

Analyze More Semivolatiles Samples Per Shift Using Split Injection

By Michelle Misselwitz, Innovations Chemist, and Jack Cochran, Director of New Business and Technology

Semivolatiles are typically analyzed using splitless injection, but this technique results in slow analysis times and injection-to-injection variability. In contrast, using split injection under the conditions established here allows faster sample throughput and improved repeatability.

Introduction

Semivolatile organic compounds (SVOCs) are usually analyzed using splitless injection because the transfer of analytes to the head of the column is more complete than with split injection. While this can enhance low-level detection, splitless injection is limited by relatively slow analysis times, variability due to longer residence periods in the injector, and system downtime resulting from matrix contamination. Slower analysis times result from the lower oven start temperatures needed to focus analytes at the head of the column using solvent focusing or cold trapping, techniques which are not necessary with split injection. Repeatability can also be a challenge, since the flow through the injection port is much slower, resulting in broader peaks, degradation of thermally labile compounds, and adsorption of active analytes. Variability resulting from these factors can reduce the number of samples that can be analyzed before quality control criteria are no longer met.

Split injection is a viable alternative to splitless injection that has not yet been fully explored. It is allowed by EPA Method 8270D, as long as sensitivity requirements are met. Potential benefits include higher sample throughput, better separation efficiency due to narrower peaks, increased injection-to-injection repeatability, and reduced downtime for maintenance. In addition, GC stationary phase overload of compounds such as PAHs can be reduced by employing split injection. Here we evaluate the applicability of split injection using higher oven start temperatures and faster cycle times in terms of sample throughput, sensitivity, and linearity for EPA Method 8270D.

Procedure

Several mixed semivolatiles standards were prepared in methylene chloride at concentrations ranging from 1 µg/mL to 160 µg/mL. Surrogates and internal standards were included. Liner geometries differed between split and splitless techniques, but in both cases liners were packed with Restek's Semivolatiles Wool. This wool was selected because the robust deactivation does not degrade at high temperatures, assuring an inert surface and good peak shape.

Standards were analyzed using 2 different GC oven programs with split injection and compared to results from a typical oven program with splitless injection. One program was developed to maintain resolution of all SVOCs; the other was developed to optimize speed and sample throughput. Injector and oven conditions are given in Table I.

An Rxi®-5Sil MS column (30 m, 0.25 mm ID, 0.25 µm) was used for analysis, as it has been demonstrated to be highly inert and reliably provides good peak shape even for active compounds, such as 2,4-dinitrophenol.

Table I: Injector and oven conditions—higher oven start temperatures and faster cycle times were used for split injection.

	Split (Fast Cycle)	Split (Faster Cycle)	Splitless
Inj. vol. (µL)	1.0 µL split (10:1)	1.0 µL split (10:1)	1.0 µL splitless (1.0 min.)
Liner	4 mm Split Precision with Semivolatiles Wool	4 mm Split Precision with Semivolatiles Wool	4 mm Gooseneck Splitless with Semivolatiles Wool
Inj. temp.	270 °C	270 °C	260 °C
Purge flow	--	--	60 mL/min.
Oven program	80 °C (hold 1 min.), to 280 °C at 25 °C/min., to 320 °C at 5 °C/min. (hold 1 min.)	80 °C (hold 1 min.), to 320 °C at 25 °C/min., to 330 °C at 5 °C/min. (hold 2 min.)	40 °C (hold 1 min.), to 280 °C at 25 °C/min., to 320 °C at 5 °C/min. (hold 1 min.)
Carrier gas	Helium, 1.2 mL/min.	Helium, 1.2 mL/min.	Helium, 1.2 mL/min.

Results

Increase Sample Throughput Using Split Injection

Split injection uses higher initial oven temperatures and produces narrower injection bands than splitless injection. The higher starting temperature (80 °C) reduces oven cycle times, allowing up to 10 more samples to be analyzed per 12-hour shift, compared to typical splitless analyses (Figure 1, Table II). Savings in analysis time and GC oven cool-down time varied depending on the oven program used. Both split injection programs increased sample throughput relative to splitless injection, but the fastest program resulted in reduced separation of some later eluting compounds, including benzo(b)fluoranthene and benzo(k)fluoranthene (Figure 2). Using split injection with the slower temperature program may be preferable when increased separation of these compounds is desired. While faster oven cycles increased sample throughput for split injection, higher starting temperatures could not be used with splitless injection as it resulted in significant band broadening that made accurate integration impossible (Figure 3).

Table II: Split injection significantly increases sample throughput compared to splitless injection.

	Split (Fast Cycle)	Split (Faster Cycle)	Splitless
Total run time (min.)	21	18.5	25.5
Sample analysis (min.)	18	15	20
Oven cooling (min.)	3	3.5	5.5
Sample throughput* (Samples/shift)	30	34	24
% Increase in sample throughput (vs. splitless)	25%	42%	--

* 12-hr. shift = 10.5 hr. sample analysis period + 1.5 hr. quality control/method performance analysis period. Sample throughput calculation based on number of samples that can be analyzed in 10.5 hours.

