Aqueous and polar 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 PL aquagel-OH SEC columns

SEC with durability and versatility

Aqueous size exclusion chromatography (SEC) is widely used for the determination of molecular weight distributions of a variety of synthetic and naturally occurring water soluble polymers, and separations of oligomers and small molecules. The requirement to eliminate ionic and hydrophobic effects makes aqueous SEC very demanding.

The PL aquagel-OH series provides a chemically and physically stable matrix for reliable aqueous SEC separations. The columns are packed with macroporous copolymer beads with an extremely hydrophilic polyhydroxyl functionality. The "neutral" surface and the capability to operate across a wide range of eluent conditions provide for high performance analyses of compounds with neutral, ionic and hydrophobic moieties, alone or in combination. PL aquagel-OH is available for analytical and preparative 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

1260 Infinity GPC/SEC Multi Detector Suite and PolarGel columns
The 1260 Infinity MDS turns any LC into a powerful multi-detector GPC system, and PolarGel columns analyze polar samples in any solvent system

Agilent PL aquagel-OH SEC columns

Optimizing conditions for aqueous sec with PL aquagel-OH columns

Due to the complex nature of water soluble polymers, it is often necessary to modify the eluent in order to avoid sample-to-sample and sample-to-column interactions which can result in poor aqueous SEC separations. The excellent stability of the PL aquagel-OH packing material allows the eluent to be tailored to suit the polymer, while retaining the high column efficiency. For ionic interactions, the eluent can be modified by the addition of salt and/or the adjustment of pH. For water soluble polymers with a hydrophobic character, only the addition of a weak organic solvent (methanol) is required to inhibit hydrophobic interactions.

- **PL aquagel-OH Analytical Columns** – Available with mixed and individual pore sizes, and 5, 8 and 15 µm particle sizes, to cover a very wide range of molecular weights.
- **PL aquagel-OH Preparative Columns** – For rapid and convenient scale-up from analytical separations. The columns are packed with the same robust macroporous particles as the analytical column range

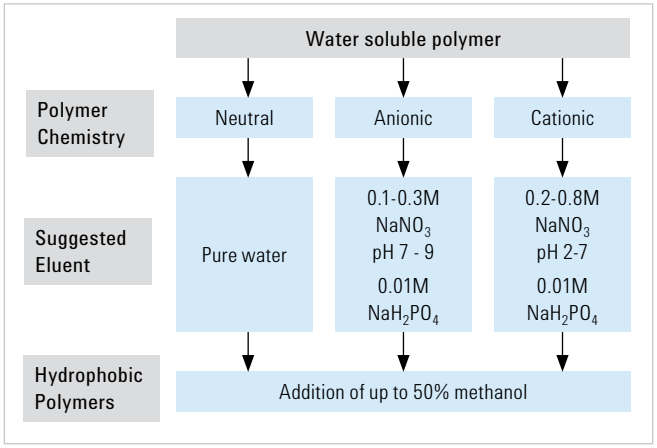

Figure 1. *Guide to eluent selection for PL aquagel-OH applications*

PL aquagel-OH column selection guide

Sample type	Typical applications	Recommended column sets
Low MW polymers and oligomers	Surfactants, oligosaccharides, PEGs, lignosulfonates, polyacrylates	Set of 2 or 3 PL aquagel-OH 30/20 PL aquagel-OH 8 µm, or PL aquagel-OH 20 5 µm, or PL aquagel-OH MIXED-M 8 µm
Polydisperse synthetic or naturally occurring polymers	Polysaccharides, PVA, cellulose derivatives, PEO, polyacrylic acid	2 or 3 PL aquagel-OH MIXED-H 8 µm, or PL aquagel-OH 60/50/40 8 µm
Very high MW polymers	Polyacrylamides, hyaluronic acids, CMC, starches, gums	PL aquagel-OH 60/50/40 15 µm in series

Tip: When using a set of columns containing different pore sizes, put the highest pore size first to reduce the viscosity in the system as early as possible to improve column lifetimes.

