Columns for HPLC

Adsorbents for liquid chromatography

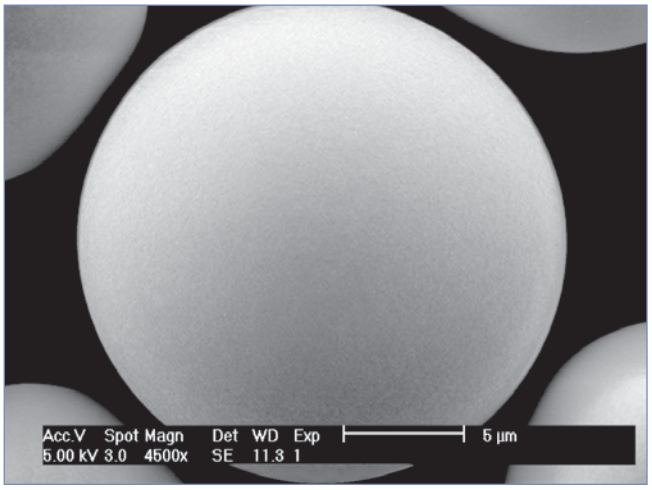
NUCLEODUR® high purity silica for HPLC

NUCLEODUR® is a fully synthetical type B silica (silica of 3rd generation) offering highly advanced physical properties like **totally spherical** particle shape, outstanding **surface microstructure,** high **pressure stability** and **low metal content.**

NUCLEODUR® as a state-of-the-art silica is the ideal base material for modern HPLC phases. It is the result of MACHEREY-NAGEL's pioneering research in chromatography for more than 40 years.

In RP liquid chromatography the efficiency of the packing is strongly affected by the quality of the base silica itself. Shortcomings in the surface geometry of the particles or metal contaminants are the main reasons for inadequate coverage with the covalently bonded alkylsilanes in the subsequent derivatization steps. It is well known, that poor surface coverage and, in consequence, high activity of residual free silanols often results in peak tailing or adsorption, particularly with basic compounds.

Particle shape and surface symmetry



NUCLEODUR® silicas are synthesized in a unique and carefully controlled manufacturing process which provides silica particles, which are totally spherical. The picture shows the outstanding smoothness of the NUCLEODUR® surface.

Purity

As already mentioned above, a highly pure silica is required for achieving symmetric peak shapes and maximum resolution. Inclusions of, e.g., iron or alkaline earth metal ions on the silica surface are largely responsible for the unwanted interactions with ionizable analytes, e.g. amines or phenolic compounds.

NUCLEODUR® is virtually free of metal impurities and low acidic surface silanols. Elemental analysis data of NUCLEODUR® 5 µm measured by AAS are listed below.

Elementary analysis (metal ions) of NUCLEODUR® 100-5

Aluminium	<	5	ppm
Iron	<	5	ppm
Sodium	<	5	ppm
Calcium	<	10	ppm
Titanium	<	1	ppm
Zirconium	<	1	ppm
Arsenic	<	0.5	ppm
Mercury	<	0.05	ppm

Pressure stability

The totally spherical and 100% synthetic silica gel exhibits an outstanding mechanical stability, even at high pressures up to 800 bar and elevated eluent flow rates.

In addition, after several cycles of repeated packing, no significant drop in pressure can be observed. The latter is of prime importance for preparative and process-scale applications.

Physical data of NUCLEODUR®

Surface area (BET)	340 m^2/g
Pore size	110 Å
Pore volume	0.9 mL/g

NUCLEODUR® modifications

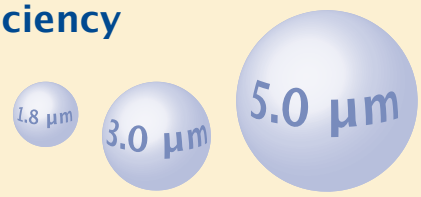
Several different surface modifications based on NUCLEODUR® silica have been developed over the last years providing a full range of specified HPLC phases and an ideal tool for every separation:

- NUCLEODUR® C_{18} Gravity and C_8 Gravity
- NUCLEODUR® C_{18} Isis
- NUCLEODUR® C_{18} Pyramid
- NUCLEODUR® PolarTec *NEW!*
- NUCLEODUR® PFP *NEW!*
- NUCLEODUR® Sphinx RP
- NUCLEODUR® C_{18} HTec
- NUCLEODUR® C_{18} ec and C_8 ec
- NUCLEODUR® HILIC
- NUCLEODUR® CN and CN-RP
- NUCLEODUR® NH_2 and NH_2-RP

For a summary of important properties of our NUCLEODUR® phases please see page 112.

1.8 µm particles for increased separation efficiency

- **Key features**
  - Decrease of analysis time (ultra fast HPLC)
  - Shorter columns with high separation efficiency and significant improvement of resolution and detection sensitivity
  - Suitable for **LC/MS** due to low bleeding characteristics



- NUCLEODUR® 1.8 µm particles are fractionated to limit the increase in back pressure.
- Available in 1.8 µm: C_{18} Gravity, C_8 Gravity, C_{18} Isis, C_{18} Pyramid, PolarTec, PFP, Sphinx RP, C_{18} HTec, HILIC

Advantages of 1.8 µm particle size

Miniaturization started in the early stage of HPLC with the reduction of particle size from 10 µm via 7 µm to standard 5 µm – still the most used particle diameter in analytical HPLC – to 3 µm spherical particles. With the introduction of 1.8 µm NUCLEODUR® particles researchers have turned over a new leaf in HPLC column technology, featuring extraordinary improvements in terms of plate numbers, column efficiency and resolution compared with 3 µm particles.

- **Increased separation efficiency by higher number of theoretical plates (N):**
  50 x 4.6 mm NUCLEODUR® C_{18} Gravity
  3 µm: N ≥ 100 000 plates/m (h value ≤ 10)
  1.8 µm: N ≥ 166 667 plates/m (h value ≤ 6)

Increase of the plate number by ~67% offers the possibility of using shorter columns with equal plate number resulting in a decrease of analysis time.

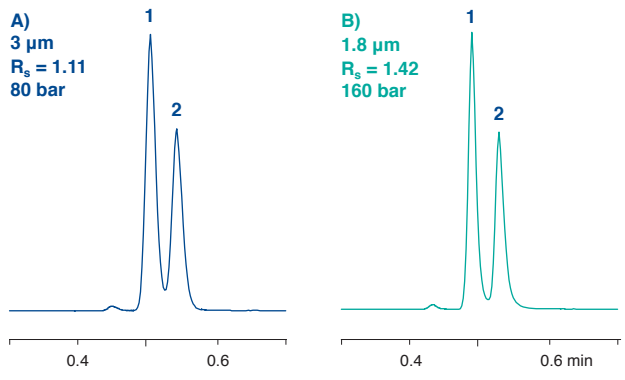
- **Significant improvement in resolution**

$$R_s = \frac{\sqrt{N}}{4}\left(\frac{\alpha-1}{\alpha}\right)\left(\frac{k_i'}{k_i'+1}\right)$$

R_s = resolution, α = selectivity (separation factor), k_i' = retention
N = plate number with $N \propto 1/d_P$, d_P = particle diameter

Resolution as a function of particle size

Column: 50 x 4 mm NUCLEODUR® C_{18} Gravity
A) 3 µm, B) 1.8 µm
Eluent: acetonitrile – water (80:20, v/v)
Flow rate: 2 mL/min
Detection: UV, 254 nm
Peaks: 1. naphthalene, 2. ethylbenzene



Use of 1.8 µm instead of 3 µm particles leads to an increase of resolution by a factor of 1.29 (29%) since the resolution is inversely proportional to the square root of the particle size.

- **Column back pressure**

Due to the smaller particles the back pressure will increase according to

$$\Delta_P = \frac{\Phi \cdot L_C \cdot \eta \cdot u}{{d_P}^2}$$

Δ_P = pressure drop; Φ = flow resistance (nondimensional)
L_C = column length; u = linear velocity
η = viscosity; d_P = particle diameter

The high sphericity of the NUCLEODUR® particles and the very narrow particle size distribution allow to keep the back pressure on a moderate level.

Comparison of back pressures:
100% methanol, 1.5 mL/min, 22 °C, column 50 x 4.6 mm

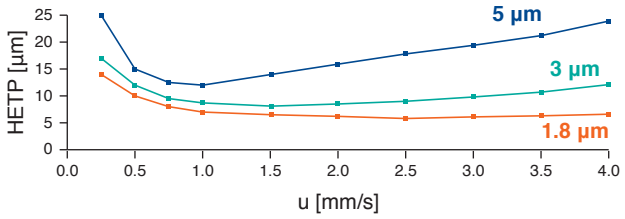
	NUCLEODUR® C_{18} Gravity	Competitor A
3 µm	70 bar	–
1.8 µm	130 bar	170 bar

- **Higher flow rates and shorter run times**

The optimal flow rate for 1.8 µm particles is higher than for 3 and 5 µm particles (see figure – the flow rate should be at the van Deemter minimum).

Van Deemter curves

Column 50 x 4.6 mm, CH_3CN – H_2O (50:50, v/v), analyte toluene



- **Technical requirements**

To gain best results with 1.8 µm particles certain technical demands must be met including pumps for flow rates of 2–3 mL with pressures of 250–1000 bar, minimized dead volume, and fast data recording

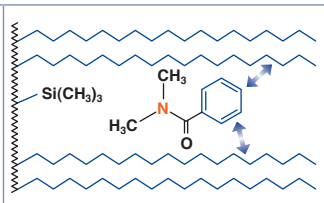
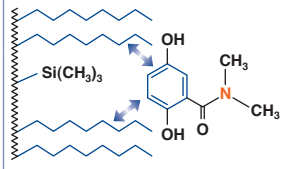
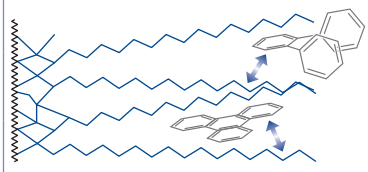
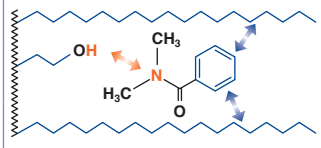
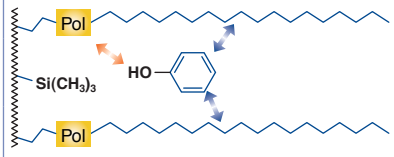
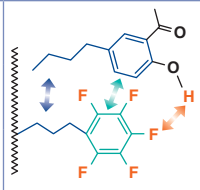
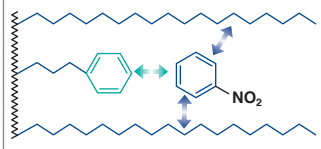
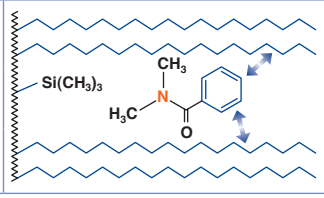
NUCLEODUR® high purity silica for HPLC

Overview of NUCLEODUR® HPLC phases

NUCLEODUR® phase	Specification	Characteristics*	Stability	Structure
C_{18} Gravity	Octadecyl phase, high density coating, multi-endcapping, 18 % C · **USP L1**	A ⬢⬢⬢⬢⬢ B ◖ C ⬢⬢◖	pH 1–11, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$
C_8 Gravity	Octyl phase high density coating multi-endcapping 11 % C · **USP L7**	A ⬢⬢◖ B ⬢ C ⬢◖	pH 1–11, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$
C_{18} Isis	Octadecyl phase with specially crosslinked surface modification endcapping 20 % C · **USP L1**	A ⬢⬢⬢⬢◖ B ⬢⬢ C ⬢⬢⬢⬢⬢	pH 1–10, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$
C_{18} Pyramid	Octadecyl phase with polar endcapping 14 % C · **USP L1**	A ⬢⬢⬢⬢ B ⬢⬢◖ C ⬢⬢	Stable against 100 % aqueous eluents, pH 1–9, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$ OH OH
PolarTec	Octadecyl phase with embedded polar group, endcapping 17 % C · **USP L1** and **L60**	A ⬢⬢⬢⬢ B ⬢⬢◖ C ⬢⬢⬢⬢	Stable against 100 % aqueous eluents, pH 1–9, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$ Pol Si–OH Pol Si–O–Si$(CH_3)_3$
PFP	Pentafluorophenyl-propyl modification with multi-endcapping 8 % C · **USP L43**	A ⬢⬢ B ⬢⬢⬢⬢ C ⬢⬢⬢⬢	pH 1–9, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$ Si–OH F F F F F Si–O–Si$(CH_3)_3$
Sphinx RP	Bifunctional RP phase, phenylpropyl and C_{18} ligands; endcapping 15 % C · **USP L1** and **L11**	A ⬢⬢⬢ B ⬢⬢◖ C ⬢	pH 1–10, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$
C_{18} HTec	Octadecyl phase with high capacity, high density coating, multi-endcapping 18 % C · **USP L1**	A ⬢⬢⬢⬢⬢ B ◖ B ⬢⬢◖	pH 1–11, suitable for LC/MS	NUCLEODUR® $(Si–O_2)_n$

* A = ⬢ hydrophobic selectivity, B = ⬢ polar / ionic selectivity, C = ⬢ steric selectivity

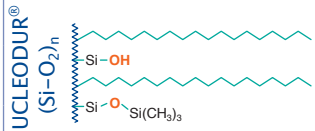
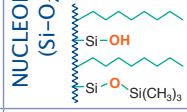
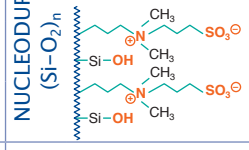
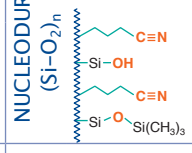
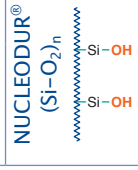
Columns for HPLC

	Application	Similar phases**	Interactions · retention mechanism		Page
	In general compounds with ionizable functional groups such as basic pharmaceuticals and pesticides	**NUCLEOSIL® C_{18} HD** Xterra® RP18 / MS C_{18}; Luna® C18(2), Gemini®, Synergi® Max RP; Zorbax® Extend-C18; Inertsil® ODS III; Purospher® STAR RP-18; Hypersil™ BDS	**Hydrophobic** (van der Waals interactions)		116
	Like C_{18} Gravity, however, generally shorter retention times for nonpolar compounds	**NUCLEOSIL® C_8 HD** Xterra® RP8 / MS C_8; Luna® C8; Zorbax® Eclipse XDB-C8			
	High steric selectivity, thus suited for separation of positional and structural isomers, planar / non-planar molecules	**NUCLEOSIL® C_{18} AB** Inertsil® ODS-P; Pro C18 RS; Zorbax® SB	**Steric** and **hydrophobic**		120
	Basic pharmaceuticals, very polar compounds, organic acids	Aqua, Synergi® Hydro-RP; AQ; Atlantis® dC_{18}	**Hydrophobic** and **polar** (H bonds)		122
	Basic pharmaceuticals, organic acids, pesticides, amino acids, water-soluble vitamins	**NUCLEOSIL® C_{18} Nautilus** ProntoSIL® C18, Zorbax® Bonus-RP, Polaris® Amide-C18; Ascentis® RP Amide, SymmetryShield™ RP18; SUPELCOSIL™ LC-ABZ+; HyPURITY™ ADVANCE	**Hydrophobic** and **polar** (H bonds)		124
	Aromatic and unsaturated compounds, halogen compounds, phenols, isomers, polar pharmaceuticals, antibiotics	ACQUITY® CSH Fluoro-Phenyl; Hypersil™ GOLD PFP; Luna® PFP(2); Discovery® HS F5; Allure® PFP Propyl; Ultra II PFP Propyl	**Polar** (H bonds), **dipole-dipole, π-π** and **hydrophobic**		126
	Compounds with aromatic and multiple bond systems	no similar phases	**π-π** and **hydrophobic**		128
	Robust and well base deactivated C_{18} phase; all separation tasks with preparative potential	Xterra® RP18 / MS C_{18} / SunFire™ C_{18}; Luna® C18(2), Gemini®, Synergi® Max RP; Zorbax® Extend-C18; Inertsil® ODS III; Purospher® STAR RP-18; Hypersil™ BDS	**Hydrophobic** (van der Waals interactions)		130

** Phases which provide a similar selectivity based on chemical and physical properties

NUCLEODUR® high purity silica for HPLC

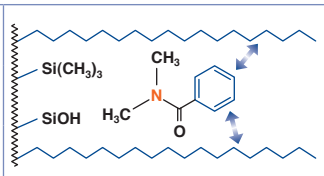
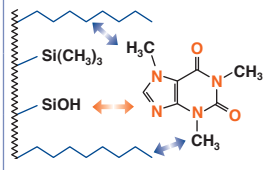
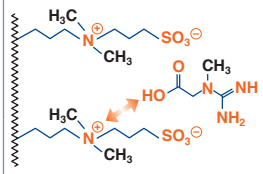
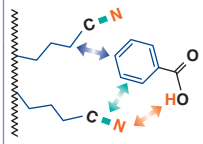
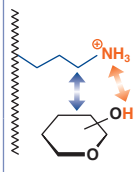
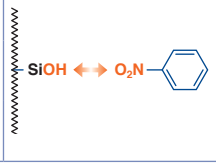
Columns for HPLC

NUCLEODUR® phase	Specification	Characteristics*	Stability	Structure
C_{18} ec	Octadecyl phase, medium density coating endcapping 17.5 % C · **USP L1**	A ⬢⬢⬢⬢ B ⬢ C ⬢⬢⬢◗	pH 1–9	
C_8 ec	Octyl phase, medium density coating endcapping 10.5 % C · **USP L7**	A ⬢⬢ B ⬢◖ C ⬢⬢◖	pH 1–9	
HILIC	Zwitterionic ammonium – sulfonic acid phase 7 % C	A ⬢ B ⬢⬢⬢⬢⬢ C –	pH 2–8.5, suitable for LC/MS	
CN / CN–RP	Cyano (nitrile) phase for NP and RP separations 7 % C · **USP L10**	A ⬢ B ⬢⬢⬢⬢ C –	pH 1–8, stable towards highly aqueous mobile phases	
NH_2 / NH_2–RP	Amino phase for NP and RP separations 2.5 % C · **USP L8**	A ⬢ B ⬢⬢⬢⬢ C –	pH 2–8, stable towards highly aqueous mobile phases	
SiOH	Unmodified high purity silica **USP L3**	A – B – C –	pH 2–8	

* A = ⬢ hydrophobic selectivity, B = ⬢ polar / ionic selectivity, C = ⬢ steric selectivity

High purity NUCLEODUR® silica

NUCLEODUR® high purity silica for HPLC

	Application	Similar phases**	Interactions · retention mechanism		Page
	Robust C_{18} phase for routine analyses	**NUCLEOSIL® C_{18}** Spherisorb® ODS II; Symmetry® C_{18}; Hypersil™ ODS; Inertsil® ODS II; Kromasil C_{18}; LiChrospher® RP-18	**Hydrophobic** (van der Waals interactions) some residual silanol interactions		133
	Robust C_8 phase for routine analyses	**NUCLEOSIL® C_8 ec / C_8** Spherisorb® C_8; Symmetry® C_8; Hypersil™ MOS; Kromasil C_8; LiChrospher® RP-8			
	Hydrophilic compounds such as polar organic acids and bases, polar natural compounds	Sequant™ ZIC®-HILIC; Obelisc™	**Ionic / hydrophilic** and **electrostatic**		136
	Polar organic compounds (basic drugs), molecules containing π-electron systems	**NUCLEOSIL® CN / CN-RP**	**π-π** and **polar** (H bonds), **hydrophobic**		138
	Sugars, sugar alcohols and other hydroxy compounds, DNA bases, polar compounds in general	**NUCLEOSIL® NH_2 / NH_2-RP**	**Polar / ionic** and **hydrophobic**		140
	Polar compounds in general	NUCLEOSIL® SiOH	**Polar / ionic**		142
	** Phases which provide a similar selectivity based on chemical and physical properties				

Columns for HPLC

An optimized phase for every separation

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® C_{18} Gravity · C_8 Gravity — nonpolar high density phases

Key features:
- Suitable for **LC/MS** and HPLC at pH extremes (pH 1–11)
- Superior base deactivation
- Ideal for method development

Technical characteristics:
Available as octadecyl (C_{18}) and octyl (C_8), multi-endcapped

Pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm for C_{18}, 1.8 and 5 µm for C_8; 7, 10, 12 and 16 µm particles for preparative purposes on request

Carbon content 18% for C_{18}, 11% for C_8

Recommended application:
Overall sophisticated analytical separations

Compound classes separated include pharmaceuticals, e.g., analgesics, anti-inflammatory drugs, antidepressants; herbicides; phytopharmaceuticals; immunosuppressants

USP L1 (C_{18}) / **USP L7** (C_8)

Base deactivation

NUCLEODUR® C_{18} Gravity and NUCLEODUR® C_8 Gravity are based on the ultrapure NUCLEODUR® silica. Derivatization generates a homogeneous surface with a high density of bonded silanes (~18% C for C_{18}, ~11% C for C_8). Thorough endcapping suppresses any unwanted polar interactions between the silica surface and the sample, which makes "Gravity" particularly suitable for the separation of basic and other ionizable analytes. Even strongly basic pharmaceuticals like amitriptyline are eluted without tailing under isocratic conditions. For a discussion of the different retention behavior of C_{18} phases compared to C_8 phases see page 134.

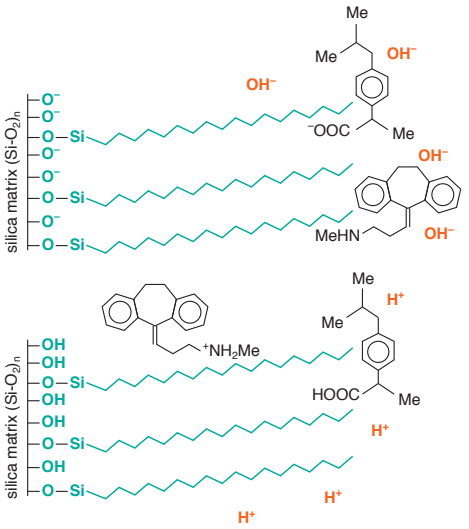
Enhanced pH stability

One major disadvantage of silica stationary phases is limited stability at strongly acidic or basic pH. Cleavage of the siloxane bonding by hydrolysis, or dissolution of the silica will rapidly lead to a considerable loss in column performance. Conventional RP phases are usually not recommended to be run with mobile phases at pH > 8 or pH < 2 for extended periods of time. The special surface bonding technology and the low concentration of trace elements of NUCLEODUR® C_{18} and C_8 Gravity allow for use at an expanded pH range from pH 1 to 11.

Benefits of enhanced pH stability

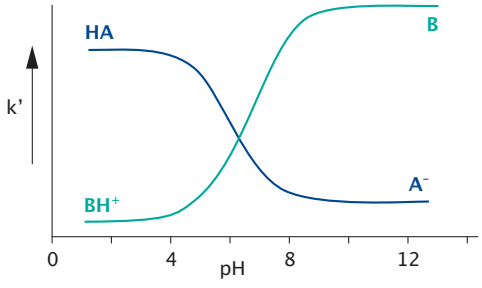
An expanded pH range is often required in method development. Many nitrogen containing compounds like basic drugs are protonated at acidic or neutral pH and exhibit poor retention on a standard C_{18} phase. The retention behavior can be improved by working at a higher pH, where the analyte is no longer protonated, but formally neutrally charged, as a rule between pH 9–10. For acidic analytes it is exactly in inverse proportion, maximum retention can be attained at low pH.

Surface silanols at different pH values



The figure above shows the extent of protonation of surface silanols and of two exemplary analytes at acidic and alkaline pH. The following graph explains the general correlation between retention and pH.

Correlation between retention and pH for basic and acidic compounds

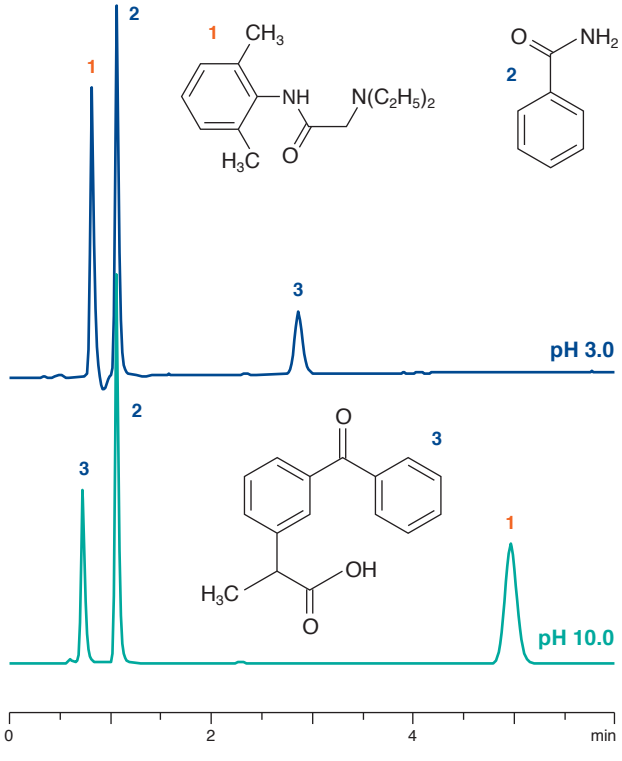


An example how selectivity can be controlled by pH is the separation of the acid ketoprofen, the base lidocaine and benzamide. Under acidic conditions the protonated lidocaine is eluted very fast due to lack of sufficiently strong hydrophobic interactions between analyte and C_{18} chains, while the formally neutral ketoprofen is eluted after about 3 min. However, at pH 10 a reversal of the elution order, with a visibly longer retention time for the basic lidocaine, is observed.

Influence of the pH value on selectivity

Column: 125 x 4 mm NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: A) acetonitrile – 10 mmol/L ammonium formate, pH 3.0 (50:50, v/v); B) acetonitrile – 10 mmol/L ammonium bicarbonate, pH 10.0 (50:50, v/v)
Flow rate: 1.0 mL/min
Temperature: 30 °C
Detection: UV, 230 nm
Injection: 2 µL

Peaks:
1. Lidocaine
2. Benzamide
3. Ketoprofen



MN Appl. No. 120860

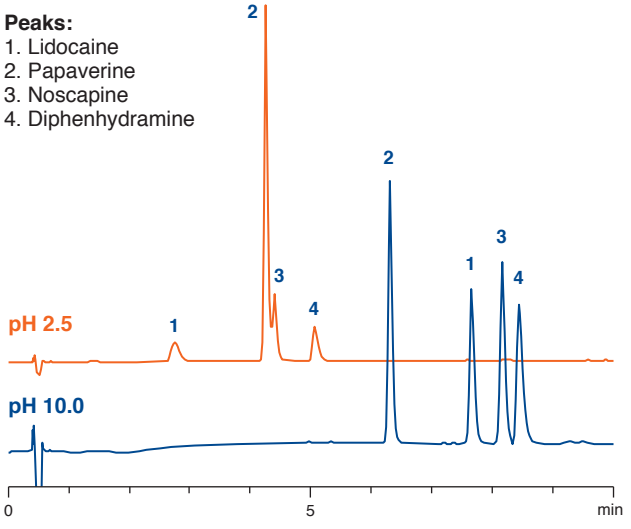
As mentioned above, pH stability of the stationary phase can be helpful for improving selectivity in method development. The following figure shows the separation of 4 basic drugs under acidic and basic conditions.

At pH 2.5 the protonated analytes exhibit poor retention (early elution) and in addition an inadequate resolution for papaverine and noscapine, whilst the formally non ionized molecules can be baseline separated due to the better retention pattern at alkaline pH.

Separation of basic alkaloids

Column: 125 x 4 mm NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: A) acetonitrile
B) 20 mmol/L $(NH_4)_2HPO_4$, pH 2.5 / 10.0
10 % A (1 min) → 75 % A in 10 min
Flow rate: 1.0 mL/min
Temperature: 25 °C
Detection: UV, 254 nm
Injection: 2 µL

Peaks:
1. Lidocaine
2. Papaverine
3. Noscapine
4. Diphenhydramine



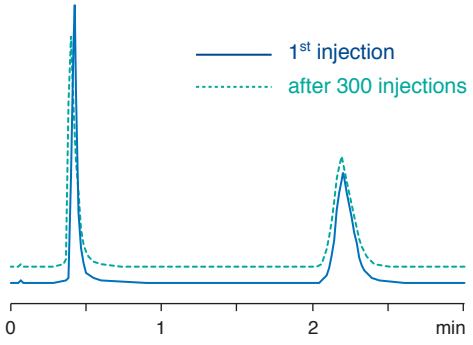
MN Appl. No. 118010

The following chromatogram demonstrates the stability of NUCLEODUR® C_{18} Gravity under alkaline conditions. The ultrapure Gravity with its unique high density surface bonding technology withstands strong alkaline mobile phase conditions.

Stability of NUCLEODUR® C_{18} Gravity at pH 11

Column: 50 x 4.6 mm NUCLEODUR® Gravity, 5 µm
Eluent: methanol – water – ammonia (20:80:0.5, v/v/v), pH 11
Flow rate: 1.3 mL/min
Temperature: 30 °C
Detection: UV, 254 nm
Injection: 2.0 µL

Peaks: 1. Theophylline, 2. Caffeine



MN Appl. No. 120850

NUCLEODUR® high purity silica for HPLC

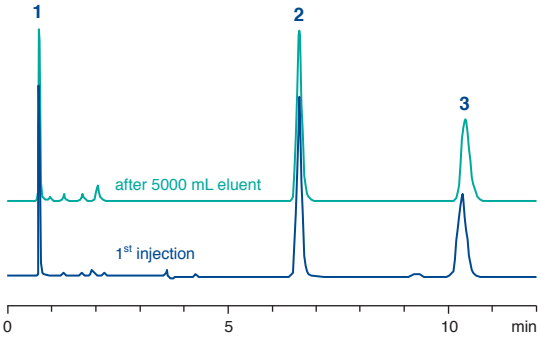
Even after 300 injections no loss of column efficiency – identified, e.g., by peak broadening or decrease in retention times – could be observed.

Under alkaline conditions dissolution of the silica support is possible, resulting in dead volume and thus peak broadening. It is worth mentioning, that this phenomenon also depends on type and concentration of buffers, as well as on the temperature. It is well known that the use of phosphate buffers, particularly at elevated temperatures, can reduce column lifetime even at moderate pH. If possible, phosphate buffers should be replaced by less harmful alternatives.

The following chromatograms show the excellent column stability of NUCLEODUR® C_{18} Gravity in acidic conditions. Retention times of all three compounds in the column performance test remain consistent and virtually unchanged, even after the column is run with 5000 mL eluent. Due to the extremely stable surface modification, no cleavage of the Si-O-Si bonding occurs, column deterioration is therefore successfully prevented.

Stability of NUCLEODUR® C_{18} Gravity at pH 1.5

Column: 125 x 4 mm NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: acetonitrile – 1 % TFA in water (50:50, v/v), pH 1.5
Flow rate: 1.0 mL/min
Temperature: 30 °C,
Detection: UV, 230 nm
Injection: 5 µL
Peaks: 1. Pyridine, 2. Toluene, 3. Ethylbenzene



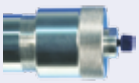
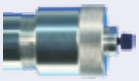
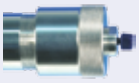
MN Appl. No. 120840

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® C_{18} Gravity, 1.8 µm				octadecyl phase, particle size 1.8 µm, 18 % C			
Analytical EC columns							
2 mm ID	**760078.20**	**760079.20**	**760071.20**	**760076.20**		**760075.20**	
3 mm ID	**760078.30**	**760079.30**		**760076.30**			
4 mm ID	**760078.40**	**760079.40**		**760076.40**			
4.6 mm ID	**760078.46**	**760079.46**		**760076.46**			
EC guard columns*		4 x 2 mm: **761901.20**		4 x 3 mm: **761901.30**			
NUCLEODUR® C_{18} Gravity, 3 µm				octadecyl phase, particle size 3 µm, 18 % C			
Analytical EC columns							
2 mm ID		**760080.20**		**760084.20**	**760081.20**	**760083.20**	**760082.20**
3 mm ID		**760080.30**		**760084.30**	**760081.30**	**760083.30**	**760082.30**
4 mm ID		**760080.40**		**760084.40**	**760081.40**	**760083.40**	**760082.40**
4.6 mm ID		**760080.46**	**760086.46**	**760084.46**	**760081.46**	**760083.46**	**760082.46**
EC guard columns*		4 x 2 mm: **761902.20**		4 x 3 mm: **761902.30**			
CC guard columns**		8 x 3 mm: **761124.30**		8 x 4 mm: **761124.40**			
NUCLEODUR® C_{18} Gravity, 5 µm				octadecyl phase, particle size 5 µm, 18 % C			
Analytical EC columns							
2 mm ID		**760102.20**		**760104.20**	**760100.20**	**760103.20**	**760101.20**
3 mm ID		**760102.30**		**760104.30**	**760100.30**	**760103.30**	**760101.30**
4 mm ID		**760102.40**		**760104.40**	**760100.40**	**760103.40**	**760101.40**
4.6 mm ID		**760102.46**	**760106.46**	**760104.46**	**760100.46**	**760103.46**	**760101.46**
EC guard columns*		4 x 2 mm: **761903.20**		4 x 3 mm: **761903.30**			
CC guard columns**		8 x 3 mm: **761125.30**		8 x 4 mm: **761125.40**			

NUCLEODUR® high purity silica for HPLC

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
VarioPrep columns							
 10 mm ID		**762103.100**			**762109.100**		**762113.100**
21 mm ID		**762103.210**			**762109.210**		**762113.210**
32 mm ID							**762113.320**
40 mm ID						**762100.400**	**762113.400**
VP guard columns***		10 x 8 mm: **762160.80**		10 x 16 mm: **762160.160**		15 x 32 mm: **762163.320**	
NUCLEODUR® C_{18} Gravity, 10 µm				octadecyl phase, particle size 10 µm, 18% C			
VarioPrep columns							
 21 mm ID							**762250.210**
40 mm ID							**762250.400**
VP guard columns***				10 x 16 mm: **762160.160**		15 x 32 mm: **762163.320**	
NUCLEODUR® C_8 Gravity, 1.8 µm				octyl phase, particle size 1.8 µm, 11% C			
Analytical EC columns							
 2 mm ID	**760756.20**	**760755.20**	**760760.20**	**760757.20**		**760759.20**	
3 mm ID	**760756.30**	**760755.30**		**760757.30**			
4 mm ID	**760756.40**	**760755.40**		**760757.40**			
4.6 mm ID	**760756.46**	**760755.46**		**760757.46**			
EC guard columns*		4 x 2 mm: **761905.20**		4 x 3 mm: **761905.30**			
NUCLEODUR® C_8 Gravity, 5 µm				octyl phase, particle size 5 µm, 11% C			
Analytical EC columns							
 2 mm ID		**760750.20**		**760754.20**	**760751.20**	**760752.20**	**760753.20**
3 mm ID		**760750.30**		**760754.30**	**760751.30**	**760752.30**	**760753.30**
4 mm ID		**760750.40**		**760754.40**	**760751.40**	**760752.40**	**760753.40**
4.6 mm ID		**760750.46**	**760749.46**	**760754.46**	**760751.46**	**760752.46**	**760753.46**
EC guard columns*		4 x 2 mm: **761907.20**		4 x 3 mm: **761907.30**			
CC guard columns**		8 x 3 mm: **761754.30**		8 x 4 mm: **761754.40**			
VarioPrep columns							
 10 mm ID		**762081.100**			**762071.100**		**762070.100**
21 mm ID		**762081.210**			**762071.210**	**762082.210**	**762070.210**
VP guard columns***		10 x 8 mm: **762097.80**		10 x 16 mm: **762097.160**			
EC and VarioPrep columns in packs of 1 column, guard columns see below							

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® C_{18} Isis — phase with high steric selectivity

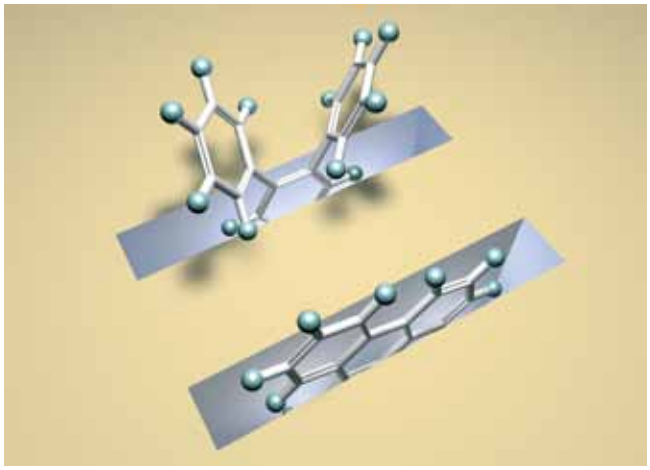
- **Key features:**
  - Exceptional steric selectivity
  - Outstanding surface deactivation
  - Suitable for **LC/MS** and HPLC at pH 1–10
- **Technical characteristics:**
  C_{18} phase with special polymeric, crosslinked surface modification; pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm; carbon content 20%
- **Recommended application:**
  Steroids, (*o,p,m*–) substituted aromatics, fat-soluble vitamins
  USP L1

Surface modification

By use of specific C_{18} silanes and polymeric bonding technologies a dense shield of alkyl chains protects the subjacent silica matrix. Elemental analysis of NUCLEODUR® C_{18} Isis shows a carbon load of 20%. The target crosslinking of the C_{18} chains on the surface enables the separation of compounds with similar molecular structure but different stereochemical properties. The technical term for this feature is steric selectivity.

Slot model

Sander and Wise [LCGC **8** (1990) 378–390] proposed a model for the retention of aromatic compounds based on molecular shape, which is referred to as "Slot Model". This model pictures the bonded C_{18} phase on the silica surface with slots which the analytes have to penetrate during retention. Planar molecules are able to penetrate these slots deeper than non-planar molecules of similar molecular weight and length-to-breadth ratio. Thus triphenylene is longer retained than *o*-terphenyl.

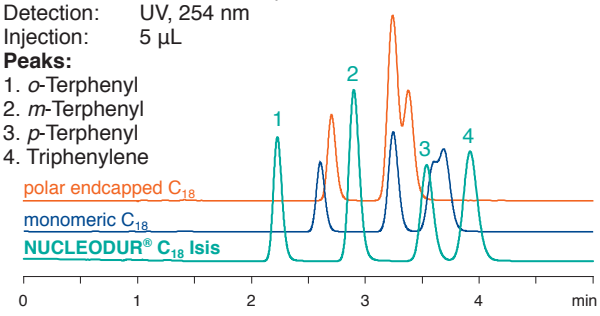


Steric selectivity

The following chromatograms reveal the improved resolution for positional isomers in a test mixture of aromatic compounds on NUCLEODUR® C_{18} Isis (green) in direct comparison with monomerically coated (blue) and polar endcapped (red) C_{18} columns.

Steric selectivity of NUCLEODUR® C_{18} Isis

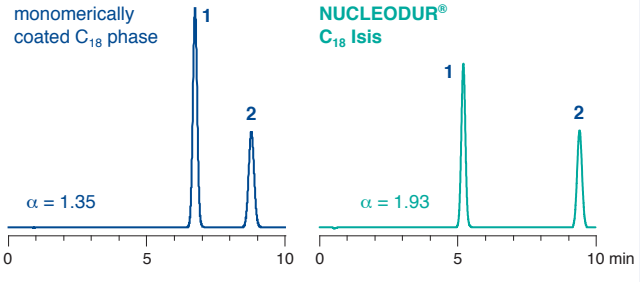
Columns: 125 x 4 mm; **NUCLEODUR® C_{18} Isis**, **monomerically coated C_{18} phase**, **polar endcapped phase**
Eluent: methanol – water (90:10, v/v)
Flow rate: 1 mL/min, temperature 35 °C
Detection: UV, 254 nm
Injection: 5 µL
Peaks:
1. *o*-Terphenyl
2. *m*-Terphenyl
3. *p*-Terphenyl
4. Triphenylene



The separation of *o*-terphenyl and triphenylene is a good example to evaluate the selectivity of a RP column in terms of the shape of two molecules. The phenyl rings of *o*-terphenyl are twisted out of plane while triphenylene has a planar geometry. The separation factor α is a measure for the steric selectivity. As is shown below the α value is considerable larger on NUCLEODUR® C_{18} Isis compared to a conventional C_{18} column.

Steric selectivity of NUCLEODUR® C_{18} Isis

Columns: 125 x 4 mm
Eluent: methanol – water (80:20, v/v)
Flow rate: 1 mL/min, temperature 40 °C
Detection: UV, 254 nm, injection 1 µL
Peaks: 1. *o*-Terphenyl, 2. Triphenylene



The surface bonding technology also provides improved stability features for the NUCLEODUR® C_{18} Isis phase.

Surface deactivation

The chromatography of basic analytes requires a high density of surface-bonded C_{18} silanes combined with a thorough endcapping procedure to keep silanol activity at a minimum. This ensures tailing-free elution of even strongly basic amino-containing compounds (see Appl. 121210 at ***www.mn-net.com/apps***).

