IJBPAS, November, 2025, 14(11): 5920-5928

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

ANALYTICAL TECHNIQUES FOR FESOTERODINE FUMARATE: A COMPREHENSIVE OVERVIEW

PATEL AS[1] AND MEHTA HS[*2]

1: Research Scholar, Parul Institute of Pharmacy and Research, Parul University, Vadodara PO. Limda, TA-Waghodia, District-Vadodara-391760, Gujarat, India

2: Assistant Professor, Parul Institute of Pharmacy and Research, Parul University, Vadodara PO. Limda, TA-Waghodia, District-Vadodara-391760, Gujarat, India

***Corresponding Author: Dr. Mehta Hiralben Satishchandra: E Mail: hiralben.mehta29533@paruluniversity.ac.in**

Received 15th July 2024; Revised 20th Sept. 2024; Accepted 1st Nov. 2024; Available online 1st Nov. 2025

https://doi.org/10.31032/IJBPAS/2025/14.11.9556

ABSTRACT

Fesoterodine Fumarate, a potent antimuscarinic agent, has gained prominence when dealing with an overactive bladder. This review comprehensively evaluates analytical methodologies employed for the quantification of Fesoterodine Fumarate, both as a standalone entity and in combination with other drugs. A meticulous examination of the literature reveals the predominant utilization of chromatographic techniques, including RP-HPLC, UPLC, and LCMS, as the cornerstone for Fesoterodine Fumarate analysis. Furthermore, the study delves into the application of spectroscopic methods, such as UV-VIS, to complement the chromatographic approaches. By providing a systematic overview of these analytical techniques. This review provides a Summary of Work done on Fesoterodine fumarate alone or combined with other pharmaceutical drugs.

Keywords: Fesoterodine Fumarate, analytical methods, RP-HPLC, RP-UPLC, UV-VIS, LC-MS

INTRODUCTION

With the onset of aging, the frequency of overactive bladder (OAB) rises in tandem with increasing aging. This condition affects both men and women **[1]**. Lower urinary tract symptoms (LUTS) and overactive bladder (OAB) are accompanied by a complex of

symptoms. This condition is characterized by urinary urgency, often accompanied by frequent urination and nocturia. It may be associated with urgent urinary incontinence, or there may not be any urinary tract infection. Infections and other evident pathologies are growing correlated with a higher risk of increasing age. In addition to the negative effects of LUTS on well-being and quality of life, OAB is linked to several health issues in the elderly. Urinary incontinence is linked to a higher risk of urinary tract infections, falls and fractures, depression, sleep disturbances, and institutionalization **[2], [3]**.

Researchers have identified three main explanations for detrusor overactivity, but the cause of OAB remains unknown.

The myogenic concept suggests that the characteristics of detrusor muscle cells are modified when the muscle's nerve supply is partially disrupted, which raise exuberance, and in turn cause rises in involuntary pressure.

According to the neurogenic theory, detrusor overactivity is caused by primitive voiding reflexes that are hidden by damage to central inhibitory pathways.

The autonomic bladder hypothesis, a third theory, was put out in 2004. It implies that improper phasic activity modulation or activation results in detrusor hyperactivity.

The aging population in developed countries coupled with a rising prevalence of OAB is expected to drive an increased demand for effective treatments **[2], [3]**.

FESOTERODINE FUMARATE

Fesoterodine Fumarate is a recently developed potent antimuscarinic agent, an inventive derivative of 3,3-diphenylpropylamine used to treat overactive bladder. "(E)-but-2-enedioic acid; [2-[(1R)-3-[di(propan-2-yl) amino]-1-phenylpropyl]-4-(hydroxymethyl) phenyl]2 methyl propanoate" is the chemical name for Fesoterodine Fumarate. The molecular weight of this compound is 527.66 and its empirical formula is C_{30} H_{41} NO_7. Fesoterodine fumarate is a salt derived from the compound Fesoterodine **[4],[5]**.

Fesoterodine fumarate is a white to off-white powder that readily dissolves in water. Once absorbed into the body, it undergoes rapid metabolism to form its active form, 5-hydroxymethyl tolterodine (5-HMT).

Fesoterodine fumarate is a muscarinic receptor antagonist that is nonselective, specific, and competitive. It lowers the bladder's smooth muscle tone, enabling the bladder to hold large volumes of urine and reducing the frequency of incontinence episodes by blocking acetylcholine from binding to these receptors **[1],[2],[4]**.

