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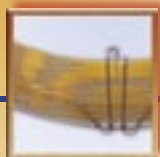
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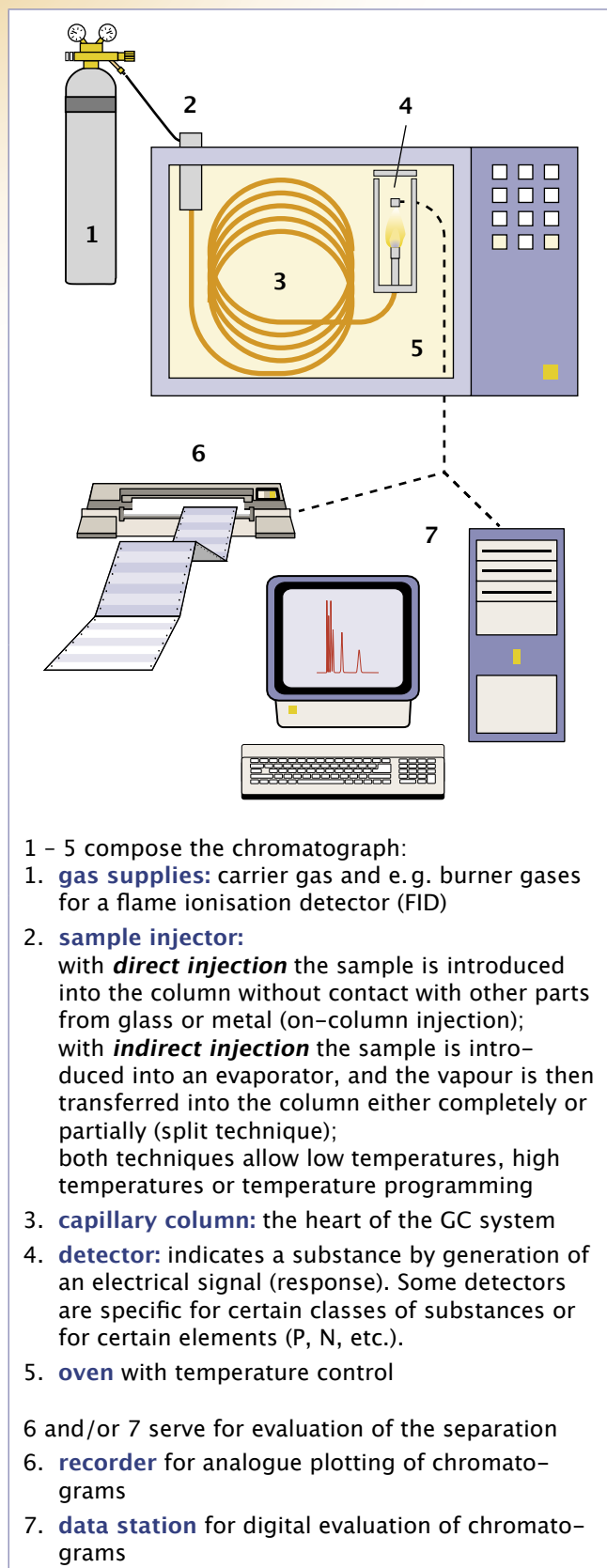
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Basic principles of capillary GC

Capillary columns for GC

The GC system



The separation process

Chromatographic separation is achieved by repeated distribution of each sample component between two phases:

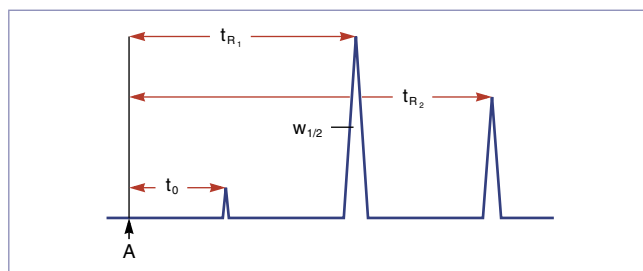
In GC, the **mobile phase** is always a gas (mostly N_2 , H_2 , He).

The **stationary phase** is a mostly viscous gumlike liquid coated to the inner wall of a capillary column (WCOT = Wall Coated Open Tubular).

Transport of the components is achieved exclusively in the gas phase, separation is accomplished in the stationary phase. The quality of a separation (resolution) depends on how long the components to be separated stay in the stationary phase and on how often they interact with this phase. The type of interaction between component and phase (selectivity) is determined by the functional groups. The polarity of the phase is a function of stationary phase 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):

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

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_{Ri} : retention time = time interval between peak i and the point of injection

t_{Ri}' : 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 characterising a separation:

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

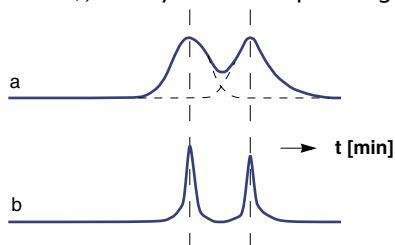
$$k'_i = \frac{t_{Ri} - t_0}{t_0}$$



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

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

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



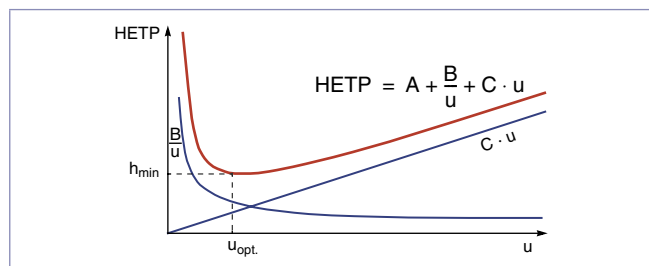
R: resolution: a measure for the quality of a separation, taking the peak width at half height ($w_{1/2}$) into account according to

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

N_{th} : number of theoretical plates: characterises 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 better works 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 Van Deemter equation shows how the plate height h depends on the flow velocity u :



- A Eddy diffusion; for WCOT capillary columns $A = 0$
- 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, since higher carrier velocities mean shorter retention times.

Parameters characterising 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

reaches 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 compounds, temperature labile or very closely eluting substances. Increasing film thickness will increase the capacity, the retention time for low boiling compounds and improve inertness. This is especially useful for samples with widely differing concentrations, or for the separation of volatile polar substances.

Better coverage of the column wall by a thicker film and a reduction of the column surface due to a reduced length are favourable for extremely active substrates, which in many cases cause noticeable tailing, if they come in contact with uncoated spots of the column wall.

Thick films also mean more phase in the column, and consequently higher bleeding. This results in lower maximum operating temperatures for thick film columns. In addition, thick film columns may have a lower efficiency.

C. Column length

column length is directly proportional to the separation efficiency (number of plates N). Routine separations are most frequently performed on 25 or 30 m columns, while complex mixtures may require 50 or 60 m columns. 10 m columns with 0.1 mm ID are used for fast GC (see page 224)

D. Inner diameter (ID)

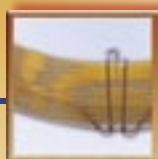
the lower the ID, the higher is the theoretically possible number of plates per meter;

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

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, which may improve a separation. When increasing the polarity, e.g. by introducing phenyl and / or cyanopropyl groups, separation is increasingly influenced by differences in dipole moment and by charge transfer (e.g. for 5 – 50 % diphenylpolysiloxane phases). Typical analytes are hydrocarbons, which contain oxygen, sulphur, nitrogen, phosphorus or halogen atoms, unsaturated molecules which can be polarised and aromatics.

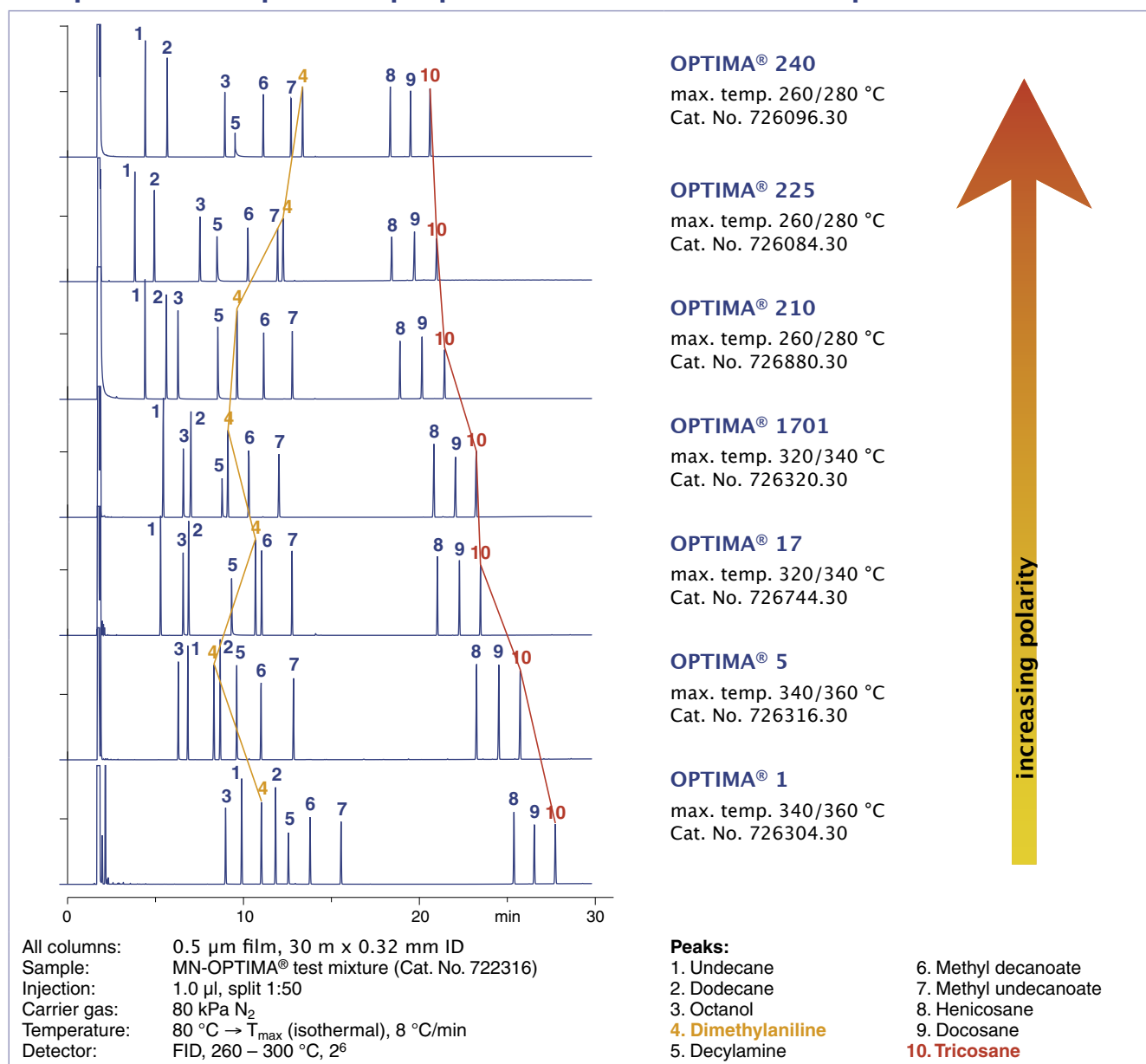
For components featuring different hydrogen bonding capacities and the ability to form strong hydrogen bonds, polyethylene glycol phases (WAX) are the best choice for a separation. Typical analytes are alcohols and carboxylic acids.

Selectivity has to be optimised for the critical pair of components or the main component. You should always select the least polar column which solves your separation task. About 70 % of all separations can be performed on non- to midpolar columns. These columns generally feature high temperature stability.

For columns for special separations please see page 223.

Capillary columns for GC

Comparison of separation properties of selected OPTIMA® phases



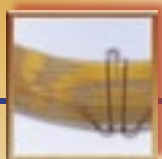


Phase	Composition	max. Temperature ¹	USP	Similar phases ²	Page
OPTIMA® 1	100 % dimethylpolysiloxane	340/360 °C	G1 G2 G38	PERMABOND® SE-30 (page 221), OV-1, DB-1, SE-30, HP-1, SPB-1, CP-Sil 5 CB, Rtx®-1, 007-1, BP1, MDN-1, AT™-1, ZB-1, OV-101	205
OPTIMA® 1 MS	100 % dimethylpolysiloxane	340/360 °C	G1 G2 G38	Ultra-1, DB-1MS, HP-1MS, Rtx®-1MS, Equity™-1, AT™-1MS, VF-1MS, CP-Sil 5 CB MS	206
OPTIMA® 1 MS Accent	100 % dimethylpolysiloxane	340/360 °C	G1 G2 G38		207
OPTIMA® 5	5 % phenyl – 95 % dimethylpolysiloxane	340/360 °C	G27 G36	PERMABOND® SE-52 (page 221), SE-54, SE-52, DB-5, HP-5, SPB-5, CP-Sil 8, Rtx®-5, 007-5, BP5, MDN-5, AT™-5, ZB-5	208
OPTIMA® 5 MS	5 % diphenyl – 95 % dimethylpolysiloxane	340/360 °C	G27 G36	DB-5MS, HP-5MS, Ultra-2, Equity™-5, CP-Sil 8CB low bleed/MS, Rtx®-5SIL-MS, Rtx®-5MS, 007-5MS, BPX5, MDN-5S, AT™-5MS, VF-5MS	209
OPTIMA® 5 MS Accent	silylene phase with selectivity similar to 5 % diphenyl – 95 % dimethylpolysiloxane	340/360 °C	G27 G36		210
OPTIMA® XLB	silylene phase as above, higher aromatic content	340/360 °C	–	DB-XLB, Rtx®-XLB, MDN-12, VF-XMS	211
OPTIMA® δ-3	phase with autoselectivity ³	340/360 °C	G49	no similar phases	203
OPTIMA® δ-6	phase with autoselectivity ³	340/360 °C	–	no similar phases	204
OPTIMA® 17	phenylmethylpolysiloxane, 50 % phenyl	320/340 °C	G3	OV-17, DB-17, HP-50+, HP-17, SPB-50, SP-2250, Rtx®-50, CP-Sil 24 CB, 007-17, ZB-50	212
OPTIMA® 1301	6 % cyanopropylphenyl – 94 % dimethylpolysiloxane	300/320 °C	G43	HP-1301, DB-1301, SPB-1301, Rtx®-1301, CP-1301, 007-1301	214
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	215
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	213
OPTIMA® 210	trifluoropropylmethylpolysiloxane (50 % trifluoropropyl)	260/280 °C	G6	OV-210, DB-210, Rtx®-200, 007-210	216
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	217
OPTIMA® 240	33 % cyanopropylmethyl – 67 % dimethylpolysiloxane	260/280 °C	–	no similar phases	218
OPTIMA® WAX	polyethylene glycol 20 000 daltons	250/260 °C	G16	PERMABOND® CW 20 M (page 222), DB-Wax, Supelcowax™, HP-Wax, HP-INNOWax, Rtx®-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT™-Wax, ZB-Wax	219
OPTIMA® FFAP	polyethylene glycol 2-nitroterephthalate	250/260 °C	G25 G35	PERMABOND® FFAP (page 222), DB-FFAP, HP-FFAP, CP-SIL 58 CB, 007-FFAP, CP-FFAP CB, Nukol	220

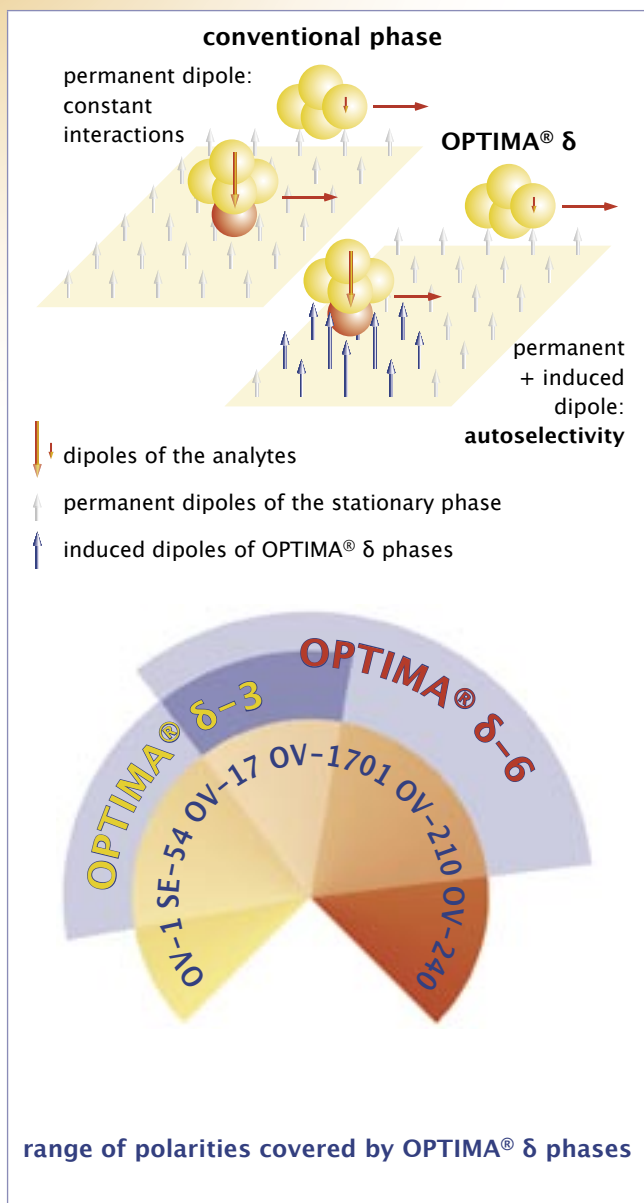
¹ first temperature for isothermal operation, second value for short isotherms in a temperature programme
Please note, that for columns with 0.53 mm ID and for columns with thicker films temperature limits are generally lower.
For details refer to the description of individual phases.

² phases which provide a similar selectivity based on chemical and physical properties

³ see description on page 202



OPTIMA® δ · unique phases with autoselectivity



Key features of the OPTIMA® δ are:

- ⊞ wide range of applications due to autoselectivity
- ⊞ outstanding thermal stability similar to nonpolar phases
- ⊞ low bleed levels
- ⊞ extremely inert
- ⊞ medium polar without CN groups

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.

