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A Review on Analytical Methods for Estimation of Teneligliptin and Pioglitazone in Pharmaceutical Dosage Form

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ABSTRACT

Diabetes Mellitus is a Chronic Progressive disease. It is characterized by Hyperglycaemia. This review article is intended to highlight the analytical method of Teneligliptin and Pioglitazone in individually as well as combined pharmaceutical dose form. Teneligliptin and Pioglitazone play important role in Diabetes Mellitus disease. As for treatment of Diabetes Mellitus type 2 in combination form Teneligliptin and Pioglitazone is used. The aim of this review is to focus on update of determination of Teneligliptin and Pioglitazone in bulk and in pharmaceutical preparation used in RP-HPLC, UV- Spectroscopic method. This review provides detail information on separation for Teneligliptin and Pioglitazone in single and in combination form

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INTRODUCTION TO ANALYTICAL METHOD

Nowadays, a variety of analytical techniques are used for estimating. In the subject of analysis, a number of analytical techniques are used, including potentiometers, HPLC, aqueous and non-aqueous titrations. In the realm of analysis, aqueous and non-aqueous titrations are also used. However, in the field of analysis nowadays, HPLC is important for quantitative determination.

High pressure liquid chromatography, also known as HPLC, is a method of separation based on a solid stationary phase and a liquid mobile phase.[1] A process of mass transfer called chromatography involves adsorption. The column's active element is the adsorbent, which is a granular substance made of solid particles (silica, polymers). Adsorption, in which the substances move or separate in accordance with their respective affinities, provides the basis for separation in both the normal phase mode and the reverse phase mode. In the field of pharmaceutical analysis nowadays, HPLC is essential for separating different chemicals from mixtures of substances.[2]

INTRODUCTION TO DRUG PROFILE

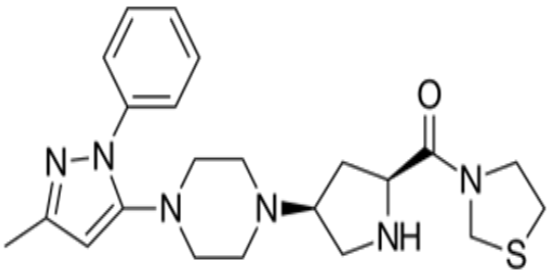
Teneligliptin

Teneligliptin is an inhibitor of dipeptidyl peptidase 4 (DPP-4), with hypoglycemic activity.

The chemical name of Teneligliptin is {(2S,4S)-4-[4-(3-Methyl-1-phenyl-1H-pyrazol-5-yl)-1-piperazinyl]-2-pyrrolidinyl}(1,3-thiazolidin-3-yl)methanone.

It has a molecular formula of $C_{22}H_{30}N_6OS$ And a molecular weight of 426.58 g/mol.

Soluble in organic solvents such as Ethanol, DMSO, and Dimethyl Formamide (DMF).[3]



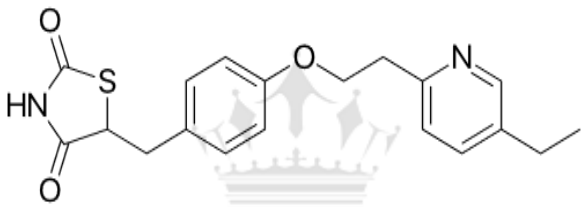
Chemical Structure of Teneligliptin

Pharmacological Action of Teneligliptin[4]

Blood glucose levels are raised by glucagon while being lowered by DPP-4 inhibitors. DPP-4 inhibitors work by increasing incretin levels (GLP-1 and GLP), which block the release of glucagon, which then stimulates insulin production, slows down stomach emptying, and lowers blood glucose levels.

Pioglitazone [5]

Pioglitazone is an orally active thiazolidinedione with significant antineoplastic action and anti-diabetic properties. The chemical name of Pioglitazone is 5-[[4-[2-(5-ethylpyridin-2-yl)ethoxy]phenyl]methyl]-1,3-thiazolidine-2,4-dione. It has a molecular formula of $C_{19}H_{20}N_2O_3S$. And the molecular weight of 356.4 g/mol. Soluble in dimethyl formamide; slightly soluble in Ethanol; very slightly soluble in Acetone, Acetonitrile and insoluble in water.



