



Featured Application: LC-MS/MSによるRaptor C18 を用いたマルチクラス動物用医薬品分析

60を超えるマルチクラス抗生物質の分析

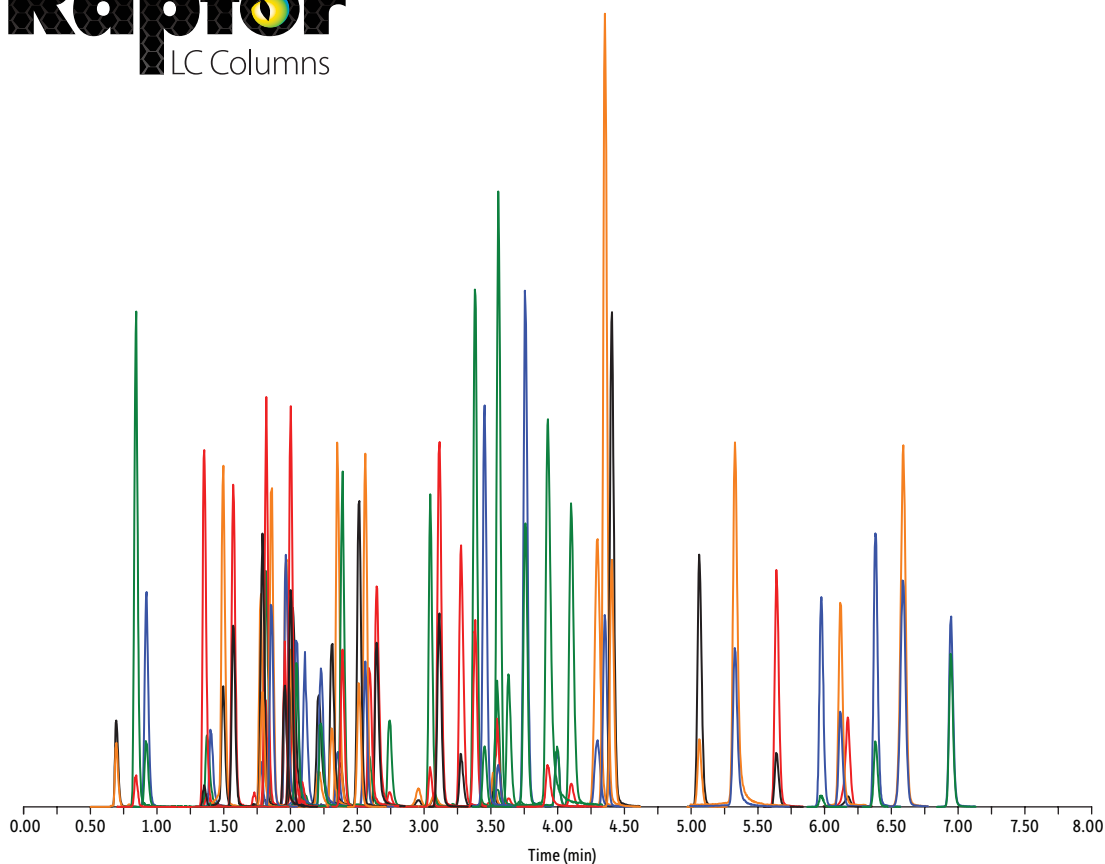
- ・ 高い分離効率と迅速な分析時間
- ・ 残留抗生物質分析の汎用性とグローバルな適用性一定量用に各クラスのパネルの最適化が可能：
 - マクロライド、リンコサミド、ストレプトグラミン系抗生物質(図1)
 - アンフェニコールとテトラサイクリン系抗生物質 (図2)
 - キノロン系抗生物質 (図3)
 - ペニシリン、セファロスポリン、およびテトラサイクリン系抗生物質 (図4)
 - サルファ剤(図5)
 - (イオノフォアの場合は、Raptor Biphenylを使用[図6])

食用動物に対する抗生物質の使用は、薬剤耐性菌を発生させる可能性があるため、公衆衛生上および安全上の懸念事項です。EUおよびカナダの多くの国では、治療以外の目的での抗生物質の使用を禁止しており、米国では抗生物質の成長促進剤としての使用を減らす政策を実施しています。動物用抗生物質の適切な使用を規制するために、米国食品医薬品局(FDA)は、様々な動物組織および食品について最大残留限界(MRL)を設定しています(21CFR Part556)。この規則を満たすためには、さまざまな種類の抗生物質の高感度、効率的、信頼性の高い分析法が必要であり、Raptor C18LCカラムが理想的な選択肢です。

Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion	Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Desacetyl cephalirin	0.70	150	382.03	111.92	124.21	31. Sarafloxacin	2.59	10	386.20	342.20	368.15
2. Sulfanilamide	0.85	200	172.98	93.07	75.23	32. Difloxacin	2.65	10	400.23	356.17	299.13
3. Amoxicillin	0.92	100	366.24	349.10	208.07	33. Cefazolin	2.75	100	455.10	323.06	295.09
4. Cephalirin	1.36	50	424.17	292.08	124.14	34. Spiramycin	2.96	200	843.64	540.36	699.48
5. Tildipirosin	1.38	200	734.59	561.45	204.15	35. Pirlimycin	3.05	20	411.32	363.18	327.21
6. Desfuranyl ceftiofur cysteine disulfide	1.40	300	549.16	183.02	126.00	36. Chlortetracycline	3.08	25	479.27	154.07	371.06
7. Lincomycin	1.50	50	407.32	359.23	389.28	37. Sulfachlorpyridazine	3.12	20	285.05	156.03	108.09
8. Sulfadiazine	1.57	20	251.18	156.04	92.08	38. Gamithromycin	3.28	100	777.63	619.52	601.45
9. Cefquinome	1.73	200	529.19	134.10	125.12	39. Sulfadoxine	3.39	10	311.17	156.03	108.09
10. Ampicillin	1.78	50	350.19	106.07	160.06	40. Sulfamethoxazole	3.46	20	254.18	155.98	147.06
11. Sulfathiazole	1.79	10	256.16	156.03	92.08	41. Cefoperazone	3.52	100	646.26	143.07	148.02
12. Marbofloxacin	1.81	10	363.20	72.11	320.10	42. Florfenicol*	3.55	200	356.10	336.02	184.98
13. Cefalexin	1.82	100	348.10	158.05	174.05	43. Sulfaethoxypyridazine	3.56	20	295.17	267.07	156.03
14. Sulfapyridine	1.86	10	250.13	156.10	92.08	44. Tilmicosin	3.64	100	869.72	696.50	522.42
15. Norfloxacin	1.96	20	320.23	276.20	233.13	45. Sulfisoxazole	3.76	20	268.14	156.03	113.10
16. Ofloxacin	1.98	10	362.21	318.20	261.15	46. Oxolinic acid	3.94	5	262.10	244.06	215.96
17. Sulfamerazine	2.00	20	265.08	156.03	92.08	47. Chloramphenicol*	4.00	200	321.16	151.99	257.04
18. Cefalonium	2.01	100	459.16	337.03	123.10	48. Ceftiofur	4.11	50	524.14	241.08	125.24
19. Oxytetracycline	2.02	25	461.27	426.15	443.32	49. Erythromycin	4.31	25	734.64	576.40	558.38
20. Ciprofloxacin	2.04	20	332.18	288.22	245.15	50. Sulfadimethoxine	4.36	10	311.17	156.09	108.09
21. Cefacetrile	2.09	300	362.07	258.08	178.01	51. Sulfaquinoxaline	4.42	20	301.18	156.04	108.02
22. Tulathromycin A	2.11	100	806.65	577.42	420.31	52. Tylosin**	4.67	100	916.62	772.49	598.36
23. Tetracycline	2.21	25	445.28	154.07	427.32	53. Penicillin G	5.07	100	335.18	176.07	160.07
24. Danofloxacin	2.23	20	358.22	340.16	314.21	54. Flumequine	5.34	5	262.15	244.11	202.03
25. Enrofloxacin	2.32	10	360.29	316.22	245.13	55. Penicillin V	5.56	100	351.10	160.06	114.07
26. Orbifloxacin	2.35	10	396.22	352.17	226.12	56. Oxacillin	5.99	100	402.15	160.05	114.06
27. Thiamphenicol*	2.38	200	354.16	290.04	184.98	57. Virginiamycin M1	6.13	50	526.43	508.31	355.10
28. Sulfamethazine	2.39	10	279.23	186.08	124.08	58. Tylvalosin	6.19	50	1042.71	814.46	640.39
29. Sulfamethizole	2.52	10	271.17	156.02	108.02	59. Cloxacillin	6.39	100	436.15	277.06	160.05
30. Sulfamethoxypyridazine	2.56	10	281.14	156.03	126.07	60. Nafcillin	6.60	25	415.19	199.09	171.06
						61. Dicloxacillin	6.96	100	470.11	160.05	311.02