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

All stationary phases in GC offer a selectivity, called polarisability, that is influenced by the sample, but OPTIMA® δ -3 and OPTIMA® δ -6 offer this valuable feature to a greater extent than any other phase. The polymers consist of cross-linked polysiloxane block polymers with defined composition, and extremely narrow molecular weight distribution, which are exclusively produced for MACHEREY-NAGEL. Especially polar analytes are able to induce a dipole moment in the stationary phase, so that the molecules show stronger interactions with the phase. This enhanced interaction is maintained at higher temperatures, where normally interactions between molecule and phase become reduced due to the Brownian movement. We call this phenomenon "autoselectivity", because the stationary phase adjusts itself to the polarity of the analytes. Thus 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.

Due to this feature, the OPTIMA® δ columns show interesting patterns of selectivity. For example, inversions in the sequence of peak elution may occur, which recommends the columns for reference use (e.g. in combination with OPTIMA® 5).

In conventional midpolar phases the polarity is induced by phenyl, but especially by cyano and trifluoromethyl groups. The two latter often cause bleeding, which results in severe problems with some detectors. In contrast, the OPTIMA® δ phases show very 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 analyse with standard GC phases (e.g. OPTIMA® 5 or OPTIMA® 17) because of coelutions. 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.

References

- W. Röder, D. Lennartz, GiT 3/99, p. 226
R. Looser, K. Ballschmiter, J. Chromatogr. 836 (1999), 271-284
R. Baycan-Keller, M. Oehme, J. Chromatogr. 837 (1999), 201 – 210



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 programme 360 °C

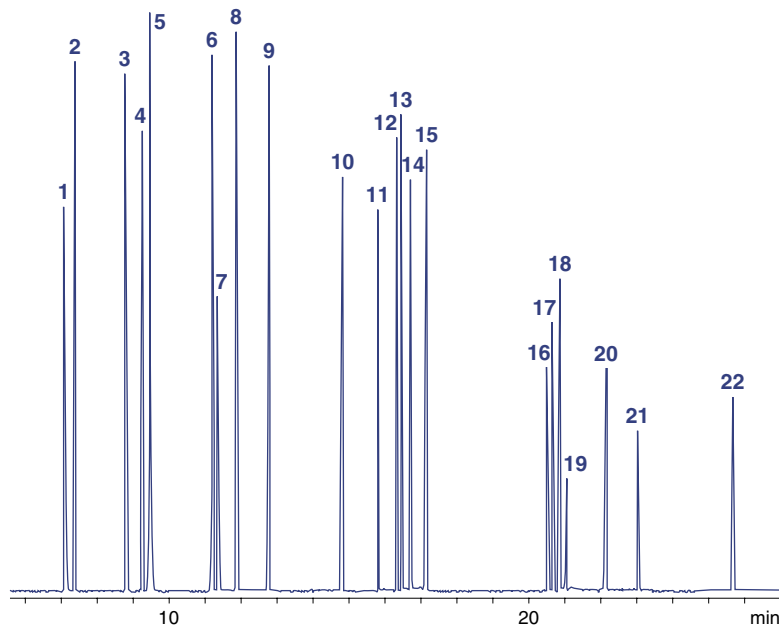
- autoselectivity resulting in a wide range of polarities from approximately the non-polar OPTIMA® 5 to the midpolar OPTIMA® 1701

Analysis of isomeric phenols

Column: OPTIMA® δ-3, 0.25 µm film, 60 m x 0.25 mm ID, max. temperature 340/360 °C, Cat. No. 726420.60
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:

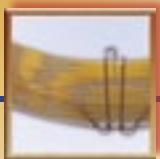
1. Phenol
2. 2-Chlorophenol
3. 2-Methylphenol
4. 4-Methylphenol
5. 3-Methylphenol
6. 2,4-Dimethylphenol
7. 2-Nitrophenol
8. 2,4-Dichlorophenol
9. 2,6-Dichlorophenol
10. 4-Chloro-3-methylphenol
11. 2,3,5-Trichlorophenol
12. 2,4,6-Trichlorophenol
13. 2,4,5-Trichlorophenol
14. 2,3,4-Trichlorophenol
15. 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 programme 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

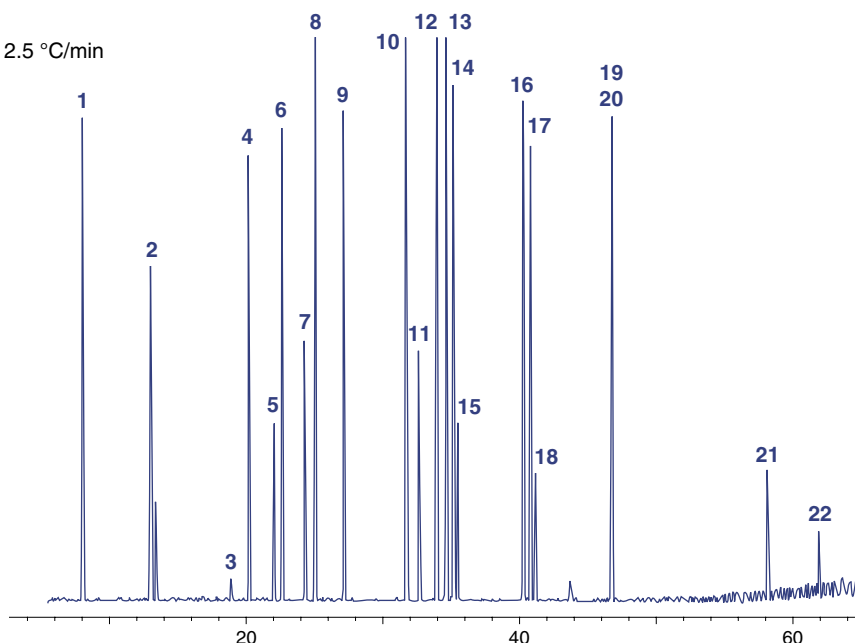
- max. temperature for isothermal operation 340 °C,
max. temperature for short isotherms in a temperature programme 360 °C
- autoselectivity resulting in a wide range of polarities from approximately the non-polar OPTIMA® 17 to the midpolar OPTIMA® 210

Separation of organophosphorus pesticides (EPA 8140/8141)

Column: OPTIMA® δ -6, 0.2 μ m film, 50 m x 0.2 mm ID, max. temperature 340/360 °C, Cat. No. 726465.50
 Sample: EPA 8140 OP pesticide calibration mix (Restek), 200 μ g/ml each in hexane – acetone (95:5)
 Injection volume: 1 μ l, split 1:30
 Carrier gas: 2.0 bar He
 Temperature: 150 °C $\rightarrow$ 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

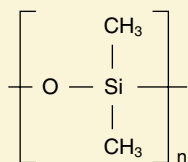
Ordering information

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 programme we will be happy to supply columns custom-made to your specifications.					



OPTIMA® 1

nonpolar phase



similar phases: PERMABOND® SE-30 (page 221), 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

100 % dimethylpolysiloxane



for columns with 0.1 – 0.32 mm ID and films < 3 µm the max. temperature for isothermal operation is 340 °C, the max. temperature for short isotherms in a temperature programme is 360 °C
for 0.53 mm ID columns with films < 3 µm the max. temperatures are 320 and 340 °C, resp.
for thick film columns with films ≥ 3 µm the max. temperatures are 300 and 320 °C, resp.

separation of components according to boiling points
thick film columns ≥ 3 µm film are especially recommended for solvent analysis

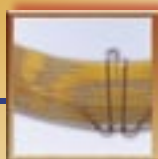
USP G1 / G2 / G38

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					726519.25	726519.30		
1.00 µm film	726529.10		726529.15		726529.25	726529.30		
2.00 µm film	726521.10				726521.25	726521.30		
5.00 µm film	726926.10				726926.25	726926.30	726926.50	
In addition to this standard programme 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. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.

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OPTIMA® high performance capillary columns

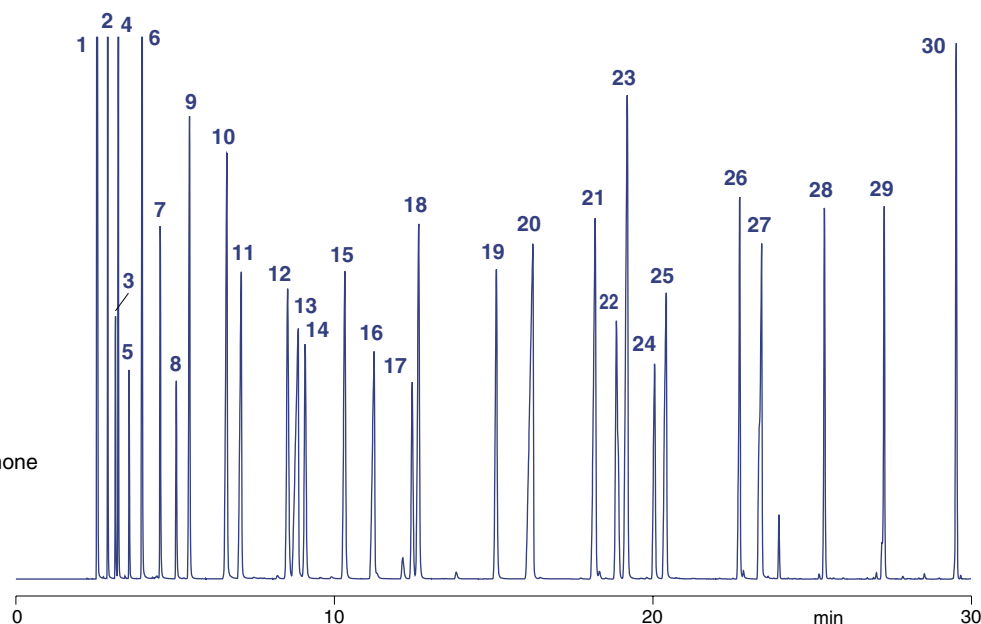
Capillary columns for GC

Solvent analysis

Column: OPTIMA® 1, 1.0 µm film, 60 m x 0.32 mm ID, max. temperature 340/360 °C, Cat. No. 726323.60
 Sample: solvent mixture, courtesy of J. Lutz, Alcan Rorschach, Switzerland
 Injection volume: 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, 2⁶

Peaks:

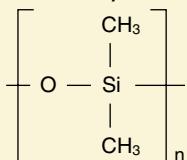
1. Methanol
2. Ethanol
3. Acetone
4. 2-Propanol
5. Methyl acetate
6. *n*-Propanol
7. Methyl ethyl ketone
8. Ethyl acetate
9. Isobutanol
10. *n*-Butanol
11. 1-Methoxy-2-propanol
12. Isooctane
13. Ethyl glycol
14. Isoheptane
15. Methyl isobutyl ketone
16. 1-Ethoxy-2-propanol
17. Toluene
18. Isobutyl acetate
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. Ethyldiglycol
28. Butyldiglycol
29. Butyl glycol acetate
30. Butyldiglycol acetate



MN Appl. No. 201390

OPTIMA® 1 MS

selectivity identical to OPTIMA® 1



similar phases: Ultra-1, DB-1MS, HP-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 programme 360 °C

phase with low bleeding
 ideal for GC/MS and ECD applications and general analyses at trace level

USP G1 / G2 / G38

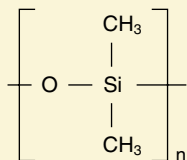
Ordering information

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 programme we will be happy to supply columns custom-made to your specifications.						



OPTIMA® 1 MS Accent

selectivity identical to OPTIMA® 1



NEW!

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 programme 360 °C
- lowest column bleed, nonpolar phase, ideal for ion trap and quadrupol MS detectors
- perfect inertness for basic compounds
- solvent rinsing for removal of impurities applicable
- application areas: 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, Rtx-1 MS, Equity-1, AT-1 MS, VF-1 MS, CP-Sil 5 CB MS

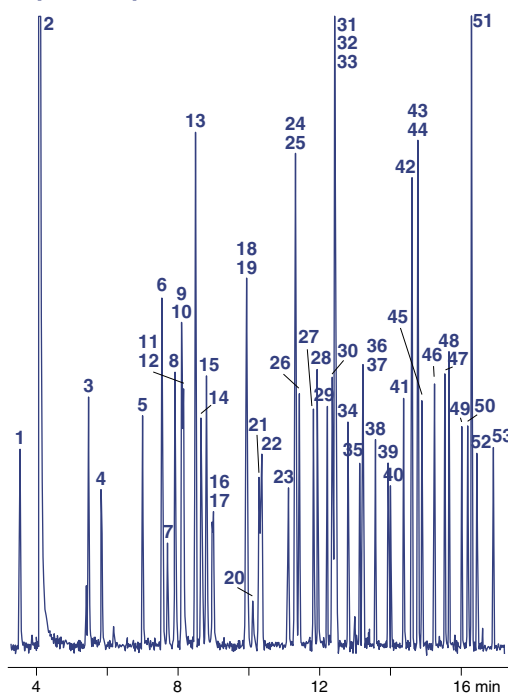
EPA 8140 / 8141 / 8141 A Organophosphorus pesticides

Column: OPTIMA® 1 MS Accent, 0.50 µm film, 30 m x 0.32 mm ID, Cat. No. 725807.30
 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: splitless (hold 1 min)
 Inj. temperature: 250 °C
 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. Crotoxyphos, 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

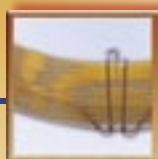
MN Appl. No. 213030



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

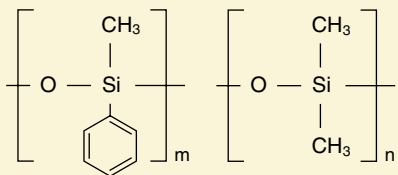
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



OPTIMA® high performance capillary columns

OPTIMA® 5

nonpolar phase



similar phases: PERMABOND® SE-52 (page 221), 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



for columns with 0.1 – 0.32 mm ID and films < 3 µm the max. temperature for isothermal operation is 340 °C, the max. temperature for short isotherms in a temperature programme is 360 °C
for 0.53 mm ID columns with films < 3 µm the max. temperatures are 320 and 340 °C, resp.
for thick film columns with films ≥ 3 µm the max. temperatures are 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		
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 programme we will be happy to supply columns custom-made to your specifications.						

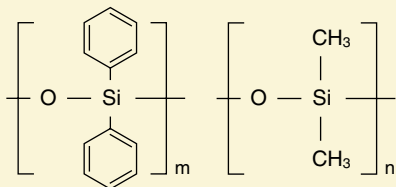
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.

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



OPTIMA® 5 MS

selectivity identical to OPTIMA® 5



similar phases see OPTIMA® 5 MS Accent page 210

5 % diphenyl – 95 % dimethylpolysiloxane



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



phase with low bleeding

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

perfect inertness for basic compounds



USP G27 / G36

Analysis of various phenols

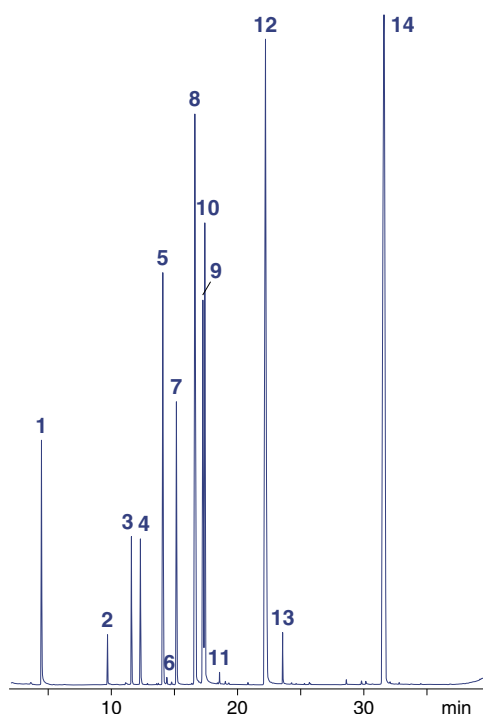
Column: OPTIMA® 5 MS, 30 m x 0.25 mm ID, 0.25 µm film,
Cat. No. 726220.30, max. temperature 340/360 °C
Sample: 5 ppm of each compound except *N*-*i*-propylaniline (9.4 ppm)
Method: SPME
Temperature: 40 °C (2 min) → 240 °C, 6 °C/min → 320 °C, 20 °C/min
Detector: MSD

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

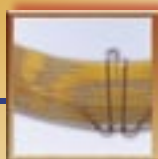
Courtesy of Riedel-de-Haën, Seelze, Germany

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		
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 programme we will be happy to supply columns custom-made to your specifications.						

