Organic GPC/SEC columns

Product guide

The Measure of Confidence

Agilent Technologies

Contents

Over 30 years' experience in GPC/SEC

1976

PLgel columns, individual standards and standard kits
Polymer Laboratories founded to develop market-leading products for organic GPC/SEC

1981

PLgel MIXED columns, PL aquagel columns
MIXED columns improve data quality, and novel chemistries for analysis of water-soluble polymers

1984

GPC software
Dedicated software streamlines GPC/SEC calculations

1990

PL aquagel-OH columns
Vastly improve resolution and data quality in aqueous GPC

1993

EasiCal standards
New format shortens sample preparation time and the speed of calibration

Agilent PLgel GPC Columns

For polymer applications using organic solvents

PLgel materials have high pore volume and high efficiency to maximize resolution. Their unequalled solvent compatibility makes for easy transfer between polar and non polar eluents, and outstanding physical rigidity provides extended lifetimes that minimize downtime.

The key to successful GPC separations is the correct choice of columns. The comprehensive range of PLgel products has been designed to cover virtually all organic solvent-based polymer analysis application areas, and to make selection of the correct column, solvent and calibration standard fast and reliable.

PLgel is a highly cross linked, porous polystyrene/divinylbenzene matrix, which is recognized as a market leader in GPC column technology. Manufactured and packed exclusively by Agilent since 1976, PLgel is manufactured to ISO 9001:2000 and benefits from comprehensive QC/QA for total reproducibility, batch to batch and column to column.

The PLgel range

- PLgel MIXED for polydisperse materials
- PLgel MIXED LS for light scattering and viscometry applications
- PLgel MiniMIX Narrow Bore saves solvent costs
- PLgel Individual Pore Size Columns for specific applications
- PLgel Preparative Columns for polymer fractionation
- PLgel Olexis for the analysis of polyolefins

Temperature stability to 220 °C

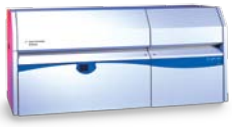
PLgel columns can be used at temperatures up to 220 °C and operating pressures up to 150 bar (2200 psi).

Robust performance under the most exacting conditions

Elevated temperature is used in GPC either to reduce eluent viscosity, for example in polar solvent applications, or to maintain sample solubility, as in polyolefin applications.

1999

PL-GPC 220 instrument
Market-leading high temperature GPC system for routine analysis of even the most difficult samples by multi-detector GPC at temperatures up to 220 °C



2003

PL-GPC 50 instrument with light scattering and viscometry
Cost-effective solution to low temperature polymer analysis, including multi-detector GPC/SEC

2004

PlusPore columns and EasiVial standards
New chemistries deliver high-pore-volume materials for increased resolution, and EasiVial standards simplify calibration procedures even further

2007

PLgel Olexis columns
Optimized for polyolefin analysis with highest resolution and data quality for even ultrahigh molecular weight samples

2009

390-MDS Multi Detector Suite and PolarGel columns
The 390-MDS turns any LC into a powerful multi-detector GPC system, and PolarGel columns analyze polar samples in any solvent system

Solvent compatibility

PLgel columns are routinely supplied in ethyl benzene* but you can easily and rapidly transfer between solvents of varying polarity. In organic GPC, sample to column interaction may occur occasionally and eluent modification can be used to eliminate these effects. PLgel columns are the ideal choice for such analyses, as they easily tolerate eluents in the pH range 1-14, as well as up to 10% water in a miscible organic solvent.

PLgel is compatible with all of these solvents

Solvent polarity	Solvent
6.0	Perfluoroalkane
7.3	Hexane
8.2	Cyclohexane
8.9	Toluene
9.1	Ethyl acetate
9.1	Tetrahydrofuran (THF)
9.3	Chloroform
9.3	Methyl ethyl ketone (MEK)
9.7	Dichloromethane
9.8	Dichloroethene
9.9	Acetone
10.0	0-Dichlorobenzene (o-DCB)
10.0	Trichlorobenzene (TCB)
10.2	m-Cresol
10.2	o-Chlorophenol (o-CP)
10.7	Pyridine
10.8	Dimethyl acetamide (DMAc)
11.3	n-Methyl pyrolidone (NMP)
12.0	Dimethyl sulfoxide (DMSO)
12.1	Dimethyl formamide (DMF)

* We also provide a custom packing service in which columns can be shipped in specific solvents to provide extra convenience to our customers.

PLgel frit porosity

Media type	Porosity (µm)
PLgel 3 µm	2
PLgel 5 µm	2
PLgel 10 µm	5
PLgel 20 µm	10

Ordering information

PLgel Column accessories

Description	Quantity (pk)	Part No.
Frit Removal Tool for Threaded Columns only	1	PL1310-0001
Frit (2 µm) Kit for Threaded Columns, 7.5 mm ID	5	PL1310-0002
Frit (5 µm) Kit for Threaded Columns, 7.5 mm ID	5	PL1310-0012
Frit (10 µm) Kit for Threaded Columns, 7.5 mm ID	5	PL1310-0036
PLgel 10 µm Column Repair Gel	1	PL1410-0101
PLgel 5 µm Column Repair Gel	1	PL1410-0501
Column Connecting Nuts, 1/16 in. Tube	5	PL1310-0007
Tubing Ferrules, 1/16 in. Tube	5	PL1310-0008
Connecting Tubing, 10 cm Length, 0.01 in. ID	10	PL1310-0048

See also

- Polymer Calibration Standards, with highly characterized molecular weights, publication 5990-7996EN

Tip: For good quality GPC make sure your solvent matches the polarity of your sample and packing material.

PLgel MIXED

For polydisperse materials covering a very broad range of molecular weights

The PLgel MIXED range greatly simplifies column selection for easy decision making. Using these mixed columns you can eliminate mismatched column sets and spurious peaks for more reliable results. Simply add extra columns for even greater resolution.

Analysis of polydisperse materials was traditionally achieved by combining individual pore size columns in series to accommodate the molecular weight range of the polymer. However, this approach is often problematic because spurious peak shapes could be introduced and precision lost in the calculated averages due to "mismatched" calibration curves. MIXED gel columns overcome these drawbacks.

The modern approach to column selection for polydisperse materials is to choose MIXED gel columns from Agilent. Every column contains a mixture of individual pore size materials, accurately blended to cover a specified broad range of molecular weight with a linear calibration to eliminate column mismatch.

PLgel MIXED column selection guide

As market leaders in this field, our comprehensive range of MIXED gel GPC columns are designed for specific application areas.

PLgel MIXED gel column selection guide

UHMW polymer distributions	PLgel 20 µm MIXED-A
High MW polymers, demanding eluents	PLgel 10 µm MIXED-B
Mid range MW polymers, high resolution	PLgel 5 µm MIXED-C
Resins, condensation polymers	PLgel 5 µm MIXED-D
Low MW resins, prepolymers	PLgel 3 µm MIXED-E

10^2 10^3 10^4 10^4 10^6 10^7

PLgel MIXED gel calibration curves

MIXED gel calibration curves are designed to be linear over a specified molecular weight range, ensuring that the same degree of resolution is achieved across the full operating range of the column. The particle size of the packing and porosity of a particular MIXED gel column are carefully matched to the MW range and application, thus optimizing performance and eliminating the effects of shear degradation. Resolution in GPC is controlled by the slope of the calibration curve and the particle size of the packing material. Agilent has scientifically determined the minimum number of MIXED gel columns required to perform accurate MWD determinations based on specific resolution (Rsp). Thus you can have complete confidence in the accuracy and precision of the calculated data.

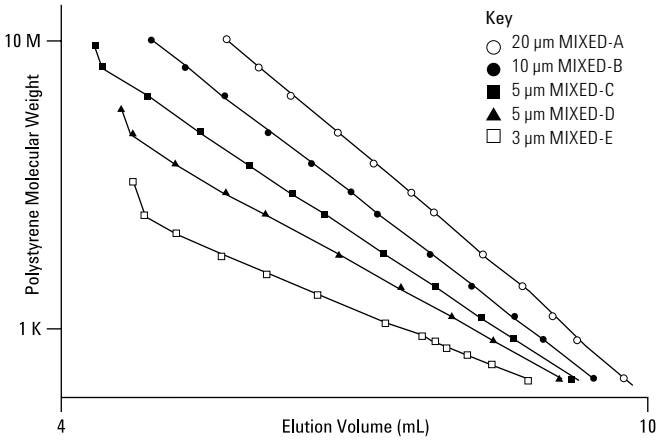


Figure 1. *PLgel MIXED gel calibration curves*

Reference

Meehan, E. (1998) Size exclusion chromatography columns from Polymer Laboratories. In: Chi-San Wu (Ed.) Column Handbook for Size Exclusion Chromatography. Academic Press, New York, USA.

See also

- PLgel MiniMIX Columns, reduce the need for expensive solvents, page 12
- Polymer Calibration Standards, with highly characterized molecular weights, publication 5990-7996EN

PLgel 20 µm MIXED-A

For polymers containing high MW material

- Extremely high exclusion limit tailored to the MW (molecular weight) of the application
- Large particle size matched to the MW range for optimum performance
- Low shear prevents sample degradation

Characteristics

Linear MW Operating Range: 2000 to 40,00,000 g/mol (PS equiv)

Guaranteed Column Efficiency: >18,000 p/m

Typical Pressure:
1 mL/min (7.5 mm ID): ≈ 3 bar (44 psi) per 300 mm
0.3 mL/min (4.6 mm ID): ≈ 2.4 bar (35 psi) per 250 mm
(THF @ 20 °C, TCB @ 140 °C)

Maximum Flow Rate:
7.5 mm ID: 1.5 mL/min
4.6 mm ID: 0.5 mL/min

Maximum Pressure: 150 bar (2175 psi)

Maximum Temperature: 220 °C

Recommended no. of Columns/set:
4 x 250 mm, 4 x 300 mm or 2 x 600 mm

Recommended Calibrants:
EasiVial PS-H for convenient 12 point calibration in just three injections

EasiCal PS-1 or S-H2-10 Kit provides rapid 10 point calibration

S-H-10 plus S-M2-10 Kits for accurate 19 point calibration

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel 20 µm MIXED-A Columns

Description	Part No.
PLgel 20 µm MIXED-A, 300 x 7.5 mm	PL1110-6200
PLgel 20 µm MiniMIX-A, 250 x 4.6 mm	PL1510-5200
PLgel 20 µm MIXED-A, 600 x 7.5 mm	PL1110-8200
PLgel 20 µm Guard, 50 x 7.5 mm	PL1110-1220
PLgel 20 µm MiniMIX-A Guard, 50 x 4.6 mm	PL1510-1200

Typical applications

Polyolefins, polybutadienes, starches, polyisoprenes

Conditions
Columns: 4 x PLgel 20 µm MIXED-A, 300 x 7.5 mm
Eluent: DMSO + 5mM $NaNO_3$
Flow Rate: 1.0 mL/min
Temp: 80 °C
Detector: PL-GPC 220 (RI)