*Acquired in negative ion mode

クロマトグラムと分析条件は2ページ目を参照



LC_FS0506

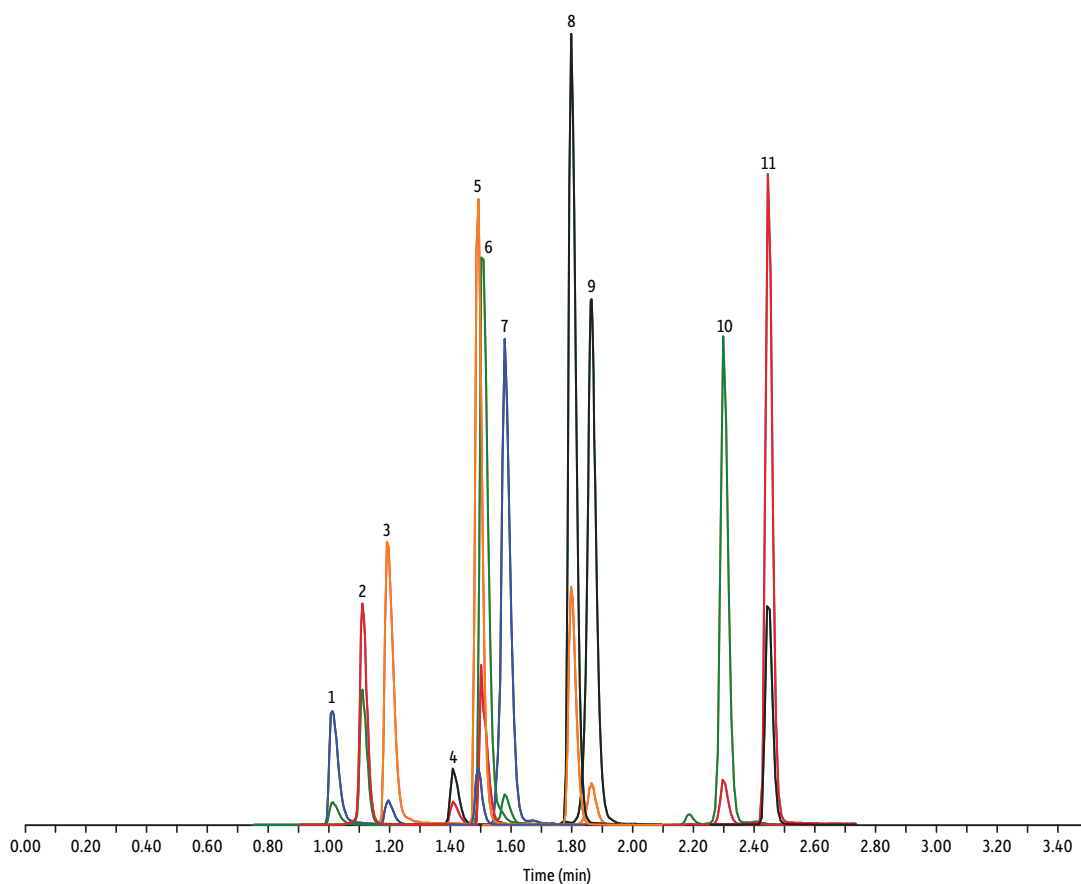
Column Raptor C18 (cat.# 9304A12)
Dimensions: 100 mm x 2.1 mm ID
Particle Size: 2.7 µm
Pore Size: 90 Å
Guard Column: Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
Temp.: 35 °C
Sample
Diluent: Water
Conc.: 5–300 ng/mL
Inj. Vol.: 2 µL
Mobile Phase
A: 0.1% Formic acid in water
B: 0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
4.50	0.4	65	35
7.00	0.4	45	55
7.01	0.4	90	10
9.00	0.4	90	10

Detector MS/MS
Ion Mode: ESI+/ESI-
Mode: Scheduled MRM
Instrument UHPLC
Notes

1. Positive and negative polarity data were collected simultaneously from a single injection.
 2. Amphenicol compounds (chloramphenicol, thiamphenicol, and florfenicol) were detected with negative polarity.
 3. The MRM was scheduled at +/- 20 to 30 seconds for each analyte.
 4. Multiclass antibiotics include penicillin, cephalosporin, tetracycline, sulfonamide, macrolide, lincosamide, streptogramin, amphenicol, and quinolone.
- **The retention time for Tylosin is noted in the peak list; however, it was not included in the chromatogram.