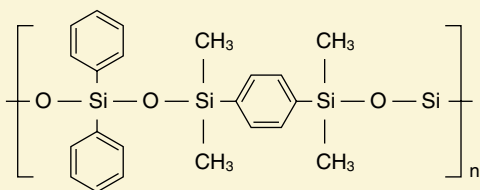


OPTIMA® high performance capillary columns

OPTIMA® 5-MS Accent

chemically bonded, cross-linked silarylene phase with polarity similar to a 5 % diphenyl – 95 % dimethylpoly-siloxane phase

NEW!



silarylene phase

max. temperature for isothermal operation 340 °C,
max. temperature for short isotherms in a temperature programme 360 °C,
for columns with films > 0.5 µm max. temperatures are 320 and 340 °C, respectively

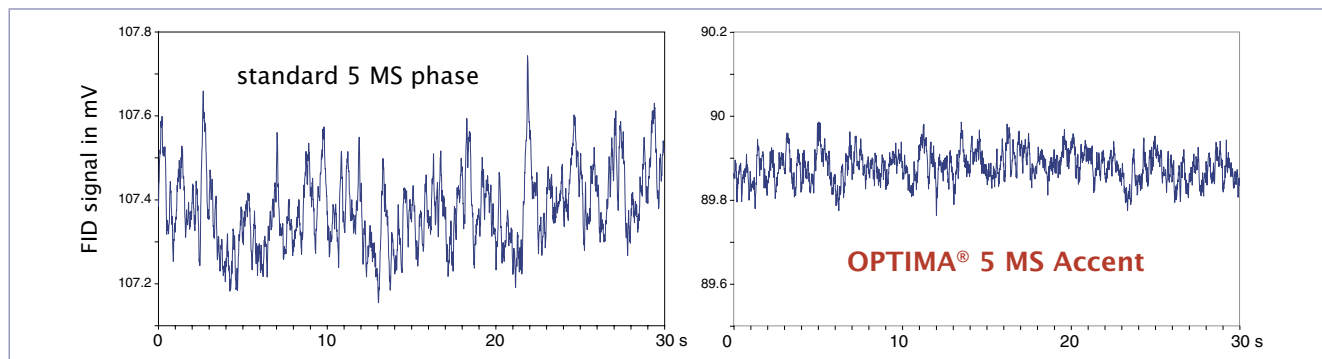
- lowest column bleed, nonpolar phase, ideal for ion trap and quadrupol MS detectors
- solvent rinsing for removal of impurities applicable
- application areas: all-round phase for environmental analyses, trace analyses, EPA methods, pesticides, PCB, food and drug analyses
- similar phases: DB-5 MS, HP-5 MS, Ultra-2, Equity-5, CP-Sil 8 CB low bleed/MS, Rtx-5SIL-MS, Rtx-5 MS, 007-5 MS, BPX5, MDN-5S, AT-5 MS, VF-5 MS
- USP G27 / G36

increased sensitivity due to an unmatched low background level

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

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 the application in trace analyses particularly of high-boiling compounds.

Background noise at 340 °C



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. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



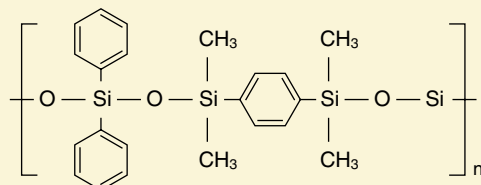
OPTIMA® XLB

chemically bonded, cross-linked
silarylene phase, optimised silarylene
content for lowest column bleed

NEW!



max. temperature for isothermal operation 340 °C,
max. temperature for short isotherms in a tempera-
ture programme 360 °C,



similar phases: DB-XLB, Rtx-XLB,
MDN-12, VF-XMS

silarylene phase

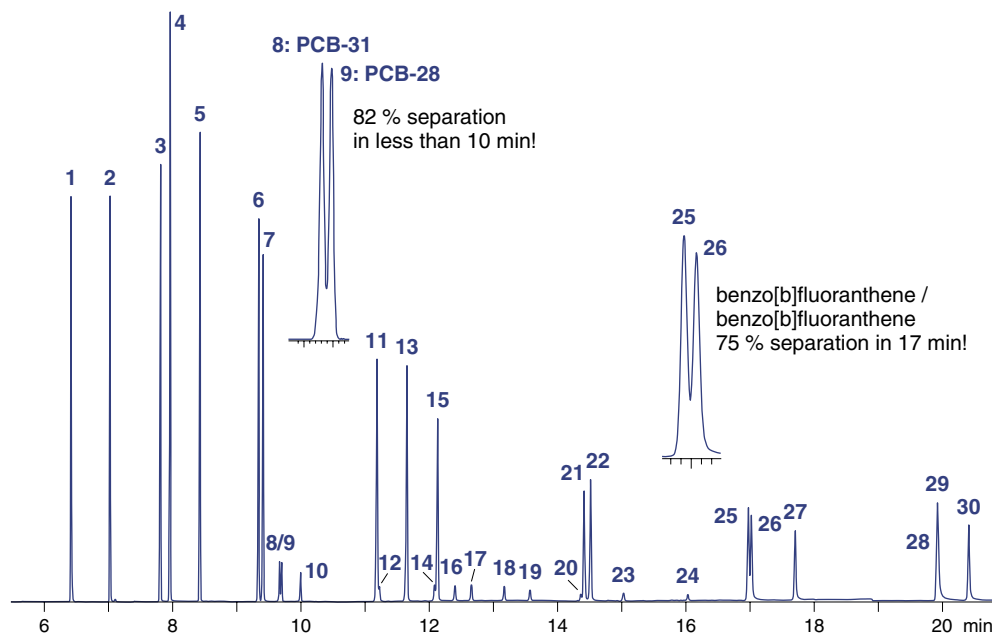
- **lowest column bleed**, nonpolar phase, ideal for ion trap and quadrupol MS detectors
- perfect inertness for basic compounds
- solvent rinsing for removal of impurities applicable
- application areas: ultra low bleed phase, highly selective for environmental and trace analyses, pesticides
- recommended phase for PCB separations

Rapid separation of PCB and PAH

Column: OPTIMA® XLB, 0.25 µm film, 30 m x 0.25 mm ID, Cat. No. 725850.30
Injection volume: 1 µl, standard 0.005 ng/µl
Injection: 250 °C, pulsed, splitless, pulse 1.38 bar in 1 min
Purge flow: 60 ml/min He
Temperature: 40 °C (2 min) → 240 °C (2 min), 30 °C/min → 340 °C (5 min), 10 °C/min
Detection: MS source 230 °C, interface 280 °C, quadrupol 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



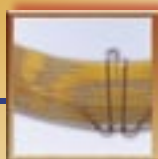
Courtesy of Centre d'Analyses de Recherche, Lab. d'Hydrologie, F-65400 Illkirch, France

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

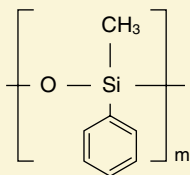
On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. For ordering, please add an E at the end of the catalogue number (e.g. 725850.60E).



OPTIMA® high performance capillary columns

OPTIMA® 17

medium polar phase



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

phenylmethylpolysiloxane (50 % phenyl)

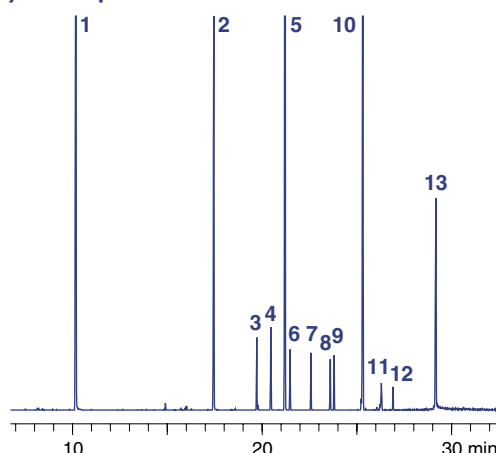
max. temperature for isothermal operation 320 °C, max. temperature for short isotherms in a temperature programme 340 °C
for 0.53 mm ID columns the max. temperatures are 300 and 320 °C, resp.

suitable for higher temperatures
preferred applications: steroids, pesticides, drug analyses

USP G3

Column: OPTIMA® 17, 0.20 µm film, 25 m x 0.20 mm ID, max. temperature 320/340 °C, Cat. No. 726065.25
Samples: pesticides, standard of the cantonal laboratory Schaffhausen (Switzerland), 0.1 mg/ml or 0.01 mg/ml each
Injection volume: 1.0 µl
Carrier gas: He, 25 cm/s, 3 sec without split
Temperature: 100 °C (3 min), 8 °C/min → 250 °C, 10 °C/min → 320 °C
Detector: MSD HP 5971

Analysis of pesticides



Peaks:

1. Dichlorophos
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 programme we will be happy to supply columns custom-made to your specifications.							

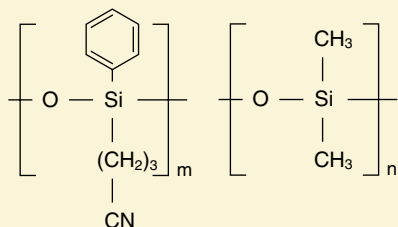
On request, all columns can be supplied on a 5 inch (13 cm) cage for the Agilent GC 6850. For ordering, please add an E at the end of the catalogue number (e.g. 726470.30E)



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 programme 320 °C
for 0.53 mm ID columns the max. temperatures
are 280 and 300 °C, resp.

special selectivity due to high cyanopropyl con-
tent

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

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

USP G46

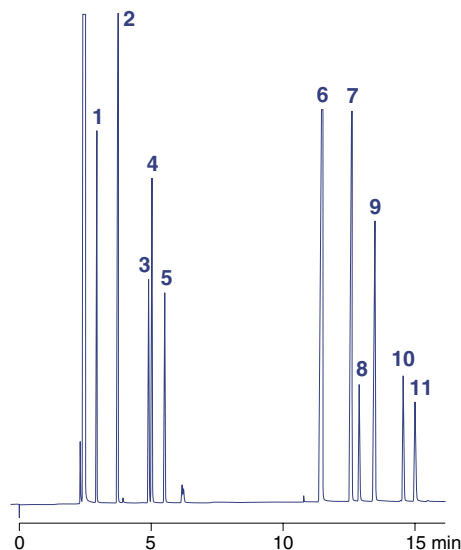
Analysis of aromatic hydrocarbons

Column: OPTIMA® 1701, 0.25 μm film, 25 m x 0.32 mm ID,
Cat. No. 726318.25, max. temperature 300/320 °C
Injection volume: 1 μl
Carrier gas: 0.6 bar N_2
Split: 1:40
Temperature: 60 °C $\rightarrow$ 120 °C, 4 °C/min
Detector: FID 260 °C

Peaks:

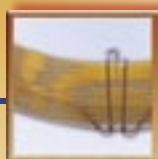
1. Benzene
2. Toluene
3. Ethylbenzene
4. *p*-Xylene
5. *o*-Xylene
6. Phenol
7. 2-Methylphenol
8. 2,6-Dimethylphenol
9. 4-Methylphenol
10. 2,4-Dimethylphenol
11. 2,4,6-Trimethylphenol

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 programme we will be happy to supply columns custom-made to your specifications.						

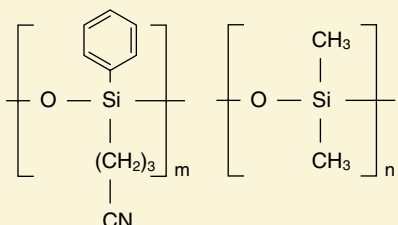


OPTIMA® high performance capillary columns

OPTIMA® 1301

6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane

medium polar phase



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

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

ideal for pesticide analyses

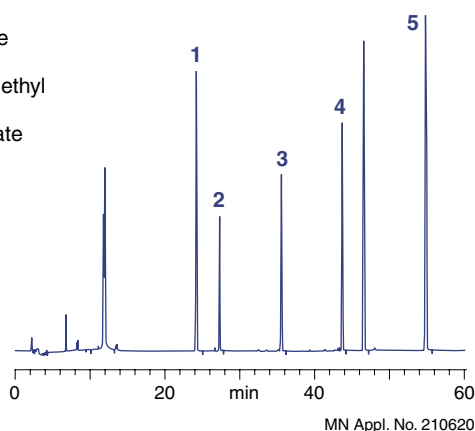
for corresponding columns with higher film thickness see OPTIMA® 624

USP G43

Analysis of a pesticide mixture

Column: OPTIMA® 1301, 0.25 µm film, 60 m x 0.25 mm ID, max. temperature 300/320 °C, Cat. No. 726 771.60
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. Brompropylate

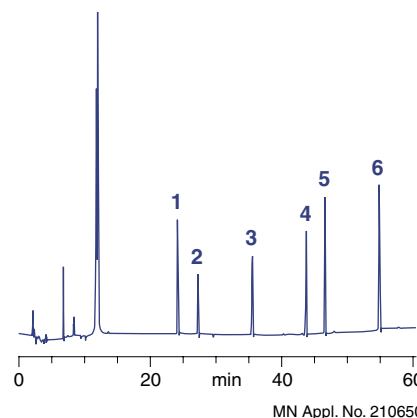


MN Appl. No. 210620

Analysis of a PCB mixture

Column: OPTIMA® 1301, 0.25 µm film, 60 m x 0.25 mm ID, max. temperature 300/320 °C, Cat. No. 726 771.60
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

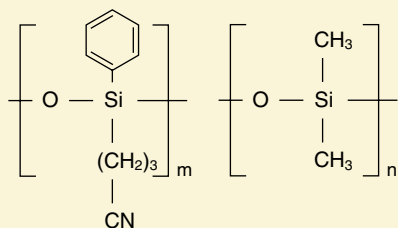
Length →	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)				
0.25 µm film	726771.25	726771.30	726771.50	726771.60
0.32 mm ID (0.5 mm OD)				
0.25 µm film	726777.25	726777.30		726777.60
1.00 µm film		726780.30	726780.50	726780.60
0.53 mm ID (0.8 mm OD)				
1.00 µm film	726783.25			
In addition to this standard programme 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. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



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 programme 300 °C

recommended for 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, Cat. No. 726786.30; retention gap Phe-Sil 0.5 m x 0.53 mm, Cat. No. 723711.10

Carrier gas: 1.1 bar He

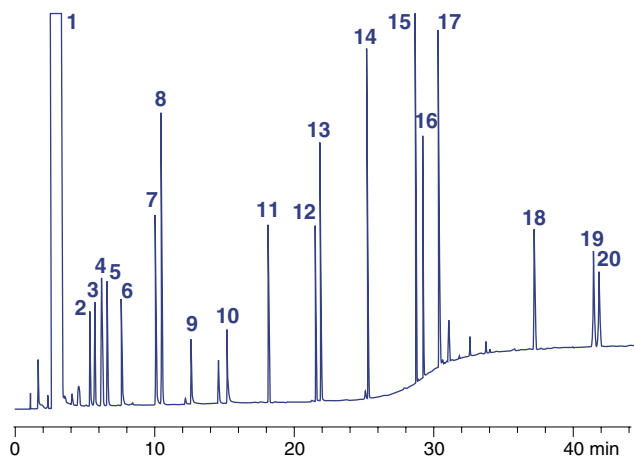
Temperature: 45 °C (3 min) → 150 °C (6 °C/min) → 300 °C (18 °C/min), 20 min 300 °C

Injection: 1 µl (10 ppm per substance in acetone), cold on-column

Detection: FID 280 °C

Peaks:

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

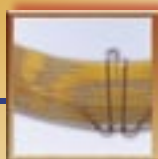


MN Appl. No. 212520

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
OPTIMA® 624 LB	0.53 mm ID (0.8 mm OD)			
	3.00 µm film	726789.25	726789.30	
In addition to this standard programme 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. For ordering, please add an E at the end of the catalogue number (e.g. 726470.30E)

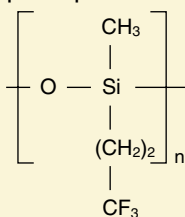


OPTIMA® high performance capillary columns

OPTIMA® 210

trifluoropropyl-methylpolysiloxane (50 % trifluoropropyl)

⬢ 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 programme 280 °C



recommended for environmental analyses,
especially for *o*-, *m*- and *p*-substituted aromatic hydrocarbons



close equivalent to USP G6

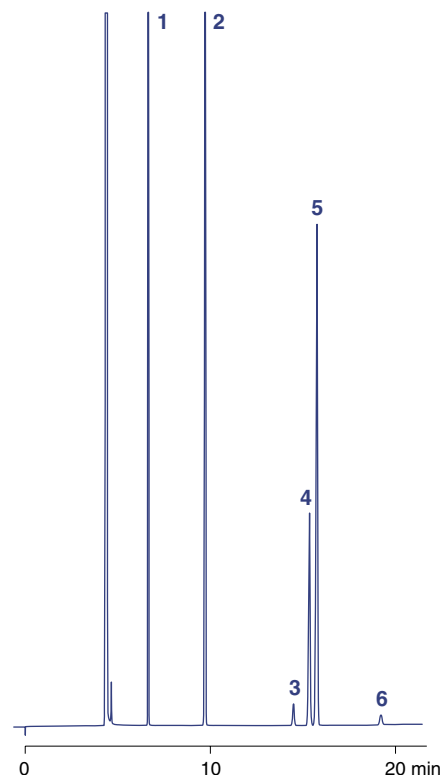
Capillary columns for GC

Aromatic hydrocarbons (BTX)

Column: OPTIMA® 210, 0.5 µm film, 50 m x 0.25 mm ID,
max. temperature 240/260 °C, Cat. No. 726874.50
Injection volume: 0.5 µl
Carrier gas: 130 kPa N₂ (1.1 ml/min)
Split: 105 ml/min
Temperature: 50 °C
Detector: FID 250 °C, 2⁶

Peaks:

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



MN Appl. No. 2000230

Ordering information

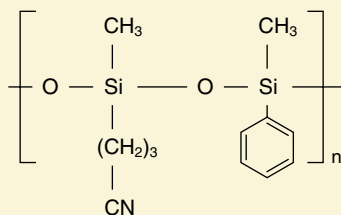
Length →	15 m	25 m	30 m	50 m	60 m
0.25 mm ID (0.4 mm OD)					
0.25 µm film	726871.15	726871.25	726871.30	726871.50	726871.60
0.50 µm film			726874.30	726874.50	726874.60
0.32 mm ID (0.5 mm OD)					
0.25 µm film	726877.15		726877.30	726877.50	726877.60
0.50 µm film		726880.25	726880.30	726880.50	726880.60
In addition to this standard programme 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. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



OPTIMA® 225 50 % cyanopropyl-methyl - 50 % phenylmethylpolysiloxane

◈ polar phase



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

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

◈ recommended for fatty acid analyses

◈ close equivalent to USP G7 / G19

Analysis of FAME in porcine fat

Column: OPTIMA® 225, 0.25 µm film, 25 m x 0.32 mm ID, max. temperature 260/280 °C, Cat. No. 726352.25

Injection volume: 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)

