Silica-based for protein analysis:

TSKgel SW mAb
TSKgel SW
TSKgel SW$_{XL}$
TSKgel SuperSW

Polymer-based for desalting:

TSKgel BioAssist DS Columns

Polymethacrylate-based for water-soluble polymers analysis:

TSKgel PW
TSKgel PW$_{XL}$
TSKgel PW$_{XL}$-CP
TSKgel SuperMultiporePW

Polymethacrylate-based for polar organic-soluble polymers analysis:

TSKgel Alpha
TSKgel SuperAW

Polystyrene-divinylbenzene-based for organic-soluble polymers analysis:

TSKgel H$_{XL}$
TSKgel H$_{HR}$
TSKgel SuperH
TSKgel SuperHZ
TSKgel SuperMultiporeHZ

About: 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 G4000PW
- TSKgel G5000PW
- TSKgel G6000PW
- TSKgel GMPW

The mixed bed column, TSKgel GMPW, has an extended linear calibration range, suitable for samples with a broad molar mass distribution, as well as for unknown samples. The pore volume can be accessed by polymers ranging in molar mass from 500 to 8.0 × 10^6 Da. By quickly categorizing the molar mass 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 12. 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 13. The calibration curve for polyethylene glycol and oxides for the TSKgel PW columns is shown in Figure 32.

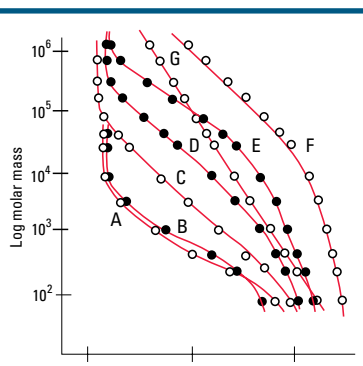
Table 12: Product attributes

TSKgel column	Particle size (mean)	Pore size (mean)	Calibration range
G2000PW	12 µm	12.5 nm	Up to 2,000 Da (polyethylene glycols and oxides)
G2500PW	12 µm and 17 µm	<20 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	500 - 8.0 × 10^6 Da (polyethylene glycols and oxides)

Table 13: Representative application examples for TSKgel PW columns

Classification	Examples
1. Synthetic polymers • Nonionic • Cationic • Anionic	• PEG, polyglycerin, 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 32: Polyethylene glycol and oxide calibration curves for TSKgel PW columns

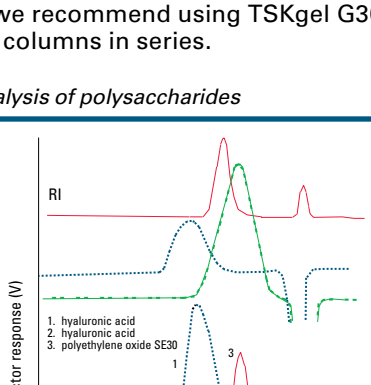


Column:	**A. G2000PW B. G2500PW C. G3000PW D. G4000PW E. G5000PW F. G6000PW G. GMPW all 7.5 mm ID × 60 cm**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	RI

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 33 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 33: Analysis of polysaccharides

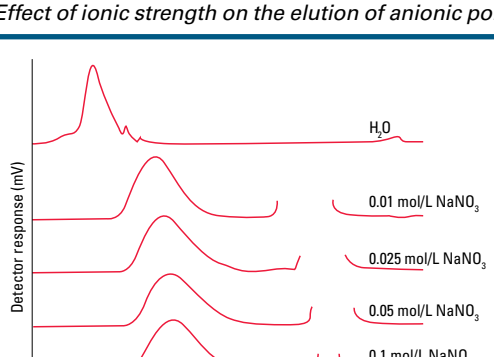


Columns:	**TSKgel G6000PW + G4000PW, two 7.5 mm ID × 60 cm columns in series**
Mobile phase:	0.2 mol/L NaCl
Flow rate:	0.9 mL/min
Temperature:	40 °C
Sample:	hyaluronic acid, polyethylene oxide

Polymers

Sodium polyacrylate, an anionic polymer, is effectively separated on two TSKgel GMPW columns in Figure 34. 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 34: 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, 0.01 mol/L, 0.025 mol/L, 0.05 mol/L or 0.1 mol/L $NaNO_3$ in H_2O
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

About: 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

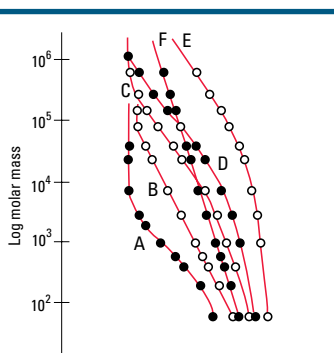
Attributes and Applications

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 14. 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 35 - 39 show the calibration curves for all of the TSKgel PWXL columns.