Chemical Structure of Pioglitazone

Pharmacological Action of Pioglitazone [6]

By acting as a selective agonist for the nuclear "peroxisome proliferator-activated receptor Gama (PPAR Gama)," which increases the transcription of multiple insulin responsive genes, the medication has anti-diabetic effects.

By promoting GLUT4 (glucose transporter 4) production and translocation and enhancing glucose entry into muscle and adipose tissue, it reduces insulin resistance. Additionally, it inhibits hepatic gluconeogenesis.

The drug's ability to increase insulin sensitivity is also aided by the activation of genes that control fatty acid metabolism and lipogenesis in adipose tissue. It improves glycemic control, lowers insulin levels in the blood, and lowers blood glucose and HbA1c. Without significantly affecting LDL levels, it also increases HDL levels and decreases serum triglyceride level.

Summary of Analytical Methods for Teneligliptin

Reported Methods for Teneligliptin

Sr. No.	Drug	Method	Brief Description
1.	Teneligliptin[7]	**UV**	**Solvent:** Distilled Water **Wavelength:** 244 nm **Linearity range:** 5-70 µg/ml
2.	Teneligliptin[8]	**RP-HPLC**	**Column:** Grace SmartC_{18} column (250 x 4.6mm, 5µm) **Mobile phase:** 0.05M KH_2PO_4 pH 4.0 :Acetonitrile (80:20 % v/v) **Detected Wavelength:** 242 nm **Flow rate:** 1 ml/min **Retention time**: 7.443 min **Linearity range**: 500-3000 µg/ml
3.	TeneligliptinHydrobromideHydrate[9]	**RP-HPLC**	**Column:** Kromasil C_{18} column **Mobile phase:** pH 5.5 phosphate buffer: Methanol (75:25%v/v) **Detected Wavelength:** 270 nm **Flow rate:** 1.2 ml/min **Retention time**: 2.51 min **Linearity range**: 80- 120 µg/ml
4.	Teneligliptin[10]	**RP-HPLC**	**Column:** Kromasil C_{18} column (150 × 4.6 mm, 5.0 µm) **Mobile phase:** A)Acetonitrile: water:Trifluoroacetic acid (60: 1940: 2 v/v) B)Acetonitrile:Trifluoroacetic acid (2000: 2 v/v) **Detected Wavelength:** 245nm **Flow rate:**1.0 ml/min **Retention time:**11.2 min **Linearity range:** 50-150µg/ml
5.	Teneligliptin[11]	**RP-HPLC**	**Column:** Cosmosil C_{18}column(250 × 4.6mm, 5.0 µm) **Mobile phase:** Methanol: Phosphate buffer pH:3 (70:30 %v/v) **Detected Wavelength:** 246 nm **Flow rate:** 0.8 ml/min **Retention time:**4.2 min **Linearity range :**10-50 µg/ml
6.	Teneligliptin[12]	**HPLC**	**Column:** Protecol C_{18} ENDURO (250×4.6mm ,5µm) **Mobile phase:** Methanol: Buffer pH 3.5(72:28% v/v) **Detected Wavelength:** 243.5 nm **Flow rate:** 1 ml/min **Retention time**:5.8 min **Linearity range**:10-90 µg/ml