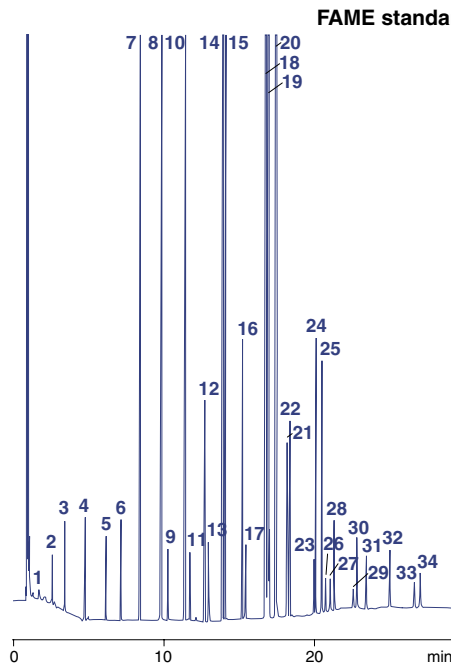
Detector: FID 260 °C

Peaks:

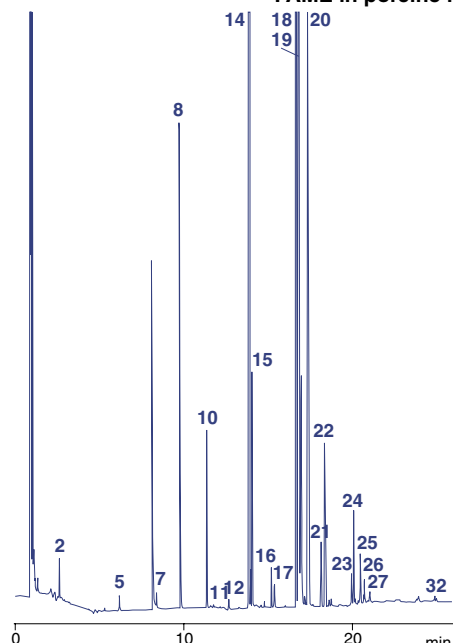
- | | |
|-----------|-----------|
| 1. C4:0 | 18. C18:0 |
| 2. C5:0 | 19. C18:1 |
| 3. C6:0 | 20. C18:2 |
| 4. C8:0 | 21. C18:3 |
| 5. C10:0 | 22. C19:0 |
| 6. C11:0 | 23. C20:0 |
| 7. C12:0 | 24. C20:1 |
| 8. C13:0 | 25. C20:2 |
| 9. C13:1 | 26. C20:4 |
| 10. C14:0 | 27. C20:3 |
| 11. C14:1 | 28. C20:5 |
| 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 |

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

MN Appl. No. 210060



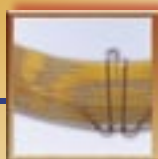
FAME in porcine fat



Ordering information

Length →	10 m	15 m	25 m	30 m	50 m	60 m
0.10 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 programme 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. For ordering, please add an E at the end of the catalogue number (e.g. 726470.30E)

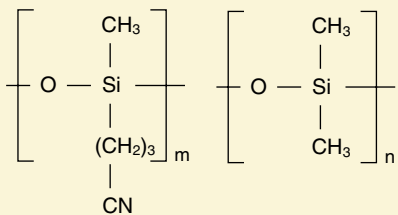


OPTIMA® high performance capillary columns

OPTIMA® 240

33 % cyanopropyl-methyl – 67 % dimethylpolysiloxane

⬢ polar phase



no similar phases

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

⬢ recommended for FAMEs, dioxins

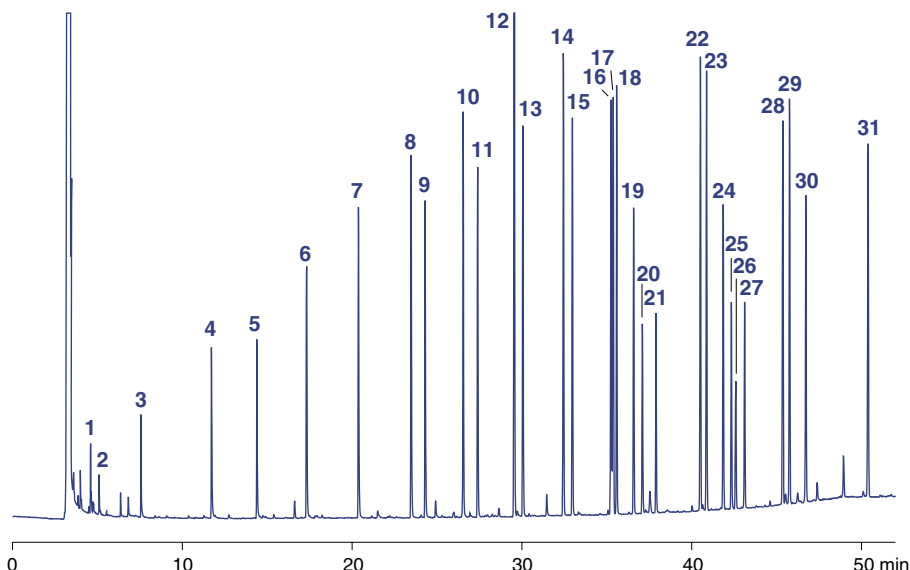
Capillary columns for GC

Fatty acid methyl esters *cis/trans* C 18:1 (FAME)

Column: OPTIMA® 240, 0.25 film, 60 m x 0.25 mm ID, max. temperature 260/280 °C, Cat. No. 726089.60
Sample: FAME mixture
Injection volume: 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

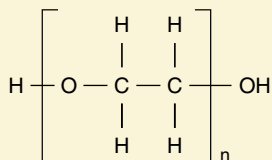
In addition to this standard programme we will be happy to supply columns custom-made to your specifications.

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



OPTIMA® WAX

🔸 polar phase



similar phases: PERMABOND® CW 20 M (page 222), DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax

polyethylene glycol 20 000 dalton

🌡️ for columns with 0.25 – 0.32 mm ID the max. temperature for isothermal operation is 250 °C, the max. temperature for short isotherms in a temperature programme is 260 °C
for 0.53 mm ID columns the max. temperatures are 220 and 240 °C, resp.

🔸 recommended for solvent analysis and alcohols suitable for aqueous solutions

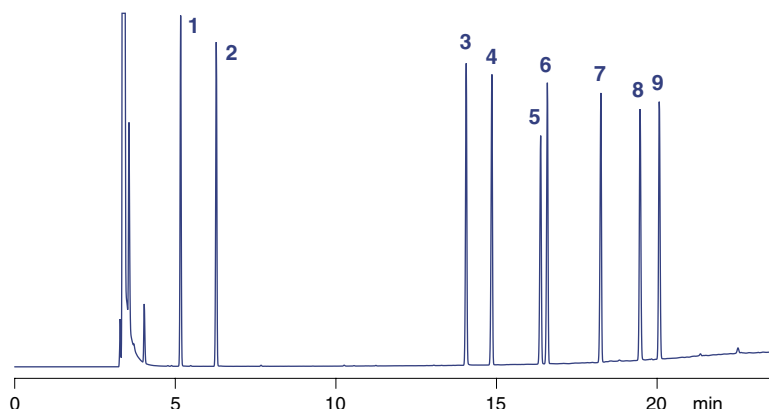
🔸 USP G16

Modified Grob test

Column: OPTIMA® WAX, 0.5 µm film, 50 m x 0.32 mm ID, max. temperature 250/260 °C, Cat. No. 726296.50
Injection volume: 1 µl
Carrier gas: 1.2 bar He
Split: 1:20
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

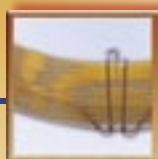


MN Appl. No. 211170

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 programme 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. For ordering, please add an E at the end of the catalogue number (e.g. 726470.30E)



OPTIMA® high performance capillary columns

OPTIMA® FFAP

- ⬢ polar phase
- similar phases: PERMABOND® FFAP (page 222), DB-FFAP, HP-FFAP, CP-Sil 58 CB, 007-FFAP, CP-FFAP CB, Nukol
- ⬢ close equivalent to USP G25 / G35

polyethylene glycol 2-nitroterephthalate

- ⬢ for columns with 0.10 – 0.32 mm ID the max. temperature for isothermal operation is 250 °C, the max. temperature for short isotherms in a temperature programme is 260 °C for 0.53 mm ID columns the max. temperatures are 220 and 240 °C, resp.
- ⬢ recommended for FAME, free carboxylic acids

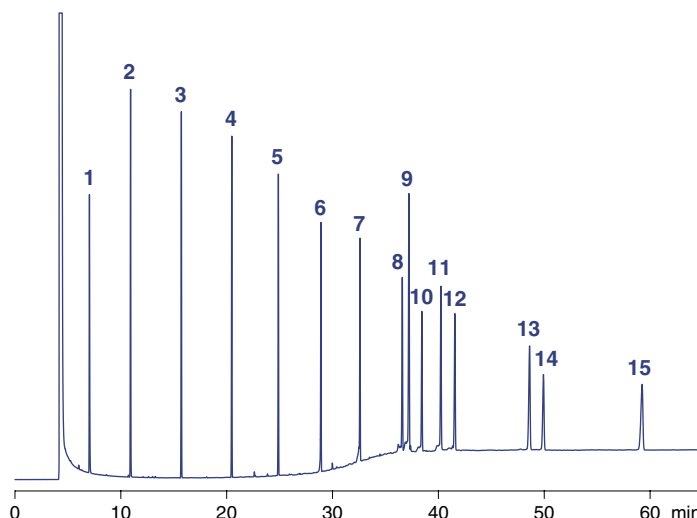
FAME test

Column: OPTIMA® FFAP, 0.25 µm film, 60 m x 0.32 mm ID, max. temperature 250/260 °C, Cat. No. 726341.60
 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

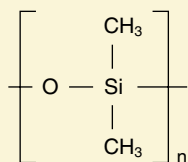
Length →	10 m	25 m	30 m	50 m	60 m
0.10 mm ID (0.4 mm OD)					
0.10 µm film	726180.10				
0.25 mm ID (0.4 mm OD)					
0.25 µm film		726116.25	726116.30	726116.50	726116.60
0.32 mm ID (0.5 mm OD)					
0.25 µm film		726341.25	726341.30	726341.50	726341.60
0.50 µm film		726344.25	726344.30	726344.50	
0.53 mm ID (0.8 mm OD)					
0.50 µm film			726345.30		
1.00 µm film		726346.25			
In addition to this standard programme 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. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



PERMABOND® SE-30

nonpolar phase



100 % dimethylpolysiloxane



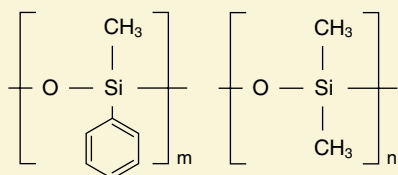
max. temperature for isothermal operation 300 °C,
max. temperature for short isotherms in a temperature programme 320 °C

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 programme we will be happy to supply columns custom-made to your specifications.		

PERMABOND® SE-52

nonpolar phase



5 % phenyl – 95 % dimethylpolysiloxane

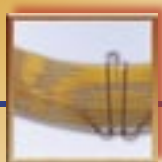


max. temperature for isothermal operation 300 °C,
max. temperature for short isotherms in a temperature programme 320 °C

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 programme we will be happy to supply columns custom-made to your specifications.	

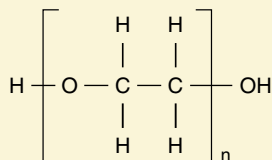
Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Column ends are melted or closed with septa, and thus protected from atmospheric oxygen. Additionally, we supply the corresponding test mixture with each column.



PERMABOND® capillary columns

PERMABOND® CW 20 M

⬢ polar phase



similar phases see OPTIMA® WAX page 219

polyethylene glycol 20 000 dalton

- 0.1 – 0.32 mm ID: max. temperature for isothermal operation 220 °C, max. temperature for short isotherms in a temperature programme 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 programme we will be happy to supply columns custom-made to your specifications.					

PERMABOND® FFAP

⬢ polar phase

similar phases see OPTIMA® FFAP page 220

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 programme 240 °C; 0.53 mm ID: max temperatures 200 and 220 °C, resp.
- ⬢ recommended for FAME, free carboxylic acids

Ordering information

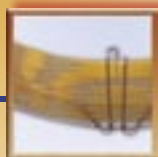
Length →	10 m	20 m	25 m	30 m	50 m	60 m
0.1 mm ID (0.4 mm OD)						
0.10 µm Film	723180.10	723180.20				
0.25 µm Film	723181.10					
0.25 mm ID (0.4 mm OD)						
0.10 µm film			723936.25		723936.50	
0.25 µm film	723116.10		723116.25	723116.30	723116.50	723116.60
0.32 mm ID (0.5 mm OD)						
0.10 µm film			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 programme we will be happy to supply columns custom-made to your specifications.						



Capillary columns for special GC separations

Certain analytical separations can be performed more easily with chromatographic columns, which have been especially developed for the respective task. The following table summarises our programme of GC speciality capillaries, the individual column types are described in detail on the following pages.

Separation / special application		Recommended capillary column	Page
Fast GC		OPTIMA® δ -3, OPTIMA® δ -6 OPTIMA® 1, OPTIMA® 5, OPTIMA® 17, OPTIMA® 225, OPTIMA® FFAP PERMABOND® CW 20 M, FFAP all 0.10 mm ID	224
Amines	polyfunctional amines	OPTIMA® 5 Amine	225
	amine separations	FS-CW 20 M-AM	226
Petrochemical products (complex hydrocarbon mixtures)		PERMABOND® P-100	226
Environmental analyses	volatile halogenated hydrocarbons	PERMABOND® SE-54 HKW	227
Triglycerides		OPTIMA® 1-TG OPTIMA® 17-TG	228
Silanes (monomeric, e. g. chlorosilanes)		PERMABOND® Silane	229
Diethylene glycol, e. g. for the quality control of wine		PERMABOND® CW 20 M-DEG	229
Enantiomer separation	cyclodextrin phases	FS-LIPODEX® A	230
		FS-LIPODEX® B	-
		FS-LIPODEX® C	-
		FS-LIPODEX® D	231
		FS-LIPODEX® E	-
		FS-LIPODEX® G	-
		FS-HYDRODEX β -PM	-
		FS-HYDRODEX β -3 P	232
		FS-HYDRODEX β -6TBDM	-
		FS-HYDRODEX β -TBDAC	233
	diamide type chiral polysiloxane	FS-HYDRODEX γ -TBDAC	-
		PERMABOND® L-CHIRASIL-VAL	234



Capillary columns for special separations

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 programmes can reduce the analysis time by up to 80 %
- high heating rates place special demands on stationary phases: OPTIMA® columns meet exactly this requirement, as they show very low bleeding and provide long lifetimes, even when continuously subjected to high heating rates
- small inner diameters result in high column inlet pressures and a lower volume flow of the mobile phase, which as a consequence require very fast injection of very small samples against a high pressure
- the amount of sample, which can be injected, is limited by the inner diameter and the thin film
- high sensitivity detectors with small volume and extremely short response time, as well as a very rapid data acquisition and processing are required

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

A) Fast GC column

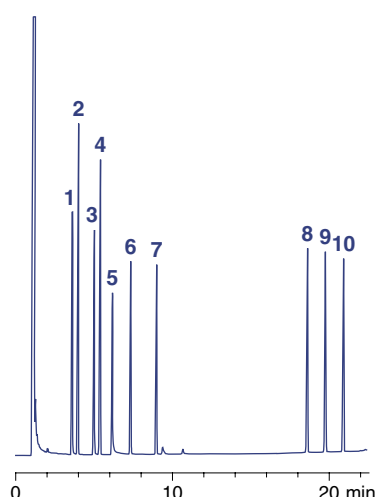
Column: OPTIMA® 5, 0.1 µm film, 10 m x 0.1 mm ID,
max. temperature 340/360 °C, Cat. No. 726846.10
injection 1 µl, split 1 : 40, carrier gas 0.75 bar He

both separations: temperature:
80 °C → 320 °C (10 min),
8 °C/min, detector: FID
While maintaining the temperature programme and halving the pressure a time saving of 30 % results with identical separation efficiency.

Peaks:

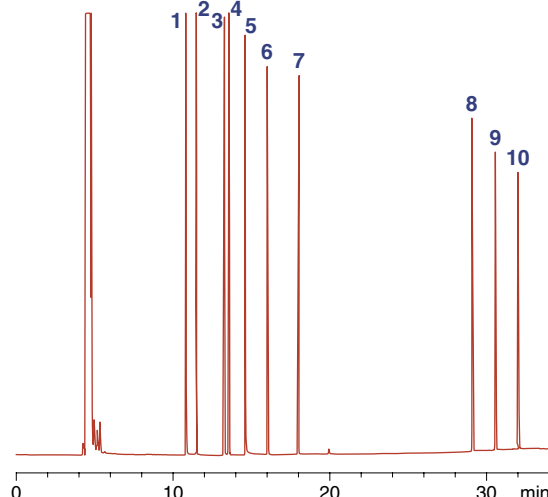
1. Octanol
2. Undecane
3. Dimethylaniline
4. Dodecane
5. Decylamine
6. Methyl decanoate
7. Methyl undecanoate
8. Henicosane
9. Docosane
10. Tricosane

MN Appl. No. 211260



B) standard GC column

Column: OPTIMA® 5, 0.25 µm film, 50 m x 0.25 mm ID,
max. temperature 340/360 °C, Cat. No. 726056.50
injection 1 µl, split 1 : 35, carrier gas 1.5 bar He



Ordering information

Phase	max. temperature	ID [mm]	film thickness [µm]	Cat. No. (10 m)	Cat. No. (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® 8-3	340/360 °C	0.10	0.10	726410.10	726410.20
OPTIMA® 8-6	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 PERMABOND® FFAP	220/240 °C	0.10	0.10	723064.10	
	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 programme, all MN GC phases can be custom-made as fast GC columns.



