TSKgel HILIC COLUMNS

HILIC
HYDROPHILIC INTERACTION LIQUID CHROMATOGRAPHY

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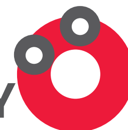
TOSOH HISTORY

1935	Founding of Toyo Soda Manufacturing Co., Ltd.
1936	Operation of Nanyo Manufacturing Complex begins
1971	First TSKgel GPC column developed
1974	HPLC Column Plant starts production
1977	First silica based TSKgel SW column for protein analysis
1979	Tosoh develops TOYOPEARL media
1987	TSKgel SW_{XL} for size exclusion chromatography of proteins introduced
1995	Tosoh Nanyo gel factory receives ISO9001
1997	Reaching the milestone of 10 000 TSKgel $G3000SW_{XL}$ columns
2008	TSKgel STAT ion exchange columns introduced
2013	High capacity TOYOPEARL Protein A resin for antibody purification introduced
2014	TOSOH Bioscience GmbH celebrates its 25th anniversary
2015	TSKgel UP-SW3000 SE-UHPLC columns allow method transfer from TSKgel SW_{XL}
2016	Protein A column for fast mAb titer determination
2017	Construction of a new R & D laboratory center announced

HILIC
HYDROPHILIC INTERACTION LIQUID CHROMATOGRAPHY



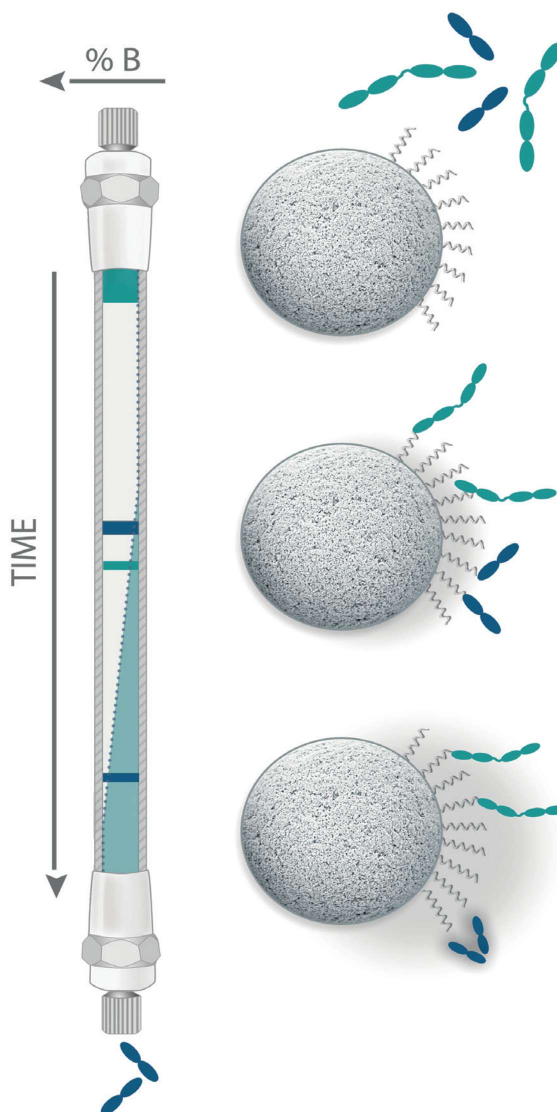
Hydrophilic interaction liquid chromatography (HILIC) is used primarily for the separation of polar and hydrophilic compounds. HILIC stationary phases are polar, similar to normal phase chromatography (NPC), but mobile phases are similar to reversed phase chromatography (RPC). Typical mobile phases are aqueous buffers with organic modifiers - primarily acetonitrile - applied in isocratic or gradient mode. In contrast to RPC, water has the highest elution power in HILIC mode. Therefore HILIC gradients usually start with a high percentage of acetonitrile. Typical HILIC stationary phases are silica or polymer particles carrying polar functional groups, e.g. hydroxyl, carbamoyl, amino or zwitterionic groups.

Analysis of glycans, carbohydrates, peptides, polar drugs and metabolites, vitamins and other hydrophilic compounds are typical HILIC applications. HILIC is ideally suited for mass spectrometric analysis of water soluble polar compounds, because the high organic content in the mobile phase increases MS detection sensitivity. While using similar eluent systems HILIC and reversed phase can also be combined for two-dimensional liquid chromatography (2D-LC).
Tosoh Corporation employs state-of-the-art manufacturing techniques that result in uniformly bonded packing materials with narrow pore size distributions and well-defined particle sizes to ensure high performance. Silica based TSKgel Amide-80 and NH_2-100 HILIC columns enable the user to solve the most complex separation problems.

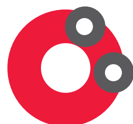
HIGHLIGHTS

- HILIC offers orthogonal selectivity to reversed phase chromatography
- Covalently bonded carbamoyl and amino phases expand selectivity options
- TSKgel NH_2-100 columns show superior stability compared to conventional amino phases
- TSKgel Amide-80 columns provide unique retention mechanism for saccharide analysis
- Superior resolution and sensitivity for UHPLC and HPLC with 2 µm particle size

HILIC ILLUSTRATION



MORE INFORMATION ON bit.ly/TSKgelHILIC



HILIC HOW IT WORKS

It is commonly believed that in HILIC the aqueous content of the mobile phase creates a water rich layer on the surface of the stationary phase. This allows for partitioning of solutes between the more organic mobile phase and the aqueous layer. Hydrogen bonding and dipole-dipole interactions have been supposed to be the dominating retention mechanisms in HILIC mode (Figure 1).

The number of polar groups, as well as the conformation and solubility of the sample in the mobile phase determine the elution order. Since the retention is also related to the type of functional groups of the stationary phase, it varies between different HILIC phases. Compared to RPC the elution order in HILIC mode is inversed for most compounds. Figure 2 gives an example for the differences in selectivity of HILIC and RPC. Peptides were separated by C18 and HILIC columns of the same dimensions using the same eluents but almost inverse gradients.

At low acetonitrile concentrations HILIC columns show a reversed phase mode of retention. The HILIC mode can only be executed when starting at high acetonitrile concentrations.

HILIC offers unique advantages for mass spectrometric detection of very polar compounds when compared to reversed phase mode. The higher organic content of the eluent in HILIC mode supports efficient evaporation of the solvent thus enhancing sensitivity and altering ion suppression.

In method development HILIC is an option as soon as polar compounds have to be analyzed and retention on reversed phase columns is too low. Since common RPC solvents can be used, TSKgel HILIC columns can be implemented in method development systems using automated column selection. A range of reversed phase columns differing in hydrophobicity or carrying polar embedded groups and one of the TSKgel HILIC column types should deliver an indication for the right direction of method development.

TSKgel HILIC columns are available in various dimensions and particles sizes, functionalized with carbamoyl- or amino-groups. This enables the user to perfectly match HILIC selectivity to specific separation needs.

