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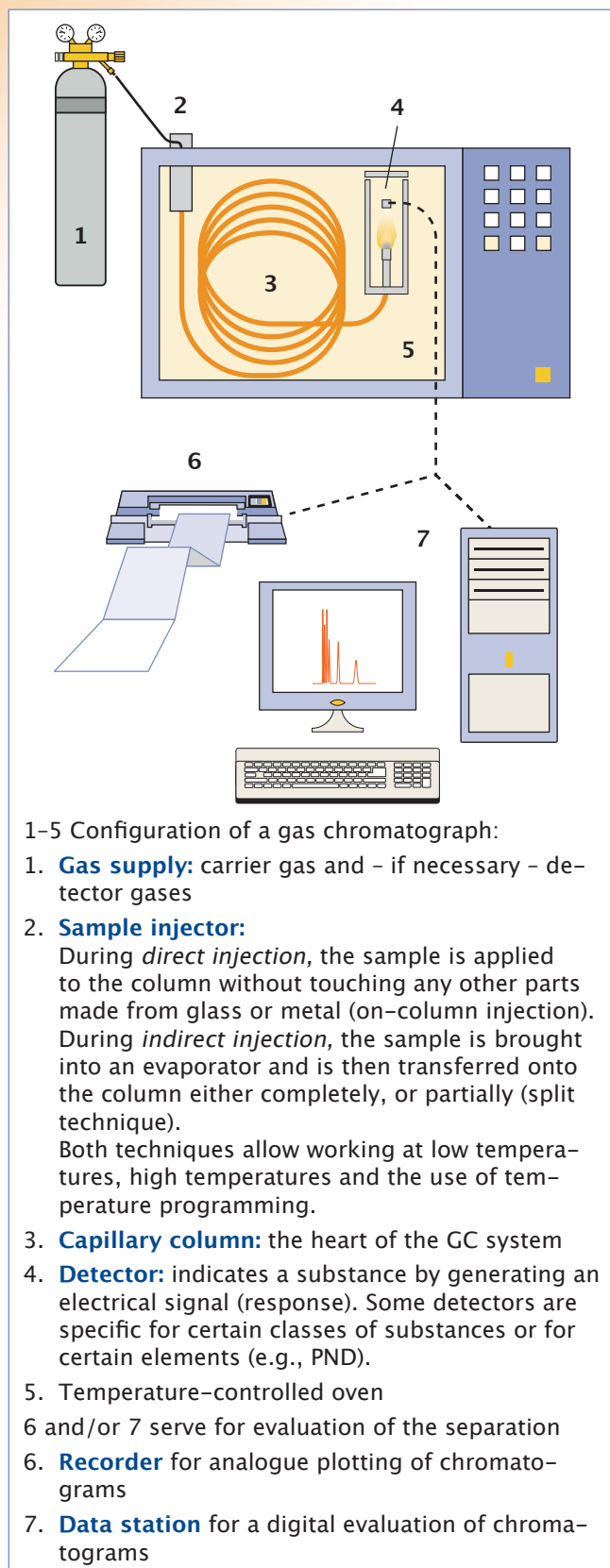
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Basic principles of capillary GC

The GC system



The separation process

Chromatographic separation is achieved through continuous distribution of each sample component between the mobile and the stationary phase:

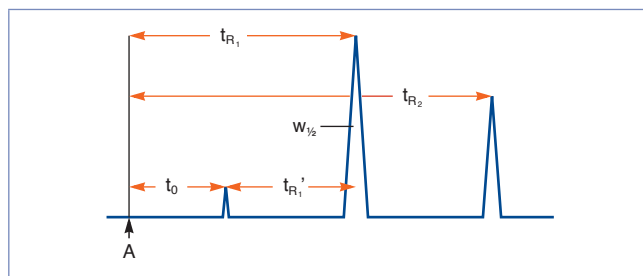
In GC, the **mobile phase** is always a gas, either He, N₂, Ar, or H₂.

The **stationary phase** is often a viscous, gum-like liquid adhered to the inner wall of a capillary column (WCOT = Wall Coated Open Tubular).

Transport of the components occurs exclusively in the mobile phase, while separation only takes place in the stationary phase. The quality of a separation (resolution) depends on the residence time of the components within the stationary phase and on the rate of interactions. The type of interaction between component and phase (selectivity) is determined by the functional groups of the stationary phase. The polarity of the phase is a function of its substituents.

The chromatogram

A chromatogram consists of a base line and a number of peaks. The area of a peak allows quantitative determinations:



A: starting point of a chromatogram = time of injection of a dissolved solute

A component can be identified by its retention time (qualitative determination):

$$t_{R_i} = t_0 + t_{R_i}'$$

t_0 : dead time = residence time of a solute in the mobile phase (time required by a component to migrate through the chromatographic system without any interaction with the stationary phase)

t_{R_i} : retention time = time interval between peak i and the point of injection

t_{R_i}' : net retention time = difference between total retention time and dead time t_0 . It indicates how long a substance stays in the stationary phase.

Other terms characterizing a separation:

k' : retention factor: a measure for the position of a sample peak in the chromatogram. The retention factor is specific for a given compound and constant under constant conditions.

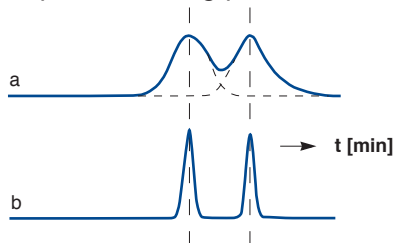
$$k'_i = \frac{t_{R_i} - t_0}{t_0}$$



α : relative retention, also called separation factor or selectivity coefficient, is the ratio of two capacity factors. The reference substance is always in the denominator.

$$\alpha = \frac{k'_2}{k'_1}$$

The relative retention does not provide any information on the quality of a separation. For equal values of α two very broad peaks may overlap (as shown in a), or may be completely resolved (as in b), if they are accordingly narrow.



$w_{1/2}$: peak width at half height

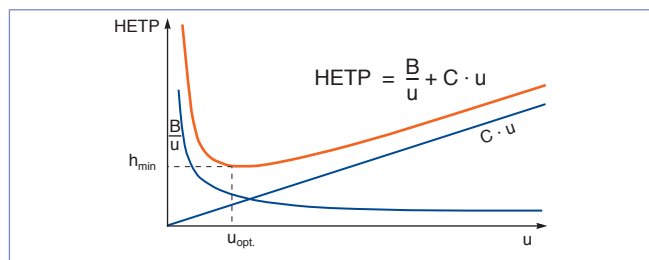
R: resolution: a measure for the quality of a separation, taking $w_{1/2}$ into account according to

$$R = \frac{t_{R2} - t_{R1}}{(w_{1/2})_2 + (w_{1/2})_1}$$

N_{th} : number of theoretical plates: characterizes the quality of a column (should be determined for $k' > 5$). The height equivalent to a theoretical plate (h, HETP) is calculated by dividing the length L of the column by the number of theoretical plates N_{th} . The smaller this value the more efficient the column.

$$N_{th} = 5.54 \cdot \left(\frac{t_{Ri}}{w_{1/2}} \right)^2 \quad h = \text{HETP} = \frac{L}{N_{th}}$$

The Golay equation shows how the plate height h depends on the flow velocity u:



B molecular axial diffusion; B is a function of the diffusion coefficient of the component in the respective carrier gas

C resistance to mass transfer

In practice often higher velocities than $u_{opt.}$ are chosen, if separation efficiency is sufficient. Higher carrier velocities mean shorter retention times.

Parameters characterizing a capillary column

OPTIMA® 5, 1.0 μm film 30 m x 0.32 mm ID

A

B

C

D

A. Stationary phase

Different chemical structures of stationary phases are responsible for the type of interaction (selectivity) between the phase and the analytes. The stationary phase also limits the temperature range for chromatography. For a detailed summary of MN phases for GC please see the following chapter.

B. Film thickness

ranges from 0.1 to 5.0 μm . The standard film thickness is 0.25 μm . Thin films (0.1–0.2 μm) are very well suited for high-boiling, temperature-sensitive or almost contemporaneously eluting substances. Increasing the film thickness will increase the capacity, the retention for low-boiling substances and the inertness of the column. This is especially helpful for samples with a broad range of concentrations, or the separation of volatile polar substances.

A better coverage of the column wall by a thicker film and a reduced column surface due to a shorter columns have a positive impact on the separation of very active substrates, that may cause noticeable tailing when they come in contact with non-coated spots of the column wall.

Thick films, however, always mean more stationary phase in the column, hence increased column bleeding. Therefore, maximum operating temperatures for thick-film columns are reduced. In addition, thick-film columns may have a lesser separating capacity.

C. Column length

The separating efficiency (better the number of plates N) of a column is directly proportional to its length. Most routine separations are carried out on 25 or 30 m columns, while more complex samples may require 50 or 60 m. 10 m columns are common for Fast GC (see page 267).

D. Inner diameter (ID)

The lower the ID, the higher is the theoretically possible number of plates per meter;

0.1–0.2 mm ID: for high resolution and short retention times at low carrier gas flow

0.25 mm ID: for analyses of complex mixtures

0.32 mm ID: for routine analyses with short retention times, but increased capacity

0.53 mm ID: for rapid separations with inert surface and highest capacity



Summary of MN phases for GC

MN offers more than 40 different phases for gas chromatography, from very nonpolar to polar columns.

Nonpolar stationary phases (e.g., 100% dimethylpolysiloxane phases) separate by volatility (i.e. boiling point) only. Typical analytes are linear hydrocarbons (*n*-alkanes).

Polar phases offer additional interactions that may improve a separation. When the polarity is increased, e.g., by introducing phenyl and / or cyanopropyl groups, differences in dipole moment and charge transfer effects, e.g., in 5–50% diphenylpolysiloxane phases, gain more and more influence on the separation. Typical analytes are hydrocarbons containing oxygen, sulfur, nitrogen, phosphorus or halogens, as well as unsaturated, polarizable molecules and aromatics.

For the separation of components with various abilities to form strong hydrogen bonds, polyethylene glycol phases (WAX) are the best choice. Typical analytes are alcohols and carboxylic acids.

The selectivity of a column has to be optimized for either the critical pair of components, or the main constituent. Always select the least polar column your separation works on. About 70% of all separations can be accomplished on non- to midpolar columns. These columns generally show a high temperature stability.

For GC columns for special separations, please go to page 266.

Phase	Composition	Max. temperature ¹	USP	Similar phases ²	Page
OPTIMA[®] 1	100% dimethylpolysiloxane	340 / 360 °C	G1 G2 G38	PERMABOND [®] SE-30 (page 264), OV-1, DB-1, SE-30, HP-1, SPB [™] -1, CP-Sil 5 CB, Rtx [®] -1, 007-1, BP1, MDN-1, AT [™] -1, ZB-1, OV-101	242
OPTIMA[®] 1 MS	100% dimethylpolysiloxane	340 / 360 °C	G1 G2 G38	Ultra-1, DB-1MS, HP-1MS, Rxi [®] -1MS, Rtx [®] -1MS, Equity [™] -1, AT [™] -1MS, VF-1MS, CP-Sil 5 CB MS	243
OPTIMA[®] 1 MS Accent					244
OPTIMA[®] 5	5% phenyl – 95% methylpolysiloxane	340 / 360 °C	G27 G36	PERMABOND [®] SE-52 (page 264), SE-54, SE-52, HP-5, SPB [™] -5, CP-Sil 8, Rtx [®] -5, 007-5, BP5, MDN-5, AT [™] -5, ZB-5	245
OPTIMA[®] 5 MS	5% diphenyl – 95% dimethylpolysiloxane	340 / 360 °C	G27 G36	DB-5, DB-5MS, HP-5MS, Ultra-2, Equity [™] -5, CP-Sil 8CB low bleed/MS, Rxi [®] -5MS, Rtx [®] -5SIL-MS, Rtx [®] -5MS, 007-5MS, BPX [™] 5, MDN-5S, AT [™] -5MS, VF-5MS	246
OPTIMA[®] 5 MS Accent	silarylene phase with selectivity similar to 5% diphenyl – 95% dimethylpolysiloxane	340 / 360 °C	G27 G36		247
OPTIMA[®] XLB	silarylene phase, optimized silarylene content for low bleeding	340 / 360 °C	–	DB-XLB, Rxi [®] -XLB, Rtx [®] -XLB, MDN-12, VF-XMS	248
OPTIMA[®] δ-3	phase with autoselectivity ³	340 / 360 °C	G49	no similar phases	249
OPTIMA[®] δ-6	phase with autoselectivity ³	340 / 360 °C	–	no similar phases	250
OPTIMA[®] 1301	6% cyanopropylphenyl – 94% dimethylpolysiloxane	300 / 320 °C	G43	HP-1301, DB-1301, SPB [™] -1301, Rtx [®] -1301, CP-1301, 007-1301	251
OPTIMA[®] 624	6% cyanopropylphenyl – 94% dimethylpolysiloxane	280 / 300 °C	G43	HP-624, HP-VOC, DB-624, DB-VRX, SPB [™] -624, CP-624, Rtx [®] -624, Rtx [®] -Volatiles, 007-624, BP624, VOCOL	252
OPTIMA[®] 624 LB	as above, low bleed phase	280 / 300 °C	G43		
OPTIMA[®] 1701	14% cyanopropylphenyl – 86% dimethylpolysiloxane	300 / 320 °C	G46	OV-1701, DB-1701, CP-Sil 19 CB, HP-1701, Rtx [®] -1701, SPB [™] -1701, 007-1701, BP10, ZB-1701	253



Phase	Composition	Max. temperature ¹	USP	Similar phases ²	Page
OPTIMA® 35 MS	silarylene phase with selectivity similar to 35% diphenyl – 65% dimethylpolysiloxane	360 / 370 °C	G28 G32 G42	DB-35 MS, HP-35, SPB™-35, Rxi®-35SIL MS, Rtx-35, 007-35, BPX™-35, MDN-35, AT™-35 MS, ZB-35, OV-11, VF-35 MS	254
OPTIMA® 17	phenylmethylpolysiloxane, 50% phenyl	320 / 340 °C	G3	OV-17, DB-17, HP-50+, HP-17, SPB™-50, SP-2250, Rxi®-17, Rtx®-50, CP-Sil 24 CB, 007-17, ZB-50	255
OPTIMA® 17 MS	silarylene phase with selectivity similar to 50% phenyl – 50% methylpolysiloxane	340 / 360 °C	G3	OV-17, AT™-50, BPX™-50, DB-17, DB-18ms, HP-50+, HP-17, SPB™-50, SPB™-17, SP-2250, Rtx®-50, CP-Sil 24 CB, 007-17, VF-17ms, ZB-50	256
OPTIMA® 210	trifluoropropylmethylpolysiloxane (50% trifluoropropyl)	260 / 280 °C	G6	OV-210, DB-210, Rtx®-200, 007-210	257
OPTIMA® 225	50% cyanopropylmethyl – 50% phenylmethylpolysiloxane	260 / 280 °C	G7 G19	DB-225, HP-225, OV-225, Rtx®-225, CP-Sil 43, 007-225, BP225	258
OPTIMA® 240	33% cyanopropylmethyl – 67% dimethylpolysiloxane	260 / 280 °C	–	no similar phases	259
OPTIMA® WAX	polyethylene glycol 20 000 Da	240 / 250 °C	G16	PERMABOND® CW 20 M (page 265), DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax	260
OPTIMA WAXplus®	polyethylene glycol with optimized cross-linking	260 / 270 °C	G16	DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax	261
OPTIMA® FFAP	polyethylene glycol 2-nitro-terephthalate	240 / 250 °C	G35 G25	PERMABOND® FFAP (page 265), DB-FFAP, HP-FFAP, CP-Wax 58 FFAP CB, 007-FFAP, CP-FFAP CB, Nukol™	262
OPTIMA® FFAPplus	polyethylene glycol 2-nitro-terephthalate with optimized cross-linking	250 / 260 °C	G35 G25	DB-FFAP, HP-FFAP, CP-Wax 58 FFAP CB, 007-FFAP, CP-FFAP CB, Nukol™	263
¹ First temperature for isothermal operation, second value for short isotherms in a temperature program Please note that for columns with 0.53 mm ID and for columns with thicker films temperature limits are generally lower. For details refer to the description of individual phases. ² Phases which provide a similar selectivity based on chemical and physical properties ³ See description on page 241					

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.

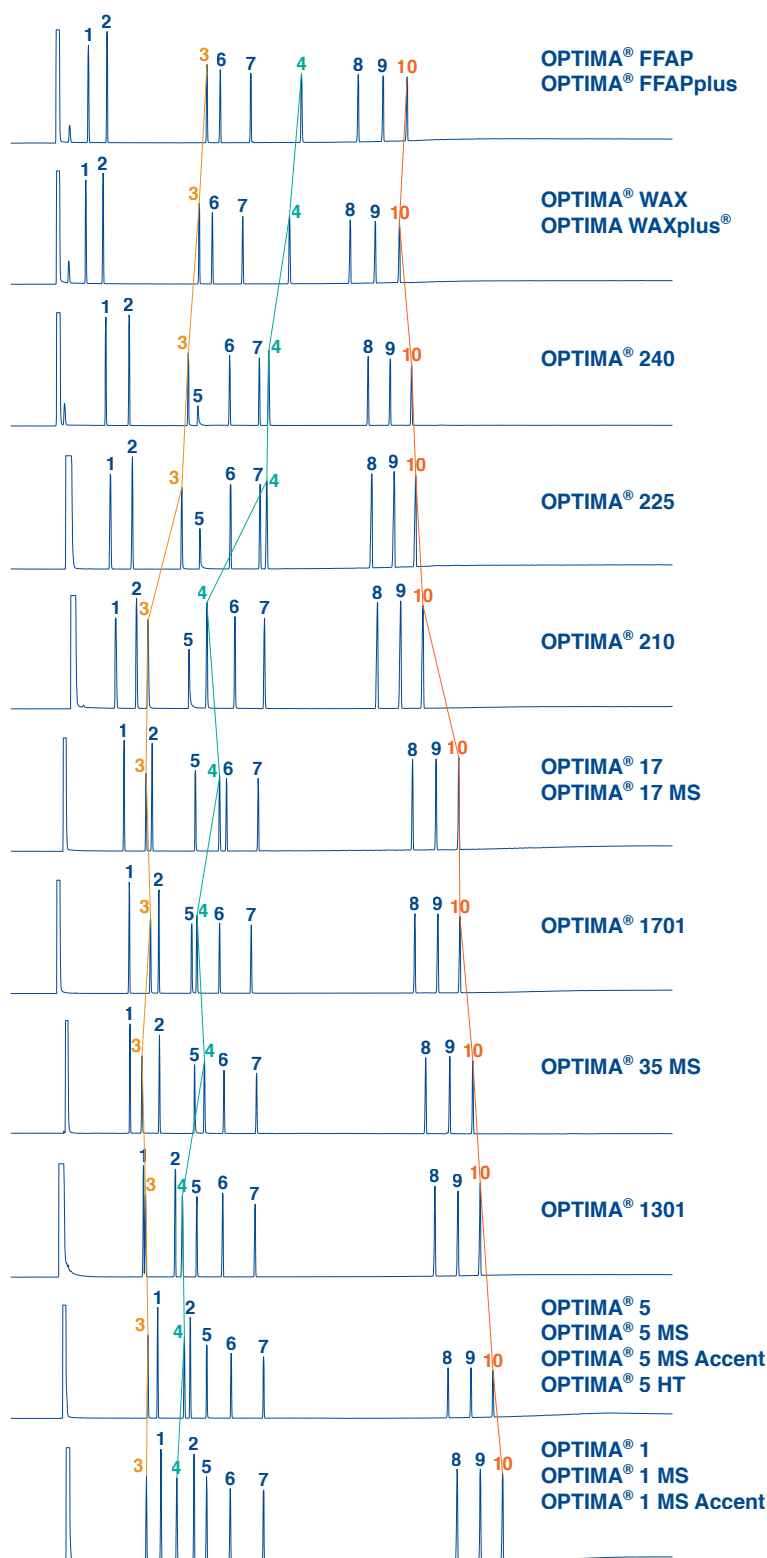
On request, all columns can be supplied on a **5 inch (13 cm) cage** for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an **integrated guard column**. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



Separation properties of OPTIMA® phases

Capillary columns for GC

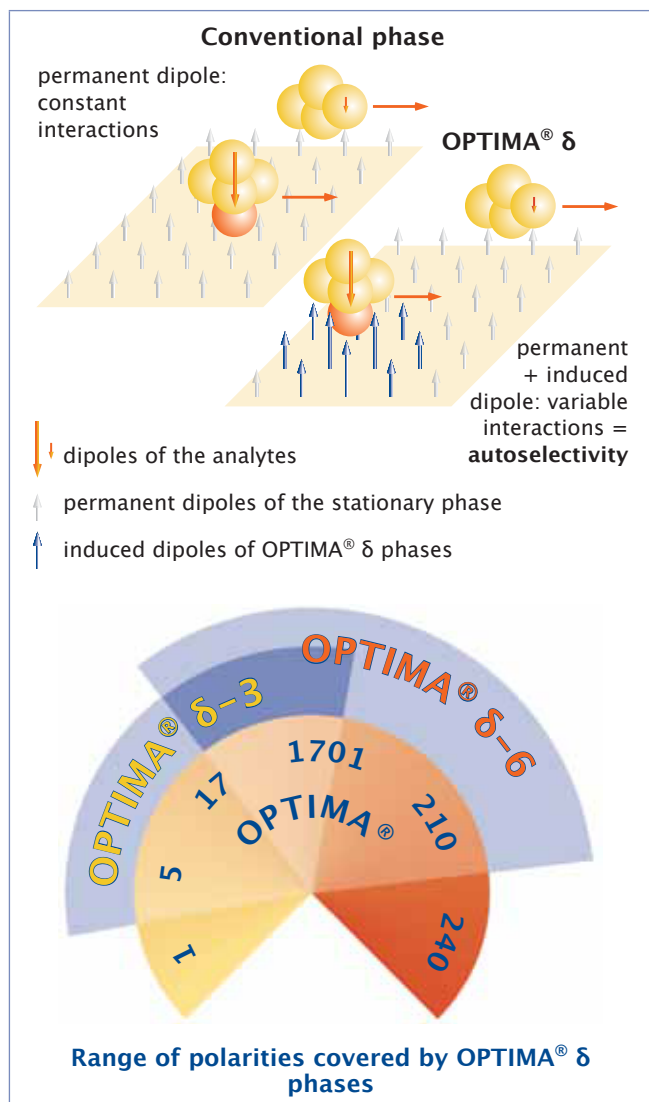


increasing polarity

All columns: 0.25 µm film, 30 m x 0.25 mm ID
 Sample: MN OPTIMA® test mixture (REF 722316)
 Injection: 1.0 µL, split 15 mL/min
 Carrier gas: 0.80 bar He
 Temperature: 80 °C → Tmax (isothermal), 8 °C/min (20 min Tmax)
 Detector: FID 260–280 °C

Peaks:
 1. Undecane
 2. Dodecane
 3. Octanol
 4. Dimethylaniline
 5. Decylamine

6. Methyl decanoate
 7. Methyl undecanoate
 8. Henicosane
 9. Docosane
 10. Tricosane

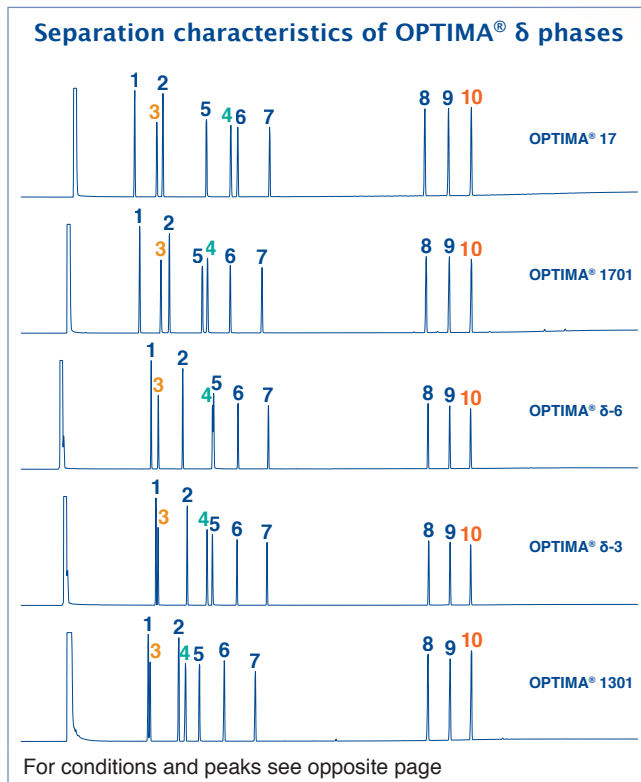


All stationary GC phases can be classified by their polarities. While the selectivity of common GC phases is generally determined by permanent dipole-dipole interactions, OPTIMA® δ -3 and OPTIMA® δ -6 show an additional feature. Large, polarizable groups in the polymer chain of the stationary phase enable the analyte to induce a further dipole moment that increases with the polarity of said analyte. We call this phenomenon "Autoselectivity", because the column adjusts itself to the polarity of the analyte. The implemented polymers consist of cross-linked polysiloxanes with a defined composition and an extremely narrow distribution of molecular weight.

OPTIMA® δ phases cover broad ranges of polarities. Compared with conventional phases, OPTIMA® δ -3 polarity ranges from approximately the nonpolar OPTIMA® 5 to the midpolar OPTIMA® 1701, while for OPTIMA® δ -6 the polarity covers a range from about the midpolar OPTIMA® 17 to the polar OPTIMA® 210.

OPTIMA® δ phases show high temperature limits (340 / 360 °C), as well as low bleed levels, which makes them ideal for the use with mass selective (MSD) or phosphorus/nitrogen detectors (PND) in the field of environmental trace analysis.

Isomeric phenols, such as chloro- and nitrophenols, are difficult to analyze with standard GC phases (e.g., OPTIMA® 5 or OPTIMA® 17) because of co-elutions. The autoselective OPTIMA® δ -3 is able to separate all 22 phenols due to stronger interactions occurring with more polar molecules, because polar analytes induce a dipole moment in the phase of the OPTIMA® δ -3 (see chromatogram page 249).



Key features of OPTIMA® δ phases:

- ✦ Wide range of application due to autoselectivity
- ✦ Outstanding thermal stability similar to nonpolar phases
- ✦ Low bleed levels
- ✦ Medium polar without CN groups

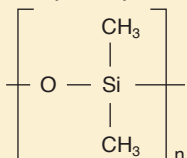
For ordering information of OPTIMA® δ phases see pages 249-250.



OPTIMA® high performance capillary columns

OPTIMA® 1

Nonpolar phase



Similar phases: PERMABOND® SE-30 (page 264), OV-1, DB-1, SE-30, HP-1, SPB-1, CP-Sil 5 CB, Rtx-1, 007-1, BP1, MDN-1, AT-1, ZB-1, OV-101

USP G1 / G2 / G38

100 % dimethylpolysiloxane



Columns with 0.1–0.32 mm ID and films < 3 µm:
max. temperature for isothermal operation 340 °C,
max. temperature for short isotherms in a temperature program 360 °C
0.53 mm ID columns with films < 3 µm:
max. temperatures 320 and 340 °C, resp.
Thick film columns with films ≥ 3 µm:
max. temperatures 300 and 320 °C, resp.