Table 14: Product attributes

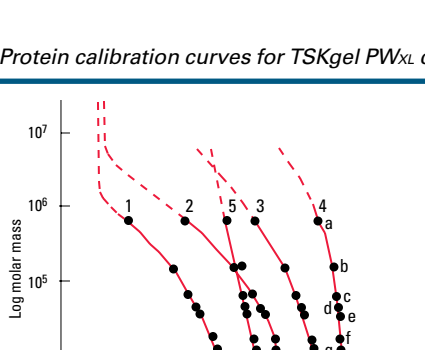
TSKgel column	Particle size (mean)	Pore size (mean)	Calibration range
G2500PWXL	7 µm	<20 nm	<3,000 Da (polyethylene glycols and oxides)
G3000PWXL	7 µm	20 nm	$<4.0 \times 10^4$ Da (polyethylene glycols and oxides)
G4000PWXL	10 µm	<50 nm	2,000 - 3.0×10^5 Da (polyethylene glycols and oxides)
G5000PWXL	10 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	100 - 3,000 Da (PEO,PEG/H_2O)

Figure 35: Polyethylene glycol and oxide calibration curves for TSKgel PW$_{XL}$ columns



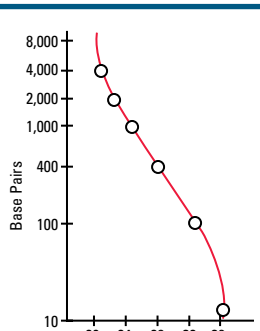
Column:	**A. G2500PW$_{XL}$ B. G3000PW$_{XL}$ C. G4000PW$_{XL}$ D. G5000PW$_{XL}$ E. G6000PW$_{XL}$ F. GMPW$_{XL}$ all 7.8 mm ID × 30 cm**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	RI

Figure 36: Protein calibration curves for TSKgel PW$_{XL}$ columns



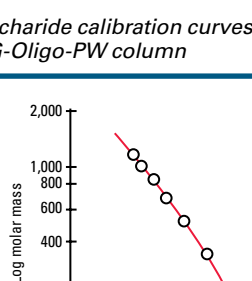
Column:	**1. TSKgel G3000PW$_{XL}$ 2. TSKgel G4000PW$_{XL}$ 3. TSKgel G5000PW$_{XL}$ 4. TSKgel G6000PW$_{XL}$ 5. TSKgel GMPW$_{XL}$ all 7.8 mm ID × 30 cm**
Mobile phase:	0.2 mol/L phosphate buffer, pH 6.8
Flow rate:	1.0 mL/min
Detection:	UV @ 280 nm
Samples:	a. thyroglobulin (6.6×10^5 Da) b. γ-globulin (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 37: Double stranded DNA calibration curves for TSKgel G-DNA-PW column



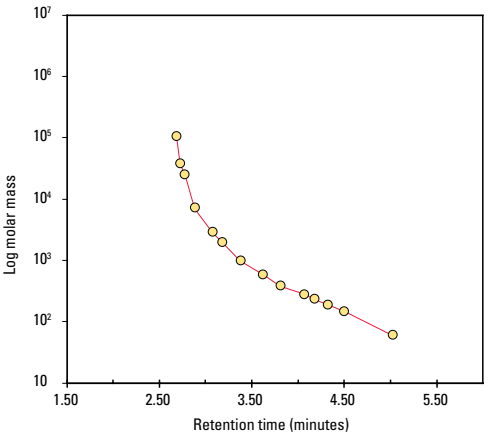
Column:	**TSKgel G-DNA-PW, 10 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	0.3 mol/L NaCl in 0.1 mol/LTris-HCl, pH 7.5, + 1 mmol/L EDTA
Flow rate:	0.15 mL/min
Detection:	UV @ 260 nm
Sample:	*Eco* RI and *Bst* NI-cleaved pBR322 DNA, void volume determined with λ-DNA

