

7| Successful GPC/SEC Separation



Gel Permeation Chromatography (GPC), Size Exclusion Chromatography (SEC), or Gel Filtration Chromatography (GFC) are names used interchangeably for a liquid chromatography technique to obtain separation according to molecular dimensions.

Contrary to LAC- (Liquid Adsorption Chromatography) methods like HPLC, that rely on interactions between sample and stationary phase (column material), GPC/SEC must operate free of interactions. Only then is a separation according to the size of the molecules ensured. Ideally, only entropic effects should influence this type of separation.

The following information should help you to successfully install GPC/SEC in your lab.

1. Select an appropriate stationary phase (column material) that fits your samples and ensures interaction free separation.
2. Make sure to select and use a mobile phase (eluent) that is compatible with the stationary phase (column material, gel).
3. To improve the resolution and/or expand the molecular weight separation range, PSS recommends to use multiple columns in series.
4. Select the proper particle size and the appropriate pore size distribution.
5. Maintain a flow rate and a temperature that agrees with the column diameter and viscosity of the solvent to prevent sample shearing and high backpressure.
6. Use precolumns to increase the overall column life time.
7. Filter your samples through a 0.45 μm filter for 5 μm particle size or 1 μm filter for 10/20 μm particle size to prevent solids from entering the column.
8. Determine the plate count, asymmetry and resolution of your column(s) regularly to check their performance.
9. Determine the molecular weight range of the separation with a calibration curve.
10. Use appropriate concentration and injection volume balance to prevent column overload.
11. The higher the molecular weight of your sample the lower the sample concentration. Refer to chapter "Standards Handling" for guidelines.

8| GPC/SEC Columns Powerful solutions for size separation

Our high performance columns are the result of comprehensive research focusing on the development of more efficient and robust gel materials and an improved packing technology. We manufacture stationary phase gels for the chromatography able to separate synthetic and natural macromolecules by their hydrodynamic volume. PSS offers the widest range of column materials optimized for aqueous or organic solvents alike:

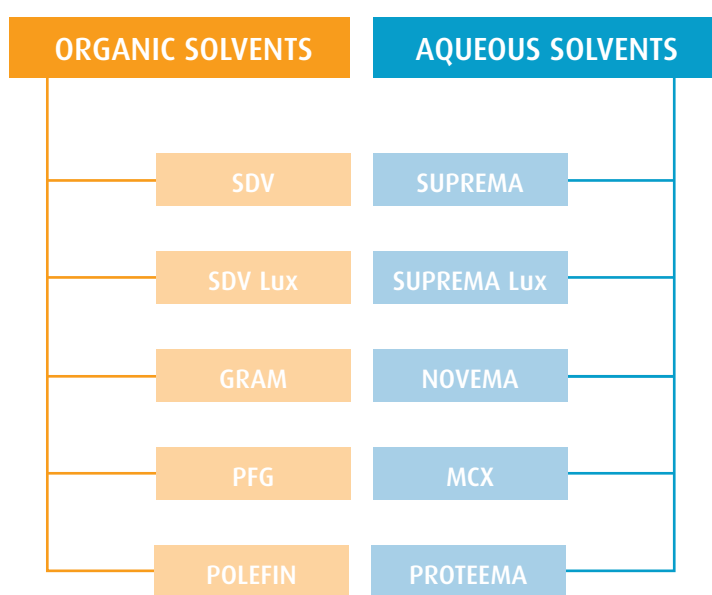


Fig. 1: Overview of gel materials

TIP: See summary of specifications on last page

8.1. Column Selection

A GPC/SEC column can be selected by different criteria depending on your analytical goal (highest resolution, product screening, etc.). This chapter will present the most important and essential criteria.

1. Step: Optimum Stationary Phase

The PSS column concept is to minimize interactions between polymer and stationary phases. In general, the sample is the determinant factor: the polarity of the sample defines the polarity of the solvent and therefore also that of the stationary phase. To ensure interaction free chromatography the stationary phase needs to be selected carefully.

PSS allows the selection of stationary phases of different polarities. The PSS Magic Triangle provides a quick visual aid for the selection of columns, where the three sides represent sample, mobile phase, and stationary phase (see Fig. 2).

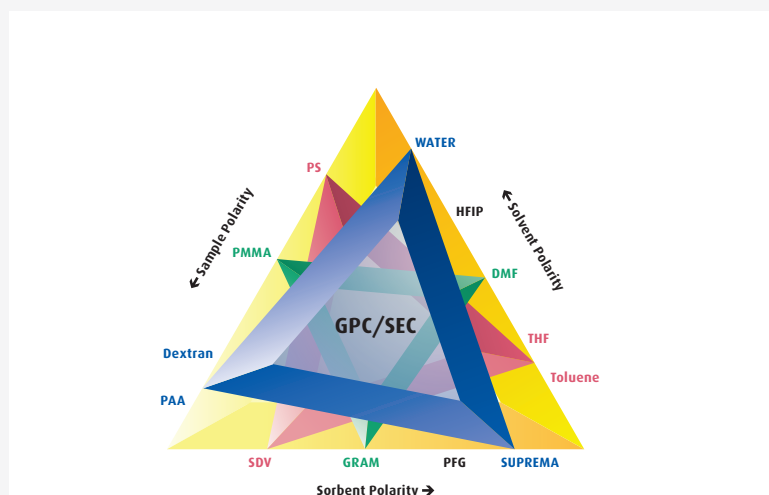


Fig. 2: PSS Magic Triangle for GPC/SEC applications

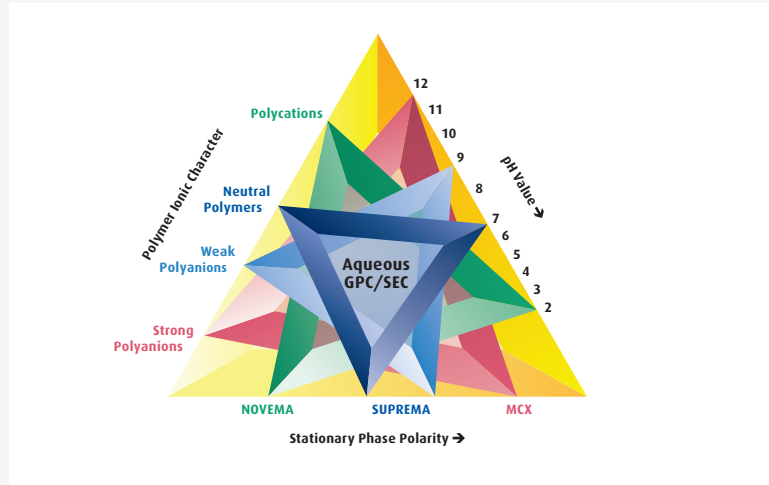


Fig. 3: PSS Magic Triangle for aqueous GPC/SEC applications

Handling of the PSS Magic Triangle

Construct an isosceles triangle by locating the polarity of sample and mobile phase; the peak of the Magic Triangle guides you to the proper stationary phase. This concept is also applicable for aqueous GPC/SEC. The magic triangle for aqueous systems takes the pH value instead of the stationary phase into account (see Fig. 3).

TIP: Solvent Compatibility

It is imperative that a sample passing through a column be soluble in the mobile phase. When using a solvent different from the mobile phase to dissolve and inject a sample, both solvents must be completely miscible and compatible with the stationary phase. PSS recommends to use the mobile phase also for sample preparation.

2. Step: Column Dimensions and Field of Application

Our stationary phases are packed in stainless steel (V4A) columns of standard dimensions that fit any HPLC or GPC/SEC instrument

101 Column dimension and field of application

Column Type	I.D.* x length [mm]**	Field of application
Precolumn	8 x 50	Protection
	4.6 x 30	
	20 x 50	
Analytical	8 x 300	Conventional analysis
	8 x 600	
Micro	4.6 x 250	Solvent saving, small sample amounts
Preparative	20 x 300	Preparative sample fractionation, sample collection
	20 x 600	
	40 x 250	
HighSpeed	20 x 50	Ultra fast analysis
Lux	8 x 300	GPC Light Scattering

* I.D.: internal diameter

** Any other column dimension on request

TIP:

For additional column dimensions please call us or your closest representative.

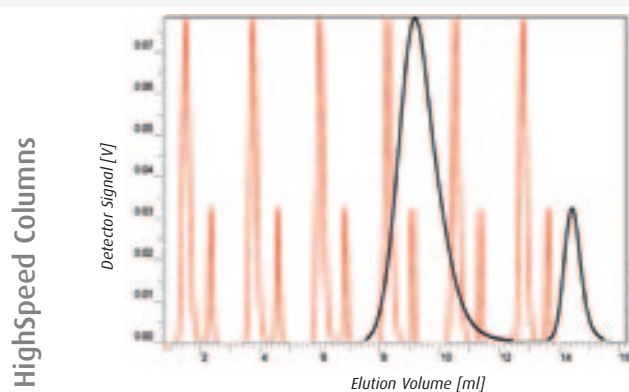


Fig. 4: A HighSpeed column (red line) reduces the run time for a sample (broad Poly(styrene)) by a factor of 6 - 8 compared to a conventional column (black line).

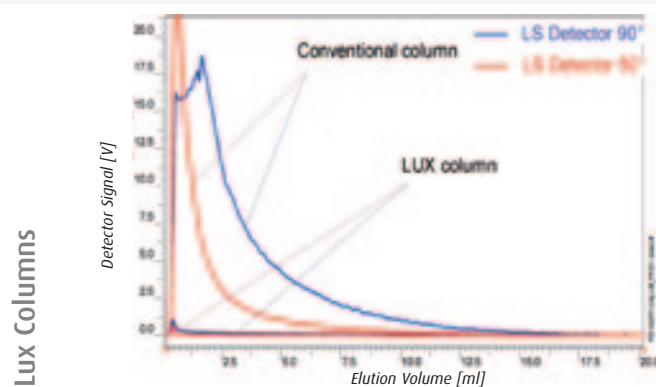


Fig. 5: Lux columns reach the steady state mode > 25 times faster than conventional columns, and their overall noise reduction is more than 25 times better.

3. Step: Particle Sizes and Porosities

PSS GPC/SEC column materials are available in several particle sizes from 3 µm up to 20 µm particles.

The optimum particle size depends on

- the solvent viscosity (higher viscosity requires higher particle size)
- the sample molar mass (higher molar masses require higher particle sizes).

Porosities

The pore size distribution of the column material determines the separation range.

- To separate low molecular weight products use small porosities.
- The higher the molecular weight the higher is the required porosity.
- Single porosity columns show a high resolution in a narrow molecular weight range.
- A wide molecular weight range at constant high resolution is covered if columns with single porosities are coupled in series.
- Linear or mixed bed columns provide a very wide porosity range therefore offering a broad separation range with a smaller resolution.

For any desired application PSS offers the optimum column or column combination (single porosity or linear).

