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应用纪要

Qualitative and Quantitative Analysis of Gentamicin Sulfate and Related Impurities on ACQUITY UPLC with QDa

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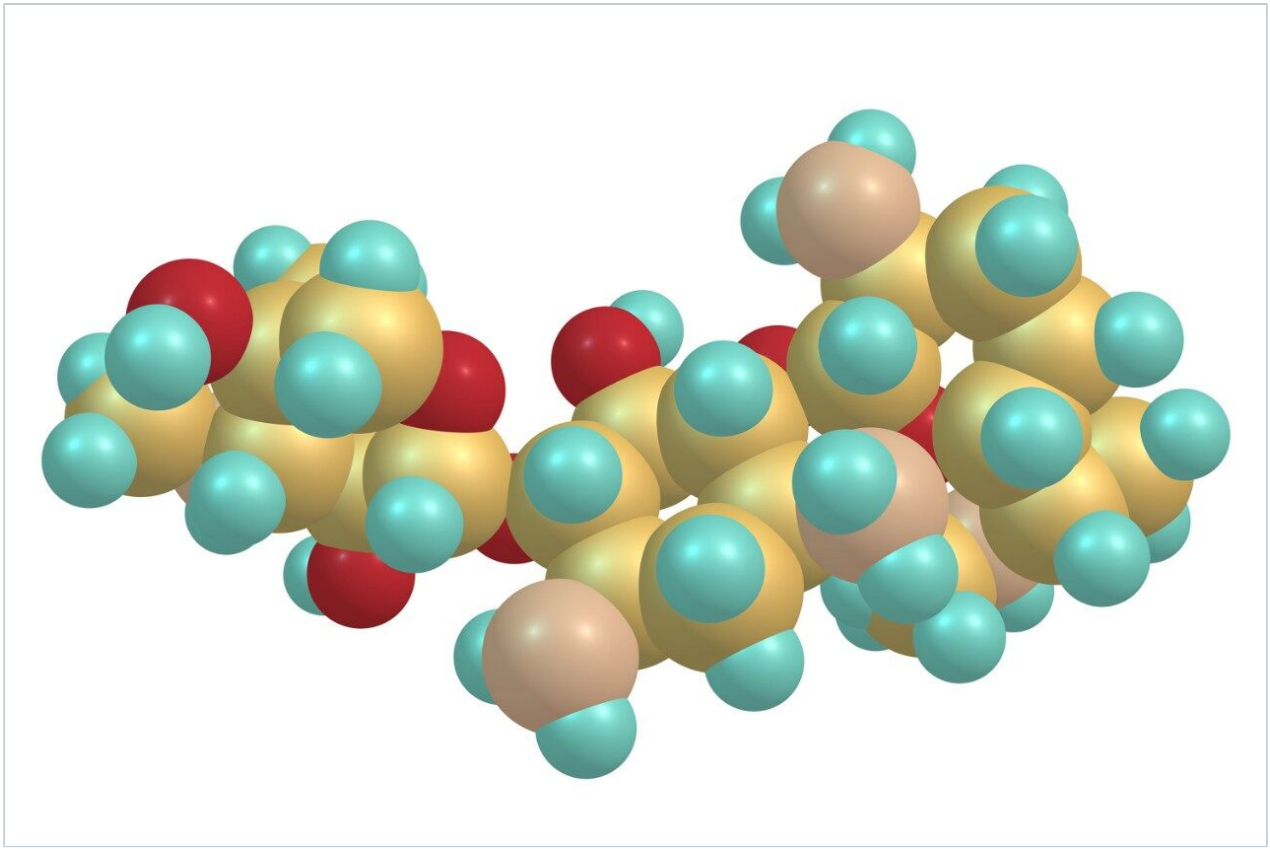
Waters Corporation



Abstract

In this method, five main analytes of Gentamicin (C_1, C_{1a}, C_2, C_{2a}, and C_{2b}) and related impurities of sisomicin, G1-418, garamine, gentamicin B, and gentamicin A, A1, A3 are separated within 35 minutes using an ACQUITY UPLC H-Class System with an ACQUITY QDa Mass Detector. The ACQUITY QDa Mass Detector is robust, reliable, and requires minimal user setup optimization, calibration, or adjustment. It integrates with current LC, ACQUITY UPLC, ACQUITY UPC^2, and purification systems.

Benefits

Separation of five active components of gentamicin and its related impurities within a 35-minute run time on ACQUITY UPLC H-Class System with ACQUITY QDa Detector.

Introduction

Gentamicin is an aminoglycoside antibiotic (AG) produced by Micromonospora purpurea and is widely used for the treatment of serious infections caused by both gram-negative and gram-positive bacteria. It is a mixture consisting of five major components, designated C_1, C_{1a}, C_2, C_{2a}, and C_{2b} together with numerous minor components including A, B, B1, and X2. Gentamicins are basic, water-soluble, relatively stable, structurally and closely related compounds without UV absorbing chromophores. This makes the HPLC analysis more difficult and challenging. Detection techniques like UV are not sensitive enough to detect low levels of related compounds of gentamicin.

Mass spectrometry is the technique of choice for the detection of aminoglycosides including gentamicin because of its high sensitivity and identification of compounds. There are no derivatization steps involved for this analysis technique.

In this experiment we have developed a 35-minute method for the qualitative and quantitative analysis of gentamicin sulfate and its related impurities on an ACQUITY UPLC System with an ACQUITY QDa Mass Detector.

The ACQUITY QDa Mass Detector is robust, reliable, and requires minimal user setup optimization, calibration, or adjustment. It integrates with current LC, ACQUITY UPLC, ACQUITY UPC^2, and purification systems. This mass spectral information integrates seamlessly into the same workflow.

The ACQUITY QDa Detector offers extended sample detection to quantify compounds with no UV response and is compatible with Empower Chromatography Data Software.

Experimental

LC conditions

System:	ACQUITY UPLC H-Class with ACQUITY QDa Detector
Column:	Atlantis T3, 3 µm, 4.6 mm × 150 mm (p/n: 186003729)
Flow rate:	0.6 mL/min
Buffer preparation:	0.2% TFA in water adjusted pH 2.3 with ammonia solution
Mobile phase A:	99.5% (buffer):0.5% (ACN+IPA:[1:1])
Mobile phase B:	100% methanol
Column temp.:	25 °C
Sample temp.:	5 °C
Injection volume:	1 µL
Sample concentration:	100 µg/mL
Wash and purge solvent:	1:1 water:acetonitrile
Seal wash:	9:1 water:methanol

Diluent: Water

Gradient:

Time (min)	Flow rate (mL/min)	%A	%B
0.00	0.600	100	0
18.00	0.600	100	0
20.00	0.600	0	100
25.00	0.600	0	100
26.00	0.600	100	0
35.00	0.600	100	0

Method parameters for ACQUITY QDa:

Instrument parameter	ESI positive
Mass range	150 to 1000 *m/z*
Capillary (KV)	0.8
Sampling cone	10
Sampling rate	1 pts/sec

SIR channels:

Name	Mass (Da)	Polarity	Cone voltage (V)
Garamine	322.20	Positive	10
Sisomicin	448.27		
Gentamicin C_{1a}	450.34		
Gentamicin C_2, C_{2a}, C_{2b}	464.34		
Gentamicin C_1	478.34		
G-418	497.31		

Standard solution preparation

Accurately weighed 10 mg of gentamicin sulfate (API) and dissolved in 2 mL of water as a standard stock solution of 5000 µg/mL concentration. Working solutions were prepared by appropriate dilutions from stock.

