ORIGINAL ARTICLE

Reverse Phase High-Performance Liquid Chromatography Method Development and Estimation of Sulbactam and Durlobactam 1 g of Injection in Parenteral Dosage Form and Bulk

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Abstract

Aims: A straightforward, stability-indicating, and reliable reverse-phase high-performance liquid chromatography (HPLC) technique has been validated and created for the concurrent estimation of sulbactam and durlobactam in both pharmaceutical and bulk dosage forms, including degradation studies, which are forced. **Materials and Methods:** The immobile phase utilized for separation is a SunFire C18 HPLC column with a particle size of 5 µm, measuring L × I.D. 250 mm × 4.6 mm. Mobile phase consists of methanol and 0.01N KH_2PO_4 in a 70:30 ratio, maintained at a rate of flow of 1 mL/min, with a maximum wavelength set at 248 nm. The temperature was established at 30°C. The average retention time (R.T.) for sulbactam and durlobactam was recorded as 3.552 and 2.483 min, respectively. **Results:** The relative standard deviation values for sulbactam and durlobactam were determined to be 0.3 and 0.6, respectively. Recovery rates were achieved at 99.85% for sulbactam and 100.31% for durlobactam. The limit of detection and limit of quantification values derived from the regression equations for sulbactam and durlobactam were 0.41, 1.24 and 0.46, 1.39, respectively. The regression equation for sulbactam is expressed as y = 16378x + 8015.2, whereas for durlobactam, it is also y = 16364x + 7769.9. Both recovery tests and statistical validation of the approach were carried out. The mentioned compounds, whether in pure form or in pharmaceutical formulations, have been successfully analyzed using the recommended approach with good accuracy and precision. This technique can be applied to pharmaceutical compositions for routine medication analysis and quality monitoring. **Conclusion:** Precision, Accuracy, LOD, LOQ & Robustness were among the validation metrics & found to be acceptable limits. The recovery percentage for Sulbactam and Durlobactam were found to be 99.93% & 99.91%.

Key words: Durlobactam, immobile phase, limit of detection, limit of quantification, reverse phase high-performance liquid chromatography, sulbactam

INTRODUCTION

Patients receiving antibiotics for carbapenem-resistant *Acinetobacter baumannii* (CRAB) infection, hard-to-treat Gram-negative bacteria, *A. baumannii* infection is one of the most contentious topics. Due to the dearth of proven treatment alternatives and the low activity of currently available antimicrobial medicines against them, it presents a substantial therapeutic challenge. Ampicillin–sulbactam is regarded as the sole drug for monotherapy against these pathogens on a global scale.[1,2] Most additional treatment options combine ampicillin–sulbactam with a variety of other medicines. It can be challenging to discern between colonization and infection in hospitalized patients, especially those who are getting care in intensive care units (ICUs) or are on ventilators. These organisms commonly colonize these people. We want to shed light on the problems, such as colonization, infection, and available treatments, in this narrative review. Since this evaluation draws from

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already published research and peer-reviewed literature, the institutional ethical review board was not consulted. The synthesis of carbapenems, drug resistance in AB is usually caused by enzymes that are resistant to carbapenem antibiotics, such as the widely disseminated oxacillinases (OXA)-23, OXA-24, and OXA-58.[3,4]

Although carbapenems were originally thought to be the cornerstone of treatment for clinically significant infections, their extensive usage has also led to an increase in carbapenem resistance. To prevent the emergence and spread of multidrug-resistant (MDR) infections, it is crucial to conduct surveillance for antimicrobial resistance in ICUs.[5] Hospitals are seriously threatened by the development and spread of carbapenem-resistant non-fermenting Gram-negative bacilli in ICUs. ICUs have a difficult time controlling MDR strains because of the few available treatments, higher rates of morbidity and mortality, and higher healthcare expenses. Patients in these units are frequently exposed to antibiotics.[6] Sulbactam–durlobactam (SUL-DUR) was administered to patients in an observational setting who had colistin-resistant isolates or in cases where using colistin was contraindicated, confirming positive outcome rates. Certain cautions should be noted, even if these results may support a very promising treatment for severe carbapenem-resistant A. baumannii infections.[7]

Analyte background

The novel inhibitor of β-lactam-β-lactamase, SUL-DUR, previously referred to as ETX2514SUL, is specifically designed to address CRAB infections. Upon the completion of the phase III ATTACK trial, which compared SUL-DUR and colistin in conjunction with imipenem-cilastatin for patients suffering from CRAB-related hospital-acquired pneumonia bacteria, pneumonia which is ventilator-associated, and bacteraemia, the Food and Drug Administration (FDA) is presently anticipating fast-track approval for SUL-DUR to treat CRAB infections.[8]

