RESTEK REFINED innovative petrochemical solutions

Stabilized GC PLOT Columns

- New bonding process minimizes particle release, reducing column blockage and protecting instrument parts.
- More consistent flow means stable retention times in Deans and related flow switching techniques.
- Outstanding peak symmetry improves impurity analysis for gases, solvents, and hydrocarbons.

Columns Now **AVAILABLE:**

Rt®-Alumina BOND
Rt®-Msieve 5A
Rt®-Q-BOND,
Rt®-QS-BOND
Rt®-S-BOND
Rt®-U-BOND

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New Generation of Porous Layer Open Tubular (PLOT) Columns

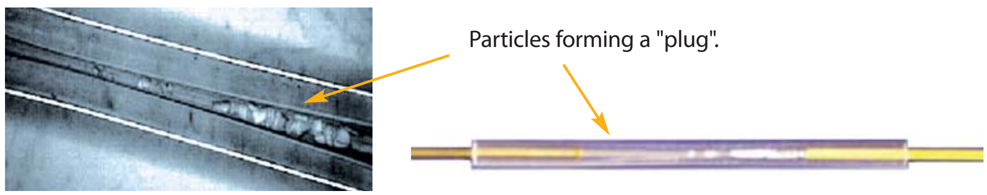
- Stabilized particle layers improve robustness and reproducibility of retention and flow.
- Fully compatible with valve switching and Deans switching systems.
- Highly efficient, reproducible analyses; ideal for permanent gases, solvents, and hydrocarbons.
- New manufacturing procedure reduces particle generation and improves performance of porous polymers, molecular sieves, and PLOT columns.

Porous layer open tubular (PLOT) columns are very beneficial for solving application problems, especially for the analysis of volatile compounds. PLOT columns have a unique selectivity, allowing for the separation of gaseous compounds at room temperature. Due to the adsorption mechanism of the supports used in PLOT columns, permanent gases and light hydrocarbons can be resolved at room temperature. Columns can then be programmed to higher temperatures to elute higher boiling compounds.

Traditional PLOT Columns Offer Poor Stability

The traditional PLOT column is built with a 5-50µm layer of particles adhered to the tubing walls. Because this layer of particles generally lacks stability, PLOT columns must be used very carefully, as particle release is common and can cause unpredictable changes in retention time and flow behavior. PLOT columns generally must be used in conjunction with particle traps to prevent the contamination of valves, injectors, and GC detectors. Figure 1 shows an example of particle accumulation resulting in a blockage inside a Press-Tight® liner. If particle traps are not used, particles will hit the detector resulting in electronic noise, seen as spikes on the baseline. In the case of valves, particles can become lodged in the valve and result in leaks.

Figure 1 Particles released from traditional PLOT columns can cause blockages.



New Stabilized PLOT Columns Minimize Particle Release

Restek has developed new procedures to manufacture PLOT columns with concentric stabilized adsorption layers. The new generation PLOT columns show a constant flow behavior (permeability) and have significantly improved mechanical stability, resulting in easier operation, better chromatography, and reduced particle release. Greater particle stability means more reproducible retention times, virtually no spiking, and longer column lifetimes. This innovative stabilization chemistry technology is currently applied to Rt®-Alumina BOND, Rt®-Msieve 5A, Rt®-Q-BOND, Rt®-QS-BOND, Rt®-S-BOND, and Rt®-U-BOND columns.

Consistent Flow Restriction Factor (F) Guarantees Reproducible Flow

Thick layers of particles are difficult to deposit in a homogeneous layer and, in traditionally manufactured PLOT columns, this results in variable coating thicknesses. The positions where the layer is thicker act as restrictions and affect flow (Figure 2). Depending on the number and intensity of these restrictions, traditional PLOT columns often show greater variation in flow restriction than wall coated open tubular (WCOT) columns. In practice, conventional PLOT columns with the same dimensions can differ in flow by a factor of 4-6, when operated at the same nominal pressure. For applications where flow is important, such as with Deans switching, the nonreproducible flow behavior of most commercially available PLOT columns is a problem.

Figure 2 Inconsistent coating thicknesses result in restrictions that cause significant variation in flow.

In order to evaluate flow restriction reproducibility, Restek is introducing a new factor: the flow restriction factor (F). This factor is based on the retention time of an unretained marker compound, as measured on both coated and uncoated tubing using the same backpressure setting (Equation 1). For quality control purposes, methane is used as the marker when evaluating porous polymer columns and helium is used for testing Rt®-Msieve 5A columns.