Accurately weighed 6 mg of sisomicin and dissolved in 10 mL of water as a stock solution of 600 µg/mL concentration. Working solutions were prepared by appropriate dilutions from stock.

Sample preparation

Sample solutions of injections containing 20 mg/2 mL of gentamicin sulfate, were prepared by diluting the sample with water to a working concentration of 100 µg/mL of total gentamicin.

Results and Discussion

Injected API spiked with sisomicin standard and observed all five analytes and impurities.

System suitability parameters:

Parameter	EP criteria	USP criteria	Measured value
Resolution between sisomicin and gentamicin C1a	>1.2	N/A	1.3
Resolution between gentamicin C2 and C2b	N/A	>1.5	2.3
Signal-to-noise ratio for sisomicin	>20	N/A	27 (for 0.1 µg/mL Conc. of Sisomicin)

Name	*m/z*	RT (min)	Area	Area %	Resolution
Garamine	322.20	2.186	2300897	1.15	
Gentamicin A, A_1, A_3	469.28	2.495	574461	0.29	1.6
Gentamicin B	483.27	2.775	2692746	1.24	2.8
G-418	497.31	3.998	4027768	1.85	5.0
Sisomicin	448.27	4.872	18735960	8.63	3.5
Gentamicin C_{1a}	450.34	5.175	13322703	6.13	1.3
Gentamicin C_2	464.34	7.641	46785146	21.54	7.1
Gentamicin C_{2b}	464.39	8.555	4539737	2.09	2.3
Gentamicin C_{2a}	464.34	9.881	35808693	16.49	3.2
Gentamicin C_1	478.34	12.721	89074521	41.01	5.2

Reproducibility

The reproducibility test was performed with API of 100 µg/mL concentration spiked with 50 µg/mL of sisomicin impurity, the %RSD observed for the eight components in SIR method were within 5%.

Sr. no.	Component name	% RSD
1	Garamine	2.2
2	G-418	4.1
3	Sisomicin	1.5
4	Gentamicin C_{1a}	2.4
5	Gentamicin C_2	1.5
6	Gentamicin C_{2b}	2.1
7	Gentamicin C_{2a}	1.4
8	Gentamicin C_1	0.9

%RSD values for the eight components in SIR method.

Quantitation of sisomicin in gentamicin

Sisomicin LOD and LOQ

Injected 0.03 µg/mL (LOD) and 0.1 µg/mL (LOQ) concentration of sisomicin standard solution and observed that the S/N is 9 for sisomicin peak in 0.03 µg/mL and 27 is for 0.1 µg/mL.

Recovery study performed for sisomicin

Injected 20 µg/mL concentration of sisomicin individual standard and 20 µg/mL sisomicin solid powder spiked with 100 µg/mL concentration of API gentamicin. 105.96% recovery was observed.

% Recovery = (Sisomicin peak area in spiked solution – API solution)/[sisomicin std area (20 µg/mL)]

= (5216574-69266)/4857972

= 105.96%

Linearity for sisomicin

Prepared linearity solutions of sisomicin with different concentrations of 0.15 µg/mL, 0.3 µg/mL, 0.6 µg/mL, and 1.5 µg/mL solutions and plotted calibration curve, observed R value is 0.999 and R^2 value is 0.998.

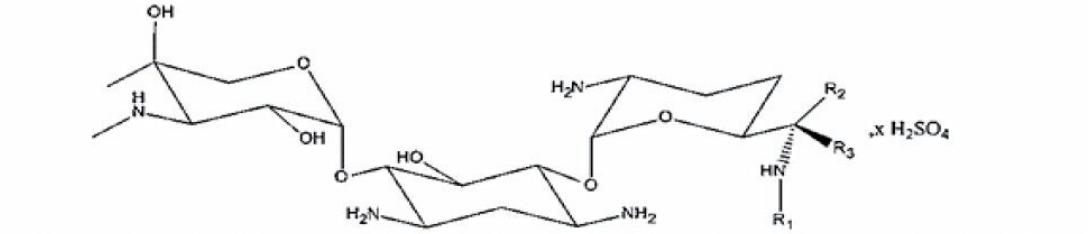
Qualitative/sample analysis

Diluted gentamicin sulfate USP injectable sample (Lot No: 6110501 – 20 mg/2 mL) to 100 µg/mL concentration and injected, observed the related impurities in SIR method.

Conclusion

In this method, five main analytes of Gentamicin (C_1, C_{1a}, C_2, C_{2a}, and C_{2b}) and related impurities of sisomicin, G1-418, garamine, gentamicin B, and gentamicin A, A1, A3 are separated within 35 minutes using an ACQUITY UPLC H-Class System with an ACQUITY QDa Mass Detector.

The ACQUITY QDa Mass Detector successfully achieved high sensitivity detection for sisomicin impurity at 0.03 µg/mL as LOD and 0.1 µg/mL as LOQ. It achieved reliable results. The %RSD obtained for all gentamicin analytes and impurities sisomicin and G-418 is less than 5%.



Gentamicin	R_1	R_2	R_3	MW ($g.mol^{-1}$)
C_1	CH_3	CH_3	H	477.60
C_{1a}	H	H	H	449.55
C_2	H	CH_3	H	463.58
C_{2a}	H	H	CH_3	463.58
C_{2b}	CH_3	H	H	463.58

Figure 1. Gentamicin sulfate.

Figure 2. ACQUITY UPLC H-Class System with ACQUITY QDa Detector.

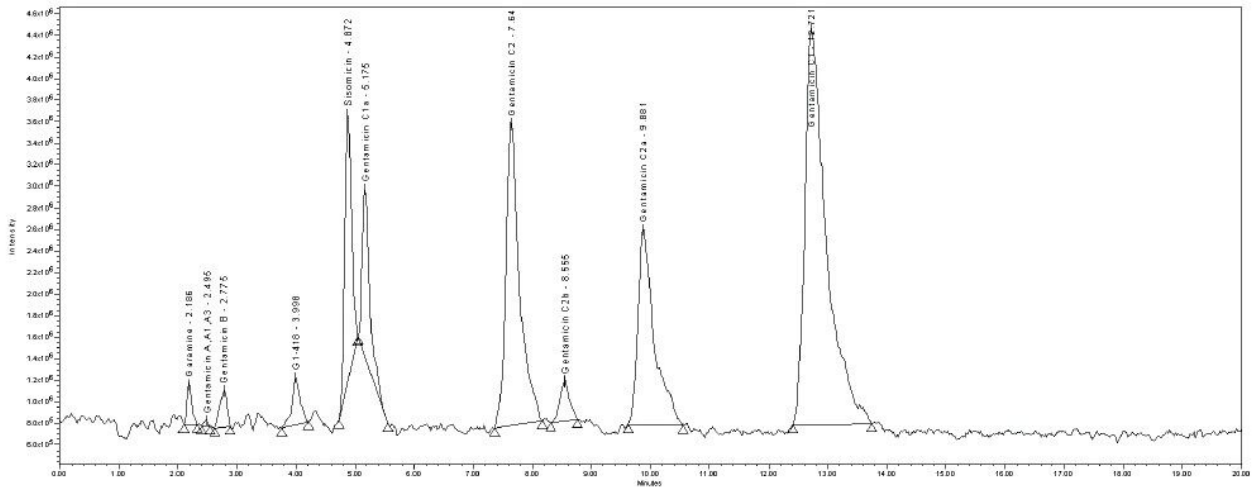


Figure 3. MS TIC of API spiked with sisomicin.

