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SPECTROPHOTOMETRIC DETERMINATION OF TRIFLUOPERAZINE HYDROCHLORIDE DRUG IN PURE AND PHARMACEUTICAL FORMULATIONS USING POTASSIUM PERMANGANATE

MAHA SALAH NASR*[1], MOHAUMAN MOHAMMAD AL-RUFAIE[2]

[1]*College of Food Science, AL-Qasim Green University, Babylon, Iraq.*
[2]*Department of Chemistry, Faculty of Science, Kufa University. Najaf, Iraq.*

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***CORRESPONDING AUTHOR**
Maha Salah Nasr

ABSTRACT

It is known that creating and documenting an analytical method for analytes of pharmaceutical compounds/drugs is challenging, often time consuming sometimes leads to unexpected problems. Of the several methods, certain spectrophotometric approaches are more helpful in dealing with these challenges. This study continues to develop a simple and rapid visible spectrophotometric method for the determination of trifluoperazine hydrochloride, which is a phenothiazine-derived drug (in its pure form as well as in the pharmaceutical formulation), based on its reaction with potassium permanganate. The ideal circumstances, such as the influence of pH, optimal ion concentration and volume, time, temperature, and addition sequences, have also been systematically studied. The findings showed that the Beer-Lambert law was verified between 5 and 80 μg/mL. In addition, the colored product showed good stability, exhibiting maximum absorbance after 5 min. In particular, the spectrophotometric method used has also demonstrated remarkable specificity with a limit of detection (LOD) equal to 0.125 μg/mL and a limit of quantitation (LOQ) equal to 0.418 μg/mL.

1. INTRODUCTION

Creating and documenting an analytical method for clinical research and bioanalysis to identify pharmaceutical compounds and drugs is a complex and challenging process that involves many unforeseen issues and can be time-consuming [1].The determination of drugs is helpful in several areas. For example, when evaluating a particular drug over time, it is possible to know the biological availability, absorption of the analyte, and its disposal by assessing the drug [2].

The characteristic action of the drug is closely related to its chemical composition. Pharmaceutical analysis requirements are very necessary nowadays. Thus, there is a necessity to develop sensitive analytical methods for drug analysis. Methods that allow the examination of concentrations of drugs and metabolites in body fluids can be useful in the study of pharmacology [3].Spectrophotometric determination has many advantages over other analytical methods. These benefits make it a preferred choice due to its ease of application, user-friendliness, and reliance on low-cost reagents. Additionally, it utilizes devices that consume less energy, resulting in a lower environmental impact [4].UV-visible spectrophotometry is of great importance as one of the spectroscopic techniques supporting drug investigations. The spectrophotometric application can be considered a complementary method to mass spectrometry, infrared, which are certainly more effective tools for elucidating the structure of potential drugs. Contrary to other spectroscopic techniques mentioned earlier, the quantitative analytical application is of high significance in the use of UV-visible spectroscopy in drug analysis[5].

Phenothiazines are a paramount family of drugs that are predominantly recognized for their antipsychotic characteristics. Phenothiazines mediate their antipsychotic impacts by preventing (inhibiting) the reaction of dopamine and dopamine type 2 (D2) receptors[6].

Phenothiazines also work as antagonists against receptors for other neurotransmitters such as adrenergic (α1), muscarinic (M1), serotonin (5HT2A) and histamine (H1) receptors, however, their interactions are not as strong as that of dopamine receptors [7,8].

As a result of increased pulse rate and decreased blood pressure, phenothiazines are not prescribed to patients with vascular and heart diseases as they are alpha-adrenergic blockers. When antipsychotics, including phenothiazines, are used for a long time and in high doses, they may lead to tardive dyskinesia syndrome [7].

Trifluoperazine hydrochloride ($C_{21}H_{24}F_3N_3S.2HCl$) (TFP.HCl) is a phenothiazine antipsychotic medication that is also used as an antidepressant. It is frequently recommended for the treatment of mental illnesses and to alleviate the symptoms of schizophrenia [9]. The TFP.HCl is 10-[3-(4-methyl-1-piperazinyl)propyl] -2-(trifluoromethyl)-10H-phenothiazine dihydrochloride [10]. TFP. HCl can be found in the form of a white powder that dissolves in water [11]. Hysteria, sadness, nausea, vomiting, and schizophrenia are some conditions that TFP.HCl is widely used to treat [12,13]. It is also utilized in the treatment of certain heart ailments, such as aortic occlusion [14], and as a sedative for managing anxiety and aiding in sleep [15]. Due to its low oral bioavailability, TFP.HCl is an excellent option for an infectious drug delivery system because its side effects are dose-dependent and decreasing the total oral dose minimizes toxicity [16]

Analytical chemists utilized TFP.HCl extensively to create simple and rapid processes for its detection due to its attractive qualities reflected by the chemical structure [17]. These features are characterized by the fact that this compound belongs to the phenothiazine derivatives [18].