Flow restriction factor determination can be used both to assess the degree of column restriction and to evaluate the reproducibility of the column coating process. Percent flow restriction can also be calculated (Equation 2). Figure 3 shows typical results for PLOT columns manufactured using a conventional process. Because of the difference in flow restriction, individual columns have very different flow characteristics. In contrast, Figure 4 shows results for columns made using the new PLOT column process (Rt®-QS-BOND, bonded porous polymer). Clearly, the new manufacturing process results in greater consistency in both column coating thickness and flow restriction; which, in turn, results in more stable retention times and better performance in Deans switching and related flow switching techniques.

Figure 3 Traditional PLOT columns show significant flow variability, indicating inconsistent column coating thicknesses.

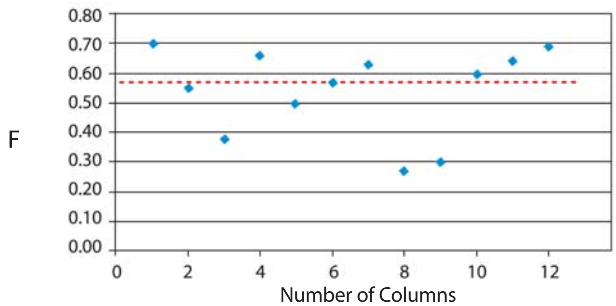
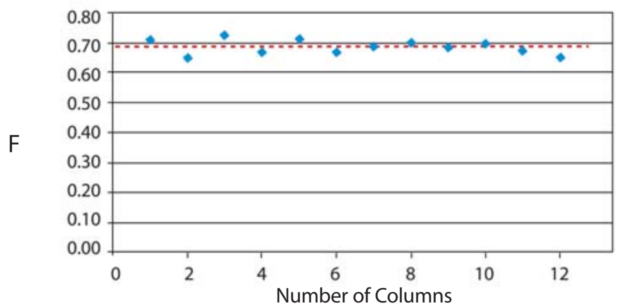


Figure 4 Restek's new stabilized PLOT columns offer consistent flow resistance, giving more reproducible results column-to-column.



Equation 1 Flow restriction factor (F) is used to demonstrate coating consistency.

$$F = \frac{t_{R1} \text{ of unretained component (uncoated tubing)}}{t_{R2} \text{ of unretained component (coated column)}}$$

t_R = retention time

Note, F values will always be <1 as the coated column always has more restriction than the uncoated column.

Equation 2 Percent flow restriction of coated column.

% restriction = (1 - F) x 100

In summary, Restek's new PLOT column manufacturing process produces exceptionally robust PLOT columns, featuring concentric stabilized coating layers. These new columns have more consistent flow resistance and are recommended for applications sensitive to variation in retention time or flow. These columns are a significant advance in PLOT column technology and are ideal for more efficient, reproducible analyses of permanent gases, solvents, and hydrocarbons.

PLOT Column Phase Cross-Reference: Similar Selectivity

Restek	Porous Layer	Agilent/J&W	Supelco	Alltech	Varian/Chrompack	Quadrex
Rt-Alumina BOND / Na_2SO_4	Aluminum oxide	GS-Alumina, HP PLOT S, HP PLOT M	Alumina-PLOT	AT-Alumina	CP-Al_2O_3/NA_2SO_4	——
Rt-Alumina BOND / KCl	Aluminum oxide	GC-Alumina KCl	——	——	CP-Al_2O_3/KCl	——
Rt-Msieve 5A	Molecular sieve 5A	GS-Molsieve, HP PLOT/Molesieve	Molsieve 5A PLOT	AT-Molesieve	CP-Molesieve 5A	PLT-5A
Rt-Q-BOND	DVB porous polymer	——	Supel-Q-PLOT	AT-Q	CP-PoraPlot Q, PoraBond Q	——
Rt-QS-BOND	Intermediate polarity porous polymer	GS-Q	——	——	——	——
Rt-S-BOND	DVB vinylpyridine polymer	——	——	——	CP-PoraPlot S	——
Rt-U-BOND	DVB ethyleneglycol-dimethylacrylate polymer	HP-UPLOT	——	——	CP-PoraPlot U, PoraBond U	——

Rt®-Alumina BOND Columns

- Applications for C1-C10 volatile hydrocarbon separations at percent levels, as well as impurity analyses at ppm concentrations.
- High capacity and loadability give exceptionally symmetric peaks.
- Reproducible retention times and predictable flow behavior column-to-column.

tech tip

Traces of water in the carrier gas and samples will affect the retention and selectivity of alumina. If exposed to water, the retention times will shorten. The column can be regenerated by conditioning for 15-30 min. at 200°C under normal carrier gas flow. Periodic conditioning ensures excellent run-to-run retention time reproducibility.