MS spectrum in ESI positive mode

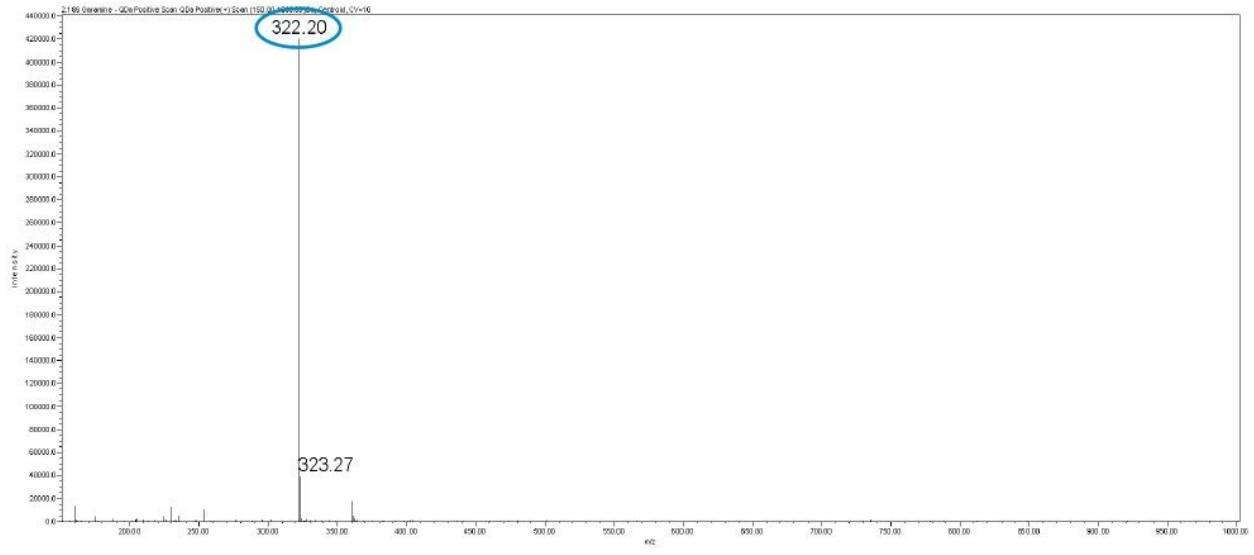


Figure 4. MS spectrum of garamine.

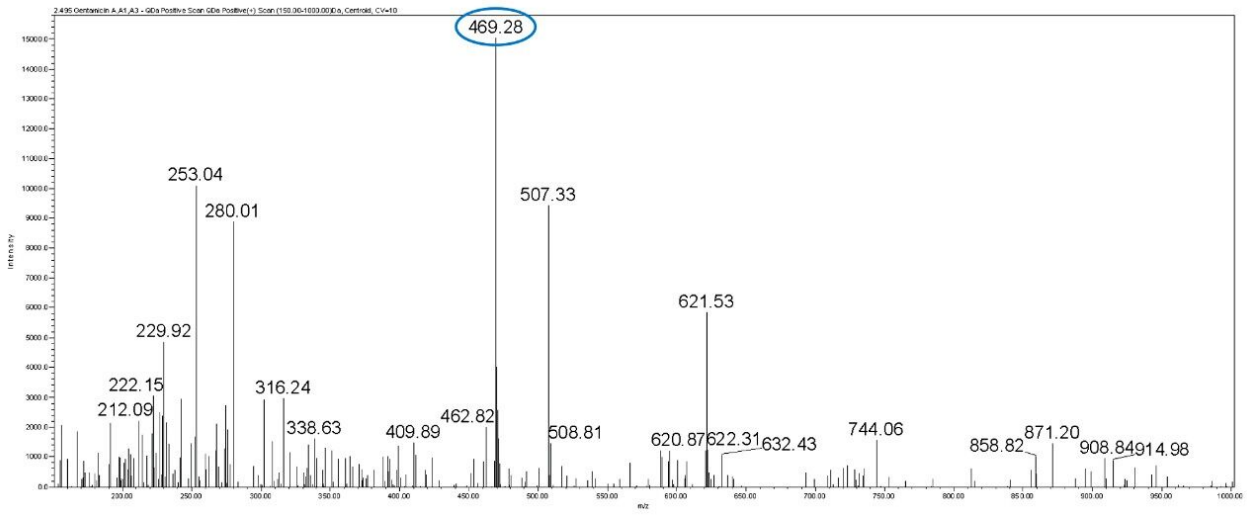


Figure 5. MS spectrum of gentamicin A, A_1, A_3.

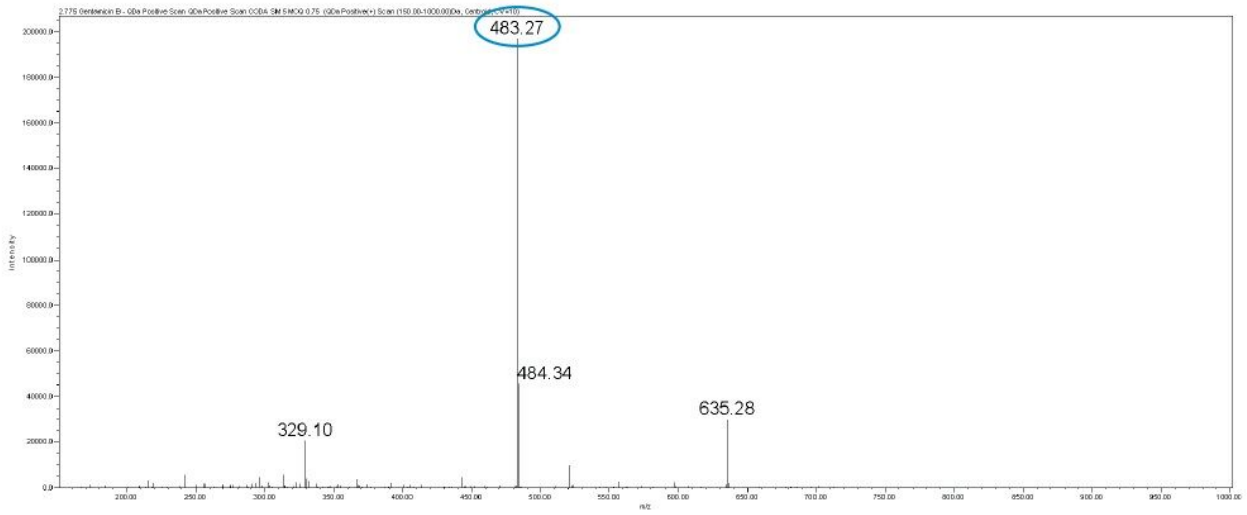


Figure 6. MS spectrum of gentamicin B.