An example of an inorganic chemical compound is potassium permanganate, often known as $KMnO_4$. This substance may be dissolved in water and is made up of two ions, one of which is permanganate and the other of which is potassium. In its solid state, it manifests as a dark purple substance that does not emit any odor. Potassium permanganate is a powerful oxidizing agent that also possesses antiseptic properties [19]. It is an environmentally friendly and versatile industrial oxidizing agent. Its strong oxidizing properties have gained significant attention, leading to its widespread use over the years in the synthesis, identification, and measurement of both organic and inorganic compounds [20].The solution that is produced when potassium permanganate crystals are dissolved in water is a dark purple color. In most cases, it is produced by the processing of other minerals, such as manganese oxide. Conducting a redox reaction with potassium permanganate allows one to observe the oxidizing power of the compound, as the color of the solution changes dark purple as the reaction continues [21].

This research aims to develop a simple spectrophotometric method for detecting TFP by examining its reaction with potassium permanganate and the formation of a colored solution. The method involves studying the optimal conditions and proposing the stoichiometric configuration.

2. EXPERIMENTAL PROGRAM

2.1 Chemical materials

The chemicals used in the current study, their purity, and their manufacturers are shown in Table 01. Moreover, the pharmaceutical preparations, their composition, and the manufacturer are shown in Table 02.

Table 01: The chemicals used detials.

Chemical	Molecular formula	Molecular weight, $g.mol^{-1}$	Company	Purity, %
Trifluoperazine hydrochloride (TFP.HCl)	$C_{21}H_{24}F_3N_3S.2HCl$	480.400	SDI	99
Potassium Permanganate	$KMnO_4$	158.034	BDH	99
Glocose	$C_6H_{12}O_5$	180.156	BDH	99
Sucrose	$C_{12}H_{22}O_{11}$	342.300	BDH	99
Lactose	$C_{12}H_{22}O_{11}$	342.297	BDH	99
Starch	$(C_6H_{10}O_5)_n$	Variable	BDH	99

Table 02: The pharmaceutal preparations utilized.

Preparation	Composition	Company
Iralazin (10 tablets)	5 mg of Trifluoperazine HCl per tablet	SDI, Iraq

2.2 Devices

The devices used in the experimental examinations are shown in Table (3):

Table 03: The devices used.

Aparatus	Description
Double beam UV-Visible Spectrophotometer	The qualitative test of the compounds was performed by Shimadzu Company (Japan) UV-1650 PC.
Single beam UV-Visible Spectrophotometer	The UV-2900 PC, a spectrophotometer manufactured by Shimadzu Company (Japan), was utilized in the experiment. The quantitative study of the colored solution produced involved the utilization of a single-beam UV-Vis spectrometer to determine the absorb-

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Aparatus	Description
	ance at the highest wavelength
FT-IR Spectrophotometer	Shimadzu Company's (Japan) FT-IR device Type 8400S.
pH meter	A pH meter from Infitek company (China).
Electronic balance	BL 210S Type balance from Sartorius company.
Water bath	GFL 1083 water bath (Berlin, Germany).

2.3 Solution preparations

Standard solutions of salts and drugs under study were prepared by dissolving the necessary weights of these substances in an appropriate volume of deionized water. Then, using the dilution law, solutions of different concentrations of standard concentration were prepared to be used in spectroscopic measurements.

2.3.1 Preparation of pure drug solutions

Trifluoperazine hydrochloride, 250 $\mu g.mL^{-1}$ was prepared by dissolving 0.025 g of the purified substance in deionized water using a 100 mL volumetric flask. The volume was filled to the mark.

2.3.2 Preparation of potassium permanganate solution (1×10^{-2} M)

The potassium permanganate solution was prepared by dissolving the equivalent mass of (0.158 g) in deionized water up to 100 mL using a volumetric flask, then completing the volume until reaching the mark.

2.3.3 Preparation of pharmaceutical solutions for the drugs under study

The solution of the pharmaceutical solution of Trifluoperazine hydrochloride (5 mg tablets); (250 $\mu g.mL^{-1}$)was prepared by collecting and grinding five tablets of the drug and then taking a weight equivalent to (250 $\mu g.mL^{-1}$) of the powder and dissolving it in deionized water using a 100 mL volumetric flask, and completing the volume to the mark.

2.3.2.2 Preparation of FTIR solution for colored product D

It was prepared by adding 2 mL of trifluoperazine hydrochloride solution (50 $\mu g.mL^{-1}$), 2 mL of potassium permanganate solution (10×10^{-5} M) and 2 mL of solution with pH = 3 in a volumetric flask up to 10 mL. Deionized water was added into the volume to mark.