Separation of components according to boiling points
Thick film columns ≥ 3 µm film are especially recommended for solvent analysis.

Ordering information

Length →	10 m	12 m	15 m	20 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)								
0.10 µm film	726024.10			726024.20				
0.40 µm film				726025.20				
0.2 mm ID (0.4 mm OD)								
0.10 µm film					726832.25			
0.20 µm film		726834.12			726834.25		726834.50	
0.35 µm film		726837.12			726837.25		726837.50	
0.50 µm film							726839.50	
0.25 mm ID (0.4 mm OD)								
0.10 µm film	726038.10		726038.15		726038.25	726038.30		726038.60
0.25 µm film	726050.10		726050.15		726050.25	726050.30	726050.50	726050.60
0.50 µm film	726081.10				726081.25	726081.30	726081.50	726081.60
1.00 µm film					726802.25	726802.30	726802.50	726802.60
0.32 mm ID (0.5 mm OD)								
0.10 µm film	726301.10				726301.25	726301.30	726301.50	726301.60
0.25 µm film	726302.10		726302.15		726302.25	726302.30	726302.50	726302.60
0.35 µm film					726821.25	726821.30	726821.50	726821.60
0.50 µm film	726304.10				726304.25	726304.30	726304.50	726304.60
1.00 µm film	726323.10		726323.15		726323.25	726323.30	726323.50	726323.60
3.00 µm film					726805.25	726805.30	726805.50	726805.60
5.00 µm film	726931.10				726931.25	726931.30	726931.50	
0.53 mm ID (0.8 mm OD)								
0.50 µm film			726519.15		726519.25	726519.30		
1.00 µm film	726529.10		726529.15		726529.25	726529.30		
2.00 µm film	726521.10				726521.25	726521.30	726521.50	
5.00 µm film	726926.10				726926.25	726926.30	726926.50	

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.

On request, all columns can be supplied on a **5 inch (13 cm) cage** for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an **integrated guard column**. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.

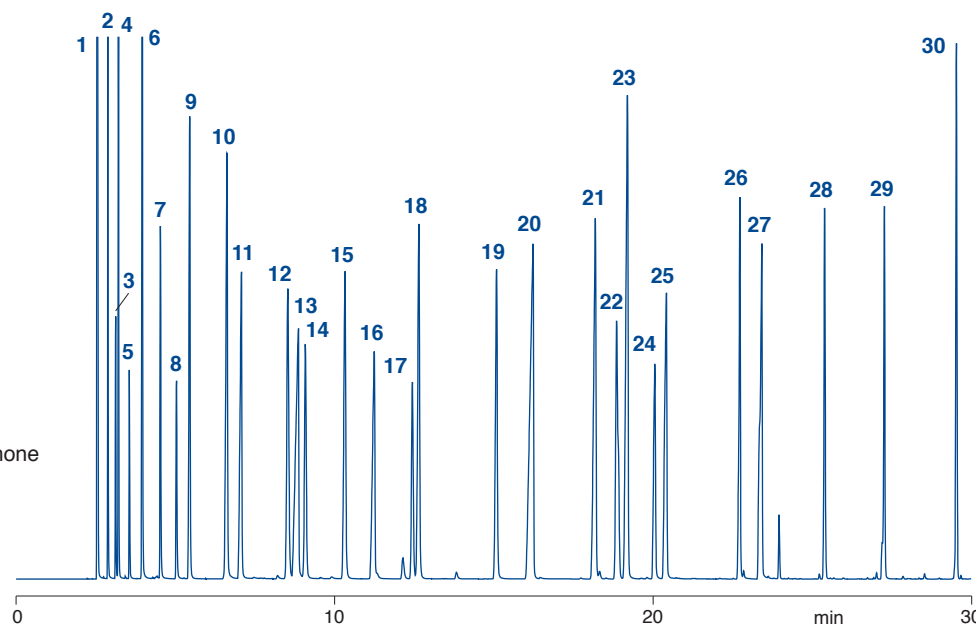


Solvent analysis

Column: OPTIMA® 1, 1.0 µm film, 60 m x 0.32 mm ID
 Sample: solvent mixture, courtesy of J. Lutz, Alcan Rorschach, Switzerland
 Injection: 0.4 µL, split 1:60
 Carrier gas: H₂, 120 kPa
 Temperature: 50 °C (9 min) → 90 °C, 4 °C/min → 280 °C (2 min), 14 °C/min
 Detector: FID 300 °C

Peaks:

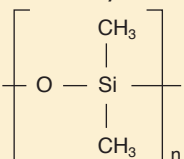
1. Methanol
2. Ethanol
3. Acetone
4. 2-Propanol
5. Methyl acetate
6. *n*-Propanol
7. Methyl ethyl ketone
8. Ethyl acetate
9. Isobutanol
10. *n*-Butanol
11. 1-Methoxy-2-propanol
12. Isooctane
13. Ethyl glycol
14. Isoheptane
15. Methyl isobutyl ketone
16. 1-Ethoxy-2-propanol
17. Toluene
18. Isobutyl acetate
19. Butyl acetate
20. 4-Hydroxy-4-methyl-2-pentanone
21. 1-Methoxy-2-propyl acetate
22. Xylene
23. Cyclohexanone
24. Ethyl glycol acetate
25. Butyl glycol
26. Heptanol
27. Ethyl diglycol
28. Butyl diglycol
29. Butyl glycol acetate
30. Butyl diglycol acetate



MN Appl. No. 201390

OPTIMA® 1 MS

Selectivity identical to OPTIMA® 1



Similar phases: Ultra-1, DB-1MS, HP-1MS, Rxi-1MS, Rtx-1MS, Equity-1, AT-1MS, VF-1MS, CP-Sil 5 CB MS

100% dimethylpolysiloxane

Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C

Phase with low bleeding
 Suited for GC/MS and ECD applications and general analyses at trace level

USP G1 / G2 / G38

Ordering information

Length →	12 m	15 m	25 m	30 m	50 m	60 m
0.2 mm ID (0.4 mm OD)						
0.20 µm film			726201.25		726201.50	
0.35 µm film	726203.12					
0.25 mm ID (0.4 mm OD)						
0.25 µm film		726205.15		726205.30		726205.60
0.32 mm ID (0.5 mm OD)						
0.25 µm film				726202.30		726202.60

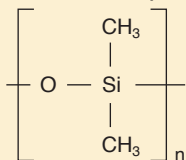
In addition to this standard program we will be happy to supply columns custom-made to your specifications.



OPTIMA[®] high performance capillary columns

OPTIMA[®] 1 MS Accent

- Selectivity identical to OPTIMA[®] 1



Increased sensitivity due to an unmatched low background level

- USP G1 / G2 / G38

100 % dimethylpolysiloxane

- Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C
- Lowest column bleed, nonpolar phase, ideal for ion trap and quadrupole MS detectors
perfect inertness for basic compounds
solvent rinsing for removal of impurities applicable
- Recommended application: all-round phase for environmental analyses, trace analyses, EPA methods, pesticides, PCB, food and drug analyses
- Similar phases: Ultra-1, DB-1 MS, HP-1 MS, Rxi-1 MS, Rtx-1 MS, Equity-1, AT-1 MS, VF-1 MS, CP-Sil 5 CB MS

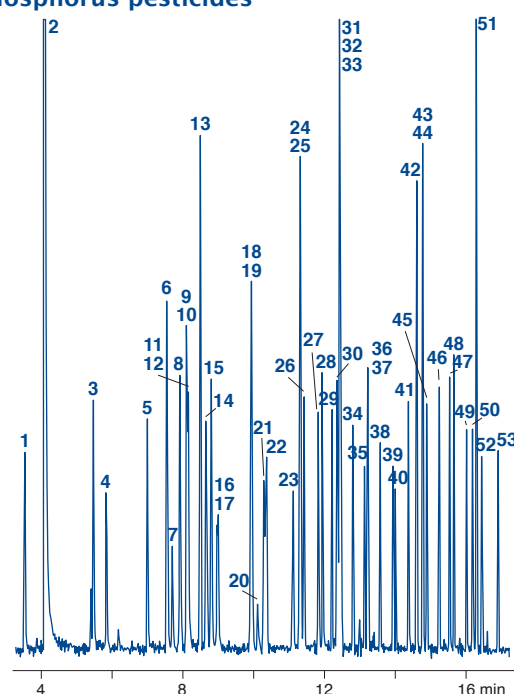
EPA 8140 / 8141 / 8141 A Organophosphorus pesticides

Column: OPTIMA[®] 1 MS Accent, 0.50 µm film,
30 m x 0.32 mm ID
Sample: 0.2 µg/mL in hexane,
8140/8141 OP pesticides calibration mix A and 8141
OP pesticides calibration mix B;
IS triphenyl phosphate and tributyl phosphate
Injection: 250 °C, splitless (hold 1 min)
Carrier gas: He, 1 mL/min, constant pressure
Temperature: 100 °C → 180 °C, 10 °C/min (2 min) → 300 °C,
18 °C/min (3 min)
Detector: FPD (Flame Photometric Detector), 280 °C

Peaks:

1. Dichlorvos, 2. Hexamethylphosphoramide, 3. Mevinphos,
4. Trichlorfon, 5. TEPP, 6. Thionazin, 7. Demeton-O, 8. Ethoprop
9. Tributyl phosphate (IS), 10. Dicrotophos, 11. Monocrotophos,
12. Naled, 13. Sulfotepp, 14. Phorate, 15. Dimethoate, 16. Demeton-S,
17. Dioxathion, 18. Terbufos, 19. Fonophos, 20. Phosphamidon isomer,
21. Diazinon, 22. Disulfoton, 23. Phosphamidon, 24. Dichlorofenthion,
25. Parathion-methyl, 26. Chlorpyrifos methyl, 27. Ronnel,
28. Fenitrothion, 29. Malathion, 30. Fenthion, 31. Aspon,
32. Parathion-ethyl, 33. Chlorpyrifos, 34. Trichloronate,
35. Chlorfenvinphos, 36. Merphos, 37. Crotoxypfos, 38. Stirofos,
39. Tokuthion, 40. Merphos oxidation product, 41. Fensulfothion,
42. Famphur, 43. Ethion, 44. Bolstar, 45. Carbophenothion, 46. Triphenyl
phosphate (IS), 47. Phosmet, 48. EPN, 49. Azinphos-methyl,
50. Leptophos, 51. Tri-*o*-cresyl phosphate, 52. Azinphos-ethyl,
53. Coumaphos

MN Appl. No. 213030



Ordering information

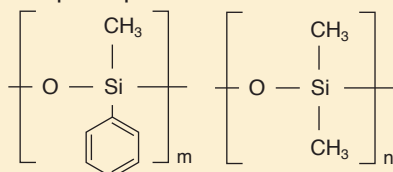
Length →	15 m	25 m	30 m	50 m	60 m
0.2 mm ID (0.4 mm OD)					
0.20 µm film		725801.25		725801.50	
0.25 mm ID (0.4 mm OD)					
0.25 µm film	725805.15		725805.30		725805.60
0.50 µm film			725806.30		725806.60
0.32 mm ID (0.5 mm OD)					
0.25 µm film			725802.30		725802.60
0.50 µm film			725807.30		725807.60

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA® 5

Nonpolar phase



Similar phases: PERMABOND® SE-52 (page 264), SE-54, SE-52, DB-5, HP-5, SPB-5, CP-Sil 8, Rtx-5, 007-5, BP5, MDN-5, AT-5, ZB-5

5 % phenyl – 95 % methylpolysiloxane



Columns with 0.1–0.32 mm ID and films < 3 µm:
max. temperature for isothermal operation 340 °C,
max. temperature for short isotherms in a temperature program 360 °C
0.53 mm ID columns with films < 3 µm:
max. temperatures 320 and 340 °C, resp.
Thick film columns with films ≥ 3 µm:
max. temperatures 300 and 320 °C, resp.

- Standard phase with large range of application
- USP G27 / G36

Ordering information

Length →	10 m	15 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)						
0.10 µm film	726846.10					
0.20 mm ID (0.4 mm OD)						
0.10 µm film			726854.25			
0.20 µm film			726857.25		726857.50	
0.35 µm film			726860.25		726860.50	
0.50 µm film			726863.25		726863.50	
0.25 mm ID (0.4 mm OD)						
0.10 µm film			726911.25	726911.30	726911.50	726911.60
0.25 µm film	726056.10	726056.15	726056.25	726056.30	726056.50	726056.60
0.35 µm film			726623.25	726623.30	726623.50	726623.60
0.50 µm film			726099.25	726099.30	726099.50	726099.60
1.00 µm film			726807.25	726807.30	726807.50	726807.60
0.32 mm ID (0.5 mm OD)						
0.10 µm film	726313.10	726313.15	726313.25	726313.30	726313.50	726313.60
0.25 µm film		726314.15	726314.25	726314.30	726314.50	726314.60
0.35 µm film			726628.25	726628.30	726628.50	726628.60
0.50 µm film			726316.25	726316.30	726316.50	726316.60
1.00 µm film		726325.15	726325.25	726325.30	726325.50	726325.60
3.00 µm film			726809.25	726809.30	726809.50	726809.60
5.00 µm film		726934.15	726934.25	726934.30	726934.50	
0.53 mm ID (0.8 mm OD)						
0.50 µm film	726523.10		726523.25	726523.30		
1.00 µm film	726541.10	726541.15	726541.25	726541.30		
2.00 µm film	726525.10		726525.25	726525.30	726525.50	726525.60
5.00 µm film	726916.10		726916.25	726916.30	726916.50	
In addition to this standard program we will be happy to supply columns custom-made to your specifications.						

On request, all columns can be supplied on a **5 inch (13 cm) cage** for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

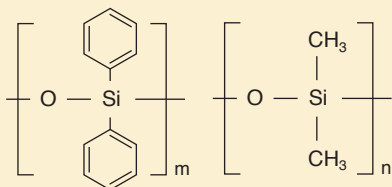
To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an **integrated guard column**. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



OPTIMA® high performance capillary columns

OPTIMA® 5 MS

Selectivity identical to OPTIMA® 5



Similar phases see OPTIMA® 5 MS Accent page 247

5 % diphenyl – 95 % dimethylpolysiloxane



Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C



Phase with low bleeding

Suited for GC/MS and ECD applications and general analyses at trace level

Perfect inertness for basic compounds



USP G27 / G36

Analysis of various phenols

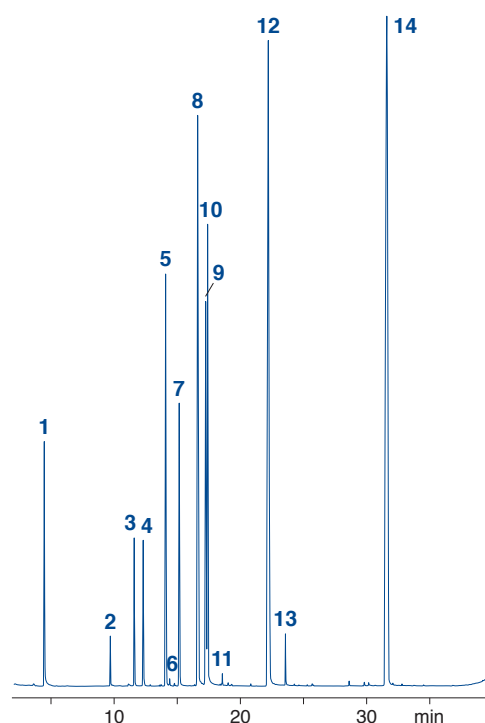
Column: OPTIMA® 5 MS, 30 m x 0.25 mm ID, 0.25 µm film
Sample: 5 ppm of each compound except *N*-*i*-propylaniline (9.4 ppm)
Method: SPME
Temperature: 40 °C (2 min) → 240 °C, 6 °C/min → 320 °C, 20 °C/min
Detector: MSD

Peaks:

1. Toluene-D₈
2. Phenol
3. 2-Methylphenol (*o*-Cresol)
4. Nitrobenzene-D₅
5. *N*-*i*-Propylaniline
6. 2,4-Dichlorophenol
7. 4-Chlorophenol
8. 4-Bromo-2-chlorophenol
9. 3-Bromophenol
10. 4-Chloro-3-methylphenol
11. 2,4-Dibromophenol
12. 2-Hydroxybiphenyl
13. 2-Cyclohexylphenol
14. Hexafluorobisphenol A

Courtesy of Riedel-de-Haën, Seelze, Germany

MN Appl. No. 210110



Ordering information

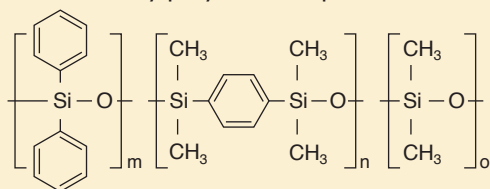
Length →	12 m	15 m	25 m	30 m	50 m	60 m
0.2 mm ID (0.4 mm OD)						
0.20 µm film	726210.12		726210.25		726210.50	
0.35 µm film	726215.12		726215.25		726215.50	
0.25 mm ID (0.4 mm OD)						
0.25 µm film		726220.15		726220.30		726220.60
0.50 µm film				726225.30		726225.60
1.00 µm film				726226.30		726226.60
0.32 mm ID (0.5 mm OD)						
0.25 µm film				726211.30		
0.50 µm film				726213.30		
1.00 µm film			726212.25		726212.50	726212.60

In addition to this standard program we will be happy to supply columns custom-made to your specifications.



OPTIMA[®] 5 MS Accent

Chemically bonded, cross-linked silarylene phase with polarity similar to a 5% diphenyl – 95% dimethylpolysiloxane phase



Increased sensitivity due to an unmatched low background level

USP G27 / G36

silarylene phase



Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C, Columns with films > 0.5 µm: max. temperatures 320 and 340 °C, respectively



Lowest column bleed, nonpolar phase, ideal for ion trap and quadrupole MS detectors

Solvent rinsing for removal of impurities applicable
Recommended application: all-round phase for environmental analyses, trace analyses, EPA methods, pesticides, PCB, food and drug analyses

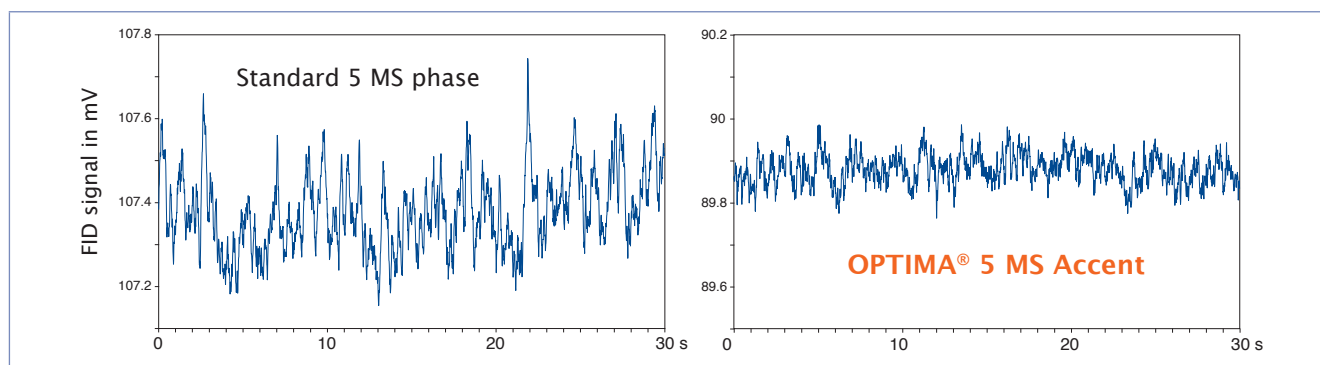
Similar phases:

DB-5 MS, HP-5 MS, Ultra-2, Equity-5, CP-Sil 8 CB low bleed/MS, Rxi-5 MS, Rtx-5SIL-MS, Rtx-5 MS, 007-5 MS, BPX5, MDN-5S, AT-5 MS, VF-5 MS

The bleed comparison test of OPTIMA[®] 5 MS Accent with a conventional 5 MS phase shows the outstanding performance of the silarylene phase.

Background noise at 340 °C

The unmatched low background level of the OPTIMA[®] 5 MS Accent, which is approximately three times lower compared to a 5 MS brand column, provides significantly increased sensitivity and allows its application in trace analyses particularly of high-boiling compounds.



Ordering information

Length →	12 m	15 m	25 m	30 m	50 m	60 m
0.2 mm ID (0.4 mm OD)						
0.20 µm film			725810.25		725810.50	
0.35 µm film	725815.12				725815.50	
0.25 mm ID (0.4 mm OD)						
0.25 µm film		725820.15		725820.30		725820.60
0.50 µm film				725825.30		725825.60
1.00 µm film				725826.30		725826.60
0.32 mm ID (0.5 mm OD)						
0.25 µm film				725811.30		725811.60
0.50 µm film				725813.30		
1.00 µm film			725812.25			725812.60

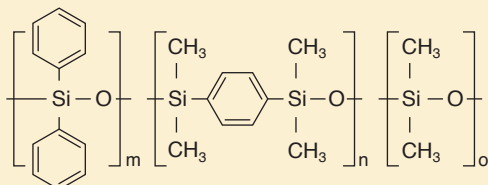
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA[®] high performance capillary columns

OPTIMA[®] XLB

Chemically bonded, cross-linked silarylene phase, optimized silarylene content for lowest column bleed



Similar phases: DB-XLB, Rxi-XLB, Rtx-XLB, MDN-12, VF-XMS

silarylene phase

Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C,

Lowest column bleed, nonpolar phase, ideal for ion trap and quadrupole MS detectors

Perfect inertness for basic compounds

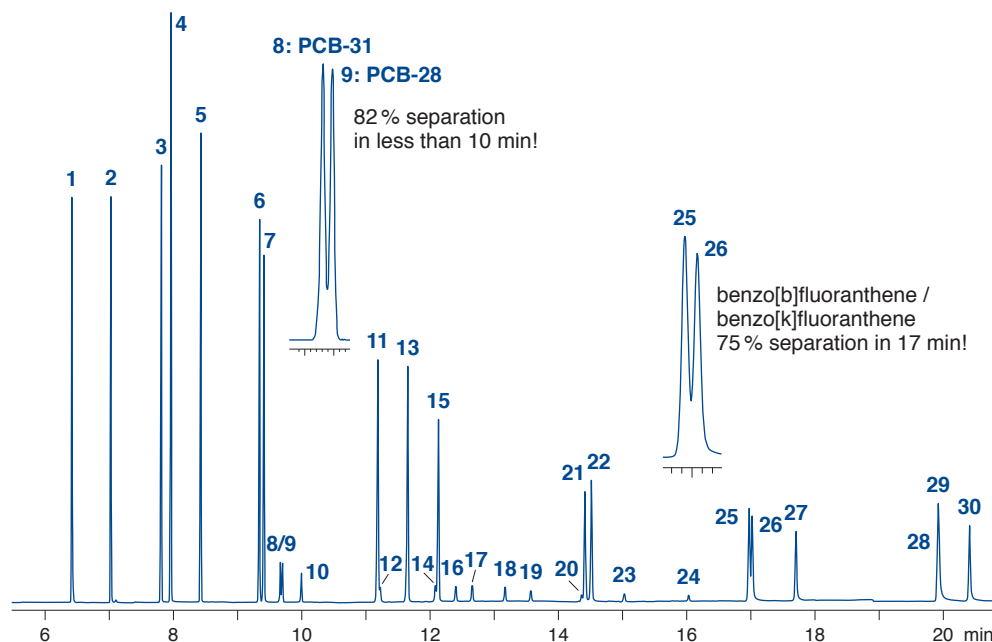
Solvent rinsing for removal of impurities applicable

Recommended application: ultra low bleed phase, highly selective for environmental and trace analyses, pesticides

Recommended phase for PCB separations

Rapid separation of PCB and PAH

Column: OPTIMA[®] XLB, 0.25 µm film, 30 m x 0.25 mm ID
Injection: 1 µL, standard 0.005 ng/µL; 250 °C, pulsed, splitless, pulse 1.38 bar in 1 min
Carrier gas: 60 mL/min He
Temperature: 40 °C (2 min) → 240 °C (2 min), 30 °C/min → 340 °C (5 min), 10 °C/min
Detector: MS source 230 °C, interface 280 °C, quadrupole 150 °C



Peaks:

1. Naphthalene
2. 2-Methylnaphthalene
3. Acenaphthylene
4. Acenaphthene
5. Fluorene
6. Phenanthrene
7. Anthracene
8. PCB-31
9. PCB-28
10. PCB-52
11. Fluoranthene
12. PCB-101
13. Pyrene
14. PCB-77
15. 2-Methylfluoranthene
16. PCB-118
17. PCB-153
18. PCB-138
19. PCB-126
20. PCB-180
21. Benz[a]anthracene
22. Chrysene
23. PCB-169
24. PCB-194
25. Benzo[b]fluoranthene
26. Benzo[k]fluoranthene
27. Benzo[a]pyrene
28. Dibenzo[ah]anthracene
29. Indeno[1,2,3-cd]pyrene
30. Benzo[ghi]perylene

Courtesy of Centre d'Analyses de Recherche, Lab. d'Hydrologie, 65400 Illkirch, France

MN Appl. No. 212920

Ordering information

Length →	30 m	60 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	725850.30	725850.60

On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)



OPTIMA® δ-3

- Medium polar without CN groups
- Analytes determine the polarity of the phase
- Unique from MN, no similar phase
- Ideal for MSD and PND detectors
- USP G49

polysiloxane phase with autoselectivity

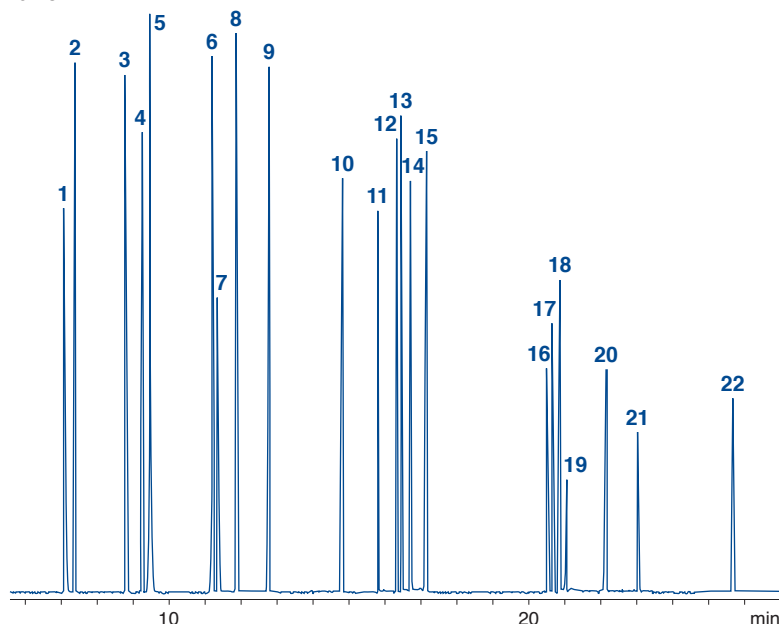
- Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C; 0.53 mm ID columns: max. temperatures 320 and 340 °C, resp.
- Autoselectivity resulting in a wide range of polarities from approximately the non-polar OPTIMA® 5 to the midpolar OPTIMA® 1701 (see page 241)

Analysis of isomeric phenols

Column: OPTIMA® δ-3, 0.25 µm film, 60 m x 0.25 mm ID
 Injection: 1.0 µL, split 1:80
 Carrier gas: He, 1.3 bar
 Temperature: 60 °C (3 min) → 320 °C, 6 °C/min
 Detector: MSD HP 5971

Peaks:

1. Phenol
2. 2-Chlorophenol
3. 2-Methylphenol
4. 4-Methylphenol
5. 3-Methylphenol
6. 2,4-Dimethylphenol
7. 2-Nitrophenol
8. 2,4-Dichlorophenol
9. 2,6-Dichlorophenol
10. 4-Chloro-3-methylphenol
11. 2,3,5-Trichlorophenol
12. 2,4,6-Trichlorophenol
13. 2,4,5-Trichlorophenol
14. 2,3,4-Trichlorophenol
15. 2,3,6-Trichlorophenol
16. 2,3,5,6-Tetrachlorophenol
17. 2,3,4,5-Tetrachlorophenol
18. 2,3,4,6-Tetrachlorophenol
19. 2,4-Dinitrophenol
20. 3,4,5-Trichlorophenol
21. 2-Methyl-4,6-dinitrophenol
22. 2-Isopropyl-4,6-dinitrophenol



MN Appl. No. 250060

Ordering information

Length →	10 m	20 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)						
0.10 µm film	726410.10	726410.20				
0.2 mm ID (0.4 mm OD)						
0.20 µm film		726400.25			726400.50	
0.25 mm ID (0.4 mm OD)						
0.25 µm film				726420.30		726420.60
0.50 µm film				726421.30		
0.32 mm ID (0.5 mm OD)						
0.25 µm film				726440.30		726440.60
0.35 µm film				726441.30		726441.60
1.00 µm film				726442.30		726442.60
0.53 mm ID (0.8 mm OD)						
1.00 µm film				726443.30		
In addition to this standard program we will be happy to supply columns custom-made to your specifications.						