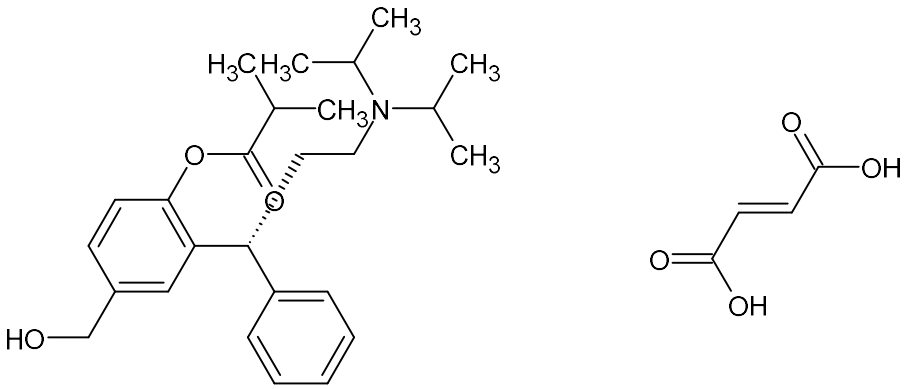

Figure 1: Chemical Structure of Fesoterodine Fumarate

An Overview of Analytical Techniques for Method Development

The development of methods in analytical chemistry involved the precise application of various techniques for both quantitative and qualitative drug determination.

1. Spectroscopic techniques

The most crucial technique for the method development process was the spectroscopic technique. This method is based on other chemical reactions and the absorption of UV radiation as found in our pharmacopoeias. The wavelength function, properties transmission, and quantitative measurement are the three main pillars of spectroscopy. This approach has a lot to offer in terms of labor cost or time savings. Furthermore, this method is incredibly accurate and precise.

UV-Visible Spectroscopy

UV-Visible spectroscopy measures the wavelength and absorbance of samples in the 200–800 nm range by using energy and electron excitation. Only in the presence of conjugated pi-electrons can absorption take place; the region of absorption is determined by the energy of light.

FTIR Spectroscopy

Lower energy states are detected by infrared spectroscopy, which excites or vibrates atoms and molecules. It shows original peaks and functional groups, which helps with the creation of new techniques.

Mass Spectroscopy (MS)

By ionizing molecules with high-energy electrons and monitoring changes in the magnetic field and the acceleration of electrostatic waves, mass spectroscopy determines the mass of molecules precisely **[6],[7]**.

2. The Chromatographic Method

High Performance Thin Layer Chromatography (HPTLC)

This method was applied all over the world to identify, estimate, and verify the analytical profile of drug molecules. It's a highly sophisticated method that will be acknowledged as a key analytical tool for drug analysis. It's quick separation action and adaptability allow it to analyze a wide range of drug components in the pharmaceutical industry. The primary benefit of this technique is its ability to analyze drugs quickly and easily, as well as clean crude drug samples with ease. This method allows us to characterize the chromatogram for a wide range of parameters without having to worry about a time limit **[6],[7],[8]**.

High-Pressure Liquid Chromatography (HPLC)

High-performance liquid chromatography (HPLC) is a powerful analytical technique employed to separate and analyze complex mixtures of compounds. It was the first technique to analyze bulk drug materials from the USP-1980 when it was created in 1980. Prior to analysis, HPLC requires precise, accurate sample analysis. A UV detector, which measures a sample's wavelength, is used to estimate samples. UV detector estimation starts with the application of several wavelength scanning programs. For both chemical and biological components, this method works well **[6]**.

Thin Layer Chromatography (TLC)

Thin-layer chromatography (TLC) is a well-established technique for pharmaceutical analysis. This method relies on the interaction between a mobile phase and a stationary phase. The latter is typically a thin layer of silica gel spread on a glass or aluminum plate. TLC has been widely applied to examine both organic and inorganic compounds due to its several advantages over other techniques. These include its simplicity, versatility in mobile phase selection, ability to handle large sample volumes, and low cost **[6],[7],[8]**.

Ultra-High Performance Liquid Chromatography (UPLC)

Ultra-performance liquid chromatography (UPLC) presents a significant advancement over traditional high-performance liquid chromatography (HPLC). UPLC excels in terms of speed, efficiency, and reduced resource consumption. Nevertheless, the complexity introduced by numerous critical variables necessitates more intricate method development compared to HPLC.

Similar to HPLC, UPLC finds broad application in pharmaceutical analysis, including assay development, impurity profiling, characterization of degradation products, and quantification of drugs and their metabolites in biological matrices **[9]**.

