

# Stabilized GC PLOT Columns

- Reduced particle release means longer column lifetimes.
- More consistent flow; stable retention times column-to-column.
- Ideal for permanent gases, solvents, and hydrocarbons.

Now  
**AVAILABLE:**

Rt<sup>®</sup>-Alumina BOND,  
Rt<sup>®</sup>-Msieve 5A,  
Rt<sup>®</sup>-Q-BOND,  
Rt<sup>®</sup>-QS-BOND,  
Rt<sup>®</sup>-S-BOND,  
Rt<sup>®</sup>-U-BOND columns



**Chromatography Products**

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### New Generation of Porous Layer Open Tubular (PLOT) Columns

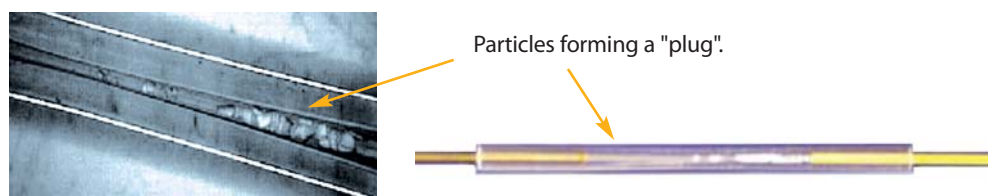
- Stabilized particle layers improve robustness and reproducibility of retention and flow; no retention time changes between columns.
- Fully compatible with valve switching and Deans switching systems.
- Highly efficient, reproducible analyses; ideal for permanent gases, solvents, and hydrocarbons.
- New manufacturing procedure reduces particle generation and improves performance of porous polymers and molecular sieves.

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 5-50 $\mu\text{m}$  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<sup>®</sup> 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.



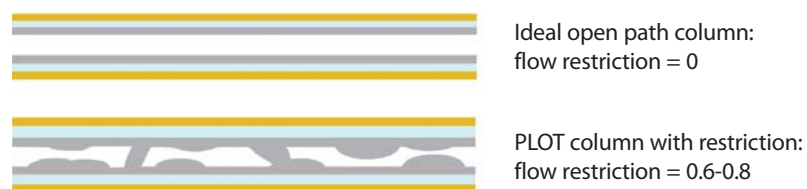
### New Stabilized PLOT Columns Minimize Particle Release

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<sup>®</sup>-Alumina BOND, Rt<sup>®</sup>-Msieve 5A, Rt<sup>®</sup>-Q-BOND, Rt<sup>®</sup>-QS-BOND, Rt<sup>®</sup>-S-BOND, and Rt<sup>®</sup>-U-BOND columns.

### Consistent Flow Restriction Factor (F) Guarantees Reproducible Flow

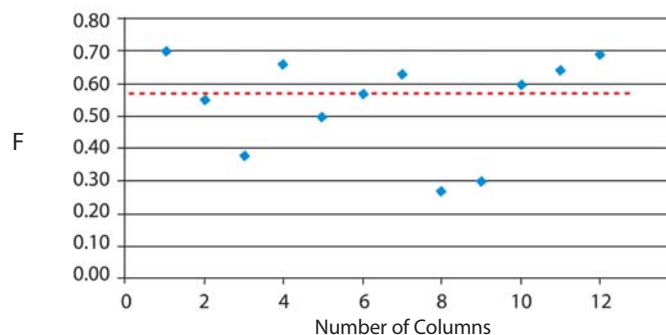
Thick layers of particles are difficult to deposit in a homogeneous layer and, in traditionally manufactured PLOT columns, this results in variable coating thicknesses. The positions where the layer is thicker act as restrictions and affect flow (Figure 2). Depending on the number and intensity of these 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). The flow restriction factor is based on the retention time of an unretained compound (Equation 1). It can be used to assess the degree of restriction of the column and to evaluate the reproducibility of the column coating process. Percent flow restriction can also be calculated as shown in Equation 2. Figure 3 shows what typically happens when a conventional PLOT column manufacturing process is used. Because of the difference in flow restriction, individual columns have very different flow characteristics. In contrast, Figure 4 shows results for columns generated using the new process (Rt®-QS-BOND, bonded porous polymer). Clearly, the new PLOT column process results in greater consistency in both column coating thickness and flow restriction.