図1: Raptor C18を用いたマクロライド、リンコサミドおよびストレプトグラミン系抗生物質のLC-MS/MSによる分析



LC_FS0502

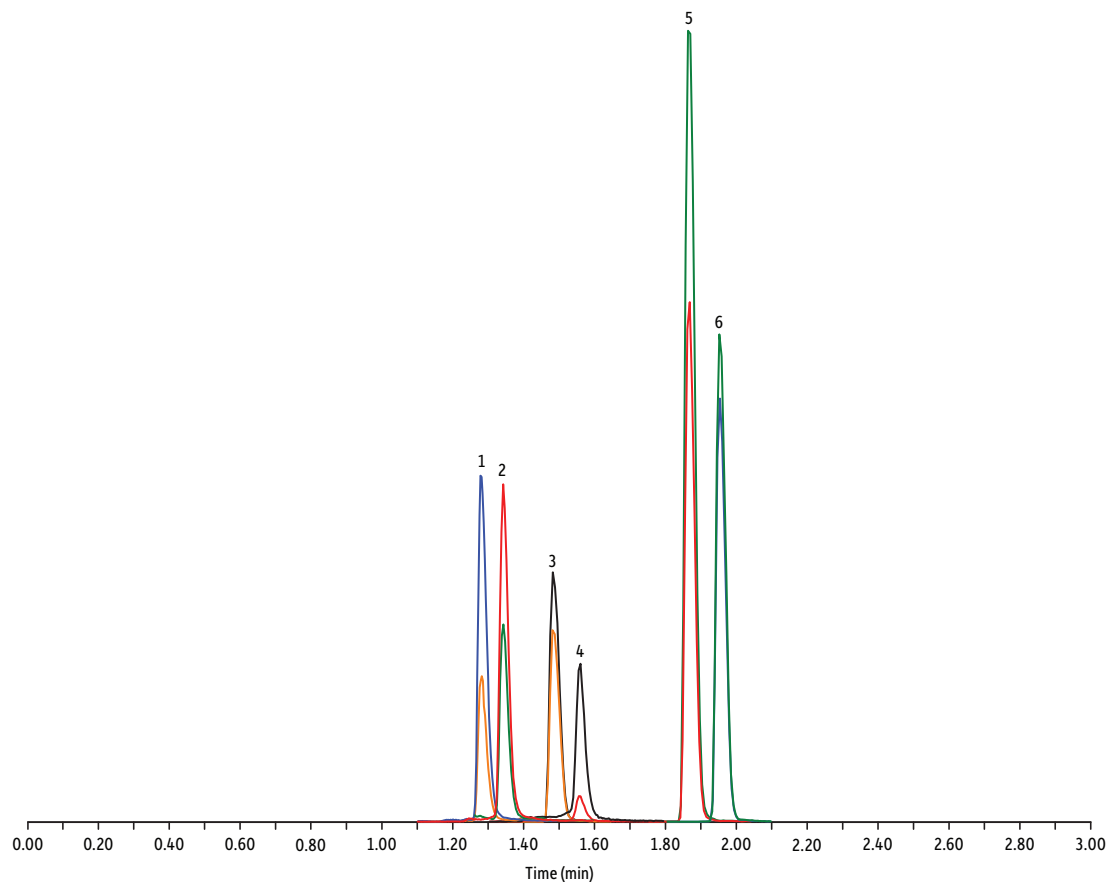
Peaks	tg (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Tildipirosin	1.01	200	734.59	561.45	204.15
2. Lincomycin	1.11	50	407.32	359.23	389.28
3. Tulathromycin A	1.19	100	806.65	577.42	420.31
4. Spiramycin	1.41	200	843.64	540.36	699.48
5. Pirlymycin	1.49	20	411.32	363.18	327.21
6. Gamithromycin	1.50	100	777.63	619.52	601.45
7. Tilimicosin	1.58	100	869.72	696.50	522.42
8. Erythromycin	1.80	25	734.64	576.40	558.38
9. Tylosin	1.87	100	916.62	772.49	598.36
10. Tylvalosin	2.30	50	1042.71	814.46	640.39
11. Virginiamycin M1	2.45	50	526.43	508.31	355.10

Column	Raptor C18 (cat.# 9304A12)
Dimensions:	100 mm x 2.1 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Guard Column:	Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
Temp.:	40 °C
Sample	
Diluent:	Water
Conc.:	20–200 ng/mL
Inj. Vol.:	2 µL
Mobile Phase	
A:	0.1% Formic acid in water
B:	0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
3.00	0.4	20	80
3.01	0.4	90	10
5.00	0.4	90	10

Detector	MS/MS
Ion Mode:	ESI+
Mode:	MRM
Instrument	UHPLC

図 2: Raptor C18を用いたアンフェニコール系、テトラサイクリン系抗生物質のLC-MS/MSによる分析



LC_FS0504

Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Oxytetracycline	1.28	25	461.27	426.15	443.32
2. Tetracycline	1.34	25	445.28	154.07	427.32
3. Thiamphenicol*	1.48	200	354.16	290.04	184.98
4. Chlortetracycline	1.56	25	479.27	154.07	371.06
5. Florfenicol*	1.86	200	356.10	336.02	184.98
6. Chloramphenicol*	1.95	200	321.16	151.99	257.04