PL aquagel-OH SEC columns

High performance aqueous size exclusion chromatography

- Highly stable matrix ensures reliable separations, even with modified eluents
- MIXED columns cover a wide spread of molecular weights, simplifying column selection
- Highly versatile for neutral, polar, anionic and cationic samples

The PL aquagel-OH analytical series has a pH range 2 – 10, compatibility with organic solvent (up to 50% methanol), mechanical stability up to 140 bar (2030 psi) and low column operating pressures.

PL aquagel-OH MIXED 8 µm columns offer high resolution over a very wide range of molecular weight, simplifying column selection and providing a versatile analytical system.

PL aquagel-OH 20 5 µm columns are ideal for analysis of low MW polymers. The '20' column ensures maximum resolution for the analysis of low viscosity samples.

PL aquagel-OH 30 8 µm columns separate relatively low MW polymers, combining low exclusion limit, high pore volume and high column efficiency for maximum resolution.

PL aquagel-OH Individual Pore Size 8 µm columns are designed for high performance separations from 10,000 to >10,000,000. (g/mol PEG/PEO equiv.).

PL aquagel-OH 15 µm columns analyze very high MW polymers. Where molecular shear degradation is a consideration, the larger particle size and larger frit porosity permit the analysis of high viscosity polymers from 1 M to 100 M.

For molecular weight ranges of these columns, see page 7.

Tip Buffers in a stored column may crystallize out and cause damage, so flush out the column with water containing a small amount of sodium azide, to prevent biological growth.

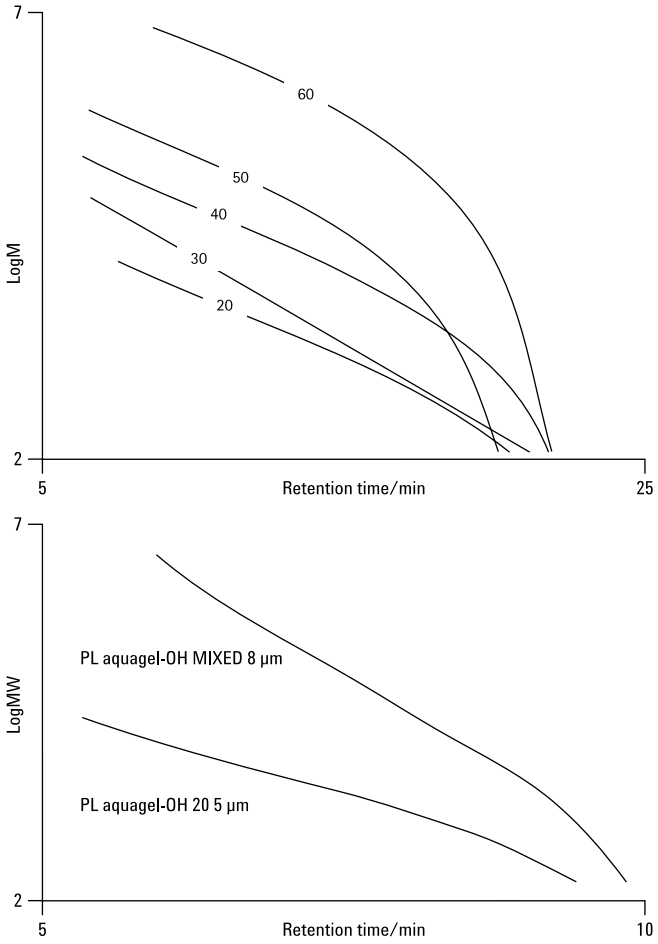

Figure 2. *PL aquagel-OH calibration curves*

PL aquagel-OH SEC columns

Typical applications

Heparin, gum, polyacrylic acid, polyacrylamide, pectin, dextran

Conditions

Columns:	3 x PL aquagel-OH MIXED 8 µm, 7.5 x 300 mm
Eluent:	0.2 M $NaNO_3$, 0.01 M NaH_2PO_4, pH 7
Flow Rate:	1.0 mL/min
Detector:	PL-GPC 50 (RI)

