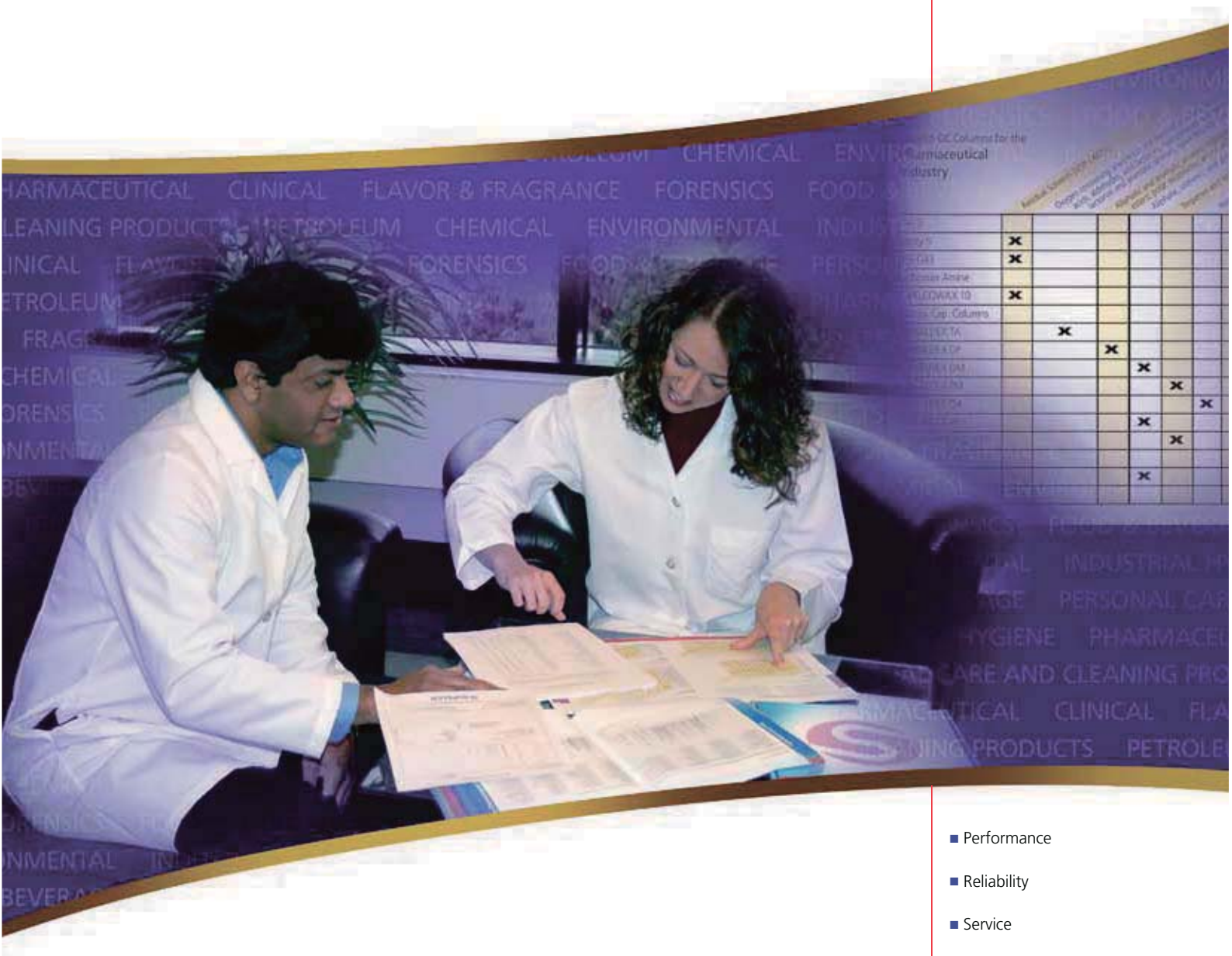
GC Column Selection Guide

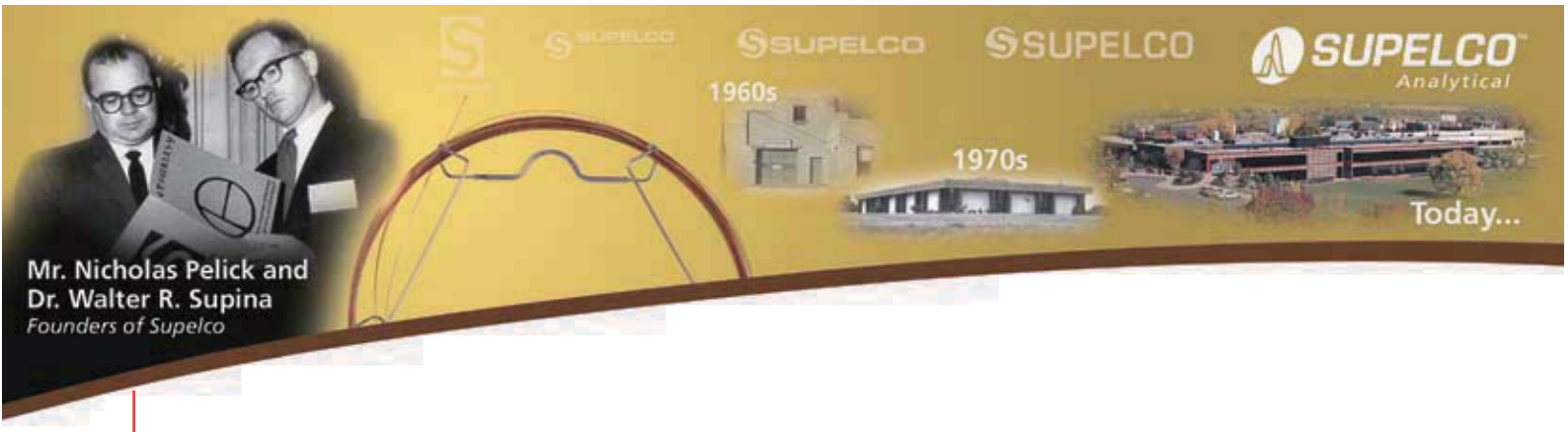
Achieve Optimal Method Performance

SUPELCO® Analytical



- Performance
- Reliability
- Service

SIGMA-ALDRICH®



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.

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

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 reference 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 (β), 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*

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

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.

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

Phase Polarity Based on Compound Polarity

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

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.

to be analyzed. Phase selection is based on the general chemical principle that "likes dissolves like." A non-polar column is the recommended starting point for the analyses of non-polar compounds. Likewise, polar columns are usually recommended for the separation of polar compounds. The "Phase Polarity" insert (see Page 4) describes several recommended phases for each group of compound polarities.

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.

Table 1. Effects of Column I.D.

Internal Diameter (mm)	Efficiency: Plates/Meter (N/m)	Efficiency: Total Plates (N)	Capacity Each Analyte (ng)
0.53	1,300	39,000	1000-2000
0.32	2,300	69,000	400-500
0.25	2,925	87,750	50-100
0.20	3,650	109,500	<50
0.18	4,050	121,500	<50
0.10	7,300	219,000	<10

Theoretical values for 30 m long columns, calculated @ a k' = 6.00 and 85% coating efficiency

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.

Table 2. Effects of Film Thickness

	0.10 to 0.25 µm film	1 to 5 µm film
Benefits	Sharper peak shape May increase resolution Decreased column bleed Increased signal-to-noise Increased max. temp.	Reduced interaction w/tubing Increased analyte capacity
Drawbacks	Increased interaction w/tubing Decreased analyte capacity	Increased peak width May decrease resolution Increased column bleed Decreased max. temp.
Other	Decreased retention Decreased elution temp.	Increased retention May increase resolution Increased elution temperature
Uses	High boiling point analytes Semivolatiles Trace analyses	Low boiling point analytes Volatiles, gases High analyte concentrations

Phase Ratio (β)

Effects of phase film thickness are interdependent with column I.D. The phase ratio, beta (β), expresses the ratio of the gas volume and the stationary phase volume in a column:

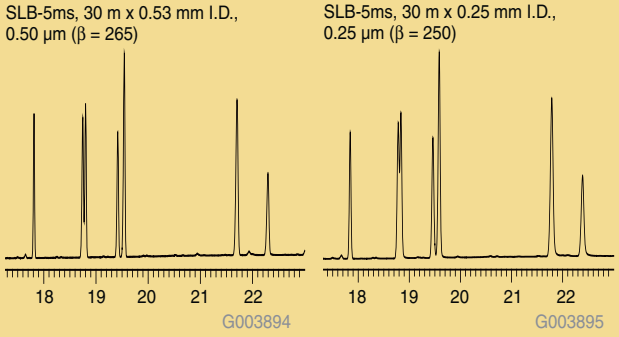
$$\beta = \frac{\text{column radius (µm)}}{\text{2 x film thickness (µm)}}$$

In contrast to relative terms ("thick film" and "thin film"), β values establish a distinct ranking for columns. As a general rule, select columns by β values as follows:

β Value	Uses
<100	Highly volatile, low molecular weight compounds
100-400	General purpose analyses Wide range of compounds
>400	High molecular weight compounds Trace analyses

β values are also useful when changing column I.D. and film thickness combinations for a particular analysis, because columns with the same phase ratio will provide very similar retention times and elution order under the same analytical conditions.

Columns With Similar β Values



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.

Table 3. Effects of Column Length

Column Length (m)	Inlet Pressure (psi)	Peak 1 Retention (min)	Peak 1/2 Resolution (R)	Efficiency: Total Plates (N)
15	5.9	8.33	0.8	43,875
30	12.0	16.68	1.2	87,750
60	24.9	33.37	1.7	175,500

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

Fused Silica Tubing Inner/Outer Diameters

Tubing I.D.	Tubing I.D. Range	Tubing O.D. Range
0.10 mm ▲	0.094 – 0.106 mm	0.349 – 0.369 mm
0.10 mm ▼	0.094 – 0.106 mm	0.290 – 0.310 mm
0.18 mm ▲	0.174 – 0.186 mm	0.349 – 0.369 mm
0.18 mm ▼	0.174 – 0.186 mm	0.330 – 0.350 mm
0.20 mm ◆	0.194 – 0.206 mm	0.349 – 0.370 mm
0.25 mm ◆	0.244 – 0.256 mm	0.349 – 0.370 mm
0.32 mm ◆	0.314 – 0.326 mm	0.425 – 0.450 mm
0.53 mm ◆	0.526 – 0.546 mm	0.640 – 0.680 mm
0.75 mm ◆	0.737 – 0.758 mm	0.875 – 0.925 mm

▲ 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.

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*

Title	Identification
GC Column Literature	
SLB-5ms Capillary GC Columns	T405130 (IKA)
Dioxin & PCB Analysis	(JXB)
Petroleum/Chemical Application Guide	T109858 (AYD)
Free and Total Glycerin in B100 Biodiesel	T107943 (JLH)
Alumina PLOT Capillary GC Columns	T403145 (GFE)
Carboxen PLOT Capillary GC Columns	T403146 (GFF)
Mol Sieve 5A PLOT Capillary GC Columns	T403147 (GFG)
Supel-Q PLOT Capillary GC Columns	T403148 (GFH)
Fatty Acid/FAME Application Guide	T408126 (KUK)
Analyzing Fatty Acids by Capillary GC	T110855 (AYC)
37-Component FAME Mix on Four Capillary Columns	T196907 (AZC)
Capillary Column Choices for Residual Solvents	T103933 (FLX)
CHIRALDEX Chiral Capillary GC Columns	T407123 (JCH)
Chiral Cyclodextrin Capillary GC Columns	T194877 (AXA)
Supelco Columns for USP Methods (Poster)	T403109 (FWK)
Fast GC Brochure	T407096 (JTW)
Equity Capillary GC Columns	T402049 (FAQ)
General Purpose Non-Polar Capillary GC Columns	T405132 (IKC)
General Purpose Polar Capillary GC Columns	T405131 (IKB)
General Purpose Intermediate Polarity Capillary GC Columns	T405133 (IKD)
Capillary GC Troubleshooting Guide	T112853 (AIP)
Installation/Maintenance of 0.25 & 0.32 mm I.D. Columns	T195895 (DLV)
Installation/Maintenance of 0.53 mm I.D. Columns	T195897
Packed GC Column Application Guide	T195890 (AYT)
Sulfur Gases by Packed GC	T100722 (AXP)
Permanent Gases and Light Hydrocarbons by Packed GC	T396112 (BYL)
Packed GC Troubleshooting Guide	T109792 (AIS)

Title	Identification
Related Product Literature	
GC Accessories and Gas Purification/Management	T407103 (JWE)
Capillary Injector Products for Agilent Technologies GCs	T401027 (DWM)
Molded Thermogreen LB-2 Septa	T407082 (JQV)
Capillary GC Inlet Liner Selection Guide	T196899 (BBB)
FocusLiner™ Inler Liners	T408101 (KOX)
Selecting The Appropriate Inlet Liner (Poster)	T404081 (HCH)
The Supelco Guide to Leak-Free Connections	T100741 (AXR)
Selecting Purifiers for Gas Chromatography	T197918 (BIT)
Gas Management Systems for GC	T196898 (AYW)
Gas Generators	T407110 (JXP)
Purge-and-Trap Troubleshooting Guide	T197916 (BIN)
A Tool for Selecting an Adsorbent for Thermal Desorption	T402025 (EQF)
Carbon Adsorbent Kits	T406044 (IPS)
Syringes for Chromatographic & Analytical Applications	T406108 (JCS)
Vials	(IXH)
Vial Selection Guide (Poster)	T405074 (IBV)
Supelco Solid Phase Extraction Products	T402150 (FEB)
Discovery Ag-Ion SPE for cis/trans FAME Fractionation	T406062 (IRV)
Solid Phase Microextraction Application Guide (CD-ROM)	T199925 (CJQ)
SPME: Theory and Optimization of Conditions	T198923 (BQT)
Solid Phase Microextraction Troubleshooting Guide	T101928 (EDV)
A Practical Guide to Quantitation with SPME	T101929 (EDW)
Derivatization Reagents	T407138 (KDI)

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.

1. Harold McNair and James Miller, "Basic Gas Chromatography" (1997), Wiley, ISBN 0-471-17261-8.
2. David Grant, "Capillary Gas Chromatography" (1996), Wiley, ISBN 0-471-95377-6.
3. Dean Rood, "A Practical Guide to the Care, Maintenance, and Troubleshooting of Capillary Gas Chromatographic Systems" (1991), Hüthig, ISBN 3-7785-1898-4.
4. Konrad Grob, "Split and Splitless Injection in Capillary GC" (1993), Hüthig, ISBN 3-7785-2151-9.
5. Konrad Grob, "On-Column Injection in Capillary Gas Chromatography" (1991), Hüthig, ISBN 3-7785-2055-5.
6. William McFadden, "Techniques of Combined Gas Chromatography/Mass Spectrometry: Applications in Organic Analysis" (1988), Robert E. Krieger Publishing Company, ISBN 0-89464-280-4.
7. Marvin McMaster and Christopher McMaster, "GC/MS: A Practical User's Guide" (1998), Wiley-VCH, ISBN 0-471-24826-6.
8. Janusz Pawliszyn, "Solid Phase Microextraction: Theory and Practice" (1997), Wiley-VCH, ISBN 0-471-19034-9.

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.

Supelco GC Columns for the **Environmental Industry**	GC-MS Volatiles	GC Volatiles	GC-MS Semivolatiles	GC Semivolatiles	GC-MS Dioxins	GC-MS PCB Congeners	GC-MS PBDE Congeners	Toxic Organics - TO-1/TO-2	Toxic Organics - TO-4/TO-10	Toxic Organics - TO-9	Toxic Organics - TO-13	Toxic Organics - TO-14/TO-15/TO-17	Hazardous Air Pollutants
SPB-Octyl						X							
SPB-HAP													X
Equity-1								X				X	
SLB-5ms			X	X	X	X	X		X	X	X		
SPB-624	X	X											
VOCOL	X	X											
SPB-608				X					X				
Sup-Herb				X									
Equity-1701				X					X				
SPB-50				X									
SPB-225					X					X			
SP-2331					X					X			
SLB-IL100						X							

Industrial Hygiene Industry

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

Supelco GC Columns for the **Industrial Hygiene Industry**	Indoor Air Quality - EPA IP-8	Indoor Air Quality - NIOSH 1003	Indoor Air Quality - NIOSH 1403	Indoor Air Quality - NIOSH 1500/1501	Indoor Air Quality - NIOSH 2530	Indoor Air Quality - NIOSH 2542	Indoor Air Quality - NIOSH 5503	Indoor Air Quality - OSHA 53	Indoor Air Quality - OSHA 56	Indoor Air Quality - OSHA 62	Indoor Air Quality - OSHA 80	Toxic Organics - TO-1/TO-2	Toxic Organics - TO-4/TO-10	Toxic Organics - TO-9	Toxic Organics - TO-13	Toxic Organics - TO-14/TO-15/TO-17	Hazardous Air Pollutants
SPB-HAP																	X
Equity-1			X	X		X		X	X			X				X	
SLB-5ms	X				X		X			X			X	X	X		
VOCOL		X															
SPB-608													X				
Equity-1701													X				
SPB-225														X			
SUPELCOWAX 10										X							
SP-2331														X			

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**

	Residual Solvents [USP <467>]	Oxygen containing analytes in the form of alcohols, ketones, acids, aldehydes, and lactones; halogenated compounds; lactones and aromatic amines; epoxides; styrene oxide; furans	Aliphatic and aromatic amines; aliphatic and some aromatic esters; polar racemates; amino acids; amines	Aliphatic, olefenic, and aromatic enantiomers	Terpenes and tertiary amines	Heterocyclic amines	Small molecules, such as alcohols, aldehydes, ketones, esters, and flavor compounds	Basic Compounds	Individual USP/NF Monographs
PTA-5								X	
Equity-5	X								
OVI-G43	X								
Carbowax Amine								X	
SUPELCOWAX 10	X								
Various Cap. Columns									X
CHIRALDEX TA		X							
CHIRALDEX DP			X						
CHIRALDEX DM				X					
CHIRALDEX PM					X				
CHIRALDEX DA						X			
CHIRALDEX PH				X					
Supelco DEX 110, 120					X				
Supelco DEX 225							X		
Supelco DEX 325				X					
Various Pkd. Columns									X

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**

	Antiepileptics	Antihistamines	Basic Drug Screen	Benzodiazepines (acetic anhydride)	Benzodiazepines (TBDMS)	Cold and Sinus Medications	Phenothiazines	Steroids	Sympathomimetic Amines	Sympathomimetic Amines (HFBA)	Sympathomimetic Amines (TFAA)	Tricyclic Antidepressants
Equity-1				X				X				
SLB-5ms			X				X	X		X	X	
PTA-5		X	X			X			X			
SAC-5								X				
SPB-20	X											
SPB-35			X		X							
Equity-1701	X											X
Carbowax® Amine		X	X			X			X			
SP-2510 Packed Column	X											

NOTE: Parentheses indicate analytes analyzed as the specified derivative.

Flavor & Fragrance Industry

Volatiles, 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**

	Flavor & Fragrance Volatiles	Essential Oils	Oxygen containing analytes in the form of alcohols, ketones, acids, aldehydes, and lactones; halogenated compounds; lactones and aromatics amines; epoxides; styrene oxide; furans	Aliphatic and aromatic amines; aliphatic and some aromatic esters; polar racemates; amino acids; amines	Aliphatic, olefenic, and aromatic enantiomers	Terpenes and tertiary amines	Heterocyclic amines	Small molecules, such as alcohols, aldehydes, ketones, esters, and flavor compounds
SLB-5ms	X	X						
SUPELCOWAX 10	X	X						
CHIRALDEX TA			X					
CHIRALDEX DP				X				
CHIRALDEX DM					X			
CHIRALDEX PM						X		
CHIRALDEX DA							X	
CHIRALDEX PH					X			
Supelco DEX 110, 120						X		
Supelco DEX 225								X
Supelco DEX 325					X			

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**

	Accelerants	Blood Alcohols	Drugs of Abuse - Barbiturates	Drugs of Abuse - Basic Drug Screen	Drugs of Abuse - Cannabinoids (TMS)	Drugs of Abuse - Cocaine (TMS)	Drugs of Abuse - Drug Screen (TBDMS)	Drugs of Abuse - Drug Screen (TMS)	Drugs of Abuse - GHB (MTBSTFA)	Drugs of Abuse - Inhalants	Drugs of Abuse - Ketamines (MBTFA)	Drugs of Abuse - LSD (TMS)	Drugs of Abuse - MDMA/Ecstasy (HFBPC)	Drugs of Abuse - Opiates (TMS)	Drugs of Abuse - Phencyclidine [PCP]	Drugs of Abuse - Steroids	Drugs of Abuse - Tryptamines	Glycols
Equity-1	X	X							X									
SLB-5ms	X		X	X	X	X			X		X	X	X	X	X		X	
PTA-5				X														
SAC-5																X		
Equity-5										X						X		
VOCOL		X								X								
SPB-35			X	X			X	X										
Equity-1701			X															
SPB-1000																		X
Nukol																		X
Carbowax Amine				X														

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, trigylcerides, glycols, and sterols can be separated on these special purpose columns.

Supelco GC Columns for the
Food & Beverage Industry

	Alcoholic Beverage Analyses	Sulfur Compounds in Alcoholic Beverages	Solvents	Free Fatty Acids	Polyunsaturated FAMEs by Chain Length	Omega-3 and Omega-6 FAMEs	cis/trans FAME Isomers	Triglycerides	Glycols	Preservatives [Phenolic Antioxidants]	Sterols	Sugars as Alditol Acetates	Pesticide Residues
SPB-1 SULFUR		X											
SLB-5ms			X							X	X		X
MET-Biodiesel								X					
SAC-5											X		
SPB-624	X		X									X	
SPB-20	X		X							X			
SPB-608													X
Sup-Herb													X
Equity-1701	X		X									X	X
SPB-50										X			X
SPB-PUFA					X	X							
Nukol	X		X	X	X	X			X				
SPB-1000	X		X	X	X	X			X				
Omegawax					X	X							
SUPELCOWAX 10	X	X	X		X	X							
SP-2380							X					X	
SP-2560							X						
SLB-IL100					X	X	X						
Supel-Q PLOT		X											

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

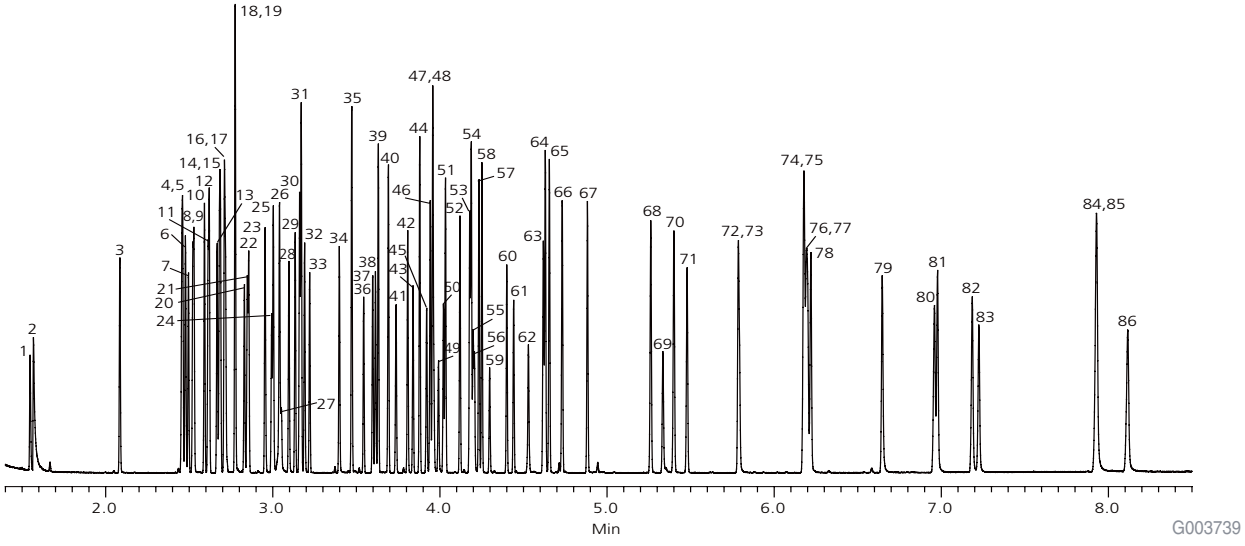
	Alkalis	Coloring Compounds	Fragrance Compounds	Glycols	Preservatives [Phenolic Antioxidants]	Solvents in Cleaning Products	Surfactants [Anionic]	Surfactants [Nonionic]
Equity-1								X
SLB-5ms		X	X			X		X
PTA-5	X							
SPB-20					X			
SPB-50					X			
SPB-1000		X	X	X		X	X	
Nukol		X	X	X		X	X	
Carbowax Amine	X							
SUPELCOWAX 10		X	X			X		

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**

	Detailed Hydrocabon Analyses [DHA]	Simulated Distillation [Sim Dis]	Aromatics	$H_2/O_2/N_2/CO/CH_4/CO_2$	$H_2/N_2/CO/CH_4/CO_2$	$H_2/O_2/N_2/CO/CH_4$	O_2/Argon	C1-C3 Hydrocarbons	C1-C5 Alkanes, Alkenes, and Alkynes	C1-C12 Hydrocarbon	Fluorocarbons	Sulfur Compounds	Process Analyzers	Natural Gas Liquids / Natural Gas	Biodiesel Glycerin Impurity
Petrocol DH Octyl	X														
Petrocol DH 50.2	X													X	
Petrocol DH	X													X	
Petrocol DH 150	X													X	
Petrocol 2887		X													
Petrocol EX2887		X													
SPB-1 SULFUR												X			
MET-Biodiesel															X
HT-5		X													
SP-2380			X												
SLB-IL100			X												
TCEP			X												
Alumina sulfate PLOT								X	X						
Alumina chloride PLOT								X	X		X				
Carboxen-1010 PLOT				X	X	X		X							
Carboxen-1006 PLOT					X			X							
Mol Sieve 5A PLOT						X	X	X							
Supel-Q PLOT			X					X		X	X	X			
Bentone 34/DNDP SCOT			X										X		
BMEA SCOT													X		
Squalane SCOT													X		
TCEP SCOT													X		
Fluorocol™ Packed Column											X				
GPA Packed Columns														X	
Micropacked Columns													X		

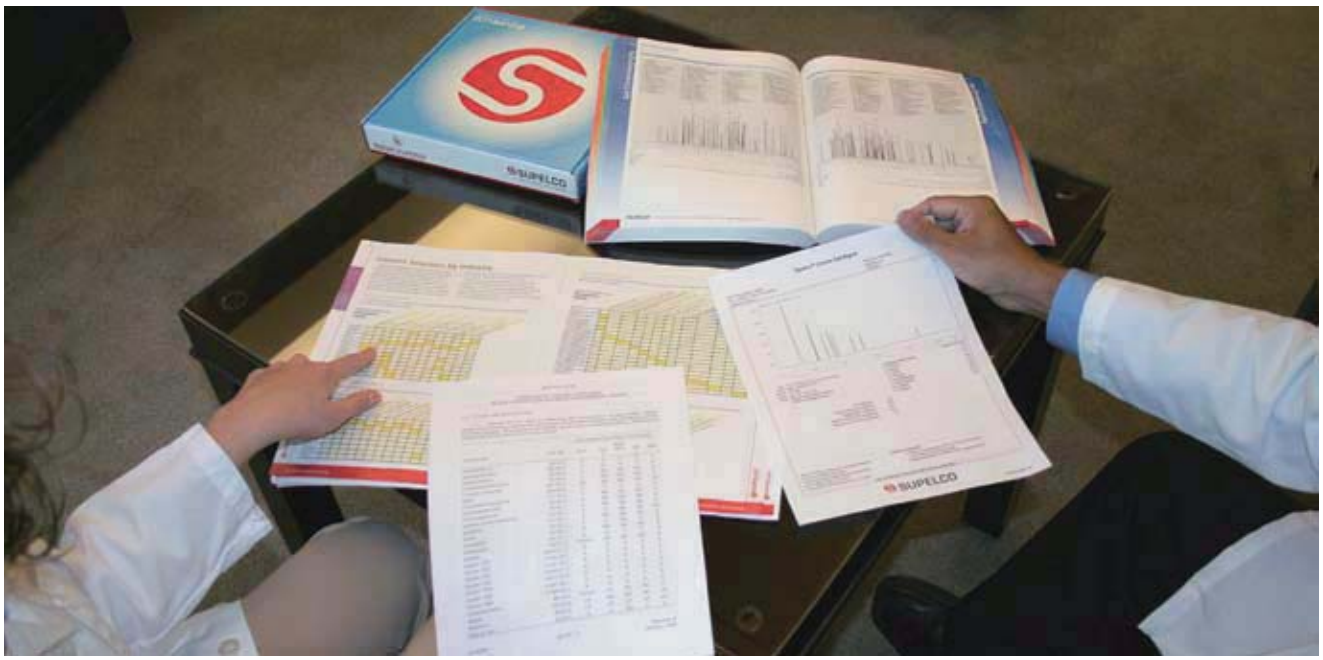


Chemical Industry

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

	Solvents on a Nonpolar Column	Solvents on a Polar Column	Aromatics	$H_2/O_2/N_2/CO/CH_4/CO_2$	$H_2/N_2/CO/CH_4/CO_2$	$H_2/O_2/N_2/CO/CH_4$	O_2/Argon	C1-C3 Hydrocarbons	C1-C5 Alkanes, Alkenes, and Alkynes	C1-C12 Hydrocarbons	Freons	Sulfur Compounds	Acidic Compounds / Glycols	Basic Compounds	Process Analyzers
SPB-1 SULFUR	X											X			
SLB-5ms	X		X												
PTA-5														X	
SPB-1000		X											X		
Nukol		X											X		
Carbowax Amine														X	
SUPELCOWAX 10		X	X												
SLB-IL100			X												
TCEP			X												
Alumina sulfate PLOT								X	X						
Alumina chloride PLOT								X	X		X				
Carboxen-1010 PLOT				X	X	X		X							
Carboxen-1006 PLOT					X			X							
Mol Sieve 5A PLOT						X	X	X							
Supel-Q PLOT			X					X		X	X	X			
Bentone 34/DNDP SCOT			X												X
BMEA SCOT															X
Squalane SCOT															X
TCEP SCOT															X
Fluorocol Packed Column											X				
Micropacked Columns															X



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.

Supelco GC Columns for **Fast GC Applications**

	Environmental Volatiles	Environmental Semivolatiles	Environmental Pesticides and PCBs	Petroleum Aromatics	Food & Beverage Omega-3 and -6 FAMEs	Food & Beverage *cis*/*trans* FAME Isomers	General Purpose Polar	General Purpose Nonpolar
SPB-624	X							
VOCOL	X							
SLB-5ms		X	X					
Equity-1701			X					
SLB-IL100				X	X	X		
TCEP				X				
Omegawax 100					X			
SP-2560						X		
SUPELCOWAX 10							X	
Equity-1								X
SPB-1								X
Equity-5								X
SPB-5								X

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.