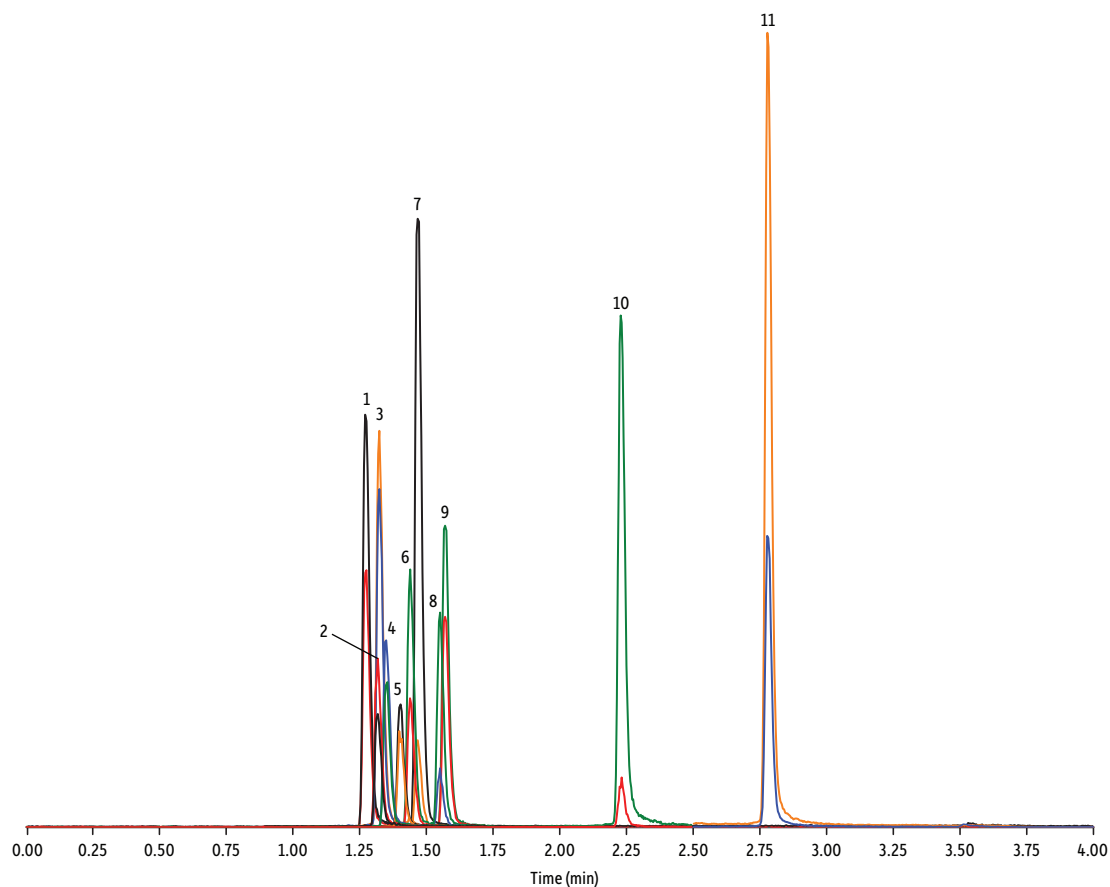
*Acquired in negative ion mode.

Column	Raptor C18 (cat.# 9304A12)
Dimensions:	100 mm x 2.1 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Guard Column:	Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
Temp.:	40 °C
Sample	
Diluent:	Water
Conc.:	25–200 ng/mL
Inj. Vol.:	2 µL
Mobile Phase	
A:	0.1% Formic acid in water
B:	0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
3.00	0.4	20	80
3.01	0.4	90	10
5.00	0.4	90	10

Detector	MS/MS
Ion Mode:	ESI+/ESI-
Mode:	MRM
Instrument	UHPLC
Notes	Tetracyclines and amphenicols were analyzed with ESI+ and ESI- mode, respectively.