4. Step: Laboratory workflow requirements/Tasks

Once you know the stationary phase, particle size and porosity, there are different options to optimize the polymer separation, depending on laboratory workflow requirements:

102 Application of different column types	
Select	Recommended application
HighSpeed columns	Very fast results needed in process control and high throughput screening Analysis time: 2 - 4 min per sample
Linear or mixed bed columns	Product screening at constant peak resolution Analysis time: ~ 12 min per sample
Combination of single porosity columns	Highest resolution and maximum information Analysis time: > 12 min per sample

TIP: The combination of single porosity columns has the inherent risk of column mismatch. Use the column combinations recommended by PSS to avoid column mismatch.

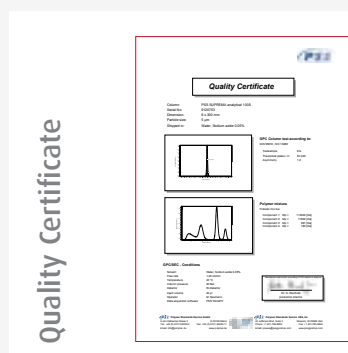
8.2. Advantages of PSS Column Technology

- Excellent separation efficiency obtained with narrowly classified gels and optimized frit technology.
- Excellent stability under a wide range of physical, chemical and biological environments.
- High solvent compatibility with organic or aqueous mobile phases alike.
- Column production under DIN EN ISO 9001 quality standards.
- Controlled Quality: each column is tested according to DIN 55672 and ISO/EN 13885
- Delivery with a detailed user documentation and a quality certificate.
- PSS engineered fittings and their integrated diffusers provide excellent sample injection.
- Easy to service: easy to change end frits.
- Refill Service: PSS will refurbish cost saving old columns with new gel-material.
- Dedicated support in questions, problems and applicational demands from a team of committed and experienced scientists.

8.3. Column Order Deliverables

Installation Tips

1. Purge the system with mobile phase first. Pump solvent through the system to remove air and to prevent that air is entering the columns. Don't forget to flush the injection loop.
2. Use the column connections supplied from PSS to connect columns in series.



Quality Certificate

PSS carefully tests every column according resolution, asymmetry and plate count number. The quality certificate contains the testing results and the corresponding test chromatograms.

Solvent of Choice

PSS delivers the columns in the eluent of the customer choice, except solvents with a high freezing point like DMSO and TCB.

The solvent within the columns is marked with colour-coded screw stops.

Column Connector

PSS ships connection fittings with the column.

Test mixture

PSS ships a polymer mixture for testing with the column if possible.

User documentation

Each column is delivered with detailed user documentation.

Refill Services

PSS will refill your old columns at a considerable cost saving upon request. They will be tested individually and delivered with a new quality certificate.

8.4. Column Handling

Installation Tips

1. Purge the system with mobile phase first. Pump solvent through the system to remove air and to prevent that air is entering the columns. Don't forget to flush the injection loop.
2. Use the column connections supplied from PSS to connect columns in series.

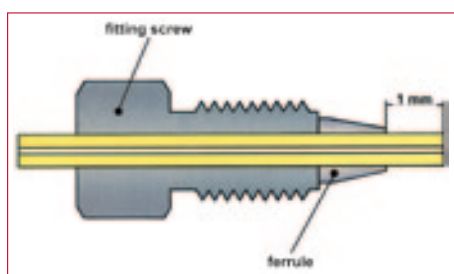


Fig. 6: Maximum distance between ferrule and capillary end.

WARNING: Make sure that the fitting tubing protrudes a maximum of 1 mm inside the column head (see Fig. 6)

3. Be aware of column flow direction. Operating the flow rate in the reverse direction is only part of trouble-shooting or operating after a long storage time.
4. Thread the column fittings finger tight into the system. Do not over tighten the fitting. Overtightening may damage the column and the column head.
5. Flush the column with 10 times of the column volume at 1/5 of the recommended flow rate.

103 Recommended flow rates

Flow	I.D. 8 mm	I.D. 4.6 mm	I.D. 20 mm
Operating	1 ml/min	0.33 ml/min	6.25 ml/min
Reduced	0.25 ml/min	0.1 ml/min	1.5 ml/min
Idle	0.1 ml/min	0.03 ml/min	0.6 ml/min

6. Eluent should come out after 2-3 minutes at 0.2 ml/min flow rate. If not, see "Recovering partially dry columns".
7. When the solvent exchange is completed, connect to the detector(s).
8. Slowly increase the flow rate to the typical operating flow rate which depends on the column dimensions (see table 103).
9. Check the column pressure.

WARNING: Maximum pressure should never exceed twice the pressure specified in the column certificate.

10. Give the columns time to equilibrate.
11. Check the plate count of the whole chromatographic system incl. columns (see column user documentation). If this test fails, first check each column separately when using a column combination, then contact PSS or a PSS representative.

TIP: For Multiple Columns Use

- Install the middle porosity first and use the largest porosity connected into the detector.
- Use only column combinations recommended by PSS.
- Do not combine linear and single porosity columns.
- Do not combine different particle sizes.

Cleaning

When columns loose efficiency (Rsp, Asymmetry) or you suspect the presence of foreign material adsorbed on the column, PSS recommends the following procedures:

- Remove the column from the detector.
- Install the column in reverse direction for clean-up.
- Flush the column at 0.1 ml/min flow rate with a solvent that dissolves the suspect impurities and is fully compatible with your system, until the impurities are removed.



TIP: To clean aqueous columns, use variation of pH, buffer concentration, or mixtures of organic and aqueous eluents. Organic columns are cleaned best by variation of eluent polarity. Use mixtures of appropriate solvents (e.g. THF in toluene resp. chloroform) or solvent additives (TFAc in THF).

Storage

PSS recommends to store the columns in the solvent used during shipment; f.e. columns shipped in DMAc or DMF must be stored in DMAc or DMF.

1. Remove salt solutions with pure solvent, disconnect the column from the GPC/SEC system and tightly plug with the original end plugs.
2. It is a good practice to store columns with volatile mobile phases in a refrigerator (4°C) to prevent solvent evaporation.

WARNING: Never let the column temperature fall below the freezing point of the storage solvent. This will destroy the stationary phase.

Recovering partially dry columns

Occasionally solvent is lost during long-term storage or due to high storage temperatures. When after (re-) installing the column no solvent overflows or the expected system pressure does not build up, this can be an indication for a partially dry column.

To re-wet a partially dry column:

- Install the column in the reverse direction.
- Fill the column with solvent, using a flow rate of 0.1 ml/min, until no more bubbles appear at the column outlet.
- Change the column to the correct flow direction and use 0.1 ml/min for 2h.
- Increase the flow rate slowly to the operating flow rate with an increment of 0.2 ml/min per 5 minutes.

8.5. Warranty

PSS Polymer Standards Service offers the warranty for the columns according to specifications given in the Quality Certificate.

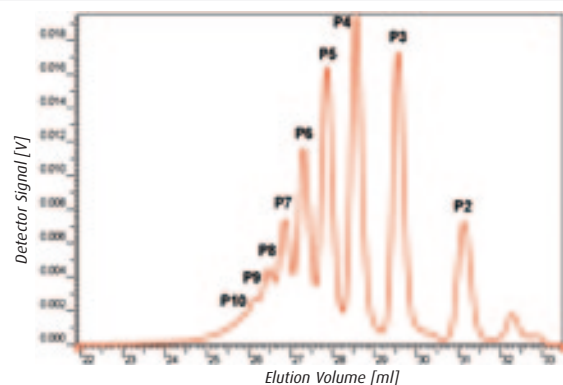
9| Columns for Organic Solvents

9.1. SDV Columns

104 GPC/SEC of Polymers in Unpolar and Medium Polar Organic Solvents	
Field of Application	
Applicability	Poly(styrene), Poly(vinyl chloride), Poly(carbonate), Elastomers, Resins and others
Eluents	THF, Toluene, TCM, DCM
Specifications	
Material	Styrene-divinylbenzene copolymer network
Maximum Pressure	45 - 150 bar (650 - 2180 psi), depending on porosity
Maximum Temperature	100° C
Maximum Flow Rate	3 ml/min (8 mm I.D., 5 resp. 10 µm)
Particle Size	3, 5, 10, 20 µm
Molecular Weight Range	100 to 30 000 000 Da
Incompatibility	Water, alcohol, drying, and freezing
Separation range	
50 Å	100 - 5 000 Da
100 Å	100 - 10 000 Da
500 Å	100 - 30 000 Da
1 000 Å	100 - 60 000 Da
10 000 Å	500 - 700 000 Da
100 000 Å	1 000 - 1 000 000 Da
1 000 000 Å	1 000 - 3 000 000 Da
10 000 000 Å	5 000 - 30 000 000 Da
linear S	100 - 150 000 Da
linear M	100 - 1 000 000 Da
linear XL	100 - 3 000 000 Da
Recommended Column Combination	
Low molar mass:	100 Å + 1 000 Å + 10 000 Å
Med. mol. mass:	1 000 Å + 100 000 Å + 1 000 000 Å
High molar mass:	1 000 Å + 100 000 Å + 10 000 000 Å

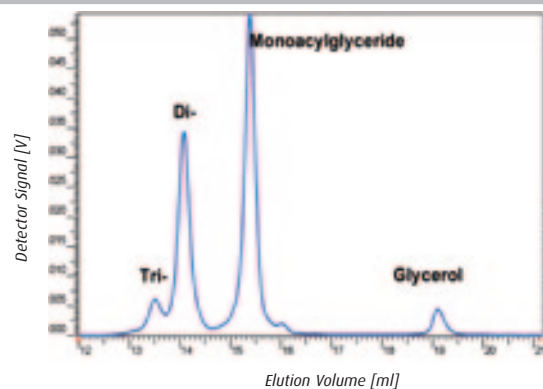
Applications

Oligomeric Poly(styrene)



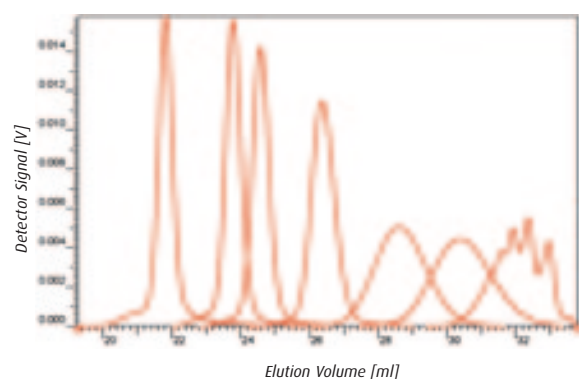
Flow rate: 0.5 ml/min, Loading: 1 g/l, 20 µl;
Eluent: THF; Temp.: 25° C; Detector: SEccurity RI;
Columns: SDV 5 µm, 50 Å, 100 Å, 100 Å (8 x 300 mm) + precolumn

Glyceride acc. EUP



Flow rate: 1 ml/min; Loading: 40 g/l, 40 µl;
Eluent: THF; Temp.: 25° C; Detector: SEccurity RI;
Column: SDV 5 µm, 100 Å (8x 600 mm)