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® C_{18} Isis, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	**760406.20**	**760405.20**	**760396.20**	**760407.20**		**760409.20**	
3 mm ID	**760406.30**	**760405.30**		**760407.30**			
4 mm ID	**760406.40**	**760405.40**		**760407.40**			
4.6 mm ID	**760406.46**	**760405.46**		**760407.46**			
EC guard columns*		4 x 2 mm: **761910.20**		4 x 3 mm: **761910.30**			
NUCLEODUR® C_{18} Isis, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		**760400.20**		**760401.20**	**760402.20**	**760403.20**	**760404.20**
3 mm ID		**760400.30**		**760401.30**	**760402.30**	**760403.30**	**760404.30**
4 mm ID		**760400.40**		**760401.40**	**760402.40**	**760403.40**	**760404.40**
4.6 mm ID		**760400.46**	**760397.46**	**760401.46**	**760402.46**	**760403.46**	**760404.46**
EC guard columns*		4 x 2 mm: **761911.20**		4 x 3 mm: **761911.30**			
CC guard columns**		8 x 3 mm: **761300.30**		8 x 4 mm: **761300.40**			
NUCLEODUR® C_{18} Isis, 5 µm						particle size 5 µm	
Analytical EC columns							
2 mm ID		**760410.20**		**760415.20**	**760412.20**	**760413.20**	**760414.20**
3 mm ID		**760410.30**		**760415.30**	**760412.30**	**760413.30**	**760414.30**
4 mm ID		**760410.40**		**760415.40**	**760412.40**	**760413.40**	**760414.40**
4.6 mm ID		**760410.46**	**760416.46**	**760415.46**	**760412.46**	**760413.46**	**760414.46**
EC guard columns*		4 x 2 mm: **761912.20**		4 x 3 mm: **761912.30**			
CC guard columns**		8 x 3 mm: **761310.30**		8 x 4 mm: **761310.40**			
VarioPrep columns							
10 mm ID		**762404.100**			**762405.100**		**762403.100**
21 mm ID		**762404.210**			**762405.210**		**762403.210**
32 mm ID							**762403.320**
40 mm ID						**762406.400**	**762403.400**
VP guard columns***		10 x 8 mm: **762420.80**		10 x 16 mm: **762420.160**		15 x 32 mm: **762422.320**	
EC and VarioPrep columns in packs of 1 column, guard columns see below							

Guard column systems						Guard column holder
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® C_{18} Pyramid — phase for highly aqueous eluents

- **Key features:**
  - Stable in 100 % aqueous mobile phase systems
  - Interesting polar selectivity features
  - Excellent base deactivation; suitable for **LC/MS** due to low bleeding characteristics
- **Technical characteristics:**
  Special phase with polar endcapping; pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm (7 and 10 µm particles for preparative purposes on request); carbon content 14 %; pH stability 1–9
- **Recommended application:**
  Analgesics, penicillin antibiotics, nucleic acid bases, water-soluble vitamins, complexing agents, organic acids

  USP L1

Columns for HPLC

RP-HPLC with highly aqueous mobile phases

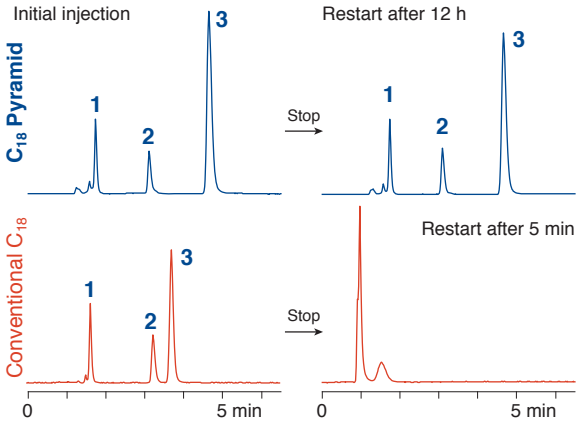
The efforts to neutralize unwanted silanol activity often results in well base-deactivated RP phases with high carbon load, but a limited scope of selectivity beyond non-polar interactions. Polar compounds like carboxylic acids or drug metabolites show only weak retention on densely bonded RP columns due to distinct hydrophobic properties but low polar interactions. Very polar analytes require highly aqueous mobile phases for solubility and retention. Conventional reversed phase columns often display stability problems in eluent systems with high percentage of water (> 95 %) as evidenced by a sudden decrease of retention time and overall poor reproducibility. This phenomenon is described as phase collapse caused by the mobile phase expelled from the pores due to the fact, that hydrophobic RP phases are incompletely wetted with the mobile phase [U. D. Neue et al., Chromatographia **54** (2001) 169–177].

Different approaches can be used to increase column stability with highly aqueous mobile phase systems. The most promising concepts are incorporating a polar group in the hydrophobic alkyl chain, or using hydrophilic endcapping procedures to improve the wettability of the reversed phase modification. NUCLEODUR® PolarTec may be taken as an example for the embedded polar group strategy, in which a C_{18} silane with a polar function is successfully linked to the silica surface.

Stability features

NUCLEODUR® C_{18} Pyramid is a silica phase with hydrophilic endcapping, designed especially for use in eluent systems of up to 100 % water. The upper figure shows the retention behavior of tartaric, acetic and maleic acid under purely aqueous conditions on NUCLEODUR® C_{18} Pyramid in comparison with a conventionally bonded C_{18} phase. It can be shown that the retention times for NUCLEODUR® C_{18} Pyramid remain nearly unchanged between initial injection and restart after the flow has been stopped for 12 h, whilst the performance of the conventional RP column already collapsed totally 5 min.

Stability test



Both columns: 125 x 4 mm
Eluent: 50 mmol/L KH_2PO_4 pH 2.5
Flow rate: 0.7 mL/min, temperature 25 °C
Detection: UV, 210 nm
Injection: 1 µL
Peaks: 1. Tartaric acid, 2. Acetic acid, 3. Maleic acid

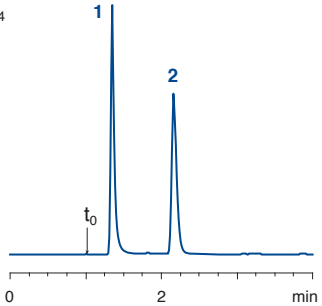
MN Appl. No. 120870

Retention characteristics

Separation of very polar compounds

Column: 125 x 4 mm NUCLEODUR® C_{18} Pyramid, 5 µm
Eluent: 0.2 % H_3PO_4
Flow rate: 1.0 mL/min
Temperature: 22 °C
Detection: UV, 202 nm
Injection: 2 µL

Peaks:
1. Formic acid
2. Acetic acid



MN Appl. No. 119170

The polar surface exhibits retention characteristics different from conventional C_{18} phases. Application 119170 shows the improved retention behavior of the very polar short chain organic acids, which are insufficiently retained on RP columns with predominantly hydrophobic surface properties. In addition to the exceptional polar selectivity NUCLEODUR® C_{18} Pyramid also provides adequate hydrophobic retention (see application No. 119190 at ***www.mn-net.com***). The perceptible increase in polarity has no impact on the retention behavior of ionizable analytes. Even with the strongly basic compounds of the tricyclic antidepressant drug test mixture, no unwanted interactions or a so-called lack in base deactivation are observed (see application 119200 at ***www.mn-net.com/apps***).

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® C_{18} Pyramid, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	**760271.20**	**760272.20**	**760275.20**	**760273.20**		**760274.20**	
3 mm ID	**760271.30**	**760272.30**		**760273.30**			
4 mm ID	**760271.40**	**760272.40**		**760273.40**			
4.6 mm ID	**760271.46**	**760272.46**		**760273.46**			
EC guard columns*		4 x 2 mm: **761915.20**		4 x 3 mm: **761915.30**			
NUCLEODUR® C_{18} Pyramid, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		**760263.20**		**760264.20**	**760260.20**	**760261.20**	**760262.20**
3 mm ID		**760263.30**		**760264.30**	**760260.30**	**760261.30**	**760262.30**
4 mm ID		**760263.40**		**760264.40**	**760260.40**	**760261.40**	**760262.40**
4.6 mm ID		**760263.46**	**760259.46**	**760264.46**	**760260.46**	**760261.46**	**760262.46**
EC guard columns*		4 x 2 mm: **761916.20**		4 x 3 mm: **761916.30**			
CC guard columns**		8 x 3 mm: **761854.30**		8 x 4 mm: **761854.40**			
NUCLEODUR® C_{18} Pyramid, 5 µm						particle size 5 µm	
Analytical EC columns							
2 mm ID		**760200.20**		**760204.20**	**760201.20**	**760203.20**	**760202.20**
3 mm ID		**760200.30**		**760204.30**	**760201.30**	**760203.30**	**760202.30**
4 mm ID		**760200.40**		**760204.40**	**760201.40**	**760203.40**	**760202.40**
4.6 mm ID		**760200.46**	**760205.46**	**760204.46**	**760201.46**	**760203.46**	**760202.46**
EC guard columns*		4 x 2 mm: **761917.20**		4 x 3 mm: **761917.30**			
CC guard columns**		8 x 3 mm: **761800.30**		8 x 4 mm: **761800.40**			
VarioPrep columns							
10 mm ID		**762271.100**			**762273.100**		**762272.100**
21 mm ID		**762271.210**			**762273.210**		**762272.210**
32 mm ID							**762272.320**
40 mm ID						**762269.400**	**762272.400**
VP guard columns***		10 x 8 mm: **762291.80**		10 x 16 mm: **762291.160**		15 x 32 mm: **762293.320**	

EC and VarioPrep columns in packs of 1, guard columns see below; details of our column systems see pages 189–196

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® PolarTec

RP phase with embedded polar group

- **Key features:**
  - Excellent base deactivation
  - Suitable for **LC/MS** and 100% aqueous eluents
  - Pronounced steric selectivity
- **Technical characteristics:**
  Phase with embedded polar group; pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm; carbon content 17%; pH stability 1–9
- **Recommended application:**
  Exceptional selectivity for phenols and nitrogen containing compounds, polar compounds like basic pharmaceuticals, organic acids, pesticides, amino acids, water-soluble vitamins, etc.

  USP L1 and **L60**

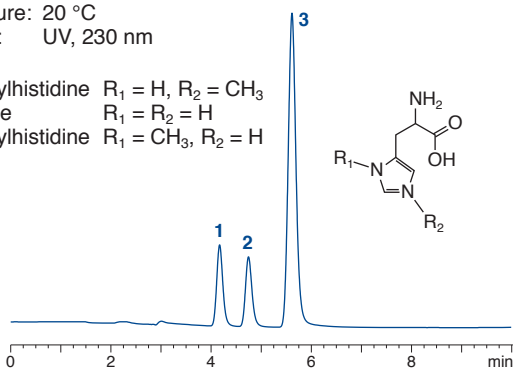
RP-HPLC under 100% aqueous conditions

The dominant form of interactions of conventional C_{18} phases are nonpolar London dispersion forces. Besides nonpolar interactions phases with embedded polar groups possess the ability to show polar interactions (dipole-dipole, hydrogen bonds, π-π, etc.) These interactions enhance retention and selectivity for polar compounds like carboxylic acids, phenols and nitrogen containing compounds.

Separation of histidines

Column: 150 x 3 mm NUCLEODUR® PolarTec, 3 µm
Eluent: 1.0 mmol/L perfluoropentanoic acid in water – 0.5 mmol/L perfluoropentanoic acid in acetonitrile (99.5:0.5, v/v)
Flow rate: 0.4 mL/min
Temperature: 20 °C
Detection: UV, 230 nm

Peaks:
1. 3-Methylhistidine $R_1 = H, R_2 = CH_3$
2. Histidine $R_1 = R_2 = H$
3. 1-Methylhistidine $R_1 = CH_3, R_2 = H$



MN Appl. No. 125140

In order to increase retention for polar compounds it is often necessary to decrease the organic ratio of the mobile phase to zero. Under these conditions many conventional C_{18} phases display the so-called dewetting effect which means that the mobile phase is expelled from the pores. This phenomenon leads to a dramatic loss in retention. NUCLEODUR® PolarTec is stable in 100% aqueous mobile phases and therefore especially suited for the separation of polar compounds like organic acids.

Due to the shielding effect of the embedded group NUCLEODUR® PolarTec shows an excellent base deactivation, which is at the top-notch of embedded polar group phases on the market. The pronounced steric selectivity (see Tanaka plot) is an additional tool for the separation of complex mixtures.

Due to low bleeding characteristics NUCLEODUR® PolarTec is also suitable for LC/MS.

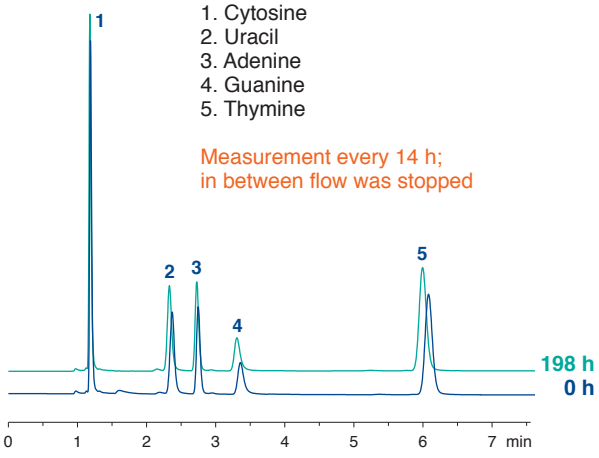
Even after days or weeks of operation in purely aqueous eluents the C_{18} chains of NUCLEODUR® PolarTec are neither folded nor show any collapsing. A significant reduction of retention time cannot be observed.

Stability of NUCLEODUR® PolarTec

Column: 150 x 3 mm NUCLEODUR® PolarTec, 3 µm
Eluent: 30 mmol/L KH_2PO_4, pH 3.0
Flow rate: 0.5 mL/min
Temperature: 30 °C
Detection: UV, 220 nm

Peaks:
1. Cytosine
2. Uracil
3. Adenine
4. Guanine
5. Thymine

Measurement every 14 h;
in between flow was stopped



MN Appl. No. 124610

NUCLEODUR® high purity silica for HPLC

In spite of the polar character of the embedded functional group NUCLEODUR® PolarTec exhibits sufficient hydrophobic properties and is very well suited for analyzing basic compounds.

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® PolarTec, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	**760461.20**	**760463.20**	**760465.20**	**760466.20**		**760468.20**	
3 mm ID	**760461.30**	**760463.30**		**760466.30**			
4 mm ID	**760461.40**	**760463.40**		**760466.40**			
4.6 mm ID	**760461.46**	**760463.46**		**760466.46**			
EC guard columns*		4 x 2 mm: **761980.20**		4 x 3 mm: **761980.30**			
NUCLEODUR® PolarTec, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		**760473.20**		**760476.20**	**760477.20**	**760478.20**	**760479.20**
3 mm ID		**760473.30**		**760476.30**	**760477.30**	**760478.30**	**760479.30**
4 mm ID		**760473.40**		**760476.40**	**760477.40**	**760478.40**	**760479.40**
4.6 mm ID		**760473.46**	**760475.46**	**760476.46**	**760477.46**	**760478.46**	**760479.46**
EC guard columns*		4 x 2 mm: **761981.20**		4 x 3 mm: **761981.30**			
CC guard columns**		8 x 3 mm: **761160.30**		8 x 4 mm: **761160.40**			
NUCLEODUR® PolarTec, 5 µm						particle size 5 µm	
Analytical EC columns							
2 mm ID		**760483.20**		**760486.20**	**760487.20**	**760488.20**	**760489.20**
3 mm ID		**760483.30**		**760486.30**	**760487.30**	**760488.30**	**760489.30**
4 mm ID		**760483.40**		**760486.40**	**760487.40**	**760488.40**	**760489.40**
4.6 mm ID		**760483.46**	**760485.46**	**760486.46**	**760487.46**	**760488.46**	**760489.46**
EC guard columns*		4 x 2 mm: **761982.20**		4 x 3 mm: **761982.30**			
CC guard columns**		8 x 3 mm: **761161.30**		8 x 4 mm: **761161.40**			
VarioPrep columns							
10 mm ID		**762220.100**			**762221.100**		**762223.100**
21 mm ID		**762220.210**			**762221.210**		**762223.210**
32 mm ID							**762223.320**
40 mm ID						**762222.400**	**762223.400**
VP guard columns***		10 x 8 mm: **762224.80**		10 x 16 mm: **762224.160**		15 x 32 mm: **762226.320**	
EC and VarioPrep columns in packs of 1, guard columns see below							

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® PFP — hydrophobic pentafluorophenyl phase

Key features:
- Hydrophobic phase with alternative selectivity in comparison to classical C_{18} modifications
- Separation principle based on 4 retention mechanisms (polar interactions (H bonds), dipole–dipole, π–π, and hydrophobic interactions)
- Suitable for **LC/MS** due to low bleeding characteristics

Technical characteristics:
Phase with pentafluorophenyl-propyl modification and multi-endcapping; pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm; carbon content 8%; pH stability 1–9

Recommended application:
Aromatic and unsaturated compounds, phenols, halogen compounds, isomers, polar compounds like pharmaceuticals, antibiotics; strong retention of basic compounds

USP L43

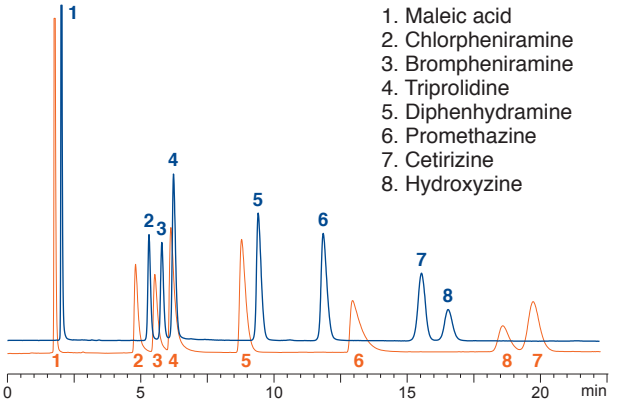
Orthogonality in selectivity

Fluorinated stationary phases in HPLC have gained increasing interest over the last years. Most common representative of fluorinated silica phases is the pentafluorophenyl modification (PFP or F5). Especially the orthogonal selectivity compared to traditional alkyl phases widens the scope in analytical HPLC. Thus NUCLEODUR® PFP offers an excellent selectivity especially for highly polar analytes like aromatic and unsaturated compounds, phenols or halogenated hydrocarbons.

Separation of antihistamines

Columns: **250 x 3 mm NUCLEODUR® PFP, 5 µm**
250 x 3 mm NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: acetonitrile – 20 mmol/L KH_2PO_4 (30:70, v/v)
Flow rate: 0.563 mL/min
Temperature: 30 °C
Detection: UV, 210 nm

Peaks:
1. Maleic acid
2. Chlorpheniramine
3. Brompheniramine
4. Triprolidine
5. Diphenhydramine
6. Promethazine
7. Cetirizine
8. Hydroxyzine



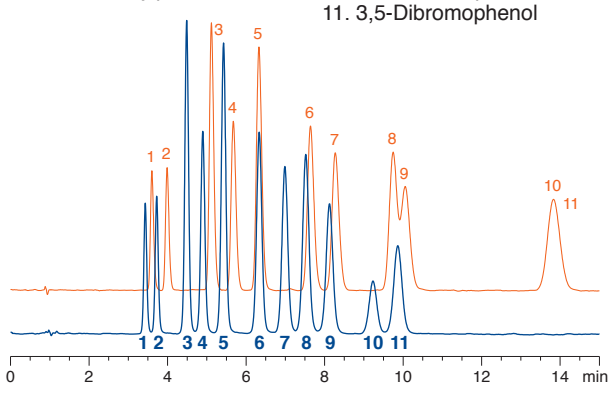
MN Appl. No. 124861

While a typical C_{18} phase just provides hydrophobic interactions between stationary phase and analyte NUCLEODUR® PFP offers four different retention mechanisms: polar interactions (H bonds), dipole–dipole, π–π, and hydrophobic interactions. Especially the pronounced ion exchange capacity and distinct steric selectivity are typical for fluorinated phases. Due to low bleeding characteristics NUCLEODUR® PFP is also suitable for LC/MS. Based on a special surface modification procedure NUCLEODUR® PFP offers highest stability also at low pH values.

Separation of phenol isomers

Columns: **125 x 4 mm NUCLEODUR® PFP, 5 µm**
125 x 4 mm NUCLEODUR® C_{18} HTec, 5 µm
Eluent: acetonitrile, 0.1 % formic acid – water, 0.1 % formic acid (35:65, v/v)
Flow rate: 1 mL/min, temperature 35 °C
Detection: UV, 280 nm

Peaks:
1. *o*-Cresol
2. *m*-Cresol
3. 3,4-Dimethylphenol
4. 3,5-Dimethylphenol
5. 2,5-Dimethylphenol
6. 2,6-Dichlorophenol
7. 2,3-Dichlorophenol
8. 2,4-Dichlorophenol
9. 3,4-Dichlorophenol
10. 2,4-Dibromophenol
11. 3,5-Dibromophenol



MN Appl. No. 124531

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® PFP offers a completely different retention behavior compared to alkyl modified silica and is often used for separations which provide insufficient results on traditional C_{18} phases. Applications in the areas of (bio-) pharma, natural compounds and environment show the broad applicability of this phase.

Ordering information

Eluent in column acetonitrile – water

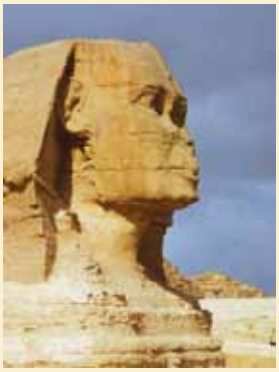
Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® PFP, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	**760431.20**	**760433.20**	**760435.20**	**760436.20**		**760438.20**	
3 mm ID	**760431.30**	**760433.30**		**760436.30**			
4 mm ID	**760431.40**	**760433.40**		**760436.40**			
4.6 mm ID	**760431.46**	**760433.46**		**760436.46**			
EC guard columns*		4 x 2 mm: **761975.20**		4 x 3 mm: **761975.30**			
NUCLEODUR® PFP, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		**760443.20**		**760446.20**	**760447.20**	**760448.20**	**760449.20**
3 mm ID		**760443.30**		**760446.30**	**760447.30**	**760448.30**	**760449.30**
4 mm ID		**760443.40**		**760446.40**	**760447.40**	**760448.40**	**760449.40**
4.6 mm ID		**760443.46**	**760445.46**	**760446.46**	**760447.46**	**760448.46**	**760449.46**
EC guard columns*		4 x 2 mm: **761976.20**		4 x 3 mm: **761976.30**			
CC guard columns**		8 x 3 mm: **761145.30**		8 x 4 mm: **761145.40**			
NUCLEODUR® PFP, 5 µm						particle size 5 µm	
Analytical EC columns							
2 mm ID		**760453.20**		**760456.20**	**760457.20**	**760458.20**	**760459.20**
3 mm ID		**760453.30**		**760456.30**	**760457.30**	**760458.30**	**760459.30**
4 mm ID		**760453.40**		**760456.40**	**760457.40**	**760458.40**	**760459.40**
4.6 mm ID		**760453.46**	**760455.46**	**760456.46**	**760457.46**	**760458.46**	**760459.46**
EC guard columns*		4 x 2 mm: **761977.20**		4 x 3 mm: **761977.30**			
CC guard columns**		8 x 3 mm: **761146.30**		8 x 4 mm: **761146.40**			
VarioPrep columns							
10 mm ID		**762210.100**			**762211.100**		**762213.100**
21 mm ID		**762210.210**			**762211.210**		**762213.210**
32 mm ID							**762213.320**
40 mm ID						**762212.400**	**762213.400**
VP guard columns***		10 x 8 mm: **762214.80**		10 x 16 mm: **762214.160**		15 x 32 mm: **762216.320**	
EC and VarioPrep columns in packs of 1, guard columns see below							

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® Sphinx RP — bifunctional RP phase



- **Key features:**
  - Distinct selectivity based on well-balanced bifunctional surface coverage
  - Widens the scope for method development based on additional π–π interactions
  - Suitable for **LC/MS** due to low bleeding characteristics
- **Technical characteristics:**
  Octadecyl and propylphenyl modified silica; pore size 110 Å; particle sizes 1.8 µm, 3 µm and 5 µm; carbon content 15 %;
  pH stability 1–10; high reproducibility and consistent quality
- **Recommended application:**
  Quinolone antibiotics, sulfonamides, xanthines, substituted aromatics
  USP L1 and **L11**

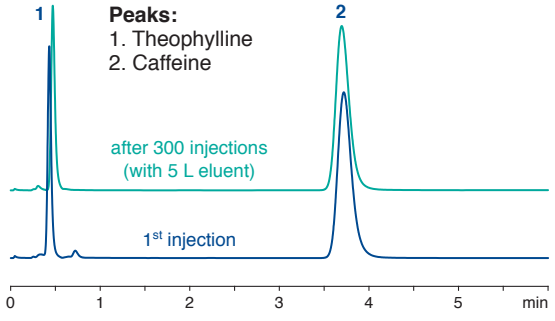
Alternative RP selectivity

NUCLEODUR® Sphinx RP is characterized by exceptional selectivity features generated by a **well-balanced ratio of covalently bonded octadecyl and phenyl groups**. The combination of classical hydrophobic with π–π interactions (aromatic ring system) expands the scope of selectivity in comparison with conventional reversed phase packings. NUCLEODUR® Sphinx RP is particularly suited for the separation of molecules containing aromatic and multiple bonds. For the separation of polar compounds NUCLEODUR® Sphinx RP can be especially recommended and can also outperform many customary C_{18} phases. In addition, exhaustive endcapping steps minimize unwanted surface silanol activity and guarantee excellent peak shapes even for strong basic analytes.

Stability of NUCLEODUR® Sphinx RP at pH 10

Column: 50 x 4.6 mm NUCLEODUR® Sphinx RP, 5 µm
Eluent: methanol – dil. NH_3, pH 10 (20:80, v/v)
Flow rate: 1.0 mL/min, temperature 30 °C
Detection: UV, 275 nm, injection 3 µL

Peaks:
1. Theophylline
2. Caffeine



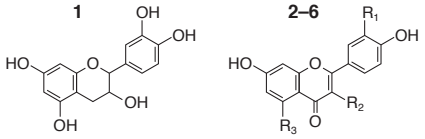
MN Appl. No. 120900

Different from standard phenyl phases, NUCLEODUR® Sphinx RP is far more stable towards hydrolysis and is also suggested for LC/MS applications. Due to the additional intermolecular interactions NUCLEODUR® Sphinx RP is an interesting replenishment to the high density bonded phases NUCLEODUR® C_8/C_{18} Gravity and the polar endcapped NUCLEODUR® C_{18} Pyramid.

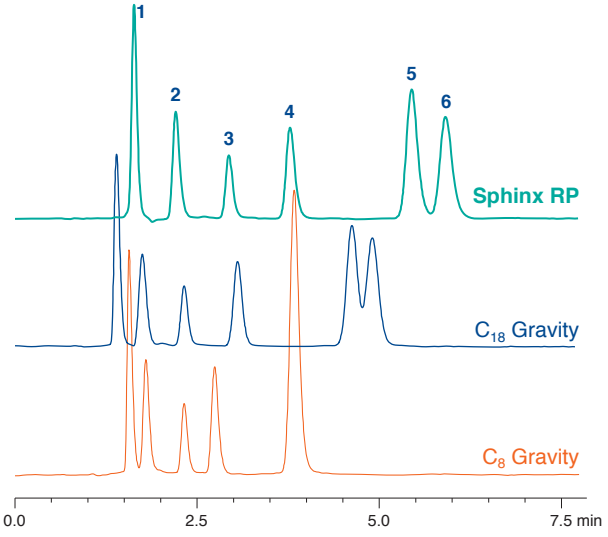
Separation of flavonoids on 3 different NUCLEODUR® phases

Columns: 150 x 4.6 mm
NUCLEODUR® Sphinx RP, 5 µm
NUCLEODUR® C_{18} Gravity, 5 µm
NUCLEODUR® C_8 Gravity, 5 µm
Eluent: water – methanol (40:60, v/v)
Flow rate: 1 mL/min
Temperature: 30 °C
Detection: UV, 270 nm
Injection: 3 µL

Peaks:



1. Catechin
2. Rutin — $R_1 = R_3 = OH$, R_2 = O-Rutinose
3. Fisetin — $R_1 = R_2 = OH$, $R_3 = H$
4. Quercetin — $R_1 = R_2 = R_3 = OH$
5. Kaempferol — $R_1 = H$, $R_2 = R_3 = OH$
6. Isorhamnetin — $R_1 = OCH_3$, $R_2 = R_3 = OH$



MN Appl. No. 119830

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® Sphinx RP, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	760821.20	760822.20	760825.20	760823.20		760824.20	
3 mm ID	760821.30	760822.30		760823.30			
4 mm ID	760821.40	760822.40		760823.40			
4.6 mm ID	760821.46	760822.46		760823.46			
EC guard columns*		4 x 2 mm: 761920.20		4 x 3 mm: 761920.30			
NUCLEODUR® Sphinx RP, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		760806.20		760812.20	760807.20	760805.20	760808.20
3 mm ID		760806.30		760812.30	760807.30	760805.30	760808.30
4 mm ID		760806.40		760812.40	760807.40	760805.40	760808.40
4.6 mm ID		760806.46	760813.46	760812.46	760807.46	760805.46	760808.46
EC guard columns*		4 x 2 mm: 761921.20		4 x 3 mm: 761921.30			
CC guard columns**		8 x 3 mm: 761557.30		8 x 4 mm: 761557.40			
NUCLEODUR® Sphinx RP, 5 µm						particle size 5 µm	
Analytical EC columns							
2 mm ID		760800.20		760809.20	760801.20	760802.20	760803.20
3 mm ID		760800.30		760809.30	760801.30	760802.30	760803.30
4 mm ID		760800.40		760809.40	760801.40	760802.40	760803.40
4.6 mm ID		760800.46	760815.46	760809.46	760801.46	760802.46	760803.46
EC guard columns*		4 x 2 mm: 761922.20		4 x 3 mm: 761922.30			
CC guard columns**		8 x 3 mm: 761550.30		8 x 4 mm: 761550.40			
VarioPrep columns							
10 mm ID		762372.100			762375.100		762373.100
21 mm ID		762372.210			762375.210		762373.210
32 mm ID							762373.320
40 mm ID						762371.400	762373.400
VP guard columns***		10 x 8 mm: 762390.80		10 x 16 mm: 762390.160		15 x 32 mm: 762392.320	
EC and VarioPrep columns in packs of 1, guard columns see below							

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® C_{18} HTec — base-deactivated preparative octadecyl phase

Key features:
- Reliable and durable standard RP phase for up-scaling to preparative scale, suited for **LC/MS**
- High loading capacity and excellent stability
- Outstanding base deactivation

Technical characteristics:
High density octadecyl modification (C_{18}); pore size 110 Å; particle sizes 1.8 µm, 3 µm, 5 µm, 7 µm and 10 µm for analytical and preparative separations; carbon content 18%, pH stability 1–11

Recommended application:
Sophisticated analytical and preparative separations of basic, neutral and acidic pharmaceuticals, derivatized amino acids, pesticides, fat-soluble vitamins, aldehydes, ketones and phenolic compounds

USP L1

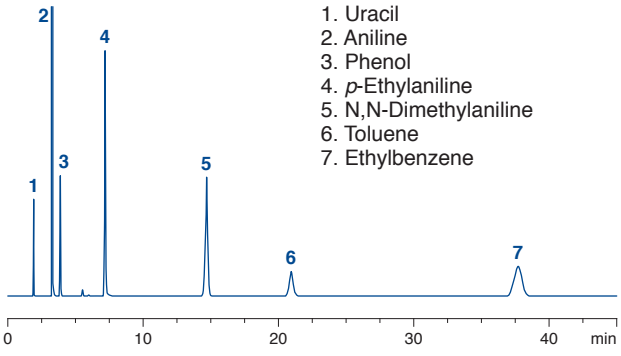
Preparative separations place high demands on silica based HPLC materials. Apart from excellent selectivity and base deactivation, robustness (pH, pressure stability, ...) and capacity are vital criteria for optimal and efficient separation at the preparative scale.

Selectivity and base deactivation

The innovative endcapping procedure leads to exceptionally good base deactivation – the Engelhardt test demonstrates superb selectivity, peak symmetry and peak shape over the entire polarity range. In addition NUCLEODUR® C_{18} HTec scores in low bleed characteristics and is therefore highly suitable for LC/MS.

Engelhardt test

Column: 250 x 4 mm NUCLEODUR® C_{18} HTec, 5 µm
Eluent: methanol – water (49:51, v/v)
Flow rate: 1 mL/min
Temperature: 40 °C
Detection: UV, 254 nm
Injection: 5 µL



Peaks:
1. Uracil
2. Aniline
3. Phenol
4. *p*-Ethylaniline
5. N,N-Dimethylaniline
6. Toluene
7. Ethylbenzene

MN Appl. No. 123580

Stability and lifetime

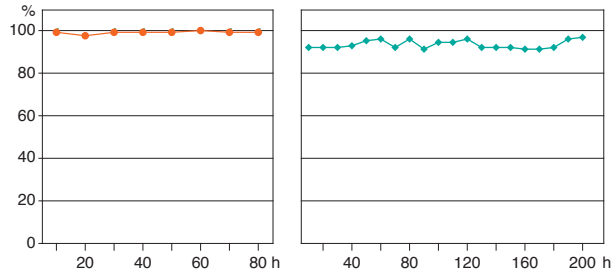
Based on fully synthetic and extremely robust totally spherical NUCLEODUR® silica, NUCLEODUR® C_{18} HTec offers outstanding mechanical rigidity and is thus the perfect choice also for self-packing of prep-columns. The special surface modification and endcapping procedure result in high chemical stability even at extreme chromatographic conditions like high flow rates, temperature or critical solvents (DMSO). Furthermore, NUCLEODUR® C_{18} HTec columns show a remarkably long lifetime in acidic (pH 1) as well as basic (pH 10) mobile phases.

pH stability test

Column: 150 x 4 mm NUCLEODUR® C_{18} HTec, 5 µm
Flow rate: 1 mL/min
Detection: UV, 254 nm
Injection: 5 µL

pH 1:
Eluent: acetonitrile – 1 % TFA in water (50:50, v/v); 80 °C
● % initial retention of ethylbenzene
693 injections

pH 10:
Eluent: methanol – 50 mmol/L triethylamine (25:85, v/v); 50 °C
◆ % initial N of theophylline
1034 injections



Due to innovative surface coating procedures NUCLEODUR® C_{18} HTec offers excellent analytical separation properties and is the first choice for up-scaling to preparative column dimensions.

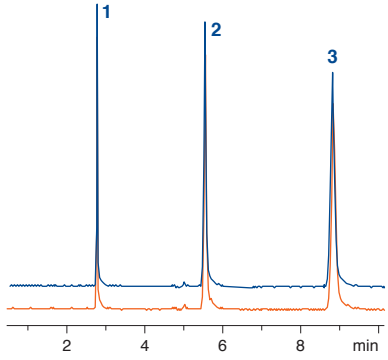
Up-scaling

Due to highest quality standards in silica production and phase chemistry combined with optimized packing technology, NUCLEODUR® C_{18} HTec allows exceptional transferability from analytical to preparative scale with respect to different particle sizes (e.g., 5, 7 or 10 µm) as well as column dimensions (e.g., ID 4.6 to 21 mm).

Up-scaling with NUCLEODUR® C_{18} HTec

Columns: **EC 250 x 4.6 mm NUCLEODUR® C_{18} HTec, 5 µm**
VP 250 x 21 mm NUCLEODUR® C_{18} HTec, 5 µm
Eluent: acetonitrile – water (80:20, v/v)
Flow rate: 1.3 mL/min / 27 mL/min
Temperature: 22 °C
Pressure: 84 bar / 109 bar
Detection: UV, 254 nm
Injection: 3 µL / 60 µL

Peaks: (1 mg/mL each)
1. Phenol
2. Naphthalene
3. Anthracene



MN Appl. No. 123780

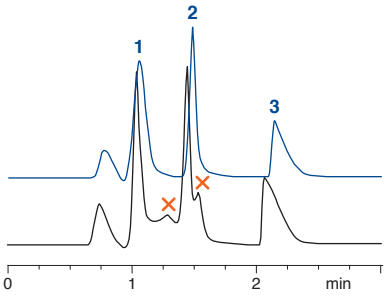
Capacity

A vital criterion for efficiency in preparative HPLC is the capacity of the separation medium. NUCLEODUR® C_{18} HTec is characterized by a notably high loading capacity under both basic and acidic conditions, while competitor columns show overload effects even at lower loads (x).

Loading capacity under acidic conditions

Columns: **VP 100 x 21 mm NUCLEODUR® C_{18} HTec, 5 µm**
100 x 21.2 mm AXIA™ Gemini® 5 µm C_{18} 110 Å
Eluent: acetonitrile – formic acid in H_2O pH 3.0 (30:70, v/v)
Flow rate: 28 mL/min
Temperature: 22 °C
Pressure: 124 bar
Detection: UV, 254 nm

Peaks:
total load 40 mg
(sample dissolved in DMSO)
1. 4-Acetamidophenol (5 mg)
2. 2-Acetamidophenol (10 mg)
3. Acetylsalicylic acid (25 mg)



MN Appl. No. 123890

Ordering information

Eluent in column acetonitrile – water

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® C_{18} HTec, 1.8 µm						particle size 1.8 µm	
Analytical EC columns							
2 mm ID	**760301.20**	**760305.20**	**760304.20**	**760306.20**		**760308.20**	
3 mm ID	**760301.30**	**760305.30**		**760306.30**			
4 mm ID	**760301.40**	**760305.40**		**760306.40**			
4.6 mm ID	**760301.46**	**760305.46**		**760306.46**			
EC guard columns*		4 x 2 mm: **761925.20**		4 x 3 mm: **761925.30**			
NUCLEODUR® C_{18} HTec, 3 µm						particle size 3 µm	
Analytical EC columns							
2 mm ID		**760321.20**		**760323.20**	**760324.20**	**760325.20**	**760326.20**
3 mm ID		**760321.30**		**760323.30**	**760324.30**	**760325.30**	**760326.30**
4 mm ID		**760321.40**		**760323.40**	**760324.40**	**760325.40**	**760326.40**
4.6 mm ID		**760321.46**	**760322.46**	**760323.46**	**760324.46**	**760325.46**	**760326.46**
EC guard columns*		4 x 2 mm: **761926.20**		4 x 3 mm: **761926.30**			
CC guard columns**		8 x 3 mm: **761120.30**		8 x 4 mm: **761120.40**			

NUCLEODUR® high purity silica for HPLC

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® C_{18} HTec, 5 µm							particle size 5 µm
Analytical EC columns							
2 mm ID		760311.20		760313.20	760314.20	760315.20	760316.20
3 mm ID		760311.30		760313.30	760314.30	760315.30	760316.30
4 mm ID		760311.40		760313.40	760314.40	760315.40	760316.40
4.6 mm ID		760311.46	760312.46	760313.46	760314.46	760315.46	760316.46
EC guard columns*		4 x 2 mm: 761927.20		4 x 3 mm: 761927.30			
CC guard columns**		8 x 3 mm: 761110.30		8 x 4 mm: 761110.40			
Preparative VarioPrep columns							
10 mm ID		762551.100			762554.100		762556.100
21 mm ID		762551.210		762553.210	762554.210		762556.210
32 mm ID				762553.320		762555.320	762556.320
40 mm ID						762555.400	762556.400
50 mm ID				762553.500		762555.500	762556.500
VP guard columns***		10 x 8 mm: 762591.80		10 x 16 mm: 762591.160			
		15 x 32 mm: 762592.320		15 x 50 mm: 762592.500			
NUCLEODUR® C_{18} HTec, 7 µm							particle size 7 µm
Preparative VarioPrep columns							
10 mm ID		762561.100			762564.100		762566.100
21 mm ID		762561.210		762563.210	762564.210		762566.210
32 mm ID				762563.320		762565.320	762566.320
40 mm ID						762565.400	762566.400
50 mm ID				762563.500		762565.500	762566.500
VP guard columns***		10 x 8 mm: 762591.80		10 x 16 mm: 762591.160			
		15 x 32 mm: 762592.320		15 x 50 mm: 762592.500			
NUCLEODUR® C_{18} HTec, 10 µm							particle size 10 µm
Preparative VarioPrep columns							
10 mm ID		762571.100			762574.100		762576.100
21 mm ID		762571.210		762573.210	762574.210		762576.210
32 mm ID				762573.320		762575.320	762576.320
40 mm ID						762575.400	762576.400
50 mm ID				762573.500		762575.500	762576.500
VP guard columns***		10 x 8 mm: 762591.80		10 x 16 mm: 762591.160			
		15 x 32 mm: 762592.320		15 x 50 mm: 762592.500			
EC and VarioPrep columns in packs of 1, guard columns see below							

Guard column systems						
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196

NUCLEODUR® C_{18} HTec bulk material in 5, 7 and 10 µm for self-packing of preparative columns see page 198

NUCLEODUR® C_{18} ec · C_8 ec — nonpolar phases for routine analysis

Key features:
- Ideal and reliable standard RP phase for daily routine analysis and up-scaling for preparative HPLC
- Medium density octadecyl (C_{18}) and octyl (C_8) modification with exhaustive end-capping
- Wide range of application areas

Technical characteristics:
Pore size 110 Å; particle sizes 3 µm and 5 µm; 7 µm, 10 µm, 12 µm, 16 µm, 20 µm, 30 µm and 50 µm for preparative separations; carbon content 17.5 % for C_{18}, 10.5 % for C_8

pH stability 1–9, high reproducibility from lot to lot

Recommended application:
Basic, neutral or acidic drugs, derivatized amino acids, pesticides
fat-soluble vitamins, aldehydes and ketones, phenolic compounds

USP L1 (C_{18}) / **L7** (C_8)

NUCLEODUR® C_{18} ec for daily routine analysis and up-scaling for preparative HPLC

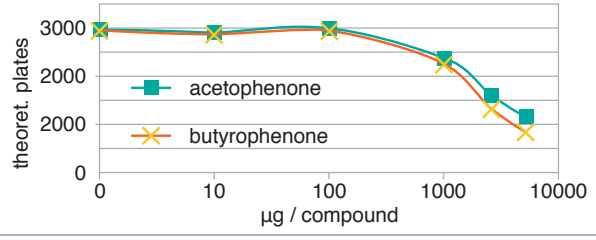
The efficiency of a separation is controlled by particle size and selectivity of the stationary phase. The exceptional surface coverage of monomeric bonded alkylsilanes, combined with an exhaustive endcapping, results in a surface with lowest silanol activity. This allows the tailing-free elution of polar compounds such as basic drugs. NUCLEODUR® C_{18} ec is available in 9 different particle sizes (3, 5, 7, 10, 12, 16, 20, 30 and 50 µm) which cover the whole range from high speed analytical HPLC up to medium and low pressure prep LC. NUCLEODUR® C_{18} ec is also an ideal tool for scale-up purposes.

Loading capacity

Loading capacity, probably the most important feature for preparative LC applications, is determined by pore size, pore volume and surface area of the packing. However, it can also be influenced by the molecular weight of the analytes. In the figure below the mass loading curve for acetophenone and butyrophenone on a NUCLEODUR® 100-20 C_{18} ec column describes the correlation between the increase of column loading and the decrease of separation efficiency.