Split Injection Results in Excellent Repeatability and Linearity

In addition to increasing sample throughput, split injection provides sensitivity that exceeds method requirements and better injection-to-injection repeatability at 0.5 ng on-column than splitless injection. Using split injection, coupled with a Precision® Liner packed with Semivolatiles Wool, lower relative standard deviations (%RSD) for base/neutral and acid (BNA) extractable SVOCs were achieved at the lowest calibration level in most cases, demonstrating that split injection reliably meets the minimum response factor criteria in the method (Table III). Better repeatability makes it easier to meet method requirements and allows more injections to be made before column maintenance is needed.

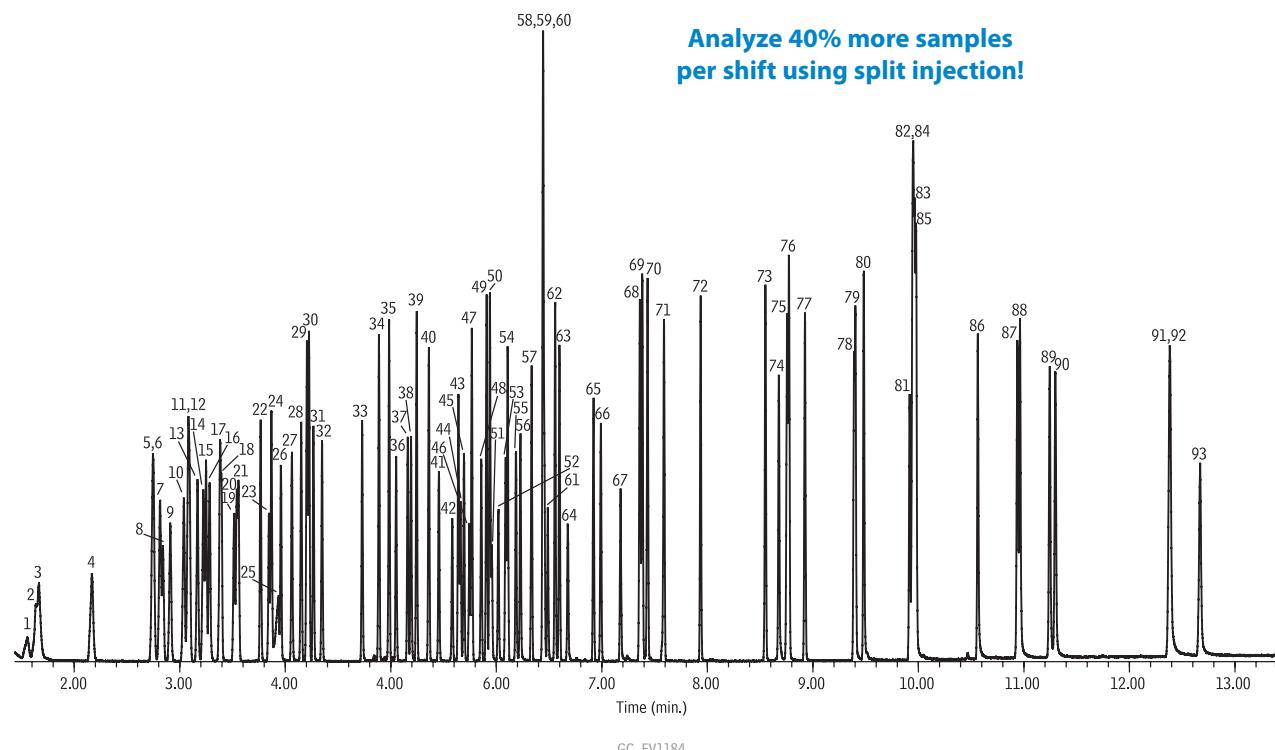
Table III: Using split injection better repeatability is achieved at low levels.

	8270D Min. RF	Split (10:1)		Splitless	
		RF	%RSD	RF	%RSD
Pyridine	--	1.534	2	1.038	9
Phenol	0.800	1.861	0.7	1.857	5
1,4-Dichlorobenzene-d4 (IS)	--	--	--	--	--
N-Nitroso-di-n-propylamine	0.500	1.053	2	1.266	3
2,4-Dichlorophenol	0.200	0.317	2	0.325	3
Naphthalene-d8 (IS)	--	--	--	--	--
Naphthalene	0.700	1.249	0.5	1.238	2
Hexachlorocyclopentadiene	0.050	0.407	1	0.414	5
2-Nitroaniline	0.010	0.395	3	0.514	3
Acenaphthylene	0.900	2.188	0.9	2.139	1
Acenaphthene-d10 (IS)	--	--	--	--	--
2,4-Dinitrophenol	0.010	0.113	8	0.127	13
4-Nitrophenol	0.010	0.256	6	0.296	5
4,6-Dinitro-2-methylphenol	0.010	0.175	6	0.110	9
N-Nitrosodiphenylamine	0.010	0.712	1	0.694	1
Pentachlorophenol	0.050	0.115	3	0.098	5
Phenanthrene-d10 (IS)	--	--	--	--	--
Phenanthrene	0.700	1.252	0.7	1.259	2
Perylene-d12 (IS)	--	--	--	--	--
Benzo(ghi)perylene	0.500	0.940	4	0.252	26
		Avg. %RSD	3	Avg. %RSD	6

Comparison based on faster split conditions provided in Table I; 0.5 ng on-column (n = 5).