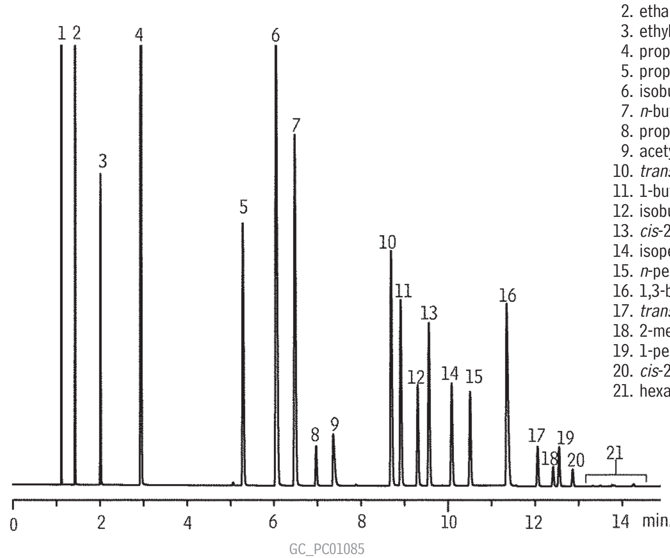
The maximum programmable temperature for an Rt®-Alumina BOND column is 200°C. Higher temperatures cause irreversible changes to the porous layer adsorption properties.

Rt®-Alumina BOND / Na_2SO_4

- Acetylene/propadiene elute after butanes (impurities in acetylene/propadiene).
- Best separation for butene isomers (impurities in butene streams).
- Methyl acetylene elutes after 1,3-butadiene.
- Cyclopropane (impurity in propylene) elutes well before propylene.

ID	df (μm)	temp. limits	30-Meter	50-Meter
0.32mm	5	to 200°C	19757	19758
0.53mm	10	to 200°C	19755	19756

Refinery gas on an Rt®-Alumina BOND / Na_2SO_4



1. methane
2. ethane
3. ethylene
4. propane
5. propylene
6. isobutane
7. *n*-butane
8. propadiene
9. acetylene
10. *trans*-2-butene
11. 1-butene
12. isobutylene
13. *cis*-2-butene
14. isopentane
15. *n*-pentane
16. 1,3-butadiene
17. *trans*-2-pentene
18. 2-methyl-2-butene
19. 1-pentene
20. *cis*-2-pentene
21. hexanes

Column:	Rt®-Alumina BOND / Na_2SO_4, 50m, 0.53mm ID, 10μm (cat.# 19756)
Sample:	refinery gas
Inj.:	10μL split (split vent flow 80mL/min.), 2mm single gooseneck liner (cat.# 20795)
Inj. temp.:	200°C
Carrier gas:	hydrogen, constant pressure, 8.0psi
Linear velocity:	74cm/sec. @ 45°C
Oven temp.:	45°C (hold 1 min.) to 200°C @ 10°C/min. (hold 3.5 min.)
Det.:	FID @ 200°C

NEW!

Rt®-Alumina BOND columns now available with KCl deactivation!

Rt®-Alumina BOND / KCl

- Acetylene elutes before C4 hydrocarbons (impurities in butane/isobutane).
- Methyl acetylene (impurity in 1,3-butadiene) elutes before 1,3-butadiene.

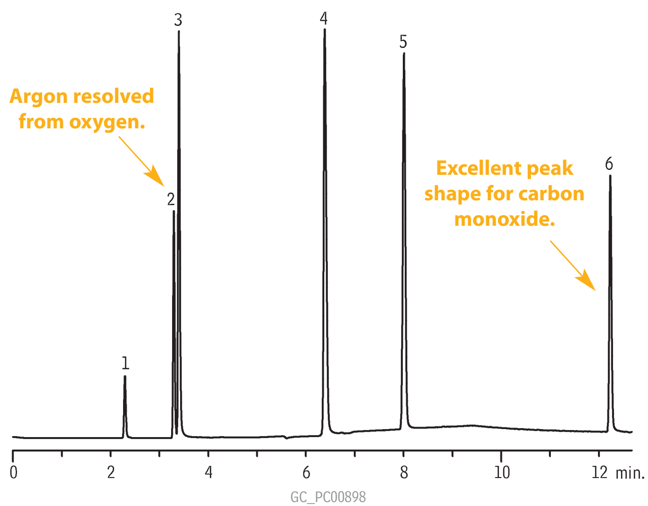
ID	df (μm)	temp. limits	30-Meter	50-Meter
0.32mm	5	to 200°C	19761	19762
0.53mm	10	to 200°C	19759	19760