2.4 Determination of the maximum wavelength (λ max) of the colored product solutions

The TFP.HCl-$KMnO_4$solution was prepared in a 10 mL volumetric flask consisting of 2 mL of TFP.HCl solution at a concentration of (50 $\mu g.mL^{-1}$) and 2 mL of $KMnO_4$ solution at a concentration of (1×10^{-3} M) and then the volume was supplemented to the mark by adding deionized water. To find out the maximum wavelength, the absorbance of the solution was measured in a range between (190 to 1000 nm) against the blank solution that was formed from the $KMnO_4$ solution with deionized water. All measurements were made using a 1 cm thick quartz cell.

2.5 Determining of the optimal conditions

After determining the maximum wavelength for the colored product, experiments were carried out to determine the optimal conditions for solutions of colored products by spectral method to obtain the best concentrated sensitivity.

2.5.1 The optimal pH value

The optimal pH value was obtained for the colored product under study, within a range of pH = 1-8, where drug solution were reacted with the ions used to estimate it according to the specific wavelength. TFP.HCl concentration (50 $\mu g.mL^{-1}$), $KMnO_4$concentration (1×10^{-3} M) and λmax (400.6 nm) against blank solutionwere prepared in volumetric flask of 10 mL consisting of 2 mL of the drug, 2 mL of the ion solution, 2 mL of the pH solution and the volume was completed to 10 mL by deionized water.

2.5.2 The best ion concentration

The effect of the optimal concentration of potassium permanganate ion by which the drug was evaluated on the colored product under study was studied. The colored product solution was prepared in volumetric flasks of 10 mL according to optimal conditions. It was made by blending 2 mL of TFP.HCl (50 $\mu g.mL^{-1}$) with 2 mL of different concentrations (within the range 1×10^{-5} - 25×10^{-5} M) of $KMnO_4$ and 2 mL of (pH = 3) solution in a 10 mL volumetric flask. The volume was completed to the mark using deionized water. The measurement of absorbance was conducted at the maximum wavelength (λmax = 400.5 nm) relative to the blank solution.

2.5.3 The best ion volume

The best volume of the ions of the colored product solution under study was measured with a range between 0.5 to 4 mL. The solution of the colored product was prepared in a volumetric flask with a capacity of 10 mL by mixing 2 mL of the drug solution with different volumes of the ion solution (by which was determined) with 2 mL of pH solution. By adding deionized water, the volume was supplemented to the mark according to ideal conditions. TFPH.HCl concentration (50 $\mu g.mL^{-1}$), $KMnO_4$ concentration (10×10^{-5} M) and λmax (400.5 nm) against blank solution.

2.5.4 The effect of time

The effect of time on the stability of the solutions of the colored product under study was studied at optimal conditions (such as maximum wavelength, pH, and ion concentration) obtained from previous measurements. The absorbance of the colored product solutions was measured at different times, starting from the moment of mixing the solutions up to 60 minutes. Where the solutions were prepared in a volumetric flask of 10 mL, according to the optimal conditions. It was made by blending 2 mL of TFP.HCl (50 $\mu g.mL^{-1}$) with 2 mL of $KMnO_4$ in a concentration of 10×10^{-5} M and 2 mL of (pH = 3) solution in a 10 mL volumetric flask. By adding deionized water, the volume was supplemented to the mark. Then, the absorbance was measured against the blank solution (at λmax 400.5 nm) every 5 minutes up to 60 minutes.

2.5.5 The effect of temperature

Under the optimized conditions, effects of temperature on colored product was investigated. It was made by blending 2 mL of TFP.HCl (50 µg.mL^{-1}) with 2 mL of $KMnO_4$ in a concentration of 10×10^{-5} M and 2 mL of (pH = 3) solution in a 10 mL volumetric flask. By adding deionized water, the volume was supplemented to the mark.Then, the solution was left for 5 minutes, after which the absorbance was recorded over the range of 15-50 °C at the maximum wavelength (400.5 nm) against the blank solution.

2.5.6 The influence of the addtion sequence

The impact of the sequence of addition on the colored product was studied to find the best sequence for the colored product that gives the highest absorbance. The addition sequences adopted are shown in Table 04.

Table 04: The squences of addition adopted ofthe colored product.

No.	Addition sequence
1	Drug+Element+pH
2	Drug+pH+Element
3	Element+Drug+pH
4	Element+pH+Drug

The solutions were prepared in volumetric flasks of 10 mL according to the optimal conditions. The solution was prepared by mixing 2 mL of TFP.HCl (50 µg.mL^{-1}) with 2 mL of $KMnO_4$ in a concentration of 10×10^{-5} M and 2 mL of (pH = 3) solution in a 10 mL volumetric flask. By adding deionized water, the volume was supplemented to the mark. The absorbance was measured at the maximum wavelength (400.5 nm) and the optimum temperature and time against the blank solution.