Loading curve

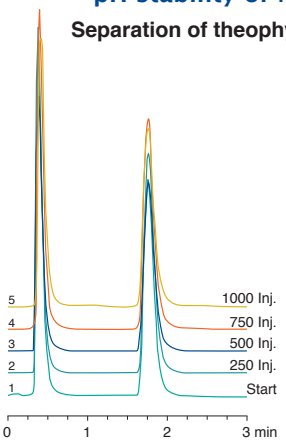
Column: 250 x 4.6 mm NUCLEODUR® 100-20 C_{18} ec, eluent: acetonitrile – H_2O 80:20 (v/v), flow rate: 1.0 mL/min, temperature: 25 °C, detection: UV, 280–370 nm



pH stability of NUCLEODUR® C_{18} ec

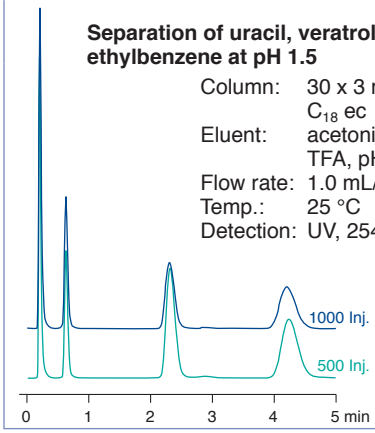
Separation of theophylline and caffeine at pH 10

Columns: 30 x 3 mm
NUCLEODUR® 100-5 C_{18} ec
Eluent: methanol – aq. NH_3 (20:80, v/v), pH 10
Flow rate: 0.5 mL/min
Temperature: 25 °C
Detection: UV, 254 nm



Separation of uracil, veratrol, toluene and ethylbenzene at pH 1.5

Column: 30 x 3 mm NUCLEODUR® 100-5 C_{18} ec
Eluent: acetonitrile – H_2O (65:35, v/v), TFA, pH 1.5
Flow rate: 1.0 mL/min
Temp.: 25 °C
Detection: UV, 254 nm



Chemical stability

The utmost purity of the base silica and the exceptional silane bonding chemistry minimize the risk of dissolution, or hydrolysis at pH extremes. The chromatograms show the retention behavior at pH values of 1.5 and 10.0 for NUCLEODUR® 100-5 C_{18} ec.

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® octyl phases

In addition to NUCLEODUR® C_{18} phases MACHEREY-NAGEL offers octyl modified NUCLEODUR® C_8 Gravity and NUCLEODUR® C_8 ec columns to expand the RP tool box. Based on the same spherical high purity silica the C_8 phases exhibit the same chemical and mechanical stability as the C_{18} counterparts. Indeed NUCLEODUR® C_8 Gravity can also be run at pH extremes (pH 1–11) by choosing appropriate elution parameters. Due to the shorter chain and less hydrophobic properties of the stationary phase the retention of non-polar compounds is decreased, and in consequence a reduction in time of analysis can be achieved. Moreover a stronger polar selectivity, particularly with the separation of ionizable analytes is frequently observed (as distinct from the C_{18} phases). NUCLEODUR® C_8 ec and NUCLEODUR® C_8 Gravity are most suitable for the development of new methods but also for robust routine analyses.

There are no general guidelines which could make the choice between C_8 and C_{18} phases easier but it will always be beneficial to add both phases to the existing pool of RP columns in the laboratory.

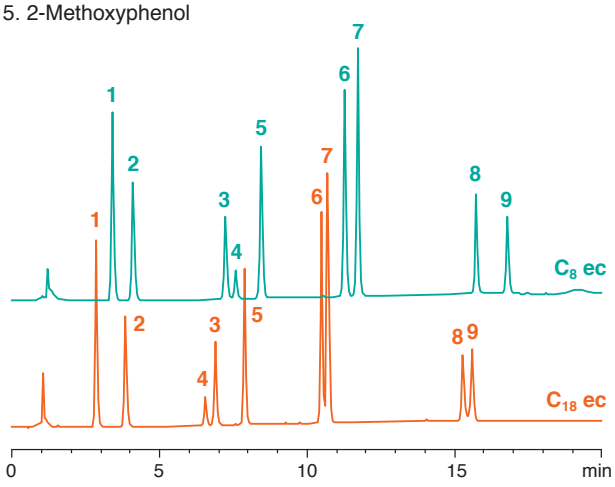
Comparative studies reveal some different selectivity patterns of NUCLEODUR® C_8 ec and C_{18} ec. The separation of phenols at right shows baseline separation for 2-ethoxyphenol and dimethoxybenzene (veratrol) and in addition a reversal of the elution order of phenol and 4-methoxyphenol can be shown on the octyl phase.

Separation of phenols

Column: 250 x 4 mm NUCLEODUR® 100-5 C_8 ec / C_{18} ec
Eluent: A) water, B) methanol
C_8: 20 % B (2 min) → 60 % B in 12 min
C_{18}: 25 % B (2 min) → 65 % B in 12 min
Flow rate: 1.0 mL/min, temperature 25 °C
Detection: UV, 275 nm, injection 10 µL

Peaks:

1. Resorcinol
2. Pyrocatechol
3. 4-Methoxyphenol
4. Phenol
5. 2-Methoxyphenol
6. 2-Ethoxyphenol
7. Veratrol
8. Biphenyl-2-ol
9. Phenetole



MN Appl. No. 120890/120891

C_{18} or C_8 · the best of both worlds

- High density C_8 and C_{18} phases allow tailing-free elution, also for very polar compounds.
- Octyl phases (C_8) show superior polar selectivity.
- Octadecyl phases (C_{18}) show superior hydrophobic selectivity.
- Hydrophobic compounds show shorter retention times on C_8 phases.

Ordering information

Eluent in column acetonitrile – water

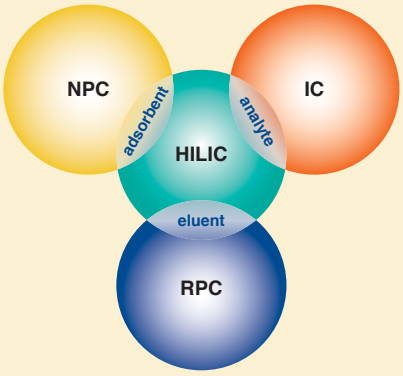
Length →	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® 100-3 C_{18} ec			octadecyl phase, 17.5 % C, particle size 3 µm			
Analytical EC columns						
2 mm ID	**760050.20**		**760054.20**	**760051.20**	**760053.20**	**760052.20**
3 mm ID	**760050.30**		**760054.30**	**760051.30**	**760053.30**	**760052.30**
4 mm ID	**760050.40**		**760054.40**	**760051.40**	**760053.40**	**760052.40**
4.6 mm ID	**760050.46**	**760046.46**	**760054.46**	**760051.46**	**760053.46**	**760052.46**
EC guard columns*		4 x 2 mm: **761931.20**		4 x 3 mm: **761931.30**		
CC guard columns**		8 x 3 mm: **761005.30**		8 x 4 mm: **761005.40**		

Guard column systems see previous NUCLEODUR® phases
For details of our column systems see pages 189–196
NUCLEODUR® C_{18} ec bulk material with 10–50 µm for self-packing of preparative columns see page 198

Length →	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® 100-5 C_{18} ec				octadecyl phase, 17.5 % C, particle size 5 µm		
Analytical EC columns						
2 mm ID	760004.20		760013.20	760001.20	760008.20	760002.20
3 mm ID	760004.30		760013.30	760001.30	760008.30	760002.30
4 mm ID	760004.40		760013.40	760001.40	760008.40	760002.40
4.6 mm ID	760004.46	760035.46	760013.46	760001.46	760008.46	760002.46
EC guard columns*		4 x 2 mm: **761932.20**		4 x 3 mm: **761932.30**		
CC guard columns**		8 x 3 mm: **761100.30**		8 x 4 mm: **761100.40**		
VarioPrep columns						
10 mm ID	762003.100			762029.100		762022.100
21 mm ID	762003.210			762029.210		762022.210
32 mm ID						762022.320
40 mm ID					762027.400	762022.400
VP guard columns***		10 x 8 mm: **762090.80**		10 x 16 mm: **762090.160**		
		15 x 32 mm: **762311.320**		15 x 50 mm: **762311.500**		
NUCLEODUR® 100-10 C_{18} ec				octadecyl phase, 17.5 % C, particle size 10 µm		
VarioPrep columns						
10 mm ID	762011.100			762302.100		762010.100
21 mm ID	762011.210			762302.210		762010.210
32 mm ID						762010.320
40 mm ID					762303.400	762010.400
50 mm ID						762010.500
VP guard columns***		10 x 8 mm: **762090.80**		10 x 16 mm: **762090.160**		
		15 x 32 mm: **762311.320**		15 x 50 mm: **762311.500**		
NUCLEODUR® 100-3 C_8 ec				octyl phase, 10.5 % C, particle size 3 µm		
Analytical EC columns						
2 mm ID	760063.20		760059.20	760060.20		760062.20
3 mm ID	760063.30		760059.30	760060.30		760062.30
4 mm ID	760063.40		760059.40	760060.40		760062.40
4.6 mm ID	760063.46	760064.46	760059.46	760060.46	760061.46	760062.46
EC guard columns*		4 x 2 mm: **761936.20**		4 x 3 mm: **761936.30**		
CC guard columns**		8 x 3 mm: **761012.30**		8 x 4 mm: **761012.40**		
NUCLEODUR® 100-5 C_8 ec				octyl phase, 10.5 % C, particle size 5 µm		
Analytical EC columns						
2 mm ID	760700.20		760704.20	760701.20		760703.20
3 mm ID	760700.30		760704.30	760701.30		760703.30
4 mm ID	760700.40		760704.40	760701.40		760703.40
4.6 mm ID	760700.46	760706.46	760704.46	760701.46	760702.46	760703.46
EC guard columns*		4 x 2 mm: **761937.20**		4 x 3 mm: **761937.30**		
CC guard columns**		8 x 3 mm: **761704.30**		8 x 4 mm: **761704.40**		
VarioPrep columns						
10 mm ID	762072.100			762061.100		762062.100
21 mm ID	762072.210			762061.210		762062.210
32 mm ID						762062.320
40 mm ID					762079.400	762062.400
VP guard columns***	10 x 8 mm: **762092.80**		10 x 16 mm: **762092.160**		15 x 32 mm: **762321.320**	
EC and VarioPrep columns in packs of 1, guard columns see previous NUCLEODUR® phases						

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® HILIC — zwitterionic phase



- **Key features:**
  - Ideal for reproducible and stable chromatography of highly polar analytes
  - Suitable for analytical and preparative applications as well as **LC/MS**
  - Very short column conditioning period
- **Technical characteristics:**
  Ammonium – sulfonic acid modified silica; pore size 110 Å; particle sizes 1.8, 3 and 5 µm; carbon content 7%; pH stability 2–8.5
- **Recommended application:**
  Hydrophilic compounds such as organic polar acids and bases, polar natural compounds, nucleosides, oligonucleotides, amino acids, peptides, water soluble vitamins

Columns for HPLC

NUCLEODUR® HILIC

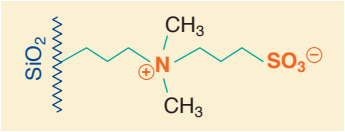
Separation science is always looking for new and effective strategies to accomplish the tasks of modern analytics. Especially for polar compounds reversed phase HPLC – the most common analytical method – is often limited. Here, hydrophilic stationary phases provide an additional tool for the separation of polar analytes in HPLC.

The expression HILIC (Hydrophilic Interaction Chromatography) was firstly published by Andrew Alpert in 1990 – since then it took quite some efforts to develop robust and reproducible hydrophilic HPLC phases for HILIC chromatography [A. Alpert, J. Chromatography **499** (1990), 177–196].

HILIC combines the characteristics of the 3 major methods in liquid chromatography – reversed phase (RPC), normal phase (NPC) and ion chromatography (IC):

- Stationary phases (adsorbents) are mostly polar modifications of silica or polymers (SiOH, NH_2, Diol, (zwitter) ions, ...) – like in NPC
- Mobile phases (eluents) are mixtures of aqueous buffer systems and organic modifier like acetonitrile or methanol – like in RPC
- Fields of application include quite polar compounds as well as organic and inorganic ions – like in IC

"HILIC is NP chromatography of polar and ionic compounds under RP conditions."



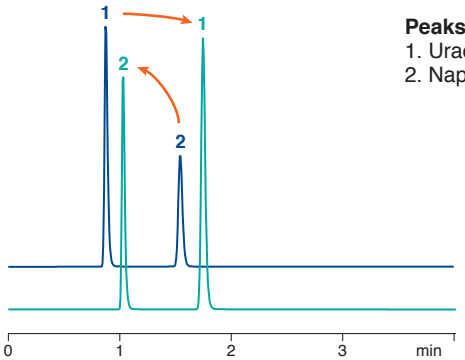
NUCLEODUR® HILIC is a special zwitterionic modified stationary phase based on ultra spherical NUCLEODUR® particles. The betaine character of the ammonium-sulfonic acid ligands results in total charge equalization and in an overall neutrally charged but highly polar surface.

Retention characteristic

Commonly HILIC is described as partition chromatography or liquid-liquid extraction system between mobile and stationary phases. Versus a water-poor mobile phase a water-rich layer on the surface of the polar stationary phase is formed. Thus, a distribution of the analytes between these two layers will occur. Furthermore HILIC includes weak electrostatic mechanisms as well as hydrogen donor interactions between neutral polar molecules under high organic elution conditions. This distinguishes HILIC from ion exchange chromatography – main principle for HILIC separation is based on compound's polarity and degree of solvation.

Separation of uracil and naphthalene

Columns: 125 x 4 mm NUCLEODUR® C_{18} Pyramid, 3 µm
125 x 4 mm NUCLEODUR® HILIC, 3 µm
Eluent: acetonitrile – water (90:10, v/v)
Flow rate: 1.0 mL/min, temperature 25 °C
Detection: UV, 254 nm



Peaks:
1. Uracil
2. Naphthalene

MN Appl. No. 122911/122912

More polar compounds will have stronger interaction with the stationary aqueous layer than less polar compounds – resulting in a stronger retention. Nonpolar compounds exhibit faster elution profiles due to minor hydrophobic interactions. In the separation of uracil and naphthalene the elution order is quite often inverse on HILIC columns compared to RP columns.

Stability features

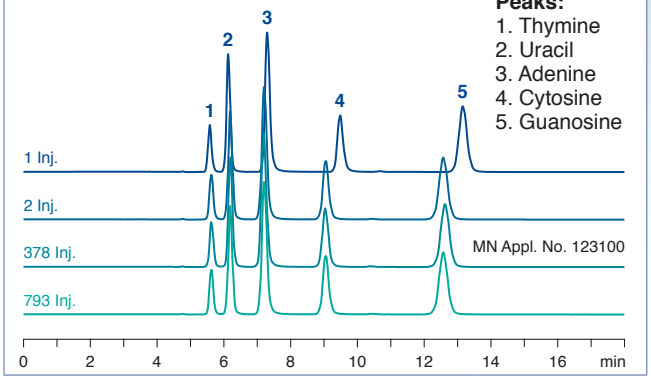
Due to an advanced and unique surface modification procedure (pat. pend.) NUCLEODUR® HILIC columns provide short equilibration times – after just 20 min equilibration already the 2nd injection shows stable and reproducible results. Beyond this, NUCLEODUR® HILIC columns are characterized by an outstanding column life time – even after nearly 800 runs the columns show no loss of pristine performance – peak shape and retention are still immaculate.

Due to its high loading capacity NUCLEODUR® HILIC is absolutely suitable for preparative and semi-preparative applications.

Overall NUCLEODUR® HILIC provides excellent chromatographic features and is hereby the perfect choice for separation of polar or charged compounds.

Stability and equilibration

Column: 250 x 4 mm NUCLEODUR® HILIC, 5 µm
Eluent: CH_3CN – 5 mmol/L ammonium acetate (80:20, v/v)
Flow rate: 0.6 mL/min, temperature 25 °C
Detection: UV, 254 nm



Ordering information

Eluent in column acetonitrile – water (80:20, v/v)

Length →	30 mm	50 mm	75 mm	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® HILIC, 1.8 µm						particle size 1.8 µm	
EC columns							
2 mm ID	**760521.20**	**760523.20**	**760525.20**	**760526.20**		**760528.20**	
3 mm ID	**760521.30**	**760523.30**		**760526.30**			
4 mm ID	**760521.40**	**760523.40**		**760526.40**			
4.6 mm ID	**760521.46**	**760523.46**		**760526.46**			
EC guard columns*		4 x 2 mm: **761960.20**		4 x 3 mm: **761960.30**			
NUCLEODUR® HILIC, 3 µm						particle size 3 µm	
EC columns							
2 mm ID		**760532.20**		**760534.20**	**760531.20**	**760533.20**	**760530.20**
3 mm ID		**760532.30**		**760534.30**	**760531.30**	**760533.30**	**760530.30**
4 mm ID		**760532.40**		**760534.40**	**760531.40**	**760533.40**	**760530.40**
4.6 mm ID		**760532.46**		**760534.46**	**760531.46**	**760533.46**	**760530.46**
EC guard columns*		4 x 2 mm: **761961.20**		4 x 3 mm: **761961.30**			
CC guard columns**		8 x 3 mm: **761580.30**		8 x 4 mm: **761580.40**			
NUCLEODUR® HILIC, 5 µm						particle size 5 µm	
EC columns							
2 mm ID		**760552.20**		**760554.20**	**760551.20**	**760553.20**	**760550.20**
3 mm ID		**760552.30**		**760554.30**	**760551.30**	**760553.30**	**760550.30**
4 mm ID		**760552.40**		**760554.40**	**760551.40**	**760553.40**	**760550.40**
4.6 mm ID		**760552.46**		**760554.46**	**760551.46**	**760553.46**	**760550.46**
EC guard columns*		4 x 2 mm: **761962.20**		4 x 3 mm: **761962.30**			
CC guard columns**		8 x 3 mm: **761590.30**		8 x 4 mm: **761590.40**			

EC columns in packs of 1, guard columns in packs of 3; for details see page 189

Guard column systems

Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® CN / CN-RP — cyano-modified high purity silica phase

Key features:
- High retention capacity especially for very polar and unsaturated compounds
- Multi-mode column (RP and NP) widens scope of selectivity
- Stable against hydrolysis at low pH (working range pH 1–8)

Technical characteristics:
Cyanopropyl-modified high purity silica; pore size 110 Å; particle sizes 3 µm and 5 µm; carbon content 7%; special endcapping, high reproducibility from lot to lot; different retention characteristics in comparison to C_8 and C_{18}

Recommended application:
Tricyclic antidepressants
steroids
organic acids
USP L10

Alternative bonded-phase functionality

In reversed phase HPLC it is fairly common to start with C_{18} or C_8 columns, if new methods have to be developed. However, superior polarity and selectivity properties often required for more sophisticated separations, are not always sufficiently provided by classical RP phases, which are usually characterized by a hydrophobic layer of monomeric or polymeric bonded alkylsilanes.

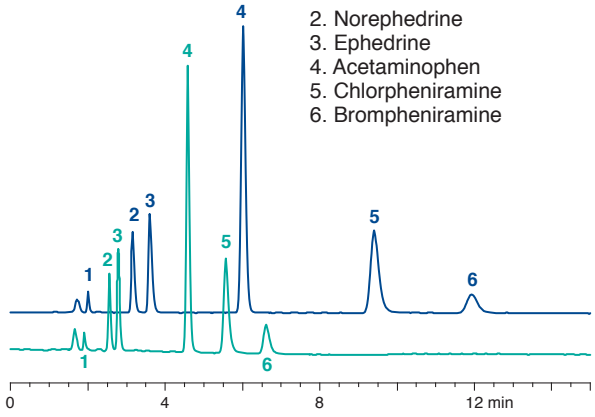
One approach to improve the resolution of compounds poorly separated on nonpolar stationary phases, is to change bonded-phase functionality. The fully endcapped and highly reproducible NUCLEODUR® 100-5 CN-RP phase has cyanopropyl groups on the surface able to generate a clearly recognizable different retention behavior compared to purely alkyl-functionalized surface modifications (see figure below).

The polarity of NUCLEODUR® 100-5 CN-RP can be classified as intermediate based on multiple retention mechanisms such as dipole-dipole, π-π, and also hydrophobic interactions [C. S. Young and R. J. Weigand, LCGC **20** (2002) 464–473]. Therefore, this phase shows a distinct selectivity for polar organic compounds as well as for molecules containing π electron systems (e.g. analytes with double bonds, tricyclic antidepressants) [V. R. Meyer, Practical High Performance Liquid Chromatography (John Wiley & Sons, New York, 3rd ed., 1999)]. Short-chain bonded phases are sometimes suspected of revealing shortcomings in stability towards hydrolysis at low pH [J. J. Kirkland, LCGC **14** (1996) 486–500]. The following chromatograms show that even after 100 sample injections and four weeks storage at pH 1 (blue curve), neither a considerable shift in retention, nor a visible change in peak symmetry could be noticed (green curve = new column).

Separation of cold medicine ingredients on two different NUCLEODUR® phases

Columns: A) 250 x 4 mm NUCLEODUR® 100-5 C_{18} ec
B) 250 x 4 mm NUCLEODUR® 100-5 CN-RP
Eluent: acetonitrile – 100 mmol/L sodium citrate pH 2.5 (15:85, v/v)
Flow rate: 1.0 mL/min, temperature 25 °C
Detection: UV, 270 nm, injection 10 µL

Peaks:
1. Maleic acid
2. Norephedrine
3. Ephedrine
4. Acetaminophen
5. Chlorpheniramine
6. Brompheniramine

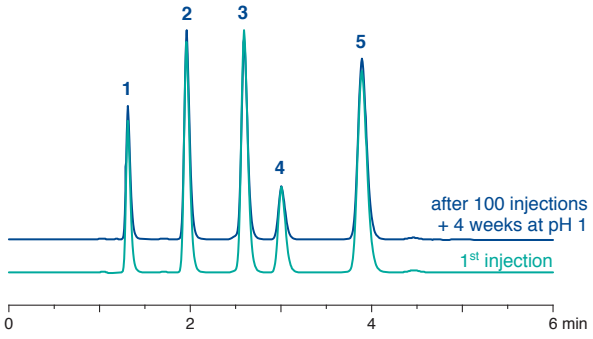


MN Appl. No. 119340

Stability of NUCLEODUR® CN-RP at pH 1

Column: 125 x 4 mm NUCLEODUR® 100-5 CN-RP
Eluent: acetonitrile – water, 2% TFA pH 1 (50:50, v/v)
Flow rate: 1.0 mL/min
Temperature: 25 °C
Detection: UV, 254 nm
Injection: 5 µL

Peaks:
1. Benzamide
2. Dimethyl phthalate
3. Phenetole
4. *o*-Xylene
5. Biphenyl



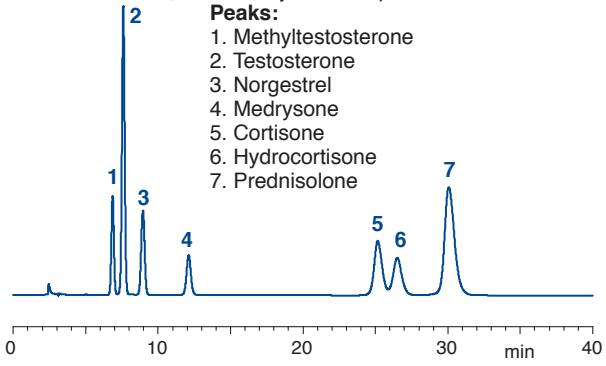
MN Appl. No. 119350

Due to its polarity the cyano phase can also be run in normal phase mode. NUCLEODUR® CN columns for NP applications are shipped in *n*-heptane. The change in selectivity and order of elution for a mixture of various steroids in NP and RP mode is displayed below. The high coverage combined with a thorough endcapping makes NUCLEODUR® 100-5 CN-RP suitable for separation of ionizable compounds such as basic drugs.

Separation of steroids in normal phase and reversed phase mode

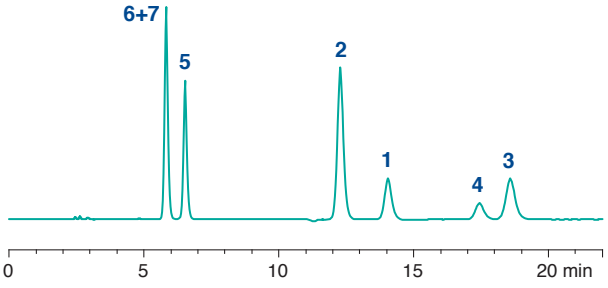
Normal phase mode
Column: 250 x 4 mm NUCLEODUR® 100-5 CN
Eluent: *n*-heptane – 2-propanol (90:10, v/v)
Flow rate: 1.0 mL/min, temperature 25 °C
Detection: UV, 254 nm, injection 10 µL

Peaks:
1. Methyltestosterone
2. Testosterone
3. Norgestrel
4. Medrysone
5. Cortisone
6. Hydrocortisone
7. Prednisolone



Reversed phase mode
Column: 250 x 4 mm NUCLEODUR® 100-5 CN-RP
Eluent: acetonitrile – water (25:75, v/v)
other conditions as for normal phase mode

MN Appl. Nos. 119271/119272



Ordering information

Length →	50 mm	125 mm	150 mm	250 mm
NUCLEODUR® 100-3 CN-RP		particle size 3 µm; eluent in column acetonitrile – water		
EC columns				
2 mm ID	**760159.20**	**760157.20**		
3 mm ID		**760157.30**		
4 mm ID			**760156.40**	
4.6 mm ID			**760156.46**	
EC guard columns*	4 x 2 mm: **761941.20**		4 x 3 mm: **761941.30**	
CC guard columns**	8 x 3 mm: **761430.30**		8 x 4 mm: **761430.40**	
NUCLEODUR® 100-5 CN-RP		particle size 5 µm; eluent in column acetonitrile – water		
EC columns				
4 mm ID		**760153.40**		**760152.40**
4.6 mm ID		**760153.46**	**760154.46**	**760152.46**
EC guard columns*			4 x 3 mm: **761944.30**	
CC guard columns**			8 x 4 mm: **761420.40**	
NUCLEODUR® 100-5 CN		particle size 5 µm; eluent in column *n*-heptane		
EC columns				
4 mm ID		**760151.40**	**760149.40**	**760150.40**
4.6 mm ID		**760151.46**	**760149.46**	**760150.46**
EC guard columns*			4 x 3 mm: **761943.30**	
CC guard columns**			8 x 4 mm: **761419.40**	

EC columns in packs of 1, guard columns in packs of 3; for details see page 189

Guard column systems

Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® NH_2 / NH_2-RP — amino-modified high purity silica

- **Key features:**
  - Multi-mode columns (for RP, NP and IC)
  - Stable against hydrolysis at low pH (working range pH 2–8), 100 % stable in water; suitable for **LC/MS**
  - Widens scope of analytical HPLC into the polar range
- **Technical characteristics:**
  Aminopropyl modified high purity silica; pore size 110 Å; particle sizes 3, 5 and 7 µm; carbon content 2.5 %; not endcapped
- **Recommended application:**
  Polar compounds under RP conditions (sugars, DNA bases), hydrocarbons under NP conditions
  USP L8

- **Normal phase chromatography (NP)** with hexane, dichloromethane or 2-propanol as mobile phase for polar compounds such as substituted anilines, esters, chlorinated pesticides
- **Reversed phase chromatography (RP)** of polar compounds in aqueous-organic eluent systems
- **Ion exchange chromatography** of anions and organic acids using conventional buffers and organic modifiers

Some compounds, especially polar substances, cannot be sufficiently resolved on C_{18} phases. Polar-modified silica phases offer alternative selectivities thus expanding the spectrum of analytical HPLC into the polar range.

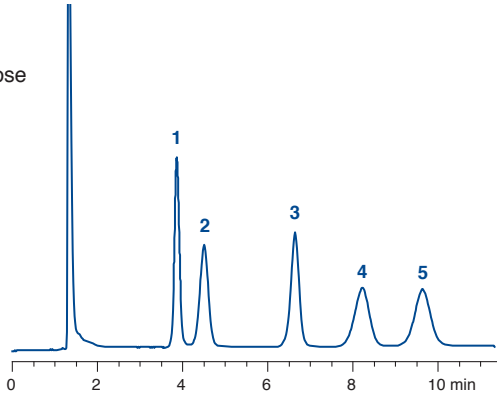
Multi-mode columns

Besides cyano modifications, amino modifications belong to the most frequently used polar silica phases – both feature the important advantage, that they can be run in the RP mode using aqueous-organic eluent mixtures as well as in the NP mode, e.g., with hexane as mobile phase.

Reversed phase separation of sugars

Column: 250 x 4 mm NUCLEODUR® 100-5 NH_2-RP
Eluent: acetonitrile – water (79:21, v/v)
Flow rate: 2 mL/min
Detection: RI

Peaks:
1. Fructose
2. Glucose
3. Saccharose
4. Maltose
5. Lactose



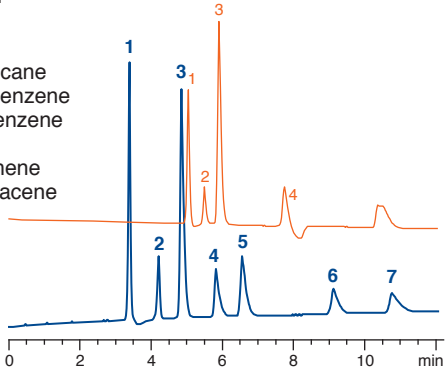
MN Appl. No. 122160

NUCLEODUR® NH_2, too, belongs to the so-called multi-mode columns. It can be used for RP chromatography of polar compounds such as sugars in aqueous-organic eluent systems, for NP chromatography of substituted aromatics or chlorinated pesticides with organic mobile phases such as hexane, dichloromethane or 2-propanol, but also for ion exchange chromatography of anions and organic acids using conventional buffers and organic modifiers. Main field of application of NUCLEODUR® NH_2 is the separation of simple and complex sugars, sugar alcohols and other hydroxy compounds under RP conditions as well as hydrocarbons under NP conditions.

Normal phase separation of middle distillates in accordance with DIN EN 12916

Columns: **A) 250 x 4 mm NUCLEODUR® 100-5 NH_2**
B) conventional aminopropyl phase
Eluent: heptane
Flow rate: 1 mL/min
Detection: RI

Peaks:
1. Cyclohexane
2. 1-Phenyldodecane
3. 1,2-Dimethylbenzene
4. Hexamethylbenzene
5. Naphthalene
6. Dibenzothiophene
7. 9-Methylanthracene



MN Appl. No. 122180

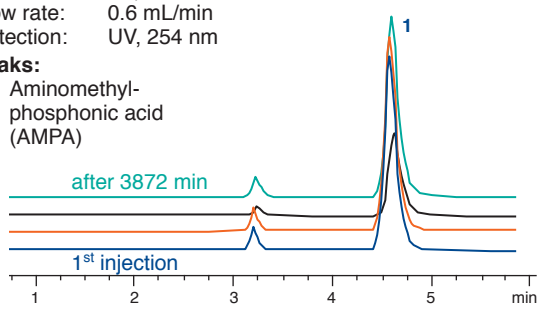
Due to the special method of surface modification NUCLEODUR® NH_2 features a pronounced stability at higher as well as at lower pH values. The following figure shows, that even after several days of exposure of the column material at pH 1.75 good separation efficiency and peak symmetry are maintained. The resulting high column life allows cost reduction due to lower column consumption. This example shows the enhanced pH stability of NUCLEODUR® NH_2 and the outstanding

suitability for the separation of total herbicides (AMPA, glyphosate, glufonisate, ...) – see application 122190 in our online data base at ***www.mn-net.com/apps***.

Hydrolytical resistance of NUCLEODUR® NH_2-RP

Column: 250 x 4 mm NUCLEODUR® 100-5 NH_2-RP
Eluent: acetonitrile – 50 mmol/L KH_2PO_4, pH 1.75 (50:50, v/v)
Flow rate: 0.6 mL/min
Detection: UV, 254 nm

Peaks:
1. Aminomethyl-phosphonic acid (AMPA)

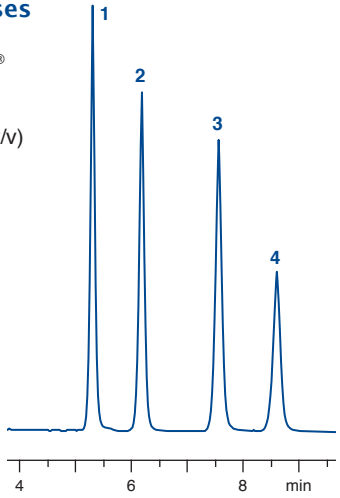


Separation of DNA bases

Column: 250 x 4 mm NUCLEODUR® 100-5 NH_2-RP
Eluent: acetonitrile – water (80:20, v/v)
Flow rate: 0.6 mL/min
Temperature: 35 °C
Pressure: 30 bar
Detection: UV, 254 nm

Peaks:
1. Thymine
2. Uracil
3. Cytosine
4. Adenine

MN Appl. No. 122170



Based on superspherical NUCLEODUR® this phase features a high pressure stability, which makes it the perfect choice for preparative separations as well as for LC/MS. Additionally, the high batch-to-batch reproducibility of NUCLEODUR® NH_2 enables reliable analyses especially for routine work.

Ordering information

Length →	100 mm	125 mm	150 mm	250 mm
NUCLEODUR® 100-3 NH_2-RP		particle size 3 µm; eluent in column acetonitrile – water		
EC columns				
2 mm ID	**760740.20**	**760741.20**		
4.6 mm ID			**760742.46**	**760739.46**
EC guard columns*	4 x 2 mm: **761951.20**		4 x 3 mm: **761951.30**	
CC guard columns**	8 x 3 mm: **761035.30**		8 x 4 mm: **761035.40**	
NUCLEODUR® 100-5 NH_2-RP		particle size 5 µm; eluent in column acetonitrile – water		
EC columns				
2 mm ID		**760730.20**		**760732.20**
3 mm ID		**760730.30**		**760732.30**
4 mm ID		**760730.40**		**760732.40**
4.6 mm ID		**760730.46**	**760731.46**	**760732.46**
EC guard columns*	4 x 2 mm: **761953.20**		4 x 3 mm: **761953.30**	
CC guard columns**	8 x 3 mm: **761137.30**		8 x 4 mm: **761137.40**	
NUCLEODUR® 100-5 NH_2		particle size 5 µm; eluent in column *n*-heptane		
EC columns				
4 mm ID		**760720.40**		**760722.40**
4.6 mm ID		**760720.46**	**760721.46**	**760722.46**
EC guard columns*			4 x 3 mm: **761952.30**	
CC guard columns**			8 x 4 mm: **761130.40**	

EC columns in packs of 1, guard columns in packs of 3; for details see page 189

Guard column systems

Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

NUCLEODUR® high purity silica for HPLC

NUCLEODUR® SiOH — unmodified silica for normal phase separations

Key features:

- Totally spherical high purity silica
- Pressure stable up to 600 bar
- Suitable for analytical and preparative separation of polar and midpolar compounds

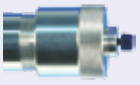
Technical characteristics:
Unmodified high purity silica; pore size 110 Å; particle sizes 3 to 50 µm; pore volume 0.9 mL/g; surface area (BET) 340 m^2/g; pH stability 2–8; metal content < 10 ppm (see page 110)

Recommended application:
Polar and midpolar compounds under normal phase conditions

USP L3

Ordering information

Eluent in column *n*-heptane

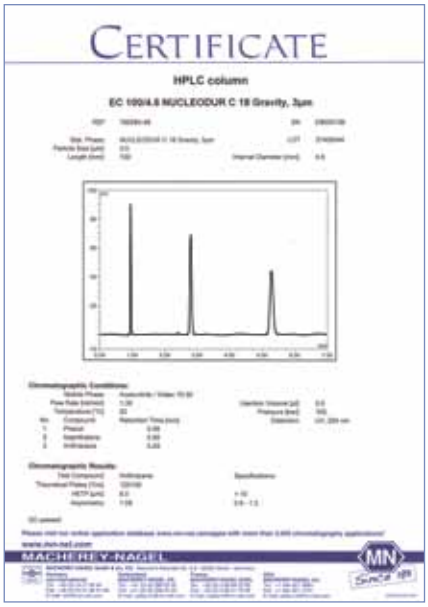
Length →	50 mm	125 mm	150 mm	250 mm
NUCLEODUR® 100-3				particle size 3 µm
EC columns				
 4.6 mm ID	**760170.46**		**760172.46**	**760173.46**
EC guard columns*			4 x 3 mm: **761966.30**	
CC guard columns**			8 x 4 mm: **761007.40**	
NUCLEODUR® 100-5				particle size 5 µm
EC columns				
 4 mm ID				**760007.40**
4.6 mm ID	**760023.46**		**760012.46**	**760007.46**
EC guard columns*			4 x 3 mm: **761967.30**	
CC guard columns**			8 x 4 mm: **761055.40**	
VarioPrep columns				
 10 mm ID	**762077.100**	**762078.100**		**762007.100**
21 mm ID	**762077.210**	**762078.210**		**762007.210**
40 mm ID			**762075.400**	**762007.400**
VP guard columns*	10 x 8 mm: **762094.80** 15 x 32 mm: **762330.320**		10 x 16 mm: **762094.160**	
EC and VarioPrep columns in packs of 1, guard columns see below				

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189–196
Unmodified NUCLEODUR® bulk material in 10–50 µm for self-packing of preparative columns see page 198

Our HPLC QC policy

- **Highest production standard**
  our facilities are EN ISO 9001:2008 certified
- **Strict quality specifications**
  for outstanding reliability
- **Perfect reproducibility** from batch to batch and within each lot
- Each column is individually tested and supplied with test chromatogram and test conditions.


CERTIFICATE

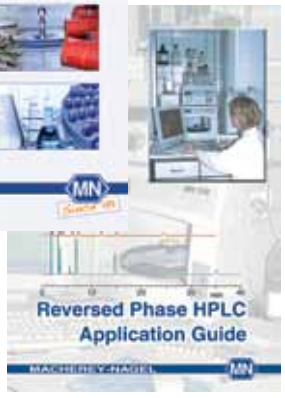
HPLC column

MACHEREY-NAGEL

Test mixture for reversed phase columns

Designation	Pack of	REF
Test mixture for reversed phase columns in acetonitrile *	1 mL	722394

Further information and many applications for our NUCLEODUR® phases are compiled in our brochure "NUCLEODUR® – Professional solutions for HPLC".



Our Reversed Phase HPLC Application Guide offers an introduction to RP chromatography and numerous applications with our NUCLEODUR® and NUCLEOSIL® phases.

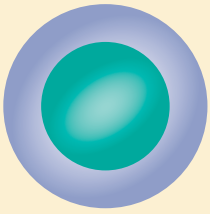
Please contact us for further literature under info@mn-net.com.

* This product contains harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.

NUCLEOSHELL® core-shell silica for HPLC

Core-shell technology

NUCLEOSHELL® 2.7 µm

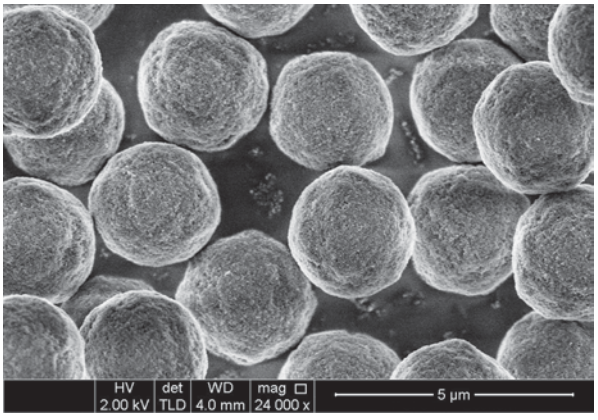


NEW!

- Solid core of silicon dioxide, homogeneous shell of porous silica
- Highest efficiency compared to traditional totally porous materials
- Pore size 90 Å; particle size 2.7 µm (core 1.7 µm); specific surface 130 m^2/g
  lower back pressure enables use on conventional LC systems
- Pressure stability 600 bar

Demands on HPLC separations are constantly increasing with respect to separation efficiency, detection limits, and the time requirements for each analysis.

Several approaches have been made to achieve fast separations without losing chromatographic performance. HPLC columns packed with particles < 2 µm show very high efficiencies (plates/meter) and allow the use of smaller column sizes with the positive side effect of significant solvent saving. However they generate a high back pressure of the mobile phase during column runs which requires specifically designed equipment.