Entasis Therapeutics Inc. has created a co-packaged antibacterial treatment known as sulbactam/durlobactam (XACDURO((R))) aimed at addressing infections caused by the *A. baumannii*-calcoaceticus complex (ABC). Sulbactam is a recognized class A beta-lactamase inhibitor that exhibits antibacterial properties against *A. baumannii*.[9]

The coadministration of durlobactam, a beta-lactamase inhibitor known for its strong efficacy against a wide variety of serine beta-lactamases, along with sulbactam, effectively stops ABC-produced beta-lactamases from breaking down sulbactam. In May 2023, sulbactam/durlobactam received approval in the United States to treat hospital-acquired bacterial pneumonia/ventilator-associated bacterial pneumonia (HABP/VABP) caused by susceptible ABC isolates in patients who are 18 years of age or older. This article outlines the steps involved in the development of sulbactam/durlobactam through analytical detection using high-performance liquid chromatography (HPLC), which contributed to its initial detection and purity.

Sulbactam

In addition to other antibiotics, sulbactam is a beta-lactamase inhibitor that is used to treat a range of bacterial infections that are susceptible to treatment.

By hydrolysing β-lactams and blocking the enzyme that causes drug resistance, sulbactam and β-lactam antibiotics work in concert. Sulbactam is derived from the basic structure of penicillin and functions as an inhibitor of beta (β)-lactamases. Adult patients with HABP/VABP caused by susceptible strains of the ABC should be treated with a combination of sulbactam and durlobactam.[10]

Durlobactam

A non-beta-lactam beta-lactamase inhibitor is used to treat bacterial pneumonia that is acquired in hospitals and pneumonia that is associated with ventilators.

Durlobactam is a non-beta-lactam beta-lactamase inhibitor that is diazabicyclooctane-based. Usually administered in conjunction with sulbactam, it guards against breakdown by certain serine-beta-lactamases. It is used to treat HABP/VABP, which is brought on by isolates of the ABC that are susceptible.[11-13] Durlobactam is a non-beta-lactam, beta-lactamase inhibitor that is diazabicyclooctane-based. When used with sulbactam, it prevents certain serine-beta-lactamases from breaking down sulbactam. β-lactamase uses the serine nucleophile located in the active region of the enzyme to carbamoylate durlobactam. Durlobactam can be moved from one enzyme molecule to another because the sulfated amine group on durlobactam recycles the covalent link between it and β-lactamase, making it reversible. The combination product of durlobactam and sulbactam was first approved by the FDA in May 2023.[14-16]

Drug estimation can be determined by effective separation analytical procedures such as HPLC. The literature does not mention any reverse phase HPLC (RP-HPLC) methods for estimating the dose forms of sulbactam [Figure 1], durlobactam [Figure 2], and a few additional medications, either separately or in combination.[17,18]

A straightforward, affordable stability-indicating simultaneous estimate of sulbactam and durlobactam by RP-HPLC in pharmaceutical dosage form must be developed and validated in accordance with International Council for Harmonisation (ICH) recommendations (Q2 specification), as more economical methods were noted in the literature review.[19,20]

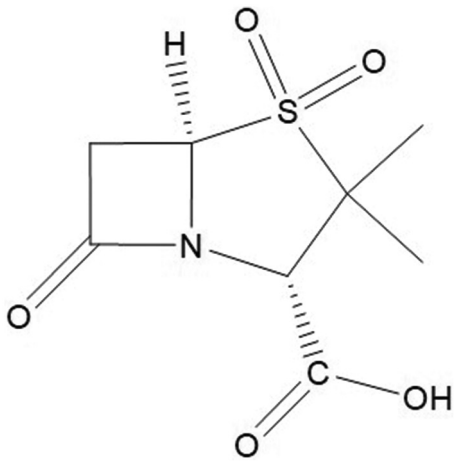

Figure 1: Sulbactam

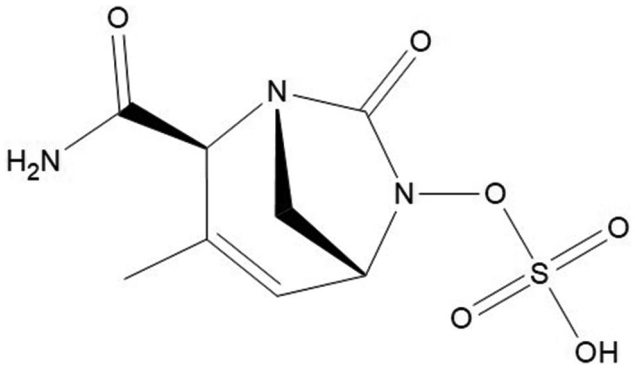

Figure 2: Durlobactam

MATERIALS AND METHODOLOGY

Sulbactam [Figure 1] and durlobactam [Figure 2] pure drugs were obtained from Jiyan Chemicals and Pharmaceuticals. The HPLC-grade methanol and acetonitrile were procured from Rankem Chemical Division, India. Sodium hydrogen phosphate procured from Rankem, India, and pure Milli-Q water are used with the help of 0.45 µ Millipore filters (Rankem, India).