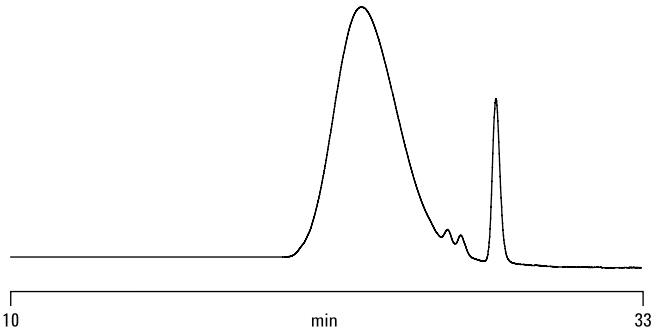

Figure 3. *Polyvinyl alcohol*

Conditions

Columns:	2 x PL aquagel-OH 30 8 µm, 7.5 x 300 mm
Eluent:	0.2 M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate:	1.0 mL/min
Detector:	PL-GPC 50 (RI)

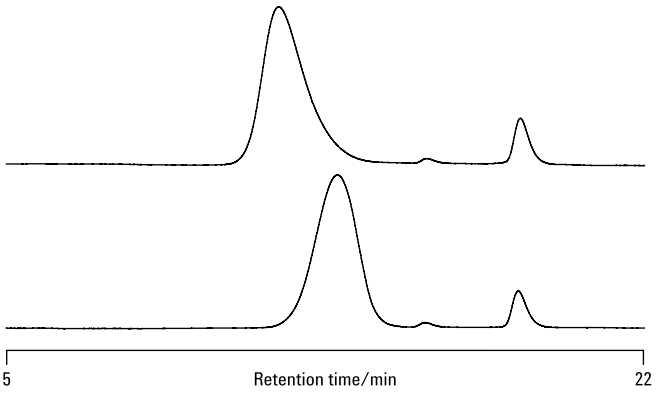

Figure 4. *Heparin*

Conditions

Columns:	PL aquagel-OH 60 15 µm, 7.5 x 300 mm PL aquagel-OH 40 15 µm, 7.5 x 300 mm
Eluent:	0.2 M $NaNO_3$, 0.01 M NaH_2PO_4, pH 7
Flow Rate:	1.0 mL/min
Detector:	PL-GPC 50 (RI)

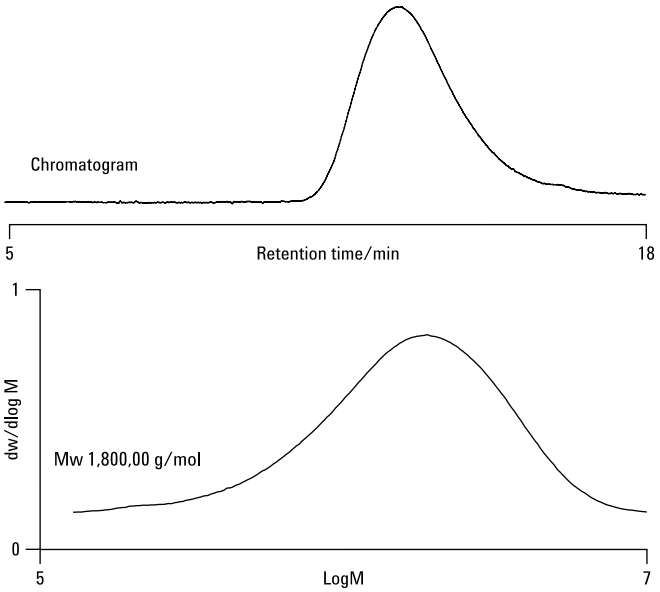

Figure 5. *Hyaluronic acid*

Conditions

Columns:	2 x PL aquagel-OH 20 5 µm, 7.5 x 300 mm
Eluent:	0.25 M ammonium formate in water
Flow Rate:	1.0 mL/min
Inj. Vol:	20 µL
Software:	Agilent GPC/SEC software
Detector:	Agilent ELS (neb = 30 °C, evap = 30 °C, gas = 1.4 SLM)