Rt®-Msieve 5A PLOT Columns

Rt®-Msieve 5A PLOT columns are designed for efficient separation of Ar/O_2 and other permanent gases, including CH_4, C_2H_6, and CO. Special coating and deactivation procedures ensure chromatographic efficiency and the integrity of the porous layer coating. Our deactivation technology also allows the CO peak to elute as a sharp peak. This is in contrast with other suppliers where CO often tails badly and cannot be quantified below % levels. Restek's unique immobilization process guarantees that the uniform particles remain adhered to the tubing—even after continuous valve-cycling.

Our revolutionary molecular sieve 5A PLOT columns separate Ar/O_2 and H_2/He at ambient temperature or above (see figure). These columns also are an excellent choice for rapid separation of permanent gases in refinery or natural gas.

Permanent gases on an Rt®-Msieve 5A PLOT column.



1. hydrogen 40ppm
2. argon 30ppm
3. oxygen 50ppm
4. nitrogen 50ppm
5. methane 40ppm
6. carbon monoxide 50ppm

Column:	Rt®-Msieve 5A, 30m, 0.53mm ID, 50µm (cat.# 19723)
Sample:	permanent gases (ppm)
Inj.:	5µL sample loop, 6-port Valco® valve, valve temp.: ambient
Inj. temp.:	200°C
Carrier gas:	helium, constant flow
Flow:	5mL/min.
Oven temp.:	27°C (hold 5 min.) to 100°C @ 10°C/min. (hold 5 min.)
Det.:	Valco® helium ionization detector @ 150°C

Rt®-Msieve 5A Columns (fused silica PLOT)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	30	to 300°C	19720	19722
0.53mm	50	to 300°C	19721	19723

NEW!

did you know?

Rt®-Msieve 5A PLOT columns are designed for efficient separation of Ar/O_2 and other permanent gases, including CH_4, C_2H_6, and CO.

tech tip

Because molecular sieve materials are very hydrophilic, they will adsorb water from the sample or carrier gas. Water contamination can have a detrimental effect on peak symmetry and can reduce the resolution of all compounds. If water contamination occurs, reactivate your Rt®-Msieve 5A PLOT column by conditioning at 300°C with dry carrier gas flow for 3 hours.

Metal PLOT Columns

MXT®-Msieve 5A (Siltek®-treated stainless steel PLOT)

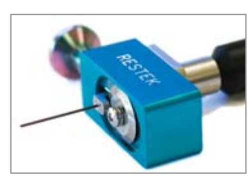
ID	df (µm)	temp. limits	30-Meter
0.53mm	50	to 300°C	79723

Restek Tubing Scorer for MXT® Columns

- Makes perfect cuts every time.
- Easy to use.
- Leaves column entrance perfectly round.

Description	qty.	cat.#
Restek Tubing Scorer for MXT Columns (0.25-0.53mm ID & 0.5-0.8mm OD)	ea.	20523
Replacement Scoring Wheel	ea.	20522

Simple Solutions:
Perfect cuts every time!



Porous Polymers: Rt®-Q-BOND, Rt®-QS-BOND, Rt®-S-BOND, Rt®-U-BOND

Restek chemists have developed a new process for the manufacturing of porous polymer PLOT columns. The process incorporates the particles to the walls of the tubing, so there is virtually no particle generation. Because of the particle adhering to the walls of the tubing, there is reproducible performance from column to column, including selectivity and flow.

Rt®-Q-BOND Columns (fused silica PLOT)

NEW!

