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Supelco’s new and improved line of capillary GC columns deliver the capillary GC column performance you demand for your general purpose, special purpose GC/MS, or environmental applications.

Significant improvements in the polymer chemistry are at the heart of the enhanced performance you will receive with our new Equi Capillary GC Columns. The polymer improvements result in better cross-linking, higher thermal stability, and superior product reproducibility.

The consistent resolution, analyte response, low bleed, and column life from one Equi column to the next will allow you to transfer methods between sites or instruments within the same site. Also, maintain the expected column performance over time within the same instrument when you need to replace your column. The reproducible performance Equi provides will minimize time consuming method adjustments and troubleshooting with column changes which means more tests run with higher confidence.

The Resolution You Need
For accurate identification, reliable quantitation, and confidence in your results choose Equi Capillary GC Columns. The consistently high resolution you demand and the service you deserve.

The Analyte Response You Require
For lower detection limits and less instrument downtime, you can depend on Equi Capillary GC Columns. The reproducible analyte response you demand and the service you deserve.

Equi-1

Column: 30m x 0.25mm ID, 0.25µm
Cat. No.: E6178-U
Oven: 50°C to 200°C @ 10°C/min. (5 min.)
Inj.: 250°C
Det.: FID, 300°C
Flow: 30cm/sec. @ 50°C
Injection: 1.0µL, 100:1 split
Sample: UST Modified Gasoline Range Organics (48167)

2,3-Butanediol: Excellent response & peak symmetry

Equi-5

Column: 30m x 0.25mm ID, 0.25µm
Cat. No.: E6179-U
Oven: 40°C (4 min.) to 325°C @ 10°C/min (5 min.)
Inj.: 250°C
MSD Interface: 325°C
Scan Range: 45-450 amu
Flow: 12.5psi constant pressure
Injection: 1.0µL, splitless
Sample: 25ng on-column of a 16 component semivolatile standard

Excellent response and peak symmetry for pentachlorophenol

Excellent response and peak symmetry for benzidine
The Low Bleed You Expect

For great sensitivity, reliable identification, and increased sample throughput rely on Equity Capillary GC Columns. The consistent low bleed performance you demand and the service you deserve.

Equity-1

Column: 30m x 0.25mm ID, 0.25μm
Cat. No.: 28089-U
Oven: 110°C (14 min.) to 325°C (15 min) @ 15°C/min.
Inj.: 250°C
Det.: FID, 360°C
Flow: 30cm/sec. @ 110°C
Injection: 1.0μL, 100:1 split
Sample: Nonpolar Column Test Mix (47300-U)

The Column Life You Count On

To increase your productivity and reduce your instrument downtime, use Equity Capillary GC Columns. The durable, consistent column life you demand and the service you deserve.

Equity-5

Column: 30m x 0.25mm ID, 0.25μm
Cat. No.: 28089-U
Oven: 110°C (14 min.) to 325°C (15 min) @ 15°C/min.
Inj.: 250°C
Det.: FID, 360°C
Flow: 30cm/sec. @ 110°C
Injection: 1.0μL, 100:1 split
Sample: Nonpolar Column Test Mix (47300-U)

Supelco plans to add more phases and dimensions to the Equity line of capillary GC columns. Our original nonpolar capillary GC columns are still available and are located on the “Other Columns” pages following the Capillary GC section.

RELATED INFORMATION

For more information on the Equity line of capillary GC columns request T402049.
Capillary GC
Equity-1 Columns

Industrial Solvents (GC)
Column: Equity-1, 30m x 0.32mm ID, 1.0μm
Cat. No.: 28057-U
Oven: 35°C (8 min) to 130°C @ 4°C/min. (2 min)
Inj.: 250°C
Det.: FID, 250°C
Flow: Helium, 25cm/sec constant @ 35°C
Inj.: 0.5μL, split (200:1)
Liner: Split, cup design
Sample: 0.5μL of a 59 component neat solvent mixture

Excellent peak shapes and resolution

Hydrocarbons and Alcohols (GC)
Column: Equity-1, 30m x 0.53mm ID, 3.0μm
Cat. No.: 28076-U
Oven: 40°C (5 min.) to 225°C @ 8°C/min.
Inj.: 250°C
Det.: FID, 225°C
Flow: Helium, 30 cm/sec @ 40°C
Inj.: 0.10μL, split 100:1
Liner: Split, cup design
Sample: 32 component mixed solvent sample, equal by weight

Equity-1 Capillary GC Columns
Phase: bonded; poly(dimethylsiloxane)
Temp. Limits: 0.25 and 0.32mm ID: -60°C to 325/350°C
0.53mm ID: -60°C to 300/320°C (<=1.5μm df)
-60°C to 260/280°C (>1.5μm df)

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US EPA Method 8270 Semivolatile Compounds (GC/MS)

Column: Equity-5, 30m x 0.25mm ID, 0.5μm
Cat. No.: 28089-U
Oven: 40°C (2 min) to 100°C @ 50°C/min to 200°C @ 10°C/min to 210°C @ 30°C/min (7.5 min)
Inj.: 280°C
Det.: 5973 MSD, Scan range 45-450 amu, 325°C transfer line
Flow: Pressure programmed, 20psi (0.0 min.), ramp to 80psi (0.0 min), ramp to 16.5psi (3 min), ramp to 25psi (hold for remainder of run)
Injection: 1.0μL, splitless (0.6 min)
Liner: Single taper, unpacked
Sample: 50ng on-column of a 74 component semivolatile standard, 6 internal standards, and 8 surrogates

US EPA Method 8081 Chlorinated Pesticides (GC)

Column: Equity-5, 30m x 0.25mm ID, 0.25μm
Cat. No.: 28089-U
Oven: 100°C (2 min) to 160°C @ 15°C/min to 300°C @ 5°C/min (10 min)
Inj.: 225°C
Det.: ECD, 310°C
Flow: Helium, 30cm/sec @ 100°C
Injection: 2.0μL, splitless (0.5 min)
Liner: Splitless double taper, unpacked
Sample: 50pg of a 22 component chlorinated pesticide standard (Cat. No. 46845-U)
Capillary GC
General Purpose Columns

SPB-Octyl
Polarity approaches that of squalane, and is substantially less than that of the widely used “nonpolar” methyl silicone phase. Because these columns offer unique selectivity compared to the commonly used low and intermediate polarity columns, we recommend SPB-Octyl columns for multidimensional or confirmational analyses of PCB-containing samples.

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

Phase: bonded; poly(50% n-octyl/50% methylsiloxane)
Temp. Limits: -60°C to 280°C (isothermal)
McReynolds Nos.: x’ y’ z’ u’ s’ = 3 14 11 12 11

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SPB-20
SPB-20 columns have intermediate polarity as a result of the higher (20%) phenyl content of the stationary phase. The higher polarity produces different elution order for polar compounds, providing confirmational information.

This column meets USP G28 and G32 requirements

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

Phase: bonded; poly(20% diphenyl/80% dimethylsiloxane)
Temp. Limits: -25°C to 300°C
McReynolds Nos.: x’ y’ z’ u’ s’ = 67 116 117 174 131

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SPB-35
SPB-35 columns have higher polarity than SPB-20 columns as a result of a greater phenyl content (35%). These columns are useful for analyses of polar compounds, because these compounds are retained longer, relative to nonpolar compounds.

This column meets USP G42 requirements

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

Phase: bonded; poly(35% diphenyl/65% dimethylsiloxane)
Temp. Limits: 0°C to 300°C
McReynolds Nos.: x’ y’ z’ u’ s’ = 101 146 151 219 202

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SPB-50
These columns have the highest phenyl content of the common phenyl-containing series of phases, and hence provide the highest polarizability. They are useful for analyses of polar materials and provide useful confirmational information.

This column meets USP G3 requirements

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

Phase: bonded; poly(50% diphenyl/50% dimethylsiloxane)
Temp. Limits: 30°C to 310°C
McReynolds Nos.: x’ y’ z’ u’ s’ = 125 175 183 268 220

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**SP-2250**

The nonbonded 50% phenyl polymer that is matched in polarity by the bonded version, SPB-50.

This column meets USP G3 requirements.

**Phase:** nonbonded; poly(50% phenyl/50% methylsiloxane)

**Temp. Limits:** 0°C to 250°C

**McReynolds Nos.:** $x' y' z' u' s' = 119 \ 158 \ 162 \ 243 \ 202$

---

**SPB-17**

This bonded, crosslinked (50%-phenyl)-methylpolysiloxane, intermediate polarity phase is excellent for confirmational analyses.

This column meets USP G3 requirements.

**Operating Conditions:** Columns can be rinsed.

**Phase:** bonded; (50% phenyl) methylpolysiloxane

**Temp. Limits:** 0.25 and 0.32mm ID: 40°C to 280/300°C
0.53mm ID: 40°C to 260/280°C

**McReynolds Nos.:** $x' y' z' u' s' = 125 \ 169 \ 174 \ 253 \ 207$

---

**PAG**

Less polar than polyethylene glycol phases, due to the incorporation of propylene oxide into the polymer backbone. Fills the polarity gap between 50% phenyl columns and Carbowax-type columns (polarity similar to UCON and Pluronics phases).

This column meets USP G18 requirements.

**Operating Conditions:** Chemically compatible with water and other injection solvents, but solvents such as water and methanol must be vaporized before reaching the column inlet. Avoid these solvents when using on-column injection techniques.

**Phase:** bonded; poly(14% cyanopropylphenyl/86% dimethylsiloxane)

**Temp. Limits:** subambient to 280°C

**McReynolds Nos.:** $x' y' z' u' s' = 67 \ 170 \ 153 \ 228 \ 171$

---

**SPB-1701**

Intermediate polarity SPB-1701 columns have a mixed functionality which provides unique elution order characteristics, relative to the phenyl-containing silicone phases.

This column meets USP G46 requirements.

**Operating Conditions:** Columns can be rinsed.

**Phase:** bonded; poly(14% cyanopropylphenyl/86% dimethylsiloxane)

**Temp. Limits:** subambient to 280°C

**McReynolds Nos.:** $x' y' z' u' s' = 67 \ 170 \ 153 \ 228 \ 171$

---

**Capillary GC**

**General Purpose Columns**

---

**LENGTH (m) D (μm) BETA CAT. NO. PRICE**

**0.25mm ID FUSED SILICA**

15 0.25 250 24374-U
30 0.25 250 24380-U

**0.32mm ID FUSED SILICA**

30 0.25 320 24381
30 0.50 160 24376

**0.53mm ID FUSED SILICA**

15 1.0 250 25472
30 1.0 250 25369

---

**LENGTH (m) D (μm) BETA CAT. NO. PRICE**

**0.25mm ID FUSED SILICA**

15 0.25 250 24374-U
30 0.25 250 24380-U

**0.32mm ID FUSED SILICA**

30 0.25 320 24381
30 0.50 160 24376

**0.53mm ID FUSED SILICA**

15 1.0 250 25472
30 1.0 250 25369
SUPELCOWAX 10

The bonded equivalent to the CARBOWAX 20M phase, with much higher thermal stability. Because this phase offers higher polarity than any of the phenylsilicone phases, it is widely used for separation and purity analyses of many polar compounds, including alcohols, aromatics, and other solvents, flavors, fragrances and FAMEs.

This column meets USP G16 requirements.

Operating Conditions: Chemically compatible with water and other injection solvents, but solvents such as water and methanol must be vaporized before reaching the column inlet. Avoid these solvents when using on-column injection techniques. Sensitive to strong inorganic acids. Columns can be rinsed.

SPB-1000

An improved version of our Nukol phase, SPB-1000 is a bonded, PEG-type phase incorporating acidic functional groups and displaying a polarity closer to the SP-1000 phase than does Nukol. It displays the acidic character necessary for analyses of volatile acidic compounds. It also offers improved performance for analyses of glycols, compared to the Nukol phase. It is the recommended column for ethylene glycol analysis.

This column meets USP G25 and G35 requirements.

Operating Conditions: Columns can be rinsed.

SUPELCO

General Purpose Columns

Nukol (Bonded Free Fatty Acid Phase)

This bonded PEG-type phase, incorporating acidic functional groups, displays an acidic character and is useful for analyses of volatile acidic compounds. Even free carboxylic acids can be analyzed with excellent peak shape and minimal adsorption.

This column meets USP G25 and G35 requirements.

Operating Conditions: Sensitive to strong inorganic acids. Columns can be rinsed.

Order: 1.800.325.3010 Technical Service: 1.800.359.3041 Web: www.sigma-aldrich.com/supelco
SPB-225

This bonded, crosslinked (50% cyanopropylphenyl) methylpolysiloxane, intermediate-high polarity phase is excellent for separations of cis and trans FAMEs.

This column meets USP G7 and G19 requirements.

**Operating Conditions:** Columns can be rinsed.

**Phase:** bonded; (50% cyanopropylphenyl) methylpolysiloxane

**Temp. Limits:** 45°C to 220/240°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>Df (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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SP-2330

Substitution of the bis-cyanopropyl and phenyl groups on the polymer backbone provides the phase with both polar and polarizable characteristics. These columns (and all high cyanopropyl-substituted polymers) are useful for both high and low temperature separations of samples such as geometric isomers of fatty acid methyl esters, dioxins, and aromatic compounds.

This column meets USP G8 requirements.

**Operating Conditions:** More susceptible to damage by oxygen, moisture, and HCI than other silicone phases. Avoid solvents such as water and methanol when using on-column injection techniques. Columns should not be rinsed.

**Phase:** nonbonded; poly(80% bis-cyanopropyl/20% cyanopropylphenyl siloxane)

**Temp. Limits:** subambient to 250°C

**McReynolds Nos.:** x' y' z' u' s' = 382 610 506 710 591

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>CAT. NO.</th>
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</table>

SP-2380

Between the traditional nonbonded cyanosilicone phases SP-2330 and SP-2340 in polarity. The high polarity of this phase allows the separation of geometric (cis/trans) fatty acid methyl ester isomers as a group. Stabilized phase with a maximum temperature slightly higher than SP-2330 or SP-2340. Significantly more stable than SP-2330.

This column meets USP G48 requirements.

**Operating Conditions:** More susceptible to damage by oxygen, moisture, and HCI than other silicone phases. Avoid solvents such as water and methanol when using on-column injection techniques. Columns should not be rinsed.

**Phase:** stabilized poly(90% bis-cyanopropyl/10% cyanopropylphenyl siloxane)

**Temp. Limits:** subambient to 275°C

**McReynolds Nos.:** x' y' z' u' s' = 402 629 520 744 623

<table>
<thead>
<tr>
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<th>BETA</th>
<th>CAT. NO.</th>
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<td>663</td>
<td>25319</td>
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</table>

SP-2340

The highest polarity of any of the general purpose cyanosilicone phases. As with all cyano phase columns, these columns are useful for both high and low temperature separations of samples such as geometric isomers of fatty acid methyl esters, dioxins, and aromatic compounds.

This column meets USP G5 requirements.

**Operating Conditions:** More susceptible to damage by oxygen, moisture, and HCI than other silicone phases. Avoid solvents such as water and methanol when using on-column injection techniques. Columns should not be rinsed.

**Phase:** nonbonded; poly(biscyanopropyl siloxane)

**Temp. Limits:** subambient to 250°C

**McReynolds Nos.:** x' y' z' u' s' = 419 654 541 758 637

<table>
<thead>
<tr>
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<th>Df (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tr>
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<td>320</td>
<td>24076</td>
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</tbody>
</table>
Capillary GC
Special Purpose Columns (Chiral)

α-DEX 120
α-DEX 120 columns provide unique selectivity for enantiomeric separations of small molecules; also recommended for separating positional isomers (phenols, xylenes, etc.).

Phase: nonbonded; 20% permethylated α-cyclodextrin in SPB-35 poly(35% phenyl/65% dimethylsiloxane)

β-DEX 110, β-DEX 120
We recommend β-DEX columns for enantiomeric separations of a wide range of chiral compounds (ketones, esters, alkanes, alkenes, alcohols, acids, ethers, etc.). The 10% (β-DEX 110) and 20% (β-DEX 120) β-cyclodextrin content alters the elution order while maintaining similar enantioselectivity.

Phase: nonbonded; 10% and 20% permethylated β-cyclodextrin in SPB-35 poly(35% diphenyl/65% dimethylsiloxane)

γ-DEX 120
Because the elution order of the members of a chiral pair frequently reverses (enantioreversal) on a γ-DEX column, compared to the elution order on an α-DEX or β-DEX column, we recommend γ-DEX columns as complements to α-DEX and β-DEX columns.

Phase: nonbonded; 20% permethylated γ-cyclodextrin in SPB-35 poly(35% diphenyl/65% dimethylsiloxane)

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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</table>

Temperature limits for all DEX columns: 30°C to 230°C.

Resolve positional isomers in highly disproportionate mixtures

Use γ-DEX to reverse elution order for many compounds (methyl mandelate shown)

Resolve positional isomers in highly disproportionate mixtures

Use γ-DEX to reverse elution order for many compounds (methyl mandelate shown)
**Cycloextrin Column Selection Kits**

These kits provide the tools you need to perform most chiral separations. Confirm identities of enantiomers by monitoring elution order changes (enantioresolution) from one column to another. In combination, the columns in the two kits span the full range of DEX column enantioselectivity, at substantial savings relative to purchasing individual columns.

Kit I: one 30 m x 0.25 mm ID, 0.25 μm film column of each type: α-DEX 120, β-DEX 120, γ-DEX 120.

Kit II: one 30 m x 0.25 mm ID, 0.25 μm film column of each type: β-DEX 120, β-DEX 225, γ-DEX 225, β-DEX 325.

**Related Information**

Request free literature by phone or fax, or see our website.

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
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<tbody>
<tr>
<td>T194877</td>
<td>Chiral applications/selection guide</td>
</tr>
<tr>
<td>T499055</td>
<td>Using DEX Column Selection Kit II</td>
</tr>
</tbody>
</table>

**DE-225 and DE-325 Columns**

It is difficult to predict the best phase for a given chiral or positional isomer separation, so we offer a broad range of DEX selectivities. We prepare DE-225 and DE-325 columns using dimethyl- and diacetyl-derivatized cyclodextrins. These columns can separate volatile chiral molecules, including alcohols, aldehydes, carboxylic acids, epoxides, esters, and halogenated compounds. We are continually developing specific applications on all our cyclodextrin columns, and suggest that you regularly consult our Web site for the most current chiral applications.

**α-DEX 225**

**Phase:** nonbonded; 25% 3,3-di-O-acetyl-6-O-TBDMS-α-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**β-DEX 225**

These columns provide unique selectivity for enantiomeric separations of small molecules: alcohols, aldehydes (e.g., 2-phenylpropionaldehyde), esters (e.g., methyl malate, methyl lactate), flavor compounds, and ketones.

**Phase:** nonbonded; 25% 3,3-di-O-acetyl-6-O-TBDMS-β-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**γ-DEX 225**

**Phase:** nonbonded; 25% 3,3-di-O-acetyl-6-O-TBDMS-γ-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**α-DEX 325**

**Phase:** nonbonded; 25% 3,3-di-O-methyl-6-O-TBDMS-α-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**β-DEX 325**

**Phase:** nonbonded; 25% 3,3-di-O-methyl-6-O-TBDMS-β-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**γ-DEX 325**

**Phase:** nonbonded; 25% 3,3-di-O-methyl-6-O-TBDMS-γ-cyclodextrin in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**LENGTH (m) Df (μm) BETA CAT. NO. PRICE**

| α-DEX 225 | 30 | 0.25 | 250 | 24311 |
| β-DEX 225 | 30 | 0.25 | 250 | 24348 |
| γ-DEX 225 | 30 | 0.25 | 250 | 24312 |
| α-DEX 325 | 30 | 0.25 | 250 | 24303 |
| β-DEX 325 | 30 | 0.25 | 250 | 24308 |
| γ-DEX 325 | 30 | 0.25 | 250 | 24306 |

Fused silica columns, 0.25 mm ID
Capillary GC
Special Purpose Columns (Environmental)

Volatile: VOCOL

These intermediate polarity columns, designed for volatile organic compounds (VOCs) analysis, ensure greater retention and resolution of the more volatile compounds. Use in direct injection ports or coupled to purge-and-trap systems, for US EPA volatiles methods, including 502.2, 524.2, 624, 8240, 8260, and 8021.

**Temp. Limits:** subambient to 250°C (1.5μm film) or 230°C (3μm film)

### VOCOL Specifications

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D₀ (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tr>
<td>0.32mm ID Fused Silica</td>
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<td>44</td>
<td>24217-U</td>
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<tr>
<td>0.53mm ID Fused Silica</td>
<td>3.0</td>
<td>44</td>
<td>25320-U</td>
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</tr>
</tbody>
</table>

Column: VOCOL, 30m x 0.53mm ID, 3.0μm film
Cat. No.: 25320-U

Oven: 5°C (2 min) to 200°C at 5°C/min
Carrier: helium, 7.5mL/min
Det.: MS, Scan Range m/z = 35-260 at 0.6 sec/scan
Inj.: 11min, 40mL/min, Dry Purge 3min, Desorb 250°C, 4 min

Volatile: SPB-624

For purge-and-trap analyses of volatile compounds - Specially tested for separation, efficiency, and baseline bleed. Designed for purge-and-trap analyses of volatile halogenated, nonhalogenated and aromatic contaminants from air, drinking and waste water, and soil. SPB-624 columns meet the requirements of various US EPA methods: CLP-VOA, 502.2, 524.2, 601, 602, 624, 1624, TO-1, TO-2, TO-3, TO-14, 5041, 8010, 8015, 8020 and 8260.

**Temp. Limits:** subambient to 250°C (1.4μm or 1.8μm film) or 230°C (3.0μm film)

### SPB-624 Specifications

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
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Column: SPB-624, 75m x 0.53mm ID, 3μm film
Cat. No.: 25422

Oven: 40°C (2 min) to 65°C at 5°C/min, to 155°C at 12°C/min, to 210°C at 25°C/min
Carrier: helium, 10mL/min
Det.: MSD, m/z = 35-260
Inj.: Purge 11 min, Dry Purge 3min, Desorb 250°C, 5 min
**Gas Chromatography**

SUPELCO

Order: 1.800.325.3010 Technical Service: 1.800.359.3041 Web: www.sigma-aldrich.com/supelco

**Proprietary bonded phase**

Column: SPB-608, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 24103-U

Oven: 150°C (4 min) to 290°C at 8°C/min, hold 10 min
Carrier: helium, 38cm/sec, set at 150°C
Detector: ECD, 300°C
Inj.: 1μL (0.4μg/mL each analyte), on-column, 220°C

Resolve key compound pairs

Minimum breakdown of 4,4’-DDT and endrin

### Pesticides/Herbicides: SPB-608

For chlorinated pesticides - Specially tested with low concentrations of 18 chlorinated pesticides, with an electron capture detector (ECD). These columns meet the criteria for minimum breakdown of 4,4’-DDT and endrin for US EPA Methods 508, 608, 8080, 8081, and SW-Pesticides.

Temp. Limits: subambient to 300°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
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### Temp. Limits: subambient to 300°C

**Capillary GC**

Special Purpose Columns (Environmental)

Column: Sup-Herb, 15m x 0.53mm ID, 0.5μm film
Cat. No.: 25322

Oven: 60°C (1 min) to 280°C at 16°C/min
Carrier: helium, 5mL/min
Detector: NPD, 300°C
Inj.: 0.5μL 22 Herbicides Mix (5μg/mL each analyte in ethyl acetate), direct, 220°C

Resolve all herbicides in US EPA Method 507

Unique elution pattern – valuable for confirming results from a 5% phenyl column

### Pesticides/Herbicides: Sup-Herb

Specially tested intermediate polarity column for analyses of herbicides, per US EPA Method 507.

Temp. Limits: subambient to 300°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
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<tr>
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</table>

**Order:** 1.800.325.3010 Technical Service: 1.800.359.3041 Web: www.sigma-aldrich.com/supelco
**Capillary GC**

**Special Purpose Columns (Environmental, Air Monitoring, High Temperature)**

### Dioxins: SP-2331

For TCDD (dioxin) isomers - A highly polar cyanosilicone stationary phase, specially tested for analyses of TCDD isomers. The phase is stabilized, providing a maximum temperature slightly higher than nonbonded cyanosilicone phases, such as SP-2330.

Temp. Limits: subambient to 275°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>BETA</th>
<th>CAT. NO.</th>
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<td>24104-U</td>
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### Air Monitoring: SPB-HAP

For hazardous air pollutants - This column was developed to provide the best resolution of very volatile, regulated components. The thick film focuses analyses on the front of the column, without cryogenic focusing.

<table>
<thead>
<tr>
<th>Phase</th>
<th>bonded poly(dimethylsiloxane)</th>
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</thead>
<tbody>
<tr>
<td>Temp. Limits</td>
<td>-60°C to 300°C</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>CAT. NO.</th>
<th>PRICE</th>
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### High Temperature: HT-5

For highest-temperature separations - SGE aluminum-clad columns coated with a carborane phase, offering the highest maximum temperature of any commercially available column. They display low bleed for GC/MS and simulated distillation analyses.

<table>
<thead>
<tr>
<th>Phase</th>
<th>bonded; siloxane-carborane (5% phenyl equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. Limits</td>
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</table>

<table>
<thead>
<tr>
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<th>CAT. NO.</th>
<th>PRICE</th>
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<td>25</td>
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<tr>
<td>12</td>
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<td>883</td>
<td>25005-U</td>
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</table>
Capillary GC
Special Purpose Columns (Solvents, Steroids)

Solvents: OVI-G43
For USP Analysis of organic volatile impurities (OVIs) - This column is specially prepared and tested to meet the requirements of United States Pharmacopoeia (USP) Method 467 and the European Pharmacopoeia general method for determining residual organic solvents in pharmaceutical preparations. Use this column to separate OVIs for research purposes or qualitative analysis. The USP and European Pharmacopoeia methods also specify using a deactivated 5-meter guard column.

This column meets USP G43 requirements.

Phase: bonded; poly(6% cyanopropylphenyl/94% dimethylsiloxane)
Temp. Limits: -20°C to 260°C

Steroids: SAC-5
An SE-54 type phase, developed and tested for reproducible analyses of plant sterols, cholesterol, and other animal sterols.

Phase: bonded; poly(5% diphenyl/95% dimethylsiloxane)
Temp. Limits: -60°C to 320°C
McReynolds Nos.: x’ y’ z’ u’ s’ = 19 74 64 93 62

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
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<td>0.53mm ID Fused Silica</td>
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<td>30</td>
<td>3.0</td>
<td>44</td>
<td>25396</td>
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</table>

Deactivated Guard Column for OVI-G43
5m x 0.53mm ID | 25339

Other Columns for Residual Solvents Analysis
G27 (SPB-5) 30m x 0.53mm ID, 5.0μm | 25347
G16 (SUPELCOWAX 10) 30m x 0.53mm ID, 1.0μm | 25301-U
Capillary GC
Special Purpose Columns (Sulfur Compounds, SCOT Columns)

Resolve H₂S, COS, SO₂

Column: SPB-1 SULFUR, 30m x 0.32mm ID, 4μm film
Cat. No.: 24158
Oven: -10°C (3min) to 300°C at 10°C/min
Carrier: helium, 20cm/sec
Det.: sulfur chemiluminescence
Inj.: 0.1mL sulfur gas standard, split 10:1

Sulfur Compounds (Volatile): SPB-1 SULFUR
A very thick film version of our SPB-1 columns, specially developed for analyses of sulfur gases and other volatile sulfur compounds. The column displays relatively low column bleed, even for the exceptionally thick film (4μm) of stationary phase, which makes it compatible for use with the Sievers Sulfur Chemiluminescence Detector (SCD) and other sulfur-specific detectors.

Phase: bonded; poly(dimethylpolysiloxane)
Temp. Limits: -60°C to 300°C

LENGTH (m) Dₜ (μm) BETA CAT. NO. PRICE
0.32mm ID Fused Silica
30 4.0 20 24158

Gases: SCOT Stainless Steel
Support-coated open tubular (SCOT) columns are prepared by depositing a layer of liquid phase-coated support particles on the inner wall of the tubing. This technology, developed by PerkinElmer, makes available many phases that cannot be obtained on conventional wall-coated open tubular capillary columns. SCOT columns combine the sensitivity and excellent sample resolution of capillary GC with the extensive stationary phase library of packed column GC.

50’ x 1/32” OD x 0.02” ID with 1/16” connections

<table>
<thead>
<tr>
<th>LIQUID PHASE</th>
<th>MAX. TEMP. (°C)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel SCOT Columns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentone 34/DNDP²</td>
<td>150</td>
<td>45</td>
<td>25521</td>
<td></td>
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<tr>
<td>BMEA</td>
<td>100</td>
<td>40</td>
<td>25538</td>
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<tr>
<td>Squalane</td>
<td>120</td>
<td>50</td>
<td>25535</td>
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<td>TCEP</td>
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<td>40</td>
<td>25536</td>
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</tr>
</tbody>
</table>

² Di-n-decylphthalate
Capillary GC
Special Purpose Columns (Gases - PLOT Columns)

Gases: Carboxen-1006 PLOT¹
For permanent gases and C1 – C3 light hydrocarbons - The porous carbon molecular sieve (surface area ~ 750m²/gram) in Carboxen-1006 porous layer open tubular (PLOT) columns separates permanent gases and C1, C2, and C3 light hydrocarbons, using above-ambient initial temperatures. The columns also are ideal for resolving formaldehyde/water/methanol (formalin) mixtures and monitoring impurities in ethylene. Use Carboxen-1006 columns with high flow rates and rapid temperature programs, up to 250°C, to ensure excellent, fast separations.

<table>
<thead>
<tr>
<th>DIMENSIONS (FUSED SILICA)</th>
<th>MAX. TEMP. ⁰C</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>30m x 0.32mm ID</td>
<td>250</td>
<td>24241-U</td>
<td></td>
</tr>
<tr>
<td>30m x 0.53mm ID²</td>
<td>250</td>
<td>25461</td>
<td></td>
</tr>
</tbody>
</table>

Column: Carboxen-1006 PLOT, 30m x 0.53mm ID
Cat. No.: 25461
Oven: 35°C (5min) to 225°C at 24°C/min

Gases: Mol Sieve 5A PLOT³
For permanent gases - Oxygen, nitrogen, carbon monoxide and methane can be separated in less than 5 minutes. More difficult separations, such as argon from oxygen, can be achieved by using subambient temperatures (15°C or below).

<table>
<thead>
<tr>
<th>DIMENSIONS (FUSED SILICA)</th>
<th>MAX. TEMP. ⁰C</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>30m x 0.32mm ID</td>
<td>300</td>
<td>24243</td>
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</tr>
<tr>
<td>30m x 0.53mm ID²</td>
<td>300</td>
<td>25463</td>
<td></td>
</tr>
</tbody>
</table>

Column: Mol Sieve 5A PLOT, 30m x 0.53mm ID
Cat. No.: 25463
Oven: 65°C, helium, 10mL/min.

Gases: Supel-Q PLOT³
For many hydrocarbon and other compounds - Supel-Q PLOT columns contain a porous divinylbenzene polymer that effectively resolves carbon dioxide and C1-C4 hydrocarbons at above ambient temperatures. It also is suitable for analyses of other gases, such as sulfur gases, and alcohols, ketones, aldehydes, and many polar compounds. Gasoline and other petroleum fractions can be analyzed as well. These columns exhibit very little bleed, even at the maximum temperature. Relative to packed columns (e.g., Porapak-Q), Supel-Q PLOT columns offer better resolution in less time.