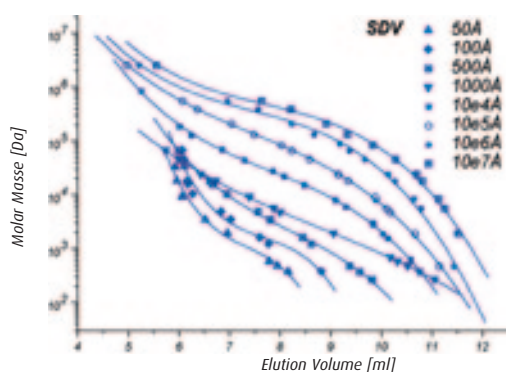
Poly(dimethyl siloxane)



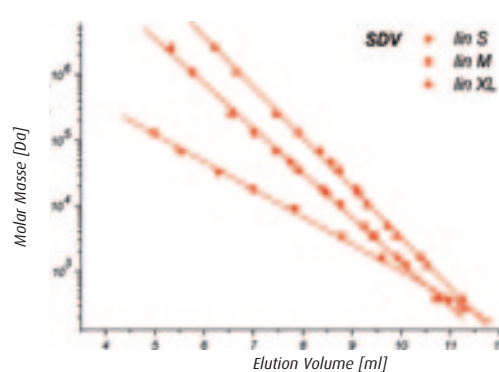
Flow rate: 1 ml/min; Loading: 2 g/l, 20 µl;
Eluent: Toluene; Temp.: 25° C; Detector: SEccurity RI;
Columns: SDV 5 µm, 1000 Å, 100 000 Å, 1 000 000 Å (8 x 300 mm) + precolumn

Calibration Curves

Single Porosity Columns

Eluent: THF; Calibrants:
Poly(styrene)

Linear Columns

Eluent: THF; Calibrants:
Poly(styrene)

Part numbers

105 PSS SDV Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	precolumn	8 x 50	sda080503
5	precolumn	8 x 50	sda080505
10	precolumn	8 x 50	sda080510
20	precolumn	8 x 50	sda080520
3	50 Å	8 x 300	sda0830035e1
3	100 Å	8 x 300	sda0830031e2
3	500 Å	8 x 300	sda0830035e2
3	1 000 Å	8 x 300	sda0830031e3
3	10 000 Å	8 x 300	sda0830031e4
3	100 000 Å	8 x 300	sda0830031e5
5	50 Å	8 x 300	sda0830055e1
5	100 Å	8 x 300	sda0830051e2
5	500 Å	8 x 300	sda0830055e2
5	1 000 Å	8 x 300	sda0830051e3
5	10 000 Å	8 x 300	sda0830051e4
5	100 000 Å	8 x 300	sda0830051e5
5	1 000 000 Å	8 x 300	sda0830051e6
10	50 Å	8 x 300	sda0830105e1
10	100 Å	8 x 300	sda0830101e2
10	500 Å	8 x 300	sda0830105e2
10	1 000 Å	8 x 300	sda0830101e3
10	10 000 Å	8 x 300	sda0830101e4
10	100 000 Å	8 x 300	sda0830101e5
10	1 000 000 Å	8 x 300	sda0830101e6
10	10 000 000 Å	8 x 300	sda0830101e7
20	100 Å	8 x 300	sda0830201e2
20	500 Å	8 x 300	sda0830205e2
20	1 000 Å	8 x 300	sda0830201e3
20	10 000 Å	8 x 300	sda0830201e4
20	100 000 Å	8 x 300	sda0830201e5
20	1 000 000 Å	8 x 300	sda0830201e6
20	10 000 000 Å	8 x 300	sda0830201e7

106 PSS SDV Columns analytical, linear

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	precolumn	8 x 50	sda080503
5	precolumn	8 x 50	sda080505
10	precolumn	8 x 50	sda080510
20	precolumn	8 x 50	sda080520
3	linear S	8 x 300	sda083003lis
3	linear M	8 x 300	sda083003lim
5	linear S	8 x 300	sda083005lis
5	linear M	8 x 300	sda083005lim
5	linear XL	8 x 300	sda083005lxl
10	linear S	8 x 300	sda083010lis
10	linear M	8 x 300	sda083010lim
10	linear XL	8 x 300	sda083010lxl
20	linear M	8 x 300	sda083020lim
20	linear XL	8 x 300	sda083020lxl

107 PSS SDV Lux Columns analytical
(for light scattering)

Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	8 x 50	sdl080505
10	precolumn	8 x 50	sdl080510
5	1 000 Å	8 x 300	sdl0830051e3
5	100 000 Å	8 x 300	sdl0830051e5
5	1 000 000 Å	8 x 300	sdl0830051e6
5	linear M	8 x 300	sdl083005lim
5	linear XL	8 x 300	sdl083005lxl
10	1 000 Å	8 x 300	sdl0830101e3
10	100 000 Å	8 x 300	sdl0830101e5
10	1 000 000 Å	8 x 300	sdl0830101e6
10	linear M	8 x 300	sdl083010lim
10	linear XL	8 x 300	sdl083010lxl

108 PSS SDV Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	100 Å	20 x 50	sds2005031e2
3	500 Å	20 x 50	sds2005035e2
3	1 000 Å	20 x 50	sds2005031e3
3	10 000 Å	20 x 50	sds2005031e4
3	100 000 Å	20 x 50	sds2005031e5
5	100 Å	20 x 50	sds2005051e2
5	500 Å	20 x 50	sds2005055e2
5	1 000 Å	20 x 50	sds2005051e3
5	10 000 Å	20 x 50	sds2005051e4
5	100 000 Å	20 x 50	sds2005051e5
5	1 000 000 Å	20 x 50	sds2005051e6
10	100 Å	20 x 50	sds2005101e2
10	500 Å	20 x 50	sds2005105e2
10	1 000 Å	20 x 50	sds2005101e3
10	10 000 Å	20 x 50	sds2005101e4
10	100 000 Å	20 x 50	sds2005101e5
10	1 000 000 Å	20 x 50	sds2005101e6
10	10 000 000 Å	20 x 50	sds2005101e7
20	100 Å	20 x 50	sds2005201e2
20	1 000 Å	20 x 50	sds2005201e3
20	10 000 Å	20 x 50	sds2005201e4
20	100 000 Å	20 x 50	sds2005201e5
20	1 000 000 Å	20 x 50	sds2005201e6
20	10 000 000 Å	20 x 50	sds2005201e7

109 PSS SDV Columns HighSpeed, linear

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	linear S	20 x 50	sds200503lis
3	linear M	20 x 50	sds200503lim
5	linear S	20 x 50	sds200505lis
5	linear M	20 x 50	sds200505lim
5	linear XL	20 x 50	sds200505lxl
10	linear S	20 x 50	sds200510lis
10	linear M	20 x 50	sds200510lim
10	linear XL	20 x 50	sds200510lxl
20	linear M	20 x 50	sds200520lim
20	linear XL	20 x 50	sds200520lxl

110 PSS SDV Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	20 x 50	sdp200505
10	precolumn	20 x 50	sdp200510
20	precolumn	20 x 50	sdp200520
5	50 Å	20 x 300	sdp2030055e1
5	100 Å	20 x 300	sdp2030051e2
5	500 Å	20 x 300	sdp2030055e2
5	1 000 Å	20 x 300	sdp2030051e3
5	10 000 Å	20 x 300	sdp2030051e4
5	100 000 Å	20 x 300	sdp2030051e5
5	1 000 000 Å	20 x 300	sdp2030051e6
10	50 Å	20 x 300	sdp2030105e1

111 PSS SDV Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	100 Å	20 x 300	sdp2030101e2
10	500 Å	20 x 300	sdp2030105e2
10	1 000 Å	20 x 300	sdp2030101e3
10	10 000 Å	20 x 300	sdp2030101e4
10	100 000 Å	20 x 300	sdp2030101e5
10	1 000 000 Å	20 x 300	sdp2030101e6
10	10 000 000 Å	20 x 300	sdp2030101e7
20	100 Å	20 x 300	sdp2030201e2
20	500 Å	20 x 300	sdp2030205e2
20	1 000 Å	20 x 300	sdp2030201e3
20	10 000 Å	20 x 300	sdp2030201e4
20	100 000 Å	20 x 300	sdp2030201e5
20	1 000 000 Å	20 x 300	sdp2030201e6
20	10 000 000 Å	20 x 300	sdp2030201e7

112 PSS SDV Columns preparative, linear

Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	20 x 50	sdp200505
10	precolumn	20 x 50	sdp200510
20	precolumn	20 x 50	sdp200520
5	linear S	20 x 300	sdp203005lis
5	linear M	20 x 300	sdp203005lim
5	linear XL	20 x 300	sdp203005lxl
10	linear S	20 x 300	sdp203010lis
10	linear M	20 x 300	sdp203010lim
10	linear XL	20 x 300	sdp203010lxl
20	linear M	20 x 300	sdp203020lim
20	linear XL	20 x 300	sdp203020lxl

113 PSS SDV Columns micro

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	precolumn	4.6 x 30	sdm05030350
3	50 Å	4.6 x 250	sdm0525035E1
3	100 Å	4.6 x 250	sdm0525031E2
3	500 Å	4.6 x 250	sdm0525035E2
3	1 000 Å	4.6 x 250	sdm0525031E3
3	10 000 Å	4.6 x 250	sdm0525031E4
3	100 000 Å	4.6 x 250	sdm0525031E5
3	1 000 000 Å	4.6 x 250	sdm0525031E6
3	linear S	4.6 x 250	sdm052503lis
3	linear M	4.6 x 250	sdm052503lim

9.2. GRAM Columns

114 GPC/SEC of polymers in polar organic solvents

Field of Application

Applicability Polyurethane, Polyimide, Starches, Celluloses, certain Polyamide, other polar polymers

Eluents DME, DMAc, NMP, DMSO

Specifications

Material Polyester copolymer network

Maximum Pressure 50 -120 bar (725 - 1740 psi), depending on porosity

Maximum Temperature 90° C

Maximum Flow Rate 2 ml/min (8 mm i.D.)