Figure 38: Oligosaccharide calibration curves 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 39: Polyethylene glycol, oxide and ethylene glycol calibration curve for TSKgel SuperOligoPW column

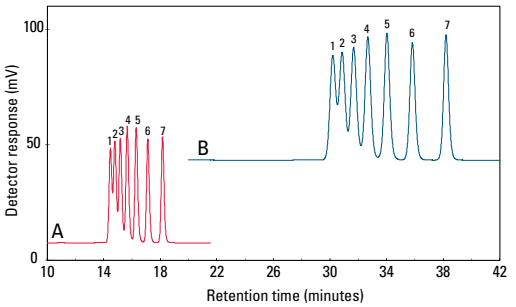


Column:	**TSKgel SuperOligoPW, 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.60 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	PEO, PEG and ethylene glycol

Oligosaccharides

Figure 40 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 40: Analysis of maltose oligomers

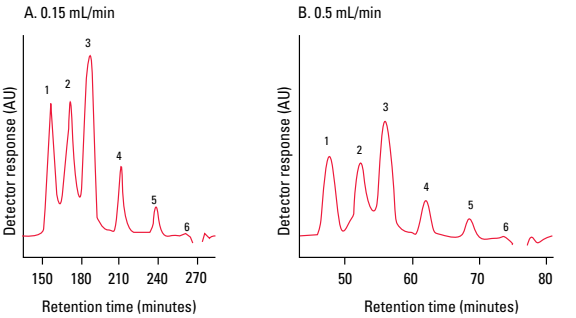


Columns:	**A. TSKgel SuperOligoPW, 3 µm, 6.0 mm ID × 15 cm × 4** **B. TSKgel G-Oligo-PW, 7 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	H_2O
Flow rate:	A: 0.6 mL/min B: 1.0 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol.:	A: 10 µL B: 50 µL
Samples:	1. maltoheptose 2. maltohexose 3. maltopentose 4. 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 41A 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 41B.

Figure 41A and 41B: Analysis of large DNA fragments

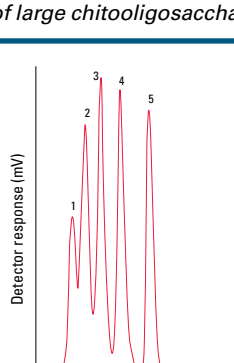


Column:	**TSKgel G-DNA-PW, 10 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	0.3 mol/L NaCl in 0.1 mol/L Tris-HCl, pH 7.5, + 1 mmol/L EDTA
Flow Rate:	A. 0.15 mL/min B. 0.5 mL/min
Detection:	UV @ 260 nm
Samples:	60 µL of Eco RI and Bst NI - cleaved pBR322 DNA, base pairs: 1. 4362 2. 1857 3. 1060 & 928 4. 383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

Oligomers

The TSKgel G-Oligo-PW column is designed for high resolution separations of nonionic and cationic oligomers. Figure 42 demonstrates excellent resolution of chito-oligosaccharides obtained by using the smaller, 6 µm particle size packing in the TSKgel G-Oligo-PW column.

Figure 42: Analysis of large chitooligosaccharides

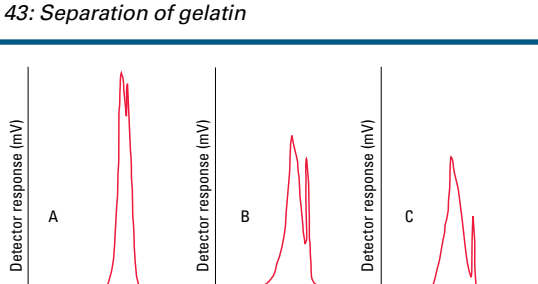


Column:	**TSKgel G-Oligo-PW, 7 µm, 7.8 mm ID × 30 cm × 2**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	RI
Samples:	1. chitohexaose 2. chitopentaose 3. chitotetraose 4. chitotriose 5. chitobiose

Complex Polymers

An example on the influence of pore size on the separation of complex polymers is shown in Figure 43. While on the large pore TSKgel G6000PWXL column, gelatin elutes in one narrow peak, on the G4000PWXL column the peak is much broader and the shoulder nearly separated from the main peak. This allows better determination of M_w/M_n and M_z/M_w.