Supelco GC Columns for **General Purpose Applications**

	Nonpolar Column	Intermediate Polarity Column	Polar Column	High Polarity Column
SPB-Octyl	X			
Equity-1	X			
SPB-1	X			
Equity-5	X			
SPB-5	X			
SPB-20		X		
SPB-35		X		
Equity-1701		X		
SPB-50		X		
SPB-225			X	
PAG			X	
SUPELCOWAX 10			X	
SP-2330				X
SP-2380				X
SP-2340				X

Cross-Reference Chart

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

Supelco	Agilent	Grace	Macherey-Nagel	Phenomenex®	Restek	SGE	Varian
TRADITIONAL (phases by increasing phase polarity)							
Petrocol DH Octyl	-	-	-	-	-	-	-
SPB-Octyl	-	-	-	-	-	-	CP-Sil 2 CB
SPB-HAP	-	-	-	-	-	-	-
Petrocol DH 50.2	DB-Petro, HP-PONA	-	-	-	-	BP1 PONA	-
Petrocol DH	DB-Petro	AT-Petro	-	-	Rtx-1PONA	BP1 PONA	CP-Sil PONA CB
Petrocol DH 150	-	-	-	-	-	-	-
Petrocol 2887, Petrocol EX2887	DB-2887	AT-2887	-	-	Rtx-2887	-	CP-SimDist
SPB-1 SULFUR	-	AT-Sulfur	-	-	-	-	CP-Sil 5 CB for Sulfur
Equity-1, SPB-1	DB-1, HP-1	AT-1	Optima-1	ZB-1	Rtx-1	BP1	CP-Sil 5 CB
SLB-5ms	DB-5ms, HP-5ms	AT-5ms	Optima-5 MS	ZB-5ms	Rtx-5Sil MS	BPX5	VF-5ms
MET-Biodiesel	-	-	-	-	MXT-BiodieselTG	-	Select Biodiesel for Triglycerides
HT-5 (aluminum clad)	DB-5ht	-	-	ZB-5ht	-	HT-5	VF-5ht
PTA-5	-	AT-Amine	-	-	Rtx-5 Amine	-	CP-Sil 8 CB for Amines
SAC-5	-	-	-	-	-	-	-
Equity-5, SPB-5	DB-5, HP-5	AT-5	Optima-5	ZB-5	Rtx-5	BP5	CP-Sil 8 CB
SPB-624	DB-624, DB-VRX	AT-624	Optima-624	ZB-624	Rtx-624	BP624	CP-Select 624 CB
OVI-G43	HP-Fast Residual Solvent	-	-	-	Rtx-G43	-	-
VOCOL	DB-502.2, HP-VOC	AT-502.2	-	-	Rtx-502.2, Rtx-Volatiles	-	-
SPB-20	-	AT-20	-	-	Rtx-20	-	-
Equity-1701	DB-1701	AT-1701	Optima-1701	ZB-1701	Rtx-1701	BP10	CP-Sil 19 CB
SPB-608	DB-608	AT-Pesticide	-	-	-	-	-
Sup-Herb	-	-	-	-	-	-	-
SPB-35	DB-35, HP-35	AT-35	-	ZB-35	Rtx-35	-	-
SPB-50	DB-17, HP-50	AT-50	Optima-17	ZB-50	-	-	CP-Sil 24 CB
SPB-225	DB-225	AT-225	Optima-225	-	Rtx-225	BP225	CP-Sil 43 CB
SPB-PUFA	-	-	-	-	-	-	-
PAG	-	-	-	-	-	-	-
SPB-1000, Nukol	DB-FFAP, HP-FFAP	AT-1000, AT-AquaWax-DA	Optima-FFAP	ZB-FFAP	Stabilwax-DA	BP21	CP-FFAP CB
Carbowax Amine	CAM	AT-CAM	-	-	Stabilwax-DB	-	CP-Wax 51 for Amines
Omegawax	-	AT-FAME	-	-	FAMEWAX	-	-
SUPELCOWAX 10	DB-WAX	AT-WAX, AT-AquaWax	Optima-WAX	ZB-WAX	Rtx-WAX, Stabilwax	BP20	CP-Wax 52 CB
SP-2330	HP-88	-	-	-	Rtx-2330	-	-
SP-2331	DB-Dioxin	-	-	-	Rtx-Dioxin2	-	CP-Sil 88 for Dioxins
SP-2380	-	AT-Silar 90	-	-	-	-	-
SP-2560	-	-	-	-	Rt-2560	-	CP-Sil 88 for FAME
SP-2340	-	AT-Silar 100	-	-	-	-	CP-Sil 88
SLB-IL100	-	-	-	-	-	-	-
TCEP	-	-	-	-	Rt-TCEP	-	CP-TCEP
CHIRAL PHASES							
CHIRALDEX	-	-	-	-	-	-	-
α-DEX	-	-	FS-LIPODEX	-	-	-	-
β-DEX	CycloSil-B	-	FS-LIPODEX, FS-HYDRODEX	-	Rt-βDEX	CYDEX-B	-
γ-DEX	-	-	FS-LIPODEX	-	Rt-γDEX	-	-
PLOT COLUMNS							
Alumina sulfate PLOT	HP-PLOT Al2O3 "S"	-	-	-	-	-	CP-Al_2O_3 PLOT Na_2SO_4
Alumina chloride PLOT	HP-PLOT Al2O3 "KCl"	-	-	-	-	-	CP-Al_2O_3 PLOT KCl
Carboxen-1010 PLOT	-	-	-	-	-	-	CP-CarboPLOT P7
Carboxen-1006 PLOT	GS-Carbon PLOT	Carbograph VOC	-	-	-	-	CP-CarboBOND
Mol Sieve 5A PLOT	HP-PLOT Molesieve	AT-Mole Sieve	-	-	Rt-Msieve 5A	-	CP-Molsieve 5A
Supel-Q PLOT	HP-PLOT Q	AT-Q	-	-	Rt-QPLOT	-	CP-PoraPLOT Q
SCOT COLUMNS							
SCOT Columns	-	-	-	-	-	-	-

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 0.53mm 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 cyanopropy-lphenyl 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-35

- **Application:** With a phenyl content of 35%, this column offers a higher polarity option compared to columns containing a lower phenyl content. This column is useful for analyses of polar compounds because they are retained longer relative to non-polar compounds.
- **USP Code:** This column meets USP G42 requirements.
- **Phase:** Bonded; poly(35% diphenyl/ 65% dimethylsiloxane)
- **Temperature Limits:** 0 °C 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 interme-diate 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 tetrachlorodibenzodioxin (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-positional (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) sulfonyl imidate
- **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/DNDP 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

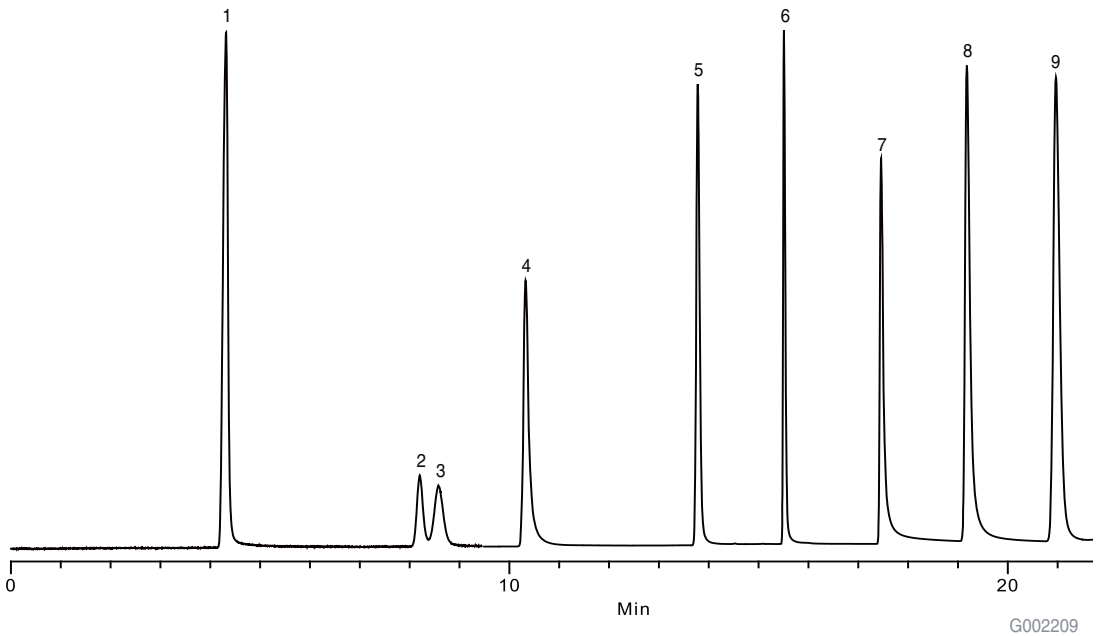
- **Application:** Use for analyses of olefins.
- **USP Code:** None
- **Phase:** bis-methoxyethyladipate
- **Temperature Limits:** Ambient to 100 °C

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)

Phase	I.D. (mm)	Length (m)	d_f (µm)	Beta Value	Cat. No.
SPB-Octyl	0.25	30	0.25	250	24218-U
Petrocol DH 50.2	0.20	50	0.50	100	24133-U
Petrocol DH	0.25	100	0.50	125	24160-U
Petrocol DH 150	0.25	150	1.00	63	24155
SPB-1 SULFUR	0.32	30	4.00	20	24158
Equity-1	0.10	15	0.10	250	28039-U
Equity-1	0.25	30	0.25	250	28046-U
Equity-1	0.25	60	0.25	250	28047-U
Equity-1	0.32	30	0.25	320	28055-U
SPB-1	0.25	30	0.25	250	24028
SPB-1	0.32	30	0.25	320	24044
SPB-1	0.32	30	1.00	80	24045-U
SPB-1	0.32	60	1.00	80	24047
SPB-1	0.53	30	1.50	88	25303
SPB-1	0.53	30	3.00	44	25341-U
SPB-1	0.53	30	5.00	27	25345-U
SLB-5ms	0.10	10	0.10	250	28465-U
SLB-5ms	0.10	15	0.10	250	28466-U
SLB-5ms	0.18	20	0.18	250	28564-U
SLB-5ms	0.18	20	0.36	125	28576-U
SLB-5ms	0.25	30	0.25	250	28471-U
SLB-5ms	0.25	60	0.25	250	28472-U
SLB-5ms	0.32	30	0.25	320	28482-U
MET-Biodiesel	0.53	14	0.16	828	28668-U
HT-5 (aluminum clad)	0.32	25	0.10	800	25003
PTA-5	0.25	30	0.50	125	24277
PTA-5	0.53	30	3.00	44	25439
SAC-5	0.25	30	0.25	250	24156
Equity-5	0.25	30	0.25	250	28089-U
Equity-5	0.25	60	0.25	250	28090-U
Equity-5	0.25	30	0.50	125	28092-U
Equity-5	0.32	30	0.25	320	28097-U
Equity-5	0.53	30	5.00	27	28279-U
SPB-5	0.20	30	0.20	250	24166
SPB-5	0.25	30	0.25	250	24034
SPB-5	0.32	15	0.25	320	24101-U
SPB-5	0.32	30	0.25	320	24048
SPB-5	0.53	30	0.50	265	25317
SPB-5	0.53	30	1.50	88	25305-U
SPB-5	0.53	30	5.00	27	25347
SPB-5	0.53	60	5.00	27	25351
SPB-624	0.18	20	1.00	45	28662-U
SPB-624	0.25	30	1.40	45	24255
SPB-624	0.25	60	1.40	45	24256
SPB-624	0.32	60	1.80	44	24251
SPB-624	0.53	30	3.00	44	25430
SPB-624	0.53	75	3.00	44	25432
OVI-G43	0.53	30	3.00	44	25396
VOCOL	0.18	20	1.00	45	28463-U
VOCOL	0.25	30	1.50	42	24205-U
VOCOL	0.25	60	1.50	42	24154
VOCOL	0.32	60	1.80	44	24217-U
VOCOL	0.32	60	3.00	27	24157
VOCOL	0.53	30	3.00	44	25320-U
VOCOL	0.53	60	3.00	44	25381
VOCOL	0.53	105	3.00	44	25358
SPB-20	0.25	30	1.00	63	24196-U
Equity-1701	0.10	15	0.10	250	28343-U
Equity-1701	0.25	30	0.25	250	28372-U
SPB-608	0.25	30	0.25	250	24103-U
SPB-608	0.53	30	0.50	265	25312
SPB-50	0.25	30	0.25	250	24181
SPB-1000	0.53	30	0.50	265	25445
Nukol	0.25	30	0.25	250	24107

Phase	I.D. (mm)	Length (m)	d_f (µm)	Beta Value	Cat. No.
Nukol	0.53	15	0.50	265	25326
Nukol	0.53	30	0.50	265	25327
Carbowax Amine	0.53	30	1.00	133	25353
Omegawax 100	0.10	15	0.10	250	23399-U
Omegawax 250	0.25	30	0.25	250	24136
Omegawax 320	0.32	30	0.25	320	24152
SUPELCOWAX 10	0.10	15	0.10	250	24343
SUPELCOWAX 10	0.25	30	0.25	250	24079
SUPELCOWAX 10	0.25	60	0.25	250	24081
SUPELCOWAX 10	0.25	30	0.50	125	24284
SUPELCOWAX 10	0.32	30	0.25	320	24080-U
SUPELCOWAX 10	0.32	60	0.25	320	24082
SUPELCOWAX 10	0.32	30	0.50	160	24084
SUPELCOWAX 10	0.32	60	0.50	160	24085-U
SUPELCOWAX 10	0.32	30	1.00	80	24211
SUPELCOWAX 10	0.32	60	1.00	80	24212
SUPELCOWAX 10	0.53	30	0.50	265	25325
SUPELCOWAX 10	0.53	30	1.00	133	25301-U
SUPELCOWAX 10	0.53	60	1.00	133	25391
SUPELCOWAX 10	0.53	30	2.00	63	25375-U
SUPELCOWAX 10	0.53	60	2.00	53	25376
SP-2330	0.25	30	0.20	313	24019
SP-2331	0.25	60	0.20	313	24104-U
SP-2331	0.32	60	0.20	400	24105-U
SP-2380	0.25	30	0.20	313	24110-U
SP-2380	0.25	60	0.20	313	24111
SP-2380	0.25	100	0.20	313	24317
SP-2380	0.32	30	0.20	400	24116-U
SP-2560	0.18	75	0.14	321	23348-U
SP-2560	0.25	100	0.20	313	24056
SP-2560	0.25	100	0.20	313	23362-U▲
SP-2340	0.25	60	0.20	313	24023
SLB-IL100	0.10	15	0.08	313	28882-U
SLB-IL100	0.18	20	0.14	313	28883-U
SLB-IL100	0.25	30	0.20	313	28884-U
SLB-IL100	0.25	60	0.20	313	28886-U
SLB-IL100	0.32	30	0.26	313	28887-U
SLB-IL100	0.32	60	0.26	313	28888-U
TCEP	0.25	60	0.44	142	24153

❒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 6. Chiral Phases

Phase	I.D. (mm)	Length (m)	d_f (µm)	Beta Value	Cat. No.
CHIRALDEX G-TA	0.25	30	0.12	500	73033AST
CHIRALDEX G-DP	0.25	30	0.12	500	78033AST
CHIRALDEX B-DM	0.25	30	0.12	500	77023AST
CHIRALDEX B-PM	0.25	30	0.12	500	76023AST
CHIRALDEX Bonded B-PM	0.25	30	0.12	500	66023AST
CHIRALDEX B-DA	0.25	30	0.12	500	72023AST
CHIRALDEX B-PH	0.25	30	0.12	500	71023AST
β-DEX 120	0.25	30	0.25	250	24304
β-DEX 225	0.25	30	0.25	250	24348
β-DEX 325	0.25	30	0.25	250	24308

Table 7. PLOT Columns

Phase	I.D. (mm)	Length (m)	Cat. No.
Alumina sulfate PLOT	0.53	30	28323-U
Alumina chloride PLOT	0.53	30	28328-U
Carboxen-1010 PLOT	0.53	30	25467
Carboxen-1006 PLOT	0.53	30	25461
Mol Sieve 5A PLOT	0.53	30	25463
Supel-Q PLOT	0.53	30	25462

Argentina
SIGMA-ALDRICH DE ARGENTINA S.A.
Free Tel: 0810 888 7446
Tel: (+54) 11 4556 1472
Fax: (+54) 11 4552 1698

Australia
SIGMA-ALDRICH PTY LTD.
Free Tel: 1800 800 097
Free Fax: 1800 800 096
Tel: (+61) 2 9841 0555
Fax: (+61) 2 9841 0500

Austria
SIGMA-ALDRICH HANDELS GmbH
Tel: (+43) 1 605 81 10
Fax: (+43) 1 605 81 20

Belgium
SIGMA-ALDRICH NV/S.A.
Free Tel: 0800 14747
Free Fax: 0800 14745
Tel: (+32) 3 899 13 01
Fax: (+32) 3 899 13 11

Brazil
SIGMA-ALDRICH BRASIL LTDA.
Free Tel: 0800 701 7425
Tel: (+55) 11 3732 3100
Fax: (+55) 11 5522 9895

Canada
SIGMA-ALDRICH CANADA LTD.
Free Tel: 1800 565 1400
Free Fax: 1800 265 3858
Tel: (+1) 905 829 9500
Fax: (+1) 905 829 9292

Chile
SIGMA-ALDRICH QUIMICA LIMITADA
Tel: (+56) 2 495 7395
Fax: (+56) 2 495 7396

China
SIGMA-ALDRICH (SHANGHAI)
TRADING CO. LTD.
Free Tel: 800 819 3336
Tel: (+86) 21 6141 5566
Fax: (+86) 21 6141 5567

Czech Republic
SIGMA-ALDRICH spol. s r. o.
Tel: (+420) 246 003 200
Fax: (+420) 246 003 291

Denmark
SIGMA-ALDRICH DENMARK A/S
Tel: (+45) 43 56 59 00
Fax: (+45) 43 56 59 05

Finland
SIGMA-ALDRICH FINLAND OY
Tel: (+358) 9 350 9250
Fax: (+358) 9 350 92555

France
SIGMA-ALDRICH CHIMIE S.à.r.l.
Free Tel: 0800 211 408
Free Fax: 0800 031 052
Tel: (+33) 474 82 28 00
Fax: (+33) 474 95 68 08

Germany
SIGMA-ALDRICH CHEMIE GmbH
Free Tel: 0800 51 55 000
Free Fax: 0800 64 90 000
Tel: (+49) 89 6513 0
Fax: (+49) 89 6513 1160

Greece
SIGMA-ALDRICH (O.M.) LTD.
Tel: (+30) 210 994 8010
Fax: (+30) 210 994 3831

Hungary
SIGMA-ALDRICH Kft
Ingyenes telefonszám: 06 80 355 355
Ingyenes fax szám: 06 80 344 344
Tel: (+36) 1 235 9055
Fax: (+36) 1 235 9050

India
SIGMA-ALDRICH CHEMICALS
PRIVATE LIMITED
Telephone
Bangalore: (+91) 80 6621 9400
New Delhi: (+91) 11 4358 8000
Mumbai: (+91) 22 2570 2364
Hyderabad: (+91) 40 4015 5488
Kolkata: (+91) 33 4013 8003
Fax
Bangalore: (+91) 80 6621 9650
New Delhi: (+91) 11 4358 8001
Mumbai: (+91) 22 2579 7589
Hyderabad: (+91) 40 4015 5466
Kolkata: (+91) 33 4013 8016

Ireland
SIGMA-ALDRICH IRELAND LTD.
Free Tel: 1800 200 888
Free Fax: 1800 600 222
Tel: (+353) 402 20370
Fax: (+ 353) 402 20375

Israel
SIGMA-ALDRICH ISRAEL LTD.
Free Tel: 1 800 70 2222
Tel: (+972) 8 948 4100
Fax: (+972) 8 948 4200

Italy
SIGMA-ALDRICH S.r.l.
Numero Verde: 800 827018
Tel: (+39) 02 3341 7310
Fax: (+39) 02 3801 0737

Japan
SIGMA-ALDRICH JAPAN K.K.
Tel: (+81) 3 5796 7300
Fax: (+81) 3 5796 7315

Korea
SIGMA-ALDRICH KOREA
Free Tel: (+82) 80 023 7111
Free Fax: (+82) 80 023 8111
Tel: (+82) 31 329 9000
Fax: (+82) 31 329 9090

Malaysia
SIGMA-ALDRICH (M) SDN. BHD
Tel: (+60) 3 5635 3321
Fax: (+60) 3 5635 4116

Mexico
SIGMA-ALDRICH QUÍMICA, S.A. de C.V.
Free Tel: 01 800 007 5300
Free Fax: 01 800 712 9920
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World Headquarters
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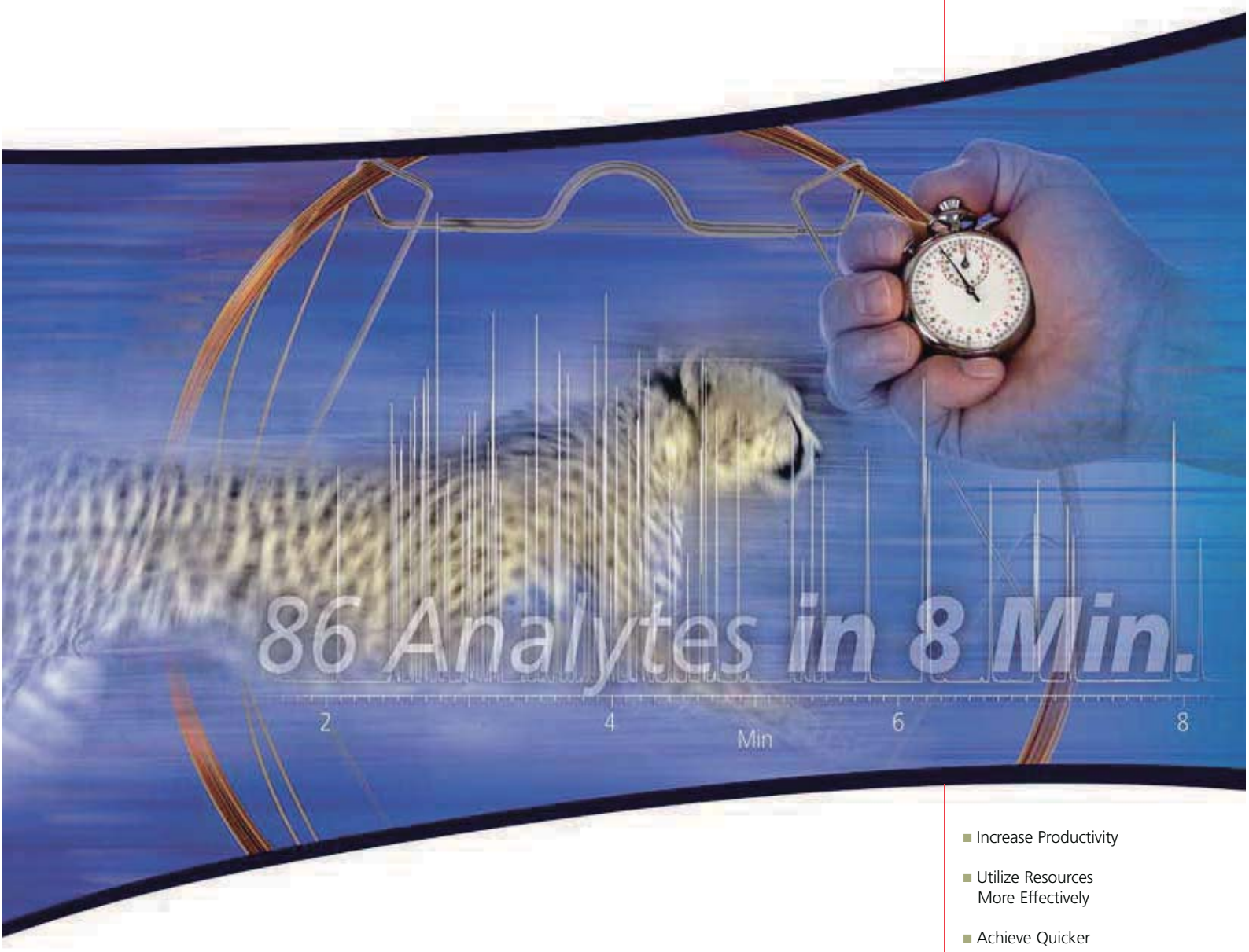
SUPELCO® Analytical

Fast GC

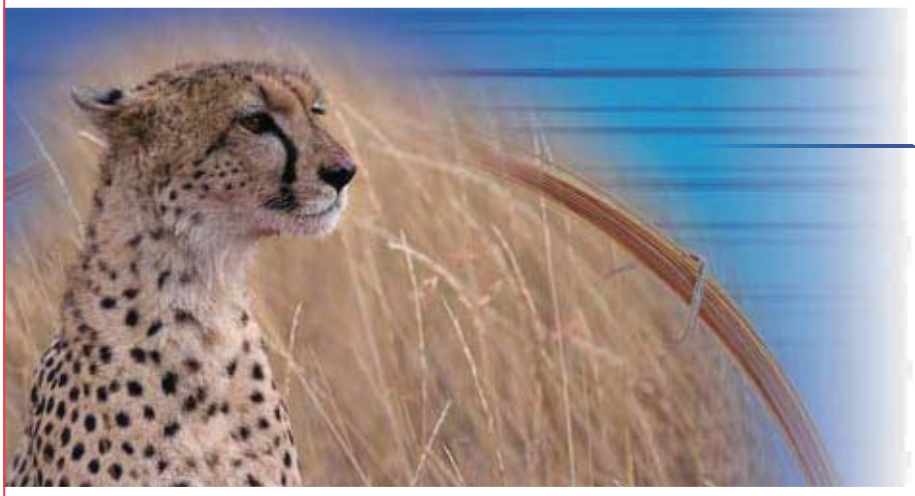
A Practical Guide for Increasing Sample Throughput without Sacrificing Quality



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

Fast GC

A Practical Guide for Increasing Sample Throughput without Sacrificing Quality



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.

Dear Colleague,

Gas chromatography is, by far, the most suitable method for the analysis of complex volatile and semi-volatile mixtures. Since its introduction over 50 years ago, there has been enormous progress in both instrumental design and column technology. Amongst all GC methods, the most commonly applied is still conventional capillary gas chromatography. Although such an approach is more than fine in many applications, in others a series of limitations exist. One of the most common complaints is that "the separation of the compounds of interest takes just too long".

In the last 15-20 years there has been an ever-present increasing interest within the chromatographic community for faster GC methods. This is obviously related to the fact that the number of samples subjected to GC analysis has risen greatly. Nowadays, in routine analytical applications, sample throughput is often one of the most important considerations in choosing an analytical method.

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[1]
Luigi Mondello[1]
Roberto Ferrari[2]

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

	Carrier Gas Linear Velocity							
	Helium				Hydrogen			
Column (L x I.D.)	20	30	40	50	40	50	60	70
5 m x 0.10 mm	12	19	25	32	12	15	18	21
10 m x 0.10 mm	25	39	54	69	25	31	38	45
20 m x 0.10 mm	54	84	115	146	52	66	81	96
40 m x 0.10 mm	115	177	239	302	111	141	171	201

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).

Table 2. Increased Plates/Meter with Narrow I.D. Columns

Column I.D. (mm)	Plates/Meter (N/m)	Total Plates (N)
0.32	2300	69000
0.25	2925	87750
0.20	3650	109500
0.18	4050	121500
0.10	7300	219000

Theoretical values for 30 m long columns, calculated @ a k' = 6.00 and 85% coating efficiency.

Figures 1-3. Increased Efficiency as Column I.D. Decreases

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-d_{12}
6. Indeno(1,2,3-cd)pyrene
7. Dibenzo(a,h)anthracene
8. Benzo(ghi)perylene

Figure 1. SLB-5ms, 30 m x 0.53 mm I.D., 0.50 µm

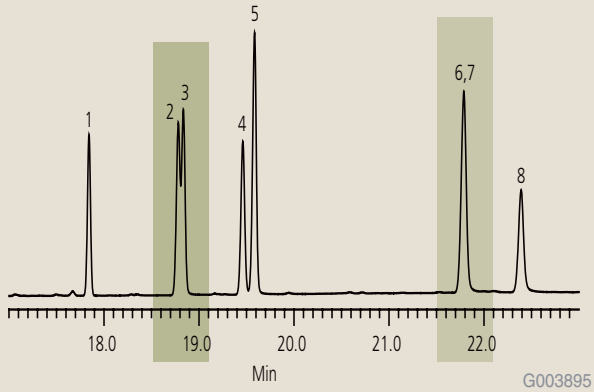


Figure 2. SLB-5ms, 30 m x 0.25 mm I.D., 0.25 µm

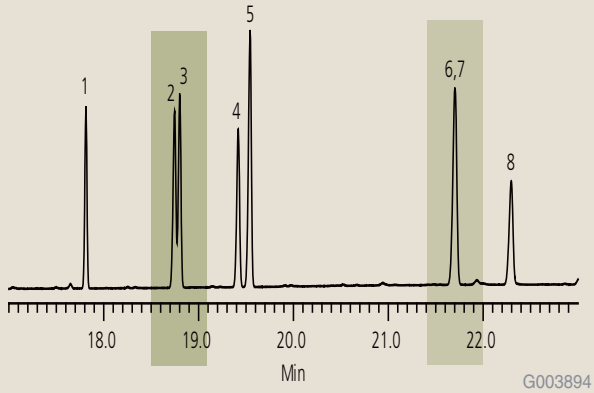
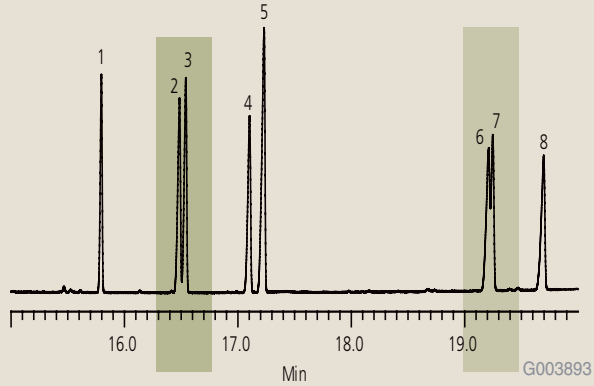


Figure 3. SLB-5ms, 15 m x 0.10 mm I.D., 0.10 µm



The decrease in column I.D. results in increased efficiency (desirable) and is necessary to offset the decrease in efficiency caused by the decrease in column length. Figures 1-3 illustrate that the high efficiency of a 0.10 mm I.D. column provides better resolution of sample components with a decrease in analysis time, relative to 0.53 and 0.25 mm I.D. columns. The increase in the number of plates/meter as column I.D. decreases makes it possible for the 15 m x 0.10 mm I.D. column to have a greater number of total plates (N) than both of the 30 m columns. As a result, the 0.10 mm I.D. column exhibits better resolution than either the 0.53 or 0.25 mm I.D. columns.

Narrow I.D. Columns Allow A Faster Linear Velocity

In GC, linear velocity ($\bar{u}$, 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 $\bar{u}_{opt}$) 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.

Figure 4. Helium Golay Curves Relative to Column I.D.

From P. Sandra and C. Bicchi, "Capillary Gas Chromatography in Essential Oil Analyses," Huethig, 1987

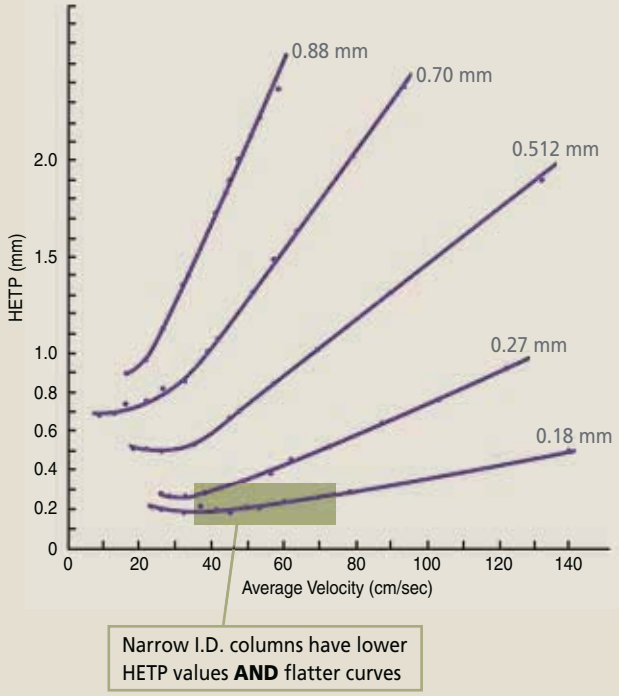
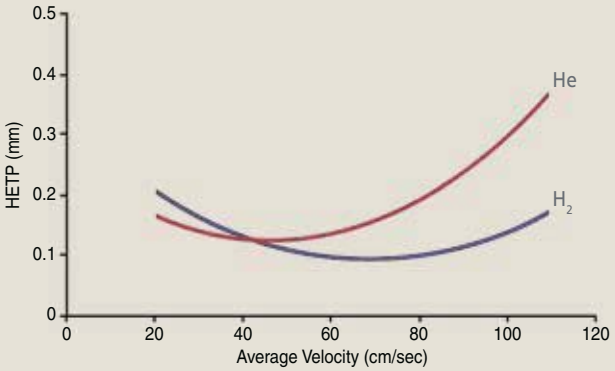


Figure 5. Helium and Hydrogen Golay Curves on a 0.10 mm I.D. Column



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.