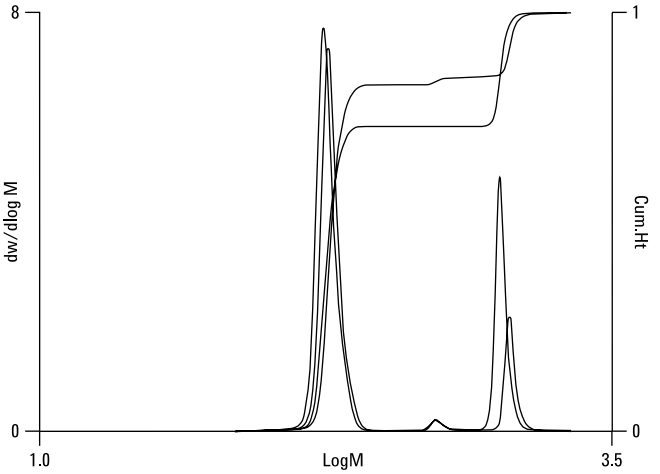

Figure 6. *Differences in composition of two alkyl naphthalene sulfonates*

PL aquagel-OH SEC columns

Ordering information

PL aquagel-OH Columns, 7.5 x 300 mm

Description	Particle size (µm)	MW range (g/mol) (PEG/PEO)	Guaranteed Efficiency (p/m)	Part No.
PL aquagel-OH 20	5	100 to 20,000	>55,000	PL1120-6520
PL aquagel-OH 30	8	100 to 60,000	>35,000	PL1120-6830
PL aquagel-OH 40	8	10,000 to 200,000	>35,000	PL1149-6840
PL aquagel-OH 40	15	10,000 to 200,000	>15,000	PL1149-6240
PL aquagel-OH 50	8	50,000 to 600,000	>35,000	PL1149-6850
PL aquagel-OH 50	15	50,000 to 600,000	>15,000	PL1149-6250
PL aquagel-OH 60	8	200,000 to 10,000,000	>35,000	PL1149-6860
PL aquagel-OH 60	15	200,000 to 10,000,000	>15,000	PL1149-6260
PL aquagel-OH MIXED-H	8	6,000 to 10,000,000	>35,000	PL1149-6800
PL aquagel-OH MIXED-M	8	1,000 to 500,000	>35,000	PL1149-6801

Ordering information

PL aquagel-OH Analytical 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
Column Connecting Nuts, 1/16 in. Tube	5	PL1310-0007
Tubing Ferrules, 1/16 in. Tube	5	PL1310-0008
LDV Intercolumn SS Connector	1	PL1310-0005
Connecting Tubing, 10 cm length, 0.01 in. id	10	PL1310-0048

Ordering information

PL aquagel-OH Guard Columns

Description	Particle size (µm)	id (mm)	Length (mm)	Part No.
PL aquagel-OH Guard	10	25.0	25	PL1249-1120
PL aquagel-OH Guard	5	7.5	50	PL1149-1530
PL aquagel-OH Guard	8	7.5	50	PL1149-1840

See also

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

PL aquagel-OH preparative SEC columns

Rapid and convenient scale-up

- Up to 10 x scale-up maximizes yield
- High loading maximizes sample throughput
- Carefully chosen particle size provides optimum resolution

Preparative SEC is used for the fractionation of a wide variety of water soluble samples based on their size in solution. The technique is applied to the fractionation of disperse polymers or to isolate components in a polymer formulation.

Preparative PL aquagel-OH columns and associated guard columns enable rapid and convenient scale-up from analytical separations. The 25 mm id prep column offers at least a x10 scale-up in loading from the 7.5 mm id analytical columns. Typically, a 10 mL/min flow rate results in a separation time of ten minutes with a 300 mm column. The columns are packed with the same robust macroporous particles as the analytical column range. The 8 µm particle size provides optimum resolution and loading characteristics with column efficiency >20,000 plates/m.