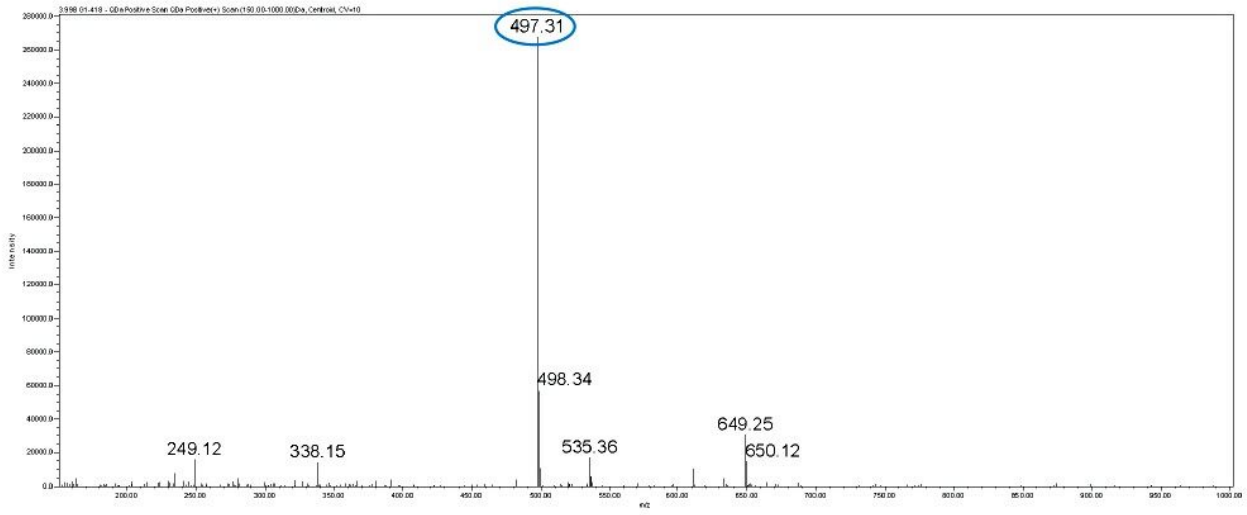


Figure 7. MS spectrum of G-418.

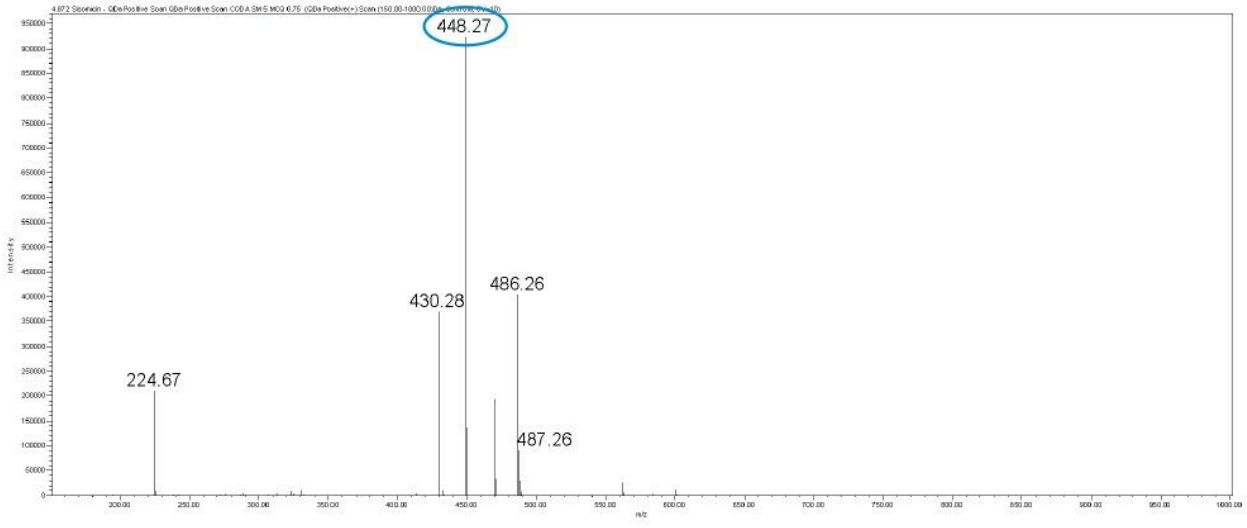


Figure 8. MS spectrum of sisomicin.

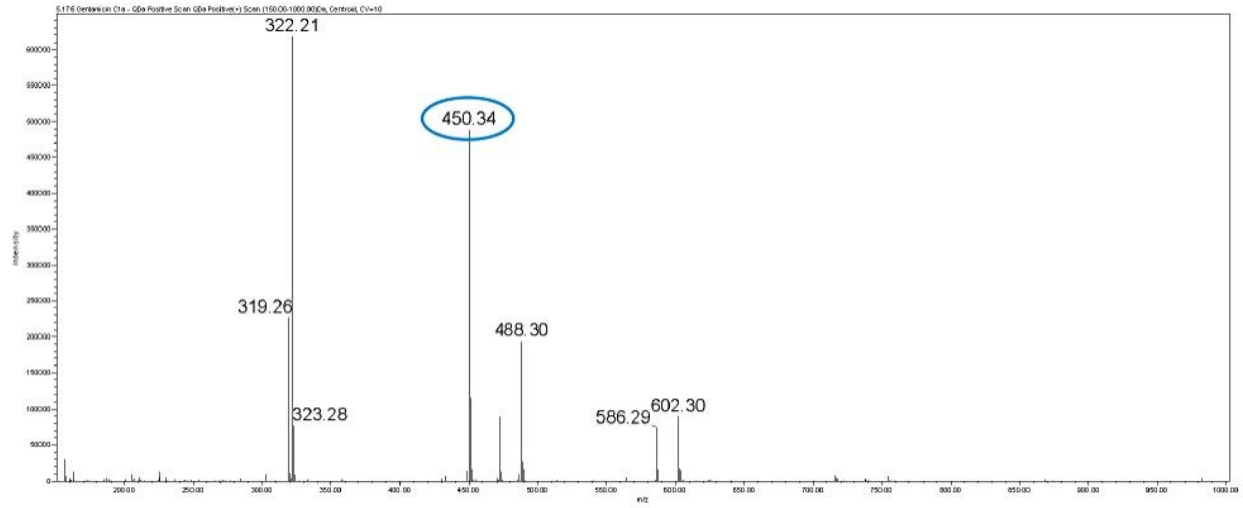


Figure 9. MS spectrum of gentamicin C_{1a}.