Supelco Fast GC Columns

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

Phase	I.D. (mm)	Length (m)	df (µm)	Beta Value	Cat. No.
SPB-624	0.18	20	1.0	45	**28662-U**
VOCOL	0.18	20	1.0	45	**28463-U**
SLB-5ms	0.10	10	0.10	250	**28465-U**
		15	0.10	250	**28466-U**
	0.18	20	0.18	250	**28564-U**
		12	0.30	150	**28566-U**
		30	0.30	150	**28575-U**
		20	0.36	125	**28576-U**
Equity-1701	0.10	15	0.10	250	**28343-U**
TCEP	0.10	15	0.18	139	**28348-U**
Omegawax 100	0.10	15	0.10	250	**23399-U**
SP-2560	0.18	75	0.14	321	**23348-U**
SUPELCOWAX 10	0.10	5	0.10	250	**25025-U**
		10	0.10	250	**25026-U**
		15	0.10	250	**24343**
Equity-1	0.10	15	0.10	250	**28039-U**
SPB-1	0.10	15	0.10	250	**24338**
Equity-5	0.10	15	0.10	250	**28083-U**
SPB-5	0.10	15	0.10	250	**24341**

Comparable Fast GC Column Cross Reference Chart

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

Supelco	Agilent	Alltech	Macherey-Nagel	Phenomenex	Quadrex	Restek	SGE	Varian
SPB-624	DB-624 DB-VRX	---	---	---	---	Rtx-624	---	CP-Select 624 CB VF-624ms
VOCOL	---	---	---	---	---	Rtx-502.2	---	---
SLB-5ms	DB-5ms	---	---	ZB-5ms	007-5MS	Rtx-5Sil MS Rxi-5ms	BPX5	VF-5ms
Equity-1701	DB-1701	AT-1701	---	---	007-1701	Rtx-1701	---	CP-Sil 19 CB
TCEP	---	---	---	---	---	---	---	---
Omegawax 100	DB-WAX	---	Permabond CW 20M	ZB-WAXplus	---	---	BP20	CP-Wax 52 CB
SP-2560	---	---	---	---	---	---	---	---
SUPELCOWAX 10	DB-WAX	AT-WAX	Permabond CW 20M	ZB-WAXplus	007-CW	Rtx-WAX	BP20	CP-Wax 52 CB
Equity-1, SPB-1	DB-1	AT-1	Optima 1	---	007-1	Rtx-1	BP1	CP-Sil 5 CB
Equity-5, SPB-5	DB-5	AT-5	Optima 5	---	007-5	Rtx-5	---	CP-Sil 8 CB

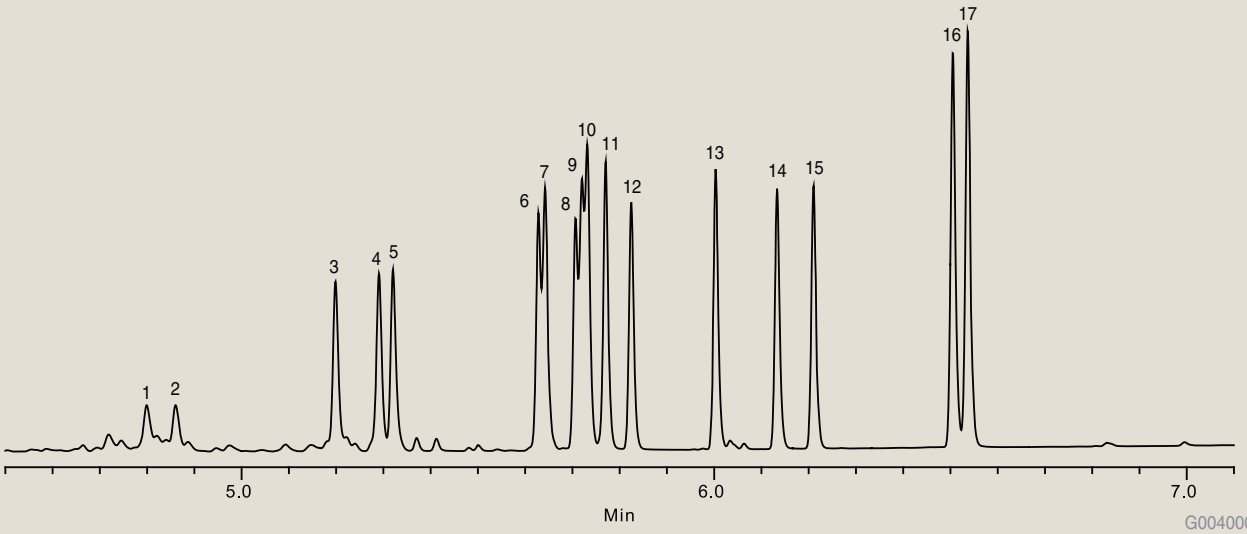
Fast GC Applications

Dioxins and Furans

Dioxin and Furan Congeners on the SLB-5ms

column: SLB-5ms, 15 m x 0.10 mm I.D., 0.10 µm (28466-U)
oven: 150 °C (1 min.), 35 °C/min. to 340 °C (1 min.)
inj.: 250 °C
det.: ECD, 340 °C
carrier gas: hydrogen, 45 cm/sec, constant
injection: 1 µL, splitless (1 min.)
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-PCDD, 250 ppb
6. 1,2,3,4,7,8-HxCDF, 500 ppb
7. 1,2,3,6,7,8-HxCDF, 500 ppb
8. 2,3,4,6,7,8-HxCDF, 250 ppb
9. 1,2,3,4,7,8-HxCDD, 500 ppb
10. 1,2,3,6,7,8-HxCDD, 500 ppb
11. 1,2,3,7,8,9-HxCDD, 250 ppb
12. 1,2,3,7,8,9-HxCDF, 250 ppb
13. 1,2,3,4,6,7,8-HpCDF, 250 ppb
14. 1,2,3,4,6,7,8-HpCDD, 250 ppb
15. 1,2,3,4,7,8,9-HpCDF, 250 ppb
16. OCDD, 500 ppb
17. OCDF, 500 ppb

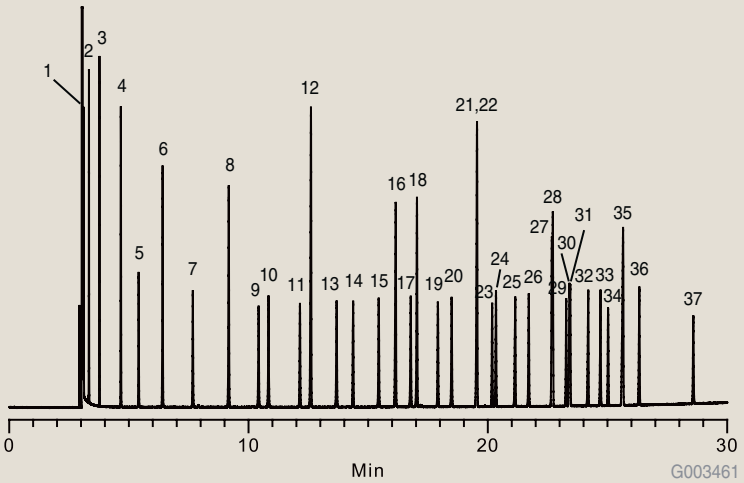


FAMEs

37-Component FAME Mix on the SP-2560

column: SP-2560, 75 m x 0.18 mm I.D., 0.14 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
injection: 1 µL, split 100:1
liner: 4 mm I.D split, cup design
sample: 37-component FAME mix at concentrations listed in methylene chloride (47885-U)

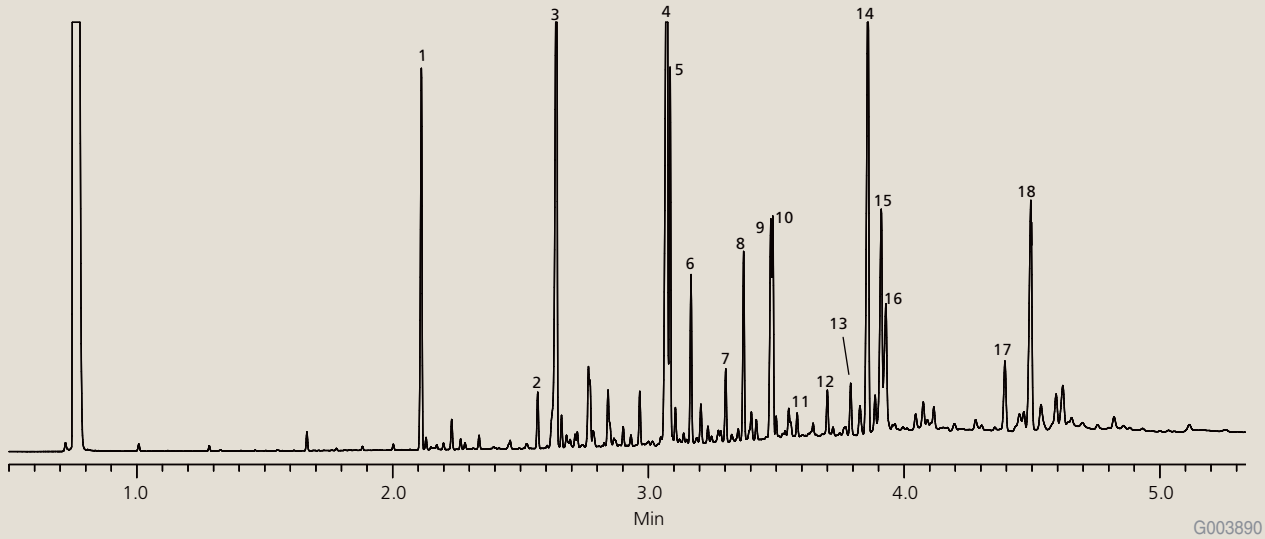
1. Butyric Acid Methyl Ester (C4:0) at 4 wt %
2. Caproic Acid Methyl Ester (C6:0) at 4 wt %
3. Caprylic Acid Methyl Ester (C8:0) at 4 wt %
4. Capric Acid Methyl Ester (C10:0) at 4 wt %
5. Undecanoic Acid Methyl Ester (C11:0) at 2 wt %
6. Lauric Acid Methyl Ester (C12:0) at 4 wt %
7. Tridecanoic Acid Methyl Ester (C13:0) at 2 wt %
8. Myristic Acid Methyl Ester (C14:0) at 4 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 (C18:1n9c) at 4 wt %
19. Linolelaidic Acid Methyl Ester (C18:2n6t) at 2 wt %
20. Linoleic Acid Methyl Ester (C18:2n6c) at 2 wt %
21. Arachidic Acid Methyl Ester (C20:0) at 4 wt %
22. γ-Linolenic Acid Methyl Ester (C18:3n6) at 2 wt %
23. Linolenic Acid Methyl Ester (C18:3n3) at 2 wt %
24. cis-11-Eicosenoic Acid Methyl Ester (C20:1) at 2 wt %
25. Heneicosanoic Acid Methyl Ester (C21:0) at 2 wt %
26. cis-11,14-Eicosadienoic Acid Methyl Ester (C20:2) at 2 wt %
27. cis-8,11,14-Eicosatrienoic Acid Methyl Ester (C20:3n6) at 2 wt %
28. Behenic Acid Methyl Ester (C22:0) at 4 wt %
29. cis-11,14,17-Eicosatrienoic Acid Methyl Ester (C20:3n3) at 2 wt %
30. Erucic Acid Methyl Ester (C22:1n9) at 2 wt %
31. Arachidonic Acid Methyl Ester (C20:4n6) at 2 wt %
32. Tricosanoic Acid Methyl Ester (C23:0) at 2 wt %
33. cis-13,16-Docasadienoic Acid Methyl Ester (C22:2) at 2 wt %
34. cis-5,8,11,14,17-Eicosapentaenoic Acid Methyl Ester (C20:5n3) at 2 wt %
35. Lignoceric Acid Methyl Ester (C24:0) at 4 wt %
36. Nervonic Acid Methyl Ester (C24:1) at 2 wt %
37. cis-4,7,10,13,16,19-Docasahexaenoic Acid Methyl Ester (C22:6n3) 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

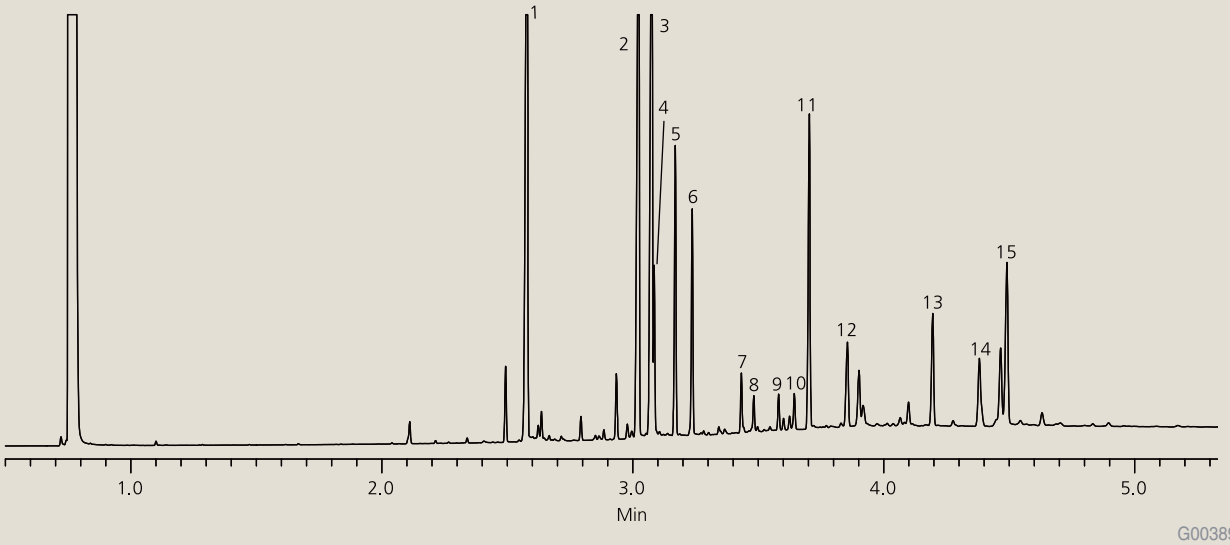
1. C14:0
2. C16:0
3. C16:1n7
4. C18:1n9
5. C18:1n7
6. C18:2n6
7. C18:3n3
8. C18:4n3
9. C20:1n11
10. C20:1n9
11. C20:1n7
12. C20:4n6
13. C20:4n3
14. C20:5n3
15. C22:1n11
16. C22:1n9
17. C22:5n3
18. C22:6n3



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

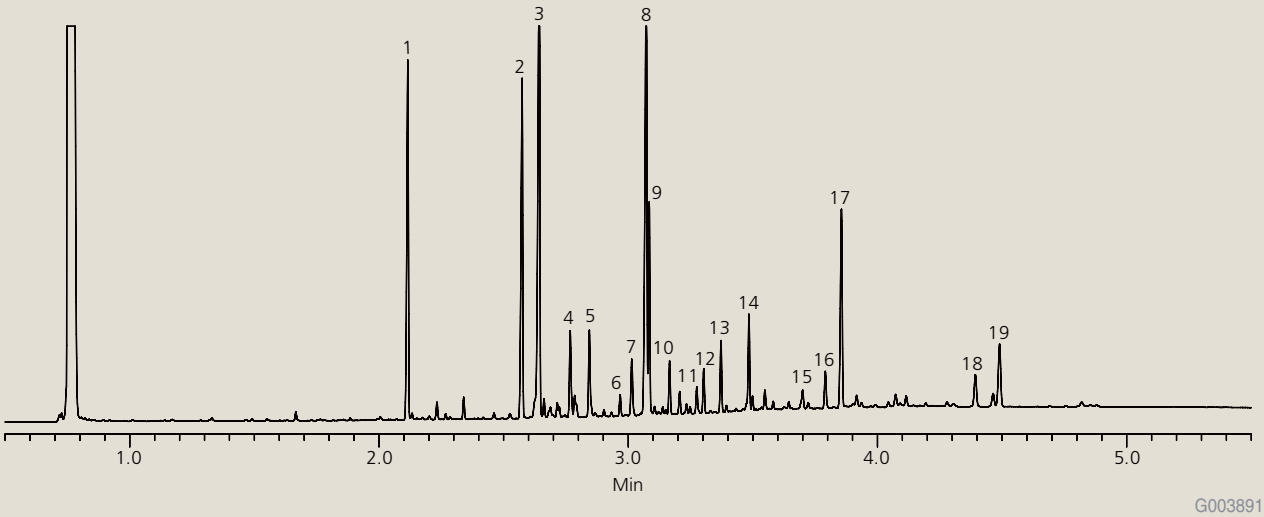
1. C16:0
2. C18:0
3. C18:1n9
4. C18:1n7
5. C18:2n6
6. C18:3n6
7. C20:0
8. C20:1n9
9. C20:2n9
10. C20:3n6
11. C20:4n6
12. C20:5n3
13. C22:5n6
14. C22:5n3
15. C22:6n3



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.: 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. III – Menhaden Oil (47085-U), diluted to 50 mg/mL in methylene chloride

1. C14:0
2. C16:0
3. C16:1n7
4. C16:2n4
5. C16:3n4
6. C16:4n1
7. C18:0
8. C18:1n9
9. C18:1n7
10. C18:2n6
11. C18:3n4
12. C18:3n3
13. C18:4n3
14. C20:1n9
15. C20:4n6
16. C20:4n3
17. C20:5n3
18. C22:5n3
19. C22:6n3



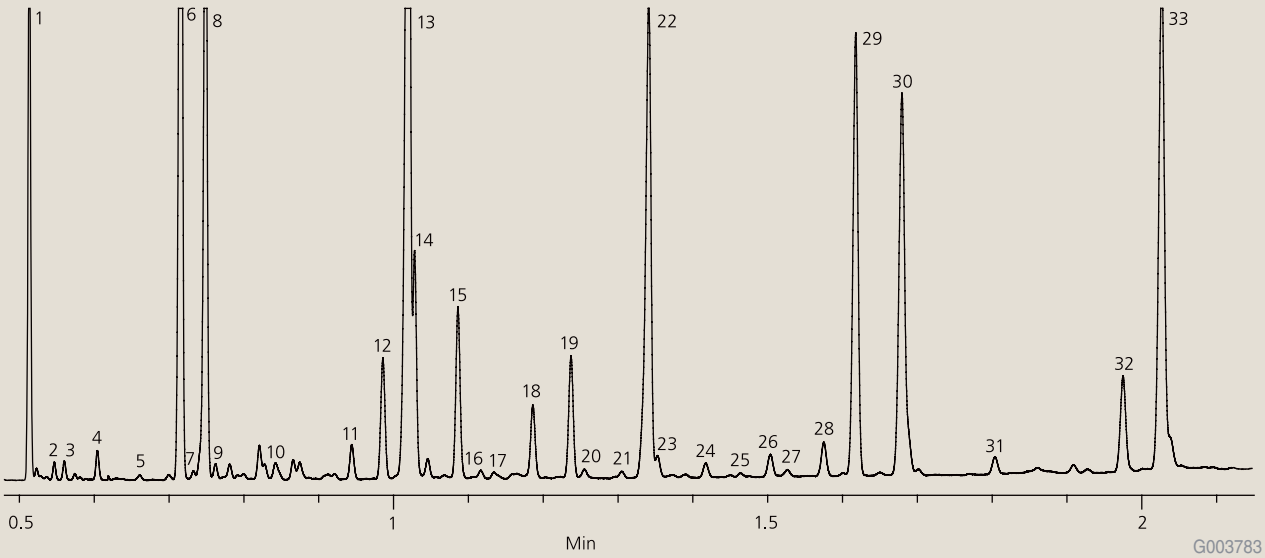
G003891

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. C16:1ω9
8. C16:1ω7
9. C16:1ω5
10. C16:3ω4
11. C16:4ω4
12. C18:0
13. C18:1ω9
14. C18:1ω7
15. C18:2ω6
16. C18:2ω4
17. C18:3ω6
18. C18:3ω3
19. C18:4ω3
20. C18:4ω1
21. C20:0
22. C20:1ω9
23. C20:1ω7
24. C20:2ω6
25. C20:3ω6
26. C20:4ω6
27. C20:3ω3
28. C20:4ω3
29. C20:5ω3
30. C22:1ω9
31. C21:5ω3
32. C22:5ω3
33. C22:6ω3

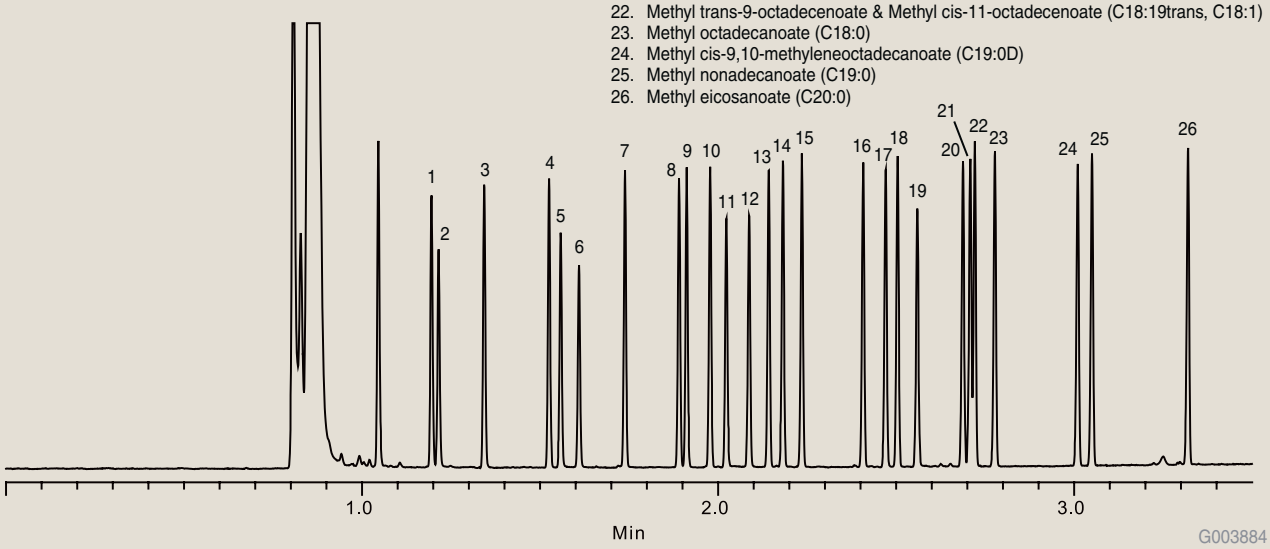


G003783

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: 175 °C, 30 °C/min. to 275 °C (1 min.)
inj.: 280 °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)

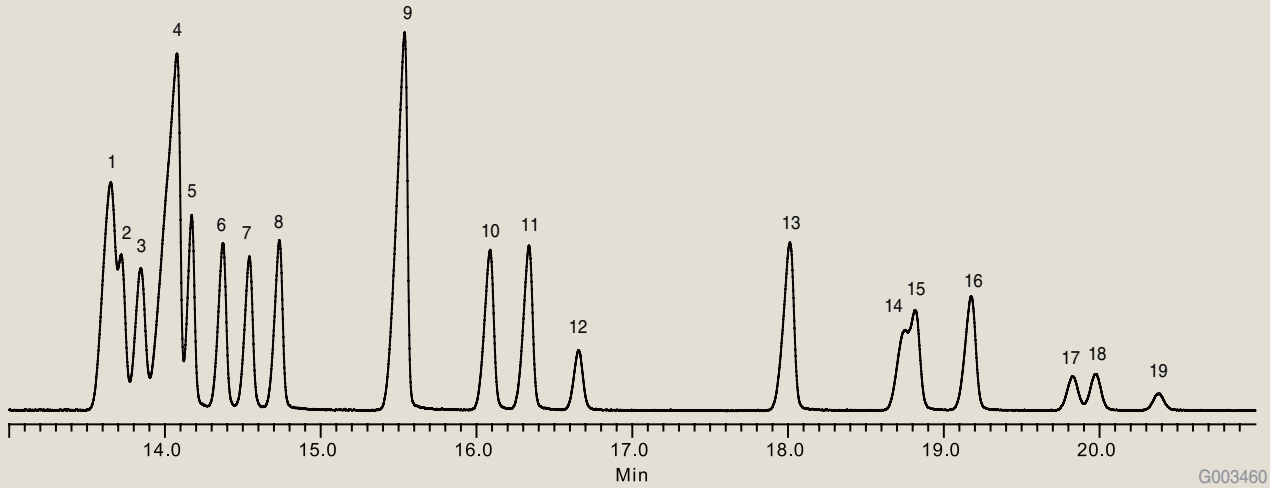
1. Methyl undecanoate (C11:0)
2. Methyl 2-hydroxydecanoate (2-OH C10:0)
3. Methyl dodecanoate (C12:0)
4. Methyl tridecanoate (C13:0)
5. Methyl 2-hydroxydodecanoate (2-OH C12:0)
6. Methyl 3-hydroxydodecanoate (3-OH C12:0)
7. Methyl tetradecanoate (C14:0)
8. Methyl 13-methyltetradecanoate (iC15:0)
9. Methyl 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 (iC16:0)
14. Methyl cis-9-hexadecenoate (C16:19)
15. Methyl hexadecanoate (C16:0)
16. Methyl 15-methylhexadecanoate (iC17:0)
17. Methyl cis-9,10-methylenehexadecanoate (C17:0D)
18. Methyl heptadecanoate (C17:0)
19. Methyl 2-hydroxyhexadeanoate (2-OH C16:0)
20. Methyl cis-9,12-octadienoate (C18:29,12)
21. Methyl cis-9-octadecenoate (c18:19cis)
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 6t
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 9t, 12t, 15c
15. C18:3 Δ 9t, 12c, 15t
16. C18:3 Δ 9c, 12t, 15t and C18:3 Δ 9c, 12c, 15t
17. C18:3 Δ 9c, 12t, 15c
18. C18:3 Δ 9t, 12c, 15c
19. C18:3 Δ 9c, 12c, 15c



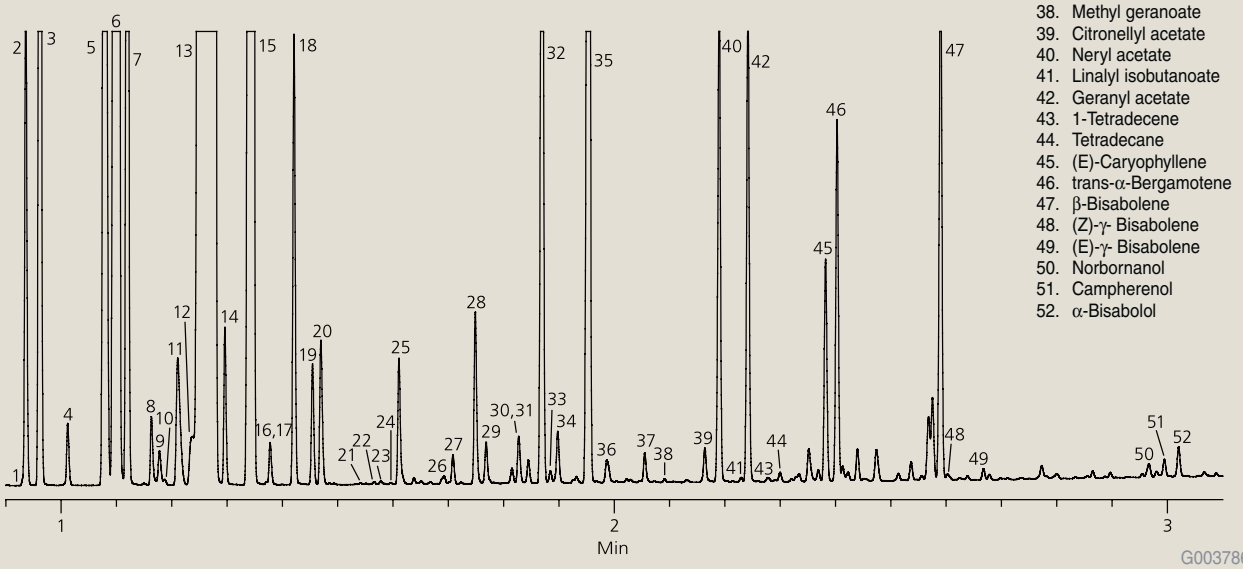
Foods, Flavors, and Fragrances

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
inj.: 320 °C
det.: FID, 320 °C
carrier gas: hydrogen, 81.5 cm/sec constant
injection: 0.4 µL, 300:1 split
sample: lemon essential oil in hexane

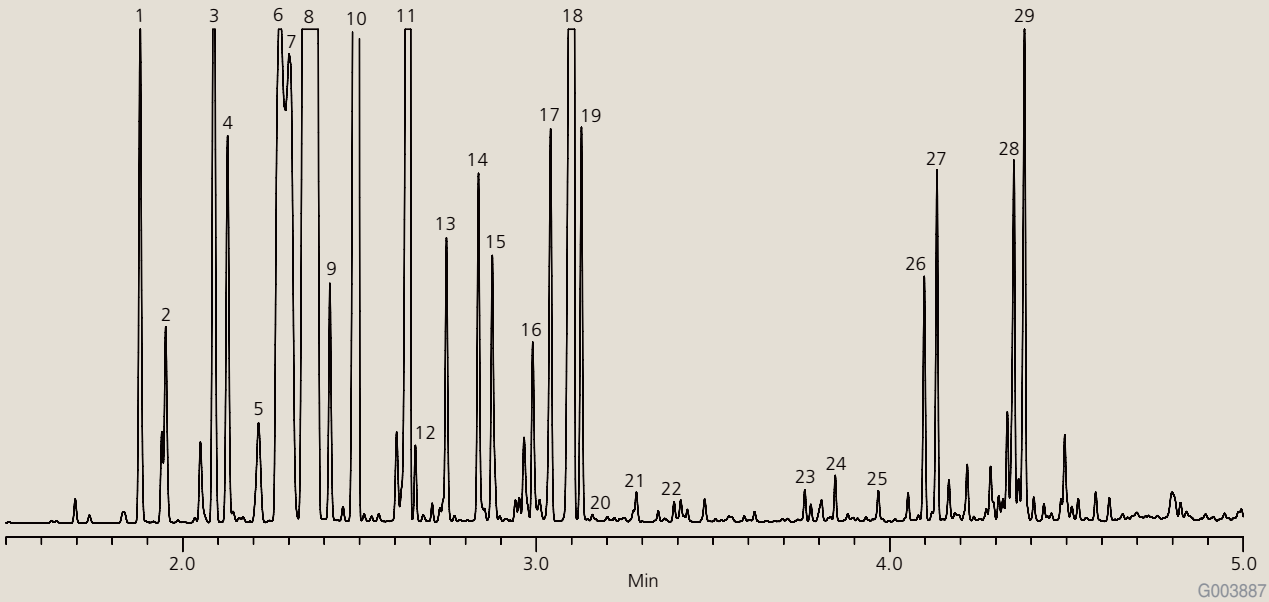
1. Tricyclene
2. α-Thujene
3. α-Pinene
4. Camphene
5. Sabinene
6. β-Pinene
7. Myrcene
8. Octanal
9. α-Phellandrene
10. δ-3-Carene
11. α-Terpinene
12. π-Cymene
13. Limonene
14. (E)-β-Ocimene
15. γ-Terpinene
16. cis-Sabinene hydrate
17. Octanol
18. Terpinolene
19. Linalool
20. Nonanal
21. cis-Limonene oxide
22. trans-Limonene oxide
23. (E)-Myroxide
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 geranoate
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. Norbornanol
51. Campherenol
52. α-Bisabolol



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.)
inj.: 250 °C
det.: FID, 250 °C
carrier gas: helium, 45 cm/sec constant
injection: 0.10 µL, 300:1 split
liner: 2 mm I.D., straight
sample: distilled lime oil, neat

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-Fencyl 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. Dodecanal
26. β-Carophyllene
27. trans-α-Bergamotene
28. trans-α-Farnesene
29. β-Bisabolene

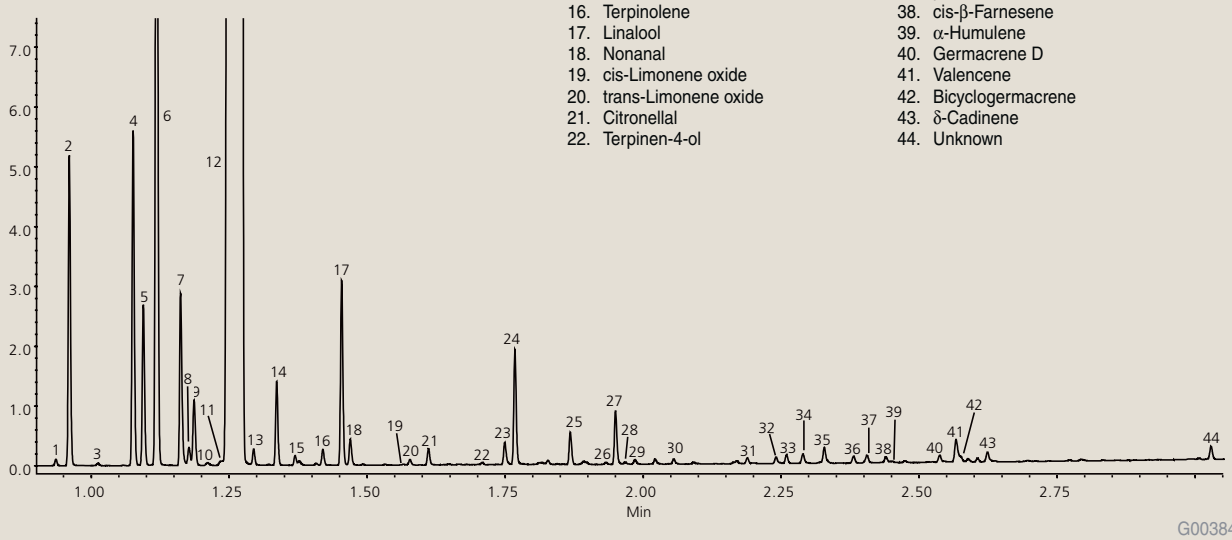


Sweet Orange Essential Oil on the SLB-5ms

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-Terpinene
11. π-Cymene
12. Limonene
13. (E)-β-Ocimene
14. γ-Terpinene
15. Octanol
16. Terpinolene
17. Linalool
18. Nonanal
19. cis-Limonene oxide
20. trans-Limonene oxide
21. Citronellal
22. Terpinen-4-ol
23. α-Terpineol
24. Decanal
25. Neral
26. 2-(E)-Decenal
27. Geranial
28. Perilla aldehyde
29. Perilla alcohol
30. Undecanal
31. Neryl acetate
32. α-Copaene
33. Geranyl acetate
34. β-Cubebene + β-Elemene
35. Dodecanal
36. (E)-Caryophyllene
37. β-Copaene
38. cis-β-Farnesene
39. α-Humulene
40. Germacrene D
41. Valencene
42. Bicyclogermacrene
43. δ-Cadinene
44. Unknown



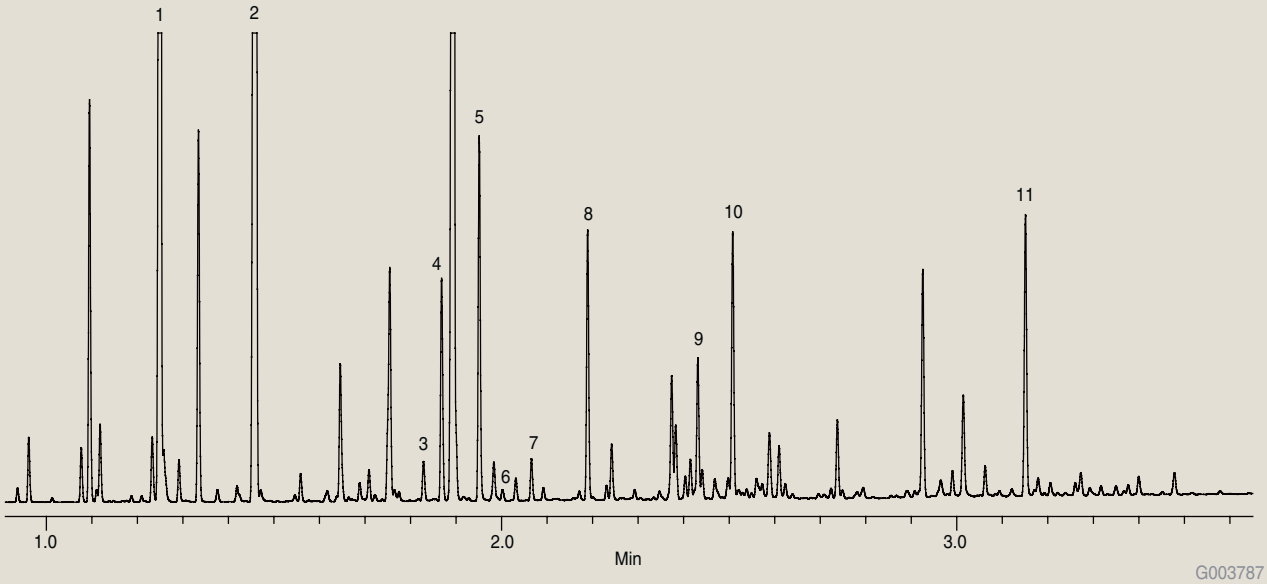
G003840

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 cinnamylaldehyde



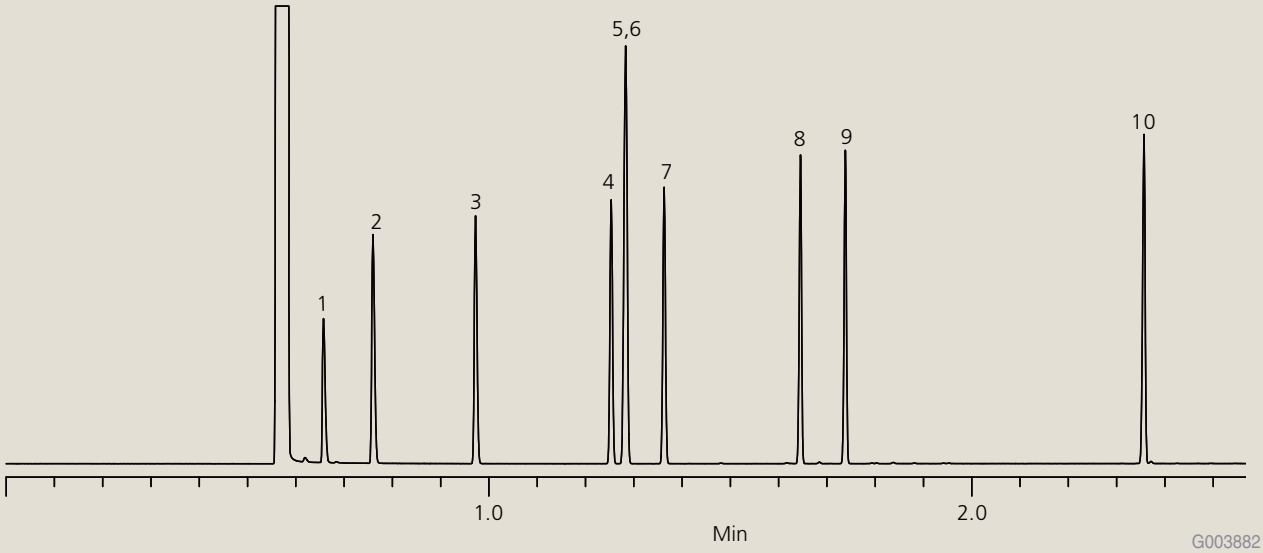
G003787

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)