7.	Teneligliptin[13]	**Stability studies by RP-HPLC**	**Column:** Kromasil C_{18} (250×4.6mm, 5µm) **Mobile phase:** pH 6.0 phosphate buffer: Acetonitrile (60:40 %v/v) **Detected Wavelength:** 246 nm **Flow rate:** 1.0 ml/min **Retention time:** 25 min **Linearity range:**100 -500 µg/ml
8.	Teneligliptin[14]	**Stability indicating RP-UPLC**	**Column:** C_8phenomenex (250 ×4.6 mm ,5 µm) **Mobile phase:** Formic acid:Methanol:Acetic acid (25:75:0.1, v/v/v) **Detected Wavelength:** 245 nm **Flow rate:** 0.4 mL/min **Retention time**: 4.982±0.02 min **Linearity range**: 1–100 µg/ml
9.	Teneligliptin and Pioglitazone[15]	**RP-HPLC**	**Column:** Peerless C_{18} (250 × 4.6 mm, 5 µm) **Mobile Phase:** Methanol: Phosphate Buffer: Acetonitrile (pH 3.3 with OPA) (50:25:25%v/v) **Detected Wavelength:** 225 nm **Flow Rate:** 1 ml/min **Retentiontime**: Teneligliptin: 2.58 min Pioglitazone: 6.13 min **Linearity range:** Teneligliptin:1-5 µg/ml Pioglitazone:1.5-7.5µg/ml
10.	Teneligliptin and Metformin[16]	**RP-UHPLC**	**Column:** Eclipse plus C_{18} (150 × 4.6 mm, 5 µm) **Mobile phase:** Buffer: acetonitrile (65:35 % v/v) (pH 3.5 with OPA) **Detected Wavelength:**233 nm **Flow rate :**0.7 ml/min **Retention time:** Teneligliptin**:** 2.81 min Metformin**:** 1.71min **Linearity range:**20-100 µg/ml
11.	Metformin Hydrochloride and Teneligliptin Hydrobromide Hydrate[17]	**RP-HPLC**	**Column:** BDS Hypersil C_{18} (250×4.6 mm,5µm) **Mobile Phase:** A) octane sulfonic acid : Phosphate buffer pH 3 triethylamine & B) Acetonitrile (75:25% v/v) **Detected Wavelength:** 210 nm **Flow rate:** 1 mL/min
12.	Teneligliptin and Metformin Hydrochloride[18]	**RP-HPLC**	**Column:** Thermo C18, (250 × 4.6mm, 5µm) **Mobile Phase:** 0.1M KH_2PO_4 buffer :Methanol (60:40%v/v) **Detected Wavelength:** 280nm **Flow rate:** 1.0ml/min **Retention time:** Teneligliptin**:** 4.421 min Metformin**:** 3.421 min **Linearity range:**

			Teneligliptin**:** 50- 150µg/ml Metformin**:** 50- 150µg/ml
13.	Metformin and Teneligliptin[19]	**RP-HPLC**	**Column:** C_8 Phenomenex (250 × 4.6 mm, 5 µm) **Mobile Phase:** Methanol: formic acid: acetic acid (75:25:0.1, v/v/v) **Detected Wavelength**:210 nm **Flow rate:** 0.5 mL/min **Retention time:** Teneligliptin**:** 6.234±0.03min Metformin**:** 4.024±0.02min **Linearity range:** Teneligliptin**:** 50- 150µg/ml Metformin**:** 50- 150µg/ml
14.	Teneligliptin and Metformin[20]	**Stability indicating RP-HPLC**	**Column:** Kromasil C18 (250×4.6 mm, 5 µm) **Mobile phase:** 0.1% orthophosphoric acid buffer: Acetonitrile: Methanol (65:25:10, v/v/v) **Detected Wavelength:** 254 nm **Flow rate :**1.0 ml/min **Retention time:** Teneligliptin: 2.842 min Metformin :2.017 min **Linearity range:** Teneligliptin :5-30 µg/ml Metformin :125-750 µg/ml
15.	Metformin and Teneligliptin[21]	**Stability indicating RP-HPLC**	**Column**: Discovery (250 X 4.6 mm: 5 µm) **Mobile phase** :0.1% orthophosphoric acid buffer: acetonitrile (65:35, v/v) **Detected Wavelength** :260 nm **Flow rate**: 1 ml/min **Retention time:** Metformin:2.517 min Teneligliptin: 3.687 min **Linearity range** : Metformin:125-750 µg/ml Teneligliptin:5-30 µg/ml
16.	Teneligliptin and Metformin[22]	**RP-HPLC**	**Column:** Cosmosil C18 (250X4.6mm, 5µm) **Mobile phase:**Methanol: Water (pH 3.5) (50:50 % v/v) **Detected Wavelength:**242 nm **Flow rate :**0.7 ml/min **Retention time:** Teneligliptin**:** 2.45 min Metformin**:** 6.21 min **Linearity range:** Teneligliptin**:** 2-10µg/ml Metformin**:** 50-250 µg/ml

Summary of Analytical Methods for Pioglitazone

Official Methods for Pioglitazone

Sr. No.	Official in	Method	Description
1.	**IP 2010**[23]	**Liquid Chromatography**	**Column:** ODS C18(250 × 4.6mm, 5.0 µm) **Mobile Phase:** KH_2PO_4 buffer: Acetonitrile(50:50%v/v) **Flow rate:**1.0 ml/min **Wavelength:**225 nm
2.	**BP 2020**[24]	**Liquid Chromatography**	**Column:** ODS C18(150 × 4.6mm, 5.0 µm) **Mobile Phase:** Glacial acetic acid: Acetonitrile: Ammonium Acetate (1:25:25 v/v/v) **Flow rate:**0.7 ml/min **Wavelength:**269 nm