2.6 The calibration curve constructing

The calibration curve for the colored product was created using the following procedure:2 mL of $KMnO_4$ solution with a concentration of 10×10^{-5} M was mixed with 2 mL of TFP.HCl solution with a concentration ranging from 5 to 80 µg.mL^{-1} with 2 mL of (pH = 3) in a volumetric flask of 10 mL. By adding deionized water, the volume was supplemented to the mark. The absorbance was measured at the optimal time and temperature for this colored product at a wavelength of 400.5 nm against the Blank solution.The absorbance was measured at optimal conditions for the colored product.

2.7 Suggested stoichiometries for colored products

The continuous variation method was used in this study to determine the potential stoichiometry for the colored product.This method included preparing solutions consisting of the drug and the salt of the element to be measured by with, provided that they are of the same concentration but in different volume ratios. In contrast, the total volume of these solutions is fixed each time, which is 10 mL in this study. The absorbance curve (on the y-axis) and the volumetric ratio (on the x-axis) were plotted where the point of intersection of the two drawn lines represents the volumetric ratio (drug: element). TFP.HCl solution was mixed with $KMnO_4$ solution, both of which had the same concentration of 10×10^{-5}M but with different volume ratios ranging from 1 to 8 mL with 2 mL of pH = 3 solution. This colored product was mixed under optimal conditions in terms of time and temperature, and the absorbance was measured at the maximum wavelength (λmax) of 400.5 nm against a blank solution.

3. RESULTS AND DISCUSSIONS

3.1UV-visible spectroscopy

Figure (1) displays the spectrum of the colored product. It can be seen through the figure (as previously indicated) that the absorption spectrum of the aqueous solution of the colorless TFP.HCl showed a wavelength of 258 nm against the blank solution (water). The λmax of the $KMnO_4$ solution was 525 nm (which is a violet) against the blank solution (water). The absorption spectrum of the colored product solution showed a λmax of 400.5 against the blank solution (2 mL $KMnO_4$ solution + 8 mL water) and the color of the resulting solution was green-yellow. In addition, it was found that the absorption spectrum of the pure drug solution had a redshift of 142.5 nm compared to the spectrum of the colored product solution, while the absorption spectrum of $KMnO_4$ had a blue shift toward a shorter wavelength of 124.5 nm compared to the absorption spectrum of the colored product.

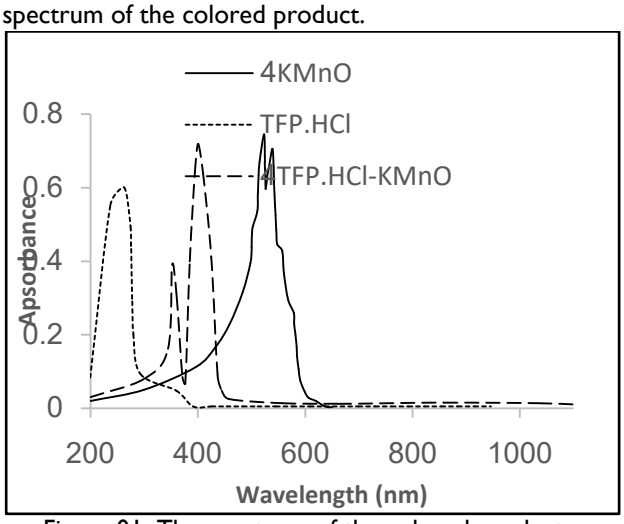

Figure 01: The spectrum of the colored product (TFP.HCl- $KMnO_4$).

3.2 Optimal conditions

3.2.1 Effect of pH

Figure (2) shows the results of changing on the pH of the colored product. it was observed that with increasing pH, the absorbance increased until reaching its maximum at pH = 3 and thereafter decreases. Thus, the best pH is 3.

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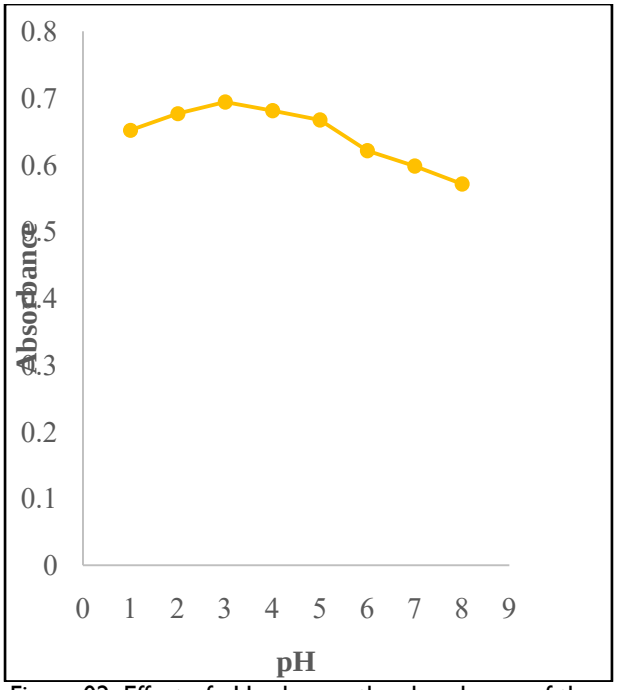