Electron microscopic image of NUCLEOSHELL®

NUCLEOSHELL® silica particles consist of a non-porous solid core of 1.7 µm diameter and a porous outer shell of 0.5 µm thickness. Accordingly the total diameter of the particle is 2.7 µm. Utilizing a proprietary process of synthesis, NUCLEOSHELL® particles exhibit a distinct narrow particle size distribution (d_{90}/d_{10} ~ 1.1). Columns packed with NUCLEOSHELL core shell particles feature exceptional separation efficiencies with theoretical plate numbers easily comparable to totally porous sub 2 micron particles.

$$R_s = \frac{\sqrt{N}}{4}\left(\frac{\alpha - 1}{\alpha}\right)\left(\frac{k_i'}{k_i' + 1}\right)$$

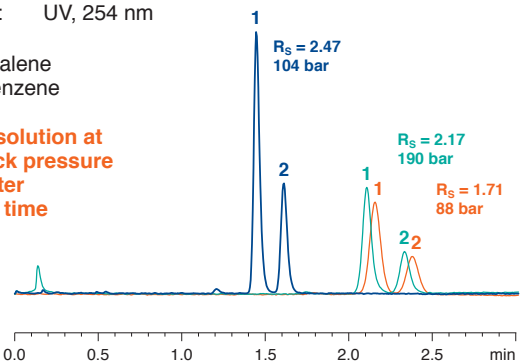
R_s = resolution
α = selectivity
k_i' = retention
N = theoretical plates $N \propto 1/d_P$
d_P = particle size

Resolution R_S as function of particle size

Columns: 50 x 4 mm
NUCLEOSHELL® RP 18, 2.7 µm
NUCLEODUR® C_{18} Gravity, 3 µm
NUCLEODUR® C_{18} Gravity, 1.8 µm
Eluent: acetonitrile – water (60:40, v/v)
Flow rate: 1 mL/min
Temperature: 25 °C
Detection: UV, 254 nm

Peaks:
1. Naphthalene
2. Ethylbenzene

Better resolution at lower back pressure and shorter retention time



MN Appl. No. 125270

Theoretical column efficiency (optimal conditions)

Silica	d_p [µm]	L [m]	HETP [µm]	Efficiency [plates/m]	L [mm]	N	R_s	Analysis time
NUCLEOSHELL®	**2.7**	**1**	**4**	**250 000**	**100**	**25 000**	**112 %**	**40 %**
NUCLEODUR®	1.8	1	4.5	222 222	100	22 000	105 %	40 %
	3	1	7.5	133 333	150	20 000	100 %	60 %
	5	1	12.5	80 000	250	20 000	100 %	100 %

Benefits of core-shell technology

Short diffusion paths

- Fast mass transfer (term C of Van Deemter equation)
- High flow velocity without peak broadening for fast LC

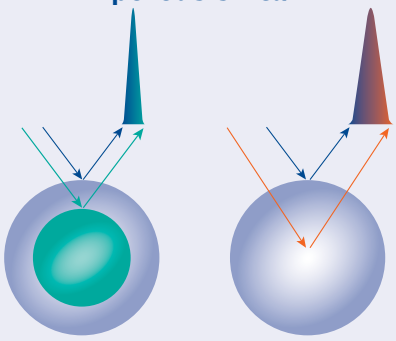
Narrow particle size distribution (d_{90}/d_{10} ~ 1.1)

- Stable packing

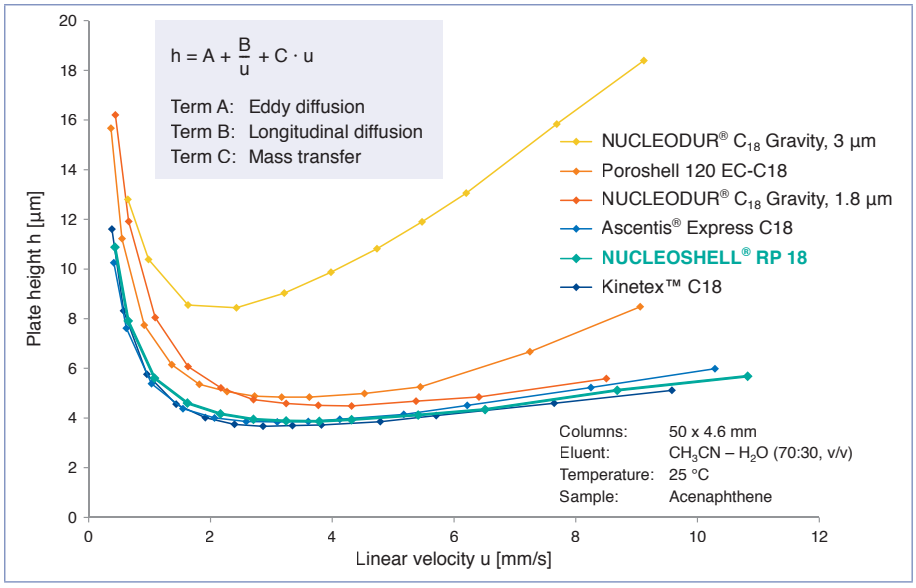
High heat transfer

- Minimized influence of frictional heat
- Efficiency of NUCLEOSHELL® ~ 250 000 m^{-1} (HETP ~ 4 µm)

Core-shell particles vs. totally porous silica



With conventional fully porous particles the mass transfer between stationary and mobile phase usually results in peak broadening at higher flow rates (C-term in van Deemter equation). The short diffusion paths in the core-shell particles reduce the dwell time of the analyte molecules in the stationary phase, so that even at high flow velocities of the mobile phase, optimal separation results can be obtained.

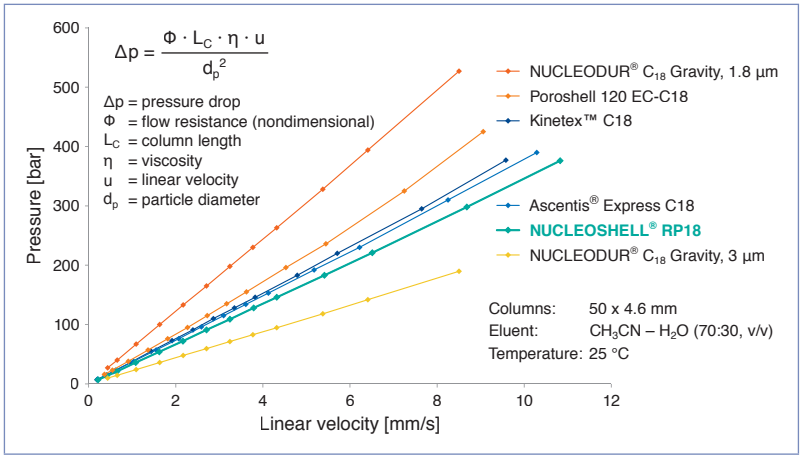


Van-Deemter plots

The van Deemter plots demonstrate how efficiency is affected by flow rate. In comparison with fully porous silicas, core-shell particles from various manufacturers maintain the efficiency optimum (max. plates/m) over a long range of increasing linear mobile phase velocity.

Pressure drop

In direct comparison with conventional sub 2 micron phases, NUCLEOSHELL® columns only generate about 60 % of the back pressure and can be operated with the majority of conventional HPLC systems. In order to develop the maximum performance of NUCLEOSHELL® columns, we recommend reducing extra column voids by using suitable capillaries (< 0.15 mm inner diameter) and specially adapted detector cells. Moreover detector settings should be optimized by increasing the measuring rate or by decrease of the time constant.



Core-shell particle technology from MACHEREY-NAGEL is an alternate route to gain highest column efficiency and resolution in HPLC at short run time, but with moderate back pressure.

NUCLEOSHELL® core-shell silica for HPLC

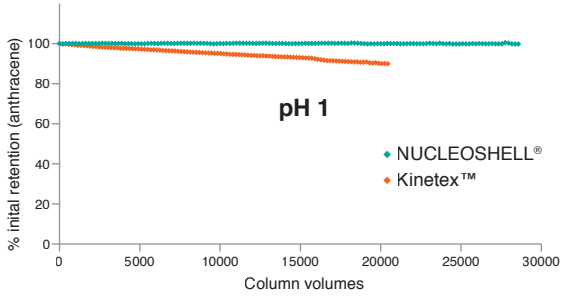
Features of NUCLEOSHELL® particles

A criterion for the long-term stability of the column at pH extremes is the percentage decrease of initial retention and initial plates, respectively.

The following figure shows a column stability test of NUCLEOSHELL® RP 18 at mobile phase levels pH 1 and pH 10 compared with three competing phases.

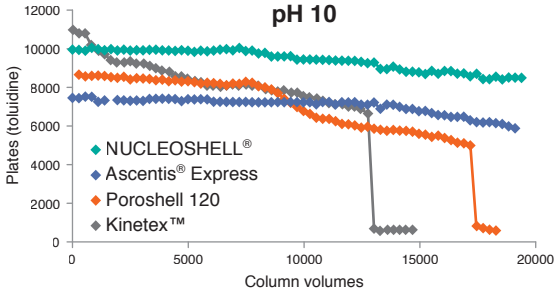
Stability under acidic and basic conditions

Column: **50 x 4.6 mm NUCLEOSHELL® RP 18, 2.7 µm**
50 x 4.6 mm Kinetex™ 2.6 µm C18
Eluent: acetonitrile – 1 % TFA in water,
pH 1 (50:50, v/v)
Flow rate: 1.3 mL/min
Temperature: 80 °C
Detection: UV, 254 nm
Analyte: anthracene



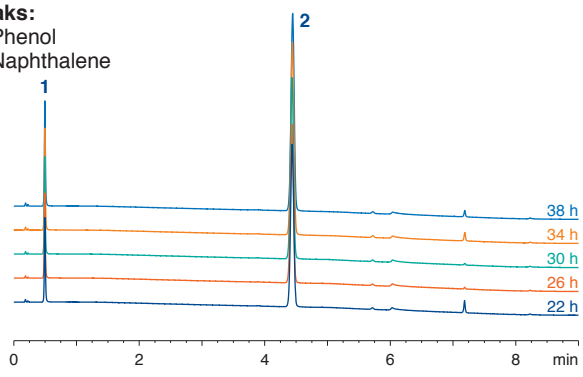
MN Appl. No. 125520 / 125530

Columns: **50 x 4.6 mm NUCLEOSHELL® RP 18, 2.7 µm**
50 x 4.6 mm Ascentis® Express C18, 2.7 µm
50 x 4.6 mm Poroshell 120 EC-C18
50 x 4.6 mm Kinetex™ 2.6 µm C18
Eluent: 20 mmol/L Na borate – 10 mmol/L NaOH – methanol,
pH 10 (21:49:30, v/v/v)
Flow rate: 1.5 mL/min
Temperature: 40 °C
Detection: UV, 220 nm
Analyte: toluidine



Temperature stability

Stability test:
Column: 50 x 2 mm NUCLEOSHELL® RP 18, 2.7 µm
Eluent: A) 10 mmol/L ammonium formate – methanol (9:1, v/v) + 120 µL formic acid, ~ pH 4
B) 10 mmol/L ammonium formate – methanol (1:9, v/v) + 120 µL formic acid, ~ pH 4
0–100 % B in 7 min
Flow rate: 0.5 mL/min, temperature **100 °C**
Detection: UV, 220 nm
Peaks:
1. Phenol
2. Naphthalene



MN Appl. No. 125400

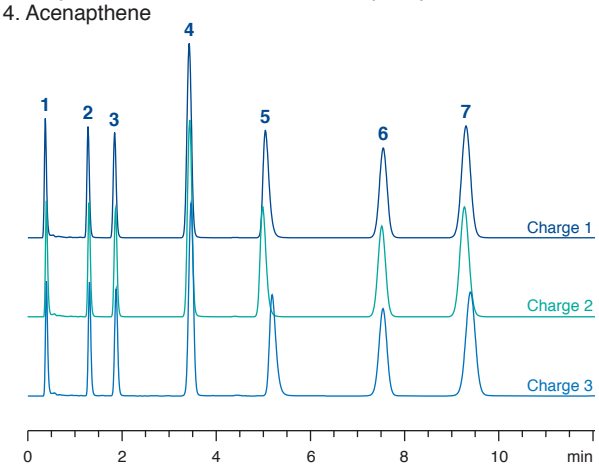
Effficiency test:
Eluent: acetonitrile – water (60:40, v/v)
Flow rate: 0.33 mL/min; temperature 25 °C
Detection: UV, 254 nm
Analyte: anthracene

	HETP [µm]	Asymmetry
Start (t = 0)	5.2	0.98
End (t = 40 h)	5.2	1.01

Columns can be operated at elevated temperatures without loss in retention, efficiency or peak symmetry.

Batch-to-batch reproducibility

Column: 50 x 4 mm NUCLEOSHELL® RP 18, 2.7 µm
Eluent: methanol – 25 mmol/L KH_2PO_4, pH 7
(70:30, v/v)
Flow rate: 1 mL/min
Temperature: 40 °C
Detection: UV, 254 nm
Peaks:
1. Uracil
2. Toluene
3. Ethylbenzene
4. Acenapthene
5. Amitriptyline
6. *o*-Terphenyl
7. Triphenylene



MN Appl. No. 125410

Uniformly shaped NUCLEOSHELL® particles combined with optimized bonding technology safeguard tightly packed columns for 100 % reproducible results.

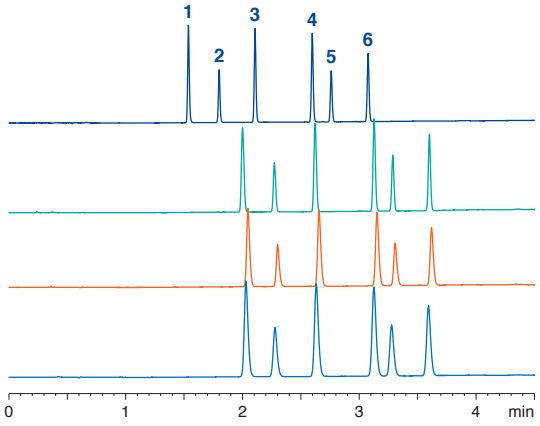
Peak capacity

The peak capacity is a measure for the number of sample analytes that can be separated on HPLC columns per time unit. Narrow peaks increase the peak capacity and thus the efficiency of the analytical column.

Peak capacity

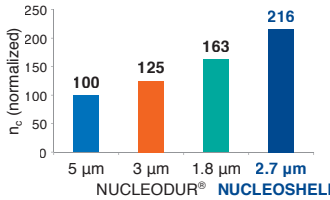
Columns: 100 x 4.6 mm
NUCLEOSHELL® RP 18, 2.7 µm
NUCLEODUR® C_{18} Gravity, 1.8 µm
NUCLEODUR® C_{18} Gravity, 3 µm
NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: A) acetonitrile, B) water, 40–100 % A in 4 min
Flow rate: 1.5 mL/min
Temperature: 25 °C
Detection: UV, 230 nm

Peaks:
1. Acetophenone
2. Benzoin
3. Propiophenone
4. Butyrophenone
5. Benzophenone
6. Valerophenone



MN Appl. No. 125540

	Max. pressure [bar]	Resolution (4, 5)
NUCLEOSHELL®, 2.7 µm	**255**	**5.45**
NUCLEODUR®, 1.8 µm	450	4.14
NUCLEODUR®, 3 µm	214	2.97
NUCLEODUR®, 5 µm	142	2.30



$$n_c = 1 + \left(\frac{t_g}{W}\right)$$

n_c: peak capacity
t_g: gradient time
W: peak width (at baseline)

The example shows, that in comparison with totally porous NUCLEODUR® silica (1.8 µm) NUCLEOSHELL® provides 33 % higher peak capacity.

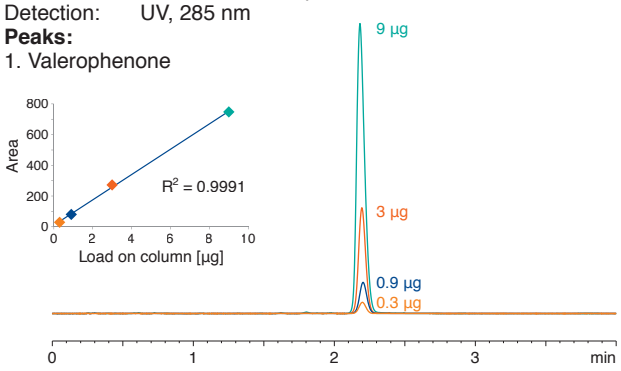
Loading capacity

NUCLEOSHELL® columns allow **reliable quantification** in a wide analytical detection range. Retention time and peak width at 50 % height remain constant with increasing columns load although core-shell particles are suspected of showing a slightly lower loading capacity compared to fully porous silica materials.

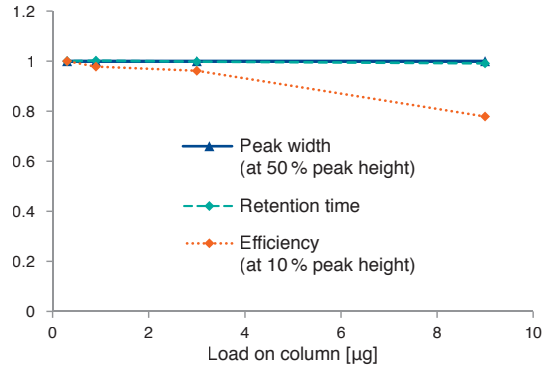
Loading capacity

Column: 50 x 3 mm NUCLEOSHELL® RP 18, 2.7 µm
Eluent: acetonitrile – 25 mmol/L KH_2PO_4, pH 3 (70:30, v/v)
Flow rate: 0.66 mL/min, temperature 30 °C
Detection: UV, 285 nm

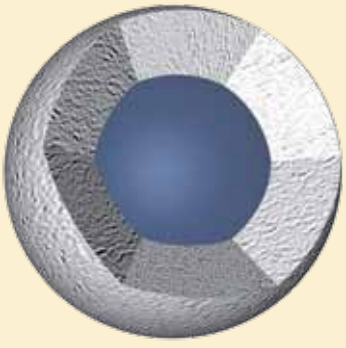
Peaks:
1. Valerophenone



Normalized column parameters



NUCLEOSHELL® modifications



The program of NUCLEOSHELL® surface modifications now comprises the following phases:

- NUCLEOSHELL® RP 18
- NUCLEOSHELL® PFP
- NUCLEOSHELL® HILIC

NUCLEOSHELL® core-shell silica for HPLC

NUCLEOSHELL® RP 18

nonpolar high density phase

Key features:

- Core-shell technology for fast and efficient HPLC
- Suitable for **LC/MS** and HPLC at pH extremes (pH 1–11)
- Superior base deactivation, ideal for method development

Technical characteristics:
Octadecyl modification, multi-endcapped; pore size 90 Å, particle size 2.7 µm, carbon content 7.5 %

Recommended application:
Overall sophisticated analytical separations, e.g., analgesics, anti-inflammatory drugs, antidepressants; herbicides; phytopharmaceuticals; immunosuppressants

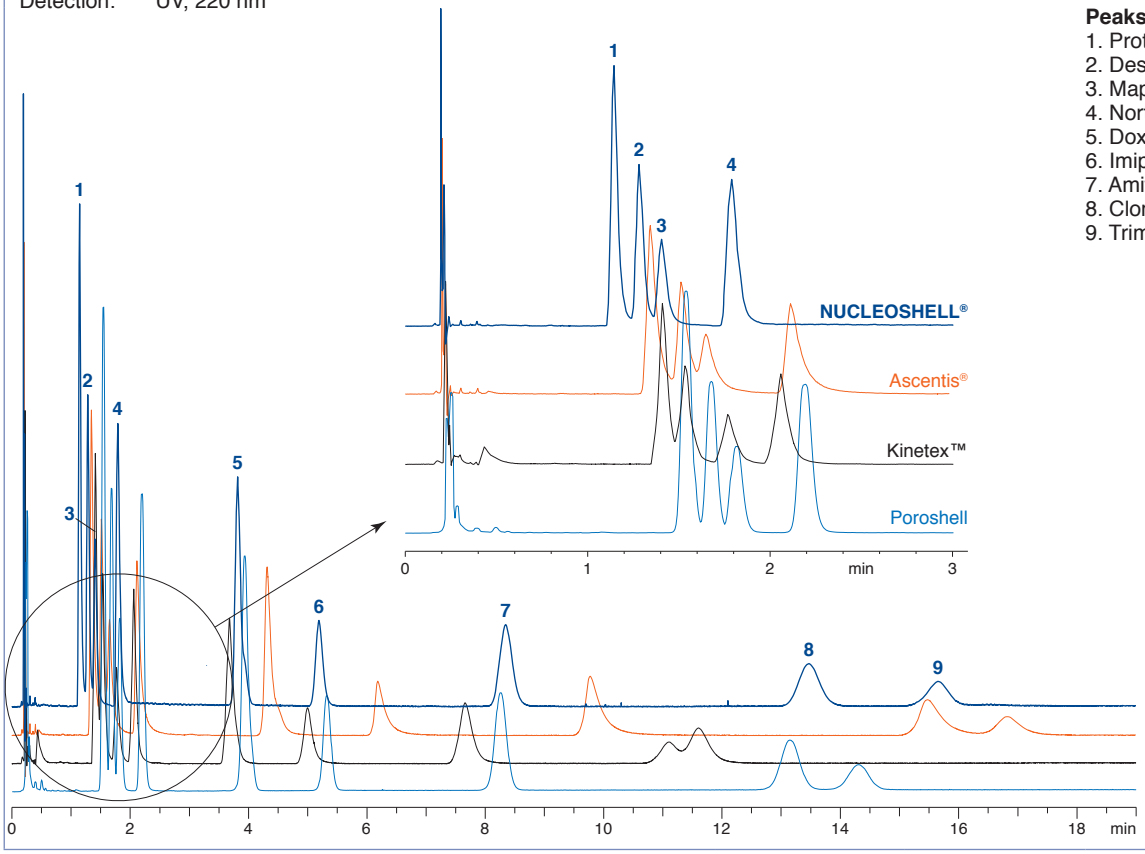
USP L1

NUCLEOSHELL® RP 18 is based on core-shell silica. A unique derivatization process generates a homogeneous surface with a high density of bonded silanes (carbon content ~7.5 %). The following thorough end-capping suppresses any unwanted polar interactions between the silica surface and the sample, which makes NUCLEOSHELL® RP 18 particularly suitable for the separation of basic and other ionizable analytes. The extremely reduced silanol activity of the phase can be demonstrated by applying basic analytes, such as tricyclic antidepressants. The chromatogram below shows a sharp elution profile (superior resolution!) of these highly polar compounds with an excellent asymmetry value for amitriptyline of 1.12.

Tricyclic antidepressants · comparison of selectivity and resolution

Columns: 50 x 4.6 mm
NUCLEOSHELL® RP 18, 2.7 µm
Ascentis® Express C18
Kinetex™ 2.6 µm C18
Poroshell 120 EC-C18
Eluent: methanol – acetonitrile – 25 mmol/L KH_2PO_4, pH 7 (22.5:22.5:55, v/v/v)
Flow rate: 2 mL/min
Pressure: **224 bar,** 239 bar, 248 bar, 212 bar
Temperature: 40 °C
Detection: UV, 220 nm

	Asymmetry (amitriptyline)	Resolution (8, 9)
NUCLEOSHELL®	**1.12**	**3.35**
Ascentis® Express	2.07	1.91
Kinetex™	1.33	n.a.
Poroshell	1.05	1.95



Peaks:
1. Protriptyline
2. Desipramine
3. Maprotiline
4. Nortriptyline
5. Doxepin
6. Imipramine
7. Amitriptyline
8. Clomipramine
9. Trimipramine

MN Appl. No. 124960

NUCLEOSHELL® core-shell silica for HPLC

The separation of 13 β-lactam antibiotics illustrates how time of analysis can be shortened to a fractional part by using core-shell particles without loss of resolution at moderate back pressure.

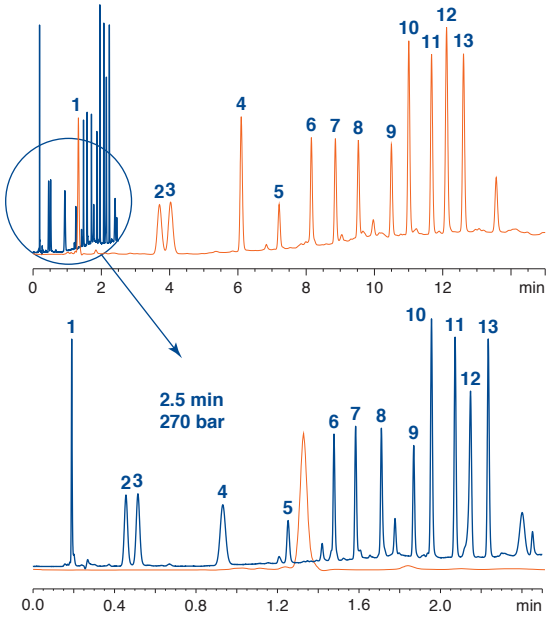
NUCLEOSHELL® RP 18 combines innovative silica technology and excellent surface deactivation, that outperforms conventional C_{18} silicas in terms of efficiency, resolution and speed. Due to the applied core-shell particle design the back pressure at elevated flow rates remains at a moderate level and in many cases permits the use of existing HPLC equipment. NUCLEOSHELL® RP 18 with extended pH stability, low bleed characteristics in LC/MS applications, and overall robustness is an ideal tool for method development and routine analyses in modern HPLC.

13 β-lactam antibiotics in less than 3 min

Columns: **50 x 4 mm NUCLEOSHELL® RP 18, 2.7 µm**
150 x 4 mm NUCLEODUR® C_{18} Gravity, 5 µm
Eluent: A) acetonitrile; B) 20 mmol/L KH_2PO_4, pH 3.5
10 % A (0.5 min) → 50 % A in 1.5 min (0.5 min 50 % A)
10 % A (3 min) → 50 % A in 9 min (3 min 50 % A)
Flow rate: **2 mL/min,** 1 mL/min
Pressure: **270 bar,** 110 bar
Temperature: 25 °C
Detection: UV, 220 nm

Peaks:

1. Amoxicillin
2. Ampicillin
3. Cephalexin
4. Cefotaxime
5. Cefoxitin
6. Cefamandole
7. Cephalothin
8. Piperacillin
9. Penicillin V
10. Oxacillin
11. Cloxacillin
12. Nafcillin
13. Dicloxacillin



MN Appl. No. 124940

Ordering information

Eluent in column acetonitrile – water

Length →	50 mm	100 mm	150 mm
NUCLEOSHELL® RP 18, 2.7 µm			particle size 2.7 µm
EC columns			
2 mm ID	**763132.20**	**763134.20**	**763136.20**
3 mm ID	**763132.30**	**763134.30**	**763136.30**
4 mm ID	**763132.40**	**763134.40**	**763136.40**
4.6 mm ID	**763132.46**	**763134.46**	**763136.46**
EC guard columns*	4 x 2 mm: **763138.20**		4 x 3 mm: **763138.30**
EC columns in packs of 1, guard columns in packs of 3; for details see page 189			

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966

NUCLEOSHELL® core-shell silica for HPLC

NUCLEOSHELL® PFP — hydrophobic pentafluorophenyl phase

Key features:

- Core-shell technology for fast and efficient HPLC
- Hydrophobic phase with alternative selectivity in comparison to classical C_{18} modifications
- Separation principle based on 4 retention mechanisms (polar interactions (H bonds), dipole-dipole, π-π, hydrophobic interactions)

Technical characteristics:
Phase with pentafluorophenyl-propyl modification, multi-endcapping; pore size 90 Å, particle size 2.7 µm; carbon content ~ 3 %; pH stability 1-9; suitable for **LC/MS**

Recommended application:
Aromatic and unsaturated compounds, phenols, halogen compounds, isomers, polar compounds like pharmaceuticals, antibiotics; strong retention of basic compounds

USP L43

Orthogonality in selectivity

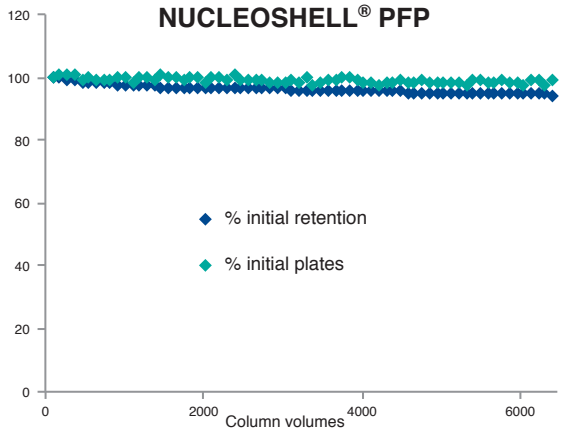
Fluorinated stationary phases in HPLC have gained increasing interest over the last years. Most common representative of fluorinated silica phases is the pentafluorophenyl modification (PFP or F5). Especially the orthogonal selectivity compared to traditional alkyl phases widens the scope in analytical HPLC. Thus NUCLEOSHELL® PFP offers an excellent selectivity especially for highly polar analytes, aromatic and unsaturated compounds, phenols or halogenated hydrocarbons.

While a typical C_{18} phase just provides hydrophobic interactions between stationary phase and analyte NUCLEOSHELL® PFP offers four different retention mechanisms: polar interactions (H bonds), dipole-dipole interactions, π-π interactions and hydrophobic interactions. Especially the pronounced ion exchange capacity and distinct steric selectivity are typical for the character of fluorinated phases.

Stability of NUCLEOSHELL® PFP at pH 1

Column: 100 x 4.6 mm NUCLEOSHELL® PFP, 2.7 µm
Eluent: acetonitrile – 0.5 % TFA, pH 1 (50:50, v/v)
Flow rate: 1.3 mL/min, temperature 60 °C
Detection: UV, 254 nm

Sample:
Ethylbenzene

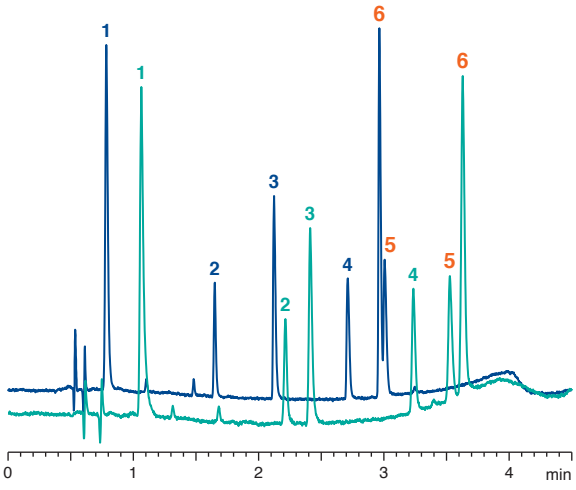


MN Appl. No. 125560

β-Blockers · orthogonal selectivity of NUCLEOSHELL® PFP

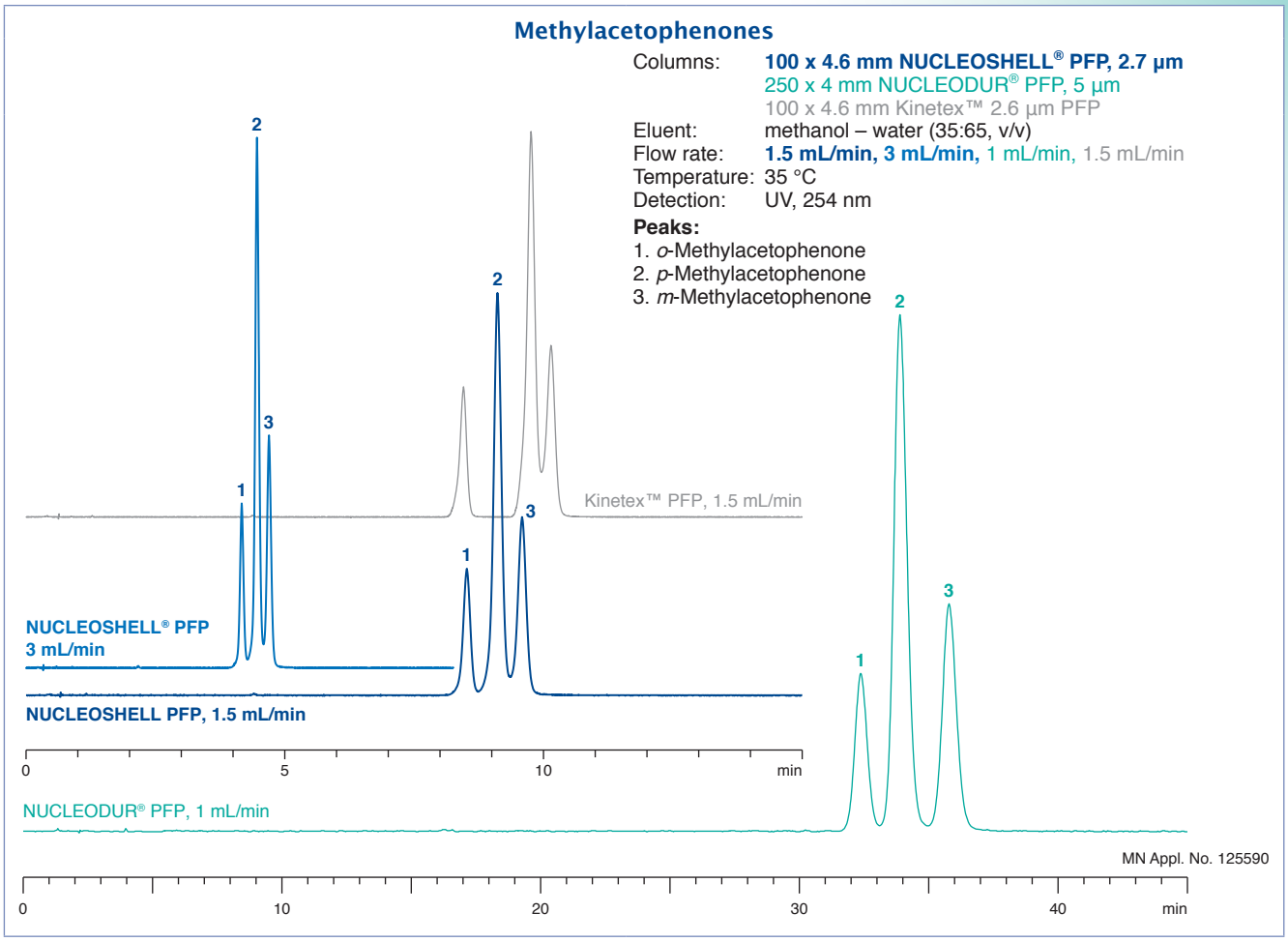
Columns: 100 x 4.6 mm
NUCLEOSHELL® RP 18, 2.7 µm
NUCLEOSHELL® PFP, 2.7 µm
Eluent: A) acetonitrile + 0.1 % formic acid
B) 0.1 % formic acid
10–35 % A in 2.5 min, 35-50 % A in 2 min
Flow rate: 1.7 mL/min
Temperature: 25 °C
Detection: UV, 280 nm

Peaks:
1. Atenolol
2. Pindolol
3. Metroprolol
4. Labetalol
5. Alprenolol
6. Propranolol



MN Appl. No. 125610

Columns for HPLC



NUCLEOSHELL® PFP combines the benefits of core-shell technology, high stability, and orthogonal selectivity. Thus it is a useful complementary tool for highly efficient separations especially of isomers, halogenated, aromatic and / or polar compounds.

Ordering information

Eluent in column acetonitrile – water

Length →	50 mm	100 mm	150 mm
NUCLEOSHELL® PFP, 2.7 µm			particle size 2.7 µm
EC columns			
2 mm ID	**763532.20**	**763534.20**	**763536.20**
3 mm ID	**763532.30**	**763534.30**	**763536.30**
4 mm ID	**763532.40**	**763534.40**	**763536.40**
4.6 mm ID	**763532.46**	**763534.46**	**763536.46**
EC guard columns*	4 x 2 mm: **763538.20**		4 x 3 mm: **763538.30**

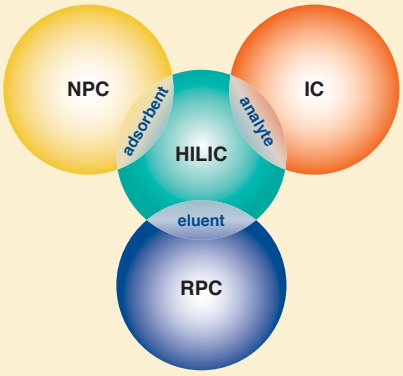
EC columns in packs of 1, guard columns in packs of 3; for details see page 189

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966

NUCLEOSHELL® core-shell silica for HPLC

NUCLEOSHELL® HILIC

zwitterionic phase



- **Key features:**
  - Core-shell technology for fast and efficient HPLC
  - Ideal for reproducible and stable chromatography of highly polar analytes
  - Very short column equilibration times
- **Technical characteristics:**
  Ammonium – sulfonic acid modified silica; pore size 90 Å, particle size 2.7 µm; carbon content 1.3 %; pH stability 2–8.5; suitable for **LC/MS**
- **Recommended application:**
  Hydrophilic compouds such as polar organic acids and bases, polar natural compounds, nucleosides, oligonucleotides, amino acids, peptides, water-soluble vitamins

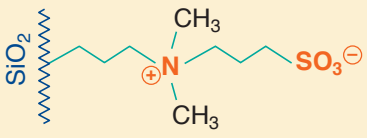
Columns for HPLC

NUCLEOSHELL® HILIC

Hydrophilic interaction chromatography (HILIC) is a separation technique using polar stationary phases and organic-aqueous mobile phases. A minimum water content of at least 2 % is indispensable to provide a permanent water layer between the adsorbent surface and the organic fraction of the mobile phase. The sample molecules become separated in a partition chromatography, in which polar analytes are more strongly retained than neutral, less hydrophilic compounds. Consequently, increasing the aqueous part in the mobile phase will diminish retention of the polar sample constituents. In this way HILIC behaves inverse to classical RP chromatography. The particular retention profile of HILIC enables the chromatography of very polar and often small molecules, which won't show any retention on C_8 or C_{18} reversed phases.

Ultra-fast separations at moderate back pressure

NUCLEOSHELL® HILIC is a core-shell technology based stationary phase with a covalently bonded 3-*N,N*-dimethylaminopropane sulfonic acid ligand (pat. pend.). The betaine character of the strong ion-exchanger results in full charge balancing and facilitates fast equilibration times.

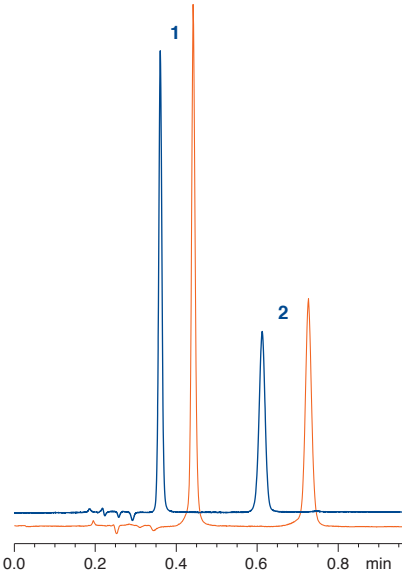


Good separation of polar compounds like the physiologically important substances creatine and creatinine can be achieved on NUCLEOSHELL® HILIC as well as on NUCLEODUR® HILIC, 1.8 µm at similar retention, but much lower back pressure.

Separation of creatine and creatinine

Columns: **50 x 4 mm NUCLEOSHELL® HILIC, 2.7 µm**
50 x 4 mm NUCLEODUR® HILIC, 1.8 µm
Eluent: acetonitrile – 10 mmol/L ammonium acetate, pH 4.0 (90:10, v/v)
Flow rate: 1.7 mL/min
Pressure: **129 bar**
180 bar
Temperature: 25 °C
Detection: UV, 210 nm

Peaks:
1. Creatinine
2. Creatine

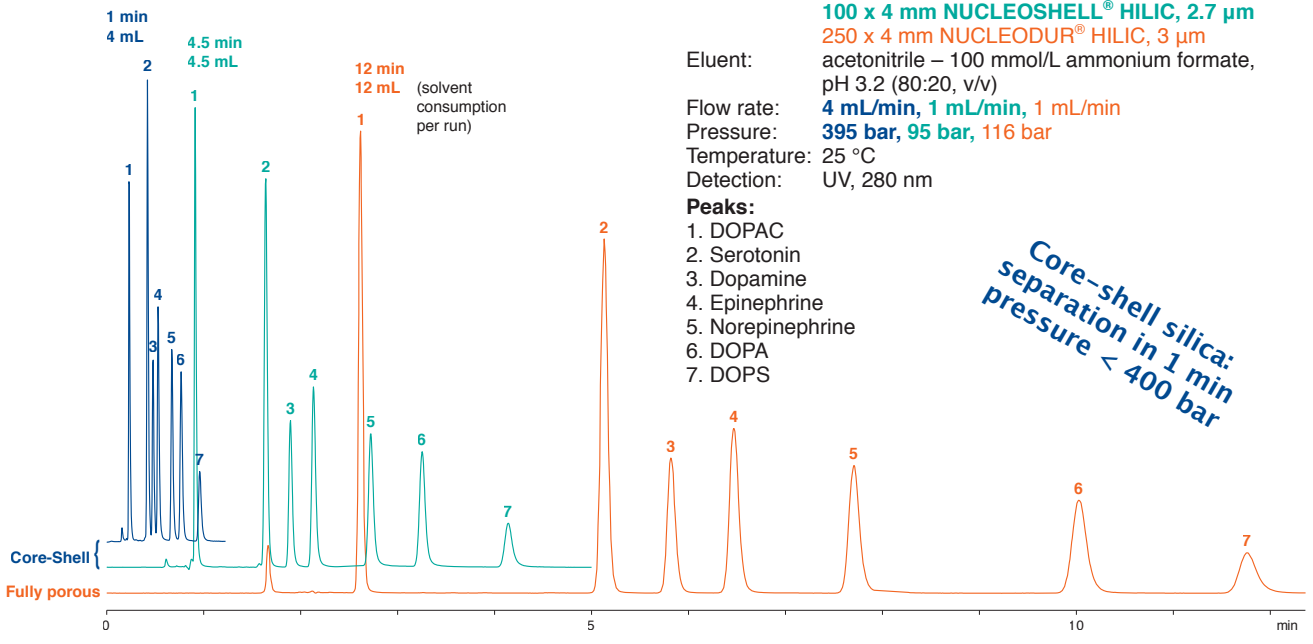


MN Appl. No. 124990

The following chromatograms show the method transfer from a fully porous 3 µm HILIC phase to 2.7 µm core-shell silica with equal selectivity features.

Run time has been cut down to 1 min. Column back pressure remains modest < 400 bar, while solvent demand is reduced to less than 35 %.

Separation of catecholamines



Columns: **100 x 4 mm NUCLEOSHELL® HILIC, 2.7 µm**
100 x 4 mm NUCLEOSHELL® HILIC, 2.7 µm
250 x 4 mm NUCLEODUR® HILIC, 3 µm
Eluent: acetonitrile – 100 mmol/L ammonium formate, pH 3.2 (80:20, v/v)
Flow rate: **4 mL/min, 1 mL/min,** 1 mL/min
Pressure: **395 bar, 95 bar,** 116 bar
Temperature: 25 °C
Detection: UV, 280 nm

Peaks:
1. DOPAC
2. Serotonin
3. Dopamine
4. Epinephrine
5. Norepinephrine
6. DOPA
7. DOPS

MN Appl. No. 125440

NUCLEOSHELL® HILIC provides stable and reproducible chromatography, comprising all the benefits of a state-of-the-art core-shell silica.

Ordering information

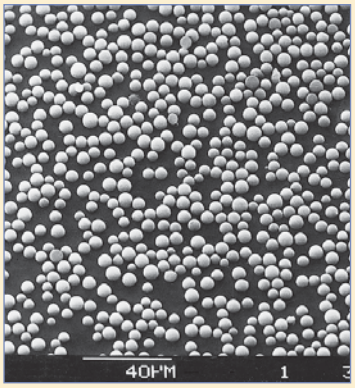
Eluent in column acetonitrile – water

Length →	50 mm	100 mm	150 mm
NUCLEOSHELL® HILIC, 2.7 µm			particle size 2.7 µm
EC columns			
2 mm ID	**763332.20**	**763334.20**	**763336.20**
3 mm ID	**763332.30**	**763334.30**	**763336.30**
4 mm ID	**763332.40**	**763334.40**	**763336.40**
4.6 mm ID	**763332.46**	**763334.46**	**763336.46**
EC guard columns*	4 x 2 mm: **763338.20**		4 x 3 mm: **763338.30**
EC columns in packs of 1, guard columns in packs of 3			

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966

For details of the EC column system please see page 189

NUCLEOSIL® standard silica for HPLC



NUCLEOSIL® is a family of totally porous spherical silicas. They feature a very pure and uniform SiO_2 structure and have gained wide acceptance as routine chromatographic packings for very different fields of modern chromatography.