See also

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

Typical applications

Fractionation of disperse polymers, component isolation

Conditions

Column:	PL aquagel-OH 40 8 µm, 25 x 300 mm
Eluent:	0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate:	10.0 mL/min
Loading:	10 mg/mL, 2 mL
Detector:	PL-GPC 50 (RI)

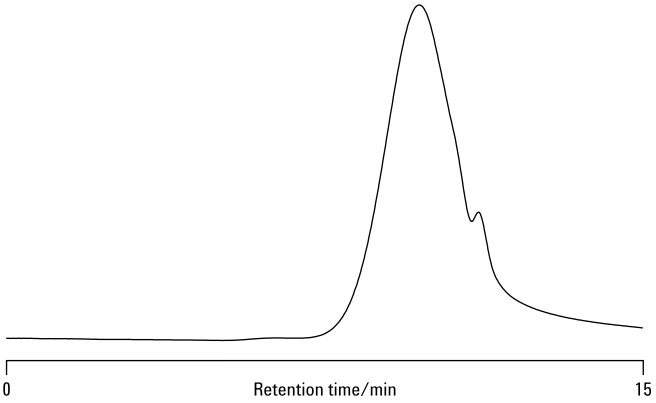

Figure 7. *Polyvinyl alcohol*

Ordering information

PL aquagel-OH Preparative Columns 8 µm, 25 x 300 mm

Description	MW range (g/mol) (PEG/PEO)	Part No.
PL aquagel-OH 30	100 to 60,000	PL1220-6130
PL aquagel-OH 40	10,000 to 200,000	PL1249-6140
PL aquagel-OH 50	50,000 to 600,000	PL1249-6150
PL aquagel-OH MIXED	6,000 to 10,000,000	PL1249-6100
PL aquagel-OH Guard, 25 x 25 mm		PL1249-1120

Agilent PolarGel GPC columns

For intermediate polarity solvents and polar solvent combinations

The PolarGel range is ideal for use with polar solvents, for example dimethyl formamide and dimethyl sulfoxide, and for solvent combinations such as tetrahydrofuran with water. These eluents are very useful in GPC/SEC to separate polar materials, such as polar resins, modified polysaccharides or complex polar polymers that are difficult to analyze in traditional SEC solvents, such as tetrahydrofuran alone. PolarGel-L is used for low molecular weight polar polymers and PolarGel-M for high MW polar polymers.

With polar polymers, highly polar groups can lead to non-specific interactions and secondary separation mechanisms when using polar solvents and traditional non-polar styrene/divinylbenzene columns. Additives and/or column conditioning are normally required to reduce these interactions. PolarGel has no need for these interventions, and also avoids the interactions and secondary effects that produce chromatogram distortions.

These PolarGel "mixed bed" columns have a medium polarity surface and high mechanical stability. They are capable of operating in a wide range of solvents and solvent combinations, greatly enhancing your ability to analyze polar polymers that are not necessarily water soluble. PolarGel is available in two resolving ranges to meet your precise requirements.

Charateristics

PolarGel-L
Particle Size: 8 µm
Resolving Range (PEG/PEO in water): Up to 60,000 g/mol

PolarGel-M
Particle Size: 8 µm
Resolving Range (PEG/PEO in water): Up to 500,000 g/mol

Conditions

Columns:	2 x PolarGel-M, 7.5 x 300 mm
Sample:	Melamine resins
Eluent:	Dimethylformamide + 0.1% LiBr
Flow Rate:	1.0 mL/min
Temp:	50 °C
Detector:	PL-GPC 50 (RI)

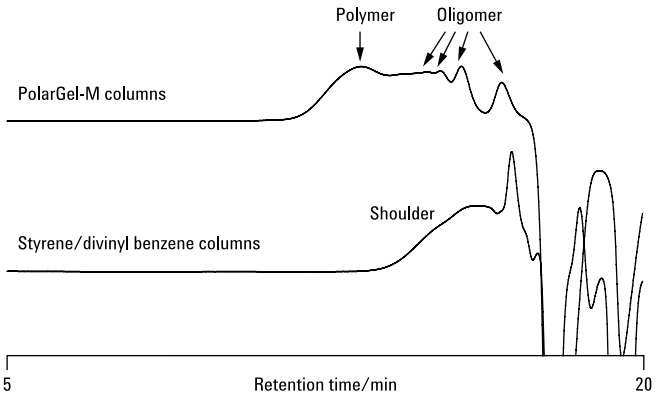

Figure 8. *Superior polar performance from PolarGel columns*

PolarGel-L

For analysis of low molecular weight polymers in polar solvents

- Specifically designed for polar samples
- Mixed bed technology delivers near linear calibrations for greater accuracy
- Mechanical stability for longer column lifetimes