Reported Methods for Pioglitazone

Sr. No.	Drug	Method	Brief Description
1.	Pioglitazone Hydrochloride[25]	**UV**	**Solvent**: Methanol **Wavelength**:268nm **Linearity range**:10-50µg/ml
2.	Pioglitazone Hydrochloride[26]	**UV**	**Solvent**: Methanol **Wavelength**:270 nm **Linearity range**:10-50µg/ml
3.	Pioglitazone Hydrochloride[27]	**RP-HPLC**	**Column:** C_{18} column (250 X 4.6 mm, 5µm) **Mobile phase:** Methanol: pH4.6 buffer adjusted with 0.1 % v/v glacial acetic acid (80:20 %v/v) **Detected Wavelength:** 273 nm **Flow rate:** 1.5 ml/min **Retention time:** 3.4 min **Linearity range**: 5-30 µg/ml
4.	Pioglitazone[28]	**RP-HPLC**	**Column:**C_{18} column (300× 3.9 mm, 5 µm) **Mobile phase:** Acetonitrile: phosphate buffer, (50:50 %v/v) **Detected Wavelength:** 267 nm **Flow rate:** 1.00 ml/min **Retention time:**8.08 min **Linearity range**:10-30µg/ml
5.	Pioglitazone Hydrochloride[29]	**RP-HPLC**	**Column:** Hypersil BDS, (250 x 4.6mm, 5 µm) **Mobile phase:** 0.01M KH_2PO_4: acetonitrile, (40:60 %v/v) **Detected Wavelength:**225 nm **Flow rate:** 1.0 ml/min **Retention time:**4.726 min **Linearity range**:80- 320 µg/ml
6.	Metformin Hydrochloride and Pioglitazone[30]	**UV**	**Solvent:** Methanol **Wavelength:** Metformin Hydrochloride:231 nm

			Pioglitazone: 269 nm **Linearity range**: Metformin Hydrochloride : 5-30 µg/ ml Pioglitazone: 2-12 µg/ ml
7.	Metformin Hydrochloride and Pioglitazone[31]	**UV**	**Solvent:** Methanol **Wavelength:** Metformin Hydrochloride:237.4 nm Pioglitazone:225.4 nm **Linearity range**: Metformin Hydrochloride :5-40µg/ ml Pioglitazone:5-40µg/ ml
8.	Dapagliflozin and PioglitazoneHydrochloride[32]	**RP-HPLC**	**Column:** Kromstar Vertex C_{18} column (250 ×4.6 mm, 5µm) **Mobile phase:** Acetonitrile: KH_2PO_4 Buffer (pH 4) adjusted with OPA (25:75%v/v) **Detected Wavelength:**228 nm **Flow rate:** 1 ml/min **Retention time:** Dapagliflozin: 3 min Pioglitazone: 6.5 min **Linearity range**: Dapagliflozin: 2-10 µg/ml Pioglitazone: 3–15 µg/ml
9.	Pioglitazone and Rosiglitazone[33]	**RP-HPLC**	**Column:** Inertsil ODS (150x4.6mm, 3.5 µm) **Mobile phase:**buffer containing 0.1% formic acid: Acetonitrile (30:70% v/v) **Detected Wavelength:**261 nm **Flow rate:**1 ml/min **Retention time:** Rosiglitazone:5.118 min Pioglitazone:2.770 min **Linearity range**: Rosiglitazone:1-15 µg/ml Pioglitazone:3-45 µg/ml
10.	Alogliptin and Pioglitazone[34]	**RP-HPLC**	**Column:** Develosil ODS C_{18} column (4.6mm×250mm, 5µm) **Mobile phase:** Acetonitrile: Methanol: 1% Orthophosphoric acid (50:30:20% v/v) **Detected Wavelength:** 242 nm **Flow rate:** 1.0 ml/ min **Retention time:** Alogliptin**:** 2.24 min Pioglitazone**:** 5.44 min **Linearity range:** Alogliptin**:** 30-70 µg/ml Pioglitazone**:** 60-140µg/ml
11.	Metformin and Pioglitazone[35]	**RP-HPLC**	**Column:** A Gemini C18 column (150x4.6mm, 5µm) **Mobile phase:** Acetonitrile: Ammonium Acetate buffer (pH-3) (42: 58% v/v) **Detected Wavelength:**255 nm