Figure 1 Semivolatiles analysis in less than 13 minutes with faster temperature programming.

Peaks			
1. 1,4-Dioxane	25. Benzoic acid	50. Acenaphthene	74. Benzidine
2. N-Nitrosodimethylamine	26. Bis(2-chloroethoxy)methane	51. 2,4-Dinitrophenol	75. Pyrene-d10 (SS)
3. Pyridine	27. 2,4-Dichlorophenol	52. 4-Nitrophenol	76. Pyrene
4. 2-Fluorophenol (SS)	28. 1,2,4-Trichlorobenzene	53. 2,4-Dinitrotoluene	77. <i>p</i> -Terphenyl-d14 (SS)
5. Phenol-d6 (SS)	29. Naphthalene-D8 (IS)	54. Dibenzofuran	78. 3,3'-Dimethylbenzidine
6. Phenol	30. Naphthalene	55. 2,3,5,6-Tetrachlorophenol	79. Butyl benzyl phthalate
7. Aniline	31. 4-Chloroaniline	56. 2,3,4,6-Tetrachlorophenol	80. Bis(2-ethylhexyl) adipate
8. Bis(2-chloroethyl) ether	32. Hexachlorobutadiene	57. Diethyl Phthalate	81. 3,3'-Dichlorobenzidine
9. 2-Chlorophenol	33. 4-Chloro-3-methylphenol	58. 4-Chlorophenyl phenyl ether	82. Benz[a]anthracene
10. 1,3-Dichlorobenzene	34. 2-Methylnaphthalene	59. Fluorene	83. Bis(2-ethylhexyl)phthalate
11. 1,4-Dichlorobenzene-D4 (IS)	35. 1-Methylnaphthalene	60. 4-Nitroaniline	84. Chrysene-D12 (IS)
12. 1,4-Dichlorobenzene	36. Hexachlorocyclopentadiene	61. 4,6-Dinitro-2-methylphenol	85. Chrysene
13. Benzyl Alcohol	37. 2,4,6-Trichlorophenol	62. N-Nitrosodiphenylamine	86. Di-n-octyl phthalate
14. 1,2-Dichlorobenzene	38. 2,4,5-Trichlorophenol	(as Diphenylamine)	87. Benz[b]fluoranthene
15. 2-Methylphenol	39. 2-Fluorobiphenyl (SS)	63. 1,2-Diphenylhydrazine (as Azobenzene)	88. Benz[k]fluoranthene
16. Bis(2-chloroisopropyl) ether	40. 2-Chloronaphthalene	64. 2,4,6-Tribromophenol (SS)	89. Benz[a]pyrene
17. 4-Methylphenol/3-Methylphenol	41. 2-Nitroaniline	65. 4-Bromophenyl phenyl ether	90. Perylene-D12 (IS)
18. N-Nitrosodi-N-propylamine	42. 1,4-Dinitrobenzene	66. Hexachlorobenzene	91. Dibenzo[a,h]anthracene
19. Hexachloroethane	43. Dimethyl phthalate	67. Pentachlorophenol	92. Indeno[1,2,3-cd]pyrene
20. Nitrobenzene-D5 (SS)	44. 1,3-Dinitrobenzene	68. Phenanthrene-D10 (IS)	93. Benzo[ghi]perylene
21. Nitrobenzene	45. 2,6-Dinitrotoluene	69. Phenanthrene	
22. Isophorone	46. 1,2-Dinitrobenzene	70. Anthracene	
23. 2-Nitrophenol	47. Acenaphthylene	71. Carbazole	
24. 2,4-Dimethylphenol	48. 3-Nitroaniline	72. di-n-Butyl phthalate	
	49. Acenaphthene-d10 (IS)	73. Fluoranthene	



Column Sample	Rxi®-5Sil MS, 30 m, 0.25 mm ID, 0.25 µm (cat.# 13623) 8270 MegaMix® (cat.# 31850) Benzoinic acid (cat.# 31879) 8270 Benzidines Mix (cat.# 31852) Acid Surrogate Mix (4/89 SOW) (cat.# 31025) 1,4-dioxane (cat.# 31853) Revised B/N Surrogate Mix (cat.# 31887) SV Internal Standard Mix (cat.# 31206)	Oven Oven Temp.: 80 °C (hold 1 min.) to 320 °C at 25 °C/min. to 330 °C at 5 °C/min. Carrier Gas He, constant flow Flow Rate: 1.2 mL/min. Detector Mode: MS Mode: Scan Transfer Line Temp.: 280 °C Analyzer Type: Quadrupole Source Temp.: 250 °C Quad Temp.: 150 °C Tune Type: DFTPP Ionization Mode: EI Scan Range: 35-550 amu Instrument Agilent 7890A GC & 5975C MSD
Diluent:	Methylene chloride	
Conc.:	40 µg/mL (4 ng on-column)	
Injection		
Inj. Vol.:	1.0 µL split (split ratio 10:1)	
Liner:	4mm Split Precision® Liner w/ Semivolatiles Wool (cat.# 21023-231.5)	
Inj. Temp.:	270 °C	

Figure 2 Using split injection with either temperature program speeds up cycle time and sample throughput, but resolution of later eluting compounds is reduced when operating under the faster oven program.