(100% divinylbenzene)

- Nonpolar PLOT column incorporating 100% divinyl benzene.
- Excellent for analysis of C1 to C3 isomers and alkanes up to C12.
- High retention for CO_2 simplifies gas analysis; CO_2 and methane separated from O_2/N_2/CO (Note: O_2/N_2/CO not separated at room temperature).
- Use for analysis of oxygenated compounds and solvents.
- Maximum temperature of 300°C.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 280/300°C	19743	19744
0.53mm	20	to 280/300°C	19741	19742

Rt®-QS-BOND Columns (fused silica PLOT)

(porous divinyl benzene homopolymer)

- Intermediate polarity PLOT column incorporating low 4-vinyl pyridine.
- Separates ethane, ethylene and acetylene to baseline.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19739	19740
0.53mm	20	to 250°C	19737	19738

Rt®-S-BOND Columns (fused silica PLOT)

(divinylbenzene 4-vinylpyridine)

- Midpolarity PLOT column, incorporating high 4-vinyl pyridine.
- Use for the analysis of nonpolar and polar compounds.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19747	19748
0.53mm	20	to 250°C	19745	19746

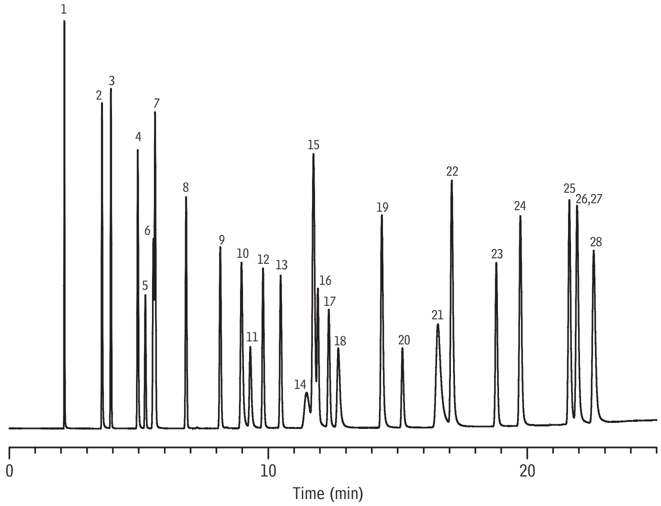
Rt®-U-BOND Columns (fused silica PLOT)

(divinylbenzene ethylene glycol/dimethylacrylate)

- Polar PLOT column, incorporating divinylbenzene ethylene glycol/dimethylacrylate.
- Use for the analysis of polar and nonpolar compounds.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 190°C	19751	19752
0.53mm	20	to 190°C	19749	19750

Solvent mixture on an Rt®-Q-BOND column.

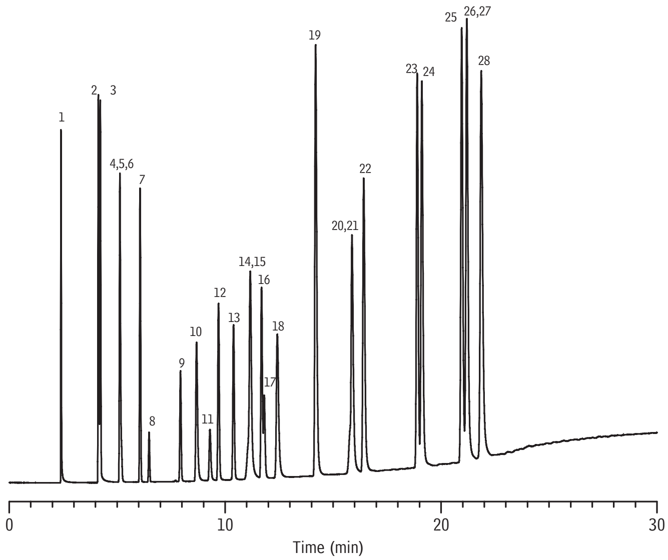


1. methanol
2. ethanol
3. acetonitrile
4. acetone
5. dichloromethane
6. 1,1-dichloroethene
7. nitromethane
8. *trans*-1,2-dichloroethylene
9. *cis*-1,2-dichloroethylene
10. tetrahydrofuran
11. chloroform
12. ethyl acetate
13. 1,2-dichloroethane
14. 1,1,1-trichloroethane
15. benzene
16. 1,2-dimethoxyethane
17. trichloroethylene
18. 1,4-dioxane
19. pyridine
20. dimethylformamide
21. methylcyclohexane
22. toluene
23. 2-hexanone
24. chlorobenzene
25. ethylbenzene
26. *m*-xylene
27. *p*-xylene
28. *o*-xylene

Column:	Rt®-Q-BOND, 30m, 0.53mm ID, 20µm (cat.# 19742)
Sample:	solvent mixture
Inj.:	1.0µL, split (split vent flow 100mL/min.), 4mm single gooseneck liner (cat.# 20798)
Inj. temp.:	200°C
Carrier gas:	hydrogen, constant pressure, 4.2psi
Linear velocity:	40cm/sec. @ 120°C
Oven temp.:	120°C to 240°C @ 5°C/min. (hold 5.0 min.)
Det.:	FID @ 240°C

GC_PC01082

Solvent mixture on an Rt®-QS-BOND column.