- One of the first spherical silicas used in HPLC
- Developed in the early seventies, it became a world-renowned HPLC packing
- Still found in many analytical and preparative applications, it is an absolutely reliable choice in HPLC
- Largest variety of modified HPLC silicas available

Due to its particle sizes NUCLEOSIL® finds application in analytical as well as in preparative columns.

Benefits of NUCLEOSIL® silica

- High bed stability due to spherical particles
- High efficiency due to narrow particle size distribution
- High separation performance due to optimized binding techniques
- High chemical and mechanical stability
- High load capacity and recovery rates
- High reproducibility from lot to lot

Physical properties

NUCLEOSIL® is manufactured with different pore diameters (50, 100, 120, 300, 500, 1000 and 4000 Å) and particle sizes from 3 µm (only NUCLEOSIL® 50, 100 and 120) to 10 µm with very narrow fractionation.

All narrow-pore NUCLEOSIL® packings are stable up to 500 bar (7 250 psi), the wide-pore NUCLEOSIL® silicas are stable up to 300 or 400 bar (4 200 or 5 600 psi).

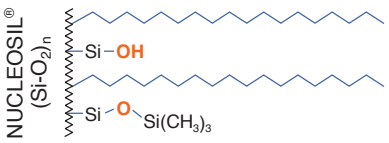
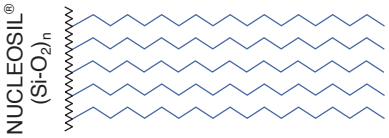
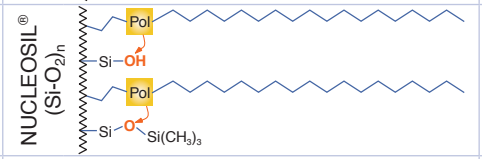
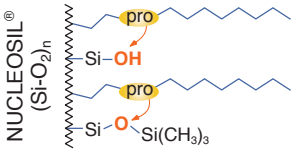
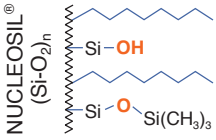
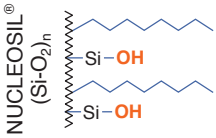
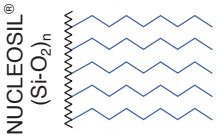
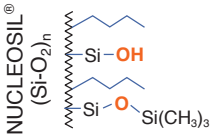
For a summary of physical properties of unmodified NUCLEOSIL® silica see page 199.

NUCLEOSIL® modifications

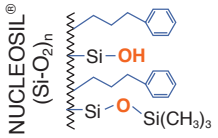
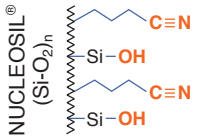
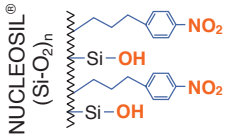
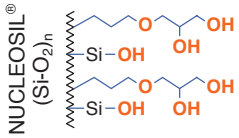
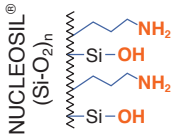
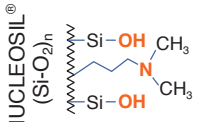
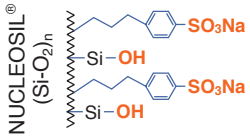
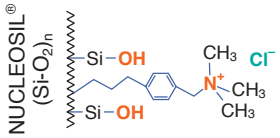
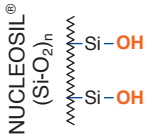
NUCLEOSIL® packings are available as unmodified silica or with numerous chemically bonded phases:

- RP phases like C_{18} AB, C_{18} HD, C_{18} Nautilus, C_{18} endcapped, Protect I, C_8 HD, C_8 ec, C_8, C_4, C_2 and Phenyl) separate mainly by hydrophobic interactions (van der Waals forces).
  The less polar the sample molecules, the more they are retained – the more polar the sample, the weaker are the hydrophobic interactions and consequently the shorter are retention times.
- Phases with chemically bonded polar groups such as CN, NO_2, NH_2, $N(CH_3)_2$, OH show selective separation properties.
  Due to the availability of different functional groups it is possible to vary the chemical characteristics of the surface and consequently the adsorption characteristics of the stationary phase.
- Silica-based ion exchangers (NUCLEOSIL® SA and SB) are stable from pH 2 to 8 and do not swell. Compared to resin-based ion exchangers they offer the advantage of constant permeability, even when the ionic strength and/or pH of the eluent are changed. The separation can be influenced by
  – the **type of buffer**
  – the **ionic strength** and
  – the **pH value**.

Summary of NUCLEOSIL® HPLC phases

NUCLEOSIL® phase	Modification	Stability	Structure	Separation principle	Page
NUCLEOSIL® RP-Phasen					
C_{18}	Octadecyl phase, medium density modification, endcapping 15 % C · **USP L1**	pH 2–8		hydrophobic (van der Waals) interactions slight residual silanol interactions	157
C_{18} HD	Octadecyl phase, high density monomeric modification, endcapping 20 % C · **USP L1**	pH 2–9		hydrophobic (van der Waals) interactions	158
C_{18} AB	Octadecyl phase, special crosslinked modification, endcapping 25 % C · **USP L1**	pH 1–9		steric interactions and hydrophobic interactions	158
C_{18} Nautilus	Octadecyl phase, embedded polar group, endcapping 16 % C · **USP L60**	pH 2–8 up to 100 % H_2O		hydrophobic interactions and polar interactions	158
Protect I	Special RP phase, protective polar group, monomeric modification, endcapping 11 % C	pH 2–8		hydrophobic interactions and polar interactions	160
C_8 ec	Octyl phase, medium density modification, endcapping 9 % C · **USP L7**	pH 2–8		hydrophobic (van der Waals) interactions slight residual silanol interactions	160
C_8	Octyl phase, no endcapping 8.5 % C · **USP L7**	pH 2–8		hydrophobic (van der Waals) interactions noticeable residual silanol interactions	160
C_8 HD	Octyl phase, high density modification, endcapping 13 % C · **USP L7**	pH 2–8		hydrophobic (van der Waals) interactions	161
C_4	Butyl phase, medium density modification, endcapping ~ 2 % C · **USP L26**	pH 2–8		hydrophobic (van der Waals) interactions residual silanol interactions	161
C_2	Dimethyl phase 3.5 % C · **USP L16**	pH 2–8		hydrophobic (van der Waals) interactions noticeable residual silanol interactions	162

NUCLEOSIL® standard silica for HPLC

NUCLEOSIL® phase	Modification	Stability	Structure	Separation principle	Page
C_6H_5 ec	Phenyl phase, medium density modification, endcapping 8% C · **USP L11**	pH 2–8		π–π interactions and hydrophobic interactions slight residual silanol interactions	200*
C_6H_5	Phenyl phase, no endcapping 8% C · **USP L11**	pH 2–8		π–π interactions and hydrophobic interactions noticeable residual silanol interactions	162
Polar NUCLEOSIL® phases and NUCLEOSIL® ion exchangers					
CN / CN-RP	Cyano (nitrile) phase **USP L10**	pH 2–8		π–π interactions, polar interactions and hydrophobic interactions	164
NO_2	Nitrophenyl	pH 2–8		π–π interactions, polar interactions and hydrophobic interactions	200*
OH (Diol)	Diol **USP L20**	pH 2–8		polar interactions (hydrogen bonds)	162
NH_2 / NH_2-RP	Amino **USP L8**	pH 2–8		polar and hydrophobic interactions, weak ion exchange interactions	163
$N(CH_3)_2$	Dimethylamino	pH 2–8		polar and hydrophobic interactions, weak ion exchange interactions	163
SA	Sulfonic acid, strongly acid cation exchanger (SCX) **USP L9**	pH 2–8		strong ion exchange interactions	164
SB	Quaternary ammonium, strongly basic anion exchanger (SAX) **USP L14**	pH 2–8		strong ion exchange interactions	165
SiOH	Unmodified spherical silica · **USP L3**	pH 2–8		polar interactions	165

* Available only as bulk packing (custom-packed columns on request)

NUCLEOSIL® octadecyl phases (C_{18})

$-(CH_2)_{17}-CH_3$

- **NUCLEOSIL® standard octadecyl phases**
  Nonpolar phases · pH stability at 20 °C: 2–8 · carbon content depending on pore size (see below) · **USP L1**
  Corresponding NUCLEODUR® phases see C_{18} ec page 133
- **NUCLEOSIL® C_{18} HD**
  Nonpolar hydrophobic high density phases, monomeric modification
  pH stability 2–9; carbon content 20% · **USP L1**
  Corresponding NUCLEODUR® phases see C_{18} Gravity page 116
- **NUCLEOSIL® C_{18} AB**
  Crosslinked hydrophobic phase, polymeric modification, inert towards acidic and basic substances with high affinity for silica; pH stability 1–9; carbon content 25%; distinct steric selectivity · **USP L1**
  Corresponding NUCLEODUR® phases see C_{18} Isis page 120
- **NUCLEOSIL® C_{18} Nautilus**
  Stable in 100% aqueous eluents; carbon content 16% · **USP L60**
  Interesting polar selectivity features, very good base deactivation
  Corresponding NUCLEODUR® phases see C_{18} PolarTec page 124
- **Wide pore octadecyl phases**
- All octadecyl phases are endcapped

Custom-packed columns with different column dimensions are available on request.

Ordering information

Eluent in column acetonitrile – water

Length →	100 mm	125 mm	150 mm	250 mm	Guard columns	
NUCLEOSIL® 50-5 C_{18} ec	particle size 5 µm, pore size 50 Å, endcapped, 14.5% C					
EC columns					EC guard col.*	CC guard col.**
4.6 mm ID				720098.46	721473.30	721829.40
NUCLEOSIL® 100-3 C_{18}	particle size 3 µm, pore size 100 Å, endcapped, 15% C					
EC columns					EC guard col.*	CC guard columns**
4 mm ID		720150.40		720133.40	721022.30	721866.40
4.6 mm ID	720841.46	720150.46	720949.46	720133.46	721022.30	721866.40
NUCLEOSIL® 100-5 C_{18}	particle size 5 µm, pore size 100 Å, endcapped, 15% C					
EC columns					EC guard col.*	CC guard col.**
2 mm ID		720002.20	720120.20	720014.20	721074.20	721602.30
3 mm ID		720002.30	720120.30	720014.30	721074.30	721602.30
4 mm ID	720141.40	720002.40	720120.40	720014.40	721074.30	721602.40
4.6 mm ID	720141.46	720002.46	720120.46	720014.46	721074.30	721602.40
VarioPrep columns						VP guard col.***
10 mm ID				715340.100		715360.80
21 mm ID				715340.210		715360.160
NUCLEOSIL® 100-7 C_{18}	particle size 7 µm, pore size 100 Å, endcapped, 15% C					
EC columns						
4 mm ID				720018.40		
4.6 mm ID		720951.46	720110.46	720018.46		
VarioPrep columns						VP guard col.***
8 mm ID				715332.80		715360.80
10 mm ID				715332.100		715360.80
16 mm ID				715332.160		715360.160
21 mm ID				715332.210		715360.160

NUCLEOSIL® standard silica for HPLC

Length →	100 mm	125 mm	150 mm	250 mm	Guard columns	
NUCLEOSIL® 100-10 C_{18}	particle size 10 µm, pore size 100 Å, endcapped, 15 % C					
EC columns						
4 mm ID				720023.40		
4.6 mm ID		720701.46	720140.46	720023.46		
NUCLEOSIL® 120-3 C_{18}	particle size 3 µm, pore size 120 Å, endcapped, 11 % C					
EC columns					EC guard col.*	CC guard col.**
4 mm ID	720149.40	720040.40		720055.40	721075.30	721606.40
4.6 mm ID	720149.46	720040.46	720740.46	720055.46	721075.30	721606.40
NUCLEOSIL® 120-5 C_{18}	particle size 5 µm, pore size 120 Å, endcapped, 11 % C					
EC columns					EC guard col.*	CC guard col.**
4 mm ID		720051.40		720041.40	721070.30	721783.40
4.6 mm ID		720051.46	720730.46	720041.46	721070.30	721783.40
NUCLEOSIL® 120-7 C_{18}	particle size 7 µm, pore size 120 Å, endcapped, 11 % C					
EC columns						
4 mm ID				720042.40		
NUCLEOSIL® 120-10 C_{18}	particle size 10 µm, pore size 120 Å, endcapped, 11 % C					
EC columns						
4 mm ID				720043.40		
4.6 mm ID				720043.46		
NUCLEOSIL® 100-3 C_{18} HD	particle size 3 µm, pore size 100 Å, 20 % C					
EC columns					EC guard col.*	CC guard col.**
4 mm ID		720191.40			721196.30	721494.40
4.6 mm ID		720191.46	720193.46		721196.30	721494.40
NUCLEOSIL® 100-5 C_{18} HD	particle size 5 µm, pore size 100 Å, 20 % C					
EC columns					EC guard col.*	CC guard col.**
4 mm ID		720296.40		720280.40	721072.30	721853.40
4.6 mm ID		720296.46	720294.46	720280.46	721072.30	721853.40
NUCLEOSIL® 100-5 C_{18} AB	particle size 5 µm, pore size 100 Å, 25 % C					
EC columns					EC guard col.*	CC guard col.**
2 mm ID		720935.20		720936.20	721073.20	721603.30
3 mm ID		720935.30		720936.30	721073.30	721603.30
4 mm ID		720935.40		720936.40	721073.30	721603.40
4.6 mm ID		720935.46	720305.46	720936.46	721073.30	721603.40
NUCLEOSIL® 100-3 C_{18} Nautilus	particle size 3 µm, pore size 100 Å, 16 % C					
EC columns					EC guard col.*	CC guard col.**
4 mm ID		720472.40			721649.30	721611.40
4.6 mm ID		720472.46	720471.46		721649.30	721611.40

NUCLEOSIL® standard silica for HPLC

Length →	100 mm	125 mm	150 mm	250 mm	Guard columns	
NUCLEOSIL® 100-5 C_{18} Nautilus				particle size 5 µm, pore size 100 Å, 16 % C		
EC columns					EC guard col.*	CC guard col.**
4 mm ID		**720430.40**		**720431.40**	**721133.30**	**721140.40**
4.6 mm ID		**720430.46**	**720432.46**	**720431.46**	**721133.30**	**721140.40**

Wide pore silica packings

Many biologically interesting molecules can not be separated using conventional narrow pore silicas with pore sizes of about 100 Å.

This is why MACHEREY-NAGEL offers a complete line of wide pore packings with pore sizes of 300, 500, 1000 and 4000 Å. These materials can also be used for size exclusion chromatography (SEC).

Length →	250 mm	Guard columns	
NUCLEOSIL® 300-5 C_{18}	particle size 5 µm, pore size 300 Å, endcapped, 6.5 % C		
EC columns		EC guard col.*	CC guard col.**
4 mm ID	**720065.40**	**721085.30**	**721608.40**
4.6 mm ID	**720065.46**	**721085.30**	**721608.40**
NUCLEOSIL® 300-7 C_{18}	particle size 7 µm, pore size 300 Å, endcapped, 6.5 % C		
VarioPrep columns			VP guard col.***
10 mm ID	**715806.100**		**715360.80**
21 mm ID	**715806.210**		**715360.160**
NUCLEOSIL® 500-7 C_{18}	particle size 7 µm, pore size 500 Å, endcapped, 2 % C		
EC columns			
4.6 mm ID	**720074.46**		
NUCLEOSIL® 1000-7 C_{18}	particle size 7 µm, pore size 1000 Å, endcapped, ~ 1 % C		
EC columns			
4.6 mm ID	**720077.46**		
NUCLEOSIL® 4000-7 C_{18}	particle size 7 µm, pore size 4000 Å, endcapped, < 1 % C		
EC columns			
4.6 mm ID	**720085.46**		

EC and VarioPrep columns in packs of 1, guard columns see below

Guard column systems						Guard column holder
Guard columns for EC columns with ID		**2 mm**	**3 mm**	**4 mm**	**4.6 mm**	
* Column Protection System (pack of)	EC	4/2 (3)	4/3 (3)	4/3 (3)	4/3 (3)	718966
** ChromCart® guard columns (pack of)	CC	8/3 (3)	8/3 (3)	8/4 (3)	8/4 (3)	721359
Guard columns for VarioPrep columns with ID		**8, 10 mm**	**16, 21 mm**	**32, 40 mm**	**≥ 50 mm**	
*** VP guard columns (pack of)	VP	10/8 (2)	10/16 (2)	15/32 (1)	15/50 (1)	
VP guard column holder		718251	718256	718253	718255	

For details of our column systems see pages 189-196

NUCLEOSIL® bulk materials for self-packing of columns see page 199 and following.

NUCLEOSIL® standard silica for HPLC

NUCLEOSIL® 100 Protect I — special RP phase with protective polar group

- RP phase with pronounced hydrophilic properties, monomeric coating, endcapped
  carbon content 11 % C

Ordering information

Eluent in column acetonitrile – water

EC columns  Length:	125 mm	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 Protect I			particle size 5 µm, pore size 100 Å		
4 mm ID	**720175.40**		**720170.40**	**721157.30**	**721154.40**
4.6 mm ID	**720175.46**	**720174.46**	**720170.46**	**721157.30**	**721154.40**

NUCLEOSIL® octyl phases (C_8) — $-(CH_2)_7-CH_3$

- **NUCLEOSIL® standard octyl phases**
  Nonpolar phases for RP and ion-pairing chromatography · **USP L7**
  Endcapped and non-endcapped modifications available; pH stability at 20 °C: 2–8
  Carbon content depending on pore size (see below)
  Corresponding NUCLEODUR® phases see C_8 ec page 133
- **NUCLEOSIL® C_8 HD**
  Nonpolar high density phases, monomeric modification, endcapped;
  Corresponding NUCLEODUR® phases see C_8 Gravity page 116
- Recommended for separation of moderately to highly polar (water-soluble) compounds
  applications: steroids, nucleosides, cyclodextrins, pharmacological plant constituents

Custom-packed columns with different column dimensions are available on request

Ordering information

Eluent in column acetonitrile – water

EC columns  Length:	125 mm	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 C_8 ec			particle size 5 µm, pore size 100 Å ; endcapped, 9 % C		
4.6 mm ID			**720165.46**	**721096.30**	**721805.40**
NUCLEOSIL® 100-5 C_8			particle size 5 µm, pore size 100 Å ; not endcapped, 8.5 % C		
4 mm ID	**720001.40**		**720013.40**	**721194.30**	**721601.40**
4.6 mm ID	**720001.46**	**720990.46**	**720013.46**	**721194.30**	**721601.40**
NUCLEOSIL® 100-7 C_8			particle size 7 µm, pore size 100 Å ; not endcapped, 8.5 % C		
4.6 mm ID			**720017.46**		
NUCLEOSIL® 100-10 C_8			particle size 10 µm, pore size 100 Å ; not endcapped, 8.5 % C		
4 mm ID			**720022.40**		
4.6 mm ID			**720022.46**		

NUCLEOSIL® standard silica for HPLC

EC columns	Length:	125 mm	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 120-3 C_8		particle size 3 µm, pore size 120 Å ; not endcapped, 6.5 % C				
4 mm ID		**720071.40**			**721093.30**	**721785.40**
4.6 mm ID		**720071.46**	**720214.46**		**721093.30**	**721785.40**
NUCLEOSIL® 120-5 C_8		particle size 5 µm, pore size 120 Å ; not endcapped, 6.5 % C				
4 mm ID		**720050.40**		**720052.40**	**721095.30**	**721787.40**
4.6 mm ID		**720050.46**	**720735.46**	**720052.46**	**721095.30**	**721787.40**
NUCLEOSIL® 300-5 C_8		particle size 5 µm, pore size 300 Å ; not endcapped, ~ 3 % C				
4.6 mm ID				**720062.46**	**721061.30**	**721101.40**
NUCLEOSIL® 100-5 C_8 HD		particle size 5 µm, pore size 100 Å, 13 % C				
4 mm ID				**720196.40**	**721071.30**	**721500.40**
4.6 mm ID			**720194.46**	**720196.46**	**721071.30**	**721500.40**

EC columns in packs of 1, guard columns in packs of 3

NUCLEOSIL® butyl phases (C_4)

$-(CH_2)_3-CH_3$

- Endcapped phases for RP and ion-pairing chromatography · **USP L26**
- pH stability at 20 °C: 2–8; carbon content ~ 2 %
- Recommended for separation of macromolecules and hydrophobic substances
- Retention times are shorter than on C_8 and C_{18} phases

For butyl phases for biochemical separations please refer to page 182.

Ordering information

Eluent in column acetonitrile – water

EC columns	Length:	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 120-5 C_4		particle size 5 µm, pore size 120 Å		
4.6 mm ID		**720096.46**	**721083.30**	**721889.40**
NUCLEOSIL® 300-5 C_4		particle size 5 µm, pore size 300 Å		
4 mm ID		**720059.40**	**721916.30**	**721607.40**
4.6 mm ID		**720059.46**	**721916.30**	**721607.40**

EC columns in packs of 1, guard columns in packs of 3

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

For details of our column systems see pages 189–196

NUCLEOSIL® standard silica for HPLC

NUCLEOSIL® dimethyl phase (C_2)

$-(CH_3)_2$

- Non-endcapped phase for RP and ion-pairing chromatography · **USP L16**
- pH stability at 20 °C: 2–8; carbon content 3.5 %
- Retention times are much shorter than for the other RP phases

Ordering information

Eluent in column acetonitrile – water

EC columns	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-7 C_2	particle size 7 µm, pore size 100 Å		
4.6 mm ID	**720089.46**	**721030.30**	**721069.40**

NUCLEOSIL® phenyl phases (C_6H_5)

$-(CH_2)_3-C_6H_5$

- Relatively nonpolar, non-endcapped phases for RP and ion pairing chromatography · **USP L11**
- Polarity similar to C_8, but with different selectivity for PAHs, polar aromatics, fatty acids etc.
- pH stability at 20 °C: 2–8; carbon content 8 %
- Recommended for separation of moderately polar compounds

Ordering information

Eluent in column acetonitrile – water

EC columns	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 C_6H_5	particle size 5 µm, pore size 100 Å, not endcapped		
4.6 mm ID	**720956.46**	**721137.30**	**721862.40**
NUCLEOSIL® 100-7 C_6H_5	particle size 7 µm, pore size 100 Å, not endcapped		
4 mm ID	**720019.40**		
4.6 mm ID	**720019.46**		

NUCLEOSIL® diol phases

$-(CH_2)_3-O-CH_2-\underset{\displaystyle OH}{\underset{|}{CH}}-\underset{\displaystyle OH}{\underset{|}{CH_2}}$

- Dihydroxypropyl modified silica for RP and NP chromatography · **USP L20**
- Less polar than unmodified silica, very easily wettable with water
- pH stability at 20 °C: 2–8; carbon content 5 %

Ordering information

Eluent in column is *n*-heptane. When using an eluent which is not miscible with *n*-heptane (e.g., water), it is necessary to rinse the columns with THF first.

EC columns	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 OH (Diol)	particle size 5 µm, pore size 100 Å		
4.6 mm ID	**720143.46**	**721142.30**	**721478.40**

NUCLEOSIL® amino phases

$-(CH_2)_3-NH_2$

- Aminopropyl modified polar silica phase · pH stability at 20 °C: 2–8; carbon content 3.5 % · **USP L8**
  Corresponding NUCLEODUR® phases see page 140
- For multi-mode chromatography:

  NP chromatography with hexane, dichloromethane or 2-propanol as mobile phase for polar compounds such as substituted anilines, esters, chlorinated pesticides

  RP chromatography of polar compounds like carbohydrates in aqueous-organic eluent systems

  Anion exchange chromatography of anions and organic acids using common buffers (e.g., acetate or phosphate) in conjunction with organic modifiers (e.g., acetonitrile)

Ordering information

Eluent in column is *n*-heptane (except for NH_2 RP). When using an eluent which is not miscible with *n*-heptane (e.g., water), it is necessary to rinse the column with THF first.

EC column	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-3 NH_2	particle size 3 µm, pore size 100 Å; eluent in column *n*-heptane		
4.6 mm ID	**720275.46**	**721933.30**	**721122.40**
NUCLEOSIL® 100-5 NH_2	particle size 5 µm, pore size 100 Å; eluent in column *n*-heptane		
4.6 mm ID	**720095.46**	**721020.30**	**721605.40**
NUCLEOSIL® 100-5 NH_2-RP	particle size 5 µm, pore size 100 Å; eluent in column acetonitrile – water (80:20)		
4.6 mm ID	**720095.46RP**	**721155.30**	**721605.40RP**
NUCLEOSIL® 100-10 NH_2	particle size 10 µm, pore size 100 Å; eluent in column *n*-heptane		
4.6 mm ID	**720025.46**		

NUCLEOSIL® dimethylamino phase

$-(CH_2)_3-N(CH_3)_2$

- Weakly basic anion exchanger for the separation of many anions; pH stability at 20 °C: 2–8; 4 % C
- Can also be used in a similar way as the NH_2 phase

Ordering information

Eluent in column is *n*-heptane. When using an eluent which is not miscible with *n*-heptane (e.g., water), it is necessary to rinse the columns with THF first.

EC columns	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 $N(CH_3)_2$	particle size 5 µm, pore size 100 Å		
4.6 mm ID	**720994.46**	**721158.30**	**721610.40**

EC columns in packs of 1, guard columns in packs of 3

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

For details of our column systems see pages 189–196

NUCLEOSIL® standard silica for HPLC

NUCLEOSIL® cyano phases

$-(CH_2)_3 - CN$

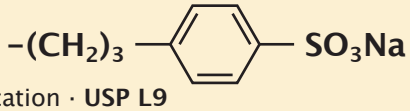
- Polar to midpolar cyano (nitrile) modified silica · **USP L10**
- For reversed phase and normal phase chromatography:
  Normal phase: with low-polarity solvents for many compounds, which can also be separated on unmodified silica, however, due to the rapid equilibration much more suitable for gradient separations
  Reversed phase: with different selectivity than C_{18}, C_8 or phenyl modified packings
- pH stability at 20 °C: 2–8; carbon content 5 % for 100 Å pores, ~ 3 % for 120 Å pores
  Corresponding NUCLEODUR® phases see page 138

Ordering information

Eluent in column (except for NUCLEOSIL® 100-5 CN-RP) is *n*-heptane. When using an eluent which is not miscible with *n*-heptane (e.g., water), it is necessary to rinse the column with THF first.

EC columns	Length: 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 CN	particle size 5 µm, pore size 100 Å ; eluent in column *n*-heptane		
4 mm ID	**720090.40**	**721078.30**	**721604.40**
4.6 mm ID	**720090.46**	**721078.30**	**721604.40**
NUCLEOSIL® 100-5 CN-RP	particle size 5 µm, pore size 100 Å; eluent in column acetonitrile – water		
4 mm ID	**720205.40**	**721039.30**	**721917.40**
4.6 mm ID	**720205.46**	**721039.30**	**721917.40**
NUCLEOSIL® 100-10 CN	particle size 10 µm, pore size 100 Å; eluent in column *n*-heptane		
4 mm ID	**720024.40**		
4.6 mm ID	**720024.46**		
NUCLEOSIL® 120-7 CN	particle size 7 µm, pore size 120 Å; eluent in column *n*-heptane		
4 mm ID	**720057.40**		
4.6 mm ID	**720057.46**		

NUCLEOSIL® SA phases



- Strongly acidic cation exchanger (SCX) with benzenesulfonic acid modification · **USP L9**
- Capacity ~ 1 meq/g; pH stability at 20 °C: 2–8; carbon content 6.5 %

Ordering information

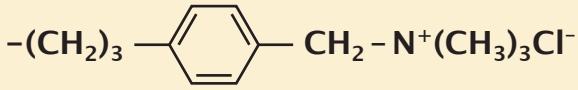
Eluent in column 0.15 mol/L $(NH_4)_2HPO_4$, pH 5

EC columns	Length: 125 mm	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 SA			particle size 5 µm, pore size 100 Å		
4 mm ID			**720097.40**	**721024.30**	**721487.40**
4.6 mm ID	**720709.46**	**720182.46**	**720097.46**	**721024.30**	**721487.40**

NUCLEOSIL® standard silica for HPLC

EC columns 	125 mm	Length: 150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-10 SA				particle size 10 µm, pore size 100 Å	
4.6 mm ID			**720028.46**		

NUCLEOSIL® SB phases



- Strongly basic anion exchanger (SAX) with quaternary ammonium modification · **USP L14**
- Capacity ~ 1 meq/g; pH stability at 20 °C: 2–8; carbon content 10%

Ordering information

Eluent in column 0.15 mol/L $(NH_4)_2HPO_4$, pH 5

EC columns 	125 mm	Length: 150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 SB				particle size 5 µm, pore size 100 Å	
4.6 mm ID	**720989.46**	**720183.46**	**720996.46**	**721025.30**	**721885.40**
NUCLEOSIL® 100-10 SB				particle size 10 µm, pore size 100 Å	
4.6 mm ID			**720029.46**		

NUCLEOSIL® SiOH

unmodified silica

- Spherical silica, pH stability 2–8 · **USP L3**

For physical properties of unmodified NUCLEOSIL® materials please see page 199; maximum working pressure for the EC columns listed below is 400 bar.

Ordering information

Eluent in column is *n*-heptane. When using an eluent which is not miscible with *n*-heptane (e.g., water), it is necessary to rinse the column with THF first.

EC columns 	Length:	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 50-5			particle size 5 µm, pore size 50 Å	
4.6 mm ID		**720093.46**	**721167.30**	**721600.40**
NUCLEOSIL® 100-5			particle size 5 µm, pore size 100 Å	
4.6 mm ID		**720099.46**	**721518.30**	**721872.40**

EC columns in packs of 1, guard columns in packs of 3

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

For details of our column systems see pages 189–196

Analytical columns with LiChrospher®

LiChrospher® packings manufactured by E. Merck (D)

Phase	USP	Particle size	Pore size	Modification	Endcapped	Carbon content
LiChrospher® 100 RP 8, 5 µm	L7	nom. 5 µm	100 Å	octyl	–	12.5 %
LiChrospher® 100 RP 8 ec, 5 µm	L7	nom. 5 µm	100 Å	octyl	✓	12.5 %
LiChrospher® 100 RP 18, 5 µm	L1	nom. 5 µm	100 Å	octadecyl	–	21 %
LiChrospher® 100 RP 18 ec, 5 µm	L1	nom. 5 µm	100 Å	octadecyl	✓	21 %
LiChrospher® 60 RP select B, 5 µm	L7	nom. 5 µm	60 Å	octyl	✓	12 %

All phases as packed ChromCart® cartridges 

ChromCart® columns require the CC connecting kit (REF 721690, see page 192).

Ordering information

Eluent in column acetonitrile – water

	Length → 125 mm	150 mm	250 mm	Guard columns
LiChrospher® 100 RP 8, 5 µm				
2 mm ID	728025.20		728026.20	728051.30
3 mm ID	728025.30		728026.30	728051.30
4 mm ID	728025.40		728026.40	728051.40
4.6 mm ID	728025.46	728027.46	728026.46	728051.40
LiChrospher® 100 RP 8 ec, 5 µm				
2 mm ID	728028.20		728029.20	728052.30
3 mm ID	728028.30		728029.30	728052.30
4 mm ID	728028.40		728029.40	728052.40
4.6 mm ID	728028.46	728030.46	728029.46	728052.40
LiChrospher® 100 RP 18, 5 µm				
2 mm ID	728031.20		728032.20	728053.30
3 mm ID	728031.30		728032.30	728053.30
4 mm ID	728031.40		728032.40	728053.40
4.6 mm ID	728031.46	728033.46	728032.46	728053.40
LiChrospher® 100 RP 18 ec, 5 µm				
2 mm ID	728034.20		728035.20	728054.30
3 mm ID	728034.30		728035.30	728054.30
4 mm ID	728034.40		728035.40	728054.40
4.6 mm ID	728034.46	728036.46	728035.46	728054.40
LiChrospher® 60 RP select B, 5 µm				
2 mm ID	728037.20		728038.20	728055.30
3 mm ID	728037.30		728038.30	728055.30
4 mm ID	728037.40		728038.40	728055.40
4.6 mm ID	728037.46	728039.46	728038.46	728055.40

8 mm ChromCart® guard column cartridges in packs of 3, all other columns in packs of 1.

HPLC columns for special separations

Summary

Separation / mechanism	Recommended column	Specification of the phase	Page
Environmental analysis			
Anion exchange chromatography of inorganic anions	NUCLEOGEL® Anion I	Strongly basic polymer-based anion exchanger	171
	NUCLEOSIL® Anion II	Strongly basic silica-based anion exchanger	
RP chromatography of PAHs	NUCLEODUR® C_{18} PAH	NUCLEODUR® polymer-coated with C_{18} groups · **USP L1**	168
	NUCLEOSIL® 100-5 C_{18} PAH	NUCLEOSIL® 100 polymer-coated with C_{18} groups · **USP L1**	170
Enantiomer separation			
Formation of inclusion complexes	NUCLEODEX α-PM, β-PM, γ-PM and β-OH	Silica-based permethylated and underivatized cyclodextrin phases · **USP L45**	172
Polar and π-π interactions	NUCLEOCEL *DELTA*	Silica-based modified cellulose phases · **USP L40**	174
Ligand exchange	NUCLEOSIL® CHIRAL-1	Covalently bonded amino acid - Cu(II) complexes · **USP L32**	176
Charge-transfer-, dipole-dipole interactions and others	NUCLEOSIL® CHIRAL-2, NUCLEOSIL® CHIRAL-3	Silica-based brush type phases · **USP L36**	177
Enantioselective binding to chiral protein surface structures	RESOLVOSIL BSA-7	Silica-based protein phase (BSA)	175
Biological macromolecules			
Anion exchange chromatography of oligonucleotides + nucleic acids	NUCLEOGEN® DEAE	Silica-based DEAE anion exchanger	178
Anion exchange chromatography of proteins and peptides	NUCLEOSIL® 4000-7 PEI	Silica-based polymeric polyethyleneimine network	180
Anion exchange chromatography of peptides, large proteins and oligonucleotides	NUCLEOGEL® SAX	Polymer-based strongly basic anion exchanger · **USP L23**	181
Cation exchange chromatography of proteins, peptides and carbohydrates	NUCLEOGEL® SCX	Polymer-based strong cation exchanger **USP L22**	181
Reversed phase chromatography of proteins, peptides and oligonucleotides	NUCLEOSIL® MPN	Monomerically bonded alkyl chains on silica · **USP L1** / **USP L26**	182
	NUCLEOSIL® PPN	Polymerically bonded alkyl chains on silica · **USP L1**	183
	NUCLEOGEL® RP 300	Polystyrene - divinylbenzene polymer **USP L21**	184
Reversed phase chromatography of small molecules	NUCLEOGEL® RP 100	Small pore macroporous PS-DVB polymer **USP L21**	184
Food analysis · Sugars			
RP chromatography of mono- and oligosaccharides	NUCLEOSIL® Carbohydrate	Silica-based special amino phase **USP L8**	185
Separation of sugars, alcohols, org. acids based on ion exclusion, ion exchange, size exclusion, ligand exchange, NP and RP effects	NUCLEOGEL® SUGAR 810 H, Ca	Resins with sulfonic acid modification in different ionic forms: H form **USP L17** · Ca form **L19** · Pb form **L34** · Na form **L58**	186
Separation of sugars, alcohols, org. acids based on steric exclusion, ligand exchange and partition effects	NUCLEOGEL® SUGAR Ca, Na, Pb		187
	NUCLEOGEL® ION 300 OA		187
Gel permeation chromatography (GPC)			
Water-insoluble compounds	NUCLEOGEL® GPC	Polystyrene - divinylbenzene polymer	188

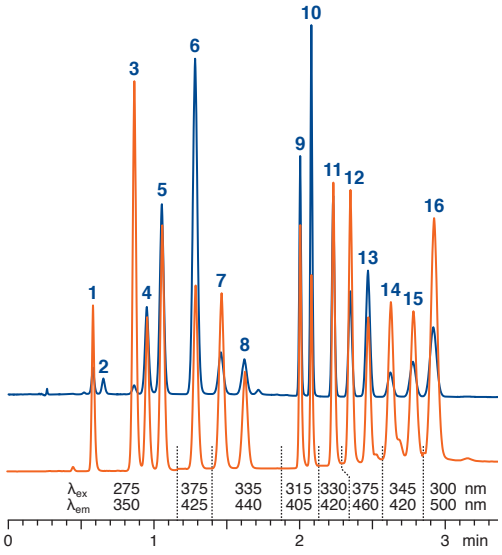
HPLC columns for environmental analyses

NUCLEODUR® C_{18} PAH — special octadecyl phase for PAH analyses

- Base material NUCLEODUR® silica, particle sizes 1.8 and 3 µm, pore size 110 Å; polymeric coating · **USP L1**
- Allows efficient gradient separation of the 16 PAHs according to EPA
- Detection of separated PAHs with UV (250–280 nm), diode array or fluorescence detection at different wavelengths for excitation and emission (acenaphthylene cannot be analyzed with fluorescence detection)

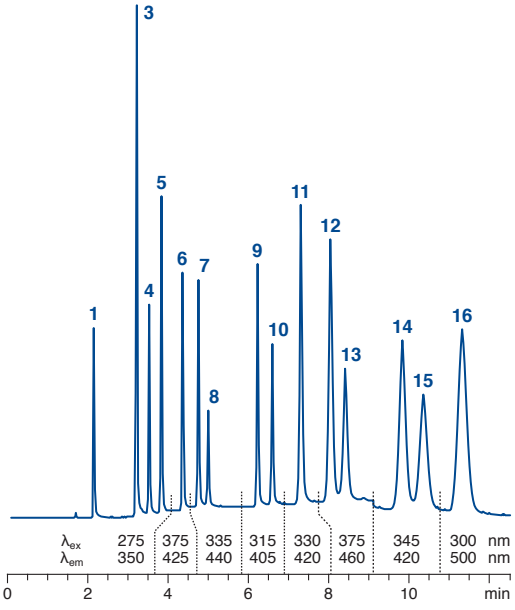
Analysis of 16 EPA PAHs with or without acetonitrile

Separation with acetonitrile
Column: 100 x 4 mm NUCLEODUR® C_{18} PAH, 3 µm
Eluent: A) methanol – water (80:20, v/v)
B) acetonitrile
2–20 % B in 1.2 min, 20–100 % B in 0.5 min, 100 % B for 2.5 min, 100–2 % B in 0.4 min
Flow rate: 2.5 mL/min, temperature 35 °C
Detection: UV, 254 nm
fluorescence (see chromatogram)



MN Appl. No. 123820

Separation without acetonitrile
Column: 125 x 4 mm NUCLEODUR® C_{18} PAH, 3 µm
Eluent: A) water
B) methanol
65–97 % B in 6 min, 97 % B for 5 min, 97–65 % B in 0.5 min
Flow rate: 2 mL/min, temperature 35 °C
Detection: fluorescence (see chromatogram)



MN Appl. No. 123830

Peaks:
1. Naphthalene
2. Acenaphthylene (not detectable by fluorescence)
3. Acenaphthene
4. Fluorene
5. Phenantrene
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. Dibenz[ah]anthracene
15. Benzo[ghi]perylene
16. Indeno[1,2,3-cd]pyrene

Ordering information · EC columns

Eluent in column acetonitrile – water (70:30, v/v)

Length →	100 mm	125 mm	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEODUR® C_{18} PAH, 1.8 µm						
2 mm ID	**760773.20**				**761970.20**	
3 mm ID	**760773.30**				**761970.30**	
4 mm ID	**760773.40**				**761970.30**	
NUCLEODUR® C_{18} PAH, 3 µm						
3 mm ID	**760783.30**	**760784.30**	**760785.30**	**760786.30**	**761971.30**	**761780.30**
4 mm ID	**760783.40**	**760784.40**	**760785.40**	**760786.40**	**761971.30**	**761780.40**

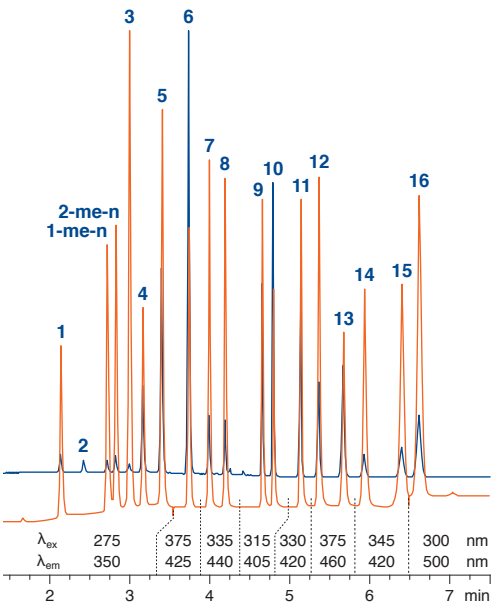
Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

Separation of 18 PAHs on NUCLEODUR® C_{18} PAH

Column: 125 x 4 mm NUCLEODUR® C_{18} PAH, 3 µm
Eluent: A) methanol – water (70:30, v/v)
B) acetonitrile
0–20 % B in 1.5 min,
20–50 % B in 1.5 min,
50–100 % B in 1.0 min,
100 % B for 3 min,
100–0 % B in 0.5 min
Flow rate: 1.5 mL/min
Temperature: 35 °C
Injection: UV: 1 µL, fluorescence: 0.5 µL
Detection: UV, 254 nm
fluorescence
(see chromatogram)

Peaks:
(concentrations 10 ng/µL per compound)
1.–16. see opposite page
1-me-n: 1-methylnaphthalene
2-me-n: 2-methylnaphthalene

MN Appl. No. 123840

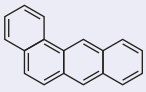


Analysis of polycyclic aromatic hydrocarbons (PAHs) by HPLC

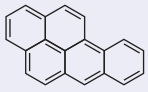
Polycyclic aromatic hydrocarbons (PAHs) are chemical compounds that consist of fused aromatic rings and do not contain heteroatoms or carry substituents. As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic. PAHs are natural components of coal or gas. They are delivered to our environment by pyrolysis (incomplete burning) of organic materials like coal, oil, fuel, wood, tobacco, … and hence can be found globally. Today most PAHs accrue from anthropogenic processes – but also natural origins (forest fire) are possible. Regarding to past pollutions an important impact had production of coke and gas from black coal. Waste products (e.g., tar) from coking or gas plants are often origin of serious ground water pollutions.