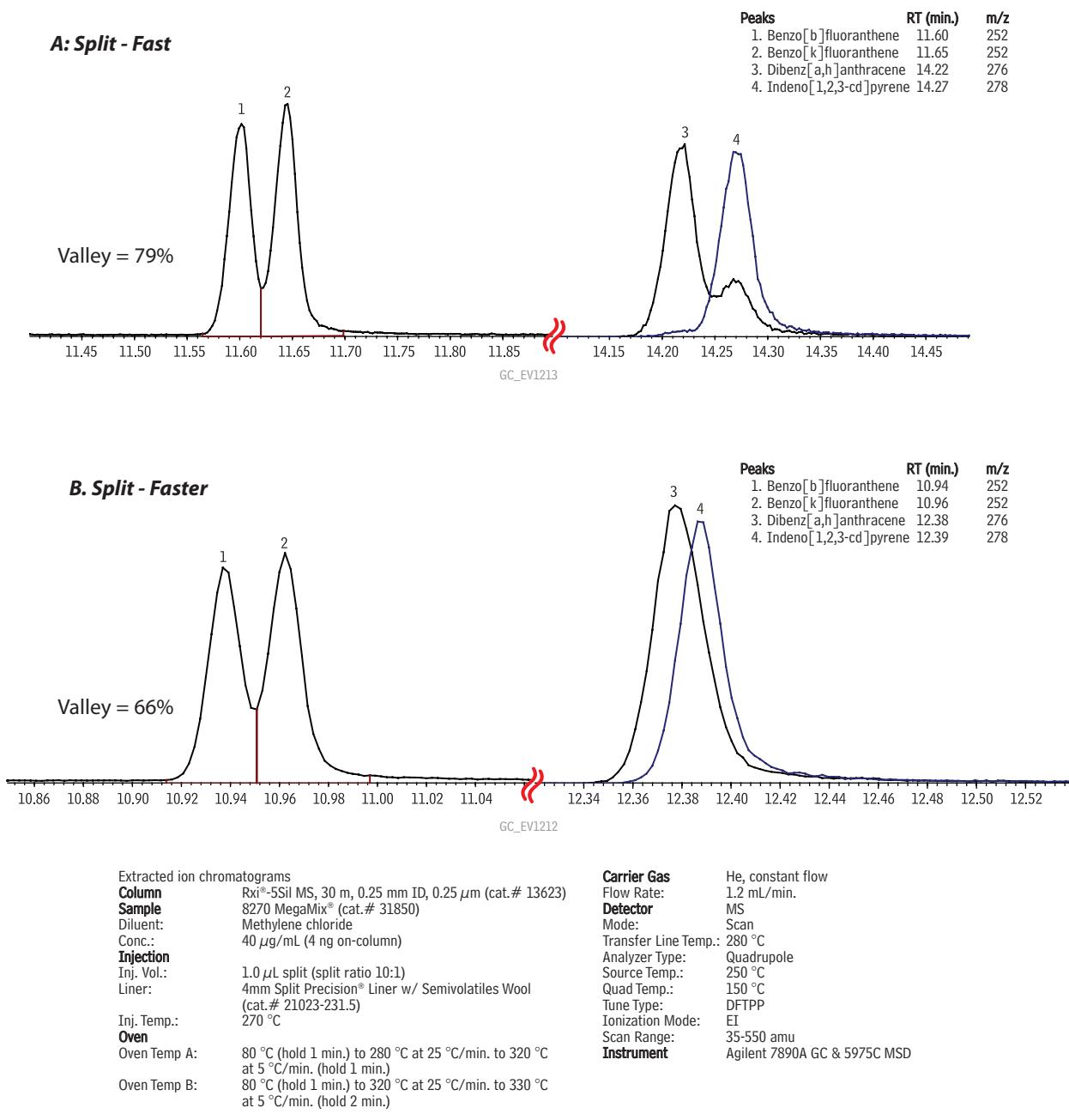
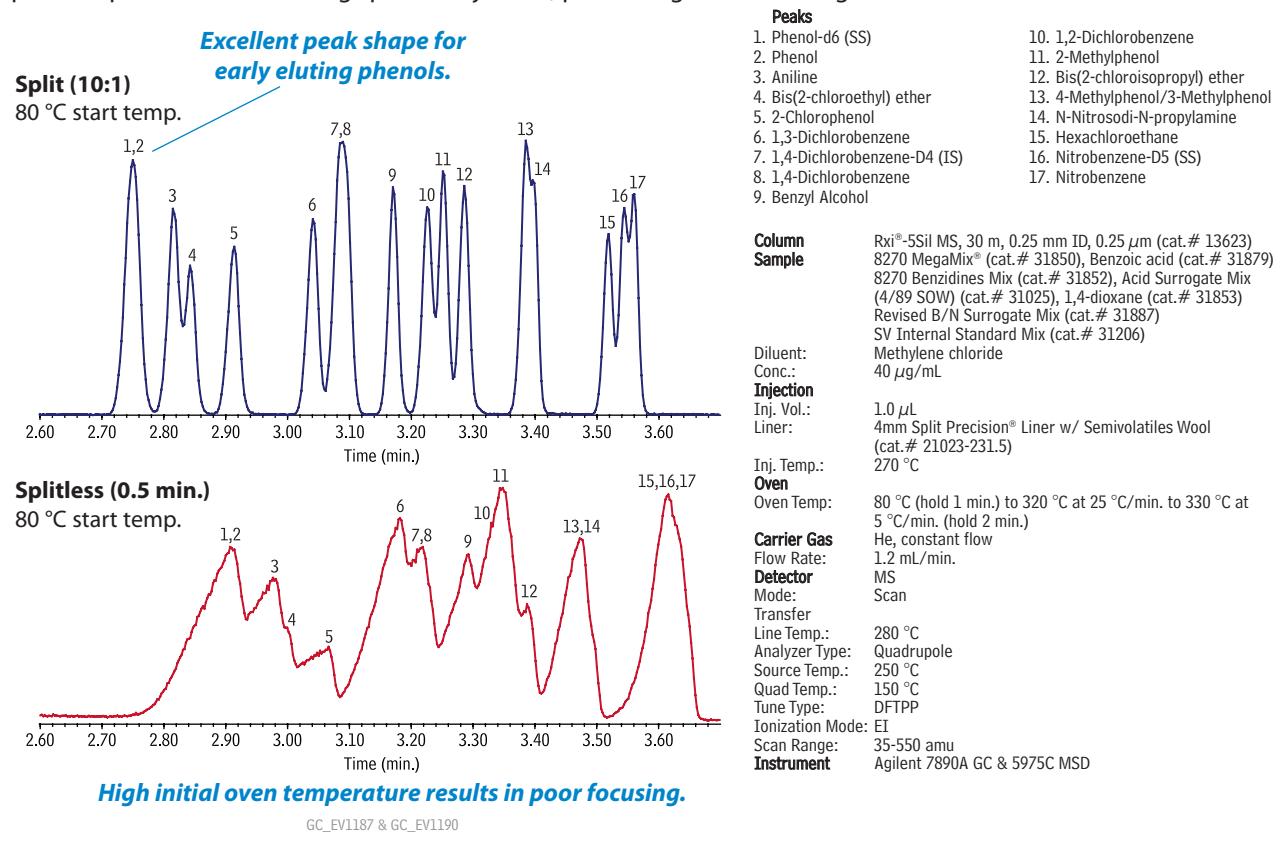