OPTIMA® 5 Amine

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

similar phases: Rtx-5 Amine, PTA-5

- USP G27 / G36

special column for analysis of amines



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



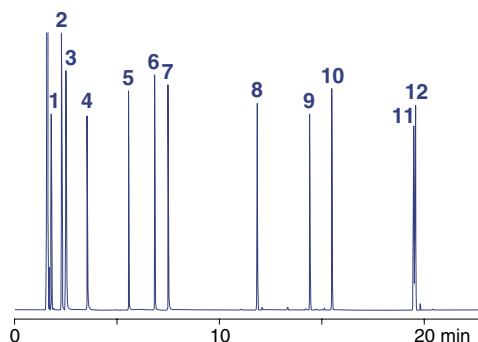
improved linearity for analyses of active components at trace levels: no amine absorptions even for aliphatic and aromatic amines at concentrations of 100 pg/peak tested with the OPTIMA® Amine test mixture (Cat. No. 722317), which among others also contains diethanol-amine and propanol-pyridine (this 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, max. temperature 300/320 °C, Cat. No. 726354.30
Injection volume: 1 µl
Carrier gas: 0.6 bar H₂, split 1:100
Temperature: 100 °C (3 min) → 280 °C, 10 °C/min
Detector: FID 280 °C

Peaks:

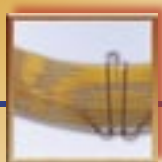
- | | |
|----------------------|-----------------------|
| 1. Diethylamine | 7. Di-isobutylamine |
| 2. Di-isopropylamine | 8. Tri-n-butylamine |
| 3. Triethylamine | 9. Di-iso-hexylamine |
| 4. Di-n-propylamine | 10. Dicyclohexylamine |
| 5. Di-n-butylamine | 11. Dibenzylamine |
| 6. Tri-n-propylamine | 12. 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		



Capillary columns for special separations

FS-CW 20 M-AM

polyethylene glycol 20 000, non-immobilised

- 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 programme 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 programme 320 °C

Ordering information

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



PERMABOND® SE-54-HKW

for volatile halogenated hydrocarbons

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



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

For the analysis of halogenated hydrocarbons we recommend our optimised columns PERMABOND® SE-54 HKW with 25 or 50 m length with the well-known polysiloxane phase SE-54.

As an alternative and for confirming analytical results, columns OPTIMA® 624 show advantages especially for the determination of 1,1,2-trichlorotrifluoroethane (F 113) besides dichloromethane.

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

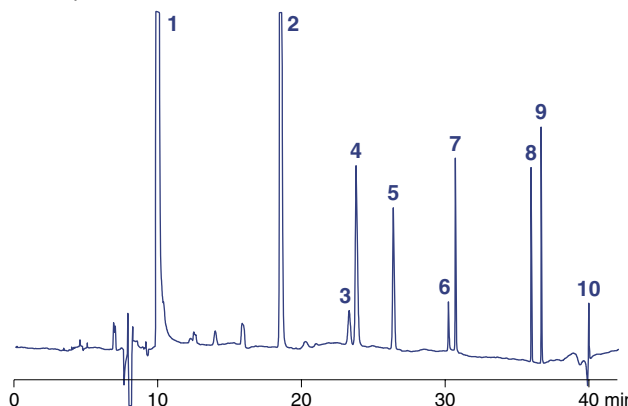
Volatile halogenated hydrocarbons

Column: PERMABOND® SE-54-HKW, 50 m x 0.32 mm ID, max. temperature 300 °C, Cat. No. 723945.50
 Injection volume: 1 µl
 Carrier gas: 0.9 bar He
 Split: about 1:30
 Temperature: 35 °C (25 min) → 160 °C (5 min), 10 °C/min
 Detector: ECD 300 °C

Peaks:

1. Dichloromethane (795 ng/ml)
2. Chloroform (75 ng/ml)
3. 1,1,1-Trichloroethane (67 ng/ml)
4. 1,2-Dichloroethane (100 ng/ml)
5. Carbon tetrachloride (15.9 ng/ml)
6. Trichloroethylene (14.6 ng/ml)
7. Bromodichloromethane (20 ng/ml)
8. Dibromochloromethane (122 ng/ml)
9. Tetrachloroethylene (81 ng/ml)
10. Bromoform (28.9 ng/ml)

MN Appl. No. 2124880



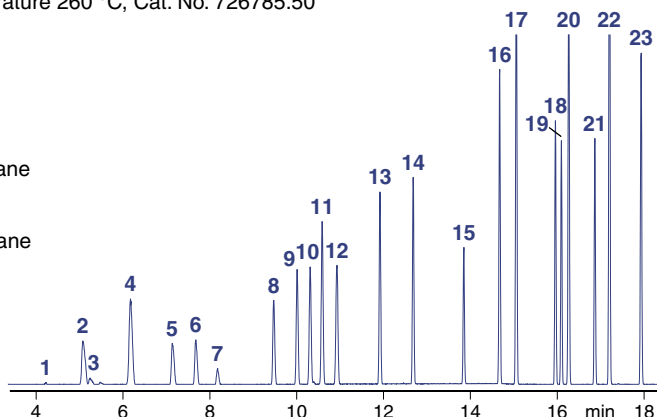
Volatile halogenated hydrocarbons and BTX

Column: OPTIMA® 624, 50 m x 0.25 mm ID, max. temperature 260 °C, Cat. No. 726785.50
 Injection volume: 1 µl
 Carrier gas: 0.9 ml/min He (constant flow), split 50 ml/min
 Temperature: 40 °C (5 min) → 160 °C, 10 °C/min
 Detector: MSD 5971

Peaks:

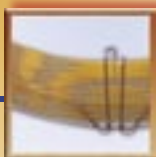
- | | |
|---|-----------------------------------|
| 1. Vinyl chloride | 13. Trichloroethene |
| 2. Trichlorofluoromethane (F 11) | 14. Bromodichloromethane |
| 3. Pentane | 15. Toluene |
| 4. 1,1,2-Trichlorotrifluoroethane (F 113) | 16. Tetrachloroethene |
| 5. Dichloromethane | 17. Dibromochloromethane |
| 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



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

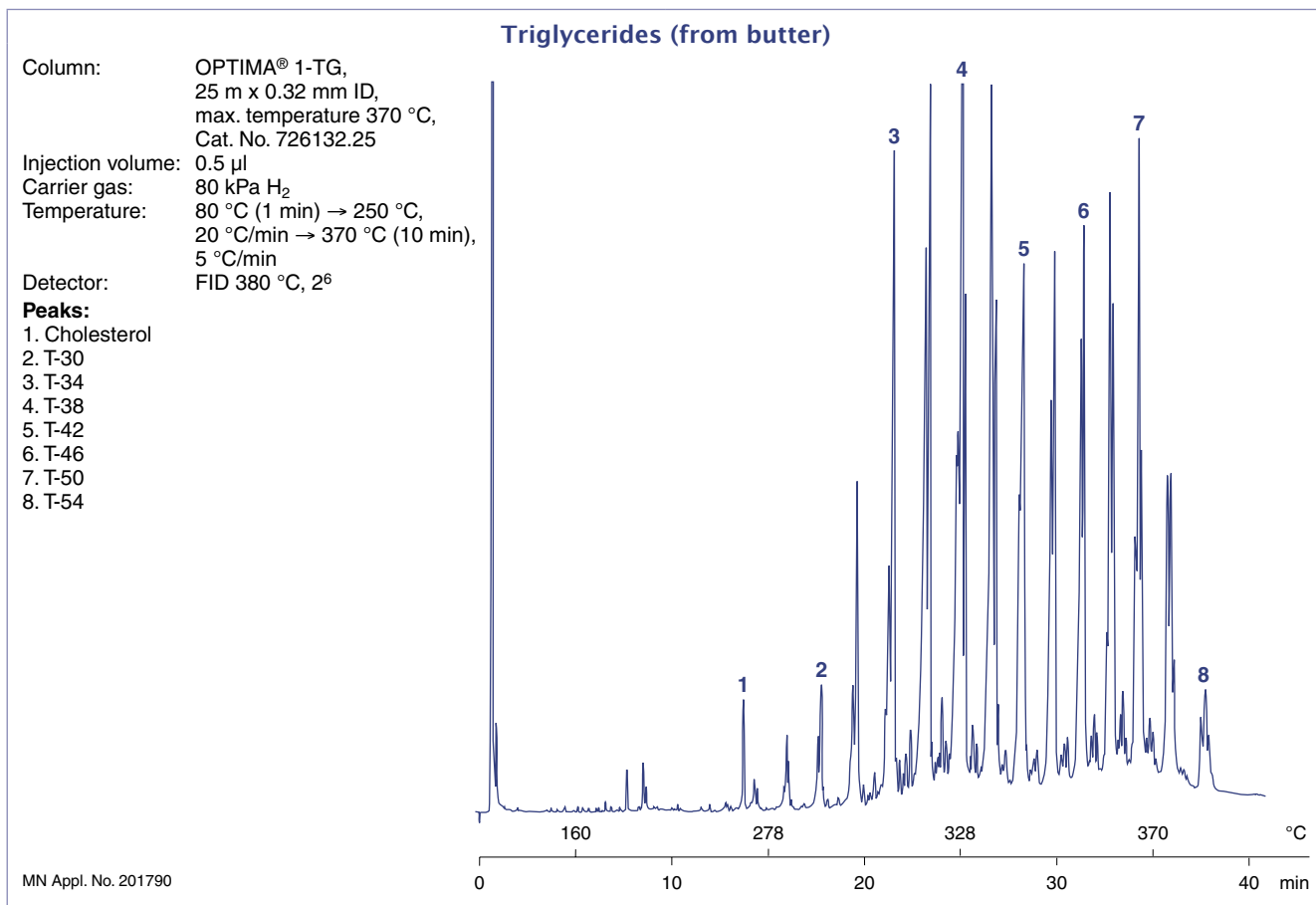


max. temperature for both phases: 370 °C



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

Capillary columns for GC



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



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

for columns with 0.32 mm ID the max. temperature for isothermal operation is 260 °C, the max. temperature for short isotherms in a temperature programme is 280 °C; for 0.53 mm ID columns the max. temperatures are 240 and 260 °C, resp.

Ordering information

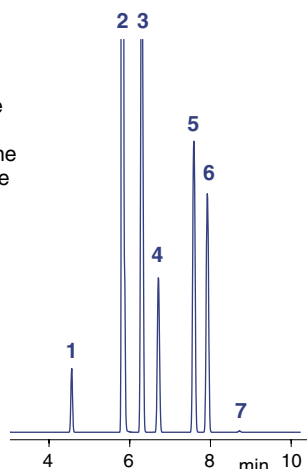
Length →	25 m	50 m
0.32 mm ID (0.5 mm OD)		723409.50
0.53 mm ID (0.8 mm OD)	723411.25	

Chloromethylsilanes

Column: PERMABOND® Silane, 50 m x 0.32 mm ID, max. temp. 260/280 °C, Cat. No. 723409.50
 Injection volume: 0.5 µl gas
 Carrier gas: 1 ml/min He (constant flow)
 Split: 80 ml/min
 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



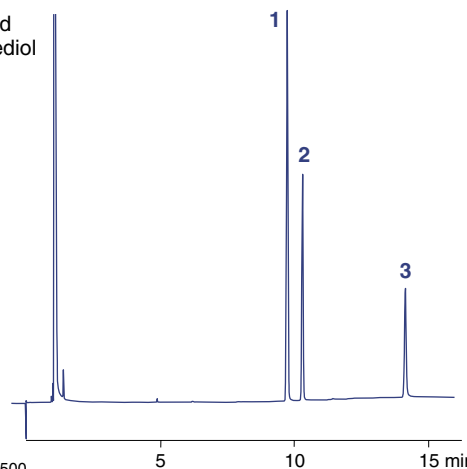
MN Appl. No. 200090

Diethylene glycol standard in wine

Column: PERMABOND® CW 20 M-DEG, 25 m x 0.25 mm ID, max. temp. 220/240 °C, Cat. No. 723063.25
 Injection volume: 0.5 µl
 Carrier gas: 1.2 bar N₂
 Split: ~1 : 40
 Temperature: 80 °C → 200 °C, 10 °C/min
 Detector: FID 260 °C, 10 x 2²

Peaks:

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



MN Appl. No. 201500

PERMABOND® CW 20 M-DEG

- polyethylene glycol 20 000 (diethylene glycol tested)
- USP G16

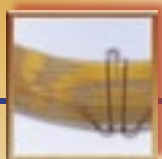
for determination of diethylene glycol

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

- recommended application: determination of diethylene glycol, e.g. for the quality control of wine

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



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 analysed without derivatisation (however, for certain substances enantioselectivity can be favourably 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.

LIPODEX® is patented under EP 0407 412 and US Re. 36.092

LIPODEX® A

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

- recommended for 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 programme 220 °C

LIPODEX® B

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

- recommended for 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 programme 220 °C

LIPODEX® C

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

- recommended for alcohols, cyanhydrins, olefins, hydroxycarboxylic acid esters, alkyl halides



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

LIPODEX® D

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

- recommended for 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 programme 220 °C

LIPODEX® E

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

- recommended for 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 programme 220 °C

LIPODEX® G

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

- recommended for menthol isomers, ketones, alcohols, carboxylic acid esters, terpenes



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



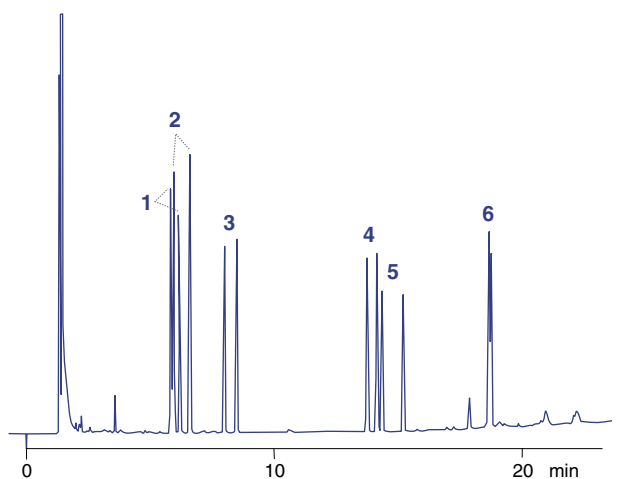
Enantiomer separation of amino acid methyl esters (TFA)

Column: FS-LIPODEX® E, 25 m x 0.25 mm ID,
max. temp. 200/220 °C, Cat. No. 723368.25
Volume: 1 µl
Carrier gas: 60 kPa H₂
Split: about 1:100
Temperature: 90 → 190 °C, 4 °C/min
Detector: FID, 250 °C, AT 2

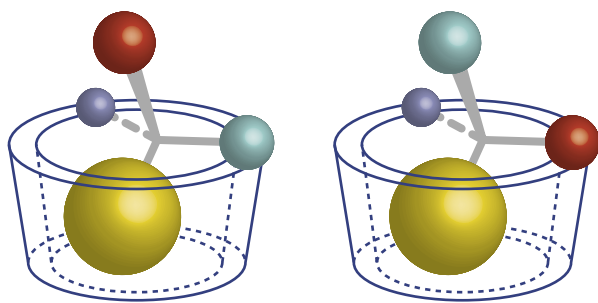
Peaks:

(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



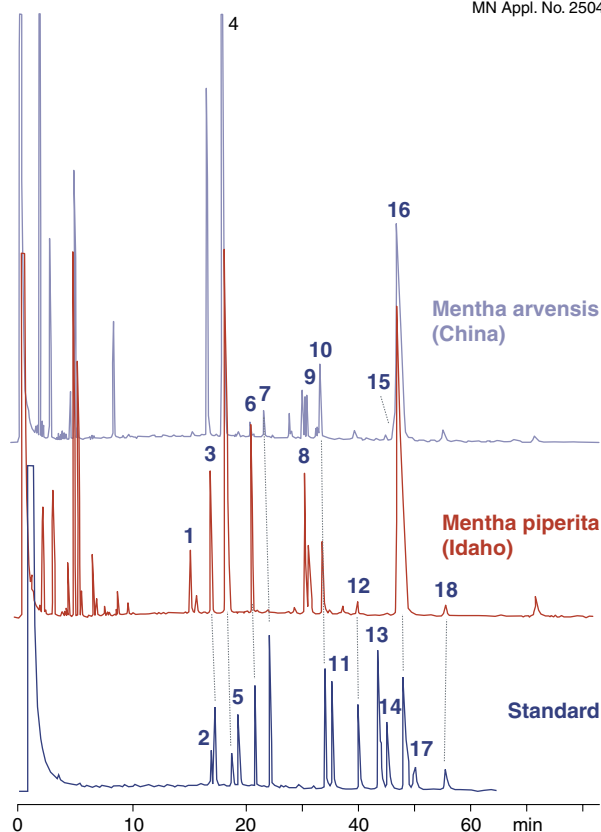
Separation of chiral constituents of peppermint oil

W. A. König et al., High Resol. Chromatogr. **20** (1997) 55 – 61
Column: FS-LIPODEX® G, 25 m x 0.25 mm ID,
max. temp. 220/240 °C, Cat. No. 723379.25
Carrier gas: He
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

phase diluted with optimised polysiloxane

- recommended for hydroxycarboxylic acid esters, alcohols, diols, olefins, lactones, acetals

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



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

HYDRODEX β -3P

phase diluted with optimised polysiloxane

- recommended for terpenes, dienes, allenes, terpene alcohols, 1,2-epoxyalkanes, carboxylic acids (esters), hydroxycarboxylic acid esters, pharmaceuticals, pesticides

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



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

HYDRODEX β -6TBDM

phase diluted with optimised polysiloxane

- recommended for γ -lactones, cyclopentanones, terpenes, esters, tartrates

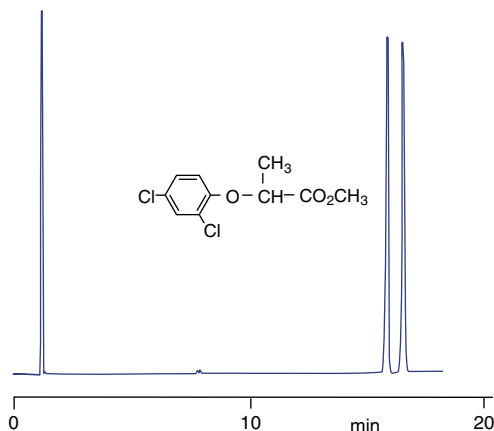
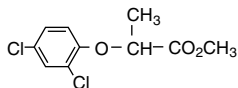
heptakis-(2,3-di-O-methyl-6-O-*t*-butyldimethyl-silyl)- β -CD



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

Enantiomer separation of dichlorprop methyl ester

Column: HYDRODEX β -3P, 25 m x 0.25 mm ID, max. temperature 250 °C, Cat. No. 723358.25
Injection volume: 0.1 μ l (~1% in CH_2Cl_2)
Carrier gas: 60 kPa H_2 (1.9 ml/min)
Split: 130 ml/min
Temperature: 160 °C
Detector: FID, 250 °C, 2⁷



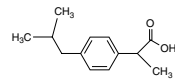
MN Appl. No. 202542

Separation of isomeric antiinflammatory drugs

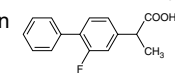
Courtesy of Prof. W.A. König, Hamburg, Germany
Column: HYDRODEX β -6TBDM, 25 m x 0.25 mm ID, max. temperature 250 °C, Cat. No. 723381.25
Carrier gas: He
Temperature: 135 °C $\rightarrow$ 200 °C, 1 °C/min
Detector: FID

Peaks:

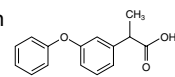
1. Ibuprofen



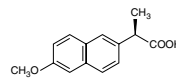
2. Flurbiprofen



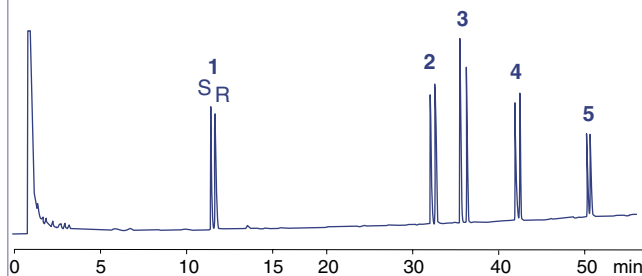
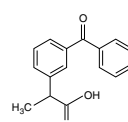
3. Fenoprofen



4. Naproxen



5. Ketoprofen



MN Appl. No. 250180



HYDRODEX β-TBDAC

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

phase diluted with optimised polysiloxane

recommended for alcohols, esters, ketones, aldehydes, δ-lactones etc.



