



## RP-HPLC method development and validation for the estimation of revaprazan in bulk form and marketed pharmaceutical dosage form

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### Article Info

**ISSN (online):** 2582-7138

**Impact Factor:** 5.307 (SJIF)

**Volume:** 05

**Issue:** 01

**January-February 2024**

**Received:** 29-10-2023;

**Accepted:** 30-11-2023

**Page No:** 122-129

### Abstract

**Objective:** The current investigation was pointed at developing and progressively validating novel, simple, responsive and stable RP-HPLC method for the Quantitative Determination of Revaprazan in active pharmaceutical ingredient and Marketed Pharmaceutical Dosage form.

**Methods:** A simple, selective, validated and well-defined stability that shows isocratic RP-HPLC methodology for the quantitative determination of Revaprazan. The chromatographic strategy utilized Symmetry C18, 250 mm x 4.6 mm i.d. 5 $\mu$ m particle size, using isocratic elution with a mobile phase consists of Methanol and Phosphate Buffer (0.02M) (pH-3.8) was taken in the ratio of 70: 30% v/v. A flow rate of 1.0 ml/min and a detector wavelength of 245nm utilizing the UV detector were given in the instrumental settings. Validation of the proposed method was carried out according to an international conference on harmonization (ICH) guidelines.

**Results:** LOD and LOQ for the active ingredients were established with respect to test concentration. The calibration charts plotted were linear with a regression coefficient of  $R^2 > 0.999$ , means the linearity was within the limit. Recovery, specificity, linearity, accuracy, robustness, ruggedness were determined as a part of method validation and the results were found to be within the acceptable range.

**Conclusion:** The proposed method to be fast, simple, feasible and affordable in assay condition. During stability tests, it can be used for routine analysis of the selected drugs.

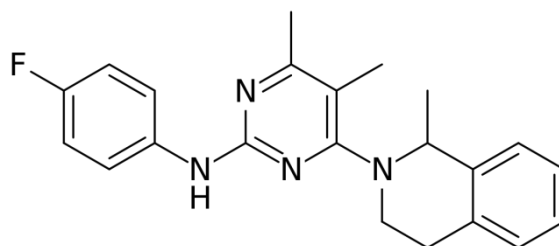
**Keywords:** Revaprazan, RP-HPLC, Method Development, Validation, Accuracy, Precision

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### Introduction

Revaprazan (trade name Revanex) is a drug that reduces gastric acid secretion which is used for the treatment of gastritis. It acts as an acid pump antagonist (potassium-competitive acid blocker). Revaprazan <sup>[1]</sup> is approved for use in South Korea, but is not approved in Europe or the United States. Revaprazan is under investigation in clinical trial NCT01750437 (Phase 2 Clinical Trial to Investigate the Safety, Tolerability and Efficacy of YH1885L in Patients with Non-erosive Reflux Disease(nerd)). Revaprazan is a member of isoquinolines. Revaprazan <sup>[2]</sup> is a proton pump inhibitor that is currently being investigated for the management of gastric and duodenal ulceration, functional dyspepsia and GERD. Revaprazan is prescribed for the treatment of duodenal ulcer, gastric ulcer and gastritis. Revaprazan is prescribed for the treatment of duodenal ulcer, gastric ulcer and gastritis <sup>[3]</sup>. Revaprazan is classified a reversible acid pump antagonist (APA or a potassium-competitive acid blocker) since it acts in a mechanism different from irreversible proton pump inhibitors, such as omeprazole. Revaprazan is not dependent upon secretion status of a proton pump or acid activation of a drug in a stomach. Revaprazan has long-lasting acid-suppressive effects <sup>[4]</sup>. Revaprazan is approved for use only in Korea and India. The pharmacodynamic analysis revealed that tegoprazan showed rapid, dose-dependent gastric acid suppression <sup>[5]</sup>. Revaprazan, a novel acid pump antagonist, exerts anti-inflammatory action against Helicobacter pylori-induced COX-2 expression by inactivating Akt signaling <sup>[6]</sup>.

The IUPAC name of Revaprazan is N-(4-fluorophenyl)-4,5-dimethyl-6-(1-methyl-3,4-dihydro-1H-isoquinolin-2-yl)pyrimidin-2-amine. The Chemical Structure of Revaprazan is shown in follows.