Figure 3 High initial oven temperature (80 °C) can speed up semivolatiles analysis using split injection, but poor peak shapes result when using splitless injection, preventing accurate integration.



Linearity was also assessed using a 6-point calibration curve (5, 20, 40, 80, 120, and 160 µg/mL) to evaluate the effect of using a 10:1 split. As shown in Table IV, analyzing just 10% of the standard did not compromise linearity. Response factors met the 8270D criterion of <20% RSD, for all SVOC compounds except 2,4-dinitrophenol. In this case, calibration was established based on the correlation coefficient ($r = 0.9997$), which easily exceeded the minimum method requirement ($r \geq 0.99$) as shown in Figure 4. Even when analyzing below the typical calibration range (0.1 ng on-column), 2,4-dinitrophenol had a response factor of 0.044 which is well above the method minimum response factor of 0.01 (Figure 5).

Based on linearity and sensitivity results, using a split injection may give analysts the option to extend the calibration range to higher levels, eliminating costly dilutions, or to expand it to lower levels, to achieve more accurate trace-level results.

Table IV Split injection provides excellent linearity across the typical calibration range of 5–160 µg/mL.

	Avg. RF	Avg. %RSD
Pyridine	1.533	0.9
Phenol	1.787	2
N-Nitroso-di-n-propylamine	0.991	2
2,4-Dichlorophenol	0.272	3
Naphthalene	0.998	5
Hexachlorocyclopentadiene	0.383	6
2-Nitroaniline	0.414	6
Acenaphthylene	1.824	3
2,4-Dinitrophenol	0.157	26
4-Nitrophenol	0.264	8
4,6-Dinitro-2-methylphenol	0.123	19
N-Nitrosodiphenylamine	0.608	3
Pentachlorophenol	0.127	16
Phenanthrene	1.082	5
Benz(ghi)perylene	0.942	5

Data acquired using faster cycle split conditions shown in Table I; 6-point calibration curve (5, 20, 40, 80, 120, and 160 µg/mL), n = 3 at each level.

Reduce Overloading, Resolve Isomeric Pairs

Since more sample is transferred to the column when using splitless injection than when using split injection, overloading of the stationary phase can occur at the highest calibration levels and result in poor separation of closely eluting peaks. By employing a 10:1 split, overloading is reduced and sharp, well-resolved peaks are obtained. For example, isomeric compounds benzo(b)fluoranthene and benzo(k)fluoranthene cannot be quantified at higher levels with splitless injection, but good separation was achieved using a 10:1 split (Figure 6). Additionally, with split injection, less sample matrix is introduced to the column and mass spectrometer, reducing the frequency of maintenance events and associated downtime.

Figure 4 Using split injection, linearity of 2,4-dinitrophenol exceeded method criterion ($r = 0.99$).

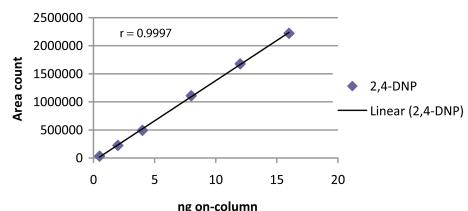


Figure 5 Response factors for 2,4-dinitrophenol exceed method criteria and assure good sensitivity and linearity.

