Chromatography Products
from Polymer Laboratories
Now a part of Varian, Inc.

GPC/SEC Columns & Standards

Instrumentation & Software for
Polymer & Materials Characterization

Evaporative Light
Scattering Detectors

Polymeric HPLC Columns & Media

Polymer Laboratories
Now a part of Varian, Inc.

VARIAN

ISSUE 5 2008

Polymer Laboratories, now a part of Varian, Inc.
A Customer Orientated Company

This catalog has been designed as an easy to use guide to Polymer Laboratories' range of chromatographic columns, standards, media, instrumentation and software.

For further information, please visit our website at www.polymerlabs.com for product news and specifications, company news, PL's Distributor directory, forthcoming seminars, job vacancies, etc.

State of the Art Chemical Engineering

To meet customer demand, Polymer Laboratories opened its new, state of the art chemical engineering production plant in 2002, and established its place as one of the world's largest suppliers of high performance polymeric particles. This ensures consistent, reliable supply of top quality chromatographic products to our customers.

ISO 9001:2000 Standard

Polymer Laboratories has recently been recognized as a customer-focussed company by the receipt of the enhanced customer satisfaction standard, ISO 9001:2000 Standard.

New Products for 2008
See pages 2 and 49

Contacting Varian and Varian Polymer Laboratories

UK / International

Polymer Laboratories
(for GPC/instrumentation)
Now a part of Varian, Inc.
Church Stretton, UK
Tel: (+44) 01694 723581
Email: Sales@polymerlabs.com

Varian Ltd
(for HPLC columns & media)
Yarnton, UK
Tel: (+44) 01865 291500
Email: uk.consumablesales@varianinc.com

For your local sales office, please contact Varian Polymer Laboratories at Church Stretton or Varian Export Department at Varian B.V., Middelburg, NL.

North America

Polymer Laboratories
Varian, Inc.
(for GPC/instrumentation)
Amherst, USA
Tel: toll free 800 767 3963
Or tel: 413 253 9554
Email: SalesUS@polymerlabs.com

Varian, Inc.
(for HPLC columns & media)
Lake Forest, USA
Tel: 800 854 0277
Or tel: 949 770 9381
Email: helpdesk.us@varianinc.com

Australia

Varian Australia Pty. Ltd
Tel: (+61) 03 9560 7133
Email: sales.Australia@varianinc.com

Belgium

Varian Belgium NV SA
Tel: (+32) 015 556460
Email: varian.belgie@varianinc.com

France

Varian S.A.
Tel: (+33) 01 69 86 38 64
Email: fr.consommables@varianinc.com

Germany

Varian Deutschland GmbH
Tel: (+49) 06151 703292
Email: analyticalsupplies.de@varianinc.com

Italy

Varian S.p.A
Tel: (+39) 011 997 9317
Email: consumable.products.it@varianinc.com

The Netherlands

Varian B.V.
Tel: (+31) 011 8671500
Email: varian.nederland@varianinc.com

Spain

Varian Ibérica S.L.
Tel: (+34) 091 472 7612
Email: consumibles.es@varianinc.com

Sweden

Varian AB
Tel: (+46) 08 555 36 200
Email: se.info@varianinc.com

Contents

GPC/SEC Columns & Standards

Instrumentation

HPLC Columns & Media

New Products for 2008

Varian Polymer Laboratories has introduced new GPC/SEC columns to expand our product offering to you.

PolarGel-M Columns for the Analysis of Polymers Soluble in Polar Solvents

PolarGel-M columns for GPC benefit from a polarity intermediate between PLgel (for organic GPC) and PL aquagel-OH (for aqueous SEC), making them ideal for use with polar solvents and in applications which fall between these two products.

Key benefits include:

- Balanced hydrophobic and hydrophilic surfaces for polar compound selectivity
- No interaction between sample and stationary phase, ensuring accurate measurement of molecular weights
- Low swell and high mechanical stability, ensuring longer column lifetimes

Ordering Information

Product	Part No.
PolarGel-M, 300 x 7.5 mm	PL1117-6800
PolarGel-M Guard, 50 x 7.5 mm	PL1117-1800

PLgel Olexis Columns for the Analysis of Polyolefins

PLgel Olexis is the optimum column choice for the analysis of very high molecular weight polymers such as polyolefins. This new column has been designed by Varian Polymer Labs specifically for the analysis of this important class of plastics. PLgel Olexis resolves up to 100,000,000 g/mol (polystyrene in THF). Packed with 13μm particles for maximum resolution with minimal shear, the columns also operate up to 220°C for the analysis of highly crystalline materials.

Key benefits include:

- No shear degradation provides a true reflection of the sample
- High resolving range, to include all engineering polymers
- One column for all polyolefin applications

Ordering Information

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

PL aquagel-OH 20 / PL aquagel-OH 10

The PL aquagel-OH range of columns from Polymer Laboratories is specifically designed for the analysis of water soluble polymers by size exclusion chromatography. In recognition of the success of the range, PL has further extended the selection of columns available by introducing the PL aquagel-OH 20 and PL aquagel-OH 10 8 μm columns. These high resolution columns have exclusion limits of 20,000 g/mol and 10,000 g/mol respectively, and are designed for the analysis of low molecular weight polymers.

In addition, Varian Polymer Laboratories has launched an ultra-high resolution 5μm column for very high resolution analyses, the PL aquagel-OH 20 5μm, 300 x 7.5mm.

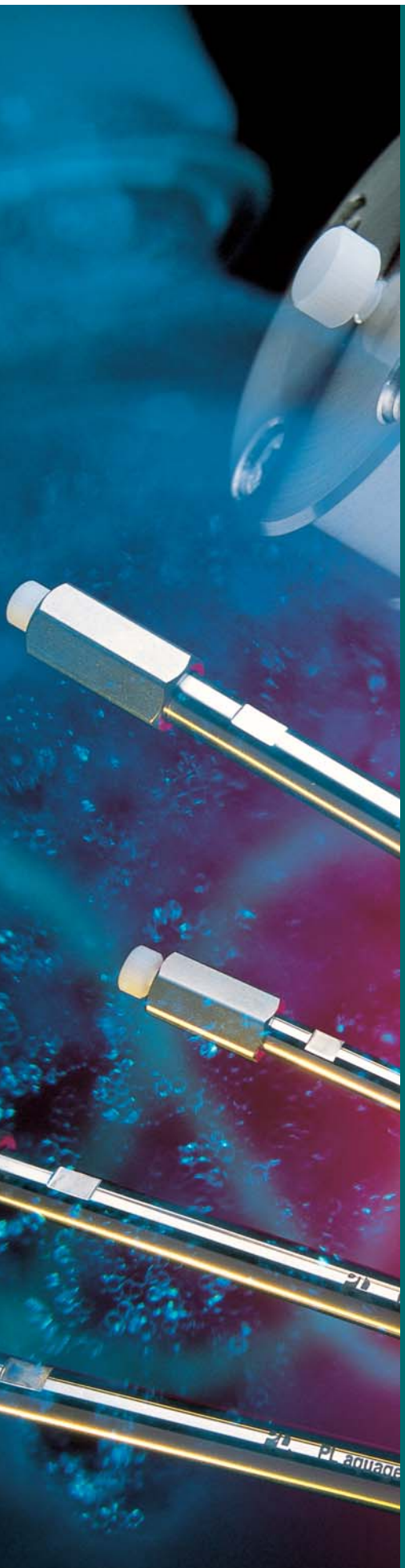
The inclusion of these columns makes the PL aquagel-OH range truly comprehensive for aqueous SEC.

Ordering Information

Product	Part No.
PL aquagel-OH 20 8μm, 300 x 7.5 mm	PL1149-6820
PL aquagel-OH 10 8μm, 300 x 7.5 mm	PL1149-6810
PL aquagel-OH 20 5μm, 300 x 7.5 mm	PL1120-6520

For information about new polymer standards products, see page 49.

Columns for Organic GPC



Gel Permeation Chromatography (GPC) is a high performance liquid chromatography technique for the separation of components based on their molecular size in solution. It is widely used as a means of characterizing the molecular weight distribution of polymers, and can also be employed for the separation of discrete components.

Polymer Laboratories offers a comprehensive range of organic GPC columns for optimum performance and reliability, and long column lifetimes, even under the most severe operating conditions.

PlusPore - *NEW* High Resolution Columns for Organic GPC

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 crosslinked polystyrene/divinylbenzene (PS/DVB), for the widest applicability and solvent compatibility. Each is made using a novel polymerization process to produce particles which exhibit a specific, controlled pore structure for optimum GPC performance.

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

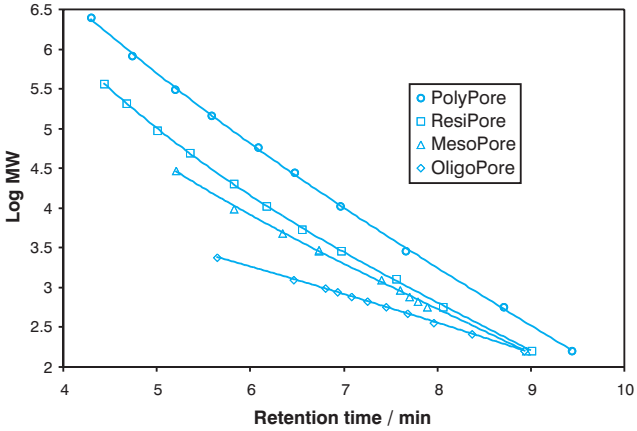
The Ideal Choice for Polymer Analysis

For high resolution polymer analysis, the PolyPore, ResiPore, MesoPore and OligoPore columns of the PlusPore product range 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. This results in very high resolution GPC columns designed for specific application areas. The highly crosslinked 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 artefacts in the shape of the molecular weight distribution.

Features and Benefits of the PlusPore Range

- High pore volume, high resolution
- Wide pore size distribution
- Optimized separation range
- Full solvent compatibility
- No MWD dislocations

PlusPore Calibration Curves



PlusPore High Resolution Columns - Specifications

	PolyPore	ResiPore	MesoPore	OligoPore
MW Operating Range	200-2,000,000	200-400,000	Up to 25,000	Up to 4,500
Nominal Particle Size	5µm	3µm	3µm	6µm
Typical Column Efficiency	>60,000 p/m	>80,000 p/m	>80,000 p/m	>55,000 p/m
Recommended Calibrants	EasiCal PS-1 or EasiVial	EasiCal PS-2	Polystyrene S-L-10 Kit Polyethylene Glycol PEG-10 Kit for DMF	Individual MW Polystyrenes

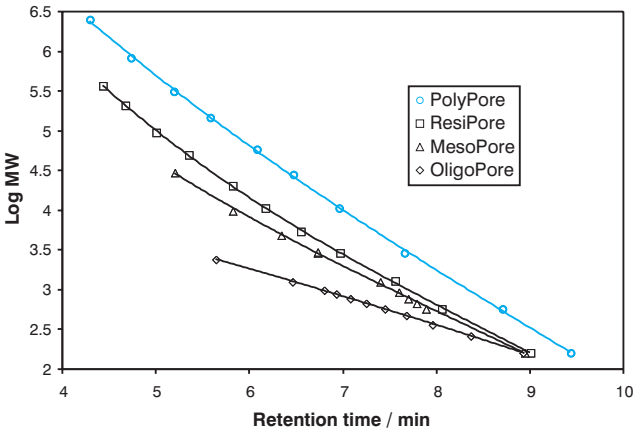
PolyPore - for the Routine Analysis of General Polymers

Typical Applications

- **Polystyrenes**
- **Polycarbonates**
- **Polyurethanes**
- **Polysiloxanes**

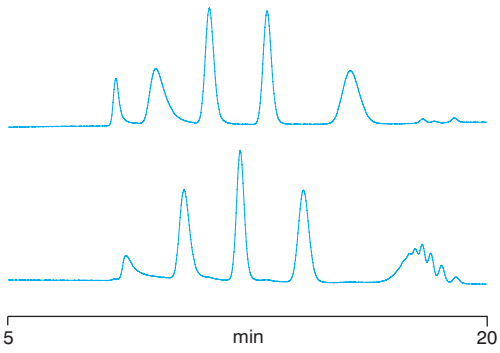
PolyPore columns have been specifically developed to give unrivalled resolution for the analysis of polymers with broad molecular weight distributions. With a wide operating range covering many decades of molecular weight, PolyPore columns combine a low 5µm particle size with extremely high pore volume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

PlusPore Calibration Curves



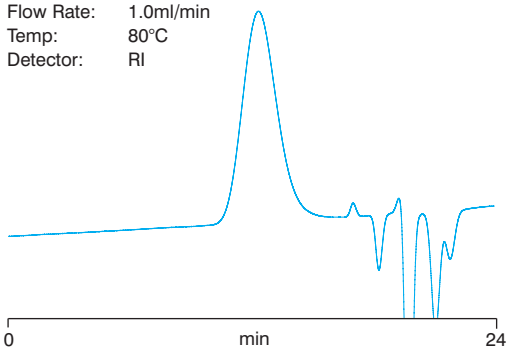
Polystyrene Standards

Sample: EasiCal PS-1
Columns: 2xPolyPore, 300x7.5mm (PL1113-6500)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm



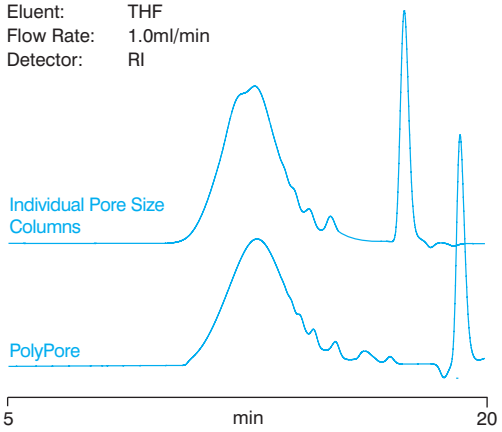
Polymethylmethacrylate in DMF

Sample: Commercial PMMA
Columns: 2xPolyPore, 300x7.5mm (PL1113-6500)
Eluent: 0.1% LiBr in DMF
Flow Rate: 1.0ml/min
Temp: 80°C
Detector: RI



