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Development and Validation of Stability Indicating Hptlc Methods for Simultaneous Estimation of Nebivilol Hydrochloride and Ramipril in Bulk and Synthetic Mixture

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ABSTRACT

ORIGINAL RESEARCH ARTICLE

The chromatographic separation has been achieved on HPTLC silica 60 F254 plates (10.0 cm × 10.0 cm, 0.20 mm thickness, E. Merck, Germany). The specimens were applied as bands measuring 6 mm in width using a 100 µl sample syringe onto precoated silica gel aluminum plates 60 F254 (10×10 cm, E Merck, Darmstadt, Germany) utilizing a Camag Linomat 5 sample applicator (Switzerland). Application was conducted through a CAMAG Linomat 5 auto-sampler employing a CAMAG microliter syringe (100.0 µL) (CAMAG, Muttenz, Switzerland). Prior to chromatography, the plates underwent methanol prewashing and were activated at 110° for 5 minutes. A constant application rate of 150 nl/sec was maintained, with a 6 mm spacing between two bands. Slit dimensions were set at 6×0.45 mm. The mobile phase, comprised of Ethyl acetate : Methanol : Toluene: Glacial acetic acid (7.5:1:1:0.5, v/v/v/v) facilitated linear ascending development in a 10×10 cm twin-trough glass chamber. The optimized chamber saturation time for the mobile phase was set at 30 minutes, at a temperature of (25±2°) and relative humidity of (60±5%). The chromatogram run length was 8 cm, and TLC plates were air-dried. Densitometric scanning was executed using a Camag TLC Scanner 3 equipped with winCATS software version 1.3.0 at 270 nm, with a deuterium lamp serving as the radiation source. Evaluation was conducted utilizing peak area with linear regression.

INTRODUCTION:

The Principle of separation is adsorption. One or more compounds are spotted on a thin layer of adsorbent coated on a chromatographic plate. The Structure phase (developing solvent) flows through because of capillary action (against gravitational force). The compounds move according their affinities towards the adsorbent. The component with more affinity towards the stationary phase travels slower. The component with lesser affinity towards the stationary phase travels faster. Validation demonstrates that the developed method is fit for its intended purpose and consistently delivers dependable results. Validation parameters include accuracy, precision, linearity, specificity, limit of detection, limit of quantitation, and robustness. These parameters guarantee method reliability for regulatory compliance and quality assurance and also perform the force degradation study in acid hydrolysis, base hydrolysis, Oxidative degradation, photolytic degradation, thermal degradation.

MATERIAL AND METHODS:

Nebivolol Hydrochloride API and Ramipril API: API utilized in the preparation and

analysis of pharmaceutical formulations. Nebivolol HCl, API gifted by Hema Pharmaceuticals Pvt. Ltd. Ankleshwar, Gujarat. Ramipril a API gifted by Kavya Pharma, Surat - 395010, Gujarat, India

- Methanol HPLC grade (Finar), Acetonitrile HPLC grade (Rankem)
- Double distilled Water
- Potassium Hydroxide, Sodium Hydroxide, Hydrochloric acid, Hydrogen Peroxide: Used in solution preparation and pH adjustments of analytical grade.
- A reagent ethyl acetate, hexane, toluene, glacial acetic acid in various analytical procedures of analytical grade were purchased from Merck or equivalent supplier.
- These reagents and materials are essential for conducting precise and reliable experiments, ensuring the accuracy and reproducibility of results in the laboratory.

SELECTION OF WAVELENGTH:

2 mL of Nebivolol HCl and 2 mL of Ramipril stock solutions were each transferred into separate volumetric flasks and diluted to volume with methanol to obtain 20 µg/mL solutions. Each solution was scanned from 200–400 nm against methanol as the blank, and their spectra were recorded.

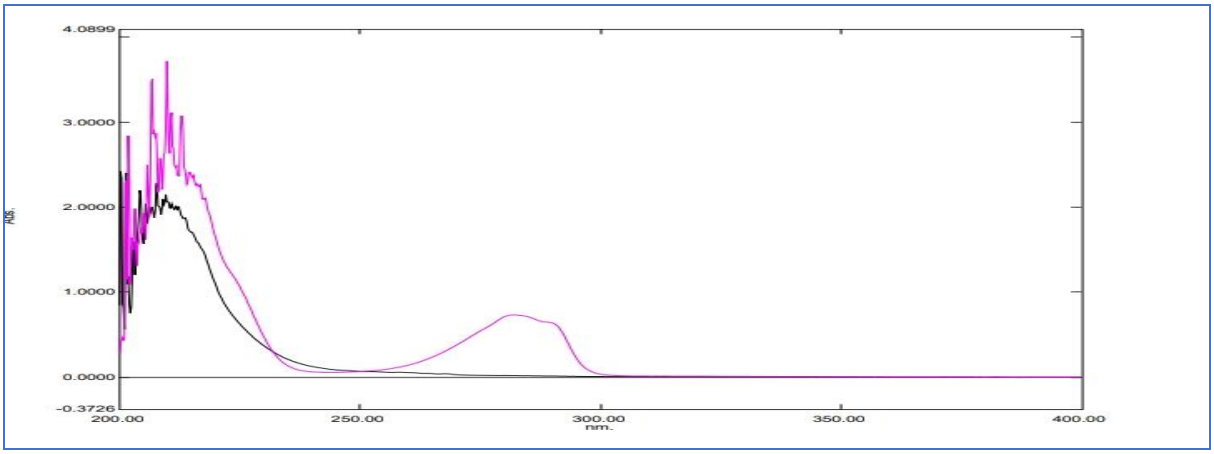
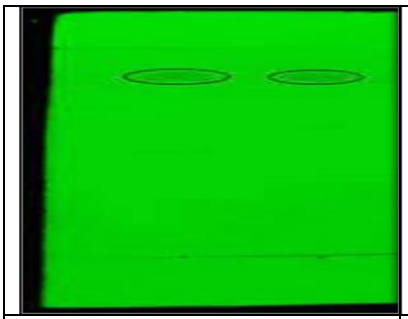
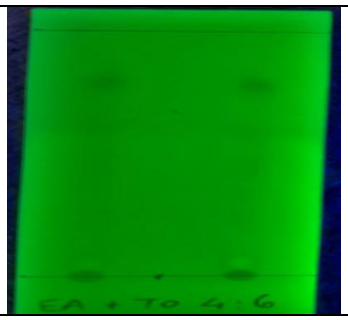
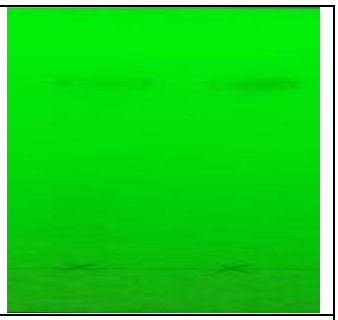
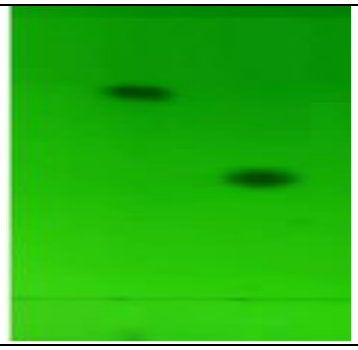


Fig : UV of overly spectra of Nebivolol hydrochloride and Ramipril

MOBILE PHASE OPTIMIZATION:

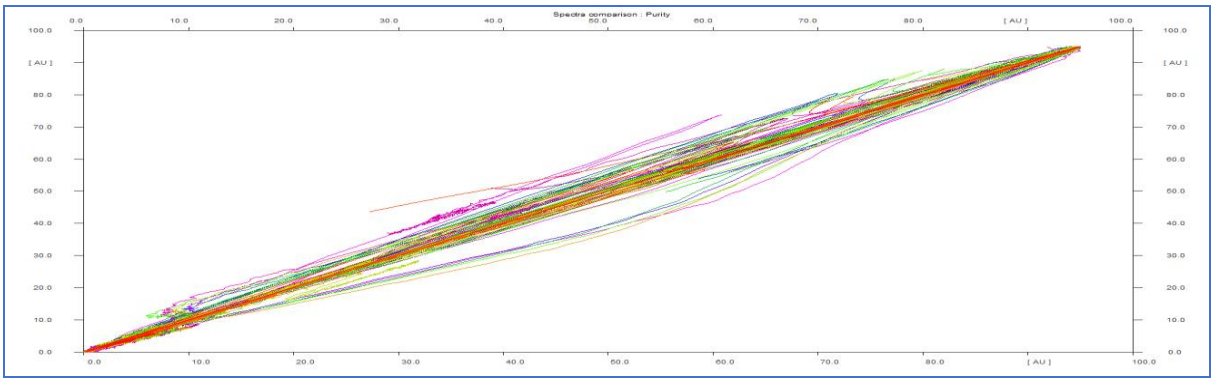
		
1. Toluene : Methanol : Triethylamine (7.5 : 2.0 : 0.5, v/v/v) - Both drug rf value same	2. Ethyl acetate :Toluene (4.0 :6.0 v/v) - This system showed sharper peaks but slightly diffused bands, no separation	3. Toluene : Ethyl acetate : Glacial acetic acid (6.5 : 2.5 : 1.0, v/v/v) - This system showed sharper peaks but slightly diffused bands, no separation

		
4. Chloroform : Methanol (9.0 : 1.0, v/v) - Fast migration and high Rf values, but poor resolution between Ramipril and Nebivolol.	5.Ethylacetate:Methanol :Toluene:Glacial acetic acid (7.5 : 1: 1:0.5, v/v/v) Produced compact and symmetrical peaks with good reproducibility, especially for Ramipril degradation studies.	ethyl acetate- methanol-toluene (4.0 : 2.5 :3.5) - Peak shape not proper

METHOD VALIDATION:

Specificity:

Specificity was assessed by comparing chromatograms of the marketed formulation with those of the pure APIs (NEBI and RAMI). Rf values and peak areas matched accurately, and peak purity confirmed no interference. No excipient peaks overlapped with NEBI or RAMI in either the synthetic mixture or the commercial formulation. This verifies that the method can clearly identify and quantify both drugs without matrix interference.



Peak purity spectra of both NEBI and RAMI

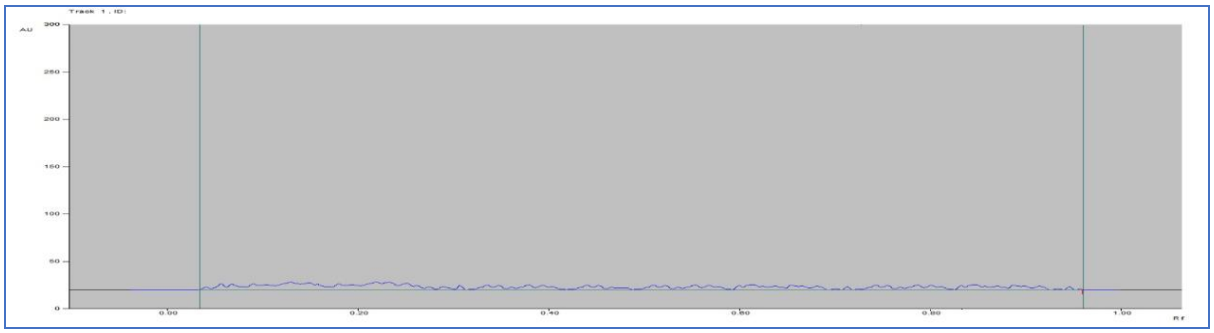


Fig: Densitogram of Blank

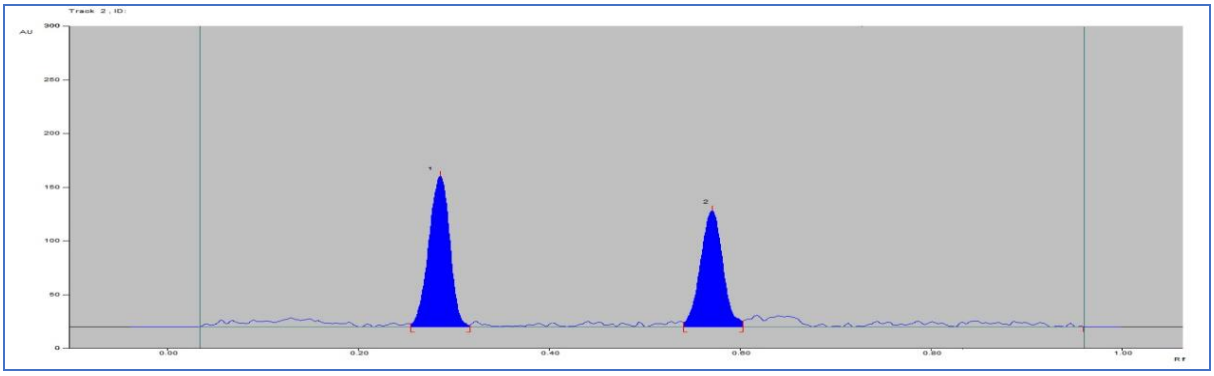
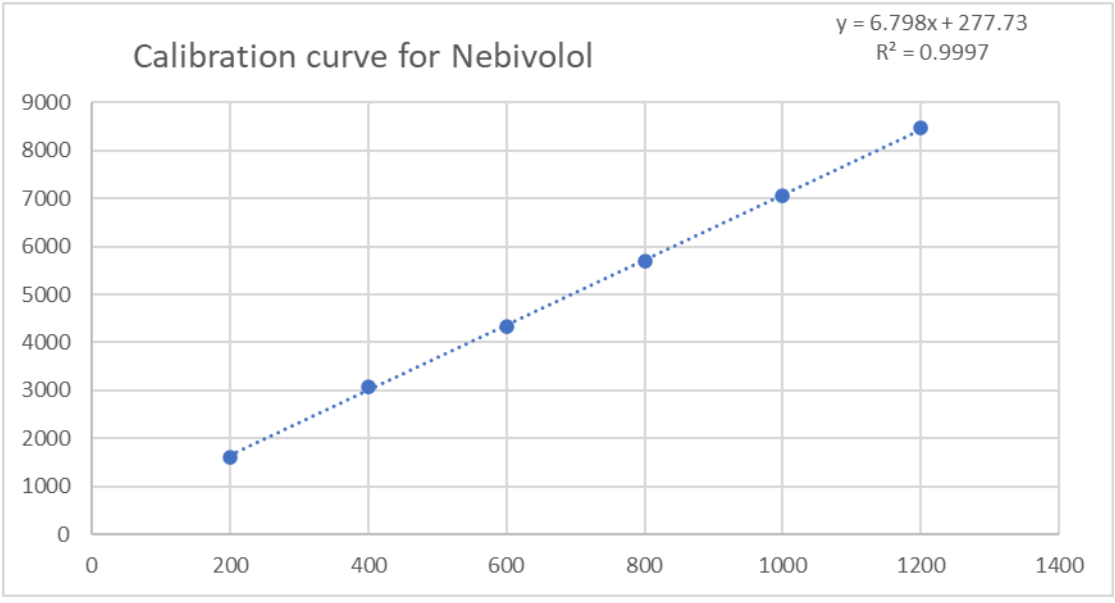