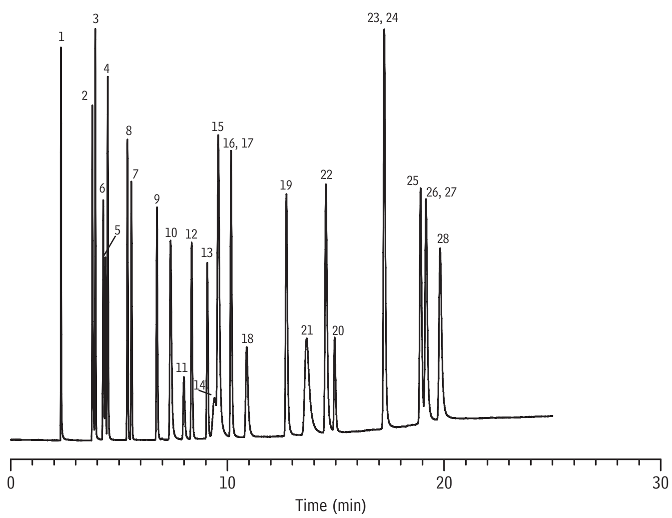


1. methanol
2. ethanol
3. acetonitrile
4. acetone
5. dichloromethane
6. 1,1-dichloroethene
7. nitromethane
8. *trans*-1,2-dichloroethylene
9. *cis*-1,2-dichloroethylene
10. tetrahydrofuran
11. chloroform
12. ethyl acetate
13. 1,2-dichloroethane
14. 1,1,1-trichloroethane
15. benzene
16. 1,2-dimethoxyethane
17. trichloroethylene
18. 1,4-dioxane
19. pyridine
20. dimethylformamide
21. methylcyclohexane
22. toluene
23. 2-hexanone
24. chlorobenzene
25. ethylbenzene
26. *m*-xylene
27. *p*-xylene
28. *o*-xylene

Column:	Rt®-QS-BOND, 30m, 0.53mm ID, 20µm (cat.# 19738)
Sample:	solvent mixture
Inj.:	1.0µL, split (split vent flow 100mL/min.), 4mm single gooseneck liner (cat.# 20798)
Inj. temp.:	200°C
Carrier gas:	hydrogen, constant pressure, 4.2psi
Linear velocity:	40cm/sec. @ 120°C
Oven temp.:	120°C to 240°C @ 5°C/min. (hold 5.0 min.)
Det.:	FID @ 240°C

GC_PC01081

Solvent mixture on an Rt®-S-BOND column.



1. methanol
2. ethanol
3. acetonitrile
4. acetone
5. dichloromethane
6. 1,1-dichloroethene
7. nitromethane
8. *trans*-1,2-dichloroethylene
9. *cis*-1,2-dichloroethylene
10. tetrahydrofuran
11. chloroform
12. ethyl acetate
13. 1,2-dichloroethane
14. 1,1,1-trichloroethane
15. benzene
16. 1,2-dimethoxyethane
17. trichloroethylene
18. 1,4-dioxane
19. pyridine
20. dimethylformamide
21. methylcyclohexane
22. toluene
23. 2-hexanone
24. chlorobenzene
25. ethylbenzene
26. *m*-xylene
27. *p*-xylene
28. *o*-xylene

Column:	Rt®-S-BOND, 30m, 0.53mm ID, 20µm (cat.# 19746)
Sample:	solvent mixture
Inj.:	1.0µL, split (split vent flow 100mL/min.), 4mm single gooseneck liner (cat.# 20798)
Inj. temp.:	200°C
Carrier gas:	hydrogen, constant pressure, 4.2psi
Linear velocity:	40cm/sec. @ 120°C
Oven temp.:	120°C to 220°C @ 5°C/min. (hold 5.0 min.)
Det.:	FID @ 220°C

GC_PC01080