Quality by design (QbD)

ICH Q8 introduced the concept of Quality by Design (QbD), challenging the traditional notion that product quality can be solely achieved through testing. This systematic approach emphasizes proactive product and process understanding, driven by defined objectives and underpinned by robust science and risk management. QbD represents a paradigm shift in pharmaceutical manufacturing, prioritizing the creation of high-quality products from inception.

While offering a promising framework for pharmaceutical excellence, QbD presents challenges for industries accustomed to rigid processes and inherent variability. Central to QbD is the identification of Critical Quality Attributes (CQAs) and the establishment of a Target Product Profile (TPP). This information guides the development of formulations and processes to deliver the desired product characteristics consistently. By pinpointing critical process parameters (CPPs) and critical material attributes (CMAs), manufacturers can effectively manage variability and ensure product quality. QbD empowers pharmaceutical companies to have greater control over their processes while maintaining stringent quality standards. This approach facilitates real-time drug product release, streamlining operations and accelerating time-to-market **[10],[11],[12]**.

Analytical Methods for Determination of Fesoterodine Fumarate in Single and combined with other drugs

This review details various analytical techniques used for the drugs listed, including UPLC, UV-VIS Spectrophotometric, HPLC, HPTLC, and others.

Sr.no	Title	Description	Ref.no
1	Photochemistry of Novel Antimuscarinic Drug Fesoterodine and Identification of it's Photodegradation Products by LC-ESI-MS studies	Stationary phase: C18 Monolithic Column (100 mm x 4.6 mm i.d.) Mobile Phase: Acetonitrile: Methanol-0.03Mol/L: Ammonium Acetate (Ph 3.8) (30:15:55,v/v/v) Flow rate: 2.4 ml/min Detection: 208 nm Retention time: 11.30 min	[5]
2	Simultaneous Estimation of Escitalopram Oxalate and Fesoterodine in Oral Dosage Forms by Validated Reverse Phase High Performance Liquid Chromatography	Stationary Phase: Kromosil C18(250 mm x 4.6 mm) 5 µm Column Mobile phase: Acetonitrile: Methanol: Ammonium Acetate Buffer pH 3.0 (30:20:50, v/v/v) Flow rate:1.0 ml/min Detection: 238 nm Retention time: Escitalopram Oxalate-5.30min Fesoterodine-5.03min	[13]
3	Fesoterodine Stress Degradation Behavior by Liquid Chromatography Coupled to Ultraviolet Detection and Electrospray	Stationary phase: Mono-lithic C18 Column (100mm x 4.6mm i.d.) Mobile phase: Acetonitrile: Methanol-0.03mol/L : Ammonium Acetate (pH 3.8) (30:15:55, v/v/v) Flow rate:2.4 ml/min	[14]

