys Beer's law in the range 5–23 μg/mL of SB. The molar absorption coefficient was 0.8054×10^4 L/mol·cm, Sandal index was 0.0296 μg/cm^2, and correlation coefficient was 0.9998. The method was successfully applied in estimating salbutamol in pharmaceutical preparations (tablets) with a recovery of 99.51%.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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