FIGURE 1

HILIC PRINCIPLES

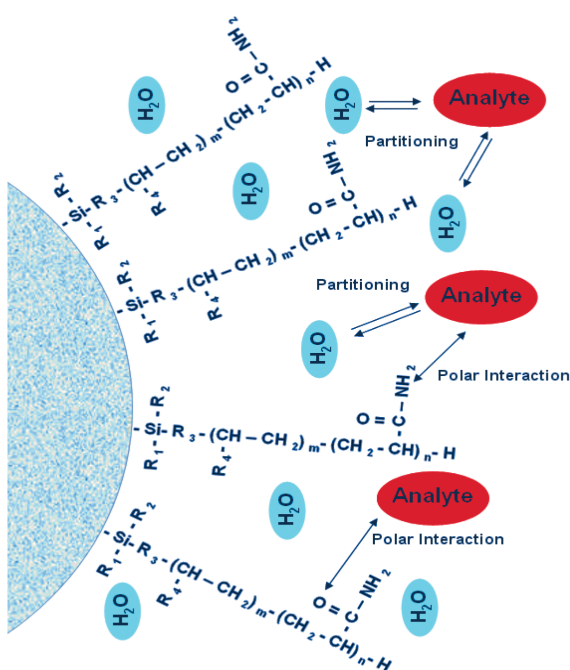
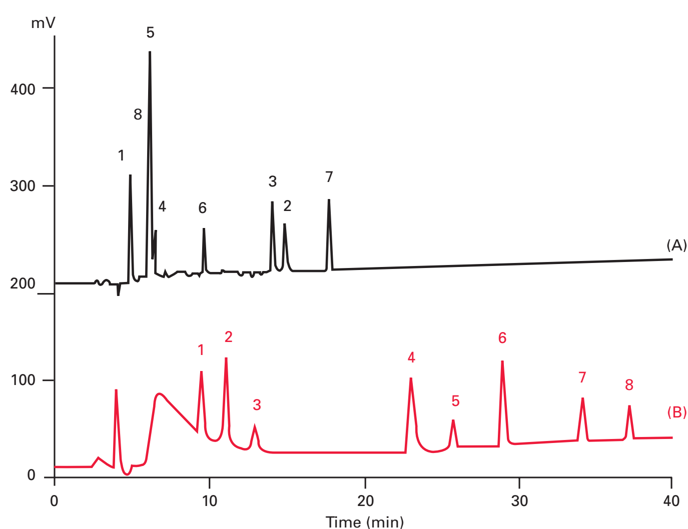


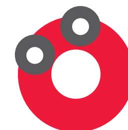
FIGURE 2

PEPTIDES SEPARATED BY RP CHROMATOGRAPHY AND HILIC



Columns:	(A) TSKgel ODS-80TS, 4.6 mm ID x 25 cm L
	(B) TSKgel Amide-80, 4.6 mm ID x 25 cm L
Sample:	1. PG; 2. LG; 3. FG; 4. EHP-NH2; 5. VGSQ; 6. GGYR; 7. WAGGDASGE; 8. DSDPR;
Mobile phase:	(A) 0.1 % TFA/ACN, linear gradient of 5 % - 55 % ACN in 83.3 min
	(B) 0.1 % TFA/ACN, linear gradient of 97 % - 55 % ACN in 70 min
Flow rate:	1 mL/min
Detection:	UV@215 nm

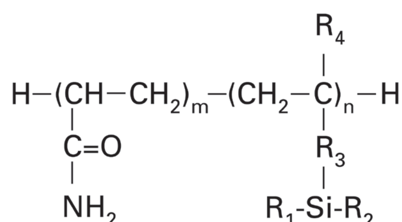
HILIC
TSKgel Amide-80

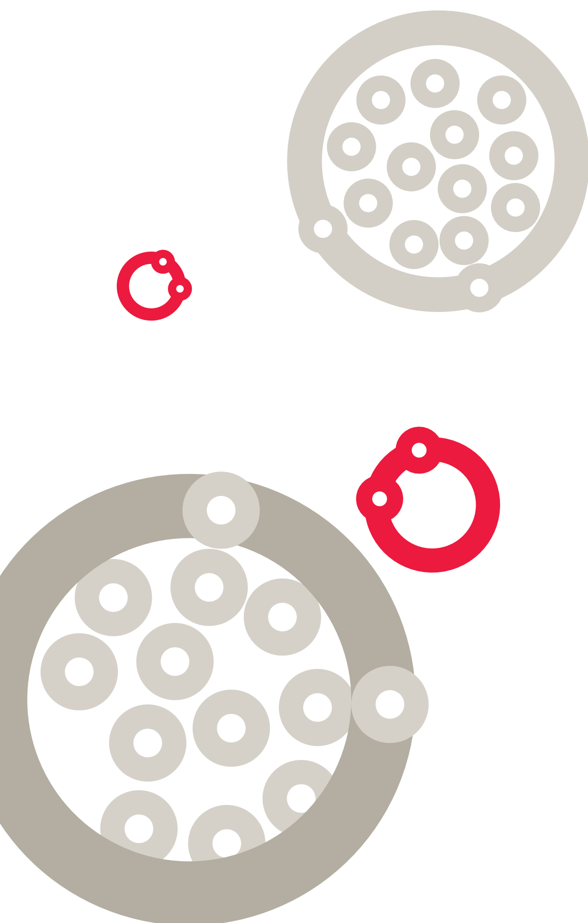


TSKgel Amide-80 stationary phase chemistry uses one of the most popular HILIC ligands, the carbamoyl group. TSKgel Amid-80 columns are packed with spherical silica particles that are covalently bonded with non-ionic carbamoyl groups (Figure 3). They provide a higher stability than conventional amino-phases and a unique selectivity for the analysis of carbohydrates. More than 250 scientific publications proof the successful use of TSKgel Amide-80 columns for the separation of polar compounds with HPLC, UHPLC, and LC-MS.

FIGURE 3

STRUCTURE OF TSKgel AMIDE-80





An important benefit of TSKgel Amide-80 for mass spectrometric as well as for evaporative light scattering detection is the virtual absence of column bleeding due to the covalently bonded functional groups.

TSKgel Amide-80 columns with 2 µm particle size suited for both HPLC and UHPLC systems are the latest addition to the Amide-80 series. TSKgel Amide-80 2 µm columns reduce analysis time and improve peak capacity and sensitivity for both, (U)HPLC and LC-MS analysis.

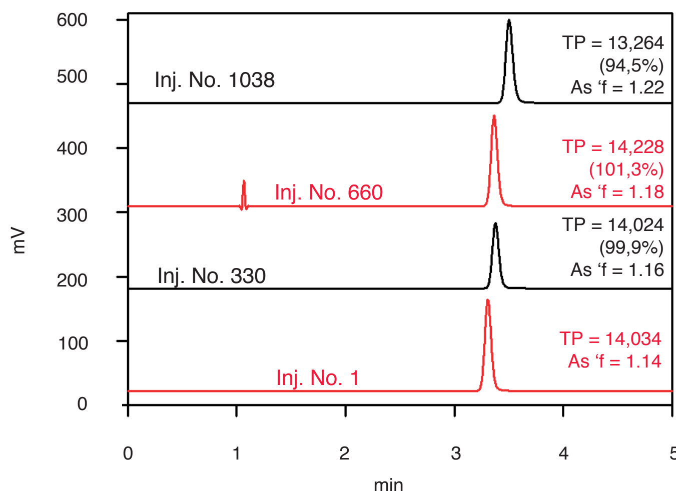
TSKgel Amide-80 LONG TERM STABILITY

The high stability of TSKgel Amide-80 columns is demonstrated in Figure 4 showing the same analysis after 330, 660 and more than 1000 runs compared to the first injection. Only 5% reduction of column performance (theoretical plates) is observed after more than 1000 injections.