Fig: Densitogram of RAMI and NEBI mixture

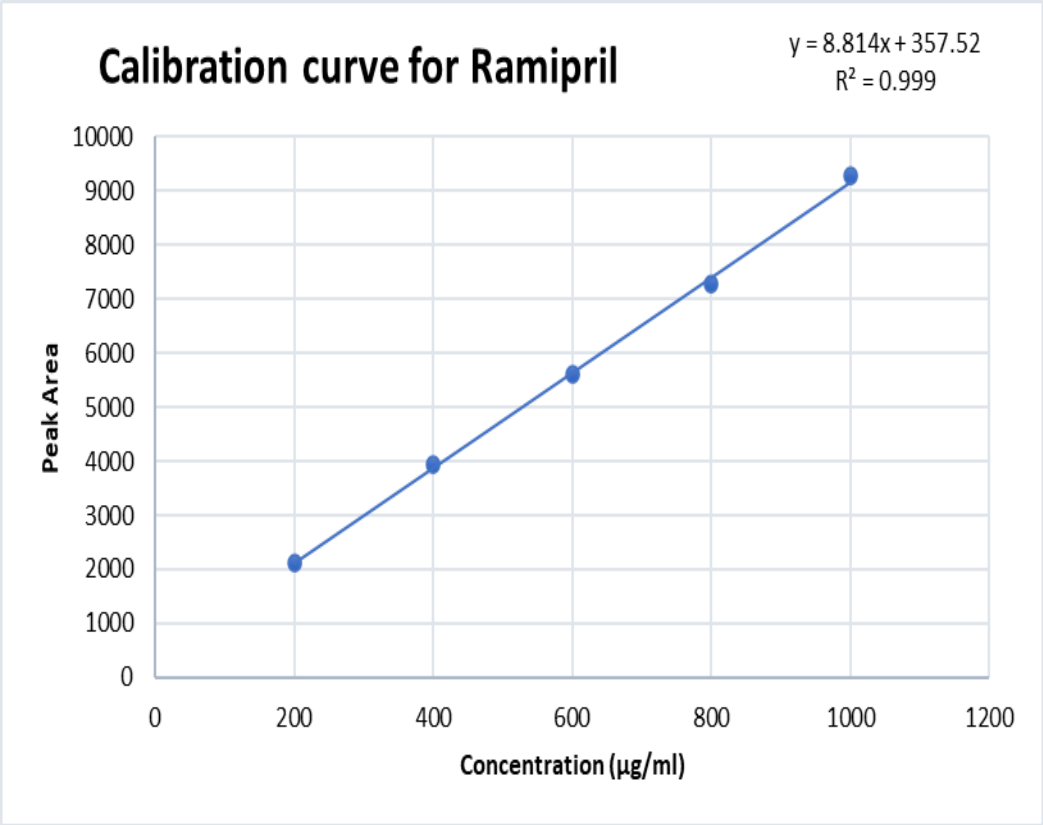
LINEARITY:

Linearity was evaluated for NEBI and RAMI across 200–1200 ng/band. Calibration curves showed strong proportionality between concentration and peak area, with $R^2 > 0.999$ for both drugs. Regression analysis confirmed excellent linear response throughout the range. Results are shown in Tables, with providing a 3D densitogram overlay supporting linearity.

Sr. no	Concentration g/band)	Mean peak area ± S.D. (n=6)	% R.S.D.
1	200	1606 ± **30.47**	1.89
2	400	3071 ± **43.88**	1.42
3	600	4337 ± **77.58**	1.78
4	800	5691 ± **66.73**	1.17
5	1000	7045 ± **113.05**	1.60
6	1200	8468 ± **145.69**	1.72



Sr. no	Concentration (ng/band)	Mean peak area ± S.D. (n=6)	% R.S.D.
1	200	2127 ± 29.47	1.39
2	400	3940 ± 67.04	1.70
3	600	5609 ± 71.67	1.28
4	800	7283 ± 100.90	1.39
5	1000	9270 ± 122.78	1.32
6	1200	10922 ± 156.21	1.43



PRECISION:

Intraday and interday precision were evaluated for NEBI and RAMI, with all %RSD values below 2%. This confirms excellent method precision both within the same day and across different days/analysts.

Conc. ng/band)		Mean peak area ± SD RAMI	% RSD	Mean peak area ± SD NEBI	% RSD
RAMI	NEBI				
200	200	2116.62 ± 21.38	1.01	1592.64 ± 12.23	0.77
600	600	5549.50 ± 79.64	1.44	4343.22 ± 55.56	1.28
1200	1200	10862.55 ± 110.81	1.02	8400.25 ± 83.40	0.99

Tab: Intraday Precision

Conc. (ng/band)		Mean peak area ± SD RAMI	% RSD	Mean peak area ± SD NEBI	% RSD
RAMI	NEBI				
200	200	2123.75 ± 32.66	1.54	1628.74 ± 31.21	1.92
600	600	5668.39 ± 101.91	1.80	4351.46 ± 50.08	1.15
1200	1200	10827.05 ± 126.39	1.17	8344.08 ± 110.18	1.32

Tab: Interday Precision

ACCURACY:

Accuracy was assessed through recovery studies at 50%, 100%, and 150% spiking levels. Recovery for RAMI ranged from 99.41–100.07%, and for NEBI from 99.70–101.25%, confirming excellent method accuracy.

Level	Conc. of RAMI from Synthetic mixture (ng/band)	Amount of Std. RAMI added (ng/band)	Total amount of RAMI (ng/band)	Total amount of RAMI Recovered (ng/band) * Mean	% Recovery
0%	400	0	400	398.89	99.72
50%	400	200	600	599.63	99.94
100%	400	400	800	800.59	100.07
150%	400	600	1000	994.12	99.41

LIMIT OF DETECTION AND QUANTIFICATION:

The LOD and LOQ were found for RAMI and NEBI shown in table respectively indicating high sensitivity of the method

Parameters	RAMI (ng/band)	NEBI (ng/band)
LOD	4.70	19.06
LOQ	14.24	57.77

ROBUSTNESS:

Robustness was assessed by introducing small deliberate changes to the HPTLC conditions. The consistently low %RSD values demonstrated that the method remains reliable and unaffected by minor variations.

Parameters	Change in condition	RAMI		NEBI	
		Peak Area	%RSD	Peak Area	%RSD
Detection wavelength (225nm)	223 nm	5603.87±39.59	0.71	4529.8±23.89	0.53
	225 nm	5563.04±18	0.32	4446.29±79.33	1.78
	227 nm	5589.17±100.82	1.80	4379.27±56.9	0.00
Chamber Saturation time (30 min)	25 min	5520.37±22.97	0.42	4465.77±75.36	1.69
	30 min	5563.04±18	0.32	4446.29±79.33	1.78
	35 min	5564.85±42.27	0.76	4412.2±79.34	1.80
Mobile Phase Ethyl acetate : Methanol : Toluene: Glacial acetic acid (7.5:1:1:0.5, v/v/v)	(7.5:0.5:1.5:0.5, v/v/v)	5587.5±27.81	0.50	4478.66±60.27	1.35
	(7.5:1:1:0.5, v/v/v)	5563.04±18	0.32	4446.29±79.33	1.78
	(7.0:1.5:1:0.5, v/v/v)	5522.26±24.29	0.44	4474.61±34.49	0.77

FORCE DEGRADATION STUDY:

Acid hydrolysis:

Under acid hydrolysis (60 °C, 30 min), Ramipril showed 11.07% degradation with two degradant peaks at Rf 0.18 and 0.51. Nebivolol showed 17.49% degradation, forming two degradant peaks at Rf 0.76 and 0.79, while parent peaks remained detectable.