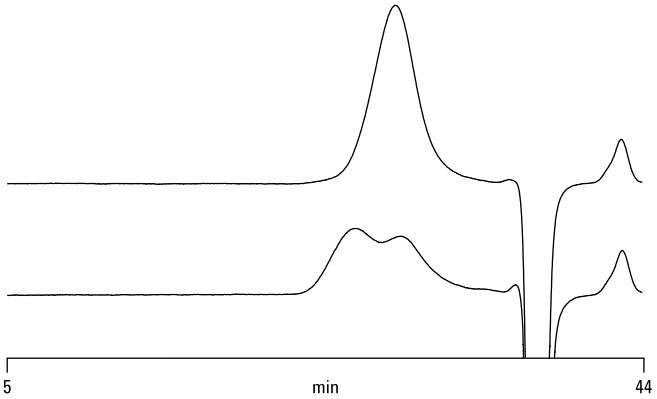


Figure 2. *Starches*

Conditions
Columns: 4 x PLgel 20 µm MIXED-A, 300 x 7.5 mm
Sample: EasiCal PS-1
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: UV, 254 nm

Peak Identification
1. 7,500,000
2. 841,700
3. 148,000
4. 28,500
5. 2,930
6. 2,560,000
7. 320,000
8. 59,500
9. 10,850
10. 580

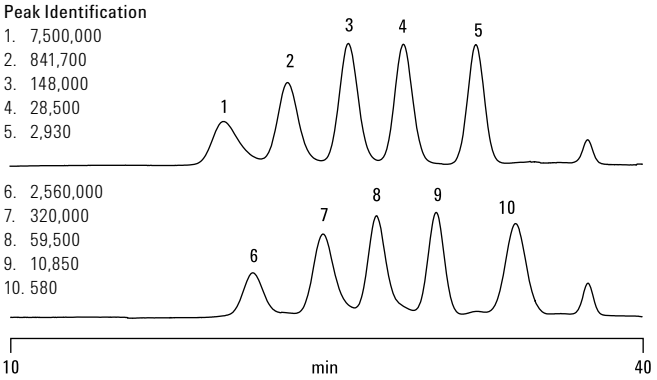


Figure 3. *Polystyrene standards separation*

See also

- PLgel MiniMIX-A Narrow Bore Columns, reduce the need for expensive solvents, page 12

PLgel 10 µm MIXED-B

High temperature applications with aggressive or unusual solvents

- Wide MW operating range maximizes column usefulness
- Low operating pressure minimizes wear on the GPC system
- Wide range of applications simplifies column choice

Characteristics

Linear MW Operating Range: 500 to 10,000,000 g/mol (PS equiv)

Guaranteed Column Efficiency: >35,000 p/m

Typical Pressure:
1 mL/min (7.5 mm ID): ≈ 10 bar (145 psi) per 300 mm
0.3 mL/min (4.6 mm ID): ≈ 8 bar (116 psi) per 250 mm
(THF @ 20 °C, TCB @ 140 °C)

Maximum Flow Rate:
7.5 mm ID: 1.5 mL/min
4.6 mm ID: 0.5 mL/min

Maximum Pressure: 150 bar (2175 psi)

Maximum Temperature: 220 °C

Recommended no. of Columns/set:
3 x 250 mm, 3 x 300 mm or 1 to 2 x 600 mm

Recommended Calibrants:
The EasiVial PS-H for convenient 12 point calibration in just three injections

EasiCal PS-1 or S-H2-10 Kit provides rapid 10 point calibration

Polystyrene S-H-10 plus S-M2-10 Kits for accurate 19 point calibration

See publication 5990-7996EN, GPC/SEC Standards Product Guide

See also

- PLgel MiniMIX-B Narrow Bore Columns, reduce the need for expensive solvents, page 12

Ordering information

PLgel 10 µm MIXED-B Columns

Description	Part No.
PLgel 10 µm MIXED-B, 300 x 7.5 mm	PL1110-6100
PLgel 10 µm MiniMIX-B, 250 x 4.6 mm	PL1510-5100
PLgel 10 µm MIXED-B, 600 x 7.5 mm	PL1110-8100
PLgel 10 µm Guard, 50 x 7.5 mm	PL1110-1120
PLgel 10 µm MiniMIX-B Guard, 50 x 4.6 mm	PL1510-1100

Typical applications

Polyolefins, fluoropolymers, acrylics/acrylates, cellulose derivatives

Conditions

Columns: 3 x PLgel 10 µm MIXED-B 300 x 7.5 mm
Eluent: o-Chloronaphthalene
Flow Rate: 1.0 mL/min
Temp: 210 °C
Detector: PL-GPC 220 (RI)

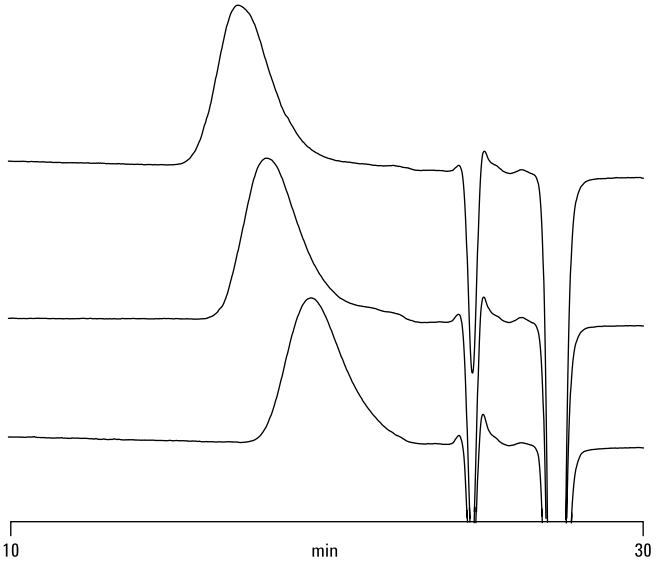


Figure 4. *Polyphenylene sulfides*

Conditions

Columns: 3 x PLgel 10 µm MIXED-B, 300 x 7.5 mm
Eluent: TCB
Flow Rate: 1.0 mL/min
Temp: 160 °C
Detector: RI

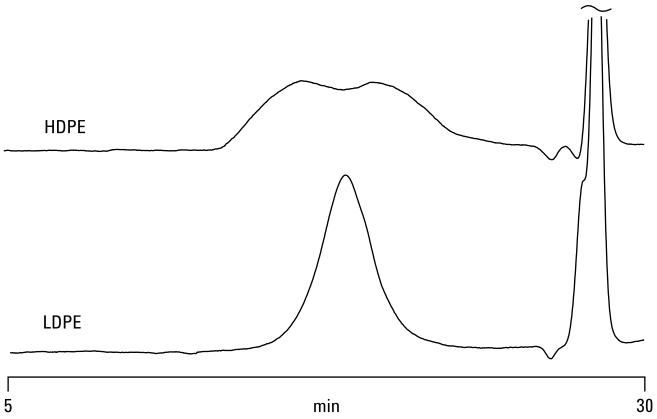


Figure 5. *Polyethylenes*

PLgel 5 µm MIXED-C

For analysis of polymers up to 2 million MW, especially those containing small additives

- Fast run times improve productivity
- Excellent solvent compatibility maximizes column utility
- Linear calibration curve ensures consistent resolution across the MW range

Characteristics

Linear MW Operating Range: 200 to 2,000,000 g/mol (PS equiv)

Guaranteed Column Efficiency: >50,000 p/m

Typical Pressure:
1 mL/min (7.5 mm ID): ≈ 30 bar (435 psi) per 300 mm
0.3 mL/min (4.6 mm ID): ≈ 24 bar (348 psi) per 250 mm
(THF @ 20 °C, TCB @ 140 °C)

Maximum Flow Rate:
7.5 mm ID: 1.5 mL/min
4.6 mm ID: 0.5 mL/min

Maximum Pressure: 150 bar (2175 psi)

Maximum Temperature: 150 °C

Recommended no. of Columns/set:
2 x 250 mm, 2 x 300 mm or 1 x 600 mm

Recommended Calibrants:
The EasiVial PS-H for convenient 10 point calibration in just three injections

EasiCal PS-1 provides rapid 10 point calibration
Polystyrene Kit S-M-10 for accurate 10 point calibration

Polyethylene Oxide/Glycol PEO/PEG-10 Kits for DMF, chemically similar for a broad MW range

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel 5 µm MIXED-C Columns

Description	Part No.
PLgel 5 µm MIXED-C, 300 x 7.5 mm	PL1110-6500
PLgel 5 µm MiniMIX-C, 250 x 4.6 mm	PL1510-5500
PLgel 5 µm MIXED-C, 600 x 7.5 mm	PL1110-8500
PLgel 5 µm Guard, 50 x 7.5 mm	PL1110-1520
PLgel 5 µm MiniMIX-C Guard, 50 x 4.6 mm	PL1510-1500

Typical applications

Polystyrenes, polyurethanes, polycarbonates, polysiloxanes

Conditions
Columns: 2 x PLgel 5 µm MIXED-C, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: PL-GPC 220 (RI)

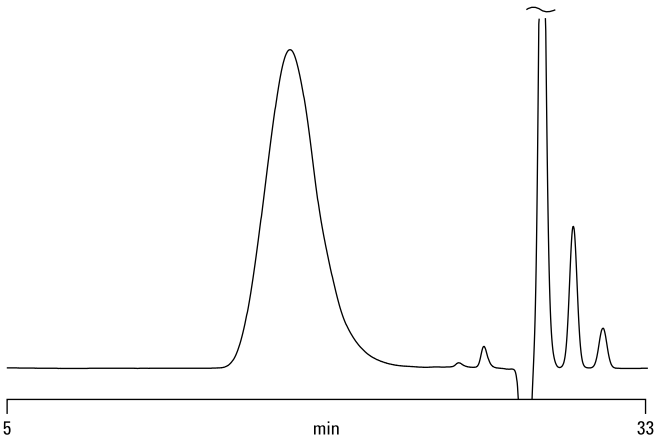


Figure 6. *Plasticized PVC*

Conditions
Columns: 2 x PLgel 5 µm MIXED-C, 300 x 7.5 mm
Eluent: DMF + 0.1% LiBr
Flow Rate: 1.0 mL/min
Temp: 80 °C
Detector: PL-GPC 220 (RI)

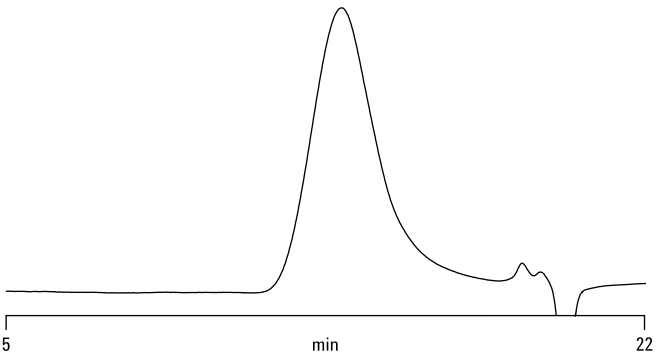


Figure 7. *Polyurethane*

See also

- PLgel MiniMIX-C Narrow Bore Columns, reduce the need for expensive solvent, page 12

PLgel 5 µm MIXED-D

For condensation polymers containing some low MW oligomers

- High pore volume and high efficiency optimize performance
- Elevated temperature capability maintains sample solubility
- Optimized particle size and porosity eliminate shearing effects for reliable results

Characteristics

Linear MW Operating Range: 200 to 400,000 g/mol (PS equiv)