**Fig 1:** Chemical Structure of Revaprazan

## Materials and Methods

### Materials and Instruments

The following are the list of instruments/Equipments,

### Equipments

chemicals/reagents and standards to perform the HPLC Analysis [7] of the drug Revaprazan.

**Table 1:** List of Equipments

S. No.	Instruments/Equipments/Apparatus
1.	HPLC WATERS with Empower2 Software with Isocratic with UV-Visible Detector.
2.	T60-LABINDIA UV – Vis spectrophotometer
3.	High Precision Electronic Balance
4.	Ultra Sonicator (Wensar wuc-2L)
5.	Thermal Oven
6.	Symmetry C <sub>18</sub> Column, 250 mm x 4.6 mm and 5µm particle size
7.	P <sup>H</sup> Analyser (ELICO)
8.	Vacuum Filtration Kit (Labindia)

### Chemicals and Reagents

**Table 2:** List of Chemicals used

S. No.	Name	Grade	Manufacturer/Supplier
1.	HPLC grade water	HPLC	Sd fine-Chem ltd; Mumbai
2.	Methanol	HPLC	Loba Chem; Mumbai.
3.	Ethanol	A.R.	Sd fine-Chem ltd; Mumbai
4.	Acetonitrile	HPLC	Loba Chem; Mumbai.
5.	DMSO	A.R.	Sd fine-Chem ltd; Mumbai
6.	DMF	A.R.	Sd fine-Chem ltd; Mumbai

**Working Standard:** Working Standard of Revaprazan: 10ppm

**HPLC Instrumentation & Conditions:** The HPLC system [8] employed was **HPLC WATERS** with Empower2 Software with Isocratic with UV-Visible Detector.

### Standard preparation for UV-spectrophotometer analysis

**The standard stock solutions-**10 mg of Revaprazan standard was transferred into 10 ml volumetric flask, dissolved & make up to volume with Methanol. Further dilutions<sup>9</sup> were done by transferring 1 ml of the above solution into a 10ml volumetric flask and make up to volume with methanol to get 10ppm concentration.

It scanned in the UV spectrum in the range of 200 to 400nm. This has been performed to know the maxima of Revaprazan, so that the same wave number can be utilized in HPLC UV

detector for estimating the Revaprazan.



**Fig 2:** Double Beam UV Spectrophotometer

## Different Trials for Chromatographic Conditions

**Table 3:** Different Chromatographic Conditions

Column Used	Mobile Phase	Flow Rate	Wave length	Observation	Result
Develosil C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Acetonitrile : Water = 65 : 35	0.8 ml/min	245nm	Base line noise is high	Method rejected
Develosil C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Acetonitrile : Water = 55 : 45	0.8ml/min	245nm	Tailing is more	Method rejected
Zorbax C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Acetonitrile = 30 : 70	0.9 ml/min	245nm	Extra peaks	Method rejected
Phenomenex C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Acetonitrile = 60 : 40	1.0 ml/min	245nm	Good sharp peak	Method accepted
Symmetry C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Acetonitrile = 50 : 50	1.0 ml/min	245nm	Improper peak separation	Method rejected
Symmetry C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Phosphate Buffer (0.01M) (pH-2.8) = 40 : 60	1.0 ml/min	245nm	Tailing peaks	Method rejected
Symmetry C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Phosphate Buffer (0.02M) (pH-3.2) = 60 : 40	1.0 ml/min	245nm	Tailing peaks	Method rejected
Symmetry C <sub>18</sub> , 250 mm x 4.6 mm and 5µm Column	Methanol : Phosphate Buffer (0.02M) (pH-3.8) = 70 : 30	1.0 ml/min	245nm	Proper Peak	Method Accepted

**Preparation of 0.02M Phosphate Buffer (pH-3.8):** Prepare 800 mL of distilled water in a suitable container. Add 2.72172g of Potassium dihydrogen Phosphate to the solution to the solution<sup>[10]</sup>. Adjust solution to final desired pH 3.8 using diluted solution of orthophosphoric acid and add distilled water until volume is 1 Litre.