<table>
<thead>
<tr>
<th>DIMENSIONS (FUSED SILICA)</th>
<th>MAX. TEMP. ⁰C</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>30m x 0.32mm ID</td>
<td>250</td>
<td>24242</td>
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</tr>
<tr>
<td>30m x 0.53mm ID²</td>
<td>250</td>
<td>25462</td>
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</table>

¹ A proprietary procedure fixes particles to the fused silica tubing and ensures they will not be dislodged in normal use. Manufactured under US patents 5,599,445; 5,607,380; 5,609,736; 5,620,603; and 5,630,937.
² 0.33mm ID column can be used in packed column chromatographs.
Capillary GC
Special Purpose Columns (FAMES)

Fatty Acids (FAMES): Omegawax

For omega 3 and 6 fatty acids - These columns were developed to provide highly reproducible analyses of fatty acid methyl esters, specifically the omega 3 and 6 fatty acids. The columns are checked for reproducibility of FAME equivalent chain length (ECL) values and resolution of key components. This column meets USP G16 requirements.

| Phase: | bonded; poly(ethylene glycol) |
| Temp. Limits: | 50°C to 280°C |

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>Df (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
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<tr>
<td>OMEGWAX 250</td>
<td>0.25 mm ID Fused Silica</td>
<td>0.25</td>
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<td>OMEGWAX 320</td>
<td>0.32 mm ID Fused Silica</td>
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<td>OMEGWAX 530</td>
<td>0.53 mm ID Fused Silica</td>
<td>0.50</td>
<td>265</td>
<td>25374</td>
</tr>
</tbody>
</table>

Fatty Acids (FAMES): SPB-PUFA

For polyunsaturated fatty acid methyl esters - These columns provide highly reproducible analyses of polyunsaturated fatty acid methyl esters. The lower polarity poly (alkylene glycol) phase features improved “carbon number” separations, compared to poly(ethylene glycol) columns such as Omegawax columns and SUPELCOWAX 10 columns.

| Phase: | bonded; poly(alkylene glycol) |
| Temp. Limits: | 50°C to 220°C |

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
<tr>
<td>0.25 mm ID Fused Silica</td>
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<tr>
<td>0.32 mm ID Fused Silica</td>
<td>0.20</td>
<td>400</td>
<td>24323</td>
<td></td>
</tr>
</tbody>
</table>
## Capillary GC
### Special Purpose Columns (FAMES)

**Fast carbon number separation of 37 component FAME mix**

![Graph showing fast carbon number separation of 37 component FAME mix]

**Positional and geometric isomers separated by very high polarity and long column length**

![Graph showing positional and geometric isomers separation]

### Fatty Acids (FAMES): SP-2380

For separations by carbon number - This column was developed for high resolution and efficiency, and fast analyses of positional and geometric isomers of fatty acid methyl esters.

**Phase:** stabilized poly(90% biscyanopropyl/10% cyanopropylphenyl siloxane)

**Temp. Limits:** subambient to 275°C

<table>
<thead>
<tr>
<th>Component (acid methyl esters)</th>
<th>Weight (acid methyl esters) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. C4:0 (Butyric)</td>
<td>4</td>
</tr>
<tr>
<td>2. C6:0 (Capric)</td>
<td>4</td>
</tr>
<tr>
<td>3. C8:0 (Caprylic)</td>
<td>4</td>
</tr>
<tr>
<td>4. C10:0 (Capric)</td>
<td>4</td>
</tr>
<tr>
<td>5. C11:0 (Undecanoic)</td>
<td>2</td>
</tr>
<tr>
<td>6. C12:0 (Lauric)</td>
<td>4</td>
</tr>
<tr>
<td>7. C13:0 (Tridecanic)</td>
<td>2</td>
</tr>
<tr>
<td>8. C14:0 (Myric)</td>
<td>4</td>
</tr>
<tr>
<td>9. C16:0 (Palmitic)</td>
<td>6</td>
</tr>
<tr>
<td>10. C18:0 (Oleic)</td>
<td>6</td>
</tr>
<tr>
<td>11. C18:1 (Linoleic)</td>
<td>6</td>
</tr>
<tr>
<td>12. C18:2 (Linolenic)</td>
<td>6</td>
</tr>
</tbody>
</table>

### Fatty Acids (FAMES): SP-2560

For cis/trans positional isomers - Specially prepared and tested columns, designed to separate geometric-positional (cis/trans) isomers of fatty acid methyl esters. Recommended for separating FAMES in hydrogenated vegetable oil samples.

**Phase:** nonbonded; biscyanopropyl polysiloxane

**Temp. Limits:** subambient to 250°C

<table>
<thead>
<tr>
<th>Component (acid methyl esters)</th>
<th>Weight (acid methyl esters) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. C18:0</td>
<td>100</td>
</tr>
<tr>
<td>2. C18:1 trans isomers</td>
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</tr>
<tr>
<td>3. C18:1 cis &amp; trans valley isomers</td>
<td></td>
</tr>
<tr>
<td>4. C18:1 isomers</td>
<td></td>
</tr>
<tr>
<td>5. C18:2</td>
<td></td>
</tr>
<tr>
<td>6. C20:0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component (acid methyl esters)</th>
<th>Weight (acid methyl esters) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. C18:3n3 (e-Linolenic)</td>
<td>2</td>
</tr>
<tr>
<td>23. C20:0 (Arachidic)</td>
<td>4</td>
</tr>
<tr>
<td>24. C20:1n9 (cis-11-Eicosanoic)</td>
<td>2</td>
</tr>
<tr>
<td>25. C20:2 (cis-11,14-Eicosadienoic)</td>
<td>2</td>
</tr>
<tr>
<td>26. C20:3n6 (cis-8,11,14-Eicosatrienoic)</td>
<td>2</td>
</tr>
<tr>
<td>27. C20:3n3 (cis-11,17-Eicosatrienoic)</td>
<td>2</td>
</tr>
<tr>
<td>28. C20:4n6 (Arachidonic)</td>
<td>2</td>
</tr>
<tr>
<td>29. C20:5n3 (cis-15-Eicosapentaenoic)</td>
<td>2</td>
</tr>
<tr>
<td>30. C21:0 (Heneicosic)</td>
<td>2</td>
</tr>
<tr>
<td>31. C22:0 (Behenic)</td>
<td>4</td>
</tr>
<tr>
<td>32. C22:1n9 (Enunic)</td>
<td>2</td>
</tr>
<tr>
<td>33. C22:2 (cis-13,Eicosadienoic)</td>
<td>2</td>
</tr>
<tr>
<td>34. C22:3n6 (cis-4,7,11-Eicosatrienoic)</td>
<td>2</td>
</tr>
<tr>
<td>35. C22:4n6 (cis-8,11,14,17-Eicosatetraenoic)</td>
<td>2</td>
</tr>
<tr>
<td>36. C24:0 (Lignocenic)</td>
<td>4</td>
</tr>
<tr>
<td>37. C24:1n9 (Erucic)</td>
<td>2</td>
</tr>
</tbody>
</table>

**Component Weight (acid methyl esters) %**

- 1. C4:0 (Butyric) 4
- 2. C6:0 (Capric) 4
- 3. C8:0 (Caprylic) 4
- 4. C10:0 (Capric) 4
- 5. C11:0 (Undecanoic) 2
- 6. C12:0 (Lauric) 4
- 7. C13:0 (Tridecanic) 2
- 8. C14:0 (Myric) 4
- 9. C16:0 (Palmitic) 6
- 10. C18:0 (Oleic) 6
- 11. C18:1 (Linoleic) 6
- 12. C18:2 (Linolenic) 6

**Column:** SP-2560, 100m x 0.25mm, 0.20μm film

**Cat. No.:** 24056

**Oven:** 250°C (2 min) to 275°C at 4°C/min, hold 15 min

**Carrier:** helium, 20cm/sec, set at 170°C

**Det.:** FID, 200°C

**Inj.:** 1μL positional cis/trans standard (Cat. No. 45170) (5.0mg/mL FAME isomers in methylene chloride), split 100:1, 200°C
Capillary GC
Special Purpose Columns (Petroleum - Hydrocarbons, MTBE)

**Straight Naphtha Run**
For highly detailed hydrocarbons analyses
Meets requirements of ASTM Method D5134

- **Column:** Petrocol DH 50.2, 50m x 0.20mm ID x 0.50μm film
- **Cat. No.:** 24133-U
- **Oven:** 35°C (30min) to 200°C (20min) at 2°C/min

**Hydrocarbons: Petrocol DH 50.2**
For detailed hydrocarbons analyses - A narrow bore column for detailed hydrocarbon analyses of naphthas, gasolines, and similar samples, according to ASTM Test Method D5134.

- **Phase:** bonded; poly(dimethylsiloxane)
- **Temp. Limits:** -60°C to 320°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<td>0.20mm ID Fused Silica</td>
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<td>0.50</td>
<td>24133-U</td>
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</tr>
</tbody>
</table>

**Light Hydrocarbons**
Length and film thickness provide ambient temperature separations, including critical isobutylene/1-butene

- Cited in ASTM Method D5441 (purity of MTBE)

**Hydrocarbons: Petrocol DH**
For PNA, PONA, PIANO-type analyses - A highly reproducible column displaying more than 400,000 theoretical plates, designed for detailed analyses of petroleum products. Includes an extensive retention index data sheet of 400+ analytes.

- **Phase:** bonded; poly(dimethylsiloxane)
- **Temp. Limits:** -60°C to 320°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (μm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>150</td>
<td>1.0</td>
<td>24155</td>
<td>24160-U</td>
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</table>

**Column:** Petrocol DH 150, 150m x 0.25mm ID, 1.0μm film
- **Cat. No.:** 24155
- **Oven:** -20°C (30min) to 75°C at 5°C/min

**MTBE**
Baseline resolution of critical MTBE contaminants

1. Methanol
2. Isopentane
3. n-Pentane
4. trans-2-Pentene
5. tert-Butanol
6. cis-2-Pentene
7. 2-Methyl-2-butene
8. tert-Butyl ethyl ether
9. tert-Amyl methyl ether (TAME)
10. 2,4,4-Trimethyl-1-pentane
11. 4,4-Dimethyl-2-neopentyl-1-pentene
12. 2,2,4,6,6-Pentamethyl-3-hexene

**Hydrocarbons: Petrocol DH**
For detailed hydrocarbons analyses - The longest capillary column commercially available as a stock item. Columns typically display more than 600,000 theoretical plates. For detailed purity analyses of light hydrocarbon gases and petroleum products (oxygenates, solvents, naphthas, gasolines, etc.).
Capillary GC
Special Purpose Columns (Petroleum - Hydrocarbons, SIMDIS)

**Hydrocarbons: Petrocol DH Octyl**
For detailed analyses of petroleum products - This highly reproducible column offers unique selectivity not obtainable with poly(dimethylsiloxane) columns, such as baseline separations of benzene/1-methylcyclopentene and toluene/2,3,3-trimethylpentane.

- **Phase:** bonded; poly(50% n-octyl/50% methylsiloxane)
- **Temp. Limits:** -60°C to 220°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>100</td>
<td>0.50</td>
<td>24282</td>
<td>125</td>
</tr>
</tbody>
</table>

Meets performance requirements of ASTM Test Method D2887

**SIMDIS: Petrocol DH Octyl**
For ASTM Test Method D2887 - A thin film version of the Petrocol 2887 column, developed for extended D2887 SIMDIS analysis of samples having final boiling points greater than 1000°F.

- **Phase:** bonded; poly(dimethylsiloxane)
- **Temp. Limits:** subambient to 380°C

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
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<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.53mm ID Fused Silica</td>
<td>5</td>
<td>0.10</td>
<td>25337</td>
<td>1325</td>
</tr>
</tbody>
</table>

**Hydrocarbons: Petrocol DH Octyl**
For detailed analyses of petroleum products - This highly reproducible column offers unique selectivity not obtainable with poly(dimethylsiloxane) columns, such as baseline separations of benzene/1-methylcyclopentene and toluene/2,3,3-trimethylpentane.

- **Phase:** bonded; poly(50% n-octyl/50% methylsiloxane)
- **Temp. Limits:** -60°C to 220°C

<table>
<thead>
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Meets performance requirements of ASTM Test Method D2887

**SIMDIS: Petrocol DH Octyl**
For ASTM Test Method D2887 - A thin film version of the Petrocol 2887 column, developed for extended D2887 SIMDIS analysis of samples having final boiling points greater than 1000°F.

- **Phase:** bonded; poly(dimethylsiloxane)
- **Temp. Limits:** subambient to 380°C

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<td>0.53mm ID Fused Silica</td>
<td>5</td>
<td>0.10</td>
<td>25337</td>
<td>1325</td>
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</tbody>
</table>

**Hydrocarbons: Petrocol DH Octyl**
For detailed analyses of petroleum products - This highly reproducible column offers unique selectivity not obtainable with poly(dimethylsiloxane) columns, such as baseline separations of benzene/1-methylcyclopentene and toluene/2,3,3-trimethylpentane.

- **Phase:** bonded; poly(50% n-octyl/50% methylsiloxane)
- **Temp. Limits:** -60°C to 220°C

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<tr>
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Meets performance requirements of ASTM Test Method D2887

**SIMDIS: Petrocol DH Octyl**
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- **Phase:** bonded; poly(dimethylsiloxane)
- **Temp. Limits:** subambient to 380°C

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<td>5</td>
<td>0.10</td>
<td>25337</td>
<td>1325</td>
</tr>
</tbody>
</table>
Capillary GC
Special Purpose Columns (Amines, Aromatics)

Amines: PTA-5
This column is a specially prepared, base-deactivated poly(5% diphenyl/95% dimethylsiloxane) column designed for analyses of amines and other basic analytes.

- **Phase:** bonded; base-modified poly(5% diphenyl/95% dimethylsiloxane)
- **Temp. Limits:** -60°C to 320°C

<table>
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| 0.32mm ID Fused Silica |
| 30 | 0.5 | 160 | 24331 |
| 30 | 1.0 | 80 | 24332 |
| 30 | 1.5 | 53 | 24333 |

| 0.53mm ID Fused Silica |
| 30 | 0.5 | 265 | 25437 |
| 30 | 1.5 | 88 | 25438 |
| 30 | 3.0 | 44 | 25439 |

Amines: Carbowax Amine
For primary, secondary, and tertiary amines - The Carbowax Amine column is a specially prepared, base-deactivated polyethylene glycol column designed for the analysis of primary, secondary, and tertiary amines and other volatile basic analytes.

- **Phase:** nonbonded; base-modified poly(ethylene glycol)
- **Temp. Limits:** 60°C to 200°C

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Aromatics: TCEP
This highly polar phase offers unique polarity for certain separations, despite its relatively low temperature limit and the fact that it is not a bonded phase. Because many aromatic compounds have retention indices greater than 1100 on TCEP, it is used for analyses of aromatics in mineral spirits and impurities in individual aromatics and oxygenates.

- **Phase:** nonbonded; 1,2,3-tris-2-cyanoethoxypropane
- **Temp. Limits:** subambient to 145°C
- **McReynolds Nos.:** x'y' z' u' s' = 594 857 759 1031 917

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| 0.32mm ID Fused Silica |
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Amines: Carbowax Amine
For primary, secondary, and tertiary amines - The Carbowax Amine column is a specially prepared, base-deactivated polyethylene glycol column designed for the analysis of primary, secondary, and tertiary amines and other volatile basic analytes.

- **Phase:** nonbonded; base-modified poly(ethylene glycol)
- **Temp. Limits:** 60°C to 200°C

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C13 elutes before toluene, critical to ASTM Method D3257 (mineral spirits)
**SPB-1**

Nonpolar methylsilicone columns that separate sample components according to boiling point. This bonded polymer matches the polarity of its nonbonded predecessors, SE-30 and SP-2100. The SPB-1 phase is used in many of our Petrocol specialty columns. This column meets USP G1, G2 and G9 requirements.

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

**Phase:** bonded; poly(dimethylsiloxane)

**Temp. Limits:** -60°C to 320°C

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**SPB-5**

The low phenyl content, 5%, improves thermal stability of the phase, while still providing essentially a boiling point elution order, and a slight increase in selectivity, especially for aromatic compounds.

This column meets USP G27 and G36 requirements.

Operating Conditions: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.

**Phase:** bonded; poly(5% diphenyl/95% dimethylsiloxane)

**Temp. Limits:** -60°C to 320°C

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**SE-30 and SE-54**

The SE-54 column meets USP G36 requirements.

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**SE-30 and SE-54**

The SE-54 column meets USP G36 requirements.
Capillary GC

Other Columns

PTE-5/QTM - meets or exceeds performance specifications of US EPA Methods 625, 1625, 8270, and QTM protocols. Low bleed, recommended for use with GC/MS systems.

**Phase:** bonded; poly(5% diphenyl/95% dimethylsiloxane)
**Temp. Limits:** -60°C to 320°C
**McReynolds Nos.:** x' y' z' u' s' = 19 74 64 93 62

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**MDN-5** - The low phenyl content (5%) improves the thermal stability of the phase, while still providing essentially a boiling point elution order, and a slight increase in selectivity, especially for aromatic compounds.

**Phase:** bonded; poly(5% diphenyl/95% dimethylsiloxane)
**Temp. Limits:** -60°C to 320°C
**Similar Phases:** DB-5MS, HP-5MS, PTE-5, XTI-5

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MDN-SS - These nonpolar columns feature very low bleed, and excellent inertness for active compounds. High sensitivity and integrity due to a better signal-to-noise ratio.

**Phase:** bonded and crosslinked; (5% phenyl) methylpolysiloxane
**Temp. Limits:** 0.25 and 0.32mm ID: -60°C to 325/350°C
**0.53mm ID:** -60°C to 300/320°C
**Similar Phases:** DB-5MS, HP-5MS, PTE-5, RTx-5MS, ULTRA-2

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</table>

MDN-12 - Low polarity and unique selectivity make these columns ideal for confirmational analyses and for separating active compounds, pesticides, herbicides, PCBs, and PAHs.

**Phase:** bonded and crosslinked; proprietary
**Temp. Limits:** 30°C to 340/360°C
**Similar Phase:** DB-XLB

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (µm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
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<td>24391</td>
<td></td>
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MDN-35 - These low polarity columns have exceptional inertness for active compounds. They are ideal for confirmational analyses.

**Phase:** bonded and crosslinked; (35% phenyl) methylpolysiloxane
**Temp. Limits:** 50°C to 340/360°C
**Similar Phases:** AT-35, DB-35MS, RTx-35, SPB-35

<table>
<thead>
<tr>
<th>LENGTH (m)</th>
<th>D (µm)</th>
<th>BETA</th>
<th>CAT. NO.</th>
<th>PRICE</th>
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<tbody>
<tr>
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Operating Conditions For All Columns On This Page: Chemically compatible with water and other injection solvents. Sensitive to strong inorganic acids and bases. Columns can be rinsed.
### General Purpose Column Equivalency (Listed in order of increasing Phase Polarity)

<table>
<thead>
<tr>
<th>AGILENT / J&amp;W</th>
<th>ALLTECH</th>
<th>CHROMPACK</th>
<th>MACHERY-NAGEL</th>
<th>QUADREX</th>
<th>RESTEK</th>
<th>SGE</th>
<th>PACKED COLUMN EQUIVALENT</th>
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<td>SPB-Octyl</td>
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<td>—</td>
<td>Squalane</td>
</tr>
<tr>
<td>Equity-1 / SPB-1</td>
<td>HP-1 / DB-1</td>
<td>AT-1000</td>
<td>CP-Sil5CB</td>
<td>Optima 1</td>
<td>007-1</td>
<td>RTx-1</td>
<td>BP-1</td>
</tr>
<tr>
<td>Equity-5 / SPB-5</td>
<td>HP-5, HP-Ultra 2 / DB-5</td>
<td>AT-5</td>
<td>CP-Sil 8CB</td>
<td>Optima 5</td>
<td>007-2</td>
<td>RTx-5</td>
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<td>RTx-20</td>
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<td>RTx-1701</td>
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<td>SP-2250</td>
<td>HP-50, HP-17 / DB-17</td>
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<td>CP-Sil 24CB</td>
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<td>007-17</td>
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<td>SP-17</td>
<td>HP-50, HP-17 / DB-17</td>
<td>AT-50</td>
<td>CP-Sil 24CB</td>
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<td>007-17</td>
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<tr>
<td>SP-50</td>
<td>HP-50 / DB-17</td>
<td>AT-50</td>
<td>CP-Sil 24CB</td>
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<td>RTx-50</td>
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<tr>
<td>PAG</td>
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</tr>
<tr>
<td>SUPELCOWAX 10</td>
<td>HP-Wax, HP-INNOWax / DB-WAX, DB-WAXetr</td>
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<td>CP-WaxCB</td>
<td>Pernambod CW 20M</td>
<td>007-CW</td>
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<td>Stabilwax</td>
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<tr>
<td>SPB-1000</td>
<td>HP-FFAP / DB-FFAP</td>
<td>AT-1000</td>
<td>CP-Wax 58CB</td>
<td>Pernambod FFAP</td>
<td>007-FFAP</td>
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<td>Stabilwax-DA</td>
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<td>HP-FFAP / DB-FFAP</td>
<td>AT-1000</td>
<td>CP-Wax 58CB</td>
<td>Pernambod FFAP</td>
<td>007-FFAP</td>
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<td>Stabilwax-DA</td>
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<tr>
<td>SPB-225</td>
<td>HP-225 / DB-225</td>
<td>AT-225</td>
<td>CR-Sil 43CB</td>
<td>Optima 225</td>
<td>007-225</td>
<td>RTx-225</td>
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<tr>
<td>SP-2330</td>
<td>DB-23</td>
<td>AT-Silar</td>
<td>CP-Sil 84</td>
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<td>007-23</td>
<td>RTx-2330</td>
<td>BPX-70</td>
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<tr>
<td>SP-2380</td>
<td>HP-23 / DB-23</td>
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<td>CP-Sil 88</td>
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<td>RTx-2330</td>
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<td>CP-Sil88</td>
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### Specially Tested Column Equivalency

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<th>ALLTECH</th>
<th>CHROMPACK</th>
<th>MACHERY-NAGEL</th>
<th>QUADREX</th>
<th>RESTEK</th>
<th>SGE</th>
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<tbody>
<tr>
<td>Chiral 0-DEX</td>
<td>HP Chiral / Cyclodex-B</td>
<td>Chiral B</td>
<td>CP-Chiral DEX CB</td>
<td>LIPODEX A</td>
<td>HYDRODEX</td>
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<td>CP-WaxCB</td>
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<td>Environmental</td>
<td>Equity-5 / PTE-5</td>
<td>HP-5MS</td>
<td>K-5</td>
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<td>Pernambod SE-54-KW</td>
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<td>DB-Oxoin</td>
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<td>SPB-608</td>
<td>HP-608 / DB-608</td>
<td>AT-Pesticides</td>
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<td>SPB-624</td>
<td>HP-624 / DB-624, DP-VRX</td>
<td>AT-624</td>
<td>CR-Sil 13CB</td>
<td>Optima 624</td>
<td>007-624</td>
<td>RTx-624</td>
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<td>CP-Sil 8CB MS</td>
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<td>SP-2380</td>
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<td>SPB-PFUA</td>
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<td>HP-Basic/Wax / DB-CAM</td>
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<td>FS-CW 20 M-AM</td>
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<td>CP-Moly-Sieve 5A</td>
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<td>CP-SimDist CB</td>
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<td>Petrocol DH</td>
<td>DB-Petro 100</td>
<td>AT-Petro</td>
<td>CP-Sil PONA</td>
<td>Pernambod P-100</td>
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<td>Supel-Q PLOT</td>
<td>HP-PLOT Q / GS-Q</td>
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<td>PoraPLOT Q</td>
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<td>TCEP</td>
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<td>OVI-G43</td>
<td>HP-624 / DB-624</td>
<td>AT-624</td>
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<td>007-624</td>
<td>RTx-624</td>
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</tbody>
</table>

**Order:** 1.800.325.3010 Technical Service: 1.800.359.3041 Web: www.sigma-aldrich.com/supelco
Capillary GC

Custom Columns

Custom Capillary GC Columns

The information below provides a general overview of the Supelco custom capillary GC capabilities. Supelco manufactures all custom capillary GC columns using our ISO 9001-registered processes to achieve the performance and reproducibility you expect. Custom capillary GC columns are tested for k' and coating efficiency.

To order your custom column, call and provide us with the phase, film thickness, ID, length, and any additional details or special needs.

Custom Fused Silica Capillary Columns

PHASES AVAILABLE*

<table>
<thead>
<tr>
<th>Phase</th>
<th>SE-30</th>
<th>SPB-35</th>
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<td>Equity-1</td>
<td>SE-54</td>
<td>SPB-225</td>
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<td>Equity-5</td>
<td>SP-2100</td>
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<td>Nurol</td>
<td>SP-2250</td>
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<td>Omegawax</td>
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<td>SPB-1000</td>
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<td>SP-2340</td>
<td>SPB-Octyl</td>
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<td>SP-2380</td>
<td>SPB-PUFA</td>
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<td>SUPELCOWAX 10</td>
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<td>SPB-1 Sulfur</td>
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<td>SPB-5</td>
<td>VOCOL</td>
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<td>SAC-5</td>
<td>SPB-50</td>
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DIMENSIONS AVAILABLE

Inside diameter: Available in 0.10mm, 0.20mm, 0.25mm, 0.32mm, 0.53mm, and 0.75mm sizes.
Film thickness: Varies from 0.05µm to 7.0µm. Actual film thickness will depend on the phase and column ID selected.
Column length: Varies from 1m to 100m. Actual lengths will depend on the column ID selected and cage style selected.
Cage: The 0.10mm to 0.25mm ID columns are placed on our standard 6'/15cm cage. All others are placed on our standard 8'/20cm cage. The smaller HP6850 column cage is also available upon request.

Custom PLOT Capillary Columns

PHASES AVAILABLE*

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<thead>
<tr>
<th>Phase</th>
<th>Alumina KCl</th>
<th>Alumina Sodium Sulfate</th>
<th>Tenax</th>
<th>HayeSep N</th>
<th>HayeSep R</th>
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<tbody>
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<td>Carboxen 1010</td>
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<td>HayeSep N</td>
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<td>Mol sieve 5A</td>
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<td>Tenax</td>
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<td>HayeSep R</td>
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<td>Supel-Q</td>
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DIMENSIONS AVAILABLE

Inside diameter: Available in 0.32mm & 0.53mm sizes.
Column length: Varies from 1m to 60m.

Custom SCOT Capillary Columns

PHASES AVAILABLE*

<table>
<thead>
<tr>
<th>Phase</th>
<th>MBMA</th>
<th>TCEP</th>
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<td>DEGS</td>
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</table>

DIMENSIONS AVAILABLE

Inside diameter: Available in .020 inch (.50mm) size.
Column length: Varies from 1 foot to 100 feet.

* Additional phases may be available. Please inquire if you require a phase not listed.

Supelco Capillary Columns for Agilent 6850 (HP6850)

Now, any Supelco capillary GC column can be made compatible with your Agilent/HP 6850 instrument by simply specifying code "PRO100060" when you order.

Until now, transferring your lab method to the Agilent/HP 6850 GC meant specifying different column part numbers because of the different size of the 6850 column cage. This meant risking a method change because you changed the purchasing information. This is no longer necessary.

- No method headaches – your Supelco capillary will fit perfectly in your 6850 instrument.
- No new part numbers to remember – just specify "PRO100060" when you order Supelco capillary.
- No delay – columns are shipped within 24 hours.

If you are changing a lab method to a 6850, you can continue to use the same Supelco capillary column and ordering information. To order any Supelco capillary column on a 6850 cage, simply ask for order code PRO100060, and then provide the Supelco column ordering information already in your method.

Upon receipt of your order, we will coil the stock or custom Supelco capillary column on an authentic Agilent Technologies 6850 GC cage and ship it within 24 hours. Transferring column ordering information from lab to 6850 methods has never been easier!

**DESCRIPTION** | **CAT. NO.** | **PRICE**
--- | --- | ---
Supelco capillary in an Agilent/HP 6850 column cage | PRO100060 | No extra charge!
**Fused Silica Tubing**

Use as transfer lines, guard columns, or retention gaps, or to make your own columns.

Tubing can be coupled through fused silica or glass GlasSeal connectors. If necessary, use polyimide glue to provide a permanent seal. These products are listed in the index.

<table>
<thead>
<tr>
<th>ID (mm)</th>
<th>UNTREATED TUBING</th>
<th>DEACTIVATED TUBING</th>
<th>DEACTIVATED TUBING</th>
<th>DEACTIVATED TUBING</th>
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<tr>
<td></td>
<td>PRICE</td>
<td>NONPOLAR</td>
<td>INTERMEDIATE POLARITY</td>
<td>POLAR</td>
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<td>25707</td>
<td>25712</td>
</tr>
<tr>
<td>0.32</td>
<td>25702</td>
<td>24058</td>
<td>25708</td>
<td>—</td>
</tr>
<tr>
<td>0.53</td>
<td>25703</td>
<td>25307</td>
<td>25709</td>
<td>25714</td>
</tr>
<tr>
<td>3-meter length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10</td>
<td>25715</td>
<td>25720-U</td>
<td>25726</td>
<td>—</td>
</tr>
<tr>
<td>0.20</td>
<td>—</td>
<td>25727</td>
<td>25727</td>
<td>—</td>
</tr>
<tr>
<td>0.25</td>
<td>25717</td>
<td>25722</td>
<td>25727</td>
<td>—</td>
</tr>
<tr>
<td>0.32</td>
<td>25718</td>
<td>25723</td>
<td>25728</td>
<td>—</td>
</tr>
<tr>
<td>0.53</td>
<td>25719</td>
<td>25724</td>
<td>25729</td>
<td>25734</td>
</tr>
<tr>
<td>5-meter length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10</td>
<td>25735</td>
<td>25740-U</td>
<td>25745-U</td>
<td>—</td>
</tr>
<tr>
<td>0.20</td>
<td>—</td>
<td>25741</td>
<td>25746</td>
<td>—</td>
</tr>
<tr>
<td>0.25</td>
<td>25737</td>
<td>25742</td>
<td>25747</td>
<td>—</td>
</tr>
<tr>
<td>0.32</td>
<td>25738</td>
<td>25743</td>
<td>25748-U</td>
<td>25752-U</td>
</tr>
<tr>
<td>0.53</td>
<td>25739</td>
<td>25744</td>
<td>25339</td>
<td>25753</td>
</tr>
<tr>
<td>15-meter length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>—</td>
<td>25755</td>
<td>—</td>
<td>25763</td>
</tr>
<tr>
<td>0.25</td>
<td>24059</td>
<td>25756</td>
<td>25760-U</td>
<td>—</td>
</tr>
<tr>
<td>0.32</td>
<td>24062</td>
<td>25757</td>
<td>25761</td>
<td>25765</td>
</tr>
<tr>
<td>0.53</td>
<td>25306</td>
<td>25758</td>
<td>25762</td>
<td>25766</td>
</tr>
<tr>
<td>30-meter length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>25767</td>
<td>25768-U</td>
<td>25772</td>
<td>—</td>
</tr>
<tr>
<td>0.25</td>
<td>—</td>
<td>25769-U</td>
<td>25777</td>
<td>—</td>
</tr>
<tr>
<td>0.32</td>
<td>24063</td>
<td>25770-U</td>
<td>25774</td>
<td>25778</td>
</tr>
<tr>
<td>0.53</td>
<td>25308</td>
<td>25771</td>
<td>25775-U</td>
<td>25779</td>
</tr>
<tr>
<td>60-meter length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>—</td>
<td>—</td>
<td>25786</td>
<td>—</td>
</tr>
<tr>
<td>0.25</td>
<td>24061</td>
<td>25783</td>
<td>25787</td>
<td>—</td>
</tr>
<tr>
<td>0.32</td>
<td>24064</td>
<td>25784</td>
<td>25788-U</td>
<td>25792</td>
</tr>
<tr>
<td>0.53</td>
<td>25781</td>
<td>25785</td>
<td>25789</td>
<td>—</td>
</tr>
</tbody>
</table>

1 Deactivated according to USP 467.

---

**Tubing Treatment**

- **Untreated**: General purposes, where high inertness is not necessary
- **Nonpolar (methyl)**: Low polarity solvents (e.g., alkanes, carbon disulfide, ethers)
- **Intermediate Polarity (phenyl/methyl)**: Intermediate polarity solvents (e.g., acetone, methylene chloride, toluene)
- **Polar (PEG)**: Polar solvents (e.g., acetonitrile, methanol, water)

<table>
<thead>
<tr>
<th>TUBING TREATMENT</th>
<th>APPLICATION</th>
<th>MAX. TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>General purposes, where high inertness is not necessary</td>
<td>360°C</td>
</tr>
<tr>
<td>Nonpolar (methyl)</td>
<td>Low polarity solvents (e.g., alkanes, carbon disulfide, ethers)</td>
<td>360°C</td>
</tr>
<tr>
<td>Intermediate Polarity (phenyl/methyl)</td>
<td>Intermediate polarity solvents (e.g., acetone, methylene chloride, toluene)</td>
<td>360°C</td>
</tr>
<tr>
<td>Polar (PEG)</td>
<td>Polar solvents (e.g., acetonitrile, methanol, water)</td>
<td>260°C</td>
</tr>
</tbody>
</table>
Capillary GC
Test Mixes for Capillary Columns

Column Test Mixes
After you install a column in your system, use a test mix to make sure you haven’t also installed some surprises, such as ferrule or tubing fragments in the column, or small leaks. Weekly tests thereafter will keep little problems from growing into big problems.

