RESEARCH ARTICLE

Spectrophotometric Determination of Trifluoperazine Hydrochloride in Pure Forms and Pharmaceutical Preparations by Oxidative Coupling Reaction as a Reagent in the Presence of N-bromosuccinimide

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ABSTRACT

The article describes a simple, speedy, and sensitive spectrophotometric method to determine the trace amounts of trifluoperazine dihydrochloride (TFPH) in an aqueous solution. The method involves the oxidative coupling reaction of TFPH with N, N-dimethyl-p-phenylenediamine dihydrochloride (DMPPDA.2HCl) reagent in an acidic medium during availability of N-bromosuccinimide to develop an intense violet color. This water-soluble product exhibits maximum absorbance at 552 nm. Beers law follows a concentration range of (1–20) µg/mL, with a molar absorptivity of 1.4×10^4 L/mol.cm, Coefficient determination ($R^2 = 0.9989$). Sandel's index of 0.030 µg /cm^2. The average recovery is 100.8045 % and D.L of 0.1435 µg/mL, Q.L. of 0.4349, and relative standard deviation of 0.11–0.59%. The proposed method gets compared with the other standard method using t-test and F-test. The results reflect no significant variation between both the methods. The proposed method was applied conveniently, to determine Trifluoperazine.2HCl in its pure state and pharmaceutical formulations.

Keywords: N, N-dimethyl-p-phenylenediamine dihydrochloride, Oxidative coupling, Spectrophotometric, Trifluoperazine dihydrochloride.

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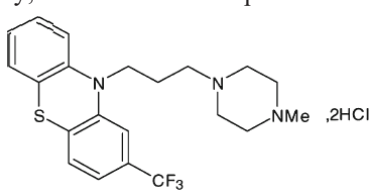
INTRODUCTION

Trifluoperazine dihydrochloride is a significant phenothiazine derivative which is 10- [3] 4-Paraxin-1-Propyl-2-Tri-Flammethyl Phenothiazine Dihydrochloride, and TFPH is 10-[3-(4-methyl-1-piperazinyl)propyl]-2-(trifluoromethyl)-10H-phenothiazine dihydrochloride.[1] The structural formula has given in Scheme 1.

The molecular formula is $C_{21}H_{24}F_3N_3S.2HCl$, and molecular weight[2] is 480.4 gm mol^{-1}. TFPH is a white powder with a bitter taste, a melting point of 240°C which is colorless and pale yellowish, dissolves in water at 20°C, and is sensitive to light.[3] This drug is determined using spectral methods,[4-18] high-performance liquid chromatography,[19-22] Densitometry,[23] Atomic absorption methods,[24] and Electrochemistry methods.[25] In this study, a sensitive and simple spectrophotometric method for determining TFPH in pure form and pharmaceutical formulations based on the oxidative coupling using DMPPDA.2HCl in the presence of potassium N-bromosuccinimide.



Scheme 1

EXPERIMENTAL

Apparatus

All spectrophotometric measurements (spectral and absorbance) were carried out on Shimadzu UV-visible 1800 Double beam Spectrophotometer (Japan) using 1 cm matched glass cell was used for recording absorbance. The following instruments were used too: Sartorius BL 2100 balance (German), pH meter 3310 Jenway (German), Water bath (Clifton, USA), Hater with a sitter (Heidolph MR3001, German).

Chemicals and Reagents

All Chemicals and Reagents used were analytical grades, and distilled water was used to prepare all solutions. TFPH, p-Ansidine reagent, Cerium(IV) sulfate, sulfuric acid, and ethanol were sourced from BDH Chemical Ltd, England.

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Trifluoperazine Hydrochloride (TFPH) Solution 1000µ/mL

A stock standard solution containing 1000µ/mL TFPH was prepared by dissolving 0.1000 g of TFPH in 100 mL volumetric flask filled with distilled water up to mark and kept in the dark place, then 250 µ/mL prepared by diluting.

N,N-dimethyl-p-phenylenediamine dihydrochloride (DMPPDA.2HCl) 5×10^{-3}M

A reagent solution 5×10^{-3}M was prepared by dissolving 0.1046 g of it in 100 mL in a volumetric flask with distilled water up to mark.

N-bromosuccinimide (NBS) solution 5×10^{-3}M

NBS solution 5×10^{-3}M was prepared by dissolving 0.0890 g in 2ml of acetone and then filled with distilled water up to mark and kept in the dark.

