TSKgel GPC Columns

A wide variety of HPLC columns are available for the analysis of polymers in aqueous, organic and polar organic solvents.

High temperature columns for applications up to 140 °C and ultra-high temperature oclumns for applications up to 220 °C for the analysis of organic-soluble polymers are offered.

TSKgel GPC Columns

Tosoh introduced its first line of GPC columns in 1971. Ever since, Tosoh scientists have made important contributions to advances in polymer analysis by developing state-of-the-art GPC columns for the most demanding applications.

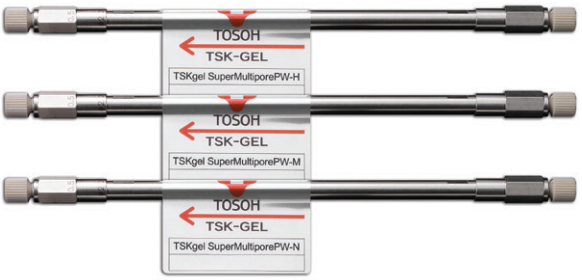
TSKgel GPC Columns for EcoSEC GPC System

Semi-micro columns are the TSKgel columns of choice for use with the EcoSEC GPC System.
They are referred to as such since their dimensions are smaller than conventional columns in terms of internal diameter as well as in length: 4.6 mm or 6 mm ID × 15 cm vs. 7.8 mm ID x 30 cm.

GPC columns for polymers soluble in organic solvents

Semi-micro columns (4.6 or 6.0 mm ID × 15 cm)

- TSKgel SuperMultiporeHZ columns
- TSKgel SuperHZ columns for ultra-low adsorption
- TSKgel SuperH columns for low adsorption



Conventional columns (7.8 mm ID × 30 cm)

- TSKgel HXL columns for ultra-low adsorption
- TSKgel HHR columns for low adsorption
- TSKgel HHR HT and HT2 columns for high temperature analysis

GPC columns for polymers soluble in polar organic solvents

Semi-micro columns (6.0 mm ID × 15 cm)

- TSKgel SuperAW columns

Conventional columns (7.8 mm ID × 30 cm)

- TSKgel Alpha columns

GPC columns for polymers soluble in aqueous solvents

Semi-micro columns (6.0 mm ID × 15 cm)

- TSKgel SuperMultiporePW columns

Conventional columns (7.5 or 7.8 mm ID × 30 or 60 cm)

- TSKgel PW columns
- TSKgel PWXL columns for higher efficiency
- TSKgel PWXL-CP columns for analysis of cationic polymers

TSKgel GPC Columns for EcoSEC High Temperature GPC System

Conventional columns (7.8 mm ID × 30 cm)

- TSKgel HHR HT and HT2 columns for high temperature analysis

TSKgel H Series Size Exclusion Columns

TSKgel H series columns are recommended for the analysis of organic-soluble polymers and are packed with spherical particles composed of polystyrene crosslinked with divinylbenzene (PS-DVB). This series includes TSKgel HXL, HHR, SuperH, Super HZ, and SuperMultiporeHZ columns. Each line of columns within this series differs in degree of inertness and operating temperature range.

The Super prefix designates short (15 cm) columns packed with particles as small as 3 µm. The smaller particle allows for equivalent resolution to conventional TSKgel HXL columns, with 50% reduction in analysis time due to the shorter column length. The TSKgel Super series columns are an excellent choice for high throughput polymer analysis.

- The TSKgel HXL columns are conventional GPC columns of 7.8 mm ID × 30 cm. The column line consists of eight columns with different pore sizes, TSKgel G1000HXL through TSKgel G7000HXL, and three columns with an extended linear range of the calibration curve, TSKgel GMHXL, TSKgel GMHXL-L and TSKgel MultiporeHXL-M. The 5 µm particles in the TSKgel MultiporeHXL-M column contain a broad range of pore sizes. This innovative approach essentially creates a linear calibration curve within each particle. As a result, columns with an extended linear calibration curve can now be prepared without mixing particles of different pore sizes.

  The main characteristics of TSKgel HXL columns are: ultra-low sample adsorption, i.e., the columns show true size exclusion behavior for most polymers, limited solvent range, and a maximum operating temperature of 60 °C for TSKgel G1000HXL - G3000HXL, and 80 °C for the remaining columns in the TSKgel HXL column line.

- The TSKgel HHR column line consists of eight conventional GPC columns of 7.8 mm ID × 30 cm with different pore sizes, TSKgel G1000HHR through TSKgel G7000HHR, and seven mixed bed columns, in which particles with different pore sizes are blended to provide an extended linear calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel GMHHR-L, GMHHR-N, GMHHR-M, to GMHHR-H. The main characteristic of these TSKgel HHR columns is a broad solvent range.

  In addition, nine TSKgel HHR mixed bed columns are available for high temperature analysis. The maximum operating temperature of the TSKgel HHR HT columns is 140 °C and the maximum operating temperature of the TSKgel HHR HT2 columns is 220 °C.

- The TSKgel SuperH column line consists of eight columns of 6.0 mm ID × 15 cm with different pore sizes, TSKgel SuperH1000 through TSKgel SuperH7000, and four mixed bed columns with an extended linear range of the calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel SuperHM-L, SuperHM-N, SuperHM-M, to SuperHM-H. TSKgel SuperH columns are high efficiency/high throughput versions of the conventional TSKgel HHR columns. Both column types are based on the same bead chemistry.

  The main characteristics of TSKgel SuperH columns are: a maximum operating temperature of 140 °C and the ability to use a broad range of solvents.

- The TSKgel SuperHZ column line consists of five columns of 4.6 mm ID × 15 cm and 6.0 mm ID × 15 cm with different pore sizes, TSKgel SuperHZ1000 through TSKgel SuperHZ4000, and three columns with an extended linear range of the calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel SuperHZM-L, SuperHZM-N to SuperHZM-H.

  The main characteristics of TSKgel SuperHZ columns are: developed for high throughput, high efficiency GPC applications such as those encountered in combinatorial chemistry experiments, ultra-low sample adsorption, limited solvent range, and a maximum operating temperature of 60 °C for TSKgel SuperHZ1000 - SuperHZ3000 and 80 °C for the remaining columns in the TSKgel SuperHZ line.

- The TSKgel SuperMultiporeHZ column line consists of three columns of 4.6 mm ID × 15 cm with particles sizes of 3, 4 and 6 µm. The particles in TSKgel SuperMultiporeHZ columns are monodisperse in size and exhibit a broad range of pore sizes. Each particle, by design, has an extended linear calibration curve, thereby greatly diminishing chromatograms with inflection points.

A comparison of TSKgel H series columns is detailed in Table 1. The cross-linking of the polystyrene particles in TSKgel H series columns ensures minimal shrinking and swelling of the column bed when the organic solvent is changed according to the solvent recommendations outlined in Table 2. Suggested flow rates for solvent exchange in TSKgel SuperH and HHR columns are outlined in Table 3. Table 4 lists the recommended solvents by application for TSKgel H series columns.

Table 1: Comparison of TSKgel H series columns

TSKgel series	SuperMultiporeHZ	SuperHZ	SuperH	HXL	HHR
Application focus	Ultra-high performance with a low dead volume and a wide pore distribution in each particle for superior linearity	High throughput polymer analysis with ultra-low polymer adsorption, limited solvent compatibility range	High throughput polymer analysis with expanded solvent compatibility range	Conventional polymer analysis with ultra-low polymer adsorption, limited solvent compatibility range	Conventional polymer analysis with expanded solvent compatibility range
Particle size	3 µm, 4 µm, and 6 µm, depending on pore size	3 µm, 5 µm, and 10 µm, depending on pore size	3 µm and 5 µm, depending on pore size	5 µm, 6 µm, 9 µm, and 13 µm, depending on pore size	5 µm, 13 µm, 20 µm, and 30 µm
Particle matrix	Polystyrene divinylbenzene (PS-DVB)	Polystyrene divinylbenzene (PS-DVB)	Polystyrene divinylbenzene (PS-DVB)	Polystyrene divinylbenzene (PS-DVB)	Polystyrene divinylbenzene (PS-DVB)
Number of solvent substitutions	None	One time only	Several[1]	One time only	Several[1]

[1] After switching to a very polar solvent such as acetone, switching back to a nonpolar solvent is not recommended.

Table 2: Solvent compatibility for TSKgel H series columns

TSKgel series	Shipping solvent*	Can be replaced with:
SuperHZ and HXL[1]	Tetrahydrofuran[3,4]	benzene, chloroform, toluene, xylene, dichloromethane, dichloroethane
	Acetone**	carbon tetrachloride[5], *o*-dichlorobenzene, dimethylformamide, dodecane, dimethyl sulfoxide, dioxane, ethylacetate, FC-113, hexane, pyridine, hexafluoroisopropanol/chloroform, methyl ethyl ketone, quinoline, cyclohexane
	Chloroform**	*m*-cresol in chloroform, up to 10% hexafluoroisopropanol/ chloroform
	Dimethylformamide	dimethyl sulfoxide, dioxane, tetrahydrofuran, toluene
SuperH and HHR[2]	Tetrahydrofuran[3]	acetone, ethanol, quinoline, benzene, *o*-dichlorobenzene, ethyl acetate, dodecane, FC-113, carbon tetrachloride[5], dichloromethane, dichloroethane, trichloroethane, *n*-hexane, cyclohexane, xylene, tetrahydrofuran, chloroform, 1,4-dioxane, hexafluoroisopropanol, toluene, 1-chloronaphthalene, N,N-dimethylacetoacetamide, methyl ethyl ketone, trichlorobenzene, *m*-cresol, dimethylformamide, methylpyrrolidone, *o*-chlorophenol/chloroform, dimethyl sulfoxide, pyridine
SuperMultiporeHZ	Tetrahydrofuran[3]	Cannot be replaced. TSKgel SuperMultiporeHZ columns can be used only in tetrahydrofuran

[1] In case of TSKgel SuperHZ and HXL, keep flow rate as mentioned below during solvent change. Solvent can be changed one way/one time only.
TSKgel HXL: below <0.5 mL/min
TSKgel SuperHZ (4.6 mm ID): below <0.15 mL/min
TSKgel SuperHZ (6.0 mm ID): below <0.3 mL/min

[2] In case of TSKgel SuperH and HHR, see Table 3 for appropriate flow rates for solvent exchange. After switching to a very polar solvent, switching to a nonpolar solvent is not recommended.

[3] All TSKgel HXL, HHR, SuperHZ, SuperH, SuperMultipore, and GMH analytical columns are shipped containing tetrahydrofuran (THF), except the TSKgel high temperature columns, which contain *o*-dichlorobenzene (ODCB).

[4] THF in TSKgel G1000HXL columns cannot be replaced with dichloromethane or dichloroethane.

[5] Prolonged exposure to carbon tetrachloride can corrode the stainless steel parts of a column and an HPLC system.

* 100% methanol cannot be used with TSKgel H series columns; use this solvent with TSKgel SW or Alpha columns.

** TSKgel H series columns may be specially ordered with this shipping solvent.

Table 3: Recommended flow rates (mL/min) for TSKgel SuperH and HHR columns

Solvent	TSKgel SuperH 6.0 mm ID × 15 cm	TSKgel HHR 7.8 mm ID × 30 cm
n-Hexane	0.5	0.9
methyl ethyl ketone	0.4	0.7
dichloromethane, ethyl acetate	0.35	0.6
toluene, chloroform	0.3	0.5
dimethylformamide	0.2	0.4
carbon tetrachloride, pyridine	0.15	0.3
dimethyl sulfoxide, dioxane, ethanol, N-methylpyrrolidone, *o*-dichlorobenzene	0.1	0.2
quinoline, hexafluoroisopropanol, 1-chloronaphthalene	0.05	0.1

Table 4: Recommended solvents by application for TSKgel H series columns

Recommended solvent	Application
THF	polystyrene, epoxy resin, phenoxy resin, polycarbonate, polyisoprene, polyvinyl acetate, polyvinyl chloride, monoglycerides, fatty acids, polybutadiene, poly(methyl methacrylate), poly(styrene-butadiene), poly(styrene-acrylonitrile)
N,N-Dimethylformamide (DMF) + 5 mmol/L LiBr	polyvinyl chloride, polyvinyl fluoride, urea resins, polyurethane, polystyrene, polyester, polyimido ether, polyimido ester, polyphenol (aqueous solution), polyacrylonitrile
o-Dichlorobenzene (ODCB)	polyethylene, polypropylene
chloroform	polycarboxylic ether, acrylic resin, epoxy resin, polystyrene
m-Cresol/Chloroform	nylon, polyester, polyamide, poly (ethylene terephthalate)
toluene	polybutadiene, polysiloxane

TSKgel HXL Size Exclusion Columns

TSKgel HXL columns are conventional GPC columns of 7.8 mm ID × 30 cm containing 5, 6, 9, or 13 µm particles composed of PS-DVB. The TSKgel HXL column lines consists of eight columns with different pore sizes, TSKgel G1000HXL through TSKgel G7000HXL, and three columns with an extended linear range of the calibration curve, TSKgel GMHXL, TSKgel GMHXL-L and TSKgel MultiporeHXL-M.

The TSKgel HXL column line consists of the following columns:

- TSKgel G1000HXL
- TSKgel G2000HXL
- TSKgel G2500HXL
- TSKgel G3000HXL
- TSKgel G4000HXL
- TSKgel G5000HXL
- TSKgel G6000HXL
- TSKgel G7000HXL
- TSKgel GMHXL mixed bed
- TSKgel GMHXL-L mixed bed
- TSKgel MultiporeHXL-M

Three of the linear columns are mixed bed columns, in which particles with different pore sizes are blended to provide an extended linear calibration curve. The remaining column is a multi-pore column, in which each particle contains a range of pore sizes that provide a linear calibration curve. The innovative multi-pore approach, pioneered by Tosoh, is a synthetic chemistry answer to the question of how to obtain a column with an extended linear calibration curve, while mixed bed columns represent a mechanical way of obtaining a linear calibration curve. In general, Multipore columns have a smoother, more linear, calibration curve.

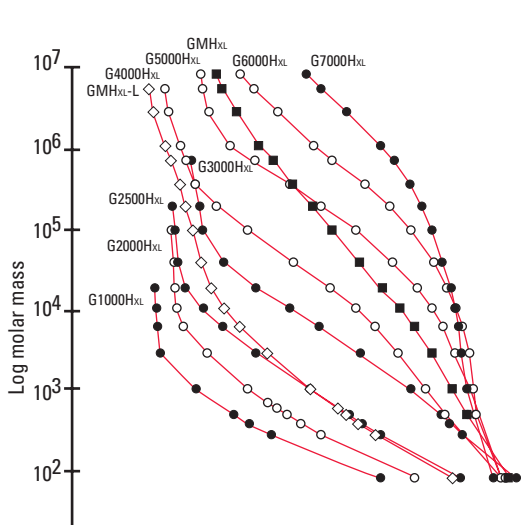
Attributes and Applications:

Product attributes of all of the TSKgel HXL columns are shown in Table 5. These columns are for the use of conventional polymer analysis and show ultra-low polymer absorption, i.e., the columns show true size exclusion behavior for most polymers. TSKgel HXL columns are shipped in THF. These columns can be exchanged for a limited number of organic solvents. See the table within the TSKgel H series column overview for a listing of these solvents. Figures 1-2 show the calibration curves for the TSKgel HXL columns.

Table 5: Product attributes

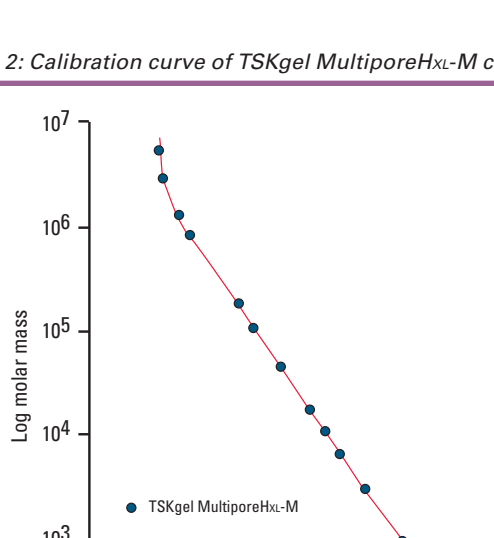
TSKgel column	Particle size	Pore size	Exclusion limit	Max. temp.
G1000HXL	5 µm	1.5 nm	1,000 Da	60 °C
G2000HXL	5 µm	2 nm	1.0×10^4 Da	60 °C
G2500HXL	5 µm	3 nm	2.0×10^4 Da	60 °C
G3000HXL	5 µm	7.5 nm	6.0×10^4 Da	60 °C
G4000HXL	5 µm	20 nm	4.0×10^5 Da	80 °C
G5000HXL	9 µm	65 nm	4.0×10^6 Da	80 °C
G6000HXL	9 µm	>65 nm	4.0×10^7 Da	80 °C
G7000HXL	9 µm	>65 nm	4.0×10^8 Da	80 °C
GMHXL	9 µm	mixed pore sizes	4.0×10^8 Da	80 °C
GMHXL-L	5 µm	mixed pore sizes	4.0×10^6 Da	80 °C
MultiporeHXL-M	5 µm	broad distribution of pore size in each particle	2.0×10^6 Da	60 °C

Figure 1: Calibration curves of TSKgel H_{XL} columns



Columns:	**TSKgel H_{XL} columns, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Temperature:	25 °C
Sample:	polystyrene standards

Figure 2: Calibration curve of TSKgel MultiporeH$_{XL}$-M column

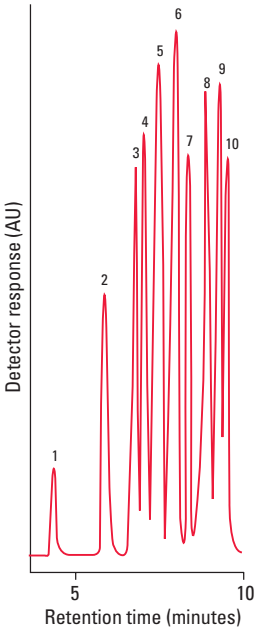


Columns:	**TSKgel MultiporeH$_{XL}$-M, 5 µm, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Temperature:	40 °C
Sample:	polystyrene standards

Phthalate Esters

Figure 3 demonstrates the high efficiency separation on a TSKgel G1000HXL column for low molar mass phthalate esters. Resolution was close to baseline even though the molar masses of the esters differed by less than 50 Da.

Figure 3: High resolution of phthalate esters

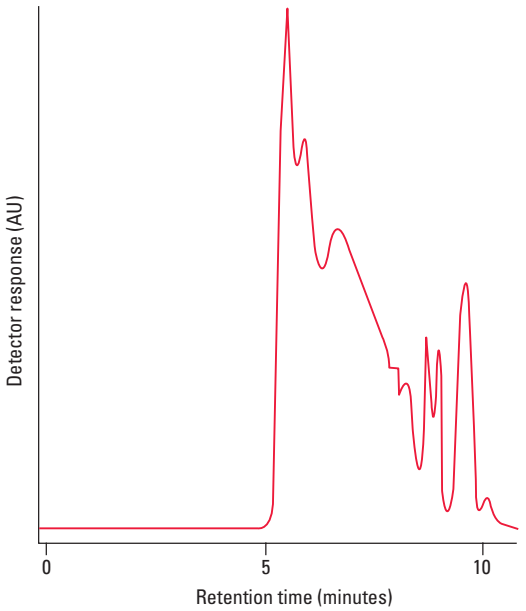


Column:	**TSKgel G1000HXL, 5 µm, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Samples:	1. polystyrene (1.0×10^4 Da) 2. dioctylphthalate (391 Da) 3. dibutylphthalate (278 Da) 4. diprophylphthalate (250 Da) 5. diethylphthalate (222 Da) 6. dimethylphthalate (194 Da) 7. n-propylbenzene (120 Da) 8. ethylbenzene (116 Da) 9. toluene (92 Da) 10. benzene (78 Da)

Phenol Resin

The TSKgel GMHXL-L column has been designed to provide a complete profile for high molar mass samples that contain low molar mass additives. The calibration curve for this mixed bed column is shallow in the low molar mass range of oligomers. Sample adsorption is not observed. For example, the complete profile of a phenol resin, with high resolution of the low molar mass components, is shown in Figure 4. Other applications for the TSKgel GMHXL-L column include analyses of paint materials, bond and adhesive components and synthetic polymer additives.

Figure 4: Separation of phenol resin



Column:	**TSKgel GMHXL-L, 5 µm, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Sample:	phenol resin

TSKgel H_{HR} Size Exclusion Columns

TSKgel H_{HR} columns are conventional GPC columns with dimensions of 7.8 mm ID × 30 cm containing spherical particles composed of PS-DVB. The TSKgel H_{HR} column line consists of eight columns with different pore sizes, TSKgel G1000H_{HR} through TSKgel G7000H_{HR}, and ten columns with an extended linear range of the calibration curve.