Acidity Test Mix
Even a highly efficient column can adsorb acidic or basic compounds. To determine the acid/base affinity of your column, simply inject this mix and compare peak heights (Grob & Grob, Chromatographia 421, 1971). Instructions included. 0.05% each component in methylene chloride.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity Test Mix</td>
<td>2mL</td>
<td>48255-U</td>
<td></td>
</tr>
</tbody>
</table>

Hydrocarbon Test Mix
An ideal mix for checking column installation when you use a capillary column in a modified packed column system. Also used to determine theoretical plates. C12-C17 hydrocarbons, 500-2000µg/mL in chloroform.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbon Test Mix</td>
<td>2mL</td>
<td>48244</td>
<td></td>
</tr>
</tbody>
</table>

Isothermal Test Mixes
Use these mixes to indicate column efficiency, leaks, dead volume, and sample adsorption. Each mix includes simple, detailed instructions.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isothermal Test Mix Kit - 2mL each of the three isothermal test mixes described below.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Nonpolar Column Test Mix - For all nonpolar phases. 500µg/mL each component in methylene chloride.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonpolar Column Test Mix</td>
<td>2mL</td>
<td>47300-U</td>
<td></td>
</tr>
</tbody>
</table>

Intermediate Polarity Column Test Mix - For SPB-20, SPB-35, and other intermediate polarity phases. 500µg/mL each component in methylene chloride.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate Polarity Column Test Mix</td>
<td>2mL</td>
<td>47301</td>
<td></td>
</tr>
</tbody>
</table>

Polar Column Test Mix - For SUPELCOWAX 10, SP-1000, and other polar phases. 500µg/mL each component in methylene chloride.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar Column Test Mix</td>
<td>2mL</td>
<td>47302</td>
<td></td>
</tr>
</tbody>
</table>

Methane Standard
Use 40µL injections of this dilute methane standard (100ppm in helium) for more accurate flow measurements than with smaller quantities of more concentrated methane. Use with the methane syringe, syringe adapter, and pressure regulator listed. Disposable cylinder.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane Standard</td>
<td>14L</td>
<td>307200</td>
<td></td>
</tr>
</tbody>
</table>

Table: Accessories for Methane Standard

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton 1725N Syringe</td>
<td>20705</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syringe Adapter</td>
<td>609010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Regulator</td>
<td>513010</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Programmed Test Mix
This mix is for a sensitive, temperature programmed analysis (Grob, et al., J. Chromatogr. 156: 1, 1978) that tests a column’s affinity for many compounds. Prepared at concentrations convenient for setting split ratios and sample sizes. In use, 0.05% each component in methylene chloride.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmed Test Mix</td>
<td>2mL</td>
<td>47304</td>
<td></td>
</tr>
</tbody>
</table>

Order: 1.800.325.3010 Technical Service: 1.800.359.3041 Web: www.sigma-aldrich.com/supelco
Test Mixes for Specific Phases
For popular Supelco capillary columns. Each mix contains active components and inactive hydrocarbons.

<table>
<thead>
<tr>
<th>COLUMN TEST MIX</th>
<th>COMPOSITION</th>
<th>QTY.</th>
<th>CAT. NO.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbowax Amine</td>
<td>500µg/mL each component in methyl tert-butyl ether. n-Octylamine n-Nonylamine n-Decylamine n-Hexadecane (C16) n-Benzylamine n-Heptadecane (C17) n-Hexane, 1% n-Octane, 1% n-Xylene, 4%</td>
<td>1mL</td>
<td>48278</td>
<td></td>
</tr>
<tr>
<td>α-DEX 120</td>
<td>500µg/mL each component in methylene chloride Nonane (C9) p-Xylene m-Xylene Decane (C10) (+)-1,2-Propanediol Undecane (C11)</td>
<td>1mL</td>
<td>48013</td>
<td></td>
</tr>
<tr>
<td>β-DEX 120</td>
<td>500µg/mL each component in methylene chloride Nonane (C9) (+)-3,3-Dimethyl-2-butanol p-Xylene, 2% n-Octane, 1% n-Nonane, 1%</td>
<td>1mL</td>
<td>48028</td>
<td></td>
</tr>
<tr>
<td>β-DEX 120</td>
<td>500µg/mL each component in methylene chloride Nonane (C9) (+)-3,3-Dimethyl-2-butanol p-Xylene, 2% n-Octane, 1% n-Nonane, 1%</td>
<td>1mL</td>
<td>48028</td>
<td></td>
</tr>
</tbody>
</table>

OMEGAWAX TEST MIXES

<table>
<thead>
<tr>
<th>Test Mix</th>
<th>Composition</th>
<th>Amount</th>
<th>Cat. No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omegawax²</td>
<td>Approximately 50mg FAMEs/mL in hexane</td>
<td>1mL</td>
<td>48476</td>
<td></td>
</tr>
<tr>
<td>Menhaden Oil²</td>
<td>Approximately 100mg FAMES/mL in hexane</td>
<td>1mL</td>
<td>48473</td>
<td></td>
</tr>
</tbody>
</table>

PETROCOL TEST MIXES

<table>
<thead>
<tr>
<th>Test Mix</th>
<th>Composition</th>
<th>Amount</th>
<th>Cat. No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrocol DH</td>
<td>Each hydrocarbon (v/v) in cyclohexane n-Hexane, 1% n-Heptane, 1% Benzenes, 1%</td>
<td>1mL</td>
<td>48872</td>
<td></td>
</tr>
<tr>
<td>Petrocol D2887</td>
<td>1% each component in n-octane n-Hexadecane n-Octadecane</td>
<td>6 x 1mL</td>
<td>48889</td>
<td></td>
</tr>
</tbody>
</table>

EQUITY/SPB TEST MIXES

<table>
<thead>
<tr>
<th>Test Mix</th>
<th>Composition</th>
<th>Amount</th>
<th>Cat. No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity/SPB Thin Film</td>
<td>500µg/mL each component in cyclohexane n-Nonane (C9) 2-Octanone n-Decane (C10)</td>
<td>1mL</td>
<td>48273</td>
<td></td>
</tr>
<tr>
<td>Equity/SPB Thick Film</td>
<td>500µg/mL each component in cyclohexane n-Nonane (C9) 2-Octanone n-Decane (C10)</td>
<td>1mL</td>
<td>48275-U</td>
<td></td>
</tr>
<tr>
<td>SPB-50</td>
<td>500µg/mL each component in cyclohexane n-Decane (C10) n-Undecane (C11) 2-Octanone 1-Octanol n-Dodecane (C12) n-Tridecane (C13) 2,6-Dimethylnaphthalene 2,6-Dimethylnaphthanol n-Pentadecane (C15)</td>
<td>1mL</td>
<td>48280-U</td>
<td></td>
</tr>
</tbody>
</table>

SUP-HERB COLUMN TEST MIXES

<table>
<thead>
<tr>
<th>Herbicides Mix 1</th>
<th>Amount</th>
<th>Cat. No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides Mix 2</td>
<td>Amount</td>
<td>Cat. No.</td>
<td>Price</td>
</tr>
</tbody>
</table>

¹ Total concentration 1000µg/mL for the two isomers.
² The Omegawax Column Test Mix and the Menhaden Oil standard are based on naturally occurring mixtures of fatty acids –relative peak sizes may vary from lot to lot.
GC Column Selection Guide
Achieve Optimal Method Performance
The History of Supelco and the Capillary Column

Supelco began in 1966 in a tiny garage in a small central Pennsylvania (USA) town manufacturing packed gas chromatography (GC) columns. Walt Supina and Nick Pelick knew exactly what they wanted to do, make quality products that serve customers’ needs, back every product with excellent technical service, and maintain steady growth by creating new products through a strong research and development program. By 1977, glass capillary GC columns were being manufactured and in 1982, production began on fused silica capillary GC columns.

Supelco has had a long history of providing specialty products for specific applications. In 1983, the first special purpose fused silica capillary GC column was introduced. Since then, an impressive list of special purpose fused silica capillary GC columns has followed.

Supelco is still dedicated to the development of leading-edge technology to meet the needs of our customers. We strive to demonstrate the belief that our customers’ needs come first. Our goal is to offer only the finest products, backed by the most reliable technical service offered anywhere in the world. That was our philosophy in the beginning, and with over forty years in business, it remains our philosophy today.

Providing total customer fulfillment through the quality of our product and service is reflected in our ISO 9001 registration. We test every capillary column we manufacture according to strict quality assurance processes, and guarantee satisfactory performance.

<table>
<thead>
<tr>
<th>Year Introduced</th>
<th>Special Purpose Fused Silica Capillary GC Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>SP™-2560</td>
</tr>
<tr>
<td>1984</td>
<td>SPB™-608, SUPELCOWAX™ 10</td>
</tr>
<tr>
<td>1985</td>
<td>SP-2331</td>
</tr>
<tr>
<td>1986</td>
<td>VOCOL™</td>
</tr>
<tr>
<td>1987</td>
<td>Sup-Herb™, SP-2380</td>
</tr>
<tr>
<td>1988</td>
<td>Petrocol™ DH, Nukol™</td>
</tr>
<tr>
<td>1989</td>
<td>Petrocol DH 150, Petrocol 2887</td>
</tr>
<tr>
<td>1990</td>
<td>Omegawax™ 320, Petrocol DH 50.2</td>
</tr>
<tr>
<td>1991</td>
<td>Omegawax 250, SPB-1 SULFUR, Petrocol EX2887, Carbowax Amine</td>
</tr>
<tr>
<td>1993</td>
<td>α-Dex™ 120, β-Dex 110, γ-Dex 120, SAC™-5, TCEP</td>
</tr>
<tr>
<td>1994</td>
<td>β-Dex 120, OVI-G43, Carboxen™-1006 PLOT, Mol Sieve 5A PLOT, Supel-Q™ PLOT, SCOT Columns</td>
</tr>
<tr>
<td>1995</td>
<td>SPB-624, SPB-PUFA, Petrocol DH Octyl, SPB-Octyl, PTA-5</td>
</tr>
<tr>
<td>1996</td>
<td>α-Dex 225, β-Dex 225, γ-Dex 225, α-Dex 325, β-Dex 325, γ-Dex 325, Omegawax 530, SPB-1000</td>
</tr>
<tr>
<td>1997</td>
<td>SPB-HAP, Carboxen-1010 PLOT</td>
</tr>
<tr>
<td>2003</td>
<td>Equity®-1701, Alumina chloride PLOT, Alumina sulfate PLOT</td>
</tr>
<tr>
<td>2005</td>
<td>SLB™-5ms</td>
</tr>
<tr>
<td>2007</td>
<td>CHIRALDEX™ column line, Omegawax 100</td>
</tr>
<tr>
<td>2008</td>
<td>SLB-IL100, MET-Biodiesel</td>
</tr>
</tbody>
</table>
How to Use this Guide

This brochure was assembled to provide the gas chromatographer a valuable resource. Novice and expert users alike should both find this guide useful.

An optimized chromatographic separation begins with selecting the proper column. A section explaining how to choose a capillary column (page 4) is included in this brochure. Step-by-step instructions cover topics such as proper phase selection, the importance of phase polarity, non-bonded versus bonded phases, column internal diameter (I.D.), film thickness considerations, phase ratio (B), and column length.

Want additional information beyond what this brochure provides? Listings of Supelco product literature and additional reading (page 7) recommend many published GC articles written by gas chromatography experts and researchers.

The main purpose of this brochure is to assist the chromatographer in identifying the proper column phase for their application. This can be accomplished by referring to the twelve easy-to-read column phase selection guides (page 8). These guides detail common applications performed in ten distinct industries plus two applications that are independent of any industry.

Need to switch to a Supelco column from a column from a different manufacturer? A cross-reference chart (page 15) will be helpful. This chart list Supelco columns along with comparable columns from several other manufacturers.

Looking for information or specifications for a particular phase? A section on capillary column phases (page 16) includes many of the most popular phases and provides application, USP code, polymer, and temperature limit information. This section is organized primarily in order of increasing phase polarity to assist in phase selection when performing method development.

A brief listing of the most commonly requested catalog numbers (page 22) is included. If you need a dimension not listed, please contact your local Sales office (page 24) or Supelco Technical Service to inquire.

Supelco Technical Service chemists are a valuable resource for providing guidance with the selection and use of capillary columns. Supelco Technical Service can be reached at 800-359-3041 (US and Canada only), 814-359-3041, or at techservice@sial.com

Trademarks
Carboxen, CHIRALDEX, DEX, Equity, Fluorocol, Nukol, Omegawax, Petrocol, SAC, SLB, SP, SPB, Supelco, SUPELCOWAX, Supel-Q, Sup-Herb, VOCOL – Sigma-Aldrich Biotechnology LP; Bentone - Elementis Specialties, Inc.; Carbowax - Union Carbide Chemicals & Plastics Technology Corp.; FocusLiner - SGE International Pty Ltd.
How to Choose a Capillary Column

An optimized chromatographic separation begins with the column. The selection of the proper capillary column for any application should be based on four significant factors: stationary phase, column I.D., film thickness, and column length. The practical effects of these factors on the performance of the column are discussed briefly on the next few pages, in order of importance. Note that this information is general. Specific situations may warrant exceptions to these guidelines.

Factor 1 – Stationary Phase

Choosing a stationary phase is the most important step in selecting a column. A stationary phase is the film coated on the inner wall of a capillary column, and should be selected based on the application to be performed. The differences in the chemical and physical properties of injected organic compounds and their interactions with the stationary phase are the basis of the separation process. When the strength of the analyte-phase interactions differs significantly for two compounds, one is retained longer than the other. How long they are retained in the column (retention time) is a measure of these analyte-phase interactions.

Changing the chemical features of the stationary phase alters its physical properties. Two compounds that co-elute (do not separate) on a particular stationary phase might separate on another phase of a different chemistry, if the difference in the analyte-phase interactions is significant. This is the reason for providing a wide variety of capillary column phases. Each phase provides a specific combination of interactions for each chemical class of analytes.

Established Applications

Gas chromatography, first established in the 1950’s, is a mature analytical technique with many established applications. Therefore, it is probable that literature, such as written methodology or journals, exists stating which stationary phases have successfully been used for a given application. Additionally, column manufacturers routinely publish phase selection charts, such as those on pages 8-14. Charts like these are conveniently arranged by industry to simplify the process of selecting the proper phase. First, find the chart that matches your industry or area of interest. Then, locate the application within that chart to identify a recommended column phase.

New Applications

For new applications, there is often no existing reference to provide guidance. In these ‘method development’ instances, one must have some knowledge of the chemistry of the compounds under analysis. Use the information provided in the application guides to identify a recommended column phase.

Phase Polarity

This is the single most important characteristic in selecting a capillary column because it dictates selectivity, or the ability of the column to separate sample components. Phase selection is based on the general chemical principle that “likes dissolves like.” A non-polar column is best for the analyses of non-polar compounds. Polar columns most effectively separate polar compounds.

Non-polar compounds are generally composed only of carbon and hydrogen atoms and contain carbon-carbon single bonds. Normal hydrocarbons (n-alkanes) are the most common non-polar compounds analyzed by capillary gas chromatography. Non-polar capillary columns separate these compounds very well. Interaction between non-polar compounds and a non-polar phase are dispersive, meaning that they are governed by Van der Waals forces. These are intermolecular attractions that increase with the size of the compound. Thus, larger compounds with higher boiling points have longer retention. Elution order generally follows the boiling points of the compounds.

Polar compounds are composed primarily of carbon and hydrogen atoms, but also contain one or more atoms of bromine, chlorine, fluorine, nitrogen, oxygen, phosphorus, or sulfur. Alcohols, amines, carboxylic acids, diols, esters, ethers, ketones, and thiols are typical polar compounds analyzed by capillary GC. Intermediate polar or polar capillary columns separate these compounds well. In addition to dispersive interactions, interactions between polar compounds and the phase include dipole, π-π, and/or acid-base interactions. Separations are determined by differences in the overall effects of these interactions.

Phase Polarity Based on Compound Polarity

<table>
<thead>
<tr>
<th>Compound Polarity</th>
<th>Compound Examples</th>
<th>Recommended Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Polar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C and H atoms only</td>
<td>alkanes</td>
<td>Petrocol, SPB-Octyl, Equity-1, SPB-1, SLB-5ms, Equity-5, SPB-5</td>
</tr>
<tr>
<td>C=C bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primarily C and H atoms; Also contain Br, Cl, F, N, O, P, S</td>
<td>alcohols, amines, carboxylic acids, diols, esters, ethers, ketones, thiols</td>
<td>SPB-624, OVI-G43, VOCIOL, SPB-20, Equity-1701, SPB-35, SPB-50, SPB-225, PAG, Omegawax, SPB-1000, Nukol, SUPLCOWAX 10</td>
</tr>
<tr>
<td>Polarizable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C and H atoms only</td>
<td>alkenes, alkyne, aromatic hydrocarbons</td>
<td>SP-2330, SP-2331, SP-2380, SP-2560, SP-2340, TCEP</td>
</tr>
<tr>
<td>C=C or C=C bonds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Polarizable compounds are compounds composed of carbon and hydrogen, but contain one or more double or triple carbon-carbon bonds. These compounds include alkenes, alylne, and aromatic (benzene-ring containing) hydrocarbons. Highly polar capillary columns are generally used to separate these compounds.
Bonded/Non-Bonded Phases

Bonded phases are immobilized/chemically bonded (crosslinked) within the tubing, while non-bonded phases are simply coated on the wall. Generally a bonded phase is preferred, because it has less bleed during use, can be used to higher temperatures, and, when necessary, can be rinsed with solvents to remove accumulated non-volatile materials. When a bonded phase is not available, such as for the highly polar phases, look for a stabilized phase. These phases are not as permanent as bonded phases (cannot be rinsed), but have greater thermal stability than non-bonded phases. For some applications, the only choice is a non-bonded phase. In these instances, extra care must be taken so the maximum temperature limit is not exceeded.

Factor 2 – Column I.D.

The current range of commercially available capillary column internal diameters enables the balancing of two factors: efficiency (number of theoretical plates) and sample capacity (amount of any one sample component that can be applied to the column without causing the desired sharp peak to overload). Optimizing one of these factors requires a sacrifice from the other. The ideal I.D. for a given application is dependent on the analytical needs.

High efficiency is observed chromatographically as narrow and well-resolved peaks. The efficiency of a capillary column, measured in plates (N) or plates per meter (N/m), increases as the I.D. of the column decreases. This is one of the basic principles behind Fast GC (see “Fast GC Brochure” insert for further details). If the sample to be analyzed contains many analytes, or has analytes that elute closely together, the most narrow I.D. capillary column that is practical should be selected. Note that very narrow bore columns, such as 0.10 or 0.18 mm I.D., may require specialized equipment, such as a GC with a pressure regulator that allows a higher column head pressure.

Sample capacity increases with column I.D., and the greatest capacity is provided from wide bore columns (0.53 mm I.D.). Wide bore columns can accommodate a larger mass of each analyte in a sample than narrow bore capillary columns. Exceeding the sample capacity of a column will result in skewed peaks and decreased resolution. Therefore, if the samples to be analyzed contain compounds at high concentrations, or represent a wide range of concentrations, then a wide bore column should be considered. If the proper I.D. is chosen, the column should allow the system to provide sufficient sensitivity for the minor components without being overloaded with the major components. The analyst must decide if the loss in efficiency resulting from using a wide bore column is problematic for their application. Note that the nature of the sample components and the polarity of the phase will affect sample capacity. Non-polar phases have higher capacities for non-polar analytes, and polar phases have higher capacities for polar analytes.

The effects of column I.D. on efficiency and sample capacity are represented in Table 1. As shown, 0.25 mm I.D. columns provide adequate plates/meter for most applications while allowing acceptable sample capacity. Because of this compromise between efficiency and sample capacity, 0.25 mm is the most popular I.D. for capillary GC columns. Columns with a smaller or larger I.D. allow the user to optimize either efficiency or sample capacity, based on the requirements of their application.

Factor 3 – Film Thickness

As listed in Table 2, the benefits of decreasing film thickness are sharper peaks, (which may increase resolution) and reduced column bleed; both resulting in increased signal-to-noise. Additionally, the column’s maximum operating temperature will be increased. The drawbacks are increased analyte interaction with the tubing wall, and decreased analyte capacity. Decreasing film thickness also allows

Fast GC Brochure

The brochure “Fast GC: A Practical Guide for Increasing Sample Throughput without Sacrificing Quality” (T407096 JTW) contains valuable information concerning Fast GC principles that is not covered in this space. Included are practical considerations, theoretical discussions, a listing of columns in Fast GC dimensions, twenty-six chromatograms, a listing of related products designed to maximize performance, plus a list of literature for additional reading. A copy of this brochure can be obtained at no-charge by contacting Supelco Technical Service at 800-359-3041 (US and Canada only), 814-359-3041, or at techservice@sial.com
analytes to elute with shorter retention times and at lower temperatures, which may be desirable or undesirable, depending on the application.

Thinner film columns, i.e. 0.10 to 0.25 μm, should be used for analytes with high (>300 °C) boiling points (such as pesticides, PCBs, FAMEs, phthalate esters, and other semivolatile compounds), or for trace analyses.

The benefits of increasing the film thickness are reduced analyte-tubing interaction and increased sample capacity. The drawbacks of increasing the film thickness are increased peak widths (which may reduce resolution), increased column bleed, and a reduced maximum operating temperature for the column. Increasing film thickness also leads to increased analyte retention (may also increase resolution, specifically for compounds with low k’) and increased elution temperature. Depending on the application, these last effects may be either desirable or undesirable.

Thick film columns, i.e. 1 to 5 μm, are best suited for analytes with low boiling points (such as volatile organic compounds and gases). These types of analytes are retained longer on the thicker film, which may eliminate the need for subambient oven conditions. A thicker film will also increase capacity, thus making the column more compatible for higher concentration samples than a thinner film column.

### Factor 4 – Column Length

The last of the four significant factors to consider when selecting a column is length. A longer column will provide greater resolution than a shorter column. However, there are practical limits to increasing column length. With an isothermal analysis, a 60 m column does in fact increase resolution by almost 40%, relative to a 30 m column, but will increase the analysis time and also the head pressure required to move analytes through the column. Selecting a column length is a compromise between speed and head pressure on one side, and resolution on the other. Table 3 summarizes the effects of column length on various performance and operating parameters of 0.25 mm I.D. columns.

It should be stressed that doubling column length will NOT double resolution (resolution only increases according to the square root of the column length). If resolution between a critical pair is less than 1, doubling column length will not bring it to baseline (resolution value of at least 1.5). Increasing column length to increase resolution should be considered as a last resort. A more effective approach to increasing resolution is to reduce column I.D.

Shorter columns, such as those <15 m, are generally used when great resolution is not required, such as for screening purposes or for simple samples whose components are dissimilar in chemical nature. However, if column I.D. is decreased along with length, resolution can be maintained, or in some cases, actually increased.

Generally a 30 m column provides the best balance of resolution, analysis time, and required column head pressure. In some cases, a 30 m column with a thicker film may be as useful as a 60 m column for achieving a separation.

Use a 60 m column when higher resolution is required. Samples that are highly complex or contain volatile analytes are commonly analyzed on 60 m columns.
Very long, >100 m, columns are also available for use when there is a need for extremely high resolution, such as in the detailed analysis of very complex samples (such as gasoline). Due to the extreme length of these columns, high head pressures are required to maintain column flow.

Very long, 100 m or longer, columns are also available for use when there is a need for extreme resolving ability for highly complex samples (such as gasoline). Longer columns also reduce the optimum linear velocity for an analysis.

### Additional Reading


### Product Literature

The following list of Supelco-published literature provides additional GC column information. To obtain any of these literature pieces at no-charge, either visit our web site at sigma-aldrich.com/gc, or contact Supelco Technical Service at 800-359-3041 (US and Canada only), 814-359-3041, or at techservice@sial.com

### Fused Silica Tubing Inner/Outer Diameters

<table>
<thead>
<tr>
<th>Tubing I.D.</th>
<th>Tubing I.D. Range</th>
<th>Tubing O.D. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10 mm</td>
<td>0.094 – 0.106 mm</td>
<td>0.349 – 0.369 mm</td>
</tr>
<tr>
<td>0.18 mm</td>
<td>0.174 – 0.186 mm</td>
<td>0.330 – 0.350 mm</td>
</tr>
<tr>
<td>0.25 mm</td>
<td>0.244 – 0.256 mm</td>
<td>0.349 – 0.370 mm</td>
</tr>
<tr>
<td>0.32 mm</td>
<td>0.314 – 0.326 mm</td>
<td>0.425 – 0.450 mm</td>
</tr>
<tr>
<td>0.53 mm</td>
<td>0.526 – 0.546 mm</td>
<td>0.640 – 0.680 mm</td>
</tr>
<tr>
<td>0.75 mm</td>
<td>0.737 – 0.758 mm</td>
<td>0.875 – 0.925 mm</td>
</tr>
</tbody>
</table>

- Analytical columns with non-polar or intermediate polarity stationary phases.
- Analytical columns with polar stationary phases. Guard columns regardless of deactivation.
- Analytical columns regardless of polarity. Guard columns regardless of deactivation.

### Table 3. Effects of Column Length

<table>
<thead>
<tr>
<th>Column Length (m)</th>
<th>Inlet Pressure (psl)</th>
<th>Peak 1 Retention (min)</th>
<th>Peak 1/2 Resolution (R)</th>
<th>Efficiency (Total Plates) (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>5.9</td>
<td>8.33</td>
<td>0.8</td>
<td>43,875</td>
</tr>
<tr>
<td>30</td>
<td>12.0</td>
<td>16.68</td>
<td>1.2</td>
<td>87,750</td>
</tr>
<tr>
<td>60</td>
<td>24.9</td>
<td>33.37</td>
<td>1.7</td>
<td>175,500</td>
</tr>
</tbody>
</table>

Theoretical values for 0.25 mm I.D. columns with 85% coating efficiency, 145 °C isothermal analyses, helium at 21 cm/sec, k' (peak 1) = 6.00.

### Additional Reading

The following is a list of GC literature written by gas chromatography experts and researchers. Consult these references to learn more about the many facets of gas chromatography.

Column Selection by Industry

Supelco has developed the most extensive line of special purpose columns designed for industry specific applications. These columns are manufactured to deliver high resolution, great analyte response, low bleed, and long column life; allowing analysts to achieve the analytical performance they require. The easy-to-read phase selection charts on the next several pages are conveniently arranged by industry to simplify the process of selecting the proper phase. First, find the chart that matches your industry. Then, locate the application within that industry to identify a recommended phase.

The stationary phase also dictates the minimum and maximum temperatures at which a column can be used. Therefore, it is critical to ensure the selected stationary phase can withstand the temperature requirements of the GC method. Temperature limitations can be located in the capillary column phase section on pages 16 to 21.

Environmental Industry

The environmental columns offered here can be used with many specific methods for the analyses of volatiles, semivolatiles, pesticides, PCBs, herbicides, and dioxins.

<table>
<thead>
<tr>
<th>Supelco GC Columns for the Environmental Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPB-Octyl</td>
</tr>
<tr>
<td>SPB-HAP</td>
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<tr>
<td>Equity-1</td>
</tr>
<tr>
<td>SLB-5ms</td>
</tr>
<tr>
<td>SPB-624</td>
</tr>
<tr>
<td>VOCOL</td>
</tr>
<tr>
<td>SPB-608</td>
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<tr>
<td>Sup-Herb</td>
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<tr>
<td>Equity-1701</td>
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<tr>
<td>SPB-50</td>
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<td>SPB-225</td>
</tr>
<tr>
<td>SP-2331</td>
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<td>SLB-IL100</td>
</tr>
</tbody>
</table>

Industrial Hygiene Industry

These columns can be used with methodologies for determining indoor air quality as well as outdoor organic compounds.

<table>
<thead>
<tr>
<th>Supelco GC Columns for the Industrial Hygiene Industry</th>
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</thead>
<tbody>
<tr>
<td>SPB-HAP</td>
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<tr>
<td>Equity-1</td>
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<td>SLB-5ms</td>
</tr>
<tr>
<td>VOCOL</td>
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<tr>
<td>SPB-608</td>
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<tr>
<td>Equity-1701</td>
</tr>
<tr>
<td>SPB-225</td>
</tr>
<tr>
<td>SUPELCOWAX 10</td>
</tr>
<tr>
<td>SP-2331</td>
</tr>
</tbody>
</table>
### Pharmaceutical Industry

Use these columns for analyses of residual solvents, basic drugs, small chiral molecules of interest to this industry, and for methods following specific monographs.

**Supelco GC Columns for the Pharmaceutical Industry**

<table>
<thead>
<tr>
<th>Column</th>
<th>Residual Solvents (USP &lt;467&gt;)</th>
<th>Oxygen containing analytes in the form of alcohols, ketones, esters, and some aromatic compounds</th>
<th>Aliphatic and aromatic amines</th>
<th>Heterocyclic amines</th>
<th>Aliphatic and aromatic amines</th>
<th>Aliphatic and aromatic amines</th>
<th>Aliphatic and aromatic amines</th>
<th>Ethers and Ester Compounds</th>
<th>Basic Compounds</th>
<th>Individual USP/NF Monographs</th>
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<tr>
<td>PTA-5</td>
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<td>X</td>
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<tr>
<td>Equity-5</td>
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<tr>
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<td>Various Cap. Columns</td>
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</tbody>
</table>

**Clinical Industry**

Use these columns for the analyses of antihistamines, basic drugs, cold/sinus medications, steroids, and tricyclic antidepressants from biological samples.

**Supelco GC Columns for the Clinical Industry**

<table>
<thead>
<tr>
<th>Column</th>
<th>Antihistaminics</th>
<th>Basic Drug Screen</th>
<th>Benzoalkanes (acetic anhydride)</th>
<th>Phenothiazines</th>
<th>Sympathomimetic Amines</th>
<th>Sympathomimetic Amines (BFA)</th>
<th>Sympathomimetic Amines (TFAA)</th>
<th>Tricyclic Antidepressants</th>
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<tbody>
<tr>
<td>Equity-1</td>
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</tbody>
</table>

**NOTE:** Parentheses indicate analytes analyzed as the specified derivative.
**Flavor & Fragrance Industry**

Volatile, essential oils, and small chiral molecules of interest to this industry can be analyzed using the following columns.

Supelco GC Columns for the **Flavor & Fragrance Industry**

<table>
<thead>
<tr>
<th>Flavor &amp; Fragrance Volatiles</th>
<th>Essential Oils</th>
<th>Aldehyde and aromatic derivatives; amino acids; alcohols; ketones; esters</th>
<th>Aliphatic and aromatic amines</th>
<th>Aliphatic; cyclic and aromatic amides; amino acids; amines</th>
<th>Aliphatic; cyclic and aromatic amides; amino acids; amines</th>
<th>Polyunsaturated fatty acids</th>
<th>Terpenes and terpene derivatives; small molecules; such as alcohols, aldehydes, ketones, esters, and flavor compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLB-5ms</td>
<td>X</td>
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<tr>
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**Forensics Industry**

Use these columns for the analyses of accelerants from arson samples, or for blood alcohols, drugs of abuse, and glycols from biological samples.

Supelco GC Columns for the **Forensics Industry**

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**NOTE:** Parentheses indicate analytes analyzed as the specified derivative.
### Food & Beverage Industry
Supelco is the recognized leader in specialty columns for the Food & Beverage industry. These columns are written into many methods, and are considered the benchmark columns in the industry. Analytes such as free fatty acids, fatty acid methyl esters, alcohols, triglycerides, glycols, and sterols can be separated on these special purpose columns.

#### Supelco GC Columns for the Food & Beverage Industry

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<th>Column</th>
<th>Alcohols</th>
<th>Coloring Compounds</th>
<th>Fragrance Compounds</th>
<th>Glycols</th>
<th>Preservatives (Phenolic Antioxidants)</th>
<th>Solvents in Cleaning Products</th>
<th>Surfactants (Anionic)</th>
<th>Surfactants (Nonionic)</th>
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### Personal Care and Cleaning Products Industry
Commercial products, such as shampoos, cosmetics, and rug cleaners, must continuously be monitored to ensure that they do not contain items hazardous to the user. These columns can be used for this purpose.

#### Supelco GC Columns for the Personal Care and Cleaning Products Industry

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<th>Alkalis</th>
<th>Coloring Compounds</th>
<th>Fragrance Compounds</th>
<th>Glycols</th>
<th>Preservatives (Phenolic Antioxidants)</th>
<th>Solvents in Cleaning Products</th>
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</table>
Petroleum Industry

This family of columns can be used for analyses such as purity, boiling point composition, aromatics, light hydrocarbons, fluorocarbons, and sulfur-containing compounds in petroleum products.