See also

- EasiVial PEG/PEO and PMMA Standards, pre-weighed to save time, publication 5990-7996EN

Typical applications

Melamines, polar resins and polar pre-polymers

Conditions

Columns:	2 x PolarGel-L, 7.5 x 300 mm
Eluent:	Dimethylacetamide + 0.1% LiBr
Flow Rate:	1.0 mL/min
Inj Vol:	100 µL
Temp:	50 °C
Detector:	PL-GPC 50 (RI)

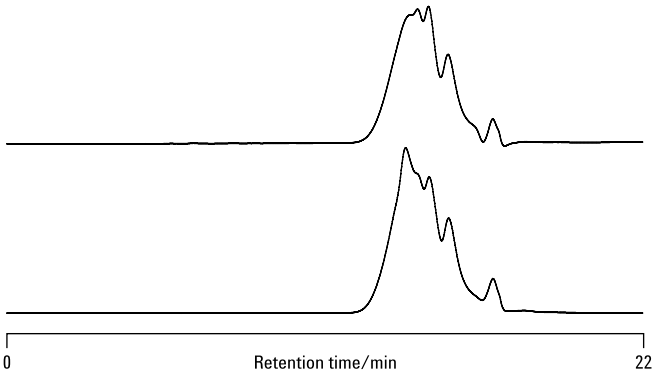

Figure 9. *Two samples of melamine resin analyzed by PolarGel-L*

Ordering information

PolarGel-L Columns

Description	Part No.
PolarGel-L, 7.5 x 300 mm	PL1117-6830
Frit Removal Tool for Threaded Columns only	PL1310-0001
End Fitting for Threaded Columns, 7.5 mm id	PL1310-0004
Frit (5 µm) Kit for Threaded Columns, 7.5 mm id (5/pk)	PL1310-0012
Column Connecting Nuts (Pk of 5), 1/16 in. (5/pk)	PL1310-0007
Tubing Ferrules (Pk of 5), 1/16 in. (5/pk)	PL1310-0008
Column End Plugs (Pk of 10), 1/16 in. (10/pk)	PL1310-0003
LDV Intercolumn SS Connector	PL1310-0005
PolarGel-L Repair Gel	PL1417-0830
PolarGel-L Guard Column, 7.5 x 50 mm	PL1117-1830

PolarGel-M

For analyzing a wide range of polymers in polar solvents

- Optimized pore size distribution and particle size for superior resolution
- Mixed bed technology simplifies column selection
- No sample and stationary phase interaction for accurate MW measurement

See also

- EasiVial PEG/PEO and PMMA Standards, pre-weighed to save time, publication 5990-7996EN

Ordering information

PolarGel-M Columns

Description	Part No.
PolarGel-M, 7.5 x 300 mm	PL1117-6800
Frit Removal Tool for Threaded Columns only	PL1310-0001
End Fitting for Threaded Columns, 7.5 mm id	PL1310-0004
Frit (5 µm) Kit for Threaded Columns, 7.5 mm id (5/pk)	PL1310-0012
Column Connecting Nuts, 1/16 in. Tube (5/pk)	PL1310-0007
Tubing Ferrules, 1/16 in. Tube (5/pk)	PL1310-0008
Column End Plugs, 1/16 in. (10/pk)	PL1310-0003
LDV Intercolumn SS Connector	PL1310-0005
PolarGel-M Repair Gel	PL1417-0800
PolarGel-M Guard Column, 7.5 x 50 mm	PL1117-1800

Tip: Filter samples through a 0.45 µm filter prior to injection to extend column lifetime.