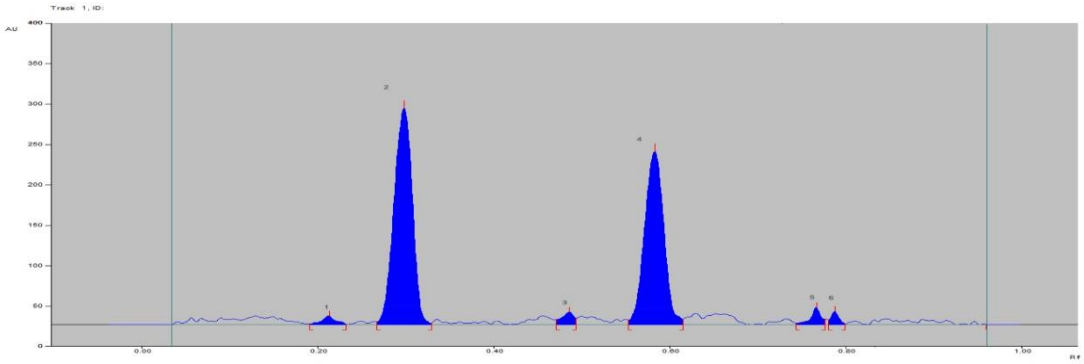


Fig: Densitogram of nebivolol and ramipril in acid hydrolysis

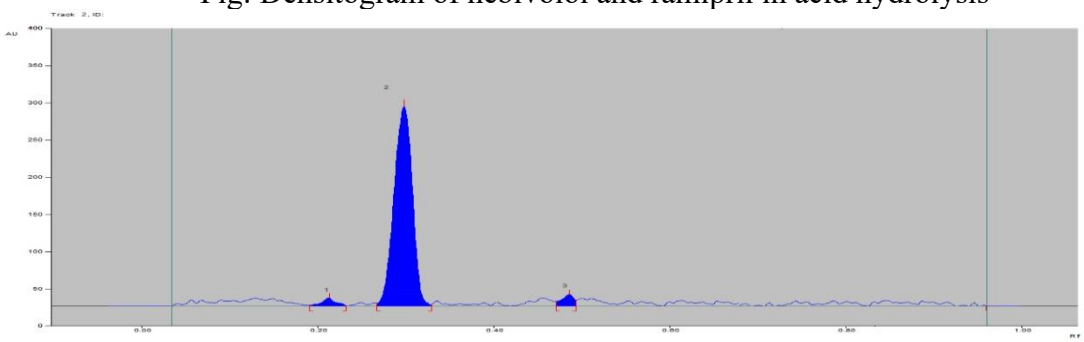


Fig: Densitogram of Ramipril

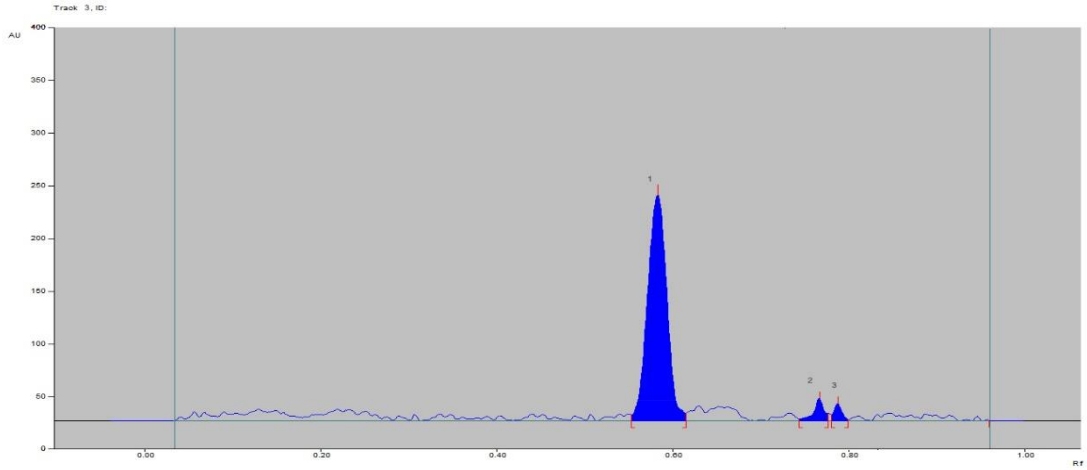


Fig: Densitogram of Nebivolol

BASE HYDROLYSIS:

Under base hydrolysis (60 °C, 30 min), Ramipril showed 14.90% degradation with degradant peaks at Rf 0.19 and 0.40. Nebivolol showed 13.63% degradation, forming additional peaks at Rf 0.52 and 0.76 alongside the parent peak.

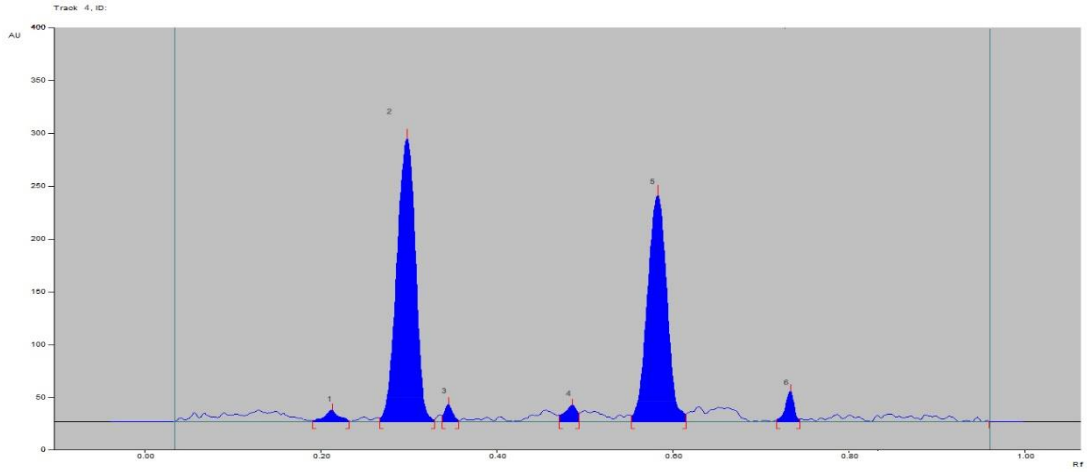


Fig: Densitogram of nebivolol and ramipril in base hydrolysis

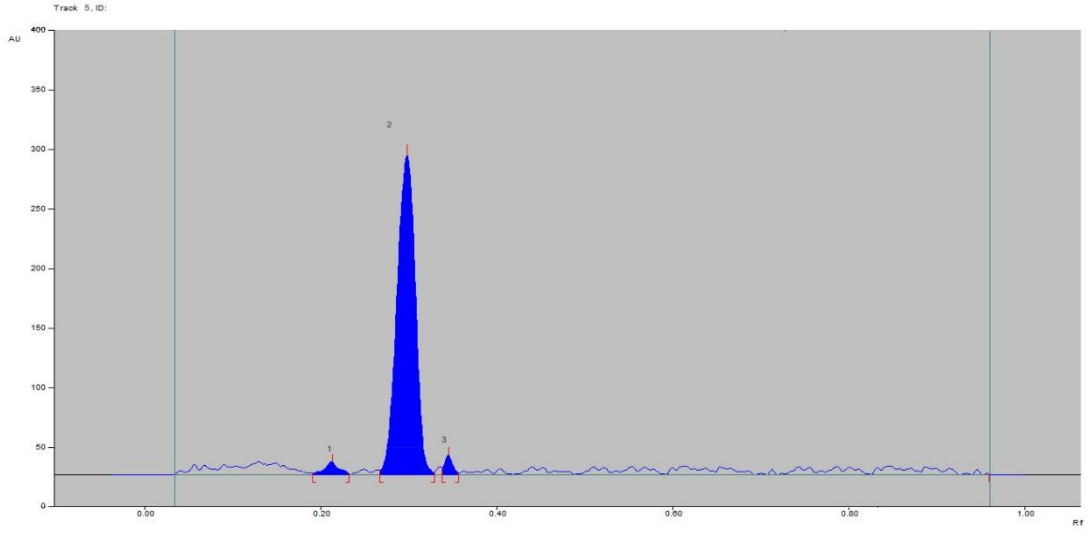


Fig: Densitogram of Ramipril

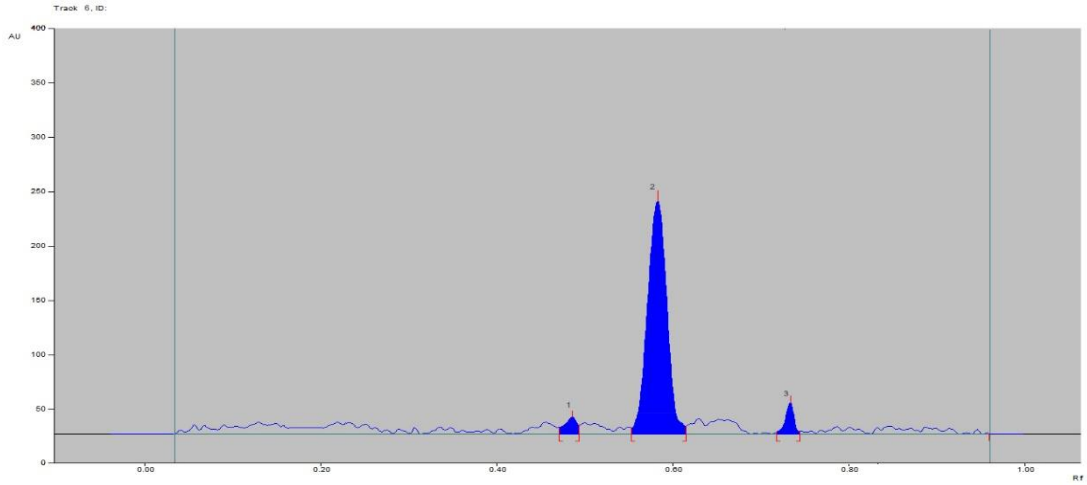


Fig: Densitogram of Nebivolol

OXIDATIVE STRESS DEGRADATION STUDY:

Under oxidative stress with hydrogen peroxide, Ramipril showed 9.64% degradation with degradant peaks at Rf 0.21 and 0.39. Nebivolol showed 9.84% degradation, producing additional peaks at Rf 0.53 and 0.83 while retaining the parent peak.