Figure 43: Separation of gelatin

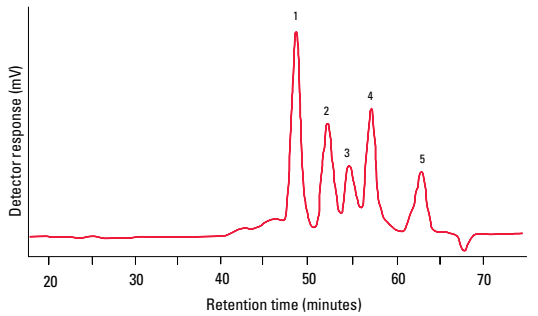


Columns:	**A. TSKgel G6000PWXL B. TSKgel G5000PWXL** **C. TSKgel G4000PWXL; all 7.8 mm ID × 30 cm**
Mobile phase:	0.2 mol/L phoshpate buffer, pH 6.0
Flow rate:	1.0 mL/min
Detection:	RI
Sample:	gelatin

Small Peptides

Figure 44 demonstrates that the separation of small peptides is possible on a TSKgel G3000PW$_{XL}$ column under denaturing conditions. Using an aqueous eluent containing 45% acetonitrile and 0.1% trifluoroacetic acid, the peptides were retained on the column using a size exclusion mechanism. An advantage of this method is that the eluent is volatile.

Figure 44: Analysis of small peptides

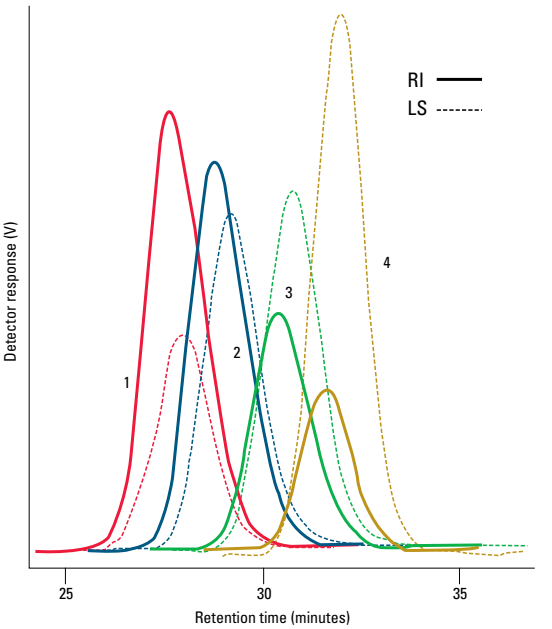


Column:	**TSKgel G3000PW$_{XL}$, 6 µm, 7.8 mm ID × 30 cm**
Mobile phase:	0.1% TFA / 45% CH_3CN
Flow rate:	1.0 mL/min
Samples:	peptides
	1. aprotinin
	2. insulin β-chain
	3. α-MSH
	4. bradykinin potentiator C
	5. glutathione

Molar Mass

Pullulan standard samples with a narrow molar mass distribution are commercially available. The molar mass of pullulan was analyzed by GFC/LALLS using a TSKgel GMPW$_{XL}$ column (Figure 45).

Figure 45: Analysis of pullulan

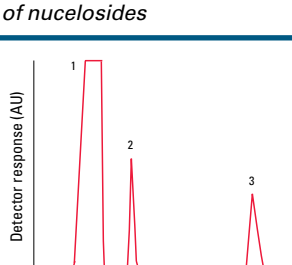


Column:	**TSKgel GMPW$_{XL}$, 13 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	0.1 mol/L sodium chloride
Flow rate:	1.0 mL/min
Temperature:	40 °C
Detection:	RI
	LS
Injection vol:	500 µL
Samples:	1. pullulan P400
	2. pullulan P200
	3. pullulan P100
	4. pullulan P50

Nucleic Acids

Desalting of nucleosides can be accomplished using the TSKgel G2500PW$_{XL}$ as depicted in Figure 46. Clearly, adenosine elutes after the void volume in the un-buffered water mobile phase.