Comparison of PolyPore with Conventional Individual Pore Size GPC Columns

Sample: High MW Resin
Columns: 2xPolyPore, 300x7.5mm (PL1113-6500)
PLgel 5µm 10^3Å, 300x7.5mm (PL1110-6530)
PLgel 5µm 10^5Å, 300x7.5mm (PL1110-6550)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Specifications

MW Operating Range	200-2,000,000
Nominal Particle Size	5µm
Typical Column Efficiency	>60,000 p/m
Recommended Calibrants	EasiCal PS-1 or EasiVial

Product	**Part No.**
PolyPore, 300x7.5mm	PL1113-6500
PolyPore, 250x4.6mm	PL1513-5500
PolyPore Guard, 50x7.5mm	PL1113-1500
PolyPore Guard, 50x4.6mm	PL1513-1500

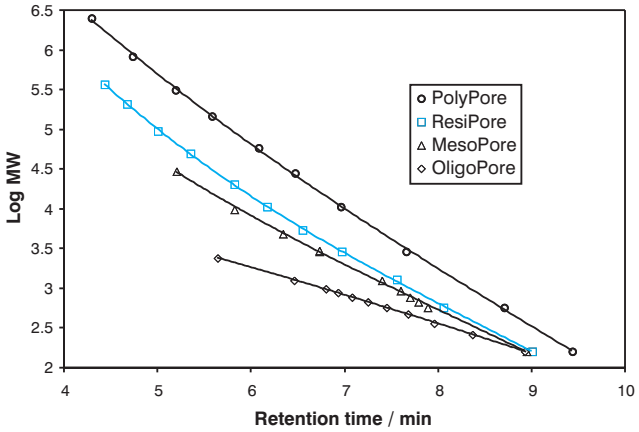
ResiPore for the Analysis of Resins and Condensation Polymers

Application Areas

- Epoxy resins
- Polyester resins
- Silicone fluids
- Polyolefin waxes

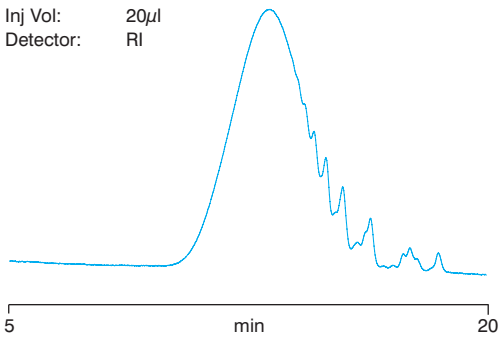
ResiPore columns are the ideal choice for the analysis of resins and condensation polymers with complex molecular weight distributions including oligomer content. By combining a low 3µm particle size and high pore volume, high efficiency ResiPore columns give the maximum resolution for the analysis of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

PlusPore Calibration Curves



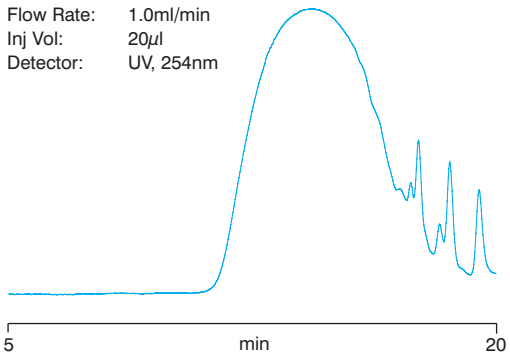
Epoxy Resin

Columns: 2xResiPore, 300x7.5mm (PL1113-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: RI



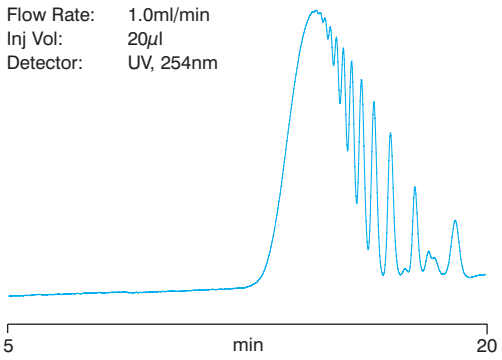
Alkyd Resin

Columns: 2xResiPore, 300x7.5mm (PL1113-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: UV, 254nm



Polyester

Columns: 2xResiPore, 300x7.5mm (PL1113-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: UV, 254nm



Specifications

MW Operating Range	200-400,000
Nominal Particle Size	3µm
Typical Column Efficiency	>80,000 p/m
Recommended Calibrants	EasiCal PS-2

Product	**Part No.**
ResiPore, 300x7.5mm	PL1113-6300
ResiPore, 250x4.6mm	PL1513-5300
ResiPore Guard, 50x7.5mm	PL1113-1300
ResiPore Guard, 50x4.6mm	PL1513-1300

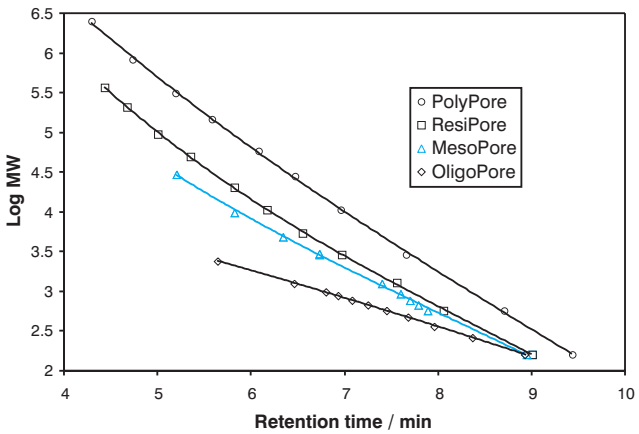
MesoPore for the Analysis of Prepolymers and Low MW Resins

Typical Applications

- **Prepolymers**
- **Resins**
- **Polyols**
- **Siloxanes**

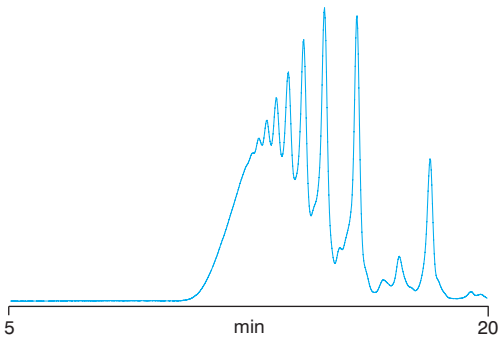
MesoPore columns have been specifically designed to give optimum results for the analysis of prepolymers: polymeric materials with a large oligomeric component. By combining a 3µm particle size with high pore volume, MesoPore columns give the highest resolution separations for the analysis of low molecular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

PlusPore Calibration Curves



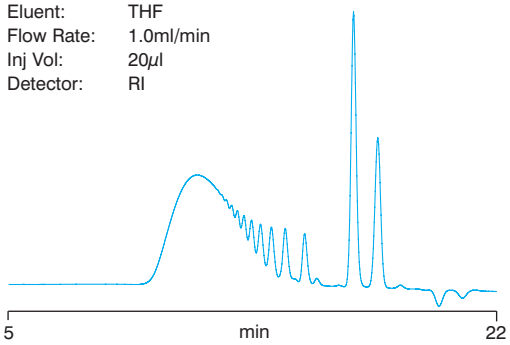
Epoxy Resin

Columns: 2xMesoPore, 300x7.5mm (PL1113-6325)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: RI



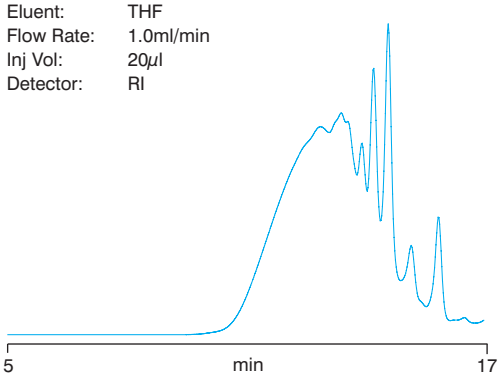
Polyurethanes

Columns: 2xMesoPore, 300x7.5mm (PL1113-6325)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: RI



Polyesterimide

Columns: 2xMesoPore, 300x7.5mm (PL1113-6325)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: RI



Specifications

MW Operating Range	Up to 25,000
Nominal Particle Size	3µm
Typical Column Efficiency	>80,000 p/m
Recommended Calibrants	Polystyrene S-L-10 Kit Polyethylene Glycol PEG-10 Kit for DMF

Product	**Part No.**
MesoPore, 300x7.5mm	PL1113-6325
MesoPore, 250x4.6mm	PL1513-5325
MesoPore Guard, 50x7.5mm	PL1113-1325
MesoPore Guard, 50x4.6mm	PL1513-1325

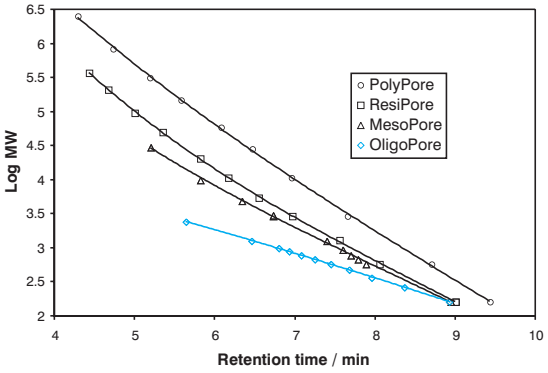
OligoPore for the Analysis of Oligomeric Samples

Typical Applications

■ **Polyurethanes** ■ **Epoxy resins** ■ **Polystyrenes**

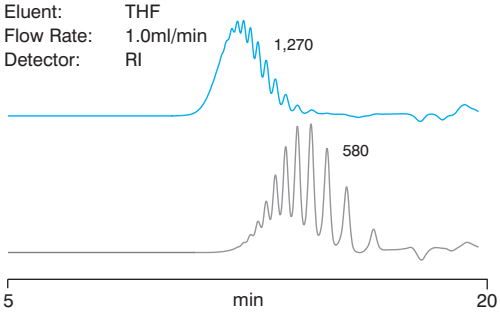
OligoPore columns have been developed from an innovative new media, which exhibits significantly increased pore volumes compared to conventional low pore size GPC columns, resulting in higher resolution in the oligomeric region.

PlusPore Calibration Curves



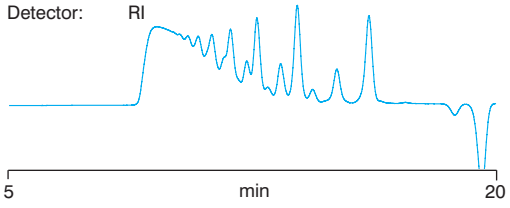
Polystyrene Standards

Columns: 2xOligoPore, 300x7.5mm (PL1113-6520)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Epoxy Resin (Epikote 1001)

Columns: 2xOligoPore, 300x7.5mm (PL1113-6520)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI

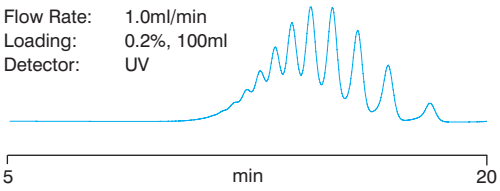


OligoPore Preparative Column

The 300x25mm preparative column offers high resolution at greatly increased loading for effective isolation of individual components.

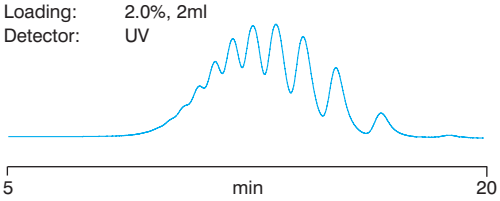
Analytical Separation

Columns: 2xOligoPore, 300x7.5mm (PL1113-6520)
Eluent: THF
Flow Rate: 1.0ml/min
Loading: 0.2%, 100ml
Detector: UV



Preparative Separation

Columns: 2xOligoPore, 300x25mm (PL1513-6520)
Eluent: THF
Flow Rate: 10.0ml/min
Loading: 2.0%, 2ml
Detector: UV

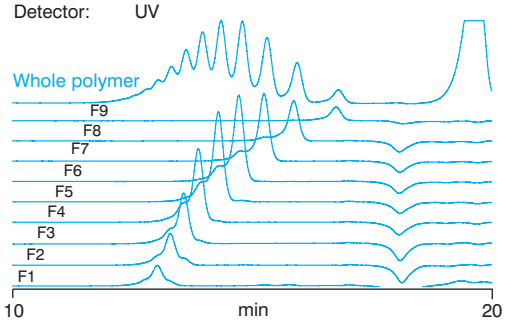


Oligomer fractions collected from the OligoPore preparative column can then be re-injected on analytical columns to check for the purity of the fractions and for comparison with the whole sample.

Analysis of Whole Polymer and Fractions Collected from OligoPore Preparative Columns

Polystyrene Oligomers

Columns: 2xOligoPore, 300x7.5mm (PL1113-6520)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV



Specifications

MW Operating Range	Up to 4,500
Nominal Particle Size	6µm
Typical Column Efficiency	>55,000 p/m
Recommended Calibrants	Individual MW Polystyrenes

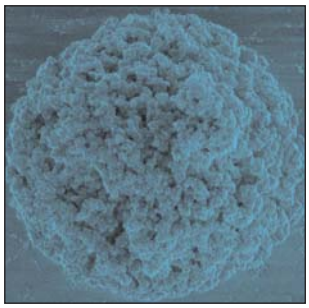
Product	**Part No.**
OligoPore, 300x7.5mm	PL1113-6520
OligoPore, 250x4.6mm	PL1513-5520
OligoPore, 300x25mm	PL1213-6520
OligoPore Guard, 50x7.5mm	PL1113-1320
OligoPore Guard, 50x4.6mm	PL1513-1320

PLgel Advanced Organic GPC Columns

PLgel is a highly crosslinked porous polystyrene/ divinylbenzene matrix which is recognized as a market leader in GPC column technology.