Instrumentation and chromatographic conditions

The WATERS HPLC system, specifically model 2695, equipped with a photodiode array detector, was utilized for method development and validation, featuring an automated sample injector. For the separation process, a SunFire C18 column (250 mm × 4.6 mm ID × 5 µ) was employed. Methanol served as mobile phase (MP) A, whereas 0.01N potassium dihydrogen phosphate (KH_2PO_4) was designated as MP B, in a ratio of 70:30. The analysis was conducted in isocratic mode, with a flow rate (FR) of 1.2 mL/min and an injection volume (vol) of 20 µL. The column temperature (temp) was maintained at 30°C, and the total run time was 6 min. Data acquisition occurred at a detection wavelength of 248 nm, utilizing Empower 3 software.

Preparation of Sols (Solutions)

Diluent

H_2O and ethyl nitrile in the ratio 1:1.

Preparation of buffer

0.01N KH_2PO_4 buffer

Precisely measure 1.36 g of potassium dihydrogen orthophosphate into a 1000 mL volumetric flask (VF), then add approximately 900 mL of Milli-Q water. Degas the sol. by sonication, and subsequently fill the flask to the mark with water. Adjust the pH to 3.5 using diluted H_3PO_4 sol.

0.1% orthophosphoric acid (OPA) buffer

Dilute 1 mL of OPA to a total volume of 1000 mL using HPLC-grade water.

Preparation of sol (standard)

Precisely measured and moved 25 mg of sulbactam and 12.5 mg of durlobactam working standard into 50 mL clean, dry VF. Subsequently, 10 mL of diluent was added, followed by sonication for 10 min, and the final volume was adjusted with diluents. This results in a concentration of 5000 µg/mL for Sulbactam and 250 µg/mL for Durlobactam.

Standard working sol

1 mL of standard stock sol was moved to 10 mL VF and made up with diluent (50 µg/mL sulbactam and 25 µg/mL durlobactam).

Preparation of sample stock sol

Copackaged kit containing each component in separate vials, equivalent weight of sulbactam: 1 g/vial and durlobactam: 0.5 g/vial equivalent weight of sample from sample vial of 20 mL of total vol was pipette out and transferred into a 100 mL clean dry VF and add about 250 mL of diluent and sonicate to dissolve it fully and make vol. up to mark with the same solvent and filtered through a 0.45 µ injection filter using a syringe (2000 µg/mL sulbactam and 1000 µg/mL durlobactam).

Sample working sol

0.25 mL of standard stock sol was moved to 10 mL VF and made up with diluent (50 µg/mL sulbactam and 25 µg/mL durlobactam).

Method validation

The validation of the HPLC method was conducted for the simultaneous estimation of the drug substances sulbactam and

durlobactam in accordance with ICH guidelines, to establish that the method is suitable for routine analysis [Figure 3].

System suitability

The assessment of system suitability was conducted for each validation parameter through the injection of a system suitability sol. containing sulbactam at a concentration of 50 µg/mL and durlobactam at 25 µg/mL. The chromatogram illustrating system suitability is presented in Figure 4, and the corresponding values are detailed in Table 1.

Specificity (selectivity)

Verification of interference with the best approach. It is expected that no interfering peaks will be observed in the blank and placebo samples at the RT of these drugs using this method. Therefore, this method is considered to be specific. Figure 5 shows an example chromatogram, and Table 2 displays the experimental results.

From the chromatogram presented above, no interference was detected in the blank and placebo sol. at the RT corresponding to sulbactam and durlobactam. All compounds exhibited good resolution and were effectively separated.

To evaluate the stability-indicating characteristics of the HPLC method, samples of sulbactam and durlobactam were subjected to stress conditions including exposure to heat, light, water, acid, base, and oxidation. A photodiode-array detector was used to analyse the resulting degraded samples.

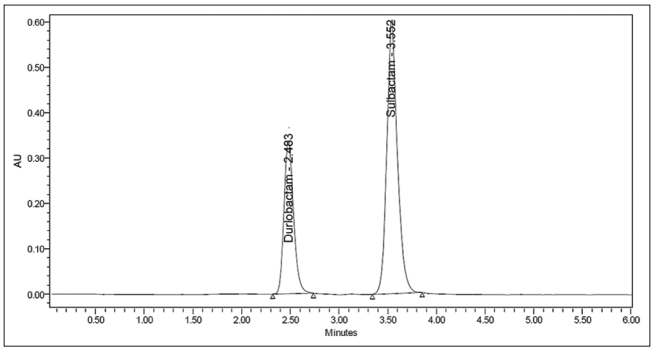

Figure 3: Optimized chromotogram of sulbactam and durlobactam

It was determined that the peak purity of durlobactam and sulbactam was satisfactory. Table 3 describes the circumstances for forced degradation, and Table 4 presents the findings.