Figure 46: Desalting of nucelosides

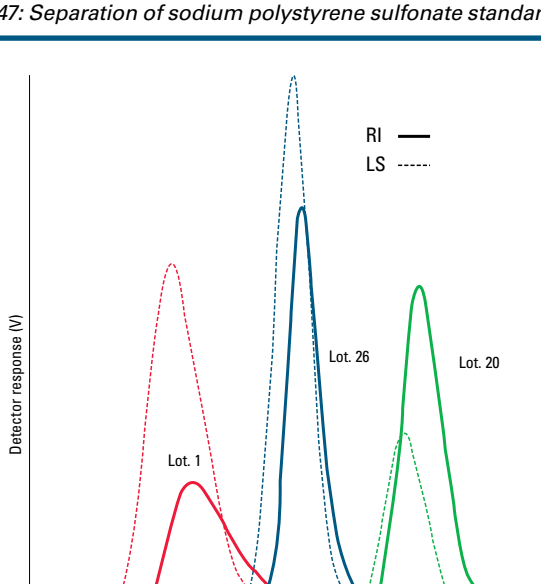


Column:	**TSKgel G2500PW$_{XL}$, 7 µm, 7.8 mm ID × 30 cm**
Mobile phase:	distilled H_2O
Flow rate:	1.0 mL/min
Detection:	UV @ 260 nm
Samples:	1. 0.5 mol/L NaCl 2. uridine 3. adenosine

Sodium Polystrene

Separation of sodium polystyrene sulfonate standards by GFC requires the addition of at least 10% acetonitrile or methanol to a 0.2 mol/L Na_2SO_4 mobile phase. Figure 47 shows chromatograms for sodium polystyrene sulfonate standards using a TSKgel GMPW$_{XL}$ column. Peak shapes for sodium polystyrene sulfonate samples obtained by adding 10% acetonitrile to a 0.2 mol/L Na_2SO_4 mobile phase remained constant upon addition of more acetonitrile.

Figure 47: Separation of sodium polystyrene sulfonate standards



Column:	**TSKgel GMPW$_{XL}$, 13 µm, 7.8 mm ID × 30 cm × 4**
Mobile phase:	ACN/0.2 mol/L sodium sulfate = 10/90
Flow rate:	1.0 mL/min
Detection:	RI LS
Temperature:	40 °C
Injection vol:	500 µL
Sample:	sodium poly(styrene sulfonates)

About: 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

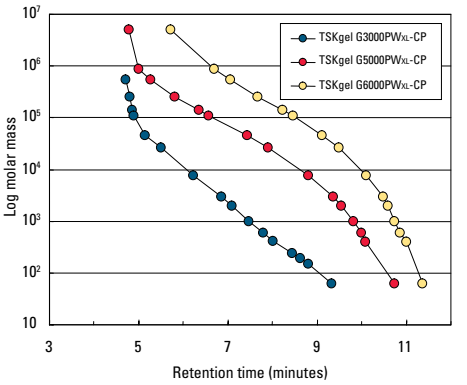
Attributes and Applications:

Table 15 shows the product attributes for each of the three TSKgel PWXL-CP columns. Figure 48 shows calibration curves produced with standard polyethylene oxide and polyethylene glycol in a 0.1 mol/L aqueous solution of sodium nitrate.

Table 15: 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 48: Polyethylene glycol and oxide calibration curves for TSKgel PWXL-CP columns

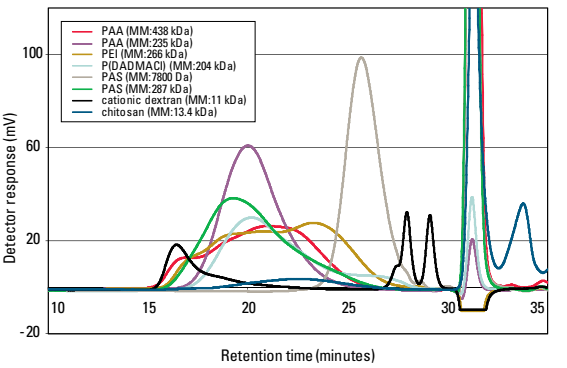


Columns: **TSKgel G3000PWXL-CP, 7 µm, 7.8 mm ID × 30 cm**
TSKgel G5000PWXL-CP, 10 µm, 7.8 mm ID × 30 cm
TSKgel G6000PWXL-CP, 13 µm, 7.8 mm ID × 30 cm
Mobile phase: 0.1 mol/L $NaNO_3$
Flow Rate: 1 mL/min
Detection: RI
Temperature: 25 °C
Samples: polyethylene oxides (PEO) standards
polyethylene glycols (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 49 demonstrates that these SEC columns can be utilized for the analysis of a wide variety of cationic polymers.