The TSKgel H_{HR} column line consists of the following columns:

- TSKgel G1000H_{HR}
- TSKgel G2000H_{HR}
- TSKgel G2500H_{HR}
- TSKgel G3000H_{HR}
- TSKgel G4000H_{HR}
- TSKgel G5000H_{HR}
- TSKgel G6000H_{HR}
- TSKgel G7000H_{HR}
- TSKgel G2000H_{HR}(20) HT
- TSKgel GMH$_{HR}$-H mixed bed
- TSKgel GMH$_{HR}$-L mixed bed
- TSKgel GMH$_{HR}$-M mixed bed
- TSKgel GMH$_{HR}$-N mixed bed
- TSKgel GMH$_{HR}$-H HT mixed bed
- TSKgel GMH$_{HR}$-H (S) HT mixed bed
- TSKgel GMH$_{HR}$-H HT2 mixed bed
- TSKgel GMH$_{HR}$-H (S) HT2 mixed bed
- TSKgel G2000H_{HR}(20) HT2

The linear, or mixed bed columns, contain particles with different pore sizes that are blended to provide an extended linear calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel GMH$_{HR}$-L, GMH$_{HR}$-N, GMH$_{HR}$-M, to GMH$_{HR}$-H. All of the TSKgel high temperature mixed bed columns are shipped in ODCB (*o*-dichlorobenzene).

The TSKgel H_{HR} HT2 mixed bed columns are available for ultra-high temperature analysis. Packed with PS-DVB beads, the maximum operating temperature of these columns is 220 °C.

The issue of shearing that occurs with the analysis of ultra-high molar mass polymers is overcome by the TSKgel GMH$_{HR}$-M (S), GMH$_{HR}$-H (S), GMH$_{HR}$-H (S) HT and GMH$_{HR}$-H (S) HT2 columns. The (S) is a reference to this shearing effect.

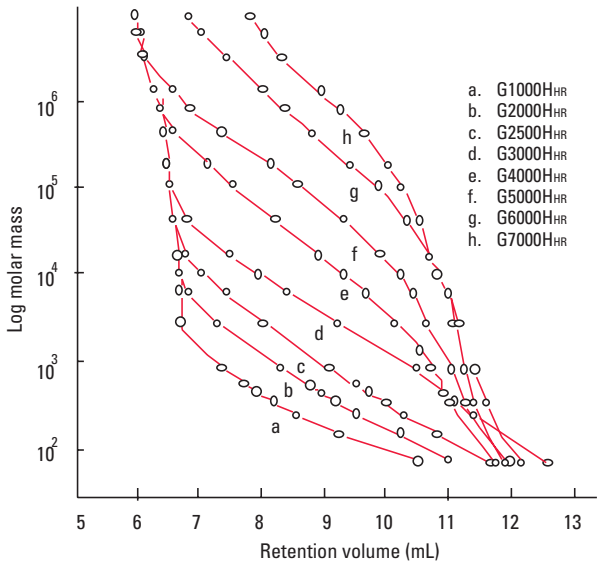
Attributes and Applications:

The product attributes for all of the TSKgel H_{HR} columns is shown in Table 6. TSKgel H_{HR} columns have a broad solvent range and are shipped in THF, except for the high temperature mixed bed columns, which are shipped in ODCB. THF can be exchanged for a wide variety of organic solvents. See the table within the TSKgel H series column overview for a listing of these solvents. Figures 5-7 show the calibration curves for the TSKgel H_{HR} columns.

Table 6: Product attributes

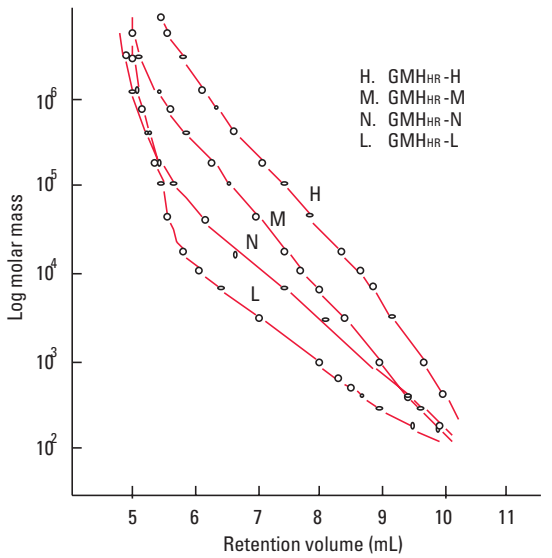
TSKgel column	Particle size	Pore size	Exclusion limit	Max. temp.
G1000H_{HR}	5 µm	1.5 nm	1,000 Da	140 °C
G2000H_{HR}	5 µm	2 nm	1.0×10^4 Da	140 °C
G2500H_{HR}	5 µm	3 nm	2.0×10^4 Da	140 °C
G3000H_{HR}	5 µm	7.5 nm	6.0×10^4 Da	140 °C
G4000H_{HR}	5 µm	20 nm	4.0×10^5 Da	140 °C
G5000H_{HR}	5 µm	65 nm	4.0×10^6 Da	140 °C
G6000H_{HR}	5 µm	>65 nm	4.0×10^7 Da	140 °C
G7000H_{HR}	5 µm	>65 nm	4.0×10^8 Da	140 °C
GMH$_{HR}$-H	5 µm, 13 µm, 20 µm, 30 µm	mixed pore sizes	4.0×10^8 Da	80 °C
GMH$_{HR}$-L	5 µm	mixed pore sizes	4.0×10^6 Da	80 °C
GMH$_{HR}$-M	5 µm, 13 µm	mixed pore sizes	4.0×10^6 Da	80 °C
GMH$_{HR}$-N	5 µm	mixed pore sizes	4.0×10^5 Da	80 °C
GMH$_{HR}$-H HT	5 µm	mixed pore sizes	4.0×10^8 Da	140 °C
GMH$_{HR}$-H (20) HT	20 µm	mixed pore sizes	4.0×10^8 Da	140 °C
GMH$_{HR}$-H (30) HT	30 µm	mixed pore sizes	4.0×10^8 Da	140 °C

Figure 5: Calibration curves of TSKgel H_{HR} columns



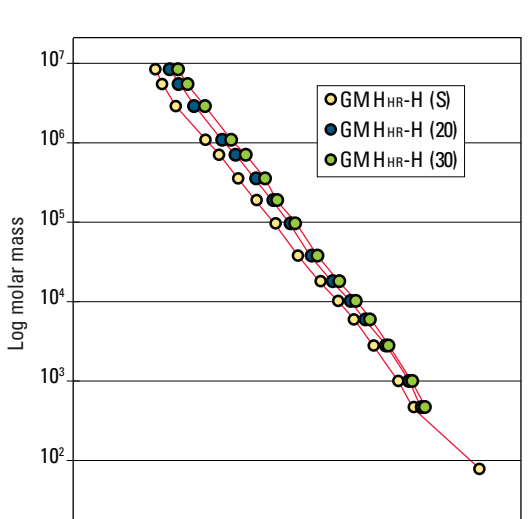
Columns:	**TSKgel H_{HR} columns, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Temperature:	25 °C
Samples:	polystyrene standards

Figure 6: Calibration curves of TSKgel H_{HR} mixed bed columns



Columns:	**TSKgel H_{HR} columns, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Temperature:	25 °C
Samples:	polystyrene standards

Figure 7: Calibration curves of TSKgel H_{HR}-H columns

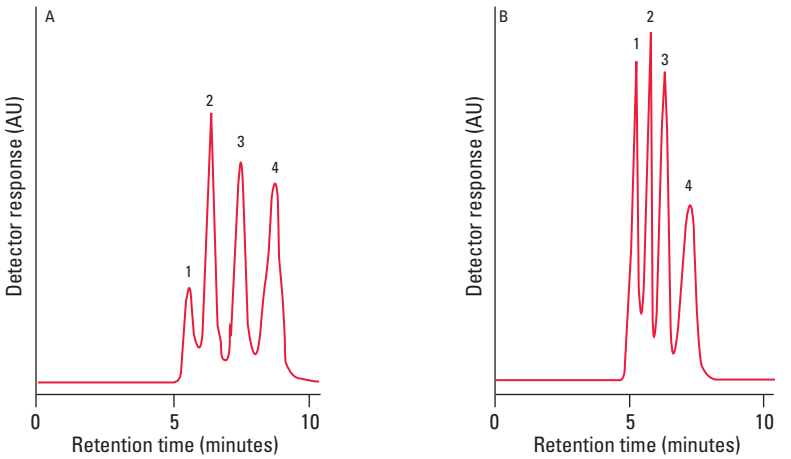


Columns:	**TSKgel GMH$_{HR}$-H (S), 13 µm, 7.8 mm ID × 30 cm** **TSKgel GMH$_{HR}$-H (20), 20 µm, 7.8 mm ID × 30 cm** **TSKgel GMH$_{HR}$-H (30), 30 µm, 7.8 mm ID × 30 cm**
Mobile phase:	THF
Flow rate:	1.0 mL/min
Detection:	UV @ 254 nm
Temperature:	25 °C
Sample:	polystyrene standards

Polymethyl methacrylate

The effect of different pore size distributions in the mixed beds of TSKgel GMH$_{HR}$-H and TSKgel GMH$_{HR}$-M is illustrated in Figure 8. The TSKgel GMH$_{HR}$-M produces sharper polymethyl methacrylate peaks in the 8.0 × 10^5 to 1.0 × 10^4 Da range.

Figure 8: Comparison of standard polymethylmethacrylate mixture



Columns:	**A. TSKgel GMH$_{HR}$-H, 5 µm, 7.8 mm ID × 30 cm**
	B. TSKgel GMH$_{HR}$-M, 5 µm, 7.8 mm ID × 30 cm
Mobile phase:	5 mmol/L sodium trifluoroacetate in HFIP
Flow rate:	1.0 mL/min
Detection:	UV @ 220 nm
Temperature:	40 °C
Sample:	standard polymethylmethacrylate
	1. 8.2 × 10^5 Da
	2. 6.7 × 10^4 Da
	3. 1.02 x 10^4 Da
	4. 1,950 Da

SuperH Size Exclusion Columns

TSKgel SuperH columns are conventional GPC columns with dimensions of 6.0 mm ID × 15 cm containing spherical particles composed of PS-DVB. The TSKgel SuperH column line consists of eight columns with different pore sizes, TSKgel SuperH1000 through TSKgel SuperH7000, and four columns with an extended linear range of the calibration curve.

TSKgel SuperH columns are high efficiency/high throughput versions of the conventional TSKgel HHR columns. Both column types are based on the same bead chemistry.

The TSKgel SuperH line consists of the following columns:

- TSKgel SuperH1000
- TSKgel SuperH2000
- TSKgel SuperH2500
- TSKgel SuperH3000
- TSKgel SuperH4000
- TSKgel SuperH5000
- TSKgel SuperH6000
- TSKgel SuperH7000
- TSKgel SuperHM-H mixed bed
- TSKgel SuperHM-L mixed bed
- TSKgel SuperHM-M mixed bed
- TSKgel SuperHM-N mixed bed

The TSKgel SuperH product line contains four linear or mixed bed columns, in which particles with different pore sizes are blended to provide an extended linear calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel SuperHM-L, SuperHM-M, SuperHM-N, to SuperHM-H.

The volume of a 6 mm ID × 15 cm TSKgel SuperH column is 3.4 times smaller than that of a conventional 7.8 mm ID × 30 cm column. As a result, peak volumes will be proportionally smaller on TSKgel SuperH columns compared to a corresponding TSKgel HHR column. Thus, your HPLC system may require optimization of components that can give rise to extra-column band broadening, such as connecting tubing, injector, injection volume, detector cell volume, and detector time constant.

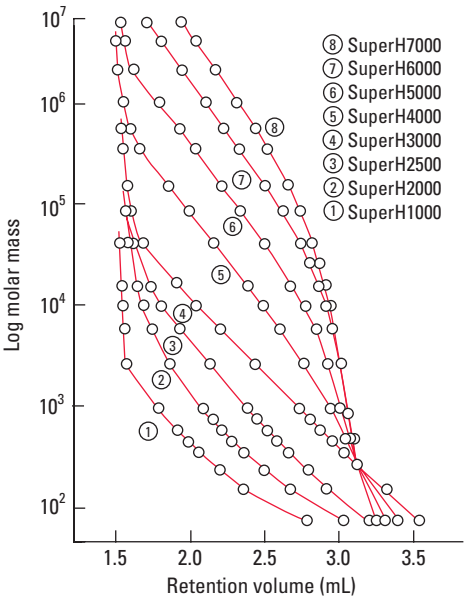
Attributes and Applications:

Table 7 shows product attributes of TSKgel SuperH columns. The maximum operating temperature for TSKgel SuperH columns is 140 °C. All TSKgel SuperH columns are shipped in THF, which can be exchanged for a wide variety of organic solvents. See the table within the TSKgel H series column overview for a listing of these solvents. Figures 9-10 show the calibration curves for the TSKgel SuperH columns.

Table 7: Product attributes

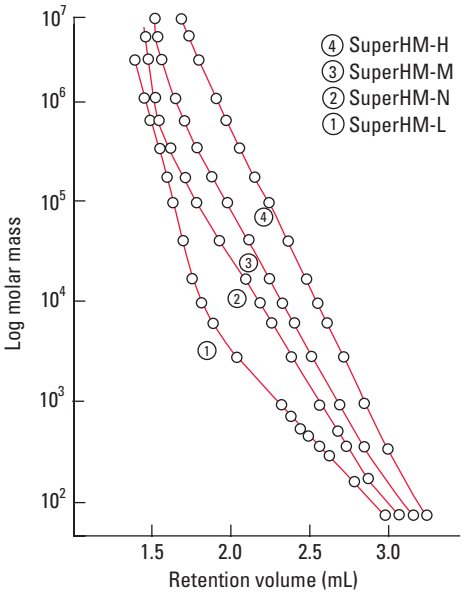
TSKgel column	Particle size (mean)	Pore size (mean)	Exclusion limit
SuperH1000	3 µm	1.5 nm	1,000 Da
SuperH2000	3 µm	2 nm	1.0×10^4 Da
SuperH2500	3 µm	3 nm	2.0×10^4 Da
SuperH3000	3 µm	7.5 nm	6.0×10^4 Da
SuperH4000	3 µm	20 nm	4.0×10^5 Da
SuperH5000	3 µm	65 nm	4.0×10^6 Da
SuperH6000	5 µm	>65 nm	4.0×10^7 Da
SuperH7000	5 µm	>65 nm	4.0×10^8 Da
SuperHM-H	3 µm	mixed pore sizes	4.0×10^8 Da
SuperHM-L	3 µm	mixed pore sizes	4.0×10^6 Da
SuperHM-M	3 µm	mixed pore sizes	4.0×10^6 Da
SuperHM-N	3 µm	mixed pore sizes	4.0×10^5 Da

Figure 9: Calibration curves for TSKgel SuperH columns



Columns:	**TSKgel SuperH columns, 6.0 mm ID × 15 cm**
Mobile phase:	THF
Flow rate:	0.6 mL/min
Detection:	UV @ 254 nm
Temperature:	25 ˚C
Sample:	polystyrene standards

Figure 10: Calibration curves for TSKgel SuperH mixed bed columns



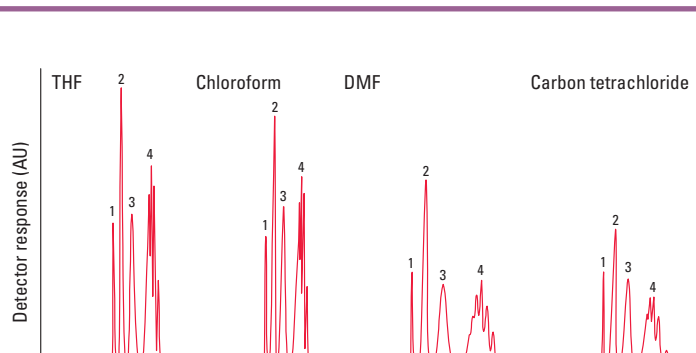
Columns:	**TSKgel SuperH columns, 6.0 mm ID × 15 cm**
Mobile phase:	THF
Flow rate:	0.6 mL/min
Detection:	UV @ 254 nm
Temperature:	25 ˚C
Sample:	polystyrene standards

Polystyrene Mixtures

Figure 11 compares chromatograms of standard polystyrene mixtures separated using a TSKgel SuperH2500 column with various organic solvents (THF, $CHCl_3$, DMF, and CCl_4) and Figure 12 compares chromatograms of standard polystyrene mixtures separated using a TSKgel SuperHM-H column with various organic solvents.

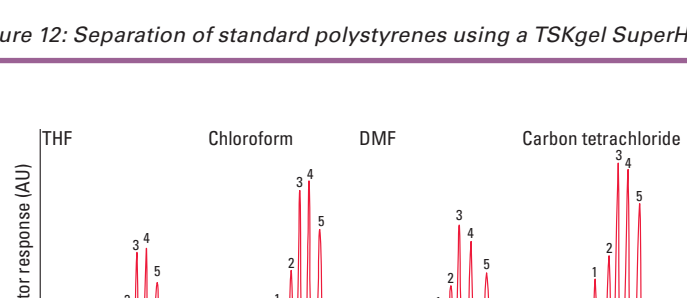
Due to the interaction between the packing material and standard polystyrene when using DMF as the mobile phase, the elution volume of standard polystyrenes is greater than it is with "good" solvents such as THF and $CHCl_3$. This effect is particularly noticeable with TSKgel SuperH2500, a column for the analysis of low molar mass samples. Under these circumstances, polyethylene oxide (PEO) is recommended as the standard sample, as this reacts very little with the packing material.

Figure 11: Separation of standard polystyrenes using a TSKgel SuperH2500 column



Column:	**TSKgel SuperH2500, 3 µm, 6 mm ID × 15 cm**
Mobile phase:	THF, chloroform, DMF, carbon tetrachloride
Flow rate:	0.6 mL/min
Temperature:	25 °C
Detection:	UV/VIS @ 254 nm or 270 nm
Samples:	1) polystyrene (1.9×10^5 Da) 2) polystyrene (9.1×10^4 Da) 3) polystyrene (2,800 Da) 4) polystyrene A-500

Figure 12: Separation of standard polystyrenes using a TSKgel SuperHM-H column



Column:	**TSKgel SuperHM-H, 3 µm, 6 mm ID x 15 cm**
Mobile phase:	THF, chloroform, DMF, carbon tetrachloride
Flow rate:	0.6 mL/min
Temperature:	25 °C
Detection:	UV/VIS @ 254 nm
Samples:	1. polystyrene (2.89×10^6 Da) 2. polystyrene (4.22×10^5 Da) 3. polystyrene (1.07×10^5 Da) 4. polystyrene (1.67×10^4 Da) 5. polystyrene (2,800 Da)

TSKgel SuperHZ Size Exclusion Columns

The TSKgel SuperHZ column line consists of five columns of 4.6 mm ID and 6.0 mm ID × 15 cm containing spherical particles composed of PS-DVB, TSKgel Super HZ1000 – 4000. Each column consists of a different pore size packing material. Subsequently, a unique separation range for each column exists, allowing researchers to choose a column that is designed for the sample type being analyzed.

The TSKgel SuperHZ column line also contains three linear, or mixed bed columns in which particles with different pore sizes are blended to provide an extended linear calibration curve. The mixed bed columns feature increasing linear calibration ranges, from TSKgel SuperHZM-M to SuperHZM-N to SuperHZM-H. The mixed bed columns are also available in 4.6 mm ID and 6.0 mm ID × 15 cm.

The following eight columns are available within the TSKgel SuperHZ column line:

- TSKgel SuperHZ1000
- TSKgel SuperHZ2000
- TSKgel SuperHZ2500
- TSKgel SuperHZ3000
- TSKgel SuperHZ4000
- TSKgel SuperHZM-H mixed bed
- TSKgel SuperHZM-M mixed bed
- TSKgel SuperHZM-N mixed bed

TSKgel SuperHZ column dimensions are 6 mm ID × 15 cm and 4.6 mm ID × 15 cm versus 7.8 mm ID × 30 cm for conventional GPC columns. The smaller column dimensions translate to a reduction of peak volume by a factor of 3.4 (6 mm ID) and a factor of 5.8 (4.6 mm ID) versus the same component eluting from a corresponding TSKgel HXL column. Thus, your HPLC system may require optimization of components that can give rise to extra-column band broadening, such as connecting tubing, injector, injection volume, detector cell volume, and detector time constant.

Attributes and Applications:

TSKgel SuperHZ columns have been developed for high throughput, high efficiency GPC applications such as those encountered in combinatorial chemistry experiments. These columns feature ultra-low sample adsorption, i.e., the columns show true size exclusion behavior for most polymers.

TSKgel SuperHZ1000 – 4000 columns are capable of measuring monomers, polymer additives, oligomers and polymers up to a molar mass of several hundred thousand with proper selection of pore size. Ultra-fine particles (3 µm) have been developed to provide high resolution over the entire molar mass range. This is especially important for the separation of low molar mass compounds.