**Figure 3** Traditional PLOT columns show significant flow variability, indicating inconsistent column coating thicknesses (n=12).



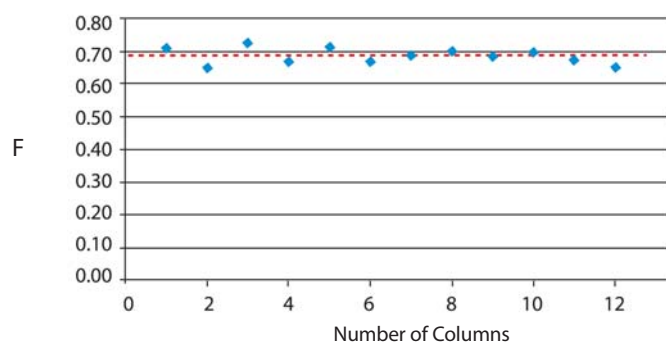
**Equation 1** Flow restriction factor (F) is used to demonstrate coating consistency.

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

$t_R$  = retention time

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

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



**Equation 2** Percent flow restriction of coated column.

$$\% \text{ restriction} = (1 - F) \times 100$$

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 <sub>2</sub> SO <sub>4</sub> deactivation)	Aluminum oxide	GS-Alumina, HP PLOT S, HP PLOT M	Alumina-PLOT	AT-Alumina	CP-Al <sub>2</sub> O <sub>3</sub> /NA <sub>2</sub> SO <sub>4</sub>	—
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-UPLLOT	—	—	CP-PoraPlot U, PoraBond U	—

## Rt®-Alumina BOND Columns

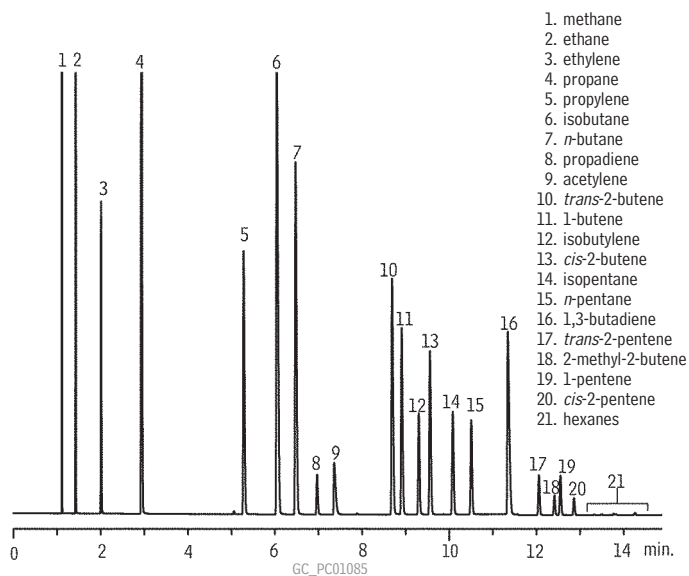
- Applications for C1-C10 volatile hydrocarbon separations at percent levels, as well as impurity analyses at ppm concentrations.
- High capacity and loadability give exceptionally symmetric peaks.
- Reproducible retention times and predictable flow behavior column-to-column.



Trace water in the carrier gas can affect the selectivity and retention of the Rt®-Alumina BOND column. The column can be regenerated by baking out the water (50°C to 200°C @ 8°C/min., 50cm/sec. flow rate). 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.

### Refining gas on an Rt®-Alumina BOND column.



Column: Rt®-Alumina BOND, 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: 45cm/sec. @ 45°C  
 Oven temp.: 45°C (hold 1 min.) to 200°C @ 10°C/min. (hold 3.5 min.)  
 Det.: FID @ 200°C

## Rt®-Alumina BOND (Na<sub>2</sub>SO<sub>4</sub> deactivation)

- 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.