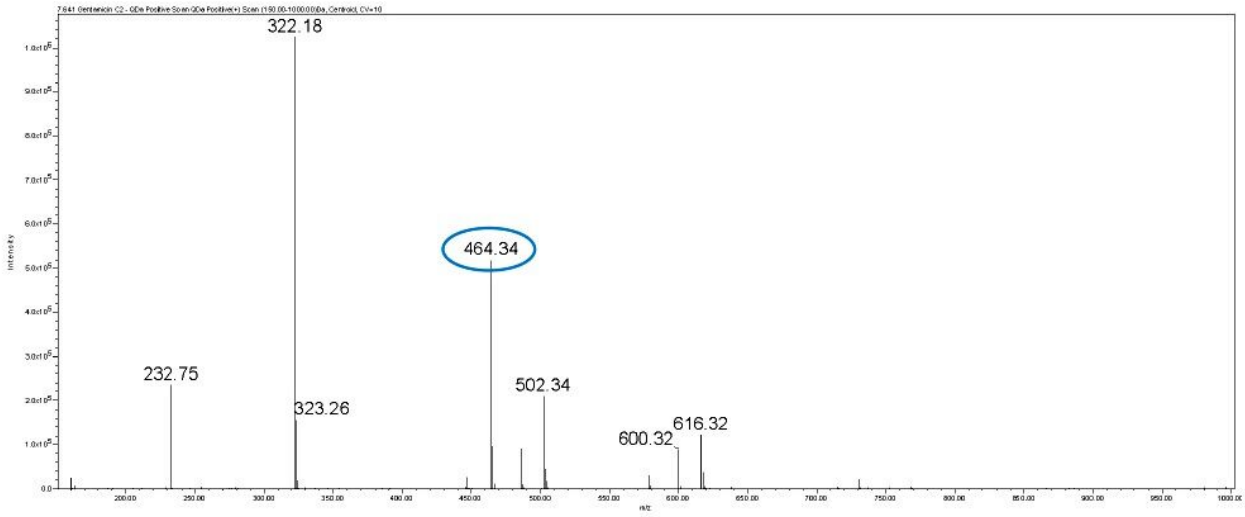


Figure 10. MS spectrum of gentamicin C_2.

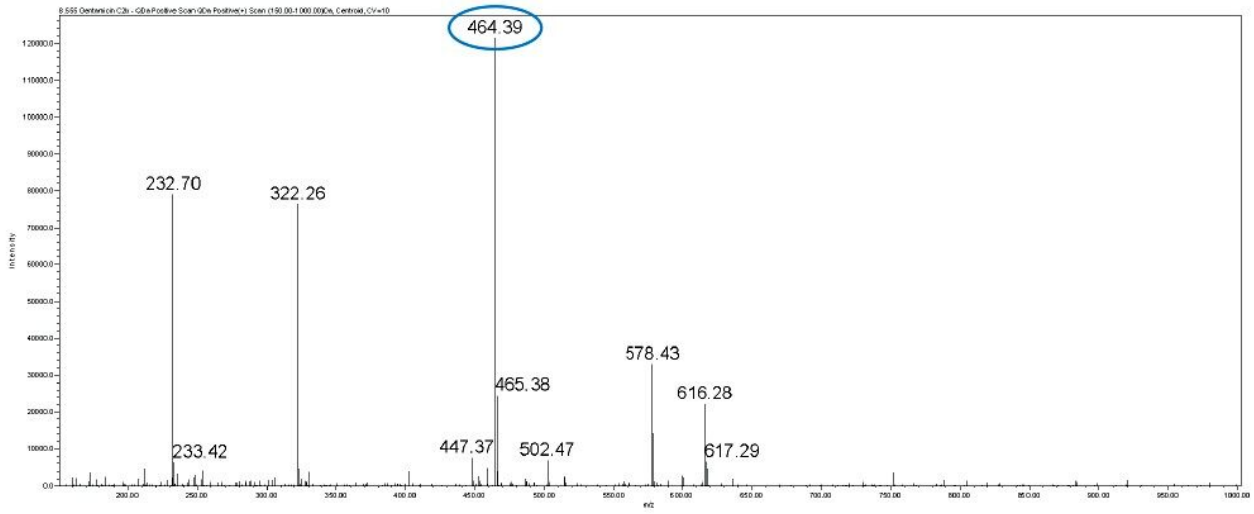


Figure 11. MS Spectrum of Gentamicin C_{2b}.

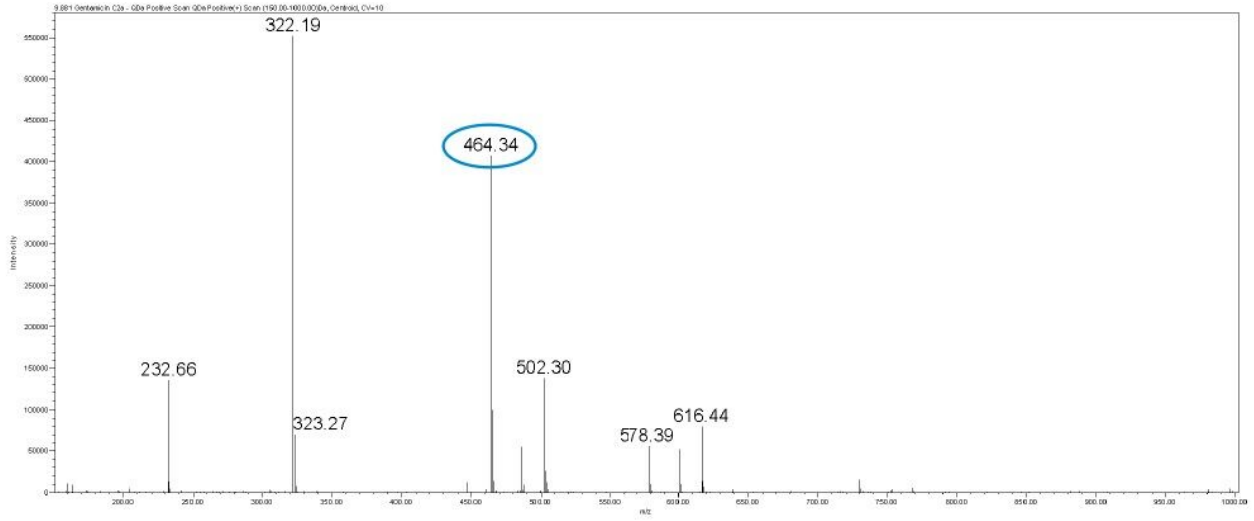


Figure 12. MS spectrum of gentamicin C_{2a}.

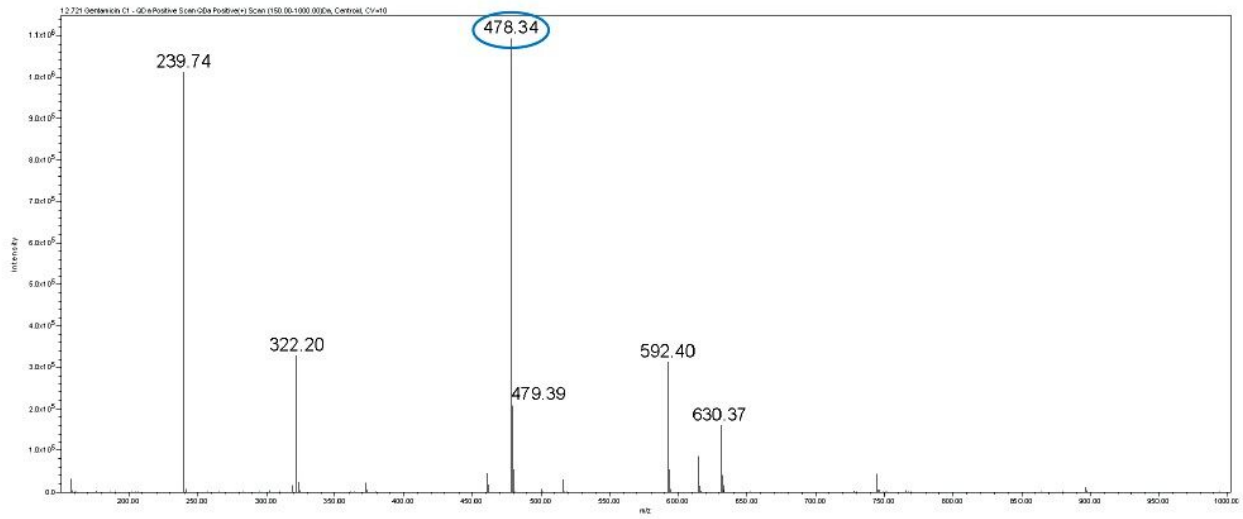


Figure 13. MS spectrum of gentamicin C_1.