Pharmaceutical Formulation Solution

Solution of TFPH tablets formulation (250 µg/mL) Salabid (5mg), production of the Pharmaceutical Company of Cairo, Cairo-Egypt. The solution (1000 µ/mL) of TFPH was prepared by weighing (20 tablets), then grounded and dissolved with distilled water, filtered, washed, and filled up to mark in 100 mL volumetric flask, 25 mL from this solution diluted to 100 mL to prepare 250 µ/mL TFPH solution.

General Procedure

The method's principle is coupling the reaction of TFPH with N, N-dimethyl-p-phenylenediamine dihydrochloride (N,DMPPDA.2HCl) in the presence of NBS (oxidizing agent) to produce a violet-colored solution which gives maximum absorption at 552 nm.

Preliminary Investigations

A 1.0 mL of NBS (oxidizing agent) 5×10^{-3}M is added to 1.0 mL standard TFPH solution (250 µg/mL) and followed by the addition of 1.0 mL of 5×10^{-3}M reagent (DMPPDA.2HCl) in acidic media (1.0 M acetic acid) and diluted with distilled water in a 25 mL volumetric flask, a violet color product is obtained with λ max 552 nm against the blank (which the blank does not give any absorption at 552 nm).

RESULTS AND DISCUSSION

Optimization of the Experimental Conditions

To institute the most favourable conditions, the effect of many variables on the absorption intensity was observed with adding 2.0 mL of standard TFPH solution (250 µg/mL) and mapping the absorption at 552 nm versus the blank.

Effect of the Amount of Oxidizing Agent

This study helps in identifying the most promising oxidizing agent and its amount, NBS (5×10^{-3} M), by adding different volumes (0.5–3.0 mL) of oxidizing agent to volumetric flasks containing 2.0 mL of TFPH (250µg/mL) and 2.0.0 mL of the reagent solution (1×10^{-2}M), then adding 1.0 mL of 1.0 M acetic acid and the volume filled with 25ml with distilled water. The results indicate that the volume of 2.0 mL of NBS (5×10^{-3}M) is the optimum amount because of the highest absorbance, so it was used in subsequent experiments.

Effect of the Amount of Coupling Reagent (DMPPDA.2HCl)

After selecting DMPPDA.2HCl, adding DMPPDA.2HCl (5×10^{-3}M) of (0.3–3.0 mL) to the volumetric flasks containing 2.0 mL of TFPH 250µg/mL) and 1 mL of the NBS (5×10^{-3}M), then the addition of 0.5 mL of 1.0 M acetic acid and remaining volume upto 25ml with distilled water, from the results obtained it is clear that the volume of 1.0 mL of DMPPDA.2HCl coupling reagent (5×10-3M) is the optimum amount because it gave the highest slope (0.149) and the correlation coefficient (0.9976). So it is adopted in subsequent experiments.

Effect of the Acids and pH

Some of the weak and strong acids (H_2SO_4, HCl, CH3COOH, 1M) have been used and found 1 mL of acetic acid give the maximum absorption intensity, and this volume was elected in all following measurements. The results indicate that the volume of 1.0 mL of acetic acid (1M) is the optimum amount because of the highest absorbance, so it was used in subsequent experiments.

After 1M acetic acid fixed the best acid, then the pH of solution studied by adding deferent volumes of (0.3-1.5 mL) acetic acid shows the best pH solution (pH3.4). That means 0.5ml acid addition is the best, gives the highest absorbance. Therefore, it is adopted in subsequent experiments.

Effect of Temperature

The temperature's effect (15–60°C) on the absorption of the developed colored product is observed with the adding 1.0 mL of DMPPDA.2HCl reagent (5×10^{-3}M), 2.0 mL of TFPH solution (250µg/mL), and 0.5 mL of NBS (5×10^{-3}M). The volume is completed to 25 mL with distilled water in a volumetric flask, and the absorption is computed at a wavelength of 552 nm versus blank reagent, the highest absorbance is found at 25 °C, so it is considered in the subsequent experiments.

Effect of Oxidation Time and Stability of Reaction Product

It was found that the value of absorption of the color product (TFPH) 16 µg/mL remained stable for not less than 70 minutes, and this time is suitable for completion of many measurements. The results obtained indicate that the 5-10 minute and remains for 70 minutes stable are suitable for completing the oxidative coupling reaction because of the highest absorbance, so it was used in subsequent experiments**.**

Effect of Solvent

After all reaction components were added according to the method used, different solvents were used to complete the volume to the extent of up to mark in 25 mL volumetric flask to obtain that water gives the highest absorption than acetone or ethanol. But it also indicates that water is a suitable medium for the reaction and gives the highest absorption at wavelength 552nm, has good absorption, economically feasible.