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

HYDRODEX γ-TBDAC

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

phase diluted with optimised polysiloxane

recommended for 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 programme 240 °C

NEW!

Separation of (R/S) citronellol + citronellal

Capillary column: FS-HYDRODEX β-TBDAC, 50 m x 0.25 mm ID, max. temp. 220/240 °C, Cat. No. 723384.50

Carrier gas: 1.5 bar H₂, split 25 ml/min

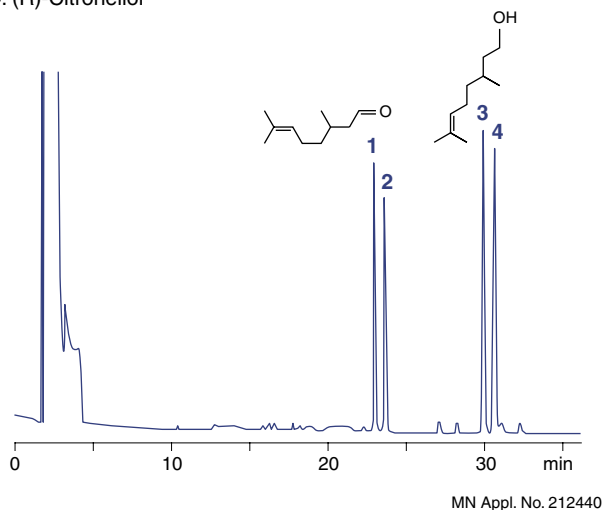
Temperature: 100 °C

Injection: 1 µl, 1:1000 in CH₂Cl₂

Detector: FID, 220 °C

Peaks:

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



Separation of essential oils

Capillary column: FS-HYDRODEX γ-TBDAC, 50 m x 0.25 mm ID, max. temp. 220/240 °C, Cat. No. 723387.50

Carrier gas: 1.2 bar H₂

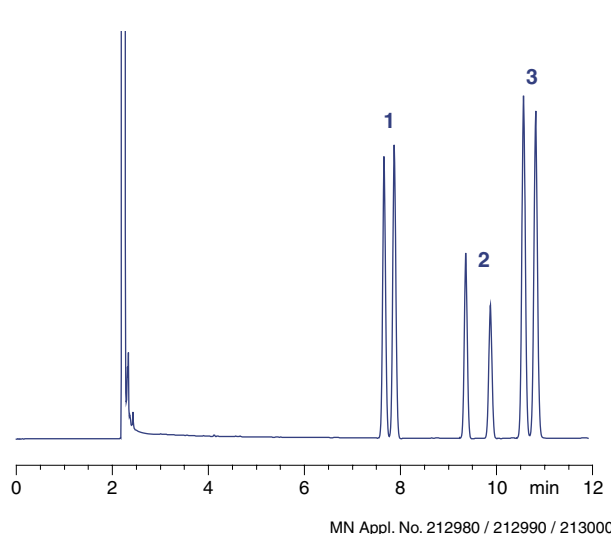
Temperature: 125 °C

Injector: 220 °C

Detector: FID, 220 °C

Peaks:

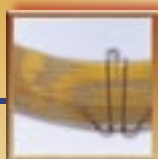
1. Fenchone (1.5 mg/ml)
2. Menthone (0.5 mg/ml)
3. Menthol (2 mg/ml)



Capillary columns for GC

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



Capillary columns for enantiomer separation

PERMABOND® L-CHIRASIL-VAL

⊕ (N-2-methylpropionyl-L-valine-t-butylamide)-methylpolysiloxane immobilised

diamide type chiral stationary phase



max. temperature 190 °C

Enantiomer separation of N-pentafluoropropionyl amino acid n-propyl esters

Column: PERMABOND® L-CHIRASIL-VAL, 25 m x 0.25 mm ID, max. temperature 190 °C, Cat. No. 723730.25

Injection volume: 0.5 µl

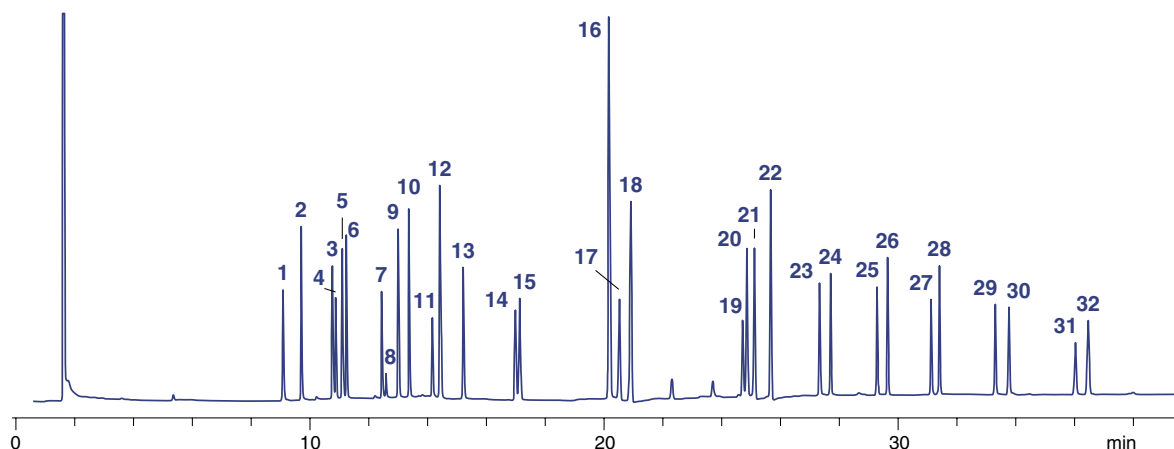
Carrier gas: 0.45 bar H₂, split 1 : 30

Temperature: 80 °C (4 min) → 128 °C (4 min), 5 °C/min → 160 °C, 4 °C/min → 190 °C (17 min), 5 °C/min

Detector: FID 250 °C, AT 3

Peaks (N-pentafluoropropionyl n-propyl esters):

- | | | |
|-------------------------------------|--------------------------|---------------------|
| 1. D-Alanine | 12. L-Serine + D-leucine | 23. D-Phenylalanine |
| 2. L-Alanine | 13. L-Leucine | 24. L-Phenylalanine |
| 3. D-Threonine | 14. D-Proline | 25. D-Glutamic acid |
| 4. D-Valine | 15. L-Proline | 26. L-Glutamic acid |
| 5. L-Threonine | 16. BHT | 27. D-Tyrosine |
| 6. L-Valine | 17. D-Cysteine | 28. L-Tyrosine |
| 7. Glycine | 18. L-Cysteine | 29. D-Ornithine |
| 8. D-allo-Isoleucine | 19. D-Aspartic acid | 30. L-Ornithine |
| 9. D-Isoleucine + L-allo-isoleucine | 20. L-Aspartic acid | 31. D-Lysine |
| 10. L-Isoleucine | 21. D-Methionine | 32. L-Lysine |
| 11. D-Serine | 22. L-Methionine | |



Courtesy of Priv. Doz. Dr. W. Brückner, Dipl. Lebensmittel-Chemiker M. Hausch, Inst. f. Lebensmitteltechnologie, Universität Hohenheim, Stuttgart, Germany

MN Appl. No. 202623

Ordering information

Length →	25 m	50 m
0.25 mm ID (0.4 mm OD)	723730.25	723730.50
0.32 mm ID (0.5 mm OD)	723732.25	723732.50

Test mixtures for chiral GC capillary columns

Test mixture for	test compound (enantiomer mixture)	pack of	Cat. No.
LIPODEX® A, HYDRODEX β-PM, β-3P, β-6TBDM, β-TBDAC, γ-TBDAC	phenylethanol	1 ml	722321
LIPODEX® B	methylbutyrolactone	1 ml	722322
LIPODEX® C, D	phenylethylamine (TFA)	1 ml	722323
LIPODEX® E, G	phenylethanol (TFA)	1 ml	722319
PERMABOND® L-CHIRASIL-VAL	amino acids (TFA)-(lprop)	1 ml	722324



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 (0.2 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. For empty cages please see page 254.			

Deactivated capillary columns (precolumns)

- 🔸 recommended applications:
for 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. For empty cages please see page 254.		



Fused silica capillaries

Retention gaps

- The retention gap technique in combination with on-column injection allows concentration of 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 empty cages please see page 254.		

Fused silica capillary columns

not chemically bonded

Ordering information

Length →	25 m	50 m
Capillary columns FS-OV-1 100% dimethylpolysiloxane (max. temperature 300 °C)		
0.32 mm ID (0.5 mm OD)		
0.25 μm film	733302.25	
1.00 μm film	733323.25	733323.50
Capillary columns FS-SE-54 5% diphenyl – 1% vinylmethyl – 94% dimethylpolysiloxane (max. temperature 300 °C)		
0.25 mm ID (0.4 mm OD)		
0.25 μm film		733056.50



Derivatisation reagents

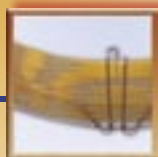
- for improved volatility, better thermal stability or a lower limit of detection in gas chromatography
prerequisite: quantitative, rapid and reproducible formation of only one derivative
halogen atoms introduced by derivatisation (e.g. trifluoroacetates) allow specific detection (ECD) with the advantage of high sensitivity
elution orders and fragmentation patterns in MS can be influenced by a specific derivatisation
- reagents for **silylation**, **acylation**, and alkylation (**methylation**) available

Derivatisation method development kits

Designation	Contents of the kit	Cat. No.
Derivatisation method development kit		
which type of derivatisation is best suited 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 derivatisation of important functional groups in GC

Function	method	derivative	recommended reagents
Alcohols,	silylation	R'O - TMS	BSA, MSTFA, MSHFBA, TSIM, SILYL-2110, SILYL-21, SILYL-1139
Phenols	acylation	R'O - CO - R	TFAA, HFBA, MBTFA, MBHFBA
R'OH	alkylation	R'O - R	TMSH
sterically hindered	silylation	R'O - TMS	TSIM, BSTFA, SILYL-991
Amines	silylation	R' - NR'' - TMS	BSA, MSTFA, MSHFBA, SILYL-991
primary, secondary	acylation	R' - NR'' - CO - R	TFAA, HFBA, MBTFA, MBHFBA
hydrochlorides	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 susceptible to hydrolysis	BSA, MSTFA, MSHFBA, TMCS, TSIM, SILYL-2110, SILYL-21, Silyl 1139
salts	alkylation silylation	R' - CO - O - R R' - CO - O - TMS susceptible to hydrolysis	DMF-DMA, MeOH/TMCS (1 M), TMSH TMCS
Carbohydrates	silylation acylation		MSTFA, TSIM, HMDS, SILYL-1139 TFAA, MBTFA
Steroids	silylation acylation		BSA, TSIM TFAA, MBTFA, HFBA, MBHFBA



Reagents and procedures for acylation

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.w. 230.52, 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 have to be removed

Trifluoroacetic acid anhydride

TFAA: $CF_3 - CO - O - CO - CF_3$

m.w. 210.04, 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.w. 410.06, Bp 106 – 107 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.665$

Bisacylamides

by-products: corresponding neutral acylamides, which can be easily removed due to their high volatility; because of neutral conditions and favourable chromatographic properties often removal of the bisacylamide is not necessary. Thus sample preparation is much more convenient.

N-methyl-bis(trifluoroacetamide)

MBTFA: $CF_3 - CO - N(CH_3) - CO - CF_3$

m.w. 223.08, 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.w. 423.1, Bp 165 – 166 °C (760 mm Hg),
density $d_{20^\circ/4^\circ} = 1.673$

Methods for acylation

Acylation with fluorinated acid anhydrides:

Acylation with TFAA or HFBA can be used for alcohols, phenols, carboxylic acids, amines, amino acids and steroids forming volatile, stable derivatives suited for FID as well as for ECD detection.

Procedure:

Dissolve 0.1 to 1 mg of the sample in 0.1 ml solvent, add 0.1 ml of the respective anhydride and heat to 60 – 70 °C for 1 – 2 hours. 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 acid in a stream of nitrogen. Dissolve the residue in 50 µl hexane, chloroform etc. and inject aliquot portions.

MN Appl. No. 213040

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 which are 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 can be chromatographed directly.

MN Appl. No. 213050

Ordering information

Code	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

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



Alkylation reagents

Except for some special cases (e.g. enantiomer separation of amino acids with PERMABOND® L-CHIRASIL-VAL) in GC generally methylation is the only type of alkylation used.

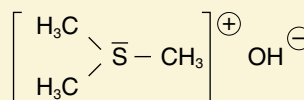
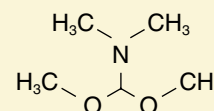
Methylation reagents

N,N-dimethylformamide dimethylacetal

DMF-DMA · m.w. 119.17 Bp 106 – 107 °C (760 mm Hg), density d₂₀⁴ = 0.897

Trimethylsulphonium hydroxide

TMSH (0.2 M in methanol) · m.w. 94.06



Methods for methylation

Methylation with TMSH

Methylation with TMSH [W. Butte, J. Chromatogr. **261** (1983) 142] is recommended for free acids, chlorophenoxycarboxylic acids, their salts and derivatives as well as for phenols and chlorophenols. One great advantage is simplification of the sample preparation. Lipids or triglycerides can be converted to the corresponding fatty acid methyl esters (FAMES) by a simple transesterification. Isomerisations of multiple unsaturated fatty acids have not been observed.

This reaction is very elegant and convenient, because it is just necessary to add the reagent (0.2 M in methanol) to the sample solution. Removal of excess reagent is not required, since in the injector of the gas chromatograph at 250 °C pyrolysis to volatile methanol and dimethylsulfide will occur. Due to the high reactivity, complete derivatisation is often obtained at ambient temperature. However, heating (e.g. 10 min at 100 °C) in a closed sample vial may be necessary.

Procedure:

Dissolve 100 mg sample (e.g. butter) in 5 ml of a suitable solvent (e.g. *tert.*-butyl methyl ether). Add 50 µl reagent to 100 µl of this solution. The mixture is injected directly. The temperature of the injector must be at least 250 °C.

MN Appl. No. 213060

Methylation with DMF-DMA

Methylation with DMF-DMA can be applied for fatty acids, primary amines and (partially) amino acids forming N-dimethyl-aminomethylene amino acid methyl esters [Thenot et al., Anal. Letters **5** (1972) 217 – 223, 519 – 529]. DMF-DMA is a poor solvent, for this reason it is necessary to use a mixture of DMF-DMA with pyridine, THF, acetone (barbiturates) or another solvent.

Procedure:

Add 1 ml of a mixture of DMF-DMA and pyridine (1:1) to 1–50 mg fatty acids. As soon as a clear solution has formed, the sample can be injected. However, it is recommended to heat the solution to 60 – 100 °C for 10 – 15 minutes.

MN Appl. No. 213070

Methylation with methanol/TMCS

A 1molar solution of TMCS in methanol is suited for the esterification of free carboxylic acids and transesterification of glycerides. Formation of HCl catalyses the reaction. TMCS and silyl ether remove water and thus drive the reaction to completion. The mixture should be prepared fresh.

Procedure:

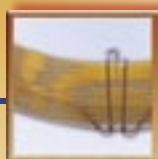
Add 1 ml methanol/TMCS to about 50 mg carboxylic acid or glyceride and heat. Then evaporate in a stream of nitrogen and dissolve again for injection in e.g. *n*-heptane.

MN Appl. No. 213080

For GC separation of FAMES from natural butter fat after derivatisation with TMSH see Appl. 201680 at www.mn-net.com

Ordering information

Code	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



Reagents and procedures for silylation

Silylation reagents

Usually the term silylation in GC stands for replacement of active hydrogen atoms by a trimethylsilyl group (TMS derivative). Sometimes, however, trialkylsilyl groups or dimethylalkylsilyl groups with longer alkyl chains are used for derivatisation. The trialkylsilyl group increases volatility and enhances thermal stability of the sample. Silylation can be catalysed 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

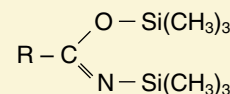
m.w. 203.4, Bp 71 – 73 °C (35 mm Hg), density d₂₀^{°/4°} = 0.832

strong silylation reagent, which forms very stable TMS derivatives of a wide variety 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. When used with DMF, BSA is the reagent of choice for derivatising phenols.