## Rt®-Alumina BOND Columns (fused silica PLOT)

(Na<sub>2</sub>SO<sub>4</sub> deactivation)

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



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

## Rt®-Alumina BOND (KCl deactivation)

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

## Rt®-Alumina BOND Columns (fused silica PLOT)

(KCl deactivation)

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<sup>®</sup>-Msieve 5A PLOT Columns

Rt<sup>®</sup>-Msieve 5A PLOT columns are designed for efficient separation of Ar/O<sub>2</sub> and other permanent gases, including CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, and CO. Special coating and deactivation procedures ensure chromatographic efficiency and the integrity of the porous layer coating. Molecular sieves have very high retention, allowing separations of permanent gases at temperatures above ambient. Additionally, Restek's unique immobilization process guarantees that the uniform particles remain adhered to the tubing—even after continuous valve-cycling.

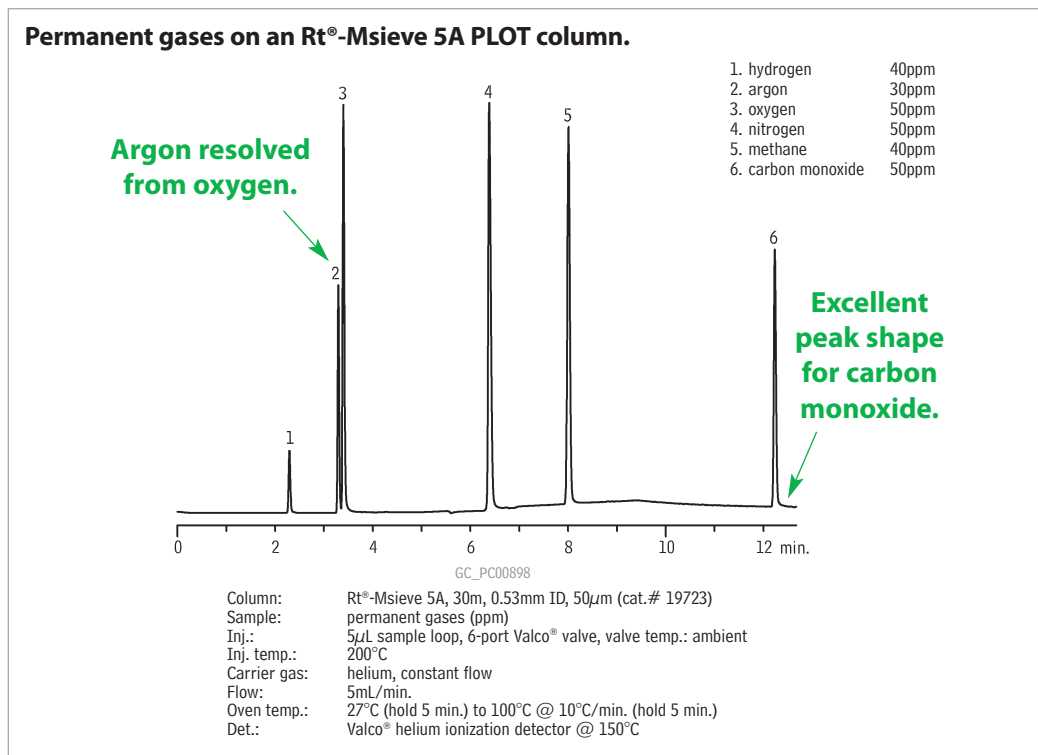
Our revolutionary molecular sieve 5A PLOT columns separate Ar/O<sub>2</sub> and H<sub>2</sub>/He at ambient temperature or above (see figure). These columns also are an excellent choice for rapid separation of permanent gases in refinery or natural gas.

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.



## did you know?

Rt<sup>®</sup>-Msieve 5A PLOT columns are designed for efficient separation of Ar/O<sub>2</sub> and other permanent gases, including CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, 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<sup>®</sup>-Msieve 5A PLOT column by conditioning at 300°C with dry carrier gas flow for 3 hours.

## Rt<sup>®</sup>-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

## MXT<sup>®</sup>-Msieve 5A (Siltek<sup>®</sup>-treated stainless steel PLOT)

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

## Restek Tubing Scorer for MXT<sup>®</sup> Columns

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

Metal MXT<sup>®</sup> columns are easy to cut. Scoring wafers can be used, but may leave the column end irregularly shaped. The Restek tubing scorer is designed to make a perfect cut every time, leaving the 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<sup>®</sup>-Q-BOND, Rt<sup>®</sup>-QS-BOND, Rt<sup>®</sup>-S-BOND, Rt<sup>®</sup>-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<sup>®</sup>-Q-BOND Columns (fused silica PLOT)

(100% divinylbenzene)

- Nonpolar PLOT column incorporating 100% divinyl benzene.
- Excellent for analysis of C1 to C3 isomers and alkanes up to C12.
- CO<sub>2</sub> and methane separated from O<sub>2</sub>/N<sub>2</sub>/CO (Note: O<sub>2</sub>/N<sub>2</sub>/CO not separated at room temperature).
- Use for analysis of oxygenated compounds and solvents.
- Maximum temperature of 320°C.