Particle Size 10 µm

Molecular Weight Range 100 to 50 000 000 Da

Incompatibility drying and freezing

Separation range

30 Å 100 - 10 000 Da

100 Å 300 - 60 000 Da

1 000 Å 1000 - 1 000 000 Da

3 000 Å 5 000 - 5 000 000 Da

10 000 Å 10 000 - 50 000 000 Da

linear 500 - 1 000 000 Da

Recommended Column Combination

Low molar mass: 100 Å + 100 Å

Med. mol. mass: 30 Å + 1000 Å + 1000 Å

High molar mass: 100 Å + 10 000 Å + 10 000 Å

Part Numbers

115 PSS GRAM Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	8 x 50	ama080510
10	30 Å	8 x 300	ama0830103e1
10	100 Å	8 x 300	ama0830101e2
10	1000 Å	8 x 300	ama0830101e3
10	3000 Å	8 x 300	ama0830103e3
10	10000 Å	8 x 300	ama0830101e4
10	linear	8 x 300	ama083010lin

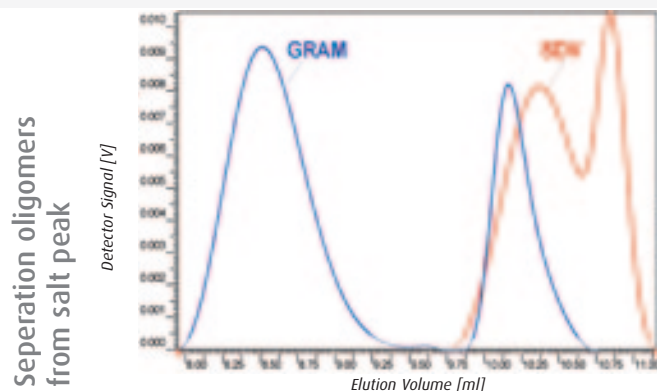
116 PSS GRAM Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	100 Å	20 x 50	ams2005101e2
10	1000 Å	20 x 50	ams2005101e3
10	3000 Å	20 x 50	ams2005103e3
10	10000 Å	20 x 50	ams2005101e4
10	linear	20 x 50	ams200510lin

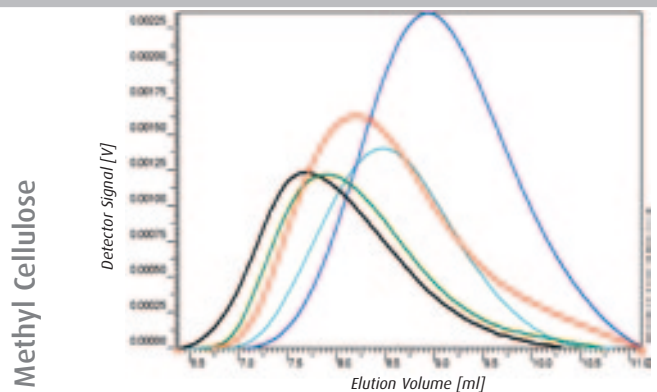
117 PSS GRAM Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	20 x 50	amp200510
10	30 Å	20 x 300	amp2030103e1
10	100 Å	20 x 300	amp2030101e2
10	1000 Å	20 x 300	amp2030101e3
10	3000 Å	20 x 300	amp2030103e3
10	10000 Å	20 x 300	amp2030101e4
10	linear	20 x 300	amp203010lin

Applications

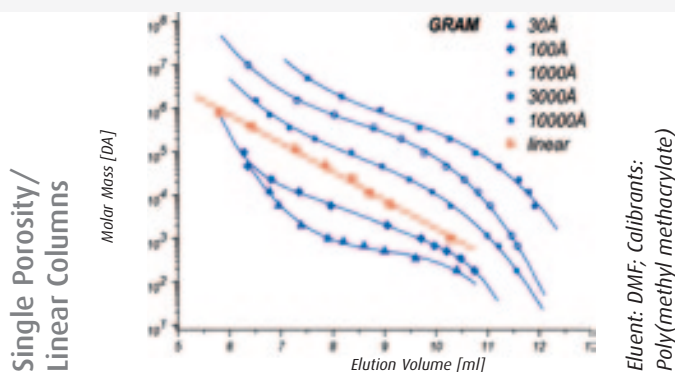


Flow rate: 1 ml/min; Loading: 1 g/l, 20 µl;
Eluent: DMAc; Temp.: 60° C; Detector: SECCurity RI;
Columns: SDV 10 µm 1 000 Å (red line); GRAM 10 µm 100 Å (blue line) (8 x 300 mm)



Flow rate: 0.5 ml/min; Loading: 1 g/l, 50 µl;
Eluent: DMSO, LiBr 5 g/l; Temp.: 60° C; Detector: SECCurity RI;
Columns: GRAM 10 µm, 1 000 Å (8 x 300 mm) + precolumn

Calibration Curves



9.3. PFG Columns

118 GPC/SEC of Crystalline Polymers in Fluorinated Organic Solvents

Field of Application

Applicability	Crystalline polymers, Polyesters, Nylons, Poly(lactide), POM, etc.
Eluents	HFIP, TFE, other fluorinated solvents

Specifications

Material	Polar modified silica
Maximum Pressure	150 - 200 bar (2180-2900 psi), depending on porosity
Maximum Temperature	90° C
Maximum Flow Rate	3 ml/min (8 mm i.D.)
Particle Size	5, 7 µm
Molecular Weight Range	100 to 3 000 000 Da
Incompatibility	Drying and freezing
Separation range	
100 Å	100 - 100 000 Da
300 Å	1 000 - 300 000 Da
1 000 Å	10 000 - 1 000 000 Da
4 000 Å	10 000 - 3 000 000 Da
linear S	100 - 300 000 Da
linear M	100 - 1 000 000 Da
linear XL	100 - 3 000 000 Da

Recommended Column Combination

Low molar mass:	100 Å + 100 Å
Med. mol. mass:	100 Å + 1 000 Å
High molar mass:	100 Å + 1 000 Å + 4 000 Å

Part Numbers

119 PSS PFG Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
7	precolumn	8 x 50	pfa080507
7	100 Å	8 x 300	pfa0830071e2
7	300 Å	8 x 300	pfa0830073e2
7	1 000 Å	8 x 300	pfa0830071e3
7	4 000 Å	8 x 300	pfa0830074e3
7	linear S	8 x 300	pfa083007lis
7	linear M	8 x 300	pfa083007lim
7	linear XL	8 x 300	pfa083007lxl

120 PSS PFG Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
7	100 Å	20 x 50	pfs2005071e2
7	300 Å	20 x 50	pfs2005073e2
7	1 000 Å	20 x 50	pfs2005071e3
7	4 000 Å	20 x 50	pfs2005074e3
7	linear S	20 x 50	pfs200507lis
7	linear M	20 x 50	pfs200507lim
7	linear XL	20 x 50	pfs200507lxl

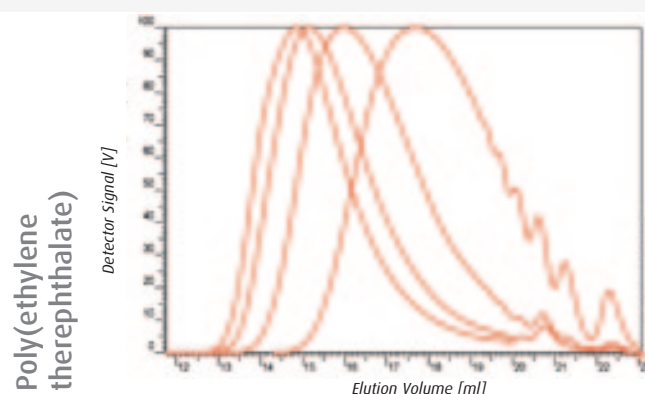
121 PSS PFG Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
7	precolumn	8 x 50	pfp200507
7	100 Å	20 x 300	pfp2030071e2
7	300 Å	20 x 300	pfp2030073e2
7	1 000 Å	20 x 300	pfp2030071e3
7	4 000 Å	20 x 300	pfp2030074e3
7	linear S	20 x 300	pfp203007lis
7	linear M	20 x 300	pfp203007lim
7	linear XL	20 x 300	pfp203007lxl

122 PSS PFG Columns micro

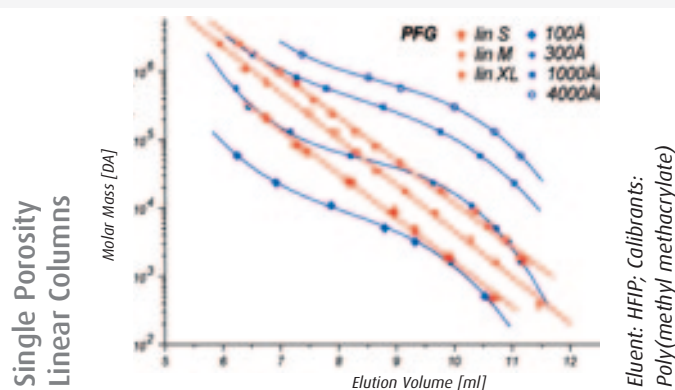
Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	4.6 x 30	pfm050305
5	100 Å	4.6 x 250	pfm0525051E2
5	300 Å	4.6 x 250	pfm0525053E2
5	1 000 Å	4.6 x 250	pfm0525051E3
5	linear S	4.6 x 250	pfm052505lis
5	linear M	4.6 x 250	pfm052505lim

Applications



Flow rate: 1 ml/min; Loading: 1.5 g/l, 100 µl;
Eluent: HFIP, K-TFAC 0.1 M; Temp.: 25° C; Detector: SECCurity RI;
Columns: PFG 7 µm 100 Å, 1 000 Å (8 x 300 mm) + precolumn

Calibration Curves



9.4. POLEFIN Columns

123 High Temperature (HT)-GPC/SEC of Polyolefins

Field of Application

Applicability Poly(ethylene), Poly(propylene), other Polyolefins

Eluents TCB, o-DCB, Decalin

Specifications

Material Modified styrene-divinylbenzene copolymer network

Maximum Pressure 100 - 150 bar (1450 - 2180 psi), depending on porosity

Maximum Temperature 200° C

Maximum Flow Rate 2 ml/min (8 mm i.D.)

Particle Size 10 µm

Molecular Weight Range 100 to 30 000 000 Da

Incompatibility Water, alcohol, drying, and freezing

Separation range

100 Å 100 - 10 000 Da

1 000 Å 100 - 60 000 Da

100 000 Å 1 000 - 1 000 000 Da

1 000 000 Å 1 000 - 4 000 000 Da

10 000 000 Å 5 000 - 30 000 000 Da

linear M 100 - 1 000 000 Da

linear XL 1 000 - 4 000 000 Da

Recommended Column Combination

Low molar mass: 100 Å + 1 000 Å + 100 000 Å

Med. mol. mass: 1 000 Å + 100 000 Å + 1 000 000 Å

High mol. mass: 1 000 Å + 100 000 Å + 10 000 000 Å

Part Numbers

124 PSS POLEFIN Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	8 x 50	poa080510
10	100 Å	8 x 300	poa0830101e2
10	1 000 Å	8 x 300	poa0830101e3
10	100 000 Å	8 x 300	poa0830101e5
10	1 000 000 Å	8 x 300	poa0830101e6
10	10 000 000 Å	8 x 300	poa0830101e7
10	linear M	8 x 300	poa083010lim
10	linear XL	8 x 300	poa083010lxl

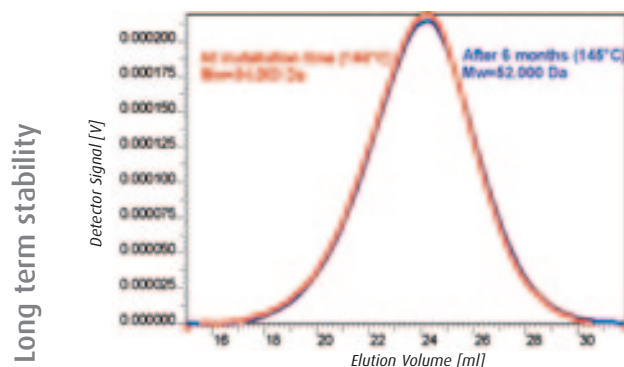
125 PSS POLEFIN Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	1 000 Å	20 x 50	pos2005101e3
10	100 000 Å	20 x 50	pos2005101e5
10	1 000 000 Å	20 x 50	pos2005101e6
10	10 000 000 Å	20 x 50	pos2005101e7
10	linear M	20 x 50	pos200510lim
10	linear XL	20 x 50	pos200510lxl