From the findings, degradation peaks were noted when the samples were subjected to acid exposure. In light of the stress analysis, the active drug's generated peaks did not co-elute with any of the degradants.

Purification was done for each validation of sample quality, the purity angle and threshold are obtained for salbactum and

Table 1: System suitability chart

Durlobactam			Sulbactam			
(min) RT	TP	Tailing	(min) RT	TP	Tailing	RS
2.486	3296	1.2	3.553	6395	1.2	5.9
2.487	3202	1.2	3.553	6395	1.2	6.1
2.487	3232	1.2	3.553	6350	1.2	6.1
2.488	3292	1.2	3.554	6396	1.1	6.0
2.488	3250	1.2	3.555	6333	1.1	6.0
2.489	3220	1.2	3.557	6382	1.2	6.1

Table 2: Specificity data

Sample name	RT (mins)
Sulbactam	2.400
Durlobactam	3.500

Table 3: Forced degradation conditions for sulbactam and durlobactam

Stress condition	Solvent	(°C) Temperature	Exposed time
Acid	2N hydrochloric acid	60°C	30 min
Base	2N sodium hydroxide	60°C	30 min
Oxidation	20% hydrogen peroxide	60°C	30 min
Thermal	Diluent	105°C	6 h
Photolytic	Diluent	-	-
Hydrolytic	Water	60°C	

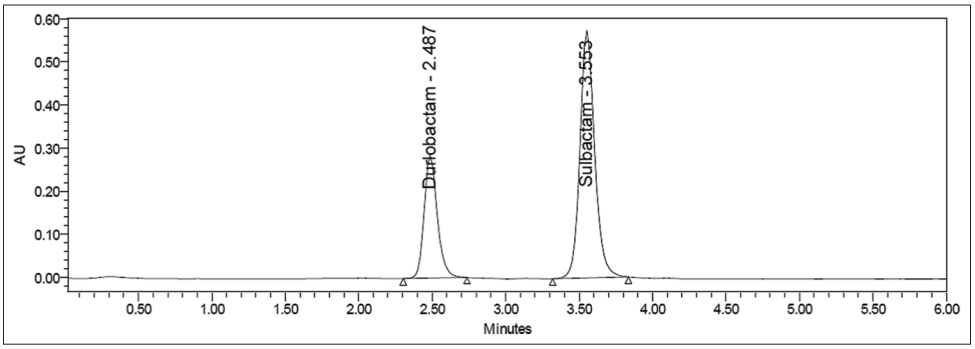

Figure 4: System suitability chromatogram of sulbactam and durlobactam

durlobactum, and are detailed in Table 5, whereas the plots are given in Figure 6.

Limit of detection (LOD) and limit of quantification (LOQ)

The term "detection limit" describes an extremely low analyte level concentration in a sample that is identifiable but might not be measurable. The limit of Quantification (LOQ) represents the lowest analytes concentration in a sample that can be quantitatively measured with acceptable, accuracy and Precision & it is dependent on the analytical technique employed, Table 6 displays the LOD and LOQ values for durlobactam and sulbactam, whereas Figures 7 and 8 show the appropriate typical chromatogram, respectively.

The LOQ Table 6 lists the values for durlobactam and sulbactam, and Figure 8 displays the appropriate example chromatogram.

Linearity

The method's linearity was established for sulbactam and durlobactam through the examination of the sols, which varied from 25% to 150% of the specification limit [Table 7]. The correlation coefficient for sulbactam and durlobactam was found to be 0.999. This result signifies a strong linearity in Figure 9a and b.

Assay data

Bearing the label claims a copackaged kit containing each component in separate vials, equivalent weight of sulbactam: 1 g/vial and durlobactam: 0.5 g/vial. Assay was performed with the above formulation. The average % assay for sulbactam and durlobactam obtained was 99.85% and 99.91%, respectively. Assay data are shown in Table 8.

Table 4: Degradation profile results

Degradation condition	Sulbactam % Undegraded	Durlobactam % Undegraded
Acid	94.13	94.03
Base	93.31	93.47
Oxidation	99.17	99.11
Thermal	99.09	99.43
Photolytic	98.85	99.19
Hydrolytic	99.09	99.67

Accuracy

Using a sol containing samples that have been tampered with of sulbactam and durlobactam, half, 100%, and 150% of the working strength, the method's accuracy was evaluated. Every sol. was made 3 times before being examined. Table 9 displays the % recovery outcomes for each contaminant.