Manufactured and packed exclusively by Polymer Laboratories since 1976, PLgel has very special features:

- High pore volume **and** high efficiency for maximum resolution
- Unequalled solvent compatibility for transfers between polar and non-polar organic eluents
- Outstanding physical rigidity for extended lifetimes especially at high temperatures and in aggressive solvents
- PL's comprehensive QC/QA for total reproducibility, batch to batch, column to column
- Manufactured to ISO 9001:2000



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 standards fast and reliable.

The PLgel Column Range Includes:

- Seven individual pore size packings, 50Å to 10^6Å
- Five linear MIXED gel packings, A to E
- Four analytical particle sizes, 3μm, 5μm, 10μm, 20μm
- Column lengths 300mm and 600mm
- 4.6mm ID narrow bore columns
- 7.5mm ID analytical columns
- 25mm ID preparative columns
- 50mm guard columns
- New PolarGel-M - See page 2
- New PLgel Olexis - See page 2

Solvent Compatibility

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

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

	Solvent Polarity	Solvent	PLgel Compatibility
Low	6.0	Perfluoralkanes	✓
	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	Dichloroethane	✓
	9.9	Acetone	✓
	10.0	o-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 sulphoxide (DMSO)	✓
High	12.1	Dimethyl formamide (DMF))	✓

Temperature Stability to 220°C

Elevated temperature is used in GPC either to reduce eluent viscosity (eg polar solvent applications), or to maintain sample solubility (eg polyolefin applications). PLgel columns can be used at temperatures up to 220°C and operating pressures up to 150 bar (2200psi).

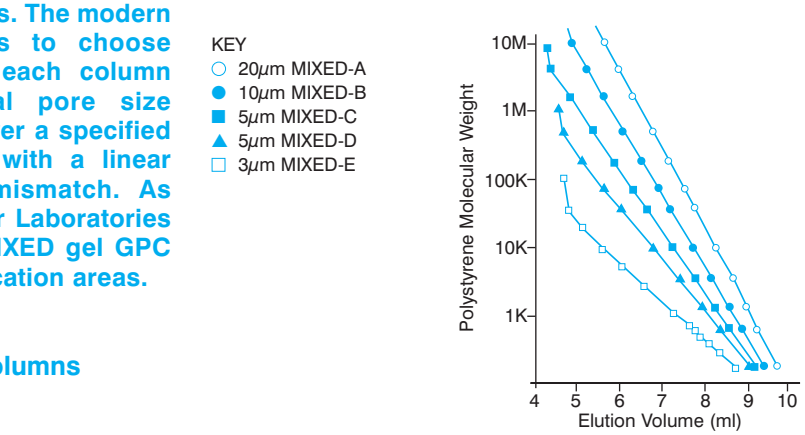
PLgel MIXED Gel GPC Columns

A significant number of GPC applications involve the analysis of polydisperse materials. The modern approach to column selection is to choose PL's MIXED gel columns, where each 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. As market leaders in this field, Polymer Laboratories offers a comprehensive range of MIXED gel GPC columns designed for specific application areas.

Key Advantages of PLgel MIXED Columns Include:

- Greatly simplified column selection
- Improved confidence in the accuracy and precision of calculated data
- Optimized particle size for each application area
- Reduced replacement stock
- Elimination of mismatched column sets and spurious peaks
- Simple addition of extra column(s) for greater resolution

PLgel MIXED Gel Calibration Curves



The 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 the 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. PL has scientifically determined the minimum number of MIXED gel columns required to perform accurate MWD determinations based on specific resolution (Rsp).

Ref: "Size exclusion chromatography columns from Polymer Laboratories", in Column Handbook for Size Exclusion Chromatography, ed. Chi-san Wu, Academic Press, 1999.

PLgel MIXED Gel Column Selection Guide

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

PLgel 20µm MIXED-A Columns

Features

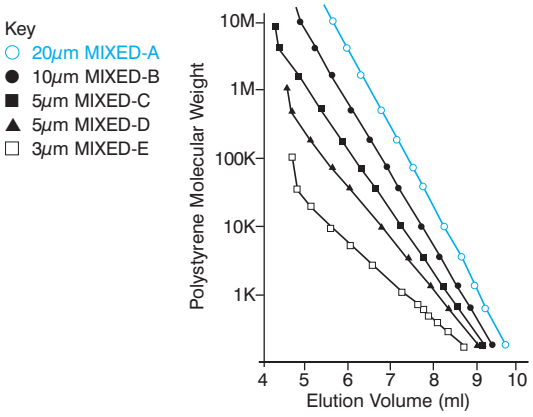
- Extremely high exclusion limit (40,000,000)
- Large particle size
- Matched frit porosity
- Low shear
- Linear calibration

Typical Applications

Polymers containing significant quantities of ultra high MW material which are relatively polydisperse

- Polyolefins
- Starches
- Polybutadienes
- Polyisoprenes

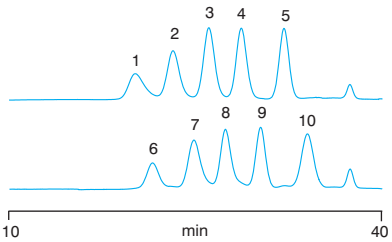
PLgel MIXED Gel Calibration Curves



Polystyrene Standards Separation

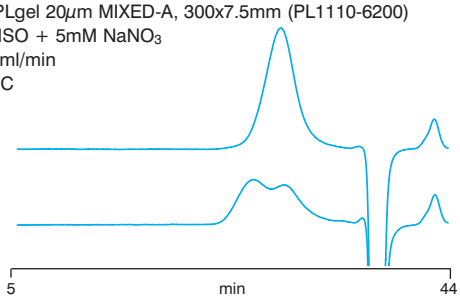
Sample: EasiCal PS-1
Columns: 4xPLgel 20µm MIXED-A, 300x7.5mm (PL1110-6200)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm

EasiCal PS-1
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



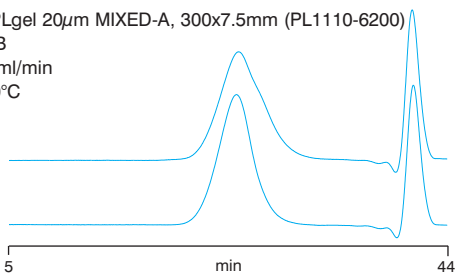
Starches

Columns: 4xPLgel 20µm MIXED-A, 300x7.5mm (PL1110-6200)
Eluent: DMSO + 5mM $NaNO_3$
Flow Rate: 1.0ml/min
Temp: 80°C
Detector: RI



Polyolefins

Columns: 4xPLgel 20µm MIXED-A, 300x7.5mm (PL1110-6200)
Eluent: TCB
Flow Rate: 1.0ml/min
Temp: 160°C
Detector: RI



PLgel 20µm MIXED-A Specifications

Linear range of MW:	2,000 - 40,000,000
Guaranteed column efficiency:	>17,000 plates/m
Typical pressure @ 1.0ml/min (7.5mm ID):	≈3 bar (45psi) per 300mm
@ 0.3ml/min (4.6mm ID):	≈2.4 bar (35psi) per 250mm
	(THF @ 20°C) (TCB @ 140°C)
Maximum flow rate @ 7.5mm ID:	1.5ml/min
@ 4.6mm ID:	0.5ml/min
Maximum pressure:	150 bar
Maximum temperature:	220°C
Recommended no. of columns in set:	4 x 250mm, 4 x 300mm or 2 x 600mm

Product	Part No.
PLgel 20µm MIXED-A, 300x7.5mm	PL1110-6200
PLgel 20µm MiniMIX-A, 250x4.6mm	PL1510-5200
PLgel 20µm MIXED-A, 600x7.5mm	PL1110-8200
PLgel 20µm Guard, 50x7.5mm	PL1110-1220
PLgel 20µm MiniMIX-A Guard, 50x4.6mm	PL1510-1200

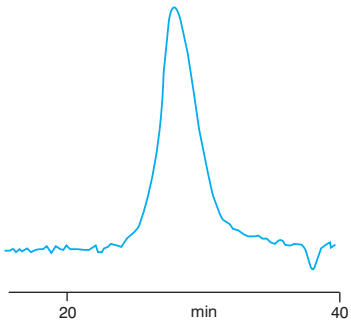
Polystyrene Calibration

EasiVial PS-H - convenient 12 point calibration in just 3 injections
EasiCal® PS-1 or S-H2-10 Kit - rapid 10 point calibration
S-H-10 plus S-M2-10 Kits - accurate 19 point calibration

Product	Part No.
EasiVial PS-H	PL2010-0200
EasiCal® PS-1	PL2010-0501
Polystyrene Calibration Kit S-H-10	PL2010-0103
Polystyrene Calibration Kit S-H2-10	PL2010-0104
Polystyrene Calibration Kit S-M2-10	PL2010-0102

Polyethylene on Narrow Bore MiniMIX Columns

Columns: 4xPLgel 20µm MiniMIX-A, 250x4.6mm (PL1510-5200)
Eluent: TCB
Flow Rate: 0.3ml/min
Loading: 0.1% w/v, 100µl
Temp: 140°C
Detector: IR



PLgel 10µm MIXED-B Columns

Features

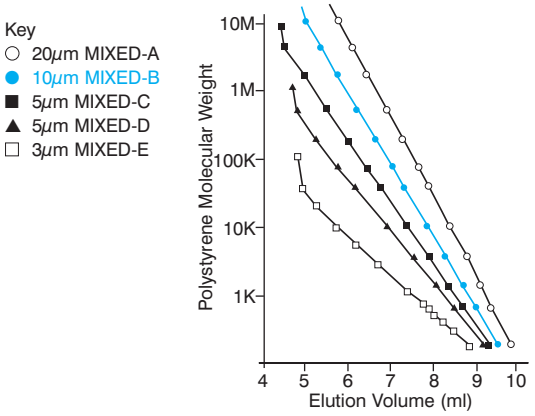
- Wide operating range of MW (500-10,000,000)
- Linear calibration
- Low operating pressure
- Wide range of applications

Typical Applications

General polymer analysis covering a wide range of MW, especially applications which use demanding conditions, eg high temperature, aggressive or unusual solvents

- Polyolefins
- Acrylics/Acrylates
- Fluoropolymers
- Cellulose derivatives

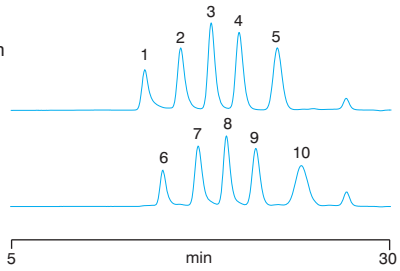
PLgel MIXED Gel Calibration Curves



Polystyrene Standards Separation

Sample: EasiCal PS-1
Columns: 3xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm

EasiCal PS-1
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



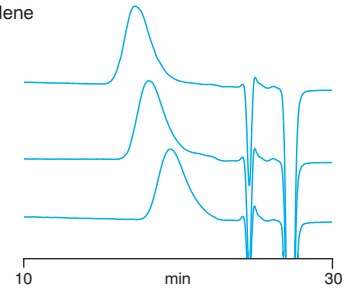
PLgel 10µm MIXED-B Specifications

Linear range of MW:	500 - 10,000,000
Guaranteed column efficiency:	>35,000 plates/m
Typical pressure @ 1.0ml/min (7.5mm ID):	≈10 bar (150psi) per 300mm
@ 0.3ml/min (4.6mm ID):	≈8 bar (120psi) per 250mm
	(THF @ 20°C) (TCB @ 140°C)
Maximum flow rate @ 7.5mm ID:	1.5ml/min
@ 4.6mm ID:	0.5ml/min
Maximum pressure:	150 bar
Maximum temperature:	220°C
Recommended no. of columns in set:	3 x 250mm, 3 x 300mm or 1-2 x 600mm

Product	Part No.
PLgel 10µm MIXED-B, 300x7.5mm	PL1110-6100
PLgel 10µm MiniMIX-B, 250x4.6mm	PL1510-5100
PLgel 10µm MIXED-B, 600x7.5mm	PL1110-8100
PLgel 10µm Guard, 50x7.5mm	PL1110-1120
PLgel 10µm MiniMIX-B Guard, 50x4.6mm	PL1510-1100

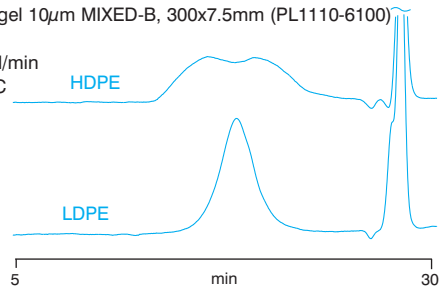
Polyphenylene Sulfides

Columns: 3xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: o-Chloronaphthalene
Flow Rate: 1.0ml/min
Temp: 210°C
Detector: RI



Polyethylenes

Columns: 3xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: TCB
Flow Rate: 1.0ml/min
Temp: 160°C
Detector: RI



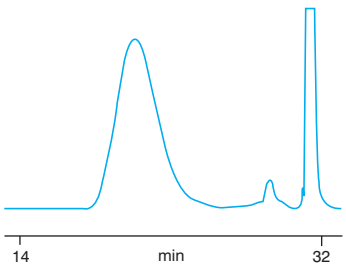
Polystyrene Calibration

EasiVial PS-H - convenient 12 point calibration in just 3 injections
EasiCal® PS-1 or S-H2-10 Kit - rapid 10 point calibration
S-H-10 plus S-M2-10 Kits - accurate 19 point calibration

Product	Part No.
EasiVial PS-H	PL2010-0200
EasiCal® PS-1	PL2010-0501
Polystyrene Calibration Kit S-H-10	PL2010-0103
Polystyrene Calibration Kit S-H2-10	PL2010-0104
Polystyrene Calibration Kit S-M-10	PL2010-0100
Polystyrene Calibration Kit S-M2-10	PL2010-0102