			Flow rate:0.3 ml/min **Retention time:** Metformin:5.17 min Pioglitazone:8.1 min **Linearity range**: Metformin:0.5-50 µg/ml Pioglitazone:0.3-30 µg/ml
12.	Pioglitazone and Glimepiride[36]	**RP-HPLC**	**Column:**X Bridge C_{18}, (250 X 4.6 mm, 5µm) **Mobile phase:**KH_2PO_4Buffer: Acetonitrile (60:40%v/v) **Detected Wavelength:**257nm **Flow rate:**1.0 ml/min **Retention time:** Glimepiride: 2.66min Pioglitazone: 4.49min **Linearity range**: Glimepiride: 32-50µg/ ml Pioglitazone: 240-350µg/ ml
13.	Alogliptin and Pioglitazone[37]	**Stability Indicating RP-UPLC**	**Column:** BEH C_{18}(2.1× 50 mm,1.7 µm) **Mobile phase:** Phosphate buffer (pH 3):Methanol (45:55 % v/v) **Detected Wavelength:** 280 nm **Flow rate:** 0.3 ml/min **Retention time:** Alogliptin: 0.4 min Pioglitazone: 0.529 min **Linearity range**: Alogliptin: 6.25–37.5µg/ ml Pioglitazone: 15–90µg/ ml
14.	Glimepiride and Pioglitazone[38]	**RP-HPLC**	**Column:** Luna C_{18} (150mm x 4.6mm; 5-µm) **Mobile phase:** Phosphate Buffer pH 3.0 : Acetonitrile (45:55% v/v) **Detected Wavelength:** 228nm **Flow rate:** 1.0 ml/ min **Retention time:** Glimepiride: 6.9 min Pioglitazone: 2.36 min **Linearity range**: Glimepiride: 4-12µg/ ml Pioglitazone: 30-90µg/ ml
15.	Atorvastatin and Pioglitazone[39]	**RP-HPLC**	**Column:** Phenomenex Luna C_{18} (250 x 4.6mm, 5 µm) **Mobile phase:** Methanol: Acetonitrile:KH_2PO_4 buffer, pH 2.5 with OPA (60:20:20 v/v) **Detected Wavelength:** 233 nm **Flow rate:** 1.0 ml/min **Linearity range**: Atorvastatin: 5-50 µg/ ml Pioglitazone: 5-50 µg/ ml
16.	Alogliptin and Pioglitazone[40]	**Stability Indicating RP-HPLC**	**Column:** Symmetry C_{18} (250 x 4.6mm, 5µm) **Mobile phase:** phosphate buffer PH 4 adjusted with OPA: Acetonitrile (20:80 %v/v)

			Detected Wavelength: 278 nm **Flow rate:** 1.0 ml/min **Retention time:** Alogliptin: 2.234 min Pioglitazone: 3.294 min **Linearity range**: Alogliptin: 0–16 µg/ml Pioglitazone: 0–16 µg/ml

CONCLUSION

Teneligliptin and Pioglitazone can be determined using several methods that have been published. In Diabetes Mellitus, Teneligliptin and Pioglitazone are essential medications. This medication is offered in the market in a variety of formulations with various doses and in combination dosage form. Teneligliptin and Pioglitazone are estimated using several RP-HPLC testing methods, either individually or in combination. Additionally, it was discovered that the majority of RP-HPLC methods give greater resolution when the mobile phase contains Acetonitrile, water, Methanol, and Phosphate buffer. Additionally reported were methods using UV-photospectroscopy. The most used solvent for spectroscopic methods is Methanol. So all methods were determined to be simple, accurate, and cost-effective.