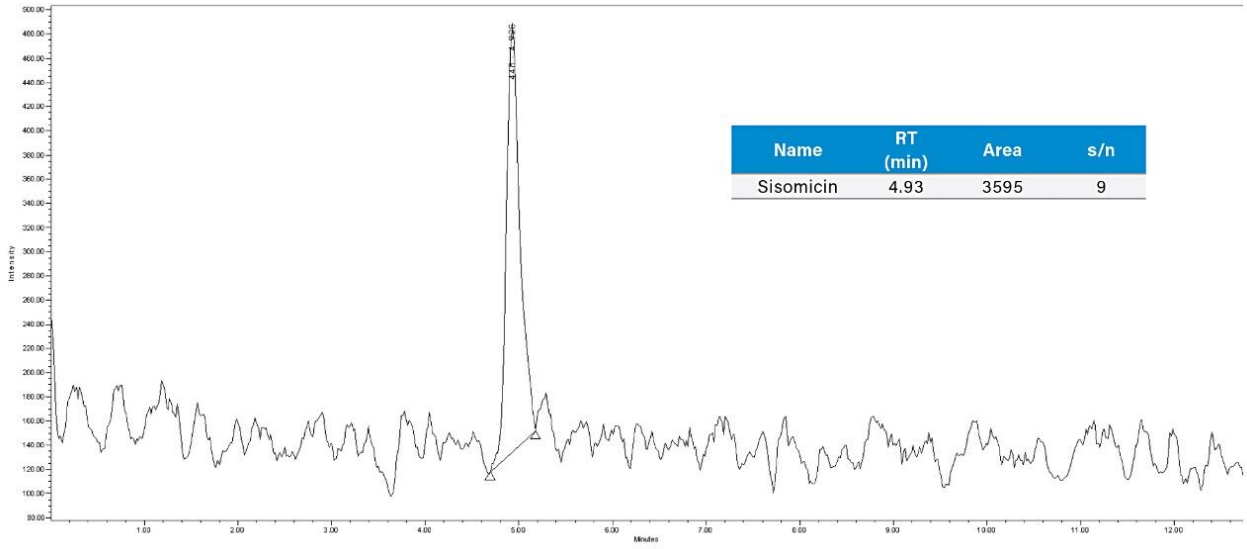
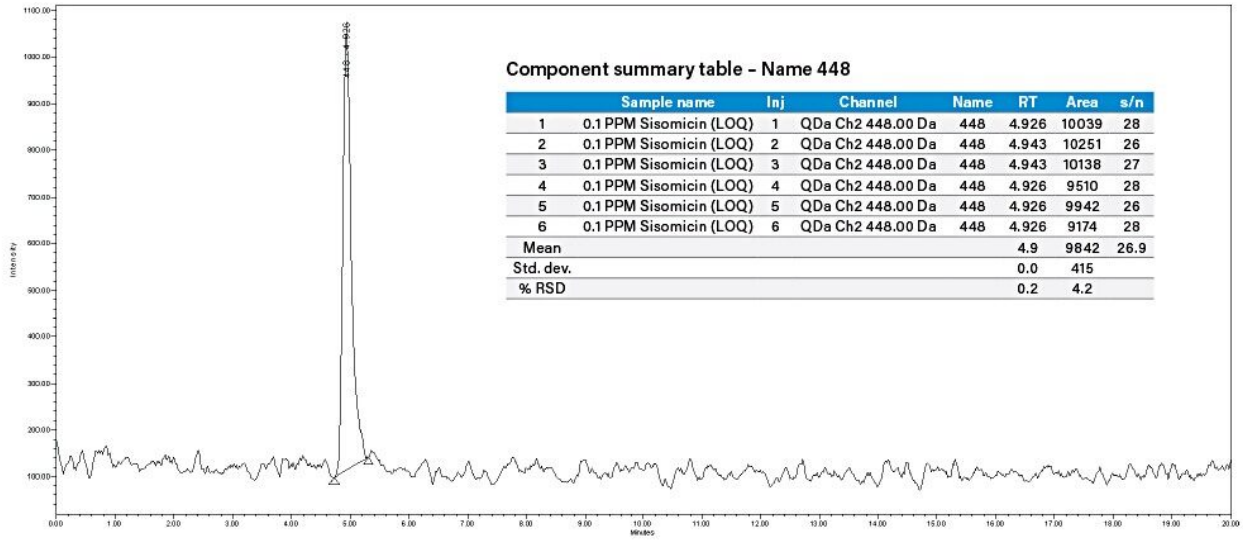


Figure 14. SIR chromatogram sisomicin of 0.03 µg/mL (LOD).



Component summary table – Name 448

	Sample name	Inj	Channel	Name	RT	Area	s/n
1	0.1 PPM Sisomicin (LOQ)	1	QDa Ch2 448.00 Da	448	4.926	10039	28
2	0.1 PPM Sisomicin (LOQ)	2	QDa Ch2 448.00 Da	448	4.943	10251	26
3	0.1 PPM Sisomicin (LOQ)	3	QDa Ch2 448.00 Da	448	4.943	10138	27
4	0.1 PPM Sisomicin (LOQ)	4	QDa Ch2 448.00 Da	448	4.926	9510	28
5	0.1 PPM Sisomicin (LOQ)	5	QDa Ch2 448.00 Da	448	4.926	9942	26
6	0.1 PPM Sisomicin (LOQ)	6	QDa Ch2 448.00 Da	448	4.926	9174	28
Mean					4.9	9842	26.9
Std. dev.					0.0	415	
% RSD					0.2	4.2	

Figure 15. SIR chromatogram sisomicin of 0.1 µg/mL (LOD).