Guaranteed Column Efficiency: >50,000 p/m

Typical Pressure:
1 mL/min (7.5 mm ID): ≈ 30 bar (435 psi) per 300 mm
0.3 mL/min (4.6 mm ID): ≈ 24 bar (348 psi) per 250 mm
(THF @ 20 °C, TCB @ 140 °C)

Maximum Flow Rate:
7.5 mm ID: 1.5 mL/min
4.6 mm ID: 0.5 mL/min

Maximum Pressure: 150 bar (2175 psi)

Maximum Temperature: 150 °C

Recommended no. of Columns/set:
2 x 250 mm, 2 x 300 mm or 1 x 600 mm

Recommended Calibrants:
The EasiVial PS-M for convenient 12 point calibration in just three injections

EasiCal PS-2 provides rapid 10 point calibration

Polystyrene Kit S-M2-10 for accurate 10 point calibration

Polyethylene Oxide/Glycol PEO/PEG-10 Kits for DMF, chemically similar for a broad MW range

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel 5 µm MIXED-D Columns

Description	Part No.
PLgel 5 µm MIXED-D, 300 x 7.5 mm	PL1110-6504
PLgel 5 µm MiniMIX-D, 250 x 4.6 mm	PL1510-5504
PLgel 5 µm MIXED-D, 600 x 7.5 mm	PL1110-8504
PLgel 5 µm Guard, 50 x 7.5 mm	PL1110-1520
PLgel 5 µm MiniMIX-D Guard, 50 x 4.6 mm	PL1510-1504

Typical applications

Epoxy resins, silicone fluids, polyester resins, polyolefins

Conditions
Columns: 2 x PLgel 5 µm MIXED-D, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: PL-GPC 220 (RI)

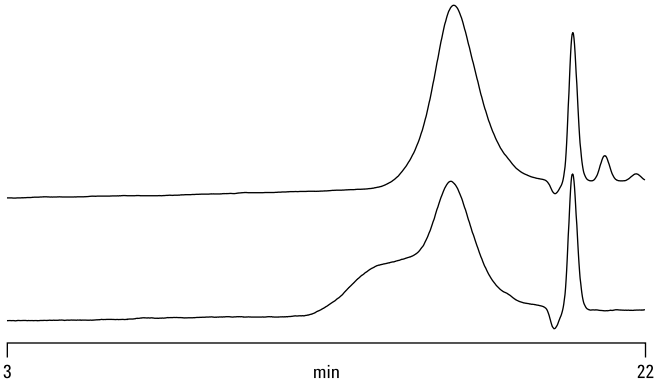


Figure 8. *Asphalts*

Conditions
Columns: 3 x PLgel 5 µm MIXED-D, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: PL-GPC 220 (RI)

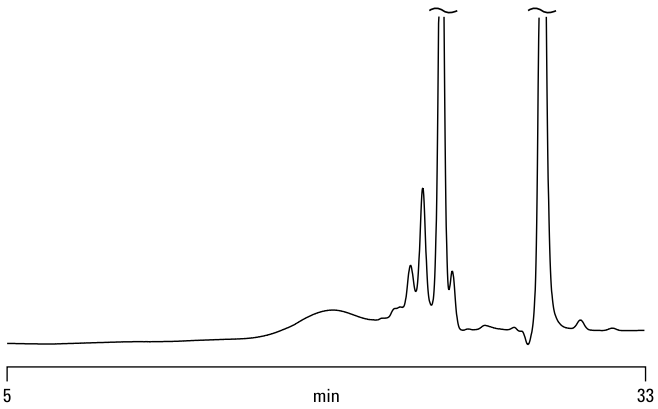


Figure 9. *Epoxy resin*

See also

- PLgel MiniMIX-D Narrow Bore Columns, reduce the need for expensive solvents, page 12

PLgel 3 µm MIXED-E

Oligomers and polymers up to 30,000 MW

- Ultra high efficiency resolves narrow peaks
- Fast analysis improves productivity
- Optimized particle size for low MW applications

Characteristics

Linear MW Operating Range: up to 30,000 g/mol (PS equiv)

Guaranteed Column Efficiency:
300 x 7.5 mm: >80,000 p/m
250 x 4.6 mm: >70,000 p/m
Highest efficiency/resolution achieved only on high performance, low dead volume equipment.

Typical Pressure:
1 mL/min (7.5 mm ID): ≈ 50 bar (725 psi) per 300 mm
0.3 mL/min (4.6 mm ID) : ≈ 42 bar (609 psi) per 250 mm
(THF @ 20 °C)

Maximum Flow Rate:
7.5 mm ID: 1.5 mL/min
4.6 mm ID: 0.5 mL/min

Maximum Pressure: 180 bar (2611 psi)

Maximum Temperature: 110 °C

Recommended no. of Columns/set:
1-3 x 250 mm or 1-3 x 300 mm

Recommended Calibrants:
Polystyrene Kit S-L-10 for accurate 10 point calibration

Polyethylene Glycol Kit PEG-10 for DMF, for low molecular weights

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel 3 µm MIXED-E Columns

Description	Part No.
PLgel 3 µm MIXED-E, 300 x 7.5 mm	PL1110-6300
PLgel 3 µm MiniMIX-E, 250 x 4.6 mm	PL1510-5300
PLgel 3 µm MIXED-E, 600 x 7.5 mm	PL1110-8504
PLgel 3 µm Guard, 50 x 7.5 mm	PL1110-1320
PLgel 3 µm MiniMIX-E Guard, 50 x 4.6 mm	PL1510-1300

Typical applications

Prepolymers, polyols, resins, siloxanes

Conditions
Columns: 3 x PLgel 3 µm MIXED-E, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: UV, 254 nm

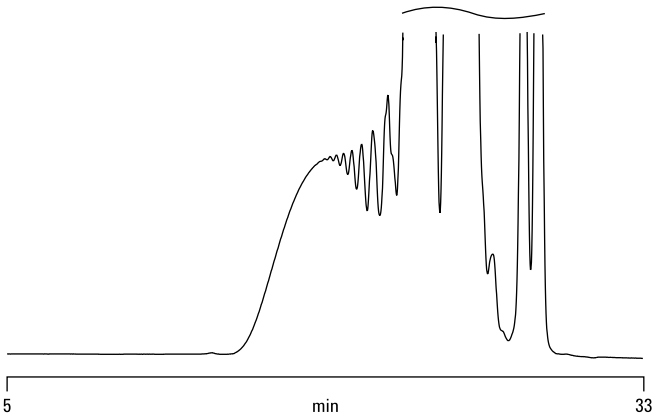


Figure 10. *Polyol*

Conditions
Columns: 2 x PLgel 3 µm MIXED-E, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: PL-GPC 220 (RI)

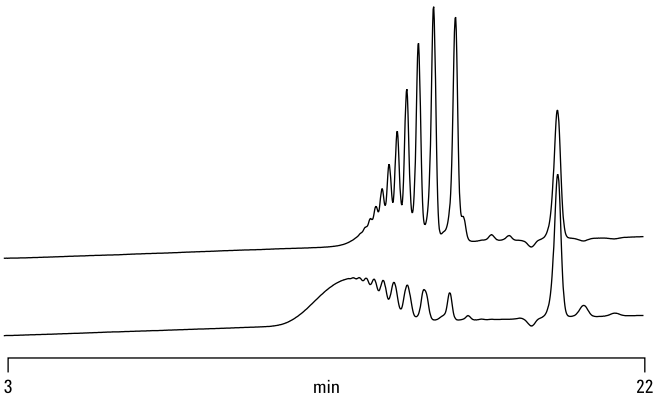


Figure 11. *Polyester resins*

See also

- PLgel MiniMIX-E Narrow Bore Columns, reduce the need for expensive solvents, page 12

PLgel MIXED-LS

Eliminates particle leakage to improve data quality with light scattering detection

- Obtain an instant improvement in data quality
- No need for conditioning, saving time and solvent costs
- Maximize the potential of light scattering detectors

PLgel MIXED-LS eliminates nano particle leakage to greatly improve the quality of light scattering data.

The PLgel MIXED-LS series is a PS/DVB packing using an innovative proprietary suspension polymerization technique to virtually eliminate nano-particle leakage. A startling improvement is achieved immediately in the quality of light scattering data obtained with PLgel MIXED-LS columns in place of conventional GPC columns. The light scattering chromatograms shown here were obtained after flushing the columns for one hour in THF at 1 mL/min. A polystyrene standard (Mp 210,000) was injected at 1 mg/mL in order to illustrate the dramatic improvement in signal to noise with the PLgel MIXED-LS column.

The performance of PLgel MIXED-LS columns has been matched to PLgel 20 µm MIXED-A and PLgel 10 µm MIXED-B columns in terms of calibration, column efficiency, wide solvent compatibility and operating temperature. MIXED-LS are also ideal for online viscosity detection, minimizing the risk of capillary blockage, and can be used with regular PLgel guard columns that are packed with rigid low pore size gels with no particle bleed.

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Typical applications

Polyethylenes, polyolefins

Conditions

Column: Conventional GPC column
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: LS

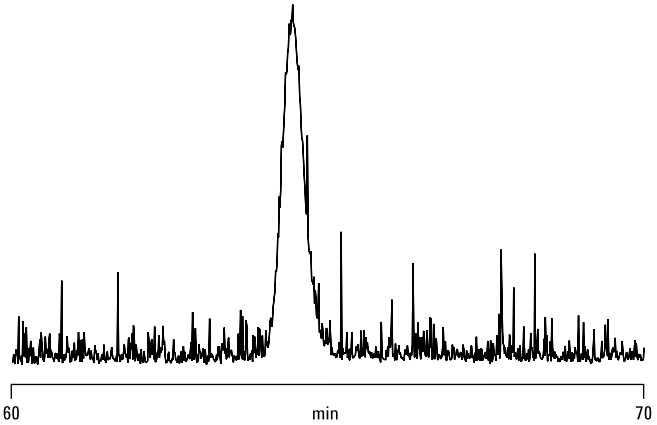


Figure 12. *Conventional GPC column*

Conditions

Column: PLgel 10 µm MIXED-B LS, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: LS

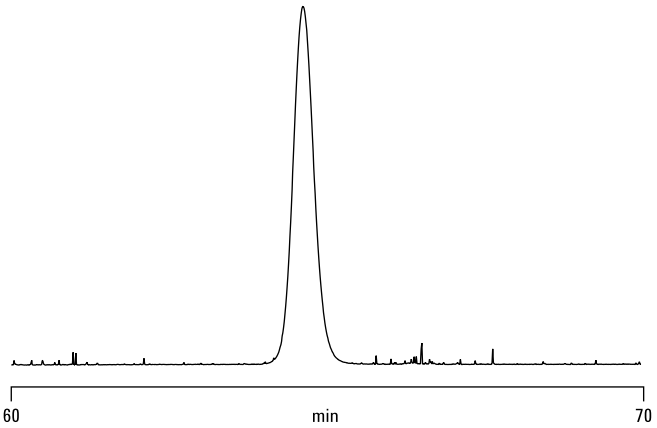


Figure 13. *PLgel LS column*

Ordering information

PLgel MIXED-LS Columns

Description	Linear MW operating range (g/mol) (PS)	Guaranteed efficiency (p/m)	Part No.
PLgel 10 µm MIXED-B LS, 300 x 7.5 mm	500-10,000,000	>35,000	PL1110-6100LS
PLgel 20 µm MIXED-A LS, 300 x 7.5 mm	2,000 to 40,000,000	>18,000	PL1110-6200LS
PLgel 10 µm Guard, 50 x 7.5 mm			PL1110-1120
PLgel 20 µm Guard, 50 x 7.5 mm			PL1110-1220

PLgel MiniMIX Narrow Bore

Reduced solvent use

- Use about 70% less solvent and save money
- Store less solvent and increase operator safety
- High performance comparable to Agilent's conventional ID columns

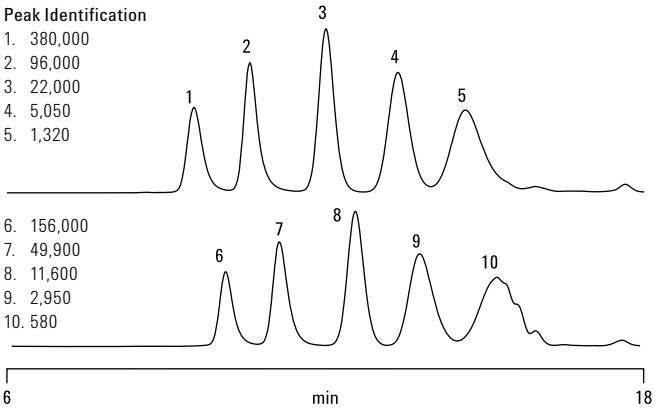
For reduced solvent cost and consumption, use industry standard PLgel MiniMIX mixed gel columns in 250 x 4.6 mm narrow bore dimensions. These narrow bore columns offer high performance, excellent solvent compatibility and mechanical stability. Both PlusPore Narrow Bore and PLgel MiniMIX columns can be used with conventional GPC equipment.