Since a number of PAHs (e.g., benzo[a]pyrene, 3-methylcholanthrene and benzanthracene) have been proven to be carcinogenic, control of the PAH content of food, water and soil is an important task for routine analysis. For choice and limiting values of the polycyclics we refer to the governmental regulations, which exist in many countries (e.g., EPA method 610 of the United States Environmental Protection Agency).

PAHs can be determined by different chromatographic techniques (TLC, GC, HPLC). Thus the 6 PAHs according to German drinking water specification (TVO) can, e.g., be analyzed by TLC (see German Standard DIN 38 409), while a much larger number of polycyclic aromatics can be determined by GC or HPLC.



benz[a]anthracene



benzo[a]pyrene

HPLC columns for PAH analysis

For PAH analyses we have developed specially modified C_{18} phases based on NUCLEODUR® and NUCLEOSIL® which allow efficient gradient separation of 16 PAHs according to EPA. Detection of the separated PAHs can be achieved by UV (250–280 nm), with diode array or with fluorescence detection at different wavelengths for excitation and emission. Acenaphthylene cannot be analyzed with fluorescence detection. For cost-effective routine PAH analysis we recommend applications using methanol instead of acetonitrile as eluent. For rapid analysis NUCLEODUR® C_{18} PAH (3 µm) in short columns (100 mm) provides excellent results at high flow rates. Hereby separation of 16 PAHs according to EPA can be achieved in less than 3 min.

Tightened regulations require determination of 2 additional PAHs (1- and 2-methylnaphthalene) – so we developed highly efficient methods for 18 PAHs on the NUCLEODUR® C_{18} PAH.

References

Determination of PASH in Diesel fuel by HPLC and photodiode-array detection; J. Bunot, W. Herbel, H. Steinhart, J. High Res. Chrom. **15** (1992) 682-685

GIT Spezial Chromat. **2** (1992) 80-85

HPLC columns for environmental analyses

NUCLEOSIL® 100-5 C_{18} PAH — special octadecyl phase for PAH analyses

- Base material NUCLEOSIL® silica, particle size 5 µm, pore size 100 Å; polymeric coating · **USP L1**
- Recommended for efficient gradient separation of the 16 PAHs according to EPA
- Detection of the separated PAH with UV (250–280 nm), diode array or fluorescence detection at different wavelengths for excitation and emission (acenaphthylene cannot be analyzed with fluorescence detection)

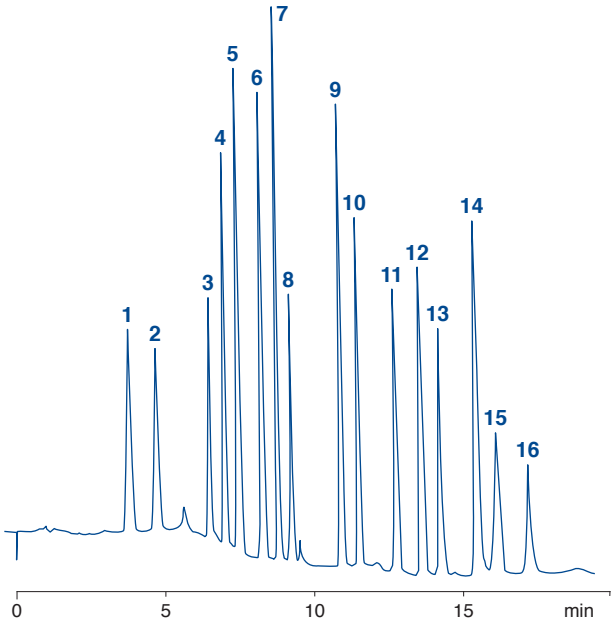
Separation of the PAH standard according to EPA (REF 722393)

Column: 150 x 4 mm NUCLEOSIL® 100-5 C_{18} PAH
Eluent: A) methanol – water (80:20)
B) acetonitrile – tetrahydrofuran (93:7)
0–100 % B in 10 min, 5 min 100 % B
Flow rate: 1 mL/min
Pressure: 140 bar
Temperature: 20 °C
Detection: UV, 260 nm

Peaks: (10 µg/mL each in acetonitrile)

1. Naphthalene
2. Acenaphthylene
3. Acenaphthene
4. Fluorene
5. Phenantrene
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. Dibenz[ah]anthracene
15. Benzo[ghi]perylene
16. Indeno[1,2,3-cd]pyrene

MN Appl. No. 115040



Ordering information

Eluent in column acetonitrile – water (70:30, v/v)

EC columns 	Length →	150 mm	250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® 100-5 C_{18} PAH					
2 mm ID			720117.20	721168.20	721599.30
3 mm ID		720923.30	720117.30	721168.30	721599.30
4 mm ID		720923.40	720117.40	721168.30	721599.40
4.6 mm ID			720117.46	721168.30	721599.40
PAH standard according to EPA for HPLC					
PAH standard for HPLC #	16 PAH according to EPA method 610 in acetonitrile (1 mL) for composition see chromatogram above			722393	

Guard column systems Guard columns for EC columns with ID		2 mm	3 mm	4 mm	4.6 mm	Guard column holder
* Column Protection System	EC	4/2	4/3	4/3	4/3	718966
** ChromCart® guard columns	CC	8/3	8/3	8/4	8/4	721359

EC columns in packs of 1, guard columns in packs of 3.

For details of our column systems see pages 189–196

This product contains harmful substances which must be specially labeled as hazardous. For detailed information please see MSDS.

Anion columns

for analysis of inorganic anions

NUCLEOGEL® Anion I

- Strongly basic polymer-based anion exchanger, particle size 10 µm; pH stability 1–14
- Eluent in column 4 mmol/L salicylate buffer pH 7.8
- Contrary to the silica-based phase also suited for fluoride analysis

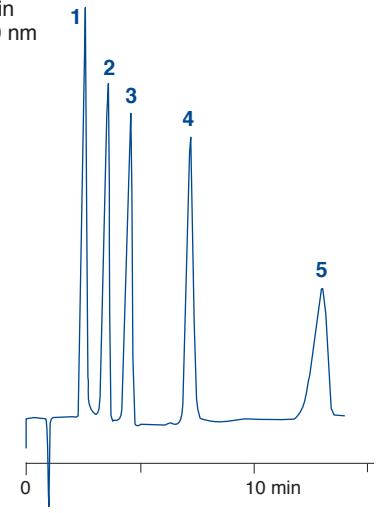
NUCLEOSIL® Anion II

- Base material NUCLEOSIL® silica, particle size 10 µm, pore size 300 Å
  strongly basic anion exchanger, exchange capacity 50 µeq/g, pH stability 2–7.5
- Eluent in column 0.15 mol/L $(NH_4)_2HPO_4$ buffer pH 5.2
  recommended buffer concentration for separation of inorganic anions: 2 mmol/L phthalate
- Preferred method of detection: conductivity or negative UV detection

Separation of an anion standard

Column: 250 x 4 mm NUCLEOSIL® Anion II
Eluent: 2 mmol/L potassium hydrogen phthalate, pH 5.7
Flow rate: 2 mL/min
Detection: UV, 280 nm

Peaks:
1. $H_2PO_4^-$
2. Cl^-
3. NO_2^-
4. NO_3^-
5. SO_4^{2-}

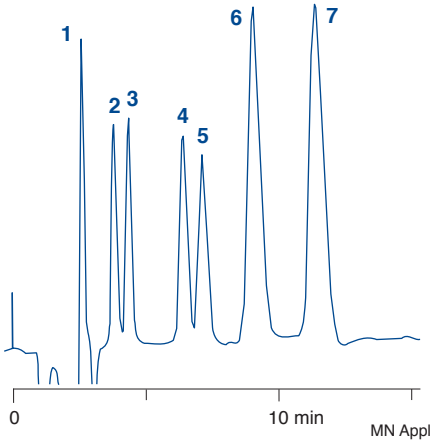


MN Appl. No. 106440

Separation of inorganic anions

Column: 120 x 4.6 mm NUCLEOGEL® Anion I
Eluent: 4 mmol/L salicylic acid – Tris pH 7.8
Flow rate: 1 mL/min
Detection: UV, 254 nm

Peaks:
1. F^-
2. Cl^-
3. NO_2^-
4. Br^-
5. NO_3^-
6. PO_4^{3-}
7. SO_4^{2-}



MN Appl. No. 115050

Ordering information

	Length →	120 mm	250 mm	Guard columns
NUCLEOGEL® Anion I				
Valco type columns 	4.6 mm ID	**719533**		**719543**
NUCLEOSIL® Anion II				
EC columns 	4 mm ID		**720094.40**	**721452.40**

NUCLEOGEL® Anion I Valco type guard columns measure 21 x 4 mm and require the guard column holder C, REF 719538, see page 193 (columns in packs of 1, guard columns in packs of 2).

As guard columns for NUCLEOSIL® Anion II EC columns use 8 x 4 mm ChromCart® cartridges with guard column adapter EC, REF 721359 (see page 191, columns and guard column cartridges in packs of 1).

NUCLEODEX columns

enantiomer separation based on cyclodextrins

- Base material NUCLEOSIL® silica, particle size 5 µm, pore size 100 Å
  modified cyclodextrins as chiral selectors
- **NUCLEODEX β-OH:** β-cyclodextrin (R = H; n = 2) · **USP L45**

  Separation based on hydrogen bonds and dipole interactions between functional groups of the analyte and hydroxyl groups of the cyclodextrin

  Examples for successful enantiomer separations: chlorthalidone and other compounds, which require free hydroxyl groups for enantioselective interactions

  Eluent in column CH_3OH – 0.1% TEAA pH 4 (55:45)

For all permethylated phases the ability to form hydrogen bonds is reduced, the hydrophobicity of the phase is increased compared to β-OH, resulting in shorter retention times.

- **NUCLEODEX α-PM:** permethylated α-cyclodextrin (R = CH_3; n = 1)

  Examples for successful enantiomer separations: mecoprop and dichlorprop as free carboxylic acids, trans-stilbene oxide, styrene oxide

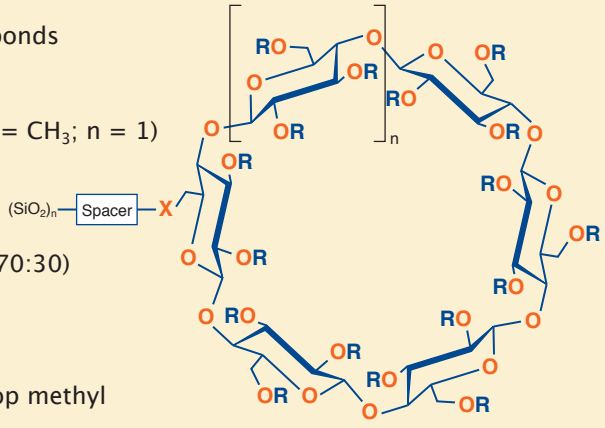
  Eluent in column CH_3OH – 50 mmol/L phosphate pH 3 (70:30)
- **NUCLEODEX β-PM:** permethylated β-cyclodextrin (R = CH_3; n = 2) · **USP L45**

  Examples for successful enantiomer separations: mephobarbital (prominal), pesticide derivatives mecoprop methyl and dichlorprop methyl

  Eluent in column CH_3OH – 0.1% TEAA pH 4 (65:35)
- **NUCLEODEX γ-PM:** permethylated γ-cyclodextrin (R = CH_3; n = 3)

  Examples for successful enantiomer separations: steroids or other larger molecules

  Eluent in column CH_3OH – 0.1% TEAA pH 4 (55:45)



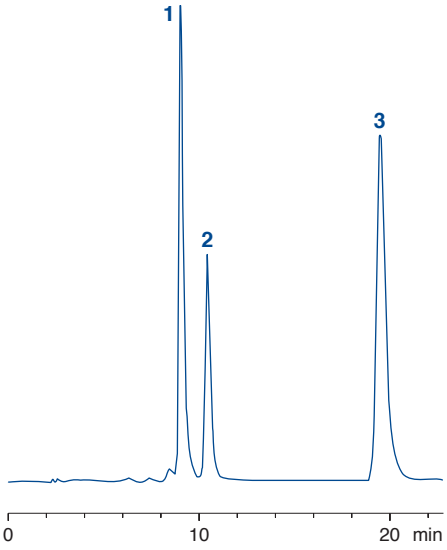
NUCLEODEX phases are especially suited for the control of optical purity, but also for semipreparative separations and for the analysis of positional and cis-trans isomers.

For numerous separations on NUCLEODEX phases please visit our website: ***www.mn-net.com/apps***.

Separation of the positional isomers of nitroaniline

Column: 200 x 4 mm NUCLEODEX β-OH
Eluent: methanol – 0.1 % triethylammonium acetate pH 4.0 (50:50, v/v)
Flow rate: 0.7 mL/min
Pressure: 180 bar
Detection: UV, 254 nm
Injection: 1 µL

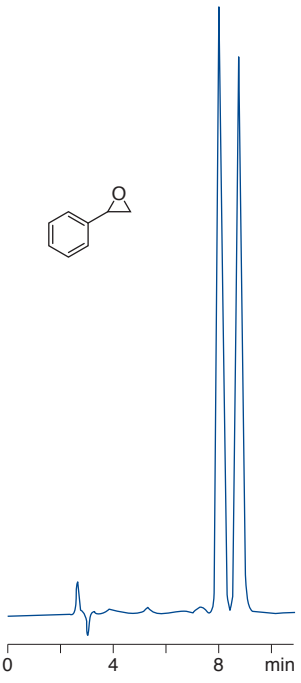
Peaks:
1. *m*-Nitroaniline
2. *o*-Nitroaniline
3. *p*-Nitroaniline



MN Appl. No. 101420

Enantiomer separation of styrene oxide

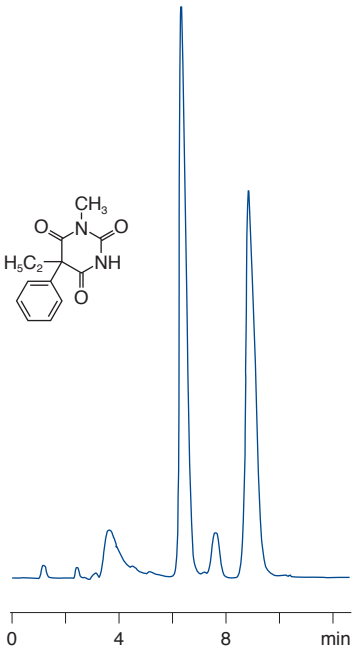
Column: 200 x 4 mm NUCLEODEX α-PM
Eluent: methanol – 0.1 % triethylammonium acetate pH 4.0 (60:40, v/v)
Flow rate: 0.7 mL/min
Pressure: 160 bar
Detection: UV, 230 nm
Injection: 2 µL



MN Appl. No. 106160

Enantiomer separation of mephobarbital

Column: 200 x 4 mm NUCLEODEX β-PM
Eluent: methanol – 0.1 % triethylammonium acetate pH 4.0 (55:45, v/v)
Flow rate: 0.7 mL/min
Pressure: 180 bar
Detection: UV, 254 nm
Injection: 1 µL



MN Appl. No. 105800

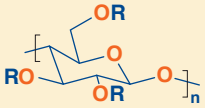
Ordering information

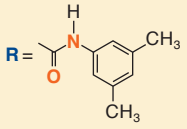
EC columns	Length: 200 mm	EC guard columns*	CC guard columns**
NUCLEODEX β-OH			
4 mm ID	**720124.40**	**721171.30**	**721460.40**
NUCLEODEX α-PM			
4 mm ID	**720127.40**	**721469.30**	**721464.40**
NUCLEODEX β-PM			
4 mm ID	**720125.40**	**721176.30**	**721462.40**
NUCLEODEX γ-PM			
4 mm ID	**720752.40**	**721178.30**	**721466.40**
NUCLEODEX CC screening kit		**721920**	
contains one CC 30/4 each with NUCLEODEX β-OH, α-PM, β-PM and γ-PM as well as one CC column holder 30 mm			

* EC 4/3 guard columns for EC columns with 4 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).
** CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).
Columns and guard columns in packs of 1.

HPLC columns for enantiomer separation

NUCLEOCEL *DELTA* enantiomer separation based on a cellulose derivative





- Base material silica,
  chiral selector cellulose tris-(3,5-dimethylphenylcarbamate) · **USP L40**
- Similar phases: Chiralcel® OD, Kromasil® CelluCoat™, Eurocel® 01, Lux™ Cellulose-1

  High resolution type (S) with 5 µm particle size, allows use of shorter columns (150 mm) for faster separations, pressure stability up to ~150 bar (2000 psi), pH stability 1-9

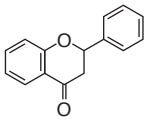
  NUCLEOCEL DELTA for normal phase applications:
  eluent in column *n*-heptane – 2-propanol (90:10, v/v)
  typical eluents are heptane – propanol mixtures

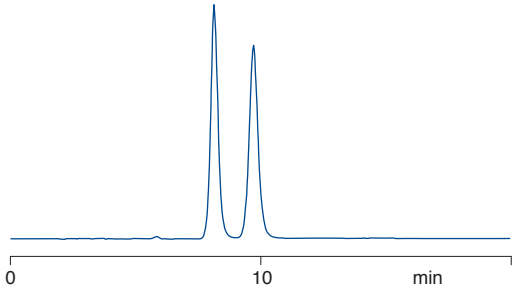
  NUCLEOCEL DELTA-RP for reversed phase applications:
  eluent in column acetonitrile – water (40:60, v/v)
  designed for use either in polar organic mode or with eluents containing high concentrations of chaotropic salts such as perchlorate
- **Recommended application:** pharmaceutically active compounds, chiral pollutants (e.g., herbicides, PCB), chiral compounds in food (dyes, preservatives), chiral catalysts and bioorganic compounds

Enantiomer separation of flavanone

Column: 250 x 4.6 mm NUCLEOCEL *DELTA S*
Eluent: *n*-heptane – 2-propanol (90:10, v/v)
Flow rate: 1 mL/min
Temperature: 25 °C
Detection: UV, 254 nm
Injection: 5 µL, 1 µg/µL

α = 1.29
R_s = 2.6



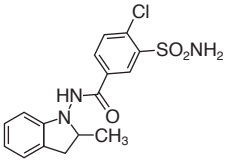


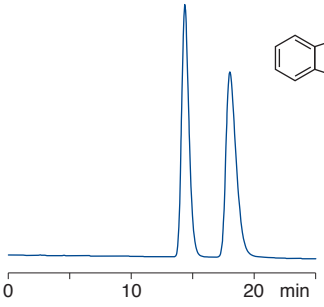
MN Appl. No. 121260

Enantiomer separation of indapamide

Column: 250 x 4.6 mm NUCLEOCEL *DELTA-RP S*
Eluent: acetonitrile – water (40:60, v/v)
Flow rate: 0.5 mL/min
Temperature: 40 °C
Detection: UV, 254 nm
Injection: 5 µL, 1 µg/µL

α = 1.3
R_s = 2.6





MN Appl. No. 121230

Ordering information

	Length →	150 mm	250 mm	EC guard columns*	CC guard columns**
EC columns 	**NUCLEOCEL *DELTA S*, 5 µm**		Eluent *n*-heptane – 2-propanol (90:10, v/v)		
	4.6 mm ID		**720445.46**	**721185.30**	**721002.40**
	NUCLEOCEL *DELTA-RP S*, 5 µm		Eluent acetonitrile – water (40:60, v/v)		
	4.6 mm ID	**720451.46**	**720450.46**	**721186.30**	**721003.40**

* EC 4/3 guard columns for EC columns with 4.6 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).

** CC 8/4 guard columns for EC columns with 4.6 mm ID require the guard column adapter EC (REF 721359, see page 191).

Columns and guard columns in packs of 1

RESOLVOSIL BSA-7 protein phase for enantiomer separation

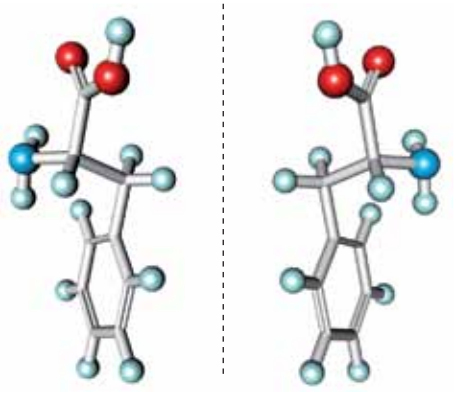
- Base material NUCLEOSIL® silica, particle size 7 µm, pore size 300 Å
  chiral selector bovine serum albumin (BSA)
- Separation based on selective interaction of proteins with low molecular compounds, i.e. principles of bio-affinity, including hydrophobic interactions (similar to a true reversed phase), interactions of polar groups and steric effects
- **Recommended application:**
  Amino acid derivatives, aromatic amino acids, aromatic sulfoxides, barbiturates, benzodiazepinones, benzoin and benzoin derivatives, β-blockers, coumarin derivatives, and for monitoring stereoselective microbial and enzymatic conversions

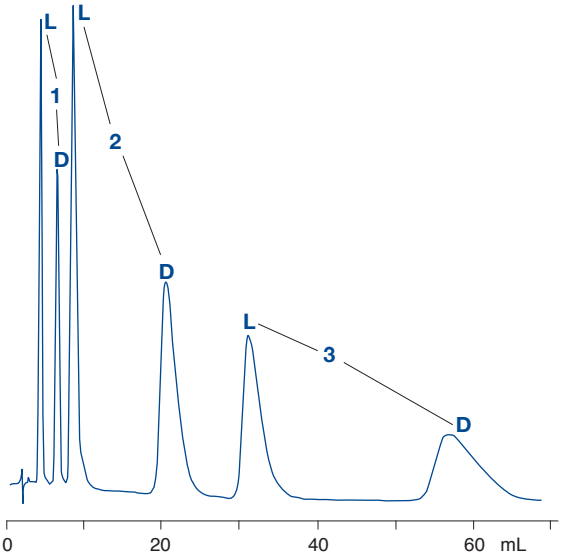
Enantiomer separation of *N*-benzoyl-*D,L*-amino acids

S. Allenmark et al. in "Affinity chromatography and biological recognition" (I. Chaiken, M. Wilchek, and I. Parikh. Eds.), Academic Press, New York, 1983, 259–260

Column: 150 x 4 mm RESOLVOSIL BSA-7
Eluent: 50 mmol/L phosphate buffer pH 6.5 + 1 % 1-propanol
Flow rate: 0.70 mL/min
Detection: UV, 225 nm

Peaks:
1. Serine
2. Alanine
3. Phenylalanine





MN Appl. No. 105450

Ordering information

Eluent in column 0.1 mol/L phosphate buffer pH 7.5, 2% 1-propanol

EC columns 	Length:	200 mm	EC guard columns*	CC guard columns**
RESOLVOSIL BSA-7				
4 mm ID		**720046.40**	**721402.30**	**721702.40**

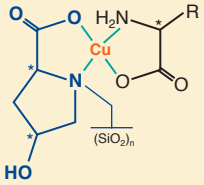
* EC 4/3 guard columns for EC columns with 4 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).

** CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).

Columns and guard columns in packs of 1

HPLC columns for enantiomer separation

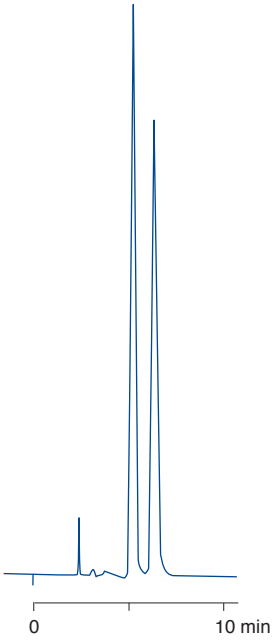
NUCLEOSIL® CHIRAL-1 enantiomer separation based on ligand exchange



- Base material NUCLEOSIL® silica, particle size 5 µm, pore size 120 Å
  chiral selector L-hydroxyproline – Cu^{2+} complexes · **USP L32**
- Principal interaction mode:
  formation of ternary mixed-ligand complexes with Cu(II) ions; differences in the stability of the diastereomeric complexes cause chromatographic separation
- **Recommended application:**
  Enantiomers with two polar functional groups with the correct spacing such as α-amino acids, α-hydroxycarboxylic acids (e.g., lactic acid), *N*-alkyl-α-amino acids etc.

D,L-alanine enantiomers

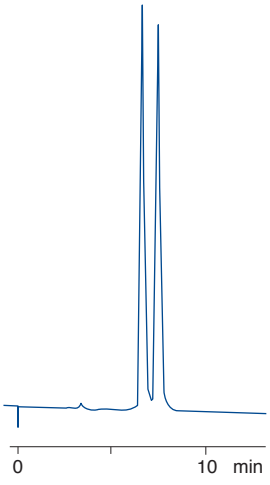
Column:	250 x 4 mm NUCLEOSIL® CHIRAL-1
Eluent:	0.5 mmol/L $CuSO_4$
Flow rate:	1 mL/min
Pressure:	60 bar
Temperature:	60 °C
Detection:	UV, 250 nm



MN Appl. No. 105410

D,L-threonine enantiomers

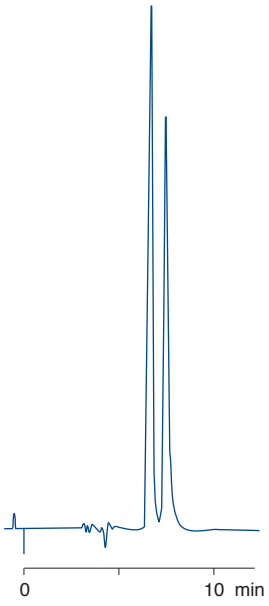
Column:	250 x 4 mm NUCLEOSIL® CHIRAL-1
Eluent:	0.25 mmol/L $CuSO_4$
Flow rate:	0.8 mL/min
Pressure:	65 bar
Temperature:	60 °C
Detection:	UV, 240 nm



MN Appl. No. 105410

Lactic acid enantiomers

Column:	250 x 4 mm NUCLEOSIL® CHIRAL-1
Eluent:	0.5 mmol/L $CuSO_4$
Flow rate:	0.8 mL/min
Temperature:	80 °C
Detection:	UV, 240 nm
Injection:	1 µL



MN Appl. No. 105560

Ordering information

Eluent in column 0.5 mmol/L copper sulfate solution

		Length 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® CHIRAL-1				
EC columns	4 mm ID	**720081.40**	**721188.30**	**721455.40**

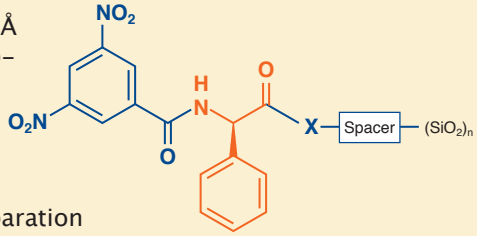
* EC 4/3 guard columns for EC columns with 4 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).

** CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).

Columns and guard columns in packs of 1

NUCLEOSIL® CHIRAL-2 / NUCLEOSIL® CHIRAL-3

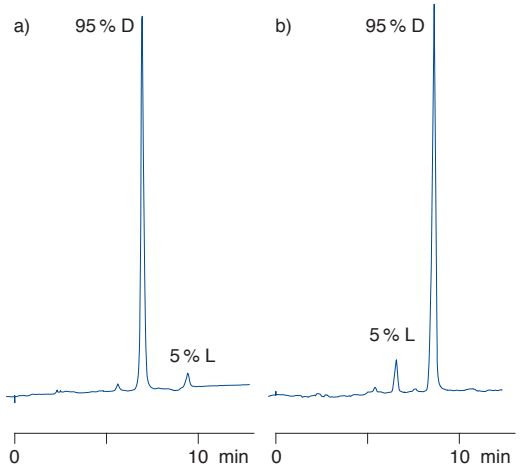
enantiomer separation in organic eluent systems



- Base material NUCLEOSIL® silica, particle size 5 µm, pore size 100 Å chiral selector for NUCLEOSIL® CHIRAL-2 is *N*-(3,5-dinitrobenzoyl)-*D*-phenylglycine, for CHIRAL-3 the optical antipode is used, "brush type" phases · CHIRAL-3 = **USP L36**
- Principle interaction modes: charge-transfer interactions, hydrogen bonds, dipole-dipole interactions and steric effects
- **Recommended application:** analysis of stereoisomers such as separation of enantiomers and diastereomers, control of optical purity of plant protectives (pesticides, e.g., propionic acid derived herbicides) pharmaceuticals etc. and for product control in chiral organic syntheses
- For control of optical purity of a substance, the columns NUCLEOSIL® CHIRAL-2 and NUCLEOSIL® CHIRAL-3 allow to select conditions such that the minor enantiomer, present as an impurity, is eluted before the main peak. Overlapping peaks are avoided. This makes an exact quantification of the impurity much easier.

Control of optical purity of mecoprop methyl

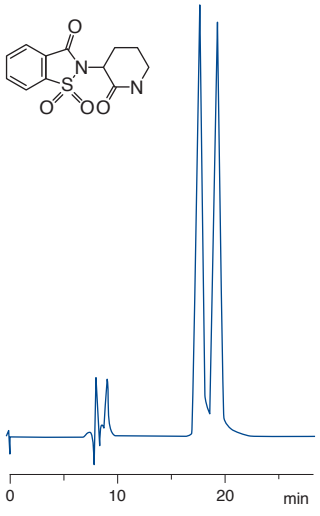
Columns: a) 250 x 4 mm NUCLEOSIL® CHIRAL-2
b) 250 x 4 mm NUCLEOSIL® CHIRAL-3
Eluent: *n*-heptane – 2-propanol – TFA (100:0.05:0.05, v/v/v)
Flow rate: 1 mL/min, ambient temperature
Detection: UV, 230 nm
Injection: 1 µL (sample with 90 % ee)



MN Appl. No. 111360

Enantiomer separation of *D,L*-supidimide

Column: 250 x 4 mm NUCLEOSIL® CHIRAL-2
Eluent: tetrahydrofuran – n-heptane (10:3, v/v)
Flow rate: 1.0 mL/min
Detection: UV, 220 nm



MN Appl. No. 105690

Ordering information

Eluent in column *n*-heptane – 2-propanol – TFAA (100:0.05:0.05, v/v/v)

		Length 250 mm	EC guard columns*	CC guard columns**
EC columns 	**NUCLEOSIL® CHIRAL-2**			
	4 mm ID	**720088.40**	**721190.30**	**721458.40**
	NUCLEOSIL® CHIRAL-3			
	4 mm ID	**720350.40**	**721190.30**	**721458.40**

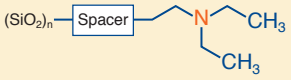
Guard columns for NUCLEOSIL® CHIRAL-2 and CHIRAL-3 are identical.

* EC 4/3 guard columns for EC columns with 4 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).

** CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).
EC columns and EC guard columns in packs of 1, CC guard columns in packs of 3

HPLC columns for biochemical separations

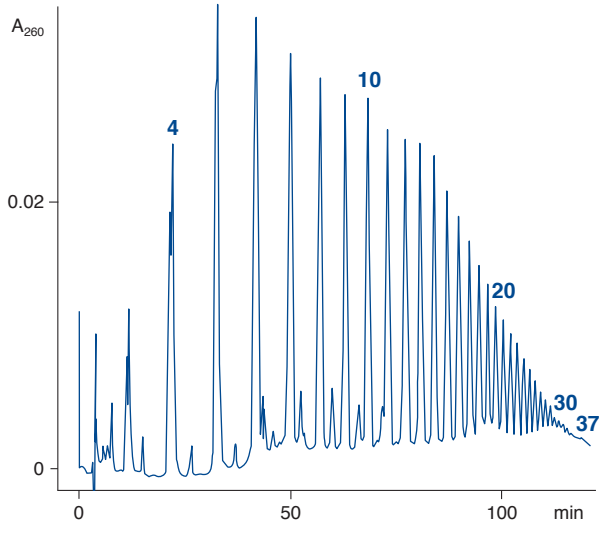
NUCLEOGEN® columns — anion exchange chromatography of nucleic acids



- Base material silica, particle size 7 µm
  DEAE anion exchanger
- **NUCLEOGEN® 60-7 DEAE:** pore size 60 Å
  Separation of oligonucleotides up to chain lengths of 40 bases with recoveries > 95 %
  capacity 200 A_{260}/mL (~ 300 A_{260} for a 125 x 4 mm ID column, 1875 A_{260} for a 125 x 10 mm ID column); preparative separations possible when using higher flow rates and longer gradient times
- **NUCLEOGEN® 500-7 DEAE:** pore size 500 Å
  Separation of tRNA, 5S RNA, viroids and messenger RNA in the intermediate molecular weight range (25–1 000 kDa) with recoveries > 95 %
  capacity 730 A_{260} for a 125 x 6 mm ID column, 1940 A_{260} for a 125 x 10 mm ID column
- **NUCLEOGEN® 4000-7 DEAE:** pore size 4000 Å
  Separation of plasmids, DNA restriction fragments, ribosomal RNA, messenger RNA and viral RNA, i.e. very high molecular weight nucleic acids (e.g., 1–50 MDa)
  capacity 120 A_{260} for a 125 x 6 mm ID column, 350 A_{260} for a 125 x 10 mm ID column
- For more separations of deoxyoligonucleotides, plasmids and DNA restriction fragments visit our website ***www.mn-net.com/apps***

Separation of oligo(rA)$_n$

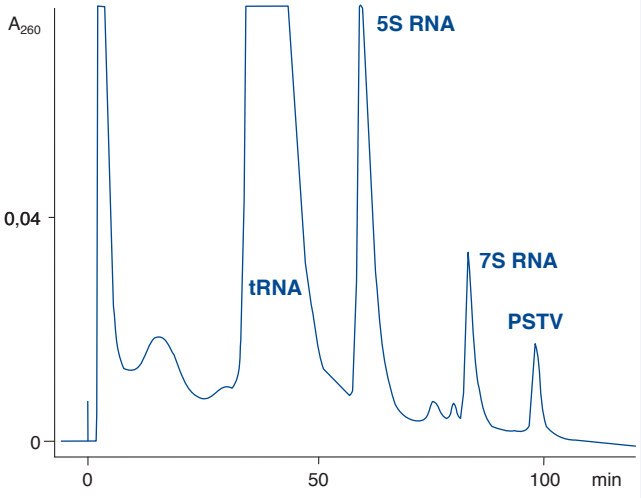
Column: 125 x 4 mm NUCLEOGEN® 60-7 DEAE
Eluent: A) 20 mmol/L phosphate buffer, pH 5.5, 5 mol/L urea; B) buffer A + 1 mol/L KCl; 0–100 % B in 200 min
Flow rate: 2 mL/min, 110 bar
Temperature: ambient
Detection: UV, 260 nm



MN Appl. No. 115180

Preparative separation of a crude RNA extract of viroid (PSTV) infected tomato plants

D. Riesner, BioEngineering **1** (1988) 42–48
Column: 125 x 6 mm NUCLEOGEN® 500-7 DEAE
Eluent: A) 250 mmol/L KCl, 20 mmol/L phosphate buffer pH 6.6, 5 mol/L urea; B) 1 mol/L KCl, 20 mmol/L phosphate buffer pH 6.6, 5 mol/L urea
0–50 % B in 120 min, 50–100 % B in 250 min
Flow rate: 3 mL/min, 40 bar, ambient temperature
Detection: 260 nm



MN Appl. No. 107490

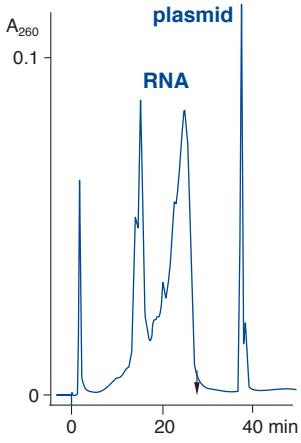
For information on DNA/RNA purification kits please ask for our catalog "Bioanalysis"

Separation of plasmid pBR 322

M. Colpan, D. Riesner, private communication

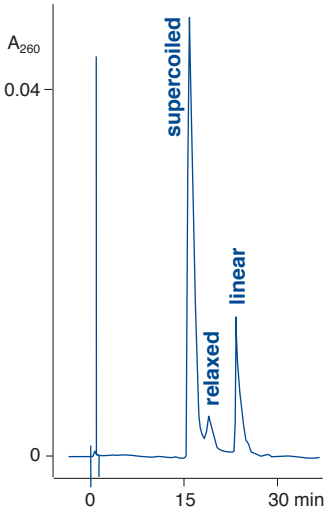
A) isolation of plasmid DNA from a crude cell lysate

Sample: 5 µg plasmid pBR 322 containing cleared lysate from *E. coli*
Column: 125 x 6 mm NUCLEOGEN® 4000-7 DEAE
Eluent: A) 20 mmol/ K phosphate buffer pH 6.9; 5 mol/L urea
B) eluent A + 1.5 mol/L KCl, 20–100 % B in 50 min;
arrow = ionic strength of 850 mmol/L
Flow rate: 1.0 mL/min, 70 bar, ambient temperature
Detection: UV, 260 nm



B) separation of supercoiled plasmid from relaxed and linear forms

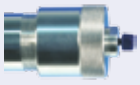
Sample: plasmid pBR 322, supercoiled, relaxed and linear
Column: 125 x 6 mm NUCLEOGEN® 4000-7 DEAE
Eluents: A) 20 mmol/L phosphate buffer pH 6.8; 6 mol/L urea; B) eluent A + 2 mol/L KCl
42–100 % B in 230 min
Flow rate: 1.5 mL/min, 45 bar, ambient temperature



MN Appl. No. 107480

Ordering information

Eluent in column methanol

	Length →	125 mm	Guard columns
EC columns  **Valco type columns**  **VarioPrep columns** 			
NUCLEOGEN® 60-7 DEAE			
EC analytical columns			
4 mm ID		736596.40	736400.40
VarioPrep preparative columns			
10 mm ID		736597.100	736400.40
NUCLEOGEN® 500-7 DEAE			
Valco type analytical columns			
6 mm ID		736598	736400.40
VarioPrep preparative columns			
10 mm ID		736599.100	736400.40
NUCLEOGEN® 4000-7 DEAE			
Valco type analytical columns			
6 mm ID		736601	736400.40
VarioPrep preparative columns			
10 mm ID		736602.100	736400.40

ChromCart® NUCLEOGEN® guard columns are 30 mm long and require the CC column holder 30 mm, REF 721823, see page 192 (columns in packs of 1, guard columns in packs of 2).