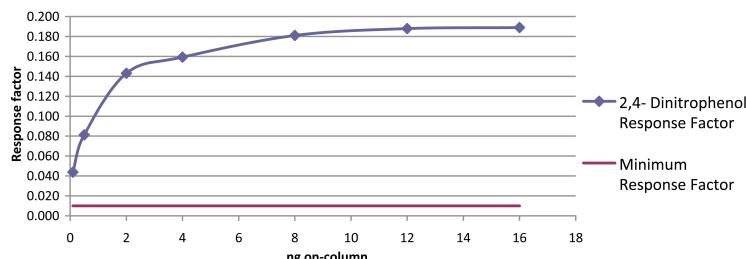
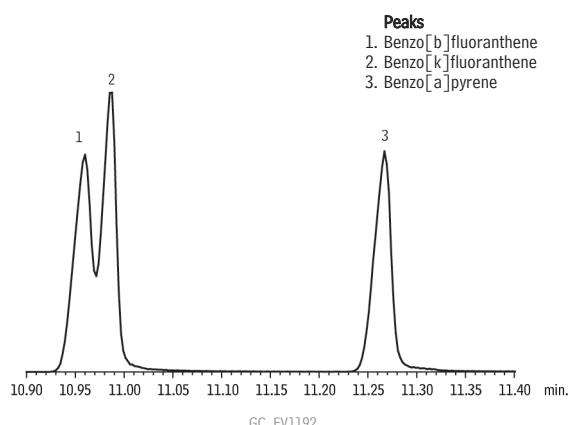


Figure 6 Benzo(b)fluoranthene and benzo(k)fluoranthene could not be quantified at high concentrations by splitless injection, but were easily resolved using split injection (180 µg/mL standard).

A: Split Injection (18 ng on-column)

Split injection reduces overloading, making quantitation possible.



Column Sample

Rxi®-5Sil MS, 30 m, 0.25 mm ID, 0.25 μ m (cat.# 13623)
8270 MegaMix® (cat.# 31850), Benzoic acid (cat.# 31879)
8270 Benzidines Mix (cat.# 31852), Acid Surrogate Mix (4/89 SOW)
(cat.# 31025), 1,4-dioxane (cat.# 31853), Revised B/N Surrogate Mix
(cat.# 31887)
Methylene chloride
180 μ g/mL (18 ng on-column)

Diluent:

Conc.:
Injection
Inj. Vol.: 1.0 μ L split (split ratio 10:1)
Liner: 4mm Split Precision® Liner w/Semivolatiles Wool (cat.# 21023-231.5)

Oven

Inj. Temp.: 270 °C
Oven Temp: 80 °C (hold 1 min.) to 320 °C at 25 °C/min. to 330 °C at 5 °C/min. (hold 2 min.)
Carrier Gas

Flow Rate: 1.2 mL/min.

Detector

Mode: MS
Transfer Line
Temp.: 280 °C

Analyzer Type:

Quadrupole

Source Temp.:

250 °C

Quad Temp.:

150 °C

Tune Type:

DFTPP

Ionization Mode:

EI

Scan Range:

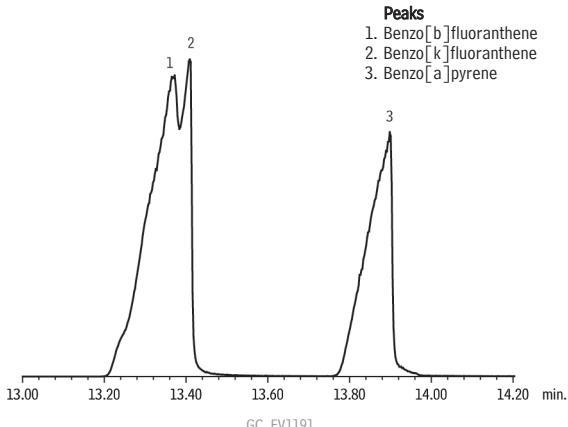
35-550 amu

Instrument Notes

Agilent 7890A GC & 5975C MSD
Extracted Ion Chromatogram (EIC): 252 m/z

B: Splitless Injection (180 ng on-column)

With splitless injection, fronting peaks makes quantitation impossible.



Column Sample

Rxi®-5Sil MS, 30 m, 0.25 mm ID, 0.25 μ m (cat.# 13623)
8270 MegaMix® (cat.# 31850), Benzoic acid (cat.# 31879)
8270 Benzidines Mix (cat.# 31852), Acid Surrogate Mix (4/89 SOW)
(cat.# 31025), 1,4-dioxane (cat.# 31853), Revised B/N Surrogate Mix
(cat.# 31887), SV Internal Standard Mix (cat.# 31206)

Methylene chloride
180 μ g/mL

Diluent:

Conc.:
Injection
Inj. Vol.: 1.0 μ L splitless (hold 1.0 min.)
Liner: Gooseneck Splitless (4mm) w/Semivolatiles Wool (cat.# 22406-231.5)

Oven

Inj. Temp.: 260 °C
Oven Temp: 40 °C (hold 1 min.) to 280 °C at 25 °C/min. to 320 °C at 5 °C/min. (hold 1 min.)
Carrier Gas

Flow Rate: 1.2 mL/min.