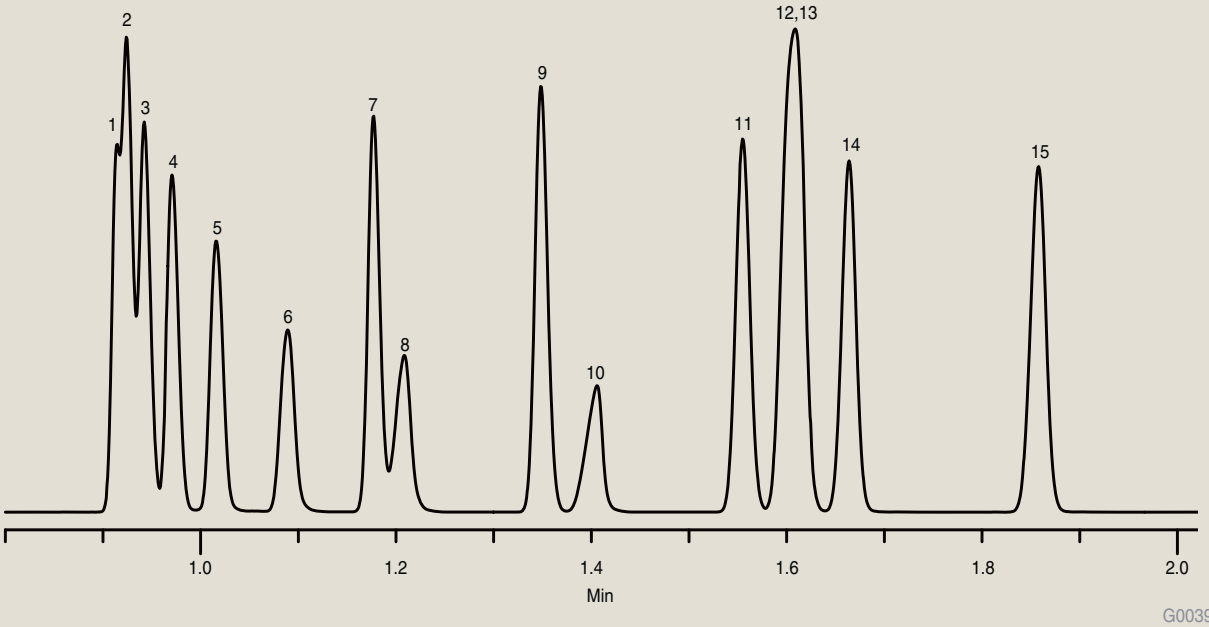
1. MTBE
2. Benzene
3. Toluene
4. Ethyl benzene
5. m-Xylene
6. p-Xylene
7. o-Xylene
8. 1,3,5-Trimethylbenzene
9. 1,2,4-Trimethylbenzene
10. Naphthalene



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

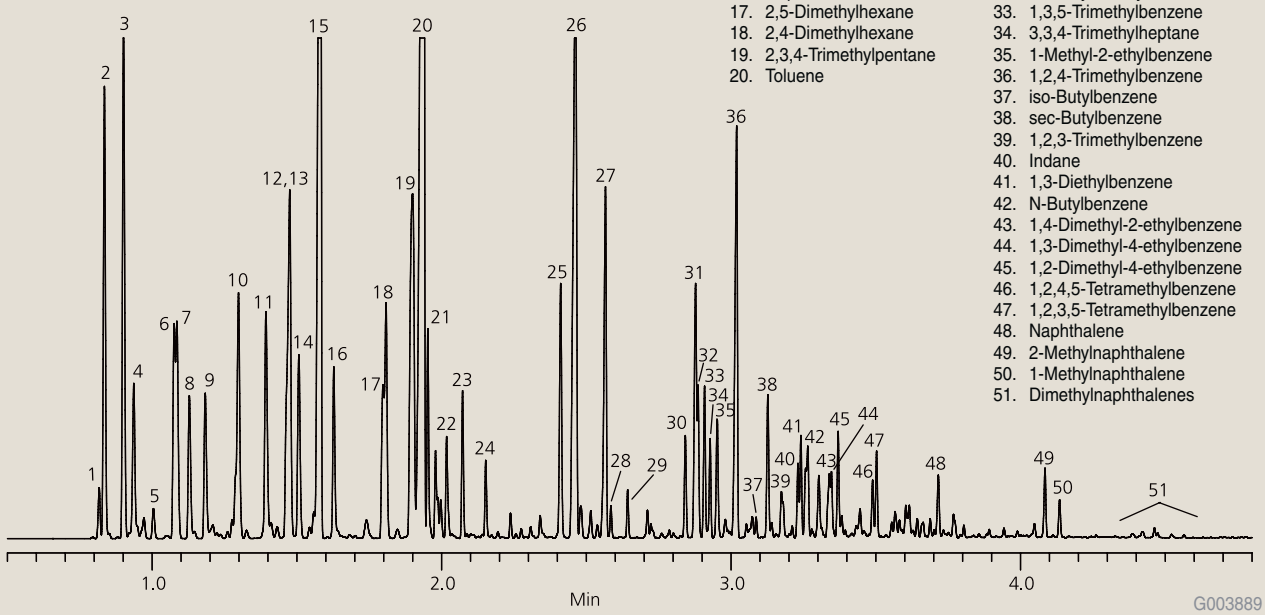
1. Hexane
2. Heptane
3. Octane
4. Nonane
5. Decane
6. Undecane
7. Dodecane
8. Benzene
9. Toluene
10. Tridecane
11. Ethyl benzene
12. m-Xylene
13. p-Xylene
14. Cumene
15. o-Xylene



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. Isooctane
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-Methylheptane
24. Octane
25. Ethylbenzene
26. m-/p-Xylene
27. o-Xylene
28. Nonane
29. iso-Propylbenzene
30. Propylbenzene
31. 1-Methyl-3-ethylbenzene
32. 1-Methyl-4-ethylbenzene
33. 1,3,5-Trimethylbenzene
34. 3,3,4-Trimethylheptane
35. 1-Methyl-2-ethylbenzene
36. 1,2,4-Trimethylbenzene
37. iso-Butylbenzene
38. sec-Butylbenzene
39. 1,2,3-Trimethylbenzene
40. Indane
41. 1,3-Diethylbenzene
42. N-Butylbenzene
43. 1,4-Dimethyl-2-ethylbenzene
44. 1,3-Dimethyl-4-ethylbenzene
45. 1,2-Dimethyl-4-ethylbenzene
46. 1,2,4,5-Tetramethylbenzene
47. 1,2,3,5-Tetramethylbenzene
48. Naphthalene
49. 2-Methylnaphthalene
50. 1-Methylnaphthalene
51. Dimethylnaphthalenes

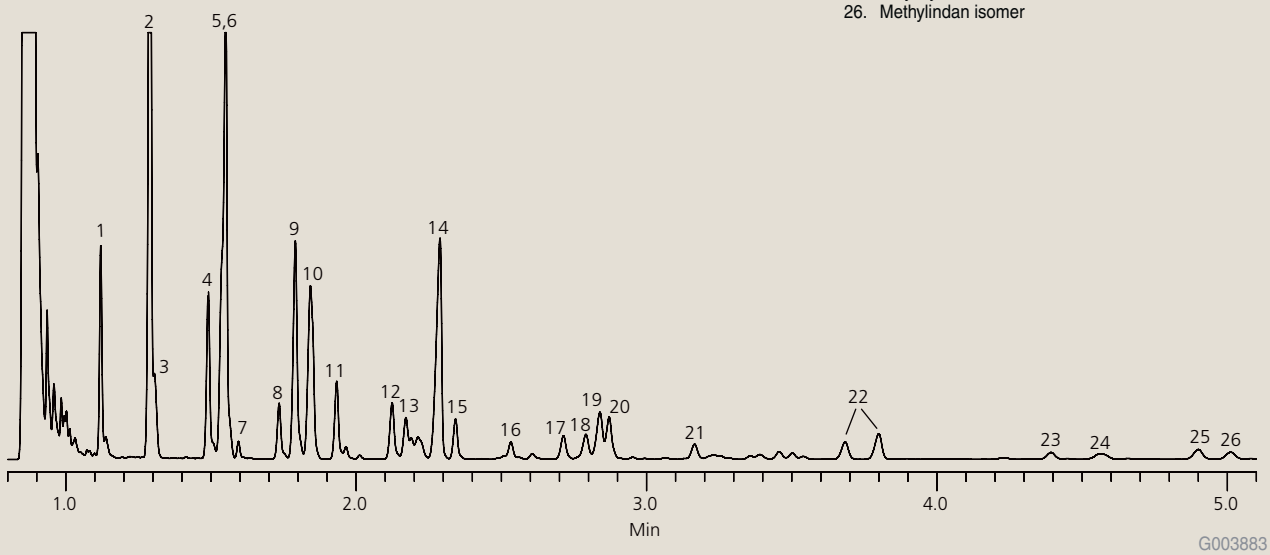


G003889

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
injection: 0.2 µL, 500:1 split
liner: 4 mm I.D., split, cup design
sample: unleaded gasoline (refinery grade)

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. Indan
22. Tetramethyl benzene isomers
23. Methylindan isomer
24. Pentamethyl benzene
25. Ethyl xylene isomer
26. Methylindan isomer

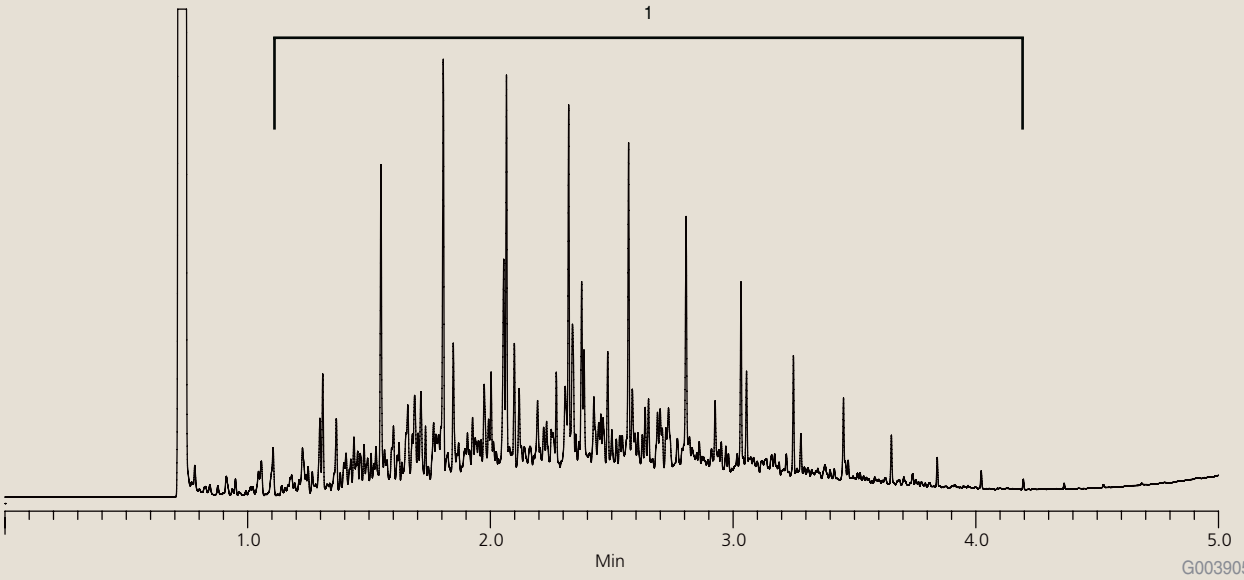


G003883

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

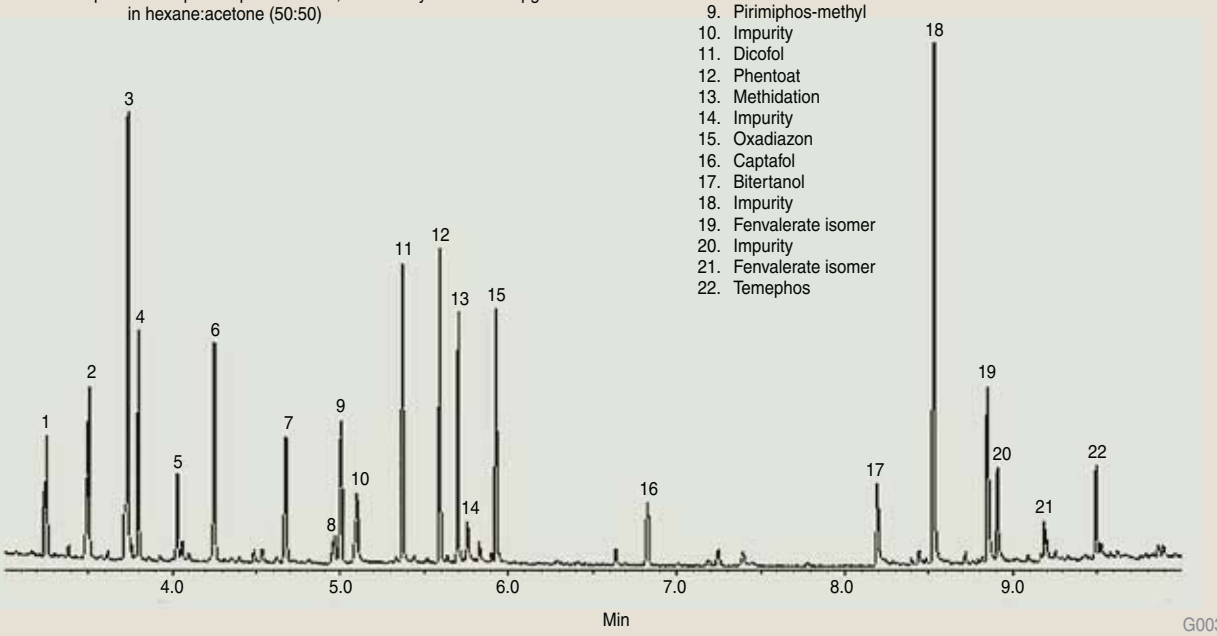


Pesticides/PCBs

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)

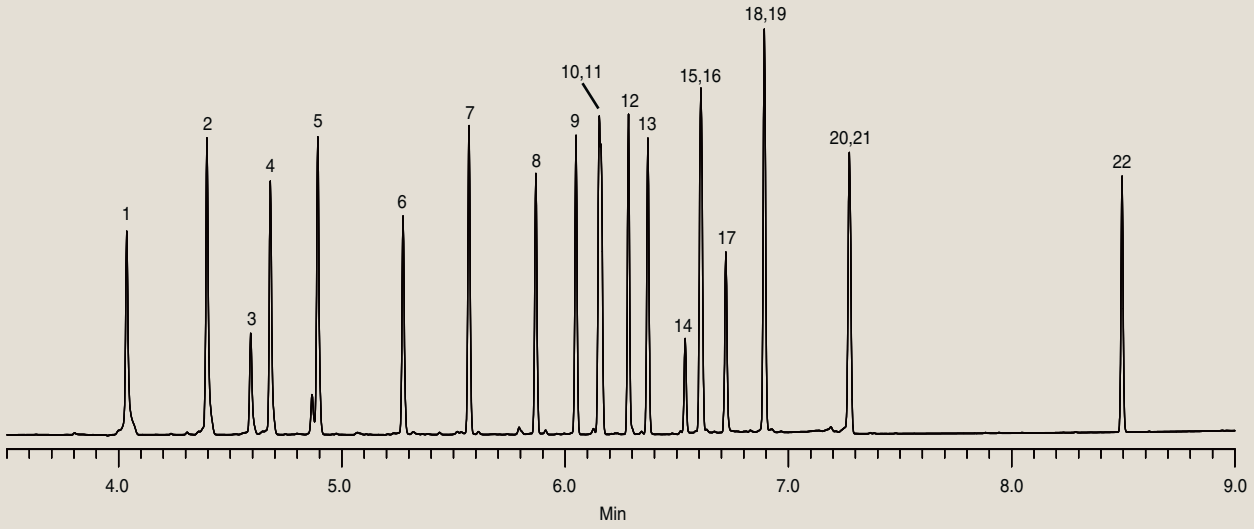
1. Chloreneb
2. Molinate
3. Cycloate
4. Sulfotep
5. Dimethoat
6. Fonofos
7. Prothoate
8. Impurity
9. Pirimiphos-methyl
10. Impurity
11. Dicofol
12. Phentoat
13. Methidation
14. Impurity
15. Oxadiazon
16. Captafol
17. Bitertanol
18. Impurity
19. Fenvalerate isomer
20. Impurity
21. Fenvalerate isomer
22. Temephos



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
inj.: 225 °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.)

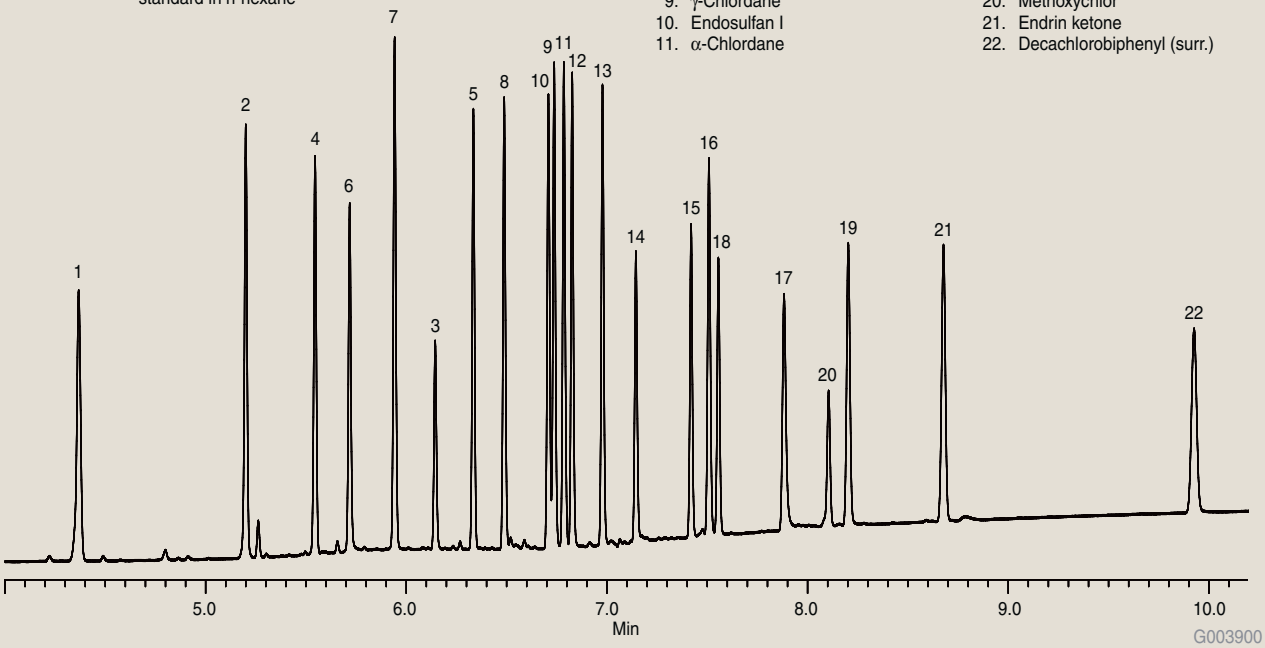


G003899

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
inj.: 225 °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.)

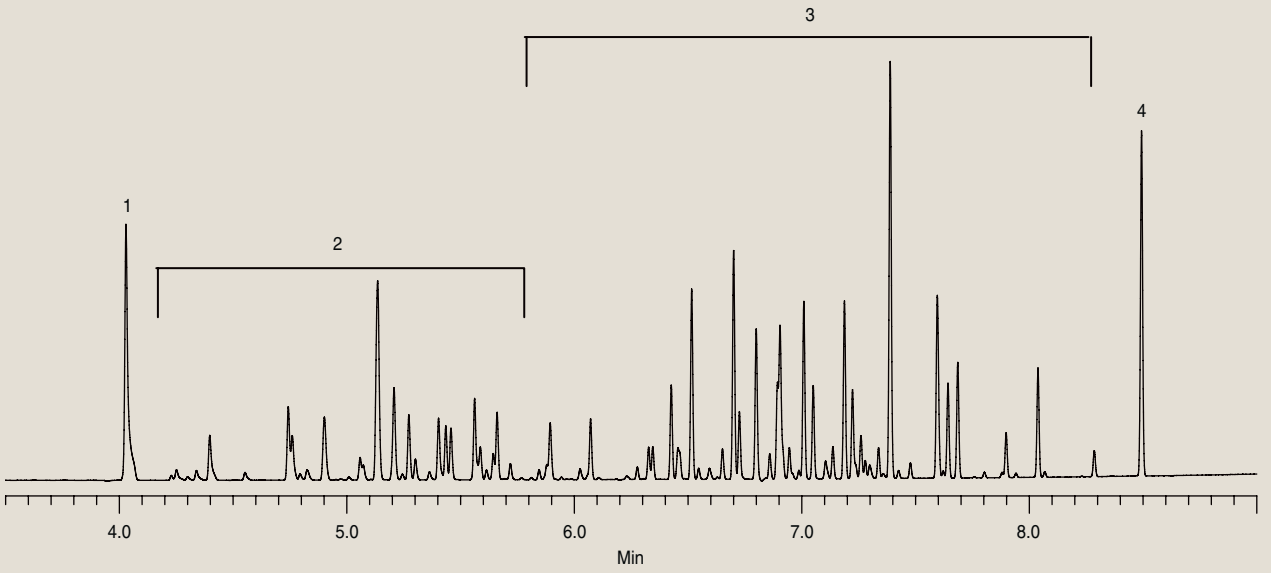


G003900

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, 360 °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.)

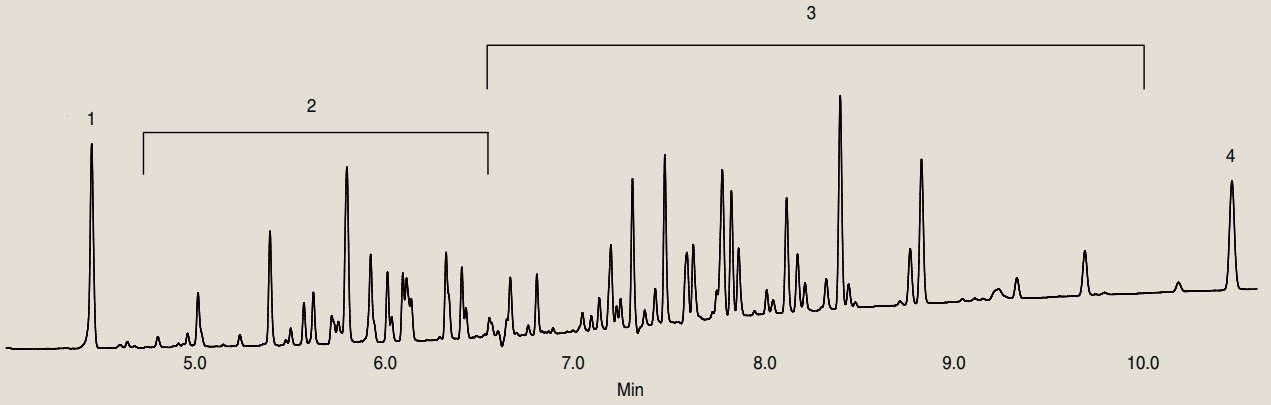


G003897

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.)



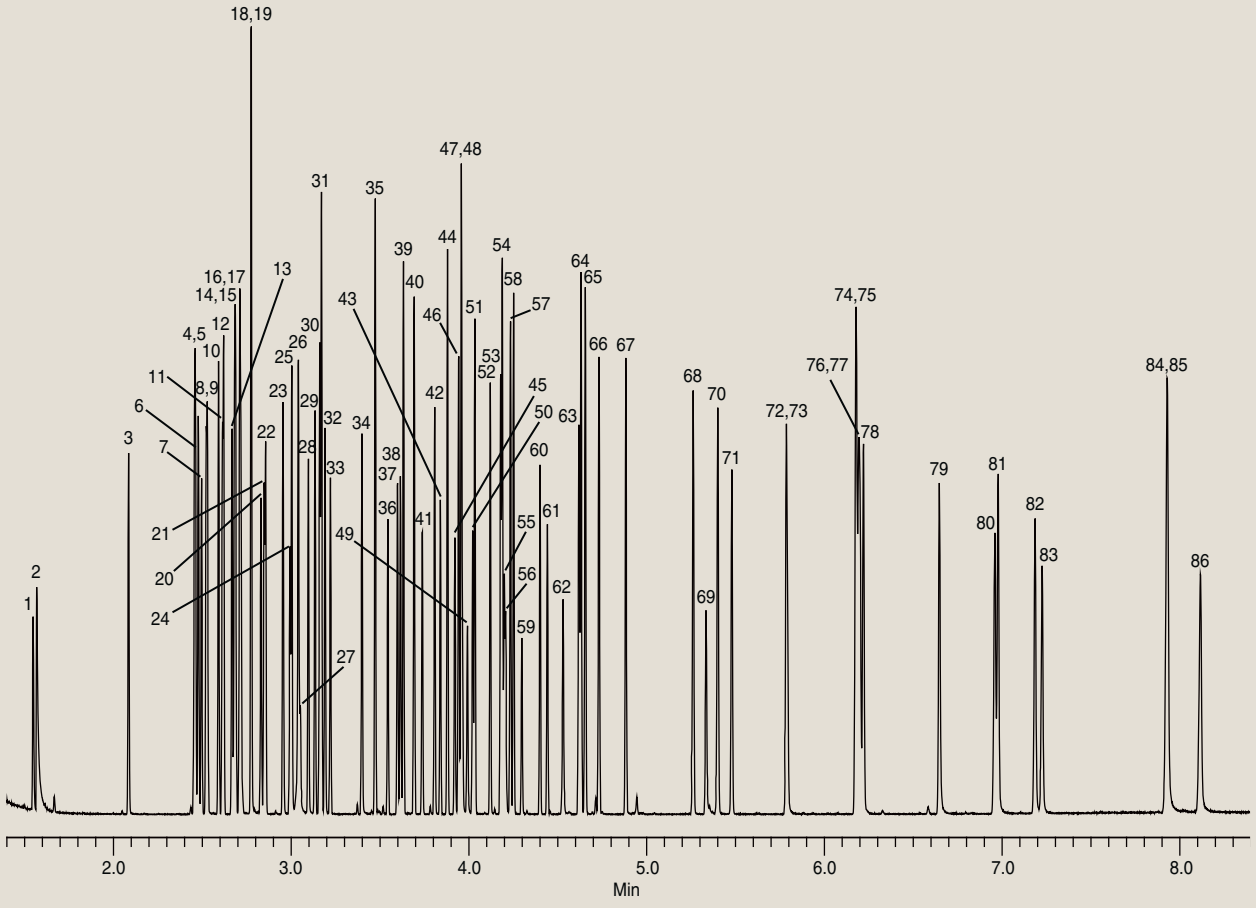
G003881

Semivolatiles

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
scan range: m/z 40-450
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 40 ppm) in methylene chloride

1. N-nitrosodimethylamine
2. Pyridine
3. 2-Fluorophenol (surr.)
4. Phenol-d_6 (surr.)
5. Phenol
6. Aniline
7. Bis(2-chloroethyl)ether
8. 2-Chlorophenol-d_4 (surr.)
9. 2-Chlorophenol
10. 1,3-Dichlorobenzene
11. 1,4-Dichlorobenzene-d_4 (I.S.)
12. 1,4-Dichlorobenzene
13. Benzyl alcohol
14. 1,2-Dichlorobenzene-d_4 (surr.)
15. 1,2-Dichlorobenzene
16. 2-Methylphenol
17. Bis(2-chloroisopropyl)ether
18. N-nitroso-di-n-propylamine
19. 4-Methylphenol
20. Hexachloroethane
21. Nitrobenzene-d_5 (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-d_8 (I.S.)
31. Naphthalene
32. 4-Chloroaniline
33. Hexachlorobutadiene
34. 4-Chloro-3-methylphenol
35. 2-Methylnaphthalene
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-Dinitrotoluene
44. Acenaphthylene
45. 3-Nitroaniline
46. Acenaphthene-d_{10} (I.S.)
47. Acenaphthene
48. 2,4-Dinitrophenol
49. 4-Nitrophenol
50. Dibenzofuran
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-d_{10} (I.S.)
64. Phenanthrene
65. Anthracene
66. Carbazole
67. Di-n-butyl phthalate
68. Fluoranthene
69. Benzidine
70. Pyrene
71. Terphenyl-d_{14} (surr.)
72. 3,3'-Dimethylbenzidine
73. Butylbenzyl phthalate
74. 3,3'-Dichlorobenzidine
75. Benzo(a)anthracene
76. Bis(2-ethylhexyl)phthalate
77. Chrysene-d_{12} (I.S.)
78. Chrysene
79. Di-n-octyl phthalate
80. Benzo(b)fluoranthene
81. Benzo(k)fluoranthene
82. Benzo(a)pyrene
83. Perylene-d_{12} (I.S.)
84. Indeno(1,2,3-cd)pyrene
85. Dibenzo(a,h)anthracene
86. Benzo(g,h,i)perylene

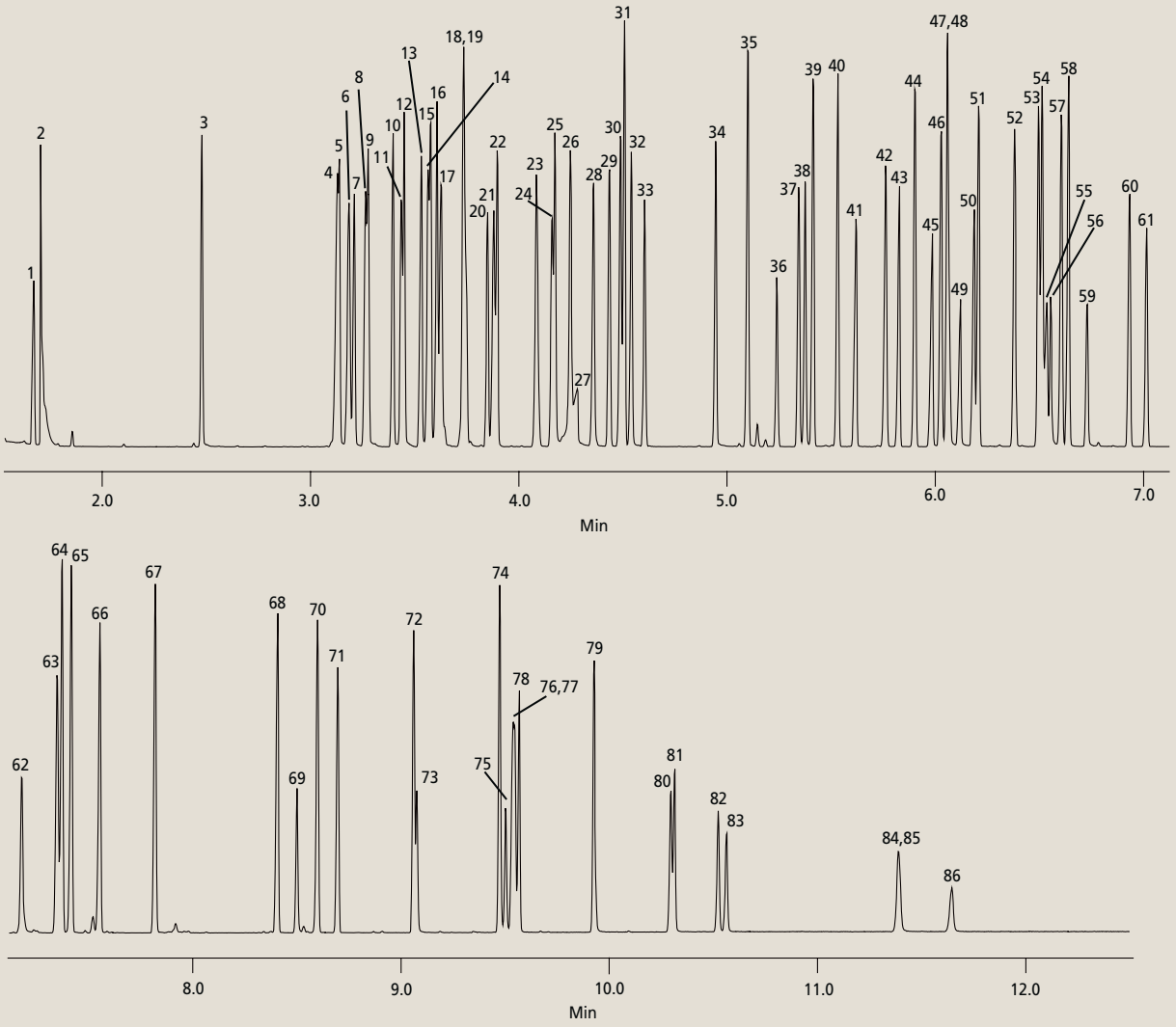


G003739

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.)
inj.: 250 °C
MSD interface: 340 °C
scan range: m/z 40-450
carrier gas: helium, 1.4 mL/min. constant
injection: 0.50 µL, reduced pressure to 20 psi at injection (0.1 min.)
(splitter open at 0.75 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