Additionally, the mixed bed columns (TSKgel SuperHZM-N, M-M, and M-H) are capable of measuring oligomers and polymers with molar masses up to tens of millions with proper selection of the pore size. The various particle sizes of the mixed bed packing materials have been optimized to ensure resolution in the low molar mass range while avoiding shear degradation of polymers in the high molar mass region.

The columns are shipped in THF, which can be exchanged for a limited number of organic solvents as shown in the table within the TSKgel H series column overview.

Table 8 shows the product attributes of TSKgel SuperHZ columns, while Table 9 lists the features of the TSKgel SuperHZ column line and the corresponding benefits. The calibration curves for the TSKgel SuperHZ columns are shown in Figures 13-14.

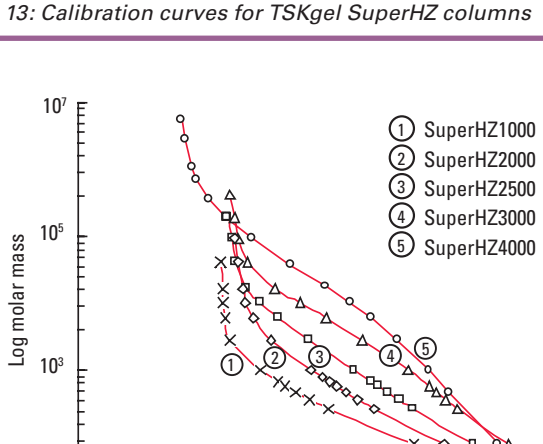
Table 8: Product attributes

TSKgel column	Particle size	Pore size	Exclusion limit	Max. temp.
SuperHZ1000	3 µm	1.5 nm	1,000 Da	60 °C
SuperHZ2000	3 µm	2 nm	1.0×10^4 Da	60 °C
SuperHZ2500	3 µm	3 nm	2.0×10^4 Da	60 °C
SuperHZ3000	3 µm	7.5 nm	6.0×10^4 Da	60 °C
SuperHZ4000	3 µm	20 nm	4.0×10^5 Da	80 °C
SuperHZM-H	10 µm	mixed pore sizes	4.0×10^8 Da	80 °C
SuperHZM-M	3 µm	mixed pore sizes	4.0×10^6 Da	80 °C
SuperHZM-N	3 µm	mixed pore sizes	7.0×10^5 Da	80 °C

Table 9: Features and benefits of TSKgel SuperHZ columns

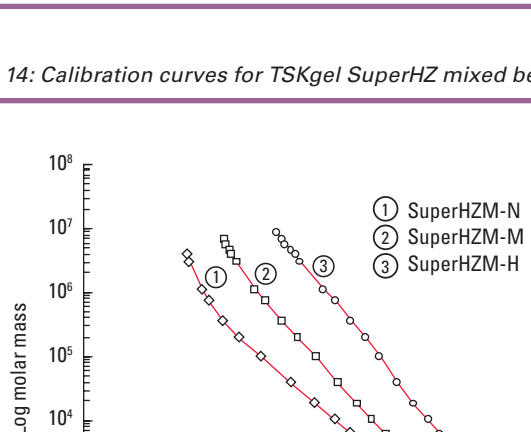
Feature	Benefit
Ultra-fine particles used in packing material	• Short measurement time is achieved. • Resolution equivalent to conventional columns (30 cm) can be obtained in ½ measurement time • Resolution does not deteriorate even under a high flow rate.
Semi-micro columns (4.6 mm ID and 6.0 mm ID)	• Reduction in solvent consumption (running costs, effluent processing costs) 1/6 to 1/3 solvent consumption compared to conventional columns
Optimization of particle size in the packing materials	• Shear degradation in polymers with high molar mass can be prevented
Adoption of low-adsorption packing materials	• Applicable to wide range of samples

Figure 13: Calibration curves for TSKgel SuperHZ columns



Columns: **TSKgel SuperHZ columns, 4.6 mm ID × 15 cm**
Mobile phase: THF
Flow rate: 0.35 mL/min
Temperature: 25 °C
Injection vol.: 2 µL
Samples: polystyrene standards

Figure 14: Calibration curves for TSKgel SuperHZ mixed bed columns

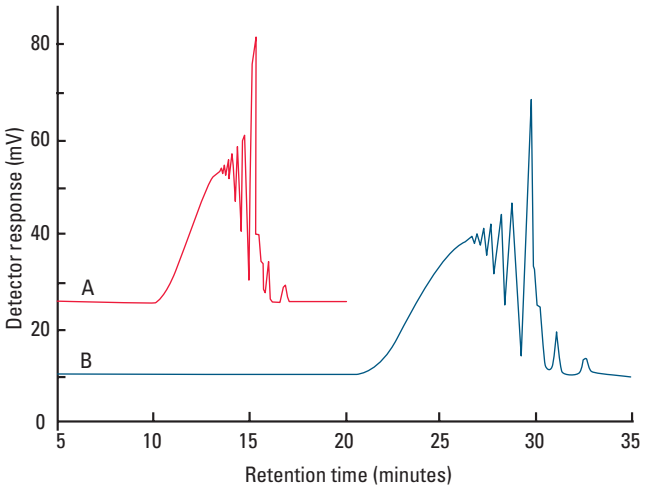


Columns: **TSKgel SuperHZ columns, 4.6 mm ID × 15 cm**
Mobile phase: THF
Flow rate: 0.35 mL/min
Temperature: 25 °C
Injection vol.: 2 µL
Samples: polystyrene standards

Faster Analysis

TSKgel SuperHZ1000-SuperHZ4000 columns are packed with 3 µm particles. The ultra-fine particles allow for high efficiency separations of low molar mass substances such as oligomers. These columns have theoretical plate values (per unit length) which are twice those of the conventional 5 µm columns. As a result, equal resolution can be obtained within half the analysis time. An example showing the analysis of phenolic resin is demonstrated in Figure 15.

Figure 15: Comparison of analysis on TSKgel SuperHZ and TSKgel HXL columns

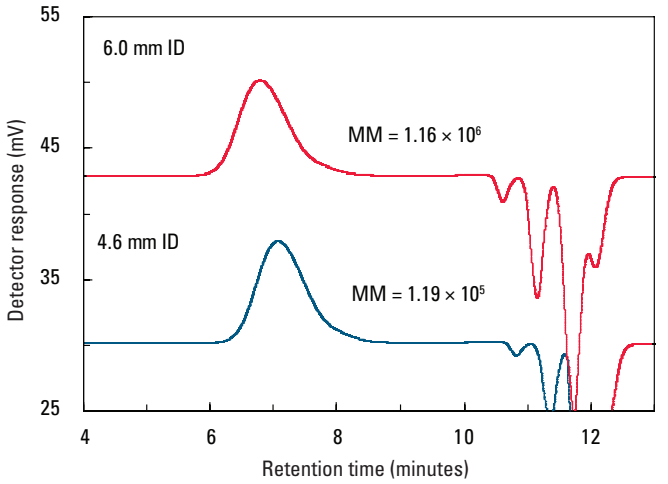


Columns:	**A. TSKgel SuperHZ columns (4000, 3000, 2500), 4.6 mm ID × 15 cm × 3** **B. TSKgel HXL columns (4000, 3000, 2500), 7.8 mm ID × 30 cm × 3**
Mobile phase:	THF
Flow rate:	A. 0.35 mL/min B. 1.0 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol.:	A. 5 µL B. 30 µL
Sample:	phenolic resin

Polyisobutylene

The chromatogram in Figure 16 shows the analysis of polyisobutylene using two TSKgel SuperHZM-M columns in series.

Figure 16: Analysis of polyisobutylene



Column:	**TSKgel SuperHZM-M, 3 µm × 2**
Mobile phase:	THF
Flow rate:	0.35 mL/min (4.6 mm ID), 0.6 mL/min (6.0 mm ID)
Detection:	RI
Temperature:	40 °C
Injection vol.:	10 µL (4.6 mm ID), 17 µL (6.0 mm ID)
Sample:	polyisobutylene (0.5 g/L)

TSKgel SuperMultiporeHZ Size Exclusion Columns

TSKgel SuperMultiporeHZ columns represent a new strategy for the separation of polymers with a wide range of molar masses. These columns are packed with particles of a uniform size, with each particle having a very broad pore size distribution. This innovative multi-pore approach, pioneered by Tosoh Bioscience, essentially creates a linear calibration curve within each particle. The spherical monodisperse, 3, 4 or 6 µm particles consist of cross-linked polystyrene/divinylbenzene copolymer. This base material, coupled with the semi-micro column dimensions (4.6 mm ID × 15 cm), offers users high speed and low solvent consumption analyses with precise results. Three columns are available within the TSKgel SuperMultiporeHZ series, each with a different particle size and separation range.

The TSKgel SuperMultiporeHZ columns offered include:

- TSKgel SuperMultiporeHZ-N
- TSKgel SuperMultiporeHZ-M
- TSKgel SuperMultiporeHZ-H

Multi-pore Technology

Prior to the introduction of TSKgel SuperMultiporeHZ columns, scientists separating polymers with a wide range of molar masses were left with two options. One option was to use multiple columns of different pore sizes linked together in series. A second was to use a column packed with a mixed bed resin of different pore sizes at an optimized mix ratio. However, problems can occur with both of these methods, which include distortion of the chromatogram or deviations between the actual calibration curve and the calibration curve approximated from data obtained from the molar mass standards.

As is shown in Figure 17, a novel approach to solve this problem was developed by Tosoh scientists and is incorporated in TSKgel SuperMultiporeHZ columns. Small particles of uniform size are synthesized with a broad distribution of pore sizes. This novel approach creates a linear calibration curve within each particle. Therefore, columns with an extended linear calibration curve can now be prepared without mixing particles of different pore sizes.

Figure 17: Graphical representations illustrate the multi-pore particle synthesis technology

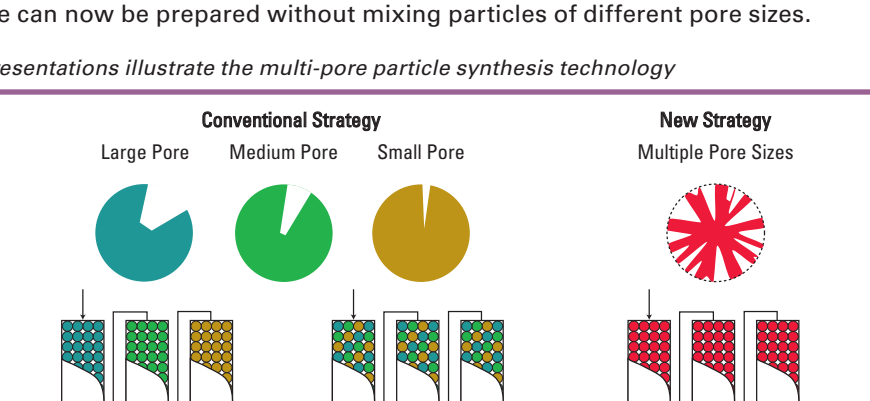
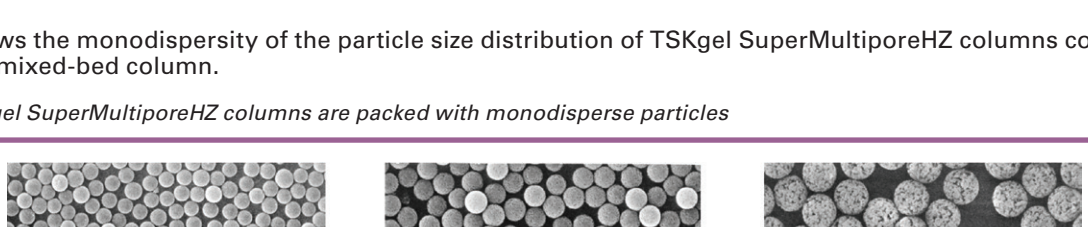


Figure 18 shows the monodispersity of the particle size distribution of TSKgel SuperMultiporeHZ columns compared to a conventional mixed-bed column.

Figure 18: TSKgel SuperMultiporeHZ columns are packed with monodisperse particles



Attributes and Applications:

Product attributes for the TSKgel SuperMultiporeHZ columns are listed in Table 10. Table 11 lists features and benefits of these columns. TSKgel SuperMultiporeHZ columns can be utilized for the analysis of polymers with a wide MM distribution range. The columns are shipped in THF, which cannot be replaced for any other organic solvent. Figure 19 shows the calibration curves for the TSKgel SuperMultiporeHZ columns.

Table 10: Product attributes

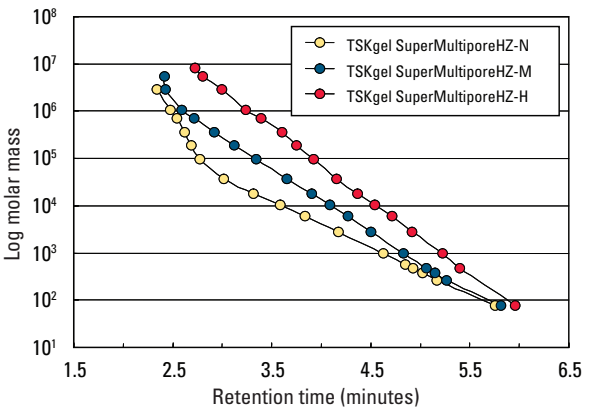
TSKgel column	SuperMultipore HZ-N	SuperMultipore HZ-M	SuperMultipore HZ-H
Base material	PS-DVB	PS-DVB	PS-DVB
Particle size	3 µm*	4 µm*	6 µm*
Pore size	8 nm	14 nm	>14 nm
Exclusion limit (PST/THF)	1.2×10^5 Da	2.0×10^6 Da	4.0×10^7 Da
Separation range	300 ~ 5.0×10^4 Da	500 ~ 1.0×10^6 Da	1,000 ~ 1.0×10^7 Da
Theoretical plates/15 cm column	20,000	16,000	11,000

* Particle size distribution is monodisperse.

Table 11: Features and benefits

Feature	Benefit
Multi-pore packing material (wide range of pores contained in single particle)	• Calibration curves with superior linearity • No observable distortion of chromatograms • Improved accuracy and repeatability of molar mass data • Capable of rapid analysis with high separation performance
Smaller particle size (monodisperse particles)	• Capable of achieving the same separation performance as conventional columns (30 cm) in half the analysis time • No reduction in separation performance even for analysis at high flow rates • Improved robustness of column performance
Semi-micro column	• Reduced solvent consumption • 1/6th the consumption of conventional (30 cm) columns
Low adsorption packing material	• Can be used for a wide variety of samples

Figure 19: Calibration curves for TSKgel SuperMultiporeHZ columns

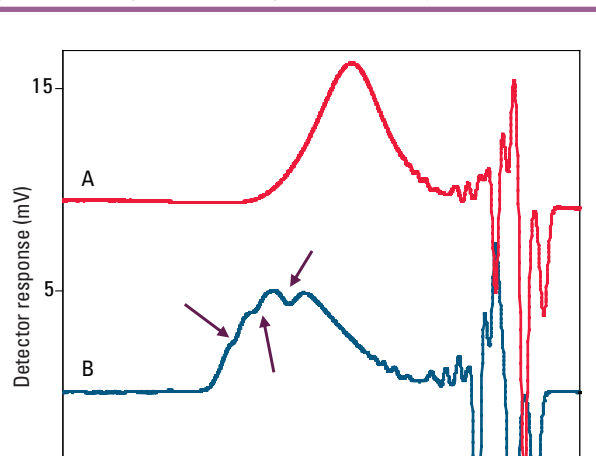


Columns: **TSKgel SuperMultiporeHZ-N, 3 µm, 4.6 mm ID × 15 cm**
TSKgel SuperMultiporeHZ-M, 4 µm, 4.6 mm ID × 15 cm
TSKgel SuperMultiporeHZ-H, 6 µm, 4.6 mm ID × 15 cm
Mobile phase: THF
Flow rate: 0.35 mL/min
Detection: UV @ 254 nm
Temperature: 25 °C
Samples: PStQuick polystyrene standards

Acrylic Resin

Figure 20 demonstrates that inflection points are no longer observed with columns packed from particles prepared by multi-pore technology.

Figure 20: Comparison for separation of acrylic resin

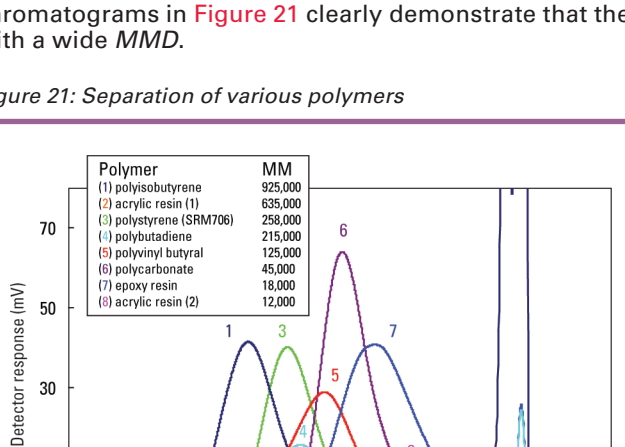


Columns:	**A. TSKgel SuperMultiporeHZ-M, 4.6 mm ID × 15 cm × 4** **B. TSKgel SuperHZ4000+3000+2500+2000, 4.6 mm ID × 15cm × 1**
Mobile phase:	THF
Detection:	RI
Temperature:	40 °C
Injection vol.:	10 µL
Samples:	acrylic resin

Various Polymers

Various polymers were analyzed on four TSKgel SuperMultiporeHZ-M columns in series. The superimposed chromatograms in Figure 21 clearly demonstrate that these new GPC columns can be utilized for the analysis of polymers with a wide *MMD*.

Figure 21: Separation of various polymers



Columns:	**SuperMultiporeHZ-M, 4 µm, 4.6 mm ID × 15 cm × 4**
Mobile phase:	THF
Flow rate:	0.35 mL/min
Detection:	RI
Temperature:	25 °C
Injection vol.:	10 µL
Sample conc.:	0.3%

TSKgel Alpha and SuperAW Size Exclusion Columns

TSKgel Alpha and SuperAW columns were developed for the GPC analysis of polymers of intermediate polarity. As in the TSKgel PW and PW$_{XL}$ columns, the particles in these TSKgel columns have a hydroxylated methacrylate polymer backbone, but they differ in that they are crosslinked to a higher degree to minimize swelling in polar organic solvents (methanol, acetonitrile, DMSO, isopropanol, THF, and HFIP). The TSKgel Alpha and SuperAW columns provide accurate molar mass determination and exhibit normal retention of polystyrene polymers in dimethyl formamide (DMF) solvent. Unlike TSKgel PW columns, which are stable to a 50% organic mixed with water at most, TSKgel SuperAW and Alpha columns are stable in a wide variety of organic solvents at concentrations up to 100%. TSKgel Alpha and SuperAW columns are offered in 5 discrete exclusion ranges and as a mixed bed column. Both column types can accommodate polymer standards up to several million Dalton molar mass.

- Use TSKgel Alpha columns when throughput is not critical, when sample mass is not limited, to collect fractions, and to obtain maximum number of plates (at the expense of analysis time). The main application area for TSKgel Alpha columns is the analysis of polymers that are soluble in polar organic solvents. Examples include cellulose derivatives, polyimide, and sodium dodecylsulfate (all in 10 mmol/L LiBr in DMF), cleansing gel in methanol, and degree of saponification of polyvinylalcohol in hexafluoroisopropanol (HFIP).

  The TSKgel Alpha Series consists of six columns with three particle sizes: 7, 10, and 13 µm. These columns span a wide MM separation range, from 100 to more than 1 x 10^6 Da, when using polyethylene oxide (PEO) as a MM standard. There is one mixed bed column within the TSKgel Alpha line, TSKgel Alpha-M, which has an extended linear calibration range and is suitable for samples with a broad MM distribution, as well as samples with unknown molar mass.

TSKgel Alpha columns include:

- TSKgel Alpha-2500
- TSKgel Alpha-3000
- TSKgel Alpha-4000
- TSKgel Alpha-5000
- TSKgel Alpha-6000
- TSKgel Alpha-M

- Use TSKgel SuperAW columns for high throughput applications, to reduce solvent consumption and to reduce solvent disposal cost. TSKgel SuperAW columns contains a similar chemistry as the TSKgel Alpha columns but offer the benefit of smaller particle sizes (4, 6, 7, and 9 µm), smaller column dimensions, and equivalent resolution. Reductions in analysis time and mobile phase consumption make TSKgel SuperAW columns ideal for high throughput applications.

  The TSKgel SuperAW column line consists of five columns and a mixed bed column. These high efficiency columns are only available in 6.0 mm ID x 15 cm dimensions.