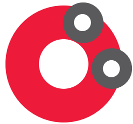
The versatility and robustness of TSKgel Amide-80 enables fast and efficient separation with extended column lifetime, needed for many applications in the food and pharmaceutical industry.

FIGURE 4

DURABILITY OF TSKGEL AMIDE-80 3 µm



Column:	TSKgel Amide-80 3 µm (2.0 mm ID x 15 cm L)
Mobile phase :	H_2O/CH_3CN = 15/85
Flow rate :	0.2 mL/min
Detection :	UV@254 nm
Temp. :	25 °C
Inj. volume :	2 µL
Sample:	Uracil (37 mg/L)



HILIC TSKgel Amide-80

INFLUENCE OF PARTICLE SIZE

Figure 5 shows the separation of sugar alcohols on a TSKgel Amide-80 3 µm column compared to a TSKgel Amide-80 5 µm column. Basically, the more hydroxyl groups in a compound the more polar it will be and the longer it will be retained on the column.

Comparison of the retention between mannitol and inositol, each with 6 hydroxyl groups, shows that inositol, which has a cyclic structure and lower solubility in the mobile phase, is retained longer. Overall the 3 µm column provides better resolution at reduced analysis time when compared to the 5 µm TSKgel Amide-80 column.

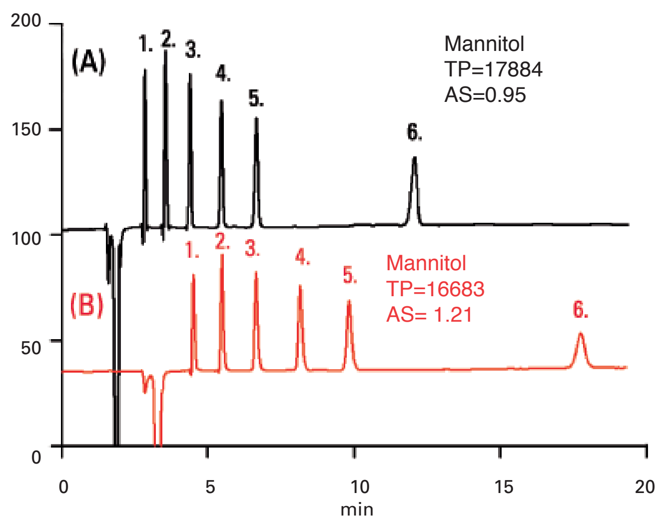
The new 2 µm TSKgel Amide-80 phase further improves peak capacity and sensitivity for both, (U)HPLC and LC-MS analysis. When using short columns this can be exploited to considerably shorten analysis time. The columns are especially suited for use in UHPLC systems, as their reduced system volume and optimized detector specifications help to maintain the high resolution that can be achieved with 2 micron columns.

Figure 6 shows the separation of standard samples on the new 2 µm packing compared to a conventional 3 µm TSKgel Amide-80 column. A 30% increase in resolution can be achieved when using the same method with the 2 µm material. The number of theoretical plates is increased by more than 60%.

MORE INFORMATION ON bit.ly/TSKgelAmide80

FIGURE 5

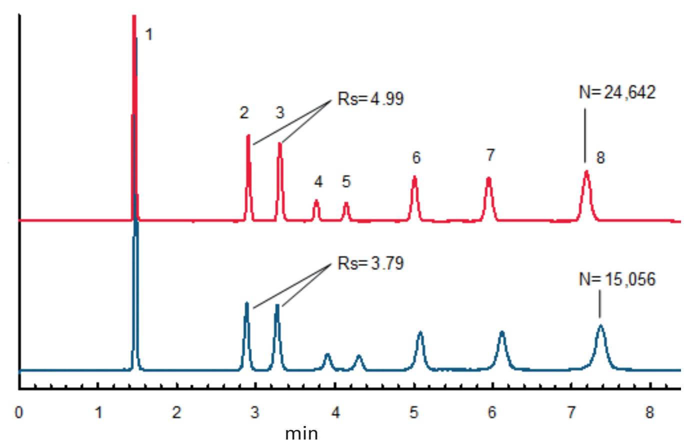
SEPARATION OF POLYALCOHOLS



Columns:	A) TSKgel Amide-80 3 µm (4.6 mm ID x 15 cm L)	
	B) TSKgel Amide-80 5 µm (4.6 mm ID x 25 cm L)	
Mobile phase:	H_2O/CH_3CN = 25/75	
Flow rate:	1.0 mL/min	
Detection:	Refractive index	
Temp.:	25 °C	
Inj. volume :	10 µL	
Sample:	1. Ethyleneglycol	2. Glycerin
	3. Erythritol	4. Xylitol
	5. Mannitol	6. Inositol

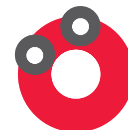
FIGURE 6

COMPARISON OF RESOLUTION OF 2 µm AND 3 µm PARTICLES



Columns:	TSKgel Amide-80 2 µm (3.0 mm ID x 15 cm)
	TSKgel Amide-80 3 µm (3.0 mm ID x 15 cm)
Mobile phase:	20 mmol/L NH_4OAc (pH 4.7) / acetonitrile = 10/90
Flow rate:	0.43 mL/min;
Temperature:	40°C;
Detection:	UV @ 254 nm;
Injection vol.:	2 µL
Samples:	1. toluene (1 g/L), 2. theophylline (0.1 g/L), 3. theobromine (0.1 g/L), 4. NP Glu (0.1 g/L), 5. NP Glu (0.1 g/L), 6. 2‘-deoxyuridine (0.1 g/L), 7. 5-methyluridine (0.1 g/L), 8. uridine (0.1 g/L)

HILIC
TSKgel NH2-100



TSKgel NH2-100 3 µm columns expand the selectivity range of TSKgel HILIC solutions by a new, robust amino-phase. In contrast to conventional silica-based amino phases it offers expanded stability under HILIC conditions. It is well suited for the analysis of all types of hydrophilic compounds like carbohydrates, peptides, vitamins, polar drugs or metabolites.

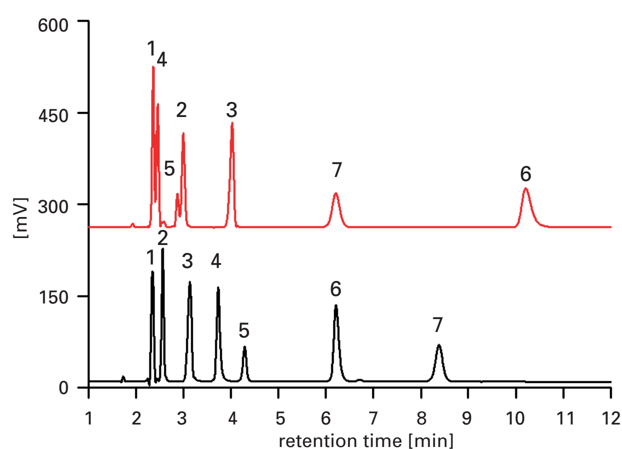
The NH2-100 phase is based on a silica particle with 3 µm particle and 100 Å pore size, treated with a special endcapping procedure. Amino groups are introduced step wisely after endcapping (Figure 8). They act as HILIC functional groups without any peak splits. Due to their high ligand density and large surface area TSKgel NH2-100 3 µm columns show high retention for very polar compounds.