1. N-Nitrosodimethylamine
2. Pyridine
3. 2-Fluorophenol (surr.)
4. Phenol-d_6 (surr.)
5. Phenol
6. Aniline
7. Bis(2-chloroethyl)ether
8. 2-Chlorophenol-d_4 (surr.)
9. 2-Chlorophenol
10. 1,3-Dichlorobenzene
11. 1,4-Dichlorobenzene-d_4 (I.S.)
12. 1,4-Dichlorobenzene
13. Benzyl alcohol
14. 1,2-Dichlorobenzene-d_4 (surr.)
15. 1,2-Dichlorobenzene
16. 2-Methylphenol
17. Bis(2-chloroisopropyl)ether
18. 4-Methylphenol
19. N-Nitroso-di-n-propylamine
20. Hexachloroethane
21. Nitrobenzene-d_5 (surr.)
22. Nitrobenzene
23. Isophorone
24. 2-Nitrophenol
25. 2,4-Dimethylphenol
26. Bis(2-chloroethoxymethane)
27. Benzoic acid
28. 2,4-Dichlorophenol
29. 1,2,4-Trichlorobenzene
30. Naphthalene-d_8 (I.S.)
31. Naphthalene
32. 4-Chloroaniline
33. Hexachlorobutadiene
34. 4-Chloro-3-methylphenol
35. 2-Methylnaphthalene
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-Dinitrotoluene
44. Acenaphthylene
45. 3-Nitroaniline
46. Acenaphthene-d_{10} (I.S.)
47. Acenaphthene
48. 2,4-Dinitrophenol
49. 4-Nitrophenol
50. 2,4-Dinitrotoluene
51. Dibenzofuran
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-d_{10} (I.S.)
64. Phenanthrene
65. Anthracene
66. Carbazole
67. Di-n-butyl phthalate
68. Fluoranthene
69. Benzidine
70. Pyrene
71. Terphenyl-d_{14} (surr.)
72. Butylbenzyl phthalate
73. 3,3'-Dimethylbenzidine
74. Bis(2-ethylhexyl)phthalate
75. 3,3'-Dichlorobenzidine
76. Benzo(a)anthracene
77. Chrysene-d_{12} (I.S.)
78. Chrysene
79. Di-n-octyl phthalate
80. Benzo(b)fluoranthene
81. Benzo(k)fluoranthene
82. Benzo(a)pyrene
83. Perylene-d_{12} (I.S.)
84. Indeno(1,2,3-cd)pyrene
85. Dibenzo(a,h)anthracene
86. Benzo(g,h,i)perylene



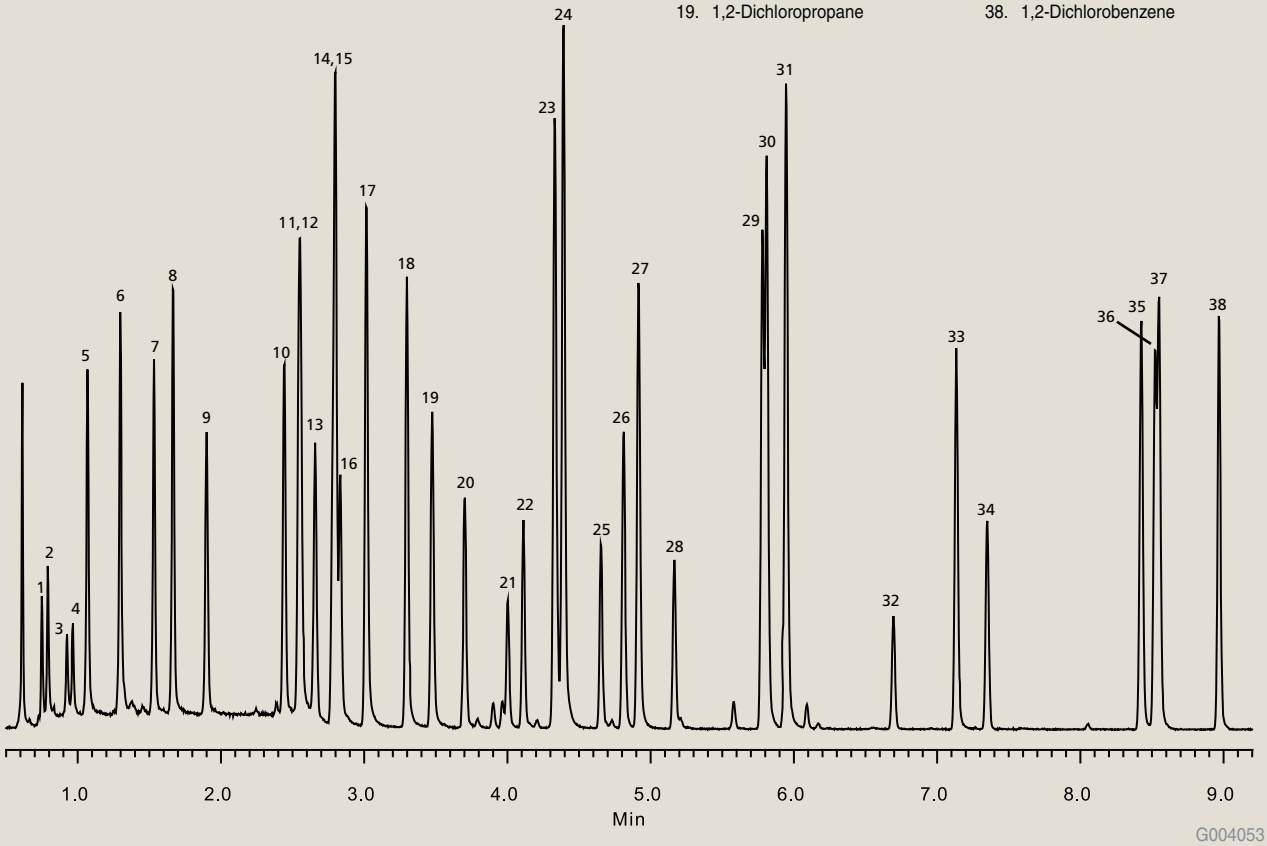
G003901

Volatiles

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

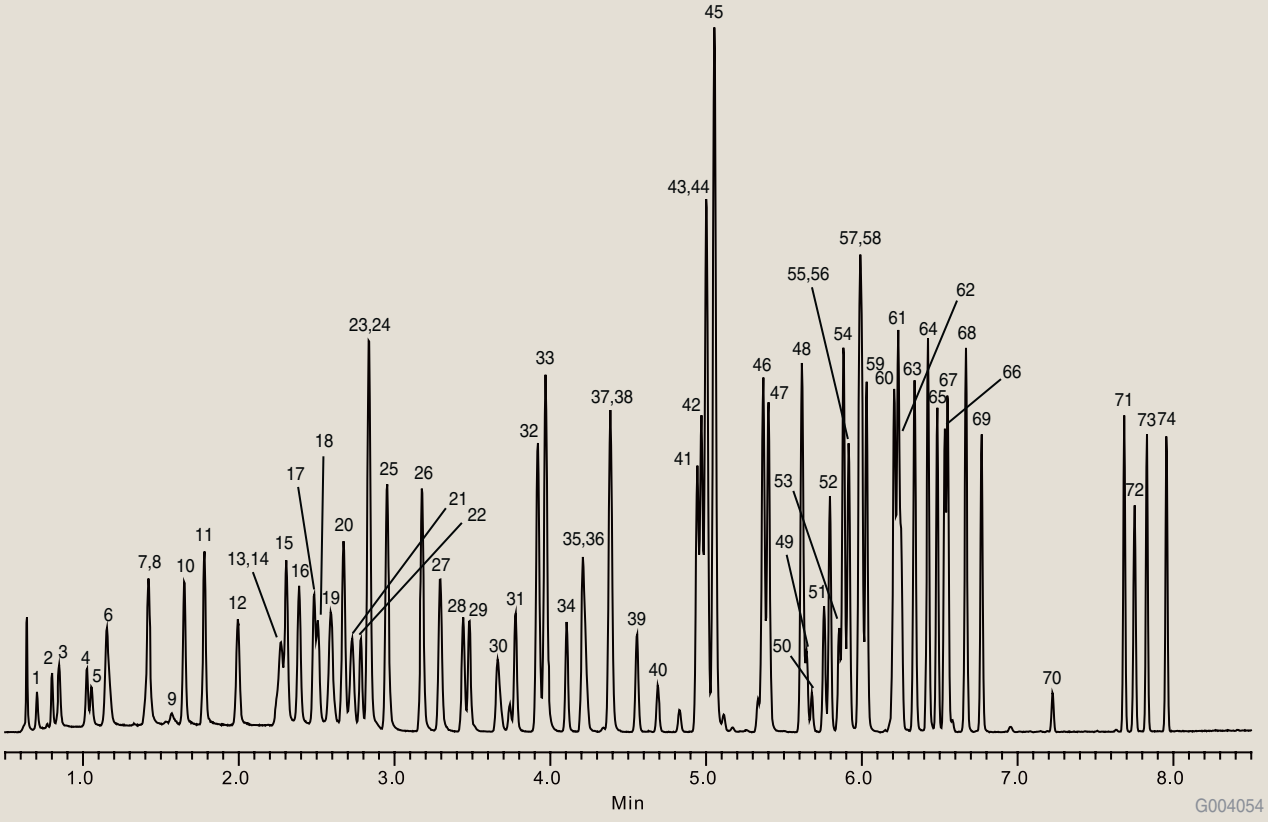
1. Chloromethane
2. Vinyl Chloride
3. Bromomethane
4. Chloroethane
5. Trichlorofluoromethane
6. 1,1-Dichloroethene
7. Methylene chloride
8. trans-1,2-Dichloroethene
9. 1,1-Dichloroethane
10. Chloroform
11. Dibromofluoromethane (surr.)
12. 1,1,1-Trichloroethane
13. Carbon tetrachloride
14. 1,2-Dichloroethane-d4 (surr.)
15. Benzene
16. 1,2-Dichloroethane
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.)
inj.:	150 °C
MSD interface:	220 °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. 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-Dichloroethane
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. 1,1,2-Trichloroethane
36. 2-Hexanone
37. 1,3-Dichloropropane
38. tetrachloroethene
39. Dibromochloromethane
40. 1,2-Dibromomethane
41. Chlorobenzene-d5 (I.S.)
42. Chlorobenzene
43. Ethylbenzene
44. 1,1,1,2-Tetrachloroethane
45. m&p-Xylenes
46. o-Xylene
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



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

P001208

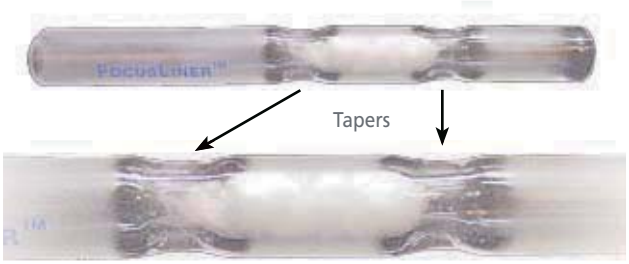
P001227

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

Description	Pkg	Cat. No.
9.5 mm	50 ea	28670-U
9.5 mm, with injection hole	50 ea	28331-U
10 mm	50 ea	28673-U
10 mm, with injection hole	50 ea	28333-U
11 mm	50 ea	28676-U
11 mm, with injection hole	50 ea	28336-U
Plug (for Shimadzu®)	50 ea	20633

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

Description	Pkg	Cat. No.
For Agilent® 5890/6890/7890 (78.5 mm x 6.3 mm O.D.)		
Split/splitless, 2.3 mm I.D., wool packed	5 ea	2879605-U
Split/splitless with single taper, 2.3 mm I.D., wool packed	5 ea	2879505-U
For Finnigan		
Same catalog numbers as Agilent		
For PerkinElmer® AutoSystem™ and Clarus® (92 mm x 6.3 mm O.D.)		
Split/splitless, 4 mm I.D., wool packed	5 ea	2879205-U
Split/splitless with single taper, 4 mm I.D., wool packed	5 ea	2879105-U
For Shimadzu® 17A with SPL-17 Injector (95 mm x 5 mm O.D.)		
Split/splitless, 3.4 mm I.D., wool packed	5 ea	2878605-U
Split/splitless with single taper, 3.4 mm I.D., wool packed	5 ea	2878405-U
For Thermo ThermoQuest 8000/TRACE™ (105 mm x 8 mm O.D.)		
Split/splitless with single taper, 5 mm I.D., wool packed	5 ea	2877505-U
For Varian® 1075/1077 Injectors (72 mm x 6.3 mm O.D.)		
Split, 2.3 mm I.D., wool packed	5 ea	2874705-U
For Varian 1078/1079 Injectors (54 mm x 5 mm O.D.)		
Split/splitless with single taper, 3.4 mm I.D., wool packed	5 ea	2875705-U
For Varian CP-1177 Injectors		
Same catalog numbers as Agilent		

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

P000752

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

Material	Pkg	Cat. No.
Non-plated	10 ea	23317-U
Gold-plated	10 ea	23319-U
Gold-plated, cross design	10 ea	23415-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.

P000301

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

Description	Cat. No.
Premium Grade 304 Stainless Steel Tubing	
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.209 inch (5.3 mm) I.D.	20527
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.085 inch (2.1 mm) I.D.	20526-U
100 ft. x 1/16 inch (1.59 mm) O.D. x 0.030 inch (0.762 mm) I.D.	20553
Cleaned Copper Tubing	
50 ft. x 1/4 inch (6.35 mm) O.D. x 0.190 inch (4.83 mm) I.D.	20489
50 ft. x 1/8 inch (3.18 mm) O.D. x 0.065 inch (1.65 mm) I.D.	20488

Swagelok® Tubing Fittings

P000252

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

Description	Cat. No.
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

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

P000329

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

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

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

1. D.H. Desty in: Advances in Chromatography, Marcel Dekker, New York, 1965.
2. M. van Lieshout, M. van Deursen, R. Derks, H-G. Janssen, C.A. Cramers, J. Microcol. Sep. 11 (1999) 155.
3. C. Bicchi, C. Brunelli, M. Galli, A. Sironi, J. Chromatogr. A 931 (2001) 129.
4. M. van Deursen, H-J. Janssen, J. Beens, P. Lipman, R. Reinierkens, G. Rutten, C.A. Cramers, J. Microcol. Sep. 12 (2000) 613.
5. J. Dallüge, R.J.J. Vreuls, D.J. van Iperen, M. Van Rijn, U.A.Th. Brinkman, J. Sep. Sci. 25 (2002) 608.
6. P. Korytár, H-G. Janssen, E. Matisová, U.A.T. Brinkman, Trends Anal. Chem. 21 (2002) 558.
7. C.A. Cramers, H-G. Janssen, M.M van Deursen, P.A. Leclercq, J. Chromatogr. A. 856 (1999) 315.
8. M.J.E. Golay, in : Gas Chromatography, Butterworths, London, 1958.
9. G.H. Stewart, S.L. Seager, J.C. Giddings, Anal. Chem. 31 (1959) 1738.
10. J.C. Giddings, S.L. Seager, L.R. Stucki, G.H. Stewart, Anal. Chem. 32 (1960) 867.
11. C.A. Cramers, C.E. van Tilburg, C.P.M. Schutjes, J.A. Rijks, G.A. Rutten, R. De Nijs, in: Capillary Chromatography. 5th Symposium, Riva del Garda, April 26-28, Elsevier, Amsterdam, 1983.
12. L.M. Blumberg, M.S. Klee, Anal. Chem. 70 (1998) 3828.
13. P. Donato, P.Q. Tranchida, P. Dugo, G. Dugo, L. Mondello, J. Sep. Sci. 30 (2007) 508.
14. G. Gaspar, J. Chromatogr. A 556 (1991) 331.
15. L. Blumberg, J. High Resol. Chromatogr. 20 (1997) 597.
16. L. Blumberg, J. High Resol. Chromatogr. 22 (1999) 403.
17. E. Matislová, M. Dömötörová, J. Chromatogr. A 1000 (2003) 199.

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Argentina
SIGMA-ALDRICH DE ARGENTINA S.A.
Free Tel: 0810 888 7446
Tel: (+54) 11 4556 1472
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Australia
SIGMA-ALDRICH PTY LTD.
Free Tel: 1800 800 097
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Tel: (+61) 2 9841 0555
Fax: (+61) 2 9841 0500

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Tel: (+43) 1 605 81 10
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Ingyenes zöld telefon: 06 80 355 355
Ingyenes zöld fax: 06 80 344 344
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Fax: (+36) 1 235 9050

India
SIGMA-ALDRICH CHEMICALS
PRIVATE LIMITED
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New Delhi: (+91) 11 4358 8000
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Italy
SIGMA-ALDRICH S.r.l.
Numero Verde: 800 827018
Tel: (+39) 02 3341 7310
Fax: (+39) 02 3801 0737

Japan
SIGMA-ALDRICH JAPAN K.K.
Tel: (+81) 3 5796 7300
Fax: (+81) 3 5796 7315

Korea
SIGMA-ALDRICH KOREA
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Tel: (+82) 31 329 9000
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SIGMA-ALDRICH Sp. z o.o.
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Fax: (+48) 61 829 01 20

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SIGMA-ALDRICH QUÍMICA, S.A.
Free Tel: 800 202 180
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Singapore
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Sweden
SIGMA-ALDRICH SWEDEN AB
Tel: (+46) 8 742 4200
Fax: (+46) 8 742 4243

Switzerland
SIGMA-ALDRICH CHEMIE GmbH
Free Tel: 0800 80 00 80
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Tel: (+41) 81 755 2828
Fax: (+41) 81 755 2815

United Kingdom
SIGMA-ALDRICH COMPANY LTD.
Free Tel: 0800 717 181
Free Fax: 0800 378 785
Tel: (+44) 1747 833 000
Fax: (+44) 1747 833 313
SAFC (UK) Free Tel: 01202 712305

United States
SIGMA-ALDRICH
P.O. Box 14508
St. Louis, Missouri 63178
Toll-Free: 800 325 3010
Toll-Free Fax: 800 325 5052
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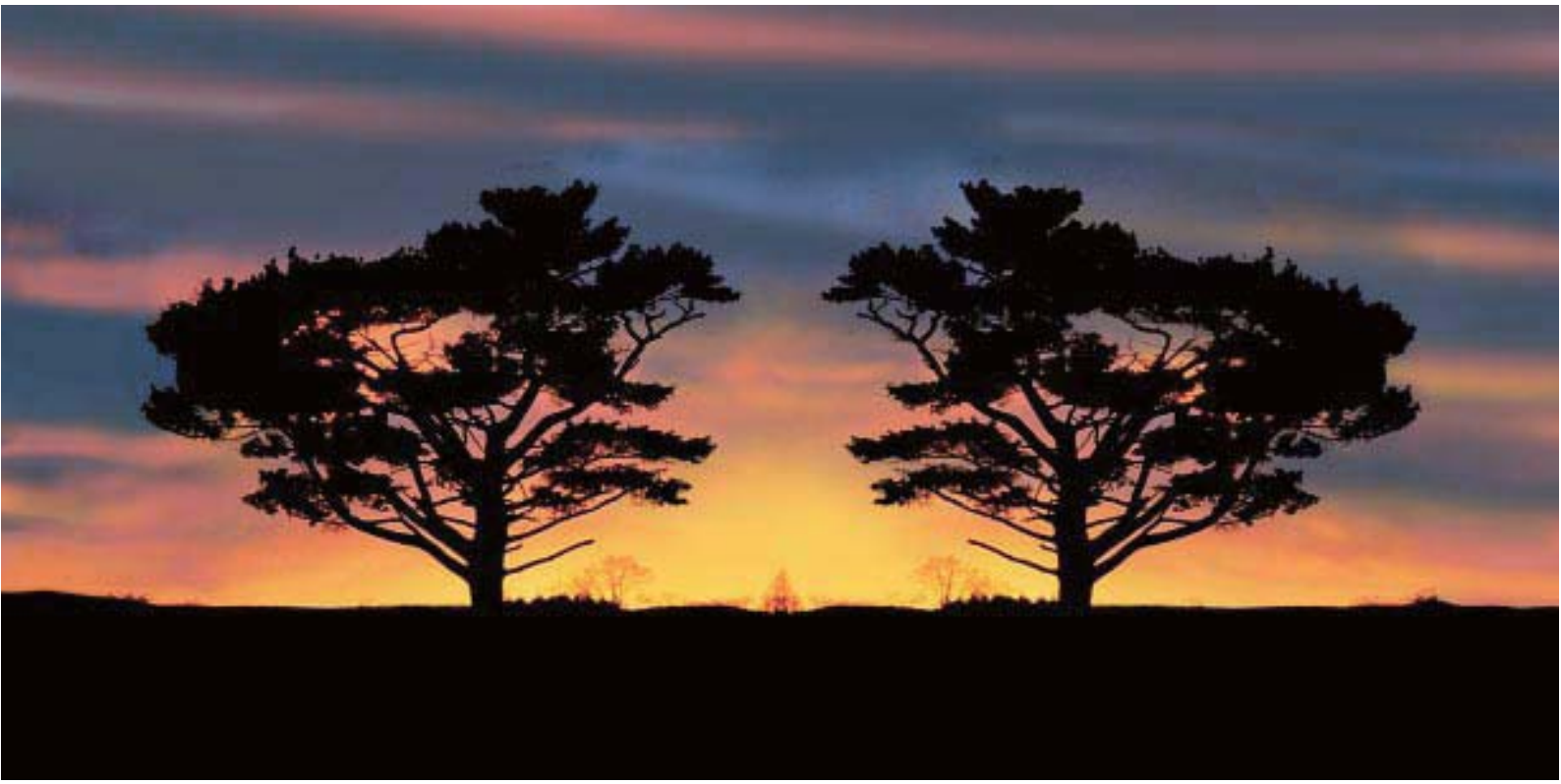
T407096A

Chiral Cyclodextrin Capillary GC Columns



895-0008

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

SUPELCO

ISO 9001 REGISTERED QSR-255

T194877A

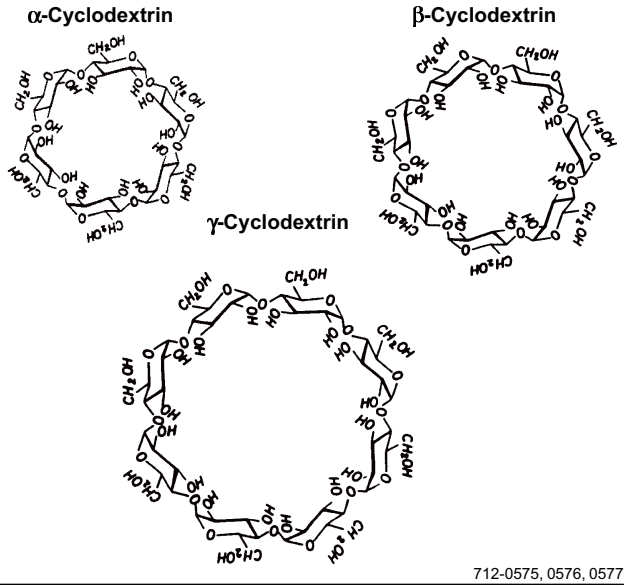
Chiral molecules can elicit very different responses in a biological system, depending on their stereochemistry (1,2). Rapid commercial introduction of optically active drugs requires reliable stereochemical analysis of the products, and of the chiral intermediates used in their synthesis. Capillary 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

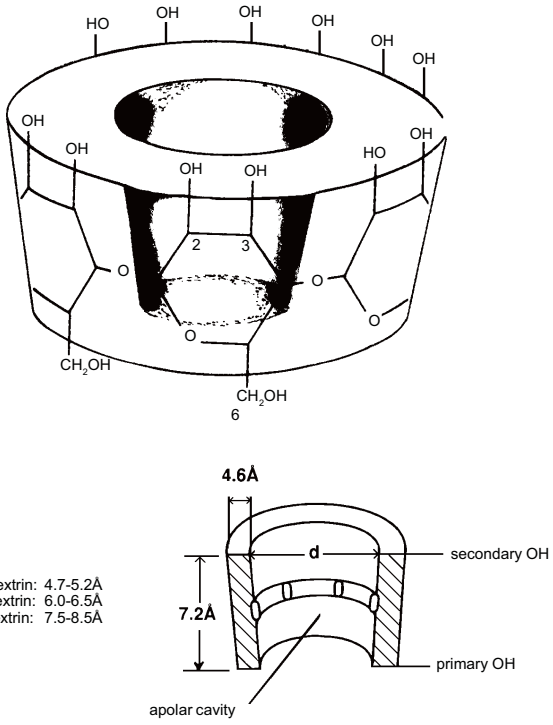
Cyclodextrins (CDs) are cyclic, chiral, torus-shaped macromolecules composed of 6 or more D(+)-glucose residues bonded through α-(1-4) glycosidic linkage. CDs are classified by the number of glucose residues they contain; α-CDs contain 6 residues (cyclohexaamylose), β-CDs contain 7 (cycloheptaamylose), 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 C_2 and C_3 atoms of each glucose unit (Figure B). The primary hydroxyl groups are located at the base of the torus, on the C_6 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.

Figure A. Cyclodextrins (approx. to scale)



712-0575, 0576, 0577

Figure B. Cyclodextrin: Molecular Model



Cross section through the cone of α-, β-, or γ-cyclodextrin (6, 7, or 8 glucose units) with the hydroxyl groups outside the cavity and the ring of glycosidic oxygens -O- inside.

712-0090,93-9512

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

DEX Column	Probability of Achieving Separation	Compounds Separated
α-DEX 120	40-50%	alcohols, diols, epoxides, ethers, halohydrocarbons, ketones, positional isomers
β-DEX 110 β-DEX 120	80-90%	acids, amines, alcohols, diols, esters, ethers, halohydrocarbons, hydrocarbons, ketones, positional isomers, silanes, terpenes, terpineols
γ-DEX 120	40-50%	acids, amines, esters, halohydrocarbons, ketones, positional isomers

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

Column	Minimum	Temperature Preliminary Conditioning	Maximum*
α-DEX 120	30°C	220°C	240°C/250°C
β-DEX 110	30°C	170°C	240°C/250°C
β-DEX 120	30°C	170°C	240°C/250°C
γ-DEX 120	30°C	120°C	240°C/250°C

*Isothermal/programmed.

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

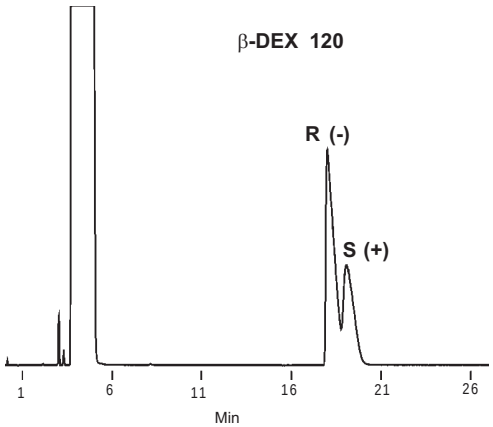
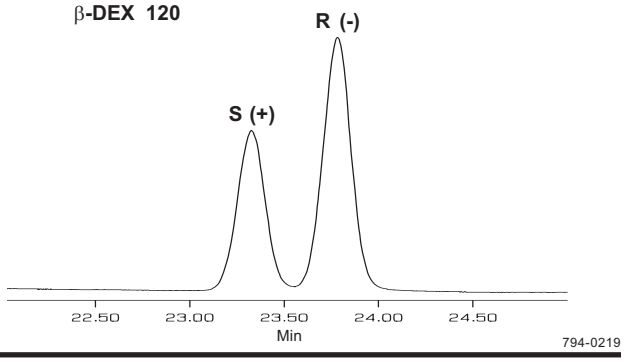


Figure D. (±)2,2,2-Trifluoro-1-(9-anthryl)ethanol at 240°C (maximum temperature for DEX columns)



Chiral Test Mixes

Each DEX column is individually tested with an appropriate isothermal 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.

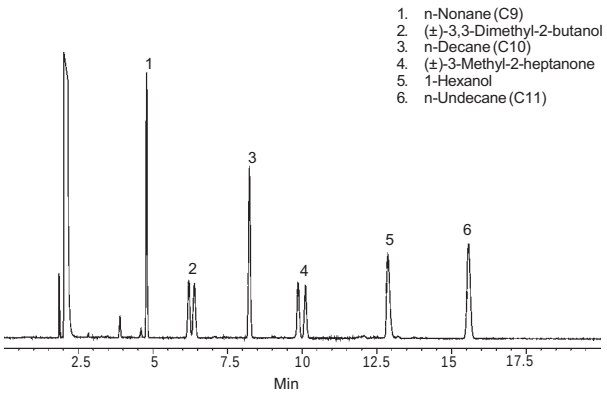
Table 3. Test Mix Components

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

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

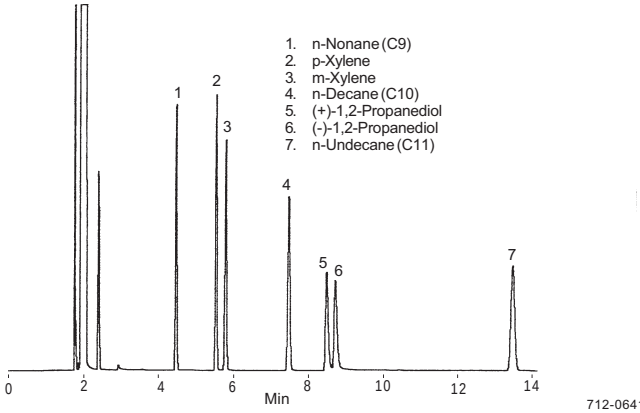
Column: **β-DEX 120 (separation shown) or β-DEX 110,** 30m or 60m x 0.25mm ID, 0.25µm film
Oven: 75°C (β-DEX 110) or 80°C (β-DEX 120)
Carrier: helium, 30cm/sec (30m columns) or 20cm/sec (60m columns)
Det.: FID, 300°C
Inj.: 1µL test mix (Cat. No. 4-8028, 0.5mg/mL each analyte in methylene chloride), split (100:1), 220°C



795-0637

Figure F. α-DEX Column: Isothermal Test Mix

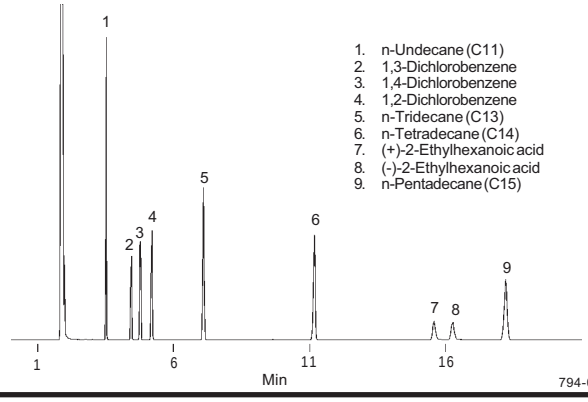
Column: **α-DEX 120,** 30m x 0.25mm ID, 0.25µm film
Oven: 80°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL test mix (Cat. No. 4-8013, 0.5mg/mL each analyte in methylene chloride), split (100:1), 220°C



712-0641

Figure G. γ-DEX Column: Isothermal Test Mix

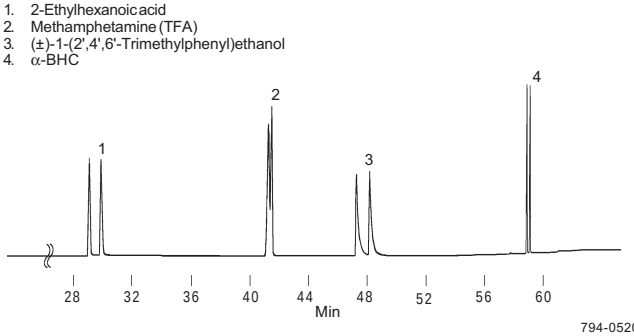
Column: **γ-DEX 120,** 30m x 0.25mm ID, 0.25µm film
Oven: 125°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL test mix (Cat. No. 4-7898, 0.5mg/mL each analyte in methylene chloride), split (100:1), 220°C



794-0153

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

Column: **γ-DEX 120,** 30m x 0.25mm ID, 0.25µm film
Oven: 90°C to 135°C at 1°C/min, then to 240°C at 5°C/min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride containing 0.5mg/mL each analyte, split (100:1), 300°C



794-0520

Enantioselectivity (α) 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 α 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 β-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 β-DEX 120 column).

Column Diameter (ID) and Resolution

Decreasing the internal diameter (ID) of DEX columns increases enantiomer resolution, while leaving separation factors (α 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).

Figure I. Decreasing the (Isothermal) Temperature Increases Enantiomer Separation

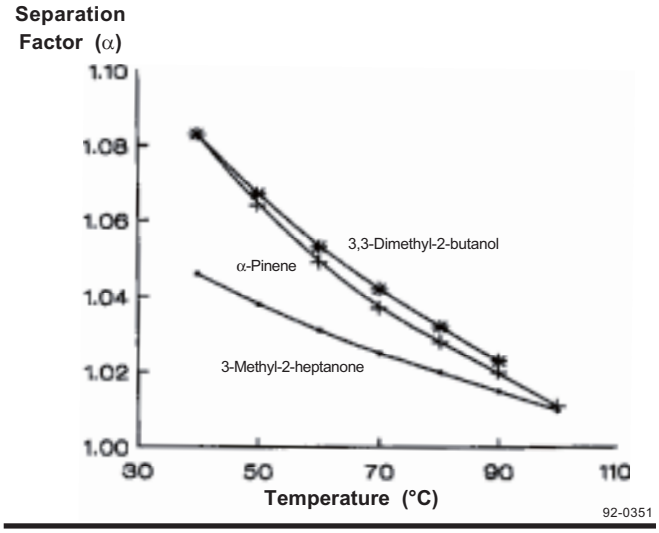


Figure J. Increasing the Cyclodextrin Percentage Increases Enantiomer Separation

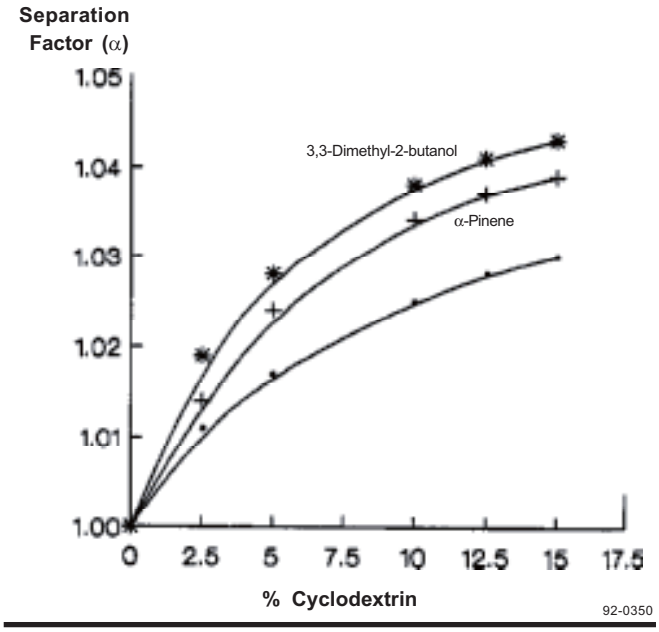


Table 4. Enantioselectivity (α) and Chiral Resolution (Rs) as Functions of Column ID*

	Test Compound					
	(+/-)-3,3-Dimethyl-2-butanol		(+/-)-α-Pinene		(+/-)-3-Methyl-2-heptanone	
Column ID	α	Rs	α	Rs	α	Rs
0.10mm	1.037	1.89	1.031	2.28	1.021	1.84
0.20mm	1.037	1.35	1.031	1.70	1.021	1.47
0.32mm	1.036	0.98	1.030	1.10	1.021	1.01
0.53mm	1.037	0.70	1.033	0.84	1.023	0.80

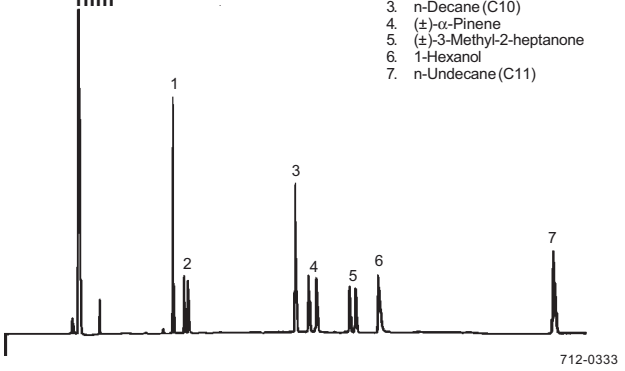
*β-DEX 110 columns (phase ratio = 250); 75°C; helium carrier.