OPTIMA® δ · unique phases with autoselectivity

OPTIMA® δ-6

- Medium polar without CN groups
- Analytes determine the polarity of the phase
- Unique from MN, no similar phase
- Ideal for MSD and PND detectors

polysiloxane phase with autoselectivity

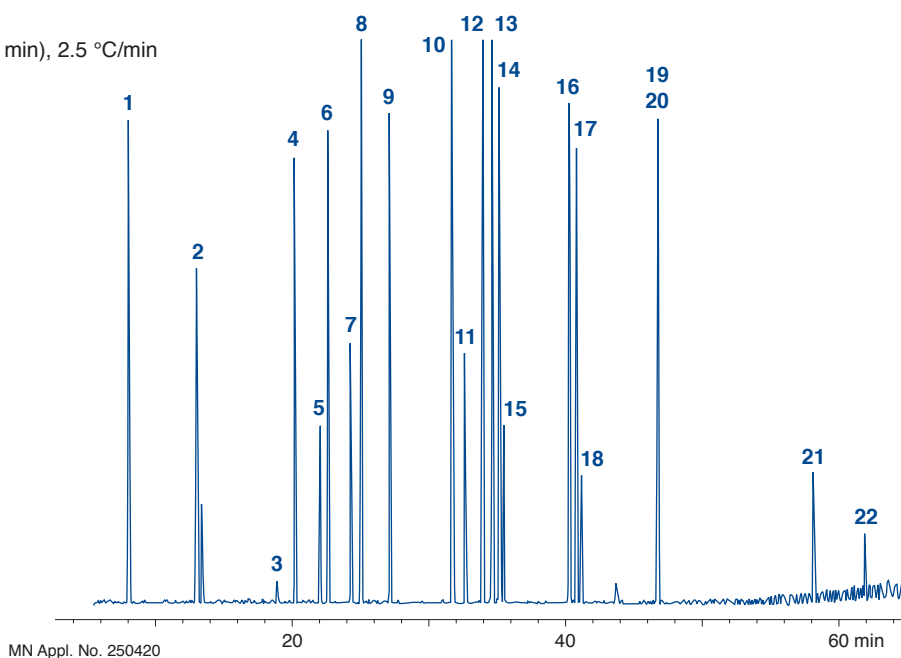
- Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C; 0.53 mm ID columns: max. temperatures 320 and 340 °C, resp.
- Autoselectivity resulting in a wide range of polarities from approximately the midpolar OPTIMA® 17 to the polar OPTIMA® 210 (see page 241)

Separation of organophosphorus pesticides (EPA 8140 / 8141)

Column: OPTIMA® δ-6, 0.2 µm film, 50 m x 0.2 mm ID
 Sample: EPA 8140 OP pesticide calibration mix (Restek), 200 µg/mL each in hexane – acetone (95:5)
 Injection: 1 µL, split 1:30
 Carrier gas: 2.0 bar He
 Temperature: 150 °C → 300 °C (10 min), 2.5 °C/min
 Detector: MSD HP 5971

Peaks:

1. Dichlorvos
2. Mevinphos
3. Demeton-S
4. Ethoprop
5. Naled
6. Phorate
7. Demeton-O
8. Diazinon
9. Disulfoton
10. Ronnel
11. Parathion-methyl
12. Chlorpyrifos
13. Trichloronate
14. Fenthion
15. Merphos
16. Stirofos
17. Tokuthion
18. Merphos oxidation product
19. Fensulfothion
20. Bolstar
21. Azinphos-methyl
22. Coumaphos



MN Appl. No. 250420

Ordering information

Length →	10 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)					
0.10 μm film	726490.10				
0.2 mm ID (0.4 mm OD)					
0.20 μm film		726465.25		726465.50	
0.25 mm ID (0.4 mm OD)					
0.25 μm film			726470.30		726470.60
0.32 mm ID (0.5 mm OD)					
0.25 μm film			726480.30		726480.60
0.35 μm film			726481.30		726481.60
1.00 μm film			726482.30		726482.60
0.53 mm ID (0.8 mm OD)					
1.00 μm film			726483.30		

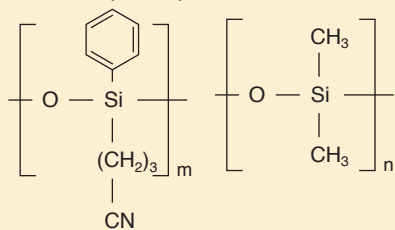
In addition to this standard program we will be happy to supply columns custom-made to your specifications.



OPTIMA[®] 1301

6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane

Medium polar phase



Max. temperature for isothermal operation 300 °C, max. temperature for short isotherms in a temperature program 320 °C

Ideal for pesticide analyses

For corresponding columns with higher film thickness see OPTIMA[®] 624

Similar phases: HP-1301, DB-1301, SPB-1301, Rtx-1301, CP-1301, 007-1301

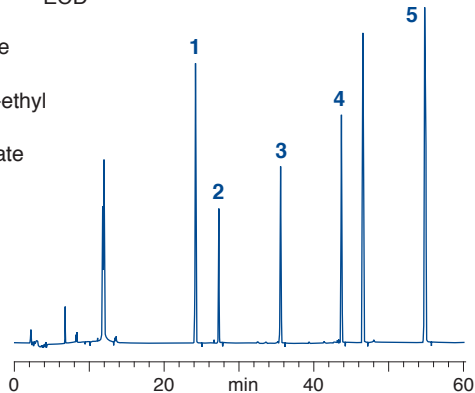
USP G43

Analysis of a pesticide mixture

Column: OPTIMA[®] 1301, 0.25 µm film, 60 m x 0.25 mm ID
 Injection: 3 µL (0.1 ng/µL), 80 °C (1 min) → 250 °C (1 min) pulsed splitless
 Carrier gas: He, 54 mL/min
 Temperature: 80 °C (2 min) → 190 °C, 20 °C/min (12 min) → 240 °C, 2 °C/min (23 min) → 260 °C, 10 °C/min (20 min)
 Detector: ECD

Peaks:

1. Propyzamide
2. Vinclozolin
3. Bromophos-ethyl
4. 2,4-DDT
5. Bromproylate



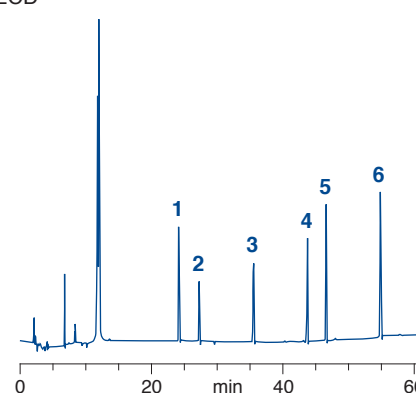
MN Appl. No. 210620

Analysis of a PCB mixture

Column: OPTIMA[®] 1301, 0.25 µm film, 60 m x 0.25 mm ID
 Injection: 3 µL (0.1 ng/µL), 80 °C (1 min) → 250 °C (1 min) pulsed splitless
 Carrier gas: He, 54 mL/min
 Temperature: 80 °C (2 min) → 190 °C, 20 °C/min (12 min) → 240 °C, 2 °C/min (23 min) → 260 °C, 10 °C/min (20 min)
 Detector: ECD

Peaks:

1. PCB-28
2. PCB-52
3. PCB-128
4. PCB-153
5. PCB-138
6. PCB-180



MN Appl. No. 210650

Ordering information

Length →	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)				
0.25 µm film	726771.25	726771.30	726771.50	726771.60
0.32 mm ID (0.5 mm OD)				
0.25 µm film	726777.25	726777.30		726777.60
1.00 µm film		726780.30	726780.50	726780.60
0.53 mm ID (0.8 mm OD)				
1.00 µm film	726783.25			

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

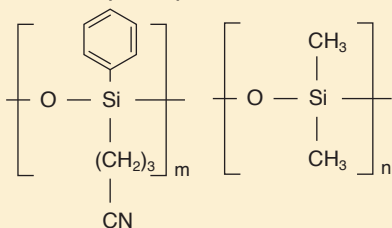
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA® high performance capillary columns

OPTIMA® 624

Medium polar phase



Similar phases: HP-624, HP-VOC, DB-624, DB-VRX, SPB-624, CP-624, Rtx-624, Rtx-Volatiles, 007-624, BP624, VOCOL

6 % cyanopropyl-phenyl - 94 % dimethylpolysiloxane

Max. temperature for isothermal operation 280 °C, max. temperature for short isotherms in a temperature program 300 °C

Recommended application: environmental analyses

For corresponding columns with lower film thickness see OPTIMA® 1301

USP G43

OPTIMA® 624 LB

Excellent Low Bleed columns for halogenated hydrocarbons, volatiles, aromatic compounds, solvents etc.

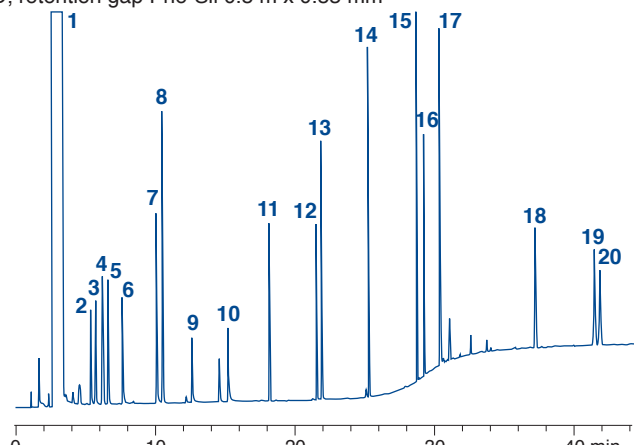
6 % cyanopropyl-phenyl - 94 % dimethylpolysiloxane

Solvents and semi-volatiles

Column: OPTIMA® 624 LB, 1.8 µm film, 30 m x 0.32 mm ID; retention gap Phe-Sil 0.5 m x 0.53 mm
Injection: 1 µL (10 ppm per substance in acetone), cold on-column
Carrier gas: 1.1 bar He
Temperature: 45 °C (3 min) → 150 °C (6 °C/min) → 300 °C (18 °C/min), 20 min 300 °C
Detector: FID 280 °C

Peaks:

- | | |
|-----------------------|---------------------------------------|
| 1. Acetone | 11. Decane |
| 2. Ethyl acetate | 12. 1-Octanol |
| 3. Tetrahydrofuran | 13. Acetophenone |
| 4. Cyclohexane | 14. Butyrophenone |
| 5. 2-Methyl-2-butanol | 15. Heptanophenone |
| 6. 1-Butanol | 16. 5-Methoxyindole |
| 7. Pyridine | 17. Dibenzylamine |
| 8. Toluene | 18. Methyl eicosanoate |
| 9. Dimethylformamide | 19. Methyl <i>cis</i> -13-docosenoate |
| 10. Dimethylsulfoxide | 20. Methyl docosanoate |



MN Appl. No. 212520

Ordering information

Length →		25 m	30 m	50 m	60 m
OPTIMA® 624	0.2 mm ID (0.4 mm OD)				
	1.10 µm film	726784.25			
	0.25 mm ID (0.4 mm OD)				
	1.40 µm film	726785.25	726785.30	726785.50	726785.60
	0.32 mm ID (0.5 mm OD)				
	1.80 µm film	726787.25	726787.30	726787.50	726787.60
	0.53 mm ID (0.8 mm OD)				
	3.00 µm film	726789.25	726789.30		
OPTIMA® 624 LB	0.32 mm ID (0.5 mm OD)				
	1.80 µm film		726786.30	726786.50	

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

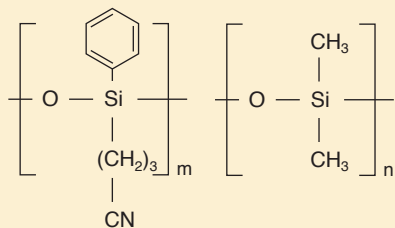
On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)



OPTIMA® 1701

14 % cyanopropyl-phenyl – 86 % dimethylpolysiloxane

Medium polar phase



Similar phases: OV-1701, DB-1701, CP-Sil 19 CB, HP-1701, Rtx-1701, SPB-1701, 007-1701, BP10, ZB-1701



Max. temperature for isothermal operation 300 °C, max. temperature for short isotherms in a temperature program 320 °C

0.53 mm ID columns:

max. temperatures 280 and 300 °C, resp.



Special selectivity due to high cyanopropyl content

Reference column for structure identification, e.g., in combination with OPTIMA® 5

Film thickness $\geq 1 \mu\text{m}$ for solvent analyses



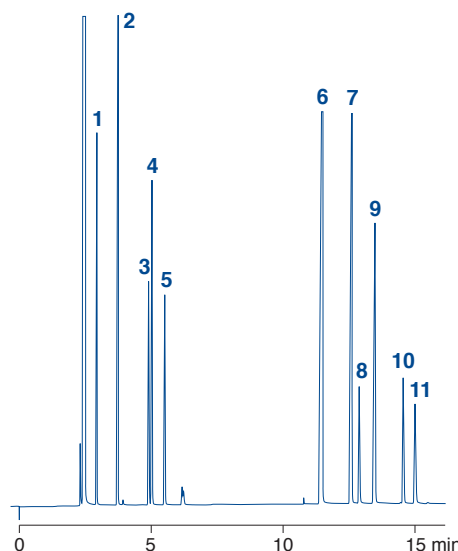
USP G46

Analysis of aromatic hydrocarbons

Column: OPTIMA® 1701, 0.25 μm film, 25 m x 0.32 mm ID
Injection: 1 μL , split 1:40
Carrier gas: 0.6 bar N_2
Temperature: 60 °C $\rightarrow$ 120 °C, 4 °C/min
Detector: FID 260 °C

Peaks:

1. Benzene
2. Toluene
3. Ethylbenzene
4. *p*-Xylene
5. *o*-Xylene
6. Phenol
7. 2-Methylphenol
8. 2,6-Dimethylphenol
9. 4-Methylphenol
10. 2,4-Dimethylphenol
11. 2,4,6-Trimethylphenol



MN Appl. No. 200400

Ordering information

Length $\rightarrow$	10 m	15 m	25 m	30 m	50 m	60 m
0.2 mm ID (0.4 mm OD)						
0.20 μm film			726841.25		726841.50	
0.25 mm ID (0.4 mm OD)						
0.25 μm film	726058.10	726058.15	726058.25	726058.30	726058.50	726058.60
0.50 μm film				726064.30		726064.60
1.00 μm film				726965.30		
0.32 mm ID (0.5 mm OD)						
0.25 μm film	726318.10	726318.15	726318.25	726318.30	726318.50	726318.60
0.35 μm film			726824.25	726824.30	726824.50	726824.60
0.50 μm film			726320.25	726320.30	726320.50	726320.60
1.00 μm film			726929.25	726929.30	726929.50	726929.60
0.53 mm ID (0.8 mm OD)						
1.00 μm film	726545.10	726545.15	726545.25	726545.30		
2.00 μm film		726735.15	726735.25	726735.30	726735.50	

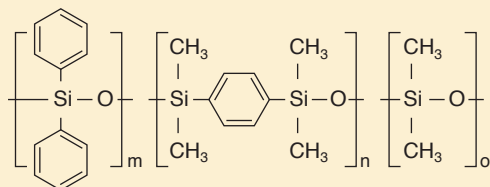
In addition to this standard program we will be happy to supply columns custom-made to your specifications.



OPTIMA[®] high performance capillary columns

OPTIMA[®] 35 MS

Chemically bonded cross-linked silarylene phase with selectivity similar to 35% phenyl – 65% methyl polysiloxane



Similar phases: DB-35 MS, HP-35, SPB-35, Rxi-35SIL MS, Rtx-35, 007-35, BPX-35, MDN-35, AT-35 MS, ZB-35, OV-11, VF-35 MS

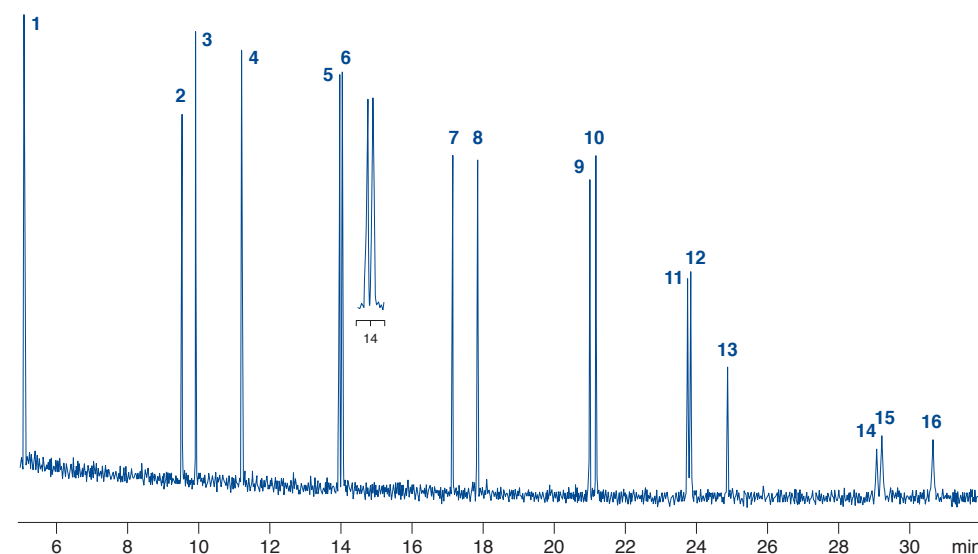
silarylene phase

- Max. temperature for isothermal operation 360 °C, max. temperature for short isotherms in a temperature program 370 °C,
- Very low column bleeding, medium polar phase, recommended for ion-trap detectors
- Optimum column for confirmation of analytical results in combination with a 1 MS or 5 MS
- Polymer without CN groups
- Recommended application: allround phase for environmental analyses, ultra trace analyses, EPA methods, pesticides, PCB, food and drug analyses
- USP G42**

Capillary columns for GC

PAH in accordance with EPA 610

Column: OPTIMA[®] 35 MS, 0.25 µm film, 30 m x 0.25 mm ID
 Injection: 1 µL, split 1:10
 Carrier gas: 0.6 bar H₂
 Temperature: 100 °C (3 min) → 300 °C (10 min), 6 °C/min
 Detector: MSD



Peaks:

1. Naphthalene
2. Acenaphthylene
3. Acenaphthene
4. Fluorene
5. Phenanthrene
6. Anthracene
7. Fluoranthene
8. Pyrene
9. Benz[a]anthracene
10. Chrysene
11. Benzo[b]fluoranthene
12. Benzo[k]fluoranthene
13. Benzo[a]pyrene
14. Indeno[1,2,3-cd]pyrene
15. Dibenzo[ah]anthracene
16. Benzo[ghi]perylene

MN Appl. No. 213190

Ordering information

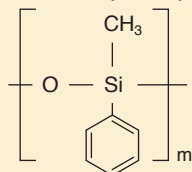
Length →	30 m	60 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	726154.30	726154.60
0.32 mm ID (0.5 mm OD)		
0.25 µm film	726157.30	726157.60

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA® 17

Medium polar phase



Similar phases: OV-17, DB-17, HP-50+, HP-17, SPB-50, SP-2250, Rxi-17, Rtx-50, CP-Sil 24 CB, 007-17, ZB-50

phenylmethylpolysiloxane (50% phenyl)



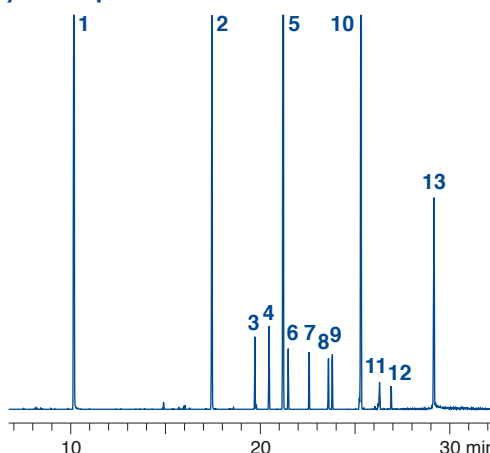
Max. temperature for isothermal operation 320 °C, max. temperature for short isotherms in a temperature program 340 °C
for 0.53 mm ID columns the max. temperatures are 300 and 320 °C, resp.

Recommended application:
steroids, pesticides, drug analyses

USP G3

Column: OPTIMA® 17, 0.20 µm film,
25 m x 0.2 mm ID
Sample: pesticides, standard of the cantonal
laboratory Schaffhausen (Switzerland),
0.1 mg/mL or 0.01 mg/mL each
Injection: 1.0 µL, 3 s without split
Carrier gas: He, 25 cm/s
Temperature: 100 °C (3 min), 8 °C/min → 250 °C,
10 °C/min → 320 °C
Detector: MSD HP 5971

Analysis of pesticides



- Peaks:**
1. Dichlorphos
 2. Naled
 3. Vinclozolin
 4. Chlorthalonil
 5. Chlorpyrifos
 6. Dichlofluanid
 7. Procymidon
 8. Captan
 9. Folpet
 10. Carbophenothion
 11. Iprodion
 12. Captafol
 13. Coumaphos

MN Appl. No. 200930

Ordering information

Length →	10 m	12 m	15 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)							
0.10 µm film	726848.10						
0.2 mm ID (0.4 mm OD)							
0.20 µm film	726065.12		726065.25		726065.50		
0.50 µm film			726066.25		726066.50		
0.25 mm ID (0.4 mm OD)							
0.15 µm film			726742.25		726742.30	726742.50	726742.60
0.25 µm film	726022.15		726022.25		726022.30	726022.50	726022.60
0.50 µm film			726067.25		726067.30	726067.50	726067.60
0.32 mm ID (0.5 mm OD)							
0.15 µm film					726755.30		
0.25 µm film			726351.25		726351.30	726351.50	726351.60
0.35 µm film			726757.25		726757.30	726757.50	726757.60
0.50 µm film			726744.25		726744.30	726744.50	726744.60
0.53 mm ID (0.8 mm OD)							
1.00 µm film	726747.10		726747.15	726747.25	726747.30		
In addition to this standard program we will be happy to supply columns custom-made to your specifications.							

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

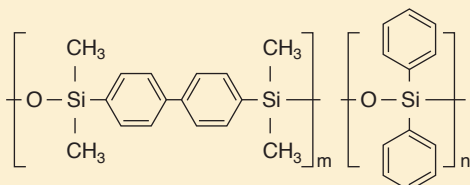


OPTIMA® high performance capillary columns

OPTIMA® 17 MS

silarylene phase

- Medium polar silarylene phase with selectivity analogue to 50% phenyl – 50% methylpolysiloxane



Similar phases: OV-17, AT-50, BPX-50, DB-17, DB-17ms, HP-50+, HP-17, SPB-50, SPB-17, SP-2250, Rtx-50, CP-Sil 24 CB, 007-17, VF-17ms, ZB-50

- Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C

- Ideal for ion trap detectors
- Optimum reference column in combination with a 1 MS or 5 MS

No CN groups in the polymer

- Recommended application: all-round phase for environmental analyses, ultra-trace analyses, EPA methods, pesticides, PCBs, food and drug analyses

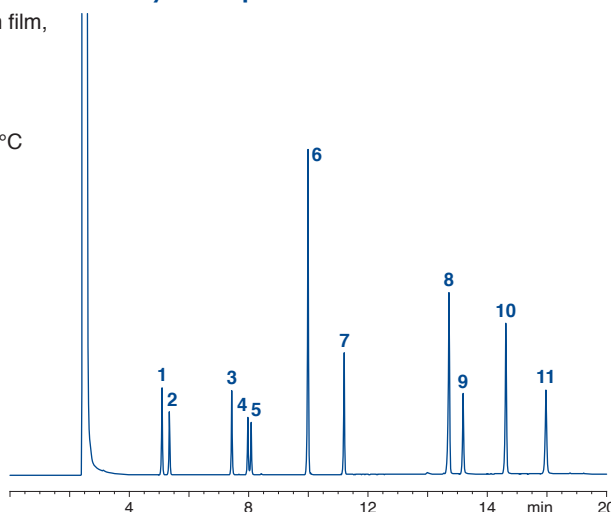
- USP G3

Analysis of phenols

Column: OPTIMA® 17 MS, 0.25 µm film, 30 m x 0.25 mm ID
Sample: phenol mix 604
Injection: 1.0 µL, 230 °C, split 1:30
Carrier gas: He, 0.8 bar
Temperature: 100 °C, 10 °C/min → 250 °C
Detector: FID 280 °C

Peaks:

- Phenol
- 2-Chlorophenol
- 2,4-Dimethylphenol
- 2-Nitrophenol
- 2,4-Dichlorophenol
- 4-Chloro-3-methylphenol
- 2,4,6-Trichlorophenol
- 4-Nitrophenol
- 2,4-Dinitrophenol
- 2-Methyl-4,6-dinitrophenol
- Pentachlorophenol



MN Appl. No. 213600

Ordering information

Length →	30 m	60 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	726162.30	726162.60
0.32 mm ID (0.5 mm OD)		
0.25 µm film	726165.30	726165.60

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.