System precision

Six replicate injections of the working sol at 100% of the specified limit were compared to the working strengths of durlobactam and sulbactam in order to assess the system's precision. Table 10 compiles the findings related to the peak area.

Six replicate injections of working sol yielded peak areas of sulbactam and durlobactam, and the percentage relative standard deviation (RSD). These areas were within the limit.

Method precision

The standard deviation (SD) of a population of data is one of the most commonly used statistical terms. By dividing the square root of the sum of the squares of the deviations of each individual result from the mean by one less than the total number of outcomes in the dataset, the SD is determined. C stands for the SD, which is represented by S.

$$S=\sqrt{\frac{\sum_{i=1}^{n}(x-x')^2}{(n-1)}}$$

The units used to measure the property and the SD are the same.

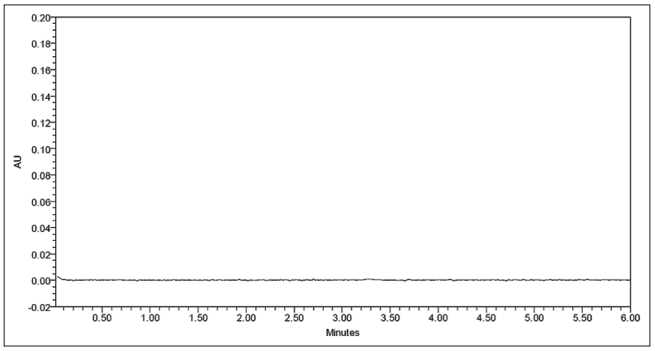

Figure 5: Specificity and overlay representation of high-performance liquid chromatography chromatogram of sulbactam and durlobactam

Table 5: Peak purity

S. no	Peak Name	RT	Area	Purity Angle	Purity Threshold	USP Plate Count	USP Tailing
1	Sulbactam	2.597	388822	0.341	0.491	4459	2.0
2	Durlobactam	3.567	787040	0.284	0.323	4179	1.1
3	Peak 1	3.857	77151	0.374	0.585	6337	1.5
4	Peak 2	5.049	20122	0.781	0.020	5703	1.1