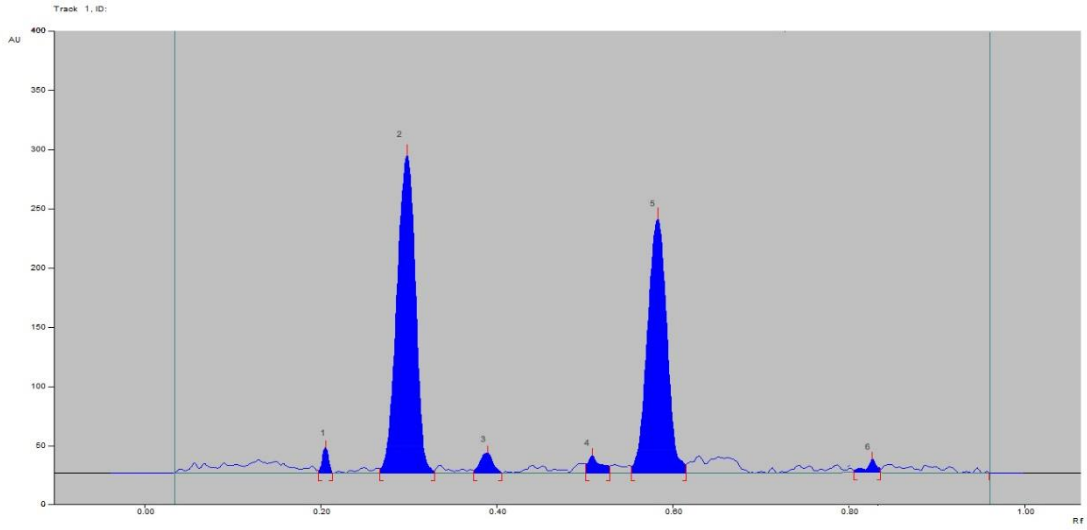


Fig: Densitogram of nebivolol and ramipril in oxidative degradation

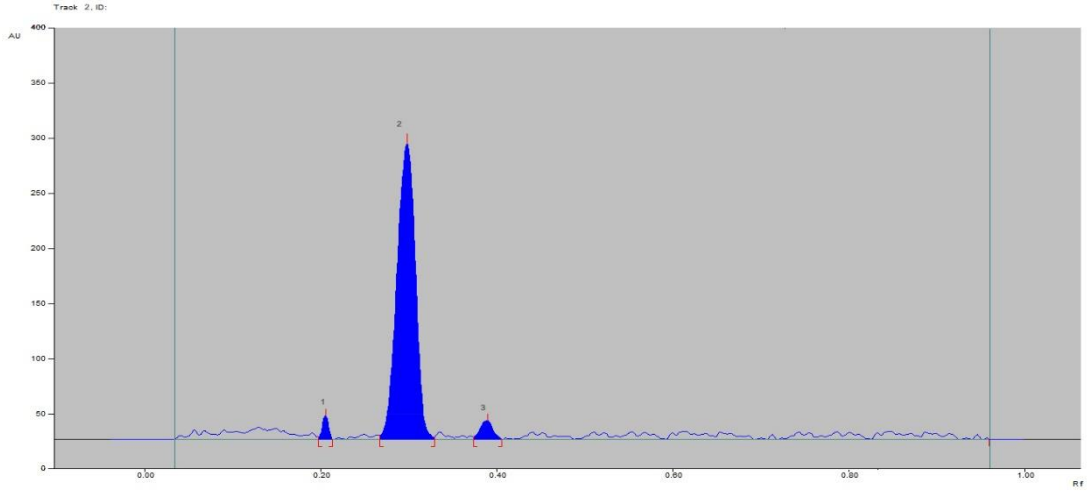


Fig: Densitogram of Ramipril

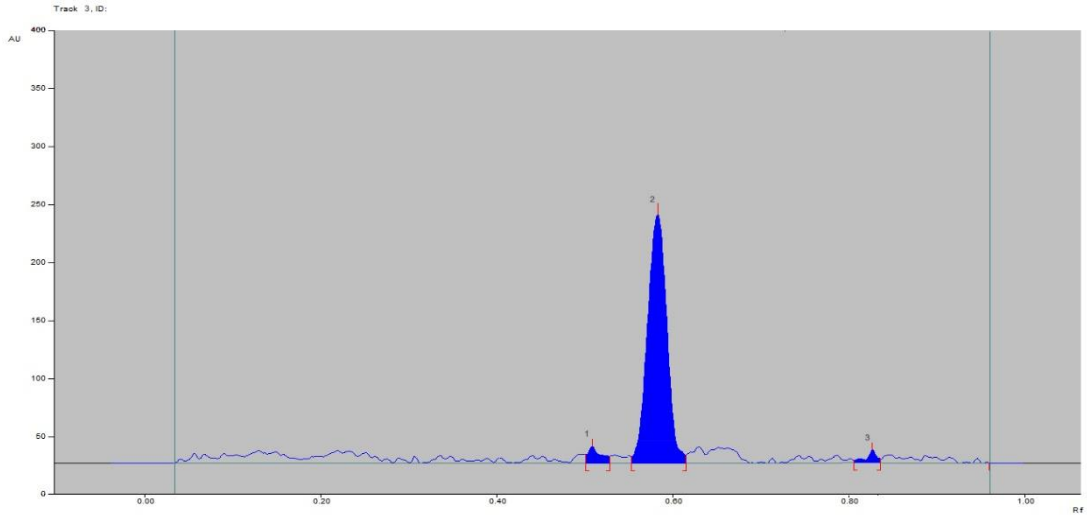


Fig: Densitogram of Nebivolol

THERMAL STRESS DEGRADATION STUDY:

Under dry heat conditions, Ramipril showed 6.11% degradation with one degradant peak at Rf 0.22. Nebivolol showed 5.76% degradation, forming a degradant at Rf 0.45 while both parent peaks remained intact.