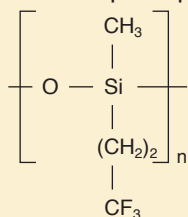
To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an **integrated guard column**. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



OPTIMA[®] 210

trifluoropropyl-methylpolysiloxane (50% trifluoropropyl)

Medium polar phase



Similar phases: OV-210, DB-210, Rtx-200, 007-210

Max. temperature for isothermal operation 260 °C, max. temperature for short isotherms in a temperature program 280 °C

Recommended application: environmental analyses, especially for *o*-, *m*- and *p*-substituted aromatic hydrocarbons

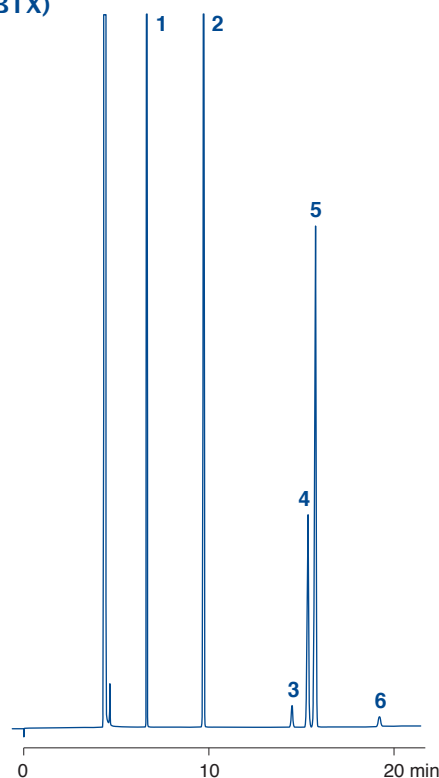
Close equivalent to USP G6

Aromatic hydrocarbons (BTX)

Column: OPTIMA[®] 210, 0.5 µm film, 50 m x 0.25 mm ID
Injection: 0.5 µL, split 105 mL/min
Carrier gas: 130 kPa N₂ (1.1 mL/min)
Temperature: 50 °C
Detector: FID 250 °C

Peaks:

1. Benzene
2. Toluene
3. Ethylbenzene
4. *p*-Xylene
5. *m*-Xylene
6. *o*-Xylene



MN Appl. No. 200230

Capillary columns for GC

Ordering information

Length →	15 m	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)					
0.25 µm film	726871.15	726871.25	726871.30	726871.50	726871.60
0.50 µm film			726874.30	726874.50	726874.60
0.32 mm ID (0.5 mm OD)					
0.25 µm film	726877.15		726877.30	726877.50	726877.60
0.50 µm film		726880.25	726880.30	726880.50	726880.60

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

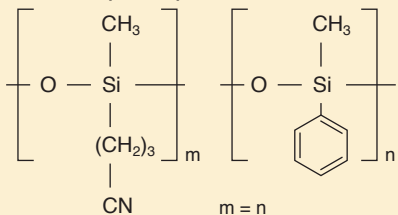


OPTIMA[®] high performance capillary columns

OPTIMA[®] 225

50% cyanopropyl-methyl – 50% phenylmethylpolysiloxane

Medium polar phase



Max. temperature for isothermal operation 260 °C, max. temperature for short isotherms in a temperature program 280 °C

Recommended for fatty acid analyses

Similar phases: DB-225, HP-225, OV-225, Rtx-225, CP-Sil 43, 007-225, BP225

Close equivalent to USP G7 / G19

Capillary columns for GC

Analysis of FAME in porcine fat

Column: OPTIMA[®] 225, 0.25 µm film, 25 m x 0.32 mm ID

Injection: 1 µL, split 1:40; carrier gas 60 kPa H₂

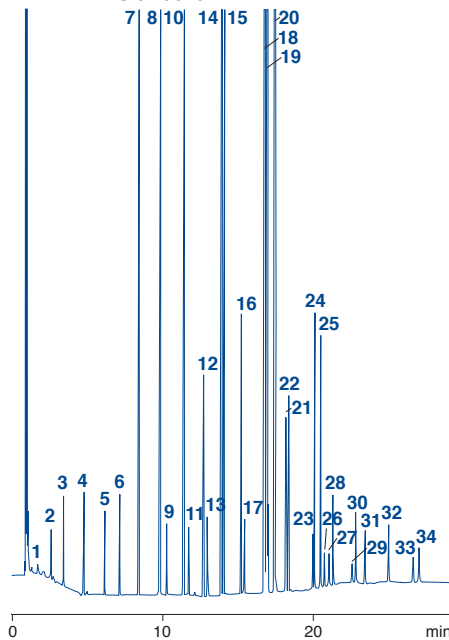
Temperature: 50 °C (2 min) → 125 °C, 30 °C/min → 160 °C, 5 °C/min → 180 °C, 20 °C/min → 200 °C, 3 °C/min → 220 °C, 20 °C/min (10 min)

Detector: FID 260 °C

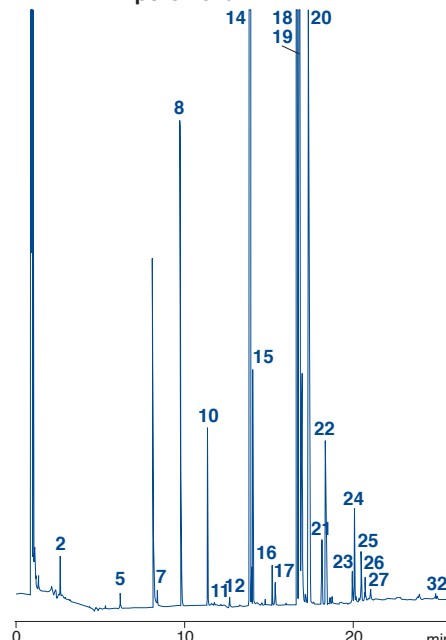
Peaks:

- | | |
|-----------|-----------|
| 1. C4:0 | 18. C18:0 |
| 2. C5:0 | 19. C18:1 |
| 3. C6:0 | 20. C18:2 |
| 4. C8:0 | 21. C18:3 |
| 5. C10:0 | 22. C19:0 |
| 6. C11:0 | 23. C20:0 |
| 7. C12:0 | 24. C20:1 |
| 8. C13:0 | 25. C20:2 |
| 9. C13:1 | 26. C20:4 |
| 10. C14:0 | 27. C20:3 |
| 11. C14:1 | 28. C20:5 |
| 12. C15:0 | 29. C22:0 |
| 13. C15:1 | 30. C22:1 |
| 14. C16:0 | 31. C22:2 |
| 15. C16:1 | 32. C22:6 |
| 16. C17:0 | 33. C24:0 |
| 17. C17:1 | 34. C24:1 |

FAME standard



FAME in porcine fat



Courtesy of Dr. Bantleon,
Mr. Leusche, Mr. Hagemann,
VFG-Labor, Versmold, Germany

MN Appl. No. 210060

Ordering information

Length →	10 m	15 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)						
0.10 µm film	726080.10					
0.25 mm ID (0.4 mm OD)						
0.25 µm film		726118.15	726118.25	726118.30	726118.50	726118.60
0.32 mm ID (0.5 mm OD)						
0.25 µm film			726352.25	726352.30	726352.50	726352.60
In addition to this standard program we will be happy to supply columns custom-made to your specifications.						

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

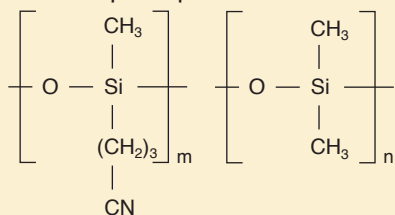
On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)



OPTIMA[®] 240

33 % cyanopropyl-methyl – 67 % dimethylpolysiloxane

Medium polar phase



Max. temperature for isothermal operation 260 °C,
max. temperature for short isotherms in a temperature pro-
gram 280 °C



Recommended for FAMES, dioxins

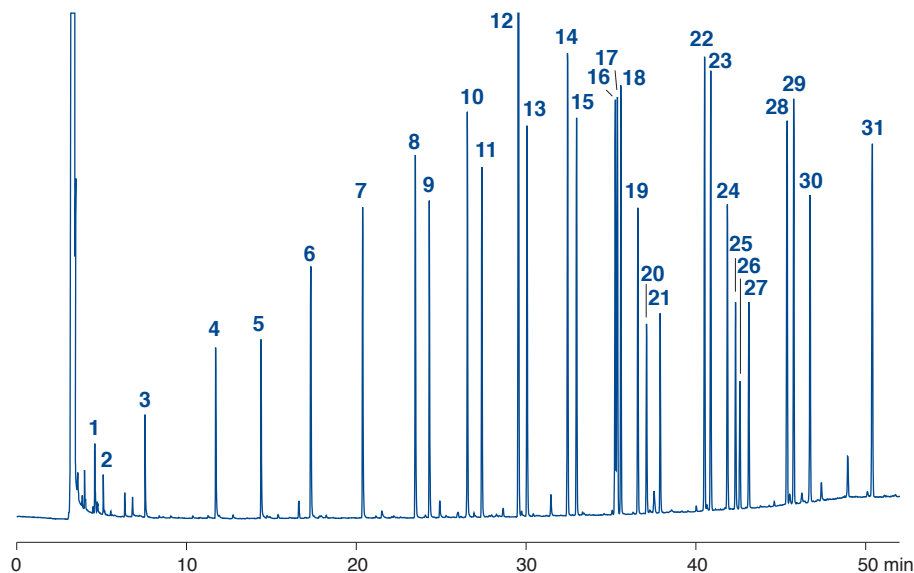
No similar phases

Fatty acid methyl esters *cis/trans* C18:1 (FAME)

Column: OPTIMA[®] 240, 0.25 µm film, 60 m x 0.25 mm ID
Sample: FAME mixture
Injection: 1.0 µL, split 1:25
Carrier gas: 150 kPa H₂
Temperature: 80 °C → 120 °C, 20 °C/min → 260 °C (10 min), 3 °C/min
Detector: FID 280 °C

Peaks:

- | | |
|-----------|-------------------------|
| 1. C4:0 | 17. <i>trans</i> -C18:1 |
| 2. C5:0 | 18. <i>cis</i> -C18:1 |
| 3. C8:0 | 19. C18:2 |
| 4. C10:0 | 20. C18:3 |
| 5. C11:0 | 21. C18:3 |
| 6. C12:0 | 22. C20:0 |
| 7. C13:0 | 23. C20:1 |
| 8. C14:0 | 24. C20:2 |
| 9. C14:1 | 25. C20:3 |
| 10. C15:0 | 26. C20:4 |
| 11. C15:1 | 27. C20:3 |
| 12. C16:0 | 28. C22:0 |
| 13. C16:1 | 29. C22:1 |
| 14. C17:0 | 30. C22:3 |
| 15. C17:1 | 31. C24:1 |
| 16. C18:0 | |



MN Appl. No. 201620

Ordering information

Length →	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)				
0.25 µm film		726089.30	726089.50	726089.60
0.50 µm film		726090.30		726090.60
0.32 mm ID (0.5 mm OD)				
0.25 µm film	726091.25	726091.30	726091.50	726091.60
0.35 µm film		726095.30		726095.60
0.50 µm film		726096.30		726096.60

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

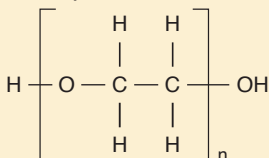
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA® high performance capillary columns

OPTIMA® WAX

Polar phase



Similar phases:
PERMABOND® CW 20 M (page 265), DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax

USP G16

polyethylene glycol 20 000 Da

Columns with 0.25–0.32 mm ID: max. temperature for isothermal operation 240 °C, max. temperature for short isotherms in a temperature program 250 °C; 0.53 mm ID columns: max. temperatures 220 and 240 °C, resp.

Recommended application: solvent analysis and alcohols, suitable for aqueous solutions



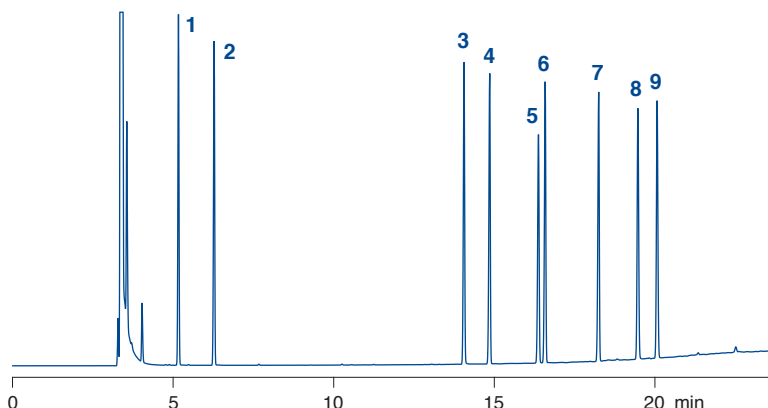
Modified Grob test

Column: OPTIMA® WAX, 0.5 µm film, 50 m x 0.32 mm ID
Injection: 1 µL, split 1:20
Carrier gas: 1.2 bar He
Temperature: 80 °C → 250 °C, 8 °C/min
Detector: FID 250 °C

Peaks:

1. Decane
2. Undecane
3. Octanol
4. Methyl decanoate
5. Dicyclohexylamine
6. Methyl undecanoate
7. Methyl dodecanoate
8. 2,6-Dimethylaniline
9. 2,6-Dimethylphenol

MN Appl. No. 211170



Ordering information

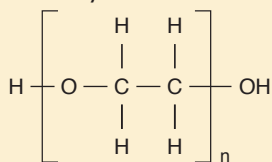
Length →	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)				
0.25 µm film	726600.25	726600.30	726600.50	726600.60
0.32 mm ID (0.5 mm OD)				
0.25 µm film	726321.25	726321.30	726321.50	726321.60
0.50 µm film	726296.25	726296.30	726296.50	726296.60
0.53 mm ID (0.8 mm OD)				
1.00 µm film	726549.25	726549.30		
2.00 µm film		726548.30		
In addition to this standard program we will be happy to supply columns custom-made to your specifications.				

On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)



OPTIMA WAXplus[®]

- Orange icon: Polar phase with improved cross-linking for lower column bleed and better temperature stability



NEW!

- Orange icon: USP G16

cross-linked polyethylene glycol

Max. temperature for isothermal operation 260 °C, max. temperature for short isotherms in a temperature program 270 °C

- Orange icon: Recommended application: broad range of application, e.g., for solvents and alcohols, suitable for aqueous solutions

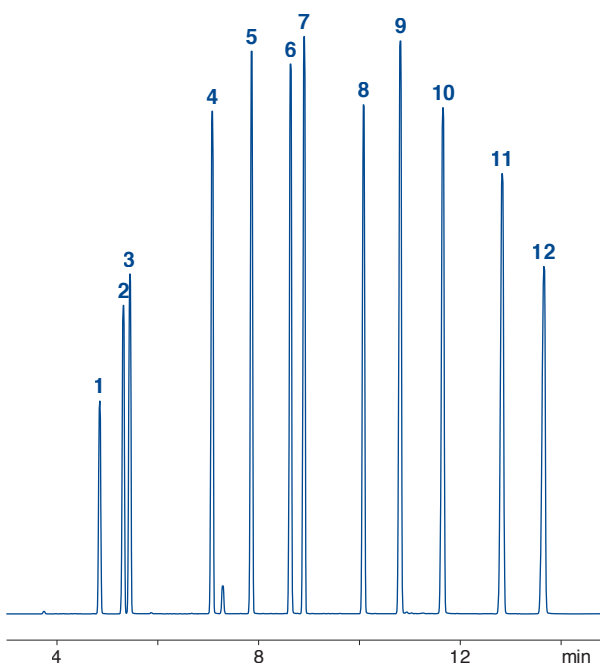
Similar phases: OPTIMA[®] WAX (previous page), DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax

Alcohols

Columns: OPTIMA WAXplus[®], 0.5 µm film, 30 m x 0.25 mm ID
 Injection: 0.1 µL, split 1:80
 Carrier gas: 1.3 bar He
 Temperature: 40 °C → 260 °C, 12 °C/min (15 min)
 Detector: FID 260 °C

Peaks:

1. Methanol
2. 2-Propanol
3. Ethanol
4. 1-Propanol
5. 2-Methyl-1-propanol
6. 1-Butanol
7. 4-Methyl-2-pentanol
8. 1-Pentanol
9. 2-Methyl-1-Pentanol
10. 1-Hexanol
11. Cyclohexanol
12. 1-Heptanol



MN Appl. No. 214160

Ordering information

Length →	30 m	60 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	726380.30	726380.60
0.50 µm film	726381.30	726381.60
0.32 mm ID (0.5 mm OD)		
0.25 µm film	726382.30	726382.60
0.50 µm film	726383.30	726383.60
In addition to this standard program we will be happy to supply columns custom-made to your specifications.		

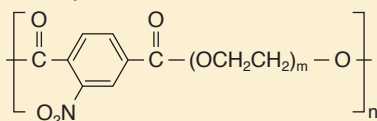
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



OPTIMA® high performance capillary columns

OPTIMA® FFAP

Polar phase



Similar phases: PERMABOND® FFAP (page 265), DB-FFAP, HP-FFAP, CP-Wax 58 (FFAP) CB, 007-FFAP, CP-FFAP CB, Nukol, BP21

polyethylene glycol 2-nitroterephthalate



Columns with 0.10–0.32 mm ID: max. temperature for isothermal operation 240 °C, max. temperature for short isotherms in a temperature program: 250 °C
0.53 mm ID columns: max. temperatures 220 and 240 °C, resp.

- Recommended application: fatty acid methyl esters (FAMES), free carboxylic acids
- USP G35 / close equivalent to G25

Capillary columns for GC

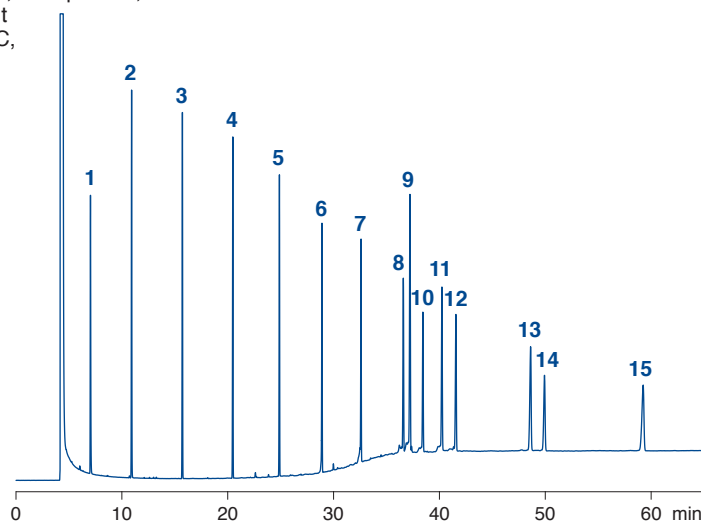
FAME test

Column: OPTIMA® FFAP, 0.25 µm film, 60 m x 0.32 mm ID
Carrier gas: 1.2 bar He, split
Temperature: 55 °C → 250 °C, 6 °C/min
Injection: 1.0 µL, 220 °C
Detector: FID 220 °C

Peaks:

1. C4
2. C6
3. C8
4. C10
5. C12
6. C14
7. C16
8. C18
9. C18:1 *cis/trans*
10. C18:2
11. C18:3
12. C20
13. C22
14. C22:1
15. C24

MN Appl. No. 211140



Ordering information

Length →	10 m	25 m	30 m	50 m	60 m
0.10 mm ID (0.4 mm OD)					
0.10 μm film	726180.10				
0.25 mm ID (0.4 mm OD)					
0.25 μm film		726116.25	726116.30	726116.50	726116.60
0.32 mm ID (0.5 mm OD)					
0.25 μm film		726341.25	726341.30	726341.50	726341.60
0.50 μm film		726344.25	726344.30	726344.50	
0.53 mm ID (0.8 mm OD)					
0.50 μm film			726345.30		
1.00 μm film		726346.25			
In addition to this standard program we will be happy to supply columns custom-made to your specifications.					

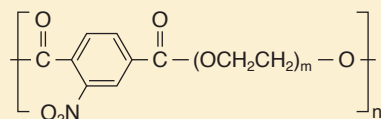
In addition to this standard program we will be happy to supply columns custom-made to your specifications.

To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an **integrated guard column**. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



OPTIMA[®] FFAPplus

Orange Polar phase



NEW!

Similar phases: OPTIMA[®] FFAP (previous page), DB-FFAP, HP-FFAP, CP-Wax 58 (FFAP) CB, 007-FFAP, CP-FFAP CB, Nukol

polyethylene glycol 2-nitroterephthalate



Max. temperature for isothermal operation 250 °C, max. temperature for short isotherms in a temperature program 260 °C



Recommended application: FAMES, free carboxylic acids



USP G35 / close equivalent to G25

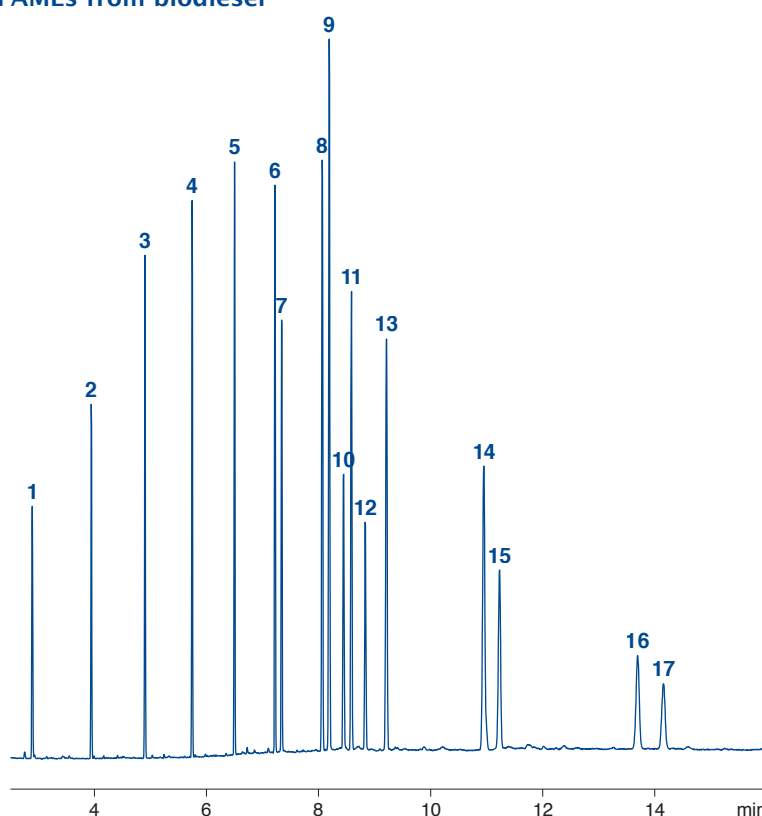
FAMES from biodiesel

Column: OPTIMA[®] FFAPplus, 0.25 µm film, 30 m x 0.25 mm ID
Injection: 1 µL, 260 °C, split 1:15
Carrier gas: 40 cm/s He
Temperature: 70 °C (1 min) → 240 °C, 30 °C/min (10 min)
Detector: MS-EI, ion source 200 °C, interface temperature 250 °C

Peaks:

Methyl esters of:

1. Caproic acid (C6:0)
2. Caprylic acid (C8:0)
3. Capric acid (C10:0)
4. Lauric acid (C12:0)
5. Myristic acid (C14:0)
6. Palmitic acid (C16:0)
7. Palmitoleic acid (C16:1)
8. Stearic acid (C18:0)
9. Oleic acid (C18:1 *cis*)
10. Linoleic acid (C18:2 *cis*)
11. Nonadecanoic acid (C19:0)
12. Linolenic acid (C18:3)
13. Arachidic acid (C20:0)
14. Behenic acid (C22:0)
15. Erucic acid (C22:1 *cis*)
16. Lignoceric acid (C24:0)
17. Nervonic acid (C24:1 *cis*)



MN Appl. No. 214590

Capillary columns for GC

Ordering information

Length →	30 m	60 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	726241.30	726241.60
0.50 µm film	726242.30	726242.60
0.32 mm ID (0.5 mm OD)		
0.25 µm film	726243.30	726243.60
0.50 µm film	726246.30	726246.60

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)

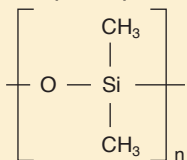


PERMABOND® capillary columns

PERMABOND® SE-30

100 % dimethylpolysiloxane

Nonpolar phase



Max. temperature for isothermal operation 300 °C,
max. temperature for short isotherms in a temperature
program 320 °C

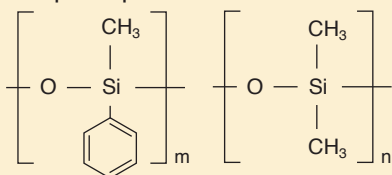
Ordering information

Length →	25 m	50 m
0.25 mm ID (0.4 mm OD)		
0.25 µm film	723052.25	723052.50
0.32 mm ID (0.5 mm OD)		
0.25 µm film	723306.25	
0.50 µm film		723308.50
In addition to this standard program we will be happy to supply columns custom-made to your specifications.		

PERMABOND® SE-52

5 % phenyl – 95 % dimethylpolysiloxane

Nonpolar phase



Max. temperature for isothermal operation 300 °C,
max. temperature for short isotherms in a temperature
program 320 °C

Ordering information

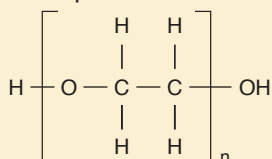
Length →	25 m
0.25 mm ID (0.4 mm OD)	
0.25 µm film	723054.25
0.32 mm ID (0.5 mm OD)	
0.25 µm film	723310.25
0.50 µm film	723312.25
In addition to this standard program we will be happy to supply columns custom-made to your specifications.	

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. A standard test mixture is included with every column.



PERMABOND® CW 20 M

Orange Polar phase



Similar phases see OPTIMA® WAX page 260

polyethylene glycol 20 000 Da



0.1–0.32 mm ID: max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

0.53 mm ID: max. temperatures 200 and 220 °C, resp.



Recommended for solvent analyses and alcohols

Suitable for aqueous solutions



USP G16

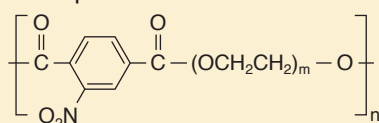
Ordering information

Length →	10 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)					
0.10 µm film	723064.10				
0.25 mm ID (0.4 mm OD)					
0.25 µm film	723060.10	723060.25	723060.30	723060.50	723060.60
0.32 mm ID (0.5 mm OD)					
0.25 µm film	723321.10	723321.25	723321.30	723321.50	723321.60
0.35 µm film	723827.10	723827.25		723827.50	
0.50 µm film	723296.10	723296.25	723296.30	723296.50	723296.60
0.53 mm ID (0.8 mm OD)					
0.50 µm film	723515.10	723515.25			
1.00 µm film	723549.10	723549.25	723549.30		
2.00 µm film	723517.10	723517.25	723517.30		

In addition to this standard program we will be happy to supply columns custom-made to your specifications.