Typical applications

Phenol formaldehyde resins and lignins

Conditions

Columns:	2 x PolarGel-M, 7.5 x 300 mm
Eluent:	0.2% (w/v) DMF & 0.1% LiBr to reduce sample aggregation
Flow Rate:	1.0 mL/min
Inj Vol:	100 µL
Temp:	50 °C
Detector:	PL-GPC 50 (RI)

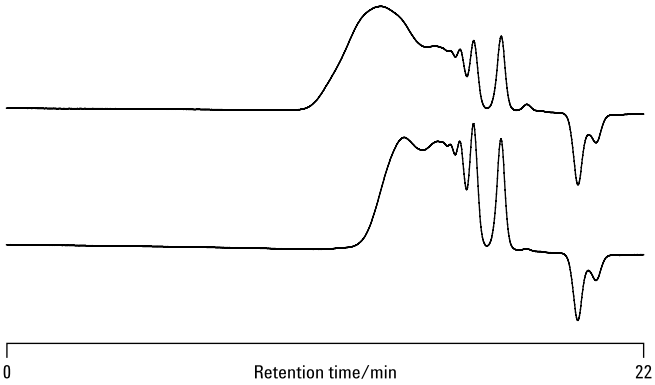

Figure 10. *Excellent separation of two phenol formaldehyde resins with PolarGel-M*

Agilent PL Rapide

Fast separations for high turnaround or when analyzing many samples

- Analysis of water-soluble polymers 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 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 and H versions for lowand high molecular weights.

Ordering information

PL Rapide Columns

Description	MW range (g/mol)	Guaranteed efficiency (p/m)	Part No.
PL Rapide Aqua H, 7.5 x 150 mm	6,000 to 10,000,000	>35,000	PL1149-3800
PL Rapide Aqua H, 10 x 100 mm	6,000 to 10,000,000	>35,000	PL1049-2800
PL Rapide Aqua L, 7.5 x 150 mm	100 to 60,000	>35,000	PL1120-3830
PL Rapide Aqua L, 10 x 100 mm	100 to 60,000	>35,000	PL1020-2830

Typical applications

Sodium acrylate

Conditions

Column:	PL Rapide Aqua H, 7.5 x 150 mm
Eluent:	Water + 0.2 M $NaNO_3$, 0.01 M NaH_2PO_4, pH 7
Flow rate:	1.0 mL/min
Detector:	PL-GPC 50