SEPARATION OF POLAR COMPOUNDS

Figure 7 shows the separation of a standard solution of water soluble vitamins on a TSKgel NH2-100 column compared to a TSKgel Amide-80 column. Dimension (4.6 mm ID x 15 cm L), particle size (3 µm), flow rate and mobile phase were identical for both columns. The elution order of the compounds changes when applying the same mobile phase to both columns: The TSKgel NH2-100 column shows stronger retention for nicotinic acid, vitamin C, and vitamin B12, while retention of vitamin B1, B2, and pyridoxine is reduced.

FIGURE 7

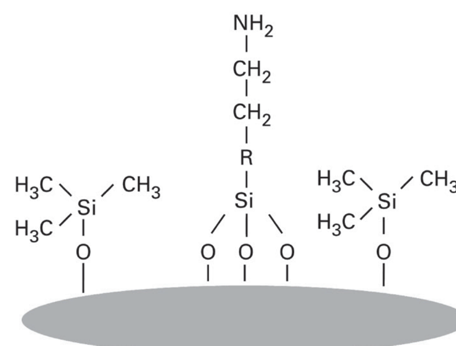
SEPARATION OF WATER SOLUBLE VITAMINS



Columns: TSKgel Amide-80 3 µm, 4.6 mm ID x 15 cm L
TSKgel NH2-100 3 µm, 4.6 mm ID x 15 cm L
Mobile phase: 25 mM phosphate buffer (pH 2.5)/ACN=30/70
Flow rate: 1 mL/min
Temp.: 40°C
Detection: UV@254 nm
Sample: Vitamin standard mixture:
1 = Nicotinamide, 2 = Vitamin B2, 3 = Pyridoxine,
4 = Nicotinic acid, 5 = Vitamin C, 6 = Vitamin B1,
7 = Vitamin B12
Injection: 5 µL

FIGURE 8

STRUCTURE OF TSKgel NH2-100



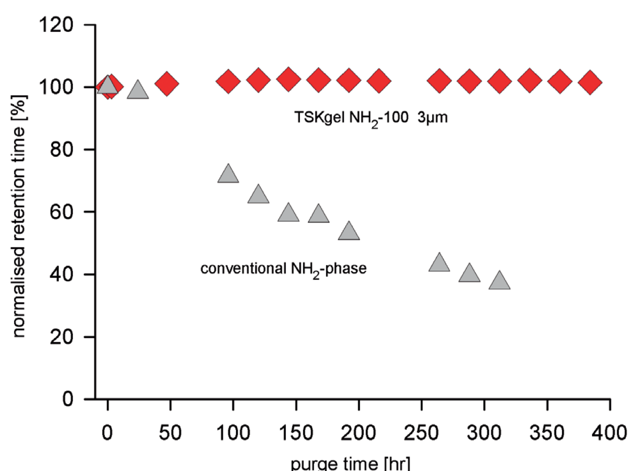
TSKgel NH2-100 LONG TERM STABILITY

The high stability of TSKgel NH2-100 columns is demonstrated in Figure 9 showing the change in retention time of inositol after more than 400 hours of flushing with mobile phase compared to the first injection. Only slight reduction of retention time is observed with the TSKgel NH2-100 column compared to a conventional amino-phase.

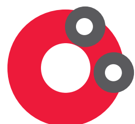
MORE INFORMATION ON bit.ly/TSKgelNH2

FIGURE 9

LONG TERM STABILITY OF TSKgel NH2-100 COLUMNS



Column: TSKgel NH2-100 3 µm, 4.6 mm ID x 15 cm L
Conventional Amino column, 4.6 mm ID.x 25 cm L
Mobile phase: H_2O/ACN (25/75)
Flow rate: 1.0 mL/min
Detect: RI
Temp.: 40 °C
Injection.: 10 µL
Sample: Inositol



HILIC APPLICATIONS GLYCAN ANALYSIS

Glycosylation is one of the most common post-translational modifications in eukaryotic cells. Complex N- and O-linked structures composed of repeating sugar moieties form the so called glycans. HILIC with fluorescence detection is the method of choice to effectively separate, identify and quantify glycans after exoglycosidase cleavage and fluorescent labelling.

In order to normalize retention times of complex glycan structures a dextran ladder consisting of glucose oligomers is used as calibration reference. The calculated numbers of glucose units (GU) can be used in subsequent database queries (Glycobase, autoGU) to predict the glycan structure.

For years TSKgel Amide-80 5 µm columns have been used successfully in glycan analysis. Amide-80 chemistry is ideally suited for the separation of carbohydrate structures.

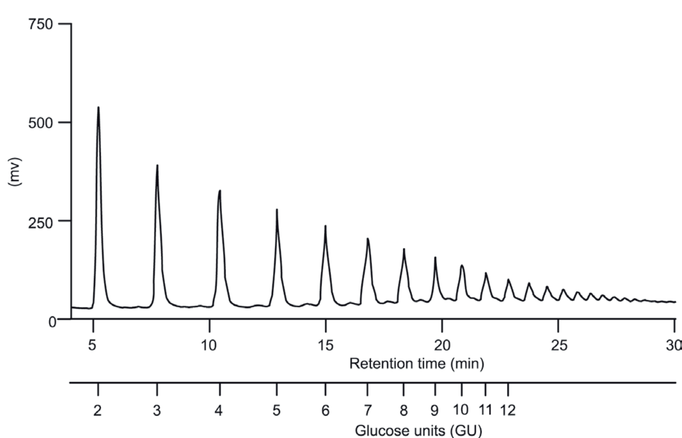
With the 3 µm particles resolution and sensitivity can be further enhanced. Figure 10 shows the high-resolution separation of a 2-aminobenzamide (2AB) labeled dextran ladder within 30 minutes on a TSKgel Amide-80 3 µm column.

The selectivity of the TSKgel NH2-100 series differs from TSKgel Amide-80 selectivity as shown in Figure 11. The type of HILIC column should be selected according to the sample type and separation need.

If selectivity or regulatory requirements are not limiting the choice of columns we recommend selecting TSKgel Amide-80 columns instead of amino-phases because they show better long term stability.