PERMABOND® FFAP

Orange Polar phase



polyethylene glycol 2-nitroterephthalate



0.1–0.32 mm ID: max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C;

0.53 mm ID: max. temperatures 200 and 220 °C, resp.



Recommended for FAME, free carboxylic acids

Similar phases see OPTIMA® FFAP page 262

Ordering information

Length →	10 m	20 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)						
0.10 µm film	723180.10	723180.20				
0.25 µm film	723181.10					
0.25 mm ID (0.4 mm OD)						
0.10 µm film			723936.25		723936.50	
0.25 µm film	723116.10		723116.25	723116.30	723116.50	723116.60
0.32 mm ID (0.5 mm OD)						
0.10 µm film			723356.25		723356.50	
0.25 µm film			723341.25	723341.30	723341.50	723341.60
0.35 µm film	723830.10		723830.25		723830.50	
0.50 µm film	723344.10		723344.25	723344.30	723344.50	723344.60
0.53 mm ID (0.8 mm OD)						
1.00 µm film	723555.10		723555.25		723555.50	

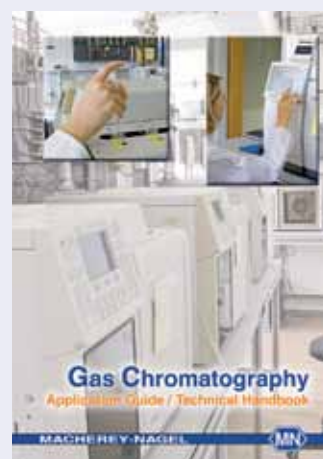
In addition to this standard program we will be happy to supply columns custom-made to your specifications.



Capillary columns for special separations

GC Application Guide

- ✦ Explaining basics and principles of GC: phase selection by column properties, important GC parameters, helpful hints for troubleshooting
- ✦ **280 selected applications from the fields**
 - ✓ Environmental pollutants
 - ✓ Solvents · chemicals
 - ✓ Fragrances · food and cosmetic components
 - ✓ Drugs · pharmaceutical ingredients
 - ✓ Petrochemical products
 - ✓ Chiral separations
- ✦ Latest and more applications at www.mn-net.com/apps



Capillary columns for special GC separations

- ✦ Certain analytical separations can be accomplished more easily with chromatographic columns, that have been especially developed for that task, compared with standard columns. The following table summarizes our program of GC speciality capillaries, the individual columns will be described in detail on the following pages.

Separation / special application		Recommended capillary column	Page
Fast GC		OPTIMA® 8-3, OPTIMA® 8-6 OPTIMA® 1, OPTIMA® 5, OPTIMA® 17, OPTIMA® 225, OPTIMA® FFAP PERMABOND® CW 20 M, PERMABOND® FFAP all 0.10 mm ID	267
Enantiomer separation	cyclodextrin phases	FS-LIPODEX® A, FS-LIPODEX® B FS-LIPODEX® C, FS-LIPODEX® D FS-LIPODEX® E, FS-LIPODEX® G	268
		FS-HYDRODEX β-PM, FS-HYDRODEX β-3 P FS-HYDRODEX β-6TBDM FS-HYDRODEX β-TBDAC, FS-HYDRODEX γ-TBDAC	270
Biodiesel	methanol analysis	OPTIMA® BioDiesel M	272
	FAME analysis	OPTIMA® BioDiesel F	272
	glycerol and triglycerides	OPTIMA® BioDiesel G	272
Triglycerides		OPTIMA® 1-TG OPTIMA® 17-TG	274
High temperature GC		OPTIMA® 5 HT	275
Amines	polyfunctional amines	OPTIMA® 5 Amine	276
	amine separations	FS-CW 20 M-AM	277
Petrochemical products (complex hydrocarbon mixtures)		PERMABOND® P-100	277
Environmental analyses	volatile halogenated hydrocarbons	PERMABOND® SE-54 HKW	278
Silanes (monomeric, e.g., chlorosilanes)		PERMABOND® Silane	279
Diethylene glycol, e.g., for the quality control of wine		PERMABOND® CW 20 M-DEG	279



Columns for Fast GC



- Characteristics of Fast GC: decreased column diameters, high heating rates and decreased column lengths for faster GC separations with high resolution efficiency; small inner diameters combined with very fast temperature programs can reduce the analysis time by up to 80 %
- High heating rates place special demands on stationary phases: OPTIMA® columns meet exactly this requirement: very low bleeding, long lifetimes, even for continuous high heating rates
- System requirements for Fast GC: high sensitivity detectors with small volume and very short response time, as well as very rapid data acquisition and processing · small inner diameters result in high column inlet pressures and a lower volume flow of the mobile phase: very fast injection of very small samples against a high pressure · amount of sample, which can be injected, is limited by the inner diameter and the thin film

Comparison of a separation on a 50 m standard capillary with separation on a 10 m fast GC column

A) Fast GC column

Column: OPTIMA® 5, 0.1 µm film, 10 m x 0.1 mm ID
injection 1 µL, split 1:40, carrier gas 0.75 bar He

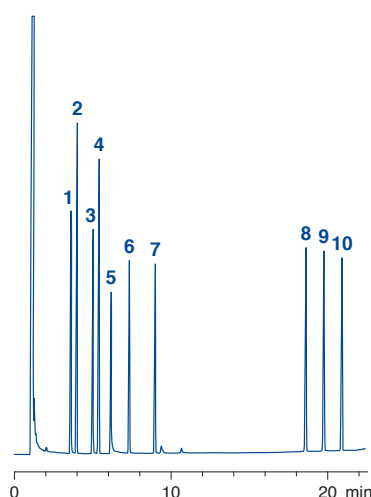
Both separations: temperature
80 °C → 320 °C (10 min), 8 °C/min,
detector: FID

While maintaining the temperature
program and halving the pressure
a time saving of 30 % results with
identical separation efficiency

Peaks:

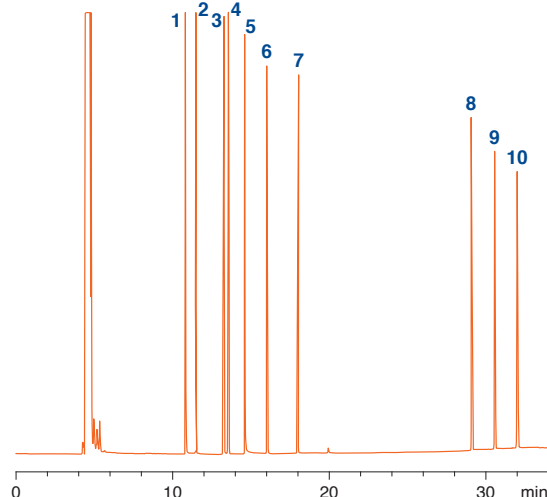
- Octanol
- Undecane
- Dimethylaniline
- Dodecane
- Decylamine
- Methyl decanoate
- Methyl undecanoate
- Henicosane
- Docosane
- Tricosane

MN Appl. No. 211260



B) standard GC column

Column: OPTIMA® 5, 0.25 µm film, 50 m x 0.25 mm ID
injection 1 µL, split 1:35, carrier gas 1.5 bar He



Ordering information

Phase	Max. temperature	ID [mm]	Film thickness [µm]	REF (10 m)	REF (20 m)
OPTIMA® 1	340 / 360 °C	0.10	0.10	726024.10	726024.20
		0.10	0.40		726025.20
OPTIMA® 5	340 / 360 °C	0.10	0.10	726846.10	
OPTIMA® 5-3	340 / 360 °C	0.10	0.10	726410.10	726410.20
OPTIMA® 5-6	340 / 360 °C	0.10	0.10	726490.10	
OPTIMA® 17	320 / 340 °C	0.10	0.10	726848.10	
OPTIMA® 225	260 / 280 °C	0.10	0.10	726080.10	
OPTIMA® FFAP	250 / 260 °C	0.10	0.10	726180.10	
PERMABOND® CW 20 M	220 / 240 °C	0.10	0.10	723064.10	
PERMABOND® FFAP	220 / 240 °C	0.10	0.10	723180.10	723180.20
		0.10	0.25	723181.10	
OPTIMA® 5 Amine	300 / 320 °C	0.10	0.40	726361.10	
FS-CW 20 M-AM	220 / 240 °C	0.10	0.20	733111.10	
FS-LIPODEX® E	200 / 220 °C	0.10	0.10	723382.10	
FS-HYDRODEX β-6TBDM	230 / 250 °C	0.10	0.10	723383.10	

In addition to this standard program, all MN GC phases can be custom-made as fast GC columns.



Capillary columns for enantiomer separation

LIPODEX®

cyclodextrin phases for enantiomer separation

- Base material: cyclic oligosaccharides consisting of six (α -cyclodextrin), seven (β -cyclodextrin) or eight (γ -cyclodextrin) glucose units bonded through α -1,4-linkages
Regioselective alkylation and / or acylation of the hydroxyl groups leads to lipophilic phases with varying enantioselectivity, which are well suited for GC enantiomer analyses
Important advantage: many compounds can be analyzed without derivatization (however, for certain substances enantioselectivity can be favorably influenced by formation of derivatives)
- A large number of separations have been achieved, however, it is not possible to make a general prediction, which phase could solve a given separation task. Even for compounds with small structural differences or within homologous series the enantiodifferentiation can be quite different. The descriptions below list some of the typical separations possible with individual phases.
- Water as solvent is strictly forbidden for all cyclodextrin phases. We recommend to dry the sample with our CHROMAFIX® Dry cartridges (page 47) and to dissolve it in an appropriate nonpolar solvent in any case.

LIPODEX® A

hexakis-(2,3,6-tri-O-pentyl)- α -cyclodextrin

- Recommended application: carbohydrates, polyols, diols, hydroxycarboxylic acid esters, (epoxy-) alcohols, glycerol derivatives, spiroacetals, ketones, alkyl halides



Max. temperature for isothermal operation 200 °C, max. temperature for short isotherms in a temperature program 220 °C

LIPODEX® B

hexakis-(2,6-di-O-pentyl-3-O-acetyl)- α -cyclodextrin

- Recommended application: lactones, diols (cyclic carbonates), aminols, aldols (O-TFA), glycerol derivatives (cyclic carbonates)



Max. temperature for isothermal operation 200 °C, max. temperature for short isotherms in a temperature program 220 °C

LIPODEX® C

heptakis-(2,3,6-tri-O-pentyl)- β -cyclodextrin

- Recommended application: alcohols, cyanhydrins, olefins, hydroxycarboxylic acid esters, alkyl halides



Max. temperature for isothermal operation 200 °C, max. temperature for short isotherms in a temperature program 220 °C

LIPODEX® D

heptakis-(2,6-di-O-pentyl-3-O-acetyl)- β -cyclodextrin

- Recommended application: amines (TFA), aminols (TFA), trans-cycloalkane-1,2-diols, trans-cycloalkane-1,3-diols (TFA), β -amino acid esters



Max. temperature for isothermal operation 200 °C, max. temperature for short isotherms in a temperature program 220 °C

LIPODEX® E

octakis-(2,6-di-O-pentyl-3-O-butyryl)- γ -cyclodextrin

- Recommended application: α -amino acids, α - and β -hydroxycarboxylic acid esters, alcohols (TFA), diols (TFA), ketones, pheromones (cyclic acetals), amines, alkyl halides, lactones



Max. temperature for isothermal operation 200 °C, max. temperature for short isotherms in a temperature program 220 °C

LIPODEX® G

octakis-(2,3-di-O-pentyl-6-O-methyl)- γ -cyclodextrin

- Recommended application: menthol isomers, ketones, alcohols, carboxylic acid esters, terpenes



Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C



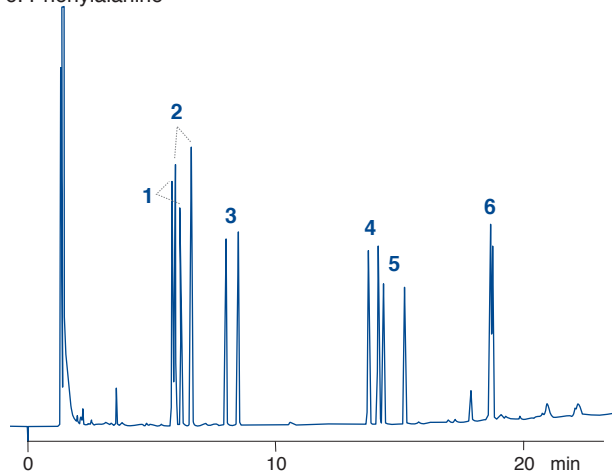
Enantiomer separation of amino acid methyl esters (TFA)

Column: FS-LIPODEX® E, 25 m x 0.25 mm ID
 Volume: 1 µL, split ~ 1:100
 Carrier gas: 60 kPa H₂
 Temperature: 90 → 190 °C, 4 °C/min
 Detector: FID 250 °C

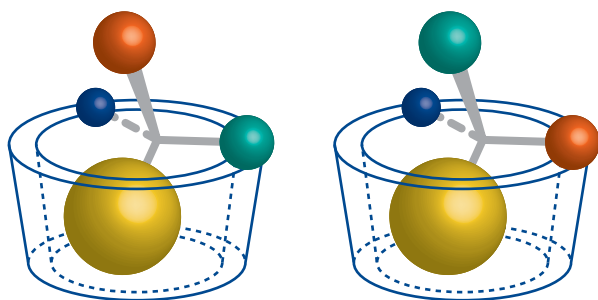
Peaks:

(D is eluted before L except for proline: L before D)

1. Alanine
2. Valine
3. Leucine
4. Proline
5. Aspartic acid
6. Phenylalanine



MN Appl. No. 202592



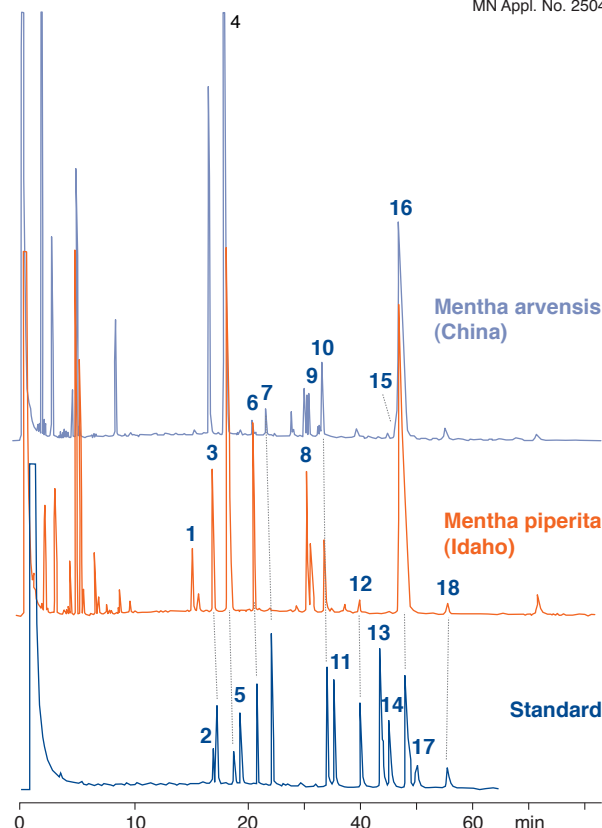
Separation of chiral constituents of peppermint oil

W. A. König et al., High Resol. Chromatogr. **20** (1997) 55–61
 Column: FS-LIPODEX® G, 25 m x 0.25 mm ID
 Carrier gas: 50 kPa H₂
 Temperature: 75 °C, isothermal
 Detector: FID

Peaks:

- | | |
|--|-----------------------|
| 1. (+)- <i>trans</i> -Sabinene hydrate | 10. (+)-Neomenthol |
| 2. (+)-Menthone | 11. (-)-Neomenthol |
| 3. (+)-Isomenthone | 12. (+)-Neoisomenthol |
| 4. (-)-Menthone | 13. (+)-Menthol |
| 5. (-)-Isomenthone | 14. (-)-Neoisomenthol |
| 6. (+)-Menthofuran | 15. (+)-Piperitone |
| 7. (-)-Isopulegol | 16. (-)-Menthol |
| 8. (-)-Menthyl acetate | 17. (+)-Isomenthol |
| 9. (+)-Pulegone | 18. (-)-Isomenthol |

MN Appl. No. 250410



Ordering information

Length → all columns 0.4 mm OD	10 m 0.10 mm ID	25 m 0.25 mm ID	50 m 0.25 mm ID
FS-LIPODEX® A		723360.25	723360.50
FS-LIPODEX® B		723362.25	723362.50
FS-LIPODEX® C		723364.25	723364.50
FS-LIPODEX® D		723366.25	723366.50
FS-LIPODEX® E	723382.10	723368.25	723368.50
FS-LIPODEX® G		723379.25	723379.50



Capillary columns for enantiomer separation

HYDRODEX

cyclodextrin phases for enantiomer separation

🔸 Cyclodextrin derivatives with high melting point: for GC enantiomer separation diluted with polysiloxanes

HYDRODEX β-PM

heptakis-(2,3,6-tri-O-methyl)-β-cyclodextrin (CD)

Phase diluted with optimized polysiloxane

🔸 Recommended application: hydroxycarboxylic acid esters, alcohols, diols, olefins, lactones, acetals



Max. temperature for isothermal operation 230 °C, max. temperature for short isotherms in a temperature program 250 °C

HYDRODEX β-3P

heptakis-(2,6-di-O-methyl-3-O-pentyl)-β-CD

Phase diluted with optimized polysiloxane

🔸 Recommended application: terpenes, dienes, allenes, terpene alcohols, 1,2-epoxyalkanes, carboxylic acids (esters), hydroxycarboxylic acid esters, pharmaceuticals, pesticides



Max. temperature for isothermal operation 230 °C, max. temperature for short isotherms in a temperature program 250 °C

HYDRODEX β-6TBDM

heptakis-(2,3-di-O-methyl-6-O-*t*-butyldimethyl-silyl)-β-CD

Phase diluted with optimized polysiloxane

🔸 Recommended application: γ-lactones, cyclopentanones, terpenes, esters, tartrates



Max. temperature for isothermal operation 230 °C, max. temperature for short isotherms in a temperature program 250 °C

HYDRODEX β-TBDac

heptakis-(2,3-di-O-acetyl-6-O-*t*-butyldimethyl-silyl)-β-CD

Phase diluted with optimized polysiloxane

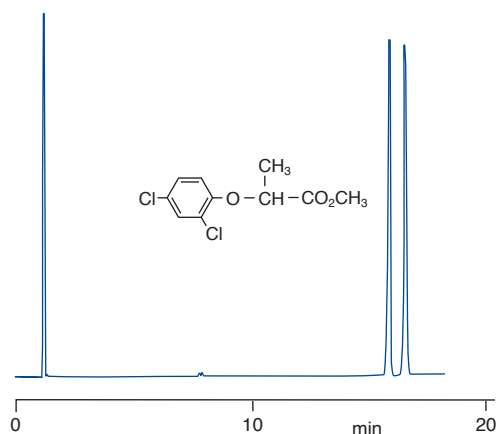
🔸 Recommended application: alcohols, esters, ketones, aldehydes, δ-lactones etc.



Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

Enantiomer separation of dichlorprop methyl ester

Column: HYDRODEX β-3P, 25 m x 0.25 mm ID
Injection: 0.1 µL (~1 % in CH₂Cl₂), split 130 mL/min
Carrier gas: 60 kPa H₂ (1.9 mL/min)
Temperature: 160 °C
Detector: FID 250 °C



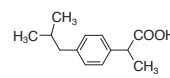
MN Appl. No. 202542

Separation of isomeric antiinflammatory drugs

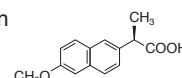
Courtesy of Prof. W.A. König, Hamburg, Germany
Column: HYDRODEX β-6TBDM, 25 m x 0.25 mm ID
Carrier gas: He
Temperature: 135 °C → 200 °C, 1 °C/min
Detector: FID

Peaks:

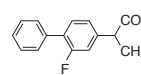
1. Ibuprofen



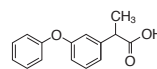
4. Naproxen



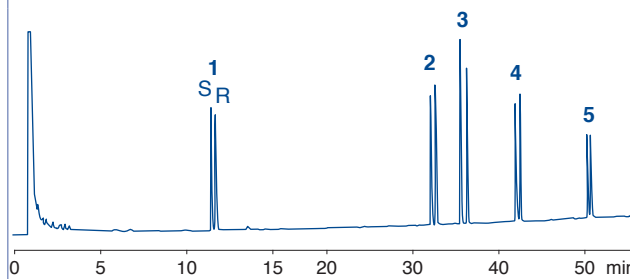
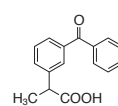
2. Flurbiprofen



3. Fenopropfen



5. Ketoprofen



MN Appl. No. 250180



HYDRODEX γ -TBDAC

octakis-(2,3-di-O-acetyl-6-O-*t*-butyldimethyl-silyl)- γ -CD

Phase diluted with optimized polysiloxane

- Recommended application: cyclic ketones, aromatic ketones, oxiranes, aromatic esters, aromatic amides etc.



Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

HYDRODEX γ -DiMOM

octakis-(2,3-di-O-methoxymethyl-6-O-*t*-butyldimethylsilyl)- γ -CD

Phase diluted with optimized polysiloxane

- Recommended application: ketones, terpenes, cyclic ethers, alcohols, amines



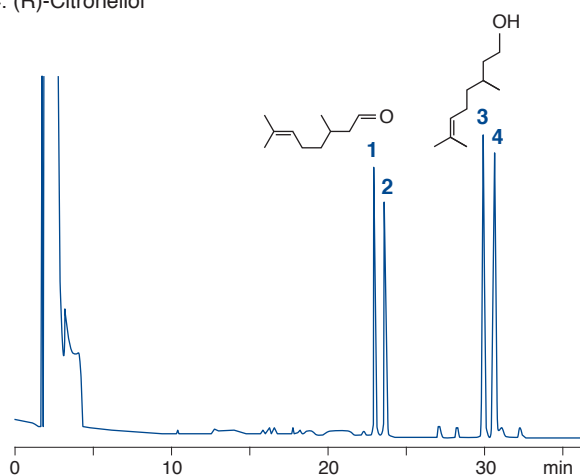
Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

Separation of (R/S) citronellol + citronellal

Column: FS-HYDRODEX β -TBDAC, 50 m x 0.25 mm ID
Injection: 1 μ L, 1:1000 in CH₂Cl₂, split 25 mL/min
Carrier gas: 1.5 bar H₂
Temperature: 100 °C
Detector: FID 220 °C

Peaks:

1. (R)/(S)-Citronellal
2. (S)/(R)-Citronellal
3. (S)-Citronellol
4. (R)-Citronellol



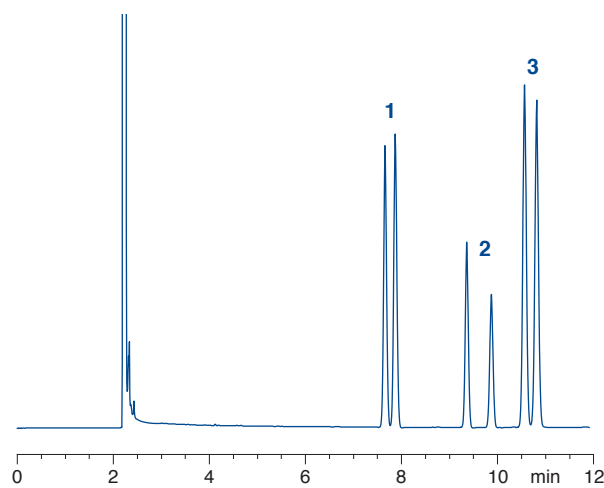
MN Appl. No. 212440

Separation of essential oils

Column: FS-HYDRODEX γ -TBDAC, 50 m x 0.25 mm ID
Injector: 220 °C
Carrier gas: 1.2 bar H₂
Temperature: 125 °C
Detector: FID 220 °C

Peaks:

1. Fenchone (1.5 mg/mL)
2. Menthone (0.5 mg/mL)
3. Menthol (2 mg/mL)



MN Appl. No. 212980 / 212990 / 213000

Ordering information

Length →	10 m	25 m	50 m
all columns 0.4 mm OD	0.10 mm ID	0.25 mm ID	0.25 mm ID
FS-HYDRODEX β -PM		723370.25	723370.50
FS-HYDRODEX β -3P		723358.25	723358.50
FS-HYDRODEX β -6TBDM	723383.10	723381.25	723381.50
FS-HYDRODEX β -TBDAC		723384.25	723384.50
FS-HYDRODEX γ -TBDAC		723387.25	723387.50
FS-HYDRODEX γ -DiMOM		723388.25	723388.50



Capillary columns for analysis of biodiesel

OPTIMA® BioDiesel

for the analysis of biodiesel (DIN EN 14214 / ASTM D 6751)

OPTIMA® BioDiesel M

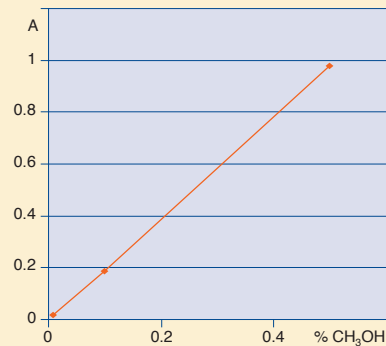
for analysis of methanol in accordance with DIN EN 14110

The methanol content in biodiesel as specified in DIN EN 14110 must not exceed 0.2%. The column OPTIMA® BioDiesel M allows the GC headspace analysis of the methanol content in biodiesel in the concentration range from 0.01 to 0.5% with 2-propanol as internal standard. The graph on the right shows the linearity of the determination in the required range ($A = \text{area}[\text{methanol}]/\text{area}[\text{2-propanol}]$).

Similar phases: Select™ Biodiesel for Methanol, Trace TR-BioDiesel (M)



Max. temperature for isothermal operation 340 °C, max. temperature for short isotherms in a temperature program 360 °C



OPTIMA® BioDiesel F

for analysis of FAMES in accordance with DIN EN 14103:2011

The analysis of biodiesel requires separation of typical FAMES between myristic acid (C14) and nervonic acid (C24:1) methyl esters. This analysis is possible on OPTIMA® BioDiesel F in only 22 min. Additionally, linolenic acid methyl ester can be determined due to the good resolution.

The extended standard DIN EN 14103:2011 also covers smaller FAMES starting from C6 (see application 214510 on opposite page). Change of the internal standard from C17 to C19 also allows the analysis of animal fats.