Tip: To maintain the same linear velocity through the column, the volumetric flow rate must be reduced to 0.3 mL/min in line with the column cross sectional area, resulting in significantly lower solvent consumption. Sample loading should also be scaled down in line with reduced column volume, and system dead volume should be minimized to avoid excessive band broadening.

Typical applications
As for MIXED ranges

Conditions
Columns: 2 x PLgel 5 µm MIXED-D, 300 x 7.5 mm
Sample: EasiCal PS-2
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 100 µL
Detector: UV, 254 nm

Peak Identification
1. 380,000
2. 96,000
3. 22,000
4. 5,050
5. 1,320
6. 156,000
7. 49,900
8. 11,600
9. 2,950
10. 580



Conditions
Columns: 2 x PLgel MiniMIX-D, 300 x 7.5 mm
Sample: EasiCal PS-2
Eluent: THF
Flow Rate: 0.3 mL/min
Inj Vol: 20 µL
Detector: UV, 254 nm

Peak Identification
1. 380,000
2. 96,000
3. 22,000
4. 5,050
5. 1,320
6. 156,000
7. 49,900
8. 11,600
9. 2,950
10. 580

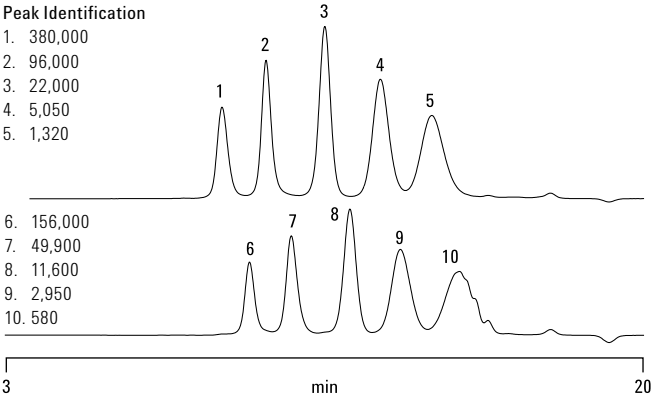


Figure 14. *Comparison of conventional and narrow bore columns*

PLgel MiniMIX Narrow Bore

Ordering information

PLgel MiniMIX Columns, 250 x 4.6 mm

Description	Linear MW operating range (g/mol) (PS)	Guaranteed efficiency (p/m)	Part No.
PLgel 20 µm MiniMIX-A	2,000 to 40,000,000	>17,000	PL1510-5200
PLgel 10 µm MiniMIX-B	500 to 10,000,000	>35,000	PL1510-5100
PLgel 5 µm MiniMIX-C	200 to 2,000,000	>50,000	PL1510-5500
PLgel 5 µm MiniMIX-D	200 to 400,000	>50,000	PL1510-5504
PLgel 3 µm MiniMIX-E	up to 30,000	>70,000	PL1510-5300

See also

- PlusPore Columns, very high resolution without artifacts, page 21
- PLgel MIXED Columns, simplify column selection, page 5
- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Tip: Reduce the size of system peaks when using a refractive index detector by preparing the samples in the eluent that is flowing in the system.

PLgel Individual Pore Size Columns

High resolution over a specific molecular weight range

- Very high efficiency improves productivity
- Choose the optimum column for a perfect match of performance and application
- Fast analysis with fewer columns saves time and money

Individual pore size GPC columns offer high resolution over a specific molecular weight range. The linear portion of the calibration curve, where the slope is at its shallowest, defines the MW region over which optimum resolution will be achieved.

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Tip: Look for peak broadening and tailing to indicate a column is reaching the end of its lifetime and needs replacing.

Typical applications

PLgel 3 µm: Triglycerides, linear hydrocarbons

PLgel 5 µm: Acrylates

PLgel 10 µm: Rubbers

Conditions

Calibrant: Polystyrene
Eluent: THF
Flow Rate: 1.0 mL/min

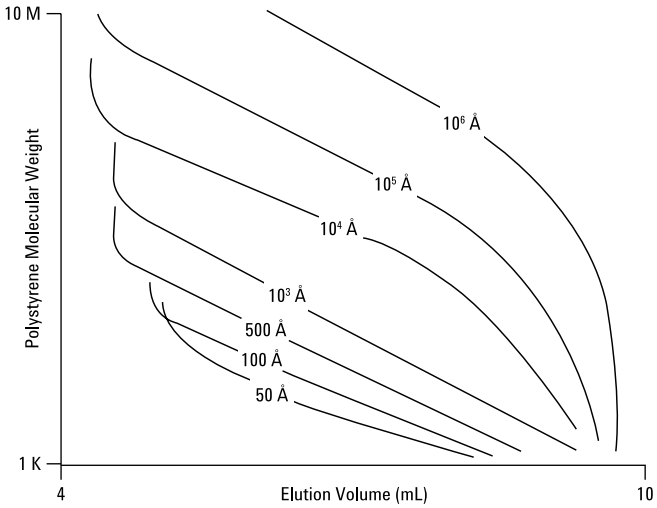


Figure 15. *Calibration curves*

PLgel Individual Pore Size Columns

Ordering information

PLgel Individual Pore Size Columns

Description	Pore size (Å)	MW range (g/mol) (PS)	Guaranteed efficiency (p/m)	Part No. 300 x 7.5 mm
PLgel 3 µm	100	up to 4,000	>100,000	PL1110-6320
PLgel 5 µm	50	up to 2,000	>60,000	PL1110-6515
PLgel 5 µm	100	up to 4,000	>60,000	PL1110-6520
PLgel 5 µm	500	500 to 30,000	>60,000	PL1110-6525
PLgel 5 µm	10^3	500 to 60,000	>50,000	PL1110-6530
PLgel 5 µm	10^4	10,000 to 600,000	>50,000	PL1110-6540
PLgel 5 µm	10^5	60,000 to 2,000,000	>50,000	PL1110-6550
PLgel 10 µm	50	up to 2,000	>35,000	PL1110-6115
PLgel 10 µm	100	up to 4,000	>35,000	PL1110-6120
PLgel 10 µm	500	500 to 30,000	>35,000	PL1110-6125
PLgel 10 µm	10^3	500 to 60,000	>35,000	PL1110-6130
PLgel 10 µm	10^4	10,000 to 600,000	>35,000	PL1110-6140
PLgel 10 µm	10^5	60,000 to 2,000,000	>35,000	PL1110-6150
PLgel 10 µm	10^6	600,000 to 10,000,000	>35,000	PL1110-6160

Ordering information

PLgel Guard Columns, 50 x 7.5 mm

Description	Part No.
PLgel 3 µm Guard	PL1110-1320
PLgel 5 µm Guard	PL1110-1520
PLgel 10 µm Guard	PL1110-1120
PLgel 20 µm Guard	PL1110-1220

PLgel Preparative Columns

Fractionation of samples based on their molecular size in solution

- Excellent column efficiency provides optimum resolution
- High loading can isolate mg amounts for further study
- Over x10 scale up permits efficient quantification

Preparative GPC is generally employed to fractionate polymers, isolate components in a polymer formulation or simplify mixtures of relatively small molecules in complex matrices. Mixtures of materials are easily separated on the basis of size, preferably in a low boiling organic solvent. They are then collected as a series of discrete fractions and isolated by simple evaporation of the solvent.

PLgel preparative columns are packed with the same rigid, high performance media as the analytical columns. The 10 µm particle provides high column efficiency (>25,000 p/m) for optimum resolution and loading characteristics. PLgel 25 mm ID preparative columns offer over x10 scale up compared to the 7.5 mm analytical columns. The increased ID and column volume permit even higher loading. With low molecular weight materials, sample concentration can also be significantly increased, enabling production of milligram quantities of very pure material. The actual loading is ultimately controlled by the sample and its molecular weight.

Typical applications

Polymer fractionation, component isolation, mixture simplification

Conditions

Column: PLgel 10 µm 500Å, 600 x 25 mm
Sample Conc: 100 mg/mL, 2 mL
Eluent: Dichloromethane
Flow Rate: 9.0 mL/min
Loading: 200 mg on column
Detector: UV, 254 nm

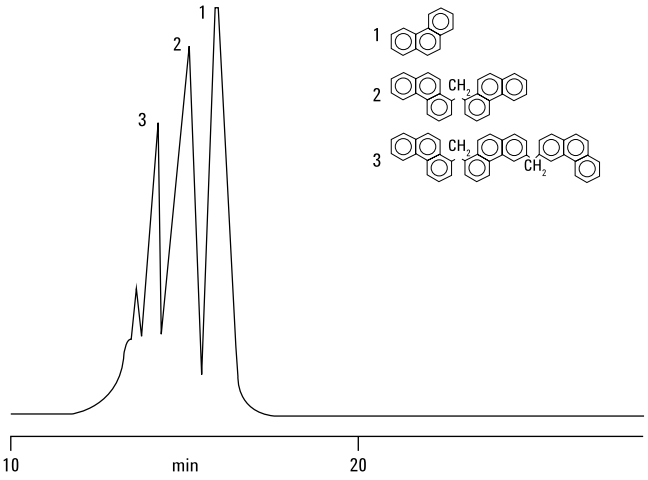


Figure 16. *Fractionation of an oil distillate*

Select your PLgel preparative column

Column ID (mm)	Column volume per 300 mm length (mL)	Minimum scale up
PLgel 7.5 Analytical	13	x1
PLgel 25 Preparative	147	x11

Tip: Not sure which prep column to use? Phone for free application advice.

