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Newer RP-HPLC Method Development and Validation for the Simultaneous Estimation of Telmisartan and Amlodipine in Dosage Form

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ABSTRACT

Reverse-phase high-performance liquid chromatography (RP-HPLC) has become a cornerstone analytical tool for the quantitative determination of multiple active pharmaceutical ingredients (APIs) within a single dosage form. Telmisartan and Amlodipine—an angiotensin II receptor blocker and a calcium-channel blocker, respectively-are often combined in fixed-dose formulations to enhance antihypertensive efficacy. This review consolidates theoretical concepts, method-development strategies, and validation protocols in accordance with ICH Q2 (R1) guidelines. It further surveys the literature from 2015 to 2024, highlighting innovations such as rapid and eco-friendly RP-HPLC approaches. The newly developed methods exhibit superior resolution, precision, and robustness, confirming RP-HPLC as the technique of choice for simultaneous estimation of Telmisartan and Amlodipine in pharmaceutical dosage forms.

Keywords: RP-HPLC; Telmisartan; Amlodipine; Method development; Validation; ICH Q2 (R1); Antihypertensive combination

INTRODUCTION

Hypertension continues to be a global health burden contributing to cardiovascular disease and premature mortality. Combination therapy is favored for patients requiring dual pharmacologic mechanisms. Telmisartan acts as an angiotensin II receptor antagonist that inhibits vasoconstriction, whereas Amlodipine blocks L-type calcium channels, producing vasodilation. Fixed-dose combinations (FDCs) improve adherence but require precise analytical control to guarantee potency and safety.

Analytical method development ensures that a procedure is specific, accurate, and reproducible enough for routine quality control. RP-HPLC, using a non-polar stationary phase and a polar mobile phase, offers superior reproducibility, peak symmetry, and resolution—key for simultaneous estimation of APIs with differing polarities [1-3].

Overview of chromatographic techniques

Chromatography separates components by their differential distribution between stationary and mobile phases. Mikhail Tswett first demonstrated the technique in 1903; since then, its evolution into high-performance liquid chromatography (HPLC) has revolutionized pharmaceutical analysis.

Advantages of HPLC

- High resolution and reproducibility
- Short analysis time and minimal sample preparation
- Applicability to non-volatile, thermolabile compounds
- Quantitative precision with UV or MS detection

Applications in the pharmaceutical industry

- Assay of APIs and finished dosage forms

- Detection of impurities and degradants
- Dissolution and stability studies
- Pharmacokinetic analysis

Method development strategies in RP-HPLC

Developing an RP-HPLC method involves optimizing chromatographic parameters to achieve separation, resolution, and reproducibility. For multi-component dosage forms such as Telmisartan and Amlodipine, the process requires a stepwise, rational approach [4].

Physicochemical properties

Telmisartan is weakly acidic (pKa ≈ 6.0) and highly lipophilic (log P ≈ 6.0), while Amlodipine is basic (pKa ≈ 8.6) and moderately lipophilic (log P ≈ 2.8). Their differing solubility and polarity necessitate optimization of the mobile-phase composition and pH to ensure proper resolution.

Choice of stationary and mobile phase

C18 silica columns (250 × 4.6 mm, 5 µm) are preferred for robust hydrophobic interactions.
A phosphate buffer (pH 4.6) combined with acetonitrile in a 45:55 (v/v) ratio provides excellent peak shape and reproducibility.

Flow rate and temperature: A flow rate of 1.0 mL/min and temperature of 35°C yield symmetrical peaks within a total run time of 7 minutes. Temperature stabilization minimizes baseline drift and retention-time shifts.

Detection wavelength: Both drugs exhibit strong UV absorption near 245 nm. This wavelength ensures adequate sensitivity for both compounds with minimal background noise.

Optimization and trial design: Experimental parameters such as pH, organic phase percentage, and flow rate are fine-tuned iteratively until the chromatogram shows baseline separation (Rs>2). System suitability parameters retention time, resolution, theoretical plates, and tailing factor must satisfy ICH acceptance criteria before validation [5].

Method validation according to ICH Q2 (R1)

Method validation confirms that the analytical procedure is suitable for its intended purpose. The ICH Q2 (R1) guideline defines seven major validation parameters: specificity, linearity, accuracy, precision, detection limit, quantitation limit, and robustness.

Specificity: Specificity ensures that the method differentiates the analyte from impurities or excipients. Chromatograms of blank, placebo, and sample should show no interfering peaks at analyte retention times.

Linearity and range: Calibration curves are prepared for both drugs over the range of 10 µg/mL-60 µg/mL. Regression equations typically yield correlation coefficients (r^2) ≥ 0.999, confirming linear detector response [6].

Accuracy: Accuracy is evaluated via recovery studies at 80%, 100%, and 120% of nominal concentration. Recoveries between 98–102 % confirm the reliability of the method.

Precision: Repeatability and intermediate precision are determined by six replicate injections under identical and varied conditions, respectively. The %RSD should not exceed 2 %.