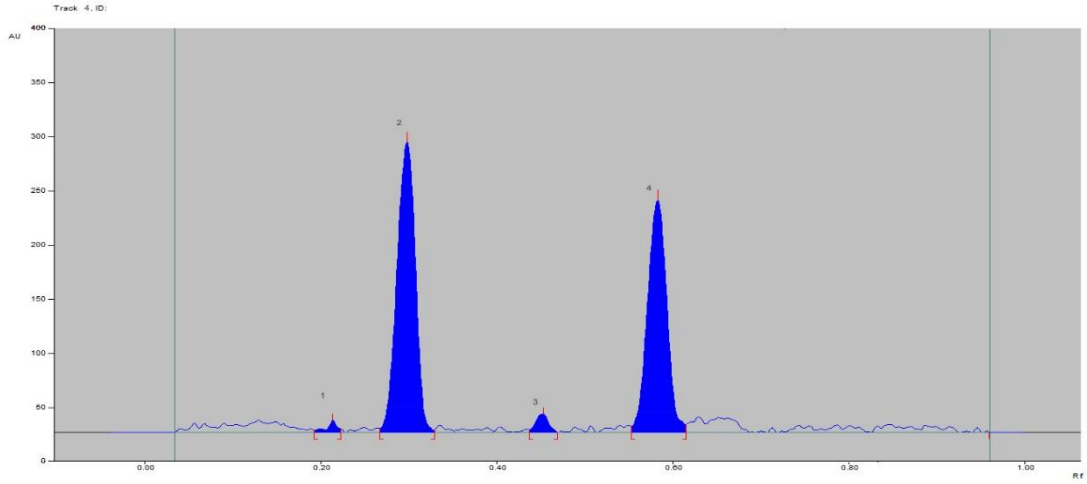


Fig: Densitogram of nebivolol and ramipril in Thermal degradation

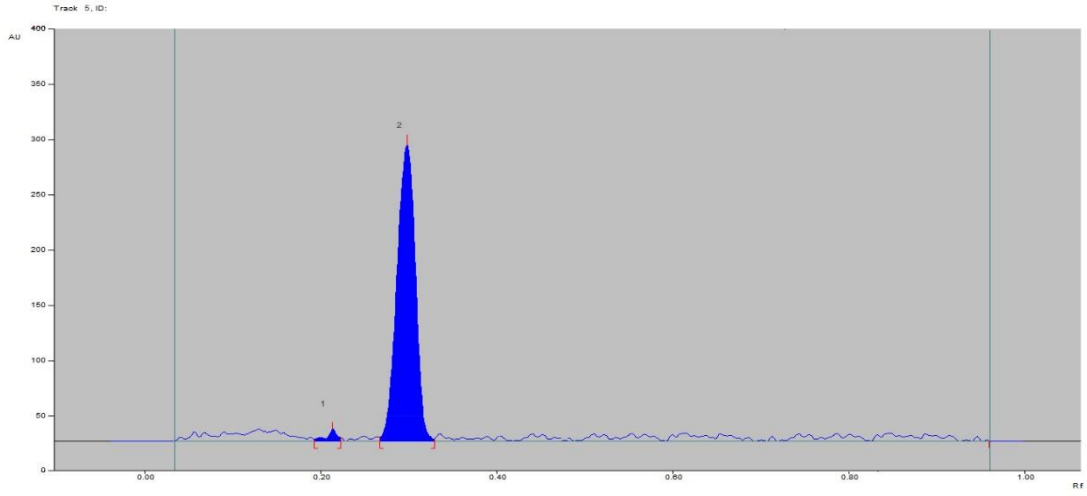


Fig: Densitogram of Ramipril

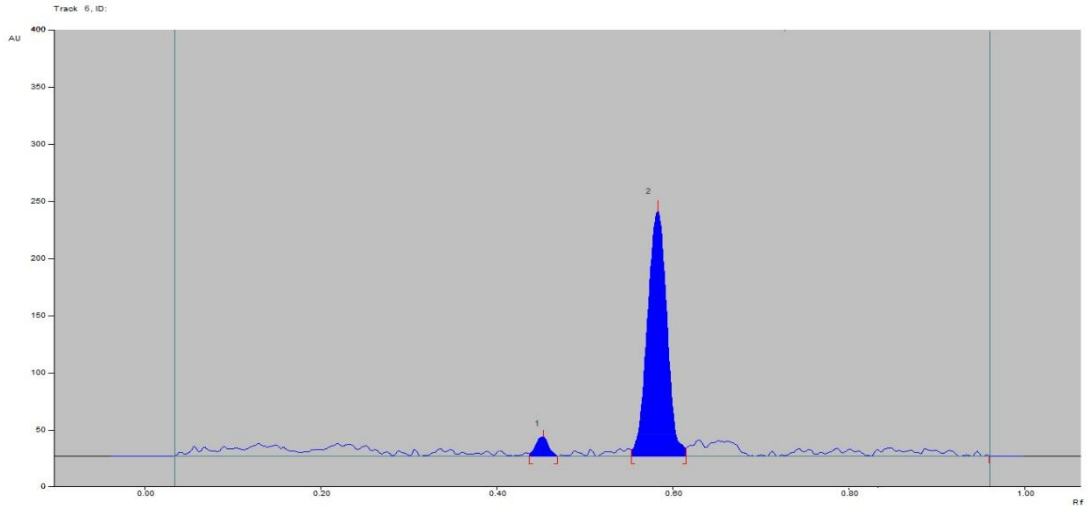


Fig: Densitogram of Nebivolol

PHOTOLYTIC STRESS DEGRADATION STUDY:

Under photolytic (UV) exposure, Ramipril showed 4.49% degradation with a minor degradant at Rf 0.20. Nebivolol showed 6.74% degradation, forming a degradant at Rf 0.47 while its parent peak remained visible.