Polystyrene on Narrow Bore MiniMIX Columns

Columns: 3xPLgel 10µm MiniMIX-B, 250x4.6mm (PL1510-5100)
Eluent: THF
Flow Rate: 0.3ml/min
Loading: 0.2% w/v, 20µl
Detector: UV, 254nm



PLgel 5µm MIXED-C Columns

Features

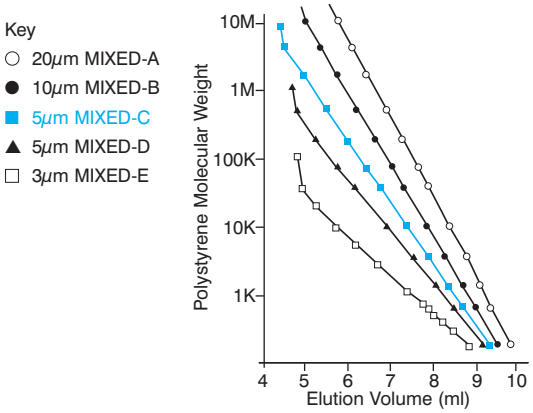
- High efficiency
- Linear calibration
- Excellent solvent compatibility
- Fast analysis

Typical Applications

For polymer analysis up to 2 million MW, especially polymers containing small molecule additives

- Polystyrenes
- Polycarbonates
- Polyurethanes
- Polysiloxanes

PLgel MIXED Gel Calibration Curves



PLgel 5µm MIXED-C Specifications

Linear range of MW:	200 - 2,000,000
Guaranteed column efficiency:	>50,000 plates/m
Typical pressure @ 1.0ml/min (7.5mm ID):	≈30 bar (450psi) per 300mm
@ 0.3ml/min (4.6mm ID):	≈24 bar (350psi) per 250mm
	(THF @ 20°C) (TCB @ 140°C)
Maximum flow rate @ 7.5mm ID:	1.5ml/min
@ 4.6mm ID:	0.5ml/min
Maximum pressure:	150 bar
Maximum temperature:	150°C
Recommended no. of columns in set:	2 x 250mm, 2 x 300mm or 1 x 600mm

Product	**Part No.**
PLgel 5µm MIXED-C, 300x7.5mm	PL1110-6500
PLgel 5µm MiniMIX-C, 250x4.6mm	PL1510-5500
PLgel 5µm MIXED-C, 600x7.5mm	PL1110-8500
PLgel 5µm Guard, 50x7.5mm	PL1110-1520
PLgel 5µm MiniMIX-C Guard, 50x4.6mm	PL1510-1500

Calibration

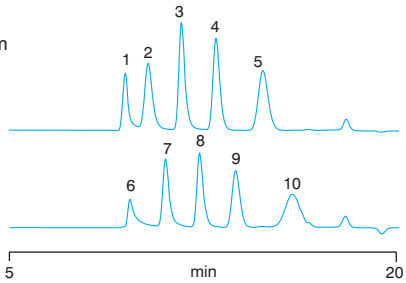
Polystyrene EasiVial PS-H
Polystyrene EasiCal® PS-1
Polystyrene S-M-10 Kit
Polyethylene Oxide/Glycol PEO-10 / PEG-10 Kits for DMF

Product	**Part No.**
EasiVial PS-H	PL2010-0200
EasiCal® PS-1	PL2010-0501
Polystyrene Calibration Kit S-M-10	PL2010-0100
Polyethylene Oxide Kit PEO-10	PL2080-0101
Polyethylene Glycol Kit PEG-10	PL2070-0100

Polystyrene Standards Separation

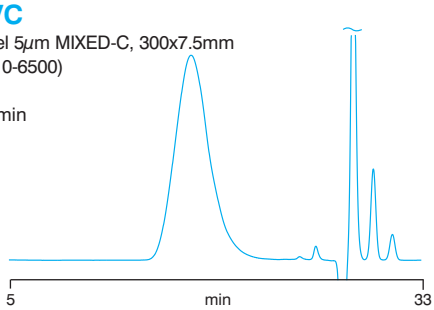
Sample: EasiCal PS-1
Columns: 2xPLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm

EasiCal PS-1
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



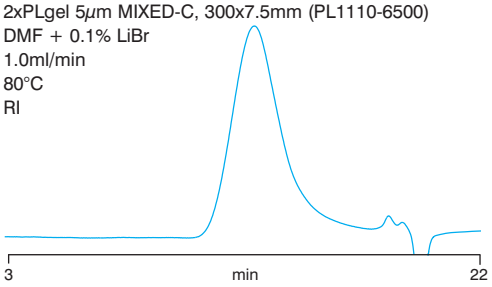
Plasticized PVC

Columns: 3xPLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



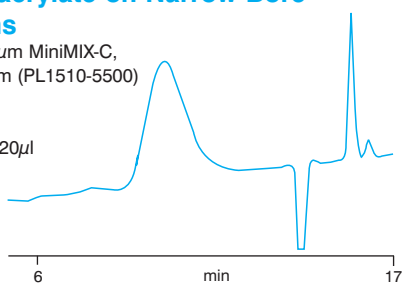
Polyurethane

Columns: 2xPLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: DMF + 0.1% LiBr
Flow Rate: 1.0ml/min
Temp: 80°C
Detector: RI



Polymethylmethacrylate on Narrow Bore MiniMIX Columns

Columns: 2xPLgel 5µm MiniMIX-C, 250x4.6mm (PL1510-5500)
Eluent: DMF
Flow Rate: 0.3ml/min
Loading: 0.1% w/v, 20µl
Detector: RI



PLgel 5µm MIXED-D Columns

Features

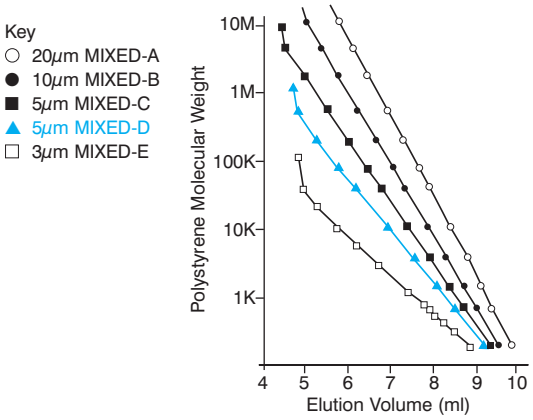
- High efficiency
- High pore volume
- Optimized linear resolving range
- Polymer plus some oligomer resolution

Typical Applications

Ideal for condensation polymers, paints and resins which may contain some low molecular weight oligomeric species

- Epoxy resins
- Polyester resins
- Silicone fluids
- Polyolefins

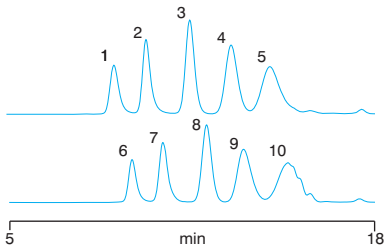
PLgel MIXED Gel Calibration Curves



Polystyrene Standards Separation

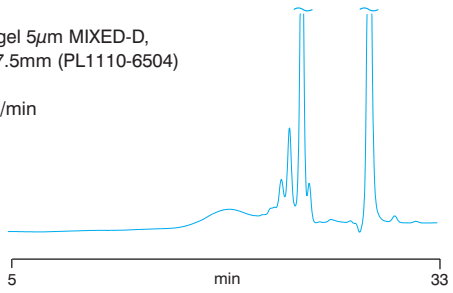
Sample: EasiCal PS-2
Columns: 2xPLgel 5µm MIXED-D, 300x7.5mm (PL1110-6504)
Eluent: THF
Flow Rate 1.0ml/min
Detector: UV, 254nm

EasiCal PS-2
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



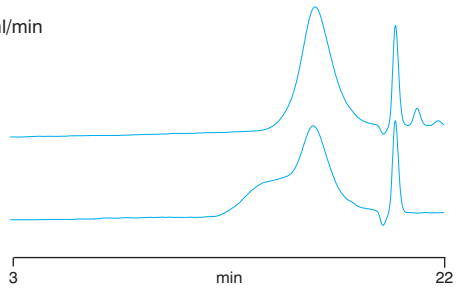
Epoxy Resin

Columns: 3xPLgel 5µm MIXED-D, 300x7.5mm (PL1110-6504)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Asphalts

Columns: 2xPLgel 5µm MIXED-D, 300x7.5mm (PL1110-6504)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



PLgel 5µm MIXED-D Specifications

Linear range of MW:	200 - 400,000
Guaranteed column efficiency:	>50,000 plates/m
Typical pressure @ 1.0ml/min (7.5mm ID):	≈50 bar (450psi) per 300mm
@ 0.3ml/min (4.6mm ID):	≈24 bar (350psi) per 250mm
	(THF @ 20°C) (TCB @ 140°C)
Maximum flow rate @ 7.5mm ID:	1.5ml/min
@ 4.6mm ID:	0.5ml/min
Maximum pressure:	150 bar
Maximum temperature:	150°C
Recommended no. of columns in set:	2 x 250mm, 2 x 300mm or 1 x 600mm

Product	Part No.
PLgel 5µm MIXED-D, 300x7.5mm	PL1110-6504
PLgel 5µm MiniMIX-D, 250x4.6mm	PL1510-5504
PLgel 5µm MIXED-D, 600x7.5mm	PL1110-8504
PLgel 5µm Guard, 50x7.5mm	PL1110-1520
PLgel 5µm MiniMIX-D Guard, 50x4.6mm	PL1510-1504

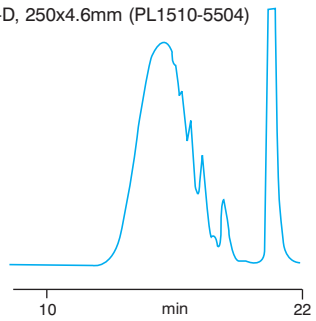
Calibration

EasiVial PS-M
EasiCal® PS-2
Polystyrene S-M2-10 Kit
Polyethylene Oxide/Glycol PEO-10 / PEG-10 Kits for DMF

Product	Part No.
EasiVial PS-M	PL2010-0200
EasiCal® PS-2	PL2010-0601
Polystyrene Calibration Kit S-M2-10	PL2010-0102
Polyethylene Oxide Kit PEO-10	PL2080-0101
Polyethylene Glycol Kit PEG-10	PL2070-0100

Epoxy Resin on Narrow Bore MiniMIX Columns

Columns: 2xPLgel 5µm MiniMIX-D, 250x4.6mm (PL1510-5504)
Eluent: THF
Flow Rate: 0.3ml/min
Loading: 0.1% w/v, 20µl
Detector: UV, 254nm



PLgel 3µm MIXED-E Columns

Features

- Ultra high efficiency
- Fast analysis
- Outstanding resolution

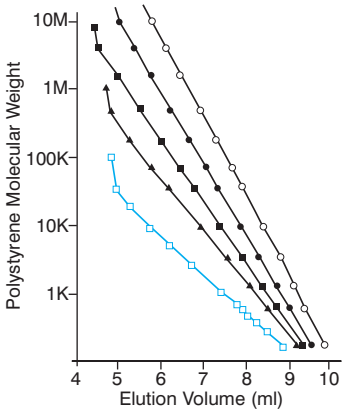
Typical Applications

Ideal for low molecular weight samples which contain oligomeric fractions as well as polymers up to 30,000 MW

- Prepolymers
- Polyols
- Resins
- Siloxanes

PLgel MIXED Gel Calibration Curves

Key
- ○ 20µm MIXED-A
- ● 10µm MIXED-B
- ■ 5µm MIXED-C
- ▲ 5µm MIXED-D
- □ 3µm MIXED-E



PLgel 3µm MIXED-E Specifications

Linear range of MW:	Up to 30,000
Guaranteed column efficiency	
300x7.5mm:	>80,000 plates/m
250x4.6mm:	>70,000 plates/m
Highest efficiency/resolution will only be achieved on high performance, low dead volume equipment	
Typical pressure @ 1.0ml/min (7.5mm ID):	≈50 (750psi) per 300mm
@ 0.3ml/min (4.6mm ID):	≈42 bar (610psi) per 250mm (THF @ 20°C)
Maximum flow rate @ 7.5mm ID:	1.5ml/min
@ 4.6mm ID:	0.5ml/min
Maximum pressure:	180 bar
Maximum temperature:	110°C
Recommended no. of columns in set:	1-3 x 250mm
	1-3 x 300mm

Product	**Part No.**
PLgel 3µm MIXED-E, 300x7.5mm	PL1110-6300
PLgel 3µm MiniMIX-E, 250x4.6mm	PL1510-5300
PLgel 3µm Guard, 50x7.5mm	PL1110-1320
PLgel 3µm MiniMIX-E Guard, 50x4.6mm	PL1510-1300

Calibration

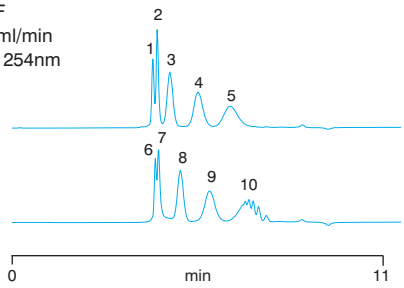
Polystyrene S-L-10 Kit
Polyethylene Glycol Kit PEG-10 for DMF

Product	**Part No.**
Polystyrene Calibration Kit S-L-10	PL2010-0101
Polyethylene Glycol Kit PEG-10	PL2070-0100

Polystyrene Standards Separation

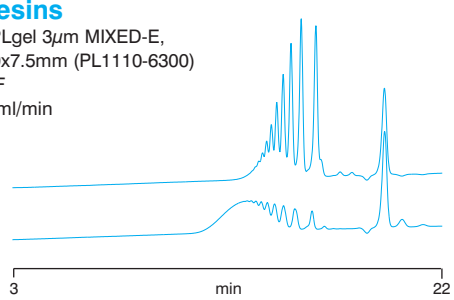
Sample: EasiCal PS-2
Column: PLgel 3µm MIXED-E, 300x7.5mm (PL1110-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm

EasiCal PS-2
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



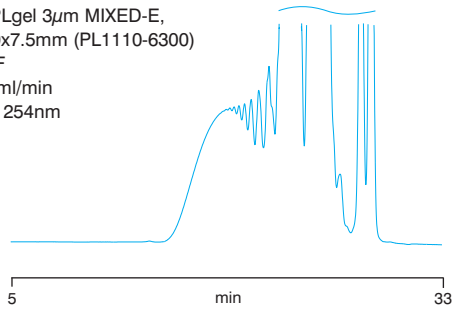
Polyester Resins

Columns: 2xPLgel 3µm MIXED-E, 300x7.5mm (PL1110-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



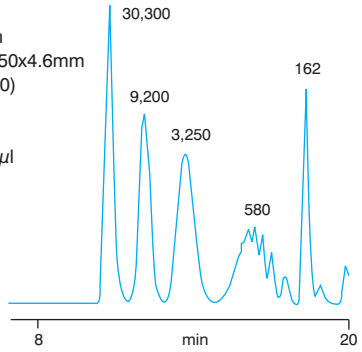
Polyol

Columns: 3xPLgel 3µm MIXED-E, 300x7.5mm (PL1110-6300)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: UV, 254nm



Polystyrene Standards on Narrow Bore MiniMIX Columns

Columns: 2xPLgel 3µm MiniMIX-E, 250x4.6mm (PL1510-5300)
Eluent: THF
Flow Rate: 0.3ml/min
Loading: 0.1% w/v, 20µl
Detector: UV, 254nm

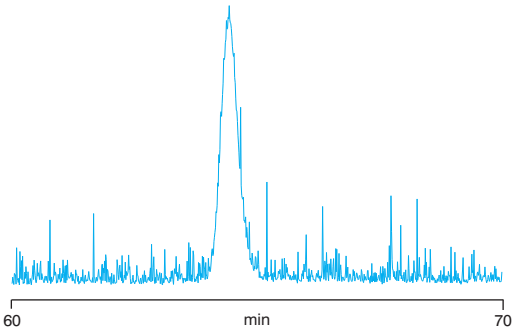


PLgel LS Columns for Light Scattering & Viscosity

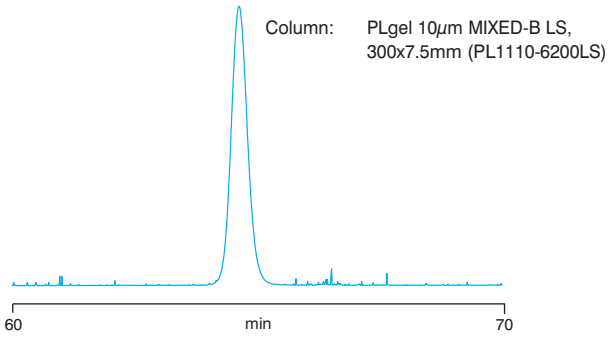
When using online molecular weight sensitive detectors in GPC, particularly light scattering detectors, excessive baseline noise arising from particulates in the eluent stream can significantly deteriorate the quality of the data. Traditionally, GPC columns can be one source of particulates, especially columns containing large pore size packing materials which, when new, bleed microparticles from their structure. This means that a new column set needs a 'conditioning' process, involving pumping the columns to waste to remove the particulates.

Polymer Laboratories has developed the PLgel LS series, 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 LS columns in place of conventional GPC columns. The light scattering chromatograms below were obtained after flushing the columns for one hour in THF at 1.0ml/min. A polystyrene standard (Mp 210,000) was injected at 1mg/ml in order to illustrate the dramatic improvement in signal to noise with the PLgel LS column.

Conventional GPC Column



PLgel LS Column



Polymer Laboratories has matched the performance of its PLgel LS columns to its very successful PLgel 20µm MIXED-A and PLgel 10µm MIXED-B columns in terms of calibration, column efficiency, wide solvent compatibility and operating temperature.

PLgel 5µm and PLgel 3µm GPC columns all exhibit very low particle shedding and these regular columns are ideal for all detector operations.

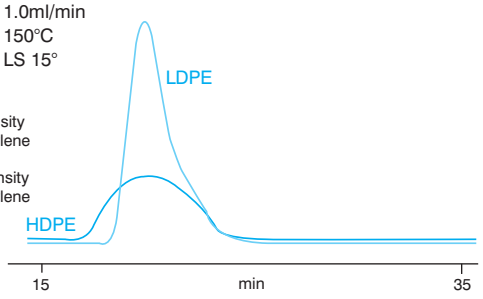
PLgel 20µm MIXED-A LS and PLgel 10µm MIXED-B LS columns are also ideal for online viscosity detection, minimizing the risk of capillary blockage. They can be used with regular PLgel guard columns which are packed with rigid low pore size gels (see page 23), which do not exhibit particle bleed.

Signal to Noise

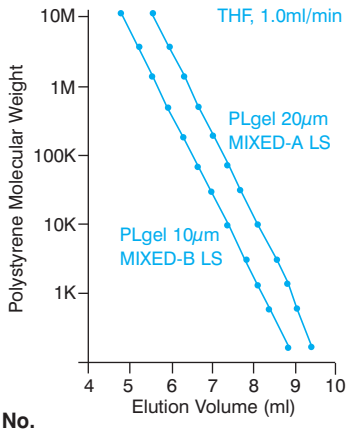
Columns: 3xPLgel 20µm MIXED-A LS, 300x7.5mm (PL1110-6200LS)
Eluent: TCB
Flow Rate: 1.0ml/min
Temp: 150°C
Detector: LS 15°

Key
LDPE= Low density polyethylene

HDPE=High density polyethylene



PLgel MIXED-LS Calibration Curves



PLgel MIXED-LS Specifications

Column	Linear Operating Range (PS equivalent)	Guaranteed Column Efficiency (plates/m)	Part No.
PLgel 10µm MIXED-B LS, 300x7.5mm	500-10,000,000	>35,000	PL1110-6100LS
PLgel 20µm MIXED-A LS, 300x7.5mm	2,000-40,000,000	>17,000	PL1110-6200LS
PLgel 10µm Guard, 50x7.5mm	-	-	PL1110-1120
PLgel 10µm Guard, 50x7.5mm	-	-	PL1110-1220

Polymer Laboratories' Narrow Bore GPC Columns

PLgel MiniMIX & PlusPore Columns

- High Performance Comparable to PL's Conventional ID Columns
- Benefit of ~70% Reduction in Solvent Consumption
- Increased Operator Safety
- Reduced Solvent and Solvent Disposal Costs

Safety and Cost Benefits

The result is two ranges of exceptional performance narrow bore GPC columns, ideal for laboratories wishing to reduce solvent costs, solvent usage and solvent disposal, with reduced risk from the minimized use of unpleasant solvents.

For reduced solvent cost and consumption, Polymer Laboratories manufactures both new PlusPore high pore volume/high resolution columns and industry standard PLgel MiniMIX mixed gel columns in 250x4.6mm narrow bore dimensions. PL's narrow bore GPC 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.

To maintain the same linear velocity through the column, the volumetric flow rate must be reduced to 0.3ml/min in line with the column cross sectional area, resulting in *significantly lower solvent consumption.*

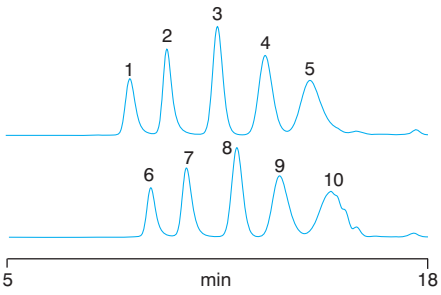
Sample loadings should be scaled down in line with reduced column volume, and system dead volume should be minimized to avoid excessive band broadening.

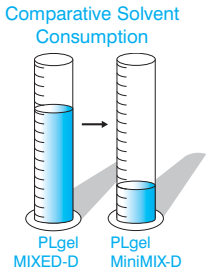
Safety and Cost Benefits

The result is two ranges of exceptional performance narrow bore GPC columns, ideal for laboratories wishing to reduce solvent costs, solvent usage and solvent disposal, with reduced risk from the minimized use of unpleasant solvents.

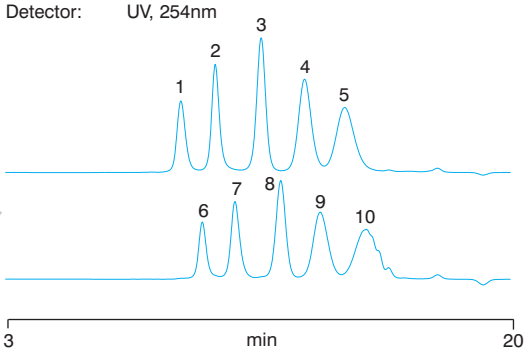
Comparison of Conventional and Narrow Bore Columns

Sample: EasiCal PS-2
Columns: 2xPLgel 5µm MIXED-D, 300x7.5mm (PL1110-6504)
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 100µl
Detector: UV, 254nm





Sample: EasiCal PS-2
Columns: 2xPLgel MiniMIX-D, 250x4.6mm (PL1510-5504)
Eluent: THF
Flow Rate: 0.3ml/min
Inj Vol: 20µl
Detector: UV, 254nm



KEY
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

PLgel MiniMIX - Specifications

Column Type	Linear MW Range (PS)	Guaranteed Efficiency (p/m)	Part No.
PLgel 20µm MiniMIX-A, 250x4.6mm	2,000-40,000,000	>17,000	PL1510-5200
PLgel 10µm MiniMIX-B, 250x4.6mm	500-10,000,000	>35,000	PL1510-5100
PLgel 5µm MiniMIX-C, 250x4.6mm	200-2,000,000	>50,000	PL1510-5500
PLgel 5µm MiniMIX-D, 250x4.6mm	200-400,000	>50,000	PL1510-5504
PLgel 3µm MiniMIX-E, 250x4.6mm	up to 30,000	>70,000	PL1510-5300

PlusPore - Specifications

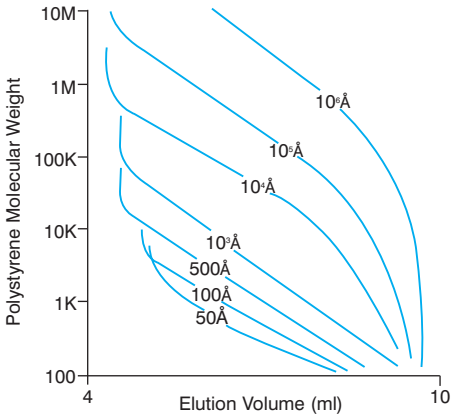
Column Type	MW Range (PS)	Guaranteed Efficiency (p/m)	Part No.
PolyPore, 250x4.6mm	200-2,000,000	>50,000	PL1513-5500
ResiPore, 250x4.6mm	200-400,000	>70,000	PL1513-5300
MesoPore, 250x4.6mm	up to 25,000	>70,000	PL1513-5325
OligoPore, 250x4.6mm	up to 4,500	>50,000	PL1513-5520

PLgel Individual Pore Size GPC Columns

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 molecular weight region over which optimum resolution will be achieved.

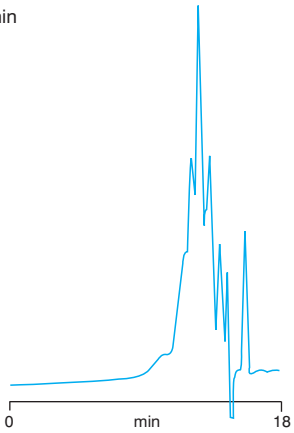
Calibration Curves

Calibrants: Polystyrene
Eluent: THF
Flow Rate: 1.0ml/min



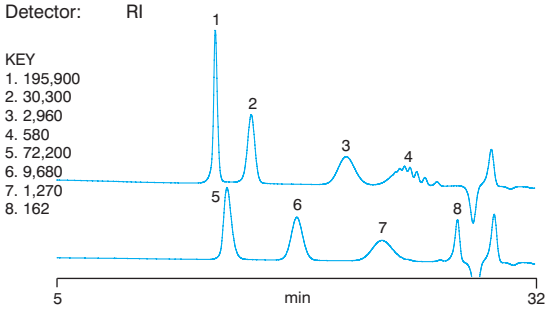
Phenolic Resin Analysis

Column: PLgel 5µm 100Å, 600x7.5mm (PL1110-8520)
Eluent: DMF
Flow Rate: 1.0ml/min
Temp: 80°C
Detector: RI



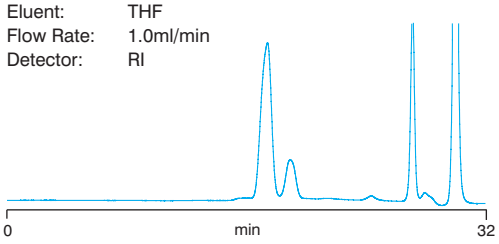
Polystyrene Standards Separation

Columns: 3xPLgel 5µm 10^3Å, 300x7.5mm (PL1110-6530)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Kraton Analysis

Columns: 3xPLgel 5µm 10^5Å, 300x7.5mm (PL1110-6550)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



PLgel Individual Pore Size Columns - Specifications

Column Type		Effective MW Range (PS)	Guaranteed Efficiency (p/m)	Part No. 300x7.5mm	Part No. 600x7.5mm
PLgel 3µm	100Å	up to 4,000	>100,000	PL1110-6320	-
PLgel 5µm	50Å	up to 2,000	>60,000	PL1110-6515	PL1110-8515
PLgel 5µm	100Å	up to 4,000	>60,000	PL1110-6520	PL1110-8520
PLgel 5µm	500Å	500-30,000	>60,000	PL1110-6525	PL1110-8525
PLgel 5µm	10^3Å	500-60,000	>50,000	PL1110-6530	PL1110-8530
PLgel 5µm	10^4Å	10,000-600,000	>50,000	PL1110-6540	PL1110-8540
PLgel 5µm	10^5Å	60,000-2,000,000	>50,000	PL1110-6550	PL1110-8550
PLgel 10µm	50Å	up to 2,000	>35,000	PL1110-6115	PL1110-8115
PLgel 10µm	100Å	up to 4,000	>35,000	PL1110-6120	PL1110-8120
PLgel 10µm	500Å	500-30,000	>35,000	PL1110-6125	PL1110-8125
PLgel 10µm	10^3Å	500-60,000	>35,000	PL1110-6130	PL1110-8130
PLgel 10µm	10^4Å	10,000-600,000	>35,000	PL1110-6140	PL1110-8140
PLgel 10µm	10^5Å	60,000-2,000,000	>35,000	PL1110-6150	PL1110-8150
PLgel 10µm	10^6Å	600,000-10,000,000	>35,000	PL1110-6160	PL1110-8160

PLgel Individual Pore Size GPC Columns

PLgel 3µm 100Å Low MW Columns

PLgel low pore size columns are the choice for high resolution GPC separations of low molecular weight compounds.