Supelco GC Columns for the Petroleum Industry

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<th>Petrocol 2887</th>
<th>Petrocol EX2887</th>
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<th>MET-Biodiesel</th>
<th>HT-5</th>
<th>SP-2380</th>
<th>SLB-IL100</th>
<th>TCEP</th>
<th>Alumina sulfate PLOT</th>
<th>Alumina chloride PLOT</th>
<th>Carboxen-1010 PLOT</th>
<th>Carboxen-1006 PLOT</th>
<th>Mol Sieve 5A PLOT</th>
<th>Supel-Q PLOT</th>
<th>Bentone 34/DNDP SCOT</th>
<th>BMEA SCOT</th>
<th>Squalane SCOT</th>
<th>TCEP SCOT</th>
<th>Fluorocol™ Packed Column</th>
<th>GPA Packed Columns</th>
<th>Micropacked Columns</th>
</tr>
</thead>
</table>


G003739
**Chemical Industry**

These special purpose columns can be selected for analyses such as solvents, aromatics, light hydrocarbons, freons, sulfur-containing compounds, glycols, or basic compounds.

**Supelco GC Columns for the Chemical Industry**

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<th>Solvents on a Nonpolar Column</th>
<th>Solvents on a Polar Column</th>
<th>Aromatics</th>
<th>Cl-Cl Hydrocarbons</th>
<th>Cl-C2 Alkanes, Alkenes, and Alkynes</th>
<th>Freons</th>
<th>Sulphur Compounds</th>
<th>Acidic Compounds / Glycols</th>
<th>Basic Compounds</th>
<th>Process Analyzers</th>
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</table>

**technical service:** 800-359-3041 (US and Canada only) / 814-359-3041
Column Selection by Application

In addition to the industry specific selection charts on the preceding pages, these two easy-to-read phase selection charts highlight choices for two applications that are independent of any industry. Simply locate the application to identify a recommended column phase.

The stationary phase also dictates the minimum and maximum temperatures at which a column can be used. Therefore, it is critical to ensure the selected stationary phase can withstand the temperature requirements of the GC method. Temperature limitations can be located in the capillary column phase section on pages 16 to 21.

Fast GC Applications

Applying the principles of Fast GC is an effective way to increase sample throughput by decreasing the analysis time. These columns have all the characteristics necessary for developing a successful Fast GC method.

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<tr>
<td>Equity-1</td>
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<td>SPB-1</td>
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<tr>
<td>Equity-5</td>
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<td>SPB-5</td>
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General Purpose Applications

Supelco’s general purpose columns are tested to ensure they meet acceptable values for general chromatographic parameters such as retention, efficiency, and selectivity. These columns are recommended for applications that do not fall under those covered by our special purpose, industry specific columns.

<table>
<thead>
<tr>
<th>Supelco GC Columns for General Purpose Applications</th>
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<tbody>
<tr>
<td>SPB-Octyl</td>
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<td>Equity-1</td>
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<td>SPB-20</td>
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<td>SPB-35</td>
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<tr>
<td>Equity-1701</td>
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<td>SPB-50</td>
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# Cross-Reference Chart

Table 4. Supelco Capillary GC Columns with Comparable Columns from Other Manufacturers

<table>
<thead>
<tr>
<th>Supelco</th>
<th>Agilent</th>
<th>Grace</th>
<th>Macherey-Nagel</th>
<th>Phenomenex®</th>
<th>Restek</th>
<th>SGE</th>
<th>Varian</th>
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<td><strong>TRADITIONAL (phases by increasing phase polarity)</strong></td>
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<td>HP-PLOT Al2O3 °KCl</td>
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<td>CP-Al2O3, PLOT KCl</td>
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</table>
Capillary Columns by Phase

Looking for information or specifications for a particular phase? This section includes the most popular phases and provides application, USP code, polymer, and temperature limit information. Where two maximum temperatures are listed (i.e. 200/220 °C), the first is for isothermal oven analyses, whereas the second is for oven temperature programmed analyses. Where only one maximum temperature is listed, it can be used for either isothermal or temperature programmed oven analyses.

This section is organized primarily in order of increasing phase polarity to assist in phase selection when performing method development. Other, less popular, phases are available. However, these are not listed here due to space constraints. To learn more about any phases listed, or to inquire about a phase not listed, contact Supelco Technical Service at 800-359-3041 (US and Canada only), 814-359-3041, or at techservice@sial.com

TRADITIONAL PHASES
(By increasing phase polarity)

Petrocol DH Octyl
- **Application:** This column, for detailed analyses of petroleum products, is known within the petroleum and chemical industries for its unique selectivity. Baseline separations of benzene/1-methylcyclopentene and toluene/2,3,3-trimethylpentane that are possible with this column are not obtainable with classical poly(dimethylsiloxane) columns.
- **USP Code:** None
- **Phase:** Bonded; poly(50% n-octyl/50% methylsiloxane)
- **Temperature Limits:** -60 °C to 220 °C

SPB-Octyl
- **Application:** The low polarity of this column approaches squalane, making it substantially less polar than that of the widely used non-polar poly(dimethylsiloxane) columns. This column offers unique selectivity compared to non-polar and intermediate polarity columns, and can be used for confirmational analyses of PCB-containing samples.
- **USP Code:** None
- **Phase:** Bonded; poly(50% n-octyl/50% methylsiloxane)
- **Temperature Limits:** -60 °C to 260 °C

SPB-HAP
- **Application:** This column was developed to provide the best resolution of very volatile hazardous air pollutants. The thick film helps to focus analytes on the column, possibly eliminating the need to employ cryogenic focusing techniques.
- **USP Code:** This column meets USP G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:** -60 °C to 300 °C

Petrocol DH 50.2, DH, DH 150
- **Application:** These highly reproducible columns have considerable theoretical plate numbers and are designed for detailed analyses of petroleum products for PIANO, PONA, and PNA-type analytes. The 100 m version includes an extensive retention index data sheet of 400+ analytes.
- **USP Code:** These columns meet USP G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:** -60 °C to 320 °C

Petrocol 2887, EX2887
- **Application:** These columns are designed for ASTM Method D2887 (simulated distillation [SIM DIS] of petroleum fractions). Choose Petrocol 2887 for samples having boiling points up to 1000 °F. Use Petrocol EX2887 for samples having boiling points greater than 1000 °F.
- **USP Code:** These columns meet G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:** Petrocol 2887: Subambient to 350 °C Petrocol EX2887: Subambient to 380 °C

SPB-1 SULFUR
- **Application:** A specialized version of the SPB-1, this column was developed for analyses of sulfur gases and other volatile sulfur compounds. The column displays relatively low column bleed, which makes it compatible for use with sulfur-specific detectors.
- **USP Code:** This column meets USP G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:** -60 °C to 300 °C

Equity-1
- **Application:** This column is designed for general purpose applications where a non-polar column is required. Analytes will be separated primarily according to boiling point.
- **USP Code:** This column meets USP G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:**
  - 60 °C to 325/350 °C for 0.10 - 0.32 mm I.D.
  - 60 °C to 300/320 °C for 0.53 mm I.D. (>1.5 μm)
  - 60 °C to 260/280 °C for 0.53 mm I.D. (>1.5 μm)

SPB-1
- **Application:** This column is often used for traditional general purpose applications, where a non-polar column is required. Analytes will be separated primarily according to boiling point.
- **USP Code:** This column meets USP G1, G2, and G9 requirements.
- **Phase:** Bonded; poly(dimethylsiloxane)
- **Temperature Limits:** -60 °C to 320 °C
SLB-5ms

- **Application:** The 5% phenyl equivalent phase provides a boiling point elution order with a slight increase in selectivity, especially for aromatic compounds. The low bleed characteristics, inertness, and durable nature make it the column of choice for environmental analytes (such as semivolatiles, pesticides, PCBs, and herbicides) or anywhere a low bleed non-polar column is required.
- **USP Code:** This column meets USP G27 and G36 requirements.
- **Phase:** Bonded and highly crosslinked; silphenylene polymer virtually equivalent in polarity to poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:** -60 °C to 340/360 °C for 0.10 - 0.32 mm I.D.
  -60 °C to 330/340 °C for 0.53 mm I.D.

MET-Biodiesel

- **Application:** This rugged metal column was designed specifically for the determination of free and total glycerin in B100 biodiesel samples. A guard is integrated, thereby providing protection with a leak-free connection (the guard and analytical column are one continuous piece of tubing; there is no union between the guard and analytical column).
- **USP Code:** None
- **Phase:** Bonded; proprietary
- **Temperature Limits:** -60 °C to 380/430 °C

HT-5 (aluminum clad)

- **Application:** This column offers the highest maximum temperature of any commercially available column. It is well suited for simulated distillation (SIM DIS) analyses of petroleum samples.
- **USP Code:** None
- **Phase:** Bonded; siloxane-carborane equivalent in polarity to poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:** 10 °C to 460/480 °C

PTA-5

- **Application:** This column is designed for analyses of amines and other basic analytes.
- **USP Code:** None
- **Phase:** Bonded; base-modified poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:** -60 °C to 320 °C

SAC-5

- **Application:** This column is an application specific non-polar column, designed for reproducible analyses of plant sterols, cholesterol, and other animal sterols.
- **USP Code:** None
- **Phase:** Bonded; poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:** -60 °C to 320 °C

Equity-5

- **Application:** This popular column is designed for general purpose applications where a non-polar column is required. The low phenyl content provides thermal stability compared to 100% poly(dimethylsiloxane) columns.
- **USP Code:** This column meets USP G27 and G36 requirements.
- **Phase:** Bonded; poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:**
  - -60 °C to 325/350 °C for 0.10 - 0.32 mm I.D.
  - -60 °C to 300/320 °C for 0.53 mm I.D. (≤1.5 μm)
  - -60 °C to 260/280 °C for 0.53 mm I.D. (>1.5 μm)

SPB-5

- **Application:** This non-polar general purpose column provides primarily a boiling point elution order with a slight increase in selectivity, especially for aromatic compounds.
- **USP Code:** This column meets USP G27 and G36 requirements.
- **Phase:** Bonded; poly(5% diphenyl/95% dimethylsiloxane)
- **Temperature Limits:** -60 °C to 320 °C

SPB-624

- **Application:** This column is specially tested for separation, efficiency, and low bleed. It is designed for purge-and-trap analyses of volatile halogenated, non-halogenated, and aromatic contaminants from environmental samples.
- **USP Code:** This column meets USP G43 requirements.
- **Phase:** Bonded; proprietary
- **Temperature Limits:** Subambient to 250 °C for ≤0.32 mm I.D.
  Subambient to 230 °C for 0.53 mm I.D.

OVI-G43

- **Application:** This column is specially prepared and tested to meet the requirements of United States Pharmacopoeia and European Pharmacopoeia methods for determining residual solvents in pharmaceutical preparations.
- **USP Code:** This column meets USP G43 requirements.
- **Phase:** Bonded; poly(6% cyanopropylphenyl/94% dimethylsiloxane)
- **Temperature Limits:** -20 °C to 260 °C

VOCOL

- **Application:** This intermediate polarity column, designed for analyses of volatile organic compounds (VOCs), offers great retention and resolution of highly volatile compounds. Use this column in direct injection ports or coupled to purge-and-trap systems.
- **USP Code:** None
- **Phase:** Bonded; proprietary
- **Temperature Limits:**
  - Subambient to 250 °C (≤1.8 μm)
  - Subambient to 230 °C (>1.8 μm)
SPB-20
- Application: This column has intermediate polarity due to the higher (20%) phenyl content, producing a different elution order of polar compounds for confirmational information. It is often used for analyses of aromatic analytes.
- USP Code: This column meets USP G32 requirements.
- Phase: Bonded; poly(20% diphenyl/80% dimethylsiloxane)
- Temperature Limits: -25 °C to 300 °C

Equity-1701
- Application: Increased phase polarity, due to cyanopropylphenyl functional group substitution, offers unique selectivity compared to other phases. This column works well with systems employing ECD, NPD, and MSD detectors, and is often used for alcohols, oxygenates, pharmaceuticals, pesticides, and PCB applications.
- USP Code: This column meets G46 requirements.
- Phase: Bonded; poly(14% cyanopropylphenyl/86% dimethylsiloxane)
- Temperature Limits: Subambient to 280 °C for 0.10 - 0.32 mm I.D. Subambient to 260 °C for 0.53 mm I.D

SPB-608
- Application: This column is specially tested with low concentrations of 18 chlorinated pesticides, using an ECD detector. In addition to selectivity and efficiency, it is also tested to ensure minimum breakdown of 4,4’-DDT and endrin. This column is also suitable for use in herbicide analyses.
- USP Code: None
- Phase: Bonded; proprietary
- Temperature Limits: Subambient to 300 °C

Sup-Herb
- Application: This is a specially tested intermediate polarity column for analyses of herbicides, specifically for US EPA Method 507.
- USP Code: None
- Phase: Bonded; proprietary
- Temperature Limits: Subambient to 300 °C

SPB-50
- Application: This column has the highest phenyl content of the common phenyl-containing series of phases. The column is useful for analyses of polar analytes and provides useful confirmational information. It also offers additional selectivity for polynuclear aromatic hydrocarbon isomers over columns with lower phenyl content.
- USP Code: This column meets USP G3 requirements.
- Phase: Bonded; poly(50% diphenyl/50% dimethylsiloxane)
- Temperature Limits: 30 °C to 310 °C

SPB-225
- Application: Supelco offers the broadest range of cyanopropyl columns in the industry, such as this intermediate polarity column.
- USP Code: This column meets USP G7 and G19 requirements.
- Phase: Bonded; poly(50% cyanopropylphenyl/50% dimethylsiloxane)
- Temperature Limits: 45 °C to 220/240 °C

SPB-PUFA
- Application: This column provides the necessary polarity for analyses of polyunsaturated fatty acids (PUFAs) as fatty acid methyl esters (FAME). This column is specifically tuned to provide highly reproducible analyses.
- USP Code: This column meets USP G18 requirements.
- Phase: Bonded; poly(alkylene glycol)
- Temperature Limits: 50 °C to 220 °C

PAG
- Application: This column fills the polarity space between a 50% phenyl substituted column and a classical wax-type column, due to its polarity being slightly lower than a wax-type column. It is well suited for analyses of FAMEs and alcohols.
- USP Code: This column meets USP G18 requirements.
- Phase: Bonded; poly(alkylene glycol)
- Temperature Limits: 30 °C to 220 °C

SPB-1000
- Application: The incorporation of acid functional groups into the phase lends an acidic character to this column, useful for analyses of volatile acidic compounds. It offers great performance for analyses of glycols. It is the recommended column for ethylene glycol analysis.
- USP Code: This column meets USP G25 and G35 requirements.
- Phase: Bonded; acid-modified poly(ethylene glycol)
- Temperature Limits: 60 °C to 200/220 °C

Nukol
- Application: The incorporation of acid functional groups into the phase lends an acidic character to this column, useful for analyses of volatile acidic compounds. Difficult to analyze carboxylic acids (free fatty acids) can be analyzed with excellent peak shape and minimal adsorption.
- USP Code: This column meets USP G25 and G35 requirements.
- Phase: Bonded; acid-modified poly(ethylene glycol)
- Temperature Limits: 60 °C to 200/220 °C
Carbowax Amine
- **Application**: This specially prepared base-deactivated column is designed for analyses of primary, secondary, and tertiary amines, as well as other volatile basic compounds.
- **USP Code**: None.
- **Phase**: Non-bonded; base-modified poly(ethylene glycol)
- **Temperature Limits**: 60 °C to 200 °C

Omegawax
- **Application**: This column allows highly reproducible analyses of fatty acid methyl esters (FAMEs), specifically the omega-3 and -6 fatty acids. It is tested to ensure reproducible FAME equivalent chain length (ECL) values and resolution of key components.
- **USP Code**: This column meets USP G16 requirements.
- **Phase**: Bonded; poly(ethylene glycol)
- **Temperature Limits**: 50 °C to 280 °C

SUPELCOWAX 10
- **Application**: This column is based on one of the most widely used polar phases, Carbowax 20M, and is a polar column suitable for analyses of fatty acid methyl esters (FAMES), food, flavor and fragrance compounds, alcohols, and aromatics. Additionally, this column is a great choice when a polar general purpose column is required.
- **USP Code**: This column meets USP G16 requirements.
- **Phase**: Bonded; poly(ethylene glycol)
- **Temperature Limits**: 35 °C to 280 °C

SP-2330
- **Application**: Supelco offers the broadest range of biscyanopropyl phases in the industry. This column is a highly specialized column that offers both polar and polarizable features due to the substitution of biscyanopropyl and phenyl groups onto the polymer backbone. It can be used for both high and low temperature separations for analytes such as geometric isomers of fatty acid methyl esters (FAMES), dioxins, and aromatic compounds.
- **USP Code**: This column meets USP G8 requirements.
- **Phase**: Non-bonded; poly(80% biscyanopropyl/20% cyanopropylphenyl siloxane)
- **Temperature Limits**: Subambient to 250 °C

SP-2331
- **Application**: A highly polar cyanosiloxane column specially tested for analyses of dioxins, specifically tetrachlorodibenzo-p-dioxin (TCDD) isomers. Because the phase is stabilized, it has a maximum temperature slightly higher than non-bonded cyanosiloxane columns.
- **USP Code**: None
- **Phase**: Stabilized; proprietary
- **Temperature Limits**: Subambient to 275 °C

SP-2380
- **Application**: A highly polar cyanosiloxane column commonly used for separation of geometric (cis/trans) fatty acid methyl ester (FAME) isomers as a group. Also useful when a highly polar general purpose column with good thermal stability is required.
- **USP Code**: This column meets USP G48 requirements.
- **Phase**: Stabilized; poly(90% biscyanopropyl/10% cyanopropylphenyl siloxane)
- **Temperature Limits**: Subambient to 275 °C

SP-2560
- **Application**: This highly polar biscyanopropyl column was specifically designed for the separation of geometric/position (cis/trans) isomers of fatty acid methyl esters (FAMES). It is extremely effective for FAME isomer applications.
- **USP Code**: This column meets USP G5 requirements.
- **Phase**: Non-bonded; poly(biscyanopropyl siloxane)
- **Temperature Limits**: Subambient to 250 °C

SP-2340
- **Application**: This non-bonded column offers the highest polarity in its class. As with all general purpose biscyanopropyl columns, it is highly effective for both high and low temperature separations of geometric isomers of fatty acid methyl esters (FAMES), dioxins, carbohydrates, and aromatic compounds.
- **USP Code**: This column meets USP G5 requirements.
- **Phase**: Non-bonded; poly(biscyanopropyl siloxane)
- **Temperature Limits**: Subambient to 250 °C

SLB-IL100
- **Application**: This highly polar column exemplifies some of the desired characteristics that ionic liquid columns are predicted to possess. Namely, a higher maximum temperature compared to non-ionic liquid columns with similar polarity/selectivity. This column is applicable for applications such as analyses of aromatic hydrocarbons in gasoline and also of fatty acid methyl esters (FAMES).
- **USP Code**: None
- **Phase**: Non-bonded; 1,9-di(3-vinyl-imidazolium) nonane bis(trifluoromethyl)sulfonylimidate
- **Temperature Limits**: Subambient to 230 °C

TCEP
- **Application**: The unique chemistry of the phase allows for specialized separations. It is often used for analyses of alcohols and aromatics in mineral spirits, aliphatic constituents in gasoline, impurities in individual aromatics, and oxygenates.
- **USP Code**: None
- **Phase**: Non-bonded; 1,2,3-tris(2-cyanoethoxy)propane
- **Temperature Limits**: Subambient to 145 °C
**CHIRAL PHASES**

Chiral GC phases consist of derivatives of α-, β-, or γ-cyclodextrin for the separation of enantiomers. These phases can routinely separate a variety of underivatized non-aromatic enantiomers and several aromatic enantiomers that remain difficult to resolve by HPLC. These phases specifically and effectively separate many of these types of molecules, including thousands of compounds that are starting materials or intermediates for chiral synthesis, biochemical and pharmaceutical intermediates and metabolites, environmental contaminants, flavors, etc.

**CHIRALDEX**
- **Application:** These columns are used for analyses of enantiomers to determine biological activity (pharmaceutical industry), aroma (flavor & fragrance and food & beverage industries), whether hazardous (environmental industry), and purity (chemical industry).
- **USP Code:** None
- **Phase:** Sixteen specialized phase chemistries comprised of complex derivatives of cyclodextrins that impart a broad range of selectivities
- **Temperature Limits:**
  - TA Phases: -5 °C to 180 °C
  - All Other Phases: -5 °C to 220 °C

**Supelco DEX**
- **Application:** These columns are used for analyses of enantiomers to determine biological activity (pharmaceutical industry), aroma (flavor & fragrance and food & beverage industries), whether hazardous (environmental industry), and purity (chemical industry).
- **USP Code:** None
- **Phase:** Ten unique phases comprised of derivatives of cyclodextrins that are able to perform many enantiomeric separations
- **Temperature Limits:** 30 °C to 230 °C

**PLOT COLUMNS**

PLOT (Porous Layer Open Tubular) technology permits a uniform layer of solid adsorbent particles to be attached to the inside wall of fused silica tubing. The use of porous adsorbents in these columns allows for gas-solid chromatography to be performed. A proprietary and patented procedure is used to fix particles to the fused silica tubing, and ensures they will not be dislodged in normal use.

**Alumina sulfate PLOT**
- **Application:** This highly dependable column has the necessary selectivity for the separation of alkanes, alkenes, and alkynes in mixtures of C1-C4 hydrocarbons. It provides elution of acetylene after n-butane and the elution of methyl acetylene after n-pentane and 1,3-butadiene. The polymer surface is deactivated to reduce peak tailing.
- **USP Code:** None
- **Phase:** Sulfate-deactivated alumina
- **Temperature Limits:** Subambient to 180 °C

**Alumina chloride PLOT**
- **Application:** This column allows for the separation of C1-C4 hydrocarbons. Because this column is slightly less polar than the Alumina sulfate PLOT, it provides a different elution order pattern when alkane, alkene, and alkyne mixtures of light hydrocarbons are analyzed. It also provides excellent separation of many common fluorinated compounds, such as freons.
- **USP Code:** None
- **Phase:** Chloride-deactivated alumina
- **Temperature Limits:** Subambient to 180 °C

**Carboxen-1010 PLOT**
- **Application:** This column is ideal for the separation of all major components in permanent gas (helium, hydrogen, oxygen, nitrogen, carbon monoxide, methane, and carbon dioxide) and light hydrocarbons (C2-C3) in the same analysis. It is the only column commercially available that is able to separate all major components in permanent gas. This column can also separate oxygen from nitrogen at subambient temperatures.
- **USP Code:** None
- **Phase:** Carbon molecular sieve
- **Temperature Limits:** Subambient to 250 °C
Carboxen-1006 PLOT
- **Application:** This column is ideal for the separation of many permanent gas components (such as helium, hydrogen, nitrogen, carbon monoxide, methane, and carbon dioxide), and light hydrocarbons (C2-C3) in the same analysis. It is ideal for resolving formaldehyde/water/methanol (formalin) mixtures and monitoring impurities in ethylene. This column can be used with high flow rates and rapid temperature programs to ensure excellent, fast separations.
- **USP Code:** None
- **Phase:** Carbon molecular sieve
- **Temperature Limits:** Subambient to 250 °C

Mol Sieve 5A PLOT
- **Application:** This column can be used for the separation of many permanent gas components, such as oxygen, nitrogen, carbon monoxide, and methane, in less than five minutes. More difficult separations, such as argon from oxygen, can be achieved by using subambient temperatures. These columns possess the strongest adsorption strength of any PLOT column.
- **USP Code:** None
- **Phase:** Aluminosilicate
- **Temperature Limits:** Subambient to 300 °C

Supel-Q PLOT
- **Application:** This column exhibits very little bleed, even at its maximum temperature, and effectively resolves carbon dioxide and C1-C4 hydrocarbons at above ambient temperatures. It is also suitable for analyses of sulfur gases, alcohols, ketones, aldehydes, and many polar compounds. Gasoline and other petroleum fractions can be analyzed as well.
- **USP Code:** None
- **Phase:** Divinylbenzene
- **Temperature Limits:** Subambient to 250 °C

SCOT COLUMNS
SCOT (Support Coated Open Tubular) technology permits a uniform layer of support particles that have been coated with liquid phase to be deposited onto the inner wall of stainless steel tubing. This technology allows access to many phases that are inaccessible to conventional wall coated open tubular capillary column manufacturing technology. These columns combine the sensitivity and excellent sample resolution of capillary GC with the extensive stationary phase library of packed column GC.

**Bentone 34/DNPD SCOT**
- **Application:** Use for analyses of xylene isomers.
- **USP Code:** None
- **Phase:** Bentone 34/di-n-decyl phthalate
- **Temperature Limits:** 10 °C to 150 °C

**BMEA SCOT**
- **Application:** Use for analyses of olefins.
- **USP Code:** None
- **Phase:** bis-methoxyethyl adipate
- **Temperature Limits:** Ambient to 100 °C

**Squalane SCOT**
- **Application:** Use for boiling point separations.
- **USP Code:** None
- **Phase:** Squalane
- **Temperature Limits:** 20 °C to 120 °C

**TCEP SCOT**
- **Application:** Use for analyses of aromatic analytes.
- **USP Code:** None
- **Phase:** 1,2,3-tris(2-cyanoethoxy)propane
- **Temperature Limits:** 0 °C to 150 °C
# Catalog Numbers

(Common Dimensions of Popular Phases)

## Table 5. Traditional Phases (by increasing phase polarity)

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<thead>
<tr>
<th>Phase</th>
<th>I.D. (mm)</th>
<th>Length (m)</th>
<th>d (μm)</th>
<th>Beta Value</th>
<th>Cat. No.</th>
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**Table 6. Chiral Phases**

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<th>Length (m)</th>
<th>d (μm)</th>
<th>Beta Value</th>
<th>Cat. No.</th>
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<td>0.12</td>
<td>500</td>
<td>73033AST</td>
</tr>
<tr>
<td>CHIRALDEX G-DP</td>
<td>0.25</td>
<td>30</td>
<td>0.12</td>
<td>500</td>
<td>78033AST</td>
</tr>
<tr>
<td>CHIRALDEX B-DM</td>
<td>0.25</td>
<td>30</td>
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<td>500</td>
<td>77023AST</td>
</tr>
<tr>
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<td>0.12</td>
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<td>76023AST</td>
</tr>
<tr>
<td>CHIRALDEX Bonded B-PM</td>
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<td>66023AST</td>
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<tr>
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<tr>
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<td>β-DEX 225</td>
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</table>

*Plus an integrated 2 m x 0.53 mm I.D. guard.*

*Wound onto a 5 inch cage to fit an Agilent 6850 GC.*

**Table 7. PLOT Columns**

<table>
<thead>
<tr>
<th>Phase</th>
<th>I.D. (mm)</th>
<th>Length (m)</th>
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<td>Alumina sulfate PLOT</td>
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<td>Alumina chloride PLOT</td>
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<td>Carboxen-1010 PLOT</td>
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<tr>
<td>Carboxen-1006 PLOT</td>
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<td>30</td>
<td>25461</td>
</tr>
<tr>
<td>Mol Sieve 5A PLOT</td>
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<td>30</td>
<td>25463</td>
</tr>
<tr>
<td>Supel-Q PLOT</td>
<td>0.53</td>
<td>30</td>
<td>25462</td>
</tr>
</tbody>
</table>
Fast GC

A Practical Guide for Increasing Sample Throughput without Sacrificing Quality

- Increase Productivity
- Utilize Resources More Effectively
- Achieve Quicker Turn-Around-Times
- Analyze More Samples

86 Analytes in 8 Min.
The cheetah (Acinonyx jubatus) – world’s fastest land animal with a top speed over 65 miles per hour (105 kilometers per hour). This is accomplished by a combination of many physiological adaptations, all designed to maximize speed:

- Long, sleek body for fluid movements.
- Lightweight bones for reduced weight.
- Small collarbone and vertical shoulder blades on a flexible spine for great reach with the legs.
- Specialized muscles and long, slender legs for great swing of the limbs.
- Powerful back legs for long strides.
- Paws with flat, hard pads and short, straight, always-visible claws for extra grip.
- Long, muscular tail for balance.
- Large nostrils for maximum oxygen intake.
- Large heart, arteries, and lungs for efficient oxygen circulation.
- Flat face, short muzzle, and elongated eyes for great wide-angle vision.

The cheetah – nature’s fastest land animal.

Gas chromatographic analytical procedures consist essentially of 4 separate steps:

- Sample preparation
- Sample injection, separation and detection
- GC oven cooling time and re-equilibration
- Data elaboration

The first two steps have generally a greater impact on analytical time-costs, selectivity, sensitivity, ruggedness, precision, and accuracy. For this reason, both have been subjected to a great deal of development.

Considering the GC separation step, a high number of methods have been introduced in the last decades. In our opinion, the employment of narrow bore columns as a route towards fast GC is the best way to (greatly) reduce GC run times. If a correct method optimization procedure is pursued, conventional GC chromatographic profiles are reproduced or even improved, while analysis times are decreased by 5-10 times. A former disadvantage, the need for drastic experimental conditions, has been entirely overcome by the introduction of suitable GC instrumentation. The commercial availability of narrow bore columns with a wide variety of stationary phases makes high-speed gas chromatography an easy option for all.

Regards,

Peter Quinto Tranchida
Luigi Mondello
Roberto Ferrari

1. Dipartimento Farmaco-chimico, Università di Messina, Italy
2. Sigma-Aldrich s.r.l.
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Practical and Theoretical Aspects of Fast GC

History

The function of a gas chromatography (GC) system is to provide the most adequate conditions required for the separation of sample components in minimal time. Conventional GC methods use capillary columns typically 30 m long with a 0.25 mm internal diameter (I.D.). These well-established methods produce effective results but present a substantial limitation: the cost in time. In fact, satisfactory separations of complex samples may take an hour or more. The implementation of faster GC methods is, therefore, particularly important for laboratories with a high daily sample throughput and/or where there is a need for quick and correct results.

At the beginning of the 1960’s, Desty demonstrated the potential of small diameter columns [1]. Due to the lack of automated injection systems, a narrow sample band was manually injected onto the capillary column. Following this primordial narrow I.D. column experiment, other techniques to increase sample throughput were developed and introduced. These include multicapillary columns [2], short capillary columns [3], wide-bore columns operated under vacuum at the outlet [4], and accelerated temperature programs [5]. It should be noted, though, that the narrow I.D. column route is certainly the best option for rapid GC analysis of medium to highly complex samples [6-7]. The drastic instrumental requirements (rapid automated injection, high head pressures and split flows, accelerated oven temperature ramp rates, and fast detector acquisition rates) are now generally met by modern GC systems.

What is Fast GC?

The primary aim of Fast GC is to maintain (compared to conventional GC) sufficient resolving power in a shorter time. Fast GC uses column and instrument improvements in combination with optimized run conditions to provide 3- to 10-times faster analysis times, while still providing acceptable resolution. Fast GC can be accomplished by manipulating a number of the analysis parameters, such as column length, column I.D., stationary phase, film thickness, carrier gas, linear velocity, oven temperature, and ramp rate. Fast GC is typically performed using short, 0.10 mm or 0.18 mm I.D. capillary columns with hydrogen carrier gas and rapid oven temperature ramp rates. Based solely on column internal diameter (I.D.), capillary GC can be grouped into three types.

- Conventional GC: ≥0.25 mm I.D. columns.
- Fast GC: 0.10 to 0.18 mm I.D. columns (can be performed on most conventional GCs).
- Ultra-Fast GC: ≤0.050 mm I.D. columns (may require a special GC).

Why Use Fast GC?

GC is a popular and powerful analytical tool, but often suffers from long analysis times. Speed of analysis is important to many of today’s GC analysts as they look for ways to improve sample throughput. Without sacrificing the quality of the analysis, there is little that is more valuable than sample throughput. Benefits of increasing sample throughput include:

1. **Decreased costs** – Less people and/or instruments are required to do the same amount of work.
2. **Increased revenue** – More customer samples can be processed in the same amount of time.
3. **Increased revenue** – Customers may be willing to pay more to get their results faster (surcharge for quick turn-around).

Fast GC Principles

Decrease analysis time by using:

- Short columns (slight decrease in efficiency will be observed)
- High carrier gas linear velocity (slight decrease in efficiency may be observed)
- Rapid oven temperature ramp rate (slight decrease in efficiency may be observed)

The decrease in efficiency can be offset by using:

- Narrow I.D. columns
- Low film thickness
- Hydrogen carrier gas

The overall result is a shorter analysis time with acceptable resolution. Basically, Fast GC works because we use a shorter column (to reduce analysis time) with a narrow I.D. (used to offset the loss of efficiency of the shorter column). Note that the above parameters must be optimized together! Changing only one may decrease analysis time, but will likely cause a loss of resolution.