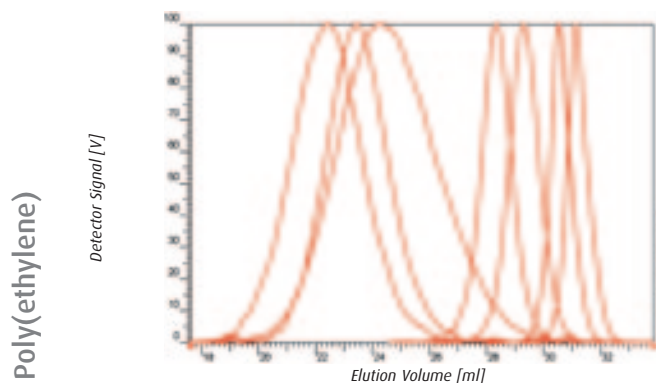
126 PSS POLEFIN Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	20 x 50	pop200510
10	1 000 Å	20 x 300	pop2030101e3
10	100 000 Å	20 x 300	pop2030101e5
10	1 000 000 Å	20 x 300	Pop2030101e6
10	10 000 000 Å	20 x 300	pop2030101e7
10	linear M	20 x 300	pop203010lim
10	linear XL	20 x 300	pop203010lxl

Applications

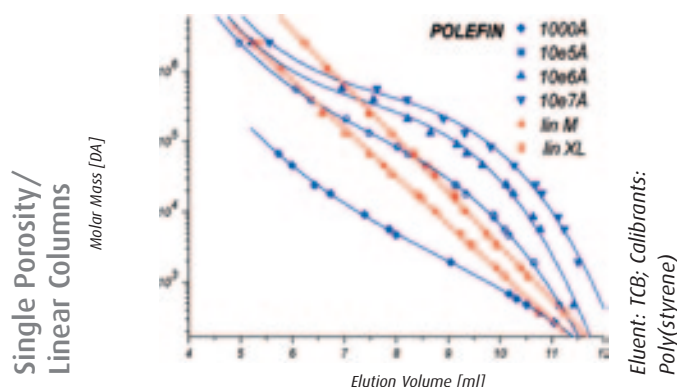


Flow rate: 1 ml/min; Loading: 5 g/l, 100 µl;
Eluent: TCB; Temp.: 145° C; Detector: SECcurity RI;
Columns: POLEFIN 10 µm 1 000 Å, 100 000 Å, 1 000 000 Å (8 x 300 mm) + precolumn



Flow rate: 1 ml/min; Loading: 5 g/l, 100 µl;
Eluent: TCB; Temp.: 145° C; Detector: SECcurity RI;
Columns: POLEFIN 10 µm 1 000 Å, 100 000 Å, 1 000 000 Å (8 x 300 mm) + precolumn

Calibration Curves



10| Columns for Aqueous Columns

10.1. SUPREMA Columns

127 Aqueous GPC/SEC of Neutral and Anionic Polymers

Field of Application

Applicability Neutral and anionic polymers, (PEO, PEG, Pullulan, Dextran, Poly(acrylamide), Hyaluronic acid, Poly(acrylic acid), Carboxymethyl cellulose, etc.)

Eluents water (with salts/buffers, MeOH, ACN) pH: 1.5 - 13

Specifications

Material Modified acrylate copolymer network

Maximum Pressure 50 - 80 bar (725 - 1160 psi), depending on porosity

Maximum Temperature 80° C

Maximum Flow Rate 2 ml/min (8 mm I.D.)

Particle Size 5, 10, 20 µm

Molecular Weight Range 100 to > 30 000 000 Da

Incompatibility Water, drying, and freezing

Separation range

30 Å 100 - 30 000 Da

100 Å 100 - 100 000 Da

1 000 Å 100 - 1 000 000 Da

3 000 Å 1 000 - 3 000 000 Da

10 000 Å 1 000 - 10 000 000 Da

30 000 Å 5 000 - > 30 000 000 Da

linear S 100 - 100 000 Da

linear M 1 000 - 1 000 000 Da

linear XL 5 000 - 3 000 000 Da

Recommended Column Combination

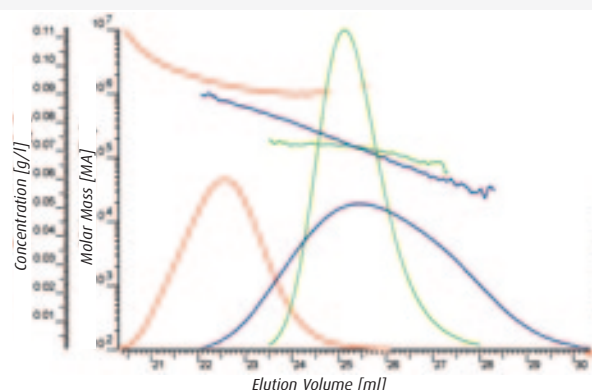
Low molar mass: 100 Å + 100 Å

Med. mol. mass: 30 Å + 1 000 Å + 1 000 Å

High molar mass: 100 Å + 3 000 Å + 3 000 Å

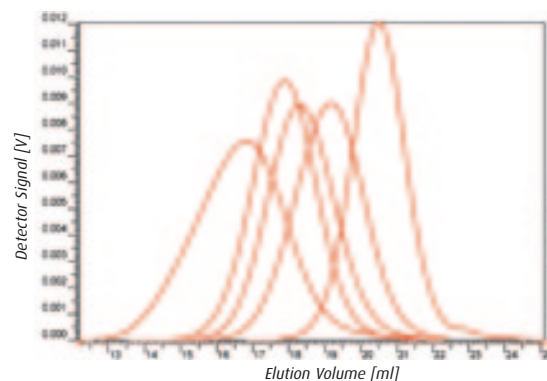
Applications

Hydroxyethyl starch GPC/SEC-MALLS acc. EUP



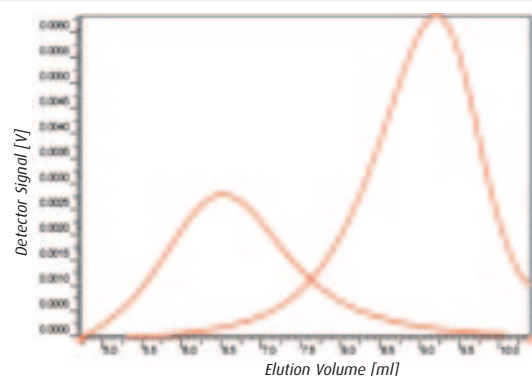
Flow rate: 1 ml/min; Loading: 3 g/l, 100 µl;
Eluent: water, Na₂S 0.1 M; Temp.: 25° C; Detectors: SECcurity RI, SLD7000 MALLS;
Columns: SUPREMA LUX 10 µm 100 Å, 3 000 Å, 3 000 Å; (8 x 300 mm) + precolumn

Dextran



Flow rate: 1 ml/min; Loading: 3 g/l, 20 µl;
Eluent: water, Na₂S 0.5 g/l; Temp.: 25° C; Detector: SECcurity RI;
Columns: SUPREMA 10 µm 30 Å, 1 000 Å (8 x 300 mm) + precolumn

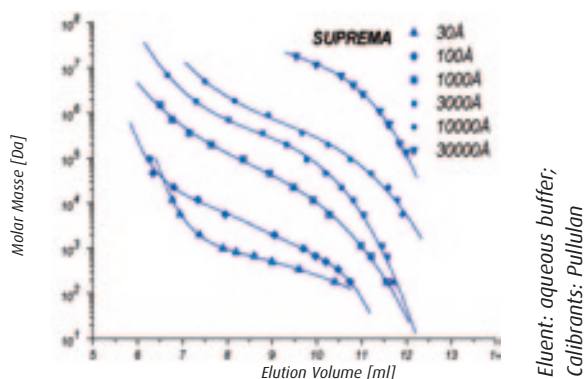
Alginate sodium salt



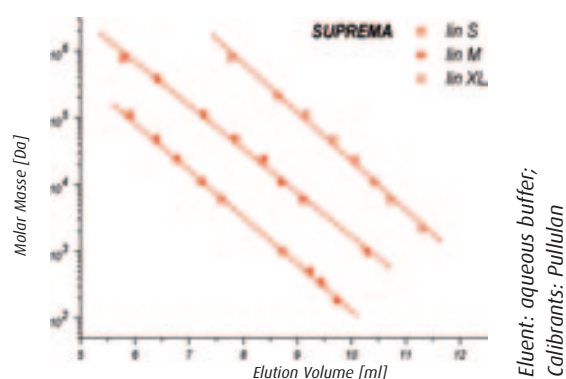
Flow rate: 1 ml/min; Loading: 0.5 g/l, 20 µl;
Eluent: water, Na₂HPO₄ 0.07 M; Temp.: 25° C; Detector: SECcurity RI;
Columns: SUPREMA 10 µm 3 000 Å (8 x 300 mm) + precolumn

Calibration Curves

Single Porosity Columns



Mixed Bed/Linear Columns



Part numbers

128 PSS SUPREMA Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	8 x 50	sua080510
20	precolumn	8 x 50	sua080520
10	30 Å	8 x 300	sua0830103e1
10	100 Å	8 x 300	sua0830101e2
10	1 000 Å	8 x 300	sua0830101e3
10	3 000 Å	8 x 300	sua0830103e3
10	10 000 Å	8 x 300	sua0830101e4
10	30 000 Å	8 x 300	sua0830103e4
10	linear S	8 x 300	sua083010lis
10	linear M	8 x 300	sua083010lim
10	linear XL	8 x 300	sua083010lxl
20	100 Å	8 x 300	sua0830201e2
20	1 000 Å	8 x 300	sua0830201e3
20	3 000 Å	8 x 300	sua0830203e3
20	10 000 Å	8 x 300	sua0830201e4
20	30 000 Å	8 x 300	sua0830203e4
20	linear M	8 x 300	sua083020lim
20	linear XL	8 x 300	sua083020lxl

129 PSS SUPREMA Lux Columns analytical (for light scattering)

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	8 x 50	sul080510
10	1 000 Å	8 x 300	sul0830101e3
10	3 000 Å	8 x 300	sul0830103e3
10	30 000 Å	8 x 300	sul0830103e4
10	linear XL	8 x 300	sul083010lxl

130 PSS SUPREMA Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	100 Å	20 x 50	sus2005101e2
10	1 000 Å	20 x 50	sus2005101e3
10	3 000 Å	20 x 50	sus2005103e3
10	10 000 Å	20 x 50	sus2005101e4
10	30 000 Å	20 x 50	sus2005103e4

131 PSS SUPREMA Columns HighSpeed

10	linear M	20 x 50	sus200510lim
10	linear XL	20 x 50	sus200510lxl
20	100 Å	20 x 50	sus2005201e2
20	1 000 Å	20 x 50	sus2005201e3
20	3 000 Å	20 x 50	sus2005203e3
20	10 000 Å	20 x 50	sus2005201e4
20	30 000 Å	20 x 50	sus2005103e4
20	linear M	20 x 50	sus200520lim
20	linear XL	20 x 50	sus200520lxl