TSKgel SuperAW columns include:

- TSKgel SuperAW2500
- TSKgel SuperAW3000
- TSKgel SuperAW4000
- TSKgel SuperAW5000
- TSKgel SuperAW6000
- TSKgel SuperAWM-H

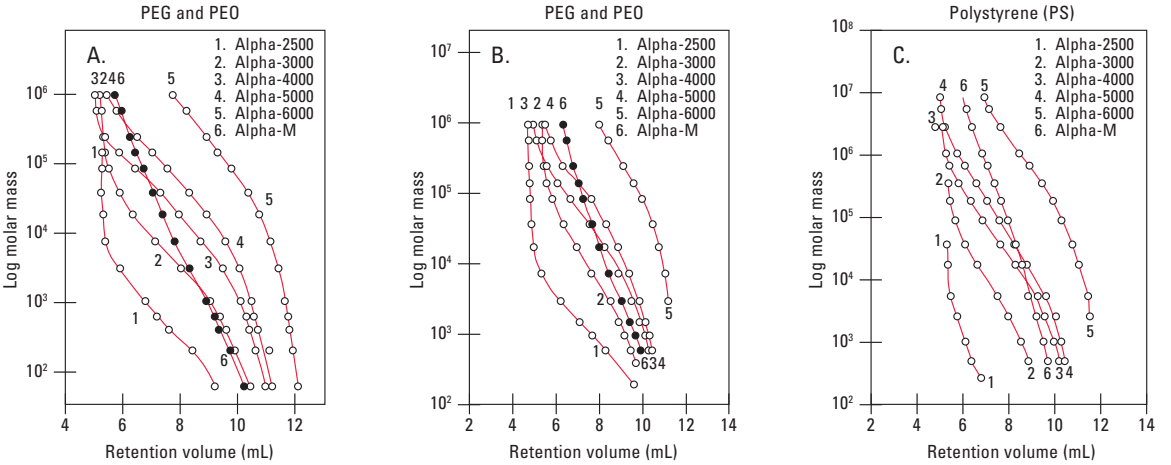
Attributes and Applications:

Product attributes of the TSKgel Alpha and SuperAW columns are shown in Table 12. These columns are for the analysis of polymers that are soluble in methanol, acetonitrile, DMSO, isopropanol, or THF and can also be used for water-soluble polymers. Figures 22-25 show the calibration curves for the TSKgel Alpha and SuperAW columns. Unlike TSKgel PW/PWXL columns, some of which are stable up to 50% organic mixed with water, TSKgel SuperAW and Alpha columns are stable in a wide variety of organic solvents at concentrations up to 100%. As shown in Figure 24, efficiency of all TSKgel SuperAW columns is maintained when changing solvents from water via acetonitrile, DMF, DMSO, THF to HFIP. Suitable solvents for TSKgel Alpha columns are shown in Figure 25.

Table 12: Product attributes

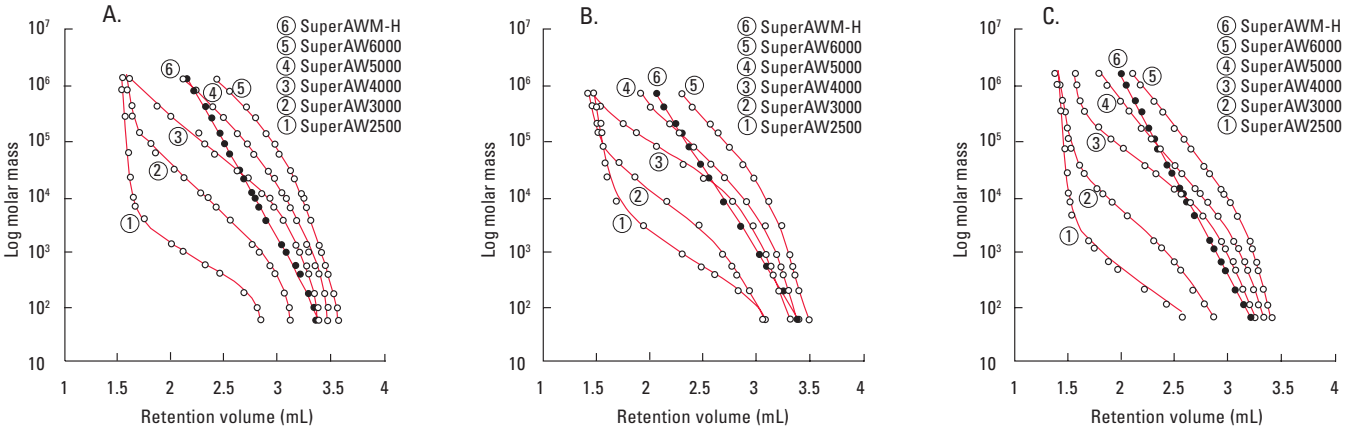
			Exclusion limit (Da) for various standards & eluents		
TSKgel column	**Particle size**	**Pore size**	**PEO in H_2O**	**PS in DMF with 10 mmol/L LiBr**	**PEG in MeOH with 10 mmol/L LiBr**
Alpha-2500	7 µm	2.5 nm	5,000	1×10^4	1×10^4
Alpha-3000	7 µm	15 nm	9×10^4	1×10^5	6×10^4
Alpha-4000	10 µm	45 nm	4×10^5	1×10^6	3×10^6
Alpha-5000	10 µm	100 nm	1×10^6	7×10^6	$>3 \times 10^5$
Alpha-6000	13 µm	>100 nm	$>1 \times 10^7$	$>1 \times 10^7$	$>3 \times 10^5$
Alpha-M	13 µm	mixed bed	$>1 \times 10^7$	$>1 \times 10^7$	$>3 \times 10^5$
SuperAW2500	4 µm	2.5 nm	5,000	1×10^4	1×10^4
SuperAW3000	4 µm	15 nm	9×10^4	1×10^5	6×10^4
SuperAW4000	6 µm	45 nm	4×10^5	1×10^6	3×10^6
SuperAW5000	7 µm	100 nm	1×10^6	7×10^6	$>3 \times 10^5$
SuperAW6000	9 µm	>100 nm	$>1 \times 10^7$	$>1 \times 10^7$	$>3 \times 10^5$
SuperAWM-H	9 µm	mixed bed	$>1 \times 10^7$	$>1 \times 10^7$	$>3 \times 10^5$

Figure 22: Polyethylene oxide, polyethylene glycol, and polystyrene calibration curves for TSKgel Alpha columns



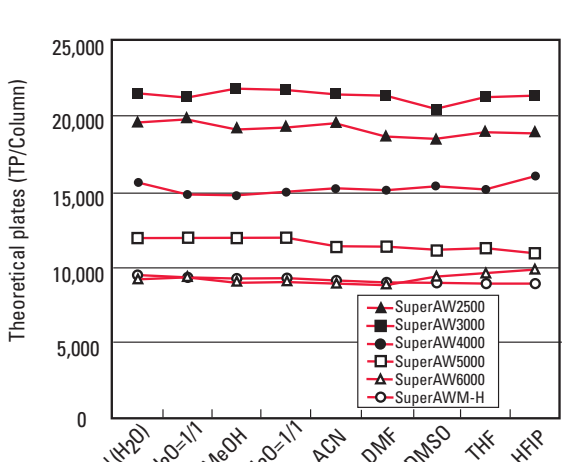
Column:	**TSKgel Alpha columns, 7.8 mm ID × 30 cm**
Mobile phase:	A. H_2O
	B. MeOH with 10 mmol/L LiBr
	C. DMF with 10 mmol/L LiBr
Flow rate:	1.0 mL/min
Detection:	RI
Temperature:	A. 25 °C B. 25 °C C. 40 °C
Samples:	A, B: polyethylene glycol (PEG) and polyethene oxide (PEO) standards
	C: polystyrene (PS) standards

Figure 23: Polyethylene oxide, polyethylene glycol, and ethylene glycol calibration curves for TSKgel SuperAW columns



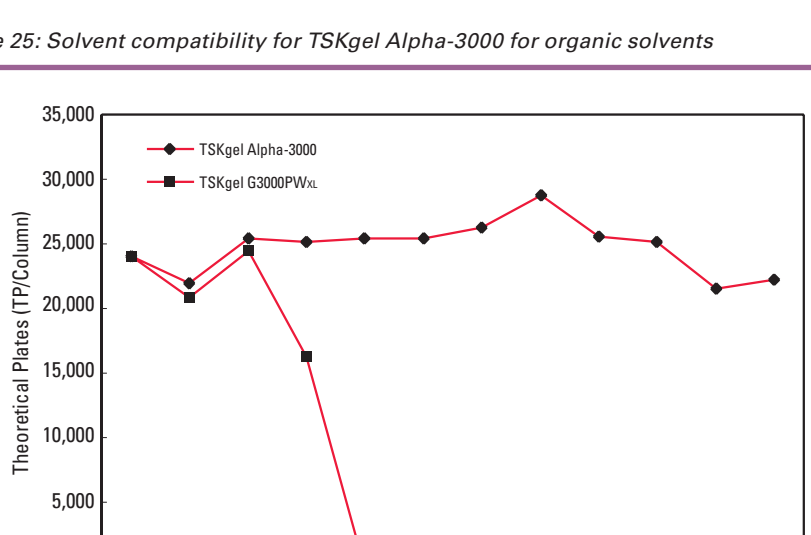
Column:	**TSKgel SuperAW columns, 6.0 mm ID × 15 cm**
Mobile phase:	A. H_2O
	B. MeOH with 10 mmol/L LiBr
	C. DMF with 10 mmol/L LiBr
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	polyethylene oxide (PEO), polyethylene glycol (PEG), and ethylene glycol (EG) standards

Figure 24: Column efficiency of TSKgel SuperAW columns



Column:	**TSKgel SuperAW columns, 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	25 °C
Injection vol.:	5 µL (2.5 g/L)
Sample:	ethylene glycol

Figure 25: Solvent compatibility for TSKgel Alpha-3000 for organic solvents



Conditions of solvent change

Flow Rate:	1.0 mL/min
Temperature:	25 °C
Time for purge:	8 h

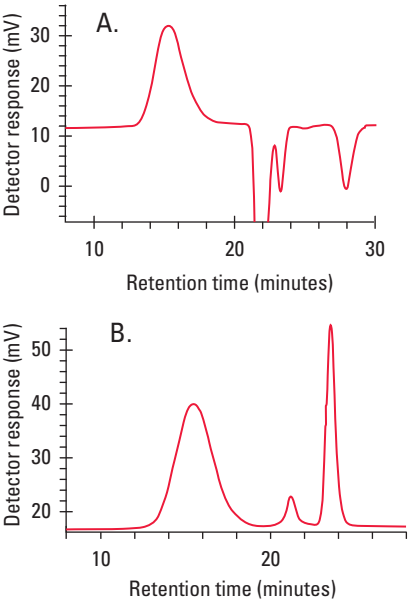
Conditions for TP measurement

Flow Rate:	1.0 mL/min
Detection:	RI
Temperature:	25 °C
Sample:	ethylene glycol

Cellulose Derivatives

The versatility of using TSKgel Alpha columns with various polar solvents is illustrated in Figure 26 for the analysis of cellulose derivatives. A TSKgel Alpha-M column was used to separate ethylcellulose with the polar solvent DMF and ethylhydroxyethyl cellulose with methanol.

Figure 26: Analysis of cellulose derivatives

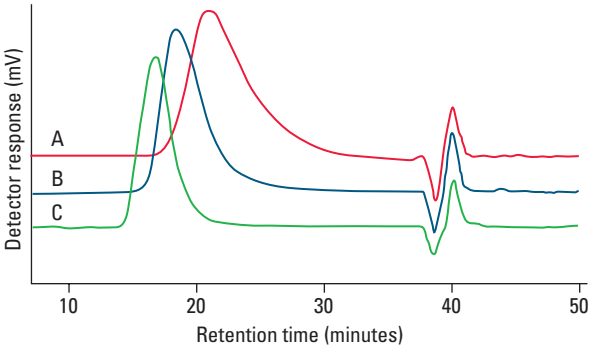


Column:	**TSKgel Alpha-M, 13 µm, 7.8 mm ID × 30 cm**
Mobile phase:	A. DMF with 10 mmol/L LiBr B. MeOH with 10 mmol/L LiBr
Flow rate:	0.5 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol.:	50 µL
Sample:	A. ethyl cellulose, 0.1% B. ethyl hydroxyethyl cellulose, 0.1%

Polyvinylalcohol Characterization

The separation of polyvinylalcohol with different degrees of saponification is shown in Figure 27. This separation was performed with a TSKgel Alpha-5000 and a TSKgel Alpha-3000 column in series using a hexafluoroisopropanol (HFIP) mobile phase.

Figure 27: Analysis of polyvinylalcohol with different degrees of saponification

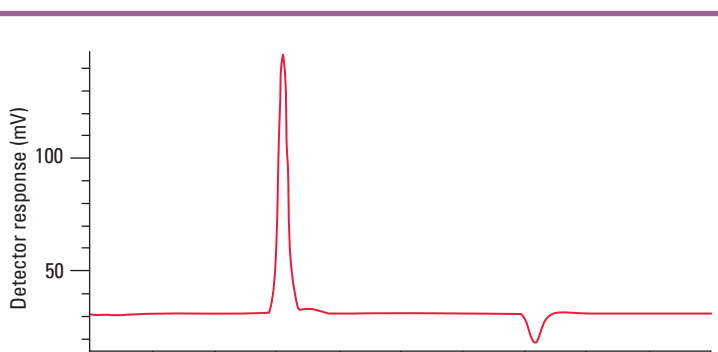


Column:	**TSKgel Alpha-5000 and Alpha-3000, 7.8 mm ID × 30 cm in series**
Mobile phase:	hexafluoroisopropanol (HFIP)
Flow rate:	0.5 mL/min
Detection:	RI
Temperature:	40 °C
Samples:	degree of saponification of polyvinyl alcohol: A. 75% B. 88% C. 100%

Glyceryl tri(2-ethylhexanoate)

Glyceryl tri(2-ethylhexanoate) is used as a plastic lubricant and as a cosmetic base. The analysis of this compound using a TSKgel Alpha-2500 column is shown in Figure 28.

Figure 28: Analysis of glyceryl tri(2-ethylhexanoate)

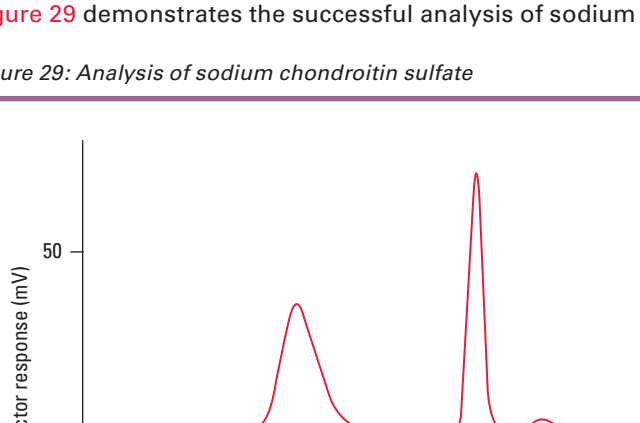


Column:	**TSKgel Alpha-2500, 7 µm, 7.8 mm ID × 30 cm**
Mobile Phase:	methanol
Flow rate:	0.5 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol:	50 µL
Sample:	glyceryl tri-2-ethylhexanoate
Sample load:	0.10%

Sodium Chondroitin Sulfate

Figure 29 demonstrates the successful analysis of sodium chondroitin sulfate on a TSKgel SuperAWM-H column.

Figure 29: Analysis of sodium chondroitin sulfate



Column:	**TSKgel SuperAWM-H, 9 µm, 6.0 mm ID × 15 cm × 2**
Mobile phase:	H_2O with 0.2 mol/L sodium nitrate
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	25 °C
Injection vol.:	5 µL (2.5 g/L)
Sample:	chondroitin sulfate

TSKgel PW Series Size Exclusion Columns

TSKgel PW and PWXL columns are recommended for analyses of water-soluble polymers and are prepared from hydrophilic polymethacrylate resin. TSKgel PWXL-CP columns are prepared from the same base resin as the TSKgel PWXL columns and were specifically developed for the analysis of water-soluble cationic polymers. TSKgel SuperMultiporePW columns are packed with particles containing a wide range of pore sizes for the analysis of water-soluble polymers with a wide molar mass range.

Stable from pH 2 to 12, TSKgel PW series columns can be used in mobile phases of water or buffer (up to 20% methanol/80% aqueous) and can tolerate temperatures up to 80 ˚C (50 ˚C for TSKgel G-DNA-PW column).

- Use TSKgel PW columns when analysis time is not critical, when sample mass is not limited, to collect fractions, or to obtain maximum number of plates (at the expense of analysis time). Particle sizes range from 12 µm for the smaller pore size columns (12.5 nm) to 17 µm for the larger pore size columns (20 nm - >100 nm).

  The TSKgel GMPW column, within the TSKgel PW column line, is a mixed bed column containing a mixture of different pore sizes that has an extended linear calibration range, suitable for samples with a broad MM distribution as well as unknown samples.

  A TSKgel G6000PW column is available in PEEK column hardware, TSKgel BioAssist G6PW, when ultra-low sample adsorption is required, such as in virus analysis.

- Use higher efficiency TSKgel PWXL columns for optimal resolution, to reduce analysis time or in sample-limited applications. TSKgel PWXL columns have smaller particle sizes than TSKgel PW columns, resulting in improved resolution.

  The TSKgel PWXL product line also offers specialty columns for analyzing carbohydrate oligomers (TSKgel G-Oligo-PW) and DNA and RNA fragments of 500-5000 base pairs (TSKgel G-DNA-PW). TSKgel GMPWXL is a mixed bed scouting column for aqueous water-soluble linear polymers. Its pore volume is accessible to polymers ranging from molar masses of 1,000 up to 8.0×10^6 Da.

- Cationic groups were introduced on the surface of the TSKgel PWXL-CP packing material to prevent adsorption of cationic polymers and allow elution under low salt conditions. These columns show high theoretical plate numbers, linear calibration curves and excellent durability. The base resin is the same as that used in the TSKgel PWXL columns.

  Three columns are available within the TSKgel PWXL-CP line, each with a different particle size, separation range and exclusion limit, allowing polymers within a wide molar mass range to be separated and characterized.

- A wide molar mass range can be analyzed with the three different TSKgel SuperMultiporePW columns, from high molar mass water-soluble polymers to oligomers. The packing material in the TSKgel SuperMultiporePW columns is more hydrophilic than that of TSKgel PWXL columns, which further reduces the chance of adsorption of hydrophilic polymers.

The range of pore sizes in which TSKgel PW and TSKgel PWXL columns are available permits a wide spectrum of water-soluble substances to be analyzed. The properties and molar mass separation ranges for all TSKgel PW series columns are summarized in Table 13.

The mechanism of SEC separation is based on the difference of apparent molecular size with no additional interaction between the column matrix and the sample molecules. In practice, however, a small number of weakly charged groups on the surface of all TSKgel PW series packings can cause changes in elution order from that of an ideal system. Fortunately, the mobile phase composition can vary greatly with TSKgel PW series columns to be compatible with a wide range of neutral, polar, anionic, and cationic samples. Table 14 lists appropriate mobile phases for GFC of major polymer types on TSKgel PW series columns.

For some nonionic, nonpolar polymers, such as polyethylene glycols, ideal size exclusion behavior can be obtained by using distilled water as the mobile phase. More polar ionic polymers may exhibit abnormal peak shapes or minor peaks near the void volume when eluted with distilled water due to ionic interactions between the sample and residual charged groups on the resin surface. To eliminate ionic interactions, a neutral salt such as sodium nitrate or sodium sulfate should be added to the aqueous eluent. Generally, a salt concentration of 0.1 mol/L to 0.5 mol/L is needed to overcome undesirable ionic interactions.

TSKgel PW resins are more hydrophobic than polysaccharide gels such as cross-linked dextran. Depending on the sample, this can lead to hydrophobic interaction as a secondary retention mechanism. The extent of hydrophobic interaction increases as the salt concentration of the eluent increases, but it can be reduced by the addition of an organic modifier such as acetonitrile. Water-soluble organic solvents are frequently used as modifiers to suppress hydrophobic interactions between the sample and the resin surface.