**Preparation of Mobile Phase:** Mix a mixture of 0.02M Phosphate Buffer (pH-3.8) 700 ml (70%) and 300 ml Methanol HPLC (30%) and degas in ultrasonic water bath for 15 minutes. Filter through 4.5 µ filter under vacuum filtration.

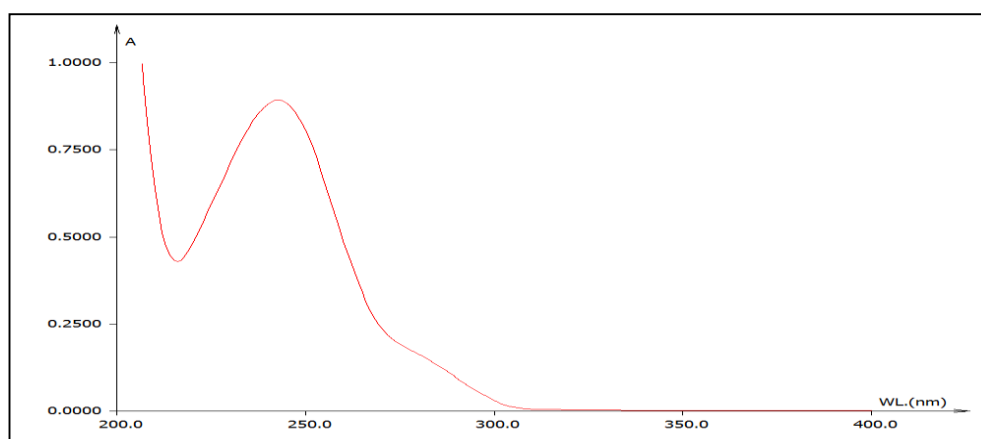
### Preparation of Standard Solution

Accurately weigh and transfer 10 mg of Revaprazan working standard into a 10ml of clean dry volumetric flasks add about 7ml of Diluents and sonicate to dissolve it completely and make volume up to the mark with the same solvent. (Stock solution)

Further pipette out 0.1ml of Revaprazan from the above stock solutions into a 10ml volumetric flask and dilute up to the mark with Diluent<sup>[11]</sup>.

## Results and Discussion

### Selection of Wavelength



**Fig 3:** UV-Spectrum for Revaprazan

**Observation:** While scanning the Revaprazan solution we observed the maxima at 245nm.

### Optimization of Analytical Method

#### Optimized Chromatographic Conditions

Column: Symmetry C<sub>18</sub>, 250 mm x 4.6 mm i.d.5µm particle size

Mobile Phase: Methanol: Phosphate Buffer (0.02M) (pH-3.8) (70: 30% v/v)