	Ionization Mass Chromatography	**Detection: 208 nm Retention time: 1.78 to 2.39 min**	
4	**Determination of Fesoterodine in Pharmaceutical Formulation By Using Liquid Chromatography-Tandem Mass Spectrometry**	**Stationary phase: Luna C8(2) Column (50 mm x 3.0 mm i.d., 3 µm) Mobile phase: Methanol-0.1%: Formic Acid (90 : 10, v/v) Flow rate: 0.2 ml/min Detection: 208 nm Retention time: 0.85 min and 0.89 min**	**[15]**
5	**Stability Indicating RP-HPLC Method for the estimation of Process Related Impurities and Degradation Products in Festoterodine Fumarate by Using a Mass Spectrometric Compatible Mobile Phase**	**Stationary phase: Water Symmetry C18, 250 x 4.6 mm, 5 µm Column Mobile phase: Mobile Phase A – (0.05% Trifluoroacetic Acid in Water) Mobile Phase B – (90% Of 0.02% TFA in Methanol And 10% Of Water) Flow rate: 1.0 ml/min Detection: 220 nm Retention time: 1.37 min**	**[16]**
6	**Isolation and Characterization of Fesoterodine Fumarate Related Impurities**	**Stationary phase: YMC Pak ODS-A (150 mm × 4.6 mm), 5 µ column YMC Pak ODS-A (250 mm × 50 mm) 12 µ column Mobile phase: Solvent-A (0.1 % Trifluoro Acetic Acid in Water and Methanol in the ratio of 70:30, V/V) Solvent-B (Acetonitrile) Flow rate: 70ml/min Detection: 215nm Retention time: 17.00 min**	**[17]**
7	**A Validated Stability Indicating HPLC Assay Method for Determination of Fesoterodine Fumarate**	**Stationary phase: Inertsil ODS-3V (150 mm × 4.6 mm × 5 µm) Mobile phase: buffer (1.15g of Ammonium dihydrogen orthophosphate, 2.0mL Triethyl amine in 1000mL of water and adjusted to pH 3.0 ± 0.05 with Orthophosphoric Acid solution): Methanol (42:58, v/v) Detection: 210 nm Flow rate: 1.0ml/min Retention time: 4.88 min**	**[18]**
8	**Second-Order Derivative UV Spectrophotometric and Chromatographic Determination of Fesoterodine in Extended-Release Tablets (LC, CE, LC-MS)**	**UV Spectrophotometric Method: 228nm LC Stationary phase: C18 Mono-lithic Column (100 mm x 4.6 mm i.d.) Mobile phase: Acetonitrile: Methanol–0.03 Mol/L: Ammonium Acetate (pH 3.8) (30:15:55, v/v/v) Flow rate: 2.4ml/min Detection: 208 nm Retention time:12 min**	**[19]**
9	**Comparison of Static and Dynamic Mode in the Electrochemical Oxidation of Fesoterodine with the use of Experimental Design Approach**	**Stationary phase: Acquity UPLC BEH C8 Column (1.7 µm, 2.1 × 100 mm) Mobile phase: 5 mM Ammonium Bicarbonate buffer (pH = 9.2, component A) and Methanol (component B) Flow rate: 0.4 ml/min Detection: 227 nm Retention time: 14-43 min**	**[20]**
10	**Ex Vivo Stability and LC-MS/MS Bioanalysis of Fesoterodine and 5-HMT in Human Plasma**	**Stationary phase: Kromasil C18 (100 mm × 4.6 mm, 5 µ) column Mobile Phase: 15 mM Ammonium Formate: Acetonitrile (25:75, v/v) Flow rate: 1.0 ml/min Detection: 589 nm Retention time: 1.82 min and 1.44 min**	**[21]**

CONCLUSION

By the literature survey, there were articles on the determination of Fesoterodine Fumarate in single or combination with other drug like Escitalopram Oxalate in Pharmaceutical Dosage forms by using analytical techniques like HPLC-MS, UPLC-MS and RP-HPLC.

Various Analytical Methods for the estimation of Fesoterodine Fumarate have been reported. In this present review article, mentioned as the determination of assay methods for the estimation of Fesoterodine fumarate by using different analytical techniques like HPTLC, HPLC by QbD approach.

REFERENCES

[1] K. Gupta, K. Kaur, B. S. Aulakh, and S. Kaushal, "Fesoterodine for overactive bladder: A review of the literature," Current Therapeutic Research vol.71, Number 5, Oct. 2010. doi: 10.1016/j.curtheres.2010.10.003.

[2] A. Wagg, "Fesoterodine fumarate for the treatment of overactive bladder in the elderly – a review of the latest clinical data," Clinical Investigation, vol. 2, no. 8, pp. 825–833, Aug. 2012, doi: 10.4155/cli.12.68.

[3] T. H. Kim, S. E. Lee, H. E. Lee, and K. S. Lee, "Safety and efficacy of fesoterodine fumarate in patients with overactive bladder: results of a post-marketing surveillance study in Korea," Current Medical Research Opinion, vol. 32, no. 8, pp. 1361–1366, Aug. 2016, doi: 10.1080/03007995.2016.1174680.

[4] FDA, "TOVIAZTM." [Online]. Available: https://www.fda.gov/drugsatfda.

[5] M. S. Sangoi, V. Todeschini, G. K. Goelzer, and M. Steppe, "Photochemistry of a novel antimuscarinic drug fesoterodine and identification of its photodegradation products by LC-ESI-MS studies," Journal of Photochemistry Photobiology A Chemistry, vol. 256, pp. 16–22, Mar. 2013, doi: 10.1016/j.jphotochem.2013.02.003.

[6] M. R. Siddiqui, Z. A. AlOthman, and N. Rahman, "Analytical techniques in pharmaceutical analysis: A review," Arabian journal of chemistry , 2017, doi: 10.1016/j.arabjc.2013.04.016.

[7] S. Sharma, N. Singh, A. D. Ankalgi, A. Rana, and M. S. Ashawat, "Modern Trends in Analytical Techniques for Method Development and Validation of Pharmaceuticals: A Review," Journal of Drug Delivery and Therapeutics, vol. 11, no. 1-s, pp. 121–130, Feb. 2021, doi: 10.22270/jddt.v11i1-s.4515.