図 3: Raptor C18を用いたキノロン系抗生物質のLC-MS/MSによる分析



LC_FS0505

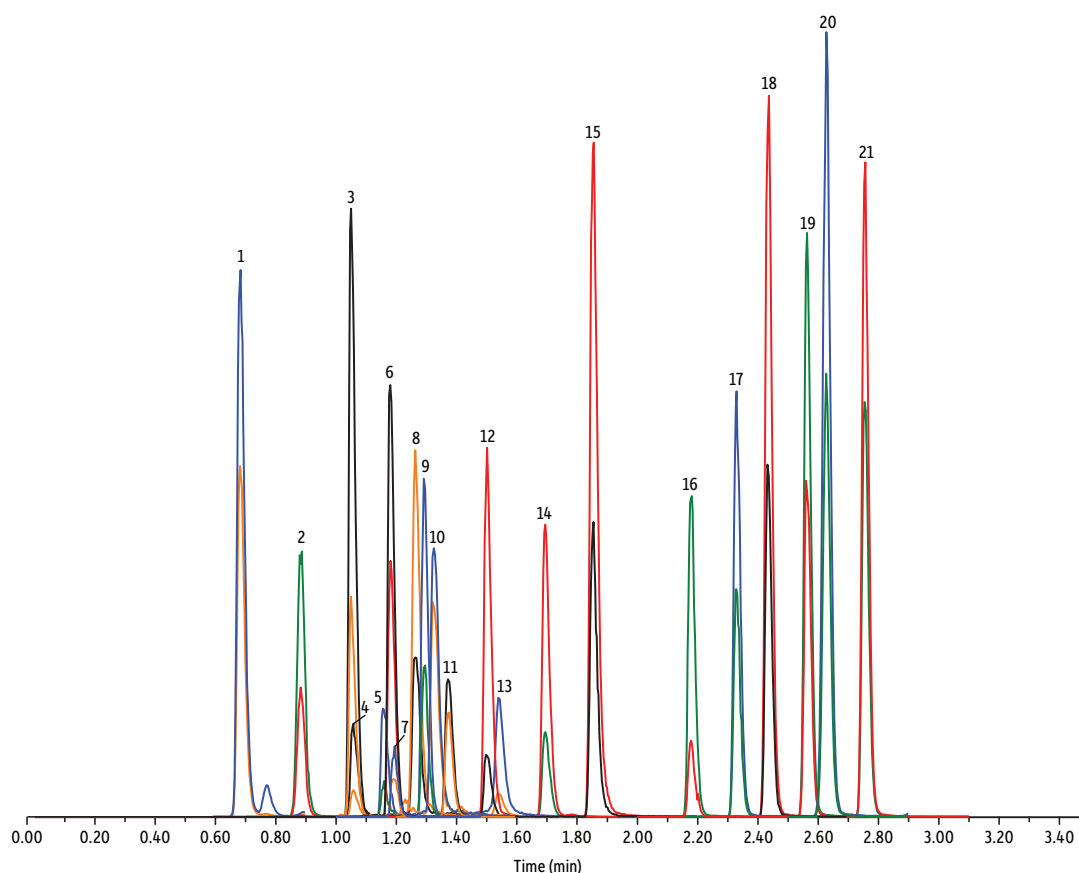
Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Marbofloxacin	1.28	10	363.20	72.11	320.10
2. Norfloxacin	1.32	20	320.23	276.20	233.13
3. Ofloxacin	1.32	10	362.21	318.20	261.15
4. Ciprofloxacin	1.35	20	332.18	288.22	245.15
5. Danofloxacin	1.40	20	358.22	340.16	314.21
6. Enrofloxacin	1.44	10	360.29	316.22	245.13
7. Orbifloxacin	1.47	10	396.22	352.17	226.12
8. Sarafloxacin	1.55	10	386.20	342.20	368.15
9. Difloxacin	1.57	10	400.23	356.17	299.13
10. Oxolinic acid	2.23	5	262.10	244.06	215.96
11. Flumequine	2.78	5	262.15	244.11	202.03

Column	Raptor C18 (cat.# 9304A12)
Dimensions:	100 mm x 2.1 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Guard Column:	Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
Temp.:	40 °C
Sample	
Diluent:	Water
Conc.:	5–20 ng/mL
Inj. Vol.:	2 µL
Mobile Phase	
A:	0.1% Formic acid in water
B:	0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
3.00	0.4	40	60
3.01	0.4	90	10
5.00	0.4	90	10