REFERENCES

1. Kazakevich Y and Lo Brutto: RP HPLC for pharmaceutical Scientists; A John Wiley and sons, 2007, pp 1-6.
2. Gupta V, Jain A D, Gill N S, Guptan K. Development and validation of HPLC method-a review. International research journal of pharmaceutical and applied sciences. 2012 Aug 31;2(4):17-25.
3. Teneligliptin. Pubchem. 28/1/2023. Available From:Teneligliptin | C22H30N6OS - PubChem (nih.gov)
4. Dipeptidyl peptidase-4 inhibitor. Wikipedia. 28/1/2023. Available From: Dipeptidyl peptidase-4 inhibitor - Wikipedia
5. Pioglitazone. Pubchem. 28/1/2023. Available From: Pioglitazone | C19H20N2O3S - PubChem (nih.gov)
6. Pioglitazone Pharmacology. Medicine India. 28/1/2023. Available From: Pioglitazone Pharmacology & Usage Details | Medicine India
7. Yadav N, Goyal A. Method development and validation of Teneligliptin in pharmaceutical dosage form by UV spectrophotometric methods. **Int J Pharm Chem Anal.** 2017;4(3):54-8.
8. Patel B D, Nidhi J D, Ankit C. Development and Validation of RP-HPLC Method for Estimation of Teneligliptin and its Impurity in Tablet. Int. J. Pharm. Sci. Rev. Res,(2021) August; 69 (2): 127.;133.
9. Dahikar G D, Bobade G. Development and Validation of Stability Indicating RP-HPLC method for Teneligliptin Hydrobromide Hydrate. Am. J. Pharm Tech Res. 2020;11(1).
10. Biswas B, Kumar M, Sharma J B, Saini V, Bhatt S. Method Development and Validation for Estimation of Teneligliptin in Tablet Dosage Form by RP-HPLC. Res J Pharm Technol. 2020;13(4):1774-8.
11. Lokhande D P. Analytical method development and validation of Teneligliptin by using RP-HPLC with ICH guidelines. Int. J. Trend. Sci. Res. Dev. 2019;3:259-63.
12. Gaikwad D D. Analytical method development and validation of Teneligliptin hydrobromide in pure form by HPLC. World J. Pharm. Pharm. Sci. 2017 Sep 29:37-48.
13. Kumar T G, Vidyadhara S, Narkhede N A, Silpa Y S, Lakshmi M R. Method development, validation, and stability studies of teneligliptin by RP-HPLC and identification of degradation products by UPLC tandem mass spectroscopy. Journal of analytical science and technology. 2016 Dec;7:1-2.

14. Annapurna M M, Almas S, Rajasree B, Narendra A. Stability indicating ultrafast liquid chromatographic method for the estimation of Teneligliptin (An Anti-diabetic agent). Asian J. Pharm. 2018 Apr 1;12:S477-83.
15. Jinal Alkesh Gheewala*, Dr. Dilip Girish Maheshwari, Development and Validation of UV Spectrophotometric Method and RP – HPLC Method for Simultaneous Estimation of Teneligliptin and Pioglitazone In Synthetic Mixture, Asian Journal of Pharmaceutical Technology & Innovation, 2017, 05 (23); 66-78.
16. Patel V, Pandya C, Patel Z, Patel D, Pandya A. Isocratic RP-UHPLC method development and validation of stability-indicating for simultaneous determination of teneligliptin and metformin in fixed-dose combination. Current Chemistry Letters. 2021;10(4):503-16.
17. Musmade B D, Baraskar M L, Ghodke V N, Bhope S G, Padmanabhan S, Lohar K S. Impurity profiling method development and validation of metformin hydrochloride and teneligliptin hydrobromide hydrate in their combination tablet dosage form by using RP-HPLC with UV/PDA detector. **Future J. Pharm. Sci.**2021 Dec;7(1):1-0.
18. Rao. S, Srinivas. Analytical method development and validation of Teneligliptin and Metformin HCl by using RP-HPLC method. J. Global Trends Pharm Sci, 2020; 11 (3): 8051 – 8056.
19. Chaitanya S M. Simultaneous determination of metformin and teneligliptin by liquid chromatography in tablets. Asian Journal of Pharmaceutics (AJP). 2018 Aug 19;12(02).
20. Vetapalem R, Yejella R P, Atmakuri L R. Development and validation of a stability indicating RP-HPLC method for simultaneous estimation of teneligliptin and metformin. Turk. J. Pharm. Sci. 2020 Apr;17(2):141.
21. Swetha A, Kuber B R. A novel stability-indicating reverse phase liquid chromatographic method for the simultaneous estimation of metformin and teneligliptin in pure and pharmaceutical formulations. Int J App Pharm. 2018;10(5):274-80.
22. Gopal S. Irache *et al.* RP-HPLC method development and validation of Teneligliptin and Metformin in pharmaceutical dosage forms. Int. Res. J. Pharm. 2017, 8 (8);52-55.
23. Indian Pharmacopeia; Ministry of Health and Family Welfare, 2nd volume; The Indian Pharmacopoeia commission, 2010, 1916-1917.
24. British Pharmacopeia; Govt. of British Ministry of Health and Family Welfare, 2nd volume; The British Pharmacopoeia commission, 2020, 2601-2603.
25. Bhavyasri K, Chandana R S, Sumakanth M, Swethasri R. Analytical Method Development and Validation for The Estimation of Pioglitazone Hydrochloride in Bulk and Formulation by UV-Spectrophotometry. Am. J. PharmTech Res. 2019; 9(04):110-117.
26. Doredla N R, Yengisetty B, Bojjagani R, Madasu S V. Method development and validation of forced degradation studies of pioglitazone hydrochloride by using UV spectroscopy. Int. J. Pharm Tech Res. 2012; 4(4):1750-7.
27. Kommana R, Rebecca S D. Development and validation of HPLC and UV spectrophotometric method for determination of pioglitazone hydrochloride in bulk and its formulations. Pharm Lett. 2013; 5(1):269-78.
28. Maste M M, Gawas N S, Shashtri U, Shelar P. RP-HPLC Method Development and Validation for Pioglitazone in Bulk and Marketed Formulation. Der Pharma Chemica, 2021, 13(6): 6-15.
29. Agarwal P T, Sharma M. Development and validation of Pioglitazone hydrochloride in bulk and pharmaceutical formulations by RP-HPLC method. World J. Pharm. Res, 2020; 9(8): 1966-1977.
30. Aravind A, Das P, TK AB, George M. Q-absorbance ratio spectrophotometric method for the simultaneous estimation of Metformin hydrochloride and Pioglitazone in tablet dosage form. World J. Pharm. Res, 2022:1(11):898-909.
31. Joshi R S, Nangare A K, Sanap D S, Sase S M. Development and Validation of UV-Spectrophotometric Method for Estimation of Metformin Hydrochloride and Pioglitazone in Tablet Dosage Form. J. drug deliv. ther. 2019 Aug 30; 9(4-A):381-4.
32. Ronak P. Method Development, Validation and Forced Degradation Studies of Dapagliflozin and Pioglitazone Hydrochlorides in Synthetic Mixtures by RP-HPLC. International Journal of Trend in Scientific Research and Development. 2022; 6(6):1858-69.
33. Rafi S, Rambabu K. New Validated Method for the Estimation of Pioglitazone and Rosiglitazone Using RP-HPLC. Journal of pharmaceutical research international, 2021; 33 (47A): 254-262.