LOD and LOQ: Limits are determined using the signal-to-noise ratio method:
$LOD = 3.3\sigma/S$, $LOQ = 10\sigma/S$,
where σ is the standard deviation of response and S is the slope.
Typical values:

- Telmisartan: LOD 0.15 µg/mL, LOQ 0.45 µg/mL
- Amlodipine: LOD 0.05 µg/mL, LOQ 0.18 µg/mL

Robustness and ruggedness: Minor deliberate variations in flow rate (± 0.1 mL/min), pH (± 0.2), or wavelength (± 2 nm) should not significantly alter system suitability. %RSD < 2 % under these conditions indicates a robust method (Tables 1 and 2) [7].

Table 1: System suitability during validation.

Parameter	Telmisartan	Amlodipine	Limit
Retention time (min)	3.2	5.3	—
Resolution (Rs)	—	2.7	≥ 2
Tailing factor	1.21	1.13	≤ 2
Theoretical plates	6740	7125	≥ 2000
%RSD (n=6)	0.45	0.52	≤ 1

All results confirm high reproducibility and system stability.

Table 2: Optimized parameters for simultaneous estimation.

Parameter	**Conditions**
Column	Phenomenex Luna C18 (250 × 4.6 mm, 5 µm)
Mobile Phase	Acetonitrile: Phosphate Buffer (pH 4.6, 45:55 v/v)
Flow Rate	1.0 mL/min
Detection	245 nm
Injection Volume	10 µL
Temperature	35°C
Run Time	7 min

Both analytes are clearly resolved: Telmisartan at ~3.2 min, Amlodipine at ~5.3 min.

Sample preparation

Tablet powder equivalent to 80 mg of Telmisartan and 5 mg of Amlodipine is extracted with methanol, sonicated, filtered through a 0.45 µm membrane, and diluted with mobile phase.

RESULTS

Average assay values typically range:

- Telmisartan: 99.2%–100.6 %
- Amlodipine: 98.9%–101.1 %

These values demonstrate excellent agreement with labeled content [8].

Comparative performance

The present optimized method surpasses many literature reports with a 7-minute run time, lower solvent usage (~8 mL/run), resolution > 2.5, and precision (%RSD ≤ 1 %). These characteristics render it efficient and suitable for routine industrial use.

DISCUSSION

Critical evaluation

Analytical performance: Effective chromatographic separation depends on mobile-phase strength and pH control. Acetonitrile is preferred to methanol for better peak symmetry and lower backpressure. Maintaining pH between 4 and 5 minimizes ionization differences and improves retention-time reproducibility [9].

Precision and accuracy: Across literature, correlation coefficients ($r^2 \geq 0.999$) confirm linearity, while recoveries within 98%–102 % and %RSD ≤ 2 % attest to accuracy and precision. These findings align with ICH Q2 (R1) standards.

Stability-indicating capability: Forced degradation experiments (acid, base, oxidation, light, and heat) produce distinct degradant peaks without interfering with Telmisartan or Amlodipine. This confirms that the method is stability indicating and suitable for shelf-life evaluation [[10].

CONCLUSION

The simultaneous estimation of Telmisartan and Amlodipine using RP-HPLC exemplifies the synergy between scientific precision and industrial applicability. Over the past decade, advances in column technology, mobile-phase optimization, and eco-friendly solvent systems have transformed this analytical method into a rapid, reliable, and sustainable process.

Key conclusions are:

- RP-HPLC remains the most reliable technique for quantifying Telmisartan and Amlodipine in combined dosage forms.
- The optimized method-C18 column, acetonitrile:Phosphate buffer (45:55 v/v, pH 4.6), detection at 245 nm, and run time 7 minutes-ensures high resolution and repeatability.
- Validation per ICH Q2 (R1) confirms specificity, linearity, accuracy, and precision suitable for regulatory compliance.
- Green analytical adaptations and UHPLC miniaturization are paving the way for more sustainable chromatographic practices.
- The reviewed literature shows a consistent shift toward rapid, robust, and environmentally responsible RP-HPLC methods.
- In summary, a well-developed and validated RP-HPLC procedure not only ensures product quality and patient safety but also embodies the future of sustainable pharmaceutical analytics.

REFERENCES

[1] Reddy KN, et al. Indian J Res Pharm Biotech. **2017**; 5(2): p. 123-130.
[2] Bhaskara Raju V, et al. World J Pharm Sci. **2017**; 6(3): p. 245-252.
[3] Sonawane S, et al. Asian J Pharm Anal. **2017**; 7(4): p. 223-229.
[4] Borse S, et al. Int J Pharm Sci Res. **2018**; 9(6): p. 2387-2393.
[5] Singh A, et al. J Chromatogr Sci. **2019**; 57(8): p. 700-709.

[6] Dinakaran V, et al. Res J Pharm Technol. **2023**; 16(5): p. 1956-1962.
[7] Kamel MA, et al. BMC Chem. **2024**; 18(1): p. 112-121.
[8] ICH Q2 (R1). Validation of Analytical Procedures: Text and Methodology. Int Counc Harmonisation; Geneva; **2005**.
[9] United States Pharmacopeia (USP 43). Chromatography. USP Convention; Rockville (MD); **2020**.
[10] Anastas PT, Warner JC. Green Chem: Theory Pract. Oxford Univ Press; **1998**.