Figure K. Decreasing Column ID Increases Enantiomer Resolution without Affecting Separation Factors*

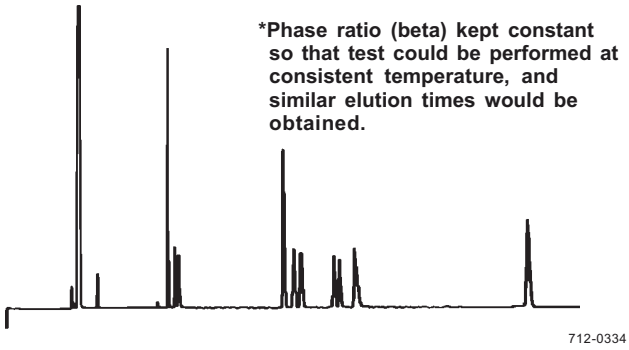
Columns: β-DEX 110, 30m
Oven: 75°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL, 0.5mg/mL each analyte in methylene chloride), split (100:1), 220°C

1. n-Nonane (C9)
2. (±)-3,3-Dimethyl-2-butanol
3. n-Decane (C10)
4. (±)-α-Pinene
5. (±)-3-Methyl-2-heptanone
6. 1-Hexanol
7. n-Undecane (C11)

100µm ID, 0.10µm film

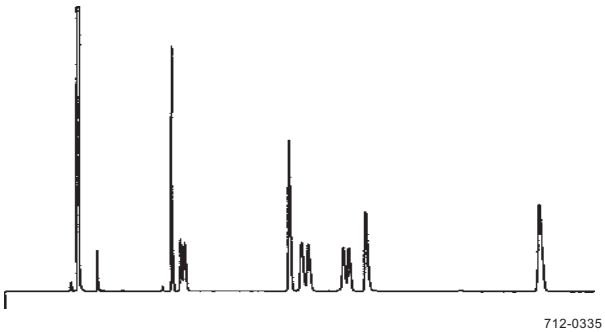


200µm ID, 0.20µm film

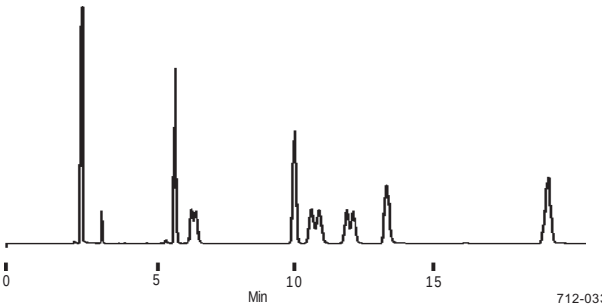


***Phase ratio (beta) kept constant so that test could be performed at consistent temperature, and similar elution times would be obtained.**

320µm ID, 0.32µm film



530µm ID, 0.53µm film



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

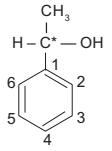
When determining optical purity with one enantiomer in large excess relative to the other, it is generally better to have the less concentrated enantiomer elute first. The enantiomer in excess frequently produces a large tailing peak that could overlap a smaller, later-eluting peak. Reversing the elution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

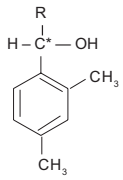
In some cases, enantio-reversal can be achieved by changing columns, such as from α-DEX to β-DEX or γ-DEX (7, 8, 10). For example, carvone enantiomers are separated in reversed order on α-DEX and γ-DEX columns, and coelute on β-DEX columns. Additional examples of enantio-reversal (α-BHC, alcohols, methyl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

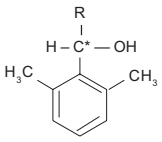
Separation Mechanism

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 5. Enantioselectivity of Substituted Phenyl Alcohols

Compound		Separation Factor (α) at 110°C α-DEX 120	β-DEX 120	γ-DEX 120
1-phenylethanol		NS*	1.065	1.015
1-(2-methylphenyl)ethanol		1.022	1.194	1.032
1-(4-methylphenyl)ethanol		NS	1.088	1.036
1-(2,4-dimethylphenyl)ethanol		1.014	1.273	1.102
1-(2,5-dimethylphenyl)ethanol		1.038	1.230	1.058
1-(2,6-dimethylphenyl)ethanol		1.111	1.191	1.035
1-(3,4-dimethylphenyl)ethanol		NS	1.043	1.026
1-(3,5-bis[trifluoromethyl]phenyl)ethanol		1.017	1.117	1.008

α-alkyl(2,4-dimethylbenzyl) alcohol alkyl (R) =		Separation Factor (α) at 140°C α-DEX 120	β-DEX 120	γ-DEX 120
-methyl**		1.012	1.125	1.043
-butyl		1.011	1.020	1.007
-isobutyl		1.015	1.059	1.032
-t-butyl		1.013	1.105	1.038
-pentyl		NS	NS	1.006
-hexyl		1.008	NS	1.008
-heptyl		1.003	1.013	1.083

α-alkyl(2,6-dimethylbenzyl) alcohol alkyl (R) =		Separation Factor (α) at 140°C α-DEX 120	β-DEX 120	γ-DEX 120
-methyl***		1.072	1.110	1.020
-butyl		NS	1.036	NS
-isobutyl		NS	1.032	1.034
-t-butyl		NS	1.113	1.024
-pentyl		NS	1.038	NS
-hexyl		1.008	1.072	NS
-heptyl		1.002	1.083	1.010
-neopentyl		1.013	1.092	NS

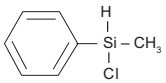
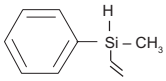
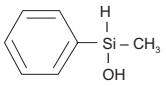
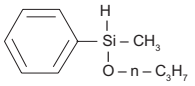
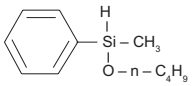
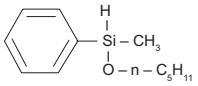
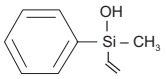
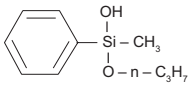
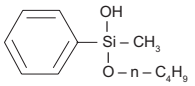
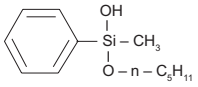
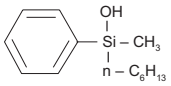
Carrier: helium, 20cm/sec, 70cc/min splitter vent flow
Detector: FID (4 x 10^{-11} AFS), 250°C
Injection: 1µL (0.1-0.5mg/mL each analyte), split (100:1), 250°C

*NS – no observable separation
**1-(2,4-dimethylphenyl)ethanol
***1-(2,6-dimethylphenyl)ethanol

References

1. Cope, M.J., *Anal. Proc.* **30:** 498 (1993).
2. Stinson, S.C., *Chem. Eng. News* **73** (41): 44 (1995).
3. Gil-Av, E., B. Feibush, and R. Charles-Sigler, *Tetrahedron Lett.* 1009 (1966).
4. Schurig, V. *Angew. Chem.* **96:** 733 (1984); *Angew. Chem. Int. Ed. Engl.* **23:** 747 (1984).
5. Schurig, V. and H.-P. Nowotny, *Angew. Chem.* **102:** 969 (1990); *Angew. Chem. Int. Ed. Engl.* **29:** 939 (1990).
6. Keim, W. A. Kohnes, W. Meltzow, and H. Romer, *HRC* **14:** 507 (1991).
7. Mani, V. and C. Woolley, *LC-GC* **14**: 734 (1995).
8. Falconer, R.L., T.F. Bidleman, D.J. Gregor, R. Semkin, and C. Teixeira, *Environ. Sci. Technol.* **29**: 1297 (1995).
9. Feibush, B., C.L. Woolley, and V. Mani, *Anal. Chem.* **65:** 1130 (1993).
10. Mani, V. and Woolley, C., *Foods and Food Ingredients Journal of Japan* **163**: 94 (1995).

Table 6. Chiral Silanes

Compound	Structure	Col. Temp.	α value• and (k'$_1$) α-DEX 110	β-DEX 110	γ-DEX 110
Phenylmethylchlorosilane (Chloromethylphenylsilane)		70°C	NS* (10.3)	NS (11.4)	1.006 (10.9)
Phenylmethylvinylsilane (Methylphenylvinylsilane)		70°C	NS (9.1)	1.012 (9.5)	NS (9.5)
Phenylmethylhydroxysilane (Methylphenylsilanol)		100°C	1.015 (9.0)	1.084 (13.5)	1.015 (10.4)
Phenylmethylpropoxysilane (Methylphenylpropoxysilane)		100°C	NS (6.1)	NS (6.2)	NS (5.6)
Phenylmethylbutoxysilane (Butoxymethylphenylsilane)		100°C	NS (11.1)	NS (11.5)	NS (10.2)
Phenylmethylpentoxysilane (Methylpentoxyphenylsilane)		100°C	NS (20.4)	1.008 (21.3)	NS (18.5)
Methylphenylvinylsilanol		120°C	1.008 (6.6)	1.019 (8.8)	1.015 (8.3)
Methylphenylpropoxysilanol		140°C	1.013 (5.6)	1.017 (6.2)	1.014 (6.5)
Methylphenylbutoxysilanol		140°C	1.018 (8.8)	1.038 (9.7)	1.015 (10.4)
Methylpentoxyphenylsilanol		140°C	1.019 (14.3)	1.065 (15.5)	1.025 (16.6)
Hexylmethylphenylsilanol		140°C	NS (17.9)	1.027 (19.4)	1.023 (20.0)

*NS – no observable separation
•See Key Words and Definitions on page 16.
k'$_1$ = k' for first eluting peak.

Table 7. Chiral Compounds

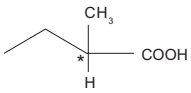
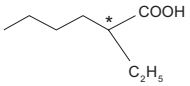
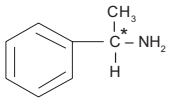
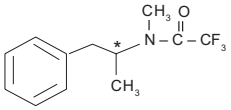
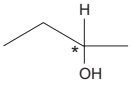
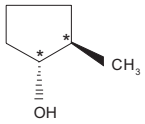
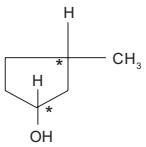
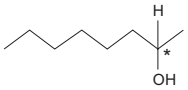
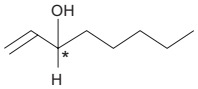
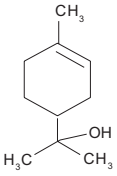
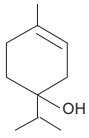
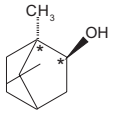
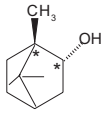
Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
Acids						
2-Methylbutyric acid		110°C	NS[1] (1.9)	1.046 (2.1)	1.051 (3.8)	1.010 (2.6)
2-Ethylhexanoic acid		125°C	1.012 (5.0)	1.035 (5.3)	—	1.048 (7.0)
Amines						
α-Methylbenzylamine		90°C	NS (7.8)	1.029 (8.5)	1.030 (11.9)	NS (9.5)
N-Trifluoroacetyl-methamphetamine		90°C 1°/min	NS (26.6)	NS (27.1)	—	1.066 (23.3)
Alcohols						
2-Butanol		30°C	NS (2.4)	1.043 (4.2)	1.070 (5.0)	NS (2.8)
trans-2-Methylcyclopentanol		70°C	1.040 (4.2)	—	1.060 (13.6)	NS (5.0)
3-Methylcyclopentanol		70°C	1.021 (5.4)	NS (7.5)	NS (13.7)	NS (4.8)
2-Octanol		80°C	1.017 (7.9)	1.011 (8.3)	1.017 (13.4)	NS (7.7)
1-Octen-3-ol		80°C	1.030 (6.9)	1.015 (8.5)	1.021 (13.5)	NS (5.3)
α-Terpineol[2]		100°C	NS (12.4)	1.031 (15.2)	1.042 (23.7)	1.028 (15.4)
Terpinen-4-ol[3]		100°C	NS (6.2)	1.032 (1.8)	1.036 (10.2)	1.010 (12.3)
Borneol		120°C	NS (4.6)	1.046 (6.7)	1.051 (7.9)	NS (6.1)
Isoborneol		120°C	NS (3.8)	1.021 (6.0)	1.025 (9.1)	NS (6.9)

Table 7. Chiral Compounds contd.

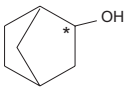
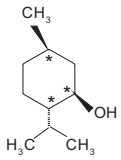
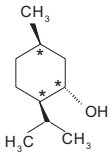
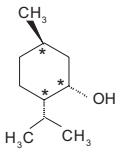
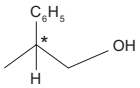
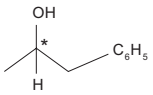
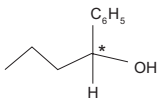
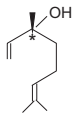
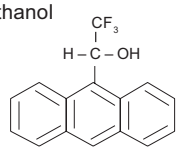
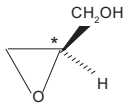
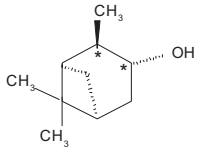
Compound	Structure	Col. Temp.	α value and (k'_1) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
Exonorborneol		120°C	NS (4.2)	—	1.026 (3.0)	NS (2.1)
Menthol		110°C	1.021 (6.7)	1.025 (7.6)	1.031 (11.5)	1.030 (8.5)
Isomenthol[4]		110°C	1.030 (7.0)	1.031 (8.6)	1.041 (14.6)	1.015 (9.9)
Neomenthol		110°C	1.060 (6.1)	1.037 (6.9)	1.048 (10.2)	1.025 (7.6)
2-Phenyl-1-propanol		110°C	1.012 (10.2)	1.016 (11.2)	1.014 (12.8)	1.006 (13.2)
1-Phenyl-2-propanol		110°C	NS (7.5)	1.018 (7.9)	1.016 (8.9)	NS (8.6)
1-Phenyl-1-butanol		130°C	1.016 (6.5)	NS (6.6)	NS (9.2)	NS (8.3)
Linalool		90°C	NS (8.4)	1.024 (12.3)	1.019 (10.7)	NS (5.6)
2,2,2-Trifluoro-1-(9-anthryl)ethanol		240°C	1.008 (18.0)	1.015 (7.3)	1.018 (8.6)	1.014 (9.7)
Glycidol		40°C	1.043 (11.5)	1.052 (12.3)	1.066 (10.9)	1.016 (10.8)
Isopinocampheol		100°C	1.027 (10.8)	1.014 (16.5)	1.061 (4.5)	1.011 (17.9)

Table 7. Chiral Compounds contd.

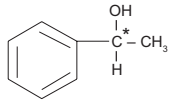
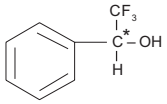
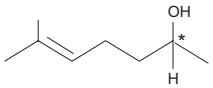
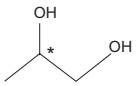
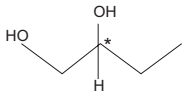
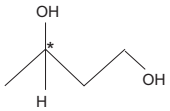
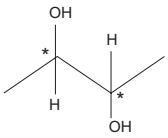
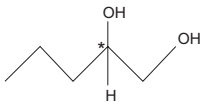
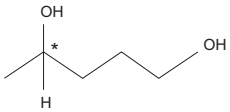
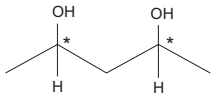
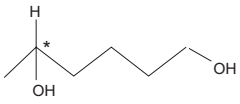
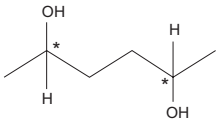
Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
1-Phenylethanol		120°C	NS (3.9)	1.051 (4.1)	1.068 (5.9)	1.021 (4.7)
1-Phenyl-2,2,2-trifluoroethanol		120°C	NS (4.8)	1.071 (5.9)	1.085 (9.7)	1.063 (7.7)
6-Methyl-5-hepten-2-ol		90°C	NS (4.6)	1.041 (5.2)	—	—
Diols						
1,2-Propanediol		80°C	1.034 (4.0)	1.028 (3.4)	1.028 (5.9)	NS (3.3)
1,2-Butanediol		100°C	1.030 (3.2)	1.040 (3.2)	1.044 (5.0)	NS (2.8)
1,3-Butanediol		100°C	1.014 (3.9)	1.017 (3.9)	1.021 (6.2)	NS (3.6)
2,3-Butanediol		100°C	NS (1.6)	1.053 (1.7)	NS (2.7)	NS (1.5)
1,2-Pentanediol		100°C	1.040 (5.9)	1.041 (6.5)	1.046 (10.4)	1.008 (5.6)
1,4-Pentanediol		100°C	NS (8.7)	1.023 (10.6)	1.027 (17.6)	NS (8.3)
2,4-Pentanediol		100°C	1.016 (3.7)	1.013 (4.0)	1.012 (6.8)	1.061 (3.4)
1,5-Hexanediol		100°C	1.015 (16.1)	1.024 (20.0)	1.028 (32.6)	1.011 (17.8)
2,5-Hexanediol		100°C	1.029 (8.2)	1.020 (11.3)	1.035 (17.8)	NS (9.8)

Table 7. Chiral Compounds contd.

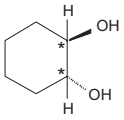
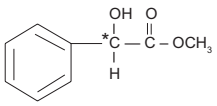
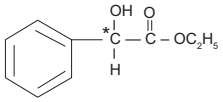
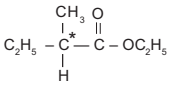
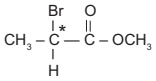
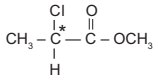
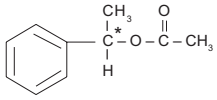
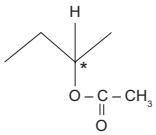
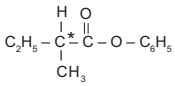
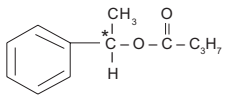
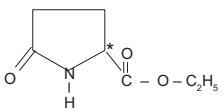
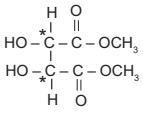
Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
trans-1,2-Cyclohexanediol		110°C	1.018 (8.5)	1.089 (11.5)	1.081 (20.8)	1.030 (11.8)
Esters						
Methyl mandelate[5]		130°C	1.021 (10.5)	NS (9.8)	NS (10.3)	1.017 (12.9)
Ethyl mandelate		130°C	1.019 (13.1)	NS (11.8)	NS (12.3)	NS (14.7)
Ethyl 2-methylbutyrate		40°C	NS (8.5)	1.027 (8.2)	1.037 (12.5)	NS (6.8)
Methyl DL-2-bromopropionate		70°C	NS (3.6)	1.109 (4.4)	1.156 (6.7)	1.022 (4.0)
Methyl DL-2-chloropropionate		70°C	NS (1.8)	1.062 (2.3)	1.089 (3.4)	1.013 (2.0)
α-Methylbenzyl acetate		90°C	NS (19.0)	1.119 (17.8)	1.115 (20.9)	1.028 (19.1)
2-Butyl acetate		60°C	—	—	1.125 (1.9)	—
Phenyl 2-methylbutyrate		130°C	—	—	1.021 (9.0)	—
1-Phenylethyl butyrate		120°C	NS (13.2)	1.013 (11.7)	1.027 (13.4)	1.016 (13.1)
Ethyl 2-pyrrolidone-5-carboxylate		100°C	—	—	1.070 (11.7)	—
Dimethyl tartrate		120°C	—	—	1.154 (20.5)	—

Table 7. Chiral Compounds contd.

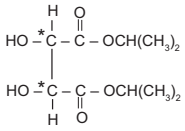
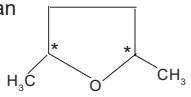
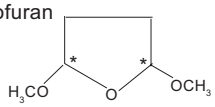
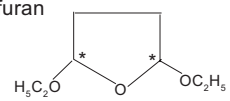
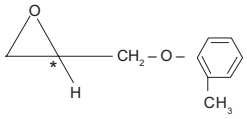
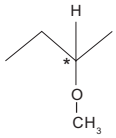
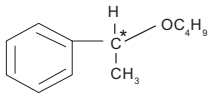
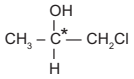
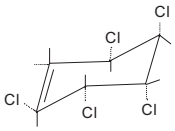
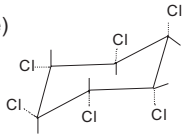
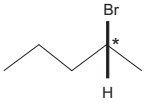
Compound	Structure	Col. Temp.	α value and (k'_1) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
Diisopropyltartarate		150°C	—	—	1.069 (7.5)	—
Ethers						
2,5-Dimethyltetrahydrofuran		60°C	1.022 (1.1)	1.046 (1.1)	1.062 (1.9)	NS (0.8)
2,5-Dimethoxytetrahydrofuran		60°C	1.027 (5.2)	1.150 (6.0)	1.208 (9.1)	1.023 (5.5)
2,5-Diethoxytetrahydrofuran		100°C	1.038 (2.2)	1.064 (1.9)	1.084 (1.8)	1.039 (2.3)
Glycidyl-2-methylphenyl-ether		120°C	1.005 (17.8)	NS (16.2)	NS (19.6)	NS (19.1)
sec-Butylmethylether		35°C	NS (1.7)	1.043 (2.9)	1.041 (2.1)	NS (1.7)
(1-Phenyl)ethylbutylether		120°C	1.027 (17.9)	1.007 (15.2)	1.018 (16.5)	NS (17.6)
Halogenated Compounds						
1-Chloro-2-propanol		40°C	1.033 (7.9)	1.018 (8.9)	NS (8.5)	1.754 (4.6)
Pentachlorocyclohexene[3]		160°C	NS (13.7)	1.026 (13.2)	1.036 (16.6)	1.017 (18.3)
α-BHC[3,6] (Hexachlorocyclohexane)		160°C	1.011 (17.6)	1.014 (16.4)	1.020 (19.0)	1.042 (22.2)
2-Bromopentane		50°C	1.015 (2.1)	1.032 (3.6)	1.044 (4.0)	NS (2.6)

Table 7. Chiral Compounds contd.

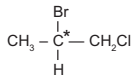
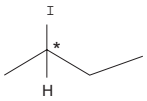
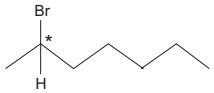
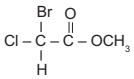
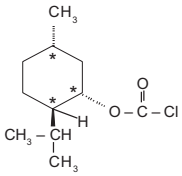
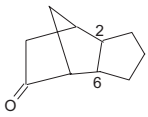
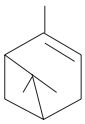
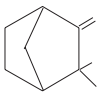
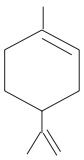
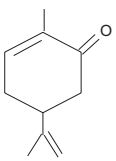
Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
2-Bromo-1-chloropropane		55°C	NS (4.9)	1.019 (3.8)	1.025 (5.8)	NS (2.3)
2-Iodobutane		60°C	NS (10.3)	1.013 (12.0)	1.015 (17.7)	1.017 (8.9)
2-Bromoheptane		60°C	NS (9.3)	1.013 (12.8)	1.012 (12.2)	1.014 (9.2)
Chlorobromoacetonitrile		70°C	NS (10.3)	1.013 (9.3)	1.013 (6.4)	NS (7.5)
Chlorobromoacetic acid methyl ester		70°C	NS (7.5)	1.024 (16.1)	1.030 (12.0)	—
Menthol chloroformate		100°C	NS (20.9)	—	1.021 (33.2)	1.033 (17.4)
Hydrocarbons 8-Ketotricyclo-[5•2•1•0^{2,6}]decane		130°C	NS (7.9)	1.030 (9.2)	1.041 (13.8)	1.018 (8.9)
α-Pinene		80°C	NS (1.9)	1.032 (2.9)	1.048 (4.5)	NS (2.4)
Camphene		80°C	NS (2.4)	1.037 (3.9)	1.051 (6.1)	NS (3.2)
Limonene		80°C	1.024 (4.9)	1.023 (5.7)	1.030 (8.2)	NS (5.3)
Ketones Carvone[7]		90°C	1.012 (23.7)	NS (24.7)	NS (43.7)	1.020 (30.6)

Table 7. Chiral Compounds contd.

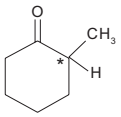
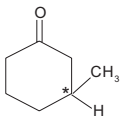
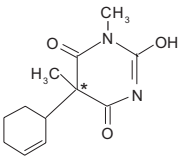
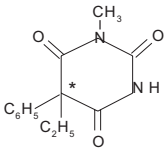
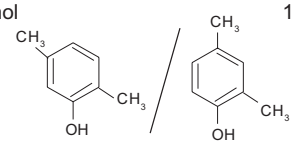
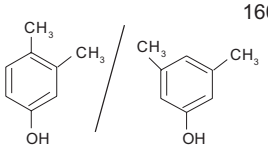
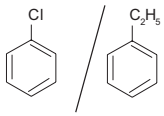
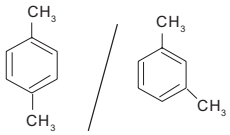
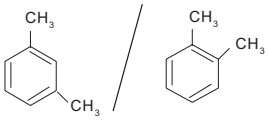
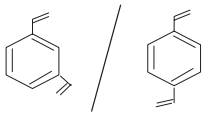
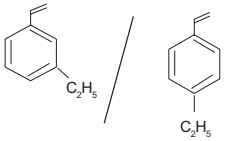
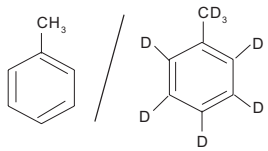
Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
2-Methylcyclohexanone		70°C	1.014 (7.8)	1.014 (9.7)	1.020 (14.7)	NS (7.8)
3-Methylcyclohexanone		70°C	1.017 (8.3)	NS (6.8)	NS (11.5)	NS (5.8)
Hexobarbital		210°C	NS (9.1)	1.025 (7.0)	1.036 (8.6)	1.010 (9.5)
Mephobarbital		210°C	NS (11.6)	1.034 (8.7)	1.050 (10.9)	1.016 (12.2)
Aromatic Positional Isomers						
2,5- and 2,4-Dimethylphenol		160°C	1.097 (1.5)	1.128 (2.7)	1.120 (1.9)	1.073 (2.3)
3,4- and 3,5-Dimethylphenol		160°C	1.039 (2.1)	1.170 (3.6)	1.157 (2.5)	1.175 (3.2)
Chlorobenzene / Ethylbenzene		110°C	1.140 (0.7)	1.081 (0.7)	1.109 (0.9)	1.088 (0.7)
p-Xylene / m-Xylene		70°C	1.090 (2.9)	NS (2.6)	NS (3.3)	1.024 (2.7)
m-Xylene / o-Xylene		70°C	1.214 (3.2)	1.355 (2.6)	1.345 (3.3)	1.276 (2.8)
m-Divinylbenzene / p-Divinylbenzene		140°C	1.088 (1.5)	1.125 (1.3)	1.153 (1.6)	1.111 (1.5)
m-Ethylvinylbenzene / p-Ethylvinylbenzene		140°C	1.066 (1.1)	1.084 (1.0)	1.108 (1.3)	1.069 (1.1)

Table 7. Chiral Compounds contd.

Compound	Structure	Col. Temp.	α value and (k'$_1$) α-DEX 120	β-DEX 110	β-DEX 120	γ-DEX 120
Toluene / Toluene-d_8		30°C	1.039 (5.9)	—	1.027 (7.7)	—

[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

W.A. König, Hüthig, 1992, 168 pp.

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.

Description	Cat. No.
Book	**2-6554**

Chromatographic Enantioseparation: Methods and Applications (2nd Edition)

S.G. Allenmark, Prentice Hall, 1991, 244 pp.

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

Description	Cat. No.
Book	**Z23,412-5**

Chiral Liquid Chromatography

W.J. Lough, Ed., Blackie/Chapman and Hall, 1989, 288 pp.

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.

Description	Cat. No.
Book	**Z23,560-1**

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., $C^*R_1R_2R_3R_4$), 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:

$$k' = \frac{\text{retention time of compound} - \text{dead time}}{\text{dead time}} = \frac{t_r - t_0}{t_0}$$

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

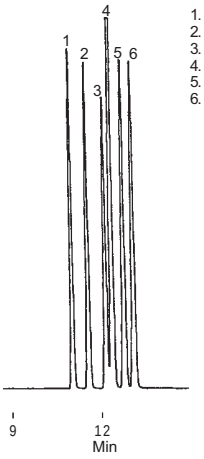
$$\alpha = \frac{\text{retention time}_{\text{isomer 2}} - \text{dead time}}{\text{retention time}_{\text{isomer 1}} - \text{dead time}} = \frac{t_{r2} - t_0}{t_{r1} - t_0} = \frac{k'_2}{k'_1}$$

stereochemistry
the study of molecules having the same molecular formula, but different spatial orientations

Menthols

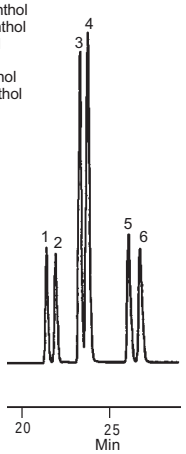
Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: **2-4310**
Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film
Cat. No.: **2-4301**
Oven: 110°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C (α-DEX 120) or 220°C (β-DEX 110)

α-DEX 120



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

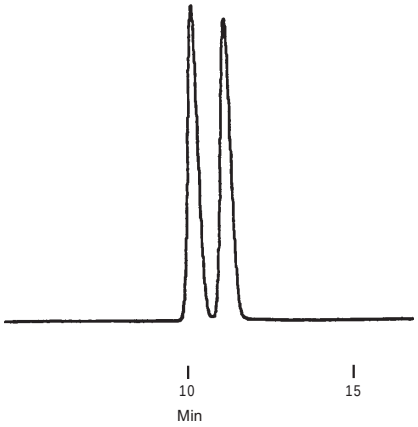
β-DEX 110



713-0089,712-0265

(±)-1-Octen-3-ol

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



713-0090

1-Phenylethanol; 1-Phenylpropanol

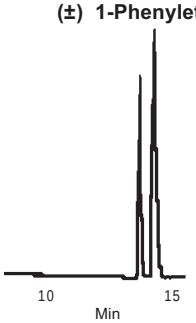
1-Phenylethanol*

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, 200°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 150°C

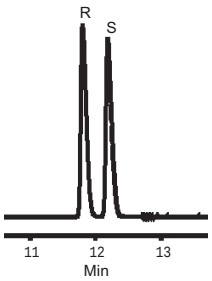
1-Phenylpropanol

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

(±) 1-Phenylethanol



1-Phenylpropanol

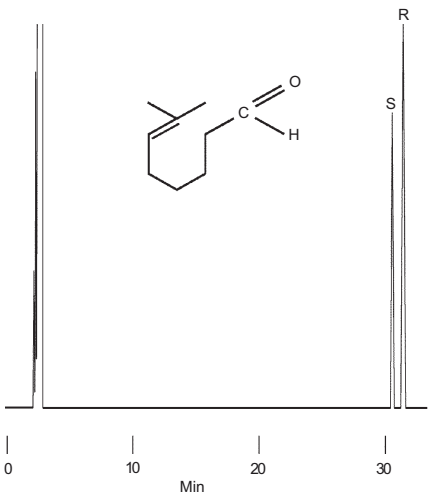


*Application developed by Dr. L. Sundaram, The Pennsylvania State University, University Park, PA USA.