FIGURE 10

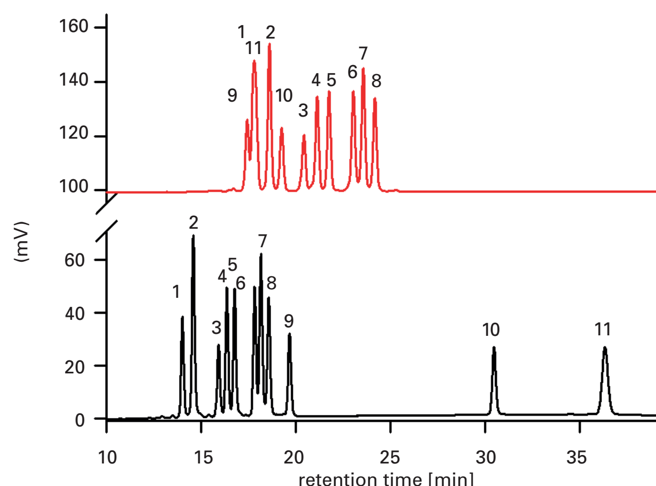
SEPARATION OF A 2AB-LABELED DEXTRAN LADDER ON TSKgel AMIDE-80



Column: TSKgel Amide-80 (3 µm, 2.0 mm ID × 15 cm L)
Mobile phase: A) 50 mM Ammonium formate (pH 4.3)
B) Acetonitrile
Gradient: 0-35 min - 75-35 % B
Flow rate: 0.22 mL/min
Detection: Fluorescence Ex@360 nm, Em@425 nm
Temperature: 50 °C
Injection vol.: 3 µl
Sample: CAB-GHP dextran ladder
(Ludger; ~ 300 fmol for GU2)

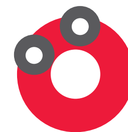
FIGURE 11

SEPARATION OF PA-GLYCANS ON TSKgel NH2-100



Columns: (a): TSKgel NH2-100 3µm, 4.6 mm ID x 15 cm L
(b): TSKgel Amide-80 3µm, 4.6 mm ID x 15 cm L
Mobile phase: (a):
(A): 0.2 M Triethylamine acetate (pH6.5)/ACN (30/70)
(B): 0.5 M Triethylamine acetate (pH6.5)/ACN (60/40)
(b):
(A): 0.2 M Triethylamine acetate (pH6.5)/ACN (26/74)
(B): 0.2 M Triethylamine acetate (pH6.5)/ACN (50/50)
Gradient: 0% - 100% B in 30 min, hold at 100% B for 15 min
Flow rate: 1.0 mL/min
Detect.: Fluorescence Ex@315 nm, Em@380 nm
Temp.: 40 °C
Inj. vol.: 10 µL

HILIC APPLICATIONS UHPLC GLYCAN ANALYSIS



The new TSKgel Amide-80 2µm column provides the same unique selectivity as TSKgel Amide-80 3 µm or 5 µm that are applied for glycan analysis in many QC labs for years.

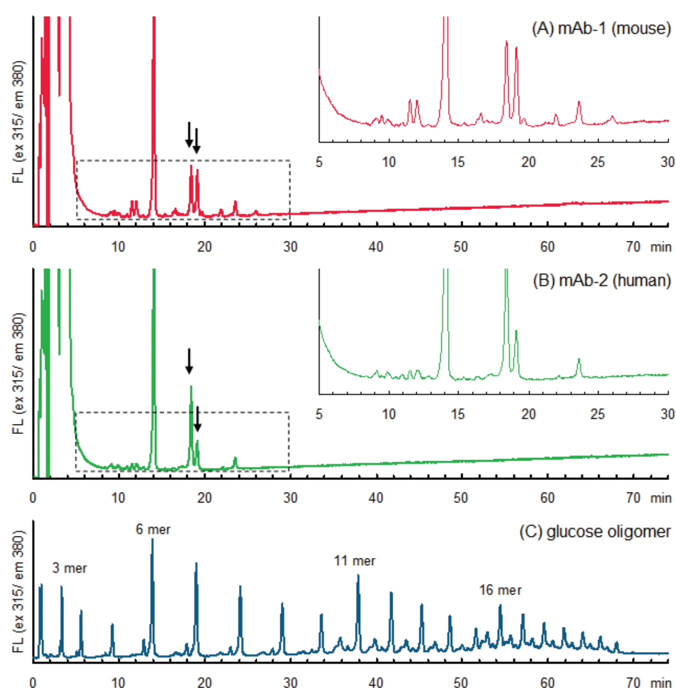
The new 2 µm material improves peak capacity and sensitivity for both, (U)HPLC and LC-MS analysis and allows a smooth transfer of established methods form HPLC to UHPLC.

The columns are especially suited for use in UHPLC systems, as their reduced system volume and optimized detector specifications help to maintain the high resolution that can be achieved with 2 micron stationary phase.

The suitability of the new 2 micron material for glycosylation analysis of labelled glycans by both fluorescence detection (Figure 12) and mass spectrometric detection (Figure 13) is demonstrated for various antibody samples.

FIGURE 12

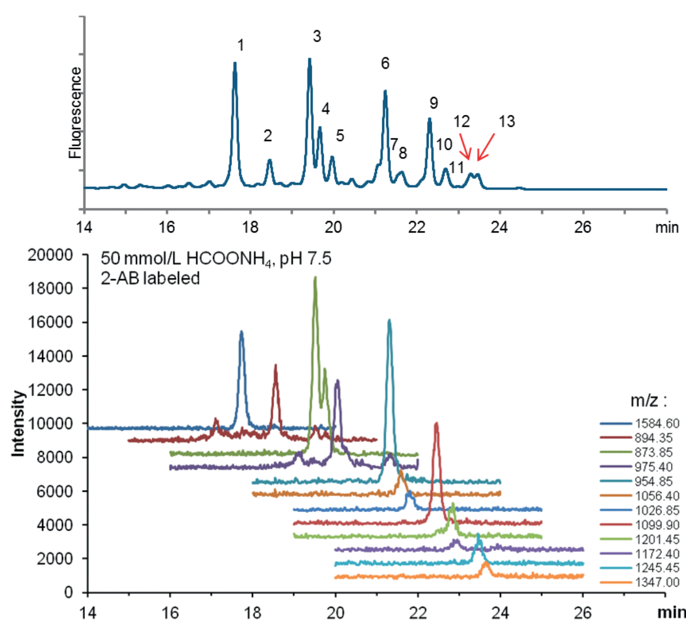
GLYCOSYLATION ANALYSIS OF ANTIBODIES



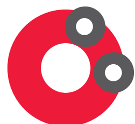
Column: TSKgel Amide-80 2 µm (2.0 mm ID x 15 cm)
Mobile phase: A: 200 mmol/L acetic acid + triethylamine (pH 7.3)
B: acetonitrile
Gradient: 75% B (0-5min), 75-50% B (5-80 min, linear)
Flow rate: 0.5 mL/min
Temperature: 40 °C
Detection: fluorescence (EX @ 315 nm, EM @ 380 nm)
Injection vol.: 50 µL
Sample: (A) pyridylaminated oligosaccharides released from mAb-1 (mouse)
(B) pyridylaminated oligosaccharides released from mAb-2 (human)
(C) PA-glucose ladder (3-22 mer)
(TaKaRa Bio)

FIGURE 13

UHPLC-MS ANALYSIS OF 2-AB GLYCANS ON TSKgel AMIDE-80 2 µm



Column: TSKgel Amide-80 2 µm (2.0 mm ID x 15 cm)
Mobile phase: A: 50 mmol/L $HCOONH_4$, pH 7.5
B: acetonitrile
Gradient: 75 %B (0-5 min), 75-50 %B (5-30 min, linear)
Flow rate: 0.3 mL/min
Temperature: 40 °C
Detection: (a) fluorescence (EX @ 315 nm, EM @ 380 nm)
(b) LC/MS, ESI positive, SIM (Shimadzu LCMS-8030)
Injection vol.: 50 µL
Sample: 2-AB labelled N-glycans released from human IgG (Ludger, cat.# CLIBN-IGG-01)



HILIC APPLICATION HILIC-MS

High-performance liquid chromatography–tandem mass spectrometry (HPLC-MS/MS) has become a powerful tool when detection sensitivity is an issue. HILIC offers unique advantages for MS detection of very polar compounds when compared to reversed phase mode. The higher organic content of the eluent in HILIC mode supports efficient evaporation of the solvent thus enhancing sensitivity and altering ion suppression.