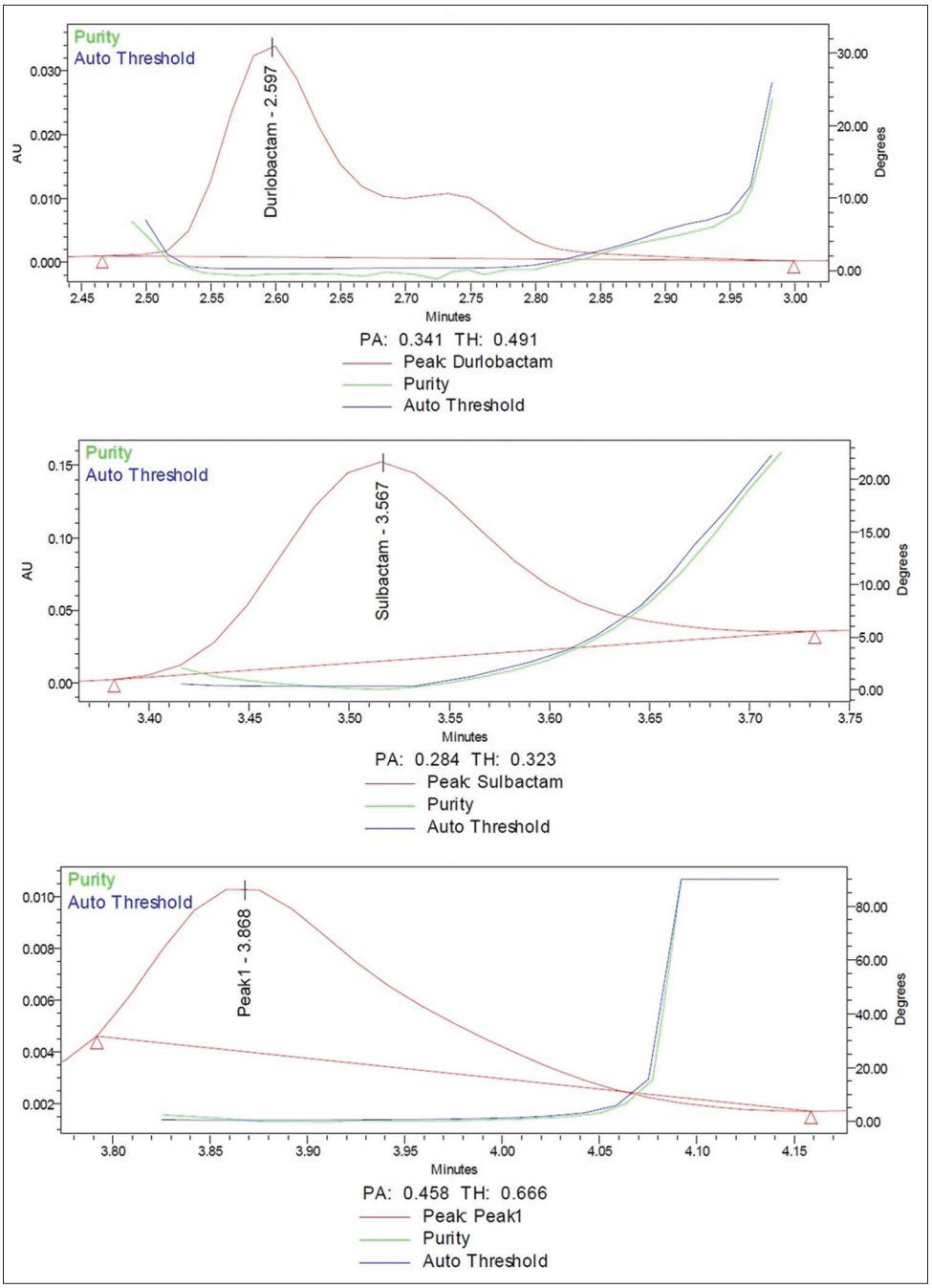

Figure 6: Purity plots are shown above to illustrate the estimated purity across the samples, included here for reference and validation of sample quality

Table 6: Summary of LOD and LOQ

Sample	LOD		LOQ	
	(µg/mL) Conc	S/N Ratio	(µg/mL) Conc	S/N ratio
Sulbactam	0.41	8.3	1.24	24.3
Durlobactam	0.46	17.0	1.39	47.2

LOD: Limit of detection, LOQ: Limit of quantification, Conc: Concentration

Variance is defined as the square of the SD (S2). The SD represented as a percentage of the average, or S/x, is known as the RSD. It is sometimes expressed as a percentage of the relative SD after being multiplied by 100. A more reliable representation of precision is offered by this approach.

$$\%\,\mathrm{RSD} = \frac{\mathrm{SD}}{\mathrm{Mean}} \times 100$$

Table 7: Linearity data

Percentage level	Sulbactam		Durlobactam	
	(µg/mL) Concentration	Area	(µg/mL) Concentration	Area
25	12.5	205625	6.25	102798
50	25	416631	12.5	219377
75	37.5	629490	18.75	317011
100	50	831976	25	417019
125	62.5	1038383	31.25	519672
150	75	1225122	37.5	618557

Table 8: Assay data of sulbactam and durlobactam

Standard area of sulbactam	Standard area of sulbactam	Percentage assay of sulbactam	Standard area of durlobactam	Standard area of durlobactam	Percentage assay of durlobactam
838285	832149	99.53	413370	417198	100.89
833302	830664	99.35	415145	412884	99.85
834391	832845	99.61	408420	415928	100.59
837576	835532	99.93	414990	412289	99.71
836209	839389	100.40	414732	416024	100.61
831692	838198	100.25	411904	414328	100.20
835243	834796	99.85	413094	414775	100.31
2558.6	3495.6	0.418	2600.9	1934.7	0.47
0.3	0.4	0.4	0.6	0.5	0.5

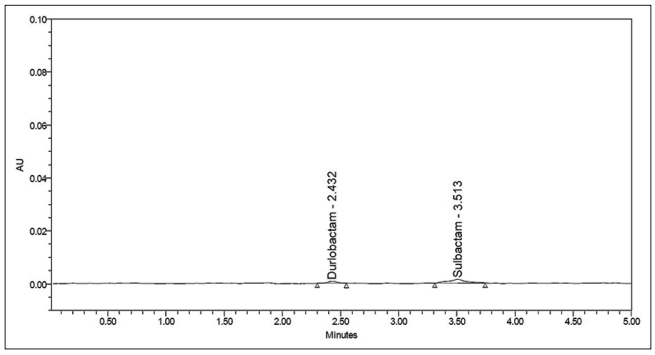

Figure 7: Limit of detection

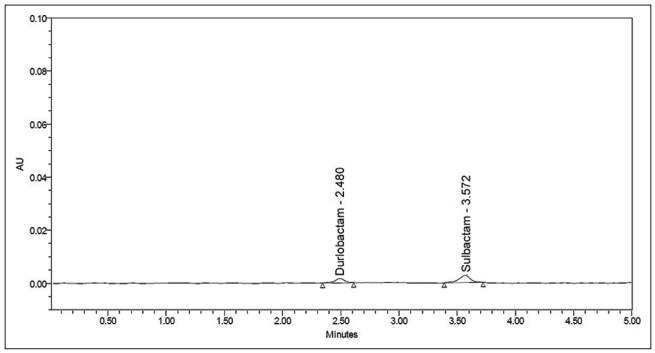

Figure 8: Limit of quantification

The method's accuracy was established through the examination of a sample consisting of sulbactam and durlobactam. (This involved six separate sample preparations.) The data collected is presented in Table 11.