Effect of Order of Addition

It was found that the best addition sequence that gives the highest absorption intensity (0.436) is order number (D+O+R+A), where: D = TFPH, R = Reagent (DMPPDA.2HCl), O= Oxidative agent (NBS), and A=acid.

Final Absorption Spectrum

The final absorption spectra were measured after optimum conditions were established Table 1.

After all components of the reaction were added according to optimum conditions in Table 1. The volume is completed to 25 mL with distilled water, and the absorption of solutions is measured at a wavelength of 552 nm versus blank, but the blank does not give any absorption at 546 nm results shown in Figure 1.

Procedure Construction of Calibration

Increasing volume (0.1–2.0 mL), which is (1–20) µg/mL of TFPH solution 250 µg/mL were added to 25 mL volumetric flask containing 2 mL of NBS 5M, 1 mL of the reagent solution $5x10^{-3}$M and 1mL (1M) acetic acid, then complete the volume to the mark with distilled water and then was measured the absorption of all solution versus Blank solution at 552 nm. Figure 3 represents linear calibration curve for TFPH solution with the concentration 1–20 µg/mL.

The linear regression equation for it is y=0.0315x+0.1187 (R^2= 0.9989), where y is the absorbance and x is the concentration, molar absorption coefficient $1.4x10^4$ $L.mol^{-1}.cm^{-1}$ and sandel's Index 0.030 $\mu g.cm^{-2}$. It indicates that the standard curve has a high linear specification and absorption Spectrum (Figure 2 and 3).

Analytical Valuation

Under the experimental conditions described, Beer's law**,** Molar absorptivity (ε), and Sandell's sensitivities for TFPH, are given in Table 2. The regression using the least-squares method made for calibration curves is also given in Table 3. The detection limit (LoD) and the limit of quantum (LoQ) were calculated from calibration graphs using the equation.[26,27]

$$LoD \text{ or } LoQ = K \times SD/s$$

Were K= 3.3 for LoD and 10 for LoQ, SD is the standard deviation of six determinations, and **s** is the calibration curve slope. LoD is the lower limit of Beer's law range. LoQ is approximately 3 times greater than LoD.

Accuracy and Precision of the Proposed Method

Accuracy and precision, both were studied by doing analysis of six replicate samples within Beer's law range consisting of same quantity of drug. TFPH was determined at three different (10, 16, and 18µg/mL) concentrations and the results are shown in Table 4. A fair accuracy could be obtained with the proposed method with an average recovery of 100.0667. The highest RSD is 0.59, which indicates fair precision and reproducibility of the method. The validity of the proposed procedure for determining TFPH in its pure state was tested by analyzing this drug being used in the proposed method. The proposed

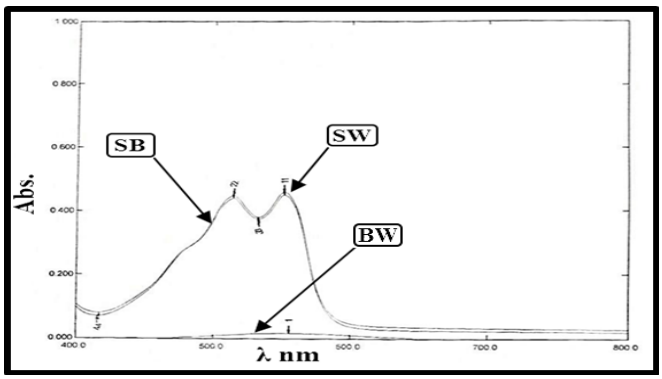


Figure 1: Final Absorption Spectrum for Determination of TFPH. **Where: SW** = Absorption Spectrum of the colored product versus water, **SB** = Absorption Spectrum of the colored product versus blank, and **BW** = Absorption Spectrum of blank versus water.