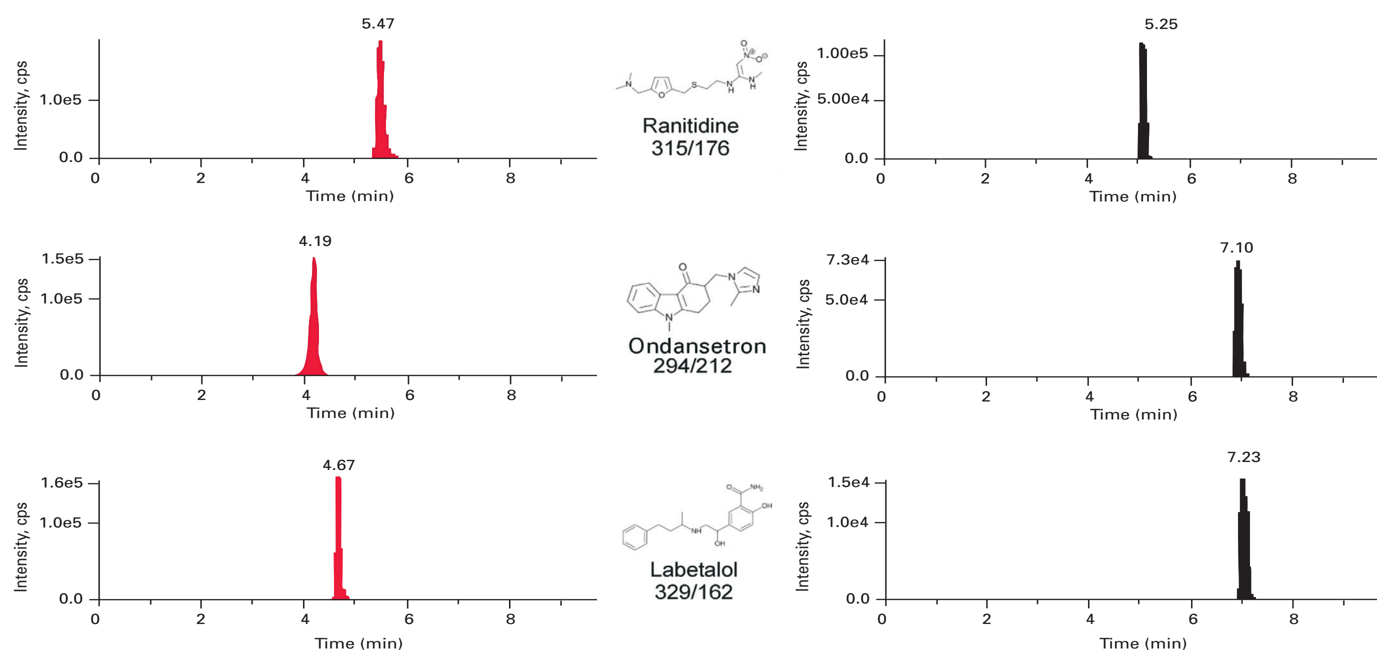
HILIC separations are performed with gradients starting with high percentage of organic solvent and ending with a high portion of aqueous solvent - opposite to typical reversed phase gradients. The elution order of compounds is usually inversed as well. As a result polar compounds are very well separated according to increased polarity in HILIC mode. At the same time the portion of organic solvent in the mobile phase is relatively high.

Figure 14 shows the analysis of basic drug substances using a TSKgel Amide-80 3 µm column compared to the same analysis using a reversed phase TSKgel ODS-100V 3 µm column. Ranitidine, a histamine H2 receptor antagonist, Ondansetron, an antiemetic serotonin receptor antagonist, and Labetalol, an alpha-1 and beta adrenergic blocker were selected to demonstrate the differences in selectivity and MS-signal response when applying different chromatographic modes.

Ranitidine has the highest number of polar groups among these molecules and as a result shows the highest retention in HILIC and the lowest retention in RPC mode. Signal intensity is almost doubled for ranitidine in HILIC mode. For Labetalol a tenfold increase in signal height can be achieved by using HILIC instead of RPC.

FIGURE 14

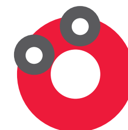
LC-MS/MS ANALYSIS OF BASIC DRUGS IN HILIC AND RPC MODE



Column: TSKgel Amide-80 3 µm (2.0 mm ID x 15 cm L)
Mobile phase: A: 10 mM Ammoniumformiate (pH 3.75)
B: ACN
Gradient: 0 min (B 90%) -> 10 min (B 40%) ->13 min (B 40%)
Flow rate: 0.2 mL/min
Inj. volume: 5 µL (50 µg/L)
Detection: QTrap® LC-MS/MS (Applied Biosystems), ESI+

Column: TSKgel ODS-100V 3 µm (2.0 mm ID x 15 cm L)
Mobile phase: A: 10 mM Ammoniumformiate (pH 3.75)
B: ACN
Gradient: 0 min (B 0%) -> 10 min (B 80%) ->13 min (B 80%)
Flow rate: 0.2 mL/min
Inj. volume: 5 µL (50 µg/L)
Detection: QTrap® LC-MS/MS (Applied Biosystems), ESI+

HILIC APPLICATION
HILIC-MS FOR BIOGENIC AMINES



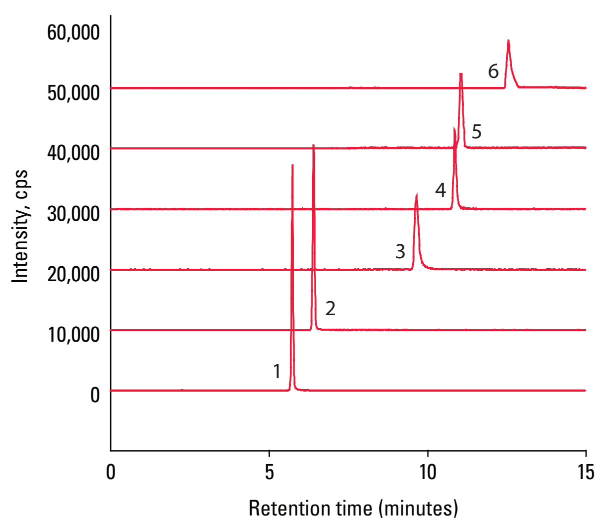
Biogenic amines, such as histamine or tyramine are low molecular weight organic bases generated through decarboxylation of free amino acids by microorganisms. They are present in a wide range of foods products, including fish, meat, cheese, wine, beer, vegetables, fruits, and nuts. In fermented foods their presence is a result of the fermentation process.