34. Kandala M, Mounika R, Sultana S, Hogue N, Ali S, Prashanthi S, Islam S, Aktar SN, Kabir S. Method development and validation of Alogliptin and pioglitazone by RP-HPLC method in bulk and its marketed dosage form. World J. Pharm. Res. 2021 Jun 10;10:782-98.
35. Lakshmi K S, Rajesh T, Sharma S. Simultaneous determination of metformin and pioglitazone by reversed phase HPLC in pharmaceutical dosage forms. Int. J. Pharm. Pharm. Sci. 2009 Oct;1(2):162-6.
36. Poonam K, Arun P, Shailendra P, Kumar D N. Development of new simultaneous RP-HPLC method for the estimation of Pioglitazone and Glimepiride in the combined tablet dosage form and then validation of the method. World J. Pharm. Res., 2020, 9(1), 1291-1305.
37. Dhani R, Guptha H K, Rajamanickam D. Development of stability indicating method for the simultaneous estimation of alogliptin and pioglitazone in bulk and tablet dosage form by reversed-phase ultra-performance liquid chromatography method. J. Appl. Pharm. Sci. 2019 Dec 3; 9(12):051-6.
38. Amin M A, Abd Halim E M, Abo-Taleb M M. Simultaneous for the estimation of Glimepiride and Pioglitazone in pharmaceutical dosage form by Reversed Phase-HPLC method. IOSR Journal of Pharmacy and Biological Sciences. 2019; 14:30-40.
39. Nizami T, Shrivastava B, Sharma P, Darwhekar G N, Sharma P. Spectrophotometric and Reversed-Phase High-Performance Liquid Chromatographic methods for simultaneous determination of atorvastatin and pioglitazone in combined tablet dosage form. J. drug deliv. ther. 2017 Dec 22; 7(7):116-7.
40. Vasanthi R, Noori K, Sundar P S, Raja M A, Dutt K R, Rao K N, Mahesh M, Charlapally N. Development of rapid stability indicating method for simultaneous estimation of alogliptin and pioglitazone in bulk and combined dosage form by RP-HPLC method. Indo. Am. J. Pharm. 2017; 3: 234-44.