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel Preparative Columns

Description	MW range (g/mol) (PS)	Part No.
PLgel 10 µm 50Å, 300 x 25 mm	up to 2,000	PL1210-6115
PLgel 10 µm 50Å, 600 x 25 mm	up to 2,000	PL1210-8115
PLgel 10 µm 100Å, 300 x 25 mm	up to 4,000	PL1210-6120
PLgel 10 µm 100Å, 600 x 25 mm	up to 4,000	PL1210-8120
PLgel 10 µm 500Å, 300 x 25 mm	500 to 30,000	PL1210-6125
PLgel 10 µm 500Å, 600 x 25 mm	500 to 30,000	PL1210-8125
PLgel 10 µm 103Å, 300 x 25 mm	500 to 60,000	PL1210-6130
PLgel 10 µm 104Å, 300 x 25 mm	10,000 to 600,000	PL1210-6140
PLgel 10 µm 105Å, 300 x 25 mm	60,000 to 2,000,000	PL1210-6150
PLgel 10 µm 106Å, 300 x 25 mm	600,000 to 10,000,000	PL1210-6160
PLgel 10 µm MIXED-B, 300 x 25 mm	500 to 10,000,000	PL1210-6100
PLgel 10 µm MIXED-B, 600 x 25 mm	500 to 10,000,000	PL1210-8100
PLgel 10 µm MIXED-D, 300 x 25 mm	200 to 400,000	PL1210-6104
PLgel 10 µm MIXED-D, 600 x 25 mm	200 to 400,000	PL1210-8104
PLgel Prep Guard, 25 x 25 mm		PL1210-1120

PLgel Olexis

Analyzing polymers of very high molecular weight

- Optimized design for polyolefin analysis
- High temperature capability
- High resolution with no damage from sample shear provides clean separations

PLgel Olexis is designed for the analysis of very high molecular weight polymers, specifically polyolefins. The column resolves up to 100,000,000 g/mol (polystyrene in THF), and is packed with 13 µm particles to optimize efficiency and resolution without the risk of sample shear degradation during analysis. The packing of PLgel Olexis has the mechanical stability and robustness expected from a PLgel column, and so it is able to operate up to 220 °C for the analysis of highly crystalline materials.

Tip: Remember to heat and cool columns for high temperature analysis slowly to avoid damage from thermal shock.

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PLgel Olexis Columns

Description	Part No.
PLgel Olexis, 300 x 7.5 mm	PL1110-6400
PLgel Olexis Guard, 50 x 7.5 mm	PL1110-1400

Typical applications

Polyolefins

Conditions

Columns: 3 x PLgel Olexis, 300 x 7.5 mm
Eluent: Trichlorobenzene + 0.0125% BHT
Flow Rate: 1.0 mL/min
Inj Vol: 200 µL
Temp: 160 °C
Detector: PL-GPC 220 (RI)

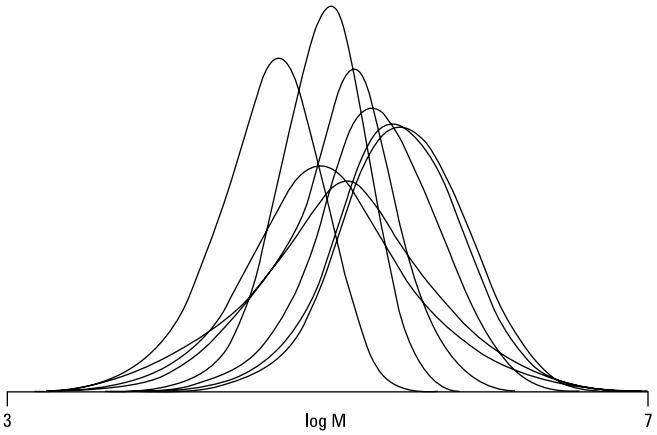


Figure 17. *PLgel Olexis reveals true modalities across the range of polyolefins*

Conditions

Columns: 3 x PLgel Olexis, 300 x 7.5 mm
Eluent: Trichlorobenzene + 0.0125% BHT
Inj Vol: 200 µL
Temp: 160 °C
Detector: PL-GPC 220 (RI) + dual angle LS + viscometry

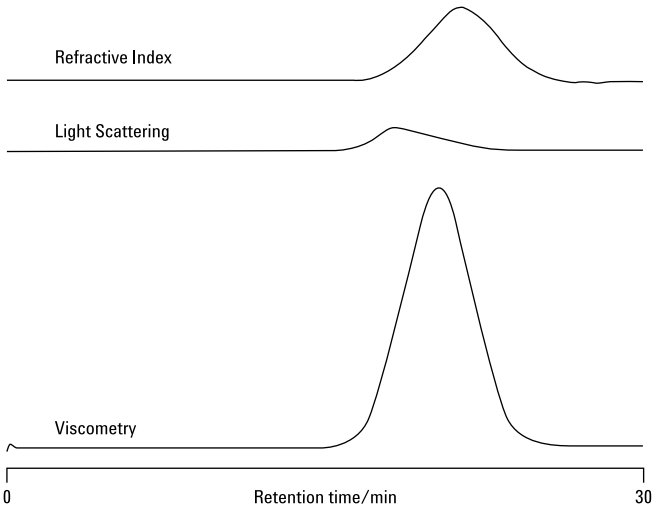


Figure 18. *GPC of polyethylene by PLgel Olexis with different detectors*

Agilent EnviroPrep

Environmental clean up with EPA methods

- High sample loading ensures effective trace analysis
- Simple clean-up procedure saves sample preparation costs
- Optimized particle size distribution provides high resolution

EnviroPrep columns permit a simple, one stage clean-up to determine pesticides in many organic matrices. The higher molecular weight fractions such as lipids, polymers, natural resins and dispersed high molecular weight components are easily eliminated in the GPC analysis.

Tip: Preparative GPC for soil extract clean-up is described in "EPA Method 3640A" using 300 x 25 mm and 150 x 25 mm columns to give higher sample loading and fraction yields, which is particularly useful for low levels of pollutants. Low pore size EnviroPrep columns are ideal for this method. The columns have 10 µm particles with 100Å pore sizes for high resolution, with an exclusion limit of 4000 MW. The preparative columns offer good resolution and high loading through optimization of the particle size distribution.

Conditions

Column:	EnviroPrep, 300 x 25 mm EnviroPrep, 150 x 25 mm
Eluent:	DCM
Flow Rate:	10 mL/min
Detector:	UV, 254 nm

Peak Identification	mg/L
1. Corn oil	25,000
2. Bis(2-ethylhexyl) phthalate	1,000
3. Methoxychlor	200
4. Perylene	20
5. Sulfur	80

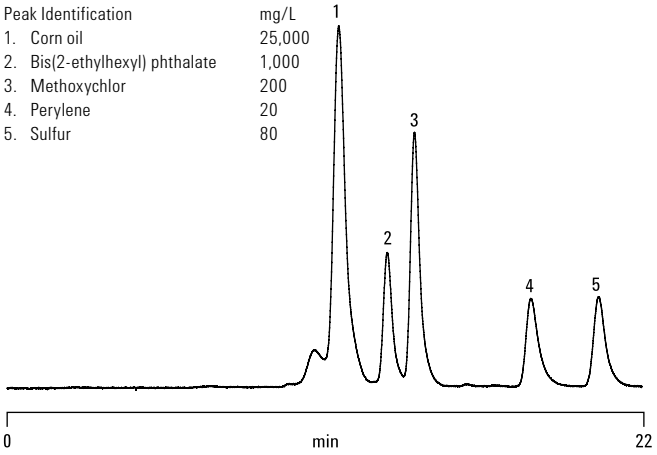


Figure 19. *Columns for sample clean-up*

Ordering information

EnviroPrep Columns

Description	Part No.
EnviroPrep, 150 x 21.2 mm	PL1E10-3120EPA
EnviroPrep, 150 x 25 mm	PL1210-3120EPA
EnviroPrep, 300 x 21.2 mm	PL1E10-6120EPA
EnviroPrep, 300 x 25 mm	PL1210-6120EPA

PL HFIPgel

Improved performance when using HFIP

- Optimized separation range delivers high performance with no artifacts
- Highly durable packing prolongs column lifetime
- Low operating pressure reduces system wear and unnecessary downtimes

Hexafluoroisopropanol (HFIP) is used as a solvent in GPC for the analysis of important industrial polymers such as polyesters, polyamides and polylactide/glycolide copolymers. For greatly improved performance in extremely polar solvents such as HFIP and trifluoroethanol, we have developed novel "multipore" technology to produce PL HFIPgel, a PS/DVB packing featuring a monodisperse particle size, high pore volume and high resolution.

Using PL HFIPgel avoids issues associated with conventional packing and HFIP, such as excessive curvature of calibration curves, dislocations/shoulders on peaks for polydisperse samples and poor resolution in the low MW region.

Column efficiency is guaranteed >30,000 p/m and the columns are very durable, with a maximum operating pressure of 145 bar (2030 psi). They are packed and tested in methanol but shipped ready to use in HFIP.

PL HFIPgel columns with 7.5 mm ID normally operate at 1 mL/min. However, the 4.6 mm ID columns run at 0.3 mL/min, providing a 70% reduction in solvent consumption with consequent savings in the cost of buying and disposing of solvents.

Ordering information

PL HFIPgel Columns

Description	Part No.
PL HFIPgel, 250 x 4.6 mm	PL1514-5900HFIP
PL HFIPgel, 300 x 7.5 mm	PL1114-6900HFIP
PL HFIPgel Guard, 50 x 7.5 mm	PL1114-1900HFIP
PL HFIPgel Guard, 50 x 4.6 mm	PL1514-1900HFIP

Typical applications

Polyesters, polyamides, polylactide/glycolide copolymers

Conditions

Columns: 2 x PL HFIPgel, 300 x 7.5 mm
Eluent: HFIP + 20mM NaTFAc
Flow Rate: 1.0 mL/min
Temp: 40 °C
Detector: PL-GPC 50 (RI)

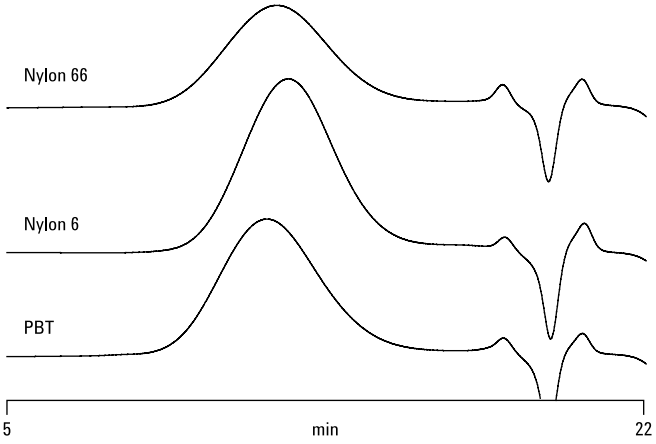


Figure 20. *Polyamides*

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Tip: Sharp peaks at the front end of GPC/SEC chromatograms (high molecular weight), indicate the sample may be excluding and a column set with a higher resolving range may be required.

Agilent PL Rapide

Fast separations for high turnaround or when analyzing many samples

- Analysis in less than ten minutes saves time
- Significantly increased sample throughput improves efficiency
- Reduced solvent consumption and disposal costs saves money

Two key parameters can be varied to reduce the analysis time of an experiment. Column length can be reduced or eluent flow rate increased. Using both methods, PL Rapide columns provides significantly increased sample throughput compared to a conventional GPC/SEC column set.