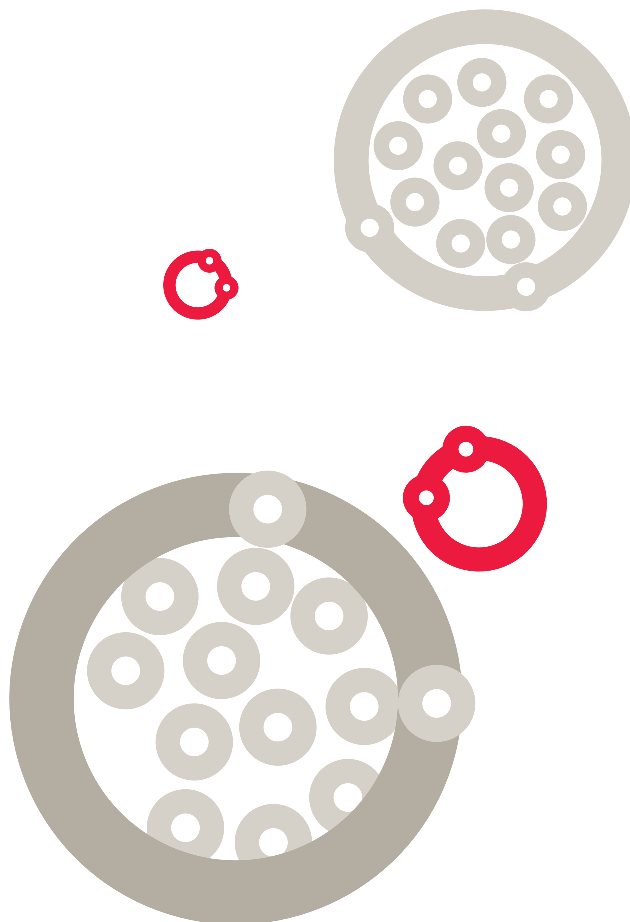
Analysis methods for biogenic amines include reversed phase HPLC with fluorescence detection using derivatization. The drawbacks of these methods are a 40 minute analysis time, derivatization, and liquid phase extraction.

TSKgel Amide-80 can be used to develop a simple, highly sensitive and direct analytical method with electrospray ionization MS/MS detection (Figure 15). Six biogenic amines were analyzed in 15 minutes without the need for a complex and time-consuming derivatization procedure.

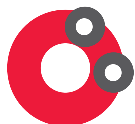
FIGURE 15

HILIC MS/MS ANALYSIS OF BIOGENIC AMINES





Column:	TSKgel Amide-80 3 µm (2mm ID x 15 cm L)
Mobile phase:	A: 30 mmol/L ammonium formate, pH 4.0 B: Acetonitrile; Flow rate: 0.2 mL/min;
Temperature:	50°C;
Injection Vol.:	2 µL;
Gradient:	90% B to 40% B in 12 min;
Sample:	(1) tryptamine (50 µg/L; 161.0/115.0 amu), (2) tyramine (20 µg/L; 138.0/121.0 amu); (3) histamine (50 µg/L; 112.0/95.0 amu); (4) cadaverine (250 µg/L; 103.1/86.1 amu); (5) putrescine (250 µg/L; 89.1/72.1 amu); (6) spermidine (50 µg/L; 146.3/72.1 amu);
Detection:	ESI pos. MRM (QTRAP®, AB SCIEX)



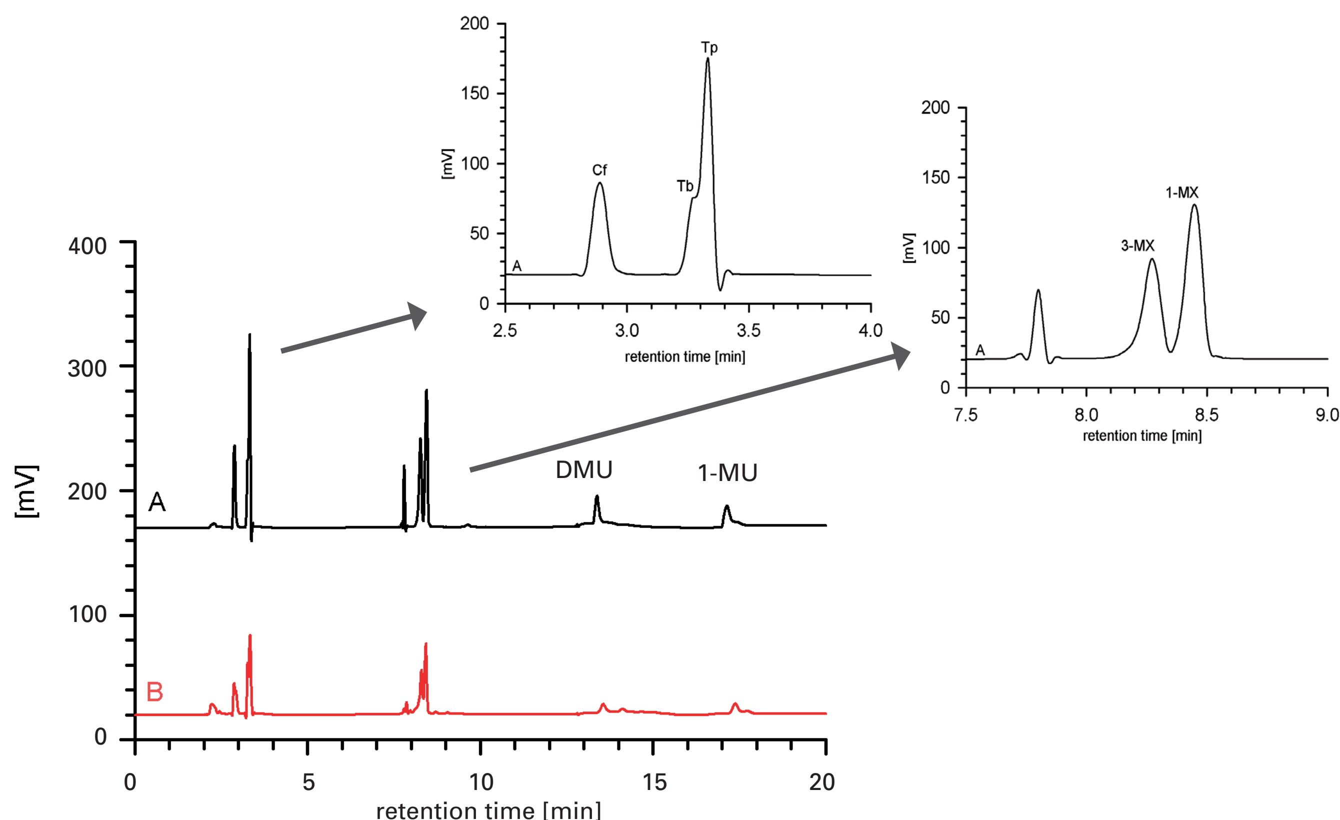
HILIC APPLICATION DRUG METABOLITES

The demand for HILIC separations in the analysis of drug substances is continuously increasing. Combined with tandem or hybrid mass spectrometric detection HILIC is a powerful separation mode for the analysis of polar metabolites in pharmacokinetics or metabolomics studies.