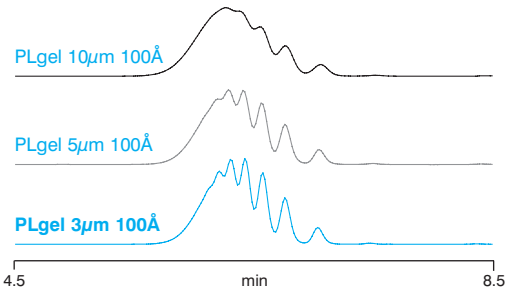
Column efficiency increases as the particle size of the packing is reduced. For low molecular weight separations, the resolution of individual species is dramatically improved.

Features

- Unrivalled solvent compatibility
- Excellent mechanical stability
- Very high efficiency
- Faster analysis time, fewer columns required

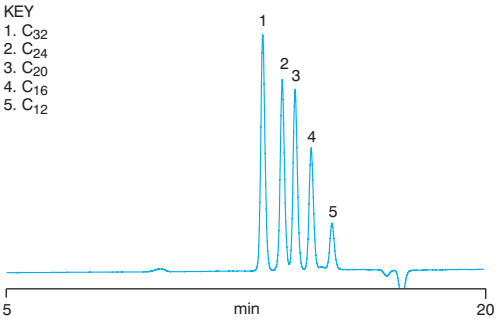
Effect of Particle Size on Resolution

Sample: Polystyrene 580
Columns: 300x7.5mm
Eluent: THF
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector: RI



Linear Hydrocarbons

Columns: 2xPLgel 3µm 100Å, 300x7.5mm (PL1110-6320)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI

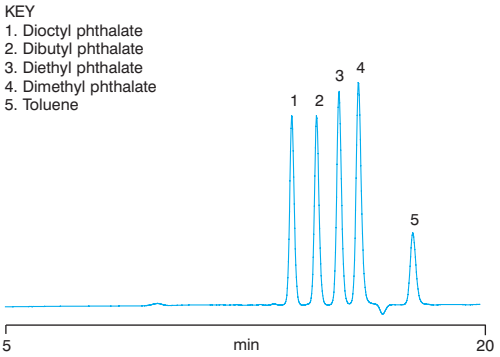


The increased efficiency of the 3µm packing material offers two benefits:

- Improved resolution for the same column length
- Faster separation with the same resolution

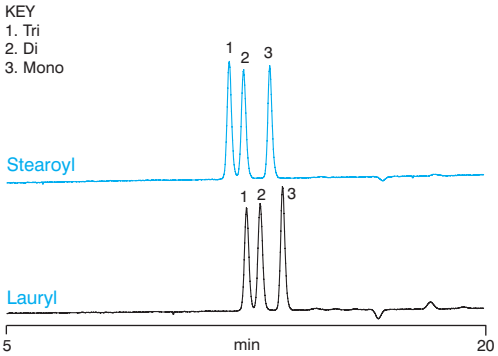
Dialkyl Phthalates

Columns: 2xPLgel 3µm 100Å, 300x7.5mm (PL1110-6320)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Mono-, di- and triglycerides

Columns: 2xPLgel 3µm 100Å, 300x7.5mm (PL1110-6320)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



Guard Columns

Choose from PLgel 3µm, 5µm, 10µm and 20µm guard columns for all PLgel 300x7.5mm column types, simply matching the particle size of the packing.

Guard Column Type	Part No.
PLgel 20µm Guard, 50x7.5mm	PL1110-1220
PLgel 10µm Guard, 50x7.5mm	PL1110-1120
PLgel 5µm Guard, 50x7.5mm	PL1110-1520
PLgel 3µm Guard, 50x7.5mm	PL1110-1320

PLgel Preparative GPC Columns

Preparative GPC is widely used for the fractionation of a wide variety of samples based on their molecular size in solution. The technique is generally used for the fractionation of polymers, to isolate components in a polymer formulation or simplify mixtures of relatively small molecules in complex matrices. Mixtures of materials can be easily separated on the basis of size, preferably in a low boiling organic solvent, collected as a series of discrete fractions and isolated by simple evaporation of the solvent.

Applications Include

- Deformulation of competitors' products
- Sample clean-up / extraction
- Polymer fractionation

High Performance, High Capacity

PLgel Preparative columns are packed with the same rigid, high performance media as the analytical column range. The 10μm particle size provides high column efficiency (>25,000 plates/m) for optimum resolution and loading characteristics.

PLgel 25mm ID preparative columns offer more than a 10x scale up compared to PLgel 7.5mm analytical columns. In comparison with other vendors' preparative columns, PL's increased ID and column volume permit even higher loadings per injection.

Column ID	Column Volume per 300mm Length	Minimum Scale Up
7.5mm	13	x1
19mm	85	x6
21mm	104	x8
25mm	147	x11

High Load

The large internal diameters of preparative columns, with their correspondingly larger bed volumes, mean that the injection volume can be significantly increased.

When fractionating low molecular weight materials, the sample concentration can also be significantly increased, enabling milligram quantities of very pure material to be isolated for further study. The actual loading is ultimately controlled by the sample and its molecular weight.

PLgel Preparative GPC columns are available in seven individual pore sizes and two MIXED gel types, and in column lengths of 300mm and 600mm. A Preparative Guard column (25x25mm) is also available.

Not sure which prep column to use?
Call us for PL's free application service.

PLgel Preparative GPC Columns

Description	Effective MW Range (PS)	Part No. 300x25mm	Part No. 600x25mm
PLgel 10μm MIXED-B	500-10,000,000	PL1210-6100	PL1210-8100
PLgel 10μm MIXED-D	200-400,000	PL1210-6104	PL1210-8104
PLgel 10μm 50Å	up to 2,000	PL1210-6115	PL1210-8115
PLgel 10μm 100Å	up to 4,000	PL1210-6120	PL1210-8120
PLgel 10μm 500Å	500-30,000	PL1210-6125	PL1210-8125
PLgel 10μm 10^3Å	500-60,000	PL1210-6130	PL1210-8130
PLgel 10μm 10^4Å	10,000-600,000	PL1210-6140	PL1210-8140
PLgel 10μm 10^5Å	60,000-2,000,000	PL1210-6150	PL1210-8150
PLgel 10μm 10^6Å	600,000-10,000,000	PL1210-6160	PL1210-8160
	Part No.		
PLgel Prep Guard, 25x25mm	PL1210-1120		

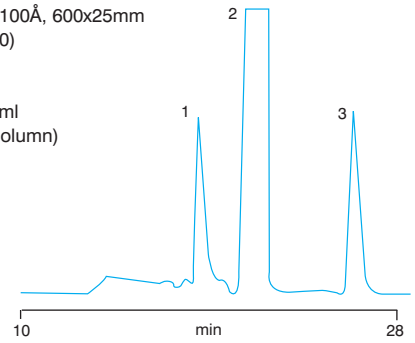
PLgel Preparative GPC

Identification of Contaminants

This phenol product was found to contain small amounts of two contaminant species. By using very high loading, sufficient quantities of fractions 1 and 3 were collected to permit identification by infra-red spectroscopy.

Column: PLgel 10µm 100Å, 600x25mm (PL1210-8120)
Eluent: Acetone
Flow Rate: 10.0ml/min
Loading: 100mg/ml, 2ml (200mg on column)
Detector: RI

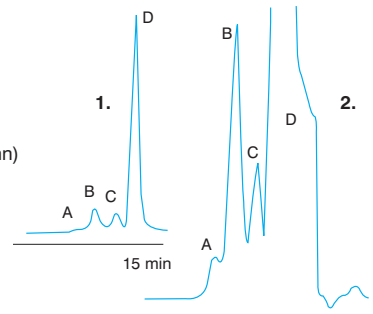
KEY
1. & 3. Contaminants
2. Phenol



Product Deformulation

Loading in preparative GPC is molecular weight dependent and is much greater for low MW materials than for polymers. Even for polymers, a minimum of 10 x scale up is routine but for very low molecular weight materials, the loading can be significantly increased.

Column: PLgel 10µm 100Å, 600x25mm (PL1210-8120)
Eluent: THF
Flow Rate: 9.0ml/min
Loading: **1.** 5mg/ml, 1ml (5mg on column)
2. 100mg/ml, 3ml (300mg on column)
Detector: RI

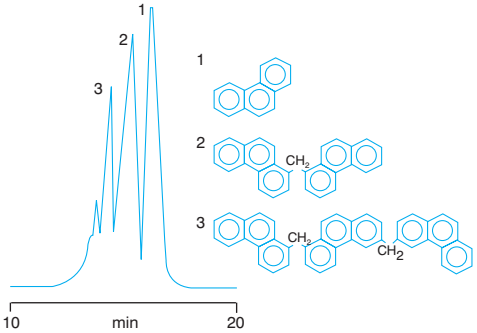


Quantification of Components A-D

Fractionation

Each fraction of this phenanthrene-formaldehyde resin was collected using a 'heart-cut' technique to avoid cross-fraction contamination. Identification was carried out using mass spectroscopy and infra-red spectroscopy.

Column: PLgel 10µm 500Å, 600x25mm (PL1210-8125)
Eluent: Dichloromethane
Flow Rate: 9.0ml/min
Loading: 100mg/ml, 2ml (200mg on column)
Detector: UV, 254nm



PL EnviroPrep Columns

NEW Columns for Sample Clean-up

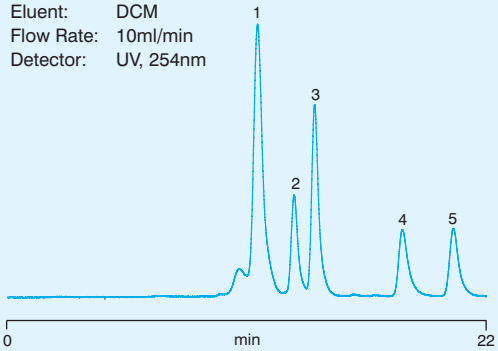
For environmental sample clean-up according to EPA Methods, Polymer Laboratories is launching PL EnviroPrep high resolution preparative GPC columns. PL EnviroPrep columns permit a simple, one stage clean-up procedure for the determination of pesticides in a variety of organic matrices, eg soil, animal tissue, etc. The matrix is extracted and the higher molecular weight fractions such as lipids, polymers, natural resins and dispersed high molecular weight components are easily eliminated in the GPC analysis.

This application of preparative GPC in the clean-up of soil extracts is described in EPA Method 3640A and is in the US EPA CLP Statement of Work for Organics Analysis, Document Number OLM01.0. Preparative GPC using a 300x25mm and a 150x25mm column is preferred, since higher sample loadings and fraction yields can be obtained, particularly useful for looking at low levels of pollutants.

Low pore size PL EnviroPrep columns are ideal for this application. PL EnviroPrep columns have a 10µm particle size and 100Å pore size for high resolution, with an exclusion limit of 4000 molecular weight. The PL EnviroPrep 10µm preparative columns offer high resolution and high loading through optimization of the particle size distribution. As a means of evaluating the performance of the GPC column and system, a separation of a test solution is suggested. The GPC calibration solution is prepared in dichloromethane containing the following analytes (in elution order):

Compound/KEY	**mg/l**
1. Corn Oil	25,000
2. Bis(2-ethylhexyl) phthalate	1,000
3. Methoxychlor	200
4. Perylene	20
5. Sulfur	80

Column: PL EnviroPrep, 300x25mm (PL1210-6120EPA)
PL EnviroPrep, 150x25mm (PL1210-3120EPA)
Eluent: DCM
Flow Rate: 10ml/min
Detector: UV, 254nm



PL HFIPgel Columns for GPC Applications in HFIP

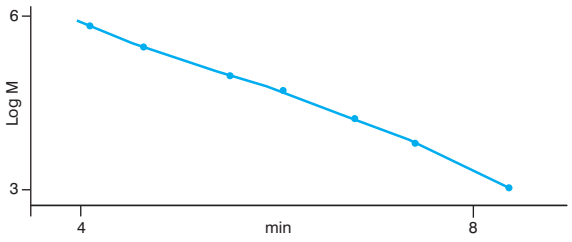
Hexafluoroisopropanol (HFIP) has been used as a solvent in GPC for many years for the analysis of important industrial polymers such as polyesters and polyamides. Conventional PS/DVB based GPC columns have been used with HFIP for this type of application. Unfortunately, the high solvent polarity generally leads to the production of unsatisfactory data. Excessive curvature of GPC calibration curves, dislocations/shoulders on peaks for polydisperse samples and poor resolution in the low MW region are commonly observed in HFIP.

For improved performance in extremely polar solvents such as HFIP and TFE, Polymer Laboratories has applied novel “multipore” technology to produce PL HFIPgel, a PS/DVB packing featuring:

- Monodisperse particle size
- Optimized separation range
- High pore volume
- High resolution
- Low column operating pressure

GPC Calibration Curve

Column: PL HFIPgel, 300x7.5mm
Eluent: HFIP + 20mM NaTFAc
Flow Rate: 1.0ml/min
Temp: 40°C
Calibrants: Polymethylmethacrylate
Detector: RI



PL HFIPgel columns are available in regular 7.5mm ID and solvent-efficient 4.6mm ID hardware. 7.5mm ID columns are normally operated at 1ml/min and the 4.6mm ID columns at 0.3ml/min, providing a 70% reduction in solvent consumption.