Figure 02: Effect of pH value on the absorbance of the colored product.

3.2.2 Effect of ion concentration

The best concentrations of permanganate ion in the solution of the colored product at the maximum wave-length were obtained. The concentration ranges of the ion were 1 - 25 × 10^{-5} M, while the drug concentration for the colored product was 50 µg.mL^{-1} as presented in Figure (3). The findings demonstrated that the best concentration of the permanganate ion was (10 × 10^{-5}M).

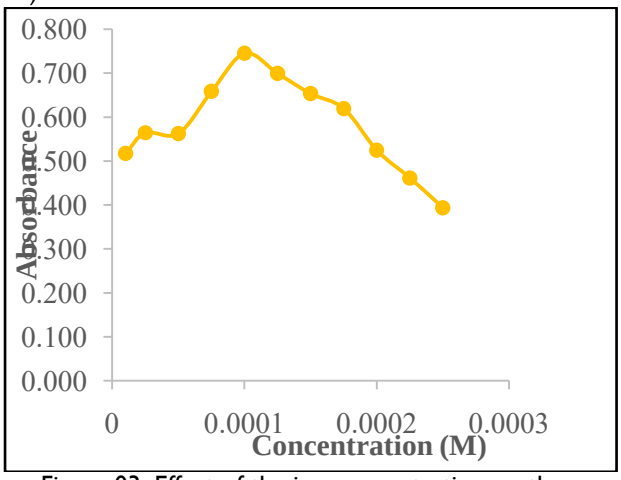

Figure 03: Effect of the ion concentration on the colored products.

3.2.3 Effect of ion volume

Theeffect of the volume of the permanganate ion on the intensity of absorption was studied, as shown in Figure (4). Through the figure above, it is noted that the best volume of the the permanganate ion in the colored product is 2 mL.

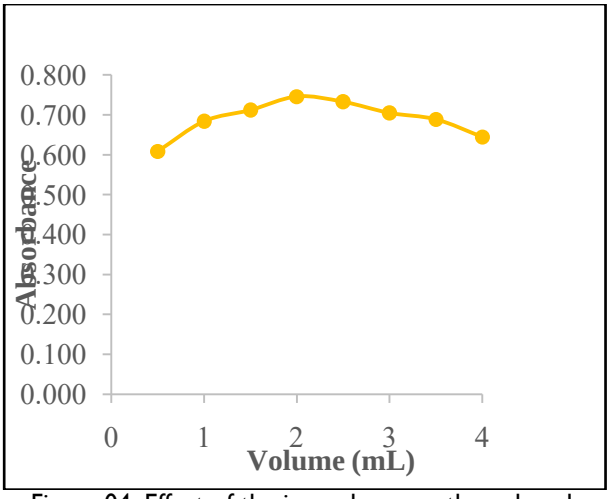

Figure 04: Effect of the ion volume on the colored product.

3.2.4 Effect of time

An obvious factor is time, it also affects the forming of colored product. A study of the variation in absorbance intensity as a function of time over the period from 1 to 60 minutes after initiation of the reaction was performed for the colored product to demonstrate the periods during which they remained stable. The time (from 0 to 60 minutes) versus stability results of the colored product are presented in Figure (5). It was found that the optimum absorbance of colored product was 5 minutes.After this value, the absorbance went down..

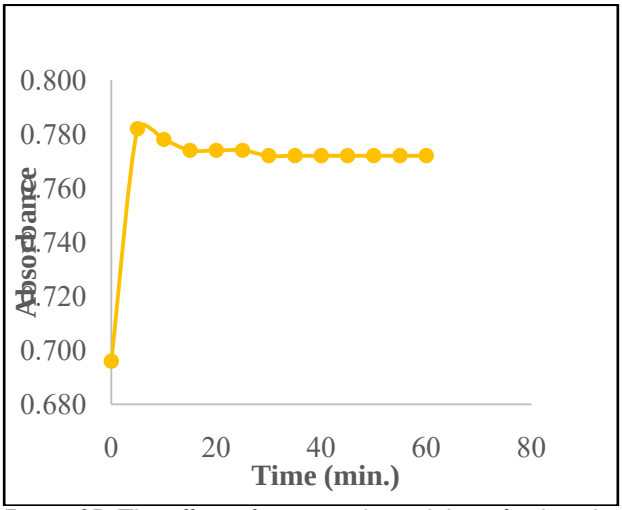

Figure 05: The effect of time on the stability of colored product.