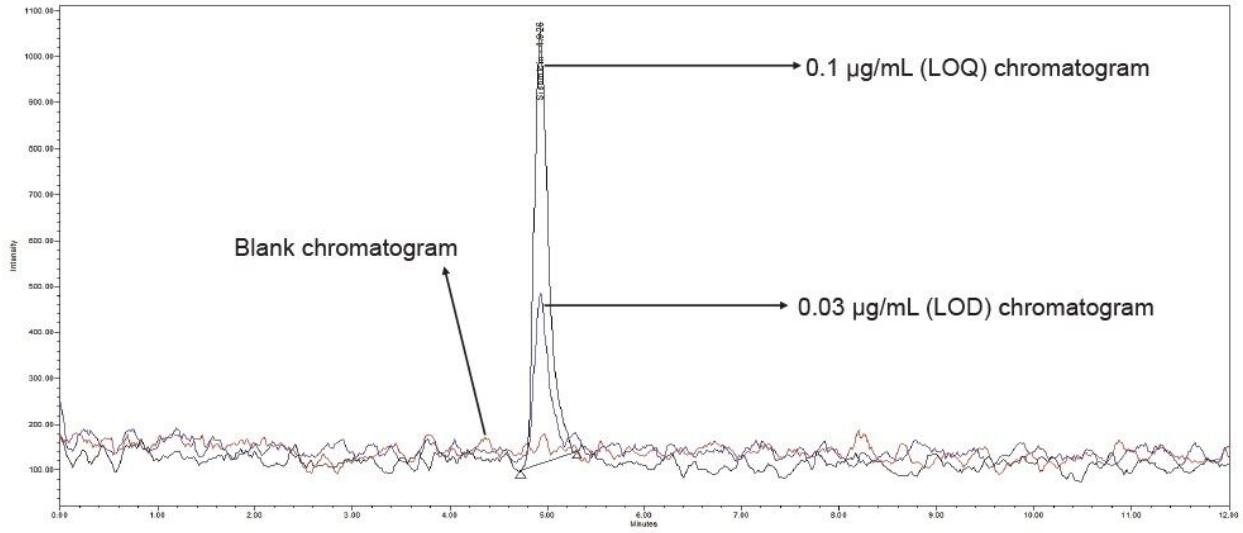


Figure 16. Overlay of SIR chromatogram of blank, LOD, and LOQ of sisomicin.

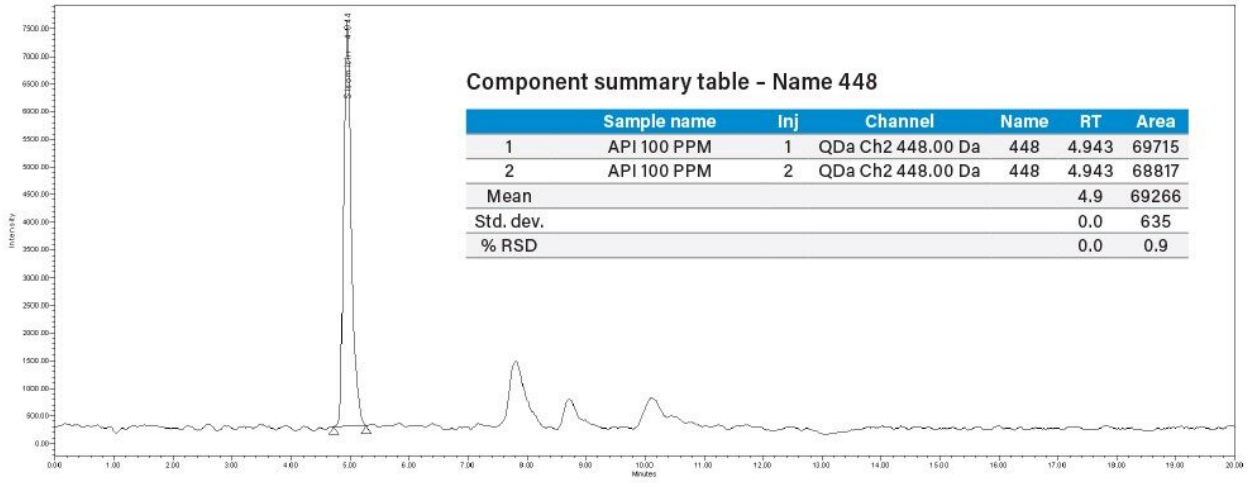


Figure 17. SIR chromatogram sisomicin in 100 µg/mL of API solution.

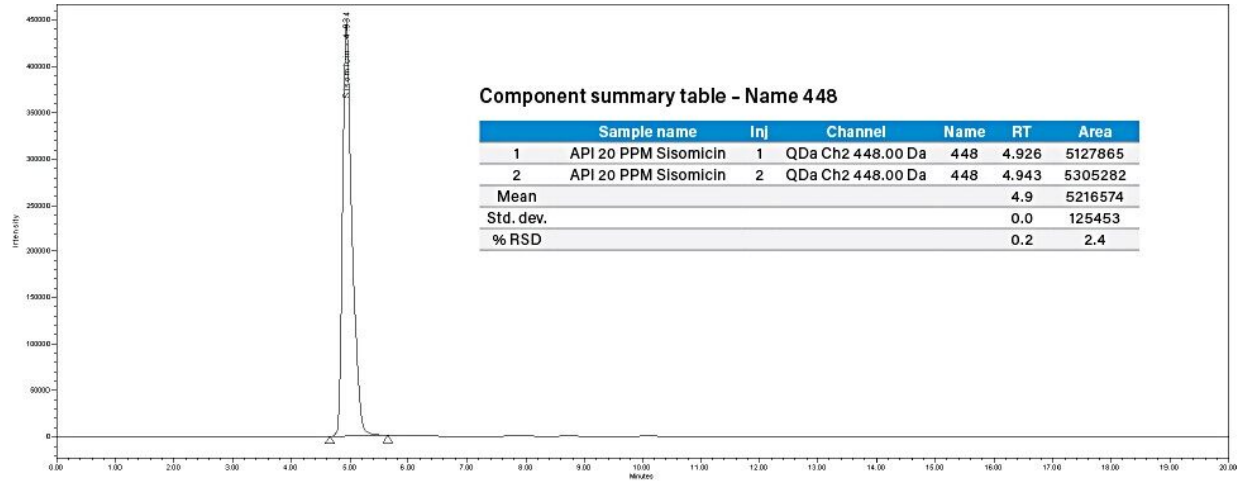
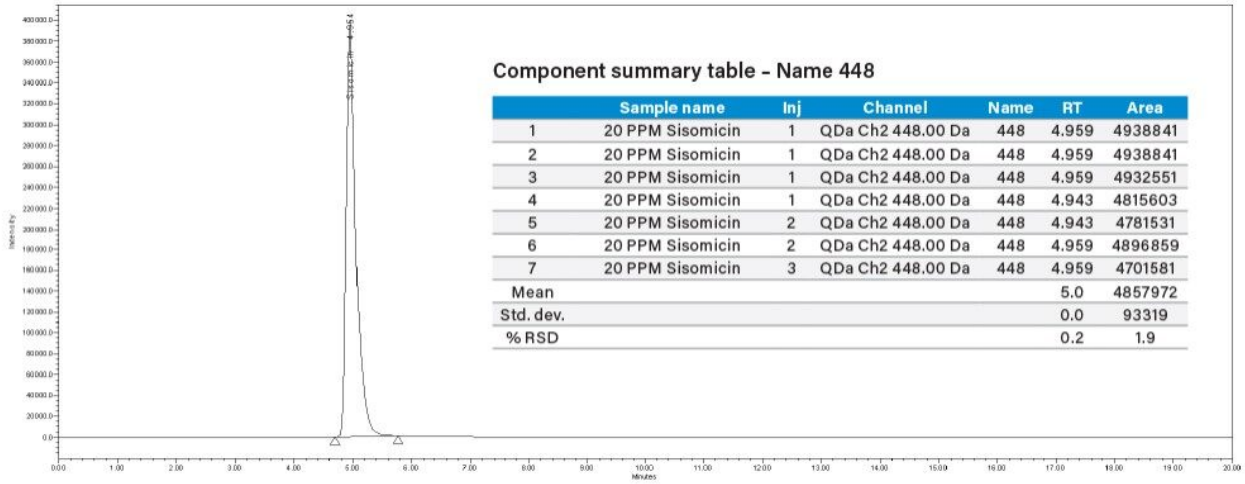


Figure 18. SIR chromatogram sisomicin 20 µg/mL spiked in 100 µg/mL of API solution.