Rapid GPC is an excellent tool for screening polymer MWD for trend analysis. Short PL Rapide columns reduce analysis times while maintaining the excellent solvent compatibility and mechanical stability of all GPC columns from Agilent.

PL Rapide columns are ideal for high speed applications such as high throughput screening, process monitoring, or tracking changes in MW distributions, where time is the most critical factor in the analysis. Packed with high quality gels, these columns cover the complete spectrum of molecular weights and are available for the analysis of both organic and water soluble polymers. Key features include high pore volume and high resolution packing materials, no special system requirements, choice of molecular weight resolving range, wide solvent compatibility, and excellent mechanical stability.

PL Rapide is available in L, M and H versions for low, medium and high molecular weights. The F version is for flow injection analysis.

Typical applications

Epoxy resins, process monitoring, flow injection analysis

Conditions

Column:	PL Rapide L, 100 x 10 mm
Sample:	Epoxy resin
Eluent:	THF
Flow Rate:	1.0 , 2.0 and 3.0 mL/min
Detector:	UV, 254 nm

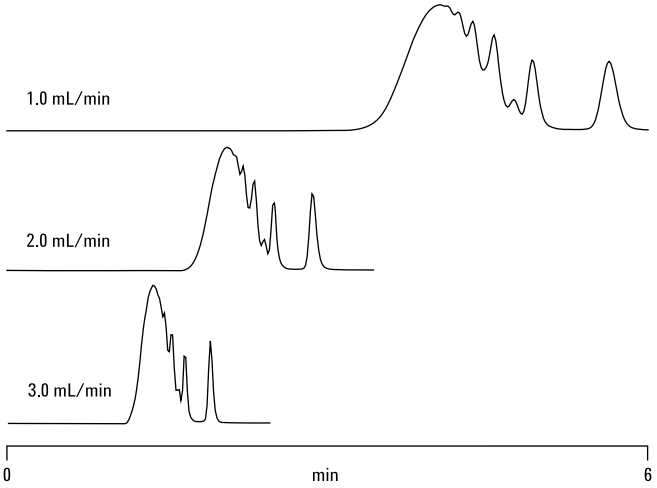


Figure 21. *Resin analysis by rapid GPC*

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PL Rapide Columns

Description	MW range (g/mol)	Guaranteed efficiency (p/m)	Part No.
PL Rapide H, 150 x 7.5 mm	500 to 10,000,000	>35,000	PL1113-3100
PL Rapide H, 100 x 10mm	500 to 10,000,000	>35,000	PL1013-2100
PL Rapide M, 150 x 7.5 mm	200 to 2,000,000	>60,000	PL1113-3500
PL Rapide M, 100 x 10 mm	200 to 2,000,000	>60,000	PL1013-2500
PL Rapide L, 150 x 7.5 mm	200 to 400,000	>80,000	PL1113-3300
PL Rapide L, 100 x 10 mm	200 to 400,000	>80,000	PL1013-2300
PL Rapide F, 150 x 7.5 mm	up to 4,000	>55,000	PL1113-3120
PL Rapide F, 100 x 10 mm	up to 4,000	>40,000	PL1013-2120

Agilent PlusPore

Very high resolution without artifacts

- High pore volume
- No artefacts
- Optimum resolution

The PlusPore range has an increased pore volume that provides high resolution for specific applications. The high stability media permits the use of a wide range of organic solvents with accuracy and precision so that there is no distortion of the MW distribution shape.

The PlusPore series of columns has been specifically designed for high resolution GPC, and represents the very latest in GPC column technology. These novel packing materials are based on the industry standard, highly cross linked polystyrene/divinylbenzene (PS/DVB), for the widest applicability and solvent compatibility. Each is made using a novel polymerization process to produce particles that exhibit a specific, controlled pore structure for optimum GPC performance. Typical applications include resins, condensation polymers, prepolymers, and oligomers.

Typical applications for the PlusPore range

- PolyPore for the routine analysis of general polymers
- ResiPore for resins and condensation polymers
- MesoPore for prepolymers and low MW resins
- OligoPore for oligomeric samples

For high resolution polymer analysis, the PolyPore, ResiPore, MesoPore and OligoPore columns of the PlusPore product series exhibit a wide pore size distribution with near linear calibration curves covering an extended molecular weight range. These so-called "multipore" structures have increased pore volume compared to regular PS/DVB packing materials, resulting in very high resolution GPC columns. The highly cross linked porous particles provide excellent chemical and physical stability and permit easy transfer across the full range of organic solvents with little change in the shape of the calibration curve or the efficiency of the columns. As this multipore column technology does not require the combination of individual pore size packing materials, the result is high accuracy and precision without any artifacts in the shape of the molecular weight distribution.

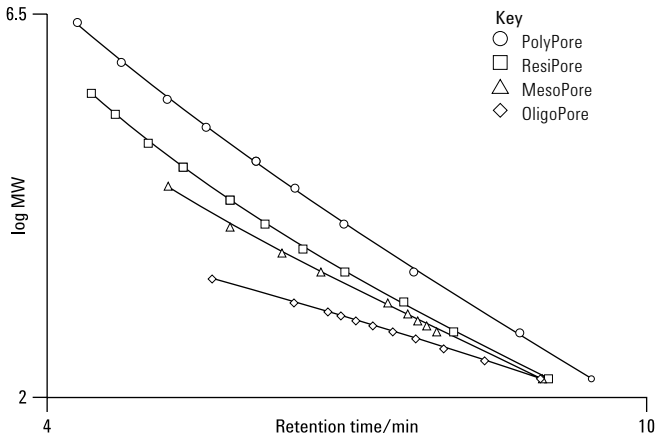


Figure 22. *PlusPore calibration curves*

See also

- Polymer calibration standards, with highly characterized molecular weights, publication 5990-7996EN, GPC/SEC Standards Product Guide

PlusPore selection guide

Column	MW range (g/mol) (PS)	Nominal particle size (µm)	Typical efficiency (p/m)	Recommended calibrants	Frit porosity (µm)
PolyPore	200 to 2,000,000	5	>60,000	EasiCal PS-1or EasiVial PS-H	2
ResiPore	200 to 400,000	3	>80,000	EasiCal PS-2 or EasiVial PS-M	2
MesoPore	up to 25,000	3	>80,000	Polystyrene S-L-10 Kit,	2
OligoPore	up to 4,500	6	>55,000	Polystyrene S-L2-10 Kit	2

Agilent PolyPore

Unrivalled resolution of general polymers

- Routine polymer analysis with very high resolution
- Wide operating range simplifies column choice
- Low particle size extracts maximum information from the analyte

PolyPore columns have been specifically developed to give unrivalled resolution for the analysis of polymers with broad molecular weight distributions. With a wide operating range covering many decades of molecular weight, PolyPore columns combine a low 5 µm particle size with extremely high pore volume to give the highest possible resolution, ensuring the most detailed information possible from your analysis.

Characteristics

MW Range: 200 to 2,000,000 (g/mol)

Nominal Particle Size: 5 µm

Typical Efficiency: >60,000 p/m

Recommended Calibrants:
EasiCal PS-1 for rapid 10 point calibration or EasiVial for convenient 10 point calibration in just three injections

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

PolyPore Columns

Description	Part No.
PolyPore, 300 x 7.5 mm	PL1113-6500
PolyPore Guard, 50 x 7.5 mm	PL1113-1500

Typical applications

Polystyrenes, polycarbonates, polyurethanes, polysiloxanes

Conditions
Columns: 2 x PolyPore, 300 x 7.5 mm
PLgel 5 µm 10^3Å, 300 x 7.5 mm
PLgel 5 µm 10^5Å, 300 x 7.5 mm
Sample: High MW Resin
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 100 µL
Detector: PL-GPC 50 (RI)

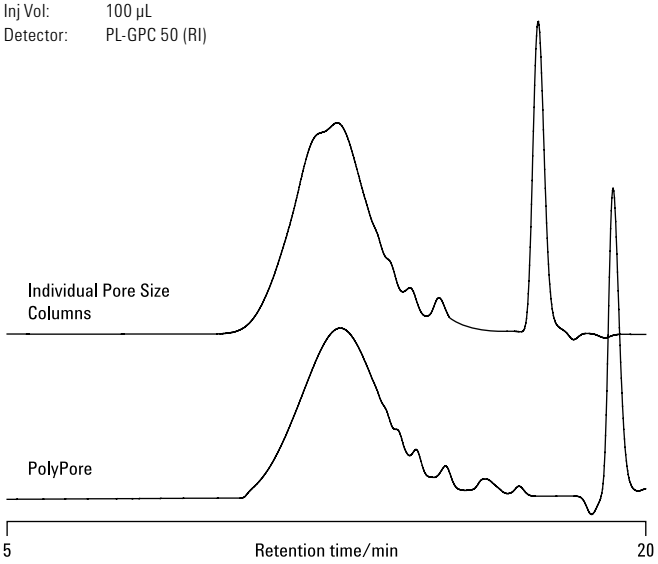


Figure 23. *Comparison of PolyPore with conventional individual pore size GPC columns*

Conditions
Columns: 2 x PolyPore, 300 x 7.5 mm
Sample: Commercial PMMA
Eluent: DMF + 0.1% LiBr
Flow Rate: 1.0 mL/min
Temp: 80 °C
Inj Vol: 100 µL
Detector: PL-GPC 50 (RI)

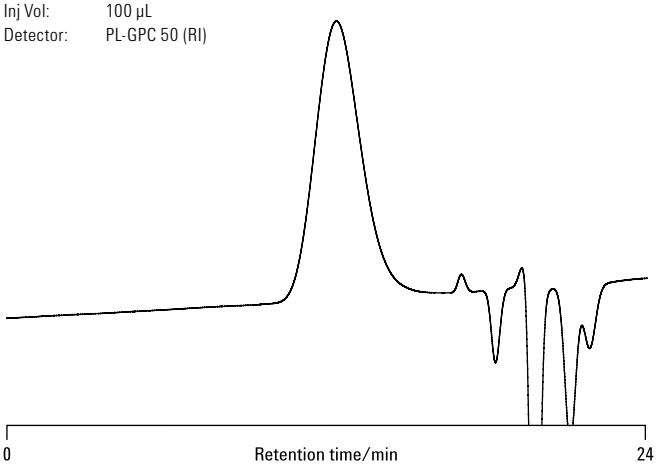


Figure 24. *Polymethylmethacrylate in DMF*

Agilent ResiPore

High resolution of resins and condensation polymers

- Efficient separation of complex molecular weight distributions
- Reveals oligomer content to provide a true representation of the sample
- High pore volume extracts maximum information from the analyte

ResiPore columns are the ideal choice for the analysis of resins, and condensation polymers with complex molecular weight distributions that include oligomer content. By combining a low 3 µm particle size and high pore volume, high efficiency ResiPore columns offer maximum resolution of these intermediate molecular weight polymers.