Table 1: Summary optimum conditions

Experimental Conditions	
λ_{max} (nm)	552
Amount (mL) of 250 µg/mL TFPH	ml2
Amount (mL) of 1	1 mL
Amount (mL) of 5×10^{-3}M N,N-dimethyl-p-phenylenediamine.2HCl	1 mL
Amount (mL) of 1 CH_3COOH	0.5 mL
Temperature	25C°
Solvent	Water
Oxidation time	5 min

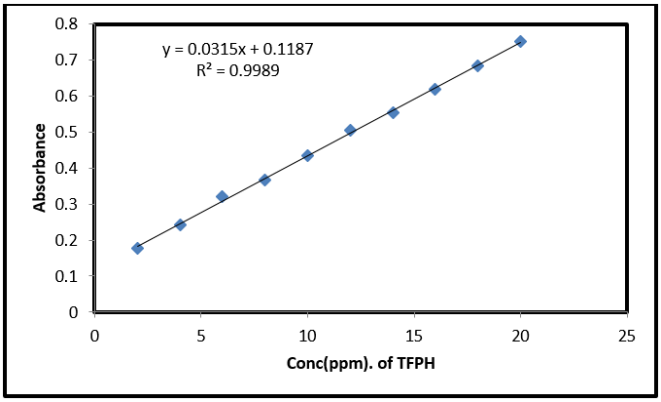


Figure 2: Calibration curve for TFPH with DMPPDA.2HCl by oxidative coupling reaction.

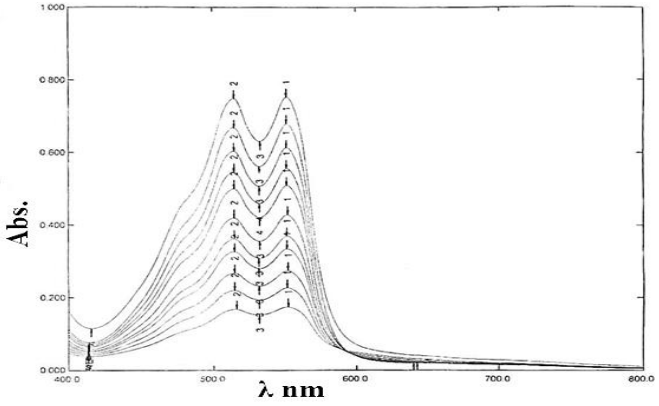


Figure 3: Absorption spectrum for the range 1-20µg/ml TFPH.

method has good accuracy and precision. The analytical results obtained from this study are summarized in Table 3.

Applications of the Method

The proposed method was successfully applied to the determination of TFPH in it's pharmaceutical preparation (Salabid, tablets 5 mg). The results, which are shown in Table 3 indicate that good recoveries were obtained.

Direct Method

In this method, three different concentrations of different pharmaceutical formulation TFPH solutions (10, 16, and 18 µg/mL) have been done in the same way in developing the calibration curve. The absorbance is noted at 552 nm five times. RE is calculated, and the results are shown in Table 4.

The results which are shown in Table 4. indicate that good recoveries Average recovery 99.9067 % were obtained.

Table 2: Analytical parameters

Parameter	*Values*
λ_{max} (nm)	552
Molar absorptivity (l/mol.cm)	$1.4x10^4$
Beer's Law range (µg.ml^{-1})	2-20
Medium	acidic
Sandel's Index (µg.cm^{-2})	0.030
LOD (µg.ml^{-1})	0.*1435*
LOQ (µg.ml^{-1})	0.4349
Regression equation	*y = bx+a
Slope (b)	0.0315
Intercept (a)	0.1187
Determination coefficient (R^2)	0.9989
Stability (min)	70
Color	violet
Average recovery	100.8045%
Average RSD%	0.4661%

y* = bx+a where y is the absorbance and x is concentration in µg.ml^{-1}.

Standard Additions Method

The interference-free advanced method known as standard additions is used to determine TFPH in its pharmaceuticals. Different volumes 0.6, 0.8 mL of a pharmaceutical formulation solutions 250 µg/mL were transferred to six volumetric flasks 25 mL for each volume, then increasing volumes 0.2, 0.5, 0.8, 1.0 mL of 250 µg/ml of TFPH standard solution were added with leaving the fifth flask. The solution was treated as in the construction of the calibration curve. The absorbance was measured at 552 nm (Figure 2). The measured concentration, results of Recovery, and RE% are shown in Table 5.

We can summarize that the results are shown in Figure 4, and Table 5 indicates that standard additions agree with the direct method within the acceptable conditions.

The results shown in Table 5 indicate that standard additions are in agreement with the direct method within the acceptable.