HPLC columns for biochemical separations

NUCLEOSIL® 4000-7 PEI — anion exchange of proteins and peptides

- Base material NUCLEOSIL® silica, particle size 7 µm, pore size 4000 Å
  polymeric, covalently bonded polyethyleneimine network, weakly basic anion exchanger
  ion exchange capacity 0.15 mmol/g; protein binding capacity 61 mg BSA/g
  pH stability 2–8.5; max. working pressure 250 bar
- Separation principle: reversible adsorption of negatively charged substances to positively charged groups on the exchanger material and their subsequent displacement by either increasing ionic strength or pH changes in the mobile phase

  High selectivity for numerous proteins; e.g., β-lactoglobulins A and B, two proteins differing in just two amino acids, can be separated in only 10 minutes; biological activity of purified proteins is preserved

  Good binding and desorption kinetics for nucleotides as well
- More examples for the purification of different peptides and proteins can be found in our application database at ***www.mn-net.com/apps***

Recovery of proteins

Column: 50 x 4 mm NUCLEOSIL® 4000-7 PEI
Eluent: 10 mmol/L NaH_2PO_4, 1.5 mol/L NaCl, pH 7.0
Flow rate: 1 mL/min
Sample: 50 µg of each protein

Protein	Recovery [%]
Myoglobin	100
Transferrin	95
Ovalbumin	98
Bovine serum albumin	100
Glucose oxidase	100
α-Amylase	100
Soybean trypsin inhibitor	100
β-Lactoglobulin	97
Ferritin	85

Recovery of specific enzyme activity after HPLC

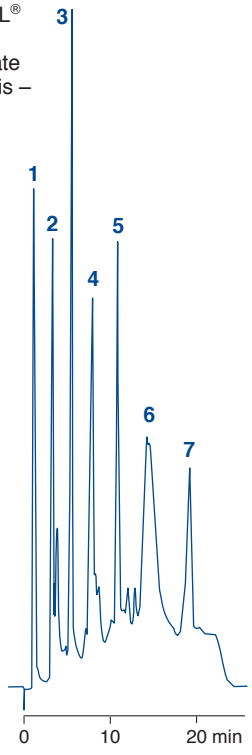
Columns: 50 x 4 mm NUCLEOSIL® 4000-7 PEI
Eluent: A) 20 mmol/L Tris-HCl pH 8.5; B) A + 1.5 mol/L NaCl; 0–100 % B in 5 min, 1 mL/min, 30 bar
Detection: UV, 280 nm

Enzyme	Recovery [%]
Catalase (bovine liver)	93
L-Lactic dehydrogenase LDH-1 isoenzyme (porcine heart)	102
Callicrein (porcine pancreas)	98
Glucose oxidase (Aspergillus niger)	104
Peroxidase (horseradish)	100

Separation of protein standards

Column: 125 x 4 mm NUCLEOSIL® 4000-7 PEI
Eluent: A) 2 mmol/L Tris – acetate pH 8.0; B) 20 mmol/L Tris – acetate pH 8.0 + 1.5 mol/L KCl 0–40 % B in 20 min
Flow rate: 1 mL/min
Pressure: 76 bar
Detection: UV, 280 nm
Injection: 20 µL

Peaks:
1. Catalase
2. Myoglobin
3. a-Amylase
4. Transferrin
5. a-Lactalbumin
6. Glucose oxidase
7. Soybean trypsin inhibitor



MN Appl. No. 108310

Ordering information

Eluent in column methanol

EC columns	Length 125 mm	CC guard columns
NUCLEOSIL® 4000-7 PEI		
4 mm ID	**720402.40**	**721091.40**

CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).
Columns in packs of 1, guard columns in packs of 2

NUCLEOGEL® SAX anion exchange of biological macromolecules

- Polymer-based strongly basic anion exchanger $-N^+(CH_3)_3$, gel matrix quaternized PEI; particle size 8 µm, pore size 1000 Å · **USP L23**
- pH working range 1–13, max. working pressure 200 bar
- **Recommended application:** purification of peptides, large proteins and oligonucleotides, high capacity for proteins even at pH 10

Ordering information

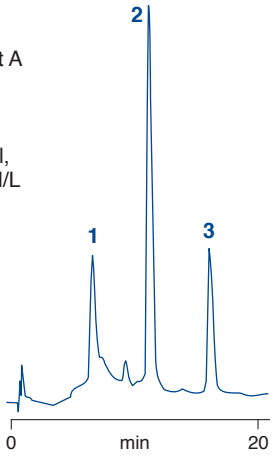
Eluent in column 0.1 mol/L Na_2SO_4 + 0.2 % NaN_3

Valco type columns	Length 50 mm	Guard columns
NUCLEOGEL® SAX		pore size 1000 Å
4.6 mm ID	**719469**	**719600**

Separation of hen's egg white

Sample: frozen egg white was thawed, filtered and diluted 1:8 with eluent A
Column: 50 x 4.6 mm NUCLEOGEL® SAX 1000-8
Eluent: A) 0.01 mol/L Tris-HCl, pH 7.5; B) A + 0.5 mol/L NaAc, pH 7.5; 0–100 % B in 20 min
Flow rate: 1 mL/min
Injection: 50 µL
Detection: UV, 280 nm

Peaks:
1. Conalbumin
2. Ovalbumin
3. not identified

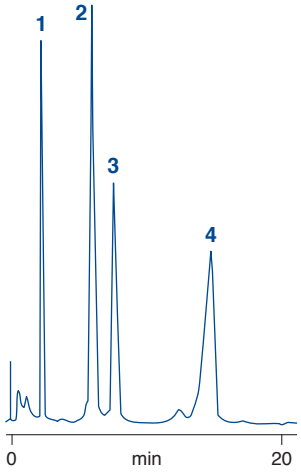


MN Appl. No. 115200

Separation of protein standards

Column: 50 x 4.6 mm NUCLEOGEL® SCX 1000-8
Eluent: A) 0.02 mol/L KH_2PO_4, pH 6.0 B) A + 0.5 mol/L NaCl, pH 6.0 0–100 % B in 20 min
Flow rate: 1 mL/min
Detection: UV, 280 nm

Peaks:
1. Myoglobin
2. α-Chymotrypsinogen A
3. Cytochrome C
4. Lysozyme



MN Appl. No. 108260

NUCLEOGEL® SCX cation exchange of biological macromolecules

- Polymer-based strongly acidic cation exchanger $-SO_3^-$, hydrophilic gel matrix; particle size 8 µm, pore size 1000 Å · **USP L22**
- pH working range 1–13, max. working pressure 200 bar
- **Recommended application:** proteins, peptides and carbohydrates with high isoelectric point

Ordering information

Eluent in column 0.1 mol/L Na_2SO_4 + 0.2 % NaN_3

Valco type columns	Length 50 mm	Guard columns
NUCLEOGEL® SCX		pore size 1000 Å
4.6 mm ID	**719475**	**719540**

NUCLEOGEL® SAX and SCX Valco type guard columns measure 5 x 3 mm and require the guard column holder B, REF 719539 (see page 193). Columns in packs of 1, guard columns in packs of 2

HPLC columns for biochemical separations

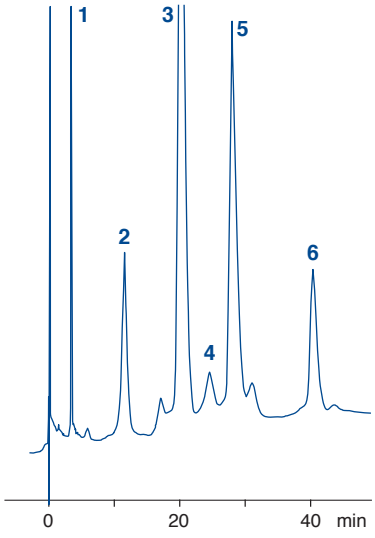
NUCLEOSIL® MPN — RP chromatography of biological macromolecules

- Silica-based reversed phase materials with monomerically bonded alkyl chains, brush type structure predominantly hydrophobic forces with a small portion of hydrophilic interactions
- **NUCLEOSIL® 100-5 C_{18} MPN:** octadecyl phase, particle size 5 µm, pore size 100 Å · **USP L1**
  dynamic protein binding capacity per g packing: 6 mg BSA, 110 mg cytochrome C
- **NUCLEOSIL® 300-5 C_4 MPN:** butyl phase, particle size 5 µm, pore size 300 Å · **USP L26**
  dynamic protein binding capacity per g packing: 14 mg BSA, 27 mg cytochrome C
  especially suited for the purification of larger, hydrophobic peptides and very different proteins
- pH working range 2–8, max. working pressure 250 bar
- Maximum separation efficiency can be achieved when the injected protein mass does not exceed 1–2 % of the maximum protein loading capacity.

Separation of haemoglobin chains

Column: 250 x 4 mm NUCLEOSIL® 300-5 C4 MPN
Eluent: A) 20 % acetonitrile, 80 % water, 0.1 % TFA
B) 60 % acetonitrile, 40 % water, 0.1 % TFA
40–60 % B in 60 min
Flow rate: 1 mL/min
Detection: UV, 220 nm

Peaks:
1. Hem
2. β-globin
3. α-globin
4. $^{A}\gamma^{T}$-globin
5. $^{G}\gamma$-globin
6. $^{A}\gamma^{I}$-globin



MN Appl. No. 108240

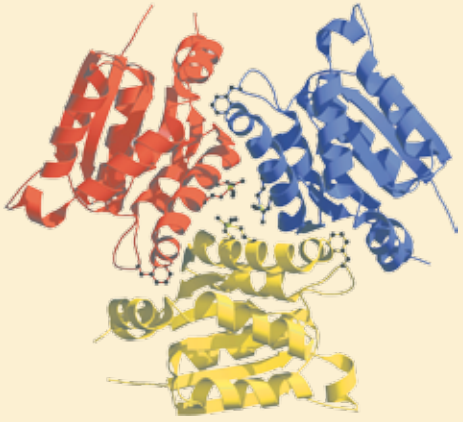
Ordering information

Eluent in column methanol

		Length 250 mm	CC guard columns
EC columns	**NUCLEOSIL® 100-5 C_{18} MPN**		
	4 mm ID	**720231.40**	
	NUCLEOSIL® 300-5 C_4 MPN		
	4 mm ID	**720245.40**	**721113.40**

CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).
Columns in packs of 1, guard columns in packs of 2

NUCLEOSIL® PPN



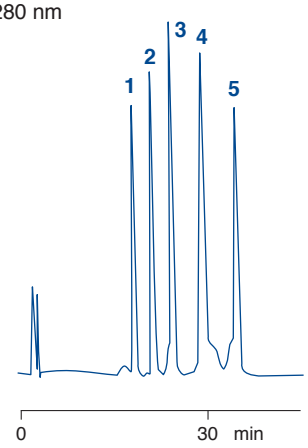
RP chromatography of biological macromolecules

- Silica-based reversed phase materials with polymerically bonded alkyl chains; exclusively hydrophobic interactions
- **NUCLEOSIL® 100-5 C_{18} PPN:**
  octadecyl phase, particle size 5 µm, pore size 100 Å · **USP L1**
  dynamic protein binding capacity per g packing: 8 mg BSA, 64 mg cytochrome C; suited for the separation of peptides and proteins up to about 40 kD, also suited for basic peptides
- **NUCLEOSIL® 500-5 C_{18} PPN:**
  octadecyl phase, particle size 5 µm, pore size 500 Å · **USP L1**
  dynamic protein binding capacity per g packing: 22 mg BSA, 40 mg cytochrome C; especially suited for large peptides and medium-size hydrophilic proteins
- pH working range 1–9, max. working pressure 250 bar

Separation of a protein standard

Column: 125 x 4 mm NUCLEOSIL® 100-5 C_{18} PPN
Eluent: A) 0.1 % TFA in H_2O
B) 0.08 % TFA in CH_3CN
20–60 % B in 10 min
Flow rate: 1.0 mL/min
Detection: UV, 280 nm

Peaks:
1. Ribonuclease
2. Cytochrome C
3. Lysozyme
4. β-Lactoglobulin
5. Ovalbumin

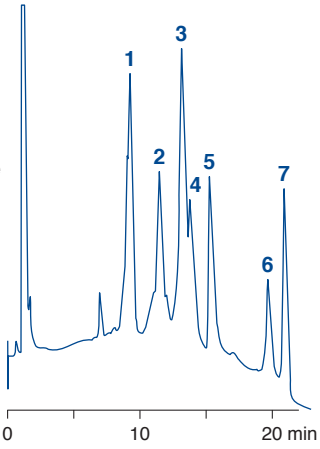


MN Appl. No. 108220

Separation of pancreatic secretion of piglets

Column: 125 x 4 mm NUCLEOSIL® 500-5 C_{18} PPN
Eluents: A) 0.1 % TFA in H_2O
B) 0.08 % TFA in CH_3CN
30–50 % B in 14 min, then 50–65 % B in 6 min
Flow rate: 1 mL/min
Detection: UV, 215 nm

Peaks:
1. Trypsin + trypsinogen
2. Proelastase
3. Lipase
   + α-chymotrypsin
4. Chymotrypsinogen
5. α-Amylase
6., 7. Procarboxypeptidase



MN Appl. No. 108280

Ordering information

Eluent in column methanol

	Length →	125 mm	250 mm	CC guard columns
EC columns 	**NUCLEOSIL® 100-5 C_{18} PPN**			
	4 mm ID	**720251.40**	**720252.40**	**721594.40**
	NUCLEOSIL® 500-5 C_{18} PPN			
	4 mm ID	**720257.40**	**720258.40**	**721687.40**

CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).
Columns in packs of 1, guard columns in packs of 2

HPLC columns for biochemical separations

NUCLEOGEL® RP columns

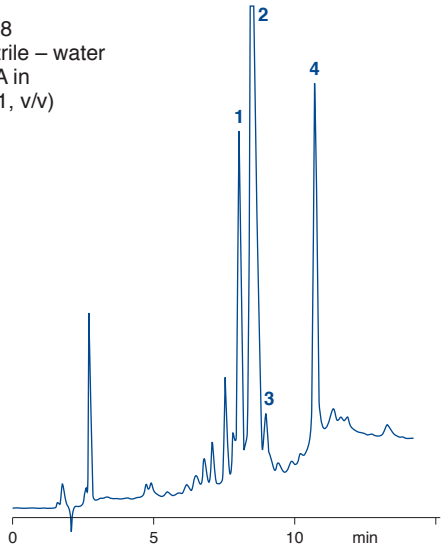
RP columns for biochemical applications

- Polystyrene resin cross-linked with divinylbenzene, available particle sizes 5 µm and 8 µm, available pore sizes 100 Å and 300 Å · **USP L21**
  pH working range 1–13, max. working pressure 180 bar
- Small pore columns for reversed phase separation of small molecules such as pharmaceuticals with basic properties, e.g., organic heterocycles; also suited for separation of nucleosides and nucleotides up to 5000 Da; allow gradient as well as isocratic elution
- Wide pore columns are especially recommended for large biomolecules
  higher background hydrophobicity compared to silica phases

Analysis of the synthetic acyl carrier protein ACP(65–74)

Column: 150 x 4.6 mm NUCLEOGEL® RP 100-8
Eluent: A) 0.1 % TFA in acetonitrile – water (1:99, v/v); B) 0.1 % TFA in acetonitrile – water (99:1, v/v)
10–60 % B in 20 min
Flow rate: 1 mL/min
Detection: UV, 220 nm

Peaks:
1. ACP(66-74)(H-Gln)
2. ACP(65-74)
3. ACP(66-74)(Glp)
4. Thioanisole



MN Appl. No. 108500

Ordering information

Eluent in column acetonitrile – water

	Length →	50 mm	150 mm	250 mm	Guard columns
Valco type analytical columns					
NUCLEOGEL® RP 100-5				pore size 100 Å, particle size 5 µm	
4.6 mm ID			719454	719455	719542
NUCLEOGEL® RP 100-8				pore size 100 Å, particle size 8 µm	
4.6 mm ID			719456	719520	719542
NUCLEOGEL® RP 300-5				pore size 300 Å, particle size 5 µm	
4.6 mm ID		719459			719542
NUCLEOGEL® RP 300-8				pore size 300 Å, particle size 8 µm	
4.6 mm ID		719460			719542

Valco type guard columns measure 5 x 3 mm snd require the guard column holder B, REF 719539, see page 193.
Columns in packs of 1, guard columns in packs of 2

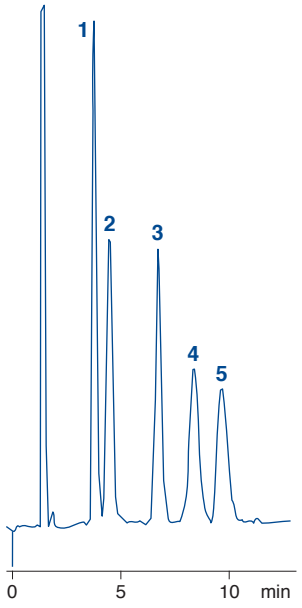
NUCLEOSIL® Carbohydrate — separation of mono- and disaccharides

- Matrix: NUCLEOSIL® silica with amino modification, particle size 10 µm · **USP L8**
- **Recommended application:** RP separation of mono- and disaccharides

Separation of sugars

Column: 250 x 4 mm NUCLEOSIL® Carbohydrate
Eluent: acetonitrile – water (79:21, v/v)
Flow rate: 2 mL/min
Temperature: 25 °C
Detection: RI
Injection: 10 µL

Peaks:
1. Fructose
2. Glucose
3. Saccharose
4. Maltose
5. Lactose



MN Appl. No. 102480

For the separation of oligosaccharides with longer chains ($10 < n < 40$) our phase NUCLEOSIL® 300-5 C_{18} can be successfully applied (see Application No. 102730 at ***www.mn-net.com***). In this case a very flat gradient allows good resolution of the carbohydrates. For ordering information of this phase please see page 159.

Ordering information

Eluent in column acetonitrile – water (79:21, v/v)

EC columns 	Length 250 mm	EC guard columns*	CC guard columns**
NUCLEOSIL® Carbohydrate			
4 mm ID	**720905.40**	**721170.30**	**721595.40**

* EC 4/3 guard columns for EC columns with 4 mm ID require the Column Protection System guard column holder (REF 718966, see page 190).

** CC 8/4 guard columns for EC columns with 4 mm ID require the guard column adapter EC (REF 721359, see page 191).

Columns and guard columns in packs of 1

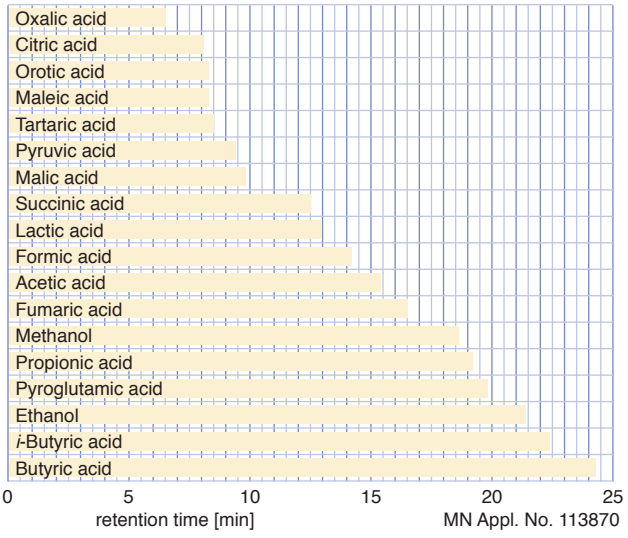
HPLC columns for sugar analysis

NUCLEOGEL® SUGAR 810 — separation of sugars

- Sulfonated polystyrene – divinylbenzene resins in different ionic forms · due to a different selectivity pattern compared to NUCLEOGEL® SUGAR columns, the range of application is considerably enlarged
- Separation mechanism includes ion exclusion, ion exchange, size exclusion, ligand exchange as well as NP and RP chromatography
- **H^+ form:** separation of sugars, sugar alcohols and organic acids · **USP L17**
  eluent in column 5 mmol/L H_2SO_4
- **Ca^{2+} form:** separation of mono-, di- and oligosaccharides · **USP L19** · eluent in column water

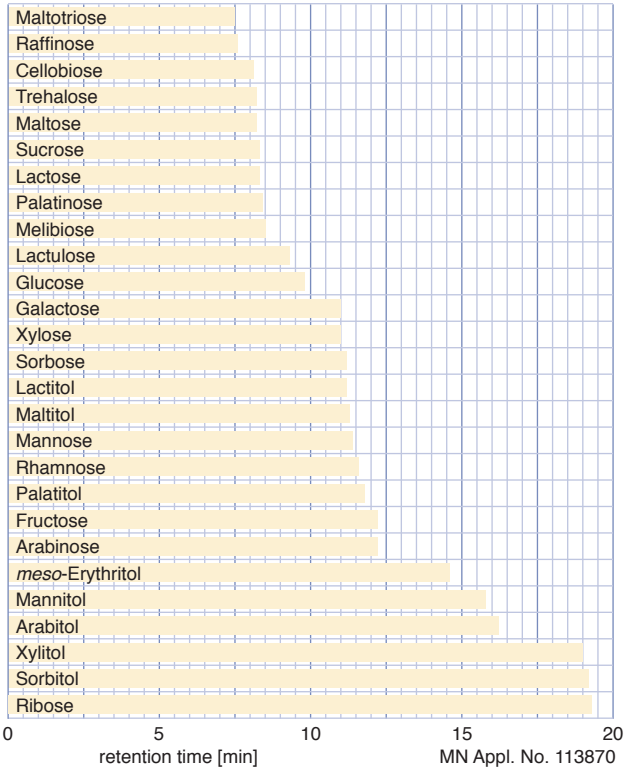
Organic acids and alcohols

Column: 300 x 7.8 mm NUCLEOGEL® SUGAR 810 H
Eluent: 5 mmol/L H_2SO_4
Flow rate: 0.6 mL/min
Temperature: 35 °C
Detection: RI
Injection: 5 µL



Sugars and sugar alcohols

Column: 300 x 7.8 mm NUCLEOGEL® SUGAR 810 Ca
Eluent: water , flow rate 0.6 mL/min
Detection: RI



Ordering information

Valco type columns	Length 300 mm	Guard columns
NUCLEOGEL® SUGAR 810 H		
7.8 mm ID	**719574**	**719575**
NUCLEOGEL® SUGAR 810 Ca		
7.8 mm ID	**719570**	**719571**

ChromCart NUCLEOGEL® SUGAR 810 guard columns measure 30 x 4 mm and require the CC column holder 30 mm, REF 721823, see page 192.

Columns in packs of 1, guard columns in packs of 2

NUCLEOGEL® ION 300 OA / SUGAR — separation of sugars

- Sulfonated spherical PS/DVB resins in different ionic forms; mean particle size 10 µm, pore size 100 Å
- Separation mechanism includes steric exclusion, ligand exchange and partition effects, ligand exchange being the predominant force, since the hydrated metal ions form strong interactions with the hydroxyl groups of the sample molecules. The intensity of these interactions decreases in the sequence Pb, Ca, Na

  NUCLEOGEL® ION 300 OA: H^+ form for separation of sugars, alcohols and organic acids · **USP L17** eluent in column 5 mmol/L H_2SO_4

  NUCLEOGEL® SUGAR:

  Ca^{2+} form: separation of mono- and oligosaccharides, sugar alcohols · **USP L19**

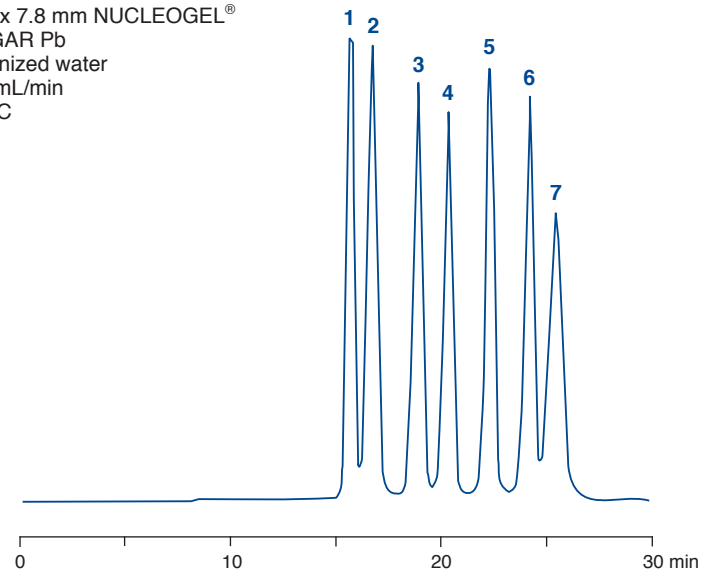
  Pb^{2+} form: separation of mono- and disaccharides from food and biological samples · **USP L34**

  Na^+ form: separation of oligosaccharides from starch hydrolysates and food · **USP L58**
- Eluent in column for Ca, Na and Pb phases: water + 0.02 % azide
- Recommended operating temperatures: 60–95 °C; maximum pressure 70 bar

Separation of carbohydrates

Column: 300 x 7.8 mm NUCLEOGEL® SUGAR Pb
Eluent: deionized water
Flow rate: 0.4 mL/min
Temperature: 80 °C
Detection: RI

Peaks:
1. Sucrose
2. Maltose
3. Glucose
4. Xylose
5. Galactose
6. Arabinose
7. Mannose



MN Appl. No. 102430

Ordering information

Valco type columns	Length 300 mm	Guard columns
NUCLEOGEL® ION 300 OA		
7.8 mm ID	**719501**	**719537**
NUCLEOGEL® SUGAR Ca		
6.5 mm ID	**719531**	**719535**
NUCLEOGEL® SUGAR Pb		
7.8 mm ID	**719530**	**719534**
NUCLEOGEL® SUGAR Na		
7.8 mm ID	**719532**	**719536**

Valco-Typ guard columns measure 21 x 4 mm and require the guard column holder C, REF 719538, see page 193.
Columns in packs of 1, guard columns in packs of 2

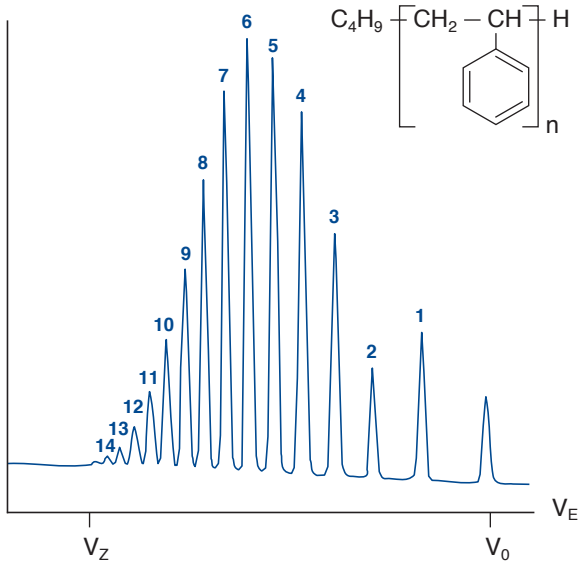
Columns for gel permeation chromatography

NUCLEOGEL® GPC

for GPC of water-insoluble substances

- Highly crosslinked macroporous, spherical polystyrene – divinylbenzene polymer matrix with good mechanical stability

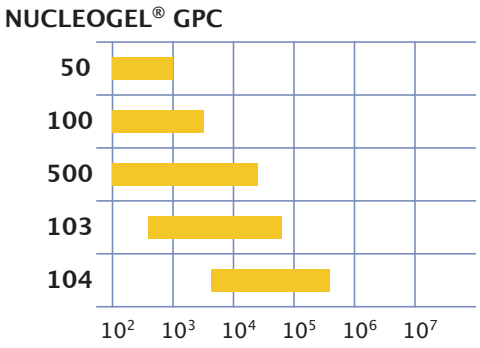
Chromatogram of styrene oligomers



Exclusion volume

Dead time

Working ranges for polystyrene



[MW in Da]

Ordering information

Eluent in column toluene

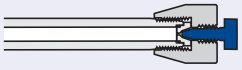
Phase	Exclusion limit [kDa]	Application	Column 300 x 7.7 mm
Valco type analytical columns			
5 µm particle size			
NUCLEOGEL GPC 50	2	low molecular weight organics	**719402**
NUCLEOGEL GPC 100	4	oligomers, oils	**719403**
NUCLEOGEL GPC 500	25	low molecular weight polymers	**719404**
NUCLEOGEL GPC 103	60	low molecular weight polymers	**719405**
NUCLEOGEL GPC 104	500	polymers up to 500 kDa	**719406**
		guard columns 50 x 7.7 mm	**719409**
10 µm particle size			
NUCLEOGEL GPC 50	2	low molecular weight organics	**719410**
NUCLEOGEL GPC 100	4	oligomers, oils	**719411**
NUCLEOGEL GPC 500	25	low molecular weight polymers	**719412**
NUCLEOGEL GPC 103	60	low molecular weight polymers	**719413**
NUCLEOGEL GPC 104	500	polymers up to 500 kDa	**719414**
		guard columns 50 x 7.7 mm	**719418**

Columns and guard columns in packs of 1

EC standard columns for analytical HPLC

- Analytical column system manufactured from stainless steel
  M8 outer threads on both ends
  combination of sealing element and very fine-meshed stainless steel screen, PTFE ring and fitting adaptor
  column heads SW 12, with inner threads M8 x 0.75 and UNF 10-32 (= 1/16" connection)
- As screw-on guard column system we recommend the **Column Protection System** used with EC guard column cartridges with 4 mm length (see next page).
- As built-in guard columns ChromCart® guard column cartridges with 8 mm length can be used with the guard column adapter EC (see page 191).
- Supplied with NUCLEODUR®, NUCLEOSHELL® and NUCLEOSIL® spherical silicas

Available standard dimensions of EC columns

ID [mm]	Length [mm]										End fitting design
	20	30	50	75	100	125	150	200	250	300	
2	+	+	+	+	+	+	+	+	+	+	
3	+	+	+	+	+	+	+	+	+	+	
4	+	+	+	+	+	+	+	+	+	+	
4.6	+	+	+	+	+	+	+	+	+	+	

Please ask for availability of certain phases

Guard columns for EC columns

(packs of 3 cartridges)		EC column with ID 2 mm	3 mm	4 mm	4.6 mm	Use guard column holder
EC guard columns for the Column Protection System guard column holder	EC	4/2	4/3	4/3	4/3	REF 718966
ChromCart® guard columns for the EC guard column adapter	CC	8/3	8/3	8/4	8/4	REF 721359

Accessories and replacement parts for EC columns · ordering information

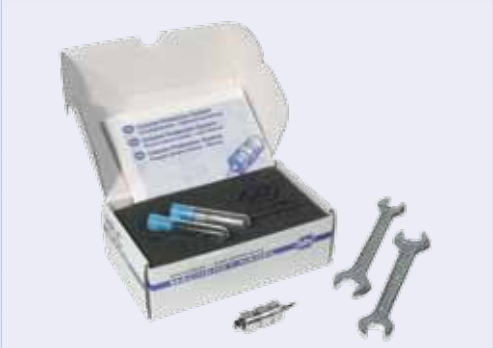
Description	Pack of	REF
EC fitting adapter	1	718987
EC column head (nut)	1	718988
EC PTFE sealing ring	4	718992
3-part sealing combination for EC columns	5 kits	718998

Column Protection System

Innovative and universal guard column holder system suitable for all analytical HPLC columns with 1/16" fittings

- Cartridges filled with special NUCLEODUR®, NUCLEOSIL® and NUCLEOSHELL® HPLC adsorbents
- Ideal protection for your analytical main column → significant increase in column lifetime
- Minimized dead volume → suitable also for ultra-fast HPLC
- Special ferrules → pressure stability up to 1034 bar (15 000 psi)
- Visual contamination check → in-time changing of the guard column
- Guard column length 4 mm, 2 mm ID (for main columns with 2 mm ID) and 3 mm ID (for main columns with 3, 4 and 4.6 mm)
- UNIVERSAL RP guard columns suitable for all HPLC columns under RP conditions

Content of the Column Protection System



Description	REF
Column Protection System	**718966**
	Contents
Cartridge holder	1
Capillaries	2
Ferrules	3
Wrenches	2
Manual	1

Replacement parts for the Column Protection System · Ordering information

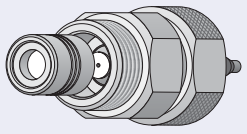
Description	Pack of	REF
Ferrules	5	**718967**
Replacement connector including O-ring	1	**718968**
Capillary tubes, nuts and metal ferrules	3	**718969**
Wrench (size 12 and 14 mm)	1	**718970**
EC 4/2 UNIVERSAL RP guard column (for main columns with 2 mm ID)	3	**728777.20**
EC 4/2 UNIVERSAL RP guard column (for main columns with 2 mm ID), value pack	9	**728778.20**
EC 4/3 UNIVERSAL RP guard column (for main columns with 3, 4 and 4.6 mm ID)	3	**728777.30**
EC 4/3 UNIVERSAL RP guard column (for main columns with 3, 4 and 4.6 mm ID), value pack	9	**728778.30**

Visual contamination check

The cartridge is fitted with a special filter membrane:

If this silver membrane is contaminated (bright or dark discoloration), it is advisable to replace the cartridge.

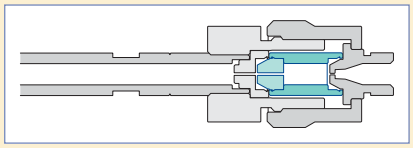
If the contaminations are colorless, replace the cartridge as soon as the pressure rises or the chromatographic performance decreases.



EC guard column adapter

Standard built-in guard column adapter system suitable for EC columns

- Cartridges filled with specified NUCLEODUR® and NUCLEOSIL® HPLC adsorbents
- Ideal protection for your analytical EC main column → significant increase of column lifetime
- Guard column length 8 mm, 3 mm ID (for main columns with 2 and 3 mm ID) and 4 mm ID (for main columns with 4 and 4.6 mm ID)



EC guard column adapter · Ordering information

Description	Pack of	REF
EC guard column adapter	**1**	**721359**

Installation of the EC guard column adapter

1. Unscrew the column head
2. Remove the fitting

3. Unscrew the EC guard column adapter

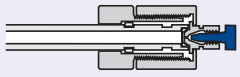
4. Screw the adapter sleeve onto the column
5. Insert the CC guard column

6. Screw the nut of the guard column adapter in place

ChromCart® cartridge system

- Analytical column system manufactured from stainless steel (US patent 5,342,515)
- Rapid and convenient installation
  columns are changed without removal of capillary connections
  all unions are screwed by hand
  easy installation of guard cartridges without special adaptor
  connection of columns of different lengths and inner diameters with one type of connecting kit (see below)
- Supplied with LiChrospher® silica manufactured by E. Merck

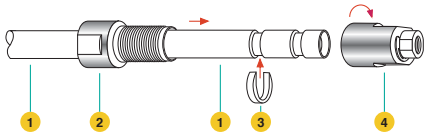
Available standard dimensions of ChromCart® cartridges

ID [mm]	Length [mm] 8*	125	150	250	End fitting design
2	–	+	+	+	
3	+	+	+	+	
4	+	+	+	+	
4.6	–	+	+	+	

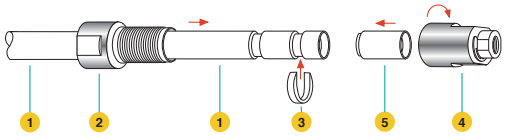
* Please note that 3 mm ID guard column cartridges are also applicable for 2 mm ID CC columns, and 4 mm ID guard column cartridges are also used for 4.6 mm ID CC columns.

Connection of ChromCart® cartridges and guard column cartridges

Use of 1 analytical column without guard column



Use of column and guard column



Legend

1. Analytical column
2. Sleeve
3. Guide ring
4. Nut
5. Guard column

Accessories for the ChromCart® cartridge system · Ordering information

Description	Pack of	REF
CC connecting kit (consists of 2 nuts with end fittings, two sleeves and two guide rings)	1 kit	**721690**
CC nut with end fitting	1 set	**721691**
CC sleeve with outer threads	1	**721692**
CC guide ring	1	**721693**
CC guard column holder 8 mm for stand-alone operation of 8 mm CC cartridges	1	**721820**
CC column holder 30 mm for stand-alone operation of 30 mm CC cartridges	1	**721823**

Microbore columns

- Analytical column system for rapid HPLC and **LC/MS** analyses with high resolution
- Available lengths: 40, 60, 100, 125, 150, 200, 250 and 300 mm, available IDs: 0.05, 0.075, 0.1, 0.15, 0.3, 0.4, 0.5, 0.75, 1, 1.5 mm
- Microbore columns up to 0.3 mm ID are fused silica capillaries, while microbore columns with 0.3–1.5 mm ID are stainless steel columns.
- On request, microbore columns and guard columns can be custom-packed with NUCLEODUR® and NUCLEOSIL® phases.

Advantages of microbore columns

Only small sample volumes required

Highest detection sensitivity

Low flow rate = reduced eluent consumption

- Time saving + reduced eluent consumption = reduced cost

Change of flow rate and solvent saving as a function of the column inner diameter

ID [mm]	Flow rate [mL/min]	Solvent saving	Increase in sensitivity
4.6	1.3	–	–
4.0	1.0	~ 25 %	~ 1.3
3.0	0.56	~ 57 %	~ 2.4
2.0	0.25	~ 81 %	~ 5.3
1.0	0.06	~ 95 %	~ 21.7

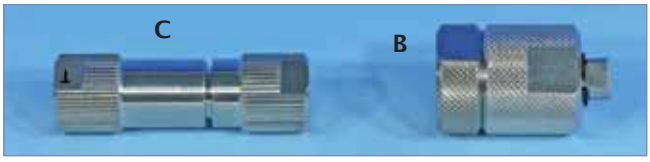
For a constant length relative to a column with 4.6 mm ID and a flow rate of 1.3 mL/min for isocratic application

Valco type columns

- Analytical column system manufactured from stainless steel
  available inner diameters:
  4.6 mm ID (1/4" OD) and 7.7 mm (3/8" OD)
- Mainly used for some phases for special separations

Accessories for Valco type columns · Ordering information

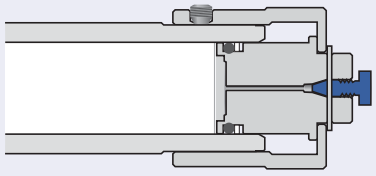
Description	Pack of	REF
Guard column holder B for VA guard columns 5 x 3 mm	1	**719539**
Guard column holder C for VA guard columns 21 x 4 mm	1	**719538**
Frits 2 µm for 4.6 mm ID columns	5	**719485**
Frits 2 µm for 7.7 mm ID columns	5	**719486**



VarioPrep (VP) columns for preparative HPLC

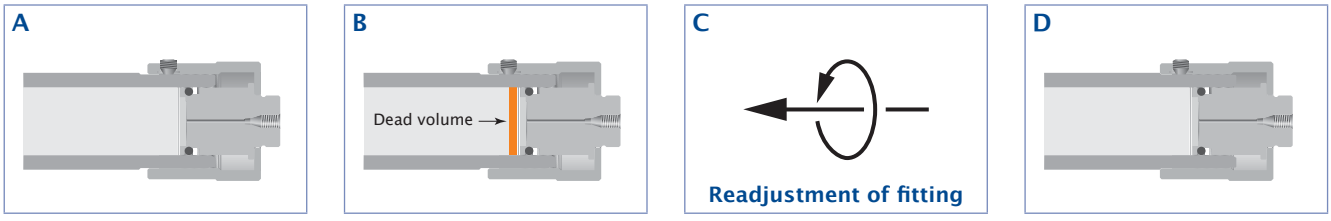
- Column system for preparative HPLC, manufactured from stainless steel with two adjustable end fittings, suitable for frequent use of back-flushing techniques
- Allows compensation of a dead volume, which could result at the column inlet after some time of operation, without need for opening the column
- Can be packed with all NUCLEODUR® and NUCLEOSIL® spherical silicas

Available standard dimensions of VarioPrep columns with axially adjustable end fittings

ID [mm]	Length [mm] 10*	15*	Length [mm] 50	75	100	125	150	250	500	End fitting design
8	+		+		+	+	+	+		
10			+		+	+	+	+		
16	+		+		+	+	+	+		
21			+	+	+	+	+	+		
32		+			+		+	+		
40			+		+	+	+	+	+	
50		+			+		+	+		
80								+	+	

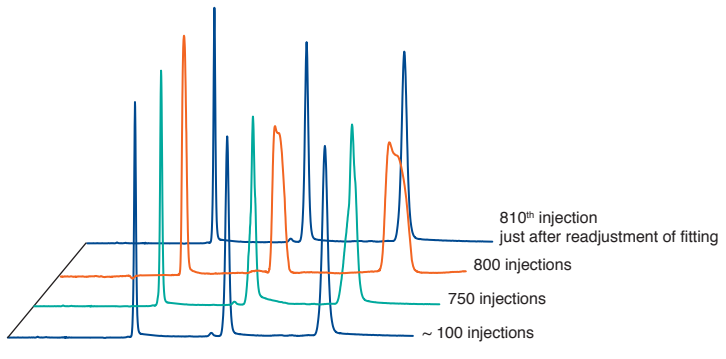
* 10 x 8, 10 x 16, 15 x 32 and 15 x 50 mm ID columns are used as guard columns and require the respective holders, see next page.

The VarioPrep principle



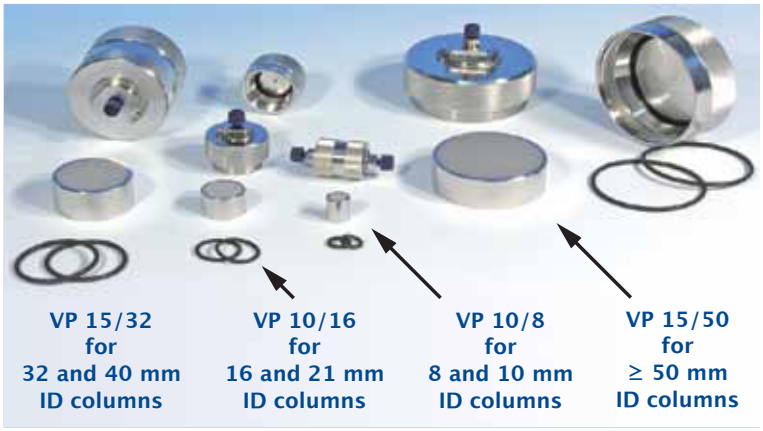
VarioPrep columns are produced with highest packing quality and bed density (**A**). Due to intensive chemical and/or mechanical exposure of the column adsorbent, shrinking of the column bed can occur (**B**; orange gap). in this even unlikely case readjustment of the VarioPrep column fitting (**C**; turning the nut at the column inlet clockwise) will eliminate the emerged dead volume (**D**). The performance of the VarioPrep column is completely reconstituted and column lifetime is significantly extended.

Column reconstitution



Reconstitution of VarioPrep column performance

- Slight peak broadening and deformation after 800 injections under strongly demanding conditions (pH 11; 50 °C; sample in DMSO)
- Readjustment of the column fitting restores column performance and prolongs column lifetime noticeably.

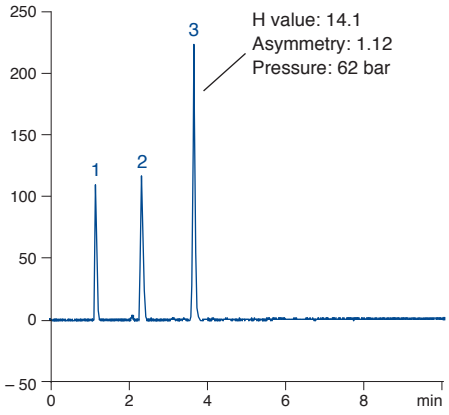


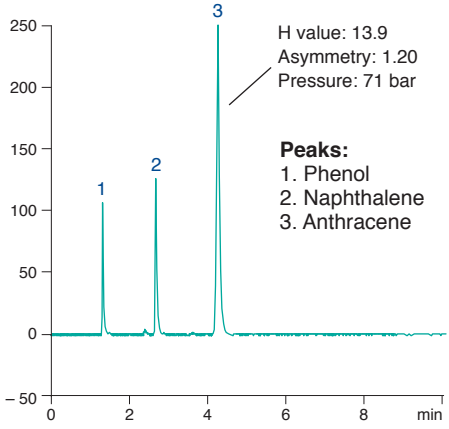
The improved guard column system for (semi-) preparative HPLC

- Easy handling and cartridge exchange
- Robust hardware
- Free rotary plunger fittings – low O-ring abrasion
- Cost-efficient cartridges
- Minimally invasive / no disturbance of the separation efficiency of main column
- Low back pressure
- Designed for pressures up to 400 bar

Column performance without and with guard column

Columns: **125 x 16 mm NUCLEODUR® C_{18} HTec, 5 µm**
125 x 16 mm NUCLEODUR® C_{18} HTec, 5 µm + 10 x 16 mm NUCLEODUR® C_{18} HTec guard column
Eluent: acetonitrile – water (80:20, v/v)
Flow rate: 16 mL/min
Temperature: 22 °C





Using VarioPrep guard columns provides ideal protection of your main column – symmetry, pressure and retention stay almost constant.