Detector	MS/MS
Ion Mode:	ESI+
Mode:	MRM
Instrument	UHPLC

図 4: Raptor C18を用いたペニシリン、セファロsporinおよびテトラサイクリン系抗生物質のLC-MS/MSによる分析



LC_FS0500

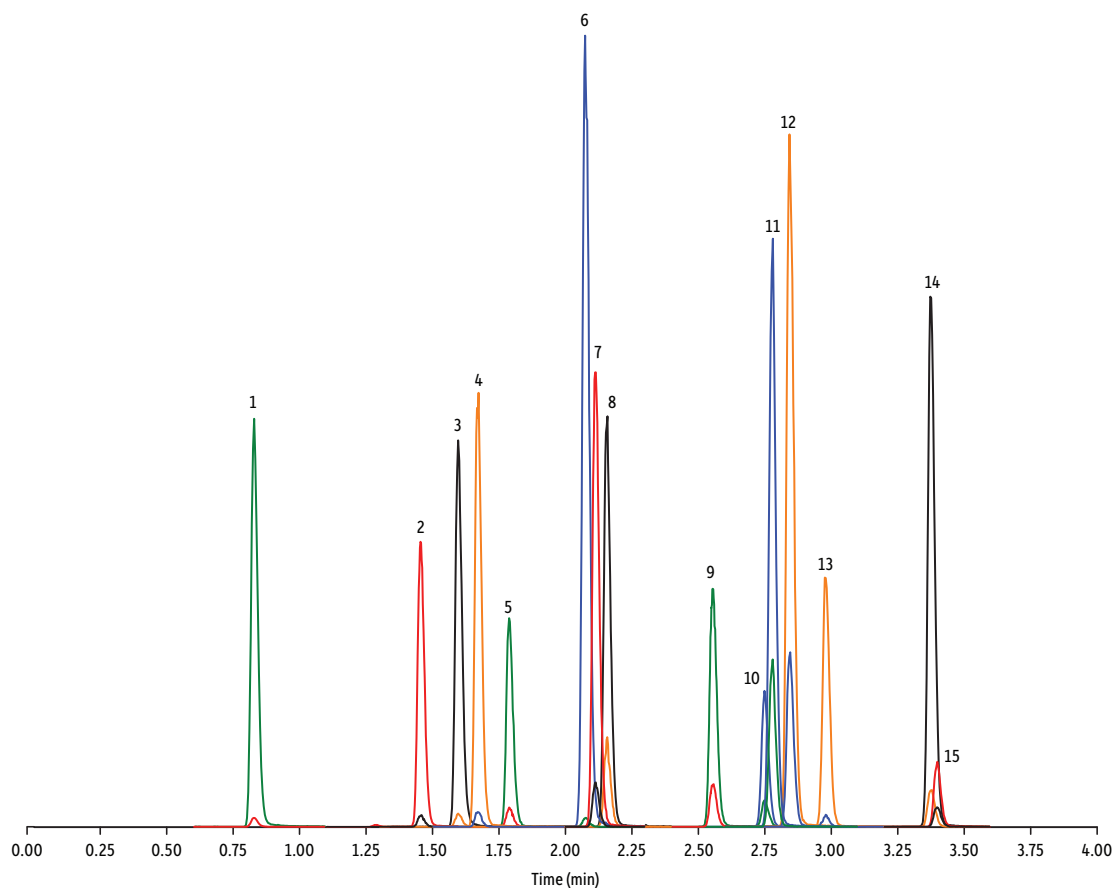
Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Desacetyl cephalirin	0.68	150	382.03	111.92	124.21
2. Amoxicillin	0.89	100	366.24	349.10	208.07
3. Cephalirin	1.05	50	424.17	292.08	124.14
4. Desfuroyl ceftiofur cysteine disulfide	1.06	300	549.16	183.02	126.00
5. Cefquinome	1.16	200	529.19	134.10	125.12
6. Ampicillin	1.18	50	350.19	106.07	160.06
7. Cefalexin	1.19	100	348.10	158.05	174.05
8. Oxytetracycline	1.26	50	461.27	426.15	443.32
9. Cefalonium	1.29	100	459.16	337.03	123.10
10. Tetracycline	1.32	50	445.28	154.07	427.32
11. Cefacetrile	1.37	300	362.07	258.08	178.01
12. Cefazolin	1.50	100	455.10	323.06	295.09
13. Chlortetracycline	1.54	50	479.27	154.07	371.06
14. Cefoperazone	1.69	100	646.26	143.07	148.02
15. Ceftiofur	1.85	50	524.14	241.08	125.24
16. Penicillin G	2.18	100	335.18	176.07	160.07
17. Penicillin V	2.33	100	351.10	160.06	114.07
18. Oxacillin	2.44	100	402.15	160.05	114.06
19. Cloxacillin	2.56	100	436.15	277.06	160.05
20. Nafcillin	2.63	25	415.19	199.09	171.06
21. Dicloxacillin	2.76	100	470.11	160.05	311.02

Column Raptor C18 (cat.# 9304A12)
 Dimensions: 100 mm x 2.1 mm ID
 Particle Size: 2.7 µm
 Pore Size: 90 Å
 Guard Column: Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
 Temp.: 40 °C
Sample
 Diluent: Water
 Conc.: 25–300 ng/mL
 Inj. Vol.: 2 µL
Mobile Phase
 A: 0.1% Formic acid in water
 B: 0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
3.00	0.4	20	80
3.01	0.4	90	10
5.00	0.4	90	10

Detector MS/MS
 Ion Mode: ESI+
 Mode: MRM
Instrument UHPLC

図 5: Raptor C18 を用いたサルファ剤のLC-MS/MSによる分析



LC_FS0501

Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Sulfanilamide	0.83	200	172.98	93.07	75.23
2. Sulfadiazine	1.45	20	251.18	156.04	92.08
3. Sulfathiazole	1.60	10	256.16	156.03	92.08
4. Sulfapyridine	1.67	10	250.13	156.10	92.08
5. Sulfamerazine	1.79	20	265.08	156.03	92.08
6. Sulfamethazine	2.07	10	279.23	186.08	124.08
7. Sulfamethizole	2.11	10	271.17	156.02	108.02
8. Sulfamethoxypyridazine	2.16	10	281.14	156.03	126.07
9. Sulfachlorpyridazine	2.55	20	285.05	156.03	108.09
10. Sulfadoxine	2.75	10	311.17	156.03	108.09
11. Sulfamethoxazole	2.78	20	254.18	155.98	147.06
12. Sulfaethoxypyridazine	2.84	20	295.17	267.07	156.03
13. Sulfisoxazole	2.98	20	268.14	156.03	113.10
14. Sulfadimethoxine	3.37	10	311.17	156.09	108.09
15. Sulfaquinoxaline	3.40	20	301.18	156.04	108.02

Column Raptor C18 (cat.# 9304A12)
Dimensions: 100 mm x 2.1 mm ID
Particle Size: 2.7 µm
Pore Size: 90 Å
Guard Column: Raptor C18 EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9304A0252)
40 °C