Characteristics

MW Range: 200 to 400,000 (g/mol)

Nominal Particle Size: 3 µm

Typical Efficiency: >80,000 p/m

Recommended Calibrants:
EasiCal PS-2 for rapid 10 point calibration, or EasiVial PS-M for convenient 10 point calibration in just 3 injections

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

ResiPore Columns

Description	Part No.
ResiPore, 300 x 7.5 mm	PL1113-6300
ResiPore Guard, 50 x 7.5 mm	PL1113-1300

Typical applications

Epoxy resins, polyester resins, silicone fluids, polyolefin waxes

Conditions
Columns: 2 x ResiPore, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 20 µL
Detector: UV, 254 nm

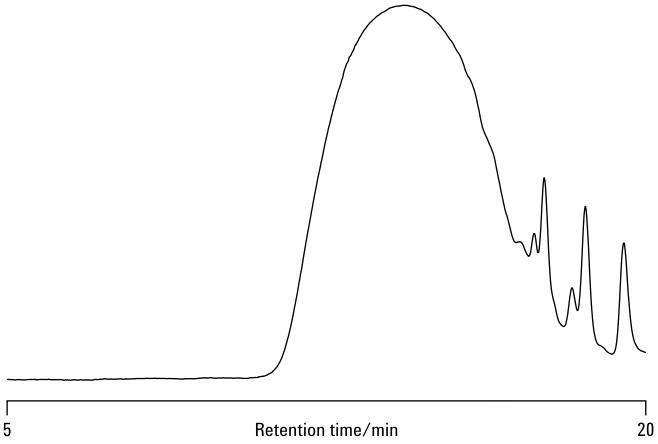


Figure 25. *Alkyd resin*

Conditions
Columns: 2 x ResiPore, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 20 µL
Detector: UV, 254 nm

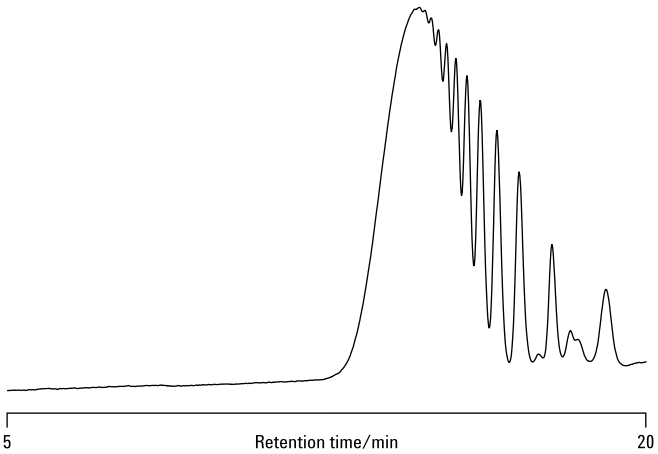


Figure 26. *Polyester*

Agilent MesoPore

Unsurpassed separation of prepolymers and low MW resins

- Full solvent compatibility with no detrimental effect on efficiency
- Low particle size extracts maximum information from the analyte
- No MWD dislocations so the distribution is a faithful representation of the sample

MesoPore columns have been specifically designed to give optimum results in the analysis of prepolymers, i.e. polymeric materials with a large oligomeric component. By combining a 3 µm particle size with high pore volume, MesoPore columns give the highest resolution separations for the analysis of low molecular weight polymers, such as prepolymers, resins, polyols and siloxanes.

Characteristics

MW Range: up to 25,000 (g/mol)

Nominal Particle Size: 3 µm

Typical Efficiency: >80,000 p/m

Recommended Calibrants:
Polystyrene S-L-10 Kit for rapid 10 point calibration, or the Polyethylene Glycol PEG-10 Kit for DMF

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

MesoPore Columns

Description	Part No.
MesoPore, 300 x 7.5 mm	PL1113-6325
MesoPore Guard, 50 x 7.5 mm	PL1113-1325

Typical applications

Prepolymers, resins, polyols, siloxanes

Conditions

Columns: 2 x MesoPore, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 20 µL
Detector: PL-GPC 50 (RI)

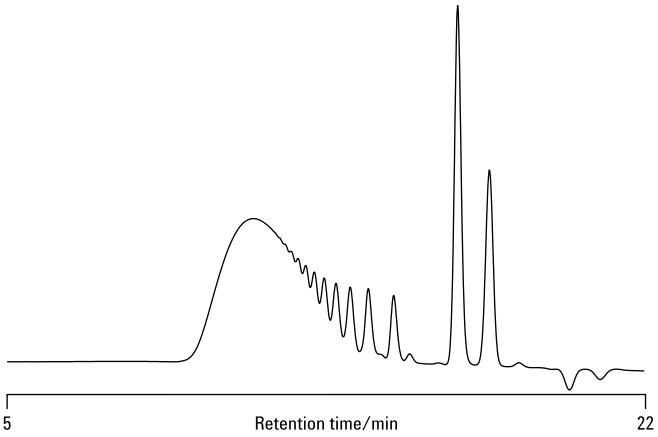


Figure 27. *Polyurethanes*

Conditions

Columns: 2 x MesoPore, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Inj Vol: 20 µL
Detector: PL-GPC 50 (RI)

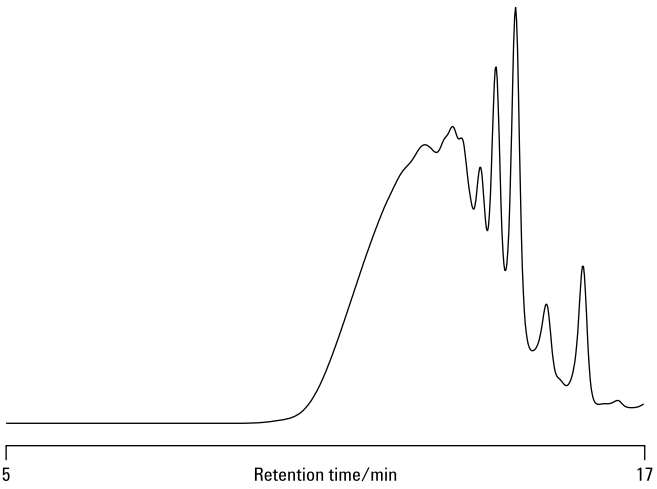


Figure 28. *Polyesterimide*

Agilent OligoPore

Excellent resolution of oligomeric samples with analytical and preparative columns

- Near linear calibration curve for best accuracy and precision
- Very stable media allows for a wide choice of solvents
- Isolation of individual fractions reveals more information from whole samples

OligoPore columns have been developed from an innovative new media that exhibits significantly increased pore volumes compared to conventional low pore size GPC columns. The outcome is higher resolution in the oligomeric region. The 300 x 25 mm preparative column offers high resolution at greatly increased loading for effective isolation of individual components. Oligomer fractions collected from the OligoPore preparative column can then be re-injected on analytical columns to check for the purity of the fractions and for comparison with the whole sample.

Characteristics

MW Range: up to 4,500 (g/mol)

Nominal Particle Size: 6 µm

Typical Efficiency: >55,000 p/m

Recommended Calibrants:
Individual MW polystyrenes – the first choice for many organic solvents

See publication 5990-7996EN, GPC/SEC Standards Product Guide

Ordering information

OligoPore Columns

Description	Part No.
OligoPore, 300 x 7.5 mm	PL1113-6520
OligoPore, 300 x 25 mm	PL1213-6520
OligoPore Guard, 50 x 7.5 mm	PL1113-1320

Typical applications

Polyurethanes, epoxy resins, polystyrenes

Conditions
Columns: 2 x OligoPore, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Detector: UV

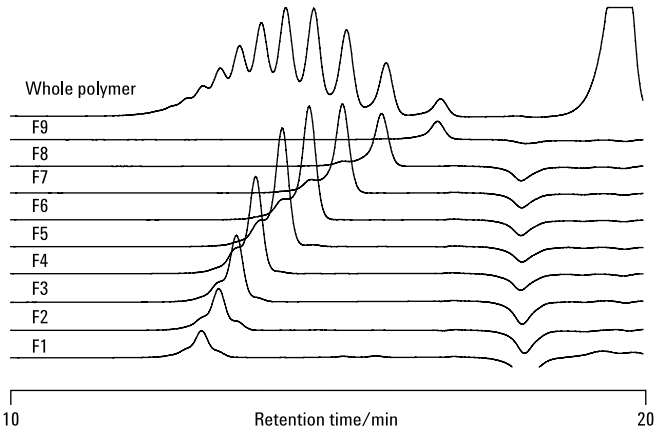


Figure 29. *Analysis of whole polymer and fractions collected from OligoPore preparative columns*

Conditions
Columns: 2 x OligoPore Analytical, 300 x 7.5 mm
Eluent: THF
Flow Rate: 1.0 mL/min
Loading: 0.2%, 100 mL
Detector: UV

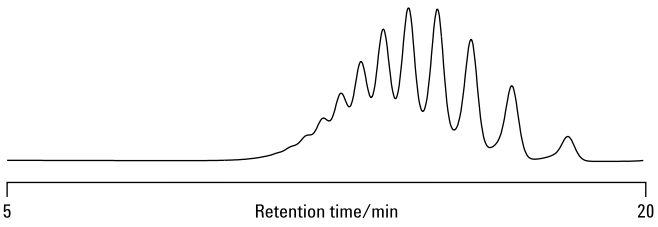


Figure 30. *Analytical separation*

Conditions
Columns: 2 x OligoPore Preparative, 300 x 25 mm
Eluent: THF
Flow Rate: 10.0 mL/min
Loading: 2.0%, 2 mL
Detector: UV

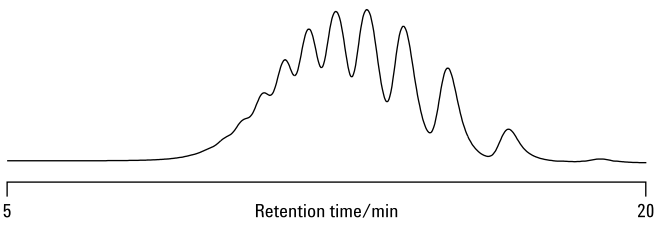


Figure 31. *Preparative separation*

Selection guide

GPC and SEC are liquid chromatographic techniques that separate individual polymer chains on the basis of their size in solution and not on their chemistry.

Gel permeation chromatography (GPC) and size exclusion chromatography (SEC) are techniques for measuring the molecular weight distribution of natural and synthetic polymers, a property that affects many of the physical parameters of materials such as strength, toughness and chemical resistance.

We use GPC to describe the analysis of polymers in organic solvents, such as tetrahydrofuran, and SEC to describe the analysis of polymers in water and water-based solvents, such as buffer solutions. GPC/SEC is the only established method for obtaining a comprehensive understanding of a polymer's molecular weight distribution.

How to use this selection guide

There are many columns available for the analysis of polymers by GPC/SEC. The purpose of this guide is to help you find a set of columns and conditions for the analysis of most common polymer types. A series of questions helps to narrow the choice down to the appropriate set. Some applications are not so easy to define and the required information may not be known, so consult your local expert in GPC/SEC for advice.