How to Perform Fast GC (Practical)

Column Dimension Considerations – A Fast GC column is typically 20 m or shorter in length with a 0.10 to 0.18 mm I.D. Short column lengths result in short analysis times. A narrow I.D. results in increased efficiency, necessary to offset the decrease caused by the short length. In addition to increased efficiency, narrow I.D. columns also provide better signal-to-noise ratios, leading to better sensitivity. The decrease in column I.D. reduces resistance to mass transfer into the gaseous phase. Compared to conventional columns, less band broadening occurs in narrow I.D. columns due to the fact that analytes are diluted in a smaller volume of carrier gas.
Stationary Phase Considerations – Any stationary phase can be used. However, selection of a stationary phase should be based on the application to be performed and/or the retention mechanism of the phase. For example, polar analytes retain longer on polar phases. Therefore, switching to a less polar phase may allow shorter analysis times. Of course, the stationary phase selected must be able to perform any critical separations. Regardless of the stationary phase, a thin film should be used to ensure the rapid partitioning of analytes back into the carrier gas stream. Thin films limit partitioning into the stationary phase, resulting in less band broadening.

Carrier Gas Considerations – Nitrogen, helium and hydrogen are the typical carrier gases for GC. However, hydrogen is the best choice for Fast GC due to its high diffusivity and high optimal linear velocity. Obviously, safety precautions and detector requirements must be considered. Regardless of the carrier gas being used, increasing linear velocity will decrease the speed of analysis. However, loss of efficiency can occur if the speed is increased much higher than its optimal linear velocity. Hydrogen has a flatter Golay curve than other carrier gases. Therefore, it can be used at a linear velocity above optimal with little observed loss of efficiency.

Oven Temperature Considerations – For isothermal analyses, the use of a higher oven temperature will decrease analysis time. For oven temperature programmed analyses, a faster oven temperature ramp rate will decrease analysis time. To achieve the desired ramp rate, a GC equipped with either a 220 V oven heater or an insert (to reduce the volume of space that must be heated) may be required. Theoretical dictations have shown that a temperature ramp rate of 10 °C per void time should be used to attain an optimum separation [12]. With faster ramp rates, analytes may not partition into the stationary phase long enough for satisfactory resolution. With slower ramp rates, resolution is achieved but with a long analysis time.

Head Pressure Considerations – As column I.D. decreases, the backpressure experienced by the GC system increases. Therefore, it is important to ensure that the GC system can handle the increased pressure requirement. Theoretical head pressure values for various column dimensions are shown in Table 1. This table illustrates why Fast GC columns are typically 20 m or shorter in length.

Table 1. Head Pressures for 0.10 mm I.D. Columns

<table>
<thead>
<tr>
<th>Column (L x I.D.)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
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</thead>
<tbody>
<tr>
<td>5 m x 0.10 mm</td>
<td>12</td>
<td>19</td>
<td>25</td>
<td>32</td>
<td>12</td>
<td>15</td>
<td>18</td>
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</tr>
<tr>
<td>10 m x 0.10 mm</td>
<td>25</td>
<td>39</td>
<td>54</td>
<td>69</td>
<td>25</td>
<td>31</td>
<td>38</td>
<td>45</td>
</tr>
<tr>
<td>20 m x 0.10 mm</td>
<td>54</td>
<td>84</td>
<td>115</td>
<td>146</td>
<td>52</td>
<td>66</td>
<td>81</td>
<td>96</td>
</tr>
<tr>
<td>40 m x 0.10 mm</td>
<td>115</td>
<td>177</td>
<td>239</td>
<td>302</td>
<td>111</td>
<td>141</td>
<td>171</td>
<td>201</td>
</tr>
</tbody>
</table>
| Values calculated @ 160 °C

Sample Capacity Considerations – A narrow I.D. column with a thin film has limited sample capacity. That is, compared to a conventional column, a smaller amount of sample can be introduced onto the column before peak shapes become distorted. Therefore, high split ratios may be required to prevent column overload. One might conclude erroneously that the smaller amount of sample results in a loss of sensitivity. Due to the generation of narrower peaks, the sensitivity level compared to conventional GC methods is maintained.

Detection Considerations – Fast GC applications typically produce rapid and narrow peaks. Consequently, detector capabilities become an important consideration, as rapid elution necessitates detectors with fast acquisition rates. The use of a low acquisition rate may lead to incorrect peak quantitation. The use of a high acquisition rate may result in increased noise and decreased sensitivity. As a general rule, 10 data points per upper half of the peak are sufficient for proper peak re-construction.

Instrument Considerations – To make the most out of the speed and efficiency of short, narrow I.D. columns, an instrument should have fast injection speed, a split/splitless injection port, fast oven temperature ramp rate capability, high-speed detectors, and fast data handling. All major instrument manufacturers make GCs that are designed for, or are compatible with, Fast GC.

Why Fast GC Works (Theory)

Narrow I.D. Columns Have Increased Efficiency

It is intuitive that just decreasing column length will decrease analysis times. However, efficiency (peak sharpness and analyte resolution) could be adversely affected unless other parameters of the analysis are adjusted. By decreasing the I.D. of the column, efficiency, measured as the number of plates, is increased. Table 2 shows typical plate numbers generated by capillary columns of various internal diameters. Narrow I.D. columns (<0.25 mm I.D.) offer a greater number of plates/meter than wider I.D. columns, thus shorter lengths can be used while maintaining or improving on the theoretical efficiency of the system. It is a rule of thumb in GC that a 10 m x 0.10 mm I.D., 0.10 μm column possesses the same resolving power as a 25 m x 0.25 mm I.D., 0.25 μm column (~100,000 theoretical plates), if both are operated under ideal conditions.

A decrease in column length results in shorter analysis times (desirable) but also results in decreased efficiency (undesirable).
oven: 40 °C (2 min.), 22 °C/min. to 240 °C, 10 °C/min. to 330 °C (1 min.)

inj.: 250 °C
det.: FID, 330 °C

carrier: helium, 30 cm/sec @ 200 °C, set using methane

injection: 0.5 μL (0.53 and 0.25 mm I.D. columns) and 0.10 μL (0.10 mm I.D. column), splitless (0.75 min.)

liner: 4 mm I.D., single taper (0.53 and 0.25 mm I.D. columns) and 2 mm I.D., straight (0.10 mm I.D. column)

sample: 72 component semivolatile standard and 8 surrogate compounds, plus 6 internal standards, in methylene chloride

1. Di-n-octyl phthalate
2. Benzo(b)fluoranthene
3. Benzo(k)fluoranthene
4. Benzo(a)pyrene
5. Perylene-d12
6. Indeno(1,2,3-cd)pyrene
7. Dibenzo(a,h)anthracene
8. Benzo(ghi)perylene

Narrow I.D. Columns Allow A Faster Linear Velocity

In GC, linear velocity (u, typically expressed in cm/sec) refers to the speed at which the carrier gas travels through the column. Because the analytes are carried through the column by the carrier gas, a faster carrier gas causes the analytes to also travel faster through the column, resulting in shorter analysis times. However, there is an optimal linear velocity (expressed as u_{opt}) where column efficiency is greatest. As linear velocity deviates from optimal, efficiency (peak sharpness and analyte resolution) suffers. At a linear velocity less than optimal, analytes spend too much time in the stationary phase (great resolution but poor peak shapes and long analysis times). At a linear velocity greater than optimal, analytes do not spend enough time in the stationary phase (short analysis times but poor peak shapes and inadequate resolution). To achieve shorter analysis times, it is a balancing act to use a linear velocity as fast as possible without deviating too far above optimal.

The height equivalent to a theoretical plate (HETP, typically expressed in mm) is a measure of column efficiency. HETP specifies the column length necessary where the partitioning of analytes between the carrier gas and the stationary phase is at equilibrium. Lower HETP values result in less band broadening and greater efficiency, observed as sharper peaks and greater resolution.

How narrow I.D. columns allow a faster linear velocity becomes clear when linear velocity is plotted against HETP. In capillary GC terminology, this type of plot is known as a Golay curve. Optimal linear velocity is specified at the point where the curve is the lowest. As shown in Figure 4, optimal linear velocity increases as column I.D. decreases. For example, linear velocity is optimal at 30 cm/sec with a 0.512 mm I.D. column and 40 cm/sec with a 0.18 mm I.D. column. Therefore, narrow I.D. columns may be operated at a higher carrier gas linear velocity, allowing for shorter analysis times. Additionally, narrow I.D. columns have flatter curves. This allows the use of a linear velocity higher than optimal with little decrease in efficiency. For example, a linear velocity of 60 cm/sec (1.5X higher than optimal) can be used with a 0.18 mm I.D. column with little observed decrease in efficiency. Attempting the same with the 0.512 mm I.D. column (45 cm/sec which is 1.5X higher than optimal), results in a measurable decrease in efficiency.
Hydrogen Carrier Gas Increases Efficiency and Decreases Time

The great influence of the carrier gas choice is illustrated in Figure 5 by comparing the helium and hydrogen Golay curves on a 0.10 mm I.D. column. The helium curve has a minimum HETP of 0.109 mm at a 45 cm/sec linear velocity. The hydrogen curve has a minimum HETP of just 0.093 mm at an impressive 70 cm/sec linear velocity.

As stated earlier, HETP specifies the column length necessary where the partitioning of analytes between the carrier gas and the stationary phase is at equilibrium. Lower HETP values result in less band broadening and greater efficiency. Because hydrogen has a lower HETP value than any of the other GC carrier gas choices, its use results in the greatest column efficiency, observed as sharper peaks and greater resolution. Of all GC carrier gas choices, hydrogen has the highest optimal linear velocity. If operating exactly at optimal linear velocities, hydrogen results in the fastest analysis times. Because hydrogen also has the flattest curve, the GC can be operated with an even higher linear velocity without a significant gain in HETP.

Hydrogen has several features (lower HETP, higher optimal linear velocity, and flatter Golay curve) that result in desirable benefits (increased efficiency and decreased analysis times) when compared to other GC carrier gas choices. Obviously, safety precautions and detector requirements must be considered before switching to hydrogen.
Gas chromatography is a popular and powerful analytical tool, but often suffers from long analysis times. By applying the principles of Fast GC (improved instruments, Fast GC column dimensions, and optimized run conditions), decreased analysis times can be achieved, saving the analyst time and money while still achieving superior resolution. Fast GC analyses are typically 3- to 10-times faster and are performed using 0.10 mm or 0.18 mm I.D. columns with column lengths typically less than 20 meters. Supelco offers an impressive line-up of columns in Fast GC dimensions; eighteen columns are available in eleven popular stationary phases. These include special purpose (SPB-624, VOCOL™, SLB-5ms, Equity®-1701, TCEP, Omegawax™ 100, SP-2560) as well as general purpose polar (SUPELCOWAX™ 10) and non-polar (Equity-1, SPB-1, Equity-5, SPB-5) columns, with the characteristics necessary for developing a successful Fast GC method.

- For environmental volatiles, choose SPB-624 or VOCOL
- For environmental semivolatiles, choose SLB-5ms
- For environmental pesticides and PCBs, choose SLB-5ms or Equity-1701
- For petroleum aromatics, choose TCEP
- For food and beverage omega 3 and 6 FAMES, choose Omegawax 100
- For food & beverage cis/trans FAME isomers, choose SP-2560
- For general purpose polar applications, choose SUPELCOWAX 10
- For general purpose nonpolar applications, choose Equity-1, SPB-1, Equity-5, or SPB-5

### Supelco Fast GC Columns

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<tr>
<th>Phase</th>
<th>I.D. (mm)</th>
<th>Length (m)</th>
<th>df (μm)</th>
<th>Beta Value</th>
<th>Cat. No.</th>
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<td>SLB-5ms</td>
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<td>10</td>
<td>0.10</td>
<td>250</td>
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<td>15</td>
<td>0.10</td>
<td>250</td>
<td>28466-U</td>
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<td>0.18</td>
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### Comparable Fast GC Column Cross Reference Chart

Competitor columns listed only if offered in Fast GC dimensions (0.10-0.18 mm I.D.).

<table>
<thead>
<tr>
<th>Supelco</th>
<th>Agilent</th>
<th>Alltech</th>
<th>Macherey-Nagel</th>
<th>Phenomenex</th>
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<th>Restek</th>
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<tr>
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<td>ZB-5ms</td>
<td>007-5MS</td>
<td>Rtx-5Sil MS</td>
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</table>

Comparable Fast GC Column Cross Reference Chart

Competitor columns listed only if offered in Fast GC dimensions (0.10-0.18 mm I.D.).
Fast GC Applications

Dioxins and Furan Congeners on the SLB-5ms

column: SLB-5ms, 15 m x 0.18 mm I.D., 0.18 μm (23348-U)
oven: 150 °C (1 min.), 35 °C/min. to 340 °C (1 min.)
inj.: 250 °C
det.: ECD, 250 °C
carrier gas: hydrogen, 40 cm/sec @ 175 °C
liner: 4 mm I.D., single taper
sample: 17-component 2,3,7,8-substituted dioxin standard, 100-500 ppb in n-nonane

1. 2,3,7,8-TCDF, 100 ppb
2. 2,3,7,8-TCDD, 100 ppb
3. 1,2,3,7,8-PCDF, 250 ppb
4. 2,3,4,7,8-PCDF, 250 ppb
5. 1,2,3,7,8-HxCDF, 500 ppb
6. 1,2,3,7,8-HxCDD, 500 ppb
7. OCDD, 500 ppb
8. OCDF, 500 ppb

FAMEs

37-Component FAME Mix on the SP-2560

column: SP-2560, 75 m x 0.18 mm I.D., 0.18 μm (23348-U)
oven: 140 °C (5 min.), 4 °C/min. to 240 °C (2 min.)
inj.: 250 °C
det.: FID, 250 °C
carrier gas: hydrogen, 40 cm/sec @ 175 °C
liner: 4 mm I.D. split, cup design
sample: 37-component FAME mix at concentrations listed in methylene chloride (47885-U)

1. Butyric Acid Methyl Ester (C4:0) at 4 wt %
2. Caproic Acid Methyl Ester (C6:0) at 4 wt %
3. Caprylic Acid Methyl Ester (C8:0) at 4 wt %
4. Capric Acid Methyl Ester (C10:0) at 4 wt %
5. Undecanoic Acid Methyl Ester (C11:0) at 2 wt %
6. Lauric Acid Methyl Ester (C12:0) at 4 wt %
7. Tridecanoic Acid Methyl Ester (C13:0) at 2 wt %
8. Myristic Acid Methyl Ester (C14:0) at 2 wt %
9. Myristoleic Acid Methyl Ester (C14:1) at 2 wt %
10. Pentadecanoic Acid Methyl Ester (C15:0) at 2 wt %
11. cis-10-Pentadecenoic Acid Methyl Ester (C15:1) at 2 wt %
12. Palmitic Acid Methyl Ester (C16:0) at 6 wt %
13. Palmitoleic Acid Methyl Ester (C16:1) at 2 wt %
14. Heptadecanoic Acid Methyl Ester (C17:0) at 2 wt %
15. cis-10-Heptadecenoic Acid Methyl Ester (C17:1) at 2 wt %
16. Stearic Acid Methyl Ester (C18:0) at 4 wt %
17. Elaidic Acid Methyl Ester (C18:1n9t) at 2 wt %
18. Oleic Acid Methyl Ester (C18:1n7t) at 2 wt %
19. Linoleic Acid Methyl Ester (C18:2n6t) at 2 wt %
20. Linolenic Acid Methyl Ester (C18:3n3) at 2 wt %
21. Arachidic Acid Methyl Ester (C20:0) at 2 wt %
22. cis-11-Eicosadienoic Acid Methyl Ester (C20:2) at 2 wt %
23. Linolenic Acid Methyl Ester (C18:3n6) at 2 wt %
24. cis-11,Eicosahexaenoic Acid Methyl Ester (C22:6n3) at 2 wt %
25. Heneicosanoic Acid Methyl Ester (C21:0) at 2 wt %
PUFA I (Marine Source) FAMEs on the Omegawax 100

column: Omegawax 100, 15 m x 0.10 mm I.D., 0.10 μm (23399-U)
oven: 140 °C, 40 °C/min. to 280 °C (2 min.)
inj.: 250 °C
det.: FID, 280 °C
carrier gas: hydrogen, 50 cm/sec constant
injection: 0.2 μL, 200:1 split
liner: 4 mm I.D., split, cup design
sample: PUFA No. I - Marine Source (47033), diluted to 50 mg/mL in methylene chloride

PUFA II (Animal Source) FAMEs on the Omegawax 100

column: Omegawax 100, 15 m x 0.10 mm I.D., 0.10 μm (23399-U)
oven: 140 °C, 40 °C/min. to 280 °C (2 min.)
inj.: 250 °C
det.: FID, 280 °C
carrier gas: hydrogen, 50 cm/sec constant
injection: 0.2 μL, 200:1 split
liner: 4 mm I.D., split, cup design
sample: PUFA No. II – Animal Source (47015-U), diluted to 50 mg/mL in methylene chloride
PUFA III (Menhaden Oil) FAMEs on the Omegawax 100

column: Omegawax 100, 15 m x 0.10 mm I.D., 0.10 μm (23399-U)
oven: 140 °C, 40 °C/min. to 280 °C (2 min.)
inj.: 280 °C
det.: FID, 280 °C
carrier gas: hydrogen, 50 cm/sec constant
injection: 0.2 μL, 200:1 split
liner: 4 mm I.D., split, cup design
sample: PUFA No. III – Menhaden Oil (47085-U), diluted to 50 mg/mL in methylene chloride

1. C14:0
2. C15:0 anteiso
3. C15:0 iso
4. C15:0
5. C16:0 iso
6. C16:0
7. C16:1
8. C16:1
9. C16:1
10. C16:3
11. C16:4
12. C18:0
13. C18:1
14. C18:1
15. C18:2
16. C18:2
17. C18:3
18. C18:3
19. C18:4
20. C18:4
21. C20:0
22. C20:1
23. C20:1
24. C20:2
25. C20:3
26. C20:4
27. C20:4
28. C20:5
29. C20:5
30. C22:1
31. C21:5
32. C22:5
33. C22:5

Fast GC Applications

Cod Liver Oil FAMEs on the SUPELCOWAX 10

Chromatogram courtesy of Prof. Luigi Mondello (Univ. of Messina, Italy)
column: SUPELCOWAX 10, 10 m x 0.10 mm I.D., 0.10 μm (25026-U)
oven: 180 °C, 40 °C/min. to 270 °C (0.5 min.)
inj.: 280 °C
det.: FID, 280 °C
carrier gas: hydrogen, 100 cm/sec constant
injection: 0.2 μL, 200:1 split
sample: cod liver oil FAMEs in hexane

1. C14:0
2. C15:0 anteiso
3. C15:0 iso
4. C15:0
5. C16:0 iso
6. C16:0
7. C16:1
8. C16:1
9. C16:1
10. C16:3
11. C16:4
12. C18:0
13. C18:1
14. C18:1
15. C18:2
16. C18:2
17. C18:3
18. C18:3
19. C18:4
20. C18:4
21. C20:0
22. C20:1
23. C20:1
24. C20:2
25. C20:3
26. C20:4
27. C20:4
28. C20:5
29. C20:5
30. C22:1
31. C21:5
32. C22:5
33. C22:5
Bacterial Acid Methyl Esters (BAMEs) on the Equity-1

column: Equity-1, 15 m x 0.10 mm I.D., 0.10 μm (28039-U)
oven: 180 °C, 30 °C/min. to 275 °C (1 min.)
inj.: 220 °C
det.: FID, 280 °C
carrier gas: hydrogen, 45 cm/sec constant
injection: 0.5 μL, split 200:1
liner: 4 mm I.D., split, cup design
sample: Bacterial Acid Methyl Ester (BAME) Mix (47080-U)

1. Methyl undecanoate (C11:0)
2. Methyl 2-hydroxydecanoate (2-OH C10:0)
3. Methyl dodecanoate (C12:0)
4. Methyl tridecanoate (C13:0)
5. Methyl 2-hydroxydodecanoate (2-OH C12:0)
6. Methyl 3-hydroxydodecanoate (3-OH C12:0)
7. Methyl tetradecanoate (C14:0)
8. Methyl 13-methyltetradecanoate (C15:0)
9. Methyl 12-methyltetradecanoate (a-C15:0)
10. Methyl pentadecanoate (C15:0)
11. Methyl 2-hydroxytetradecanoate (2-OH C14:0)
12. Methyl 3-hydroxytetradecanoate (3-OH C14:0)
13. Methyl 14-methylpentadecanoate (C16:0)
14. Methyl cis-9-hexadecenoate (C16:19)
15. Methyl heptadecanoate (C17:0)
16. Methyl 15-methylhexadecanoate (C17:0)
17. Methyl cis-9,10-methylenehexadecanoate (C17:0D)
18. Methyl heptadecanoate (C17:0)
19. Methyl 2-hydroxyhexadecanoate (2-OH C16:0)
20. Methyl cis-9,12-octadecenoate (C18:9,12)
21. Methyl cis-9-octadecenoate (c18:9cis)
22. Methyl trans-9-octadecenoate & Methyl cis-11-octadecenoate (C18:19trans, C18:1)
23. Methyl octadecanoate (C18:0)
24. Methyl cis-9,10-methyleneoctadecanoate (C19:0D)
25. Methyl nonadecanoate (C19:0)
26. Methyl eicosanoate (C20:0)

C18:1, C18:2, and C18:3 cis/trans Isomers on the SP-2560

column: SP-2560, 75 m x 0.18 mm I.D., 0.14 μm (23348-U)
oven: 180 °C, isothermal
inj.: 220 °C
det.: FID, 220 °C
carrier gas: hydrogen, 25 cm/sec. @ 180 °C
injection: 0.5 μL, 100:1 split
liner: 4 mm I.D., split, cup design
sample: mixture of C18:1, C18:2, and C18:3 FAMEs in methylene chloride

1. C18:1 Δ 7t and C18:1 Δ 8
2. C18:1 Δ 9t
3. C18:1 Δ 11t
4. C18:1 Δ 12t, 18:1 Δ 6c, C18:1 Δ 7c and C18:1 Δ 13t
5. C18:1 Δ 9c
6. C18:1 Δ 11c
7. C18:1 Δ 12c
8. C18:1 Δ 13c
9. C18:2 Δ 9t, 12t
10. C18:2 Δ 9c, 12t
11. C18:2 Δ 9t, 12c
12. C18:2 Δ 9c, 12c
13. C18:3 Δ 9t, 12t, 15t
14. C18:3 Δ 9c, 12t, 15c
15. C18:3 Δ 9t, 12c, 15t
16. C18:3 Δ 9c, 12t, 15c
17. C18:3 Δ 9c, 12c, 15t
18. C18:3 Δ 9c, 12t, 15c
19. C18:3 Δ 9c, 12c, 15c
**Foods, Flavors, and Fragrances**

**Lemon Essential Oil on the SLB-5ms**
Chromatogram courtesy of Prof. Luigi Mondello (Univ. of Messina, Italy)

- **Column:** SLB-5ms, 10 m x 0.10 mm I.D., 0.10 μm (28465-U)
- **Oven:** 40 °C, 50 °C/min. to 320 °C
- **Injection:** 0.4 μL, 300:1 split
- **Sample:** Lemon essential oil in hexane

**Distilled Lime Oil on the Equity-1**

- **Column:** Equity-1, 15 m x 0.10 mm I.D., 0.10 μm (28039-U)
- **Oven:** 75 °C (1 min.), 35 °C/min. to 200 °C (1 min.)
- **Injection:** 0.10 μL, 300:1 split
- **Sample:** Distilled lime oil, neat

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**Chemical List**

**Lemon Essential Oil on the SLB-5ms**
1. Tricyclene
2. α-Thujene
3. α-Pinene
4. Camphene
5. Sabinene
6. β-Pinene
7. Myrcene
8. Octanal
9. α-Phellandrene
10. δ-3-Carene
11. α-Terpine
12. π-Cymene
13. Limonene
14. (E)-β-Ocimene
15. γ-Terpinene
16. cis-Sabinene hydrate
17. Octanal
18. Terpinolene
19. Linalool
20. Nonanal
21. cis-Limonene oxide
22. trans-Limonene oxide
23. (E)-Myroside
24. Camphor
25. Citronellal
26. Borneol
27. Terpinen-4-ol
28. α-Terpineol
29. Decanal
30. Citronellol
31. Nerol
32. Neral
33. Carvone
34. Geraniol
35. Geranial
36. Perilla aldehyde
37. Undecanal
38. Methyl geranate
39. Citronellyl acetate
40. Neryl acetate
41. Linalyl isobutanoate
42. Geranyl acetate
43. 1-Tetradecene
44. Tetradecane
45. (E)-Caryophyllene
46. trans-α-Bergamotene
47. β-Bisabolene
48. (Z)-γ-Bisabolene
49. (E)-γ-Bisabolene
50. Nonbornanol
51. Camphenolen
52. α-Bisabolol

**Distilled Lime Oil on the Equity-1**
1. α-Pinene
2. Camphene
3. β-Pinene
4. Myrcene
5. α-Phellandrene
6. 1,4-Cineole
7. α-Terpinene
8. π-Cymene
9. δ-Limonene
10. γ-Terpinene
11. Terpinolene
12. Linalool
13. α-Fenchyl alcohol
14. Terpinen-1-ol
15. β-Terpineol
16. Borneol
17. Terpinen-4-ol
18. α-Terpineol
19. γ-Terpineol
20. Decanal
21. Neral
22. Geranial
23. Neral acetate
24. Geranyl acetate
25. Dodecanol
26. β-Caryophyllene
27. trans-α-Bergamotene
28. trans-α-Farnesene
29. β-Bisabolene
Sweet Orange Essential Oil on the SLB-5ms

Chromatogram courtesy of Prof. Luigi Mondello (Univ. of Messina, Italy)

column: SLB-5ms, 10 m x 0.10 mm I.D., 0.10 µm (28465-U)
oven: 40 °C, 50 °C/min. to 320 °C
inj.: 320 °C
det: FID, 320 °C
carrier gas: hydrogen, 81.5 cm/sec constant
injection: 0.4 µL, 300:1 split
sample: sweet orange essential oil in hexane

1. α-Thujene
2. α-Pinene
3. Camphene
4. Sabinene
5. β-Pinene
6. Myrcene
7. Octanal
8. α-Phellandrene
9. δ-3-Carene
10. α-Terpine
11. π-Cymene
12. Limonene
13. (E)-β-Ocimene
14. γ-Terpine
15. Octanol
16. Terpinolene
17. Linalool
18. Nonanal
19. cis-Limonene oxide
20. trans-Limonene oxide
21. Citronellal
22. Terpinen-4-ol

Allergens in Commercial Perfume on the SLB-5ms

Chromatogram courtesy of Prof. Luigi Mondello (Univ. of Messina, Italy)

column: SLB-5ms, 10 m x 0.10 mm I.D., 0.10 µm (28465-U)
oven: 40 °C, 50 °C/min. to 320 °C
inj.: 320 °C
det: FID, 320 °C
carrier gas: hydrogen, 81.5 cm/sec constant
injection: 0.2 µL, 500:1 split
sample: neat perfume

1. Limonene
2. Linalool
3. Citronellol
4. Neral
5. Geranial
6. Hydroxycitronellal
7. Cinnamyl alcohol
8. Eugenol
9. Coumarin
10. α-Isomethylionone
11. Hexyl cinnamaldehyde
Hydrocarbons

Underground Storage Tank (UST) Gasoline Range Organics (GRO) on the Equity-1

column: Equity-1, 15 m x 0.10 mm I.D., 0.10 μm (28039-U)
oven: 75 °C, 40 °C/min. to 110 °C, 7.5 °C/min. to 190 °C
inj.: 200 °C
det.: FID, 250 °C
carrier gas: hydrogen, 57 cm/sec @ 75 °C
injection: 0.5 μL, 200:1 split
liner: 4 mm I.D., split, cup design
sample: UST Modified GRO Mix, each analyte at 1000 ppm in methanol (48167)

C6-C13 Alkanes, BTEX, and Cumene on the TCEP

column: TCEP, 15 m x 0.10 mm I.D., 0.18 μm (28348-U)
oven: 100 °C
inj.: 170 °C
det.: FID, 170 °C
carrier gas: hydrogen, 40 cm/sec
injection: 0.04 μL, 200:1 split
liner: 4 mm I.D., split, cup design
sample: neat mix, equal volumes of each analyte
Unleaded Gasoline on the TCEP

column: TCEP, 15 m x 0.10 mm I.D., 0.18 μm (28348-U)
oven: 100 °C
inj.: 220 °C
det.: FID, 220 °C
carrier gas: hydrogen, 43 cm/sec constant
injection: 0.1 μL, 300:1 split
liner: 2 mm I.D., straight
sample: unleaded gasoline (refinery standard), neat

1. Benzene
2. Toluene
3. Tridecane
4. Ethyl benzene
5. m-Xylene
6. p-Xylene
7. Cumene
8. Propyl benzene
9. o-Xylene
10. Ethyl toluene isomer
11. Mesitylene
12. Ethyl toluene isomer
13. Propyl toluene isomer
14. 1,2,4-Trimethyl benzene
15. Ethyl xylene isomer
16. Propyl toluene isomer
17. Ethyl xylene isomer
18. Ethyl xylene isomer
19. 1,2,3-Trimethyl benzene
20. Ethyl xylene isomer
21. Indian
22. Tetramethyl benzene isomers
23. Methylindan isomer
24. Pentamethyl benzene
25. Ethyl xylene isomer
26. Methylindan isomer

Unleaded Gasoline on the Equity-1

column: Equity-1, 15 m x 0.10 mm I.D., 0.10 μm (28039-U)
oven: 40 °C (1 min.), 45 °C/min. to 150 °C (2 min.)
inj.: 175 °C
det.: FID, 175 °C
carrier gas: hydrogen, 45 cm/sec constant
injection: 0.1 μL, 300:1 split
liner: 2 mm I.D., straight
sample: unleaded gasoline (refinery standard), neat

1. Isobutane
2. Butane
3. Isopentane
4. Pentane
5. 2,2-Dimethylbutane
6. 2,3-Dimethylbutane
7. 2-Methylpentane
8. 3-Methylpentane
9. Hexane
10. 2,4-Dimethylpentane
11. Benzene
12. 2-Methylhexane
13. 2,3-Dimethylpentane
14. 3-Methylhexane
15. Isoctane
16. Heptane
17. 2,5-Dimethylhexane
18. 2,4-Dimethylhexane
19. 2,3,4-Trimethylpentane
20. Toluene
21. 2,3-Dimethylhexane
22. 2-Methylheptane
23. 3-Methylhexane
24. Ethylbenzene
25. 2-Methylhexane
26. 2-Methylpentane
27. o-Xylene
28. Nonane
29. iso-Propylbenzene
30. 1-Methyl-3-ethylbenzene
31. 1-Methyl-4-ethylbenzene
32. 1,3,5-Trimethylbenzene
33. 3,3,4-Trimethylpentane
34. 1-Methyl-2-ethylbenzene
35. 1,2,4-Trimethylbenzene
36. iso-Butylbenzene
37. sec-Butylbenzene
38. 1,2,3-Trimethylbenzene
39. Indane
40. 1,3-Diethylbenzene
41. N-Butylbenzene
42. 1,4-Dimethyl-2-ethylbenzene
43. 1,3-Dimethyl-4-ethylbenzene
44. 1,2-Dimethyl-4-ethylbenzene
45. 1,2,4,5-Tetramethylbenzene
46. 1,2,3,5-Tetramethylbenzene
47. Naphthalene
48. 2-Methylnaphthalene
49. 1-Methylnaphthalene
50. 1-Methyl-3-ethylbenzene
51. Dimethylnaphthalenes
Fuel Oil #2 on the Equity-1

- **Column:** Equity-1, 15 m x 0.10 mm I.D., 0.10 μm (28039-U)
- **Oven:** 80 °C, 50 °C/min. to 325 °C
- **Inj.:** 250 °C
- **Det.:** FID, 350 °C
- **Carrier gas:** hydrogen, 45 cm/sec constant
- **Injection:** 0.3 μL, 100:1 split, 0.02 min. pre-injection dwell time
- **Liner:** 2 mm I.D., straight
- **Sample:** No.2 fuel oil standard, 20 mg/mL in methanol (47515-U)

1. Fuel Oil #2 pattern

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**Pesticides/PCBs**

17-Component Pesticide Mix on the SLB-5ms

- **Column:** SLB-5ms, 10 m x 0.10 mm I.D., 0.10 μm (28465-U)
- **Oven:** 40 °C (1 min.), 80 °C/min. to 160 °C, 5 °C/min. to 340 °C (2 min.)
- **Inj.:** 280 °C
- **MSD Interface:** 280 °C
- **Scan range:** 45-470 m/z
- **Carrier gas:** helium, 0.52 mL/min.
- **Injection:** 0.5 μL, 10:1 split
- **Sample:** 17-component pesticide mix, each analyte at 0.8-2.0 μg/mL in hexane:acetone (50:50)

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**Graphs and Diagrams:**

- Fuel Oil #2 pattern
- 17-Component Pesticide Mix on the SLB-5ms
US EPA Method 8081 Organochlorine Pesticides on the SLB-5ms

column: SLB-5ms, 15 m x 0.10 mm I.D., 0.10 μm (28466-U)
oven: 100 °C, 25 °C/min. to 325 °C
det.: ECD, 300 °C
carrier gas: hydrogen, 40 cm/sec constant
injection: 2 μL, splitless (0.75 min.)
liner: 4 mm I.D., single taper
sample: 50 ppb of a 22-component chlorinated pesticide standard in n-hexane

1. Tetrachloro-m-xylene (surr.)
2. α-BHC
3. β-BHC
4. γ-BHC
5. δ-BHC
6. Heptachlor
7. Aldrin
8. Heptachlor epoxide
9. γ-Chlordane
10. Endosulfan I
11. α-Chlordane
12. 4,4’-DDE
13. Dieldrin
14. Endrin
15. 4,4’-DDD
16. Endosulfan II
17. Endrin aldehyde
18. 4,4’-DDT
19. Endosulfan sulfate
20. Methoxychlor
21. Endrin ketone
22. Decachlorobiphenyl (surr.)