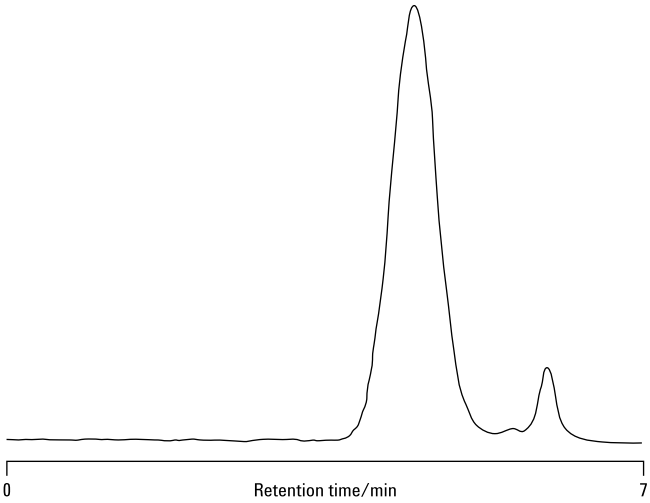

Figure 11. *Sodium acrylate*

See also

- More PL Rapide columns and applications, publication 5990-7994EN

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

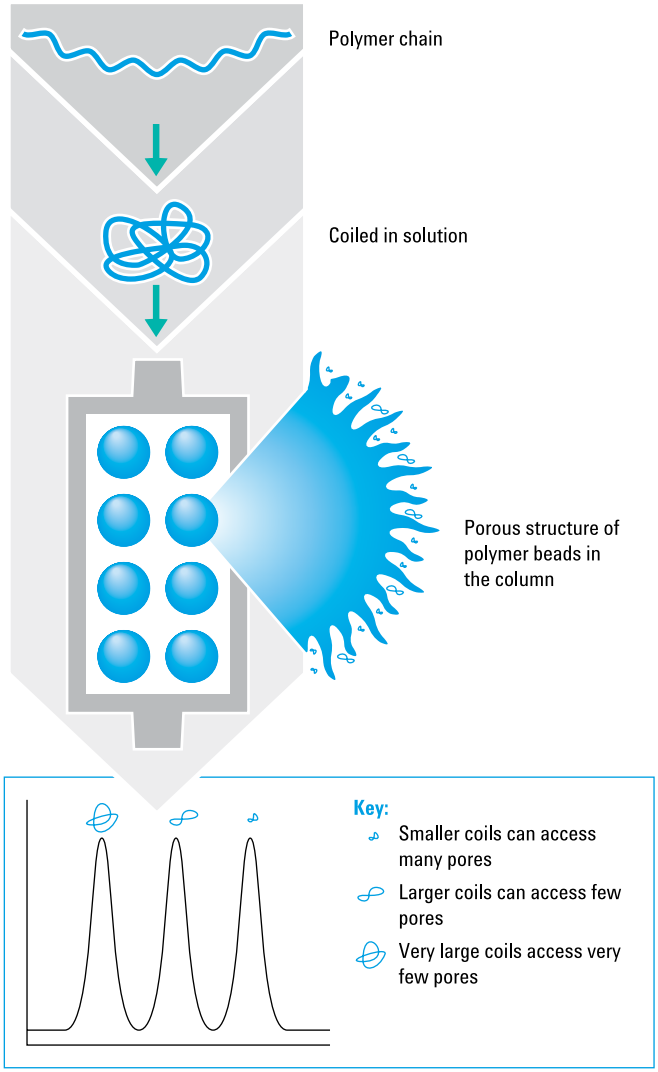

Figure 12. *Mechanism of gel permeation chromatography/size exclusion chromatography (GPC/SEC)*

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.	Water or water buffer with up to 50% methanol	Agilent PL aquagel-OH	Best choice for water-based applications but cannot accommodate organics apart from methanol up to 50%
	Organic/water mixtures or polar organics such as, DMF, NMP *(Covered in the Organic GPC/SEC columns guide, publication 5990-7994EN)*	Agilent PolarGel	PolarGel is a smaller column range than PLgel or PL aquagel-OH columns but is suited to mixtures of organics and water

Choosing a column for 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)	***Aqueous solvents*** PL aquagel-OH MIXED-H 8 µm or combination of PL aquagel-OH 40 and 60 15 µm	The 15 µm column combination is best only where sample viscosity is very high, otherwise 8 µm columns give greater resolution
		Mixed solvents PolarGel	No PolarGel column available for this molecular weight range. Contact your local GPC/SEC expert for advice
	Intermediate (up to hundreds of thousands)	***Aqueous solvents*** PL aquagel-OH MIXED-M 8 µm	A wide-ranging column that covers most water-soluble polymers
		Mixed solvents PolarGel-M	Covers most applications
	Low (up to tens of thousands)	***Aqueous solvents*** Combination of PL aquagel-OH 40 and PL aquagel-OH 30 8 µm	These two columns in a combined set cover the low end of the molecular weight range
		Mixed solvents PolarGel-L	For low molecular weight applications
	Very low (a few thousand)	***Aqueous solvents*** PL aquagel-OH 20 5 µm	This high-performance column gives high resolution at low molecular weight
		Mixed solvents PLgel	No PolarGel column covers this range so use PLgel columns as alternatives
	Unknown	***Aqueous solvents*** PL aquagel-OH MIXED-M 8 µm	Covers the molecular weight ranges of most polymer samples
		Mixed solvents PolarGel-M	Covers the majority of applications

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	Increased number of columns required for large particle sizes to make up for low efficiencies
		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	
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	Smaller particle sizes require smaller loops to minimize band broadening
		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	

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)	
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)	
Natural biopolymers such as polysaccharides	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 is a measure of the distribution of molecular mass of a polymer (Mw/Mn)

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Further reading

GPC/SEC publication	Publication number
Application compendia	
Analysis of polymers by GPC/SEC - energy & chemicals applications	5991-2517EN
Analysis of polymers by GPC/SEC - food applications	5991-2029EN
Analysis of polymers by GPC/SEC - pharmaceutical applications	5991-2519EN
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
Primers	
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