ID	df (μm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 300/320°C	19743	19744
0.53mm	20	to 300/320°C	19741	19742

### Rt<sup>®</sup>-QS-BOND Columns (fused silica PLOT)

(porous divinyl benzene homopolymer)

- Intermediate polarity PLOT column incorporating divinyl benzene homopolymer.
- 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<sup>®</sup>-S-BOND Columns (fused silica PLOT)

(divinylbenzene 4-vinylpyridine)

- Midpolarity PLOT column, incorporating divinyl benzene 4-vinylpyridine.
- 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<sup>®</sup>-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



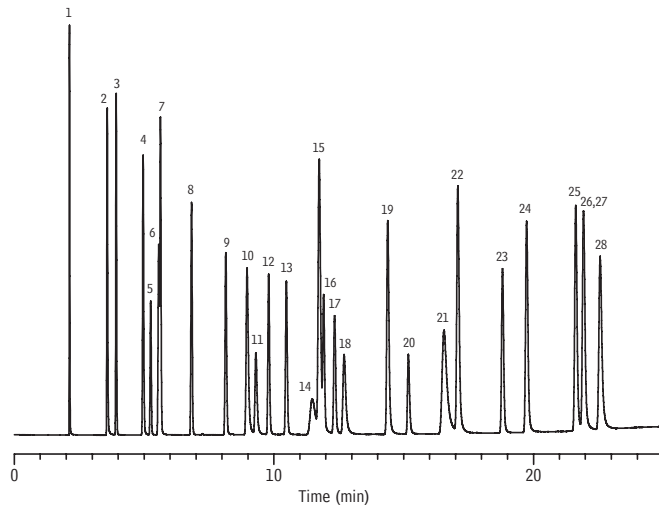
### PLOT Column Particle Trap

- Includes two Press-Tight<sup>®</sup> connectors and a 2.5m column.
- Protects detector and valves; connects between column and detector or valve.
- Eliminates detector spikes and scratches in valve rotors.

The technology used to adhere particles in PLOT columns is excellent; however, there is still a possibility for particles to dislodge. When using PLOT columns with a valve-switching system or GC/MS, we recommend using a particle trap at the outlet end of the column.

Description	qty.	cat.#
PLOT Column Particle Trap, 2.5m, 0.32mm ID w/2 Press-Tight Connectors	ea.	19753
PLOT Column Particle Trap, 2.5m, 0.53mm ID w/2 Press-Tight Connectors	ea.	19754

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

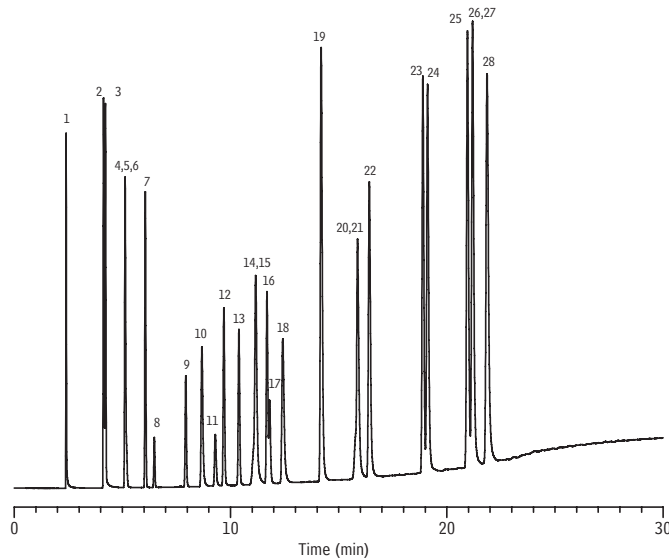


- |                                       |                         |
|---------------------------------------|-------------------------|
| 1. methanol                           | 15. benzene             |
| 2. ethanol                            | 16. 1,2-dimethoxyethane |
| 3. acetonitrile         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