Table 13: Properties and separation ranges of TSKgel PW, PW$_{XL}$, PW$_{XL}$-CP, and SuperMultiporePW columns

			Molar mass of samples (Da)
TSKgel column	**Particle size**	**Pore size**	**Polyethylene glycols & oxides**
SuperMultiporePW-N	4 µm	20 nm	300 – 5 × 10^4
SuperMultiporePW-M	5 µm	100 nm	500 – 1 × 10^6
SuperMultiporePW-H	8 µm	>100 nm	1,000 – 1 × 10^7
G2000PW	12 µm	12.5 nm	<3,000
G2500PW	12 µm and 17 µm	12.5 nm	<3,000
G3000PW	12 µm and 17 µm	20 nm	<5 × 10^4
G4000PW	17 µm	50 nm	<3 × 10^5
G5000PW	17 µm	100 nm	<1 × 10^6
G6000PW BioAssist G6PW	17 µm	>100 nm	<8 × 10^6
GMPW	17 µm	mixed pore sizes	1,000 – 8 × 10^6
G2500PW$_{XL}$	7 µm	12.5 nm	<3,000
G3000PW$_{XL}$	7 µm	20 nm	<5 × 10^4
G4000PW$_{XL}$	10 µm	50 nm	<3 × 10^5
G5000PW$_{XL}$	10 µm	100 nm	<1 × 10^6
G6000PW$_{XL}$	13 µm	>100 nm	<8 × 10^6
G-DNA-PW	10 µm	>100 nm	<8 × 10^6
GMPW$_{XL}$	13 µm	mixed pore sizes	1,000 – 8 × 10^6
SuperOligoPW	3 µm	12.5 nm	<3,000
G-Oligo-PW	7 µm	12.5 nm	<3,000
G3000PW$_{XL}$-CP	7 µm	20 nm	200 – 5 × 10^4
G5000PW$_{XL}$-CP	10 µm	100 nm	400 – 5 × 10^5
G6000PW$_{XL}$-CP	13 µm	>100 nm	1,000 – 1 × 10^7
Columns: TSKgel PW columns, 7.5 mm ID × 60 cm TSKgel PW$_{XL}$, G-Oligo-PW and G-DNA-PW columns, 7.8 mm ID × 30 cm TSKgel SuperMultiporePW and SuperOligoPW columns, 6.0 mm ID × 15 cm Mobile phase: polyethylene glycols and oxides (PEOs): distilled water Flow rate: 1.0 mL/min, except for TSKgel SuperMultiporePW and SuperOligoPW columns: 0.6 mL/min			

Modifiers are also used for optimizing the elution of both charged and neutral hydrophobic polymers. Typical examples for a variety of sample types are given in Table 14. All TSKgel PW series packings are compatible with 20% aqueous solutions of methanol, ethanol, propanol, acetonitrile, dimethyl formamide, dimethyl sulfoxide, formic acid, and acetic acid. In addition, these columns can be operated in 50% aqueous acetone.

Table 14: Recommended mobile phases for GFC of water-soluble polymers on TSKgel PW, PW$_{XL}$, PW$_{XL}$-CP, and SuperMultiporePW columns

Type of polymer	Typical sample	Suitable mobile phase
Nonionic hydrophilic	polyethylene glycol	Distilled water
	soluble starch, methyl cellulose, pullulan	0.01 mol/L NaOH
	dextran, hydroxyethyl cellulose	20% DMSO (dimethyl sulfoxide)
	polyvinyl alcohol, polyacrylamide	Buffer or salt solution (e.g. 0.1-0.5 mol/L $NaNO_3$)
Nonionic hydrophobic	polyvinylpyrrolidone	Buffer or salt solution with organic solvent (e.g. 20% CH_3CN in 0.1 mol/L $NaNO_3$)
Anionic hydrophilic	sodium chondroitin sulfate, sodium alginate, carboxymethyl cellulose, sodium polyacrylate, sodium hyaluronate	Buffer or salt solution (e.g. 0.1 mol/L $NaNO_3$)
Anionic hydrophobic	sulfonated lignin sodium salt, sodium polystyrenesulfonate	Buffer or salt solution with organic solvent (e.g. 20% CH_3CN in 0.1 mol/L $NaNO_3$)
Cationic hydrophilic	glycol chitosan, DEAE-dextran, poly(ethylene imine), poly(trimethylaminoethyl methacrylate) iodide salt	0.5 mol/L acetic acid with 0.3 mol/L Na_2SO_4 or 0.8 mol/L $NaNO_3$
Cationic hydrophobic	poly(4-vinylbenzyltrimethylammonium chloride), poly(N-methyl-2-vinylpyridinium) iodide salt	0.5 mol/L acetic acid with 0.3 mol/L Na_2SO_4
Amphoteric hydrophilic	peptides, proteins, poly- and oligosaccharides, DNA, RNA	Buffer or salt solution (e.g. 0.1 mol/L $NaNO_3$)
Amphoteric hydrophobic	blue dextran, collagen, gelatin, hydrophobic proteins, hydrophobic peptides	Buffer or salt solution with organic solvent (e.g. 20% CH_3CN in 0.1 mol/L $NaNO_3$ or 35-45% CH_3CN in 0.1% TFA)

TSKgel PW Size Exclusion Columns

TSKgel PW columns are composed of spherical, hydrophilic polymethacrylate beads. Particle sizes range from 12 µm for the smaller pore size columns to 17 µm for the larger pore size columns. Stable from pH 2 to 12, TSKgel PW columns can be used in mobile phases of water or buffer (up to 20% methanol/80% aqueous) and can tolerate temperatures up to 80 ˚C.

The TSKgel PW column line consists of the following columns:

- TSKgel G2000PW
- TSKgel G2500PW
- TSKgel G3000PW
- TSKgel GMPW
- TSKgel G4000PW
- TSKgel G5000PW
- TSKgel G6000PW

The mixed bed column, TSKgel GMPW, has an extended linear calibration range, suitable for samples with a broad MM distribution, as well as for unknown samples. The pore volume can be accessed by polymers ranging in molar mass from 1,000 to 8.0 × 10^6 Da. By quickly categorizing the MM profile of an unknown sample, the column enables a fast selection of the best TSKgel PW column for routine analysis.

Attributes and Applications

Product attributes of all eight TSKgel PW columns are shown in Table 15. All TSKgel PW columns have a base material of hydroxylated polymethacrylate, can be used in a maximum of 20% organic, and are shipped in water. The main application area for TSKgel PW columns is the analysis of water-soluble polymers, such as celluloses, acrylamides, glycols, dextrans, polyvinylalcohol, and oligosaccharides. TSKgel G2000PW, the larger particle size equivalent of TSKgel G-Oligo-PW, is most suitable for semi-preparative and preparative isolation of oligosaccharides. Representative application examples for the PW columns are illustrated in Table 16. The calibration curve for polyethylene glycol and oxides for the TSKgel PW columns is shown in Figure 30.

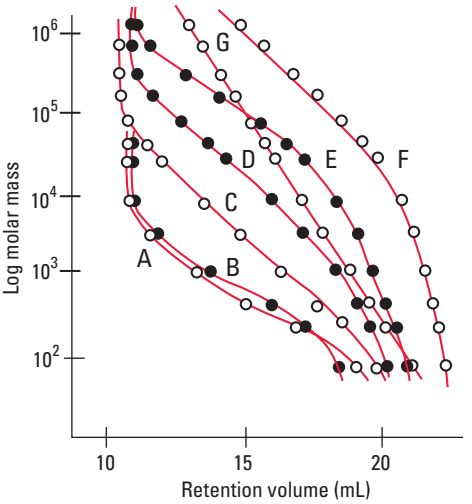
Table 15: Product attributes

TSKgel column	Particle size (mean)	Pore size (mean)	Calibration range
G2000PW	12 µm	12.5 nm	Up to 3,000 Da (polyethylene glycols and oxides)
G2500PW	12 µm and 17 µm	12.5 nm	Up to 3,000 Da (polyethylene glycols and oxides)
G3000PW	12 µm and 17 µm	20 nm	Up to 5.0 × 10^4 Da (polyethylene glycols and oxides)
G4000PW	17 µm	50 nm	Up to 3.0 × 10^5 Da (polyethylene glycols and oxides)
G5000PW	17 µm	100 nm	Up to 1.0 × 10^6 Da (polyethylene glycols and oxides)
G6000PW	17 µm	>100 nm	Up to 8.0 × 10^6 Da (polyethylene glycols and oxides)
GMPW	17 µm	mixed pore sizes	1,000 - 8.0 × 10^6 Da (polyethylene glycols and oxides)

Table 16: Representative application examples for TSKgel PW columns

Classification	Examples
1. Synthetic polymers • Nonionic • Cationic • Anionic	• PEG, polyglycerin,v polyacrylamide • Polyethyleneimine, polyvinylpyrolidine • Poly (sodium acrylate), Poly (sodium styrene sulfonate)
2. Polysaccharides and derivatives	• Standard dextran, clinical dextran, pullulan, inulin, heparin, chitosan • Carboxymethylcellulose
3. Very large biopolymers • Polynucleotides • Viruses • Proteins	• DNA fragments • TMV, SBMV, TBSV • Lipoprotein (VLDL, LDL), apoferritin, gelatin, sea worm chlorocruorin
4. Small molecules • Oligomers • Others	• oligosaccharides (dextran hydrolysate, cyclodoxtrin • hydrolysate), cyclodextrins • oligopeptides • oligonucleotides

Figure 30: Polyethylene glycol and oxide calibration curves for TSKgel PW columns

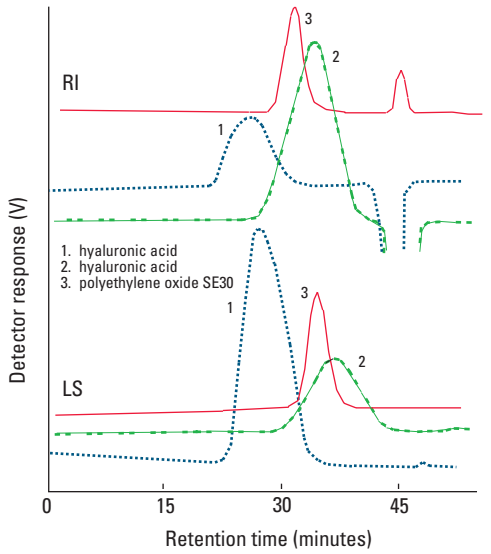


Column: **A. G2000PW, B. G2500PW, C. G3000PW, D. G4000PW, E. G5000PW, F. G6000PW, G. GMPW, all 7.5 mm ID × 60 cm**
Mobile phase: distilled H_2O
Flow rate: 1.0 mL/min
Detection: RI

Oligosaccharides

TSKgel PW columns are recommended for polysaccharide analysis due to their ability to separate a wide molar mass distribution. An effective separation of the anionic hydrophilic glucosaminoglycan, hyaluronic acid, is shown in Figure 31 on a TSKgel G6000PW and TSKgel G4000PW column in series with a 0.2 mol/L sodium chloride mobile phase. To obtain shorter analysis time and similar resolution, we recommend using TSKgel G3000PWXL and G4000PWXL columns in series.

Figure 31: Analysis of polysaccharides

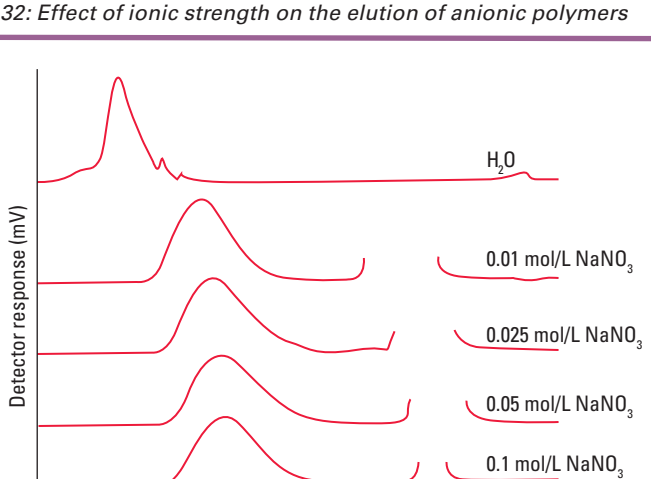


Columns: **TSKgel G6000PW + G4000PW, two 7.5 mm ID × 60 cm columns in series**
Mobile phase: H_2O with 0.2 mol/L NaCl
Flow rate: 0.9 mL/min
Temperature: 40 °C
Sample: hyaluronic acid, polyethylene oxide

Polymers

Sodium polyacrylate, an anionic polymer, is effectively separated on two TSKgel GMPW columns in Figure 32. The addition of 0.01 mol/L $NaNO_3$ results in normal elution and peak shape overcoming the ionic repulsion between the anionic sample and the resin.

Figure 32: Effect of ionic strength on the elution of anionic polymers



Column:	**TSKgel GMPW, 17 µm, 7.5 mm ID × 60 cm × 2**
Mobile phase:	H_2O with 0.01 mol/L, 0.025 mol/L, 0.05 mol/L or 0.1 mol/L $NaNO_3$
Flow rate:	0.5 mL/min
Detection:	RI
Sample:	0.5 mL of 0.05-0.1% of the sodium salt of polyacrylic acid, an anionic polymer

TSKgel PWXL Size Exclusion Columns

TSKgel PWXL columns are composed of spherical, hydrophilic polymethacrylate beads. The smaller particle size of TSKgel PWXL columns provide 1.7x higher resolution than their TSKgel PW columns counterpart, making TSKgel PWXL columns more suitable for analytical purposes. Four specialty columns are included in the TSKgel PWXL column line.

The TSKgel G-DNA-PW column is designed for the separation of large polynucleotides such as DNA and RNA fragments of 500 - 5,000 base pairs. This column is a smaller particle size version of the TSKgel G6000PWXL column. The TSKgel G-Oligo-PW column is designed for high resolution separations of aqueous nonionic and cationic oligomers, and oligosaccharides such as hydrolyzed cyclodextrins. Because of the presence of cationic groups on the gel matrix, this column is not suitable for separating anionic polymers. The TSKgel G-Oligo-PW column has a PEG and PEO calibration curve identical to that of the TSKgel G2500PWXL column. The mixed-mode column, TSKgel GMPWXL, has an extended linear calibration range, suitable for samples with a broad MM distribution and unknowns.

The TSKgel SuperOligoPW column is designed for the determination of molar mass of aqueous oligomers, particularly oligosaccharides, and low molar mass aqueous polymers. The combination of the decreased particle size and semi-micro dimensions of the TSKgel SuperOligoPW column enables high speed separation with high resolution and lowered solvent consumption. Since the packing material in the TSKgel SuperOligoPW columns is more hydrophilic compared with TSKgel G-Oligo-PW columns, an even wider range of water-soluble polymers can be analyzed without the need to add organic solvent to the eluent.

The following TSKgel PWXL columns are offered:

- TSKgel G2500PWXL
- TSKgel G3000PWXL
- TSKgel G4000PWXL
- TSKgel G5000PWXL
- TSKgel G6000PWXL
- TSKgel G-DNA-PW
- TSKgel GMPWXL
- TSKgel G-Oligo-PW
- TSKgel SuperOligoPW

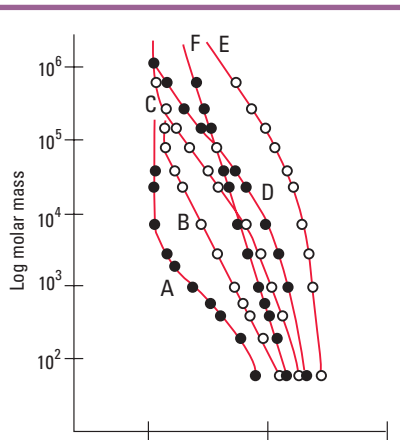
Attributes and Applications

The main application area for TSKgel PWXL columns is the analysis of water-soluble polymers, such as celluloses, acrylamides, glycols, dextrans, polyvinylalcohol, and oligosaccharides. Because of the presence of cationic groups on the base bead of TSKgel G2500PWXL, this column is not suited for separating anionic polymers. Product attributes of all of the TSKgel PWXL columns are shown in Table 17. All TSKgel PWXL columns have a base material of hydroxylated polymethacrylate, can be used in a maximum of 20% organic and are shipped in water. Figures 33-37 show the calibration curves for all of the TSKgel PWXL columns.

Table 17: Product attributes

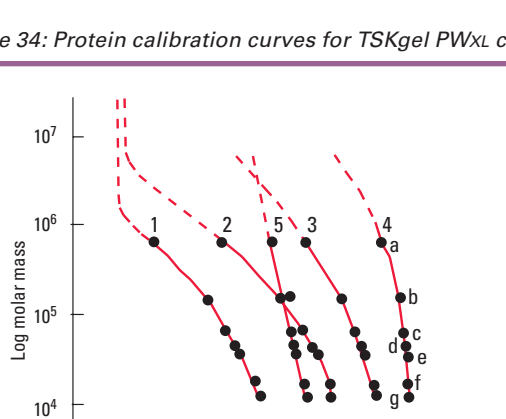
TSKgel column	Particle size (mean)	Pore size (mean)	Calibration range
G2500PWXL	7 µm	12.5 nm	<3,000 Da (polyethylene glycols and oxides)
G3000PWXL	7 µm	20 nm	<4.0×10^4 Da (polyethylene glycols and oxides)
G4000PWXL	10 µm	50 nm	2,000 - 3.0×10^5 Da (polyethylene glycols and oxides)
G5000PWXL	10 µm	100 nm	4,000 - 8.0×10^5 Da (polyethylene glycols and oxides)
G6000PWXL	13 µm	>100 nm	4.0×10^4 - 8.0×10^6 Da (polyethylene glycols and oxides)
G-DNA-PW	10 µm	>100 nm	4.0×10^4 - 8.0×10^6 Da (polyethylene glycols and oxides)
GMPWXL	13 µm	mixed pore sizes	1,000 - 8.0×10^6 Da (polyethylene glycols and oxides)
G-Oligo-PW	7 µm	12.5 nm	Up to 3,000 Da (polyethylene glycols and oxides)
SuperOligoPW	3 µm	12.5 nm	<3,000 Da (PEO,PEG/H_2O)

Figure 33: Polyethylene glycol and oxide calibration curves for TSKgel PWXL columns



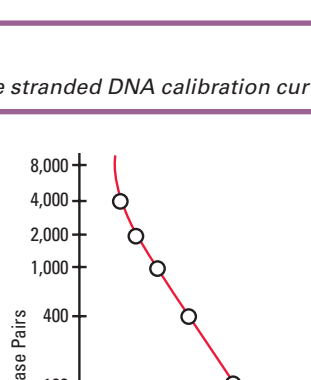
Column:	**A. G2500PWXL, B. G3000PWXL, C. G4000PWXL, D. G5000PWXL, E. G6000PWXL, F. GMPWXL, all 7.8 mm ID × 30 cm**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	RI

Figure 34: Protein calibration curves for TSKgel PWXL columns



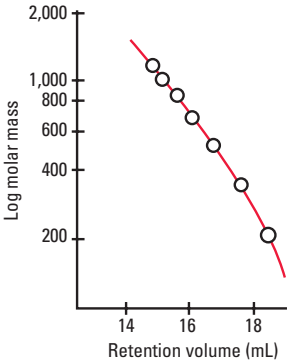
Column:	**1. TSKgel G3000PWXL** **2. TSKgel G4000PWXL** **3. TSKgel G5000PWXL** **4. TSKgel G6000PWXL** **5. TSKgel GMPWXL** **all 7.8 mm ID × 30 cm**
Mobile phase:	0.2 mol/L phosphate buffer, pH 6.8
Flow rate:	1.0 mL/min
Detection:	UV @ 280 nm
Sample:	a. thyroglobulin (6.6×10^5 Da) b. γ-globulin (1.5×10^5 Da) c. albumin (6.7×10^4 Da) d. ovalbumin (4.3×10^4 Da) e. β-lactoglobulin (3.6×10^4 Da) f. myoglobin (1.69×10^4 Da) g. cytochrome C (1.24×10^4 Da)

Figure 35: Double stranded DNA calibration curves for TSKgel G-DNA-PW column



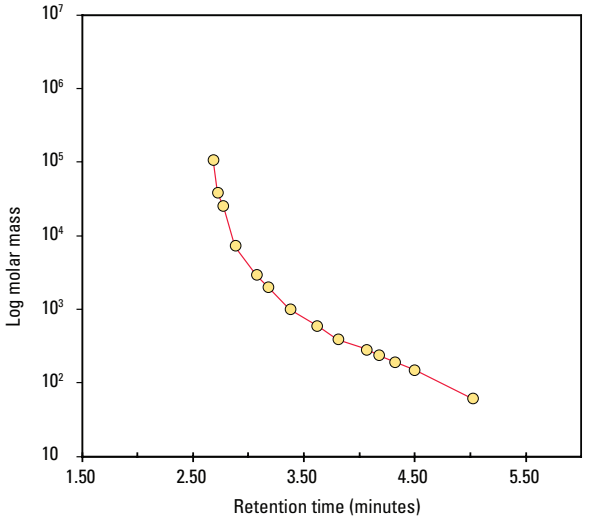
Column:	**TSKgel G-DNA-PW, 10 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	H_2O with 0.3 mol/L NaCl in 0.1 mol/LTris-HCl, pH 7.5, + 1 mmol/L EDTA
Flow rate:	0.15 mL/min
Detection:	UV @ 260 nm
Sample:	*Eco* RI and *Bst* NI-cleaved pBR322 DNA, void volume determined with λ-DNA

Figure 36: Oligosaccharide calibration curve for TSKgel G-Oligo-PW column



Column:	**TSKgel G-Oligo-PW, 7 µm, 7.8 mm ID × 30 cm × 2**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	UV @ 260 nm
Sample:	hydrolyzed β-cyclodextrin

Figure 37: Polyethylene glycol, oxide and ethylene glycol calibration curve for TSKgel SuperOligoPW column

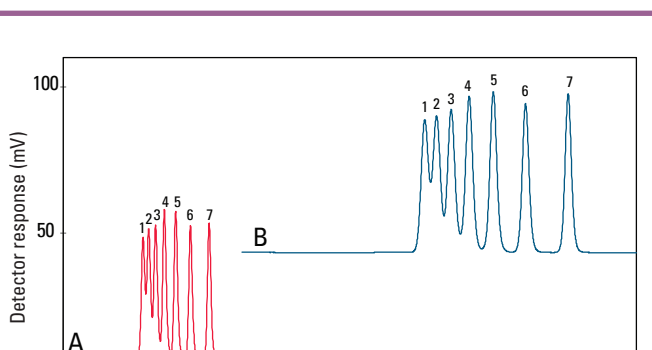


Columns:	**TSKgel SuperOligoPW, 3 µm, 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.60 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	PEO, PEG and ethylene glycol

Oligosaccharides

Figure 38 demonstrates the high speed analysis of maltose oligomers using a TSKgel SuperOligoPW column compared to a TSKgel G-Oligo-PW column. The faster analysis time is due to the semi-micro dimensions (6.0 mm ID × 15 cm) and the small particle size (3 µm) of the TSKgel SuperOligoPW column compared to the 7.8 mm ID × 30 cm size and 7 µm particle size of the TSKgel G-Oligo-PW column.