[8] V. S. Sawale and D. Umamaheshwari, "A Review on Novel Analytical Techniques Used in Method Development and Validation of Pharmaceuticals.", Journal of Pharmaceutical Science and Research, Vol.12, 2020, [Online]. Available: https://www.researchgate.net/publication/339627839

[9] S. Beg and M. Rahman, "Analytical quality by design for liquid chromatographic method development," in Handbook of Analytical Quality by Design, Elsevier, 2021, pp. 87–97. doi: 10.1016/B978-0-12-820332-3.00010-8.

[10] A. Pethe, A. S. Patil, and A. M. Pethe, "Quality by Design (QbD): A new concept for development of quality pharmaceuticals.", International Journal of Pharmaceutical Quality Assurance,13-19,[Online]. Available: www.ijpqa.com

[11] L. X. Yu et al., "Understanding pharmaceutical quality by design," The AAPS Journal, Vol.16, No.4, 2014, doi: 10.1208/s12248-014-9598-3.

[12] P. N. Mallikarjun, P. Kumari, S. M. Kumar, and G. Sowmya, "An Overview On Quality By Design In Pharmaceutical Product Development," International Journal of Pharmaceutical Sciences and Research, vol. 13, no. 6, p. 2283, 2022, doi: 10.13040/IJPSR.0975-8232.13(6).2283-93.

[13] L. Sirisha, S. Sana, S. S. Momina, and M. Tajuddin, "Simultaneous Estimation Of Escitalopram Oxalate And Fesoterodine In Oral Dosage Forms By Validated Reverse Phase High Performance Liquid Chromatography," Natural Volatiles and Essential Oils, 2021.

[14] M. S. Sangoi, V. Todeschini, and M. Steppe, "Fesoterodine stress degradation behavior by liquid chromatography coupled to ultraviolet detection and electrospray ionization mass spectrometry," Talanta, vol. 84, no. 4, pp. 1068–1079, May 2011, doi: 10.1016/j.talanta.2011.03.018.

[15] M. S. Sangoi and M. Steppe, "Determination of fesoterodine in pharmaceutical formulations by using liquid chromatography-tandem mass spectrometry," European Journal of Mass Spectrometry, vol. 16, no. 6, pp. 653–661, 2010, doi: 10.1255/ejms.1103.

[16] N. Kumar, D. Sangeetha, and L. Kalyanraman, "Stability-indicating RP-HPLC method for the estimation of process-related impurities and degradation products in fesoterodine fumarate by using a mass spectrometric compatible mobile phase," Jornal of

Chromatographic Science, vol. 59, no. 2, pp. 154–164, Feb. 2021, doi: 10.1093/chromsci/bmaa090.

[17] A. P. Rajput and M. C. Sonanis, "Isolation and characterization of fesoterodine fumarate related impurity," Asian Journal of Chemistry, vol. 25, no. 11, pp. 6369–6371, 2013, doi: 10.14233/ajchem.2013.14591.

[18] B. V. R. Reddy, B. S. Reddy, M. Sravan Kumar, and C. Rambabu, "A Validated Stability-Indicating Hplc Assay Method For Determination Of Fesoterodine Fumarate,"Rasayan Journal Of Chemistry, vol. 5, no. 2, pp. 239–245, [Online]. Available: http://www.rasayanjournal.com

[19] M. S. Sangoi, V. Todeschini, and M. Steppe, "Second-Order Derivative UV Spectrophotometric Method for the Determination of Fesoterodine and Comparison with LC, CE and LC-MS/MS in Commercial Extended-Release Tablets," Acta Chimica Solvenica, Vol.59,136-143,2012.

[20] E. Bartosińska, P. Kozlík, A. Kubíčková, J. Heřt, J. Fischer, and T. Křížek, "Comparison of static and dynamic mode in the electrochemical oxidation of fesoterodine with the use of experimental design approach," Talanta, vol. 226, May 2021, doi: 10.1016/j.talanta.2021.122141.

[21] J. M. Parekh, M. Sanyal, M. Yadav, and P. S. Shrivastav, "Investigation of ex vivo stability of fesoterodine in human plasma and its simultaneous determination together with its active metabolite 5-HMT by LC-ESI-MS/MS: Application to a bioequivalence study," Journal of Chromatography B,vol. 913–914, pp. 1–11, Jan. 2013, doi: 10.1016/j.jchromb.2012.11.010.