Column: Rt®-Q-BOND, 30m, 0.53mm ID, 20 $\mu$ m (cat.# 19742)  
 Sample: solvent mixture  
 Inj.: 1.0 $\mu$ L, 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

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

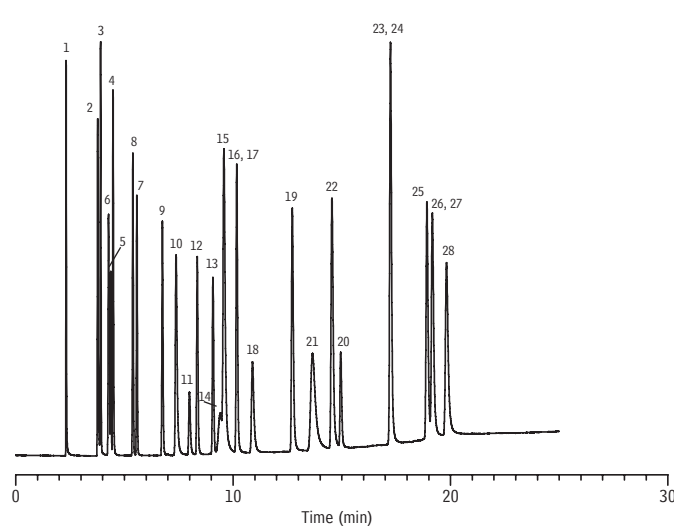


- |                                       |                         |
|---------------------------------------|-------------------------|
| 1. methanol                           | 15. benzene             |
| 2. ethanol                            | 16. 1,2-dimethoxyethane |
| 3. acetonitrile         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

Column: Rt®-QS-BOND, 30m, 0.53mm ID, 20 $\mu$ m (cat.# 19738)  
 Sample: solvent mixture  
 Inj.: 1.0 $\mu$ L, 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                           | 15. benzene             |
| 2. ethanol                            | 16. 1,2-dimethoxyethane |
| 3. acetonitrile                       | 17. trichloroethylene   |
| 4. acetone                            | 18. 1,4-dioxane         |
| 5. dichloromethane                    | 19. pyridine            |
| 6. 1,1-dichloroethene                 | 20. dimethylformamide   |
| 7. nitromethane                       | 21. methylcyclohexane   |
| 8. <i>trans</i> -1,2-dichloroethylene | 22. toluene             |
| 9. <i>cis</i> -1,2-dichloroethylene   | 23. 2-hexanone          |
| 10. tetrahydrofuran                   | 24. chlorobenzene       |
| 11. chloroform                        | 25. ethylbenzene        |
| 12. ethyl acetate                     | 26. <i>m</i> -xylene    |
| 13. 1,2-dichloroethane                | 27. <i>p</i> -xylene    |
| 14. 1,1,1-trichloroethane             | 28. <i>o</i> -xylene    |

Column: Rt®-S-BOND, 30m, 0.53mm ID, 20 $\mu$ m (cat.# 19746)  
 Sample: solvent mixture  
 Inj.: 1.0 $\mu$ L, 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

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**Restek U.S.** • 110 Benner Circle • Bellefonte, PA 16823 • 814-353-1300 • 800-356-1688 • fax: 814-353-1309 • [www.restek.com](http://www.restek.com)

**Restek France** • phone: +33 (0)1 60 78 32 10 • fax: +33 (0)1 60 78 70 90 • e-mail: [restek@restekfrance.fr](mailto:restek@restekfrance.fr)

**Restek GmbH** • phone: +49 (0)6172 2797 0 • fax: +49 (0)6172 2797 77 • e-mail: [info@restekgmbh.de](mailto:info@restekgmbh.de)

**Restek Ireland** • phone: +44 (0)2890 814576 • fax: +44 (0)2890 814576 • e-mail: [restekeurope@aol.com](mailto:restekeurope@aol.com)

**Thames Restek U.K. LTD** • phone: +44 (0)1494 563377 • fax: +44 (0)1494 564990 • e-mail: [sales@thamesrestek.co.uk](mailto:sales@thamesrestek.co.uk)