Detector

Mode: MS

Transfer

Line Temp.: 280 °C

Analyzer Type:

Quadrupole

Source Temp.:

250 °C

Quad Temp.:

150 °C

Tune Type:

DFTPP

Ionization Mode:

EI

Scan Range:

35-550 amu

Agilent 7890A GC & 5975C MSD
Extracted Ion Chromatogram (EIC): 252 m/z

Conclusion

Sample throughput for semivolatiles analysis can be significantly increased by employing split injection with a higher initial GC oven temperature and faster cycle time. Compared to splitless injection, analysis times are faster and repeatability is improved, allowing more samples to be run per shift. Sensitivity meets or exceeds method requirements, even with a 10:1 split. Excellent linearity across a typical calibration range is easily achieved, and extending this range to avoid dilutions and multiple calibration sets should be possible. Additionally, by splitting off a portion of the sample, less column maintenance will be required. Using split injection for semivolatiles analysis offers significant advantages over splitless injection and should be considered, especially when sample throughput is paramount.

Product Listing

Rxi®-5Sil MS Columns (fused silica)

(low polarity Crossbond® silarylene phase; similar to 5% phenyl/95% dimethyl polysiloxane)

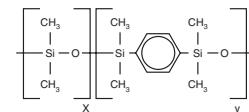
- Engineered to be a low bleed GC/MS column.
- Excellent inertness for active compounds.
- General purpose columns—ideal for GC/MS analysis of polycyclic aromatic compounds, chlorinated hydrocarbons, phthalates, phenols, amines, organochlorine pesticides, organophosphorus pesticides, drugs, solvent impurities, and hydrocarbons.
- Temperature range: -60 °C to 350 °C.

The Rxi®-5Sil MS stationary phase incorporates phenyl groups in the polymer backbone. This improves thermal stability, reduces bleed, and makes the phase less prone to oxidation. Rxi®-5Sil MS columns are ideal for GC/MS applications requiring high sensitivity, including use in ion trap systems.

ID	df	temp. limits	15-Meter	30-Meter	60-Meter
0.25mm	0.10µm	-60 to 330/350°C	13605	13608	
	0.25µm	-60 to 330/350°C	13620	13623	13626
	0.50µm	-60 to 330/350°C	13635	13638	
	1.00µm	-60 to 325/350°C	13650	13653	13697
0.32mm	0.25µm	-60 to 330/350°C	13621	13624	
	0.50µm	-60 to 330/350°C		13639	
	1.00µm	-60 to 325/350°C		13654	
	0.53mm	1.50µm	-60 to 310/330°C	13670	

ID	df	temp. limits	10-Meter	20-Meter	40-Meter	60-Meter
0.10mm	0.10µm	-60 to 330/350°C	43601			
0.18mm	0.10µm	-60 to 320/350°C			43607*	
	0.18µm	-60 to 330/350°C		43602	43605	
	0.36µm	-60 to 330/350°C		43604		

*60m, 0.18mm ID, 0.10µm column (cat.# 43607) intended for dioxin and furan analysis only.



similar phases

DB-5ms, VF-5ms,
CP-Sil 8 Low-Bleed/MS,
DB-5ms UI, Rtx-5Sil MS

Increase Accuracy with an Inert Sample Path

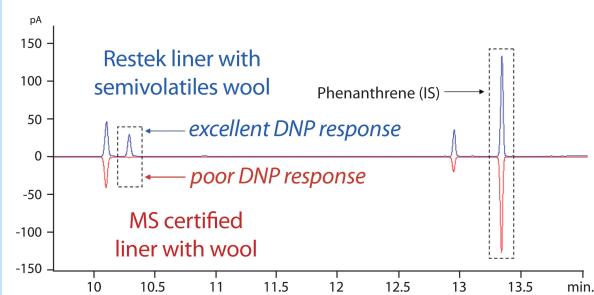
Semivolatiles Wool from Restek improves precision and accuracy, while protecting your column from contamination. This new wool is more inert than MS Certified Wool and gives you more reliable trace-level results. For the complete comparison, visit www.restek.com/adv017

To order liners prepacked with Semivolatiles Wool, add the corresponding suffix number to the liner catalog number. Visit www.restek.com/liners for a full liner listing.

qty.	IP Deactivated Liner with Semivolatiles Wool	addl. cost
each	-231.1	addl. cost
5-pk.	-231.5	addl. cost
25-pk.	-231.25	addl. cost

TECH TIP!

Response of 10 ng of 2,4-dinitrophenol relative to phenanthrene using a flame ionization detector.