BSA: R = CH₃



⬢ N,O-bis-trimethylsilyl-trifluoroacetamide

m.w. 257.4, Bp 40 °C (12 mm Hg), density d₂₀^{°/4°} = 0.961

powerful trimethylsilyl donor with approximately the same donor strength as the nonfluorinated analog BSA
advantage of BSTFA over BSA: greater volatility of its reaction products (particularly useful for GC of some lower boiling TMS amino acids).

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

BSTFA: R = CF₃

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] are used). 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.

MN Appl. No. 213090

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 hours at 60 °C). After addition of TSIM even strongly hindered hydroxyl groups will react (reaction time 6 – 24 hours at 60 °C).

MN Appl. No. 213100

Ordering information

	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

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



MSTFA · MSHFBA · MBDSTFA

■ N-methyl-N-trimethylsilyl-trifluoroacetamide

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

the most volatile trimethylsilyl amide available

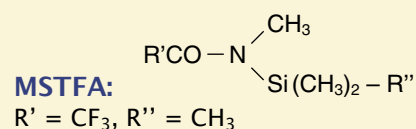
very strong TMS donor which does not cause any noticeable FID fouling even after long-time measuring series. The already good solution characteristics can be improved by addition of submolar quantities of protic solvents (e.g. TFA for extremely polar compounds such as hydrochlorides) or pyridine (e.g. for carbohydrates).

recommended application: 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 reaction with high reaction rates, even without a catalyst (1–2 % TMCS or TSIM)

the by-product of the reaction (N-methyltrifluoroacetamide) features high volatility and short retention time



■ N-methyl-N-trimethylsilyl-heptafluorobutyramide

m.w. 299.1, Bp 148 °C (760 mm Hg)

similar to MSTFA in reactivity and chromatography

recommended application: carboxylic acids, alcohols, phenols, primary and secondary amines and amino acids used either 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 ionisation detection due to the large ratio of fluorine to silicon of 7 : 1, since degradation of the excess of MSHFBA does not produce SiO_2 but volatile, non-corrosive silicon compounds

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

■ N-methyl-N-tert-butyldimethylsilyl-trifluoroacetamide

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

silylation reagent which donates a tert-butyldimethylsilyl group (TBDMS) for derivatising 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 and volatile

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

chromatographic retention times are longer due to the large protecting group, which may improve some separations; because of the high molecular ion concentration at $\text{M}^+ - 57$ useful for GC-MS applications

MBDSTFA: $\text{R}' = \text{CF}_3, \text{R}'' = \text{C}_4\text{H}_9$

Silylation with MSTFA, MSHFBA or MBDSTFA

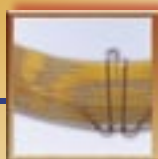
Procedure:

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 hour and can be analysed 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.

MN Appl. No. 213110

Ordering information

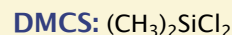
	Packing unit							
	10 x 1 ml	20 x 1 ml	1 x 10 ml	5 x 10 ml	1 x 100 ml	6 x 50 ml	6 x 100 ml	12 x 100 ml
MSHFBA		701260.201	701260.110	701260.510	701260.1100		701260.6100	
MSTFA		701270.201	701270.110	701270.510	701270.1100	701270.650	701270.6100	701270.12100
MBDSTFA	701440.101	701440.201						



Reagents and procedures for silylation

DMCS · HMDS · TMCS · TSIM

Dimethyldichlorosilane

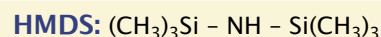


m.w. 129.06, Bp 70 °C (760 mm Hg), density $d_{20^\circ/4^\circ} = 1.07$

used to form dimethylsilyl (DMS) derivatives

DMS derivatives are much more susceptible to hydrolysis than TMS derivatives, therefore strictly anhydrous conditions during reaction are very important.

Hexamethyldisilazane



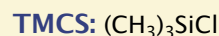
m.w. 161.4, Bp 126 °C (760 mm Hg), density $d_{20^\circ/4^\circ} = 0.7742$

weak TMS donor; used alone reaction is slow and not very effective

after addition of catalytic quantities of TMCS (e. g. 1 %) or as a mixture with TMCS (2:1, v/v; SILYL-21 and SILYL-2110) a fast and quantitative reagent for trimethylsilylation of organic compounds

Aprotic solvents like acetonitrile, pyridine, dimethylformamide, carbon disulphide and dimethylacetamide are recommended for use with HMDS.

Trimethylchlorosilane



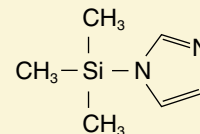
m.w. 108.7, Bp 57 °C (760 mm Hg), density $d_{20^\circ/4^\circ} = 0.8580$

often used as a catalyst with other trimethylsilyl reagents

Without additives it can be used for preparing TMS derivatives of organic acids.

N-Trimethylsilyl-imidazole

TSIM:



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

strongest hydroxyl silylator; reagent of choice for carbohydrates and most steroids (even highly hindered steroids)

The reagent is unique in that it reacts quickly and smooth with hydroxyl (even *tert.* OH) and carboxyl groups, but not with amines. This characteristic makes TSIM particularly useful in multi-derivatisation schemes for compounds with different functional groups, which are to be derivatised differently (e. g. –O–TMS / –N–HFB derivatives of catecholamines).

recommended application: 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 analysed directly.

recommended solvent pyridine

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

MN Appl. No. 213120

Ordering information

	Packing unit of			
	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	

* in vials with screw caps



Reagent mixtures for silylation

Code		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

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

Silylation with SILYL-21 or SILYL-2110

Procedure:

Carefully add SILYL-21 or SILYL-2110 to 1 – 10 mg of the sample. A precipitate of ammonium chloride does not interfere. If the sample should not dissolve within 5 minutes, 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 derivatisation of 3-ketosteroids we recommend to use DMF (dimethylformamide).

MN Appl. No. 213130

- suitable for 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

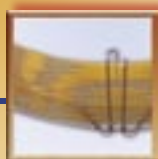
Procedure:

Completely silylate 2 mg of the sample with 0.3 ml MSTFA e.g. as described on page 241. After addition of 0.3 ml MBTFA the N-trimethylsilyl group is replaced by the N-trifluoroacetyl group. The mixture can be analysed directly.

MN Appl. No. 213140



Reagents for GC



Test mixtures for GC capillary columns

Test mixtures for GC

- Test mixtures for GC capillary columns are used for controlling the performance of fused silica capillary columns and the GC system
- Test mixtures for chiral GC columns see page 234



Ordering information

Designation	Pack of	Composition	Cat. No.
Polarity mixture POL ₅ (qualitative) in <i>n</i> -pentane	1 ml	1-butanol, benzene, methyl butyrate, toluene, cyclopentanone, 1-octene, dibutyl ether	722306
Activity test mixture (FA-TMS test according to Donike) in MSTFA/ <i>n</i> -hexane (1 + 4)	1 ml	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), tetra-cosane (C ₂₄), octacosane (C ₂₈)	722307
Grob test mixture (modified) in <i>n</i> -hexane	1 ml	(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)	722310
MN OPTIMA® test mixture in pentane	1 ml	0.1 % each of undecane, dodecane, octanol, dimethylaniline, decylamine, methyl decanoate, methyl undecanoate, heneicosane, docosane, tricosane (chromatograms see page 200)	722316
MN OPTIMA® amine test mixture in ethanol	1 ml	0.2 % diisobutylamine, 1 % diethanolamine, 0.2 % 2,6-dimethylaniline, 0.2 % <i>o</i> -propanol-pyridine, 0.2 % dicyclohexylamine, 0.2 % dibenzylamine	722317
FAME test mixture in hexane	1 ml	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 220)	722320



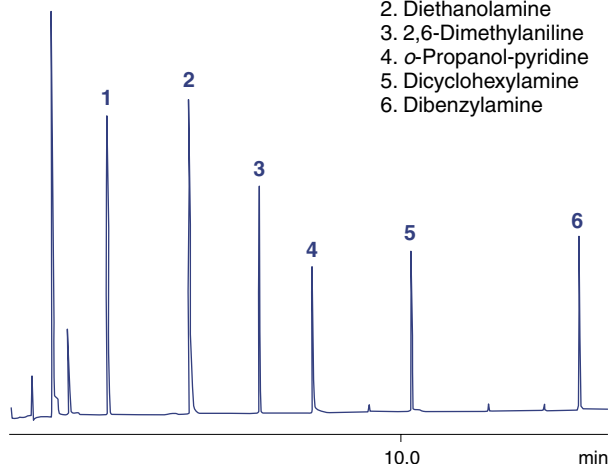
Separation of the OPTIMA® Amine test mixture (Cat. No. 722317)

Column: OPTIMA® 5 Amine, 1.0 µm film, 30 m x 0.32 mm ID, max. temp. 300/320 °C, Cat. No. 726353.30

Injection volume: 1 µl
Carrier gas: 0.6 bar H₂
Split: 1:50
Temperature: 100 °C → 290 °C, 10 °C/min
Detector: FID, 280 °C, 2⁶

Peaks:

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



MN Appl. No. 250020

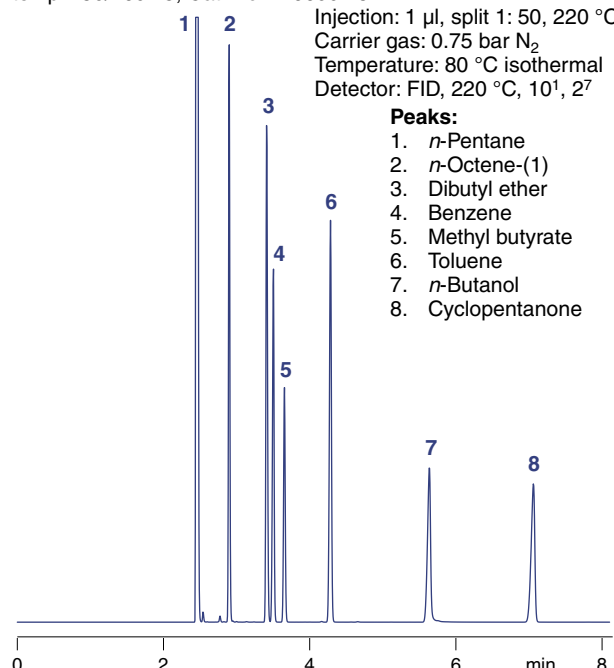
Polarity mixture POL5 (qualitative) (Cat. No. 722306)

Column: OPTIMA® Wax, 0.25 µm film, 25 m x 0.25 mm ID, max. temp. 250/260 °C, Cat. No. 726600.25

Injection: 1 µl, split 1: 50, 220 °C
Carrier gas: 0.75 bar N₂
Temperature: 80 °C isothermal
Detector: FID, 220 °C, 10¹, 2⁷

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

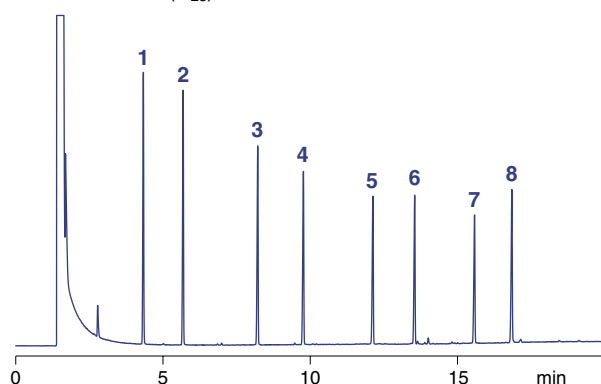
Activity test mixture (Cat. No. 722307)

Column: OPTIMA® 5, 1.0 µm film, 25 m x 0.32 mm ID, max. temp. 340/360 °C, Cat. No. 726316.25

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, 10¹, 2³

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

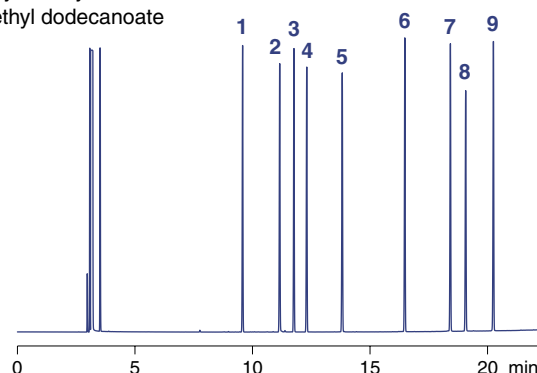
Grob test mixture (modified) (Cat. No. 722310)

Column: OPTIMA® 5, 1.0 µm film, 50 m x 0.25 mm ID, max. temp. 340/360 °C, Cat. No. 726807.50

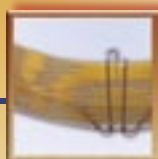
Injection: 1 µl, split 1: 40, 280 °C
Carrier gas: 1.5 bar H₂
Temperature: 80 °C → 280 °C (10 min), 8 °C/min
Detector: FID, 280 °C, 10¹, 2⁶

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



Test mixtures for environmental analyses

Ordering information

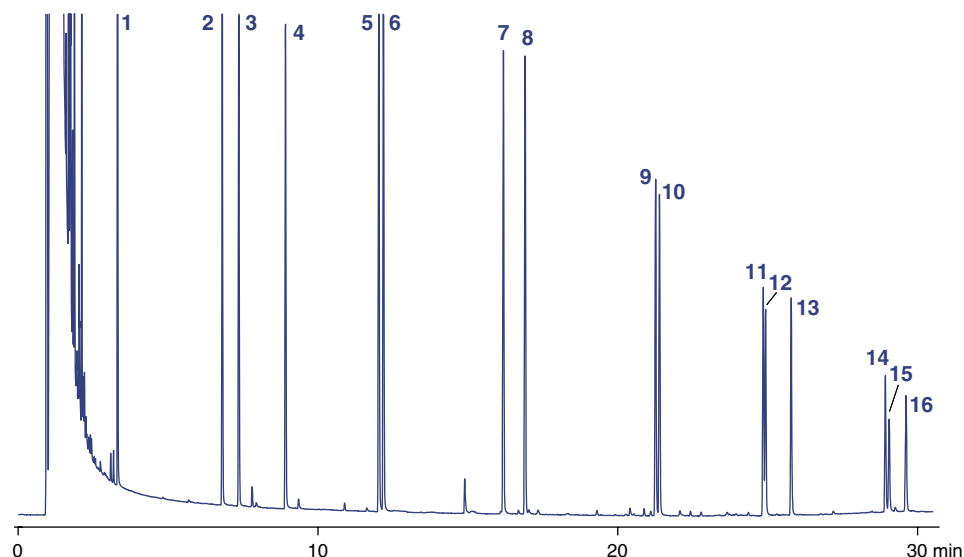
Designation	Pack of	Composition	Cat. No.
Haloform test mixture in <i>n</i> -pentane (qualitative)	1 ml	9 halogenated hydrocarbons acc. to German drinking water specifications (in ng/ml): dichloromethane (795), chloroform (75), 1,1,1-trichloroethane (67), carbon tetrachloride (80), trichloroethylene (73), bromodichloromethane (100), dibromochloromethane (122), tetrachloroethylene (81), bromoform (145)	722311
Haloform test mixture in methanol for head-space analyses (qualitative)	1 ml	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)	722371
Haloform test kit (qualitative)	11 x 1 ml	1 ml each of 9 single undiluted halogenated hydrocarbons and 1 ml each of test mixtures Cat. Nos. 722311 and 722371	722312
Pesticide test mixture in <i>n</i> -hexane (qualitative)	1 ml	10 µg/ml each of α -BHC, HCB, β -BHC, γ -BHC, δ -BHC, heptachlor, aldrin, dieldrin, endrin, <i>p,p'</i> -DDT, mirex	722313
PAH test mixture acc. to EPA in toluene	1 ml	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	722314
PAH test mixture acc. to German drinking water specifications in toluene	1 ml	20 µg/ml each of fluoranthene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, benzo[ghi]perylene	722331
BTX test mixture in methanol	1 ml	10 ng/µl each of benzene, ethylbenzene, toluene, <i>m</i> -, <i>o</i> -, <i>p</i> -xylene	722372

PAH test mixture acc. to EPA for GC (Cat. No. 722314)

Column: sOPTIMA® 5, 0.25 µm film, 30 m x 0.32 mm ID, max. temperature 340/360° C, Cat. No. 726314.30
Sample: PAH test mixture according to EPA (20 µg/ml each in toluene)
Injection volume: 1.0 µl
Carrier gas: H₂, 70 KPa
Split: 1 : 15
Temperature: 100° C, 7 °C/min → 300° C
Detector: FID, 300 °C, 2⁴

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[a,h]anthracene
16. Benzo[ghi]perylene



MN Appl. No. 200510

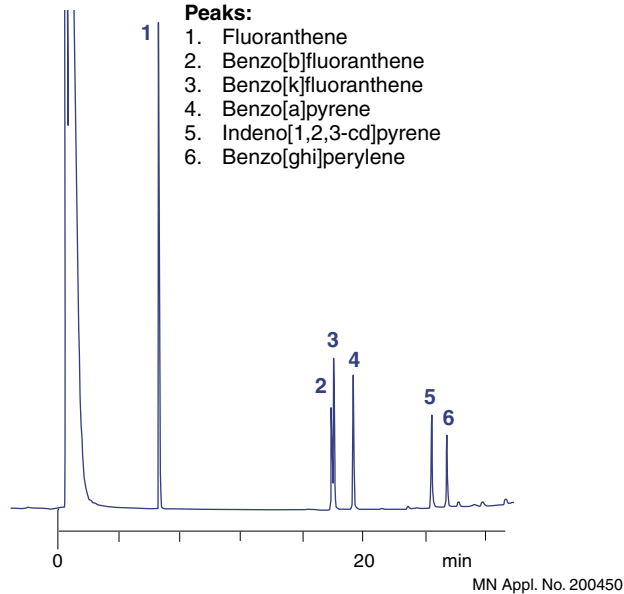


PAH test mixture acc. to German drinking water specifications (Cat. No. 722331)