Mechanisms of GPC/SEC

- Polymer molecules dissolve in solution to form spherical coils with size dependent on molecular weight
- Polymer coils introduced to eluent flowing through a column
- Column packed with insoluble porous beads with well-defined pore structure
- Size of pores similar to that of polymer coils
- Polymer coils diffuse in and out of the pores
- Result is elution based on size – large coils first, smaller coils last
- Size separation converted to molecular weight separation by use of a calibration curve constructed by the use of polymer standards

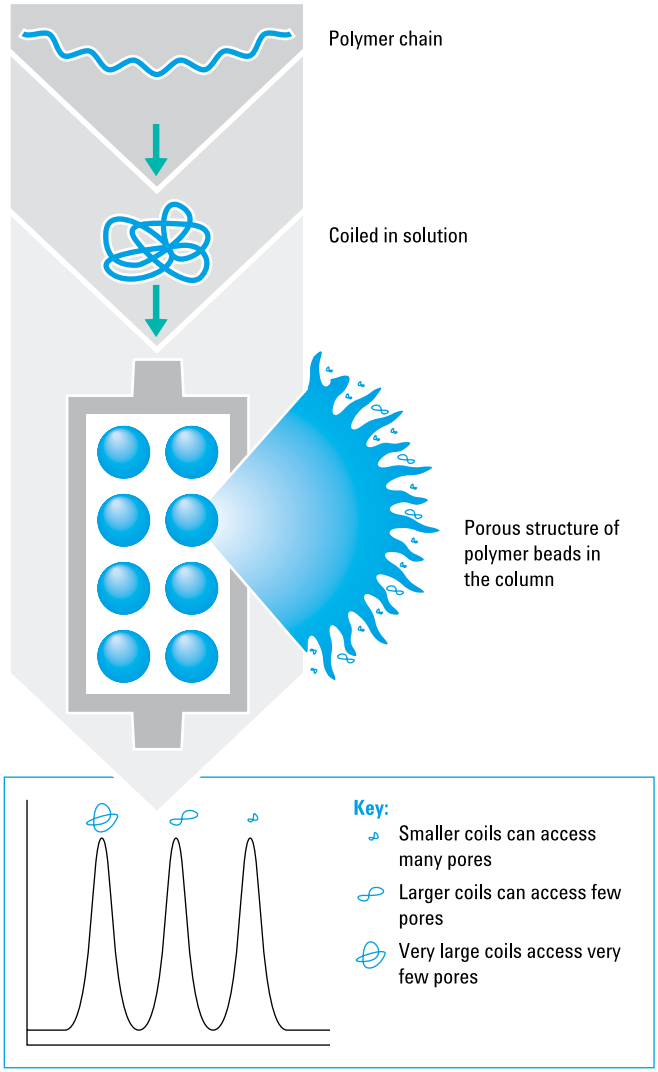


Figure 32. *Mechanism of Gel Permeation Chromatography/Size Exclusion Chromatography (GPC/SEC)*

Recommendations for setting up a GPC/SEC system

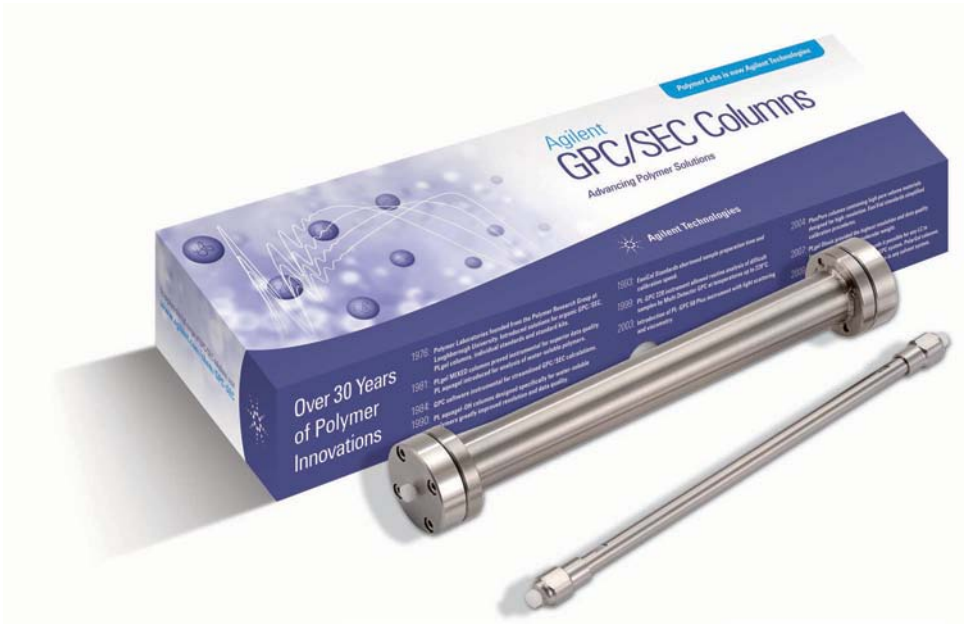
The following questions will help you find the recommended columns and standards for any given application, as well as system parameters such as injection volumes.

Choosing an eluent for GPC/SEC			
Question	**Answer**	**Recommendation**	**Comments**
1. What is the sample soluble in? Many polymers are only soluble in a small number of solvents. This is the key question when developing methods for analyzing polymers. The solvents mentioned here are all common eluents employed in GPC/SEC.	Typical organic solvent such as THF, chloroform, toluene	Agilent PLgel or Agilent PlusPore	PLgel are the workhorse columns, PlusPore columns are an alternative
	Organic/water mixtures or polar organics such as, DMF, NMP	Agilent PolarGel	PolarGel is a smaller column range than PLgel or PL aquagel-OH columns but is suited to mixtures of organics and water
	Water or water buffer with up to 50% methanol *(Covered in the Aqueous and polar GPC/SEC columns guide, publication 5990-7995EN)*	Agilent PL aquagel-OH	Best choice for water-based applications but cannot accommodate organics apart from methanol up to 50%

Choosing a column for organic GPC/SEC			
Question	**Answer**	**Recommendation**	**Comments**
2. What is the expected molecular weight? It may seem strange to ask this question, but in GPC/SEC the resolution of a column is related to the resolving range. Knowing something of the expected molecular weight of a sample helps to choose the best column that will give optimum results.	High (up to several millions)	**PLgel 10 µm MIXED-B** or PLgel 20 µm MIXED-A	The PLgel MIXED-A column resolves higher than the PLgel MIXED-B but at lower efficiency due to larger particle size
	Intermediate (up to hundreds of thousands)	**PLgel 5 µm MIXED-C** or PLgel 5 µm MIXED-D, PolyPore or ResiPore	The PLgel columns are the most widely applicable for the majority of applications; PolyPore and ResiPore columns are alternatives
	Low (up to tens of thousands)	**PLgel 3 µm MIXED-E** or MesoPore	The PLgel column provides high resolution and is designed for low molecular weight applications; the MesoPore column is an alternative
	Very low (a few thousand)	**OligoPore** or PLgel 3 µm 100Å	The OligoPore column is less prone to dispersion than the PLgel column, but both work well
	Unknown	**PLgel 5 µm MIXED-C** or PolyPore	This PLgel column is the most widely applicable for the majority of applications

Columns shown in bold are the best initial choice

Setting up the GPC/SEC system			
Question	**Answer**	**Recommendation**	**Comments**
3. How many columns to use? *The greater the particle size of the media in the column (which is dependent on the expected molecular weight of the samples), the lower the resolution and the more columns are required to maintain the quality of the results. For higher molecular weight samples, larger particles are necessary to reduce the danger of shear degradation of samples during analysis.*	Depends on the particle size of the columns	Particle size 20 µm use 4 columns Particle size 13 µm use 3 columns Particle size 10 µm use 3 columns Particle size 8 µm use 2 columns Particle size 5 µm use 2 columns Particle size 3 µm use 2 columns	Increased number of columns required for large particle sizes to make up for low efficiencies
Question	**Answer**	**Recommendation**	**Comments**
4. What size injection volume? *The injection volume required is dependent on the particle size of the column – smaller particles need lower injection volumes to minimize dead volume. Larger injection volumes allow the introduction of high molecular weight samples at lower concentrations, reducing viscosity and ensuring a quality chromatogram is obtained.*	Depends on the particle size of the columns	Particle size 20 µm use 200 µL injection Particle size 13 µm use 200 µL injection Particle size 10 µm use 200 µL injection Particle size 5 µm use 100 to 200 µL injection Particle size 3 µm use 20 µL injection	Smaller particle sizes require smaller loops to minimize band broadening



Typical polymer molecular weights

If you are unsure of the molecular weight of your sample, the table below shows some approximate molecular weight ranges for common polymers, which will help you select the right column for your application.

Polymer Type	Typical molecular weight of polymer	Typical polydispersity[1] of polymer
Polymers from free radical synthesis	High (up to several millions)	~ 2
	Intermediate (up to hundreds of thousands)	
Polymers from ionic synthesis	Intermediate (up to hundreds of thousands)	~ 1.01
	Low (up to tens of thousands)	
Polymers from addition synthesis	Intermediate (up to hundreds of thousands)	~ 2
	Low (up to tens of thousands)	
Polymers from controlled radical polymerization	Low (up to tens of thousands)	~ 1.1 to 1.5
	Very low (a few thousand)	
Polyolefins	Intermediate (up to hundreds of thousands)	~ 2 to 200
	High (up to several millions)	
Acrylates	Intermediate (up to hundreds of thousands)	~ 2
	High (up to several millions)	
Small molecule additives	Very low (a few thousand)	1
Pre-polymers	Low (up to tens of thousands)	~ 2 to 10
	Very low (a few thousand)	
Resins	Low (up to tens of thousands)	~ 2 to 10
	Very low (a few thousand)	
Natural biopolymers such as polysaccharides	Intermediate (up to hundreds of thousands)	~ 2 to 10
	High (up to several millions)	
Rubbers	Intermediate (up to hundreds of thousands)	~ 2 to 10
	High (up to several millions)	
Biodegradable polymers	Intermediate (up to hundreds of thousands)	~ 1.1 to 2
	Low (up to tens of thousands)	

[1] Polydispersity (Mw/Mn) is a measure of the distribution of molecular mass of a polymer

Further reading

GPC/SEC publication	Publication number
Application compendia	
Excipient analysis by GPC/SEC and other LC techniques	5990-7771EN
Biodegradable polymers - analysis of biodegradable polymers by GPC/SEC	5990-6920EN
Analysis of engineering polymers by GPC/SEC	5990-6970EN
Analysis of elastomers by GPC/SEC	5990-6866EN
Analysis of polyolefins by GPC/SEC	5990-6971EN
Low molecular weight resins - Analysis of low molecular weight resins and prepolymers by GPC/SEC	5990-6845EN
Primer	
An Introduction to Gel Permeation Chromatography and Size Exclusion Chromatography	5990-6969EN
Selection guide	
Quick guide for selecting columns and standards for gel permeation chromatography and size exclusion chromatography	5990-6868EN
Wallchart	
GPC/SEC Reference Guide	5990-6882EN
Product guides	
Aqueous and polar GPC/SEC columns	5990-7995EN
GPC/SEC standards	5990-7996EN

To download these publications visit www.agilent.com/chem/gpcsec

Agilent GPC/SEC Analysis Systems

For easy and reliable polymer characterization, turn to the Agilent 1260 Infinity GPC/SEC Analysis System. The isocratic solvent delivery system provides the constant, stable flow rate that is essential to maintain the high resolution of the GPC/SEC column. And with its high flow precision and excellent temperature stability, you can be confident of the highest accuracy and precision for your molecular weight determinations.

Agilent 1260 Infinity GPC/SEC Analysis System

The Agilent PL-GPC 50 Integrated GPC/SEC System is a standalone instrument containing all the components necessary for the analysis of a wide range of polymers. With pump, injection valve, column oven and optional degasser, as well as any combination of refractive index, light scattering and viscometry detectors, the PL-GPC 50 is an ideal choice when you are starting out in GPC or want the convenience of a single solution.

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