Similar phases: Select™ Biodiesel for FAME, Trace TR-BioDiesel (F)



Max. temperature for isothermal operation 240 °C, max. temperature for short isotherms in a temperature program 250 °C

OPTIMA® BioDiesel G

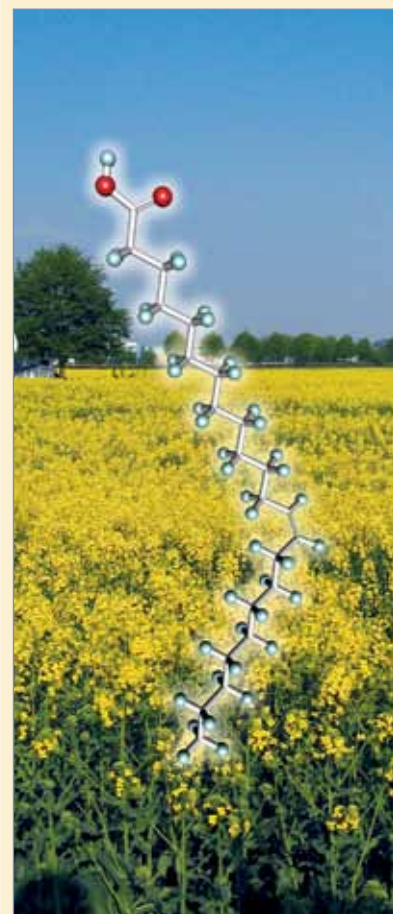
for analysis of glycerol and glycerides in accordance with DIN EN 14105

The capillary column OPTIMA® BioDiesel G allows determination of free glycerol and residues of mono-, di- and triglycerides in FAMES intended as additives for mineral oils. The procedure can be applied for FAMES from rapeseed oil, sunflower oil and soy bean oil. Glycerol as well as mono- and diglycerides are derivatized to more volatile substances by addition of MSTFA (see page 286) in the presence of pyridine.

Similar phases: Select™ Biodiesel for Glycerides, Trace TR-BioDiesel (G), MET-Biodiesel



Max. temperature for isothermal operation 380 °C, max. temperature for short isotherms in a temperature program 400 °C



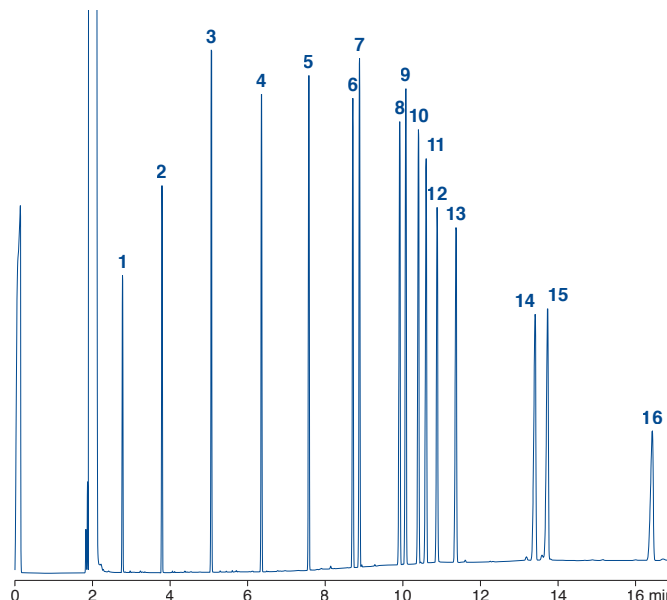


Analysis of FAMES from biodiesel in accordance with DIN EN 14103:2011

Column: OPTIMA® BioDiesel F, 30 m x 0.25 mm ID
 Sample: 50 µg/mL each in dichloromethane
 Injection: 10 µL, 250 °C, split 1:20
 Carrier gas: 1.2 bar He
 Temperature: 80 °C → 250 °C (8.5 min), 20 °C/min
 Detector: FID 260 °C

Peaks:

1. C6:0
2. C8:0
3. C10:0
4. C12:0
5. C14:0
6. C16:0
7. C16:1
8. C18:0
9. C18:1
10. C18:2
11. C19:0, int. st.
12. C18:3
13. C20:0
14. C22:0
15. C22:1
16. C24:0



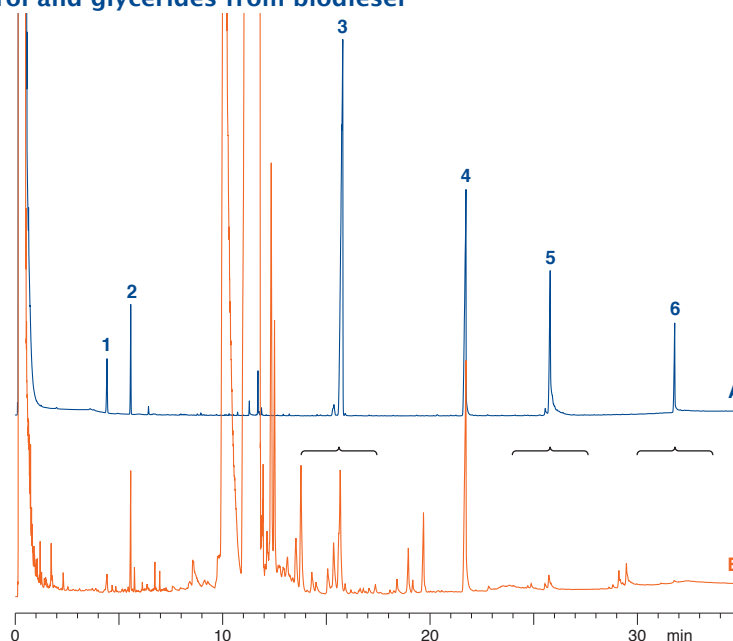
MN Appl. No. 214510

Analysis of glycerol and glycerides from biodiesel

Column: OPTIMA® BioDiesel G,
 10 m x 0.25 mm ID
 Sample: A) standard in *n*-heptane
 B) biodiesel
 Injection: 2 µL, 350 °C, split 1:2.6
 CIS (15 °C → 350 °C, 12 °C/s)
 Carrier gas: 0.8 bar H₂
 Temperature: 50 °C (3.5 min) → 180 °C, 15 °C/min
 → 280 °C, 7 °C/min
 → 370 °C (10 min), 10 °C/min
 Detector: FID 380 °C

Peaks:

1. Glycerol (TMS)
2. Butanetriol (TMS), IS
3. Monoolein = glycerol monooleate (TMS)
 + monoacylglycerides
4. Tricaprin (glycerol tricaprinate), IS
5. Diolein = glycerol dioleate (TMS)
 + diacylglycerides
6. Triolein = glycerol trioate
 + triacylglycerides



MN Appl. No. 213640

Ordering information

	Length →	10 m	30 m
OPTIMA® BioDiesel M			
0.32 mm ID (0.5 mm OD)			726905.30
OPTIMA® BioDiesel F			
0.25 mm ID (0.4 mm OD)			726900.30
OPTIMA® BioDiesel G			
0.25 mm ID (0.4 mm OD)		726903.10	



Capillary columns for special separations

OPTIMA® 1-TG · OPTIMA® 17-TG

for triglyceride analyses

OPTIMA® 1-TG

100% dimethylpolysiloxane
offers separation according to carbon number

Similar phases:

SPB-1 TG, DB-1 HT, 400-1 HT, HT-5

USP G1 / G2 / G38

OPTIMA® 17-TG

phenyl-methyl-polysiloxane (50% phenyl) for
separation according to degree of unsaturation

USP G3



Max. temperature for both phases: 370 °C



Short capillary columns (max. 25 m and 0.32 mm ID) with low-bleeding stationary phases thermally stable with optimized deactivation

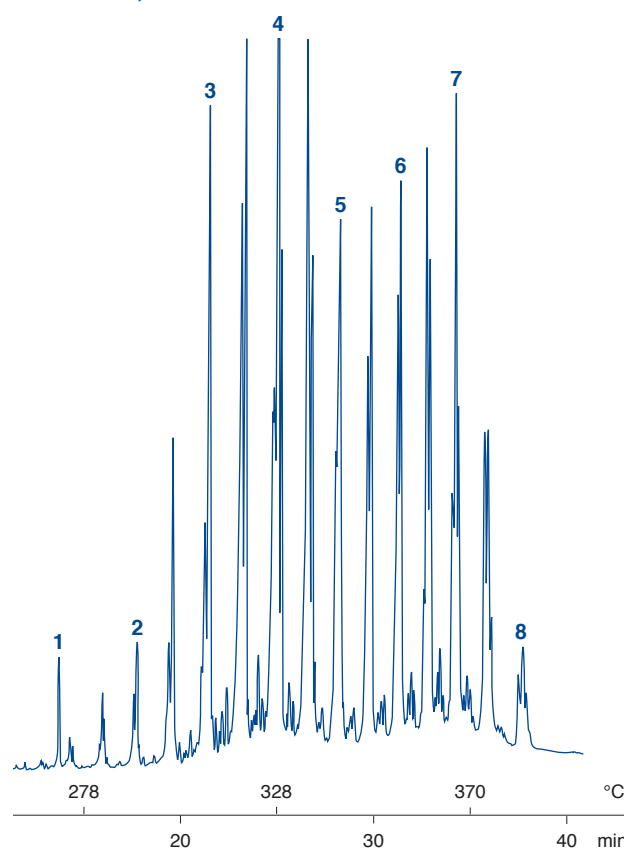
Capillary columns for GC

Triglycerides (from butter)

Column: OPTIMA® 1-TG, 25 m x 0.32 mm ID
Injection: 0.5 µL
Carrier gas: 80 kPa H₂
Temperature: 80 °C (1 min) → 250 °C, 20 °C/min → 370 °C (10 min), 5 °C/min
Detector: FID 380 °C

Peaks:

1. Cholesterol
2. T-30
3. T-34
4. T-38
5. T-42
6. T-46
7. T-50
8. T-54



MN Appl. No. 201790

Ordering information

	Length →	10 m	25 m
OPTIMA® 1-TG	0.25 mm ID (0.4 mm OD)	726133.10	726133.25
	0.32 mm ID (0.5 mm OD)	726132.10	726132.25
OPTIMA® 17-TG	0.32 mm ID (0.5 mm OD)	726131.10	726131.25



OPTIMA® 5 HT

- Ultra low bleed silarylene phase with 5-type polarity
Nonpolar phase, ideal for MS detectors, can be rinsed with solvents
- Similar phases: DB-5HT, VF-5HT, HT-5, XTI-5HT, ZB-5HT

for high temperature GC

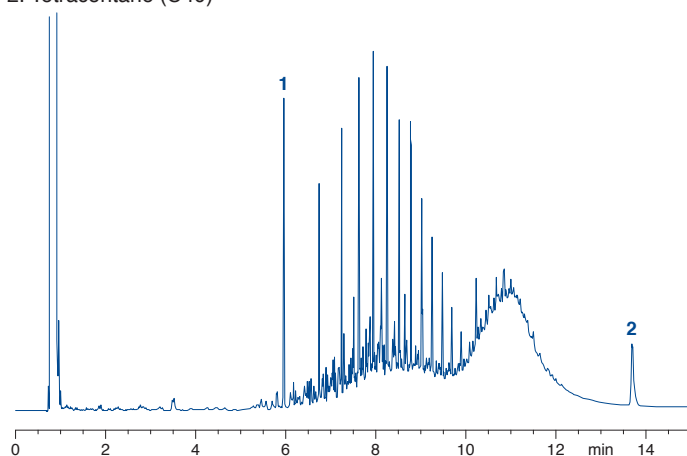
- Max. temperature for isothermal operation 380 °C, max. temperature for short isotherms in a temperature program 400 °C
- Recommended application: for simulated distillation, hydrocarbon, fuel and oil analysis, high-boiling analytes
- USP G27 / G36



Separation of motor oil / mineral oil (type A + B), rapid determination in accordance with DIN H-53 / ISO DIS 9377 with a steep heating rate

Column: OPTIMA® 5 HT, 0.25 µm film, 15 m x 0.32 mm ID
 Sample: mineral oil type A + B (hydrocarbon index kit acc. to EN ISO 9377-2) in hexane
 Injection: 1 µL, splitless, 300 °C
 Carrier gas: 0.6 bar He
 Temperature: 40 °C (5 min) → 390 °C, 50 °C/min
 Detector: FID 280 °C

- Peaks:**
- Decane (C10)
 - Tetracontane (C40)



MN Appl. No. 213400

Ordering information

Length →	15 m	30 m
0.25 mm ID (0.4 mm OD)		
0.10 µm film	726102.15	726102.30
0.25 µm film	726106.15	726106.30
0.32 mm ID (0.5 mm OD)		
0.10 µm film	726104.15	726104.30
0.25 µm film	726108.15	726108.30



Capillary columns for special separations

OPTIMA® 5 Amine

- Especially deactivated for the analysis of polyfunctional amines such as ethanol-amines, amino-functionalized diols and similar compounds, which are important base materials in industrial chemistry, and show strong tailing on standard-deactivated columns

Similar phases: Rtx-5 Amine, PTA-5, CP-Sil 8 CB for Amines

- USP G27 / G36

special column for analysis of amines



Max. temperature for isothermal operation 300 °C, max. temperature for short isotherms in a temperature program 320 °C

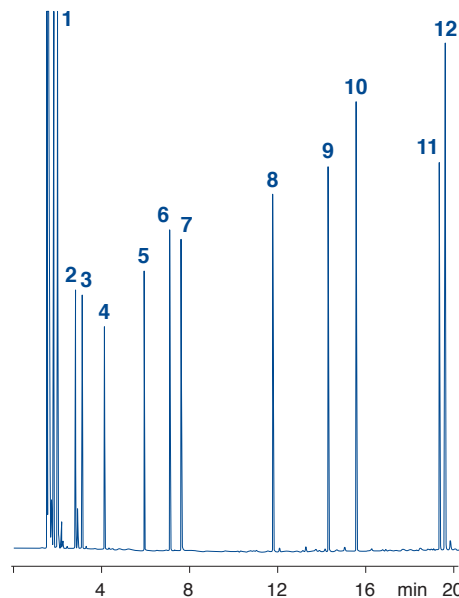
- Improved linearity for analyses of active components at trace levels: no amine absorptions even for aliphatic and aromatic amines at concentrations of 100 pg/peak
- Tested with the OPTIMA® Amine test mixture (REF 722317), which contains, amongst others, diethanol-amine and propanol-pyridine (this test mixture is supplied with each column)

Separation of secondary and tertiary amines

Column: OPTIMA® 5 Amine, 0.5 µm film, 30 m x 0.25 mm ID
Injection: 1 µL, split 1:100
Carrier gas: 0.6 bar H₂
Temperature: 100 °C (3 min) → 280 °C, 10 °C/min
Detector: FID 280 °C

Peaks:

- Diethylamine
- Di-isopropylamine
- Triethylamine
- Di-*n*-propylamine
- Di-*n*-butylamine
- Tri-*n*-propylamine
- Di-isobutylamine
- Tri-*n*-butylamine
- Di-isohexylamine
- Dicyclohexylamine
- Dibenzylamine
- Tri-*n*-hexylamine



MN Appl. No. 210280

Ordering information

Length →	10 m	25 m	30 m
0.1 mm ID (0.4 mm OD)			
0.40 µm film	726361.10		
0.2 mm ID (0.4 mm OD)			
0.35 µm film	726355.25		
0.25 mm ID (0.4 mm OD)			
0.50 µm film	726354.30		
1.00 µm film	726358.30		
0.32 mm ID (0.5 mm OD)			
0.25 µm film	726360.30		
1.00 µm film	726353.30		
1.50 µm film	726356.30		
0.53 mm ID (0.8 mm OD)			
1.00 µm film	726359.30		
3.00 µm film	726357.30		



FS-CW 20 M-AM

polyethylene glycol 20 000, non-immobilized

-  Polyethylene glycol, basic for amine separations
 Similar phases: Carbowax™ Amine, CP-Wax 51, CAM, Stabilwax® DB
-  USP G16



Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

Ordering information

Length →	10 m	25 m	50 m
0.1 mm ID (0.4 mm OD)			
0.20 µm film	733111.10		
0.25 mm ID (0.4 mm OD)			
0.25 µm film		733110.25	733110.50
0.32 mm ID (0.5 mm OD)			
0.25 µm film		733299.25	733299.50
0.35 µm film			733442.50
0.53 mm ID (0.8 mm OD)			
1.00 µm film		733551.25	

PERMABOND® P-100

for analyses of petrochemical products

-  Extra long column with nonpolar dimethylpolysiloxane phase
 High resolution and sufficient capacity for analysis of complex mixtures of hydrocarbons
-  USP G1 / G2 / G38



Max. temperature for isothermal operation 300 °C, max. temperature for short isotherms in a temperature program 320 °C



Ordering information

Length →	100 m
0.25 mm ID (0.4 mm OD)	
0.50 µm film	723890.100



Capillary columns for special separations

PERMABOND® SE-54-HKW

for volatile halogenated hydrocarbons

- SE-54 optimized for volatile halogenated hydrocarbons
- USP G36



Max. temperature for isothermal operation 300 °C, max. temperature for short isotherms in a temperature program 320 °C

For the analysis of halogenated hydrocarbons, we recommend our optimized column PERMABOND® SE-54-HKW at 25 or 50 m length with our approved polysiloxane phase SE-54. As an alternative, or to verify analytical results, the OPTIMA® 624 has proven itself as advantageous, especially for the determination of 1,1,2-trichlorotrifluoroethane (F 113) along with di-

chloromethane. Both phases are also suited for the determination of vinyl chloride as well as for the separation of *cis/trans* isomers of 1,2-dichloroethene. The high film thickness secures a high capacity and an outstanding resolution. For GC/MS coupling, we recommend OPTIMA® 624 LB or OPTIMA® 624 with 0.2 or 0.25 mm ID.

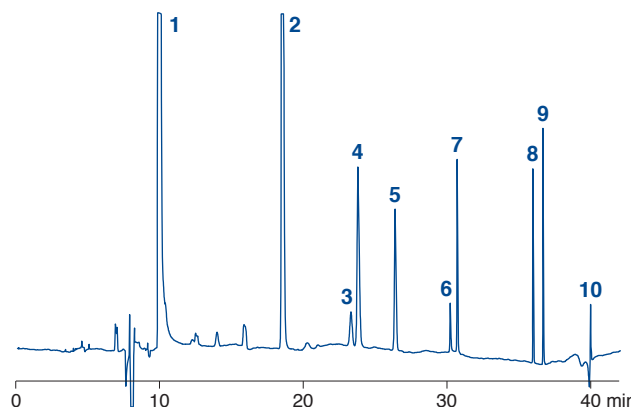
Volatile halogenated hydrocarbons

Column: PERMABOND® SE-54-HKW, 50 m x 0.32 mm ID
Injection: 1 µL, split ~ 1:30
Carrier gas: 0.9 bar He
Temperature: 35 °C (25 min) → 160 °C (5 min), 10 °C/min
Detector: ECD 300 °C

Peaks:

1. Dichloromethane (795 ng/mL)
2. Trichloromethane (75 ng/mL)
3. 1,1,1-Trichloroethane (67 ng/mL)
4. 1,2-Dichloroethane (100 ng/mL)
5. Tetrachloromethane (15.9 ng/mL)
6. Trichloroethene (14.6 ng/mL)
7. Bromodichloromethane (20 ng/mL)
8. Dibromochloromethane (122 ng/mL)
9. Tetrachloroethene (81 ng/mL)
10. Tribromomethane (28.9 ng/mL)

MN Appl. No. 2124880

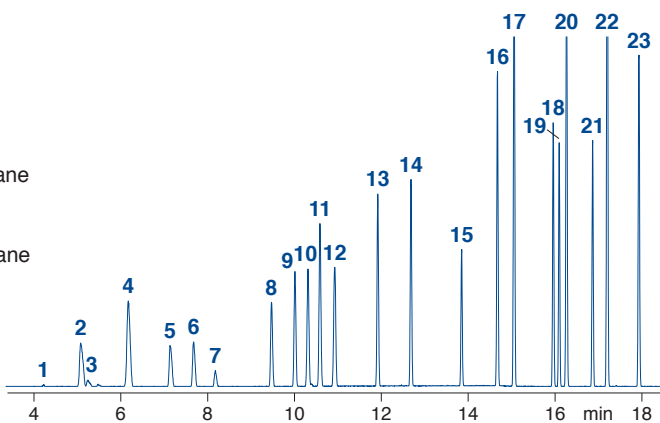


Volatile halogenated hydrocarbons and BTX

Column: OPTIMA® 624, 50 m x 0.25 mm ID
Injection: 1 µL, split 50 mL/min
Carrier gas: 0.9 mL/min He (constant flow)
Temperature: 40 °C (5 min) → 160 °C, 10 °C/min
Detector: MSD 5971

Peaks:

- | | |
|---|-----------------------------------|
| 1. Vinyl chloride | 13. Trichloroethene |
| 2. Trichlorofluoromethane (F 11) | 14. Bromodichloromethane |
| 3. Pentane | 15. Toluene |
| 4. 1,1,2-Trichlorotrifluoroethane (F 113) | 16. Tetrachloroethene |
| 5. Dichloromethane | 17. Dibromochloromethane |
| 6. <i>trans</i> -1,2-Dichloroethene | 18. Chlorobenzene |
| 7. Hexane | 19. Ethylbenzene |
| 8. <i>cis</i> -1,2-Dichloroethene | 20. <i>m</i> - + <i>p</i> -Xylene |
| 9. Trichloromethane | 21. <i>o</i> -Xylene |
| 10. 1,1,1-Trichloroethane | 22. Tribromomethane |
| 11. Tetrachloromethane | 23. Bromobenzene |
| 12. 1,2-Dichloroethane + benzene | |



MN Appl. No. 200160

Ordering information

Length →	25 m	50 m
0.32 mm ID (0.5 mm OD)		
1.80 µm film	723945.25	723945.50



PERMABOND® Silane

for silane analyses

- Developed especially for the analysis of mono-meric silanes and chlorosilanes (not for the separation of trimethylsilyl derivatives)
- Also suited for the separation of dimeric siloxanes and silazanes



Columns with 0.32 mm ID: max. temperature for isothermal operation 260 °C, max. temperature for short isotherms in a temperature program 280 °C; 0.53 mm ID columns: max. temperatures 240 and 260 °C, resp.

Ordering information

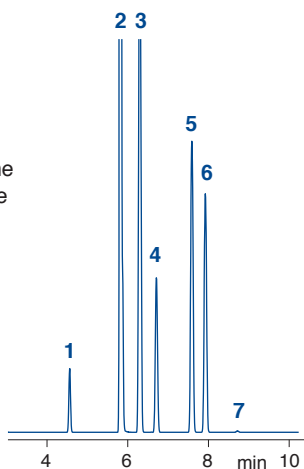
Length →	25 m	50 m
0.32 mm ID (0.5 mm OD)		723409.50
0.53 mm ID (0.8 mm OD)	723411.25	

Chloromethylsilanes

Column: PERMABOND® Silane, 50 m x 0.32 mm ID
Injection: 0.5 µL gas, split 80 mL/min
Carrier gas: 1 mL/min He (constant flow)
Temperature: 50 °C → 100 °C, 5 °C/min
Detector: MSD 5971

Peaks:

1. Tetramethylsilane
2. Dichloromethane
3. Tetrachlorosilane
4. Chlorotrimethylsilane
5. Methyltrichlorosilane
6. Dichlorodimethylsilane
7. Hexamethyldisiloxane



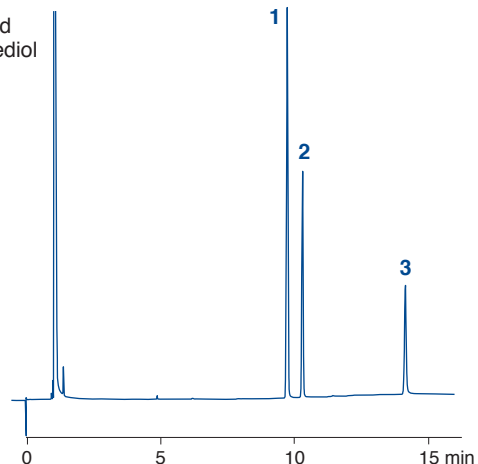
MN Appl. No. 200090

Diethylene glycol standard in wine

Column: PERMABOND® CW 20 M-DEG, 25 m x 0.25 mm ID
Injection: 0.5 µL, split ~1:40
Carrier gas: 1.2 bar N₂
Temperature: 80 °C → 200 °C, 10 °C/min
Detector: FID 260 °C

Peaks:

1. 1,4-Butanediol
2. Diethylene glycol
3. Glycerol



MN Appl. No. 201500

PERMABOND® CW 20 M-DEG

for determination of diethylene glycol

- Polyethylene glycol 20 000 (diethylene glycol tested)
- Recommended application: determination of diethylene glycol, e.g., for the quality control of wine



Max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature program 240 °C

USP G16

Ordering information

Length →		25 m
0.25 mm ID (0.4 mm OD)	0.25 µm film	723063.25
0.32 mm ID (0.5 mm OD)	0.25 µm film	723327.25



Fused silica capillaries

Untreated capillaries

- Recommended applications:
for capillary electrophoresis · for preparation of capillary columns · for capillary LC applications

Ordering information

Length →	1 m (pack of 3)	10 m (pack of 1)	25 m (pack of 1)
Capillaries for electrophoresis			
0.025 mm ID (0.4 mm OD)	723793.1	723793.2	
0.05 mm ID (0.4 mm OD)	723790.1	723790.2	
0.075 mm ID (0.4 mm OD)	723791.1	723791.2	
0.10 mm ID (0.4 mm OD)	723792.1	723792.2	
Untreated capillaries			
0.20 mm ID (0.4 mm OD)		723148.10	723148.25
0.25 mm ID (0.4 mm OD)		723101.10	723101.25
0.32 mm ID (0.5 mm OD)		723151.10	723151.25
0.53 mm ID (0.8 mm OD)		723501.10	723501.25
Untreated capillaries are supplied without cage.			

Deactivated capillary columns (precolumns)

- Recommended applications:
Preparation of capillary columns
As precolumns, whenever a larger contamination capacity is required.

Ordering information

Length →	10 m	25 m
Methyl-Sil deactivated (max. temperature 320 °C)		
0.25 mm ID (0.4 mm OD)	723106.10	723106.25
0.32 mm ID (0.5 mm OD)	723346.10	723346.25
0.53 mm ID (0.8 mm OD)	723558.10	723558.25
Phenyl-Sil deactivated (max. temperature 320 °C)		
0.25 mm ID (0.4 mm OD)	723108.10	723108.25
0.32 mm ID (0.5 mm OD)	723348.10	723348.25
0.53 mm ID (0.8 mm OD)	723560.10	723560.25
CW deactivated (max. temperature 250 °C)		
0.25 mm ID (0.4 mm OD)	723105.10	723105.25
0.32 mm ID (0.5 mm OD)	723349.10	723349.25
0.53 mm ID (0.8 mm OD)	723562.10	723562.25
Deactivated capillaries are supplied without cage.		



Retention gaps

- ✦ The retention gap technique in combination with on-column injection allows to concentrate a large sample volume in the capillary column.
 - ✦ Choice of the retention gap depends on the solvent used: the flooded zone after injection should be between 20–30 cm/μL
 - Me–Sil retention gap: only for use with *n*–hexane and diethyl ether
 - Phe–Sil retention gap: for all solvents except methanol and water
 - CW retention gap: for all solvents and especially for methanol and water
 - ✦ Calculation example: length of flooded zone ~ 20–30 cm/μL, retention gap 10 m x 0.32 mm ID, capillary column: 25 m x 0.32 mm ID, max. injection volume ~ 30–50 μL
 - ✦ A retention gap must be inert without any noticeable retention
 - Me–Sil retention gaps are more inert than Phe–Sil, while Phe–Sil is less susceptible to contamination
-  Max. temperatures: for CW retention gaps 250 °C, for Me–Sil and Phe–Sil retention gaps 320 °C
 Retention gaps can also be used as transfer lines or precolumns (contamination capacity about 5–10 μg).