Description	Part No.
PL HFIPgel, 300x7.5mm	PL1114-6900HFIP
PL HFIPgel Guard, 50x7.5mm	PL1114-1900HFIP
PL HFIPgel, 250x4.6mm	PL1514-5900HFIP
PL HFIPgel Guard, 50x4.6mm	PL1514-1900HFIP

Applications

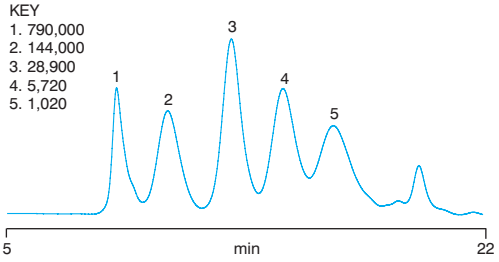
- Polyesters
- Polyamides
- Polylactide/glycolide copolymers

PL HFIPgel columns are packed and tested in methanol but shipped ready to use in HFIP. Column efficiency is guaranteed >30,000 plates/m and columns are very durable, with a maximum operating pressure of 1450psi.

Polymethylmethacrylate Standards

Columns: 2xPL HFIPgel, 300x7.5mm (PL1114-6900HFIP)
Eluent: HFIP + 20mM NaTFAc
Flow Rate: 1.0ml/min
Temp: 40°C
Detector: RI

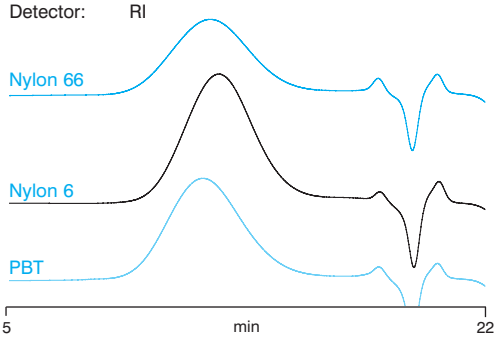
KEY
1. 790,000
2. 144,000
3. 28,900
4. 5,720
5. 1,020



For details of PL’s Polymethylmethacrylate Standards, see page 44

Polyamides

Columns: 2xPL HFIPgel, 300x7.5mm (PL1114-6900HFIP)
Eluent: HFIP + 20mM NaTFAc
Flow Rate: 1.0ml/min
Temp: 40°C
Detector: RI



Organic GPC Columns - Ordering Information

PlusPore Columns, pages 4-8

Product	300x7.5mm Part No.	250x4.6mm Part No.	300x25mm Part No.	Guard 50x7.5mm Part No.	Guard 50x4.6mm Part No.
PolyPore	PL1113-6500	PL1513-5500		PL1113-1500	PL1513-1500
ResiPore	PL1113-6300	PL1513-5300		PL1113-1300	PL1513-1300
MesoPore	PL1113-6325	PL1513-5325		PL1113-1325	PL1513-1325
OligoPore	PL1113-6520	PL1513-5520	PL1213-6520	PL1113-1320	PL1513-1320

PLgel MIXED Gel Columns, pages 10-17

Product	300x7.5mm Part No.	PLgel MiniMIX 250x4.6mm Part No.	600x7.5mm Part No.	Guard 50x7.5mm Part No.	PLgel MiniMIX Guard 50x4.6mm Part No.
PLgel 20µm MIXED-A	PL1110-6200	PL1510-5200	PL1110-8200	PL1110-1220	PL1510-1200
PLgel 20µm MIXED-A LS	PL1110-6200LS			PL1110-1220	
PLgel 10µm MIXED-B	PL1110-6100	PL1510-5100	PL1110-8100	PL1110-1120	PL1510-1100
PLgel 10µm MIXED-B LS	PL1110-6100LS			PL1110-1120	
PLgel 5µm MIXED-C	PL1110-6500	PL1510-5500	PL1110-8500	PL1110-1520	PL1510-1500
PLgel 5µm MIXED-D	PL1110-6504	PL1510-5504	PL1110-8504	PL1110-1520	PL1510-1504
PLgel 3µm MIXED-E	PL1110-6300	PL1510-5300		PL1110-1320	PL1510-1300

PLgel Individual Pore Size Columns, pages 18-19

Product	300x7.5mm Part No.	600x7.5mm Part No.	Guard 50x7.5mm Part No.
PLgel 3µm 100Å	PL1110-6320		PL1110-1320
PLgel 5µm 50Å	PL1110-6515	PL1110-8515	PL1110-1520
PLgel 5µm 100Å	PL1110-6520	PL1110-8520	PL1110-1520
PLgel 5µm 500Å	PL1110-6525	PL1110-8525	PL1110-1520
PLgel 5µm 10^3Å	PL1110-6530	PL1110-8530	PL1110-1520
PLgel 5µm 10^4Å	PL1110-6540	PL1110-8540	PL1110-1520
PLgel 5µm 10^5Å	PL1110-6550	PL1110-8550	PL1110-1520
PLgel 10µm 50Å	PL1110-6115	PL1110-8115	PL1110-1120
PLgel 10µm 100Å	PL1110-6120	PL1110-8120	PL1110-1120
PLgel 10µm 500Å	PL1110-6125	PL1110-8125	PL1110-1120
PLgel 10µm 10^3Å	PL1110-6130	PL1110-8130	PL1110-1120
PLgel 10µm 10^4Å	PL1110-6140	PL1110-8140	PL1110-1120
PLgel 10µm 10^5Å	PL1110-6150	PL1110-8150	PL1110-1120
PLgel 10µm 10^6Å	PL1110-6160	PL1110-8160	PL1110-1120

Organic GPC Columns & Accessories - Ordering Information

PLgel Preparative Columns, pages 20-21

Column Type	300x25mm Part No.	600x25mm Part No.
PLgel 10µm MIXED-B	PL1210-6100	PL1210-8100
PLgel 10µm MIXED-D	PL1210-6104	PL1210-8104
PLgel 10µm 50Å	PL1210-6115	PL1210-8115
PLgel 10µm 100Å	PL1210-6120	PL1210-8120
PLgel 10µm 500Å	PL1210-6125	PL1210-8125
PLgel 10µm 10^3Å	PL1210-6130	PL1210-8130
PLgel 10µm 10^4Å	PL1210-6140	PL1210-8140
PLgel 10µm 10^5Å	PL1210-6150	PL1210-8150
PLgel 10µm 10^6Å	PL1210-6160	PL1210-8160

PLgel Prep Guard	Part No.
25x25mm	PL1210-1120

Media Type	Frit porosity (µm)
PLgel 3µm	2
PLgel 5µm	2
PLgel 10µm	5
PLgel 20µm	10
PL HFIPgel	5
OligoPore	2
MesoPore	2
ResiPore	2
PolyPore	2

PL EnviroPrep Columns, page 21

Column Type	Part No.
PL EnviroPrep, 300x25mm	PL1210-6120EPA
PL EnviroPrep, 150x25mm	PL1210-3120EPA

PL HFIPgel Columns, page 22

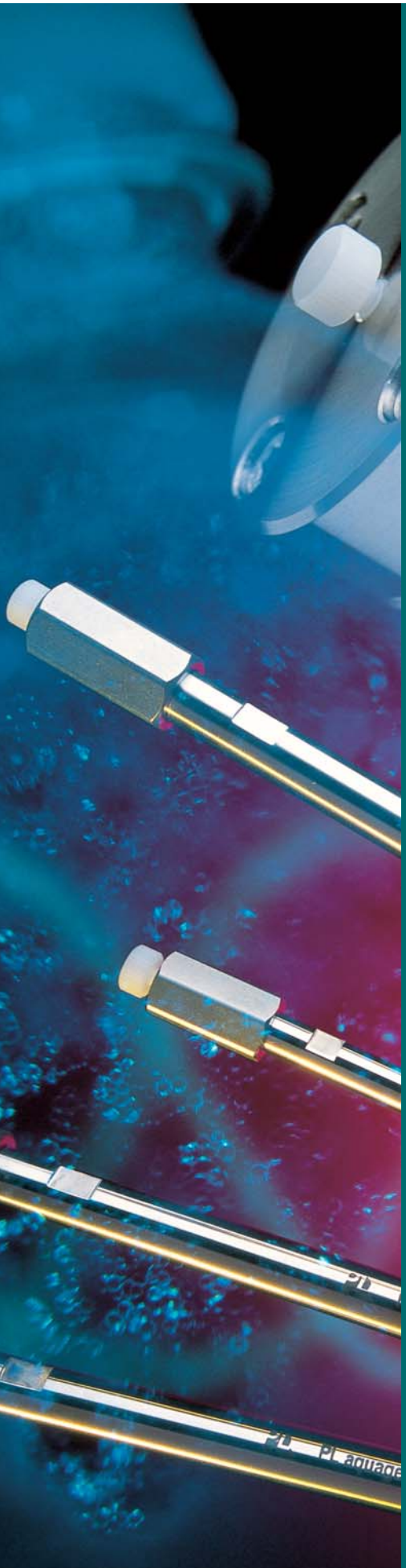
Column Type	Part No.
PL HFIPgel, 300x7.5mm	PL1114-6900HFIP
PL HFIPgel, 250x4.6mm	PL1514-5900HFIP
PL HFIPgel Guard, 50x7.5mm	PL1114-1900HFIP
PL HFIPgel Guard, 50x4.6mm	PL1514-1900HFIP

- PL offers a rapid column repair service – call us for details
- PL has the expertize and flexibility to design and manufacture custom GPC columns for specialty applications – call us to discuss your individual requirements

GPC Column Accessories Ordering Information

Item	Part No.
Frit Removal Tool - threaded columns only	PL1310-0001
End Fitting for threaded columns, 4.6mm ID	PL1310-0034
Frit (2µm) Kit (Pk of 5) for Narrow Bore MiniMIX columns, 4.6mm ID	PL1310-0041
Frit (5µm) Kit (Pk of 5) for Narrow Bore MiniMIX columns, 4.6mm ID	PL1310-0042
Frit (10µm) Kit (Pk of 5) for Narrow Bore MiniMIX columns, 4.6mm ID	PL1310-0043
End Fitting for threaded columns, 7.5mm ID	PL1310-0004
Frit (2µm) Kit (Pk of 5) for threaded columns, 7.5mm ID	PL1310-0002
Frit (5µm) Kit (Pk of 5) for threaded columns, 7.5mm ID	PL1310-0012
Frit (10µm) Kit (Pk of 5) for threaded columns, 7.5mm ID	PL1310-0036
PLgel 20µm Column Repair Gel	PL1410-0201
PLgel 10µm Column Repair Gel	PL1410-0101
PLgel 5µm Column Repair Gel	PL1410-0501
PLgel 3µm Column Repair Gel	PL1410-0301
OligoPore Column Repair Gel	PL1413-0320
MesoPore Column Repair Gel	PL1413-0325
ResiPore Column Repair Gel	PL1413-0300
PolyPore Column Repair Gel	PL1413-0500
Column Connecting Nuts (Pk of 5), 1/16" tube	PL1310-0007
Tubing Ferrules (Pk of 5), 1/16" tube	PL1310-0008
LDV Intercolumn SS Connector	PL1310-0005
Column End Plugs (Pk of 10), 1/16"	PL1310-0003
Connecting Tubing (Pk of 10), 10cm length, 0.010" ID	PL1310-0048
Connecting Tubing (Pk of 10), 5cm length, 0.010" ID	PL1310-0047
Replacement Frit and End Fitting, 25mm ID	PL1310-0011

PL aquagel-OH Columns



Size exclusion chromatography (SEC) using aqueous based eluents is used for the measurement of molecular weight distribution (MWD) of water soluble polymers.

PL aquagel-OH high performance aqueous SEC columns are durable and versatile, offering separations for a diverse range of applications.

PL aquagel-OH Columns

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 of columns provides a chemically and physically stable matrix for reliable aqueous SEC separations.

High Performance PL aquagel-OH Columns for Aqueous SEC

PL aquagel-OH 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 analytes with neutral, ionic and hydrophobic moieties or combinations thereof.

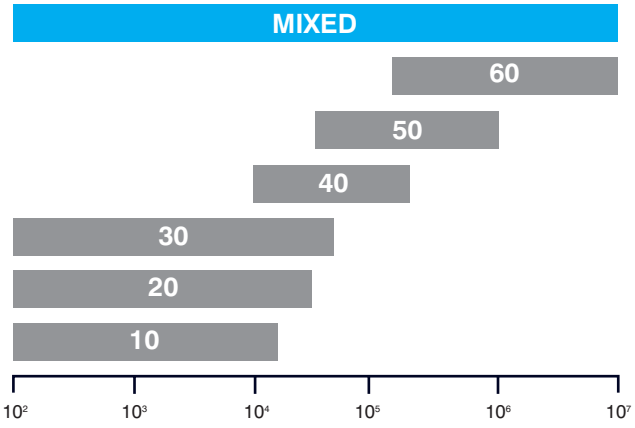
PL aquagel-OH 8µm Analytical Columns

- **PL aquagel-OH MIXED 8µm** columns offer high resolution over a very wide range of molecular weight, simplifying column selection and providing a versatile analytical system.
- **PL aquagel-OH 30 8µm** high performance columns are ideal for relatively low molecular weight separations, combining low exclusion limits, high pore volume and high column efficiency for maximum resolution.
- **PL aquagel-OH Individual Pore Size 8µm** columns for high performance separations across the MW range 10,000 to >10,000,000.