Figure 38: Analysis of maltose oligomers

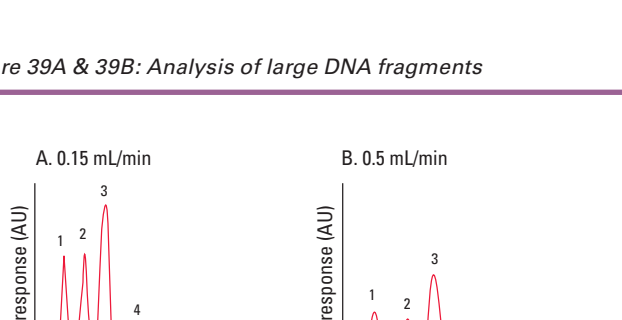


Columns:	**A. TSKgel SuperOligoPW, 3 µm, 6.0 mm ID × 15 cm × 4** **B. TSKgel G-Oligo-PW, 7 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	H_2O
Flow rate:	A: 0.6 mL/min B: 1.0 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol.:	A: 10 µL B: 50 µL
Samples:	1. maltoheptose 2. maltohexose 3. maltopentose 4. maltotetraose 5. maltotriose 6. maltose 7. glucose

Large DNA fragments

For the separation of large DNA fragments greater than 1,000 base pairs, a four column system is typically required. Baseline resolution of DNA fragments up to 7,000 base pairs can be achieved, provided there is a two-fold difference in the chain length of the fragments. Figure 39A shows the elution of double stranded DNA fragments, obtained from pBR322 DNA cleaved by both EcoRI and BstNI, on four TSKgel G-DNA-PW columns in series. The eluted peaks were collected and subjected to polyacrylamide gel electrophoresis, which showed almost complete separation of the 1060, 1857, and 4362 base pair fragments. Although lower flow rates typically yield better separations of most fragments, the resolution of the 1857 and 4362 base pair fragments was slightly greater at the higher flow rate, as shown in Figure 39B.

Figure 39A & 39B: Analysis of large DNA fragments



Column:	**TSKgel G-DNA-PW, 10 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	H_2O with 0.3 mol/L NaCl in 0.1 mol/L Tris-HCl, pH 7.5, + 1 mmol/L EDTA
Flow Rate:	A. 0.15 mL/min B. 0.5 mL/min
Detection:	UV @ 260 nm
Samples:	60 µL of Eco RI and Bst NI - cleaved pBR322 DNA, base pairs: 1. 4362 2. 1857 3. 1060 & 928 4. 383 5. 121 6. 13

TSKgel PWXL-CP Size Exclusion Columns

TSKgel PWXL-CP columns were specifically developed for the analysis of water-soluble cationic polymers. Composed of polymethacrylate beads, cationic groups are introduced on the surface of the TSKgel PWXL-CP packing material to prevent adsorption of cationic polymers and allow elution under low salt conditions. These columns show high theoretical plate numbers, linear calibration curves, and high durability because the base resin is the same as that used in the TSKgel PWXL columns.

Three columns are available within the TSKgel PWXL-CP series, each with a different particle size, separation range, and exclusion limit, allowing polymers within a wide molar mass range to be separated and characterized.

- TSKgel G3000PWXL-CP
- TSKgel G5000PWXL-CP
- TSKgel G6000PWXL-CP

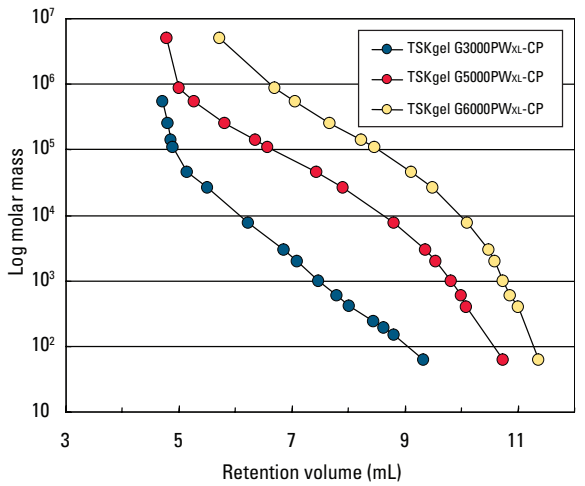
Attributes and Applications:

Table 18 shows the product attributes for each of the three TSKgel PWXL-CP columns. Figure 40 shows calibration curves produced with standard polyethylene oxide and polyethylene glycol in a 0.1 mol/L aqueous solution of sodium nitrate.

Table 18: Product attributes

TSKgel column	G3000PWXL-CP	G5000PWXL-CP	G6000PWXL-CP
Base material	polymethacrylate	polymethacrylate	polymethacrylate
Particle size	7 µm	10 µm	13 µm
Pore size	20 nm	100 nm	>100 nm
Exclusion limit	1.0×10^5 Da	1.0×10^6 Da	2.0×10^7 Da
Separation range (PEO, PEG)	200 ~ 5.0×10^4 Da	400 ~ 5.0×10^5 Da	1,000 ~ 1.0×10^7 Da
Theoretical plates	16,000	10,000	7,000

Figure 40: Polyethylene glycol and oxide calibration curves for TSKgel PWXL-CP columns

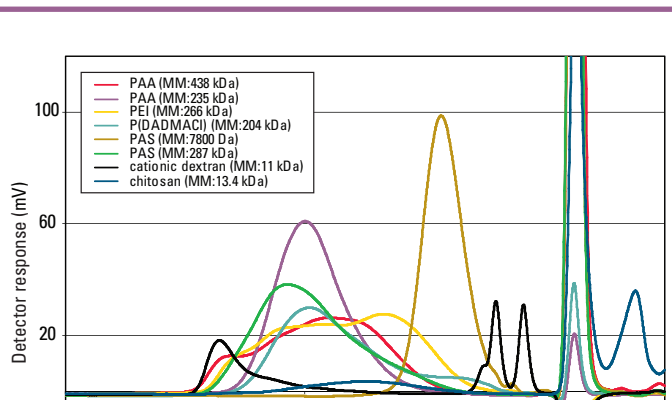


Columns:	**TSKgel G3000PWXL-CP, 7 µm, 7.8 mm ID × 30 cm** **TSKgel G5000PWXL-CP, 10 µm, 7.8 mm ID × 30 cm** **TSKgel G6000PWXL-CP, 13 µm, 7.8 mm ID × 30 cm**
Mobile phase:	H_2O with 0.1 mol/L $NaNO_3$
Flow Rate:	1 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	polyethylene oxides (PEO) standards polyethylene glycols (PEG) standards

Cationic Polymers

Various cationic polymers with different functional groups and molar masses were injected on the three TSKgel PWXL-CP columns (TSKgel G6000PWXL-CP, G5000PWXL-CP, and G3000PWXL-CP) connected in series. Figure 41 demonstrates that these SEC columns can be utilized for the analysis of a wide variety of cationic polymers.

Figure 41: Analysis of cationic polymers



Columns:	**TSKgel G3000PWXL-CP, 7 µm, 7.8 mm ID × 30 cm** **TSKgel G5000PWXL-CP, 10 µm, 7.8 mm ID × 30 cm** **TSKgel G6000PWXL-CP, 13 µm, 7.8 mm ID × 30 cm**
Mobile phase:	H_2O with 0.1 mol/L $NaNO_3$
Flow Rate:	1 mL/min
Detection:	RI
Temperature:	25 °C
Sample Load:	3 g/L, 100 µL

TSKgel SuperMultiporePW Size Exclusion Columns

The innovative multi-pore particle synthesis technology*, pioneered by Tosoh scientists, is incorporated into TSKgel SuperMultiporePW columns for water-soluble polymer analysis. Three semi-micro columns varying in linear range are available within this series, enabling high speed and high resolution analysis with lowered solvent consumption. The base material of each TSKgel SuperMultiporePW column is polymethacrylate.

A wide molar mass range can be analyzed with the three different TSKgel SuperMultiporePW columns, from high molar mass water-soluble polymers to oligomers. The packing material in the TSKgel SuperMultiporePW columns is more hydrophilic than that of TSKgel PWXL series columns, which further reduces the chance of adsorption of hydrophilic polymers.

- TSKgel SuperMultiporePW-N
- TSKgel SuperMultiporePW-M
- TSKgel SuperMultiporePW-H

*Using this proprietary technology, Tosoh can manufacture particles, each containing a broad range of pore sizes. This innovative approach essentially creates a linear calibration curve within each particle. As a result, columns with an extended linear calibration curve can now be prepared without mixing particles of different pore sizes.

Attributes and Applications:

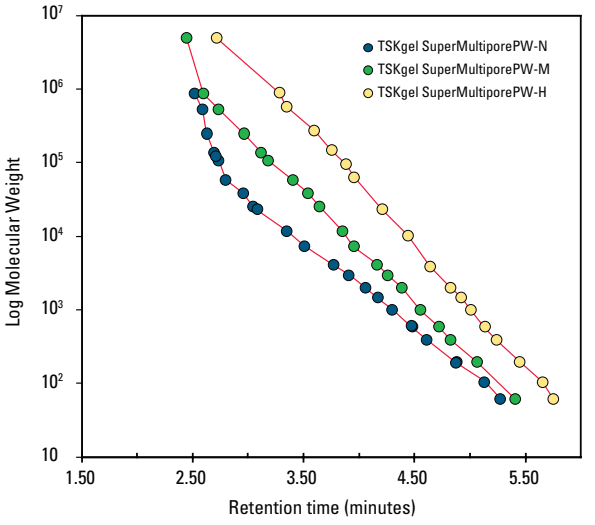
Table 19 shows the product attributes for each of the three TSKgel SuperMultiporePW columns. Figure 42 shows polyethylene glycol, oxide and ethylene glycol calibration curves for each of the TSKgel SuperMultiporePW columns.

Table 19: Product attributes

TSKgel column	SuperMultiporePW-N	SuperMultiporePW-M	SuperMultiporePW-H
Base material	polymethacrylate	polymethacrylate	polymethacrylate
Particle size	4 µm*	5 µm*	8 µm*
Pore size	20 nm	100 nm	>100 nm
Exclusion limit (PEO, PEG/H_2O)	1.0×10^5 - 1.5×10^5 Da	6.0×10^5 - 1.5×10^6 Da	-
Separation range	300 ~ 5.0×10^4 Da	500 ~ 1.0×10^6 Da	1,000 ~ 1.0×10^7 Da
Theoretical plates/15cm column	>16,000	>12,000	>7,000

* Particle size distribution is monodisperse.

Figure 42: Polyethylene glycol, oxide, and ethylene glycol calibration curves for TSKgel SuperMultiporePW columns



Columns:	**TSKgel SuperMultiporePW-N, 4 µm, 6.0 mm ID × 15 cm** **TSKgel SuperMultiporePW-M, 5 µm, 6.0 mm ID × 15 cm** **TSKgel SuperMultiporePW-H, 8 µm, 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.60 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	polyethylene oxides (PEO) standards polyethylene glycols (PEG) standards ethylene glycol (EG) standards

Ordering Information - TSKgel H columns

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
16131	TSKgel G1000H$_{XL}$, 5 µm, 1.5 nm	polymer	Stainless Steel	7.8	30
16134	TSKgel G2000H$_{XL}$, 5 µm, 2 nm	polymer	Stainless Steel	7.8	30
16135	TSKgel G2500H$_{XL}$, 5 µm, 3 nm	polymer	Stainless Steel	7.8	30
16136	TSKgel G3000H$_{XL}$, 6 µm, 7.5 nm	polymer	Stainless Steel	7.8	30
16137	TSKgel G4000H$_{XL}$, 5 µm, 20 nm	polymer	Stainless Steel	7.8	30
16138	TSKgel G5000H$_{XL}$, 9 µm, 65 nm	polymer	Stainless Steel	7.8	30
16139	TSKgel G6000H$_{XL}$, 9 µm, >65 nm	polymer	Stainless Steel	7.8	30
16140	TSKgel G7000H$_{XL}$, 9 µm, >65 nm	polymer	Stainless Steel	7.8	30
16141	TSKgel GMH$_{XL}$, 9 µm, mixed bed	polymer	Stainless Steel	7.8	30
16652	TSKgel GMH$_{XL}$-L, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
18403	TSKgel MultiporeH$_{XL}$-M, 5 µm	polymer	Stainless Steel	7.8	30
07113	TSKgel Guard Column for 7.8 mm ID TSKgel G1000H$_{XL}$-G4000H$_{XL}$ columns, 8 µm	polymer	Stainless Steel	6	4
13727	TSKgel Guard Column for 7.8 mm ID TSKgel G5000H$_{XL}$-GMH$_{XL}$ & GMH$_{XL}$-L columns, 13 µm	polymer	Stainless Steel	6	4
18404	TSKgel Guard Column for TSKgel MultiporeH$_{XL}$-M column, 5 µm	polymer	Stainless Steel	6	4
17352	TSKgel G1000H$_{HR}$, 5 µm, 1.5 nm	polymer	Stainless Steel	7.8	30
17353	TSKgel G2000H$_{HR}$, 5 µm, 2 nm	polymer	Stainless Steel	7.8	30
17354	TSKgel G2500H$_{HR}$, 5 µm, 3 nm	polymer	Stainless Steel	7.8	30
17355	TSKgel G3000H$_{HR}$, 5 µm, 7.5 nm	polymer	Stainless Steel	7.8	30
17356	TSKgel G4000H$_{HR}$, 5 µm, 20 nm	polymer	Stainless Steel	7.8	30
17357	TSKgel G5000H$_{HR}$, 5 µm, 65 nm	polymer	Stainless Steel	7.8	30
17358	TSKgel G6000H$_{HR}$, 5 µm, >65 nm	polymer	Stainless Steel	7.8	30
17359	TSKgel G7000H$_{HR}$, 5 µm, >65 nm	polymer	Stainless Steel	7.8	30
17362	TSKgel GMH$_{HR}$-L, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
17392	TSKgel GMH$_{HR}$-M, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
18055	TSKgel GMH$_{HR}$-N, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
17360	TSKgel GMH$_{HR}$-H, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
17361	TSKgel GMH$_{HR}$-H (S), 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
17393	TSKgel GMH$_{HR}$-M (S), 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
18399	TSKgel GMH$_{HR}$-H (20), 20 µm, mixed bed	polymer	Stainless Steel	7.8	30
18398	TSKgel GMH$_{HR}$-H (30), 30 µm, mixed bed	polymer	Stainless Steel	7.8	30
18420	TSKgel GMH$_{HR}$-H HT, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
18393	TSKgel GMH$_{HR}$-H (S) HT, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
18392	TSKgel GMH$_{HR}$-H (20) HT, 20 µm, mixed bed	polymer	Stainless Steel	7.8	30
18391	TSKgel GMH$_{HR}$-H (30) HT, 30 µm, mixed bed	polymer	Stainless Steel	7.8	30
18395	TSKgel G2000H$_{HR}$ (20) HT, 20 µm, 2 nm	polymer	Stainless Steel	7.8	30
22888	TSKgel GMH$_{HR}$-H (20) HT2, 20 µm, mixed bed	polymer	Stainless Steel	7.8	30
22887	TSKgel GMH$_{HR}$-H (30) HT2, 30 µm, mixed bed	polymer	Stainless Steel	7.8	30
22889	TSKgel GMH$_{HR}$-H (S) HT2, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
22890	TSKgel G2000H$_{HR}$ (20) HT2, 20 µm, 2 nm	polymer	Stainless Steel	7.8	30
17368	TSKgel Guard Column for 7.8 mm ID TSKgel G1000H$_{HR}$-G4000H$_{HR}$ & GMH$_{HR}$-L columns, 5 µm	polymer	Stainless Steel	6	4
17369	TSKgel Guard Column for 7.8 mm ID TSKgel G5000H$_{HR}$-G7000H$_{HR}$ & GMH$_{HR}$-M;-N;-H columns, 5 µm	polymer	Stainless Steel	6	4
17367	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (S), -M (S) columns, 13 µm	polymer	Stainless Steel	7.5	7.5
18402	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (20), -H (30) columns, 30 µm	polymer	Stainless Steel	7.5	7.5
18397	TSKgel Guard Column for 7.8 mm ID TSKgel GMH$_{HR}$-H (S) HT column, 13 µm	polymer	Stainless Steel	7.5	7.5
18396	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (20) HT & GMH$_{HR}$-H (30) HT columns, 30 µm	polymer	Stainless Steel	7.5	7.5
22891	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (20) HT2 & GMH$_{HR}$-H (30) HT2 columns, 30 µm	polymer	Stainless Steel	7.5	7.5
22892	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (S) HT2 column, 13 µm	polymer	Stainless Steel	7.5	7.5
17990	TSKgel SuperH1000, 3 µm, 1.5 nm	polymer	Stainless Steel	6	15
17991	TSKgel SuperH2000, 3 µm, 2 nm	polymer	Stainless Steel	6	15
17992	TSKgel SuperH2500, 3 µm, 3 nm	polymer	Stainless Steel	6	15
17993	TSKgel SuperH3000, 3 µm, 7.5 nm	polymer	Stainless Steel	6	15
17994	TSKgel SuperH4000, 3 µm, 20 nm	polymer	Stainless Steel	6	15
17995	TSKgel SuperH5000, 3 µm, 65 nm	polymer	Stainless Steel	6	15
17996	TSKgel SuperH6000, 5 µm, >65 nm	polymer	Stainless Steel	6	15
17997	TSKgel SuperH7000, 5 µm, >65 nm	polymer	Stainless Steel	6	15
17998	TSKgel SuperHM-L, 3 µm, mixed bed	polymer	Stainless Steel	6	15
17999	TSKgel SuperHM-N, 3 µm, mixed bed	polymer	Stainless Steel	6	15
18000	TSKgel SuperHM-M, 3 µm, mixed bed	polymer	Stainless Steel	6	15
18001	TSKgel SuperHM-H, 3 µm, mixed bed	polymer	Stainless Steel	6	15
18002	TSKgel Guard Column for 6 mm ID TSKgel SuperH1000-SuperH4000 columns, 3 µm	polymer	Stainless Steel	4.6	3.5
18003	TSKgel Guard Column for 6 mm ID TSKgel SuperH5000-7000;HM-L;-N;-M;-H columns, 3 µm	polymer	Stainless Steel	4.6	3.5
19309	TSKgel SuperHZ1000, 3 µm, 1.5 nm	polymer	Stainless Steel	4.6	15
19310	TSKgel SuperHZ2000, 3 µm, 2 nm	polymer	Stainless Steel	4.6	15
19311	TSKgel SuperHZ2500, 3 µm, 3 nm	polymer	Stainless Steel	4.6	15
19312	TSKgel SuperHZ3000, 3 µm, 7.5 nm	polymer	Stainless Steel	4.6	15
19313	TSKgel SuperHZ4000, 3 µm, 20 nm	polymer	Stainless Steel	4.6	15
19660	TSKgel SuperHZM-N, 3 µm, mixed bed	polymer	Stainless Steel	4.6	15
19662	TSKgel SuperHZM-M, 3 µm, mixed bed	polymer	Stainless Steel	4.6	15
19664	TSKgel SuperHZM-H, 10 µm, mixed bed	polymer	Stainless Steel	4.6	15
19302	TSKgel SuperHZ1000, 3 µm, 1.5 nm	polymer	Stainless Steel	6	15