Ordering information

Length →	10 m	25 m
Me–Sil retention gaps (max. temperature 320 °C)		
0.25 mm ID (0.4 mm OD)	723706.10	723706.25
0.32 mm ID (0.5 mm OD)	723707.10	723707.25
0.53 mm ID (0.8 mm OD)	723708.10	723708.25
Phe–Sil retention gaps (max. temperature 320 °C)		
0.25 mm ID (0.4 mm OD)	723709.10	723709.25
0.32 mm ID (0.5 mm OD)	723710.10	723710.25
0.53 mm ID (0.8 mm OD)	723711.10	723711.25
CW retention gaps (max. temperature 250 °C)		
0.25 mm ID (0.4 mm OD)	723712.10	723712.25
0.32 mm ID (0.5 mm OD)	723713.10	723713.25
0.53 mm ID (0.8 mm OD)	723714.10	723714.25
Retention gaps are supplied without cage.		

For a considerably longer lifetime, even for contaminated or matrix-containing samples, MN offers the option of **integrated precolumns**. All capillary columns are available with a 10 m guard column with matched deactivation. For ordering, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



Reagents and procedures for derivatization

Derivatization reagents

- To improve volatility, increase thermal stability or to achieve a lower limit of detection in gas chromatography
- Prerequisite: quantitative, rapid and reproducible formation of only one derivative
- Halogen atoms inserted by derivatization, e.g., trifluoroacetates, allow the specific detection in an ECD with the advantage of high sensitivity.
- Specific derivatizations may influence elution orders and fragmentation patterns in a MS.
- We provide reagents for **acylation**, **alkylation (methylation)**, and **silylation**.

Derivatization method development kits

Designation	Contents of the kit	REF
Derivatization method development kit		
Which type of derivatization is suited best for your sample (alkylation, acylation or silylation)?	2 x 1 mL each of TMSH, MSTFA, MBTFA	701952
Acylation kit		
Which is the proper reagent for acylation?	2 x 1 mL each of MBTFA, TFAA, MBHFBA	701950
Alkylation kit		
Which is the proper reagent for methylation?	3 x 1 mL each of TMSH, DMF-DMA	701951
Silylation kit		
Which is the proper reagent for silylation?	2 x 1 mL each of MSTFA, BSTFA, TSIM, MSHFBA	701953

Selection guide for derivatization of important functional groups in GC

Function	Method	Derivative	Recommended reagents
Alcohols, Phenols R'OH	silylation	R'O-TMS	BSA, MSTFA, MSHFBA, TSIM, SILYL-2110, SILYL-21, SILYL-1139
	acylation	R'O-CO-R	TFAA, HFBA, MBTFA, MBHFBA
	alkylation	R'O-R	TMSH
	silylation	R'O-TMS	TSIM, BSTFA, SILYL-991
Amines primary, secondary hydrochlorides	silylation	R'-NR''-TMS	BSA, MSTFA, MSHFBA, SILYL-991
	acylation	R'-NR''-CO-R	TFAA, HFBA, MBTFA, MBHFBA
	silylation	R'-NR''-TMS	MSTFA
Amides	silylation	not stable	
	acylation	R'-CO-NH-CO-R	TFAA, MBTFA, HFBA, MBHFBA
Amino acids	silylation	R'-CH(NH-TMS)-CO-O-TMS	BSA, BSTFA, MSTFA, MSHFBA
	alkylation (a) + acylation (b)	R'-CH(NH-CO-R)-CO-O-R	a) MeOH/TMCS, TMSH b) TFAA, HFBA, MBTFA, MBHFBA
Carboxylic acids (fatty acids)	silylation	R'-CO-O-TMS	BSA, MSTFA, MSHFBA, TMCS, TSIM, SILYL-2110, SILYL-21, Silyl 1139
		susceptible to hydrolysis	
	alkylation	R'-CO-O-R	DMF-DMA, MeOH/TMCS (1 M), TMSH
	silylation	R'-CO-O-TMS	TMCS
Carbohydrates	silylation		MSTFA, TSIM, HMDS, SILYL-1139
	acylation		TFAA, MBTFA
Steroids	silylation		BSA, TSIM
	acylation		TFAA, MBTFA, HFBA, MBHFBA



Acylation reagents

Acyl halides

By-product of acylation with acyl halides: corresponding hydrohalic acids
excess of reagent and acid have to be removed or trapped by a suitable base (e.g., pyridine)

Pentafluorobenzoyl chloride

PFBC: $C_6F_5 - CO - Cl$ M 230.52 g/mol, Bp 158–159 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.601$

Anhydrides

By-products of acylation with anhydrides: corresponding acids
excess reagent and the acid formed are to be removed

Trifluoroacetic acid anhydride

TFAA: $CF_3 - CO - O - CO - CF_3$ M 210.04 g/mol, Bp 39.5–40.5 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.490$

Heptafluorobutyric acid anhydride

HFBA: $C_3F_7 - CO - O - CO - C_3F_7$ M 410.06 g/mol, Bp 106–107 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.665$

Bisacylamides

By-products: corresponding neutral acylamides: high volatility · easily removed; due to the neutral conditions and their favorable chromatographic characteristics, the removal of surplus bisacylamides and their by-products is often not necessary. Therefore, the sample preparation is much easier.

N-methyl-bis(trifluoroacetamide)

MBTFA: $CF_3 - CO - N(CH_3) - CO - CF_3$ M 223.08 g/mol, Bp 123–124 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.55$

N-methyl-bis(heptafluorobutyramide)

MBHFBA: $C_3F_7 - CO - N(CH_3) - CO - C_3F_7$ M 423.1 g/mol, Bp 165–166 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.673$

Methods for acylation

Acylation with fluorinated acid anhydrides:

The acylation with TFAA or HFBA, under formation of volatile, stable derivatives for FID or ECD detection, is applicable for alcohols, phenols, carboxylic acids, amines, amino acids and steroids.

Procedure:

Dissolve 0.1 to 1 mg sample in 0.1 mL solvent, add 0.1 mL of the anhydride and heat to 60–70 °C for 1–2 h. If the sample need not be concentrated prior to the analysis and if there is no danger of catalytically induced side reactions, pyridine is used as solvent. The reaction solution can be injected directly into the gas chromatograph. Otherwise, use a volatile solvent and evaporate solvent, excess reagent and free acid in a stream of nitrogen. Dissolve residue in 50 µL hexane, chloroform etc. and inject aliquot portions.

TFAA MN Appl. No. 213041 · HFBA MN Appl. No. 213042

Acylation with fluorinated acid amides:

This method is recommended for alcohols, primary and secondary amines as well as for thiols under mild, neutral conditions. MBTFA also forms very volatile derivatives with carbohydrates [J. Sullivan and L. Schewe, J. Chromatogr. Sci. **15** (1977) 196–197].

Procedure:

Add 0.5 mL MBTFA or MBHFBA to about 2 mg sample. If there is no reaction at ambient temperature, heat the reaction mixture to 120 °C. Compounds difficult to dissolve, can be trifluoroacetylated in suitable solvent mixtures. It is recommended to use a ratio of solvent to MBTFA or MBHFBA of 4:1. The reaction mixture is chromatographed directly.

MBTFA MN Appl. No. 213051 · MBHFBA MN Appl. No. 213052

Ordering information

Substance	Packing unit			
	10 x 1 mL	20 x 1 mL	1 x 10 mL	5 x 10 mL
HFBA*		701110.201	701110.110	701110.510
MBTFA*		701410.201	701410.110	701410.510
MBHFBA*	701420.101	701420.201		
PFBC*	701120.101			
TFAA*			701130.110	701130.510

* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS. Due to their purpose, derivatization reagents are very reactive substances. For this reason, they should be stored cool and protected from moisture. For easy access with a syringe, our derivatization reagents are supplied in vials with crimp caps. Vials with pierced sealing disks have limited stability and should be used soon.



Apart from a few exceptions, methylation is the most common alkylation type.

N,N-dimethylformamide dimethylacetal

$$\begin{array}{c} \text{H}_3\text{C} \quad \text{CH}_3 \\ \quad \diagdown \quad \diagup \\ \quad \text{N} \\ \quad \diagup \quad \diagdown \\ \text{H}_3\text{C}-\text{O} \quad \text{O}-\text{CH}_3 \\ \quad \diagdown \quad \diagup \\ \quad \text{C} \\ \quad \diagup \quad \diagdown \\ \left[\begin{array}{c} \text{H}_3\text{C} \\ \quad \diagdown \\ \quad \text{S}^- - \text{CH}_3 \\ \quad \diagup \\ \text{H}_3\text{C} \end{array} \right]^+ \quad \text{OH}^- \end{array}$$

TMSH (0.2 mol/L in methanol) · M 94.06 g/mol

Methylation with TMSH

Methylation with DMF-DMA

Methylation with DMF-DMA, under formation of N-di-methyl-aminomethylene amino acid methyl esters, is applicable for fatty acids, primary amines and (partially) amino acids [Thenot et al., *Anal. Letters* **5** (1972) 217–223, 519–529]. Since DMF-DMA is a poor solvent, it is essential to use a mixture of DMF-DMA with pyridine, THF, acetone (barbiturates) or another solvent.

This reaction is very elegant and convenient, because it is only necessary to add the reagent (0.2 mol/L in methanol) to the sample solution. Removal of surplus reagent is not required, since at 250 °C inside the injector of the gas chromatograph, TMSH will pyrolyze solely to volatile methanol and dimethylsulfide. Due to high reactivity, a complete conversion is usually obtained at ambient temperature. Heating (e.g., 10 min at 100 °C) in a closed sample vial may be necessary, however.

Dissolve 100 mg sample (e.g., butter) in 5 mL of a solvent (e.g., *tert.*-butyl methyl ether). Add 50 μ L reagent to 100 μ L of this solution. The mixture is injected directly. The temperature of the injector must be at least 250 $^{\circ}$ C.

MN Appl. No. 213060

Add 1 mL of a mixture of DMF-DMA and pyridine (1:1) to 1-50 mg fatty acids. The sample can be injected as soon as a clear solution has formed. It is recommended, however, to heat the solution to 60-100 °C for 10-15 min.

MN Appl. No. 213070

A 1-molar solution of TMCS in methanol is suited for the esterification of free carboxylic acids and the transesterification of glycerides. Formation of HCl catalyzes the reaction. TMCS, resp. silyl ethers remove the water and thus drive the reaction to completion. The mixture should be freshly prepared.

Add 1 mL methanol – TMCS to about 50 mg carboxylic acid or glyceride and heat. Then evaporate in a stream of nitrogen and dissolve again for injection in, e.g., *n*-heptane.

MN Appl. No. 213080

Substance	Packing unit			
	10 x 1 mL	20 x 1 mL	1 x 10 mL	5 x 10 mL
DMF-DMA*		701430.201	701430.110	
TMSH*	701520.101	701520.201	701520.110	701520.510

* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS. Due to their purpose, derivatization reagents are very reactive substances. For this reason, they should be stored cool and protected from moisture. For easy access with a syringe, our derivatization reagents are supplied in vials with crimp caps. Vials with pierced sealing disks have limited stability and should be used soon.





Silylation reagents

The most common form of silylation in GC is the replacing of active hydrogen atoms with a trimethylsilyl group (TMS derivative). Less frequently, trialkylsilyl groups or dimethylsilyl groups with longer alkyl chains are also in use. The alkylsilyl group increases volatility and enhances thermal stability of the sample.

Silylation can be catalyzed either acidic by addition of TMCS or basic by addition of pyridine or TSIM (e.g., for sterically hindered functionalities like *tert.* alcohols).

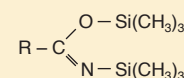
Reactivity of silylation reagents (acc. to M. Donike): TMS amides (e.g., BSA, MSTFA) > TMS amine = TSIM > Enol-O-TMS ether > S-TMS ether > O-TMS ether > TMS-O-TMS

Stability of the TMS derivatives: O-TMS ether > S-TMS ether > Enol-O-TMS ether > TMS amine > TMS amide

BSA · BSTFA · SILYL-991

● N,O-bis-trimethylsilyl-acetamide

BSA: R = CH₃



M 203.4 g/mol, Bp 71–73 °C (35 mm Hg), density d_{20°/4°} = 0.832

Strong silylation reagent, creating very stable TMS derivatives of a multitude of compounds, e.g., alcohols, amines, carboxylic acids, phenols, steroids, biogenic amines and alkaloids; not recommended for use with carbohydrates or very low molecular weight compounds; good solvent for polar compounds, but frequently used in combination with a solvent (pyridine, DMF etc.) or with other silylation reagents. Dissolved in DMF, BSA is the prime derivatization reagent for phenols.

● N,O-bis-trimethylsilyl-trifluoroacetamide

BSTFA: R = CF₃

M 257.4 g/mol, Bp 40 °C (12 mm Hg), density d_{20°/4°} = 0.961

Powerful trimethylsilyl donor with approx. the same donor strength as the nonfluorinated analog BSA

Advantage of BSTFA over BSA: greater volatility of its reaction products, particularly useful for GC analysis of low boiling TMS amino acids

BSTFA is nonpolar (less polar than MSTFA) and can be mixed with acetonitrile for improved solubility. For the silylation of fatty acid amides, hindered hydroxyl groups and other difficult to silylate compounds, e.g., secondary alcohols and amines, we recommend BSTFA + 1% trimethylchlorosilane (TMCS), available under the designation SILYL-991.

Silylation with BSA, BSTFA or SILYL-991 (BSTFA + 1% TMCS)

Procedure:

Add 0.5 mL of the silylation reagent to 1–10 mg sample; if necessary, add some solvent (normally pyridine or DMF [dimethylformamide]). Heat to 60–80 °C for 20 min to increase the reaction rate. 1–2 drops of TMCS (trimethylchlorosilane) or TSIM will also speed up the reaction.

BSA MN Appl. No. 213091 · BSTFA MN Appl. No. 213092
SILYL-991 MN Appl. No. 213093

Silylation with BSA in combination with other silylation reagents

Procedure:

BSA alone silylates all sterically unhindered hydroxyl groups of the steroid skeleton; addition of TMCS will enable reaction of moderately hindered OH groups (reaction time 3–6 h at 60 °C). After addition of TSIM even strongly hindered hydroxyl groups will react (reaction time 6–24 h at 60 °C).

MN Appl. No. 213100

Ordering information

Substance	20 x 1 mL	1 x 10 mL	Packing unit 5 x 10 mL	1 x 50 mL	1 x 100 mL
BSA*		701210.110	701210.510	701210.150	
BSTFA*	701220.201	701220.110	701220.510		
SILYL-991* (BSTFA – TMCS (99:1))	701490.201			701490.150	701490.1100

* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.



Reagents and procedures for silylation

MSTFA · MSHFBA · MBDSTFA

➤ N-methyl-N-trimethylsilyl-trifluoroacetamide

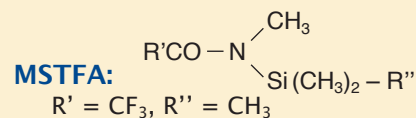
M 199.1 g/mol, Bp 70 °C (75 mm Hg), density $d_{20}^{20}/4^{\circ} = 1.11$

The most volatile trimethylsilyl amide available

Very strong TMS donor which does not cause noticeable FID fouling even during long-time measuring series. The addition of protic solvents in submolar quantities, e.g., TFA for extremely polar compounds (hydrochlorides) or pyridine for carbohydrates), can improve the already good dissolving power of MSTFA.

Recommended applications: carboxylic acids, hydroxy and ketocarboxylic acids, amino acids, amines, alcohols, polyalcohols, sugars, mercaptans and similar compounds with active hydrogen atoms. Even amine hydrochlorides can be silylated directly.

Advantages: complete conversion with high reaction rates, even without a catalyst (1–2% TMCS or TSIM); the by-product of the reaction (N-methyltrifluoroacetamide) shows a high volatility and a short retention time



➤ N-methyl-N-trimethylsilyl-heptafluorobutyramide

MSHFBA: $\text{R}' = \text{C}_3\text{F}_7, \text{R}'' = \text{CH}_3$

M 299.1 g/mol, Bp 148 °C (760 mm Hg)

Similar to MSTFA in reactivity and chromatography

Recommended applications: carboxylic acids, alcohols, phenols, primary and secondary amines and amino acids; either applied alone or in combination with a catalyst (TMCS, TSIM) or another silylation reagent with or without solvent; the by-product N-methylheptafluorobutyric amide has a lower retention time than the silylating reagent; especially useful for flame ionization detection due to the large ratio of fluorine to silicon of 7:1, since degradation of the surplus MSHFBA does not produce SiO_2 but volatile, non-corrosive silicon compounds

➤ N-methyl-N-tert-butyldimethylsilyl-trifluoroacetamide

MBDSTFA (MTB-TFA):
 $\text{R}' = \text{CF}_3, \text{R}'' = \text{C}_4\text{H}_9$

M 241.3 g/mol, Bp 168–170 °C (760 mm Hg), density $d_{20}^{20}/4^{\circ} = 1.121$

Silylation reagent that donates a *tert*-butyldimethylsilyl group (TBDMS) for derivatizing active hydrogen atoms in hydroxyl, carboxyl and thiol groups as well as primary and secondary amines; fast reactions (typically 5–20 min) with high yields (> 96%); by-products are neutral volatiles

TBDMS ethers are 10^4 times more stable than the corresponding TMS ethers

Due to the large protecting group, chromatographic retention times are longer. This may have a beneficial impact on some separations. The high concentration of $\text{M}^{+}-57$ ions is an interesting topic for GC/MS.

Silylation with MSTFA, MSHFBA or MBDSTFA

Procedure:

Dissolve 10–15 mg sample in 0.8 mL solvent, then add 0.2 mL of the silylation reagent. The reaction mixture can be heated to 60–70 °C for up to 1 h and can be analyzed directly. If TFA is used as a solvent, proceed as follows [M. Donike, J. Chromatogr. **85** (1973) 1–7]: dissolve 1–2 mg sample in 100 μL TFA. Dropwise add 0.9 mL of the silylating reagent. After cooling the sample can be chromatographed directly.

MSTFA MN Appl. No. 213111 · MSHFBA MN Appl. No. 213112 · MBDSTFA MN Appl. No. 213113

Ordering information

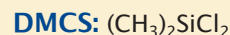
		Packing unit					
10 x 1 mL	20 x 1 mL	1 x 10 mL	5 x 10 mL	1 x 100 mL	6 x 50 mL	6 x 100 mL	12 x 100 mL
MSHFBA*							
	701260.201	701260.110	701260.510	701260.1100		701260.6100	
MSTFA*							
	701270.201	701270.110	701270.510	701270.1100	701270.650	701270.6100	701270.12100
MBDSTFA*							
701440.101	701440.201						

* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.



DMCS · HMDS · TMCS · TSIM

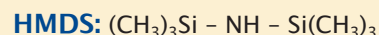
Dimethyldichlorosilane



M 129.06 g/mol, Bp 70 °C (760 mm Hg), density $d_{20}^{20}/4^\circ = 1.07$

Used to form dimethylsilyl (DMS) derivatives; DMS derivatives are much more susceptible to hydrolysis than TMS derivatives, it is therefore vital to have strictly anhydrous conditions during the conversion.

Hexamethyldisilazane



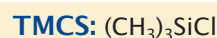
M 161.4 g/mol, Bp 126 °C (760 mm Hg), density $d_{20}^{20}/4^\circ = 0.7742$

Weak TMS donor; used as a sole reagent, it is slow and not very effective.

With catalytic quantities, e.g., 1% of, or as a mixture with TMCS (2:1, v/v; SILYL-21 and SILYL-2110) it is perfectly suited for a quick and quantitative trimethylsilylation of organic compounds.

Aprotic solvents like acetonitrile, pyridine, dimethylformamide, carbon disulfide and dimethylacetamide recommend themselves for use with HMDS.

Trimethylchlorosilane



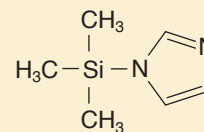
M 108.7 g/mol, Bp 57 °C (760 mm Hg), density $d_{20}^{20}/4^\circ = 0.8580$

Often used as a catalyst with other trimethylsilyl reagents

As a sole reagent, it can be used to prepare TMS derivatives of organic acids.

N-Trimethylsilyl-imidazole

TSIM:



M 140.3 g/mol, Bp 94–96 °C (760 mm Hg), density $d_{20}^{20}/4^\circ = 0.961$

Strongest hydroxyl silylator; reagent of choice for carbohydrates and most steroids (even strongly hindered steroids)

It is remarkable that TSIM reacts quickly and smooth with hydroxyl (even *tert.* OH) and carboxyl groups, but not with amines. Hence it is especially suited for multiple derivatizations, when compounds with various functional groups are to be derivatized in different ways (e.g., –O–TMS, –N–HFB derivatives of catecholamines).

Recommended applications:

alcohols, phenols, organic acids, steroids, hormones, glycols, nucleotides, narcotics

Silylation with TSIM or SILYL-1139 (TSIM – pyridine 11:39)

Procedure:

Dissolve 10–15 mg sample in 0.8 mL solvent, then add 0.2 mL of the silylation reagent. The reaction mixture can be heated to 60–70 °C for up to 1 hour and can be analyzed directly.

Recommended solvent pyridine

When using SILYL-1139, the presence of water does not interfere.

TSIM MN Appl. No. 213121 · SILYL-1139 MN Appl. No. 213122

Ordering information

Substance	Packing unit			
	20 x 1 mL	1 x 10 mL	5 x 10 mL	6 x 50 mL
DMCS*				701230.650 **
HMDS*			701240.510	701240.650 **
TMCS*	701280.201 **			701280.650 **
TSIM	701310.201	701310.110	701310.510	

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Due to their purpose, derivatization reagents are very reactive substances. For this reason they should be stored cool and protected from moisture. For easy access with a syringe, our derivatization reagents are supplied in vials with crimp caps (** in vials with screw caps). Vials with pierced sealing disks have limited stability and should be used soon.



Reagents and procedures for silylation

Reagent mixtures for silylation

Mixture	Composition	20 x 1 mL	1 x 10 mL	5 x 10 mL	1 x 50 mL	1 x 100 mL
SILYL-271	BSA – HMDS – TSIM (2:7:1)	701450.201	701450.110	701450.510		
SILYL-1139	TSIM – pyridine (11:39)	701460.201				
SILYL-21	HMDS – TMCS (2:1)	701470.201				
SILYL-2110	HMDS – TMCS – pyridine (2:1:10)	701480.201				
SILYL-991	BSTFA – TMCS (99:1)	701490.201			701490.150	701490.1100

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Silylation with SILYL-21 or SILYL-2110

Procedure:

Carefully add SILYL-21 or SILYL-2110 to 1–10 mg of the sample. Precipitated ammonium chloride does not interfere. If the sample should not dissolve within 5 min, heat to 75–85 °C. If no mutarotation is to be expected, you may dissolve the sugar in warm pyridine first and then add the silylation reagent. In some cases it may be advantageous to use a different solvent instead of pyridine. For derivatization of 3-ketosteroids we recommend to use DMF (dimethylformamide).

SILYL-21 MN Appl. No. 213131 · SILYL-2110 MN Appl. No. 213132

- Recommended applications: sugars, glycols, sterically unhindered alcohols, carboxylic acids, acids in urine, hydroxy fatty acids, nucleotides, steroids, vitamin D, xanthone derivatives

O-Trimethylsilylation with MSTFA followed by N-trifluoroacetylation with MBTFA

Procedure:

Completely silylate 2 mg of the sample with 0.3 mL MSTFA, e.g., as described on page 286. After addition of 0.3 mL MBTFA the N-trimethylsilyl group is replaced by the N-trifluoroacetyl group. The mixture can be analyzed directly.

MN Appl. No. 213140





Test mixtures for GC

- Test mixtures for GC capillary columns to control the performance of fused silica capillary columns and the GC system
- Test mixtures for chiral GC columns



Ordering information

Designation	Composition	Pack of	REF
Polarity mixture POL ₅ (qualitative) in <i>n</i> -pentane	1-butanol, benzene, methyl butyrate, toluene, cyclopentanone, 1-octene, dibutyl ether	1 mL	722306
Activity test mixture (FA-TMS test according to Donike) in MSTFA/ <i>n</i> -hexane (1 + 4)	1 mg/mL each of TMS capric acid (C ₁₀), TMS myristic acid (C ₁₄), TMS stearic acid (C ₁₈), TMS behenic acid (C ₂₂), hexadecane (C ₁₆), eicosane (C ₂₀), tetracosane (C ₂₄), octacosane (C ₂₈)	1 mL	722307
Grob test mixture (modified) in <i>n</i> -hexane	(in mg/mL) <i>n</i> -decane (~2.8), <i>n</i> -undecane (~2.9), <i>n</i> -octanol (~3.6), 2,6-dimethylphenol (~3.2), 2,6-dimethylaniline (~3.2), methyl decanoate (~4.2), dicyclohexylamine (~3.1), methyl undecanoate (~4.2), methyl dodecanoate (~4.1)	1 mL	722310
MN OPTIMA® test mixture in pentane	0.1% each of undecane, dodecane, octanol, dimethylaniline, decylamine, methyl decanoate, methyl undecanoate, henicosane, docosane, tricosane (chromatograms see page 240)	1 mL	722316
MN OPTIMA® amine test mixture in ethanol	0.2% diisobutylamine, 1% diethanolamine, 0.2% 2,6-dimethylaniline, 0.2% <i>o</i> -propanol-pyridine, 0.2% dicyclohexylamine, 0.2% dibenzylamine	1 mL	722317
FAME test mixture in hexane	0.1% each of FAMES C4, C6, C8, C10, C12, C14, C16, C18, C18:1 <i>cis</i> , C18:1 <i>trans</i> , C18:2, C18:3, C20, C22, C22:1, C24 (chromatogram see page 262)	1 mL	722320

Test mixtures for chiral GC capillary columns

Test mixture for	Test compound (enantiomer mixture)	Pack of	REF
LIPODEX® A, HYDRODEX β-PM, β-3P, β-6TBDM, β-TBDAC, γ-TBDAC	1% phenylethanol in CH ₂ Cl ₂	1 mL	722321
LIPODEX® B	methylbutyrolactone	1 mL	722322
LIPODEX® C, D	phenylethylamine (TFA)	1 mL	722323
LIPODEX® E, G, HYDRODEX γ-DiMOM	phenylethanol (TFA)	1 mL	722319

These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.