Technical data

1/16" thread · free rotary plunger fittings – low O-ring abrasion · stainless steel

Guard cartridge	Holder REF	Holder ID	Recommended for column ID	Preferred capillary ID	Typical flow rate
VP 10/8	**718251**	8 mm	8 and 10 mm ID	0.17 and 0.25 mm	1–12 mL/min
VP 10/16	**718256**	16 mm	16 and 21 mm ID	0.17, 0.25 and 0.5 mm	2–32 mL/min
VP 15/32	**718253**	32 mm	32 and 40 mm ID	0.25, 0.5 and 1.0 mm	5–150 mL/min
VP 15/50	**718255**	50 mm	≥ 50 mm ID	0.5 and 1.0 mm	20–250 mL/min

Guard column holders for VarioPrep columns · Ordering information

	VP guard columns for VarioPrep columns with ID 8, 10 mm	16, 21 mm	32, 40 mm	≥ 50 mm	Pack of [guard columns]	Replacement O-ring (pack of 2)	Holder ID	Holder REF
VP	10/8				2	**718975**	8 mm	**718251**
VP		10/16			2	**718976**	16 mm	**718256**
VP			15/32		1	**718977**	32 mm	**718253**
VP				15/50	1	**718978**	50 mm	**718255**

For REF numbers of individual VP guard column cartridges see respective NUCLEODUR® and NUCLEOSIL® phases.

HPLC fittings and capillary tubing

Replacement parts for VarioPrep columns · Ordering information

Description	Pack of	REF
for VarioPrep columns with 10 mm ID		
VP plunger fitting 10 mm without sealing ring	1	718837
VP nut 10 mm	1	718842
VP sealing element set 10 mm	1 set	718931
VP sealing ring set 10 mm	1 set	718852
VP MN Inert sealing combination 10 mm	1 set	718848
for VarioPrep columns with 21 mm ID		
VP plunger fitting 21 mm without sealing ring	1	718861
VP nut 21 mm	1	718862
VP sealing element set 21 mm	1 set	718853
VP sealing ring set 21 mm	1 set	718854
VP MN Inert sealing combination 21 mm	1 set	718870

Accessories for stainless steel HPLC columns

- Stainless steel columns are most frequently used in HPLC. The material is corrosion resistant, pressure stable and easy to work mechanically.

Stainless steel capillary tubing

Length	OD	ID	Pack of	REF
Capillary tubing in coils				
3 m	1/16"	0.25 mm	1 coil	718737
3 m	1/16"	0.5 mm	1 coil	718738
1 m	1/16"	0.12 mm	1 coil	718790
1 m	1/16"	0.25 mm	1 coil	718735
1 m	1/16"	0.5 mm	1 coil	718736

Capillary tubing, cut pieces, ready-to-use				
50 mm	1/16"	0.12 mm	2	718731
100 mm	1/16"	0.12 mm	2	718732
200 mm	1/16"	0.12 mm	2	718733
300 mm	1/16"	0.12 mm	2	718734
100 mm	1/16"	0.25 mm	5	718588
200 mm	1/16"	0.25 mm	5	718635
300 mm	1/16"	0.25 mm	5	718589
100 mm	1/16"	0.5 mm	5	718516
300 mm	1/16"	0.5 mm	5	718517
50 mm	1/32"	0.12 mm	2	718670
100 mm	1/32"	0.12 mm	2	718671
200 mm	1/32"	0.12 mm	2	718672
50 mm	1/32"	0.25 mm	2	718673
100 mm	1/32"	0.25 mm	2	718674
50 mm	1/32"	0.5 mm	2	718676
100 mm	1/32"	0.5 mm	2	718677
200 mm	1/32"	0.5 mm	2	718678

Stainless steel column accessories

Description	Pack of	REF
Capillary accessories		
1/16" column end caps (plastic)	4	718582
1/16" nut for connecting 1/16" capillaries	5	718583
1/16" ferrule	5	718584
Capillary unions		
Type 1: 100 mm x 1/16" x 0.25 mm	1	718637
Type 2: 100 mm x 1/16" x 0.12 mm	1	719489
Knife file	1	706121
Cutter for 1/16" capillary tubing	1	706290

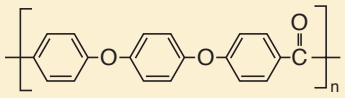
Stainless steel eluent filters			
for 1/16" tubing	2 µm frits	1	718750
for 1/16" tubing	10 µm frits	1	718752
for 1/8" tubing	2 µm frits	1	718751
for 1/8" tubing	10 µm frits	1	718753

For accessories and replacement parts for EC columns see page 189, for accessories and replacement parts for ChromCart® cartridges see page 192, for accessories and replacement parts for VarioPrep columns see page 195 and above.

PEEK accessories

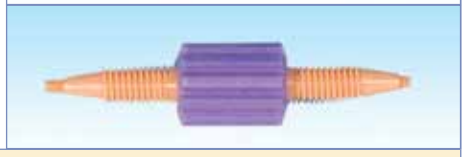
- PEEK (= polyether ether ketone) is a high performance polymer belonging to the group of polyarylether ketones (PAEK), which meets all requirements of HPLC columns with respect to chemical resistance and mechanical stability. In some fields of application in HPLC like, e.g., in ion chromatography and chromatography of biopolymers, PEEK fulfils the requirements for a nonmetallic material.

PEEK



- All fittings can be tightened by hand. The following table summarizes the available PEEK products.

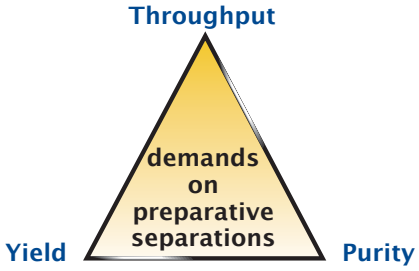
Ordering information

Description	Pack of	REF	
PEEK fittings			
1/16" PEEK fingertight fitting, 1-part combination nut + ferrule	1	**718770**	
1/16" PEEK fingertight nut	1	**718771**	
1/16" PEEK ferrule for REF 718771	1	**718772**	
1/16" PEEK double ferrule	1	**718775**	
1/16" PEEK union, both sides inner threads, equipped with 2 fingertight nuts and double ferrules	1	**718766**	
1/16" PEEK union, both sides inner threads, however without nuts and without ferrules	1	**718767**	
1/16" PEEK union, both sides outer threads	1	**718768**	
PEEK standard capillaries			
OD / ID [mm] / Length			
1/16" / 0.13 / 1 m	1	**718765**	
1/16" / 0.17 / 1 m	1	**718760**	
1/16" / 0.25 / 1 m	1	**718761**	
1/16" / 0.5 / 1 m	1	**718762**	
1/16" / 0.75 / 1 m	1	**718763**	
Tools for PEEK capillaries			
Guillotine cutter for PEEK and PTFE capillaries	1	**718769**	
Clean-Cut cutter for different capillary outer diameters	1	**718755**	

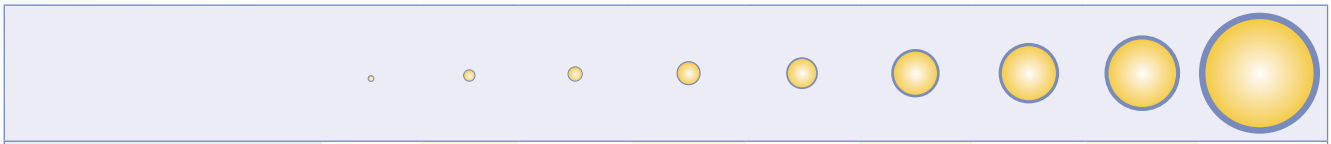
NUCLEODUR® high purity silica for HPLC

Basic rules of preparative HPLC

Basically, preparative HPLC follows the same rules as analytical scale chromatography. However, there are important differences in the aims of the two techniques. In analytical HPLC chromatographers focus on peak shape, and resolution of all eluted analytes, whereas in preparative chromatography yield and purity of the final product, as well as cost-effectiveness of the method, are emphasized.



Scale up factors and parameters for typical MN column dimensions



ID x length [mm]	4 x 250	8 x 250	10 x 250	16 x 250	21 x 250	32 x 250	40 x 250	50 x 250	80 x 250
Linear scale-up factor	1	4	6.25	16	27.6	64	100	156.3	400
Typical sample mass* [mg]	0.02–2	0.08–8	0.13–13	0.3–35	0.6–60	1.3–130	2–210	3–350	10–850
Typical flow rate [mL/min]	0.5–1.5	2–6	3–9	8–24	14–40	32–96	50–150	80–250	200–600

* For RP material; the maximum amounts given here always depend on the separation problem and on the sample composition. In some cases half of the amount given can cause drastic overload, in other cases the maximum amounts can be even higher still giving acceptable separations.

NUCLEODUR® bulk packings

- Totally spherical high purity silica
- Pore size 110 Å, pore volume 0.9 mL/g, surface (BET) 340 m^2/g, density 0.47 g/mL, pressure stability 600 bar
- Larger particles for preparative applications

Ordering information

Phase	Endcapped	Carbon content	Particle size	Pack of 100 g	Pack of 1000 g
NUCLEODUR® C_{18} HTec premium octadecyl phases (see page 130)					
NUCLEODUR® 100-5 C_{18} HTec	yes	18% C	5 µm	**713830.0100**	**713830.1**
NUCLEODUR® 100-7 C_{18} HTec	yes	18% C	7 µm	**713831.0100**	**713831.1**
NUCLEODUR® 100-10 C_{18} HTec	yes	18% C	10 µm	**713832.0100**	**713832.1**
NUCLEODUR® C_{18} ec standard octadecyl phases (see page 133)					
NUCLEODUR® 100-10 C_{18} ec	yes	17.5% C	10 µm	**713611.0100**	**713611.1**
NUCLEODUR® 100-12 C_{18} ec	yes	17.5% C	12 µm	**713618.0100**	**713618.1**
NUCLEODUR® 100-16 C_{18} ec	yes	17.5% C	16 µm	**713621.0100**	**713621.1**
NUCLEODUR® 100-20 C_{18} ec	yes	17.5% C	20 µm	**713601.0100**	**713601.1**
NUCLEODUR® 100-30 C_{18} ec	yes	17.5% C	30 µm	**713631.0100**	**713631.1**
NUCLEODUR® 100-50 C_{18} ec	yes	17.5% C	50 µm	**713550.0100**	**713550.1**
Unmodified NUCLEODUR® silica (see page 142)					
NUCLEODUR® 100-10			10 µm	**713610.0100**	**713610.1**
NUCLEODUR® 100-12			12 µm	**713615.0100**	**713615.1**
NUCLEODUR® 100-16			16 µm	**713620.0100**	**713620.1**
NUCLEODUR® 100-20			20 µm	**713600.0100**	**713600.1**
NUCLEODUR® 100-30			30 µm	**713630.0100**	**713630.1**
NUCLEODUR® 100-50			50 µm	**713551.0100**	**713551.1**

NUCLEOSIL® bulk packings

- Spherical silica
- pH stability 2–8 (for NUCLEOSIL® 100–5 C_{18} AB 1–9)
- For characterization of our NUCLEOSIL® silica see page 154

Physical properties of unmodified NUCLEOSIL® materials

Phase	Pore size	Pore volume	Surface (BET)	Density	Pressure stability*
NUCLEOSIL® 50	50 Å	0.8 mL/g	420 m^2/g	0.45 g/mL	500 bar
NUCLEOSIL® 100	100 Å	1 mL/g	350 m^2/g	0.36 g/mL	500 bar
NUCLEOSIL® 120	120 Å	0.65 mL/g	200 m^2/g	0.55 g/mL	500 bar
NUCLEOSIL® 300	300 Å	0.8 mL/g	100 m^2/g	0.45 g/mL	400 bar
NUCLEOSIL® 500	500 Å	0.8 mL/g	35 m^2/g	0.45 g/mL	400 bar
NUCLEOSIL® 1000	1000 Å	0.8 mL/g	25 m^2/g	0.45 g/mL	300 bar
NUCLEOSIL® 4000	4000 Å	0.7 mL/g	10 m^2/g	0.48 g/mL	300 bar

For description of individual modifications see chapter "Columns with NUCLEOSIL®" from page 157.
* Maximum packing pressure of NUCLEOSIL® bulk packings

Ordering information

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 10 g	Pack of 100 g
Octadecyl phases						$-(CH_2)_{17}-CH_3$
NUCLEOSIL® 50–5 C_{18} ec	yes	14.5 % C	50 Å	5 µm	**712031.10**	**712031.100**
NUCLEOSIL® 100–5 C_{18} AB	yes	24 % C	100 Å	5 µm	**712952.10**	**712952.100**
NUCLEOSIL® 100–3 C_{18}	yes	15 % C	100 Å	3 µm	**712370.10**	**712370.100**
NUCLEOSIL® 100–5 C_{18}	yes	15 % C	100 Å	5 µm	**712130.10**	**712130.100**
NUCLEOSIL® 100–7 C_{18}	yes	15 % C	100 Å	7 µm	**712140.10**	**712140.100**
NUCLEOSIL® 100–10 C_{18}	yes	15 % C	100 Å	10 µm	**712150.10**	**712150.100**
NUCLEOSIL® 120–3 C_{18}	yes	11 % C	120 Å	3 µm	**712460.10**	**712460.100**
NUCLEOSIL® 120–5 C_{18}	yes	11 % C	120 Å	5 µm	**712470.10**	**712470.100**
NUCLEOSIL® 120–7 C_{18}	yes	11 % C	120 Å	7 µm	**712480.10**	**712480.100**
NUCLEOSIL® 120–10 C_{18}	yes	11 % C	120 Å	10 µm	**712490.10**	**712490.100**
NUCLEOSIL® 300–5 C_{18}	yes	6.5 % C	300 Å	5 µm	**712520.10**	**712520.100**
NUCLEOSIL® 300–7 C_{18}	yes	6.5 % C	300 Å	7 µm	**712530.10**	**712530.100**
NUCLEOSIL® 300–10 C_{18}	yes	6.5 % C	300 Å	10 µm	**712540.10**	**712540.100**
NUCLEOSIL® 500–7 C_{18}	yes	2 % C	500 Å	7 µm	**712760.10**	**712760.100**
NUCLEOSIL® 1000–7 C_{18}	yes	~ 1 % C	1000 Å	7 µm	**712790.10**	**712790.100**
NUCLEOSIL® 4000–7 C_{18}	yes	<1 % C	4000 Å	7 µm	**712926.10**	**712926.100**
Octyl phases						$-(CH_2)_7-CH_3$
NUCLEOSIL® 50–5 C_8 ec	yes	9 % C	50 Å	5 µm	**712032.10**	**712032.100**
NUCLEOSIL® 100–5 C_8 ec	yes	9 % C	100 Å	5 µm	**712101.10**	**712101.100**
NUCLEOSIL® 100–5 C_8	no	8.5 % C	100 Å	5 µm	**712100.10**	**712100.100**
NUCLEOSIL® 100–7 C_8	no	8.5 % C	100 Å	7 µm	**712110.10**	**712110.100**
NUCLEOSIL® 100–10 C_8	no	8.5 % C	100 Å	10 µm	**712120.10**	**712120.100**
NUCLEOSIL® 120–3 C_8	no	6.5 % C	120 Å	3 µm	**712570.10**	**712570.100**
NUCLEOSIL® 120–5 C_8	no	6.5 % C	120 Å	5 µm	**712580.10**	**712580.100**
NUCLEOSIL® 120–7 C_8	no	6.5 % C	120 Å	7 µm	**712500.10**	**712500.100**
NUCLEOSIL® 120–10 C_8	no	6.5 % C	120 Å	10 µm	**712590.10**	**712590.100**
NUCLEOSIL® 300–5 C_8	no	~ 3 % C	300 Å	5 µm	**712650.10**	**712650.100**
NUCLEOSIL® 300–7 C_8	no	~ 3 % C	300 Å	7 µm	**712550.10**	**712550.100**
NUCLEOSIL® 300–10 C_8	no	~ 3 % C	300 Å	10 µm	**712660.10**	**712660.100**
NUCLEOSIL® 500–7 C_8	no	<1 % C	500 Å	7 µm	**712830.10**	**712830.100**

NUCLEOSIL® standard silica for HPLC

Packings for liquid chromatography

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 10 g	Pack of 100 g
Phenyl phases						$-(CH_2)_3-C_6H_5$
NUCLEOSIL® 100-5 C_6H_5 ec	yes	8% C	100 Å	5 µm	**712311.10**	**712311.100**
NUCLEOSIL® 100-5 C_6H_5	no	8% C	100 Å	5 µm	**712310.10**	**712310.100**
NUCLEOSIL® 100-7 C_6H_5	no	8% C	100 Å	7 µm	**712340.10**	**712340.100**
NUCLEOSIL® 120-7 C_6H_5	no	6.5% C	120 Å	7 µm	**712510.10**	**712510.100**
NUCLEOSIL® 300-7 C_6H_5	no	~ 3% C	300 Å	7 µm	**712670.10**	**712670.100**
NUCLEOSIL® 500-7 C_6H_5	no	~ 2% C	500 Å	7 µm	**712923.10**	**712923.100**
NUCLEOSIL® 1000-7 C_6H_5	no	~ 1% C	1000 Å	7 µm	**712924.10**	**712924.100**
Butyl phases						$-(CH_2)_3-CH_3$
NUCLEOSIL® 120-5 C_4	yes	~ 4% C	120 Å	5 µm	**712290.10**	**712290.100**
NUCLEOSIL® 300-5 C_4	yes	~ 2% C	300 Å	5 µm	**712620.10**	**712620.100**
NUCLEOSIL® 300-7 C_4	yes	~ 2% C	300 Å	7 µm	**712630.10**	**712630.100**
NUCLEOSIL® 300-10 C_4	yes	~ 2% C	300 Å	10 µm	**712640.10**	**712640.100**
NUCLEOSIL® 500-7 C_4	yes	<1% C	500 Å	7 µm	**712750.10**	**712750.100**
NUCLEOSIL® 1000-7 C_4	yes	<1% C	1000 Å	7 µm	**712780.10**	**712780.100**
NUCLEOSIL® 4000-7 C_4	yes	<1% C	4000 Å	7 µm	**712925.10**	**712925.100**
Dimethyl phases						$-(CH_3)_2$
NUCLEOSIL® 100-7 C_2	no	3.5% C	100 Å	7 µm	**712080.10**	**712080.100**
Cyano phases (nitrile)						$-(CH_2)_3-CN$
NUCLEOSIL® 100-5 CN		5% C	100 Å	5 µm	**712160.10**	**712160.100**
NUCLEOSIL® 100-10 CN		5% C	100 Å	10 µm	**712170.10**	**712170.100**
NUCLEOSIL® 120-7 CN		~ 3% C	120 Å	7 µm	**712600.10**	**712600.100**
NUCLEOSIL® 300-7 CN		~ 2.5% C	300 Å	7 µm	**712820.10**	**712820.100**
NUCLEOSIL® 500-7 CN		~ 2% C	500 Å	7 µm	**712840.10**	**712840.100**
Nitro phases						$-(CH_2)_3-C_6H_4-NO_2$
NUCLEOSIL® 100-5 NO_2		~ 4.5% C	100 Å	5 µm	**712180.10**	**712180.100**
NUCLEOSIL® 100-10 NO_2		~ 4.5% C	100 Å	10 µm	**712190.10**	**712190.100**
Diol phases						$-(CH_2)_3-O-CH_2-CH(OH)-CH_2OH$
NUCLEOSIL® 100-7 OH (Diol)		5% C	100 Å	7 µm	**712350.10**	**712350.100**
NUCLEOSIL® 300-7 OH (Diol)		~ 1.5% C	300 Å	7 µm	**712560.10**	**712560.100**
NUCLEOSIL® 500-7 OH (Diol)		~ 1.5% C	500 Å	7 µm	**712740.10**	**712740.100**
NUCLEOSIL® 1000-7 OH (Diol)		~ 1% C	1000 Å	7 µm	**712770.10**	**712770.100**
NUCLEOSIL® 4000-7 OH (Diol)		~ 1% C	4000 Å	7 µm	**712927.10**	**712927.100**
Amino phases						$-(CH_2)_3-NH_2$
NUCLEOSIL® 100-5 NH_2		3.5% C	100 Å	5 µm	**712200.10**	**712200.100**
NUCLEOSIL® 100-10 NH_2		3.5% C	100 Å	10 µm	**712210.10**	**712210.100**
NUCLEOSIL® 120-7 NH_2		~ 2% C	120 Å	7 µm	**712610.10**	**712610.100**
NUCLEOSIL® 300-7 NH_2		~ 2% C	300 Å	7 µm	**712919.10**	**712919.100**
Dimethylamino phases						$-(CH_2)_3-N(CH_3)_2$
NUCLEOSIL® 100-5 $N(CH_3)_2$		4% C	100 Å	5 µm	**712220.10**	**712220.100**
NUCLEOSIL® 100-10 $N(CH_3)_2$		4% C	100 Å	10 µm	**712230.10**	**712230.100**
Cation exchanger, strongly acidic (SCX)						$-(CH_2)_3-C_6H_4-SO_3\ Na$
NUCLEOSIL® 100-5 SA		6.5% C	100 Å	5 µm	**712240.10**	**712240.100**
NUCLEOSIL® 100-10 SA		6.5% C	100 Å	10 µm	**712250.10**	**712250.100**

NUCLEOSIL® standard silica for HPLC

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 10 g	Pack of 100 g
Anion exchanger, strongly basic (SAX)					$-(CH_2)_3-C_6H_4-CH_2-N^+(CH_3)_3Cl^-$	
NUCLEOSIL® 100-5 SB		10 % C	100 Å	5 µm	**712260.10**	**712260.100**
NUCLEOSIL® 100-10 SB		10 % C	100 Å	10 µm	**712270.10**	**712270.100**
Unmodified silica					**SiOH**	
NUCLEOSIL® 50-3			50 Å	3 µm	**712000.10**	**712000.100**
NUCLEOSIL® 50-5			50 Å	5 µm	**712010.10**	**712010.100**
NUCLEOSIL® 50-7			50 Å	7 µm	**712020.10**	**712020.100**
NUCLEOSIL® 50-10			50 Å	10 µm	**712030.10**	**712030.100**
NUCLEOSIL® 100-3			100 Å	3 µm	**712360.10**	**712360.100**
NUCLEOSIL® 100-5			100 Å	5 µm	**712040.10**	**712040.100**
NUCLEOSIL® 100-7			100 Å	7 µm	**712050.10**	**712050.100**
NUCLEOSIL® 100-10			100 Å	10 µm	**712060.10**	**712060.100**
NUCLEOSIL® 120-3			120 Å	3 µm	**712390.10**	**712390.100**
NUCLEOSIL® 120-5			120 Å	5 µm	**712400.10**	**712400.100**
NUCLEOSIL® 120-7			120 Å	7 µm	**712410.10**	**712410.100**
NUCLEOSIL® 120-10			120 Å	10 µm	**712420.10**	**712420.100**
NUCLEOSIL® 300-5			300 Å	5 µm	**712430.10**	**712430.100**
NUCLEOSIL® 300-7			300 Å	7 µm	**712440.10**	**712440.100**
NUCLEOSIL® 300-10			300 Å	10 µm	**712450.10**	**712450.100**
NUCLEOSIL® 500-5			500 Å	5 µm	**712680.10**	**712680.100**
NUCLEOSIL® 500-7			500 Å	7 µm	**712690.10**	**712690.100**
NUCLEOSIL® 500-10			500 Å	10 µm	**712700.10**	**712700.100**
NUCLEOSIL® 1000-5			1000 Å	5 µm	**712710.10**	**712710.100**
NUCLEOSIL® 1000-7			1000 Å	7 µm	**712720.10**	**712720.100**
NUCLEOSIL® 1000-10			1000 Å	10 µm	**712730.10**	**712730.100**
NUCLEOSIL® 4000-5			4000 Å	5 µm	**712850.10**	**712850.100**
NUCLEOSIL® 4000-7			4000 Å	7 µm	**712860.10**	**712860.100**
NUCLEOSIL® 4000-10			4000 Å	10 µm	**712870.10**	**712870.100**

POLYGOSIL® bulk packings

- Irregular silica for analytical applications
- pH stability 2–8

Physical properties of unmodified POLYGOSIL® materials

Phase	Pore size	Pore volume	Surface (BET)	Density	Pressure stability
POLYGOSIL® 60	60 Å	0.75 mL/g	350 m^2/g	0.45 g/mL	600 bar
POLYGOSIL® 100	100 Å	1 mL/g	280 m^2/g	0.35 g/mL	400 bar
POLYGOSIL® 300	300 Å	0.8 mL/g	100 m^2/g	0.45 g/mL	400 bar
POLYGOSIL® 1000	1000 Å	0.8 mL/g	25 m^2/g	0.45 g/mL	300 bar

Modification of POLYGOSIL® follows the same processes as for NUCLEOSIL® silica.

POLYGOSIL® irregular silica for HPLC

Ordering information

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 10 g	Pack of 100 g
Octadecyl phases						**$-(CH_2)_{17}-CH_3$**
POLYGOSIL® 60-5 C_{18}	yes	12% C	60 Å	5 µm	**711330.10**	**711330.100**
POLYGOSIL® 60-7 C_{18}	yes	12% C	60 Å	7 µm	**711340.10**	**711340.100**
POLYGOSIL® 60-10 C_{18}	yes	12% C	60 Å	10 µm	**711350.10**	**711350.100**
POLYGOSIL® 100-5 C_{18}	yes	14% C	100 Å	5 µm	**711560.10**	**711560.100**
POLYGOSIL® 100-7 C_{18}	yes	14% C	100 Å	7 µm	**711570.10**	**711570.100**
POLYGOSIL® 100-10 C_{18}	yes	14% C	100 Å	10 µm	**711580.10**	**711580.100**
POLYGOSIL® 300-7 C_{18}	yes	4% C	300 Å	7 µm	**711710.10**	**711710.100**
POLYGOSIL® 1000-7 C_{18}	yes	~ 1% C	1000 Å	7 µm	**711992.10**	**711992.100**
Octyl phases						**$-(CH_2)_7-CH_3$**
POLYGOSIL® 60-5 C_8	no	7% C	60 Å	5 µm	**711300.10**	**711300.100**
POLYGOSIL® 60-7 C_8	no	7% C	60 Å	7 µm	**711310.10**	**711310.100**
POLYGOSIL® 60-10 C_8	no	7% C	60 Å	10 µm	**711320.10**	**711320.100**
Butyl phases						**$-(CH_2)_3-CH_3$**
POLYGOSIL® 300-7 C_4	yes	~ 1% C	300 Å	7 µm	**711680.10**	**711680.100**
POLYGOSIL® 1000-7 C_4	yes	< 1% C	1000 Å	7 µm	**711991.10**	**711991.100**
Cyano phases (nitrile)						**$-(CH_2)_3-CN$**
POLYGOSIL® 60-5 CN		~ 5% C	60 Å	5 µm	**711380.10**	**711380.100**
POLYGOSIL® 60-10 CN		~ 5% C	60 Å	10 µm	**711390.10**	**711390.100**
Nitro phases						**$-(CH_2)_3-C_6H_4-NO_2$**
POLYGOSIL® 60-5 NO_2		~ 4.5% C	60 Å	5 µm	**711400.10**	**711400.100**
POLYGOSIL® 60-10 NO_2		~ 4.5% C	60 Å	10 µm	**711410.10**	**711410.100**
Unmodified silica						**SiOH**
POLYGOSIL® 60-5			60 Å	5 µm	**711010.10**	**711010.100**
POLYGOSIL® 60-7			60 Å	7 µm	**711280.10**	**711280.100**
POLYGOSIL® 60-10			60 Å	10 µm	**711020.10**	**711020.100**
POLYGOSIL® 100-5			100 Å	5 µm	**711510.10**	**711510.100**
POLYGOSIL® 100-7			100 Å	7 µm	**711520.10**	**711520.100**
POLYGOSIL® 100-10			100 Å	10 µm	**711530.10**	**711530.100**
POLYGOSIL® 300-7			300 Å	7 µm	**711600.10**	**711600.100**
POLYGOSIL® 1000-7			1000 Å	7 µm	**711890.10**	**711890.100**
Amino phases						**$-(CH_2)_3-NH_2$**
POLYGOSIL® 60-5 NH_2		~ 3% C	60 Å	5 µm	**711360.10**	**711360.100**
POLYGOSIL® 60-10 NH_2		~ 3% C	60 Å	10 µm	**711370.10**	**711370.100**
Dimethylamino phases						**$-(CH_2)_3-N(CH_3)_2$**
POLYGOSIL® 60-5 $N(CH_3)_2$		~ 3.5% C	60 Å	5 µm	**711420.10**	**711420.100**
POLYGOSIL® 60-10 $N(CH_3)_2$		~ 3.5% C	60 Å	10 µm	**711430.10**	**711430.100**

POLYGOPREP bulk packings

- Irregular silica for preparative applications
- pH stability 2–8

Physical properties of unmodified POLYGOPREP materials

Phase	Pore size	Pore volume	Surface (BET)	Density	Pressure stability
POLYGOPREP 60	60 Å	0.75 mL/g	350 m^2/g	0.45 g/mL	600 bar
POLYGOPREP 100	100 Å	1 mL/g	280 m^2/g	0.35 g/mL	400 bar
POLYGOPREP 300	300 Å	0.8 mL/g	100 m^2/g	0.45 g/mL	400 bar
POLYGOPREP 1000	1000 Å	0.8 mL/g	35 m^2/g	0.45 g/mL	300 bar

Modification of POLYGOPREP follows the same processes as for NUCLEOSIL® silica.

Ordering information

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 100 g	Pack of 1 kg
Octadecyl phases						$-(CH_2)_{17}-CH_3$
POLYGOPREP 60-12 C_{18}	no*	12 % C	60 Å	10–15 µm	**711009.100**	**711009.1000**
POLYGOPREP 60-20 C_{18}	no*	12 % C	60 Å	15–25 µm	**711031.100**	**711031.1000**
POLYGOPREP 60-30 C_{18}	no*	12 % C	60 Å	25–40 µm	**711480.100**	**711480.1000**
POLYGOPREP 60-50 C_{18}	no*	12 % C	60 Å	40–63 µm	**711500.100**	**711500.1000**
POLYGOPREP 60-80 C_{18}	no*	12 % C	60 Å	63–100 µm	**711011.100**	**711011.1000**
POLYGOPREP 60-130 C_{18}	no*	12 % C	60 Å	63–200 µm	**711590.100**	**711590.1000**
POLYGOPREP 100-12 C_{18}	no*	14 % C	100 Å	10–15 µm	**711018.100**	**711018.1000**
POLYGOPREP 100-20 C_{18}	no*	14 % C	100 Å	15–25 µm	**711019.100**	**711019.1000**
POLYGOPREP 100-30 C_{18}	no*	14 % C	100 Å	25–40 µm	**711032.100**	**711032.1000**
POLYGOPREP 100-50 C_{18}	no*	14 % C	100 Å	40–63 µm	**711021.100**	**711021.1000**
POLYGOPREP 300-12 C_{18}	yes	4 % C	300 Å	10–15 µm	**711024.100**	**711024.1000**
POLYGOPREP 300-20 C_{18}	yes	4 % C	300 Å	15–25 µm	**711025.100**	**711025.1000**
POLYGOPREP 300-30 C_{18}	yes	4 % C	300 Å	25–40 µm	**711720.100**	**711720.1000**
POLYGOPREP 300-50 C_{18}	yes	4 % C	300 Å	40–63 µm	**711730.100**	**711730.1000**
POLYGOPREP 1000-30 C_{18}	yes	~ 1 % C	1000 Å	25–40 µm	**711028.100**	**711028.1000**
POLYGOPREP 1000-50 C_{18}	yes	~ 1 % C	1000 Å	40–63 µm	**711029.100**	**711029.1000**
Octyl phases						$-(CH_2)_7-CH_3$
POLYGOPREP 60-12 C_8	no*	7 % C	60 Å	10–15 µm	**711007.100**	**711007.1000**
POLYGOPREP 60-20 C_8	no*	7 % C	60 Å	15–25 µm	**711008.100**	**711008.1000**
POLYGOPREP 60-30 C_8	no*	7 % C	60 Å	25–40 µm	**711470.100**	**711470.1000**
POLYGOPREP 60-50 C_8	no*	7 % C	60 Å	40–63 µm	**711490.100**	**711490.1000**
Butyl phases						$-(CH_2)_3-CH_3$
POLYGOPREP 300-12 C_4	yes	~ 1 % C	300 Å	10–15 µm	**711022.100**	**711022.1000**
POLYGOPREP 300-20 C_4	yes	~ 1 % C	300 Å	15–25 µm	**711023.100**	**711023.1000**
POLYGOPREP 300-30 C_4	yes	~ 1 % C	300 Å	25–40 µm	**711690.100**	**711690.1000**
POLYGOPREP 300-50 C_4	yes	~ 1 % C	300 Å	40–63 µm	**711700.100**	**711700.1000**
POLYGOPREP 1000-30 C_4	yes	< 1 % C	1000 Å	25–40 µm	**711026.100**	**711026.1000**
POLYGOPREP 1000-50 C_4	yes	< 1 % C	1000 Å	40–63 µm	**711027.100**	**711027.1000**
* On request, these POLYGOPREP RP phases can be endcapped at surcharge.						
Cyano phases (nitrile)						$-(CH_2)_3-CN$
POLYGOPREP 60-12 CN		~ 4.5 % C	60 Å	10–15 µm	**711015.100**	**711015.1000**
POLYGOPREP 60-20 CN		~ 4.5 % C	60 Å	15–25 µm	**711016.100**	**711016.1000**
POLYGOPREP 60-30 CN		~ 4.5 % C	60 Å	25–40 µm	**711017.100**	**711017.1000**

POLYGOPREP irregular silica for HPLC

Phase	Endcapped	Carbon content	Pore size	Particle size	Pack of 100 g	Pack of 1 kg
Amino phases						**$-(CH_2)_3-NH_2$**
POLYGOPREP 60-12 NH_2		~ 3% C	60 Å	10-15 µm	**711012.100**	**711012.1000**
POLYGOPREP 60-20 NH_2		~ 3% C	60 Å	15-25 µm	**711013.100**	**711013.1000**
POLYGOPREP 60-30 NH_2		~ 3% C	60 Å	25-40 µm	**711014.100**	**711014.1000**

Phase	Pore size	Particle size	Pack of 100 g	Pack of 1 kg	Pack of 5 kg
Unmodified POLYGOPREP silica					**SiOH**
POLYGOPREP 60-12	60 Å	10-15 µm		**711001.1000**	**711001.5000**
POLYGOPREP 60-20	60 Å	15-25 µm		**711240.1000**	**711240.5000**
POLYGOPREP 60-30	60 Å	25-40 µm		**711250.1000**	**711250.5000**
POLYGOPREP 60-50	60 Å	40-63 µm		**711260.1000**	**711260.5000**
POLYGOPREP 60-80	60 Å	63-100 µm		**711270.1000**	**711270.5000**
POLYGOPREP 60-130	60 Å	63-200 µm		**711037.1000**	**711037.5000**
POLYGOPREP 100-12	100 Å	10-15 µm		**711002.1000**	**711002.5000**
POLYGOPREP 100-20	100 Å	15-25 µm		**711003.1000**	**711003.5000**
POLYGOPREP 100-30	100 Å	25-40 µm		**711540.1000**	**711540.5000**
POLYGOPREP 100-50	100 Å	40-63 µm		**711550.1000**	**711550.5000**
POLYGOPREP 100-80	100 Å	63-100 µm		**711033.1000**	**711033.5000**
POLYGOPREP 100-130	100 Å	63-200 µm		**711034.1000**	**711034.5000**
POLYGOPREP 300-12	300 Å	10-15 µm	**711004.100**	**711004.1000**	
POLYGOPREP 300-20	300 Å	15-25 µm	**711610.100**	**711610.1000**	
POLYGOPREP 300-30	300 Å	25-40 µm	**711620.100**	**711620.1000**	
POLYGOPREP 300-50	300 Å	40-63 µm	**711630.100**	**711630.1000**	
POLYGOPREP 1000-12	1000 Å	10-15 µm	**711035.100**	**711035.1000**	
POLYGOPREP 1000-20	1000 Å	15-25 µm	**711036.100**	**711036.1000**	
POLYGOPREP 1000-30	1000 Å	25-40 µm	**711005.100**	**711005.1000**	
POLYGOPREP 1000-50	1000 Å	40-63 µm	**711006.100**	**711006.1000**	

Silica adsorbents for low pressure column chromatography

- Silica 60, pore size ~ 60 Å; pore volume ~ 0.75 mL/g; spec. surface BET ~ 500 m^2/g
  highly porous, amorphous silicic acid in the form of hard, opalescent particles, prepared by precipitation of water glass with sulfuric acid
- For higher demands on the performance of column packings we recommend our high-purity irregular POLYGOPREP silicas (see previous page).
- Silica FIA for the fluorescence indicator adsorption procedure for the determination of hydrocarbon groups in the testing of liquid fuels in accordance with DIN 51791 and ASTM D 1319-58T

  The FIA method determines saturated hydrocarbons, olefins and aromatic hydrocarbons of a sample chromatographically by adsorption and desorption in a column filled with FIA silica, in the presence of a fluorescent dye mixture.

Ordering information

Designation	Particle size	1 kg	5 kg	25 kg
Silica 60, 0.015–0.04 mm	–	**815650.1**	**815650.5**	**815650.25**
Silica 60, 0.025–0.04 mm	–	**815300.1**	**815300.5**	**815300.25**
Silica 60, 0.04–0.063 mm	230–400 mesh	**815380.1**	**815380.5**	**815380.25**
Silica 60 M, 0.04–0.063 mm	230–400 mesh	**815381.1**	**815381.5**	**815381.25**
Silica 60, 0.05–0.1 mm	130–270 mesh	**815390.1**	**815390.5**	**815390.25**
Silica 60, 0.05–0.2 mm	70–270 mesh	**815320.1**	**815320.5**	**815320.25**
Silica 60, 0.063–0.2 mm	70–230 mesh	**815330.1**	**815330.5**	**815330.25**
Silica 60, < 0.063 mm	+230 mesh	**815400.1**	**815400.5**	**815400.25**
Silica 60, < 0.08 mm	+190 mesh	**815310.1**	**815310.5**	**815310.25**
Silica 60, 0.1–0.2 mm	70–130 mesh	**815340.1**	**815340.5**	
Silica 60, 0.2–0.5 mm	35–70 mesh	**815350.1**	**815350.5**	**815350.25**
Silica 60, 0.5–1.0 mm	18–35 mesh	**815360.1**	**815360.5**	**815360.25**
Silica FIA fine	0.071–0.16 mm	**815410.1**		
Silica FIA coarse	0.071–0.63 mm	**815430.1**		

Aluminium oxide

- Aluminium oxides produced by dehydration of different aluminium hydroxides, e.g., hydrargillite between 400 and 500 °C
- Activity grade I, particle size 50–200 µm, specific surface (BET) ~ 130 m^2/g

Ordering information

Type	pH	1 kg	5 kg	25 kg
Aluminium oxide 90 basic	pH 9.5 ± 0.3	**815010.1**	**815010.5**	**815010.25**
Aluminium oxide 90 neutral	pH 7 ± 0.5	**815020.1**	**815020.5**	**815020.25**
Aluminium oxide 90 acidic	pH 4 ± 0.3	**815030.1**	**815030.5**	**815030.25**

Kieselguhr

- Naturally occurring amorphous silicic acids of fossil origin, also known as diatomaceous earth or diatomite purified for chromatographic applications
- Compared to silica, kieselguhr has a small surface of low activity → application in partition chromatography; impregnated with various substances (paraffin, silicone oil, undecane) it can be used for reversed phase chromatography
- The following grades of kieselguhr are manufactured by Johns-Manville. They are narrowly classified with homogeneous particle size distributions and high purity.

For columns packed with kieselguhr please see CHROMABOND® XTR for liquid-liquid extraction, page 56.

Ordering information

Designation	rel. purification factor	rel. flow rate	1 kg	5 kg
Filter-Cel	100	100	**815510.1**	**815510.5**
Hyflo Super-Cel	58	534	**815530.1**	**815530.5**
Celite 503	42	910	**815540.1**	**815540.5**
Celite 535	35	1269	**815550.1**	**815550.5**
Celite 545	32	1830	**815560.1**	**815560.5**

Adsorbents for column chromatography

Florisil®

- Hard granular magnesia silica gel: MgO 15.5 ± 0.5 % · SiO_2 84.0 ± 0.5 % · Na_2SO_4 ≤ 1.0 %; 60/100 mesh
  Typical applications: sample preparation (see chapter "Solid phase extraction", page 34); clean-up of pesticide residues, separation of chlorinated pesticides, extraction of steroids, sex hormones, antibiotics, lipids etc.

Ordering information

Designation	Particle size	1 kg	5 kg
Florisil® standard 60/100 mesh	0.15/0.25 mm	**815710.1**	**815710.5**

Polyamide

- Polyamide 6 = ε-aminopolycaprolactam
  separation mechanism mainly based on hydrogen bonds
- **Recommended application:** separation of phenolic compounds (e.g., isolation of natural products), carboxylic acids, aromatic nitro compounds

For SPE columns packed with polyamide see CHROMABOND® PA page 34.

Ordering information

Designation	Particle size	1 kg
Polyamide CC 6, < 0.07 mm	< 0.07 mm	**815610.1**
Polyamide CC 6, 0.05–0.16 mm	0.05–0.16 mm	**815620.1**
Polyamide CC 6, 0.10–0.30 mm	0.10–0.30 mm	**815600.1**

Unmodified cellulose

- **Cellulose MN 100:** native fibrous cellulose, standard grade
  average degree of polymerization 620–680, fiber length (85 %) 20–100 µm,
  specific surface acc. to Blaine ~ 6500 cm^2/g; residue on ignition at 850 °C < 10000 ppm,
  < 20 ppm Fe, < 5 ppm Cu, < 7 ppm P, CH_2Cl_2 extract < 0.20 %
- **Cellulose MN 2100:** native fibrous cellulose, purified grade (washed with different eluents)
  average degree of polymerization 620–680, fiber length (85 %) 20–75 µm,
  specific surface acc. to Blaine ~ 5500 cm^2/g
  residue on ignition at 850 °C < 1000 ppm, < 2 ppm Fe, < 1 ppm Cu, < 2 ppm P, CH_2Cl_2 extract < 0.15 %
  Grade MN 2100ff is a defatted cellulose MN 2100 with a CH_2Cl_2 extract < 0.02 %

Ordering information

Designation	1 kg	5 kg	25 kg
Cellulose MN 100	**815050.1**	**815050.5**	**815050.25**
Cellulose MN 2100	**815060.1**	**815060.5**	**815060.25**
Cellulose MN 2100ff (cellulose MN 2100 defatted)	**815070.1**		