Component summary table - Name 448

	Sample name	Inj	Channel	Name	RT	Area
1	20 PPM Sisomicin	1	QDa Ch2 448.00 Da	448	4.959	4938841
2	20 PPM Sisomicin	1	QDa Ch2 448.00 Da	448	4.959	4938841
3	20 PPM Sisomicin	1	QDa Ch2 448.00 Da	448	4.959	4932551
4	20 PPM Sisomicin	1	QDa Ch2 448.00 Da	448	4.943	4815603
5	20 PPM Sisomicin	2	QDa Ch2 448.00 Da	448	4.943	4781531
6	20 PPM Sisomicin	2	QDa Ch2 448.00 Da	448	4.959	4896859
7	20 PPM Sisomicin	3	QDa Ch2 448.00 Da	448	4.959	4701581
Mean					5.0	4857972
Std. dev.					0.0	93319
% RSD					0.2	1.9

Figure 19. SIR chromatogram sisomicin 20 µg/mL individual standard and result table.

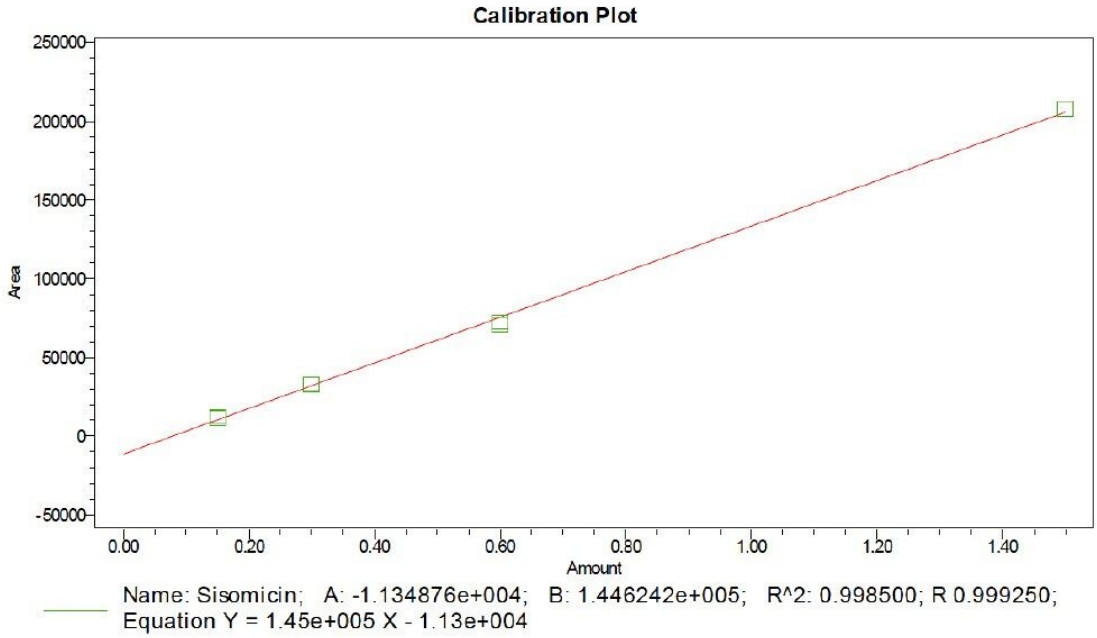
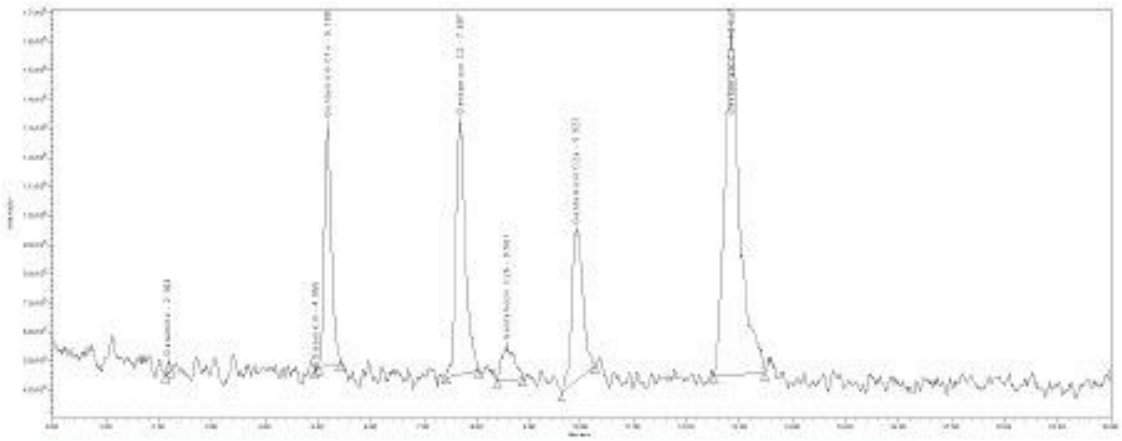


Figure 20. Linearity curve for sisomicin.



	Name	Retention time	Area (uV*sec)	% Area	Height (µV)	USP resolution
1	Garamine	2.164	132222	0.25	36358	
2	Sisomicin	4.955	32612	0.06	12685	34.67
3	Gentamicin C_{1a}	5.188	7846074	14.90	833541	1.50
4	Gentamicin C_2	7.697	11053735	20.99	871062	9.07
5	Gentamicin C_{2b}	8.561	1856000	3.52	116452	2.28
6	Gentamicin C_{2a}	9.923	7470349	14.19	516679	3.30
7	Gentamicin C_1	12.847	24270591	46.09	1197048	6.49

Figure 21. TIC chromatogram of gentamicin USP (Lot No: 6110501 – 20 mg/2 mL) of 100 µg/mL concentration.

References

1. Jammal, N.; AL-Mardini, M.A. Development and Validation of LC-MS Method for the Estimation of Gentamicin Sulfate and its Impurities in Injections. *International Journal of Pharmaceutical Sciences Review and Research*. 2014, 27(1), 70–73.
2. Graheka, R.; Zupancic-Kralj, L. Identification of Gentamicin Impurities by Liquid Chromatography Tandem Mass Spectrometry. *J. Pharm. Biomed. Anal.* 2009, 50(5), 1037–1043.
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4. Gentamicin Sulphate, *United States Pharmacopeia* (USP), USP 37–NF32, 3138–3139.

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