Flow Rate: 1.0ml/minute

Wave length: 245 nm

Injection volume: 10 µl

Run time: 7 minutes

Column temperature: Ambient

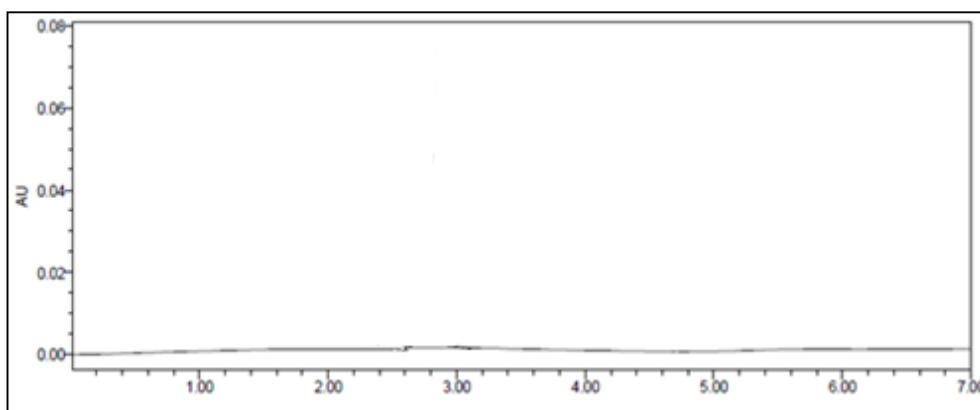


Fig 4: Chromatogram for Blank Solution

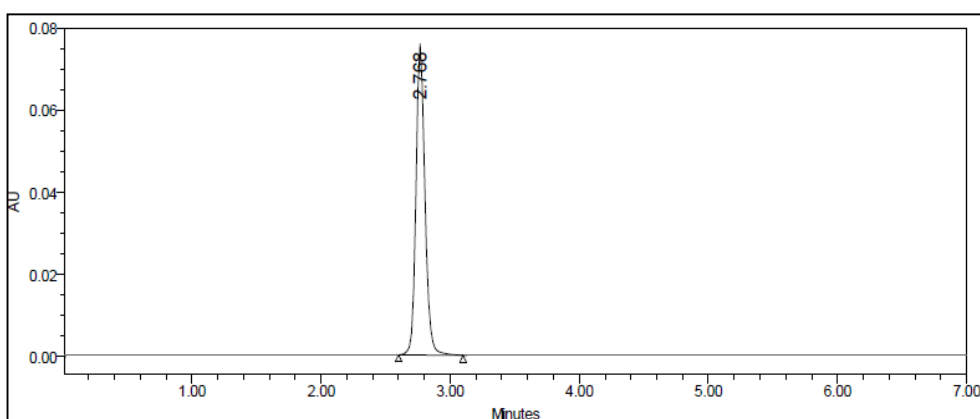


Fig 5: Optimized Chromatogram for Revaprazan

**Result:** The selected and optimized mobile phase<sup>12</sup> was Methanol: Phosphate Buffer (70: 30% v/v) and conditions optimized were flow rate (1.0 ml/minute), wavelength (245nm), Run time was 07 mins. Here the peak has shown better theoretical plate count and symmetry. The proposed chromatographic conditions<sup>[13]</sup> were found appropriate for the quantitative determination of the Revaprazan drug.

#### Analytical Method Validation

The developed HPLC method was validated according to ICH guidelines<sup>[28, 33]</sup> in terms of precision, ruggedness, linearity,

specificity, selectivity, robustness and accuracy.

#### System Suitability Test

System suitability testing<sup>[14-16]</sup> is an integral part of many analytical procedures. The tests are based on the concept that the equipment, electronics, analytical operations and samples to be analysed constitute an integral system that can be evaluated as such. Following system suitability test parameters were established. The data are shown in Table-4 & 5.

Table 4: Data of System Suitability Test

S. No.	Injection No.	RT	Area	Height	USP Plate Count	USP Tailing
1	Injection 1	2.786	715268	47844	5857	1.36
2	Injection 2	2.784	716584	46985	5986	1.38
3	Injection 3	2.768	715364	47258	5784	1.35
4	Injection 4	2.789	714895	47152	5896	1.34
5	Injection 5	2.784	716587	47258	5749	1.36
6	Injection 6	2.781	718549	47985	5657	1.39
	<b>Mean</b>		<b>716207.8</b>		<b>5821.5</b>	<b>1.36</b>
	<b>S.D</b>		<b>1347.976</b>			
	<b>%RSD</b>		<b>0.18821</b>			

Table 5: Acceptance Criteria and Result

S. No.	Parameter	Limit	Result
1	Tailing factor	$T \leq 2$	1.36
2	Theoretical plate	$N > 2000$	5821.5

#### Accuracy

#### Recovery Study

To determine the accuracy of the proposed method, recovery

studies<sup>[17]</sup> were carried out by adding different amounts (80%, 100%, and 120%) of pure drug of Revaprazan were taken and 3 replications of each has been injected to HPLC

system. From that percentage recovery values were calculated from the linearity equation  $y = 74143x + 7294.9$ . The results were shown in table-6.