US EPA Method 8081 Organochlorine Pesticides on the Equity-1701

column: Equity-1701, 15 m x 0.10 mm I.D., 0.10 μm (28343-U)
oven: 100 °C, 25 °C/min. to 280 °C
det.: ECD, 300 °C
carrier gas: hydrogen, 40 cm/sec constant
injection: 2 μL, splitless (0.75 min.)
liner: 4 mm I.D., single taper
sample: 50 ppb of a 22-component chlorinated pesticide standard in n-hexane

1. Tetrachloro-m-xylene (surr.)
2. α-BHC
3. β-BHC
4. γ-BHC
5. δ-BHC
6. Heptachlor
7. Aldrin
8. Heptachlor epoxide
9. γ-Chlordane
10. Endosulfan I
11. α-Chlordane
12. 4,4’-DDE
13. Dieldrin
14. Endrin
15. 4,4’-DDD
16. Endosulfan II
17. Endrin aldehyde
18. 4,4’-DDT
19. Endosulfan sulfate
20. Methoxychlor
21. Endrin ketone
22. Decachlorobiphenyl (surr.)
US EPA Method 8082 PCBs as Aroclors on the SLB-5ms

- Column: SLB-5ms, 15 m x 0.10 mm I.D., 0.10 μm (28466-U)
- Oven: 80 °C (0.5 min.), 50 °C/min. to 200 °C, 35 °C/min. to 360 °C (2 min.)
- Inj.: 225 °C
- Det.: ECD, 380 °C
- Carrier gas: hydrogen, 40 cm/sec constant
- Injection: 2 μL, splitless (0.75 min.)
- Liner: 4 mm I.D., single taper
- Sample: Aroclor standard mix 1 (46846-U) diluted to 500 ppb / 50 ppb (Aroclors / surrogates) in n-hexane

1. Tetrachloro-m-xylene (surr.)
2. Aroclor 1016
3. Aroclor 1260
4. Decachlorobiphenyl (surr.)

US EPA Method 8082 PCBs as Aroclors on the Equity-1701

- Column: Equity-1701, 15 m x 0.10 mm I.D., 0.10 μm (28343-U)
- Oven: 90 °C, 35 °C/min. to 280 °C (3 min.)
- Inj.: 250 °C
- Det.: ECD, 280 °C
- Carrier gas: hydrogen, 50 cm/sec constant
- Injection: 2 μL, splitless (0.75 min.)
- Liner: 4 mm I.D., single taper
- Sample: Aroclor standard mix 1 (46846-U) diluted to 200 ppb / 20 ppb (Aroclors / surrogates) in n-hexane

1. Tetrachloro-m-xylene (surr.)
2. Aroclor 1016
3. Aroclor 1260
4. Decachlorobiphenyl (surr.)
US EPA Method 8270 Semivolatiles on the SLB-5ms (0.18 μm)

column: SLB-5ms, 20 m x 0.18 mm I.D., 0.18 μm (28564-U)
oven: 40 °C (0.7 min.), 55 °C/min. to 240 °C, 28 °C/min. to 330 °C (2 min.)
inj.: 250 °C
MSD interface: 330 °C
carrier gas: helium, 40 cm/sec, constant
injection: 0.5 μL, 10:1 split
liner: 2 mm I.D., fast FocusLiner inlet liner with taper (2879501-U)
sample: 80-component semivolatile standard at 50 ppm plus
6 internal standards (at 50 ppm) in methylene chloride

1. N-nitrosodimethylamine
2. Pyridine
3. 2-Fluorophenol (surr.)
4. Phenol-d₆ (surr.)
5. Phenol
6. Aniline
7. Bis(2-chloroethyl)ether
8. 2-Chlorophenol-d₆ (surr.)
9. 2-Chlorophenol
10. 1,3-Dichlorobenzene
11. 1,4-Dichlorobenzene-d₆ (I.S.)
12. 1,4-Dichlorobenzene
13. Benzyl alcohol
14. 1,2-Dichlorobenzene-d₆ (surr.)
15. 1,2-Dichlorobenzene
16. 2-Methylphenol
17. Bis(2-chloroisopropyl)ether
18. N-nitrosodi-n-propylamine
19. 4-Methylphenol
20. Hexachloroethane
21. Nitrobenzene-d₆ (surr.)
22. Nitrobenzene
23. Isophorone
24. 2-Nitrophenol
25. 2,4-Dimethylphenol
26. Bis(2-chloroethoxy)methane
27. Benzoic acid
28. 2,4-Dichlorophenol
29. 1,2,4-Trichlorobenzene
30. Naphthalene-d₆ (I.S.)
31. Naphthalene
32. 4-Chloroaniline
33. Hexachlorobutadiene
34. 4-Chloro-3-methylphenol
35. 2-Methylphenanthrene
36. Hexachlorocyclopentadiene
37. 2,4,6-Trichlorophenol
38. 2,4,5-Trichlorophenol
39. 2-Fluorobiphenyl (surr.)
40. 2-Chloronaphthalene
41. 2-Nitroaniline
42. Dimethyl phthalate
43. 2,6-Dinitrophenol
44. Acenaphthylene
45. 3-Nitroaniline
46. Acenaphthene-d₅ (I.S.)
47. Acenaphthene
48. 2,4-Dinitrophenol
49. 4-Nitrophenol
50. Dibenzo[a,b]furans
51. 2,4-Dinitrotoluene
52. Diethyl phthalate
53. 4-Chlorophenyl phenyl ether
54. Fluorene
55. 4-Nitroaniline
56. 2-Methyl-4,6-dinitrophenol
57. N-Nitrosodiphenylamine
58. Azobenzene
59. 2,4,6-Tribromophenol (surr.)
60. 4-Bromophenyl phenyl ether
61. Hexachlorobenzene
62. Pentachlorophenol
63. Phenanthrene-d₅ (I.S.)
64. Phenanthrene
65. Anthracene
66. Carbazole
67. Di-n-butyl phthalate
68. Fluoranthene
69. Benzidine
70. Pyrene
71. 1,2-Diphenylethane (surr.)
72. 3,3’-Dimethylbenzidine
73. Bathybenzyl phthalate
74. 3,3’-Dichlorobenzidine
75. Benzo(a)anthracene
76. Bis(2-ethylhexy)phthalate
77. Chrysene-d₁₀ (I.S.)
78. Chrysene
79. 1,2-Diphenylethane
80. Benzo(b)fluoranthene
81. Benzo(k)fluoranthene
82. Benzo(a)pyrene
83. Perylene-d₁₀ (I.S.)
84. Indeno(1,2,3-cd)pyrene
85. Dibenzo(a,h)anthracene
86. Benzo(g,h,i)perylene
US EPA Method 8270 Semivolatiles on the SLB-5ms (0.36 μm)

- Column: SLB-5ms, 20 m x 0.18 mm I.D., 0.36 μm (28576-U)
- Oven: 50 °C (0.50 min.), 28 °C/min. to 250 °C, 35 °C/min. to 340 °C (5 min.)
- Injection: 250 °C
- MSD interface: 340 °C
- Carrier gas: helium, 1.4 mL/min.
- Injection: 0.50 μL, reduced pressure to 20 psi at injection (0.1 min.)
- Liner: 2 mm I.D., straight
- Sample: 80-component semivolatile standard at 50 ppm, plus 6 internal standards at 40 ppm in methylene chloride

**Compounds:**
1. N-Nitrosodimethylamine
2. Pyridine
3. 2-Fluorophenol (surr.)
4. Phenol-d₆ (surr.)
5. Phenol
6. Aniline
7. Bis(2-chloroethyl)ether
8. 2-Chlorophenol-d₆ (surr.)
9. 2-Chlorophenol
10. 1,3-Dichlorobenzene
11. 1,4-Dichlorobenzene-d₆ (I.S.)
12. 1,4-Dichlorobenzene
13. Benzyl alcohol
14. 1,2-Dichlorobenzene-d₆ (surr.)
15. 1,2-Dichlorobenzene
16. 2-Methylphenol
17. Bis(2-chloroisopropyl)ether
18. 4-Methylphenol
19. Hexachloroethylene
20. Hexachlorobenzene
21. Nitrobenzene-d₅ (surr.)
22. Nitrobenzene
23. Isophorone
24. 2-Nitrophenol
25. 2,4-Dimethylphenol
26. Bis(2-chloroethoxymethane)
27. Benzoic acid
28. 2,4-Dichlorophenol
29. 2-Chlorophenol-d₄ (surr.)
30. 2-Chlorophenol
31. Naphthalene-d₈ (I.S.)
32. 1,2-Dichlorobenzene
33. Benzyl alcohol
34. 1,2-Dichlorobenzene-d₄ (surr.)
35. 1,2-Dichlorobenzene
36. 2-Methylphenol
37. Bis(2-chloroethyl)ether
38. 4-Methylphenol
39. 4-Chloroaniline
40. 2,4-Dinitrotoluene
41. 2-Chlorophenol-d₄ (surr.)
42. 2-Chlorophenol
43. 1,3-Dichlorobenzene
44. 1,4-Dichlorobenzene-d₄ (I.S.)
45. 1,2-Dichlorobenzene
46. 2-Methylphenol
47. 2-Chlorophenol-d₄ (surr.)
48. 2-Chlorophenol
49. 1,3-Dichlorobenzene
50. 2,4-Dinitrotoluene
51. Dibenzo(a)anthracene
52. Diethylene glycol
53. 4-Chloroaniline
54. 2,4-Dinitrotoluene
55. 4-Nitrophenol
56. 2,4-Dinitrotoluene
57. N-Nitrosodiphenylamine
58. Azobenzene
59. 2,4-Dinitrotoluene
60. 4-Bromophenol
61. Hexachlorobenzene
62. Pentachlorophenol
63. Hexachloroacetone
64. Phenanthrene
65. Anthracene
66. Carbazole
67. Di-n-butyl phthalate
68. Fluoranthene
69. Benzidine
70. Pyrene
71. Terphenyl-d₆ (surr.)
72. Butylbenzyl phthalate
73. 3,3’-Dimethylbenzidine
74. Bis(2-ethylhexyl)phthalate
75. 3,3’-Dichlorobenzidine
76. Benzo(a)anthracene
77. Chrysene-d₁₀ (I.S.)
78. Chrysene
79. Di-n-octyl phthalate
80. Benzo(b)fluoranthene
81. Benzo(k)fluoranthene
82. Benzo(a)pyrene
83. Perylene-d₁₂ (I.S.)
84. Indeno(1,2,3-cd)pyrene
85. Perylene-d₁₂ (I.S.)
86. Benzo(a)anthracene
87. Benzo(g,h,i)perylene
88. Benzo(b)fluoranthene
89. Benzo(k)fluoranthene
90. Benzo(a)pyrene
91. Perylene-d₁₂ (I.S.)
92. Indeno(1,2,3-cd)pyrene
93. Perylene-d₁₂ (I.S.)
94. Indeno(1,2,3-cd)pyrene
95. Perylene-d₁₂ (I.S.)
96. Indeno(1,2,3-cd)pyrene
97. Perylene-d₁₂ (I.S.)
98. Indeno(1,2,3-cd)pyrene
99. Perylene-d₁₂ (I.S.)
100. Indeno(1,2,3-cd)pyrene
101. Perylene-d₁₂ (I.S.)
102. Indeno(1,2,3-cd)pyrene
103. Perylene-d₁₂ (I.S.)
104. Indeno(1,2,3-cd)pyrene
105. Perylene-d₁₂ (I.S.)
106. Indeno(1,2,3-cd)pyrene
107. Perylene-d₁₂ (I.S.)
108. Indeno(1,2,3-cd)pyrene
109. Perylene-d₁₂ (I.S.)
110. Indeno(1,2,3-cd)pyrene
111. Perylene-d₁₂ (I.S.)
112. Indeno(1,2,3-cd)pyrene
113. Perylene-d₁₂ (I.S.)
114. Indeno(1,2,3-cd)pyrene
115. Perylene-d₁₂ (I.S.)
116. Indeno(1,2,3-cd)pyrene
117. Perylene-d₁₂ (I.S.)
118. Indeno(1,2,3-cd)pyrene
119. Perylene-d₁₂ (I.S.)
120. Indeno(1,2,3-cd)pyrene
US EPA Method 624 Volatiles on the SPB-624

sample/matrix: each analyte at 50 ppb in 5 mL water
purge trap: VOCARB® 3000 “K” (24940-U)
purge: 40 mL/min. at 25 °C for 11 min.
dry purge: 2 min.

desorption temp.: 210 °C for 2 min.
desorption flow: 150 mL/min.
bake.: 260 °C for 10 min.
transfer line/valve temp.: 110 °C
column: SPB-624, 20 m x 0.18 mm I.D., 1.0 μm (28662-U)
oven: 40 °C (1 min.), 11 °C/min. to 125 °C, 35 °C/min. to 230 °C (2 min.)
inj.: 150 °C
MSD interface: 200 °C
scan range: m/z = 35-400
carrier gas: helium, 1.5 mL/min.
injection: 100:1 split
liner: 0.75 mm I.D. SPME

1. Chloromethane
2. Vinyl Chloride
3. Bromomethane
4. Chloroethane
5. Trichlorofluoromethane
6. 1,1-Dichloroethene
7. Methylene chloride
8. trans-1,2-Dichloroethene
9. 1,1-Dichloroethane
10. Chloroform
11. Dibromofluoromethane (surr.)
12. 1,1,1-Trichloroethane
13. Carbon tetrachloride
14. 1,2-Dichloroethane-d4 (surr.)
15. Benzene
16. 1,2-Dichloroethene
17. Fluorobenzene (I.S.)
18. Trichloroethene
19. 1,2-Dichloropropane
20. Bromodichloromethane
21. 2-Chloroethyl vinyl ether
22. cis-1,3-Dichloropropene
23. Toluene-d8 (surr.)
24. Toluene
25. trans-1,3-Dichloropropene
26. 1,1,2-Trichloroethane
27. Tetrachloroethene
28. Dibromochloromethane
29. Chlorobenzene-d5 (I.S.)
30. Chlorobenzene
31. Ethylbenzene
32. Bromoform
33. 4-Bromofluorobenzene (surr.)
34. 1,1,2,2-Tetrachloroethane
35. 1,3-Dichlorobenzene
36. 1,4-Dichlorobenzene-d4 (I.S.)
37. 1,4-Dichlorobenzene
38. 1,2-Dichlorobenzene
US EPA Method 8260 Volatiles on the VOCOL

- Sample/matrix: each analyte at 50 ppb in 5 mL water
- Purge trap: VOCARB 3000 K (24940-U)
- Purge: 40 mL/min. at 25 °C for 11 min.
- Dry purge: 1 min.
- Desorption temp.: 210 °C for 1 min.
- Desorption flow: 150 mL/min.
- Bake: 260 °C for 10 min.
- Transfer line/valve temp.: 110 °C
- Column: VOCOL, 20 m x 0.18 mm I.D., 1.0 μm (28463-U)
- Oven: 40 °C (0.8 min.), 19 °C/min. to 125 °C, 32 °C/min. to 220 °C (1 min.)
- Injection: 150 °C
- MSD interface: 220 °C
- Carrier gas: helium, 1.5 mL/min.
- Liner: 0.75 mm I.D. SPME

1. Dichlorofluoromethane
2. Chloromethane
3. Vinyl chloride
4. Bromomethane
5. Chloroethane
6. Trichlorofluoromethane
7. Acetone
8. 1,1-Dichloroethene
9. Iodomethane
10. Methylene chloride
11. trans-1,2-Dichloroethene
12. 1,1-Dichloroethane
13. 2-Butanone
14. 2,2-Dichloropropane
15. cis-1,2-Dichloroethene
16. Chloroform
17. Bromochloromethane
18. Dibromofluoromethane (surr.)
19. 1,1,1-Trichloroethane
20. 1,1-Dichloropropene
21. Carbon tetrachloride
22. 1,2-Dichloroethane-d4 (surr.)
23. 1,2-Dichloroethene
24. Benzene
25. Fluorobenzene (I.S.)
26. Trichloroethene
27. 1,2-Dichloropropane
28. Bromodichloromethane
29. Dibromomethane
30. 4-Methyl-2-pentanone
31. cis,1,3-Dichloropropene
32. Toluene-d8 (surr.)
33. Toluene
34. trans-1,3-Dichloropropene
35. 1,2-Dichloroethane
36. 1,1-Dichloroethene
37. 2-Hexanone
38. 1,3-Dichloropropene
39. tetrachloroethene
40. Dibromochloromethane
41. 1,2-Dibromomethane
42. Chlorobenzene
43. Ethylbenzene
44. 1,1,1,2-Tetrachloroethane
45. m&p-Xylenes
46. cis-Xylenes
47. Styrene
48. Isopropylbenzene
49. Bromoform
50. cis,1,4-Dichloro-2-butene
51. 1,1,2,2-Tetrachloroethane
52. 4-Bromofluorobenzene (surr.)
53. 1,2,3-Trichloropropane
54. n-Propylbenzene
55. trans-1,4-Dichloro-2-butene
56. Bromobenzene
57. 1,3,5-Trimethylbenzene
58. o-Chlorotoluene
59. p-Chlorotoluene
60. tert-Butylbenzene
61. 1,2,4-Trimethylbenzene
62. Pentachloroethane
63. sec-Butylbenzene
64. p-Isopropyltoluene
65. 1,3-Tichlorobenzene
66. 1,4-Tichlorobenzene-d4 (I.S.)
67. 1,4-Tichlorobenzene
68. Butylbenzene
69. 1,2-Tichlorobenzene
70. 1,2-Tibromo-3-chloropropane
71. 1,2,4-Trichlorobenzene
72. Hexachlorobutadiene
73. Naphthalene
74. 1,2,3-Trichlorobenzene
75. 1,2-Dichlorobenzene-d5 (I.S.)
Maximize Performance!

GC Accessories and Gas Purification/Management Items

For the practicing gas chromatographer, choosing the correct items when upgrading and replacing parts and accessories for their system can bring on many challenges due to the vast array of commercially available products. At Supelco, we offer our own unique products, as well as products from some of the most trusted names in the industry, to assist in making the selection process easier. Please note that this represents a brief listing of the GC Accessories and Gas Purification/Management products that we offer. For a complete listing, please refer to our catalog and/or web site, sigma-aldrich.com/supelco

Molded Thermogreen™ LB-2 Septa

Molded Thermogreen LB-2 septa are manufactured from high quality, low bleed material using the same exclusive rubber formulation as the popular Thermogreen LB-2 septa. Molded septa offer easier installation and also provide a better seal inside the injection port because every septum conforms to the same mold shape with crisp, clean sides. A version with an injection hole is available, allowing needle penetration through the same location, time after time, reducing septum coring and preventing septum fragments from entering the injection port.

- Ultra low bleed over a wide range of inlet temperatures (100 °C to 350 °C)
- Easier needle penetration and high puncture tolerance
- Already conditioned, ready to use

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<thead>
<tr>
<th>Description</th>
<th>Pkg</th>
<th>Cat. No.</th>
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<tbody>
<tr>
<td>9.5 mm, with injection hole</td>
<td>50 ea</td>
<td>28670-U</td>
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<tr>
<td>9.5 mm</td>
<td>50 ea</td>
<td>28331-U</td>
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<td>10 mm, with injection hole</td>
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<td>28673-U</td>
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<td>10 mm</td>
<td>50 ea</td>
<td>28333-U</td>
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<tr>
<td>11 mm, with injection hole</td>
<td>50 ea</td>
<td>28676-U</td>
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<tr>
<td>11 mm</td>
<td>50 ea</td>
<td>28336-U</td>
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<tr>
<td>Plug (for Shimadzu®)</td>
<td>50 ea</td>
<td>20633</td>
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FocusLiner™ Inlet Liners

The use of a wool plug in inlet liners has been used for many years to promote the rapid vaporization of the entire sample, minimize mass discrimination, and prevent non-volatile material from entering the column. FocusLiner inlet liners incorporate a unique design that prevents shifting of the wool plug during repeated injections or sudden inlet pressure changes.

- Typically reduce injection variability by at least 96%
- Provide maximum sensitivity and improved detection levels

<table>
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<tr>
<th>Description</th>
<th>Pkg</th>
<th>Cat. No.</th>
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<tbody>
<tr>
<td>For Agilent® 5890/6890/7890 (78.5 mm x 6.3 mm O.D.)</td>
<td>5 ea</td>
<td>2879605-U</td>
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<tr>
<td>Split/splitless, 2.3 mm I.D., wool packed</td>
<td>5 ea</td>
<td>2879605-U</td>
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<tr>
<td>Split/splitless with single taper, 2.3 mm I.D., wool packed</td>
<td>5 ea</td>
<td>2879505-U</td>
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<tr>
<td>For Finnigan Same catalog numbers as Agilent</td>
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<tr>
<td>For PerkinElmer® AutoSystem™ and Clarus® (92 mm x 6.3 mm O.D.)</td>
<td>5 ea</td>
<td>2879205-U</td>
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<tr>
<td>Split/splitless, 4 mm I.D., wool packed</td>
<td>5 ea</td>
<td>2879105-U</td>
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<tr>
<td>Split/splitless with single taper, 4 mm I.D., wool packed</td>
<td>5 ea</td>
<td>2878605-U</td>
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<tr>
<td>For Shimadzu® 17A with SPL-17 Injector (95 mm x 5 mm O.D.)</td>
<td>5 ea</td>
<td>2878405-U</td>
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<td>Split/splitless, 3.5 mm I.D., wool packed</td>
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<td>2878505-U</td>
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<tr>
<td>Split/splitless with single taper, 3.5 mm I.D., wool packed</td>
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<td>For Thermo ThermoQuest 8000/TRACE™ (105 mm x 8 mm O.D.)</td>
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<td>Split/splitless with single taper, 5 mm I.D., wool packed</td>
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<td>For Varian® 1075/1077 Injectors (72 mm x 6.3 mm O.D.)</td>
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<td>Split/splitless with single taper, 3.4 mm I.D., wool packed</td>
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<td>2875705-U</td>
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<tr>
<td>For Varian CP-1177 Injectors Same catalog numbers as Agilent</td>
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</table>
Therm-O-Ring™ Seals

Inlet liners used in an Agilent GC require an O-ring placed near the top for proper operation. This O-ring ensures that the only path for carrier gas to get to the outside of the inlet liner is through the grooves in the inlet seal at the bottom of the injection port.

- Fit 6.3 mm, 6.5 mm, or 1/4” O.D. capillary liners that use an O-ring seal
- Can be used with inlet temperatures up to 375 °C without sticking or fragmenting
- Superior replacements for O-rings made from Viton®

**Pkg** | **Cat. No.**
---|---
10 ea | 21003-U
25 ea | 21004-U

**Tubing**

Supelco recommends using stainless steel for the most sensitive applications, such as high resolution MS detection. Copper tubing is recommended for all other GC and GC-MS plumbing needs.

**Premium Grade 304 Stainless Steel Tubing**

- Virtually impermeable to the diffusion of room air through the tubing walls
- Undergoes a proprietary cleaning procedure to remove all active sites and to ensure inertness

**Cleaned Copper Tubing**

- Most commonly used tubing for gas chromatography
- Cleaned according to ASTM B-280 plus a proprietary Supelco cleaning procedure

<table>
<thead>
<tr>
<th>Description</th>
<th>Cat. No.</th>
</tr>
</thead>
</table>
| Premium Grade 304 Stainless Steel Tubing | 20527
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.209 inch (5.3 mm) I.D. |
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.085 inch (2.1 mm) I.D. |
100 ft. x 1/16 inch (1.59 mm) O.D. x 0.030 inch (0.762 mm) I.D. |
| Cleaned Copper Tubing | 20553
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.190 inch (4.83 mm) I.D. |
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.065 inch (1.65 mm) I.D. |

**Swagelok® Tubing Fittings**

Swagelok fittings combine superior design principles with close manufacturing tolerance and rigid quality to provide a leak free connection.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cat. No.</th>
</tr>
</thead>
</table>
| Swagelok Fittings Kit | 22668-U
| Nuts Plus Front and Back Ferrules, brass, 1/8 inch, 10 of each | 22014
| Tee, brass, 1/8 inch | 22020-U
| On/off throttling valve, brass, 1/8 inch | 22138-U
| On/off throttling valve, stainless steel, 1/8 inch | 22139-U
| Toggle valve, brass, 1/8 inch | 22699

**Inlet Seals**

The inlet seals in an Agilent GC must be regularly changed to prevent sample adsorption due to accumulation of sample residue and/or septum fragments. Supelco manufacturers replacement inlet seals of the highest quality.

- Stainless steel for analyses of non-reactive compounds
- Seals plated with pure gold for applications requiring more inertness
- Cross design intended for high split flows (>200 mL/min.)
- Packs of ten include one washer for each seal

<table>
<thead>
<tr>
<th>Material</th>
<th>Pkg</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-plated</td>
<td>10 ea</td>
<td>23317-U</td>
</tr>
<tr>
<td>Gold-plated</td>
<td>10 ea</td>
<td>23319-U</td>
</tr>
<tr>
<td>Gold-plated, cross design</td>
<td>10 ea</td>
<td>23415-U</td>
</tr>
</tbody>
</table>

**Description** | **Cat. No.** |
---|---|
| Premium Grade 304 Stainless Steel Tubing | 20527
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.209 inch (5.3 mm) I.D. |
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.085 inch (2.1 mm) I.D. |
100 ft. x 1/16 inch (1.59 mm) O.D. x 0.030 inch (0.762 mm) I.D. |
| Cleaned Copper Tubing | 20488
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.190 inch (4.83 mm) I.D. |
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.065 inch (1.65 mm) I.D. |
Purifiers

Gas purification begins by determining the contaminants that need to be removed from the particular gas stream, levels to which the contaminants must be reduced, flow and pressure needs of the system, and the desired frequency of purifier change-out. Multiple purifiers may be necessary to adequately remove all contaminants to the desired levels to adequately protect the column and detector.

Recommended Purifier Options per Application

**Carrier gas:** remove hydrocarbons, moisture, and oxygen
- Supelcarb HC, High Capacity Gas Purifier, OMI-2
- Supelcarb HC, Molecular Sieve 5A, Supelpure-O, OMI-2

**Compressed air (for FIDs):** remove hydrocarbons and moisture
- Supelcarb HC, Molecular Sieve 5A

**Hydrogen fuel gas (for FIDs):** remove hydrocarbons
- Supelcarb HC

**OMI™ (Oxygen Moisture Indicating) Purifier**
- Polishing purifier that removes many contaminants that other upstream purifiers miss
- Simultaneously removes moisture, oxygen, carbon monoxide, carbon dioxide, most sulfur compounds, most halogen compounds, alcohols, and phenols to less than 10 ppb
- Detects moisture and oxygen in hydrogen, helium, nitrogen, argon, and argon/methane

**High Capacity Gas Purifier**
- Removes moisture, oxygen, carbon monoxide, and carbon dioxide
- No other purifier removes both moisture and oxygen in such large quantities

**Supelcarb™ HC Hydrocarbon Purifier**
- Removes hydrocarbons from carrier gas, compressed air, and hydrogen
- Has twice the trapping ability of activated charcoal

**Molecular Sieve 5A Water Vapor Purifier**
- Can reduce moisture in the gas stream to final concentrations less than 0.1 ppm
- Also preferred for use on in-house gas lines where moisture content could be high

**Supelpure™-O Oxygen Purifier**
- Reduces oxygen to less than 0.5 ppm when the level in the incoming gas does not exceed 10 ppm
- Oxygen-removing catalyst coated on a molecular sieve, will also trap significant amounts of moisture

<table>
<thead>
<tr>
<th>Description</th>
<th>Design</th>
<th>Fittings</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Bed Purifiers, Indicating</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OMI-2 purifier tube</td>
<td>Inline</td>
<td>n/a</td>
<td>23906</td>
</tr>
<tr>
<td>OMI-2 holder</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>23921</td>
</tr>
<tr>
<td><strong>Single Bed Purifiers, Non-Indicating</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Capacity Gas Purifier, 110 V</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>23800-U</td>
</tr>
<tr>
<td>High Capacity Gas Purifier, 230 V</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>23801</td>
</tr>
<tr>
<td>High Capacity replacement purifier tube</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>22396</td>
</tr>
<tr>
<td>Supelcarb HC hydrocarbon purifier, 120 cc</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>24448</td>
</tr>
<tr>
<td>Supelcarb HC hydrocarbon purifier, 750 cc</td>
<td>Inline</td>
<td>1/4 inch</td>
<td>24564</td>
</tr>
<tr>
<td>Molecular Sieve 5A water vapor purifier, 200 cc</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>20619</td>
</tr>
<tr>
<td>Molecular Sieve 5A water vapor purifier, 750 cc</td>
<td>Inline</td>
<td>1/4 inch</td>
<td>23991</td>
</tr>
<tr>
<td>Supelpure-O oxygen purifier, 120 cc</td>
<td>Inline</td>
<td>1/8 inch</td>
<td>22449</td>
</tr>
<tr>
<td>Supelpure-O oxygen purifier, 750 cc</td>
<td>Inline</td>
<td>1/4 inch</td>
<td>503088</td>
</tr>
</tbody>
</table>

Gas Generators

Laboratory gas generators are an alternative to gas cylinders. In addition to being a much more sensible source of gas from a cost standpoint, generators are safer, cosmetically better, take up less space, and do not require the labor needed to transport bulky cylinders in the lab. Supelco offers gas generators from Parker domnick hunter. These items can be viewed by referring to our catalog and/or our web site, sigma-aldrich.com/supelco

Norgren Particle and Oil Filters

Norgren filters are designed to remove solid and liquid particles as small as 5 μm in diameter, such as dust particles and/or oils released from an air compressor, preventing damage to any downstream gas generator. These items can be viewed by referring to our catalog and/or our web site, sigma-aldrich.com/supelco
Fast GC Literature From Sigma-Aldrich/Supelco

Reporter Articles (available at sigma-aldrich.com/thereporter)
- The Derivatization and Analysis of Amino Acids by GC-MS (Vol. 25.3, page 17)
- Analysis of Adulterated Lemon Essential Oil on the SLB-5ms (Vol. 24.5, page 16)
- SLB-5ms Fast GC Columns for Semivolatile Analysis (Vol. 24.4, page 12)
- New Regulation Requires Trans Fat Content to be Listed on Food Labels (Vol. 24.1, page 5)
- Fast Analysis of Fish Oils and Animal Lipids on the SUPELCOWAX 10 Column (Vol. 22.4, page 1)
- Fast GC Analysis of Bacterial Acid Methyl Esters (BAMEs) on Equity-1 Columns (Vol. 22.2, page 6)

Tradeshow Poster Transcripts
- Comparison of Capillary Columns for FAME Analysis (T407046)
- Fast GC Using Narrow Bore Capillary Columns (T407020)
- Fast GC in Environmental Analysis (T406106)
- New Capillary Columns for Fast Trans and Omega 3 and 6 FAME Analyses (T406098)
- Trans FAME Analysis Using High Speed GC (T405073)
- Fast GC Using 100 μm I.D. Capillary Columns (T403138)

NOTE: Sigma-Aldrich/Supelco literature can be obtained electronically (as Adobe® Acrobat files) by contacting Supelco Technical Service at 800-359-3041/814-359-3041 or techservice@sial.com

References

NOTE: References are not available from Sigma-Aldrich/Supelco due to copyrights. They may be obtained by contacting the journal or possibly through a library.
Chiral Cyclodextrin Capillary GC Columns

A Selection Guide to DEX™ Columns
Stable derivatized cyclodextrin stationary phases for high resolution analyses of optical and positional isomers.