Figure 16 shows the analysis of theophylline and its metabolites in serum after online deproteination, detected by UV absorption. Combining this separation with MS detection would further increase detection sensitivity and facilitate peak identification.

FIGURE 16

SEPARATION OF THEOPHYLLINE AND ITS METABOLITES IN SERUM AFTER ONLINE DEPROTEINATION



Column: Analysis: TSKgel NH2-100, 3 µm, 4.6 mm ID x 15 cm L
Deproteination: experimental BSA-ODS-100V precolumn 2.0 mm ID x 1 cm L

Mobile phase: Pretreatment; 0.2 M HCO_2NH_4 (pH 3.6) 0 - 0.3 min
A: ACN
B: H_2O/ACN=15/85
C: 0.2 M HCO_2NH_4 (pH 3.6)/ACN=30/70

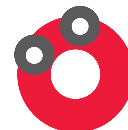
Step gradient: 0.3 - 2.0 min A, 2.0 - 8.0 min B, 8.0 – 20 min C

Flow rate: 1.0 mL/min, Detection: UV@254 nm,

Temperature: 40 °C

Injection vol.: 5 µL

Sample: A: Standard
1. Caffeine (Cf), 2. Theobromine (Tb), 3.Theophylline (TP), 4. 3-Methylxanthine (3-MX), 5. 1-Methylxanthine (1-MX), 6. 1,3-Dimethyluric acid (DMU), 7. 1-Methyluric acid (1-MU) - 50 µg each
B: Serum spiked with the standard samples

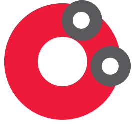


PRODUCT SPECIFICATION

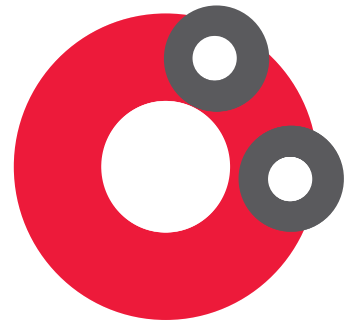
	TSKgel Amide-80	TSKgel NH_2-100
Base material	Silica	Silica
Pore size	10 nm	10 nm
Particle size	2 / 3 / 5 / 10 µm	3 µm
Functional group	Carbamoyl	Aminoethyl

ORDERING INFORMATION

Part #		Description	ID (mm)	Length (cm)	Particle Size (µm)	Number Theoretical Plates	Max. Pressure Drop (mPa)
STAINLESS STEEL COLUMNS							
0023454	NEW!	Amide-80	2.0	5.0	2	≥ 5,800	40
0023455	NEW!	Amide-80	2.0	10.0	2	≥ 14,000	60
0023456	NEW!	Amide-80	2.0	15.0	2	≥ 21,500	80
0023457	NEW!	Amide-80	3.0	5.0	2	≥ 8,300	40
0023458	NEW!	Amide-80	3.0	10.0	2	≥ 16,500	60
0023459	NEW!	Amide-80	3.0	15.0	2	≥ 24,000	80
0021864		Amide-80	2.0	5.0	3	≥ 3,500	20
0021865		Amide-80	2.0	15.0	3	≥ 13,000	20
0022850		Amide-80	3.0	5.0	3	≥ 5,500	20
0022851		Amide-80	3.0	10.0	3	≥ 11,000	20
0022852		Amide-80	3.0	15.0	3	≥ 16,000	20
0021866		Amide-80	4.6	5.0	3	≥ 6,000	20
0022849		Amide-80	4.6	10.0	3	≥ 12,000	20
0021867		Amide-80	4.6	15.0	3	≥ 18,500	20
0020009		Amide-80	1.0	5.0	5	≥ 300	3
0020010		Amide-80	1.0	10.0	5	≥ 600	6
0021486		Amide-80	1.0	15.0	5	≥ 4,000	9
0021487		Amide-80	1.0	25.0	5	≥ 6,000	12
0019694		Amide-80	2.0	5.0	5	≥ 1,000	4
0019695		Amide-80	2.0	10.0	5	≥ 2,000	8
0019696		Amide-80	2.0	15.0	5	≥ 4,000	10
0019697		Amide-80	2.0	25.0	5	≥ 6,000	15
0019532		Amide-80	4.6	5.0	5	≥ 1,500	15
0019533		Amide-80	4.6	10.0	5	≥ 3,000	15
0013071		Amide-80	4.6	25.0	5	≥ 8,000	15
0021982		Amide-80 HR	4.6	25.0	5	≥ 18,000	15
0014459		Amide-80	7.8	30.0	10	≥ 5,000	7
0014460		Amide-80	21.5	30.0	10	≥ 8,000	3
0021967		NH_2-100	2.0	5.0	3	≥ 4,000	15
0021968		NH_2-100	2.0	15.0	3	≥ 15,000	20
0021969		NH_2-100	4.6	5.0	3	≥ 6,000	5
0021970		NH_2-100	4.6	15.0	3	≥ 18,000	15
0021999		NH_2-100 DC, For direct coupling for 2D LC to other HPLC column	4.6	5.0	3	≥ 6,000	5



Part #	Description	ID (mm)	Length (cm)	Particle Size (µm)	
Guard column products					
0021862	Amide-80 Guard cartridge, pk 3	2.0	1.0	3	For 2.0 mm ID columns
0021863	Amide-80 Guard cartridge, pk 3	3.2	1.5	3	For 4.6 mm ID columns
0021941	Amide-80 Guard cartridge, pk 3	2.0	1.0	5	For all 2.0 mm ID columns
0019010	Amide-80 Guard cartridge, pk 3	3.2	1.5	5	For all 4.6 mm ID columns
0019021	Amide-80 Guard column	4.6	1.0	5	For all 4.6 mm ID columns (P/N 0013071, 0014459)
0014461	Amide-80 Guard column	21.5	7.5	10	For 21.5 mm ID column (P/N 0014460)
0023460 NEW!	Amide-80 2 µm (DC)	2.0	1.0	2	Direct Connect Guardcolumn
0021971	NH_2-100 Guard cartridge, pk 3	2.0	1.0	3	For 2.0 mm ID columns
0021972	NH_2-100 Guard cartridge, pk 3	3.2	1.5	3	For 4.6 mm ID column
0019308	Guard cartridge holder				For 2.0 mm ID x 1.0 cm L guard cartridges
0019018	Guard cartridge holder				For 3.2 mm ID x 1.5 cm L guard cartridge



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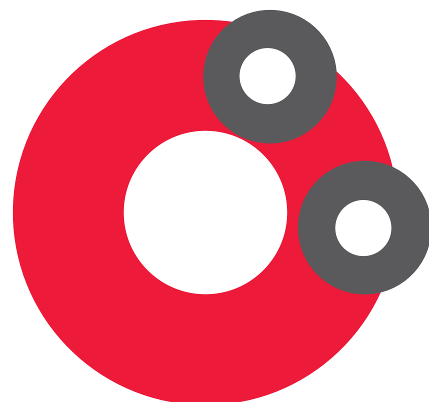

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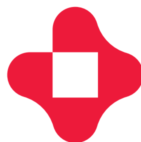

TOSOH BIOSCIENCE

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