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
19303	TSKgel SuperHZ2000, 3 µm, 2 nm	polymer	Stainless Steel	6	15
19304	TSKgel SuperHZ2500, 3 µm, 3 nm	polymer	Stainless Steel	6	15
19305	TSKgel SuperHZ3000, 3 µm, 7.5 nm	polymer	Stainless Steel	6	15
19306	TSKgel SuperHZ4000, 3 µm, 20 nm	polymer	Stainless Steel	6	15
19661	TSKgel SuperHZM-N, 3 µm, mixed bed	polymer	Stainless Steel	6	15
19663	TSKgel SuperHZM-M, 3 µm, mixed bed	polymer	Stainless Steel	6	15
19665	TSKgel SuperHZM-H, 10 µm, mixed bed	polymer	Stainless Steel	6	15
19314	TSKgel Guard Column for 4.6 mm ID TSKgel SuperHZ1000-4000 and HZM-N & -M columns, 3 µm	polymer	Stainless Steel	4.6	2
19668	TSKgel Guard Column for 4.6 mm ID TSKgel SuperHZM-H column, 10 µm	polymer	Stainless Steel	4.6	2
19666	TSKgel Guard Column for 6 mm ID TSKgel SuperHZ1000-4000 and HZM-N & -M columns, 3 µm	polymer	Stainless Steel	4.6	3.5
19667	TSKgel Guard Column for 6 mm ID TSKgel SuperHZM-H column, 10 µm	polymer	Stainless Steel	4.6	3.5
21815	TSKgel SuperMultiporeHZ-N, 3 µm, 8 nm	polymer	Stainless Steel	4.6	15
21885	TSKgel SuperMultiporeHZ-H, 6 µm, >14 nm	polymer	Stainless Steel	4.6	15
21488	TSKgel SuperMultiporeHZ-M, 4 µm, 14 nm	polymer	Stainless Steel	4.6	15
21816	TSKgel SuperMPHZ-N Guard, 3 µm	polymer	Stainless Steel	4.6	2
21886	TSKgel SuperMPHZ-H Guard, 6 µm	polymer	Stainless Steel	4.6	2
21489	TSKgel SuperMPHZ-M Guard, 4 µm	polymer	Stainless Steel	4.6	2

Ordering Information - TSKgel SuperAW and Alpha columns

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
19315	TSKgel SuperAW2500, 4 µm, 2.5 nm	polymer	Stainless Steel	6	15
19316	TSKgel SuperAW3000, 4 µm, 15 nm	polymer	Stainless Steel	6	15
19317	TSKgel SuperAW4000, 6 µm, 45 nm	polymer	Stainless Steel	6	15
19318	TSKgel SuperAW5000, 7 µm, 100 nm	polymer	Stainless Steel	6	15
19319	TSKgel SuperAW6000, 9 µm, >100 nm	polymer	Stainless Steel	6	15
19320	TSKgel SuperAWM-H, 9 µm, mixed bed	polymer	Stainless Steel	6	15
19321	TSKgel Guard Column for 6.0 mm ID TSKgel SuperAW2500-4000 columns, 7 µm	polymer	Stainless Steel	4.6	3.5
19322	TSKgel Guard Column for 6.0 mm ID TSKgel SuperAW5000-AWM-H columns, 13 µm	polymer	Stainless Steel	4.6	3.5
18339	TSKgel Alpha-2500, 7 µm, 2.5 nm	polymer	Stainless Steel	7.8	30
18340	TSKgel Alpha-3000, 7 µm, 15 nm	polymer	Stainless Steel	7.8	30
18341	TSKgel Alpha-4000, 10 µm, 45 nm	polymer	Stainless Steel	7.8	30
18342	TSKgel Alpha-5000, 10 µm, 100 nm	polymer	Stainless Steel	7.8	30
18343	TSKgel Alpha-6000, 13 µm, >100 nm	polymer	Stainless Steel	7.8	30
18344	TSKgel Alpha-M, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
18345	TSKgel Guard Column for 7.8 mm ID TSKgel Alpha-2500-Alpha-M columns, 13 µm	polymer	Stainless Steel	6	4

Ordering Information - TSKgel PW columns

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
20024	TSKgel BioAssist G6PW, 17 µm, >100 nm	polymer	PEEK	7.8	30
05761	TSKgel G2000PW, 12 µm, 12.5 nm	polymer	Stainless Steel	7.5	30
05105	TSKgel G2000PW, 12 µm, 12.5 nm	polymer	Stainless Steel	7.5	60
08028	TSKgel G2500PW, 12 µm, 12.5 nm	polymer	Stainless Steel	7.5	30
08029	TSKgel G2500PW, 12 µm, 12.5 nm	polymer	Stainless Steel	7.5	60
05762	TSKgel G3000PW, 12 µm, 20 nm	polymer	Stainless Steel	7.5	30
05106	TSKgel G3000PW, 12 µm, 20 nm	polymer	Stainless Steel	7.5	60
05763	TSKgel G4000PW, 17 µm, 50 nm	polymer	Stainless Steel	7.5	30
05107	TSKgel G4000PW, 17 µm, 50 nm	polymer	Stainless Steel	7.5	60
05764	TSKgel G5000PW, 17 µm, 100 nm	polymer	Stainless Steel	7.5	30
05108	TSKgel G5000PW, 17 µm, 100 nm	polymer	Stainless Steel	7.5	60
05765	TSKgel G6000PW, 17 µm, >100 nm	polymer	Stainless Steel	7.5	30
05109	TSKgel G6000PW, 17 µm, >100 nm	polymer	Stainless Steel	7.5	60
08026	TSKgel GMPW, 17 µm, mixed bed	polymer	Stainless Steel	7.5	30
08027	TSKgel GMPW, 17 µm, mixed bed	polymer	Stainless Steel	7.5	60
16248	TSKgel G2500PW, 17 µm, 12.5 nm	polymer	Stainless Steel	21.5	30
16249	TSKgel G3000PW, 17 µm, 20 nm	polymer	Stainless Steel	21.5	30
08030	TSKgel G2500PW, 17 µm, 12.5 nm	polymer	Stainless Steel	21.5	60
06763	TSKgel Guard Column for 7.5 mm ID TSKgel G2000PW columns, 13 µm	polymer	Stainless Steel	7.5	7.5
06762	TSKgel Guard Column for 7.5 mm ID TSKgel G2500PW-GMPW columns, 13 µm	polymer	Stainless Steel	7.5	7.5
06758	TSKgel Guard Column for 21.5 mm ID TSKgel G2500-G3000PW columns, 17 µm	polymer	Stainless Steel	21.5	7.5
08020	TSKgel G2500PW$_{XL}$, 7 µm, 12.5 nm	polymer	Stainless Steel	7.8	30
08021	TSKgel G3000PW$_{XL}$, 7 µm, 20 nm	polymer	Stainless Steel	7.8	30
08022	TSKgel G4000PW$_{XL}$, 10 µm, 50 nm	polymer	Stainless Steel	7.8	30
08023	TSKgel G5000PW$_{XL}$, 10 µm, 100 nm	polymer	Stainless Steel	7.8	30
08024	TSKgel G6000PW$_{XL}$, 13 µm, >100 nm	polymer	Stainless Steel	7.8	30
08025	TSKgel GMPW$_{XL}$, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
08032	TSKgel G-DNA-PW, 10 µm, >100 nm	polymer	Stainless Steel	7.8	30
08031	TSKgel G-Oligo-PW, 7 µm, 12.5 nm	polymer	Stainless Steel	7.8	30
22792	TSKgel SuperOligoPW, 3 µm, 12.5 nm	polymer	Stainless Steel	6	15
08033	TSKgel Guard Column for 7.8 mm ID TSKgel G2500PW$_{XL}$-GMPW$_{XL}$ columns, 12 µm	polymer	Stainless Steel	6	4
08033	TSKgel Guard Column for 7.8 mm ID TSKgel G-DNA-PW column, 12 µm	polymer	Stainless Steel	6	4
08034	TSKgel Guard Column for 7.8 mm ID TSKgel G-Oligo-PW column, 13 µm	polymer	Stainless Steel	6	4
22796	TSKgel Guard Column for 6 mm ID TSKgel SuperOligoPW column, 4 µm	polymer	Stainless Steel	4.6	3.5

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
21873	TSKgel G3000PWXL-CP, 7 µm, 20 nm	polymer	Stainless Steel	7.8	30
21874	TSKgel G5000PWXL-CP, 10 µm, 100 nm	polymer	Stainless Steel	7.8	30
21875	TSKgel G6000PWXL-CP, 13 µm, >100 nm	polymer	Stainless Steel	7.8	30
21876	TSKgel Guard Column for 7.8 mm ID TSKgel G3000-G6000PWXL-CP columns, 13 µm	polymer	Stainless Steel	6	4
22789	TSKgel SuperMultiporePW-N, 4 µm, 20 nm	polymer	Stainless Steel	6	15
22790	TSKgel SuperMultiporePW-M, 5 µm, 100 nm	polymer	Stainless Steel	6	15
22791	TSKgel SuperMultiporePW-H, 8 µm, >100 nm	polymer	Stainless Steel	6	15
22794	TSKgel SuperMP(PW)-M Guard, 8 µm	polymer	Stainless Steel	4.6	3.5
22793	TSKgel SuperMP(PW)-N Guard, 5 µm	polymer	Stainless Steel	4.6	3.5
22795	TSKgel SuperMP(PW)-H Guard, 12 µm	polymer	Stainless Steel	4.6	3.5
08035	TSKgel Top-Off for PWXL and G-DNA-PW, 10 µm, 1 g	polymer			

TSKgel High Temperature GPC Columns

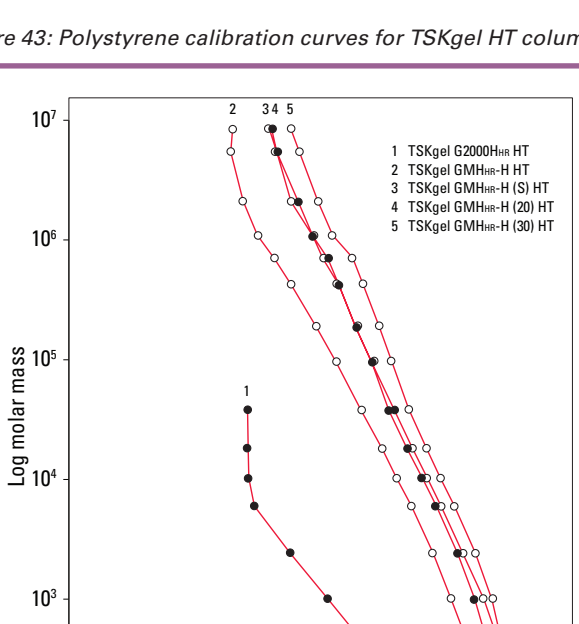
TSKgel H_{HR} HT and HT2 high temperature columns are recommended for the analysis of organic-soluble polymers and are packed with spherical particles composed of polystyrene cross-linked with divinylbenzene (PS-DVB). The "GM" prefix denotes a column packed with particles of different pore sizes blended to provide an extended linear calibration curve. The TSKgel HT columns are for high temperature applications (≤ 140 °C) while the TSKgel HT2 columns are used in ultra-high temperature (up to 220 °C) applications.

Table 20 lists the attributes of the TSKgel H_{HR} HT columns which are for high temperature applications up to 140 °C. Figure 43 shows the polystyrene calibration curves for each of the TSKgel H_{HR} HT columns.

Table 20: Properties and separation ranges for TSKgel HT columns

TSKgel column	Particle size	Pore size	Exclusion limit	Max. temp.
GMH_{HR}-H HT	5 µm	mixed pore sizes	4.0 × 10^8 Da	140 °C
GMH_{HR}-H (S) HT	13 µm	mixed pore sizes	4.0 × 10^8 Da	140 °C
GMH_{HR}-H (20) HT	20 µm	mixed pore sizes	4.0 × 10^8 Da	140 °C
GMH_{HR}-H (30) HT	30 µm	mixed pore sizes	4.0 × 10^8 Da	140 °C
$G2000H_{HR}$ (20) HT	20 µm	2 nm	1.0 × 10^4 Da	140 °C

Figure 43: Polystyrene calibration curves for TSKgel HT columns



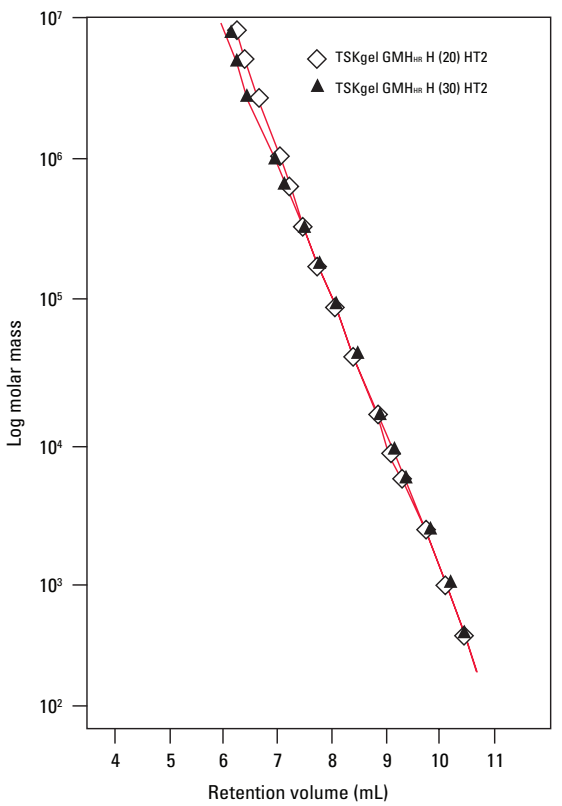
Columns: **TSKgel $G2000H_{HR}$ (20) HT, 20 µm, 7.8 mm ID × 30 cm**
TSKgel GMH_{HR}-H HT, 5 µm, 7.8 mm ID × 30 cm
TSKgel GMH_{HR}-H (S) HT, 13 µm, 7.8 mm ID × 30 cm
TSKgel GMH_{HR}-H (20) HT, 20 µm, 7.8 mm ID × 30 cm
TSKgel GMH_{HR}-H (30) HT, 30 µm, 7.8 mm ID × 30 cm
Mobile phase: ODCB with 0.05% BHT
Flow rate: 1.0 mL/min
Detector: RI (EcoSEC High Temperature GPC System)
Temperature: 135 °C
Injection vol.: 300 µL
Sample: polystyrene standards

The TSKgel high temperature column series also includes four columns for the analysis of polymers at ultra-high temperatures (up to 220 °C). The TSKgel H_{HR} HT2 columns are specifically designed for the analysis of organic-soluble polymers at extremely elevated temperatures. The attributes of the TSKgel HT2 column series are listed in Table 21. Figure 44 shows the polystyrene calibration curves for each of the TSKgel H_{HR} HT2 columns.

Table 21: Properties and separation ranges for TSKgel HT2 columns

TSKgel column	Particle size	Pore size	Exclusion limit	Max. temp.
GMH_{HR}-H (20) HT2	20 µm	mixed pore sizes	4.0 × 10^8 Da	220 °C
GMH_{HR}-H (30) HT2	30 µm	mixed pore sizes	4.0 × 10^8 Da	220 °C
GMH_{HR}-H (S) HT2	13 µm	mixed pore sizes	4.0 × 10^8 Da	220 °C
G2000H_{HR} (20) HT2	20 µm	2 nm	1.0 × 10^4 Da	220 °C

Figure 44: Polystyrene calibration curves for TSKgel HT2 columns

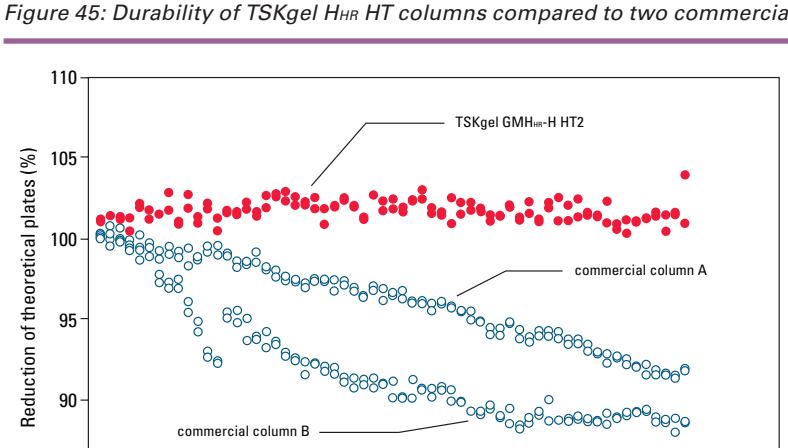


Columns: **TSKgel GMH_{HR}-H (20) HT2, 20 µm, 7.8 mm ID × 30 cm**
TSKgel GMH_{HR}-H (30) HT2, 30 µm, 7.8 mm ID × 30 cm
Mobile phase: ODCB with 0.05% BHT
Flow rate: 1.0 mL/min
Detector: RI (EcoSEC High Temperature GPC System)
Temperature: 135 °C
Sample: polystyrene standards

Performance Stability

Figure 45 demonstrates the performance stability of the TSKgel GMH$_{HR}$-H HT columns compared to other commercially available high temperature GPC columns during repetitive temperature changes. The TSKgel H$_{HR}$ HT columns and two commercially available high temperature GPC columns were subjected to drastic changes in temperature by raising the temperature for 2 hours followed by lowering the temperature for two hours for a total of 60 cycles. The number of theoretical plates was shown to remain constant for the TSKgel H$_{HR}$ HT columns and to decrease by 15% for the two commercially available high temperature GPC columns; thus revealing the superior performance stability of the TSKgel H$_{HR}$ HT columns.

Figure 45: Durability of TSKgel H$_{HR}$ HT columns compared to two commercially available high temperature GPC columns



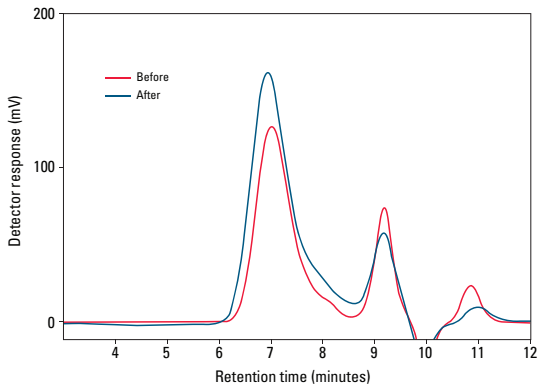
Column:	**TSKgel GMH$_{HR}$-H HT2, 5 µm, 7.8 mm ID × 30 cm × 2**
Mobile phase:	ODCB with 0.05% BHT
Flow rate:	1 mL/min
Detector:	RI (EcoSEC High Temperature GPC System)
Temperature:	40 to 145 °C

Column Durability at 220 °C

Column durability in high temperature GPC polymer analysis is essential as these columns are continuously exposed to harsh organic solvents, extremely elevated temperatures and temperature cycling as GPC systems are turned on and off. The durability of a high temperature GPC column directly influences the quality, applicability and selectivity, or resolution, of the GPC column, thus the accuracy of the molar mass averages obtained. As a high temperature GPC column begins to fail or lose resolution due to the extreme experimental conditions required for high temperature GPC polymer analysis, the number- and *z*-average molar mass values obtained become inflated and the GPC elution profile begins to shift due to a decrease in multiple factors that affect the ability of the columns to separate species varying in hydrodynamic volume.

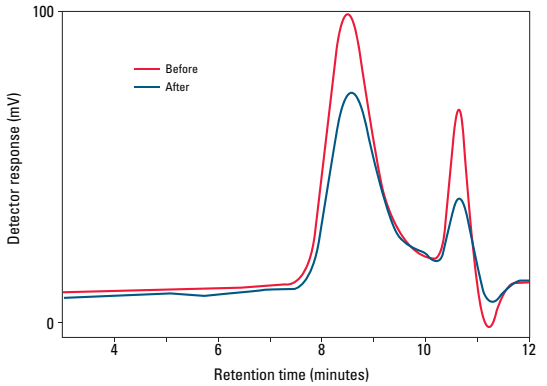
A durability and stability study of a TSKgel GMH$_{HR}$-H (S) HT high temperature GPC column was performed and the results were compared to another commercially available column for polymer analysis at 220 °C. The deterioration of the commercially available high temperature GPC column is observed in the GPC elution profiles, Figure 46, as the resolution between the sample and solvent peaks decreases after the column is exposed to temperature cycling. The GPC elution profiles obtained for the TSKgel GMH$_{HR}$-H (S) HT column before and after temperature cycling remain superimposable, Figure 47.