**Table 6:** Accuracy Readings

Sample ID	Concentration ( $\mu\text{g/ml}$ )		%Recovery of Pure drug	Mean %Recovery	% Mean Recovery = 100.364%
	Amount Injected	Amount Recovered			
S <sub>1</sub> : 80 %	8	8.013	601425	100.162	Mean = 100.195%
S <sub>2</sub> : 80 %	8	8.012	601396	100.150	
S <sub>3</sub> : 80 %	8	8.022	602123	100.275	
S <sub>4</sub> : 100 %	10	10.038	751584	100.380	Mean = 100.356
S <sub>5</sub> : 100 %	10	10.039	751642	100.390	
S <sub>6</sub> : 100 %	10	10.030	750969	100.300	
S <sub>7</sub> : 120 %	12	12.057	901253	100.475	Mean = 100.541
S <sub>8</sub> : 120 %	12	12.073	902431	100.608	
S <sub>9</sub> : 120 %	12	12.065	901864	100.541	

**Observation:** From the Accuracy Method, we observed that the mean %Recovery <sup>[19]</sup> of the drug is 99.686 which are within the range of 98-102%.

### Precision Repeatability

The precision <sup>[20-22]</sup> of each method was ascertained separately from the peak areas & retention times obtained by actual determination of six replicates of a fixed amount of drug Revaprazan (API). The percent relative standard deviation was calculated for Revaprazan.

**Table 7:** Results of Repeatability readings

HPLC Injection Replicates of Revaprazan	Retention Time	Peak Area	Theoretical Plates	Tailing Factor
Replicate – 1	2.777	716984	5986	1.36
Replicate – 2	2.795	715698	5897	1.37
Replicate – 3	2.789	716859	5869	1.39
Replicate – 4	2.797	718548	5967	1.37
Replicate – 5	2.797	714895	5984	1.35
Replicate – 6	2.799	715986	5879	1.38
<b>Average</b>		<b>716495</b>	<b>5930.333</b>	<b>1.37</b>
<b>Standard Deviation</b>		<b>1268.126</b>		
<b>% RSD</b>		<b>0.17699</b>		

**Observation:** From the Precision method, we observed that the %RSD of the Peak Area is 0.176 which are within the acceptable range as per ICH guidelines <sup>[28, 33]</sup>.

### Intermediate Precision

The Intermediate Precision <sup>[23]</sup> consists of two methods:-

**Intra Day:** In Intra Day process, the 80%, 100% and 120% concentration are injected at different intervals of time in same day.

**Inter Day:** In Inter Day process, the 80%, 100% and 120% concentration are injected at same intervals of time in different days.

**Table 8:** Peak results for Intra-Day Precision

S. No.	Name	RT	Area	Height	USP Tailing	USP Plate Count	Injection
1	Revaprazan	2.784	716587	48685	1.38	5954	1
2	Revaprazan	2.768	717845	48698	1.39	5935	2
3	Revaprazan	2.786	716857	46989	1.36	5798	3
4	<b>Average</b>		<b>717096.3</b>	<b>48124</b>	<b>1.376</b>	<b>5895.66</b>	
5	<b>S.D</b>		<b>662.2698</b>				
6	<b>% RSD</b>		<b>0.092354</b>				

**Table 9:** Peak results for Inter-Day Precision

S.No.	Name	RT	Area	Height	USP Tailing	USP Plate Count	Injection
1	Revaprazan	2.780	716987	49867	1.34	5968	1
2	Revaprazan	2.794	718695	48574	1.33	5998	2
3	Revaprazan	2.775	718542	48569	1.39	5859	3
4	<b>Average</b>		<b>718074.7</b>	<b>49003.33</b>	<b>1.353333</b>	<b>5941.667</b>	
5	<b>S.D</b>		<b>945.0483</b>				
6	<b>% RSD</b>		<b>0.131609</b>				

**Observations:** The intra & inter day variation of the method <sup>[24]</sup> was carried out for standard deviation & % RSD (% RSD < 2%) within a day & day to day variations for Revaprazan revealed that the proposed method is precise.