Stoichiometry of the Complex

The composition of the complex had been investigated using Job's method.[26] The method was based on the measurement of series of solutions in which molar concentration of TFPH and DMPPDA.2HCl 5×10^{-3}M varies, but their sum remained constant. The other solutions added as mentioned in the general procedure or the calibration graph. It was found that the drug

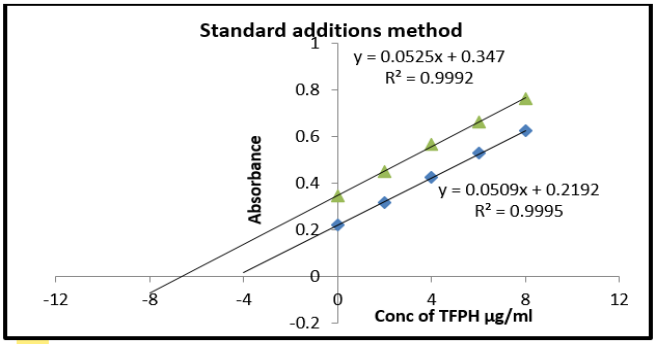


Figure 4: Standard additions method

Table 3: Accuracy and precision of the proposed method

Conc. of TFPH taken (µg.ml^{-1})	*Relative error*%*	*Recovery* %*	*Average recovery*	*RSD* %*
10	0.10	100.10		0.59
16	0.08	100.08	100.0667	0.55
18	0.02	100.02		0.11

* Average of six determinations and RSD is relative standard deviation.

Table 4: Direct Method for the determination of TFPH

Conc. of TFPH taken (µg.ml^{-1})	*Relative error*%*	*Recovery* %*	*Average recovery%*	*RSD* %*
6	-0.10	99.90		1.34
10	0.11	99.89	99.9067	0.50
18	0.07	99.93		0.24

Table 5: Standard additions Method

Tablets of the drug (TFPH)	*TFPH µg/ml present*	*TFPH µg/ml measured*	*Recovery%*	*RSD%*
Salabid tablets	6	6.0900	99.9300	0.1567
	8	8.3200	100.0500	0.1122

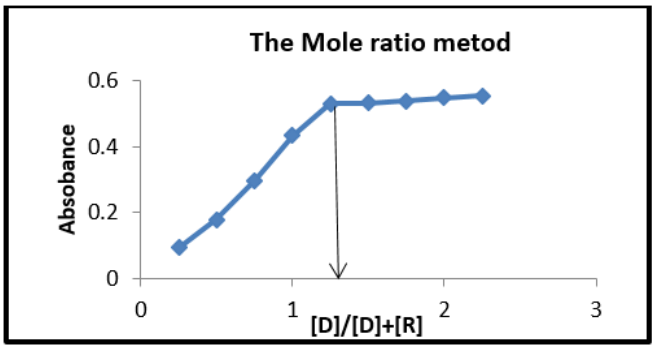


Figure 5: The Mole ratio plots for products of TFPH with DMPPDA.2HCl reagent under the optimum reaction conditions.

forms a dye-coupled product with p- Ansidine in 1:1 ratio at 552 nm.

The Mole ratio of the complexes formed between the Trifluoperazine.2HCl (TFPH) and DMPPDA.2HCl as a reagent was investigated, the results indicated that 1:1 for TFPH with the reagent by applying the mole ratio to confirmed Job's method using equimolar solutions of each (1×10^{-3}M). the products were formed in the ratio of 1:1 for TFPH and to the reagent PMZH (Figure 5).

The Mole ratio of the complexes formed between TFPH and DMPPDA.2HCl, as a reagent, was investigated. The results indicated that 1:1 for TFPH with the reagent by applying the mole ratio to confirmed Job's method using equimolar solutions of each (1×10^{-3}M). the products were formed in the ratio of 1:1 for TFPH and to the reagent DMPPDA.2HCl (Figure 5).

Therefore the formation of the product probably occurs as follows Scheme 2.