Figure 46: GPC elution profile for a polymer before and after temperature cycling obtained using a commercially available high temperature GPC column



Column:	Commercially available high temperature GPC column, 13 µm, 7.8 mm ID × 30 cm
Mobile phase:	1-CN
Flow rate:	1.0 mL/min
Detector:	RI (EcoSEC High Temperature GPC System)
Temperature:	220 °C
Injection vol.:	200 µL
Sample:	synthetic polymer

Figure 47: GPC elution profile for a polymer before and after temperature cycling obtained using a TSKgel GMH$_{HR}$-H (S) HT column



Column:	**TSKgel GMH$_{HR}$-H (S) HT, 13 µm, 7.8 mm ID × 30 cm**
Mobile phase:	1-CN
Flow rate:	1.0 mL/min
Detector:	RI (EcoSEC High Temperature GPC System)
Temperature:	220 °C
Injection vol.:	200 µL
Sample:	synthetic polymer

Ordering Information - TSKgel High Temperature GPC Columns

Part #	Description	Matrix	Housing	ID (mm)	Length (cm)
18420	TSKgel GMH$_{HR}$-H HT, 5 µm, mixed bed	polymer	Stainless Steel	7.8	30
18393	TSKgel GMH$_{HR}$-H (S) HT, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
18392	TSKgel GMH$_{HR}$-H (20) HT, 20 µm, mixed bed	polymer	Stainless Steel	7.8	30
18391	TSKgel GMH$_{HR}$-H (30) HT, 30 µm, mixed bed	polymer	Stainless Steel	7.8	30
18395	TSKgel G2000H$_{HR}$ (20) HT, 20 µm, 2 nm	polymer	Stainless Steel	7.8	30
18397	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (S) HT column, 30 µm	polymer	Stainless Steel	7.5	7.5
18396	TSKgel Guard Column for TSKgel GMH$_{HR}$- H (20) HT & GMH$_{HR}$-H (30) HT columns, 30 µm	polymer	Stainless Steel	7.5	7.5
22888	TSKgel GMH$_{HR}$-H (20) HT2, 20 µm, mixed bed	polymer	Stainless Steel	7.8	30
22887	TSKgel GMH$_{HR}$-H (30) HT2, 30 µm, mixed bed	polymer	Stainless Steel	7.8	30
22889	TSKgel GMH$_{HR}$-H (S) HT2, 13 µm, mixed bed	polymer	Stainless Steel	7.8	30
22890	TSKgel G2000H$_{HR}$ (20) HT2, 20 µm, 2 nm	polymer	Stainless Steel	7.8	30
22891	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (20) HT2 & GMH$_{HR}$-H (30) HT2 columns, 30 µm	polymer	Stainless Steel	7.5	7.5
22892	TSKgel Guard Column for TSKgel GMH$_{HR}$-H (S) HT2 column, 13 µm	polymer	Stainless Steel	7.5	7.5


TOSOH
TSKgel
TSKgel GMHhr-H (30) HT2
TOSOH
TSKgel
TSKgel GMHhr-H (20) HT2

Standards, Components and Replacement Parts

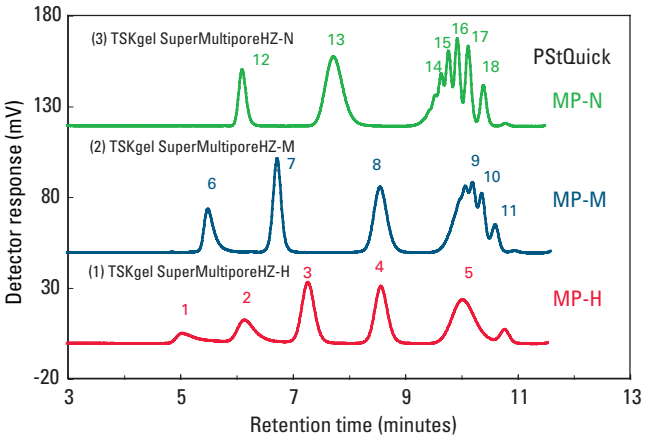
- Tosoh Bioscience offers bulk quantities of polystyrene and polyethylene oxide standards, as well as pre-mixed quantities of polystyrene polymers, for calibration of GPC columns.

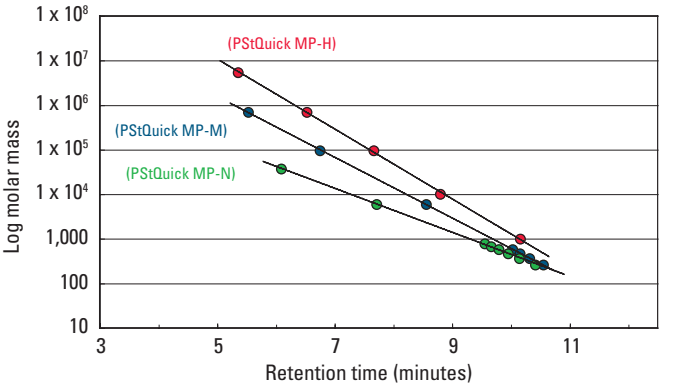
- Components and replacement parts are available for the EcoSEC GPC System and EcoSEC High Temperature GPC System.

PStQuick GPC Polystyrene Calibration Standards

PStQuick polystyrene calibration standards contain pre-mixed quantities of polystyrene polymers in autosampler vials for the calibration of GPC columns. Addition of solvent is all that is required for easy preparation and analysis. 12 different kits containing polystyrene polymers of various molar masses are available. Of the 12 kits, 9 are individual kits, each containing 3 to 5 polystyrene polymers. The remaining 3 are composite kits containing 2 or 3 of the individual kits.

Figure 1: Chromatograms and calibration curves obtained using the PStQuick MP series





PStQuick MP-H	PStQuick MP-M	PStQuick MP-N
1. M_w: 5.48 × 10^6	6. M_w: 7.06 × 10^5	12. M_w: 3.79 × 10^4
2. M_w: 7.06 × 10^5	7. M_w: 9.64 × 10^4	13. M_w: 5,970
3. M_w: 9.64 × 10^4	8. M_w: 5,970	14. M_w: 682
4. M_w: 1.02 × 10^4	9. M_w: 474	15. M_w: 578
5. M_w: 1,010	10. M_w: 370	16. M_w: 474
	11. M_w: 266	17. M_w: 370
		18. M_w: 266

Columns:	**SuperMultiporeHZ-H, 6 µm, 4.6mm ID x 15cm x 2** **SuperMultiporeHZ-M, 4 µm, 4.6mm ID x 15cm x 2** **SuperMultiporeHZ-N, 3 µm, 4.6mm ID x 15cm x 2**
Mobile phase:	THF
Flow rate:	0.35 mL/min
Detection:	UV @ 254 nm (UV-8020 microcell)
Temperature:	25 °C
Injection vol.:	10 µL
Sample:	PStQuick MP series

Contents of each kit

For example, PStQuick Kit-M contains 20 vials each of grades C and D.

Polystyrene Calibration Mixtures	TSKgel column	A	B	C	D	E	F	G	H	Vials
PStQuick MP-N	SuperMultiporeHZ-N								●	60
PStQuick MP-M	SuperMultiporeHZ-M							●		60
PStQuick MP-H	SuperMultiporeHZ-H		●							60
PStQuick Kit -H (High MW)	Mixed Bed H-type	●	●	●						60 (3 x 20)
PStQuick Kit -M (Medium MW)	Mixed Bed M-type			●	●					40 (2 x 20)
PStQuick Kit -L Low MW)	Mixed Bed N-type					●	●			40 (2 x 20)

Nominal MW of Kit Components

For example, grade B contains polystyrene polymers of nominal molecular weights 5,480,000 - 706,000, 96,400 - 10,200 and 1,000. In the above Table it is shown that grade B is part of PStQuick MP-H and PStQuick Kit-H

Polystyrene MW	A	B	C	D	E	F	G	H
8,420,000	●							●
5,480,000		●						
2,890,000			●					
1,090,000	●			●				
706,000		●					●	
355,000			●		●			
190,000	●			●		●		
96,400		●					●	
37,900			●		●			●
18,100	●			●		●		
10,200		●						
5,970			●		●		●	●
2,500	●			●		●		
1,000		●			●			
500			●			●	●	●

Ordering Information - PStQuick Polystyrene calibration standards

To calibrate TSKgel SuperMultiporeHZ columns

Part #	Description	Remarks	Calibration Range	Contents	Vials
21912	PStQuick MP-N	For SuperMultiporeHZ-N	530 to 4.4 x 10^4	A-500, A-5000, F-4	60
21913	PStQuick MP-M	For SuperMultiporeHZ-M	530 to 8.0 x 10^5	A-500, A-5000, F-10, F-80	60
21914	PStQuick MP-H	For SuperMultiporeHZ-H	950 to 5.5 x 10^6	A-1000, F-1, F-10, F-80, F-550	60

To calibrate TSKgel H-type mixed bed columns

Part #	Description	Remarks	Calibration Range	Contents	Vials
21915	PStQuick Kit-L	For H-type – N grade	530 to 4.2 x 10^5	PStQuick E, F	40**
21916	PStQuick Kit-M	For H-type – M grade	530 to 2.9 x 10^6	PStQuick C, D	40**
21917	PStQuick Kit-H	For H-type – H grade	530 to 8.4 x 10^6	PStQuick A, B, C	60*

*20 of each type x 3, **20 of each type x 2

To calibrate other TSKgel GPC columns

Part #	Description	Remarks	Calibration Range	Contents	Vials
21911	PStQuick A	For Other GPC columns	2,800 to 8.4 x 10^6	A-2500, F-2, F-20, F-128, F-850	20
21910	PStQuick B	For Other GPC columns	950 to 5.5 x 10^6	A-1000, F-1, F-10, F-80, F-550	20
21909	PStQuick C	For Other GPC columns	530 to 2.9 x 10^6	A-500, A-5000, F-4, F-40, F-288	20
21908	PStQuick D	For Other GPC columns	2,800 to 1.3 x 10^6	A-2500, F-2, F-20, F-128	20
21907	PStQuick E	For Other GPC columns	950 to 4.2 x 10^5	A-1000, A-5000, F-4, F-40	20
21906	PStQuick F	For Other GPC columns	530 to 1.9 x 10^5	A-500, A-2500, F-2, F-20	20

TSKgel Polystyrene Calibration Standards

TSKgel polystyrene bulk calibration standards are used to calibrate GPC columns for subsequent analysis of unknown samples. The standards range from 400 to 2.1 × 10^7 Da.

Ordering Information - TSKgel Polystyrene calibration standards

Part #	Description	Weight
05202	A-300, 400 Da	10 g
05203	A-500, 530 Da	10 g
05204	A-1000, 950 Da	10 g
05205	A-2500, 2,800 Da	5 g
05206	A-5000, 6,200 Da	5 g
05207	F-1, 1.0 x 10^4 Da	5 g
05208	F-2, 1.7 x 10^4 Da	5 g
05209	F-4, 4.4 x 10^4 Da	5 g
05210	F-10, 1.0 x 10^5 Da	5 g
05211	F-20, 1.9 x 10^5 Da	5 g
05212	F-40, 4.2 x 10^5 Da	5 g
05213	F-80, 7.8 x 10^5 Da	5 g
05214	F-128, 1.3 x 10^6 Da	1 g
05215	F-288, 2.9 x 10^6 Da	1 g
05216	F-380, 3.8 x 10^6 Da	1 g
05217	F-450, 4.5 x 10^6 Da	1 g
05218	F-550, 5.5 x 10^6 Da	1 g
05219	F-700, 6.8 x 10^6 Da	1 g
05220	F-850, 8.4 x 10^6 Da	1 g
05221	F-2000, 2.1 x 10^7 Da	1 g
06476	Oligomer Kit, A-500 thru F-128	12 x 1 g
06477	High MW Kit, F-10 thru F-2000	12 x 1 g

EcoSEC GPC System: Optional Components and Replacement Parts

Tosoh Bioscience offers the following replacement parts and optional components for the EcoSEC GPC System. In addition, preventative and basic maintenance kits are available for those parts that experience wear and tear due to normal usage.

Tosoh Bioscience offers extended service agreements and on-site periodic maintenance service calls. Please contact us for additional information or a quote for these services.

Part #	Description
Optional Components	
21792	UV-8320 Detector, 2 µL cell
21793	Column Switching Valve
18004	TSKgel SuperH-RC Reference Column
Autosampler Accessories	
06456	Needle, 1/16" OD, 45 mm Length, 90 degree , 12/pk
16414	Rotor Seal for 4-way Valve
16415	Rotor Seal for 6-way Valve
22015	Sample Rack
22020	Needle Assembly
22054	Syringe Assembly
05462	Sample Loop, SS, 50 µL
05679	Sample Loop, SS, 100 µL
05464	Sample Loop, SS, 500 µL
05672	Sample Loop, SS, 1000 µL
07035	Sample Loop, SS, 1500 µL
89239-030	Sample vial with disposable caps and septum, glass, 2 mL, 100/pk
17538	Drain Tube, Teflon, for Autoinjector
22016	Drain Block Seal
Pumps and Accessories	
06574	Mobile Phase Inlet Filter, SS, 5 µm pores
18517	Piston Seal, Polyethylene - for Aqueous
18524	Mold to Replace Piston Seal
18525	Shaft for Piston Seal Replacement
19056	Pump Head Sealing Gasket, PTFE, 2/pk
19190	Piston Seal, GFP - for Organics
19762	Piston, zirconium
21220	Syringe, 2500 µL, O-ring Seal
22011	Check Valve Assembly, Inlet
22012	Check Valve Assembly, Outlet
22047	Purge Pump Assembly
22048	Purge Syringe
22049	Degasser Chamber
22050	Vacuum Pump

Part #	Description
22053	Pump Assembly
22198	Piston seal (GFP) Short Lip Type - for Toluene
Detectors and Accessories	
22062	RI-8320 Detector, dual flow, 2.5 µL cell
21792	UV-8320 Detector, 2 µL cell
14243	Window for UV Detector Cell, 2/pk
17545	Micro Cell for UV, 4 mm pathlength, 2 µL
17556	Seal for UV Cell Window
17558	Retaining Nut for UV Detector Cell
18445	Deuterium Lamp
Tubing/Fittings and Accessories	
06039	Tubing, SS, 1/16" OD × 0.4 mm ID × 2 m Length
06160	Nut, SS, 1/16", 5/pk
06163	Union, Internal, 1/16" OD × 0.35 mm ID, 5/pk
06167	Tubing, SS, 1/16" OD × 0.1 mm ID × 2 m Length
06168	Tubing, SS, 1/16" OD × 0.2 mm ID × 2 m Length
06169	Tubing, SS, 1/16" OD × 0.6 mm ID × 2 m Length
06170	Tubing, SS, 1/16" OD × 0.8 mm ID × 2 m Length
06171	Tubing, SS, 1/16" OD × 1.0 mm ID × 2 m Length
06176	Ferrule, 2-piece, SS, 1/8", 10/pk
06186	Column-to-Column Connector, 1/16" OD × 0.4 mm ID × 7 cm Length
06448	Tubing, Teflon, 3 mm OD × 2 mm ID × 2 m Length
06587	Tubing, Teflon, 2 mm OD × 1 mm ID × 2 m Length
06630	Tubing, SS, 1/16" OD × 0.25 mm ID × 2 m Length
06815	Union, Teflon, for 1/4" OD tubing
07055	Tee, SS, 1/16" OD, 1 mm bore
07337	Union, SS, 1/16" OD, 1 mm bore, 5/pk
07539	Tee, SS, 1/16" OD, 0.4 mm bore
07540	Union, SS, for 1/16" OD SS to 1/8” Teflon
08278	Tee, Teflon, 1/4 × 28 UNF threads
08290	File, double edged, to cut SS tubing
08299	Nut, Long, Rheodyne, SS, 1/16", 5/pk
08851	Tubing, Silicon, 4 mm OD × 2 mm ID × 2 m Length
08878	Nut, Male, SS, 1/8", 5/pk
13652	Tee, SS, 1/4 × 28 UNF, for 1/8” OD Teflon
13656	Union, for SS and Teflon Tubing, 1 mm bore
14182	Adapter for Teflon Tubing, 2 mm OD, 10/pk
14186	Adapter for Teflon Tubing, 1/8" OD, 10/pk
14188	Adapter for Teflon Tubing, 1/16" OD, 5/pk
14189	Adapter Fitting for Teflon Tubing (p/n 14182), 2 mm OD, 10/pk
14191	Adapter Fitting for Teflon Tubing (p/n 14186), 1/8" OD, 10/pk

Part #	Description
16180	Ferrule, SS, 1/16", 10/pk
16481	Tubing, Silicon, 2.5mm OD × 1.5 mm ID × 200 cm Length
16745	Adapter Fitting for Teflon Tubing (p/n 14188), 1/16" OD, 5/pk
17714	Frit, 10 µm pores, for p/n 18444
18184	Column-to-Column Connector, 1/16" OD × 0.2 mm ID × 7 cm
18444	Inline Frit Filter Holder, SS, for p/n 17714
22005	Union, Internal, SS, 1/16" OD Short
22010	Low Dead Volume Tubing Assembly
22055	Ferrule, PEEK, for 0.3 mm ID Tubing
23276	Tubing for Degasser, Santoprene, 5 mm OD × 3 mm ID × 100 cm Length, Replaces p/n 17747
Basic Maintenance Kits	
44959	Basic Maintenance Kit with Standard GFP Seals for EcoSEC GPC System - includes p/ns 19190(×2), 19056(×1), 16415(×1), 06574(×1), 19762(×2), 21220(×1), 16414(×1), 17714(×2)
44958	Basic Maintenance Kit (Aqueous) with PE Seals for EcoSEC GPC System - includes p/ns 18517(×2), 19056(×1), 16415(×1), 06574(×1), 19762(×2), 21220(×1), 16414(×1), 17714(×2)
44957	Basic Maintenance Kit (Toluene) with Modified GFP Seals for EcoSEC GPC System - includes p/ns 22198(×2), 19056(×1), 16415(×1), 06574(×1), 19762(×2), 21220(×1), 16414(×1), 17714(×2)

EcoSEC High Temperature GPC System: Optional Components and Replacement Parts

Tosoh Bioscience offers the following replacement parts and optional components for the EcoSEC High Temperature GPC System. In addition, preventative and basic maintenance kits are available for those parts that experience wear and tear due to normal usage.

Tosoh Bioscience offers extended service agreements and on-site periodic maintenance service calls. Please contact us for additional information or a quote for these services.

Part #	Description
Optional Components	
23801	Sample Prep System
23804	Column Switching Valve
22893	TSKgel HHR HT-RC Reference Column
Autosampler Accessories	
05462	Sample Loop, SS, 50 µL
05679	Sample Loop, SS, 100 µL
05464	Sample Loop, SS, 500 µL
23809	HT Sample Vial, with Reusable Cap, Transparent, 10mL PTFE cover, 30/pk
18107	Sample Vial with Disposable Cap, Glass, 10mL, 30/pk
23810	HT Aluminum Sheets, 30 mm square, 100/pk
23811	HT Stainless Steel Mesh, 26 µm, 50mm square,100/pk
23812	HT Stainless Steel Mesh 96 µm, 50mm square,100/pk
Pumps and Accessories	
23817	HT Needle
23818	HT Needle Joint
23819	HT Sampler Syringe Assembly
23815	HT Purge Syringe Assembly
23816	HT Pump
18524	Mold to Replace Piston Seal
18525	Shaft for Piston Seal Replacement
19056	Pump Head Sealing Gasket, PTFE, 2/pk
19190	Piston Seal, GFP
22011	Check Valve Assembly, Inlet
22012	Check Valve Assembly, Outlet
22049	Degasser Chamber
22050	Vacuum Pump
23848	HT Waste Liquid Bottle for Sampler

Part #	Description
Solvent Related Accessories	
06574	Mobile Phase Inlet Filter, SS, 5 µm pores
13166	Line Filter
18118	Moisture Trap for 3 L Solvent Reservoir
06814	Solvent Bottle End Plug, 1/4", 10/pk
Tubing/Fittings and Accessories	
06160	Nut, SS, 1/16", 5/pk
08851	Tubing, Silicon, 4 mm OD × 2 mm ID × 2 m Length
16180	Ferrule, SS, 1/16", 10/pk
16566	Fingertight Fitting, 2/pk
17714	10 µm pores, for p/n 18444
18444	Inline Frit Filter Holder, SS, for p/n 17714
Valves and Accessories	
18069	Rotor Seal for 6-way Valve, Polyimide (PI)
23826	HT Temperature Sensor for CO
16415	Rotor Seal for 6-way Valve
Basic Maintenance Kits	
44959HT	Basic Maintenance Kit with Standard GFP Seals for EcoSEC High Temperature GPC System - includes p/ns 19190(×2), 19056(×1), 06574(×1), 19762(×2), 21220(×1), 18069(×1), 17714(×2)

Read all about it!

The EcoSEC GPC System was cited in the following journals:

Engstrom, J.; Hatton, F. L.; Wagberg, L.; D'Agosto, F.; Lansalot, M.; Malmstrom, E.; Carlmark, A. Soft and rigid core latex nanoparticles prepared by RAFT-mediated surfactant-free emulsion polymerization for cellulose modification - a comparative study. Polymer Chemistry. **2017**, 8:6:1061-73.

Follit, C.; Woodruff, S.; Vogel, P.; Wise, J.;. and Tsarevsky, N. Cationic branched polymers for cellular delivery of negatively charged cargo. Journal of Drug Delivery Science and Technology. **2017**, 39:324-33.

Gao, Y.; Dong, C.-M. Reduction- and thermo-sensitive core-cross-linked polypeptide hybrid micelles for triggered and intracellular drug release. Polymer Chemistry. **2017**, 8:7:1223-32.

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