712-0253,797-0151

Citronellal

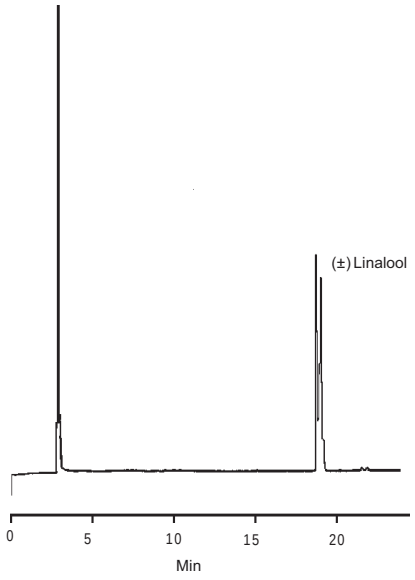
Column: β-DEX 225, 30m x 0.25mm ID, 0.25µm film
Cat. No.: **2-4348**
Oven: 95°C
Carrier: helium, 20cm/sec
Det: FID, 300°C
Inj.: 1µL methylene chloride containing 1mg/mL mixed enantiomers, split 100:1, 220°C



796-0642

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

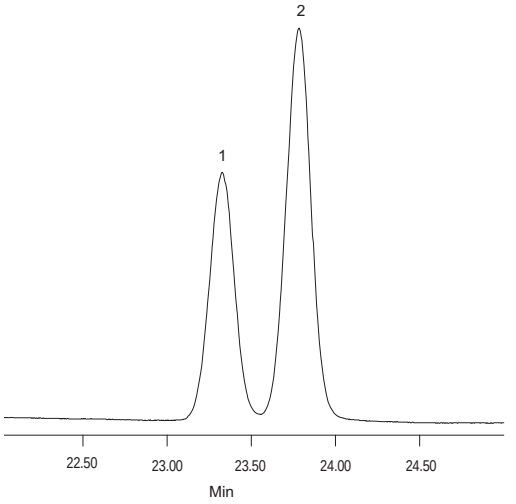


712-0267

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

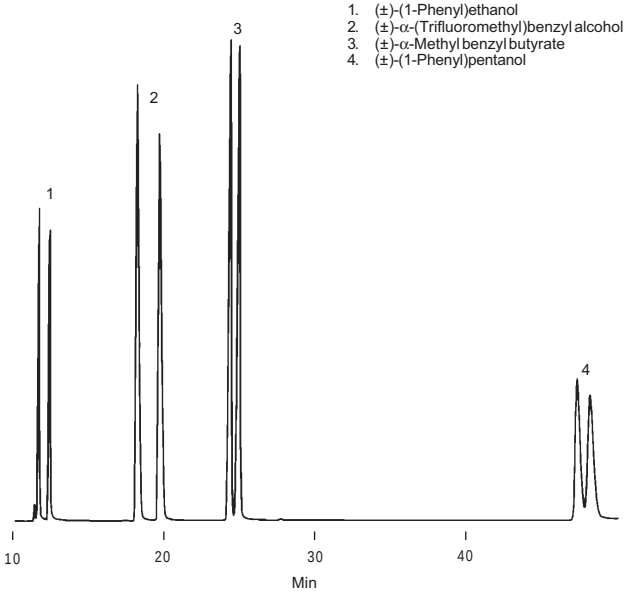


794-0219

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

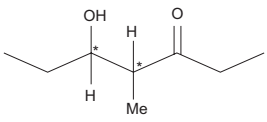
1. (±)-(1-Phenyl)ethanol
2. (±)-α-(Trifluoromethyl)benzyl alcohol
3. (±)-α-Methyl benzyl butyrate
4. (±)-(1-Phenyl)pentanol

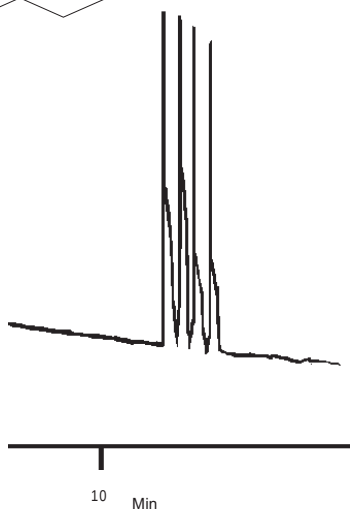


94-0340

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

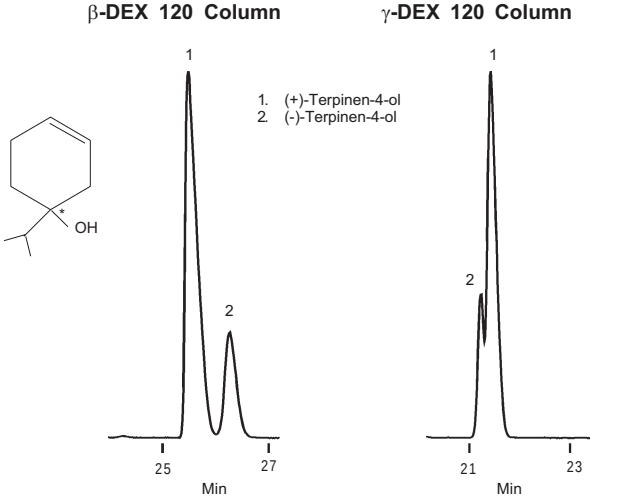




92-0344

Terpinen-4-ol (Enantio-reversal)

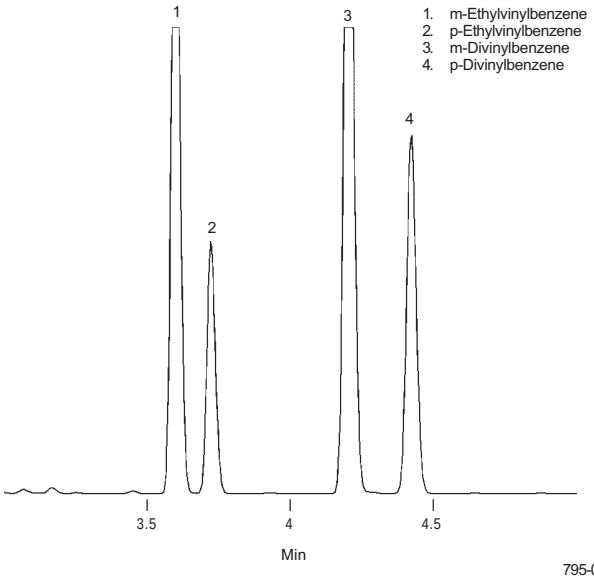
Column: β-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 100°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C



794-0284,0285

Divinylbenzenes

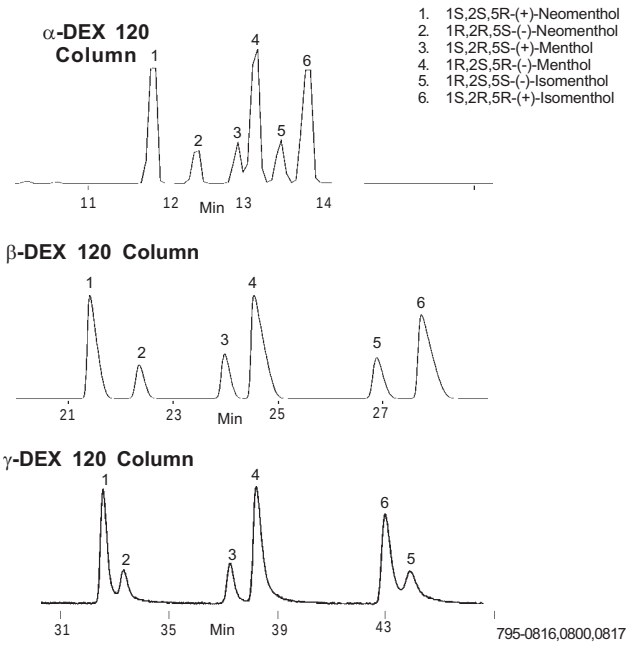
Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 140°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 4µL methylene chloride (0.5mg/mL each analyte), split (100:1), 300°C



795-0801

Menthols (Enantio-reversal)

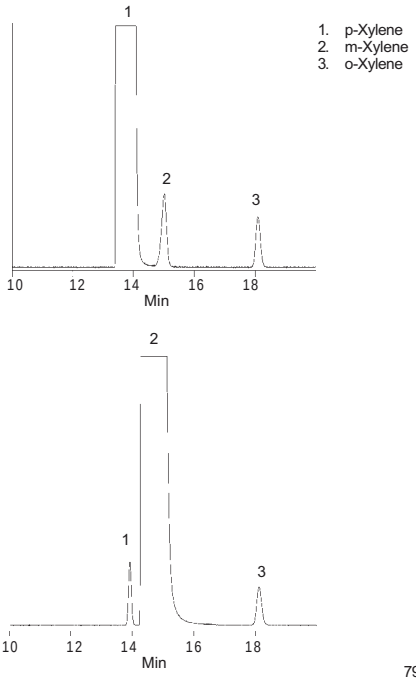
Column: α-DEX 120, β-DEX 120, and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310 (α-DEX 120), 2-4304 (β-DEX 120), 2-4307 (γ-DEX 120)
Oven: 110°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C



795-0816,0800,0817

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

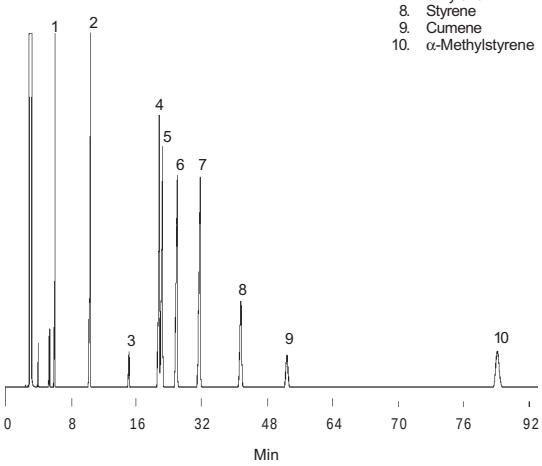


794-0648,0649

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

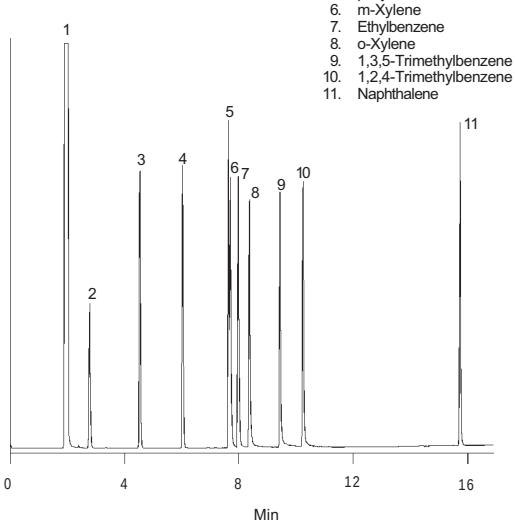


794-0652

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

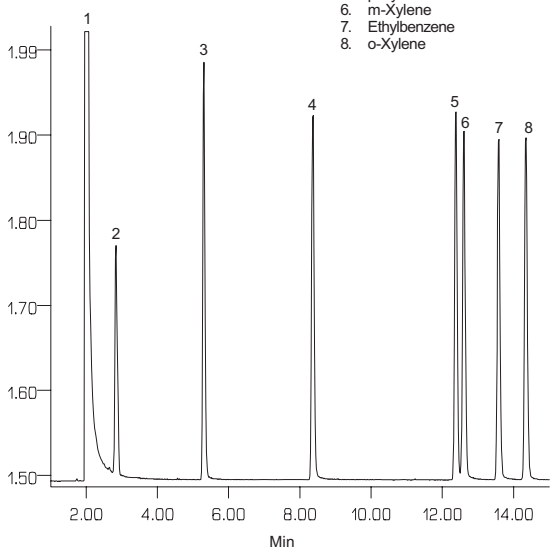


794-0580

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



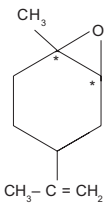
94-0338

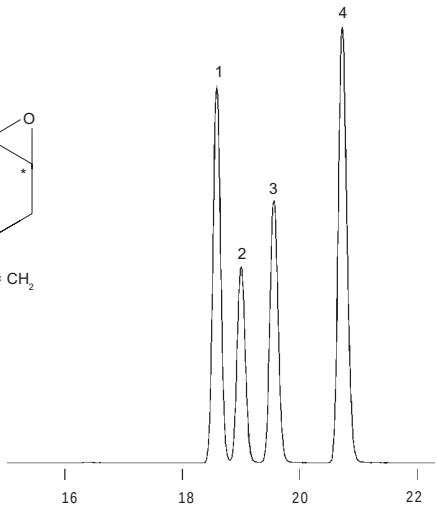
Epoxides

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.,4. cis/trans-(+)-Limonene oxide
2.,3. cis/trans-(-)-Limonene oxide



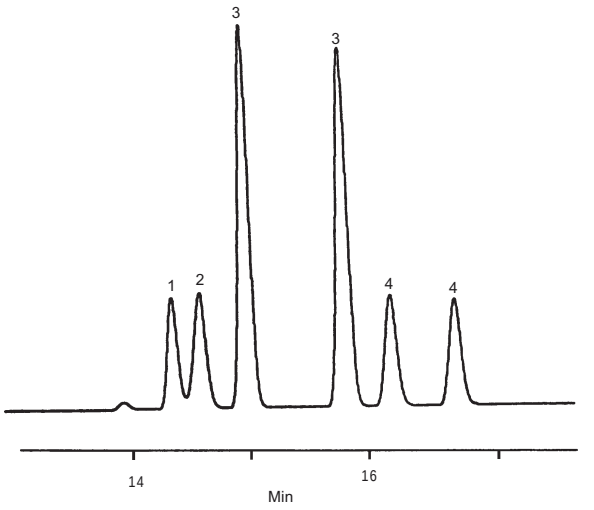


795-0802

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



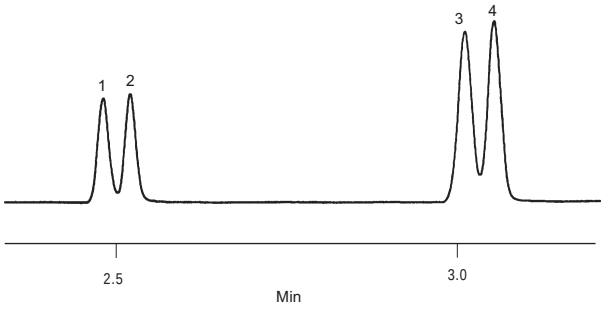
93-0404

Esters

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

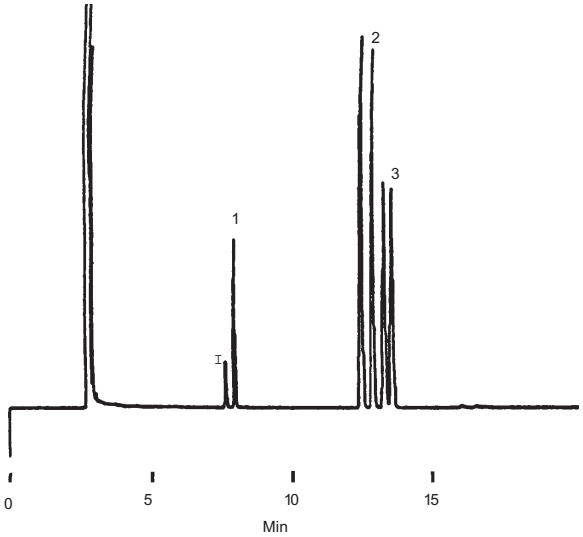


93-0405

Epoxides

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

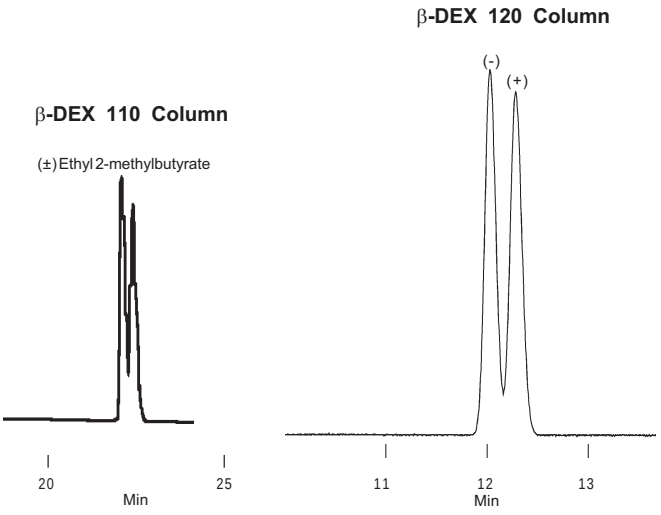
I Impurity
1. cis-Methylstyrene oxide
2. (±)-2,2-Dimethyl-3-phenyloxirane
3. (±)-trans-2-Methyl-3-phenyloxirane



92-0343

Ethyl 2-Methylbutyrate

Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film
Cat. No.: **2-4301**
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)

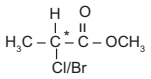


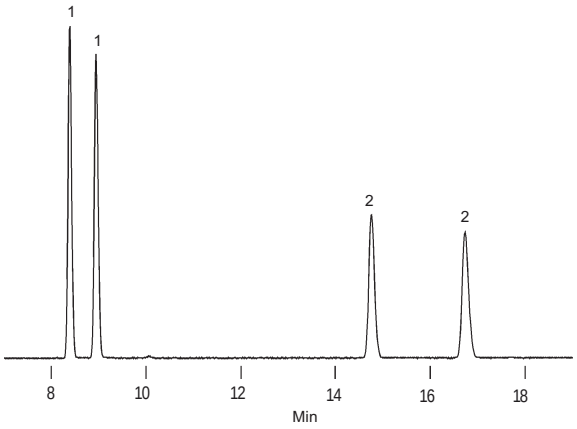
712-0268, 795-0804

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





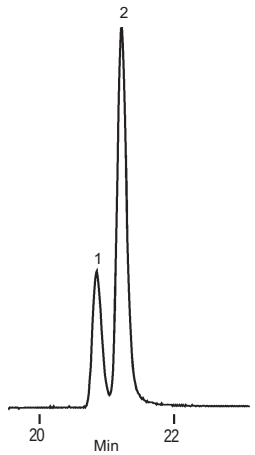
795-0803

Methyl Mandelate (Enantio-reversal)

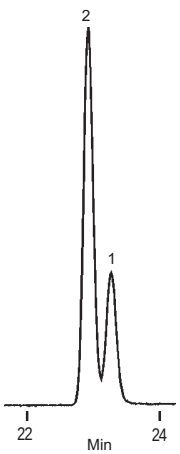
Column: α-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310 (α-DEX 120), 2-4307 (γ-DEX 120)
Oven: 130°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (1mg/mL each analyte), split (100:1), 250°C

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

α-DEX 120 Column



γ-DEX 120 Column

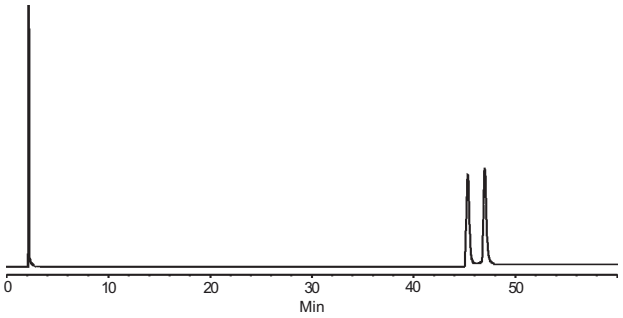


794-0282,0283

Free Acids

4-Methyloctanoic Acid

Column: γ-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



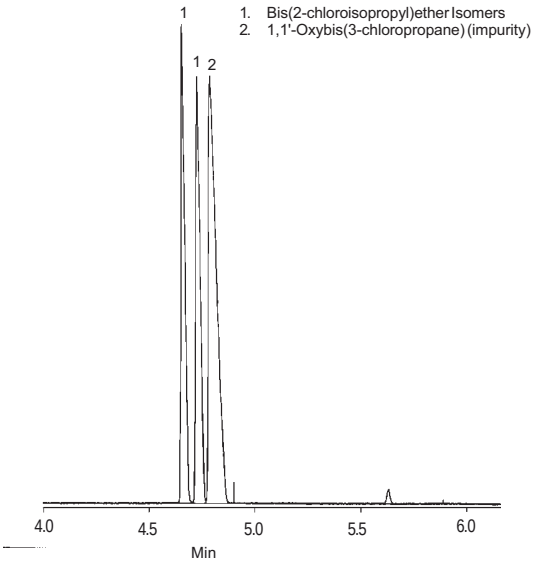
797-0225

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 (0.5mg/mL each analyte), 80°C

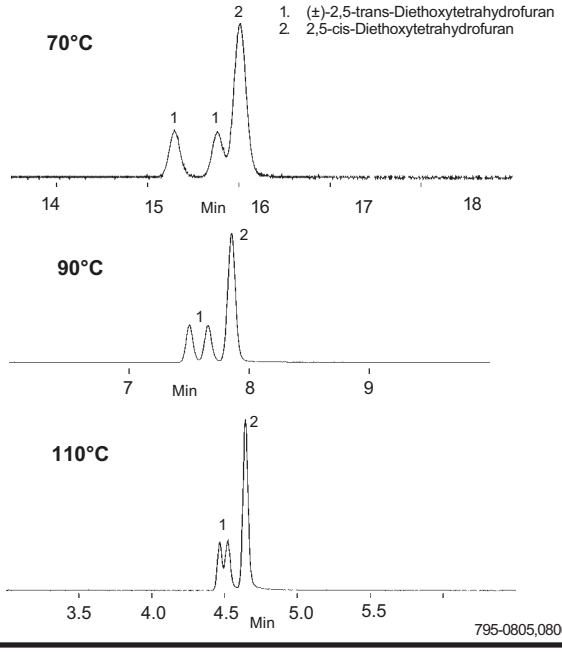
1. Bis(2-chloroisopropyl)ether Isomers
2. 1,1'-Oxybis(3-chloropropane) (impurity)



794-0188

Diethoxytetrahydrofuran

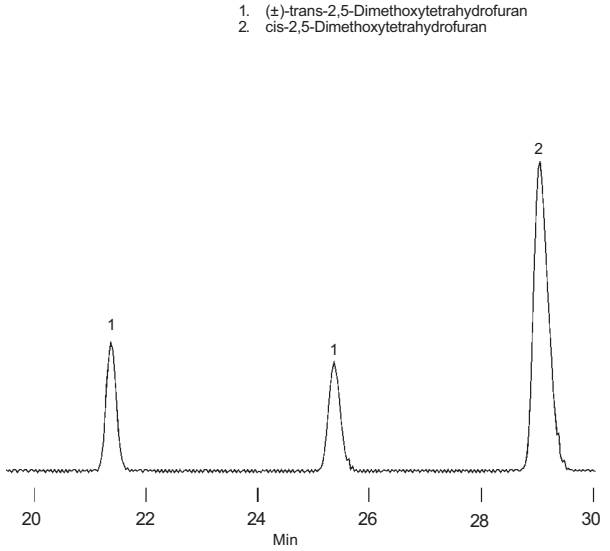
Column: α-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4310
Oven: 70°C/90°C/110°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C



795-0805,0806,0807

Dimethoxytetrahydrofuran

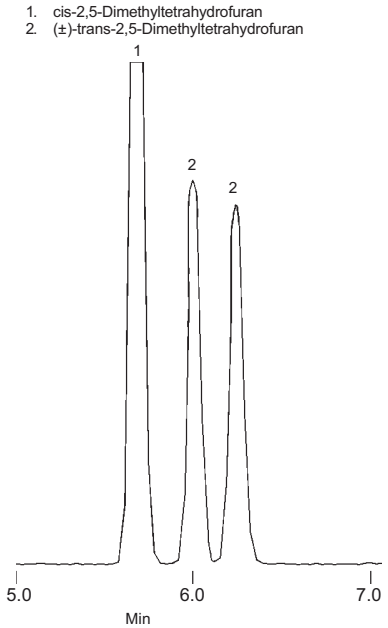
Column: β-DEX 120, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4304
Oven: 60°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C



795-0809

Dimethyltetrahydrofuran

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

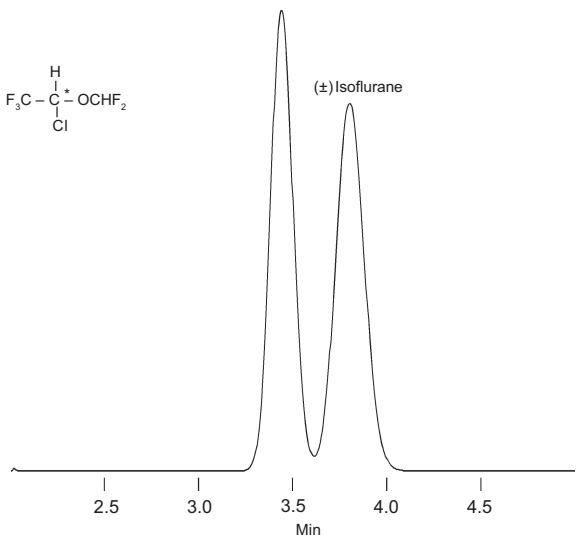


795-0808

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

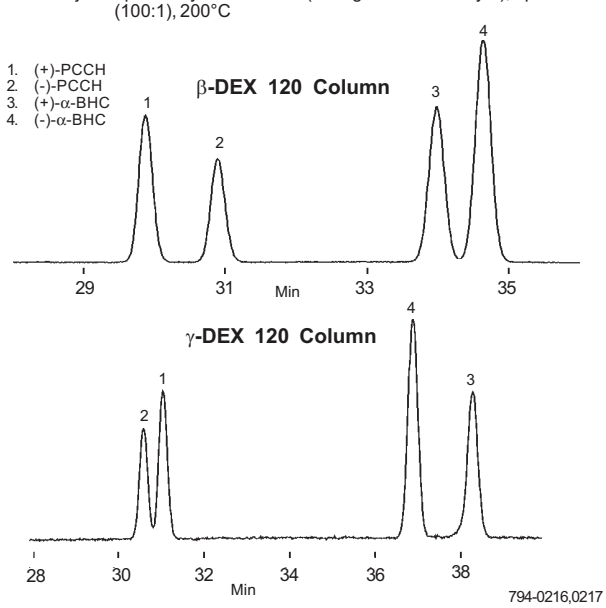


795-0810

Hydrocarbons

α-BHC and PCCH (Enantio-reversal)

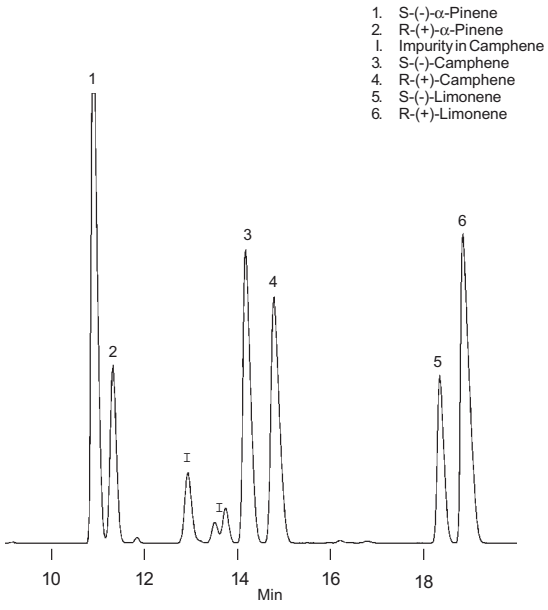
Column: **β-DEX 120 and γ-DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4304** (β-DEX 120), **2-4307** (γ-DEX 120)
Oven: 160°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 200°C



794-0216,0217

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

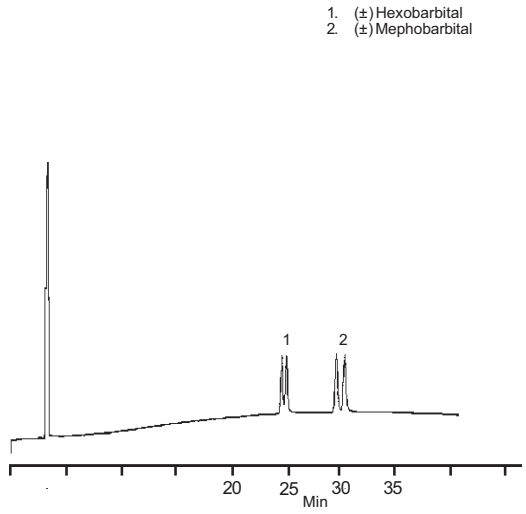


795-0811

Ketones

Barbitals

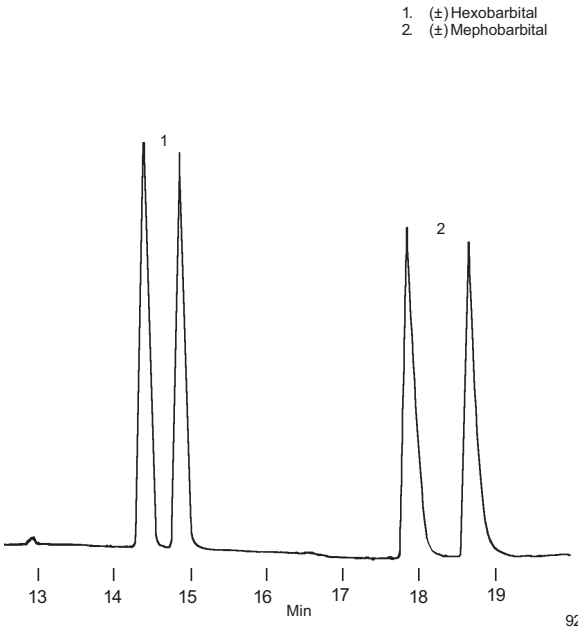
Column: **β-DEX 110, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4301**
Oven: 210°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C



712-0264

Barbitals

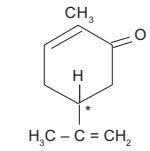
Column: **β-DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4304**
Oven: 210°C
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (5.0mg/mL each analyte), split (100:1), 300°C



92-0342

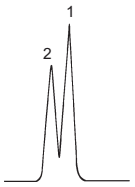
Carvone (Enantioreversal)

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

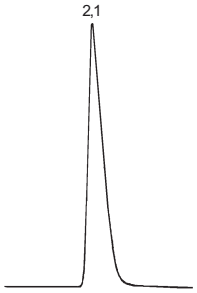


1. S-(+)-Carvone
2. R-(-)-Carvone

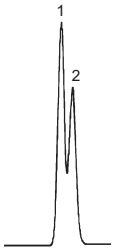
α-DEX 120 Column



β-DEX 120 Column



γ-DEX 120 Column



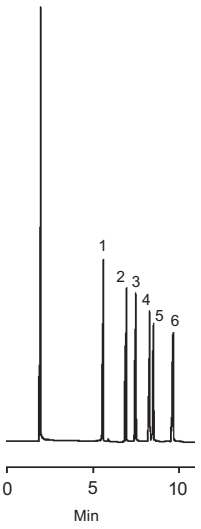
93-0540

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



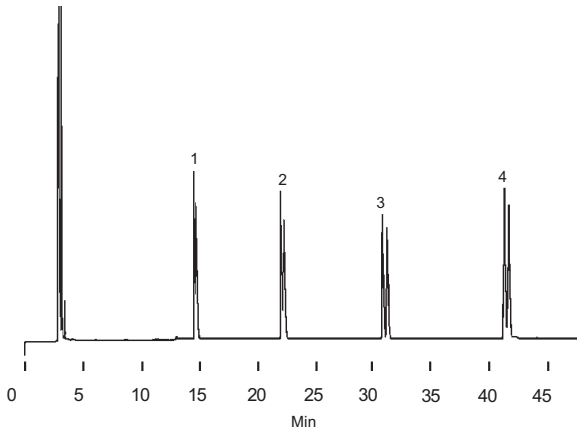
712-0276

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), 300°C

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



712-0266

Phenols

Column: **α-DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4310**
Oven: 130°C (12 min) to 220°C at 10°C/min, hold 5 min
Carrier: hydrogen, 40cm/sec
Det.: FID, 300°C
Inj.: 1µL, split (100:1), 250°C

1. Phenol
2. 2-Methylphenol (o-Cresol)
3. 2,6-Dimethylphenol
4. 4-Methylphenol (p-Cresol)
5. 3-Methylphenol (m-Cresol)
6. 2-Ethylphenol
7. 2,4-Dimethylphenol
8. 2,5-Dimethylphenol
9. 2,4,6-Trimethylphenol
10. 4-Ethylphenol
11. 2,3-Dimethylphenol
12. 2,3,5-Trimethylphenol
13. 3-Ethylphenol
14. 3,4-Dimethylphenol
15. 3,5-Dimethylphenol

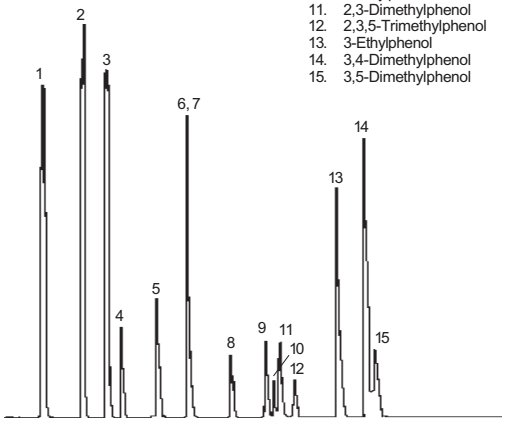


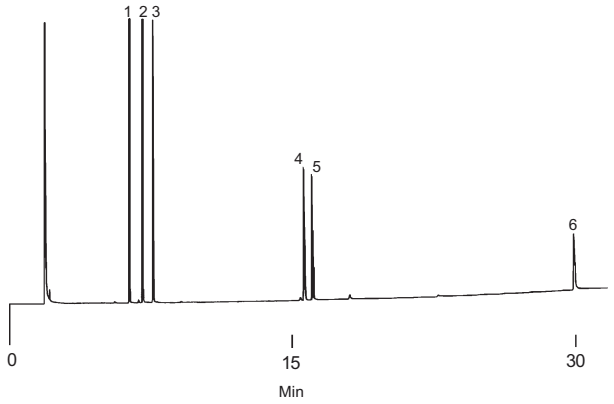
Figure provided by J. Novrocik, DEZA Corporation, Czech Republic.