Comparison the Proposed of Method with the Spectral Methods

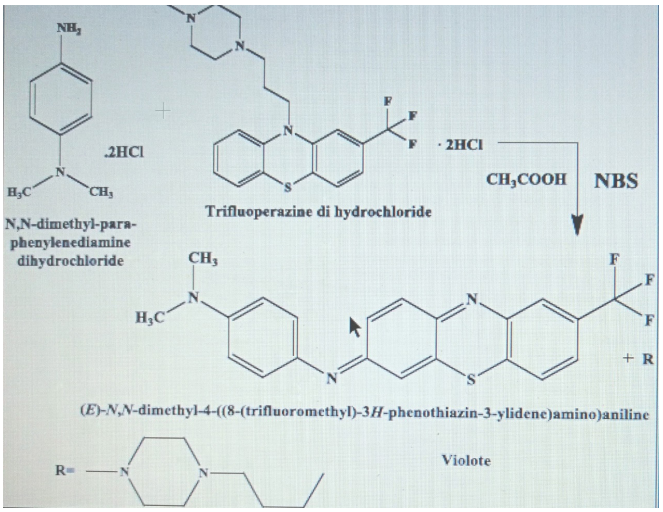
Some of the proposed method's physical variables were compared with the differences in the spectral methods from the literature[4,18] used to estimate TFPH**.** The proposed method has been applied, conveniently, in estimating the TFPH understudy in the pharmaceutical preparations, a good range and sensitivity compared to other methods.

Statistical Evaluation of the Results of the Proposed Method

The obtained results were compared statistically by student 's t-test for accuracy and a variance ratio F-test for precision with the official methods,[26] depending on the spectrophotometric method for TPFH tablet at 95% assurance level with six degrees of freedom, as referred in Table 13. The result presents that the t-test and F-test were less than the theoretical value (t= 2.57, F= 5.05), indicating no significant variance between the proposed method and official methods.

CONCLUSIONS

In this study, a simple, speedy, more accurate, sensitive, and novel spectrophotometric method for determining trace amounts of TPFH has been developed. The method was adopted on oxidative coupling with DMPPDA.2HCl (reagent) in the presence of NBS in an acidic medium, and a violet



Scheme 2: Stoichiometric ratio of TFPH with DMPPDA.2HCl

product dye was obtained at λ_{max}552 nm. Beer's law is obeyed over the range 1–20 µg.mL^{-1} with a molar absorptivity 1.4×10^{4} L.mol^{-1}.cm^{-1}, Sandel index of 0.030 µg/cm^{2}. The average recovery is 100.07 % and D.L of 0.1435 µg/mL, Q.L. of 0. 4349, a relative standard deviation of not more than 0.4166. The method was applied successfully for the estimating of TPFH in it's pure state or pharmaceutical preparations.

REFERENCES

1. The Merck Index, 12th Copyright by Merck Co., Inc. Whiteho, CD-Rom, 2000.
2. British pharmacopeia on CD-Rom, 3rd Ed. System Simulation Ltd., the stationary office, London. 2005.
3. British Pharmacopeia, Incorporating the 3rd Ed of the European pharmacopoeia, CD-Rom. 2001.
4. Al_Rashidy AA, Al_Doury MF, Al_Taiee AK. Spectrophotometric determination of Trifluoperazine Hydrochloride by oxidative coupling reaction with 4-amino benzoic acid using potassium iodate. Tikret Journal of Pharmaceutical Sciences. 2018;13(1).
5. Chaudhary HR, Ramesh B, Bhalgat CM, Patil SL. Validated Uv Spectrophotometric Method For Estimation Of Trifluoperazine Hydrochloride In Tablet Dosage Form. Inter. J. Pharm. Appl. 2010;1:76-80.
6. Hamzah MJ, Taqi RM, Hasan MM, Al-Timimi RJ. Spectrophotometeric Determination of Trifluoperazine HCL in Pure Forms and Pharmaceutical Preperations. International Journal of Pharmaceutical and Clinical Research. 2017 May 25;9(05):337-342.
7. Al-Rufaie MM, Kathem KH. New Spectrophotometric Method for Determination of Trifluoperazine HCl in pharmaceutical Preparations by using Oxidative coupling Reaction. World J. Pharm. Res. 2014;3(6):1202-1214.
8. Dabhade SL, Shetty AS, Gopinath B, Ahmed M, Sridhar B, Sureja ML. Development And Validation Of Uv Spectrophotometric Method For The Simultaneous Estimation Of Trifluoperizine Hydrochloride And Trihexyphenidyl Hydrochloride In Combined Tablet Dosage Form. Int. J. Chem. Sci. 2010;8(3):1601-1610.
9. Reddy CB, Reddy GS, Reddy NA. Development and validation of UV spectrophotometric method for determination of trifluoperazine hydrochloride in bulk and pharmaceutical dosage form. International Journal of Scientific and Research Publications. 2012 Aug;2(8):1-5.