- Low bleed, wide temperature range (30°C - 240/250°C)
- Individually tested with phase-specific test mixes to guarantee optimum performance
- Wide range of applications: foods, flavors, essential oils, natural products, pharmaceuticals, chemical syntheses
Chiral molecules can elicit very different responses in a biological system, depending on their stereochemistry (1, 2). Rapid commercial introduction of optically active drugs requires reliable stereochemical analysis of the products, and of the chiral intermediates used in their synthesis. Capillary gas chromatography is a simple, fast, accurate, sensitive, and reproducible technique for separating stereo and positional isomers of compounds that can be vaporized without decomposition. Chiral separations have been performed by gas chromatography for nearly three decades (3). First generation chiral GC columns were based on nonbonded and bonded amino acid moieties (4); the latest capillary GC columns are based on functionalized cyclodextrins (5, 6).

Key Words:
- chiral compounds
- cyclodextrins

Cyclodextrins
Cyclodextrins (CDs) are cyclic, chiral, torus-shaped macromolecules composed of 6 or more D(+)-glucose residues bonded through α-(1-4) glycosidic linkage. CDs are classified by the number of glucose residues they contain; α-CDs contain 6 residues (cyclohexaamylose), β-CDs contain 7 (cycloheptaamylose), and γ-CDs contain 8 (cyclooctaamylose) (Figure A). The mouth of the torus-shaped CD molecule has a larger circumference than the base and is linked to secondary hydroxyl groups of the C2 and C3 atoms of each glucose unit (Figure B). The primary hydroxyl groups are located at the base of the torus, on the C6 atoms. Free to rotate, they partially block the base. The size of the cavity increases with increasing number of glucose units, from 4.7-5.2Å for α-CD to 6.0-6.5Å for β-CD to 7.5-8.5Å for γ-CD. The hydroxyl groups in the glucose units can be selectively functionalized to provide various physical properties and inclusion selectivities.

In the last few years enantiomers have been chromatographically separated by using peralkylated α-, β-, and γ-CD dissolved in polysiloxanes and coated within glass or fused silica capillary tubing (5, 6). Without the cyclodextrin derivative, no enantiomeric selectivity is exhibited. Enantiomers of polar compounds (e.g., alcohols, diols, carboxylic acids) can be separated without previous derivatization on inert fused silica tubing coated with cyclodextrin/polysiloxane phases. Moreover, racemic alkanes and cycloalkanes are separated by such phases. Consequently, cyclodextrin stationary phases have broadened the capabilities of chiral separations into the fields of agriculture, foods, flavors, beverages, environmental samples, petrochemicals, chemicals and natural products.

DEX Columns
α-DEX, β-DEX, and γ-DEX columns are Supelco’s new generation of selective, fused silica capillary columns, capable of efficiently separating both optical and positional isomers. We prepare these columns by adding permethylated α-CD (α-DEX), β-CD (β-DEX), or γ-CD (γ-DEX) to a phenyl-containing polysiloxane stationary cophase. From extensive research, SPB™-35 was selected as the cophase, because of its wide operating temperature range, its propensity for dissolving permethylated CDs, and its stability against oxidation. The DEX column name denotes both the type of CD and the amount of CD in the polysiloxane (weight percent). For example, α-DEX 110 denotes 10% α-CD and β-DEX 120 denotes 20% β-CD.
DEX columns make it possible to separate chiral compounds without derivatization—enantiomers and positional isomers are separated by slight differences associated with forming reversible inclusion complexes in the cavities of the functionalized CDs. DEX columns are useful for determining the enantiomeric excess of an enantiomer in a reaction mixture or product, or for identifying impurities in a sample. Not all racemates will separate on a single DEX column. In fact, it is difficult to predict exactly which phase will best separate a particular compound, but some general guidelines are available (Table 1).

Therefore, we offer a variety of α-DEX, β-DEX, and γ-DEX columns, which differ in enantioselectivity, efficiency, and sample capacity, due to differences in:

- the size of the CD inclusion cavity
- the percentage of CD (10% or 20% from stock, 1-30% available)
- column length (30m or 60m from stock, 5-100m available)
- column diameter (0.25mm or 0.53mm ID from stock, 0.10-0.53mm ID available)

Table 1. Enantiomeric Separations Achieved with DEX Columns

<table>
<thead>
<tr>
<th>DEX Column</th>
<th>Probability of Achieving Separation</th>
<th>Compounds Separated</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-DEX 120</td>
<td>40-50%</td>
<td>alcohols, diols, epoxides, ethers, halohydrocarbons, ketones, positional isomers</td>
</tr>
<tr>
<td>β-DEX 110</td>
<td>80-90%</td>
<td>acids, amines, diols, esters, ethers, halohydrocarbons, hydrocarbons, ketones, positional isomers, silanes, terpenes, terpineols</td>
</tr>
<tr>
<td>β-DEX 120</td>
<td>40-50%</td>
<td>alcohols, diols, epoxides, ethers, halohydrocarbons, ketones, positional isomers, silanes, terpenes, terpineols</td>
</tr>
<tr>
<td>γ-DEX 120</td>
<td>40-50%</td>
<td>acids, amines, esters, halohydrocarbons, ketones, positional isomers</td>
</tr>
</tbody>
</table>

α-DEX 120 Columns

A small internal cavity in the permethylated α-cyclodextrin generates the molecule’s rigid nature and unique chiral selectivities. These columns have a high shape selectivity for positional isomers (e.g., xylenes, menthols, cresols, substituted-phenols, substituted benzenes) and epoxide enantiomers.

β-DEX 110 and β-DEX 120 Columns

The permethylated β-CD in β-DEX columns is unique because it contains an odd number (7) of glucose units. This asymmetrical geometry allows β-DEX columns to distinguish between the enantiomers of a large number of analytes. A β-DEX column is the first column of choice for separating any enantiomeric pair.

γ-DEX 120 Columns

Of the three cyclodextrins, the permethylated γ-CD in γ-DEX 120 columns has the largest cavity. This makes the γ-CD molecule more flexible and less selective in differentiating most enantiomers. Still, some large analytes (e.g., α-BHC, carvone, carboxylic acids, methamphetamine) show the greatest enantiomeric differentiation on a γ-DEX 120 column.

Because the permethylated CDs are not bonded to the polysiloxane cophase, DEX columns should not be rinsed with organic solvents. Solvents in the sample (less than 5µL) will not affect the columns.

For additional protection connect a 1-5m deactivated guard column to the inlet of the DEX column, via a GlasSeal™ connector (Cat. No. 2-0479).

The derivatized cyclodextrin in the phase makes it possible to have chromatographic separations below the melting point of the polysiloxane. To ensure reproducible retention times and enantioselectivity, however, we recommend raising the column temperature to the preliminary conditioning temperature (Table 2) for 5-10 minutes before each analysis. This is especially important with α-DEX columns, because the phase begins to solidify if the column is held below 50°C for 15 minutes. All DEX columns can be programmed to 250°C for short periods. The minimum and maximum operating temperatures are used in the examples in Figures C and D.

Table 2. Temperature Limits for DEX Columns

<table>
<thead>
<tr>
<th>Column</th>
<th>Minimum</th>
<th>Temperature Preliminary Conditioning</th>
<th>Maximum*</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-DEX 120</td>
<td>30°C</td>
<td>220°C</td>
<td>240°C/250°C</td>
</tr>
<tr>
<td>β-DEX 110</td>
<td>30°C</td>
<td>170°C</td>
<td>240°C/250°C</td>
</tr>
<tr>
<td>β-DEX 120</td>
<td>30°C</td>
<td>170°C</td>
<td>240°C/250°C</td>
</tr>
<tr>
<td>γ-DEX 120</td>
<td>30°C</td>
<td>120°C</td>
<td>240°C/250°C</td>
</tr>
</tbody>
</table>

*Isothermal/programmed.

Figure C. (±)2-Butanol at 30°C (minimum temperature for DEX columns)

Figure D. (±)2,2,2-Trifluoro-1-(9-anthryl)ethanol at 240°C (maximum temperature for DEX columns)
Chiral Test Mixes
Each DEX column is individually tested with an appropriate isotherm test mix, to guarantee consistent column performance and provide reference values for future monitoring by the analyst. The components of each mix were chosen to monitor specific column performance parameters (Table 3). By using the test mix periodically, an analyst can monitor inertness, film thickness, chiral resolution, and efficiency.

Table 3. Test Mix Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Column Performance Monitored</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal alkanes</td>
<td>column efficiency (as theoretical plates/m)</td>
</tr>
<tr>
<td></td>
<td>film thickness (as retention factor, k')</td>
</tr>
<tr>
<td></td>
<td>retention index standards</td>
</tr>
<tr>
<td>optical isomers</td>
<td>enantioselectivity (as α value)</td>
</tr>
<tr>
<td></td>
<td>retention index markers</td>
</tr>
<tr>
<td>positional isomers</td>
<td>shape selectivity (as α value)</td>
</tr>
</tbody>
</table>

The β-DEX Column Isothermal Test Mix (Cat. No. 4-8028) is formulated for monitoring the performance of β-DEX columns. The elution order of the components of this mix are shown in Figure E. The α-DEX Column Isothermal Test Mix (Cat. No. 4-8013) is similar to the β-DEX test mix. Separation factors (α values) are calculated for the racemic compound, (+/-)-1,2-propanediol, to monitor column enantioselectivity and for m- and p-xylene, to monitor column shape selectivity. Analysis of the α-DEX test mix on an α-DEX 120 column is shown in Figure F. The γ-DEX Column Isothermal Test Mix (Cat. No. 4-7898) was designed for evaluating the same performance parameters as the α-DEX test mix (Figure G). Shape selectivity of a γ-DEX column can be monitored by measuring the separation factor (α value) for 1,4- and 1,3-dichlorobenzene. Enantioselectivity (α value) can be monitored by observing the chiral separation of (+/-)-2-ethylhexanoic acid. A programmed test mix will provide a more stringent test of column performance (Figure H).

Figure E. β-DEX Column: Isothermal Test Mix

<table>
<thead>
<tr>
<th>Component</th>
<th>Column Performance Monitored</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Nonane (C9)</td>
<td></td>
</tr>
<tr>
<td>(+/-)-3,3-Dimethyl-2-butanol</td>
<td></td>
</tr>
<tr>
<td>n-Decane (C10)</td>
<td></td>
</tr>
<tr>
<td>(-)-3-Methyl-2-heptanone</td>
<td></td>
</tr>
<tr>
<td>1-Hexanol</td>
<td></td>
</tr>
<tr>
<td>n-Undecane (C11)</td>
<td></td>
</tr>
</tbody>
</table>

Figure F. α-DEX Column: Isothermal Test Mix

<table>
<thead>
<tr>
<th>Component</th>
<th>Column: α-DEX 120, 30m x 0.25mm ID, 0.25μm film</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Nonane (C9)</td>
<td>1</td>
</tr>
<tr>
<td>p-Xylene</td>
<td>2</td>
</tr>
<tr>
<td>m-Xylene</td>
<td>3</td>
</tr>
<tr>
<td>n-Decane (C10)</td>
<td>4</td>
</tr>
<tr>
<td>(+/-)-1,2-Propanediol</td>
<td>5</td>
</tr>
<tr>
<td>(+/-)-1,2-Propanediol</td>
<td>6</td>
</tr>
<tr>
<td>n-Undecane (C11)</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure G. γ-DEX Column: Isothermal Test Mix

<table>
<thead>
<tr>
<th>Component</th>
<th>Column: γ-DEX 120, 30m x 0.25mm ID, 0.25μm film</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Undecane (C11)</td>
<td>1</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
<td>2</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>3</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>4</td>
</tr>
<tr>
<td>n-Tridecane (C13)</td>
<td>5</td>
</tr>
<tr>
<td>n-Tetradecane (C14)</td>
<td>6</td>
</tr>
<tr>
<td>(+/-)-2-Ethylhexanoic acid</td>
<td>7</td>
</tr>
<tr>
<td>(+/-)-Pentadecane (C15)</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure H. γ-DEX Column: Temperature Programmed Test Mix

<table>
<thead>
<tr>
<th>Component</th>
<th>Column: γ-DEX 120, 30m x 0.25mm ID, 0.25μm film</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Ethylhexanoic acid</td>
<td>1</td>
</tr>
<tr>
<td>Methamphetamine (TFA)</td>
<td>2</td>
</tr>
<tr>
<td>(+/-)-2,4,6-Trimethylphenyl/ethanol</td>
<td>3</td>
</tr>
<tr>
<td>α-BHC</td>
<td>4</td>
</tr>
</tbody>
</table>
Enantioselectivity ($\alpha$) and Temperature

The GC oven temperature plays an important role in tuning the enantioselectivity (separation factor) of analytes on DEX columns. As depicted in Figure I, decreasing the isothermal temperature increases the separation of enantiomers (higher $\alpha$ values). When conditions yield poor separation of enantiomers, or no separation, reducing the analysis temperature might provide a satisfactory separation.

CD Content

The amount of cyclodextrin in the stationary phase affects the enantioselectivity and polarity of DEX columns. Enantioselectivity increases with higher percentages of CD (Figure J). Increasing the CD content also increases the polarity of the stationary phase. When the CD content is increased from 10% to 20%, 1-hexanol is retained longer, relative to the C10 and C11 hydrocarbons (Figure E).

We offer $\beta$-DEX columns with two levels of permethylated CD (10% and 20%) to provide columns that give similar enantiomeric separations, but different polarities. In some cases, the elution order of chiral and achiral components can be changed by connecting a conventional column of lower or higher polarity to the inlet of a DEX column (e.g., connect a SUPELCOWAX™ 10 column to a $\beta$-DEX 120 column).

Column Diameter (ID) and Resolution

Decreasing the internal diameter (ID) of DEX columns increases enantiomer resolution, while leaving separation factors ($\alpha$ values) unaffected (Table 4). To balance sample loading capacity and enantiomer resolution, you will find DEX columns of 0.25mm ID ideal for most separations. Custom-prepared 0.10mm ID DEX columns provide the highest resolution, but the lowest sample capacity. Because the opposite is true for 0.53mm ID DEX columns, the latter are best suited for semi-preparative separations (Figure K).

Applications

DEX columns are useful for separating a wide variety of optical isomers: pharmaceuticals, natural products, foods, flavors, agricultural, environmental and biological samples, synthesized asymmetric molecules, etc. (Tables 5, 6, and 7). DEX columns also effectively separate positional isomers.

Chiral Synthesis

In asymmetric synthesis using catalysts, it is important to determine the enantiomeric excess (ee) of products in the reaction mixture before doing any purification which might distort the ee value. Using DEX columns, ee or chiral purity can be determined directly, without sample modification or pretreatment.

Pharmaceuticals

Because enantiomers can have radically different potency and toxicity, single enantiomeric forms of drugs are being targeted by pharmaceutical manufacturers. DEX columns simplify the task of determining enantiomeric purity of pharmaceutical precursors, intermediates, and final products.

Foods, Flavors, and Fragrances

Individual enantiomers usually have significantly different odor and taste. Using DEX columns, analysts can detect adulteration of natural products, flavors in juices, and food additives. Extracts of caraway seed, mushrooms, citrus oils, pine oils and plant oils (obtained by solid phase microextraction) show the versatility of DEX columns for enantiomeric identification (7).

---

**Table 4. Enantioselectivity ($\alpha$) and Chiral Resolution (Rs) as Functions of Column ID**

<table>
<thead>
<tr>
<th>Column ID</th>
<th>$\alpha$</th>
<th>Rs</th>
<th>$\alpha$</th>
<th>Rs</th>
<th>$\alpha$</th>
<th>Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10mm</td>
<td>1.037</td>
<td>1.89</td>
<td>1.031</td>
<td>2.28</td>
<td>1.021</td>
<td>1.84</td>
</tr>
<tr>
<td>0.20mm</td>
<td>1.037</td>
<td>1.35</td>
<td>1.031</td>
<td>1.70</td>
<td>1.021</td>
<td>1.47</td>
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<tr>
<td>0.32mm</td>
<td>1.036</td>
<td>0.98</td>
<td>1.030</td>
<td>1.10</td>
<td>1.021</td>
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<tr>
<td>0.53mm</td>
<td>1.037</td>
<td>0.70</td>
<td>1.033</td>
<td>0.84</td>
<td>1.023</td>
<td>0.80</td>
</tr>
</tbody>
</table>

$^a$-DEX 110 columns (phase ratio = 250); 75°C; helium carrier.
Environmental Applications
Currently, few organic compounds that are classified as environmental pollutants exhibit chirality (8). However, many exist as positional isomers that are often almost as difficult to separate (see α-BHC in Figure H). Separations of benzene, toluene, ethylbenzene, and the 3 xylenes, to detect leaking underground storage tanks (UST), and of positional isomers of dichlorobenzene, cresol, and dichlorophenol are examples of analyses involving difficult-to-resolve positional isomers.

Silicon Compounds
The importance of silicon chemistry in organic synthesis is increasing. DEX columns have been used successfully to separate several asymmetric silane racemates (Table 6) (9).

Industrial Chemicals
Characterization of large-scale industrial achiral chemicals requires the separation of low level impurities with boiling points close to that of the target product. Positional isomers are typically the most difficult to separate. α-DEX 120 columns have proven useful for separating positional isomers of xylenes, divinylbenzenes, chlorinated phenols, cresols, and chlorinated benzenes. Xylene isomers can be separated on these columns regardless of their relative concentrations.

Natural Products
Using a new sample preparation technique, solid phase microextraction (SPME), chiral and nonchiral volatile flavor and fragrance components can be extracted from natural products and essential oils (10).

Reversal of Enantioselectivity with DEX Columns
When determining optical purity with one enantiomer in large excess relative to the other, it is generally better to have the less concentrated enantiomer elute first. The enantiomer in excess frequently produces a large tailing peak that could overlap a smaller, later-eluting peak. Reversing the elution order of two enantiomers (enantio-reversal) also is useful in confirming separations and in mechanistics studies.

In some cases, enantio-reversal can be achieved by changing columns, such as from α-DEX to β-DEX or γ-DEX (7, 8, 10). For example, carvone enantiomers are separated in reversed order on α-DEX and γ-DEX columns, and coelute on β-DEX columns. Additional examples of enantio-reversal (α-BHC, alcohols, methyl mandelate) are listed in Table 7.

Separation Mechanism
The mechanism by which permethylated cyclodextrin columns separate enantiomers is not fully understood. Separations are, in part, due to the formation of geometrically dissimilar cyclodextrin inclusion complexes. Hydrogen bonding interactions are also involved in the enantioselectivity (Tables 5 and 7). It has been postulated that the number of glucose units (and whether an even or odd number) and the cyclodextrin cavity size play critical roles in differentially interacting with enantiomers. This can be visualized, for example, when one enantiomer predominantly forms an asymmetrical inclusion complex within the β-CD cavity. The other enantiomer, forced by geometrical constraints to form a completely different complex, begins to separate from the first enantiomer as a result of the differences in time spent by each in interacting with the β-CD macromolecule.
<table>
<thead>
<tr>
<th>Compound</th>
<th>α-DEX 120</th>
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<th>γ-DEX 120</th>
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</thead>
<tbody>
<tr>
<td>1-phenylethanol</td>
<td></td>
<td>1.065</td>
<td>1.015</td>
</tr>
<tr>
<td>1-(2-methylphenyl)ethanol</td>
<td>1.022</td>
<td>1.194</td>
<td>1.032</td>
</tr>
<tr>
<td>1-(4-methylphenyl)ethanol</td>
<td></td>
<td>1.088</td>
<td>1.036</td>
</tr>
<tr>
<td>1-(2,4-dimethylphenyl)ethanol</td>
<td>1.014</td>
<td>1.273</td>
<td>1.102</td>
</tr>
<tr>
<td>1-(2,5-dimethylphenyl)ethanol</td>
<td>1.038</td>
<td>1.230</td>
<td>1.058</td>
</tr>
<tr>
<td>1-(2,6-dimethylphenyl)ethanol</td>
<td>1.111</td>
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</tr>
<tr>
<td>1-(3,4-dimethylphenyl)ethanol</td>
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<td>1.043</td>
<td>1.026</td>
</tr>
<tr>
<td>1-(3,5-bis[trifluoromethyl]phenyl)ethanol</td>
<td>1.017</td>
<td>1.117</td>
<td>1.008</td>
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</table>

<table>
<thead>
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<th></th>
<th></th>
</tr>
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<td>alkyl (R) =</td>
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<td>β-DEX 120</td>
<td>γ-DEX 120</td>
</tr>
<tr>
<td>-methyl**</td>
<td>1.012</td>
<td>1.125</td>
<td>1.043</td>
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<tr>
<td>-butyl</td>
<td>1.011</td>
<td>1.020</td>
<td>1.007</td>
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<tr>
<td>-isobutyl</td>
<td>1.015</td>
<td>1.059</td>
<td>1.032</td>
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<tr>
<td>-t-butyl</td>
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<td>1.105</td>
<td>1.038</td>
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<tr>
<td>-pentyl</td>
<td>NS</td>
<td>NS</td>
<td>1.006</td>
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<td>-hexyl</td>
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<td>1.013</td>
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<table>
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<th>α-alkyl(2,6-dimethylbenzyl) alcohol</th>
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<td>β-DEX 120</td>
<td>γ-DEX 120</td>
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<td>-neopentyl</td>
<td>1.013</td>
<td>1.092</td>
<td>NS</td>
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References

Fused silica columns manufactured under HP US Pat. No. 4,293,415.
<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>Col. Temp.</th>
<th>α-DEX 110</th>
<th>β-DEX 110</th>
<th>γ-DEX 110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenylmethylchlorosilane (Chloromethylphenylsilane)</td>
<td><img src="image1" alt="Structure" /></td>
<td>70°C</td>
<td>NS* (10.3)</td>
<td>NS (11.4)</td>
<td>1.006 (10.9)</td>
</tr>
<tr>
<td>Phenylmethylvinylsilane (Methylphenylvinylsilane)</td>
<td><img src="image2" alt="Structure" /></td>
<td>70°C</td>
<td>NS (9.1)</td>
<td>1.012 (9.5)</td>
<td>NS (9.5)</td>
</tr>
<tr>
<td>Phenylmethylhydroxysilane (Methylphenylsilanol)</td>
<td><img src="image3" alt="Structure" /></td>
<td>100°C</td>
<td>1.015 (9.0)</td>
<td>1.084 (13.5)</td>
<td>1.015 (10.4)</td>
</tr>
<tr>
<td>Phenylmethylpropoxysilane (Methylphenylpropoxysilane)</td>
<td><img src="image4" alt="Structure" /></td>
<td>100°C</td>
<td>NS (6.1)</td>
<td>NS (6.2)</td>
<td>NS (5.6)</td>
</tr>
<tr>
<td>Phenylmethylbutoxysilane (Butoxymethylphenylsilane)</td>
<td><img src="image5" alt="Structure" /></td>
<td>100°C</td>
<td>NS (11.1)</td>
<td>NS (11.5)</td>
<td>NS (10.2)</td>
</tr>
<tr>
<td>Phenylmethylpentoxysilane (Methylpentoxyphenylsilane)</td>
<td><img src="image6" alt="Structure" /></td>
<td>100°C</td>
<td>NS (20.4)</td>
<td>1.008 (21.3)</td>
<td>NS (18.5)</td>
</tr>
<tr>
<td>Methylphenylvinylsilanol</td>
<td><img src="image7" alt="Structure" /></td>
<td>120°C</td>
<td>1.008 (6.6)</td>
<td>1.019 (8.8)</td>
<td>1.015 (8.3)</td>
</tr>
<tr>
<td>Methylphenylpropoxysilanol</td>
<td><img src="image8" alt="Structure" /></td>
<td>140°C</td>
<td>1.013 (5.6)</td>
<td>1.017 (6.2)</td>
<td>1.014 (6.5)</td>
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<tr>
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<td><img src="image9" alt="Structure" /></td>
<td>140°C</td>
<td>1.018 (8.8)</td>
<td>1.038 (9.7)</td>
<td>1.015 (10.4)</td>
</tr>
<tr>
<td>Methylpentoxyphenylsilanol</td>
<td><img src="image10" alt="Structure" /></td>
<td>140°C</td>
<td>1.019 (14.3)</td>
<td>1.065 (15.5)</td>
<td>1.025 (16.6)</td>
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<td>140°C</td>
<td>NS (17.9)</td>
<td>1.027 (19.4)</td>
<td>1.023 (20.0)</td>
</tr>
</tbody>
</table>

*NS – no observable separation
*See Key Words and Definitions on page 16.

k'1 = k' for first eluting peak.
<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
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<th>α-DEX 120</th>
<th>α value and (k')</th>
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<th>β-DEX 120</th>
<th>γ-DEX 120</th>
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<td>2-Methylbutyric acid</td>
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<td>NS(1.9)</td>
<td>1.046</td>
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<td>1.010</td>
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<tr>
<td>2-Ethylhexanoic acid</td>
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<td>1.048</td>
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<td><strong>Amines</strong></td>
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<tr>
<td>α-Methylbenzylamine</td>
<td><img src="image3" alt="Structure" /></td>
<td>90°C</td>
<td>NS(7.8)</td>
<td>1.029</td>
<td>1.030</td>
<td>NS(9.5)</td>
<td></td>
</tr>
<tr>
<td>N-Trifluoroacetyl-</td>
<td><img src="image4" alt="Structure" /></td>
<td>90°C</td>
<td>NS(26.6)</td>
<td>1.066</td>
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<td>(27.1)</td>
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<td>2-Butanol</td>
<td><img src="image5" alt="Structure" /></td>
<td>30°C</td>
<td>NS(2.4)</td>
<td>1.043</td>
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<td>NS(2.8)</td>
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<tr>
<td>trans-2-Methylcyclopentanol</td>
<td><img src="image6" alt="Structure" /></td>
<td>70°C</td>
<td>1.040(4.2)</td>
<td>—</td>
<td>1.060</td>
<td>NS(5.0)</td>
<td></td>
</tr>
<tr>
<td>3-Methylcyclopentanol</td>
<td><img src="image7" alt="Structure" /></td>
<td>70°C</td>
<td>1.021(5.4)</td>
<td>NS(7.5)</td>
<td>NS(13.7)</td>
<td>NS(4.8)</td>
<td></td>
</tr>
<tr>
<td>2-Octanol</td>
<td><img src="image8" alt="Structure" /></td>
<td>80°C</td>
<td>1.017(7.9)</td>
<td>1.011</td>
<td>1.017</td>
<td>NS(7.7)</td>
<td></td>
</tr>
<tr>
<td>1-Octen-3-ol</td>
<td><img src="image9" alt="Structure" /></td>
<td>80°C</td>
<td>1.030(6.9)</td>
<td>1.015</td>
<td>1.021</td>
<td>NS(5.3)</td>
<td></td>
</tr>
<tr>
<td>α-Terpineol²</td>
<td><img src="image10" alt="Structure" /></td>
<td>100°C</td>
<td>NS(12.4)</td>
<td>1.031</td>
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<td>1.028</td>
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<tr>
<td>Terpinen-4-ol³</td>
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Table 7. Chiral Compounds contd.

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<th>α-DEX 120</th>
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<th>β-DEX 120</th>
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<td>(9.7)</td>
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<td>(12.3)</td>
<td>(10.9)</td>
<td>(10.8)</td>
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<td>(4.8)</td>
<td>(5.9)</td>
<td>(7.7)</td>
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**Diols**

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Table 7. Chiral Compounds contd.

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Table 7. Chiral Compounds contd.

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<th>β-DEX 110</th>
<th>γ-DEX 120</th>
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Table 7. Chiral Compounds contd.

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<th>α-DEX 110</th>
<th>β-DEX 120</th>
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Aromatic Positional Isomers

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<th>α-DEX 110</th>
<th>β-DEX 120</th>
<th>γ-DEX 120</th>
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<td>1.111</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.5)</td>
<td>(1.3)</td>
<td>(1.6)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>m-Ethylvinylbenzene / p-Ethylvinylbenzene</td>
<td>140°C</td>
<td>1.066</td>
<td>1.084</td>
<td>1.108</td>
<td>1.069</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.1)</td>
<td>(1.0)</td>
<td>(1.3)</td>
<td>(1.1)</td>
</tr>
</tbody>
</table>
Table 7. Chiral Compounds contd.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>Col.</th>
<th>Temp.</th>
<th>α-DEX 120</th>
<th>β-DEX 110</th>
<th>β-DEX 120</th>
<th>γ-DEX 120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toluene / Toluene-d₈</td>
<td></td>
<td></td>
<td>30°C</td>
<td>1.039</td>
<td>—</td>
<td>1.027</td>
<td>—</td>
</tr>
</tbody>
</table>

1 NS = no observable separation
2 Enantio-reversal from β-DEX column to γ-DEX column.
3 (+) Enantiomer elutes first from β-DEX column. (-) Enantiomer elutes first from γ-DEX column.
4 (-) Enantiomer elutes first from α-DEX or β-DEX column. (+) Enantiomer elutes first from γ-DEX column.
5 (+) Enantiomer elutes first from α-DEX column. (-) Enantiomer elutes first from γ-DEX column.
6 Elution order not determined for α-DEX column.
7 (-) Enantiomer elutes first from α-DEX column. (+) Enantiomer elutes first from γ-DEX column.

---

**Gas Chromatographic Enantiomer Separation with Modified Cyclodextrins**


Lipophilic cyclodextrin derivatives have proven superior to all other previously used chiral stationary phases for capillary GC, due to their almost unlimited range of applications. Numerous examples are given of stereochemical separations. In addition to covering the data of all the resolved chiral compounds, the preparation and characterization of lipophilic cyclodextrin derivatives and the production and testing of glass and fused silica capillary columns are described in detail.

**Chromatographic Enantioseparation: Methods and Applications (2nd Edition)**


Comprehensive treatment of chiral chromatography, including basic theory and methodology.