HROMalytic +61(0)3 9762 2034
ECHnology Pty Ltd
Australian Distributors; Importers & Manufacturers

8270 MegaMix® (76 components)

- Fewest mixtures needed for calibration and matrix spikes.
- Mixtures formulated for maximum stability.
- Contains most routinely analyzed compounds.

acenaphthene	4,6-dinitro-2-methylphenol
acenaphthylene	2,4-dinitrophenol
aniline	2,4-dinitrotoluene
anthracene	2,6-dinitrotoluene
azobenzene ¹	di-n-octyl phthalate
benzo(a)anthracene	diphenylamine ²
benzo(a)pyrene	fluoranthene
benzo(b)fluoranthene	fluorene
benzo(ghi)perylene	hexachlorobenzene
benzo(k)fluoranthene	hexachlorobutadiene
benzyl alcohol	hexachlorocyclopentadiene
benzyl butyl phthalate	hexachloroethane
bis(2-chloroethoxy)methane	indeno(1,2,3-cd)pyrene
bis(2-chloroethyl)ether	isophorone
bis(2-chloroisopropyl)ether	1-methylnaphthalene
bis(2-ethylhexyl)adipate	2-methylnaphthalene
bis(2-ethylhexyl)phthalate	2-methylphenol
4-bromophenyl phenyl ether	3-methylphenol
carbazole	4-methylphenol
4-chloroaniline	naphthalene
4-chloro-3-methylphenol	2-nitroaniline
2-chloronaphthalene	3-nitroaniline
2-chlorophenol	4-nitroaniline
4-chlorophenyl phenyl ether	nitrobenzene
chrysene	2-nitrophenol
dibenzo(a,h)anthracene	4-nitrophenol
dibenzofuran	N-nitrosodimethylamine
1,2-dichlorobenzene	N-nitroso-di-n-propylamine
1,3-dichlorobenzene	pentachlorophenol
1,4-dichlorobenzene	phenanthrene
2,4-dichlorophenol	phenol
diethyl phthalate	pyrene
2,4-dimethylphenol	pyridine
dimethyl phthalate	2,3,4,6-tetrachlorophenol
di-n-butyl phthalate	2,3,5,6-tetrachlorophenol
1,2-dinitrobenzene	1,2,4-trichlorobenzene
1,3-dinitrobenzene	2,4,5-trichlorophenol
1,4-dinitrobenzene	2,4,6-trichlorophenol
1,000µg/mL each in methylene chloride, 1mL/ampul*	
cat. # 31850 (ea.)	

*3-methylphenol and 4-methylphenol concentration is 500 µg/mL.

¹1,2-diphenylhydrazine (8270-listed analyte) decomposes to azobenzene (mix component) in the injector.

²N-nitrosodiphenylamine (8270-listed analyte) decomposes to diphenylamine (mix component) in the injector.

Acid Surrogate Mix (4/89 SOW) (3 components)

2-fluorophenol	2,4,6-tribromophenol
phenol-d6	
Each	15-pk.
2,000µg/mL each in methanol, 1mL/ampul	31025
31025	31025.15
10,000µg/mL each in methanol, 1mL/ampul	31063
31063	31063.15
10,000µg/mL each in methanol, 5mL/ampul	31087
31087	31087.15
10,000µg/mL each in methanol, 10mL/ampul	33029
33029	33029.15

PATENTS & TRADEMARKS

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Benzoic Acid

2,000µg/mL in methylene chloride, 1mL/ampul
cat. # 31879 (ea.)
1,000µg/mL in methanol, 1mL/ampul
cat. # 31415 (ea.)

Revised B/N Surrogate Mix (4 components)

2-fluorobiphenyl	p-terphenyl-d14
nitrobenzene-d5	pyrene-d10
Each	15-pk.
1,000µg/mL each in methylene chloride, 1mL/ampul	31887
31887	31887.15
5,000µg/mL each in methylene chloride, 1mL/ampul	31888
31888	31888.15
5,000µg/mL each in methylene chloride, 5mL/ampul	31889
31889	31889.15

SV Internal Standard Mix (6 components)

acenaphthene-d10	naphthalene-d8
chrysene-d12	perylene-d12
1,4-dichlorobenzene-d4	phenanthrene-d10
Each	15-pk.
2,000µg/mL each in methylene chloride, 1mL/ampul	31206
31206	31206.15
4,000µg/mL each in methylene chloride, 1mL/ampul	31006
31006	31006.15

8270 Benzidines Mix (3 components)

benzidine	3,3'-dimethylbenzidine
3,3'-dichlorobenzidine	
2,000µg/mL each in methanol, 1mL/ampul	cat. # 31688 (ea.)
2,000µg/mL each in methylene chloride, 1mL/ampul	cat. # 31852 (ea.)

1,4-Dioxane

2,000µg/mL in P&T methanol, 1mL/ampul
cat. # 30287 (ea.)
2,000µg/mL in methylene chloride, 1mL/ampul
cat. # 31853 (ea.)
1.9mg/mL in dimethyl sulfoxide, 1mL/ampul
cat. # 36294 (ea.)

4.0mm ID Precision® Inlet Liner w/ Wool

ID x OD & Length	qty.	cat.#
Precision, Intermediate Polarity (IP), Semivolatiles Wool		
4.0mm x 6.3mm x 78.5mm	ea.	21022-231.1
4.0mm x 6.3mm x 78.5mm	5-pk.	21023-231.5
4.0mm x 6.3mm x 78.5mm	25-pk.	20979-231.25

RESTEK

ISO^{9001:2008}
cert. # FM80397

Lit. Cat.# EVAN1298

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CHROMalytic +61(0)3 9762 2034
ECHnology Pty Ltd
Australian Distributors; Importers & Manufacturers