Figure 49: Analysis of cationic polymers

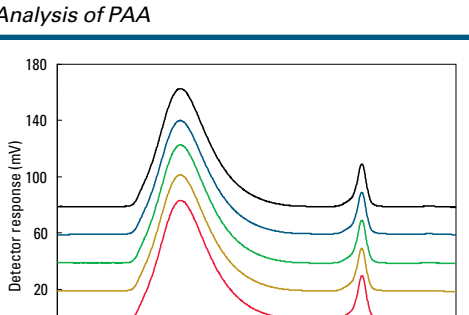


Columns: **TSKgel G3000PWXL-CP, 7 µm, 7.8 mm ID × 30 cm**
TSKgel G5000PWXL-CP, 10 µm, 7.8 mm ID × 30 cm
TSKgel G6000PWXL-CP, 13 µm, 7.8 mm ID × 30 cm
Mobile phase: 0.1 mol/L $NaNO_3$
Flow Rate: 1 mL/min
Detection: RI
Temperature: 25 °C
Sample Load: 3 g/L, 100 µL

PAA

The TSKgel PWXL-CP columns eliminate ionic adsorption onto the particle by incorporating a cationic functionality on the particle surface. This is demonstrated in Figure 50 below. PAA [poly(acrylic acid)] was injected onto a TSKgel G5000PWXL-CP column. Each chromatogram, from the first injection (red) to the fifth injection (black), showed similar elution profiles without any adsorption of the polymer.

Figure 50: Analysis of PAA

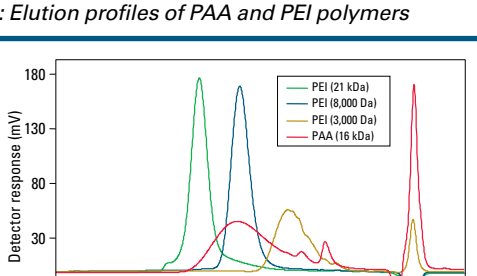


Column:	**TSKgel G5000PWXL-CP, 10 µm, 7.8 mm ID × 30 cm**
Mobile phase:	0.1 mol/L $NaNO_3$
Flow rate:	1.0 mL/min
Detection:	RI
Temperature:	25 °C
Sample:	polyallylamine-HCl (PAA)
Sample load:	3 g/L, 100 µL

Small Molar Mass Cationic Polymers

Small molar mass cationic polymers were analyzed on two TSKgel G3000PWXL-CP columns in series. As Figure 51 shows, these narrow molar mass cationic polymers eluted in order of their molar masses.

Figure 51: Elution profiles of PAA and PEI polymers



Column:	**TSKgel G3000PWXL-CP, 7 µm, 7.8 mm ID × 30 cm × 2**
Mobile phase:	0.1 mol/L $NaNO_3$
Flow rate:	1.0 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	polyethyleneimine (PEI) polyallylamine-HCl (PAA)

About: 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:

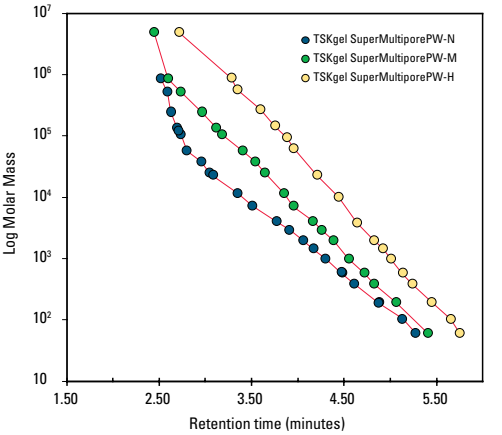
Table 16 shows the product attributes for each of the three TSKgel SuperMultiporePW columns. Figure 52 shows polyethylene glycol, oxide and ethylene glycol calibration curves for each of the TSKgel SuperMultiporePW columns.