795-0853

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-Methylphenol (o-Cresol)
2. 4-Methylphenol (p-Cresol)
3. 3-Methylphenol (m-Cresol)
4. 2,4,6-Trichlorophenol
5. 2,4,5-Trichlorophenol
6. Pentachlorophenol

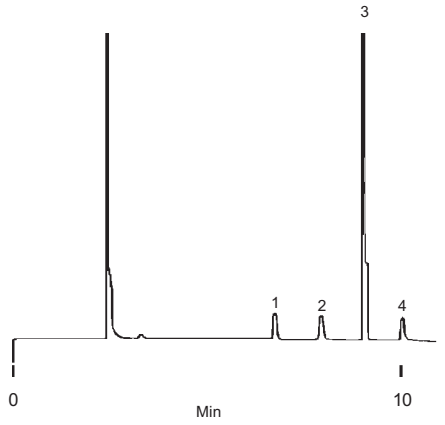


92-0328

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)

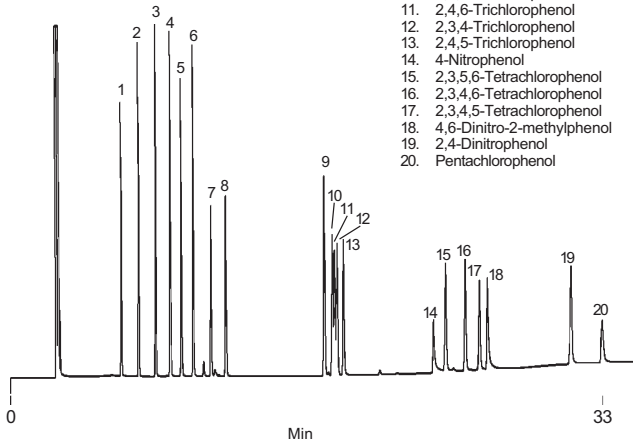


713-0082

Phenols

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 methanol (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-Dimethylphenol
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

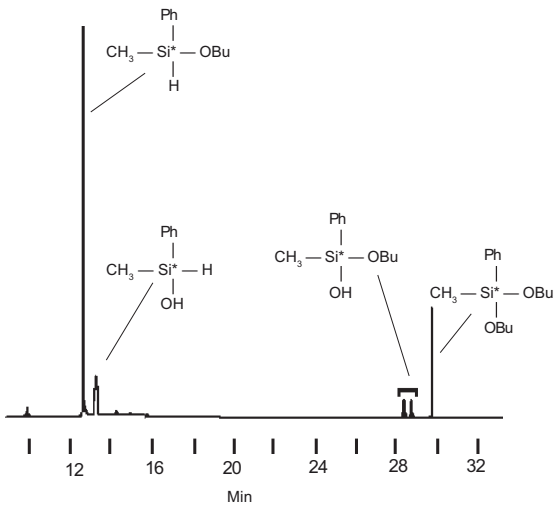


713-0083

Silicon Compounds

Silicon Compounds

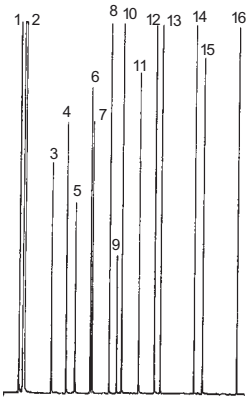
Column: β-DEX 110, 30m x 0.25mm ID, 0.25µm film
Cat. No.: 2-4301
Oven: 100°C to 220°C at 2°C/min
Carrier: helium, 20cm/sec
Det.: FID, 300°C
Inj.: 1µL methylene chloride (0.5mg/mL each analyte), split (100:1), 250°C



712-0277

Solvents

Column: α-**DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4310**
Oven: 40°C (2 min) to 180°C at 5°C/min, hold 10 min
Carrier: hydrogen, 30cm/sec
Det.: FID, 200°C
Inj.: 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C



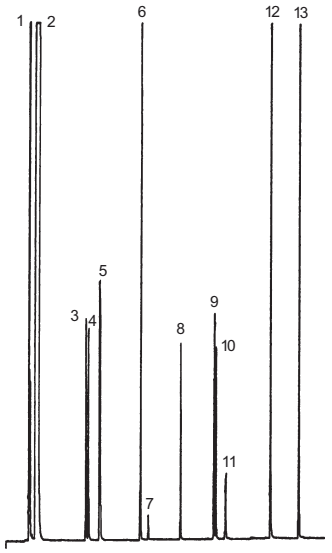
1. Methanol
2. Methylene chloride (Dichloromethane)
3. 2-Methoxyethanol (Methyl Cellosolve®)
4. 2-Ethoxyethanol (Cellosolve)
5. 2-Isopropoxyethanol (Isopropyl Cellosolve)
6. 2-Methoxyethyl acetate (Methyl Cellosolve acetate)
7. 2-Propoxyethanol (Propyl Cellosolve)
8. 2-Ethoxyethyl acetate (Cellosolve acetate)
9. n-Hexanol (int. std.)
10. 2-Butoxyethanol (Butyl Cellosolve)
11. 2-(2-Methoxyethoxy)ethanol (Methyl carbitol)
12. 2-(2-Ethoxyethoxy)ethanol (Carbitol)
13. 2-Butoxyethyl acetate (Butyl Cellosolve acetate)
14. 2-(2-Ethoxyethoxy)ethyl acetate (Carbitol acetate)
15. 2-(2-Butoxyethoxy)ethanol (Butyl carbitol)
16. 2-(2-Butoxyethoxy)ethyl acetate (Butyl carbitol acetate)

Figure provided by Mr. M.L. Shulsky, Occupational Safety and Health Administration.

713-0224

Solvents

Column: α-**DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4310**
Oven: 40°C (2 min) to 180°C at 5°C/min, hold 10 min
Carrier: hydrogen, 30cm/sec
Det.: FID, 200°C
Inj.: 1µL methylene chloride:methanol, 95:5 (1µL/mL each analyte, 0.25µL/mL int. std.), 200°C



1. Methanol
2. Methylene chloride (Dichloromethane)
3. 1-Methoxy-2-propanol (Propylene glycol methyl ether)
4. 1-Methoxy-2-propanol (2nd isomer)
5. 2-Methoxy-1-propanol
6. 1-Methoxy-2-propyl acetate (Propylene glycol methyl ester acetate)
7. 2-Methoxy-1-propyl acetate (0.05µL/mL)
8. n-Hexanol (*int. std.)
9. Dipropylene glycol methyl ester
10. Dipropylene glycol methyl ester (2nd isomer)
11. Dipropylene glycol methyl ester (3rd isomer)
12. N-Methyl-2-pyrrolidinone
13. Vinyl pyrrolidinone

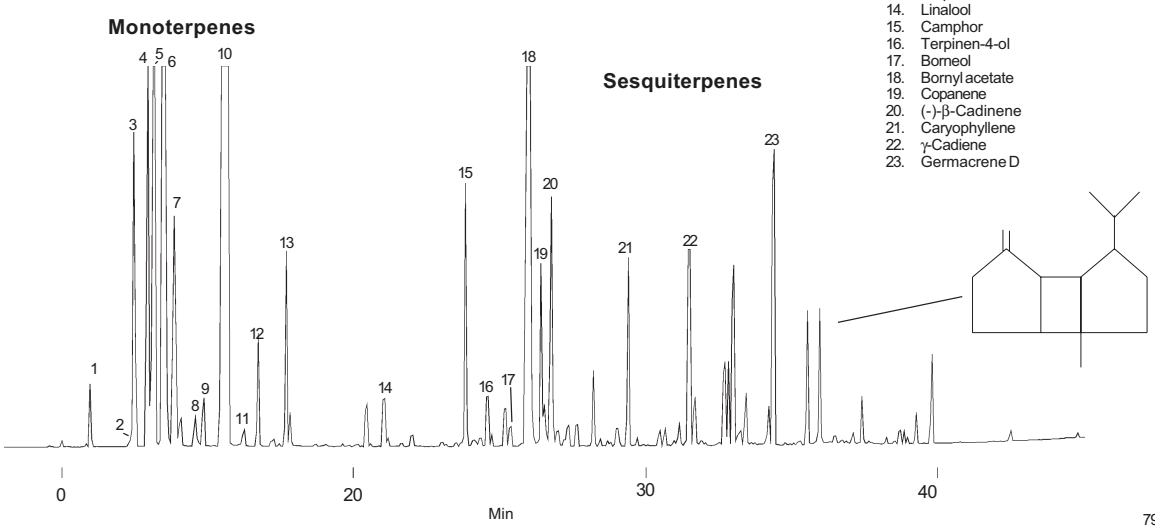
Figure provided by Mr. M.L. Shulsky, Occupational Safety and Health Administration.

713-0225

SPME/Chiral Capillary GC

Juniper Leaves

Sample: 0.5g sliced juniper 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



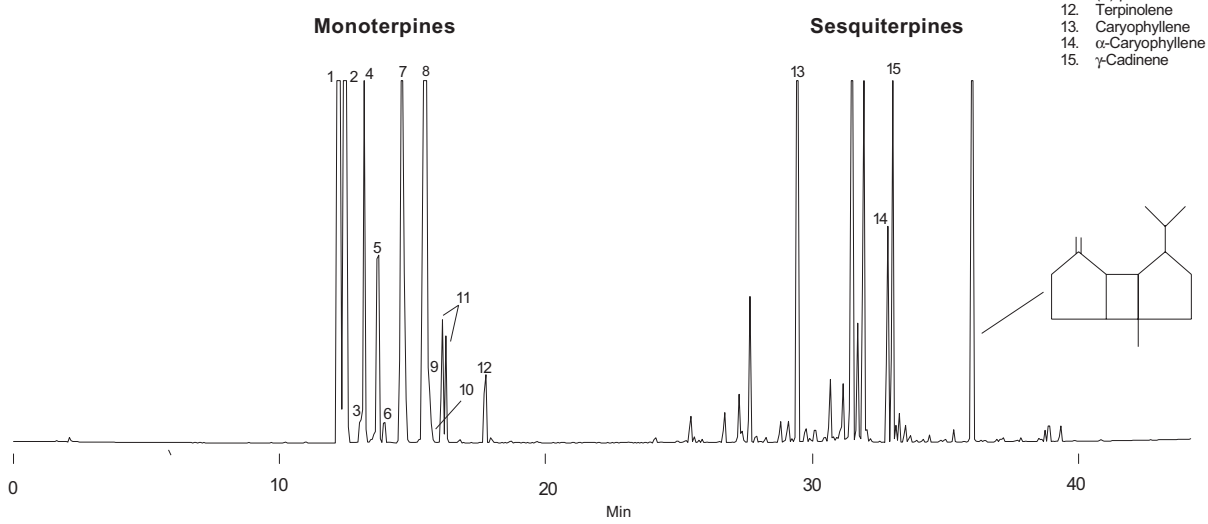
1. α-Thujene
2. (-)-α-Pinene
3. (+)-α-Pinene
4. Tricyclene
5. β-Myrcene
6. Sabinene
7. (+)-Camphene
8. (-)-Camphene
9. α-Terpinene
10. (+)-Limonene
11. β-Phellandrene
12. γ-Terpinene
13. Terpinolene
14. Linalool
15. Camphor
16. Terpinen-4-ol
17. Borneol
18. Bornyl acetate
19. Copanene
20. (-)-β-Cadinene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

795-0812

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

1. (-)-α-Pinene
2. (+)-α-Pinene
3. β-Myrcene
4. (+)-Sabinene
5. (+)-Camphene
6. (-)-Camphene
7. (+)-β-Pinene
8. 3-Carene
9. (-)-Limonene
10. (+)-Limonene
11. (±)-β-Phellandrene
12. Terpinolene
13. Caryophyllene
14. α-Caryophyllene
15. γ-Cadinene

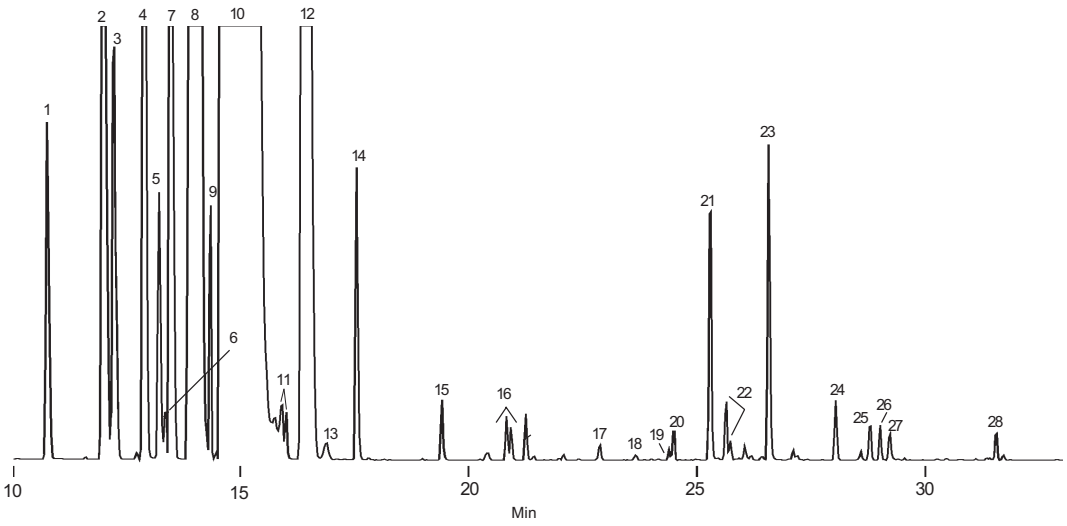


94-0298

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

1. α-Thujene
2. (-)-α-Pinene
3. (+)-α-Pinene
4. β-Myrcene
5. Sabinene
6. (+)-Camphene
7. (-)-Camphene
8. β-Pinene
9. α-Terpinene
10. (-)-Limonene
11. β-Phellandrene
12. γ-Terpinene
13. 3-Octanol
14. Terpinolene
15. Citronellal
16. Linalool
17. Linalyl acetate
18. Menthone
19. (+)-Terpinen-4-ol
20. (-)-Terpinen-4-ol
21. Geranial
22. (±)-α-Terpineol
23. Neral
24. Geranyl acetate
25. Bergamptene
26. Neryl acetate
27. Caryophyllene
28. β-Bisabolene

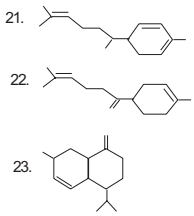


795-0814

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

1. Acetone
2. Isopropyl alcohol
3. Ethyl acetate
4. Hexanal
5. (-)-α-Pinene
6. (+)-α-Pinene
7. Tricyclene
8. β-Myrcene
9. (+)-Camphene
10. (-)-Camphene
11. (+)-β-Pinene
12. (-)-β-Pinene
13. (-)-Limonene
14. (+)-Limonene
15. 6-Methyl-5-hepten-2-one
16. β-Phellandrene
17. Cineole
18. Terpinene
19. Terpinolene
20. Borneol
21. } structures
22. } shown
23. } at left

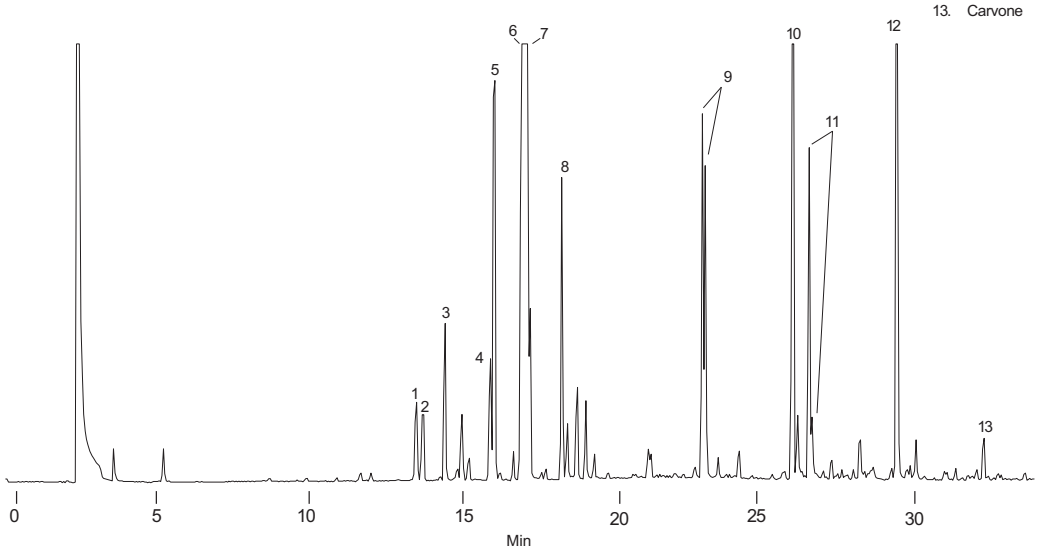


795-0815

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

1. (-)-α-Pinene
2. (+)-α-Pinene
3. β-Myrcene
4. (+)-β-Pinene
5. (-)-β-Pinene
6. (-)-Limonene
7. (+)-Limonene
8. γ-Terpinene
9. (±)-Linalool
10. (±)-Linalyl acetate
11. unknown chiral component
12. unknown
13. Carvone

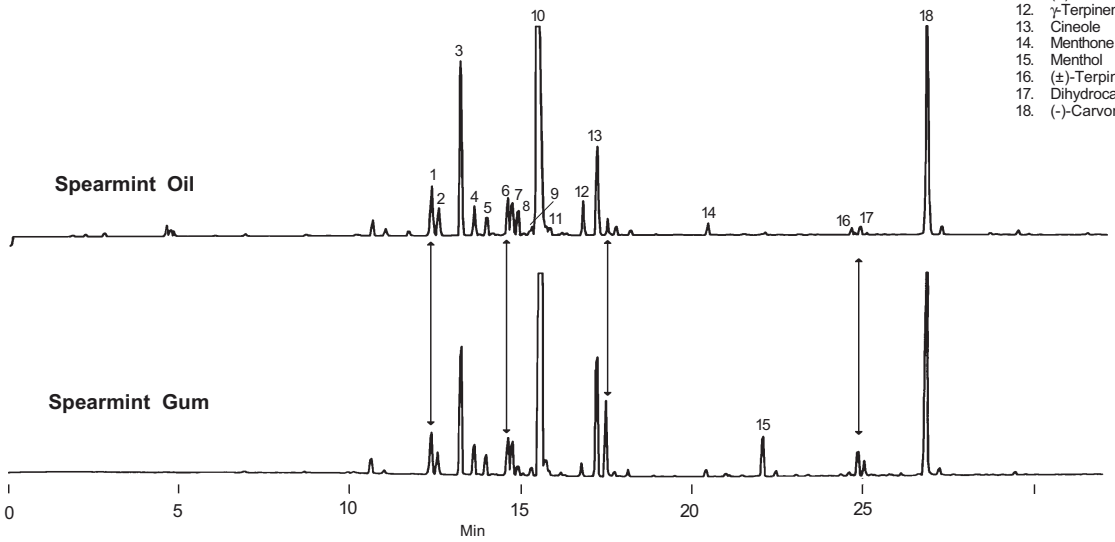


94-0297

Spearmint Oil and Spearmint Gum

Sample: 0.5g spearmint oil or gum in 7mL vial
SPME Fiber: **100µm 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

1. (-)-α-Pinene
2. (+)-α-Pinene
3. β-Myrcene
4. Sabinene
5. (-)-Camphene
6. (+)-β-Pinene
7. (-)-β-Pinene
8. α-Terpinene
9. 3-Carene
10. (-)-Limonene
11. (+)-Limonene
12. γ-Terpinene
13. Cineole
14. Menthone
15. Menthol
16. (±)-Terpinen-4-ol
17. Dihydrocarvone
18. (-)-Carvone

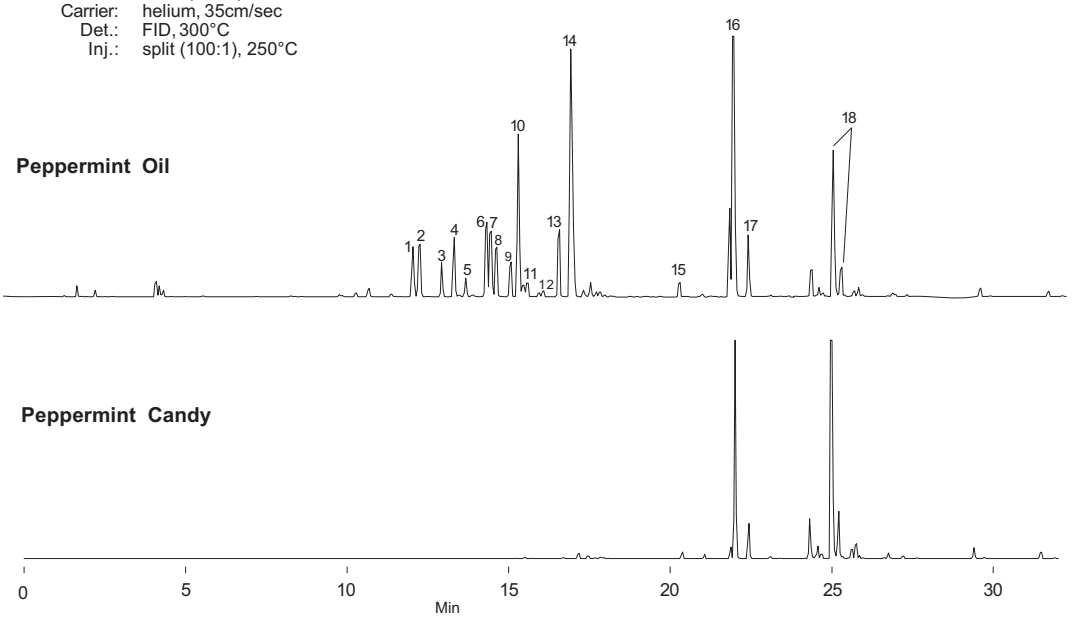


94-0281

Peppermint Oil and Peppermint Candy

Sample: 0.5g peppermint oil or crushed candy in 7mL vial
SPME Fiber: **100µm 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

1. (-)-α-Pinene
2. (+)-α-Pinene
3. β-Myrcene
4. Sabinene
5. (-)-Camphene
6. (+)-β-Pinene
7. (-)-β-Pinene
8. α-Terpinene
9. 3-Carene
10. (-)-Limonene
11. (+)-Limonene
12. (±)-β-Phellandrene
13. γ-Terpinene
14. Cineole
15. Menthone
16. (+)-Menthol
17. (-)-Menthol
18. (±)-Menthyl acetate

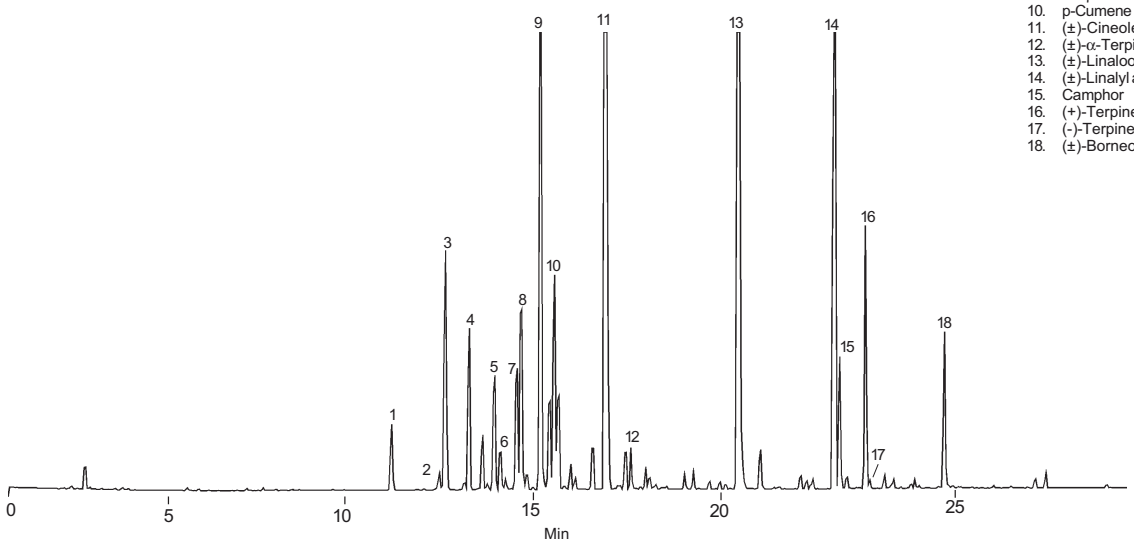


94-0278,0279

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: **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

1. α-Thujene
2. (-)-α-Pinene
3. (+)-α-Pinene
4. β-Myrcene
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. (±)-Linalyl acetate
15. Camphor
16. (+)-Terpinen-4-ol
17. (-)-Terpinen-4-ol
18. (±)-Borneol

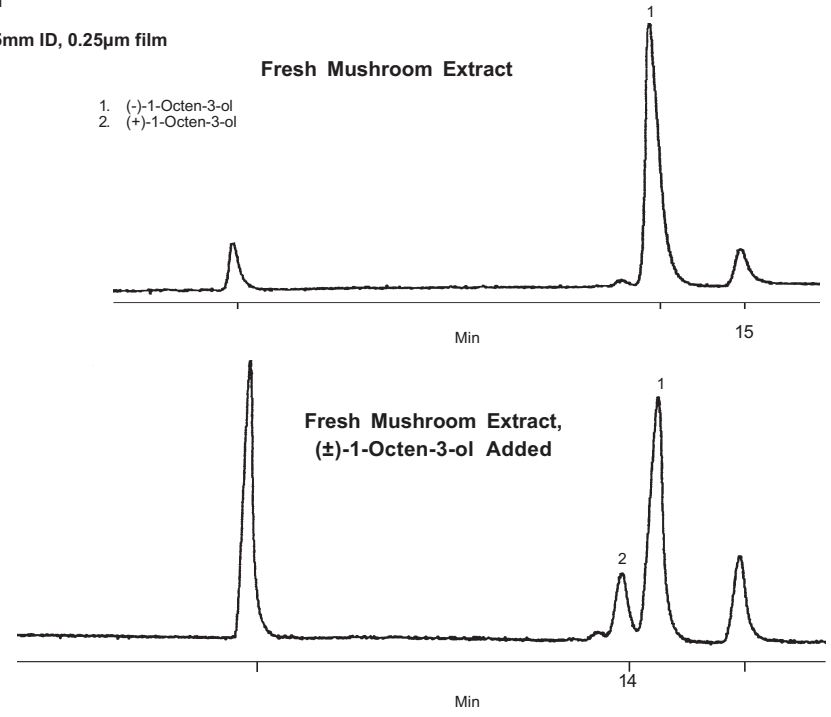


795-0813

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

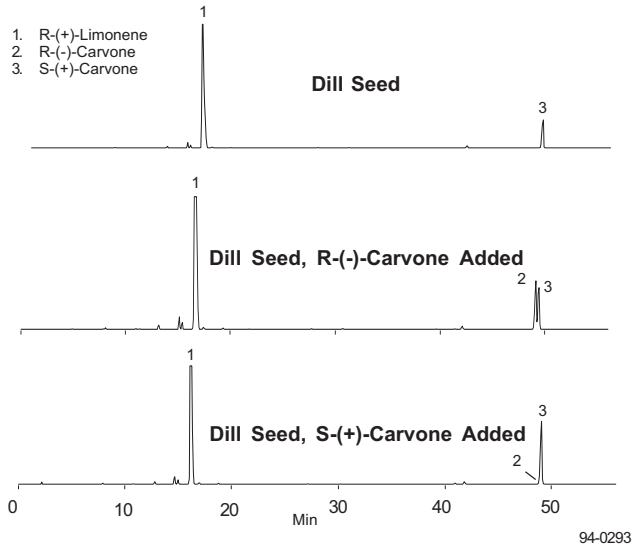
1. (-)-1-Octen-3-ol
2. (+)-1-Octen-3-ol



93-0397,0400

Dill Seed

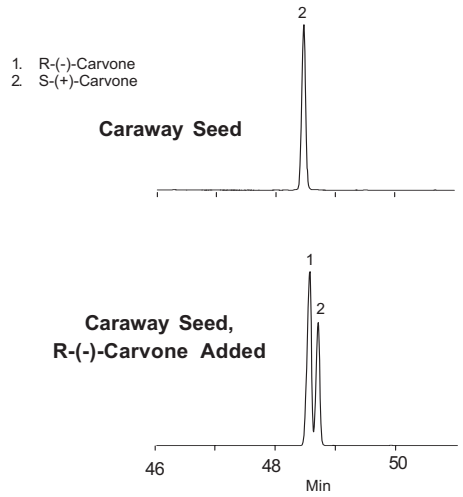
Sample: 1g dill seed or 1g dill seed plus 1µL carvone isomer in 7mL vial
SPME Fiber: **100µm polydimethylsiloxane**
Cat. No.: **57300-U** (manual sampling)
Extraction: headspace, 30°C, 5 min
Desorption: 1 min, 250°C
Column: **α-DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4310**
Oven: 80°C
Carrier: helium, 30cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C



94-0293

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
Column: **α-DEX 120, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4310**
Oven: 80°C
Carrier: helium, 35cm/sec
Det.: FID, 300°C
Inj.: split (100:1), 250°C

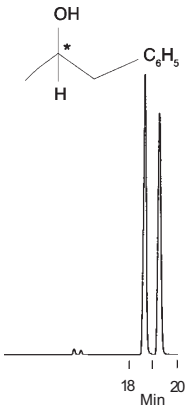


794-0294,0293

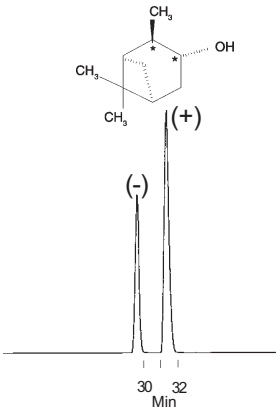
DEX 225 and DEX 325 Columns are the latest additions to the DEX column line. See inside back cover.

Column: **β-DEX 325, 30m x 0.25mm ID, 0.25µm film**
Cat. No.: **2-4308**
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

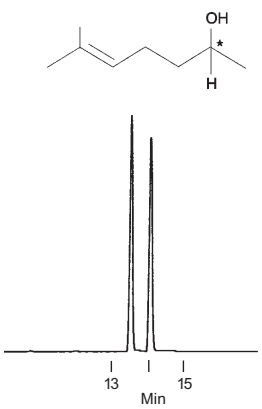
1-Phenyl-2-propanol



Isopinocampheol



6-Methyl-5-hepten-2-ol



797-0021, 797-0022, 797-0023, 797-0020, 797-0025, 797-0024

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 in SPB-35 poly(35% phenyl/65% dimethylsiloxane)

Temp. Limits: 30°C to 250°C

McReynolds Nos.: x' y' z' u' s' = 102 243 142 221 170

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24310**

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 in SPB-35 poly(35% diphenyl/65% dimethylsiloxane)

Temp. Limits: 30°C to 250°C

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24307**

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.

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, 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)

Temp. Limits: 30°C to 250°C

McReynolds Nos.: x' y' z' u' s' = 112 236 153 130 184 (β-DEX 110)

x' y' z' u' s' = 119 264 154 134 187 (β-DEX 120)

Length (m)	d_f (µm)	Beta	Cat. No.
β-DEX 110, 0.25mm ID Fused Silica			
30	0.25	250	**24301**
60	0.25	250	**24302**
β-DEX 110, 0.53mm ID Fused Silica			
30	0.5	265	**25410-U**
60	0.5	265	**25411**
β-DEX 120, 0.25mm ID Fused Silica			
30	0.25	250	**24304**
60	0.25	250	**24305-U**
β-DEX 120, 0.53mm ID Fused Silica			
30	0.5	265	**25413-U**
60	0.5	265	**25414**

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.

Description	Cat. No.
Cyclodextrin Column Selection Kit I	**24340**

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.

Description	Cat. No.
Cyclodextrin Column Selection Kit II	**24328-U**

α-DEX 225

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24311**

β-DEX 225

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24348**
0.32mm ID Fused Silica			
30	0.25	320	**24349**
0.53mm ID Fused Silica			
30	0.25	265	**25442**

γ-DEX 225

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24312**

α-DEX 325

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24303**

β-DEX 325

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24308**
0.32mm ID Fused Silica			
30	0.25	320	**24309**
0.53mm ID Fused Silica			
30	0.50	265	**25443**

γ-DEX 325

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

Length (m)	d_f (µm)	Beta	Cat. No.
0.25mm ID Fused Silica			
30	0.25	250	**24306**

For more information, or current prices, contact your nearest Supelco subsidiary listed below. If your country is not listed, see the Supelco catalog for a complete list of all Supelco representatives, or contact Supelco, Bellefonte, PA 16823-0048 USA.

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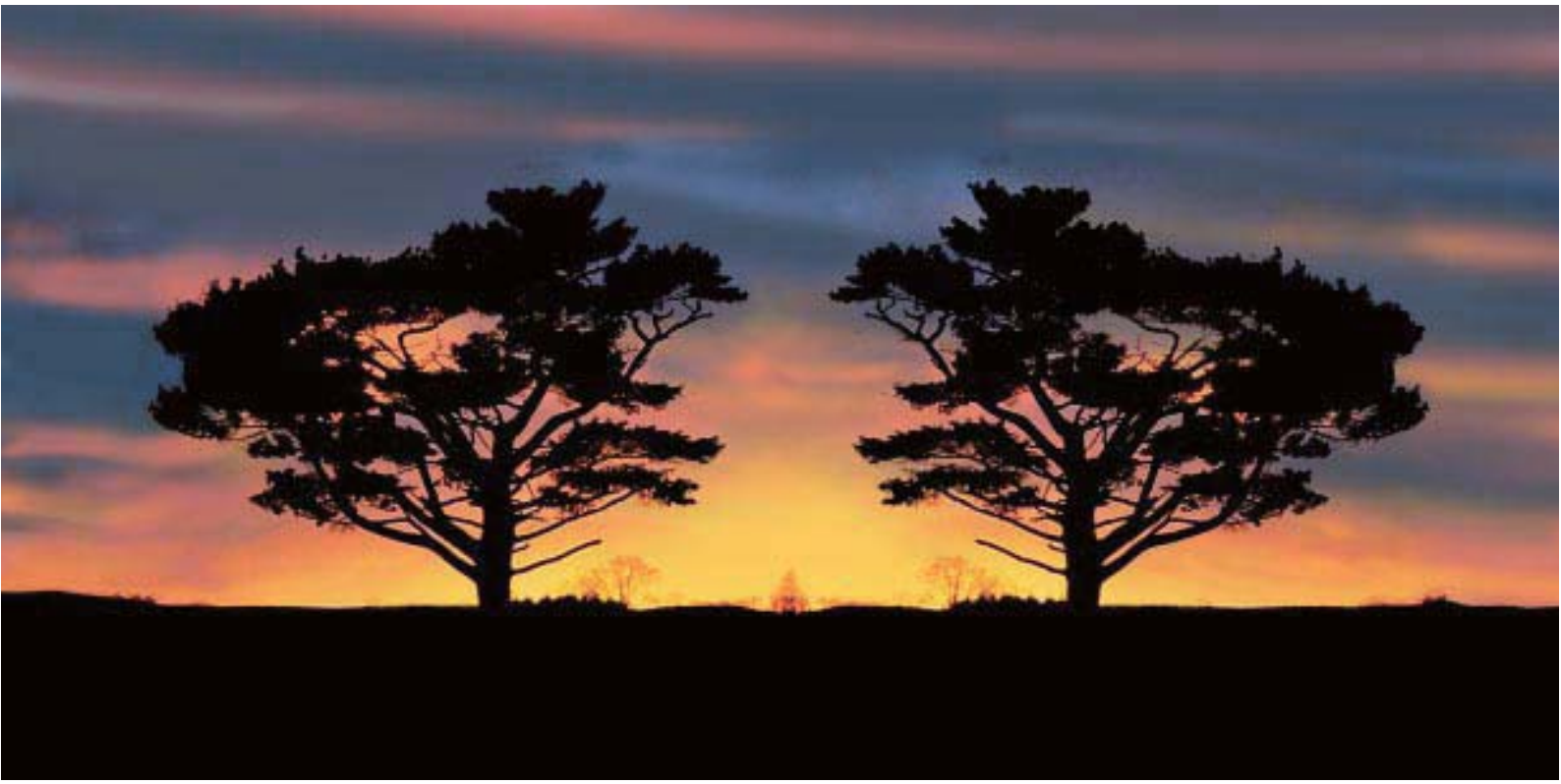
α-DEX – β-DEX – γ-DEX Chiral Cyclodextrin Capillary GC Columns



Derivatized α-, β-, and γ-cyclodextrin on a stable phenylmethylpolysiloxane cophase, for efficiently separating optical and positional isomers without derivatization: foods – flavors – essential oils – pharmaceuticals – polymers – natural products – synthesized chemicals.

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 enantioreversals. 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**

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Supelco Park • Bellefonte, PA 16823-0048 USA