3.2.5 Effect of temperature

Figure (6) showed the effect of temperature on the colored product where it was studied at 15 to 50 ºC. The results have shown that the highest average absorbance was at 25 °C Where after above value, the absorbance decreased which may be due to producing of colored product dissolves and changing the value of max wave length.

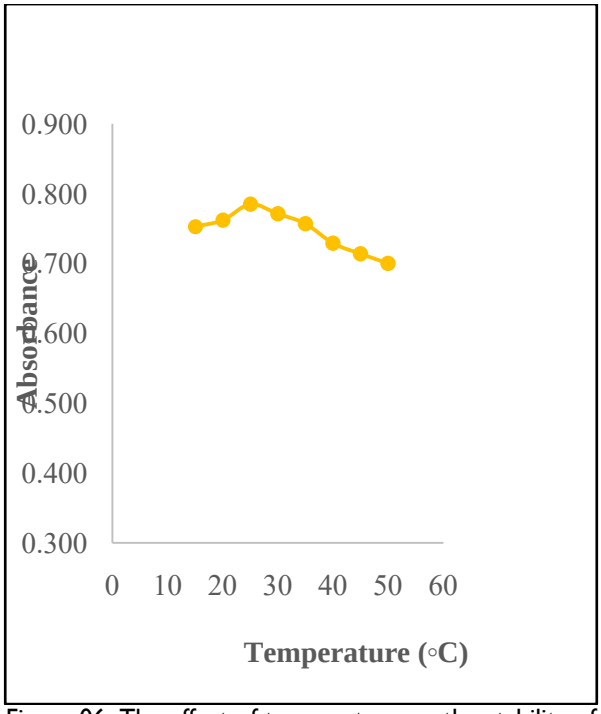

Figure 06: The effect of temperature on the stability of colored product.

3.2.6 Effect of sequence addition

To obtain the best absorbance intensity under optimal conditions, the order of addition of the materials involved in the formation of the colored products under study has been studied. The absorbance values obtained from changing the addition sequence for the colored product are shown in the Table 05.

Table (5): Sequence addtions of the colored product.

Absorbance	Sequence addition
0.763	TFP.HCl + $KMnO_4$ + pH
0.778	TFP.HCl + pH + $KMnO_4$
0.786	$KMnO_4$+TFP.HCl + pH
0.759	$KMnO_4$+ pH +TFP.HCl

3.3 Calibration curve

The calibration curve for forming the colored product through the reaction between TFP and $KMNO_4$ was established by measuring different concentrations of the TFP.HCl medication, as depicted in Figure (7). The figure analysis revealed that the concentrations obtained obeyed the Beer-Lambert law and spanned a range of 5 to 80 $\mu g.mL^{-1}$ at the wavelength of maximum absorbance, specifically 400.5 nm. Moreover, the correlation coefficient exhibited a value of 0.9971. The findings is presented in Table (6). The established limit of detection (LOD) was 0.125 $\mu g.mL^{-1}$ and the limit of quantification (LOQ) was calculated to be 0.418 µg.mL-1, respectively. According to the results, it was noted that the value of molar absorptivity was estimated as 6149.376 $L.mol^{-1}.cm^{-2}$. with a sensitivity of 0.0781, while Sandell's calculated sensitivity was 4146 $\mu g.cm^{-1}$. This sensitivity that has been observed points to the possibility of using it as a quantifying agent even at low levels in the medication.

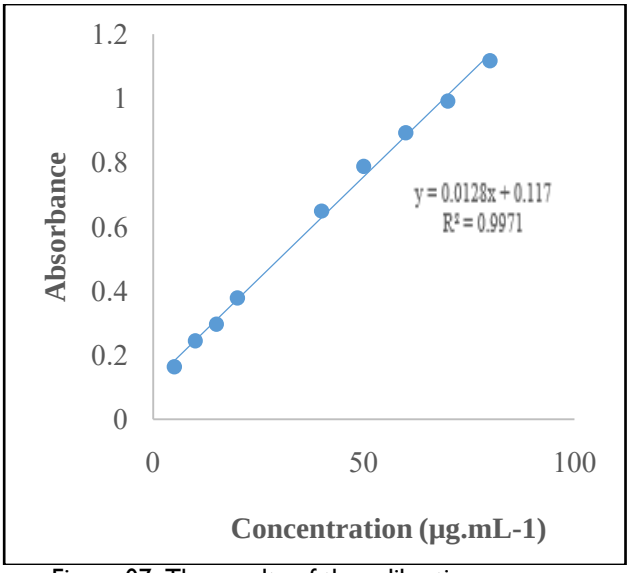

Figure 07: The results of the calibration curve.