Table 16: Product attributes

TSKgel column	SuperMultipore PW-N	SuperMultipore PW-M	SuperMultipore PW-H
Base material	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 52: Polyethylene glycol, oxide, and ethylene glycol calibration curves for TSKgel SuperMultiporePW columns

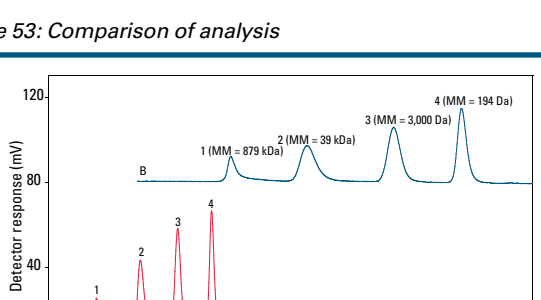


Columns:	**TSKgel SuperMultiporePW-N, 6.0 mm ID × 15 cm** **TSKgel SuperMultiporePW-M, 6.0 mm ID × 15 cm** **TSKgel SuperMultiporePW-H, 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.60 mL/min
Detection:	RI
Temperature:	25 °C
Samples:	polyethylene oxides (PEO) standards polyethylene glycols (PEG)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

Comparison with Conventional GPC Columns

A mixture of polyethylene oxide (PEO) and polyethylene glycol (PEG) was analyzed on a semi-micro TSKgel SuperMultiporePW-M column and on conventional-sized TSKgel G3000PWXL and TSKgel G5000PWXL columns in series. As shown in Figure 53, the analysis using the TSKgel SuperMultiporePW-M column was completed in ½ the time and with higher resolution than the analysis performed using the TSKgel G3000PWXL and TSKgel G5000PWXL columns. This is due to the semi-micro dimensions (6.0 mm ID × 15 cm) and the smaller particle size (4 µm) of the TSKgel SuperMultiporePW-M column compared to the 7.8 mm ID × 30 cm size and 7 and 10 µm particle size of the TSKgel G3000PWXL and TSKgel G5000PWXL columns respectively.

Figure 53: Comparison of analysis



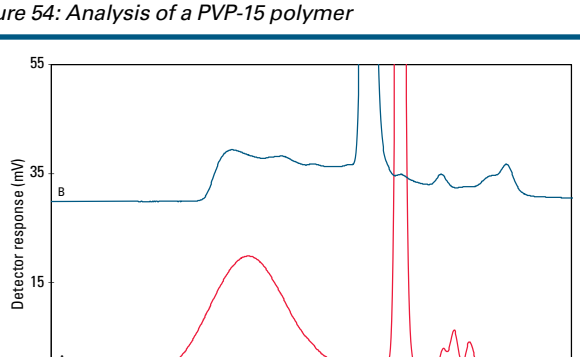
Resolution	TSKgel PWXL	TSKgel SuperMultiporePW-M
Peak 1/Peak 2	3.45	4.25
Peak 2/Peak 3	3.29	3.17
Peak 3/Peak 4	3.30	3.39

Columns:	A: **TSKgel SuperMultiporePW-M, 6.0 mm ID × 15 cm** **B: TSKgel G5000PWXL + G3000PWXL, each 6.0 mm ID × 15 cm**
Mobile phase:	H_2O
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	25 °C
Injection vol.:	A: 20 µL B: 100 µL
Samples:	mixture of PEO and PEG

PVP

Figure 54 demonstrates the lower hydrophobicity of the TSKgel SuperMultiporePW columns compared to the conventional TSKgel PWXL columns. Hydrophobic interaction causes partial adsorption of PVP-15 polymer on the TSKgel G3000PWXL and TSKgel G2500PWXL columns, while the absence of adsorption on the TSKgel SuperMultiporePW-N column suggests that the internal particle surface is more hydrophilic than the conventional columns.

Figure 54: Analysis of a PVP-15 polymer



Columns:	**A. TSKgel SuperMultiporePW-N, 6.0 mm ID × 15 cm x 2** **B. TSKgel G3000PWXL+G2500PWXL, 6.0 mm ID × 15 cm x 2**
Mobile phase:	100 mmol/L $NaNO_3$
Flow Rate:	0.60 mL/min
Detection:	RI
Temperature:	40 °C
Injection vol.:	20 µL
Samples:	PVP(K-15)