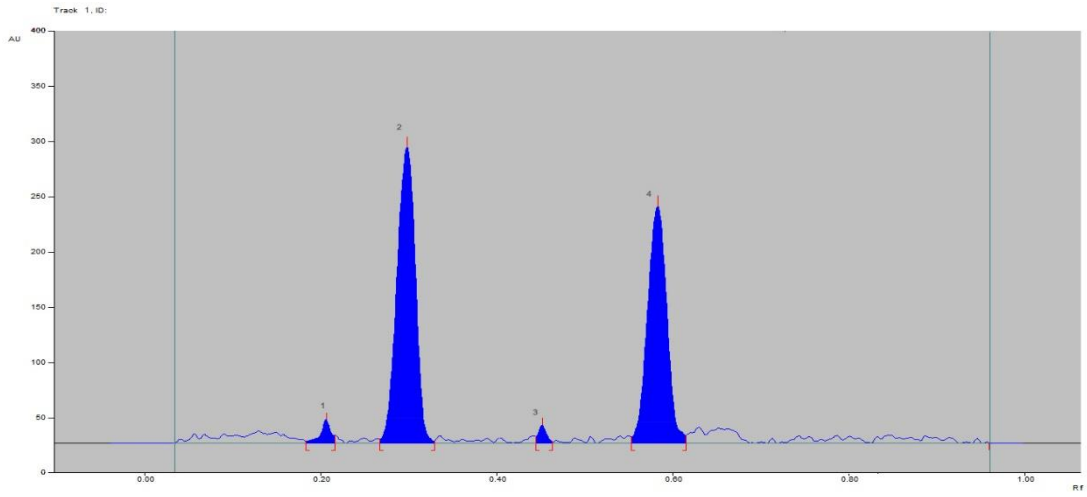


Fig: Densitogram of nebivolol and ramipril in Photolytic degradation

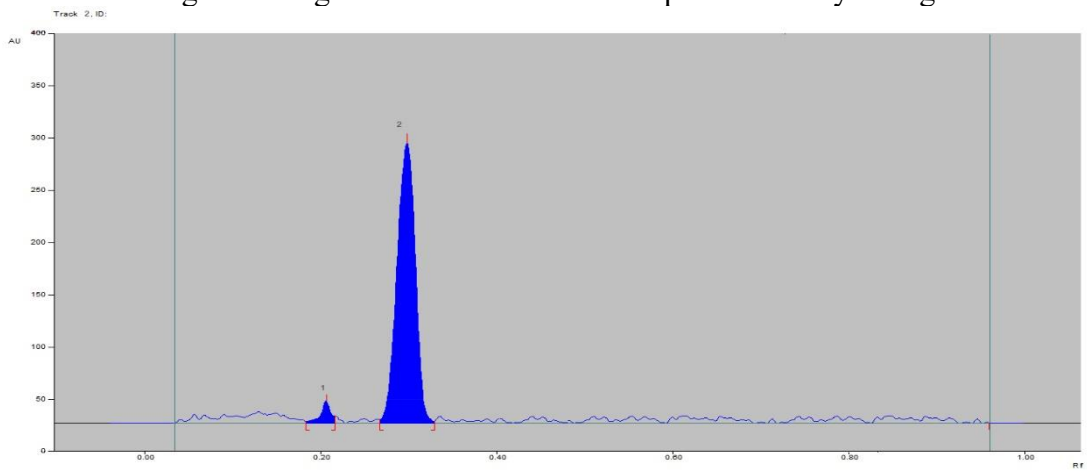


Fig: Densitogram of Ramipril

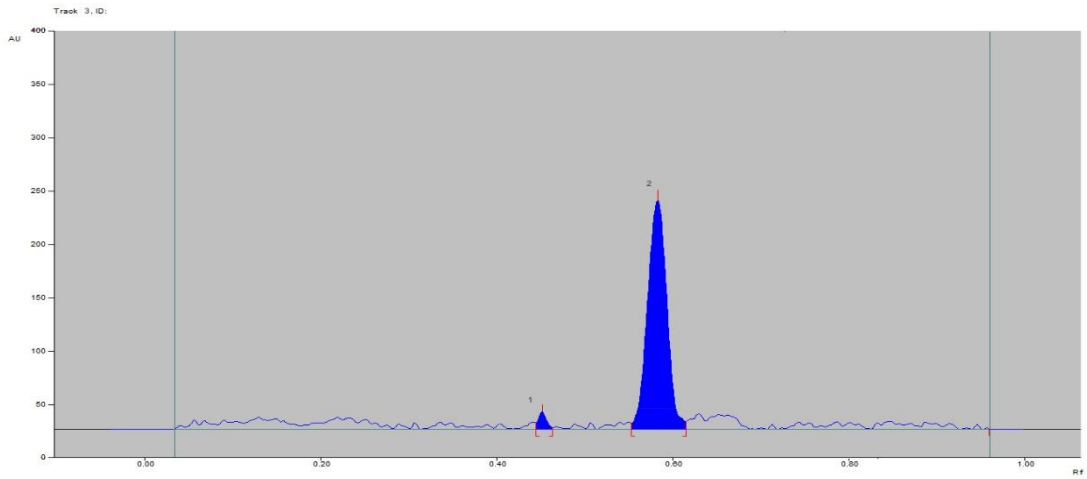


Fig: Densitogram of Nebivolo

CONCLUSION:

A robust, accurate, and stability-indicating High-Performance Thin Layer Chromatography (HPTLC) method was successfully developed and validated for the simultaneous estimation of Ramipril and Nebivolol in bulk and combined dosage forms. The method employed silica gel 60 F_{254} TLC plates with a carefully optimized mobile phase, achieving well-resolved, sharp, and reproducible peaks with Rf values of ~0.35 for Ramipril and ~0.58 for Nebivolol. Densitometric detection at 225 nm provided optimal sensitivity for both analytes.

Forced degradation studies under acidic, alkaline, oxidative, thermal, and photolytic stress conditions revealed significant degradation of both drugs under hydrolytic and oxidative environments, with minimal degradation under thermal and photolytic conditions. Distinct degradation products were observed with different Rf values, confirming drug instability in specific conditions.

Importantly, the developed HPTLC method demonstrated excellent specificity by effectively separating all degradation peaks from the intact drugs, affirming its suitability as a stability-indicating assay. The method is therefore appropriate for routine quality control, stability analysis, and regulatory submissions involving Ramipril and Nebivolol.

REFERENCES:

1. William AP. Goodman and Gilman's. The Pharmacological Basis of Therapeutics. 11th Edn. Tata Mac Graw Hill Publishing, 2008; pp 488-492.
2. Walker R and Whittlesea C. Clinical Pharmacy and Therapeutics; 5th Edn; Elsevier, 2007; 295-307.
3. ICH Q2 (R1); "validation of analytical procedure: Text and Methodology". International Conference on Harmonization, Geneva; 2005
4. Skoog DA., Holler FJ., and Nieman TA. Principle of instrumentation analysis; 5th edn, Thomson Asia Pvt Ltd, Singapore, 2005, pp 300-304. 12.
5. Jeffery GH., Bassett J., Mendham J., and Denney RC. Vogel's Textbook of Quantitative Chemical Analysis; 5th edn; Adison Wesley Longman LTD, 1966, pp 216-220.
6. Galen WE., Anaytical instrumentation handbook; 2nd edn; Marcel Dekker Inc, New York, 2004, pp 1123, 1183.
7. Giri, D, "High Performance Liquid Chromatography Principle, Types, Instrumentation and Applications", https://shodexhplc.com accessed in Decmber 2020.
8. Rajan HV. Development and validation of HPLC method - A Review. International Journal of current research in pharmacy. 2015;1(2):55-68.
9. Kumar V, Bharadwaj R, Gupta G, Kumar S. An Overview on HPLC Method Development, Optimization and Validation process for drug analysis. The Pharmaceutical and Chemical Journal. 2015; 2(2):30-40.
10. Gupta V, Jain AD, Gill NS, Gupta K. Development and validation of HPLC method

- a review. International Research Journal of Pharmaceutical and Applied Sciences. 2012; 2(4):17-25.
11. Sonia K, Nappinnai M. Development and validation of HPLC and UV-visible spectrophotometric method for the pharmaceutical dosage form and biological fluid –review. European Journal of Biomedical and Pharmaceutical sciences. 2016; 3(3): 382-391.
12. Rao G, Goyal A. An Overview on Analytical Method Development and Validation by Using HPLC. The Pharmaceutical and Chemical Journal, 2016; 3(2): 280-289.
13. Charde MS, Welankiwar AS and Kumar J. Method development by liquid chromatography with validation.International Journal of Pharmaceutical Chemistry.2014; 4(2):57-61.
14 Ranjit singh. HPLC method development and validation. J Pharm Educ Res2013; 4(1): 26-33.
15. Sabir AM, Molony M,Parminder SB. HPLC Method Development and validation: A Review. International research Journal of pharmacy. 2013; 4(4):39-46.
16. Attimarad, M., Ahmed, K. K., Aldhubaib, B. E., & Harsha, S. (2011). High-performance thin layer chromatography: A powerful analytical technique in pharmaceutical drug discovery. Pharmaceutical methods, 2(2), 71–75. https://doi.org/10.4103/2229-4708.84436
17. Sherma J. (2010). Review of HPTLC in drug analysis: 1996-2009. Journal of AOAC International, 93(3), 754–764.
18. Arup U, Ekman S, Lindblom L, Mattsson J-E. High performance thin layer chromatography (HPTLC), an improved technique for screening lichen substances. The Lichenologist. 1993;25(1):61-71. doi:10.1006/lich.1993.1018.
19. Cartenson JT. Swarbirck J. Solution kinetics-Drug stability principles and practice. 2nd Edn. Marcel Dekker series. 1995; pp 17-9.
20. Q1A (R2): Stability Testing of New Drugs and Products. International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use. Ich Harmonised Tripartite Guideline. 2003; 1-18.
21. Kamal AH, Marie AA, Hammad SF. Validated spectrophotometric methods for simultaneous determination of nebivolol hydrochloride and valsartan in their tablet. Microchemical Journal 2020;155:104741. https://doi.org/10.1016/j.microc.2020.104741.
22. Meselhy EM, Kheir AA, Henawee MME, Elmasry MS. Simultaneous determination of Nebivolol hydrochloride and Valsartan in their binary mixture using different validated spectrophotometric methods. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 2020;118083. https://doi.org/10.1016/j.saa.2020.118083.
23. Kachave RN, Mundhe AG. Development and Validation of Bioanalytical Method for Determination of Nebivolol and Valsartan in Human Plasma by Using RP-HPLC. European Pharmaceutical Journal 2021;49–58. https://doi.org/10.2478/afpuc-2021-0019.
24. Development of efficient analytical method for the multicomponent analysis of pravastatin sodium and nebivolol hydrochloride in bulk drug by RP-HPLC 2023. https://www.indianjournals.com/ijor.aspx?target=ijor:rjpt&volume=16&issue=5&article=067
25. Rawat PS, Ravi PR, Kaswan L, Raghuvanshi RS. Development and validation of a bio-analytical method for simultaneous quantification of nebivolol and labetalol in aqueous humor and plasma using LC-MS/MS and its application to ocular pharmacokinetic studies. Journal of Chromatography B 2020;121908. https://doi.org/10.1016/j.jchromb.2019.121908.
26. Makvana C, Sahoo S. Spectrophotometric Method Development and Validation for Simultaneous Estimation of Nebivolol hydrochloride and Valsartan in Bulk and Combined Pharmaceutical Dosage Form in Release Media. Int. J. Pharm. Sci. Drug Res. 2019; 11(6): 299-304. DOI: 10.25004/IJPSDR.2019.110604
27. Samantha Fernandes, Celinana Zareth, Bhakti Naik. Simultaneous Analysis of Cilnidipine and Nebivolol by Absorbance Correction Method and Q Absorption Ratio Method.