Column: OPTIMA® 5, 0.25 µm film, 25 m x 0.32 mm ID, max. temp. 340/360 °C, Cat. No. 726314.25
 Injection volume: 2 µl
 Carrier gas: 0.6 bar H₂, split 1 : 10
 Temperature: 80 °C → 180 °C → 300 °C, 4 °C/min
 Detector: FID 300 °C, 2⁴

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

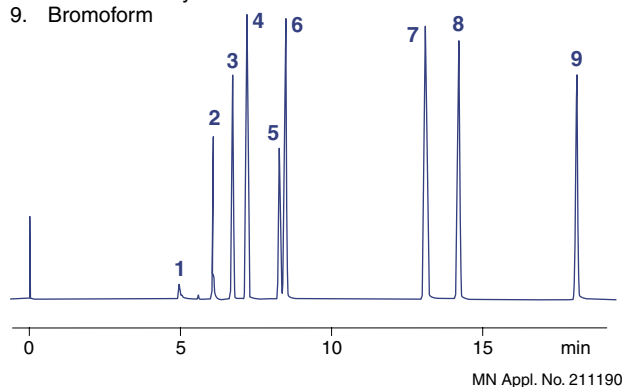


Haloform test mixture (Cat. No. 722311)

Column: FS-SE-54, 0.35 µm film, 50 m x 0.25 mm ID, max. temperature 300 °C, Cat. No. 733623.50
 Injection volume: 1 µl
 Carrier gas: 1 bar N₂
 Split: about 1 : 30
 Temperature: 45 °C (10 min) → 120 °C, 8 °C/min
 Detector: ECD 260 °C, 2⁸

Peaks:

1. Dichloromethane
2. Chloroform
3. 1,1,1-Trichloroethane
4. Carbon tetrachloride
5. Trichloroethylene
6. Bromodichloromethane
7. Dibromochloromethane
8. Tetrachloroethylene
9. Bromoform

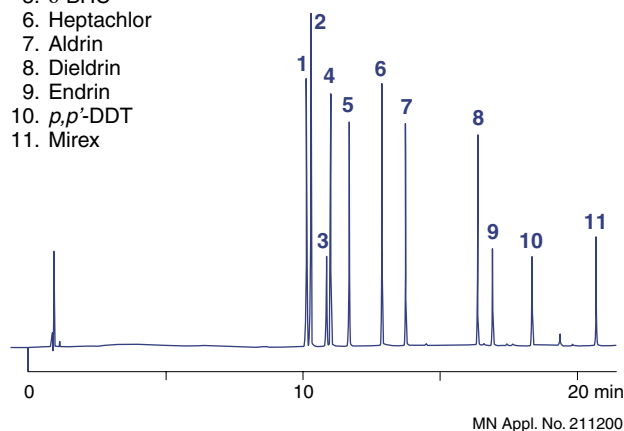


Pesticide test mixture (Cat. No. 722313)

Column: OPTIMA® 5, 0.25 µm film, 25 m x 0.25 mm ID, max. temp. 340/360 °C, Cat. No. 726056.25
 Injection volume: 0.5 µl (test mixture diluted to 1 µg/ml per component) in *n*-hexane
 Carrier gas: 100 kPa H₂
 Split: 330 ml/min
 Temperature: 100 °C → 270 °C, 8 °C/min
 Detector: ECD 300 °C, 2¹⁰

Peaks:

1. α-BHC
2. HCB
3. β-BHC
4. γ-BHC
5. δ-BHC
6. Heptachlor
7. Aldrin
8. Dieldrin
9. Endrin
10. *p,p'*-DDT
11. Mirex

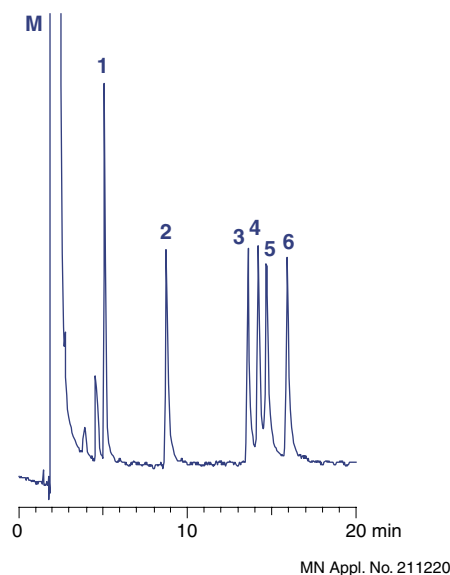


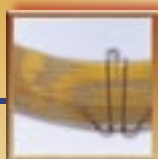
BTX test mixture (Cat. No. 722372)

Column: HYDRODEX β-PM, 50 m x 0.25 mm ID, max. temperature 250 °C, Cat. No. 723370.50
 Injection volume: 2 µl (10 ng/µl each in methanol)
 Carrier gas: 120 kPa H₂ (2.45 ml/min)
 Split: 40 ml/min
 Temperature: 60 °C → 100 °C, 2 °C/min
 Detector: FID 250 °C, 2⁴

Peaks:

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





Accessories for capillary columns

Ferrules for GC

- Graphite** ferrules provide the highest temperature stability (up to 450 °C). They are reusable when 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 stable up to 400 °C and reusable.
- Teflon** 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		Vespel		Teflon
max. temp. →	450 °C	plain 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 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 / Cat. No. please send us an old, used ferrule for the right selection.



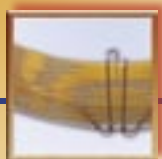
Connectors for capillary GC columns

- Graphseal connecting system for capillaries**
 based on the Graphseal ferrule: 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 Graphseal nut (with slit) and an adaptor (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 shrinking tube**
 can also be used for connecting capillaries. The minimum inner diameter expanded is 1.17 mm, the maximum ID shrunk is 0.40 mm. Shrinking occurs above 310 °C. Connections with PTFE shrinking tube are applicable up to 200 °C only. They should never be used above 250 °C.

Ordering information

Description	Pack of	Cat. No.	Specification
Graphseal connecting system for capillary columns			
Graphseal adaptor	1 set	708320	1 1/16" exit, injector or detector 2 Graphseal insert, 0.8 mm bore 3 Graphseal reducing unit 4 Graphseal ferrule 5 slotted nut 6 capillary 2 + 3 + 5 Graphseal adaptor 708320
Graphseal nut, slotted	2 nuts	708321	
Graphseal ferrule, 0.4 mm bore	10 ferrules	708337	
Graphseal ferrule, 0.5 mm bore	10 ferrules	708318	
Graphseal ferrule, 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 connecting capillaries, min. ID expanded 1.17 mm, max. ID shrunk 0.40 mm

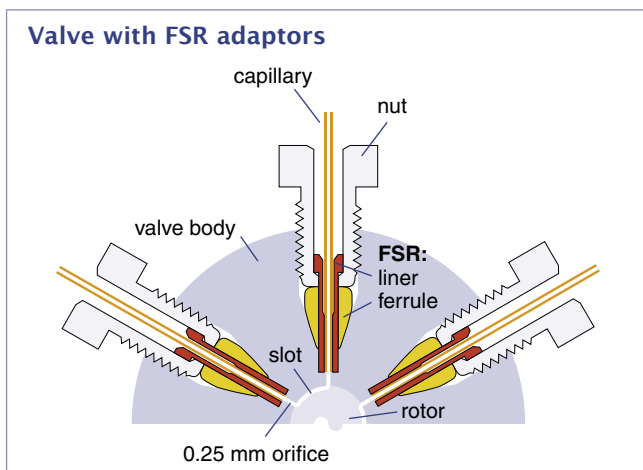
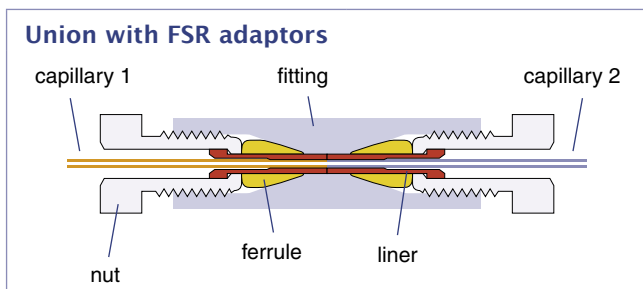
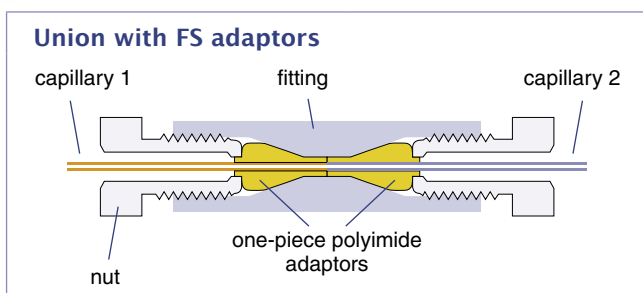
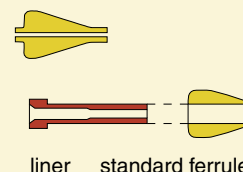




Accessories for capillary columns

Valco fused silica adaptors and fittings for capillary GC

- ◆ **one-piece FS adaptors:** recommended for use in fittings where the polyimide ferrule need not be removed
- ◆ **two-part removable FSR adaptors:** 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 with an enlarged diameter at one end fits within the nut, thus ensuring that the liner and the tube within are removed as the nut is unscrewed from the valve (see figure below)
 The 1/16" FSR adaptor comes with a special counterbored 1/16" nut (ZCN1) to receive the liner. The 1/32" adaptor works with standard Valco 1/32" nuts.



To order Valco fittings for use with fused silica adaptors (FS or FSR recommended), add suffix "J" to the fitting code and specify the appropriate number of adaptors separately. The stainless steel ferrules normally provided with the fittings are omitted since they are replaced by the FS (or FSR) adaptors. Again, for 1/16" FSR adaptors use the counterbored nut ZCN1 supplied with the adaptor.

Examples:

- 1) 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 adaptors FS.4 or a 1/32" union ZU.5TJ and 2 removable FSR adaptors FSR.4
- 2) 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 adaptors FS1-.8 or a 1/16" union ZU1TJ and 2 removable FSR adaptors FS1R.8

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

For use of fused silica adaptors with Valco valves please order the number of adaptors (FSR required) when you order the valve, or when you want to use an existing valve with open tubular columns. Please note that for 1/16" FSR adaptors you have to use the special counterbored nut ZCN1 which is supplied with the adaptors FS1R.5 and FS1R.8.

Examples:

- 1) For connecting a capillary with 0.32 mm ID (0.5 mm OD) to a valve with 1/32" fittings we recommend the removable FSR adaptor FSR.5.
- 2) For connecting a capillary with 0.53 mm ID (0.8 mm OD) to a valve with 1/16" fittings we recommend the removable FSR adaptor FS1R.8.



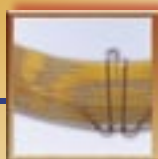
Ordering information

Valco code	Description	Pack of	Cat. No.	
One-piece fused silica adaptors				
		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 adaptors (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 adaptors				
ZCN1	1/16"	counterbored	1	724417
For standard Vespel ferrules as well as standard nuts please see the Valco programme, which is available on request.				
Unions, Tees and crosses for fused silica adaptors (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 adaptors				
OEW	open end wrench (3/16" x 1/4")		1	724423 for use with 1/32" fittings
PV	pin vise and drill index (0.34 to 1.0 mm)		1	724424 application see text below

Should a tube break in a straight-through union, remove the nuts and the tube opposite the broken one. Clear the fitting by passing a drill or wire of appropriate diameter into the unbroken side and through the centre of the fitting.

A pin vise and drill index are used for removing ferrules from Tee and cross fittings, and for enlarging the interior diameter of FS adaptors (Valco code PV).

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



Accessories for capillary columns

Glass injection liners for GC

- protect the sample from catalytic decomposition at active metal surfaces in the injector. The programme comprises liners with glass wool for split injection, liners for splitless injection and liners with flow reversal for different gas chromatographs.

Ordering information

Description	Length [mm]	OD [mm]	ID [mm]	Specification	Pack of [liners]	Cat. No.
for Hewlett-Packard (Agilent) instruments						
Liner with glass wool for split injection	78	6.1	4		1	708380
Liner for splitless injection	78	6.1	4		1	708382
Liner for splitless injection	78	6.1	2		1	708381
Liner with flow reversal b = 22 mm	78	6.1	4		1	708383
for Carlo Erba / Fisons (Thermo) instruments						
Liner with flow reversal	98	6.1	4	fig. see above, b = 46 mm	1	708384

Septa for GC

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

* When 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 which have become baked into the injection port of the gas chromatograph)						706141



Systems for point-of-use gas purification

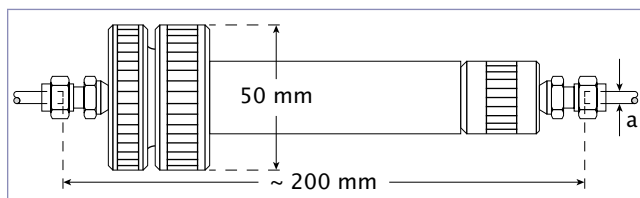
For maximum column lifetime and interference-free detector operation in GC high purity of the carrier and burner gases is prerequisite. If the gas supplies available in a laboratory do not meet quality requirements, installation of an in-line gas purification system is generally recommended. We offer purification systems which use special absorber cartridges to reduce the concentration of oxygen, water or hydrocarbons in the gas:

- O₂-free®** (formerly Oxisorb®) for removal of oxygen by chemisorption: specially treated chromium trioxide on a large surface support; as a side effect water is removed by physisorption
 capacity per cartridge 100 ml O₂ and 500 ml H₂O (gas); final purity < 5 ppb O₂, < 30 ppb H₂O;
 packed under helium in aluminium or glass cartridges (the latter for visual control of the absorber mass)
 applicable for noble gases, nitrogen, hydrogen, carbon monoxide, carbon dioxide and saturated hydrocarbons; not applicable for purification of oxygen, pressurised air and unsaturated hydrocarbons
- H₂O-free** (formerly Hydrosorb) for removal of water by physisorption: highly reactive molecular sieve, packed in aluminium cartridges under He; capacity per cartridge ~ 1 l H₂O (gas); final purity < 20 ppb H₂O
 applicable for noble gases, nitrogen, hydrogen, carbon monoxide, carbon dioxide, saturated hydrocarbons, halogenated hydrocarbons, nitrous oxide, pressurised air and oxygen
- HC-free** (formerly Accosorb) for removal of hydrocarbons (HC), especially oil traces by physisorption: activated carbon, packed in aluminium cartridges under helium
 capacity per cartridge 1 mg C₂H₆, 180 mg higher HC, 8 g oil vapour; final purity < 10 ppb HC (except CH₄)
 applicable for noble gases, nitrogen, hydrogen, carbon monoxide, carbon dioxide, methane and pressurised air; not applicable for purification of oxygen

Holders for cartridges are available for tubing lines with 1/4", 1/8" or 6 mm OD. For 1/8" lines we also supply a multiple adsorber for combination of two absorber cartridges in series (e.g. O₂-free and H₂O-free for carrier gases).

Please remember to exchange the cartridges in regular intervals (e.g. whenever you change the steel gas cylinder), because exhausted purification cartridges are useless!

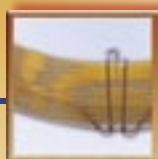
Regeneration of the adsorber mass is uneconomical or not possible.



Small absorber L for installation in gas tubes
 a = tube diameter: 6 mm, 1/4", or 1/8"

Ordering information

Description	Pack of	Cat. No.
Gas purification cartridges		
O ₂ -free cartridges, glass (with visible packing)	2	734325
O ₂ -free cartridges, aluminium, with molecular sieve	2	734329
H ₂ O-free cartridges	2	734363
HC-free activated carbon cartridges	2	734364
Holders for gas purification cartridges		
Small absorbers L (without cartridges)		
for 6 mm OD tubing	1	734326
for 1/4" OD tubing	1	734327
for 1/8" OD tubing	1	734328
Small absorbers L, PN 10, with protective jacket		
for 6 mm OD tubing	1	734322
for 1/4" OD tubing	1	734323
for 1/8" OD tubing	1	734324
Multiple absorber II		
Multiple absorber for 1/8" OD tubing (without cartridges)	1	734361
Protective plexiglas jacket PN 10	1	734362



Accessories for GC in general

Tools and general accessories for GC

- ⊕ **Soap film flowmeters:** primary standard for measuring gas flows, available in three different sizes
leak check 734145 is the ideal residue-free solution to be used with these flowmeters
- ⊕ **Diamond file:**
a useful tool for cutting capillaries and smoothing ends of capillaries. Square capillary ends without protruding particles are especially important for butt connections (e.g. in Valco unions).
- ⊕ **Magnifying lens:**
a very versatile 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 7fold magnification and is supplied with a scale as pictured in the figure below. The space between lines corresponds to 1/10 mm.
- ⊕ **Empty cages** are e.g. required for retention gaps and deactivated capillaries
- ⊕ **Glass wool, quartz wool and glass fibre wadding** are e.g. used for GC liners, packed GC columns etc.



Lens with scale



Diamond file

Ordering information

Description	Specification	Pack of	Cat. No.
Flowmeters and accessories			
1 ml soapfilm flowmeter		1	734142
10 ml soapfilm flowmeter		1	734143
25 ml soapfilm flowmeter		1	734144
Leak check in bottles		250 g	734145
Tools for capillary GC			
Diamond file	for cutting capillaries and straightening capillary ends	1	708300
Magnifying lens with scale	magnification 7x	1	706296
Empty cages for GC capillaries			
Cage 160	160 mm dia. for all column lengths up to 50 m with 0.25 and 0.32 mm ID	1	723721
Cage 190/32	190 mm dia. for column lengths up to 30 m with 0.53 mm ID / 60 m x 0.32 mm ID	1	723722
Cage 190/58	190 mm dia. recommended for 50 and 60 m columns with 0.53 mm ID	1	723734
Glass wool			
Glass wool, long fibres, DMCS treated, for packed GC columns		50 g	706201
Glass fibre wadding silanised, very fine fibres		25 g	718002
Quartz wool, very fine fibres		25 g	718587
Glass wool extractor for GC columns		1	706117