### Linearity & Range

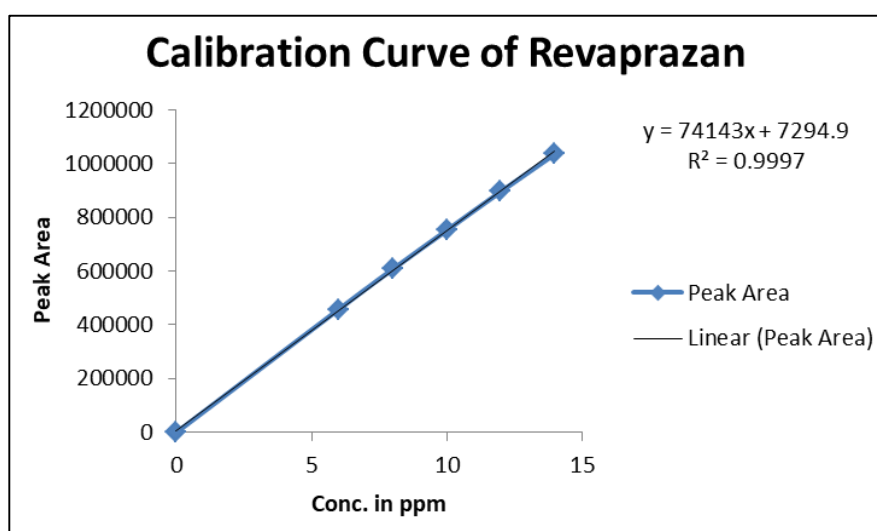
To evaluate the linearity, serial dilution of analyte were prepared from the stock solution was diluted with mobile phase to get a series of concentration ranging from 6-

14 µg/ml. The prepared solutions were sonicated. From these solutions, 10 µl injections of each concentration were injected into the HPLC system <sup>[25]</sup> and chromatographed under the

optimized conditions. Calibration curve was constructed by plotting the mean peak area (Y-axis) against the concentration (X-axis).

**Table 10:** Linearity Concentrations of Revaprazan

S. No.	Concentration (in ppm)	Peak Area
1	0	0
2	6	457896
3	8	607574
4	10	752268
5	12	896587
6	14	1036579



**Fig 6:** Calibration Curve of Revaprazan

**Observation:** We observed that the calibration curve showed good linearity in the range of 6-14 µg/ml, for Revaprazan with correlation coefficient <sup>[26]</sup> ( $R^2$ ) of 0.9997. A typical calibration curve has the regression equation of  $y = 74143x + 7294.9$  for Revaprazan.

**Specificity:** Specificity <sup>[27]</sup> of the pharmaceutical analysis is the ability to measure accurately and specifically the concentration of API, without interference from other active ingredients, diluents, mobile phase. Solutions of mobile phase, sample solution, standard solution were injected into liquid chromatography. Retention times of samples and standard were compared.

**Method Robustness:** Influence of small changes in chromatographic conditions such as change in flow rate 1ml ( $\pm 0.1$  ml/min), Wavelength of detection 245nm ( $\pm 2$ nm) & organic phase content in mobile phase 60 ( $\pm 5\%$ ) studied to determine the robustness <sup>[29]</sup> of the method are also in favour of (Table-11, % RSD < 2%) the developed RP-HPLC method for the analysis of Revaprazan (API).

**Table 11:** Results of Method Robustness Test

Change in Parameter	Theoretical Plates	Tailing Factors
Flow (1.1 ml/min)	5954	1.35
Flow (0.8 ml/min)	6188	1.39
More Organic (70+5)	5748	1.41
Less Organic (70-5)	6185	1.48
Wavelength of Detection (250 nm)	6184	1.69
Wavelength of detection (240nm)	6247	1.47
Temperature (30 °C)	6324	1.34
Temperature (20 °C)	6985	1.32

**LOD & LOQ:** The detection limit (LOD) and quantization limit (LOQ) may be expressed as:

$$\text{L.O.D.} = 3.3(\text{SD/S})$$

$$\text{L.O.Q.} = 10(\text{SD/S})$$

Where, SD = Standard deviation of the response  
S = Slope of the calibration curve

The slope S may be estimated from the calibration curve of the analyte.

The Minimum concentration level at which the analyte can be reliably detected <sup>[30]</sup> (LOD) & quantified <sup>[31]</sup> (LOQ) were found to be 0.507 & 1.539 µg/ml respectively.

#### Estimation of Revaprazan in Pharmaceutical Dosage Form

Twenty tablets were taken and the I.P. method was followed to determine the average weight. Above weighed tablets were finally powdered and triturated well. A quantity of powder equivalent to 10 mg of drug were transferred to 10 ml volumetric flask, and 8 ml of mobile phase was added and solution was sonicated for 15 minutes, there after volume was made up to 10 ml with same solvent. Then 1ml of the above solution was diluted to 10 ml with HPLC grade methanol. The solution was filtered through a membrane filter (0.45 µm) and sonicated to degas. From this stock solution (1.0 ml) was transferred to five different 10 ml volumetric flasks and volume was made up to 10 ml with same solvent system. The solution prepared was injected in five replicates into the HPLC system and the observations were recorded.