132 PSS SUPREMA Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	20 x 50	sup200510
20	precolumn	20 x 50	sup200520
10	30 Å	20 x 300	sup2030103e1
10	100 Å	20 x 300	sup2030101e2
10	1 000 Å	20 x 300	sup2030101e3
10	3 000 Å	20 x 300	sup2030103e3
10	10 000 Å	20 x 300	sup2030101e4
10	30 000 Å	20 x 300	sup2030103e4
10	linear S	20 x 300	sup203010lis
10	linear M	20 x 300	sup203010lim
10	linear XL	20 x 300	sup203010lxl
20	100 Å	20 x 300	sup2030201e2
20	1 000 Å	20 x 300	sup2030201e3
20	3 000 Å	20 x 300	sup2030203e3
20	10 000 Å	20 x 300	sup2030201e4
20	30 000 Å	20 x 300	sup2030203e4
20	linear M	20 x 300	sup203020lim
20	linear XL	20 x 300	sup203020lxl

133 PSS SUPREMA Columns micro

Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	4.6 x 30	sum050305
5	30 Å	4.6 x 250	sum0525053E1
5	100 Å	4.6 x 250	sum0525051E2
5	300 Å	4.6 x 250	sum0525053E2
5	1 000 Å	4.6 x 250	sum0525051E3
5	linear S	4.6 x 250	sum052505lis
5	linear M	4.6 x 250	sum052505lim

10.2. NOVEMA Columns

134 Aqueous GPC/SEC of Poly Cations

Field of Application

Applicability Cationic polymers, (Polymeric Quarternary Ammonium Compounds, Poly (DADMAC), Poly(vinylpyridine), Chitosan, Poly(ethylene imine), etc.)

Eluents Water, water with salt/buffer, MeOH, ACN, TFA; pH: 1.5 - 13

Specifications

Material OH-functionalized methacrylate-copolymer-network

Maximum Pressure 60 - 100 bar (870 - 1450 psi), depending on porosity

Maximum Temperature 80° C

Maximum Flow Rate 2 ml/min (8 mm I.D.)

Particle Size 10 µm

Molecular Weight Range 100 to > 5 000 000 Da

Incompatibility Water, drying, and freezing

Separation range

30 Å	100 - 30 000 Da
300 Å	100 - 300 000 Da
1 000 Å	1 000 - 1 000 000 Da
3 000 Å	1 000 - 1 600 000 Da
10 000 Å	5 000 - > 5 000 000 Da
Linear	100 - 500 000 Da

Recommended Column Combination

Low molar mass:	300 Å + 300 Å
Med. mol. mass:	30 Å + 1 000 Å + 1 000 Å
High mol. mass:	30 Å + 3 000 Å + 3 000 Å

Part numbers

135 PSS NOVEMA Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	8 x 50	noa080510
10	30 Å	8 x 300	noa0830103e1
10	300 Å	8 x 300	noa0830103e2
10	1 000 Å	8 x 300	noa0830101e3
10	3 000 Å	8 x 300	noa0830103e3
10	10 000 Å	8 x 300	noa0830101e4
10	linear	8 x 300	noa083010lin

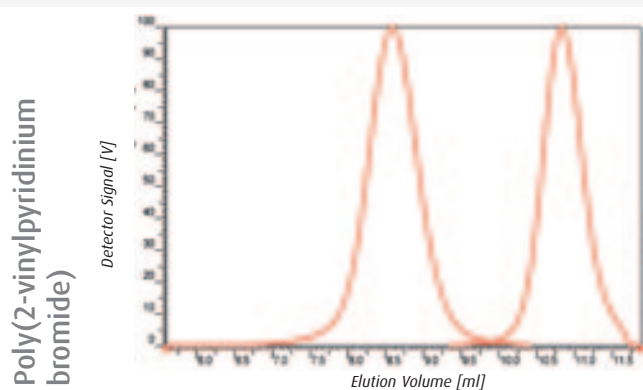
136 PSS NOVEMA Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	300 Å	20 x 50	nos2005103e2
10	1 000 Å	20 x 50	nos2005101e3
10	3 000 Å	20 x 50	nos2005103e3
10	10 000 Å	20 x 50	nos2005101e4
10	linear	20 x 50	nos200510lin

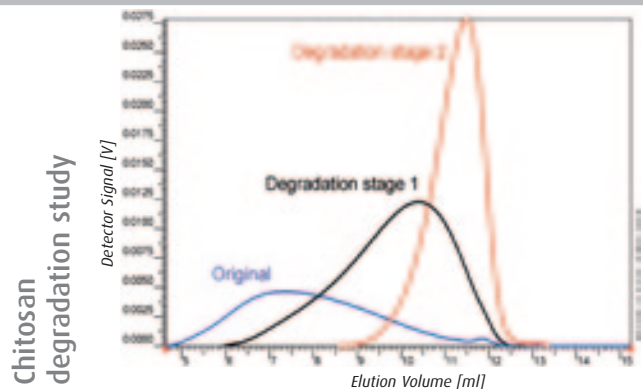
137 PSS NOVEMA Columns preparative

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	precolumn	20 x 50	nop200510
10	30 Å	20 x 300	nop2030103e1
10	300 Å	20 x 300	nop2030103e2
10	1 000 Å	20 x 300	nop2030101e3
10	3 000 Å	20 x 300	nop2030103e3
10	10 000 Å	20 x 300	nop2030101e4
10	linear	20 x 300	nop203010lin

Applications

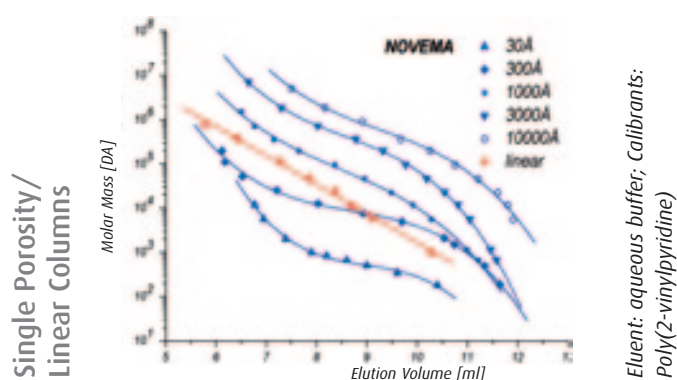


Flow rate: 1 ml/min; Loading: 1 g/l, 20 µl;
Eluent: water, NaC 0.1 M / TFAc 0.1%; Temp.: 25° C; Detector: SECCurity RI;
Columns: NOVEMA 10 µm, 3 000 Å (8 x 300 mm) + precolumn



Flow rate: 1 ml/min; Loading: 2.5 g/l, 50 µl;
Eluent: water, NaC 0.1 M / TFAc 0.1%; Temp.: 25° C; Detector: SECCurity RI;
Columns: NOVEMA 10 µm 3 000 Å (8 x 300 mm) + precolumn

Calibration Curves



Eluent: aqueous buffer; Calibrants: Poly(2-vinylpyridine)

10.3. MCX Columns

138 Aqueous GPC/SEC of Sulfonated Polymers	
Field of Application	
Applicability	Sulfonated Poly-anions, Poly(styrene sulfonate), Lignin sulfonate, Modified Starches, Acids, Alcohols, pectins, etc.)
Eluents	Water, water with salt/buffer, MeOH, ACN; pH: 7 - 13
Specifications	
Material	Sulfonated styrene-divinylbenzene copolymer-network
Maximum Pressure	100 - 150 bar (1450 - 2180 psi), depending on porosity
Maximum Temperature	80° C
Maximum Flow Rate	2 ml/min (8 mm I.D.)
Particle Size	5, 10 and 20 µm
Molecular Weight Range	100 to > 5 000 000 Da
Incompatibility	Water, drying, and freezing
Separation range	
100 Å	100 - 10 000 Da
500 Å	100 - 35 000 Da
1 000 Å	100 - 70 000 Da
100 000 Å	1 000 - 1 000 000 Da
1 000 000 Å	10 000 - 2 000 000 Da
10 000 000 Å	10 000 - > 5 000 000 Da
Recommended Column Combination	
Low molar mass:	1 000 Å + 1 000 Å
Med. mol. mass:	1 000 Å + 100 000 Å + 1 000 000 Å
High mol. mass:	1 000 Å + 100 000 Å + 10 000 000 Å

Part numbers

139 PSS MCX Columns analytical			
Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	8 x 50	mca080505
10	precolumn	8 x 50	mca080510
20	precolumn	8 x 50	mca080520
5	100 Å	8 x 300	mca0830051e2
5	500 Å	8 x 300	mca0830055e2
5	1 000 Å	8 x 300	mca0830051e3
10	1 000 Å	8 x 300	mca0830101e3
10	100 000 Å	8 x 300	mca0830101e5
10	1 000 000 Å	8 x 300	mca0830101e6
10	10 000 000 Å	8 x 300	mca0830101e7
20	10 000 000 Å	8 x 300	mca0830201e7

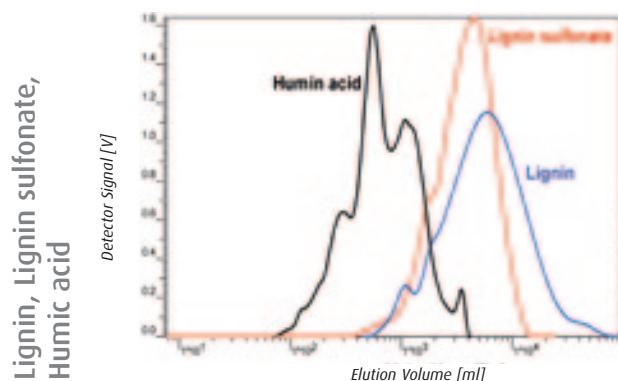
140 PSS MCX Columns HighSpeed

Particle size [µm]	Porosity	Dimension [mm]	Part Number
10	1 000 Å	20 x 50	mcs2005101e3
10	100 000 Å	20 x 50	mcs2005101e5
10	1 000 000 Å	20 x 50	mcs2005101e6
20	10 000 000 Å	20 x 50	mcs2005201e7

141 PSS MCX Columns preparative

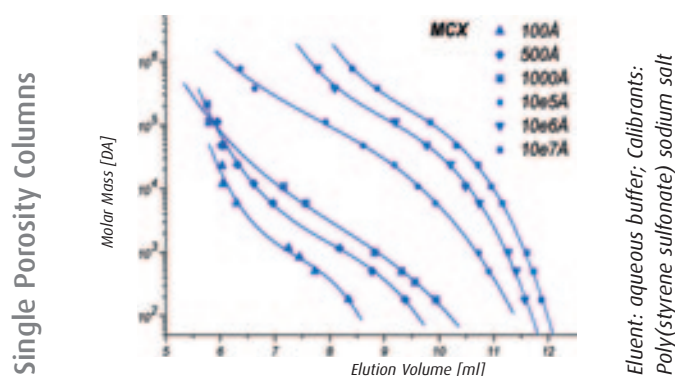
Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	20 x 50	mcp200505
10	precolumn	20 x 50	mcp200510
20	precolumn	20 x 50	mcp200520
5	100 Å	20 x 300	mcp2030051e2
5	500 Å	20 x 300	mcp2030055e2
5	1 000 Å	20 x 300	mcp2030051e3
10	1 000 Å	20 x 300	mcp2030101e3
10	10 000 Å	20 x 300	mcp2030101e5
10	1 000 000 Å	20 x 300	mcp2030101e6
20	10 000 000 Å	20 x 300	mcp2030201e7