10. Ahmed NR. Ultraviolet spectrophotometric determination of trifluoperazine. HCl in pharmaceutical preparations and environmental wastewater samples: Application to content uniformity testing. Res Rev J Pharm Anal. 2014;3:30-34.
11. Vaghela KV, Patel AB, Patel AI, Patel NK, Vyas AJ. Development and Validation of UV Spectrophotometric Method for Estimation of Trifluoperazine Bulk and Tablet Pharmaceutical Formulation. International Journal of Pharmaceutical. 2016;6(2):67-72.
12. Sharma MC, Sharma S. Development and Validation of Method for Simultaneous Estimation of Trifluoperazine Hydrochloride from Capsule Dosage Form Using Citric Acid. World Journal of Chemistry. 2011;6(2):80-84.
13. Khammas ZA, Rashid RA. Mutual determination of trifluoperazine hydrochloride and vanadium (V) ions in real matrices by visible spectrophotometry after cloud point extraction. Sci J Anal Chem. 2015;3:61-70.
14. Prashanth KN, Swamy N, Basavaiah K. Extraction Free Ion-Pair Methods for the Assay of Trifluoperazine Dihydrochloride in Bulk Drug, Tablets and Spiked Human Urine using Three Sulfonphthalein Dyes. J. App. Spect. 2014; 81(5):893-902.
15. Jalal MT. Spectrophotometric Determination of Trifluoperazine HCl in Pharmaceutical Preparations by Oxidative Coupling Reaction. Sys Rev Pharm. 2020;11(6):58-68.
16. Al-Douri A.T. MSc. Thesis, College of Education, Tikrit University, Iraq. 2020.
17. Al-Sabha T, Al-Taee OA, Al-Obidi MT. Spectrophotometric determination of trifluoperazine via oxidative coupling reaction with sulfanilic acid. Journal Of Education And Science. 2010 Mar 1;23(1):6-14.
18. Hassouna ME, Adawi AM, Ali EA. Extractive spectrophotometric determination of chlorpromazine and trifluoperazine hydrochloride in pharmaceutical preparations. Egyptian Journal of Forensic Sciences. 2012 Jun 1;2(2):62-68.
19. Navya SD, Ramamohan R, Ajitha A, Maheshwara RV. Method Development and Validation for the Simultaneous Estimation of Trifluoperazine HCl and Isopropamide in Tablet Dosage from by RP-HPLC. Int. J. Pharm. 2014;4(8):449-455.
20. Parvataneni S, Nagarjuna PJ. Development and Validation for the Simultaneous Determination of Trifluoperazine HCl and Trihexyphenidyl HCl in a Solid oral Dosage from by RP-HPLC. World J. Pharm. and Pharm. Sciences. 2014;(10):1021-1031.
21. Komal P, Ankit C, Bhadani S, Rajiv EP. Development and Validation of RP-HPLC Method for Simultaneous Estimation of Chlordiazepoxide, Trifluoperazine HCl and Trihexyphenidyl HCl in tablet Dosage from. Int. J. current Res. Pharm. 2015;1(1): 50-55.
22. Pattanayak S, Rani A. A Novel RP-HPLC Method Development and Validation for Simultaneous Estimation of Trifluoperazine and Isopropamide in Tablet Dosage Form. Int. J. Pharm. Sci. and Drug Research. 2015;7(1):105-109.
23. Sharma MC, Sharma S. Development and Validation of Densitometry Estimation of Trifluoperazine HCl in Dosage Form. American-Eurasian J. of Toxicological Sci. 2011;3(2):101-104.
24. Qasim AW, Khammas ZA. An Indirect Atomic Absorption Spectrometric Determination of Trifluoperazine HCl in Pharmaceutical Formulations Based on Chelate Formation with Palladium. E-J. Chem. 2010;7(S1):S433-S441.
25. Stakovic D, Dimitrijevic T, Kuzmanovic D, Krstic MP, Petkovic BB. Voltammetric determination of an antipsychotic agent trifluoperazine at a boron- doped diamond electrode in human urine. RSC Adv. 2015;5(129) 107058-107063.
26. Christian G D. Analytical Chemistry, 6th ed., John Wiley and Sons, Inc., New York. 2004;90-113.
27. Shivastava A. Methods for determination of limit of detection and limit of quantitation of the analytical methods. Chronicles of Young Scientists. 2011;2(1):21.