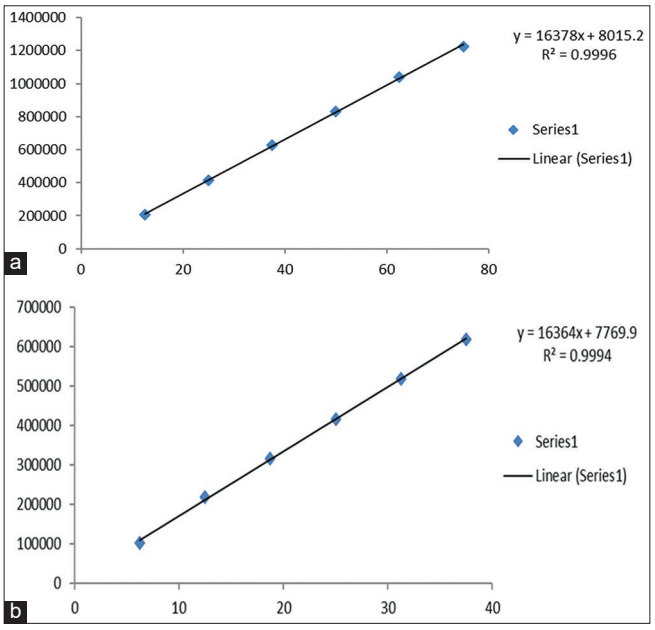

Figure 9: (a) Plot linearity of sulbactam. (b) Plot linearity of durlobactam

From the above results, the % RSD of the method precision study was within the limit for Sulbactam and Durlobactam.

Table 9: Percentage recovery data

Percentage level	Percentage recovery	
	Sulbactam	Durlobactam
50% Level	100.58	99.07
	99.94	99.44
	100.26	100.39
100% Level	100.07	100.74
	99.09	100.66
	100.05	99.51
150% Level	99.33	100.18
	100.30	99.41
	99.76	99.79
Mean %	99.93	99.91

Table 10: System precision data

Injection	Sulbactam	Durlobactam
1	838285	413370
2	833302	415145
3	834391	408420
4	837576	414990
5	836209	414732
6	831692	411904
Avg	835243	413094
Standard deviation	2558.6	2600.9
Percentage relative standard deviation	0.3	0.6

Table 11: Method precision data

Injection	Sulbactam	Durlobactam
1	832149	417198
2	830664	412884
3	832845	415928
4	835532	412289
5	839389	416024
6	838198	414328
Avg	834796	414775
Standard deviation	3495.6	1934.7
Percentage relative standard deviation	0.4	0.5

Intermediate precision differs from repeatability in that it reflects the accuracy achieved in a single laboratory over an extended duration, typically spanning a number of months, and considers a greater number of variables than repeatability. Specifically, it involves various analysts, calibrants, reagent batches, columns, spray needles, and so forth. These elements remain constant throughout a single day, meaning they exhibit systematic behavior within that daily timescale; however, they do not maintain consistency over a longer period and thus act as random factors in the context of intermediate precision. Due to the inclusion of more influencing factors in the calculation of intermediate precision, its value, represented as SD (as discussed in the following section), is greater than that of the repeatability SD and depicted in Table 12.

Table 12: Intermediate precision data

Injection	Sulbactam	Durlobactam
1	832366	414340
2	830896	417229
3	831215	415422
4	838278	416207
5	835916	412146
6	831332	413766
Avg	833334	414852
Standard deviation	3049.2	1820.7
Percentage relative standard deviation	0.4	0.4

Table 13: Robustness results

Chromatographic condition	Sulbactam (RSD)	Durlobactam (RSD)
(−) Flow	0.8	0.4
(+) Flow	0.9	0.4
(−) Temperature	0.7	0.4
(+) Temperature	0.9	0.5
(−) MP	0.5	0.4
(+) MP	0.8	0.3

RSD: Relative standard deviation, MP: Mobile phase

Robustness

To evaluate the robustness of the existing approach, the chromatographic parameters were purposefully changed. To assess the method's robustness, a system suitability sol is prepared in accordance with the methodology and put into the HPLC under a variety of modified conditions. These conditions include the MP (±10%), column oven temp (±5°C), and FR (±10%) from the actual method conditions. When the flow, temp, and MP were changed, no appreciable variations were seen, and the methodology was also followed by the system appropriateness. A summary of the robustness results is provided in Table 13.