Research Journal of Pharmacy and Technology 2023; 16(7):3213-8. doi: 10.52711/0974-360X.2023.00528
28. S. Sangeetha, S. Alexandar, M. V. Kumudhavalli, M. Kumar. Development and Validation of a Forced Degradation UPLC Method for the Simultaneous Determination of Nebivolol HCl and Valsartan in Bulk and Pharmaceutical Dosage Form. Research Journal of Pharmacy and Technology 2023; 16(3):1002-6. doi: 10.52711/0974-360X.2023.00167
29. Chinmoy Kumar, Manish Kumar, Vipin Saini, Shailendra Bhatt, A. Pandurangan, Anuj Malik, Preeti Pal, Laxmi Narayan Shetty. Dissolution Method Development and Validation for Combination Dosage Form of Telmisartan and Nebivolol hydrochloride Tablets using , UV Spectrophotometric Method. Research J. Pharm. and Tech. 2019; 12(6): 2742-2747. doi: 10.5958/0974-360X.2019.00459.1
30. Önal C, Aluç K, Aluç Ç, Önal A. High-performance Liquid Chromatography Analysis of Nebivolol and Amlodipine and Some Related Compounds in Synthetic Mixture. Bezmialem Science 2021;9(3):264-70.
31. Annadi AM, Shoheib RE, Mohamed AA. Assessments of Valsartan in the presence of Nebivolol or Amlodipine in solid formulations and its discriminative dissolution behavior via RP-HPLC and RP-UPLC methods. Egyptian Journal of Chemistry 2020;0.
32. Syed Sagheer Ahamed, Mohamed Khaleel, Nirmal. T. Havannavar, Syed Shariff Miyan. Colorimetric Estimation of Nebivolol Hydrochloride in Bulk and Pharmaceutical Dosage Form. Asian J. Pharm. Tech. 2019; 9(4):253-259. doi: 10.5958/2231-5713.2019.00042.4
33. Saeed, S., Nadim, A.H., Yehia, A.M. et al. A versatile high-performance thin-layer chromatographic method for the simultaneous determination of five antihypertensive drugs: method validation and application to different pharmaceutical formulations. JPC-J Planar Chromat 34, 467–477 (2021).
34. Pintu B Prajapati, Kajal V Jayswal, Shailesh A Shah, Estimation of Multiple Fixed-Dose Combination Products of Ramipril and Aspirin by GERV-Chromatography Using DoE & Risk-Based Enhanced Analytical QbD Approach, J AOAC INT, Volume 104, Issue 6, November-December 2021, 1726–1741.
35. Vidhya K. Bhusari, Sunil R. Dhaneshwar, "Validated HPTLC Method for Simultaneous Estimation of Atenolol and Aspirin in Bulk Drug and Formulation", International Scholarly Research Notices, vol. 2012, Article ID 609706, 5 pages, 2012.
36. Vidhya K. Bhusari, Sunil R. Dhaneshwar, "Validated HPTLC Method for Simultaneous Estimation of Atenolol and Aspirin in Bulk Drug and Formulation", International Scholarly Research Notices, vol. 2012, Article ID 609706, 5 pages, 2012.
37. Shabir G, Shaikh KA, Madgulkar A, Bhatia NM. Application of AQbD principles on the development of a stability-indicating HPLC method for determination of acetylsalicylic acid, ramipril and atorvastatin in fixed-dose polypills. Anal Methods. 2025;17(5):950-63.
38. Choudhary R, Agrawal N, Choudhary S, Gupta S. Method development and validation for the simultaneous determination of ramipril and cilnidipine by RP-HPLC. Int J Pharm Drug Anal. 2025;13(2):81-6.
39. Rahman MM, Karim MM, Ahmed S, Hossain M. Development of a validated RP-HPLC method using full factorial design for the analysis of ramipril. Dhaka Univ J Pharm Sci. 2024;23(1):37-45.
40. Sultana R, Ahmad S, Farooqui M, Ali A. Stability-indicating RP-HPLC method for determination of ramipril in pure and pharmaceutical formulation. Asian J Pharm Clin Res. 2024;17(3):129-34.
41. Patel H, Patel R, Solanki M, Mehta T. Development and validation of the HPTLC method for the simultaneous estimation of ramipril and hydrochlorothiazide in solid dosage form. Int J Pharm Sci Res. 2024;15(4):2000-6.
42. Abdallah, N.A., El-Brashy, A.M., Ibrahim, F.A. et al. Micellar eco-friendly HPLC method for simultaneous analysis of ternary combination of aspirin, atorvastatin and

ramipril: application to content uniformity testing. BMC Chemistry 17, 19 (2023).
43. Islam, M. S. ., Sultan, M. Z., Islam, M. S. ., Simol, H. A., & Salam, M. A. . (2023). Development and Validation of a New Method for Simultaneous Estimation of Ramipril and Carvedilol by HPLC. Bangladesh Pharmaceutical Journal, 26(1), 15–19.
44. Typlynska, K.; Logoyda, L. Development of the HPLC method for the determination of related substances in ramipril tablets, in Proceedings of the MOL2NET'22, Conference on Molecular, Biomed., Comput. & Network Science and Engineering, 8th ed., 1–15 January 2023, MDPI: Basel, 08-13919.
45. Nagar A, Deore S, Bendale A, Kakade R, Sonawane C. Analytical method development and validation of Ramipril and Candesartan Cilexetil in synthetic mixture. Innov Pharm Pharmacother 2020;8(2):14-20.
46. Development And Validation Of Stability Indicating Rp-Hplc Method For The Estimation Of Ramipril And Cilnidipine In Bulk And Pharmaceutical Dosage Form. (2022) Journal of Pharmaceutical Negative Results, pp. 8682–8690. doi:10.47750/pnr.2022.13.S09.1020.
47. Validated HPTLC method for simultaneous estimation of metoprolol succinate and ramipril in bulk drug and marketed formulation. (2019). Bulletin of Pure and Applied Sciences-Chemistry , 38(2), 150–157.
48. Pintu B Prajapati, Kajal V Jayswal, Shailesh A Shah, Estimation of Multiple Fixed-Dose Combination Products of Ramipril and Aspirin by GERV-Chromatography Using DoE & Risk-Based Enhanced Analytical QbD Approach, J AOAC INT, Volume 104, Issue 6, November-December 2021, 1726–1741.
49. Vidhya K. Bhusari, Sunil R. Dhaneshwar, "Validated HPTLC Method for Simultaneous Estimation of Atenolol and Aspirin in Bulk Drug and Formulation", International Scholarly Research Notices, vol. 2012, Article ID 609706, 5 pages, 2012.
50. Vidhya K. Bhusari, Sunil R. Dhaneshwar, "Validated HPTLC Method for Simultaneous Estimation of Atenolol and Aspirin in Bulk Drug and Formulation", International Scholarly Research Notices, vol. 2012, Article ID 609706, 5 pages, 2012.
51. Shabir G, Shaikh KA, Madgulkar A, Bhatia NM. Application of AQbD principles on the development of a stability-indicating HPLC method for determination of acetylsalicylic acid, ramipril and atorvastatin in fixed-dose polypills. Anal Methods. 2025;17(5):950-63.
52. Choudhary R, Agrawal N, Choudhary S, Gupta S. Method development and validation for the simultaneous determination of ramipril and cilnidipine by RP-HPLC. Int J Pharm Drug Anal. 2025;13(2):81-6.
53. Rahman MM, Karim MM, Ahmed S, Hossain M. Development of a validated RP-HPLC method using full factorial design for the analysis of ramipril. Dhaka Univ J Pharm Sci. 2024;23(1):37-45.
54. Sultana R, Ahmad S, Farooqui M, Ali A. Stability-indicating RP-HPLC method for determination of ramipril in pure and pharmaceutical formulation. Asian J Pharm Clin Res. 2024;17(3):129-34.
55. Patel H, Patel R, Solanki M, Mehta T. Development and validation of the HPTLC method for the simultaneous estimation of ramipril and hydrochlorothiazide in solid dosage form. Int J Pharm Sci Res. 2024;15(4):2000-6.