Table 06: Parameters associated with the calibration curve of the colored product.

Parameter	Value
Stoichiometric ratio	1:1
Molar absorptivity ($L.mol^{-1}.cm^{-1}$)	6149.376
λ max (nm)	400.5
Sandell's sensitivity ($\mu g.cm^{-2}$)	0.0781
LOD($\mu g.mL^{-1}$)	0.125
LOQ($\mu g.mL^{-1}$)	0.418
Slope	0.0128
Linear range ($\mu g.mL^{-1}$)	5-80
Regression equation	y = 0.0128x + 0.117
Correlation coefficient (R^2)	0.9971

3.4 The molar absorbance coefficient and Sandell's sensitivity calculations

Molar absorption coefficient and Sandell sensitivity are among the sensitivity measurement factors for spectroscopic methods. The molar absorption coefficient is defined as the absorption at a given wavelength of a solution with a molar concentration of a given substance and a path length of 1 cm^2. It is a fixed property of the compound. The molar absorption coefficient is calculated from the straight-line slope of the calibration curve (concentration utilized in $\mu g.mL^{-1}$) and according to the following formula [22]:

Molar absorptivity = Molecular weight × Slope × 100 (1)

Sandell sensitivity refers to the amount of micrograms or nanograms per milliliter of a solution of the substance being studied that produces an absorbance of 0.001 in a 10 mm path-length cell. The units for Sandell sensitivity are ($\mu g.cm^{-2}$) and it can be calculated using the equation below. [23]:

Sandell sensitivity = molecular weight/molar absorbance (2)

The molar absorptivity and Sandell sensitivity results of the colored product is presented in Table 06.

3.5 Calculation of detection limit and quantitative limit

The limit of detection (LOD), which reflects the lowest amount in material that can be detected, but not a measure at, and was used with an accurate value, whereas the limit of quantification (LOQ) is very tightly defined as the lowest amount analyte that can be identified [24]. For the quantitative limit, they were determined from the following equations and seven solutions were used to measure [25]:

LOQ = (10 × SD) / m (3)

LOD = (3 × SD) / m (4)

m: The slope of the calibration curve .

SD:The standard deviation.

Table (6) display the LOQ and LOD results.

3.6 Accuracy and precision

The accuracy quantifies how the true values and analytical outcomes compare to each other. It may be written either in terms of Erel% (relative error percentage) or Rec% (recovery percentage), using the equation:

$$Erel\% = \frac{A-R}{R} \times 100 \quad (5)$$

Whereas:

A: analyzed value.

R: the real value.

Rec% = 100 ± Erel% (6)

Precision is the extent to which repeated readings of a given concentration give results that are close together. Using the calculated relative standard deviation, it can be determined through the following equations:

$$SD = \sqrt{\frac{\Sigma(Xi-\bar{X})^2}{n-1}} \quad (7)$$

Where SD is the standard deviation.

$$RSD = \frac{SD}{\bar{X}} \times 100 \quad (8)$$

Since:

$$\bar{X} = \frac{\Sigma Xi}{n} \quad (9)$$

Since:

Xi: Represents the sample.

n: number of samples (five samples of the same concentration were adopted).

Table 07 presents the results of precision and accuracy. Results demonstrated that the maximum values of the relative errors (E%) were 2.20, 1.5, 2 and 1.25 respectively. These findings indicated that all colored products have good precision and accuracy.

Table 07: Precision and accuracy results of the colored product (D).

Concentration (µg.mL^{-1})				
Present	**Found**	**E%**	**Rec%**	**RSD%**
20	20.12	0.600	100.600	0.591
40	40.50	1.25	101.500	0.370
60	60.22	0.366	100.366	0.415

3.7 Effect of interferences

The effect of the interferences was studied by spectrophotometer for the estimated colored products, and these substances were concentrated ten times more than the concentration of the drug. One of the goals of studying these materials is to ensure that the method is selective for its application in the routine analysis of different samples [22]. In pharmaceutical preparations, there are various substances such as excipients, diluents, and flavoring agents, that are interrelated and expected to be present [26]. They are important to look at as they may affect the absorption range of the colored product formed from the drug-reagent or drug-element combination. The absorbance and rate of recovery (%) for various interfering materials are presented in Table (8). According to the table, the change in recovery did not exceed 2%, indicating that these materials did not affect the absorption of the colored product.

Table 08: The impact of interferences on the colored product absorbance.