RESULTS AND DISCUSSION

The precision of the developed analytical method was evaluated through the determination of relative standard deviation (R.S.D.) values, which were found to be 0.3 for Sulbactam and 0.6 for Durlobactam. These low R.S.D. values

clearly indicate the excellent repeatability and reliability of the method. Accuracy was assessed by recovery studies, yielding recovery rates of 99.85% for Sulbactam and 100.31% for Durlobactam, confirming that the method is highly accurate and free from significant interference from excipients present in the formulation.

The sensitivity of the method was demonstrated by calculating the limits of detection (LOD) and limits of quantification (LOQ) based on regression equations. For Sulbactam, the LOD and LOQ values were found to be 0.41 µg/mL and 1.24 µg/mL, respectively, while for Durlobactam, the corresponding values were 0.46 µg/mL and 1.39 µg/mL. These low detection and quantification limits reflect the high sensitivity of the proposed analytical technique.

Linearity was established over the studied concentration range, with regression equations of y = 16378x + 8015.2 for Sulbactam and y = 16364x + 7769.9 for Durlobactam, demonstrating a strong linear relationship between concentration and response. Recovery experiments and comprehensive statistical validation further confirmed the suitability and robustness of the method.

Overall, the developed method was successfully applied for the quantitative analysis of Sulbactam and Durlobactam in both pure drug substances and pharmaceutical dosage forms. The results obtained exhibited good accuracy, precision, and sensitivity, indicating that the method is reliable and reproducible. Therefore, the proposed analytical approach is well suited for routine quality control, assay determination, and quality monitoring of pharmaceutical formulations containing these compounds.

SUMMARY

The immobile phase utilized for separation is the SunFire C18 HPLC Column, featuring a particle size of 5 µm, with dimensions of L × ID. 250 mm × 4.6 mm. The MP consists of methanol and 0.01N KH_2PO_4 in a 70:30 ratio, maintained at a rate of flow of 1 mL/min, with a maximum wavelength set at 248 nm and a temp of 25.8°C. The average RT for sulbactam and durlobactam was determined to be 3.552 and 2.483 min, respectively. The % RSD for sulbactam and durlobactam was found to be 0.3 and 0.6, respectively. The % recovery rates achieved were 99.85% for sulbactam and 100.31% for durlobactam. The LOD and LOQ values derived from the regression equations for sulbactam and durlobactam were 0.41, 1.24 and 0.46, 1.39, respectively. The regression equation for sulbactam is y = ×16378 + 8015.2, whereas for durlobactam it is y = ×16364 + 7769.9. Both recovery tests and statistical validation of the method were conducted. The compounds in question, whether in their pure forms or within pharmaceutical formulations, have been effectively analyzed using the proposed method, demonstrating high accuracy and precision. This technique is applicable for routine analysis and quality control of pharmaceutical compositions.

ABBREVATIONS

- RP-H.P.L.C: Reverse Phase High Performance Liquid Chromatography
- H.P.L.C: High Performance Liquid Chromatography
- R.S.D: Relative Standard Deviation
- L-O-D: Limit of Detection
- L-O-Q: Limit of Quantification
- Temp: Temperature
- Vol: Volume
- KH_2PO_4: potassium dihydrogen phosphate
- µm: micrometer
- nm: nanometer
- °C: Degree Centigrade
- mins: Minutes
- I.C.H: International Council for Harmonisation
- mL: milliliter
- mm: millimeter
- v/v: volume per volume
- µg: microgram
- Std: Standard
- dev: Deviation
- RT: Retention Time
- FR: Flow Rate
- MP: Mobile Phase
- V.F: Volumetric Flask
- Sol: Solution
- Conc: Concentration

CONCLUSION

For the simultaneous approximation of analytes as tablets, a precise, dependable, and unambiguous method has been developed. Six injections of the standard were used to evaluate the attributes of system appropriateness, and the outcomes fell well within the acceptable range (limit of <2). An R^2 value of 0.999 was obtained from a linearity analysis conducted over levels ranging from 25% to 150%.

Precision, accuracy, LOD, LOQ, and robustness were among the validation metrics that were found to be within acceptable bounds. For sulbactam and durlobactam, the recovery percentages were reported as 99.93% and 99.91%, respectively. With a runtime of <8 min, this approach stands out for its simplicity, precision, sensitivity, speed, and cost-effectiveness. This technique can be utilised as well in practice to ascertain the tablet assay formulations.

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ETHICAL APPROVAL

Ethical approval was not necessary for this study.

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