A duplicate injection of the standard solution was also injected into the HPLC system and the peak areas were recorded. The data are shown in Table-12.

### Assay

$$\% \text{ Assay} = \frac{AT}{AS} \times \frac{WS}{DS} \times \frac{DT}{WT} \times \frac{P}{100} \times \frac{AW}{LC} \times 100$$

Where:

AT = Peak Area of Revaprazan obtained with test preparation

AS = Peak Area of Revaprazan obtained with standard preparation

WS = Weight of working standard taken in mg

WT = Weight of sample taken in mg

DS = Dilution of Standard solution

DT = Dilution of sample solution

P = Percentage purity of working standard

Results obtained are tabulated below:

**Table 12:** Assay of Revaprazan in Revanex 200 Mg Tablets

Brand name of Tablets/Capsules	Labelled amount of Drug (mg)	Mean ( $\pm$ SD) amount (mg) found by the proposed method (n=5)	Assay + % RSD
Revanex 200 Mg Tablet (Zydus Cadila)	200mg	199.598 ( $\pm$ 0.452)	99.375% ( $\pm$ 0.521)

**Result & Discussion:** The %Purity<sup>[32]</sup> of Revanex 200 Mg Tablet containing Revaprazan was found to be 99.375% ( $\pm$  0.521).

### Stability Studies

Following stability study protocol was strictly used for forced degradation of Revaprazan Active Pharmaceutical Ingredient (API).

The API (Revaprazan) was subjected to some stress conditions in various ways to observe the rate and amount of degradation that is likely to take place in the course of storage and/or after ingestion to body.

This is one type of accelerated stability studies that helps us determining the fate of the drug that is likely to happen after long time storage, within a very short time as compare to the real time or long term stability testing.

The various degradation pathways are studied is acid hydrolysis, basic hydrolysis, thermal degradation and oxidative degradation.

**Results of Degradation Studies:** The results of the stress studies<sup>33</sup> indicated the specificity of the method that has been developed. Revaprazan was stable in Acidic, Photolytic & Oxidative conditions. The result of forced degradation studies are given in the following table-13.

**Table 13:** Results of Forced Degradation Studies of Revaprazan

Stress Condition	Time	Assay of Active Substance	Assay of Degraded Products	Mass Balance (%)
Acid Hydrolysis (0.1N HCl)	24Hrs.	87.635	12.365	100
Basic Hydrolysis (0.1N NaOH)	24Hrs.	94.154	5.846	100
Thermal Degradation (60°C)	24Hrs.	90.311	9.689	100
UV (254nm)	24Hrs.	91.205	8.795	100
3% Hydrogen peroxide	24Hrs.	89.346	10.654	100

### Summary and Conclusion

The analytical method was developed by studying different parameters. First of all, maximum absorbance was found to be at 245nm and the peak purity was excellent. Injection volume was selected to be 10 $\mu$ l which gave a good peak area. The column used for study was Symmetry C18, 250 mm x 4.6 mm i.d. 5 $\mu$ m particle size because it was giving good peak. Ambient temperature was found to be suitable for the nature of drug solution. The flow rate was fixed at 1.0ml/min because of good peak area and satisfactory retention time. Mobile phase is Methanol: Phosphate Buffer (0.02M) (pH-3.8) (70: 30% v/v) was fixed due to good symmetrical peak. So this mobile phase was used for the proposed study. Methanol was selected because of maximum extraction sonication time was fixed to be 10min at which all the drug particles were completely soluble and showed good recovery. Run time was selected to be 7min because analyze gave peak around 2.768min and also to reduce the total run time. The percent recovery was found to be 98.0-102 was linear and precise over the same range. Both system and method precision was found to be accurate and well within range. The analytical method was found linearity over the range of 6-14ppm of the Revaprazan target concentration. The analytical passed both robustness and ruggedness tests. On both cases, relative standard deviation was well satisfactory.

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