Interference	Error %	Recovery %
Glucose	-0.594	100.594
Sucrose	0.831	99.169
Starch	-1.120	101.120
Lactose	-1.471	101.471

3.8 Suggested stoichiometry for the colored product

The continuous variation method (Job's method) was utilized to determine the amount of the drug associated with the ion. The drug was estimated in an acidic medium. Figure (8) show the obtained results. Through the figure above, it is clear that the drug has been associated with its ion in a ratio of (1:1).

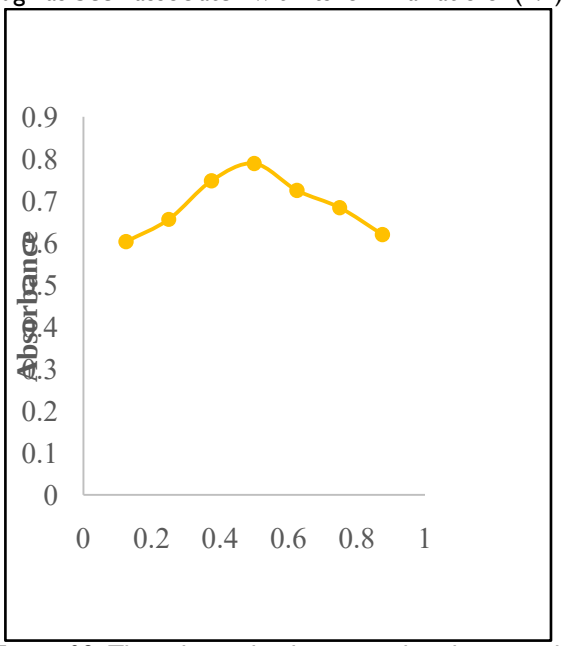

Figure 08: The relationship between absorbance and volume fraction of the colored product solution.

3.9 Applications

The results of the spectrophotometric analysis of the colored product (also known as TFP.HCl-$KMnO_4$) found in the pharmaceutical preparation (injection) are

presented in Table (9). According to the findings, the E% value was less than 2 and the RSD% was lower than 1.

Table 09: Precision and accuracy results oflralzin 5 mg tablets (with $KMnO_4$).

Concentration ($\mu g.mL^{-1}$)				
Present	**Found**	**E%**	**Rec%**	**RSD %**
10	9.98	-0.200	99.800	0.25
30	30.37	1.233	101.233	0.84
50	49.81	-0.380	99.620	0.32

According the results of the above table, it can be demonstrated that the adopted spectrophotometric method is applied successfully in estimating the pharmaceutical preparation of the drug under study.

3.10 The suggested mechanism of reactions

The suggested mechanism of reactions of the colored product is displayed in Figure (9).

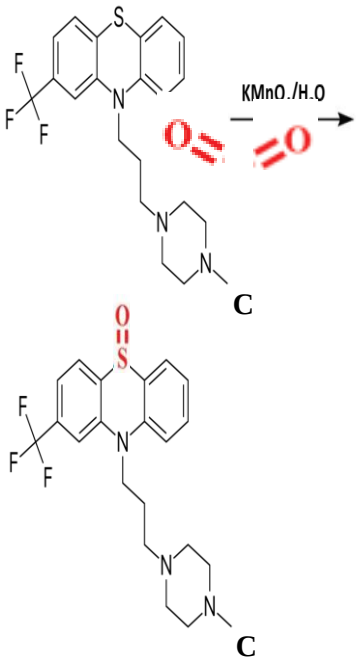

Figure 09: The suggested mechanism of the colored product.

4. CONCLUSIONS

According to what was obtained from the results and discussion, the following conclusions are taken:

1. The success of the ultraviolet-visible spectroscopy method used in identifying the compound, where colored compounds were formed from the interaction of (TFP.HCl and $KMnO_4$).
2. The acidic medium is suitable for the preparation of the colored product. The optimal pH value for the product was 3.
3. The colored product, when formed, recorded λmax of 400.5 nm. Moeoever, The (λmax) of the drug had a redshift of 142.5 nm when formed.
4. The results of continuous variation showed that the ratio of the drug: salt elements was (1:1). Furthermore, it obeys the Beer-Lambert law within the concentration range (5-80) $\mu g.mL^{-1}$.
5. The colored product showed good stability with a maximum absorbance recorded after 5 minutes.
6. The employed spectroscopic method was quite sensitive, with the LOD equal to 0.125 $\mu g.mL^{-1}$ and LOQ amounting to be at 0.418 $\mu g.mL^{-1}$; additionally, Sandell's sensitivity value being at 0 0.078 $\mu g.cm^{-2}$.

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Ethics statement

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

Statement of conflict of interests

The authors declare no conflicts of interest related to this study.

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