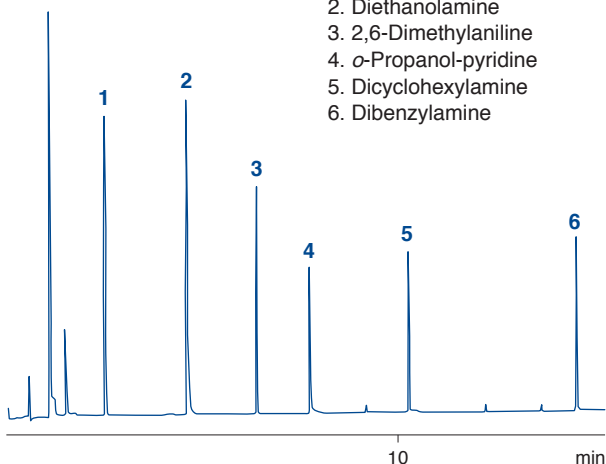
Test mixtures for GC capillary columns

OPTIMA® Amine test mixture (REF 722317)

Column: OPTIMA® 5 Amine, 1.0 µm film, 30 m x 0.32 mm ID
 Injection: 1 µL, split 1:50
 Carrier gas: 0.6 bar H₂
 Temperature: 100 °C → 290 °C, 10 °C/min
 Detector: FID 280 °C

Peaks:

1. Diisobutylamine
2. Diethanolamine
3. 2,6-Dimethylaniline
4. *o*-Propanol-pyridine
5. Dicyclohexylamine
6. Dibenzylamine



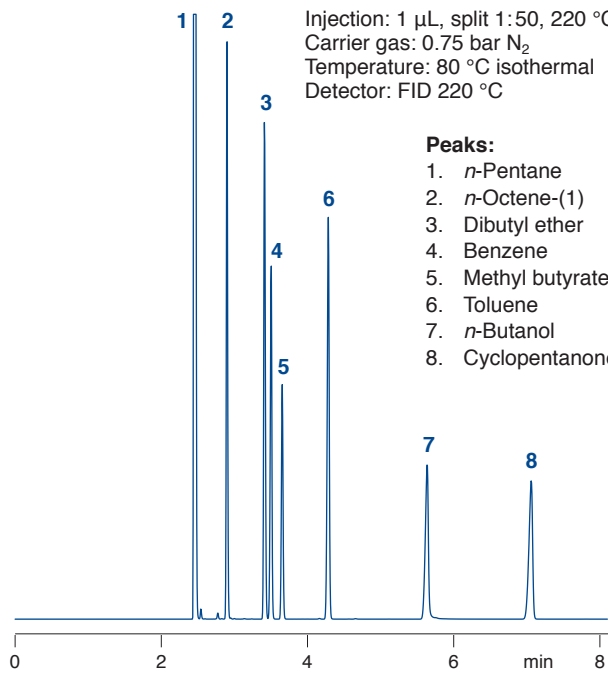
MN Appl. No. 250020

Polarity mixture POL₅ (qualitative) (REF 722306)

Column: OPTIMA® Wax, 0.25 µm film, 25 m x 0.25 mm ID
 Injection: 1 µL, split 1:50, 220 °C
 Carrier gas: 0.75 bar N₂
 Temperature: 80 °C isothermal
 Detector: FID 220 °C

Peaks:

1. *n*-Pentane
2. *n*-Octene-(1)
3. Dibutyl ether
4. Benzene
5. Methyl butyrate
6. Toluene
7. *n*-Butanol
8. Cyclopentanone



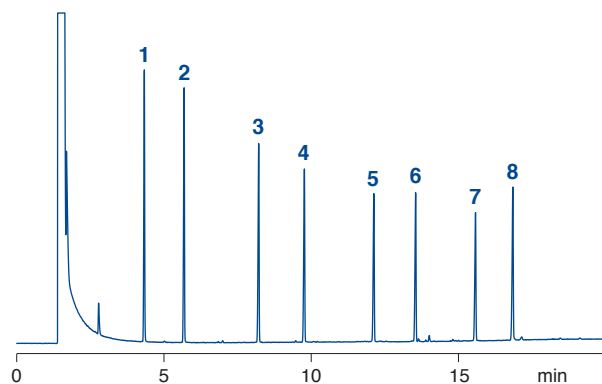
MN Appl. No. 211230

Activity test mixture (REF 722307)

Column: OPTIMA® 5, 1.0 µm film, 25 m x 0.32 mm ID
 Injection: 1 µL, split 1:40, 300 °C
 Carrier gas: 0.6 bar H₂
 Temperature: 150 °C → 300 °C (8 min), 10 °C/min
 Detector: FID 300 °C

Peaks:

1. TMS capric acid (C₁₀)
2. Hexadecane (C₁₆)
3. TMS myristic acid (C₁₄)
4. Eicosane (C₂₀)
5. TMS stearic acid (C₁₈)
6. Tetracosane (C₂₄)
7. TMS behenic acid (C₂₂)
8. Octacosane (C₂₈)



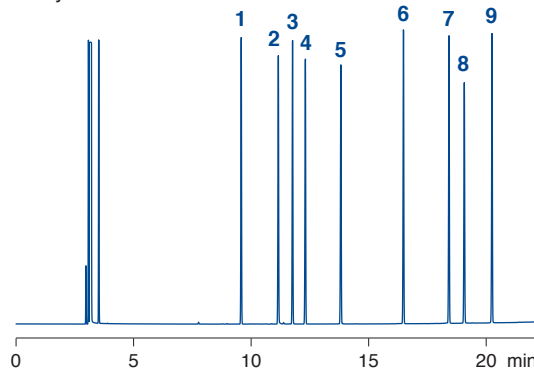
MN Appl. No. 211240

Grob test mixture (modified) (REF 722310)

Column: OPTIMA® 5, 1.0 µm film, 50 m x 0.25 mm ID
 Injection: 1 µL, split 1:40, 280 °C
 Carrier gas: 1.5 bar H₂
 Temperature: 80 °C → 280 °C (10 min), 8 °C/min
 Detector: FID 280 °C

Peaks:

1. *n*-Decane
2. 1-Octanol
3. *n*-Undecane
4. 2,6-Dimethylphenol
5. 2,6-Dimethylaniline
6. Methyl decanoate
7. Methyl undecanoate
8. Dicyclohexylamine
9. Methyl dodecanoate



MN Appl. No. 211250



Ordering information

Designation	Composition	Pack of	REF
Haloform test mixture in <i>n</i> -pentane (qualitative)	9 halogenated hydrocarbons acc. to German drinking water specifications (in ng/mL): dichloromethane (795), chloroform (75), 1,1,1-trichloroethane (67), carbon tetrachloride (80), trichloroethylene (73), bromodichloromethane (100), dibromochloromethane (122), tetrachloroethylene (81), bromoform (145)	1 mL	722311
Haloform test mixture in methanol for head-space analyses (qualitative)	9 halogenated hydrocarbons in increased concentration for calibration acc. to German Industrial Standard DIN 38407, part 5 (in µg/mL): dichloromethane (158.4), chloroform (14.9), 1,1,1-trichloroethane (13.4), carbon tetrachloride (15.9), trichloroethylene (14.6), bromodichloromethane (20), dibromochloromethane (24.5), tetrachloroethylene (16.2), bromoform (28.9)	1 mL	722371
Haloform test kit (qualitative)	1 mL each of 9 single undiluted halogenated hydrocarbons and 1 mL each of test mixtures REF 722311 and REF 722371	11 x 1 mL	722312
PAH test mixture acc. to EPA in toluene	20 µg/mL each of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenz[a,h]anthracene, benzo[ghi]perylene	1 mL	722314
PAH test mixture acc. to German drinking water specifications in toluene	20 µg/mL each of fluoranthene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, benzo[ghi]perylene	1 mL	722331
BTX test mixture in methanol	10 ng/µL each of benzene, ethylbenzene, toluene, <i>m</i> -, <i>o</i> -, <i>p</i> -xylene	1 mL	722372

These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.

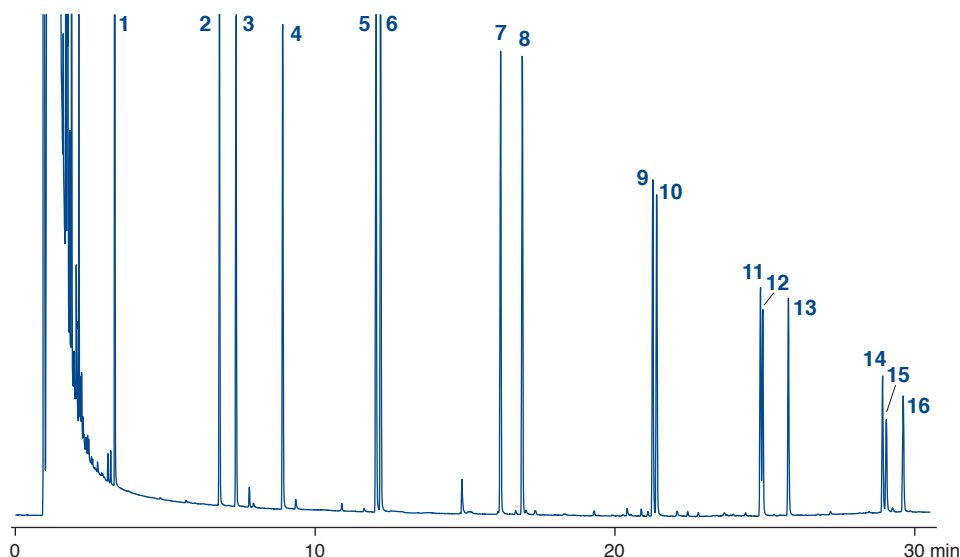
Reagents for GC

PAH test mixture acc. to EPA for GC (REF 722314)

Column: OPTIMA® 5, 0.25 µm film, 30 m x 0.32 mm ID
 Sample: PAH test mixture according to EPA (20 µg/mL each in toluene)
 Injection: 1.0 µL, split 1:15
 Carrier gas: H₂, 70 kPa
 Temperature: 100 °C, 7 °C/min → 300 °C
 Detector: FID 300 °C

Peaks:

1. Naphthalene
2. Acenaphthylene
3. Acenaphthene
4. Fluorene
5. Phenanthrene
6. Anthracene
7. Fluoranthene
8. Pyrene
9. Benz[a]anthracene
10. Chrysene
11. Benzo[b]fluoranthene
12. Benzo[k]fluoranthene
13. Benzo[a]pyrene
14. Indeno[1,2,3-cd]pyrene
15. Dibenz[ah]anthracene
16. Benzo[ghi]perylene



MN Appl. No. 200510



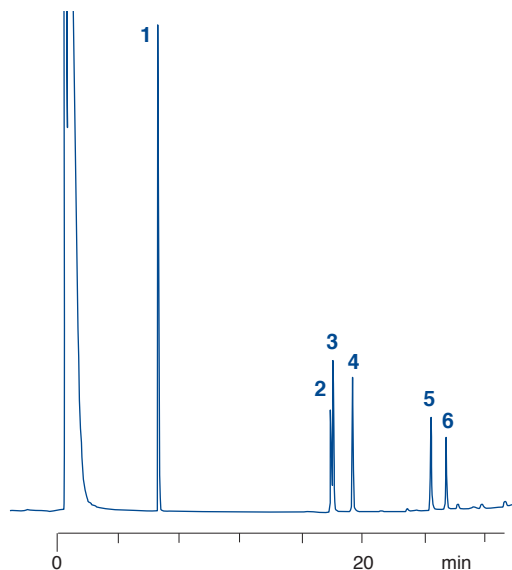
Test mixtures for environmental analyses

PAH test mixture acc. to German drinking water specifications (REF 722331)

Column: OPTIMA® 5, 0.25 µm film, 25 m x 0.32 mm ID
 Injection: 2 µL, split 1:10
 Carrier gas: 0.6 bar H₂
 Temperature: 80 °C → 180 °C → 300 °C, 4 °C/min
 Detector: FID 300 °C

Peaks:

1. Fluoranthene
2. Benzo[b]fluoranthene
3. Benzo[k]fluoranthene
4. Benzo[a]pyrene
5. Indeno[1,2,3-cd]pyrene
6. Benzo[ghi]perylene



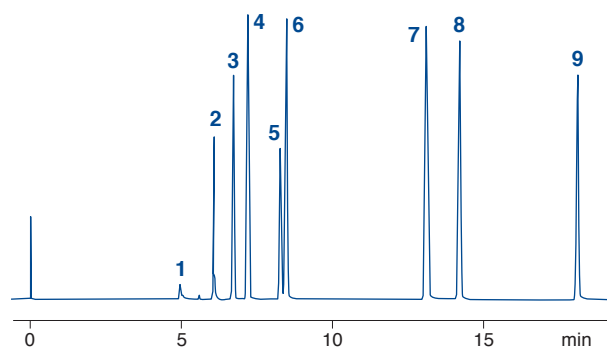
MN Appl. No. 200450

Haloform test mixture (REF 722311)

Column: FS-SE-54, 0.35 µm film, 50 m x 0.25 mm ID
 Injection: 1 µL, split ~ 1:30
 Carrier gas: 1 bar N₂
 Temperature: 45 °C (10 min) → 120 °C, 8 °C/min
 Detector: ECD 260 °C

Peaks:

1. Dichloromethane
2. Trichloromethane
3. 1,1,1-Trichloroethane
4. Tetrachloromethane
5. Trichloroethene
6. Bromodichloromethane
7. Dibromochloromethane
8. Tetrachloroethene
9. Tribromomethane



MN Appl. No. 211190

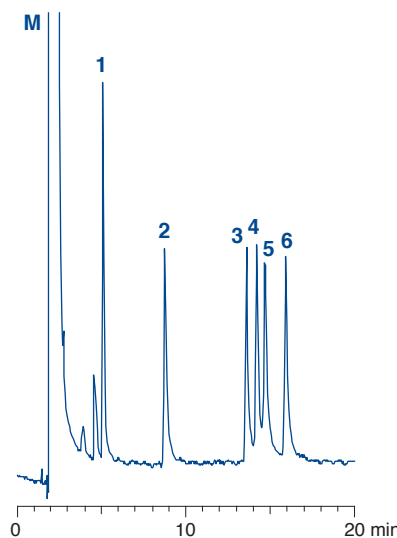
BTX test mixture (REF 722372)

Column: HYDRODEX β-PM, 50 m x 0.25 mm ID
 Injection: 2 µL (10 ng/µL each in methanol), split 40 mL/min
 Carrier gas: 120 kPa H₂ (2.45 mL/min)
 Temperature: 60 °C → 100 °C, 2 °C/min
 Detector: FID 250 °C

Peaks:

M = methanol

1. Benzene
2. Toluene
3. *p*-Xylene
4. *m*-Xylene
5. Ethylbenzene
6. *o*-Xylene



MN Appl. No. 211220



Ferrules for GC

- Graphite ferrules provide the highest temperature stability (up to 450 °C). They are reusable, if handled with care. We also offer 1/16" graphite ferrules specially designed for Carlo Erba / Fisons or for Agilent gas chromatographs.
- Vespel ferrules come in three types: pure Vespel, Vespel with 15% graphite and Vespel with 40% graphite. All versions are temperature-stable up to 400 °C and reusable.
- PTFE ferrules can only be used up to 250 °C. They are not reusable and not recommended for temperature programming. However, they show the best chemical inertness of all ferrules.



Ordering information (packing unit 10 ferrules)

Bore (= column OD)	Graphite	plain	Vespel		PTFE
max. temperature →	450 °C	400 °C	+ 15% graphite 400 °C	+ 40% graphite 400 °C	250 °C
1/16" ferrules					
no bore	708336	706187	706167		706177
0.4 mm	708309			706246	
0.5 mm	708308			706247	
0.8 mm	708301			706248	
1.0 mm	708302				
1.2 mm	708303				
1/16"	706155	706180	706160	706190	706170
1/16" ferrules for Carlo Erba (Fisons) instruments					
0.4 mm	708338				
0.5 mm	708339				
0.8 mm	708340				
1/16" ferrules for Hewlett-Packard (Agilent) instruments					
0.4 mm	708353				
0.5 mm	708354				
0.8 mm	708355				
1/8" ferrules					
no bore	708341	706188	706168		706178
0.4 mm	708342	706266	706249	706240	
0.5 mm	708343				
0.8 mm	708333	706268			
1/16"	708158	706183			
1/8"	708156	706181		706191	706171
1/4" ferrules					
no bore	708344		706169	706199	
0.4 mm	708345				
0.5 mm	708346				
1/16"			706164		
1/8"		706185			
6.0 mm	708348	706186		706196	706176
1/4"	706157	706182		706192	706172
6 mm ferrules					
no bore		706252			
6.0 mm					706259

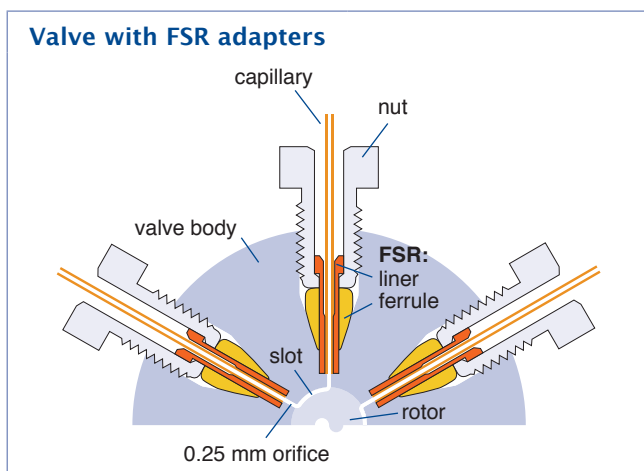
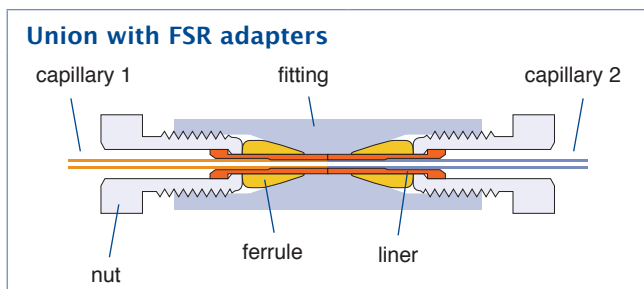
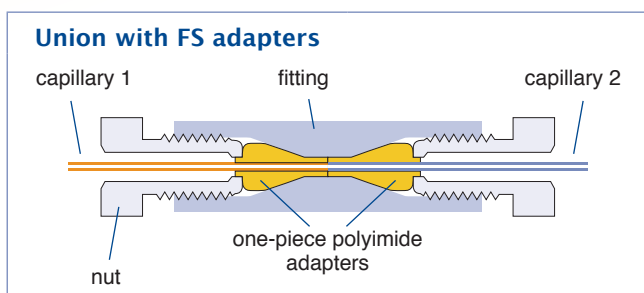
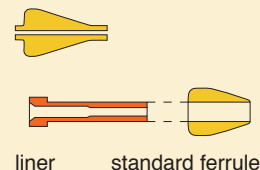
If you are in doubt about the correct size or REF please send us an old, used ferrule as a sample.



Accessories for capillary columns

Valco fused silica adapters and fittings for capillary GC

- One-piece FS adapters:** recommended for use in fittings where the polyimide ferrule need not be removed
- Two-piece removable FSR adapters:** recommended for use in Valco valves; consists of a liner which slides over the fused silica tubing, and a ferrule, both made of high temperature polyimide alloys. The liner has an enlarged diameter at one end that is captured by the nut, so both (liner and tube) are removed when the nut is unscrewed from the valve (see figure below). The 1/16" FSR adapter comes with a special counterbored 1/16" nut (ZCN1) to receive the liner. The 1/32" adapter works with standard Valco 1/32" nuts.



If you intend to use fused silica adapters (FS or FSR) with Valco unions, please order the fittings with "J" at the end of the Valco code and the appropriate number of adapters. The fittings in the table on the opposite page are supplied without stainless steel ferrules, but with standard nuts. For two-piece FSR adapters, the use of specially counterbored nuts ZCN1 (provided with the adapters) is mandatory.

Examples:

- Connection of 2 capillaries with 0.25 mm ID and 0.4 mm OD: either use a 1/32" union ZU.5TJ and 2 FS adapters FS.4 or a 1/32" union ZU.5TJ and 2 removable FSR adapters FSR.4
- Connection of 2 capillaries with 0.53 mm ID and 0.8 mm OD: we recommend either a 1/16" union ZU1TJ and 2 FS adapters FS1-.8 or a 1/16" union ZU1TJ and 2 removable FSR adapters FS1R.8

If capillaries 1 and 2 have different outer diameters, the corresponding different FS adapters have to be used.

If you want to use Valco valves with fused silica adapters, you need to order the required quantity of FSR adapters in addition to the valve. Please note that the specially counterbored nut ZCN1, included in FS1R.5 and FS1R.8, is still mandatory for 1/16" FSR adapters.

Examples:

- Attachment of a capillary with 0.32 mm ID (0.5 mm OD) to a valve with 1/32" fittings: we recommend the removable FSR adapter FSR.5.
- Attachment of a capillary with 0.53 mm ID (0.8 mm OD) to a valve with 1/16" fittings: we recommend the removable FSR adapter FS1R.8.



Ordering information

Valco code	Description	Pack of	REF	
One-piece fused silica adapters				
				for capillary OD
FS.25-5	1/32"	< 0.25 mm	5	724405
FS.4-5	1/32"	0.25-0.4 mm	5	724243
FS.5-5	1/32"	0.4-0.5 mm	5	724244
FS1.4-5	1/16"	< 0.4 mm	5	724406
FS1.5-5	1/16"	0.4-0.5 mm	5	724407
FS1.8-5	1/16"	0.6-0.8 mm	5	724408
Removable fused silica adapters (incl. nuts)				
FSR.25-5	1/32"	< 0.25 mm	5	724409
FSR.4-5	1/32"	0.25-0.4 mm	5	724410
FSR.5-5	1/32"	0.4-0.5 mm	5	724411
FS1R.5-5	1/16"	< 0.5 mm	5	724335
FS1R.8-5	1/16"	0.5-0.8 mm	5	724334
Replacement liners				
FSL.25-5	1/32"	< 0.25 mm	5	724412
FSL.4-5	1/32"	0.25-0.4 mm	5	724413
FSL.5-5	1/32"	0.4-0.5 mm	5	724414
FS1L.5-5	1/16"	< 0.5 mm	5	724415
FS1L.8-5	1/16"	0.5-0.8 mm	5	724416
Special nut for fused silica adapters				
ZCN1	1/16"	counterbored	1	724417
For standard Vespel ferrules as well as standard nuts please have a look at the Valco program, which is available on request.				
Unions, Tees and crosses for fused silica adapters (without ferrules, but incl. standard nuts)				
ZU.5TJ	1/32"- 1/32"	for butt connection	1	724418
ZU1TJ	1/16"- 1/16"	for butt connection	1	724333
ZT.5J	1/32"	Tee	1	724421
ZT1CJ	1/16"	Tee, capillary bore	1	724336
ZX.5J	1/32"	cross	1	724422
ZX1CJ	1/16"	cross, capillary bore	1	724337
Tools for Valco fused silica adapters				
OEW	open end wrench (3/16" x 1/4")		1	724423
PV	pin vise and drill index (0.34 to 1.0 mm)		1	724424
				for use with 1/32" fittings
				application see text below

In case of a broken tubing in a through-bore union, remove the nut and the intact tubing on the opposite site of the broken one. Clear the fitting by pushing a fine wire or capillary drill through the center.

To remove ferrules from fittings, we recommend the use of a ferrule removal kit (Valco code FRK1). Use a pin vise and drill index (Valco code PV) to widen the inner diameters of FS adapters.

For other fittings and valves for GC please ask for our VICI® / Valco program.

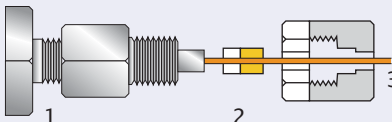


Accessories for capillary columns

Connectors for capillary GC columns

- Graphseal ferrules** for capillary columns: a stainless steel ferrule filled with graphite – the ideal sealing material for capillaries · The capillary is mounted on a 1/16" exit (detector, injector etc.), with the appropriate ferrule, a nut (with slit) and an adapter (see table below).
- Glass connectors** for fused silica capillary columns from 0.2 to 0.53 mm ID manufactured from deactivated glass with slightly tapered inner diameter; used to join two fused silica capillaries of equal or different diameters. Advantages compared to stainless steel fittings are easy connection without tools, optical control during connection, negligible heat capacity and no dead volume.
- PTFE shrink tube** also applicable for capillary connection. The minimum ID of the expanded tubing is 1.17 mm, the maximum ID of the shrunk tube is 0.40 mm. Shrinking occurs above 310 °C. Connections with PTFE shrink tube are applicable up to 200 °C only. They should never be used above 250 °C.

Ordering information

Description	Pack of	REF	Specification
Graphseal ferrules for capillary columns			
0.4 mm bore	10 ferrules	708337	 1 1/16" exit, injector or detector 2 Graphseal ferrule 3 capillary
0.5 mm bore	10 ferrules	708318	
0.8 mm bore	10 ferrules	708319	
Universal capillary glass connectors			
linear	5 connectors	707971	 
linear	10 connectors	707972	
Y splitter	1 connector	707973	
PTFE shrinking tube, thin-walled	1 m	708305	for capillary connection, min. ID expanded 1.17 mm, max. ID shrunk 0.40 mm



Septa for GC

Designation	Standard septa (ST)	High temperature septa (HT)	Silicone septa, soft	Silicone septa PTFE
				
Material	beige silicone	red, non-bleeding silicone	transparent silicone	white silicone, one side laminated with grey PTFE
Thickness	4 mm	3 mm	3 mm	3 mm
Hardness	60 shore A	60 shore A	45 shore A	
max. Temp.		320 °C *	250 °C	200 °C

* If used at considerably higher temperatures – and working without septum purge – interfering peaks can occur due to thermal decomposition of the material.



Ordering information

Septum grade (packs of 50 septa)	Outer diameter					
	9 mm N 9	10 mm N 10	11 mm N 11	12 mm N 12	13 mm N 13	17 mm N 17
Standard septa (ST)	702609	702610	702611	702612	702613	
High temperature septa (HT)	702619	702620	702621	702622	702623	702632
Silicone septa, soft	702602		702604	702605	702606	
Silicone septa PTFE		702625	702626	702627	702628	
Septum remover (tool for removing septa baked into the injection port of the gas chromatograph)						706141

Tools and general accessories for GC

- Diamond file:**
 a useful tool for cutting capillaries and smoothing ends of capillaries. Square capillary ends are especially important for butt connections (e.g., in Valco unions).
- Magnifying lens:** an essential tool for any laboratory.
 In capillary GC it is often important to inspect column integrity or check cut ends of capillaries. When closing a column by melting the magnifying lens can be used to check whether the column is really closed or whether an open channel has been formed in the sealed end. Our lens provides 8fold magnification and is supplied with a scale as pictured in the figure below. The space between lines is equivalent to 1/10 mm.
- Glass wool, quartz wool and glass fiber wadding** are used for, e.g., GC liners, packed GC columns etc.



Lens with scale



Diamond file

Ordering information

Description	Specification	Pack of	REF
Tools for capillary GC			
Diamond file	for cutting capillaries and straightening capillary ends	1	708300
Magnifying lens with scale	magnification 8x	1	706296
Glass wool			
Glass wool, long fibers, DMCS treated, for packed GC columns		50 g	706201
Glass fiber wadding silanized, very fine fibers		25 g	718002
Quartz wool, very fine fibers		25 g	718587
Glass wool extractor for GC columns		1	706117
PTFE tape for sealing, reels 10 m long, 12 mm wide, 0.1 mm thick		1 reel	706512