Applications



Flow rate: 1 ml/min; Loading: 4 g/l, 20 µl;
 Eluent: water, NaOH 0.1 M; Temp.: 25° C; Detector: SECcurity RI;
 Columns: MCX 10 µm 1 000 Å, 100 000 Å (8 x 300 mm) + precolumn

Calibration Curves



10.4. PROTEEMA Columns

142 Aqueous GPC/SEC Separation of Proteins

Field of Application

Applicability	Natural and synthetic Proteins, Peptides, Enzymes, Gelatins/ Collagens
Eluents	Water, water with salt/buffer pH < 7

Specifications

Material	Special modified silica
Maximum Pressure	150 - 200 bar (2180 - 2900 psi), depending on porosity
Maximum Temperature	70° C
Maximum Flow Rate	3 ml/min (8 mm I.D.)
Particle Size	3, 5 µm
Molecular Weight Range	100 to 7 500 000 Da
Incompatibility	Water, drying, and freezing

Separation range

100 Å	100 - 150 000 Da
300 Å	1 000 - 1 200 000 Da
1 000 Å	1 000 - 7 500 000 Da

Recommended Column Combination

Low molar mass:	100 Å + 100 Å
Med. mol. mass:	300 Å + 300 Å
High molar mass:	100 Å + 1 000 Å

* based on protein molecular weight, for other water soluble macromolecules (e.g. pullulan) separation range ends at 50 000, 400 000, and 2 500 000 Da.

Part numbers

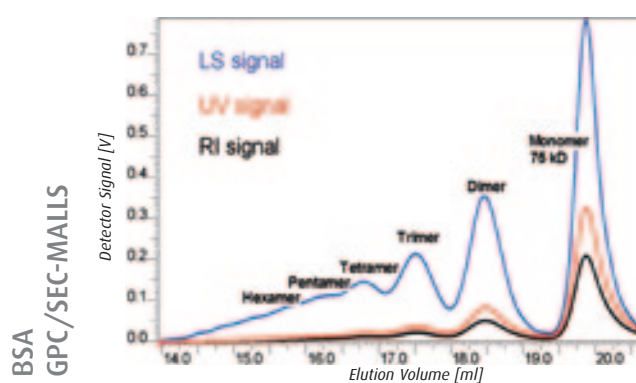
143 PSS PROTEEMA Columns analytical

Particle size [µm]	Porosity	Dimension [mm]	Part Number
5	precolumn	8 x 50	pra080505
5	100 Å	8 x 300	pra0830051e2
5	300 Å	8 x 300	pra0830053e2
5	1 000 Å	8 x 300	pra0830051e3

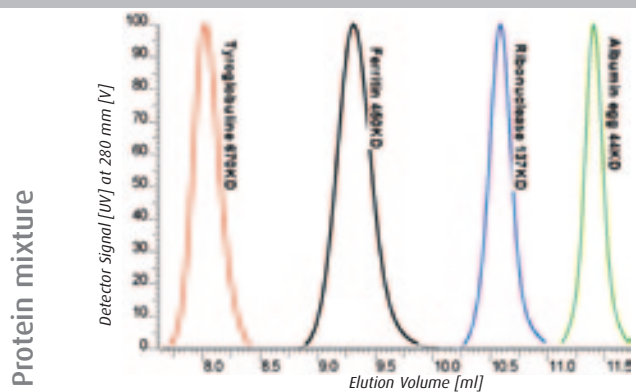
144 PSS PROTEEMA Columns micro

Particle size [µm]	Porosity	Dimension [mm]	Part Number
3	precolumn	4.6 x 30	prm050303
3	100 Å	4.6 x 250	prm0525031E2
3	300 Å	4.6 x 250	prm0525033E2

Applications

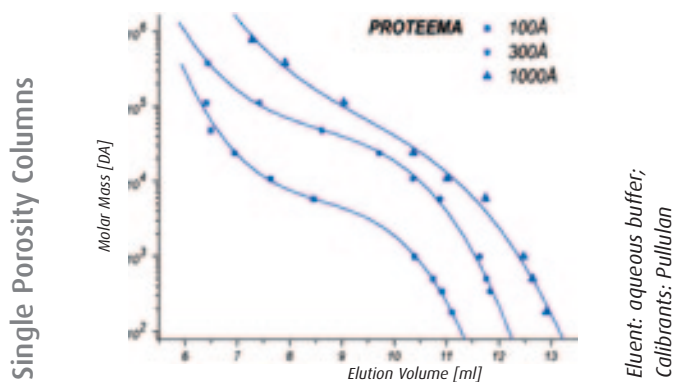


Flow rate: 0.5 ml/min; Loading: 1g/l, 20 µl; Eluent: Phosphate buffer pH = 6.6, NaCl 0.3 M; Temp.: 25° C; Detectors: SECurity RI + UV, SLD7000 MALLS; Columns: PROTEEMA 5 µm 300 Å, 300 Å (8 x 300 mm) + precolumn



Flow rate: 0.5 ml/min; Loading: 1g/l, 20 µl; Eluent: water, NaCl 0.3 M; Temp.: 25° C; Detector: SECurity RI; Columns: PROTEEMA 5 µm 300 Å, 300 Å (8 x 300 mm) + precolumn

Calibration Curves



Eluent: aqueous buffer;
Calibrants: Pullulan

11| GPC/SEC Application Guide

Polymer	Column type	Solvent	Temp [°C]	Calibration standards
Acrylic acid-Methyl methacrylate Copolymer	GRAM	DMAC, LiBr 3 g/l + acetic acid 6 g/l	60	Poly(methyl methacrylate)
Acrylic acid-Methacrylate Copolymer	GRAM	DMAC, LiBr 3 g/l + acetic acid 6 g/l	60	Poly(methyl methacrylate)
Alginate sodium salt	SUPREMA	Na ₂ HPO ₄ 0.07 M	25	Pullulan
Amino resin	PFG	DMAC LiCl 0.1 M	60	Poly(styrene)
Amylodextrine	MCX	Na ₂ HPO ₄ 0.07 M	25	Poly(styrene sulfonate) sodium salt
Anti-Human IgG	PROTEEMA	Phosphate buffer pH 6.8	25	Pullulan
Apple juice	MCX	NaN ₃ 0.05 %	25	Pullulan
Bitumen	SDV	THF	35	Poly(styrene)
BSA	PROTEEMA	Phosphatpuffer pH = 6,6 + NaCl 0,3 M	25	Pullulan
Butyl methacrylate-Styrene Copolymer	SDV	THF	35	Poly(styrene)
Carboxymethyl cellulose	SUPREMA	Na ₂ HPO ₄ 0.07 M	25	Pullulan
Carboxymethyl starch	SUPREMA	NaNO ₃ 0,1 M	25	Pullulan
Carragenan	SUPREMA	LiNO ₃ 0.1 M	25	Pullulan
Cellulose acetate	GRAM	DMAC LiBr 5g/l	60	Poly(styrene)
Cellulose nitrate	SDV	THF	25	Poly(styrene)
Cellulose triacetate	SDV	THF	25	Poly(styrene)
Chitin	NOVEMA	NaCl 0.1 M + TFAC 0.1 %	25	Pullulan
Chitosan	NOVEMA	NaCl 0.1 M + TFAC 0.1 %	25	Pullulan
Collagen	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Pullulan
Dextran	SUPREMA	NaNO ₃ 0.1 M	25	Dextran
Dextran sulfate	SUPREMA	NaNO ₃ 0.1 M	35	Pullulan
Dextran, oligomer	MCX	NaN ₃ 0.05 %	25	Dextran
Dextrine	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan
Dimethylaminoethyl methacrylate-Methacrylic ester Copolymer	GRAM	DMAC, LiBr 3 g/l + acetic acid 6 g/l	60	Poly(methyl methacrylate)
Epoxy resin	SDV	THF	25	Poly(styrene)
Ethylene-Methacrylate Copolymer	SDV	THF	35	Poly(styrene)
Ethylene-Propylene Copolymer	POLEFIN	TCB	145	Poly(styrene)
Ethylene-Vinyl acetate Copolymer	SDV	THF	25	Poly(styrene)
Ferritin	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Protein Mixture
Gelatin	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Pullulan
Glyceride	SDV	THF	25	Poly(styrene)
Glycoprotein	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Protein Mixture
Guar gum	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan
Gum arabic	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan

Polymer	Column type	Solvent	Temp [°C]	Calibration standards
Heparin	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan
Heparin (Pharmaeuropa, low molar mass)	PROTEEMA	Na ₂ SO ₄ 28.4 g/L pH = 5	25	Heparin CRS 2
Heparin sulfate	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan
Humic acid	MCX	Na ₂ HPO ₄ 0.07 M	25	Poly(styrene sulfonate) sodium salt
Hyaluronic acid	SUPREMA	Na ₂ HPO ₄ 0.07 M	25	Pullulan
Hydraulic oil	SDV	THF	25	Poly(styrene)
Hydroxyethyl starch	SUPREMA	NaNO ₃ 0.1 M	25	Hydroxy ethyl-starch
Hydroxypropyl cellulose	GRAM	DMSO, LiBr 5 g/l	25	Poly(methyl methacrylate)
Hydroxypropyl cellulose ester	SDV	THF	35	Poly(methyl methacrylate)
Hydroxypropyl cellulose ether	SDV	THF	35	Poly(methyl methacrylate)
Insulin	PROTEEMA	L-Arginin, Water, Acetic acid and ACN	25	Protein Mixture
Iron Dextran	SUPREMA	NaNO ₃ 0.1 M	25	Dextran
Isocyanate	SDV	THF	25	Poly(styrene)
Isopropyl methacrylate	SDV	THF	25	Poly(methyl methacrylate)
Lignin	MCX	NaOH 1 M	25	Poly(styrene sulfonate) sodium salt
Lignin sulfonate	MCX	Na ₂ HPO ₄ 0.07 M	25	Pullulan
Maltodextrine	MCX	NaN ₃ 0.05 %	20	Pullulan
Melamin formaldehyde resin (MF)	GRAM	NMP	60	Poly(styrene)
Methacrylic acid-Methacrylate Copolymer	GRAM	DMAC, LiBr 3 g/l + acetic acid 6 g/l	60	Poly(methyl methacrylate)
Methyl cellulose	GRAM	DMSO, LiBr 5g/l	25	Poly(methyl methacrylate)
Methyl methacrylate-Styrene Copolymer	SDV	THF	25	Poly(styrene)
Naphthalin sulfonate	MCX	Na ₂ HPO ₄ 0.07 M	25	Pullulan
Norbonyl-Cyclodextrine Copolymer	GRAM	DMF LiBr 5 g/l	25	Poly(methyl methacrylate)
Oleate	SDV	THF	25	HPLC calibration
Olive oil	SDV	THF	25	Poly(styrene)
Paraformaldehyde	PFG	HFIP, K-TFAC 0.05 M	25	Poly(methyl methacrylate)
Pectin	SUPREMA	NaNO ₃ 0,1 M	25	Pullulan
Peptide	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Protein Mixture
Phenylene ether-Sulfone Copolymer	SDV	THF	25	Poly(styrene)
Poly(2-vinylpyridine)	SDV	THF, DEAEA 0,1%		Poly(2-vinylpyridine)
Poly(2-vinylpyridine)	NOVEMA	NaCl 0.1 M + TFAC 0.1 %		Poly(2-vinylpyridin)
Poly(acrylamide)	SUPREMA	NaNO ₃ 0.1 M	25	Pullulan / Poly(acrylamide) broad
Poly(acrylic acid)	SUPREMA	Na ₂ HPO ₄ 0.07 M	25	Poly(acrylic acid) sodium salt
Poly(acrylonitrile)	SDV	DMF, LiBr 5 g/l	60	Poly(methyl methacrylate)