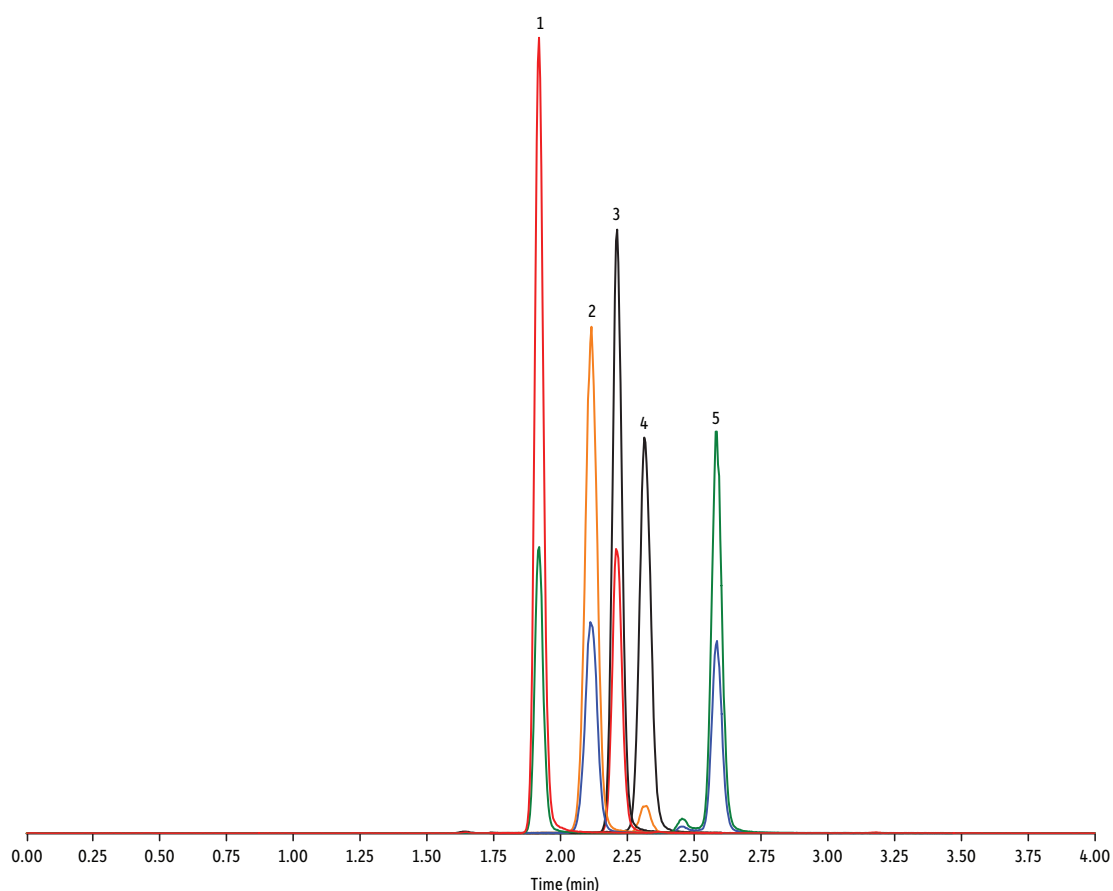
Temp.:
Sample
Diluent: Water
Conc.: 10–200 ng/mL
Inj. Vol.: 2 µL

Mobile Phase
A: 0.1% Formic acid in water
B: 0.1% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.4	90	10
3.50	0.4	60	40
3.51	0.4	90	10
5.00	0.4	90	10

Detector MS/MS
Ion Mode: ESI+
Mode: MRM
Instrument UHPLC

図 6: Raptor Biphenyl を用いたイオノフォア抗生物質のLC-MS/MSによる分析



LC_FS0503

Peaks	tr (min)	Conc. (ng/mL)	Precursor Ion	Product Ion	Product Ion
1. Lasalocid A	1.92	100	613.42	377.28	595.40
2. Monensin	2.12	100	693.50	675.44	461.30
3. Salinomycin	2.19	100	773.57	431.24	531.39
4. Maduramicin	2.30	100	939.65	877.58	473.31
5. Narasin	2.58	100	787.59	431.27	531.35

Column	Raptor Biphenyl (cat.# 9309A12)
Dimensions:	100 mm x 2.1 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Guard Column:	Raptor Biphenyl EXP guard column cartridge 5 mm, 2.1 mm ID, 2.7 µm (cat.# 9309A0252)
Temp.:	40 °C
Sample	
Diluent:	Water:methanol (10:90)
Conc.:	100 ng/mL
Inj. Vol.:	2 µL
Mobile Phase	
A:	0.5% Formic acid in water
B:	0.5% Formic acid in acetonitrile

Time (min)	Flow (mL/min)	%A	%B
0.00	0.5	35	65
3.00	0.5	25	75
3.01	0.5	35	65
5.00	0.5	35	65

Detector	MS/MS
Ion Mode:	ESI+
Mode:	MRM
Instrument	UHPLC