**Chiral Liquid Chromatography**


This comprehensive reference provides a thorough review of chiral liquid chromatography systems and their practical applications. It includes background material on the nature of chirality, the historical development and use of chiral LC, and an appendix with relevant suppliers and products.
Key Words and Definitions

α-DEX
α-cyclodextrin-containing capillary GC column, proprietary to Supelco

asymmetric molecule
molecule with different substituents to a central carbon, silicon, phosphorus, etc. atom (e.g., C\(^\ast\)R\(_1\)R\(_2\)R\(_3\)R\(_4\)), existing in two mirror image configurations with no elements of symmetry

β-DEX
β-cyclodextrin-containing capillary GC column, proprietary to Supelco

CD
cyclodextrin

chiral molecule
molecule that can exist in two non-superimposable (mirror image) configurations (e.g., d- and l-glucose)

enantiomeric resolution (Rs)
a measure of chromatographic separation of isomers in which column efficiency is considered:

\[ Rs = 1.177 \times \frac{t_{r2} - t_{r1}}{w_1 + w_2} \]

\(w_1\) & \(w_2\) are peak widths for isomers 1 & 2 at half-height

enantiomers (optical isomers)
non-superimposable mirror image molecules which rotate polarized light in equal and opposite directions (e.g., d- and l-amino acids)

enantiomeric excess (ee)
the percent by which one enantiomer of an optically active compound is in excess of the other in a mixture of the two (typically determined from area or area %):

\[ ee = \frac{\% \text{ enantiomer}_1 - \% \text{ enantiomer}_2}{\% \text{ enantiomer}_1 + \% \text{ enantiomer}_2} \times 100 \]

enantio-reversal
reversal in the elution order of two enantiomers as a result of changing the (CD) stationary phase

enantioselectivity
same as separation factor

γ-DEX
γ-cyclodextrin-containing capillary GC column, proprietary to Supelco

meso compound
a molecule which contains two or more chiral centers, but has a plane of symmetry and thus is optically inactive

optical purity
the percent of one enantiomer in excess of the other, as determined from optical rotation measurements

positional isomers
molecules having identical molecular formula, but with one substituent (Cl, OH, etc.) located at different positions

racemate (racemic mixture)
a 50:50 mixture of two enantiomers, denoted as (dl) or (+/-)

retention factor (k')
a relative measure of chromatographic retention of a compound:

\[ k' = \frac{t_{r} - t_0}{t_0} \]

separation factor (\(\alpha\) value)
a measure of chromatographic separation of isomers in which column efficiency is not considered:

\[ \alpha = \frac{t_{r2} - t_0}{t_{r1} - t_0} = \frac{k'_2}{k'_1} \]

stereochemistry
the study of molecules having the same molecular formula, but different spatial orientations
**Alcohols/ Aldehydes (also see page 31)**

**Menthols**

<table>
<thead>
<tr>
<th>Application developed by Dr. L. Sundaram, The Pennsylvania State University, University Park, PA USA.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(±)-1-Octen-3-ol</strong></td>
</tr>
<tr>
<td>Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film</td>
</tr>
<tr>
<td>Cat. No.: 2-4310</td>
</tr>
<tr>
<td>Oven: 100°C</td>
</tr>
<tr>
<td>Carrier: helium, 20cm/sec</td>
</tr>
<tr>
<td>Det.: FID, 300°C</td>
</tr>
<tr>
<td>Inj.: 1µL methanol (0.5mg/mL each analyte), split (100:1), 250°C</td>
</tr>
</tbody>
</table>

**1-Phenylethanol; 1-Phenylpropanol**

<table>
<thead>
<tr>
<th>1-Phenylethanol*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film</td>
</tr>
<tr>
<td>Cat. No.: 2-4301</td>
</tr>
<tr>
<td>Oven: 110°C</td>
</tr>
<tr>
<td>Carrier: helium, 20cm/sec</td>
</tr>
<tr>
<td>Det.: FID, 200°C</td>
</tr>
<tr>
<td>Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C (α-DEX 120) or 220°C (β-DEX 110)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1-Phenylpropanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film</td>
</tr>
<tr>
<td>Cat. No.: 2-4304</td>
</tr>
<tr>
<td>Oven: 130°C</td>
</tr>
<tr>
<td>Carrier: helium, 20cm/sec</td>
</tr>
<tr>
<td>Det.: FID, 300°C</td>
</tr>
<tr>
<td>Inj.: 1µL methylene chloride containing 1mg/mL racemate, split 100:1, 220°C</td>
</tr>
</tbody>
</table>

**Citronellal**

| 1. 1S,2S,5R-(+)-Neomenthol |
| 2. 1R,2R,5S-(-)-Neomenthol |
| 3. 1S,2R,5S-(+)-Menthol |
| 4. 1R,2S,5R-(-)-Menthol |
| 5. 1R,2S,5S-(-)-Isomenthol |
| 6. 1S,2R,5R-(+)-Isomenthol |

| Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film |
| Cat. No.: 2-4310 |
| Oven: 100°C |
| Carrier: helium, 20cm/sec |
| Det.: FID, 300°C |
| Inj.: 1µL methanol (0.5mg/mL each analyte), split (100:1), 250°C |

*Application developed by Dr. L. Sundaram, The Pennsylvania State University, University Park, PA USA.
Linalool

Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4301
Oven: 100°C
Carrier: helium, 20cm/sec
Det.: FID, 200°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 150°C

1. S-(+)-2,2,2-Trifluoro-1-(9-anthryl)ethanol
2. R-(-)-2,2,2-Trifluoro-1-(9-anthryl)ethanol

2,2,2-Trifluoro-1-(9-anthryl)ethanol

Column: γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4307
Oven: 240°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. S-(+)-2,2,2-Trifluoro-1-(9-anthryl)ethanol
2. R-(-)-2,2,2-Trifluoro-1-(9-anthryl)ethanol

Alcohols

Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 120°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 200°C

1. (±)-(1-Phenyl)ethanol
2. (±)-α-(Trifluoromethyl)benzyl alcohol
3. (±)-α-Methyl benzyl butyrate
4. (±)-(1-Phenyl)pentanol

5-Hydroxy-4-methyl-3-heptanone

Column: γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4307
Oven: 110°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. (±)-(1-Phenyl)ethanol
2. (±)-α-(Trifluoromethyl)benzyl alcohol
3. (±)-α-Methyl benzyl butyrate
4. (±)-(1-Phenyl)pentanol
**Terpinene-4-ol (Enantio-reversal)**

Column: β-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 100°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C

**Menthols (Enantio-reversal)**

Column: α-DEX 120, β-DEX 120, and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310 (α-DEX 120), 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 110°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

**Divinylbenzenes**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 140°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 4µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

**Xylene Isomers**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 50°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 0.6µL each analyte (neat), split (100:1), 80°C

**Aromatics**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 100°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C

**Bentham**

Column: a-DEX 120, b-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304 (α-DEX 120), 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 100°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C
**Aromatics**

Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4301  
Oven: 50°C  
Carrier: helium, 20cm/sec  
Det.: FID, 260°C  
Inj.: 0.1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 100°C

1. Benzene  
2. Toluene  
3. n-Nonane  
4. p-Xylene  
5. m-Xylene  
6. Ethylbenzene  
7. o-Xylene  
8. Styrene  
9. Cumene  
10. α-Methylstyrene

---

**BTEX Compounds, Gasoline Range Organics (GRO)**

Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4304  
Oven: 40°C to 180°C at 8°C/min  
Carrier: helium, 30cm/sec  
Det.: FID, 300°C  
Inj.: 1µL methanol (0.5mg/mL each analyte), direct injection, 250°C

1. Methanol  
2. Methyl tert-butyl ether (MTBE)  
3. Benzene  
4. Toluene  
5. p-Xylene  
6. m-Xylene  
7. Ethylbenzene  
8. o-Xylene  
9. 1,3,5-Trimethylbenzene  
10. 1,2,4-Trimethylbenzene  
11. Naphthalene

---

**BTEX Compounds**

Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4304  
Oven: 55°C (5 min) to 75°C at 2°C/min  
Carrier: helium, 20cm/sec  
Det.: FID, 300°C  
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. Methanol  
2. Methyl tert-butyl ether (MTBE)  
3. Benzene  
4. Toluene  
5. p-Xylene  
6. m-Xylene  
7. Ethylbenzene  
8. o-Xylene  
9. 1,3,5-Trimethylbenzene  
10. 1,2,4-Trimethylbenzene  
11. Naphthalene

---

**Epoxides**

**Limonene Oxide**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4310  
Oven: 90°C  
Carrier: helium, 30cm/sec  
Det.: FID, 250°C  
Inj.: 1µL split (100:1), 250°C

1. cis/trans (+)-Limonene oxide  
2. cis/trans (-)-Limonene oxide

---

SUPELCO  
Bulletin 877  
94-0338  
979-0580  
794-0652  
879-0802
**Epoxides**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4310  
Oven: 110°C  
Carrier: helium, 20cm/sec  
Det.: FID, 300°C  
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. R-(+)-Styrene oxide  
2. S-(-)-Styrene oxide  
3. (±)-2,2-Dimethyl-3-phenyloxirane  
4. (±)-trans-2-Methyl-3-phenyloxirane

**Methyl and Ethyl Mandelate**

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4310  
Oven: 130°C  
Carrier: helium, 30cm/sec  
Det.: FID, 300°C  
Inj.: 1µL methanol (0.5mg/mL each analyte), split (100:1), 300°C

1. S-(+)-Methyl mandelate  
2. R-(-)-Methyl mandelate  
3. S-(+)-Ethyl mandelate  
4. R-(-)-Ethyl mandelate

**Ethers**

**Methyl and Ethyl Mandelate**

Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4301  
Oven: 110°C  
Carrier: helium, 20cm/sec  
Det.: FID, 300°C  
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. cis-Methylstyrene oxide  
2. (±)-2,2-Dimethyl-3-phenyloxirane  
3. (±)-trans-2-Methyl-3-phenyloxirane

**Ethyl 2-Methylbutyrate**

Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4304  
Oven: 40°C  
Carrier: helium, 20cm/sec  
Det.: FID, 200°C (β-DEX 110) or 300°C (β-DEX 120)  
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 100°C (β-DEX 110) or 250°C (β-DEX 120)

1. S-(+)-Ethyl 2-methylbutyrate  
2. R-(-)-Ethyl 2-methylbutyrate  
3. Impurity  
4. cis-Methylstyrene oxide  
5. (±)-2,2-Dimethyl-3-phenyloxirane  
6. (±)-trans-2-Methyl-3-phenyloxirane  
7. (+) Ethyl 2-methylbutyrate
Methyl 2-Chloropropionate and Methyl 2-Bromopropionate

Column: β-DEX 120, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4304
Oven: 70°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. (±)-Methyl 2-chloropropionate
2. (±)-Methyl 2-bromopropionate

Methyl Mandelate (Enantio-reversal)

Column: α-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4310 (α-DEX 120), 2-4307 (γ-DEX 120)
Oven: 130°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C

1. S-(+)-Methyl mandelate
2. R-(-)-Methyl mandelate

Ethers

Bis(2-chloroisopropyl)ether

Column: α-DEX 120, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4310
Oven: 70°C to 200°C at 2°C/min
Carrier: helium, 20cm/sec
Det.: MSD (scan: 18-500 amu)
Inj.: 1µL methylene chloride containing ~1mg/mL racemate, split 100:1, 220°C

1. Bis(2-chloroisopropyl)ether Isomers
2. 1,1'-Oxybis(3-chloropropane) (impurity)

Free Acids

4-Methyloctanoic Acid

Column: α-DEX 120, 30m x 0.25mm ID x 0.25μm film
Cat. No.: 2-4307
Oven: 115°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride containing ~1mg/mL racemate, split 100:1, 220°C

1. S-(+)-Methyl mandelate
2. R-(-)-Methyl mandelate

H
H
\[
\begin{align*}
\text{O} & \quad \text{OCH}_3 \\
\text{Cl/Br} & \\
\end{align*}
\]

Free Acids

4-Methyloctanoic Acid

Column: α-DEX 120, 30m x 0.25mm ID x 0.25μm film
Cat. No.: 2-4307
Oven: 115°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride containing ~1mg/mL racemate, split 100:1, 220°C

1. S-(+)-Methyl mandelate
2. R-(-)-Methyl mandelate

H
H
\[
\begin{align*}
\text{O} & \quad \text{OCH}_3 \\
\text{Cl/Br} & \\
\end{align*}
\]

Free Acids

4-Methyloctanoic Acid

Column: α-DEX 120, 30m x 0.25mm ID x 0.25μm film
Cat. No.: 2-4307
Oven: 115°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride containing ~1mg/mL racemate, split 100:1, 220°C

1. S-(+)-Methyl mandelate
2. R-(-)-Methyl mandelate

H
H
\[
\begin{align*}
\text{O} & \quad \text{OCH}_3 \\
\text{Cl/Br} & \\
\end{align*}
\]
Diethoxytetrahydrofuran

Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 70°C/90°C/110°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

Oven: 70°C
1. 2,5-trans-Diethoxytetrahydrofuran
2. 2,5-cis-Diethoxytetrahydrofuran

Oven: 90°C
1. 2,5-trans-Diethoxytetrahydrofuran
2. 2,5-cis-Diethoxytetrahydrofuran

Oven: 110°C
1. 2,5-trans-Diethoxytetrahydrofuran
2. 2,5-cis-Diethoxytetrahydrofuran

Dimethoxytetrahydrofuran

Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 60°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. (±)-trans-2,5-Dimethoxytetrahydrofuran
2. cis-2,5-Dimethoxytetrahydrofuran

Halogenated Compounds

Isoflurane (Florane)

Column: β-DEX 110, 60m x 0.53mm ID, 0.5µm film
Cat. No.: 2-5411
Oven: 35°C
Carrier: helium, 20cm/sec
Det.: FID, 250°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. (±)-2,5-Diethoxytetrahydrofuran
2. 2,5-cis-Diethoxytetrahydrofuran

1. (±)-2,5-Diethoxytetrahydrofuran
2. 2,5-cis-Diethoxytetrahydrofuran

1. Isoflurane
**Hydrocarbons**

**α-BHC and PCCH (Enantio-reversal)**

- **Column:** β-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25μm film
- **Cat. No.:** 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
- **Oven:** 160°C
- **Carrier:** helium, 30cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 200°C

**Barbitals**

- **Column:** β-DEX 110, 30m x 0.25mm ID, 0.25μm film
- **Cat. No.:** 2-4301
- **Oven:** 210°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

**Ketones**

**Barbitals**

- **Column:** β-DEX 120, 30m x 0.25mm ID, 0.25μm film
- **Cat. No.:** 2-4304
- **Oven:** 210°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

**α-Pinene, Camphene, and Limonene**

- **Column:** β-DEX 120, 30m x 0.25mm ID, 0.25μm film
- **Cat. No.:** 2-4304
- **Oven:** 80°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 150°C

**Barbitals**

- **Column:** β-DEX 120, 30m x 0.25mm ID, 0.25μm film
- **Cat. No.:** 2-4304
- **Oven:** 210°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (5.0mg/mL each analyte), split (100:1), 300°C
Phenols

Dimethylphenol Positional Isomers

Column: β-DEX 110, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4301
Oven: 140°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 220°C

1. 2,6-Dimethylphenol
2. 2,4-Dimethylphenol
3. 3,5-Dimethylphenol
4. 3,4-Dimethylphenol
5. 3,5-Dimethylphenol
6. 3,4-Dimethylphenol

Lactones

Alkylated γ-Lactones

Column: β-DEX 110, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4301
Oven: 90°C to 200°C at 1°C/min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 220°C

1. (±)-Methyl-γ-lactone
2. (±)-Ethyl-γ-lactone
3. (±)-Propyl-γ-lactone
4. (±)-Butyl-γ-lactone

Carvone (Enantioreversal)

Sample: 0.3mg/mL S-(+)/0.2mg/mL R(-) solution extracted by solid phase microextraction (100μm polydimethylsiloxane-coated SPME fiber, 30°C, 10 min)
Column: α-DEX 120, β-DEX 120, and γ-DEX 120, 30m x 0.25mm ID, 0.25μm film
Cat. No.: 2-4310 (α-DEX 120), 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 90°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

1. S-(+)-Carvone
2. R-(−)-Carvone

Figure provided by J. Novrocik, DEZA Corporation, Czech Republic.
Toxicity Characteristics Leaching Procedure (TCLP)

**Acids**

- **Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film
- **Cat. No.:** 2-4310
- **Oven:** 130°C to 220°C at 3°C/min
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. 2-Chlorophenol
2. Phenol
3. 2-Methylphenol (o-Cresol)
4. 4-Methylphenol (p-Cresol)
5. 3-Methylphenol (m-Cresol)
6. 2,4,6-Trichlorophenol
7. 2,4-Dichlorophenol
8. 2,6-Dichlorophenol
9. 4-Chloro-3-methylphenol
10. 2,3,5-Trichlorophenol
11. 2,4,5-Trichlorophenol
12. Pentachlorophenol
13. 2,4-Dinitrophenol
14. Pentachlorophenol

**Methylphenols (Cresols)**

- **Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film
- **Cat. No.:** 2-4310
- **Oven:** 160°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. Phenol
2. 2-Methylphenol (o-Cresol)
3. 4-Methylphenol (p-Cresol)
4. 3-Methylphenol (m-Cresol)

**Silicon Compounds**

- **Column:** β-DEX 110, 30m x 0.25mm ID, 0.25µm film
- **Cat. No.:** 2-4301
- **Oven:** 100°C to 220°C at 2°C/min
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C

1. 2-Chlorophenol
2. Phenol
3. 2-Methylphenol (o-Cresol)
4. 4-Methylphenol (p-Cresol)
5. 3-Methylphenol (m-Cresol)
6. 2,4,6-Trichlorophenol
7. 2,4-Dichlorophenol
8. 2,6-Dichlorophenol
9. 4-Chloro-3-methylphenol
10. 2,3,5-Trichlorophenol
11. 2,4,6-Trichlorophenol
12. 2,3,4-Trichlorophenol
13. 2,4,5-Trichlorophenol
14. 4-Nitrophenol
15. 2,3,5,6-Tetrachlorophenol
16. 2,3,4,6-Tetrachlorophenol
17. 2,3,4,5-Tetrachlorophenol
18. 4,6-Dinitro-2-methylphenol
19. 2,4-Dinitrophenol
20. Pentachlorophenol
21. 2,3,4,6-Tetrachlorophenol
22. 2,3,4,5-Tetrachlorophenol
23. 4,6-Dinitro-2-methylphenol
24. 2,4-Dinitrophenol
25. Pentachlorophenol

**Phenols**

- **Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film
- **Cat. No.:** 2-4310
- **Oven:** 160°C
- **Carrier:** helium, 20cm/sec
- **Det.:** FID, 300°C
- **Inj.:** 1μL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C

1. Phenol
2. 2-Methylphenol (o-Cresol)
3. 4-Methylphenol (p-Cresol)
4. 3-Methylphenol (m-Cresol)
5. 2,4,5-Trichlorophenol
6. Pentachlorophenol
7. 2,4,6-Trichlorophenol
8. 2,4-Dichlorophenol
9. 2,6-Dichlorophenol
10. 4-Chloro-3-methylphenol
11. 2,3,5-Trichlorophenol
12. 2,4,6-Trichlorophenol
13. 2,3,4-Trichlorophenol
14. 2,4,5-Trichlorophenol
15. 4-Nitrophenol
16. 2,3,5,6-Tetrachlorophenol
17. 2,3,4,6-Tetrachlorophenol
18. 2,3,4,5-Tetrachlorophenol
19. 4,6-Dinitro-2-methylphenol
20. 2,4-Dinitrophenol
21. Pentachlorophenol
22. 2,3,4,6-Tetrachlorophenol
23. 2,3,4,5-Tetrachlorophenol
24. 4,6-Dinitro-2-methylphenol
25. 2,4-Dinitrophenol
26. Pentachlorophenol
**Solvents**

**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Cat. No.:** 2-4310  
**Cat. No.:** 57300-U  
**Cat. No.:** 2-4304  
**Cat. No.:** 2-4310  
**Cat. No.:** 795-0812

**Sample:** 0.5g sliced juniper leaves in 7mL vial  
**SPME Fiber:** 100µm polydimethylsiloxane  
**Cat. No.:** 57300-U  
**Cat. No.:** 2-4304  
**Cat. No.:** 2-4310  
**Cat. No.:** 795-0812

**Carrier:** hydrogen, 30cm/sec  
**Carrier:** helium, 35cm/sec  
**Carrier:** hydrogen, 30cm/sec  
**Carrier:** helium, 35cm/sec  
**Carrier:** helium, 35cm/sec

**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C

**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C

**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film

**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310

**Oven:** 40°C (2 min) to 180°C at 5°C/min, hold 10 min  
**Oven:** 40°C (2 min) to 180°C at 5°C/min, hold 10 min  
**Oven:** 40°C (2 min) to 220°C at 4°C/min  
**Oven:** 40°C (2 min) to 220°C at 4°C/min  
**Oven:** 40°C (2 min) to 220°C at 4°C/min

**Carrier:** hydrogen, 30cm/sec  
**Carrier:** hydrogen, 30cm/sec  
**Carrier:** helium, 35cm/sec  
**Carrier:** helium, 35cm/sec  
**Carrier:** helium, 35cm/sec

**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C

**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C  
**Inj.:** 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C

**Solvents**

**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Cat. No.:** 2-4310

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**SPME/ Chiral Capillary GC**

**Juniper Leaves**

Sample: 0.5g sliced juniper leaves in 7mL vial  
**SPME Fiber:** 100µm polydimethylsiloxane  
**Cat. No.:** 57300-U  
**Cat. No.:** 2-4304  
**Cat. No.:** 2-4310  
**Cat. No.:** 795-0812

**Extraction:** headspace, 40°C, 20 min  
**Extraction:** headspace, 40°C, 20 min  
**Extraction:** headspace, 40°C, 20 min  
**Extraction:** headspace, 40°C, 20 min

**Desorption:** 1 min, 250°C  
**Desorption:** 1 min, 250°C  
**Desorption:** 1 min, 250°C  
**Desorption:** 1 min, 250°C

**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Column:** α-DEX 120, 30m x 0.25mm ID, 0.25µm film

**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310  
**Cat. No.:** 2-4310

**Carrierr:** hydrogen, 30cm/sec  
**Carrierr:** hydrogen, 30cm/sec  
**Carrierr:** helium, 35cm/sec  
**Carrierr:** helium, 35cm/sec

**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C  
**Det.:** FID, 200°C

**Inj.:** split (100:1), 250°C  
**Inj.:** split (100:1), 250°C  
**Inj.:** split (100:1), 250°C  
**Inj.:** split (100:1), 250°C

**Monoterpenes**

1. α-Thujene  
2. (-)-α-Pinene  
3. (+)-α-Pinene  
4. Tricyclene  
5. β-Myrcene  
6. Sabineene  
7. (+)-Camphene  
8. (-)-Camphene  
9. α-Terpineene  
10. (+)-Limonene  
11. β-Pinene  
12. Terpinolene  
13. Terpinene  
14. Limonene  
15. Terpinolene  
16. Borneol  
17. Borneol  
18. Bornyl acetate  
19. Coparane  
20. (-)-β-Cadinene  
21. Caryophyllene  
22. γ-Cadinene  
23. Germacrene D

**Sesquiterpenes**

1. α-Thuene  
2. (+)-α-Pinene  
3. (+)-α-Pinene  
4. Tricyclene  
5. β-Myrcene  
6. Sabineene  
7. (+)-Camphene  
8. (-)-Camphene  
9. α-Terpineene  
10. (+)-Limonene  
11. β-Pinene  
12. Terpinolene  
13. Terpinene  
14. Limonene  
15. Terpinolene  
16. Terpinone-4-ol  
17. Bornol  
18. Bornyl acetate  
19. Coparane  
20. (-)-β-Cadinene  
21. Caryophyllene  
22. γ-Cadinene  
23. Germacrene D
White Pine Leaves

Sample: 0.5g pine leaves in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 40°C, 20 min
Desorption: 1 min, 250°C
Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 40°C (2 min) to 220°C at 4°C/min
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

Lemon Oil

Sample: 0.5g lemon oil in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 30°C, 30 sec
Desorption: 1 min, 250°C
Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 40°C (2 min) to 220°C at 4°C/min, hold 5 min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C
Ginger Oil

Sample: 0.5g ginger oil in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 30°C, 30 sec
Desorption: 1 min, 250°C
Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 40°C (2 min) to 220°C at 4°C/min, hold 5 min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

Perfume

Sample: 1g perfume in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 30°C, 1 min
Desorption: 1 min, 250°C
Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 40°C (2 min) to 220°C at 4°C/min, hold 5 min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C
### Spearmint Oil and Spearmint Gum

**Sample:** 0.5g spearmint oil or gum in 7mL vial  
**SPME Fiber:** 100 µm polydimethylsiloxane  
**Cat. No.:** 57300-U (manual sampling)  
**Extraction:** headspace, 30°C, 3 min  
**Desorption:** 1 min, 250°C  
**Column:** β-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Cat. No.:** 2-4304  
**Oven:** 40°C (2 min) to 220°C at 4°C/min  
**Carrier:** helium, 35cm/sec  
**Det.:** FID, 300°C  
**Inj.:** split (100:1), 250°C

#### Spearmint Oil

#### Spearmint Gum

### Peppermint Oil and Peppermint Candy

**Sample:** 0.5g peppermint oil or crushed candy in 7mL vial  
**SPME Fiber:** 100 µm polydimethylsiloxane  
**Cat. No.:** 57300-U (manual sampling)  
**Extraction:** headspace, 30°C, 3 min  
**Desorption:** 1 min, 250°C  
**Column:** β-DEX 120, 30m x 0.25mm ID, 0.25µm film  
**Cat. No.:** 2-4304  
**Oven:** 40°C (2 min) to 220°C at 4°C/min  
**Carrier:** helium, 35cm/sec  
**Det.:** FID, 300°C  
**Inj.:** split (100:1), 250°C

#### Peppermint Oil

#### Peppermint Candy
**Lavender Oil**

Sample: 0.5g lavender oil in 7mL vial  
SPME Fiber: 100µm polydimethylsiloxane  
Cat. No.: 57300-U (manual sampling)  
Extraction: headspace, 30°C, 30 sec  
Desorption: 1 min, 250°C  
Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4304  
Oven: 40°C (2 min) to 220°C at 4°C/min, hold 5 min  
Carrier: helium, 20cm/sec  
Det.: FID, 300°C  
Inj.: split (100:1), 250°C  

1. α-Thujene  
2. (-)-α-Pinene  
3. (+)-α-Pinene  
4. β-Mycene  
5. (+)-Camphene  
6. (-)-Camphene  
7. (+)-β-Pinene  
8. (-)-β-Pinene  
9. cis-β-Ocimene  
10. p-Cumene  
11. (±)-Cineole  
12. (±)-α-Terpinolene  
13. (±)-Linalool  
14. (±)-Linalylacetate  
15. Camphor  
16. (+)-Terpinen-4-ol  
17. (-)-Terpinen-4-ol  
18. (±)-Borneol

**Mushroom Extract**

Sample: 5g fresh mushroom extract or 5g fresh mushroom extract plus 2μL of 2ppm solution of (±)-1-octen-3-ol in 7mL vial  
SPME Fiber: 100µm polydimethylsiloxane  
Cat. No.: 57300-U (manual sampling)  
Extraction: headspace, 40°C, 5 min  
Desorption: 1 min, 250°C  
Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film  
Cat. No.: 2-4310  
Oven: 80°C  
Carrier: helium, 30cm/sec  
Det.: FID, 300°C  
Inj.: split (100:1), 250°C  

1. (-)-1-Octen-3-ol  
2. (+)-1-Octen-3-ol

**Fresh Mushroom Extract**

Min 15

1. (-)-1-Octen-3-ol  
2. (+)-1-Octen-3-ol

**Fresh Mushroom Extract, (±)-1-Octen-3-ol Added**

Min 14

1. 1  
2. 2
Dill Seed

Sample: 1g dill seed or 1g dill seed plus 1µL carvone isomer in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 30°C, 5 min
Desorption: 1 min, 250°C
Cat. No.: 24310
Oven: 80°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

1. R-(+)-Limonene
2. R-(-)-Carvone
3. S-(+)-Carvone

Caraway Seed

Sample: 0.5g caraway seed, 0.5g caraway seed plus 1µL R-(+)-carvone in 7mL vial
SPME Fiber: 100µm polydimethylsiloxane
Cat. No.: 57300-U (manual sampling)
Extraction: headspace, 40°C, 5 min
Desorption: 1 min, 250°C
Cat. No.: 24310
Oven: 80°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

1. R-(+)-Carvone
2. S-(+)-Carvone

DEX 225 and DEX 325 Columns are the latest additions to the DEX column line. See inside back cover.

Column: p-DEX 325, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 24308
Oven: 110°C, 1-phenyl-2-propanol; 100°C, isopinocampheol; 90°C, 6-methyl-5-hepten-2-ol
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1) 220°C

1-Phenyl-2-propanol

Isopinocampheol

6-Methyl-5-hepten-2-ol
Custom Columns
We can prepare fused silica capillary columns with:
1-30% permethylated cyclodextrin, 0.1-0.5µm film
5-100 meter length
0.10-0.53mm ID
alternative cyclodextrin derivatives
alternative stationary cophases
Prices for these columns are comparable to prices for stock DEX columns. Please contact our Technical Service chemists or your local sales representative for more information.

Cyclodextrin Column Selection Kit II
In combination with Kit I, this kit provides you with a library of columns that spans the full range of DEX column enantioselectivity at substantial savings, relative to purchasing individual columns. Kit includes one 30m x 0.25mm ID, 0.25µm film column of each type: β-DEX 120, β-DEX 225, γ-DEX 225, β-DEX 325.

Ordering Information:

α-DEX 120
The chiral stationary phase in α-DEX columns contains permethylated α-cyclodextrin embedded in an intermediate polarity stationary phase. The columns provide unique selectivity for the enantiomeric separation of small molecules; also recommended for separating positional isomers (phenols, xylenes, etc.).

Phase: nonbonded; 20% permethylated α-cyclodextrin

Temp. Limits: 30°C to 250°C

γ-DEX 120
The chiral stationary phase in γ-DEX columns contains 20% permethylated γ-cyclodextrin embedded in an intermediate polarity stationary phase. Because the elution order of the members of a chiral pair frequently reverses (enantioreversal) on a γ-DEX column, compared to the elution order on an α-DEX or β-DEX column, we recommend γ-DEX columns as complements to α-DEX and β-DEX columns.

Phase: nonbonded; 20% permethylated γ-cyclodextrin

Temp. Limits: 30°C to 250°C

β-DEX 110, β-DEX 120
The chiral stationary phase in β-DEX columns contains permethylated β-cyclodextrin embedded in an intermediate polarity stationary phase. Recommended for the enantiomeric separation of a wide range of chiral compounds (ketones, esters, alkanes, alkenes, acids, ethers, etc.). The 10% (β-DEX 110) and 20% (β-DEX 120) β-cyclodextrin content alters the elution order while maintaining similar enantioselectivity.

Phase: nonbonded; 10% and 20% permethylated β-cyclodextrin

Temp. Limits: 30°C to 250°C

Cyclodextrin Column Selection Kit I
This kit provides you with the tools you need to perform most chiral separations. Identities of enantiomers can be confirmed by monitoring changes in their elution order (enantioreversal) from an α-DEX column to a β-DEX column, a β-DEX column to a γ-DEX column, or an α-DEX column to a γ-DEX column.

Kit includes one 30m x 0.25mm ID, 0.25µm film column of each type: α-DEX 120, β-DEX 120, γ-DEX 120.

Cyclodextrin Column Selection Kit II
In combination with Kit I, this kit provides you with a library of columns that spans the full range of DEX column enantioselectivity at substantial savings, relative to purchasing individual columns. Kit includes one 30m x 0.25mm ID, 0.25µm film column of each type: β-DEX 120, β-DEX 225, γ-DEX 225, β-DEX 325.
The chiral stationary phase in α-DEX 225 columns contains 2,3-di-O-acetyl-6-O-TBDMS-α-cyclodextrin embedded in an intermediate polarity phase.

**Phase:** nonbonded; 25% 2,3-di-O-acetyl-6-O-TBDMS-α-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>d (µm)</th>
<th>Beta</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
</tr>
</tbody>
</table>

The chiral stationary phase in β-DEX 225 columns contains 2,3-di-O-acetyl-6-O-TBDMS-β-cyclodextrin embedded in an intermediate polarity phase. These columns provide unique selectivity for enantiomeric separations of small molecules: alcohols, aldehydes (e.g., 2-phenylpropionaldehyde), esters (e.g., methyl malate, methyl lactate), flavor compounds, and ketones.

**Phase:** nonbonded; 25% 2,3-di-O-acetyl-6-O-TBDMS-β-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>d (µm)</th>
<th>Beta</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
</tr>
<tr>
<td>0.32mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>320</td>
</tr>
<tr>
<td>0.53mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>265</td>
</tr>
</tbody>
</table>

The chiral stationary phase in γ-DEX 225 columns contains 2,3-di-O-acetyl-6-O-TBDMS-γ-cyclodextrin embedded in an intermediate polarity phase.

**Phase:** nonbonded; 25% 2,3-di-O-acetyl-6-O-TBDMS-γ-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
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<tr>
<th>Length (m)</th>
<th>d (µm)</th>
<th>Beta</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
</tr>
</tbody>
</table>

The chiral stationary phase in α-DEX 325 columns contains 2,3-di-O-methyl-6-O-TBDMS-α-cyclodextrin embedded in an intermediate polarity phase.

**Phase:** nonbonded; 25% 2,3-di-O-methyl-6-O-TBDMS-α-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>d (µm)</th>
<th>Beta</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
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</tbody>
</table>

The chiral stationary phase in β-DEX 325 columns contains 2,3-di-O-methyl-6-O-TBDMS-β-cyclodextrin embedded in an intermediate polarity phase.

**Phase:** nonbonded; 25% 2,3-di-O-methyl-6-O-TBDMS-β-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>d (µm)</th>
<th>Beta</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
</tr>
<tr>
<td>0.32mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>320</td>
</tr>
<tr>
<td>0.53mm ID Fused Silica</td>
<td>30</td>
<td>0.50</td>
<td>265</td>
</tr>
</tbody>
</table>

The chiral stationary phase in γ-DEX 325 columns contains 2,3-di-O-methyl-6-O-TBDMS-γ-cyclodextrin embedded in an intermediate polarity phase.

**Phase:** nonbonded; 25% 2,3-di-O-methyl-6-O-TBDMS-γ-cyclodextrin embedded in SPB-20 poly(20% phenyl/80% dimethylsiloxane)

**Temp. Limits:** 30°C to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.25mm ID Fused Silica</td>
<td>30</td>
<td>0.25</td>
<td>250</td>
</tr>
</tbody>
</table>

Selective, new-generation columns: high resolution, high temperature limits, low bleed, individually tested. Temperature range: 30°C – 240°C/250°C (isothermal/programmed)

Cyclodextrin Column Selection Kit
Determine which DEX column most effectively separates your samples, or use different columns to produce enantio-reversals. Kit includes three 30m x 0.25mm ID x 0.25µm film columns, one of each 20% cyclodextrin type: α-DEX 120, β-DEX 120, γ-DEX 120.

Catalog No. 2-4340

Custom-Prepared Cyclodextrin Columns
Customize enantioselectivity / efficiency / sample capacity to your exact needs, by choosing:

- CD inclusion cavity size
- CD content 1-30% CD / 0.1-0.5µm film
- Column internal diameter 0.10-0.53mm
- Column length 5-100m

Prices for these columns are comparable to prices for stock DEX columns. Please contact our Technical Service chemists for more information (Phone 800-359-3041 or 814-359-3041, FAX 800-359-3044 or 814-359-5468).

For prices, or to order:
Phone: 800-247-6628 or 814-359-3441
FAX: 800-447-3044 or 814-359-3044