Polymer	Column type	Solvent	Temp [°C]	Calibration standards
Poly(allylamine hydrochloride)	NOVEMA	NaCl 0.1 M + TFAc 0.1 %	25	Poly(2-vinyl pyridine)
Poly(butadiene) (1.2 / 1.4)	SDV	THF	25	Poly(butadiene 1.4)
Poly(butylene terephthalate) (PBT)	PFG	HFIP, K-TFAc 0.1 M	25	Poly(methyl methacrylate)
Poly(carbonate)	SDV	THF	25	Poly(styrene)
Poly(DADMAC)	NOVEMA	NaCl 0.1 M + TFAc 0.1 %	25	Poly(2-vinyl pyridine)
Poly(dimethyl siloxane)	SDV	Toluol	25	Polydimethylsiloxan
Poly(ether sulfone)	SDV	DMAc, LiBr 5 g/l	80	Poly(methyl methacrylate)
Poly(ethyl methacrylate)	SDV	THF	35	Poly(methyl methacrylate)
Poly(ethylene glycole)	SDV	THF	25	Poly(ethylene glycole)
Poly(ethylene glycole)	SUPREMA	NaN ₃ 0.05 %	25	Poly(ethylene glycole)
Poly(ethylene imine)	NOVEMA	NaCl 0.1 M + TFAc 0.1 %	25	Poly(2-vinyl pyridine)
Poly(ethylene imide)	GRAM	DMAc LiBr 2 g/l + TRIS 2 g/l	60	Poly(styrene)
Poly(ethylene imine)	PFG	HFIP, K-TFAc 0.1 M	60	Poly(methyl methacrylate)
Poly(ethylene oxide)	SUPREMA	NaN ₃ 0.05 %	25	Poly(ethylene oxide)
Poly(ethylene terephthalate) (PET)	PFG	HFIP, K-TFAc 0.1 M	25	Poly(methyl methacrylate)
Poly(ethylene)	POLEFIN	TCB	145	Poly(styrene)
Poly(isobutylene)	SDV	THF	25	Poly(isobutylene)
Poly(isoprene) (1,4 / 3,4)	SDV	THF	25	Poly(isoprene 1,4)
Poly(L-lactide)	PFG	TFE, K-TFAc 0.1 M	25	Poly(L-lactide)
Poly(L-lactide-glycolide)	PFG	TFE, K-TFAc 0.1 M	25	Poly(L-lactide)
Poly(methacrylic acid)	SUPREMA	Na ₂ HPO ₄ 0.07 M	35	Poly(methacrylic acid)
Poly(methyl methacrylate)	SDV	THF	25	Poly(methyl methacrylate)
Poly(n-butyl acrylate)	SDV	THF	25	Poly(t-butyl acrylat)
Poly(n-butyl methacrylate)	SDV	THF	25	Poly(n-butyl-methacrylat)
Poly(n-propyl methacrylate)	SDV	THF	25	Poly(methyl methacrylate)
Poly(oxymethylene)	PFG	HFIP, K-TFAc 0.1 M	25	Poly(methyl methacrylate)
Poly(phenyl acetylene)	SDV	THF	25	Poly(styrene)
Poly(propylene) (PP)	POLEFIN	TCB	150	Poly(styrene)
Poly(styrene sulfonic acid)	MCX	Na ₂ HPO ₄ 0.07 M	25	Poly(styrene sulfonate) sodium salt
Poly(styrene)	SDV	THF	25	Poly(styrene)
Poly(styrene-b-butadiene-1,4)	SDV	THF	25	Poly(styrene)
Poly(styrene-b-glycidyl methacrylate)	SDV	THF	25	Poly(styrene)
Poly(t-butyl acrylate)	SDV	THF	25	Poly(t-butyl-acrylat)
Poly(t-butyl methacrylate)	SDV	THF	25	Poly(t-butylmethacrylat)

Polymer	Column type	Solvent	Temp [°C]	Calibration standards
Poly(vinyl alcohol)	SUPREMA	NaNO ₃ 0.1 M / MeOH (10 - 30 % ²)	25	Pullulan/ Polyvinylalkohol breit
Poly(vinyl chloride)	SDV	THF	25	Poly(styrene)
Poly(vinylpyridinium bromide)	NOVEMA	NaCl 0.1 M + TFAc 0.1 %	25	Poly(2-vinyl pyridine)
Poly(vinyl pyrrolidone) broad	GRAM	DMAc, LiBr 0.1 %	60	Poly(methyl methacrylate)
Polyamide	PFG	HFIP, K-TFAc 0.1 M	25	Poly(methyl methacrylate)
Polyaminoamide	GRAM	DMF LiBr 5g/l	70	Poly(styrene)
Polycarbonaturethan (PCU)	SDV	THF	25	Poly(styrene)
Polyester	PFG	HFIP, K-TFAc 0.1M	25	Poly(methyl methacrylate)
Polyether, perfluorinated	PFG	HFIP, K-TFAc 0.1M	25	Poly(methyl methacrylate)
Poly lactide	PFG	TFE, K-TFAc 0.1M	25	Poly(L-lactide)
Polyol	SDV	THF	25	Poly(styrene)
Polyolefin	POLEFIN	TCB	160	Poly(styrene)
Polysuccinamide	SDV	NMP, LiCl 0.1 M	25	Poly(methyl methacrylate)
Polysulfone	SDV	DMAc, LiBr 5 g/l	60	Poly(methyl methacrylate)
Polyurethane	SDV	THF	25	Poly(styrene)
Protein	PROTEEMA	Phosphate buffer pH = 6.6 + NaCl 0.3 M	25	Protein-Mixture
Pullulan	SUPREMA	NaN ₃ 0.05 %	25	Pullulan
Silicone- / Motor oils	SDV	THF	25	Poly(styrene)
Styrene-Butyl acrylate Copolymer	SDV	THF	25	Poly(styrene)
Styrene-Isoprene Copolymer	SDV	THF	25	Poly(styrene)
Trimethylammonium-Ethyl methacrylaet-Methacrylicester-Cl Copolymer	GRAM	DMAc, LiBr 0.1%	60	Poly(methyl methacrylate)
Urea formaldehyde resin (UF)	GRAM	NMP	60	Poly(styrene)
Urea-melamin formaldehyde resin (UMF)	GRAM	NMP	60	Poly(styrene)
Virus	SUPREMA	Phosphate buffer pH 7.4	25	Pullulan
Xanthan	SUPREMA	Na ₂ HPO ₄ 0.07 M	25	Pullulan

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12| Summary of PSS Columns Specifications

Applications		Solvents	Particle Size [μm]	Porosities [\AA]	Range MW [Da]
Organic GPC					
SDV	Poly(styrene), Poly(vinyl chloride), Poly(carbonate), Elastomers, Resins, etc.	THF, Toluene, TCM, DCM	3	50 - 10 ⁵ , Linear S, M	100 - 1 M
			5	50 - 10 ⁶ , Linear S, M, XL	100 - 3 M
			10	50 - 10 ⁷ , Linear S, M, XL	100 - 30 M
			20	100 - 10 ⁷ , Linear S, M, XL	500 - 30 M
SDV Lux	See Applications SDV, but for use with Light Scattering Detection	THF, Toluene, TCM, DCM	5	1 000 - 10 ⁶ , Linear M, XL	100 - 3 M
			10	1 000 - 10 ⁶ , Linear M, XL	100 - 3 M
GRAM	Polyurethanes, Polyimide, Starches, Cellulosics, certain Polyamides, other polar polymers	DMF, DMAc, NMP, DMSO	10	30 - 10 000, Linear	100 - 50 M
PFG	Crystalline polymers, Polyesters, Nylons, Poly lactides, POM, etc.	HFIP, TFE, other fluorinated solvents	5	100 - 1 000, Linear S, M	100 - 1 M
			7	100 - 4 000, Linear S, M, XL	100 - 3 M
POLEFIN	Poly(ethylene), Poly(propylene), other Polyolefins	TCB, oDCB, Decalin	10	1 000 - 10 ⁷ , Linear M, XL	100 - 30 M
Aqueous GPC					
SUPREMA	Neutral and anionic polymers, (PEO, PEG, Pullulan, Dextran, Poly(acrylamide), Hyaluronic acid, Poly(acryl acid), Carboxymethyl cellulose, etc.)	water (with salts/buffers, MeOH, ACN) pH: 1.5 - 13	5	30 - 1 000, Linear S, M	100 - > 1 M
			10	30 - 30 000, Linear S, M, XL	100 - > 30 M
			20	100 - 30 000, Linear M, XL	100 - > 30 M
SUPREMA Lux	See Applications SUPREMA, but for use with Light Scattering detection	water (with salts/buffers, MeOH, ACN) pH: 1.5 - 13	10	1 000 - 30 000, Linear XL	1 000 - > 30 M
NOVEMA	Cationic polymers, (Polymeric Quaternary Ammonium Compounds, PolyDADMAC, Poly(vinyl pyridines), Chitosan, Poly(ethylene imine), etc.)	water (with salts/buffers, MeOH, ACN, TFA) pH: 1.5 - 13	10	10 000, Linear	100 - > 5 M
MCX	Sulfonated Polyanions (Poly(styrene sulfonate), Lignin (sulfonates), Modified Starches, Acids, Alcohols, Pectins, etc.	water (with salts/buffers, MeOH, ACN) pH: 7 - 13	5	100 - 10 ³	100 - 70 K
			10	1 000 - 10 ⁷	100 - > 5 M
			20	10 ⁷	10 K - > 5 M
PROTEEMA	Natural and synthetic Proteins, Peptides, Enzymes, Gelatins/Collagens	water (with salts/buffers) pH: < 7	3	100 - 300	100 - 1.2 M
			5	100 - 1 000	100 - 7.5 M