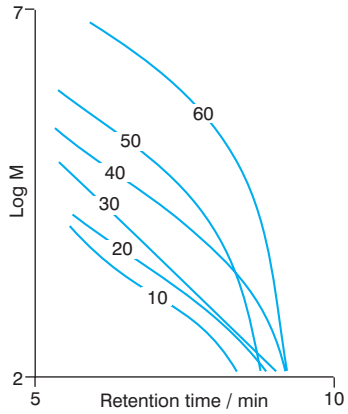
PL aquagel-OH 15µm Analytical Columns

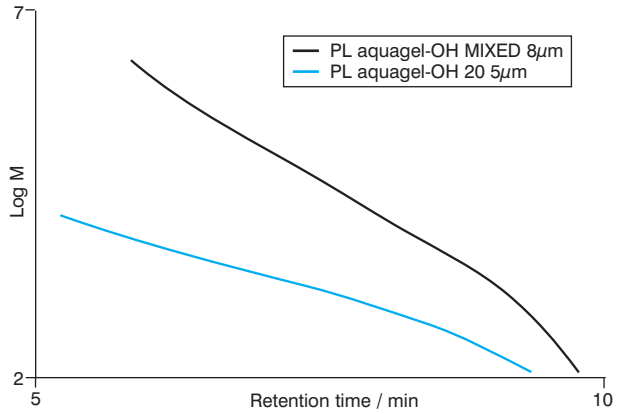
- **PL aquagel-OH 15µm** columns for the analysis of very high molecular weight polymers. Where molecular shear degradation is a real consideration, the larger particle size and larger frit porosity permit the analysis of high viscosity polymers in the range from 1M up to 100M.

Operating Ranges of PL aquagel-OH Columns



PL aquagel-OH Calibration Curves





PL aquagel-OH Features:

- pH range 2 - 10
- compatible with organic solvent, up to 50% methanol
- mechanical stability up to 140 bar (2000psi)
- low column operating pressures
- 8µm columns > 35,000 plates/m
- 15µm columns > 15,000 plates/m

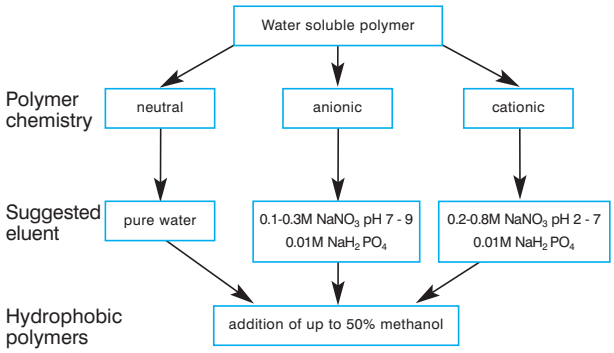
PL aquagel-OH Columns

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 modified 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 hydrophobic character, only the addition of a weak organic solvent (methanol) is required to inhibit hydrophobic interactions.

This versatility means that PL aquagel-OH columns can be used to analyse a wide range of neutral, polar, anionic and cationic samples.

Guide to Eluent Selection for PL aquagel-OH Applications



PL aquagel-OH Column Selection Guide

Sample Type	Typical Examples	Recommended Column Sets
Low MW polymers and oligomers	Surfactants, oligosaccharides, PEGs, lignosulfonates, polyacrylates	2 or 3 30, 20, 10 PL aquagel-OH 8µm or PL aquagel-OH 20 5µm
Polydisperse synthetic or naturally occuring polymers	Polysaccharides, PVA, cellulose derivatives, PEO, polyacrylic acids	2 or 3 PL aquagel-OH MIXED 8µm or PL aquagel-OH 60/50/40 8µm
Very high MW polymers	Polyacrylamides, hyaluronic acids, CMC, starches, gums	PL aquagel-OH 60/50/40 15µm in series

Calibration

PL Polymer Standards for calibration in aqueous SEC are available as individual polymers or standards kits.

See Page 39 for further details.

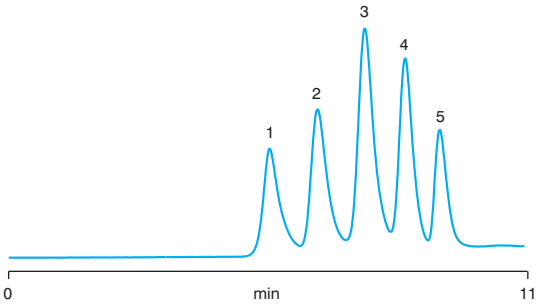
Description	Calibration Kit	Part No.
Polyethylene Oxide Kit	PEO-10	PL2080-0101
Polyethylene Glycol Kit	PEG-10	PL2070-0100
Polyacrylic Acid Kit	PAA-10	PL2140-0100
Polysaccharide Kit	SAC-10	PL2090-0100
Polyethylene Glycol/Oxide EasiVial Kit	EasiVial PEG/PEO (4ml vials)	PL2080-0200
	EasiVial PEG/PEO (2ml vials)	PL2080-0201

PL aquagel-OH MIXED Applications

Polyethylene Glycol/Oxide Standards

Column: PL aquagel-OH MIXED 8μm, 300x7.5mm (PL1149-6800)
Eluent: Water
Flow Rate: 1.0ml/min
Detector: RI

Standards:
1. 1,702,000
2. 120,000
3. 12,600
4. 1,470
5. 106

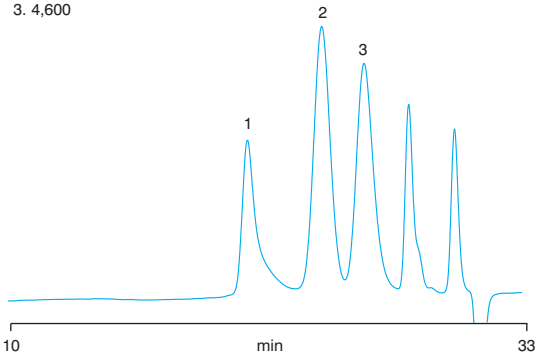


Polystyrene Sulfonate Standards

(anionic, hydrophobic)

Columns: 3xPL aquagel-OH MIXED 8μm, 300x7.5mm (PL1149-6800)
Eluent: 70% 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 9, 30% Methanol
Flow Rate: 1.0ml/min
Detector: RI

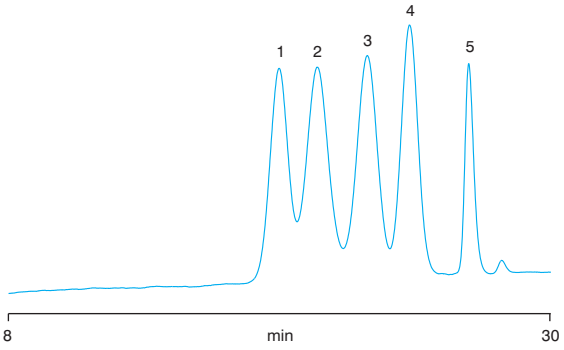
Standards:
1. 400,000
2. 35,000
3. 4,600



Pullulan Polysaccharide Standards

Columns: 3xPL aquagel-OH MIXED 8μm, 300x7.5mm (PL1149-6800)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI

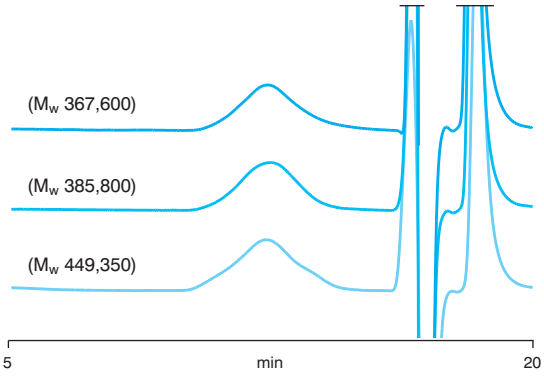
Standards:
1. 788,000
2. 212,000
3. 47,300
4. 11,800
5. 667



Chitosan Samples

(cationic)

Columns: 2xPL aquagel-OH MIXED 8μm, 300x7.5mm (PL1149-6800)
Eluent: 0.5M $NaNO_3$, 0.01M NaH_2PO_4, pH 2
Flow Rate: 1.0ml/min
Detector: RI

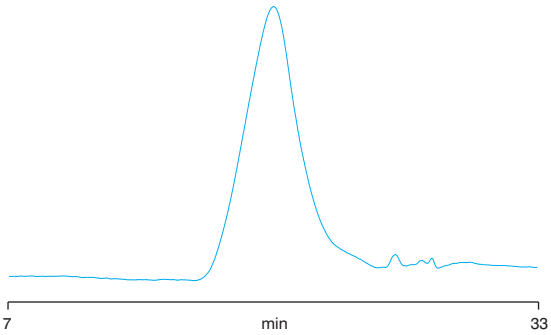


Inbalance peaks on RI as samples are prepared in strong acid for dissolution.

PL aquagel-OH MIXED Applications

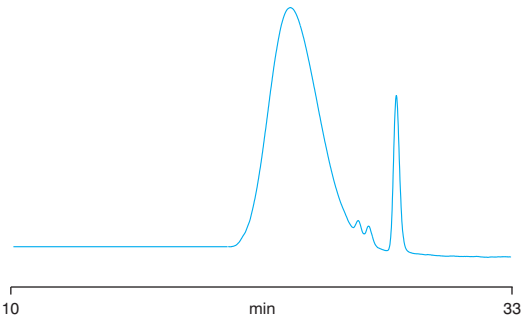
Pectin

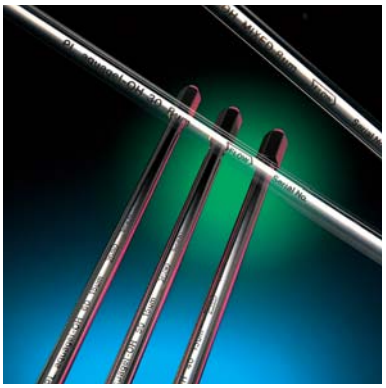
Columns: 3xPL aquagel-OH MIXED 8µm, 300x7.5mm (PL1149-6800)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Polyvinyl Alcohol (98% hydrolyzed)

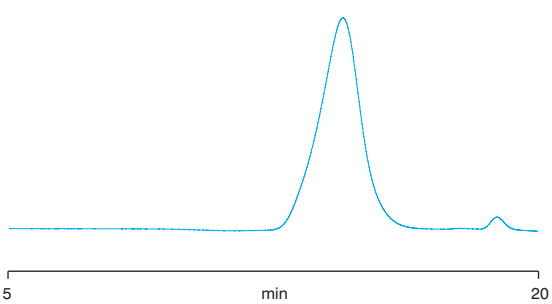
Columns: 3xPL aquagel-OH MIXED 8µm, 300x7.5mm (PL1149-6800)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI





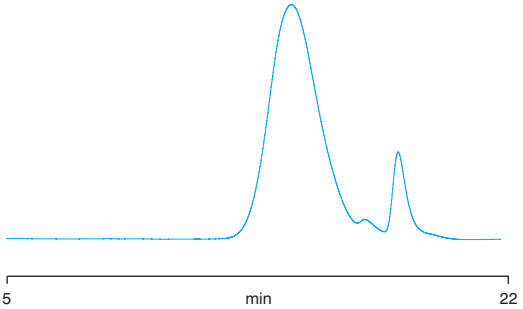
Dextran

Columns: 2xPL aquagel-OH MIXED 8µm, 300x7.5mm (PL1149-6800)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Sodium Alginate

Columns: 2xPL aquagel-OH MIXED 8µm, 300x7.5mm (PL1149-6800)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI

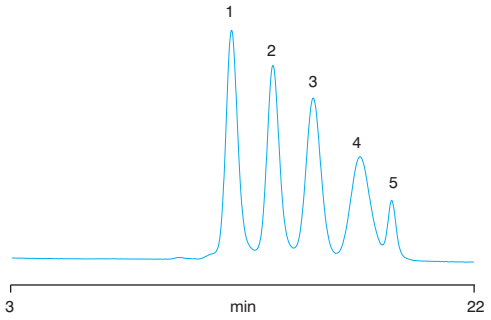


PL aquagel-OH High Performance, Low MW Applications

Polyethylene Glycol Standards

Columns: 2xPL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: Water
Flow Rate: 1.0ml/min
Detector: RI

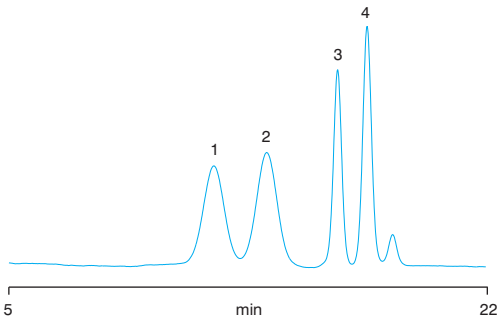
Standards:
1. 12,600
2. 4,120
3. 1,470
4. 440
5. 106



Polysaccharide Standards

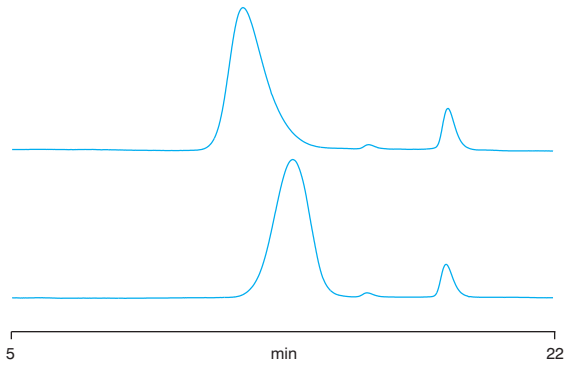
Columns: 2xPL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: Water
Flow Rate: 1.0ml/min
Detector: RI

Standards:
1. 23,700
2. 5,800
3. 667
4. 180



Heparin

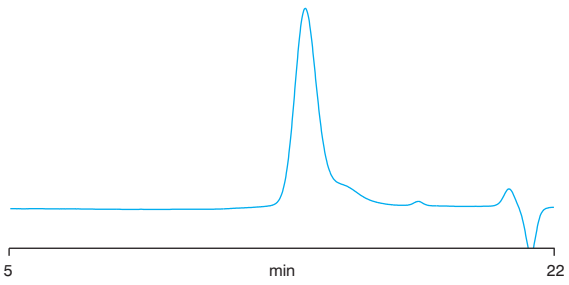
Columns: 2xPL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Non-ionic Surfactant (Pluronic F68)

(hydrophobic)

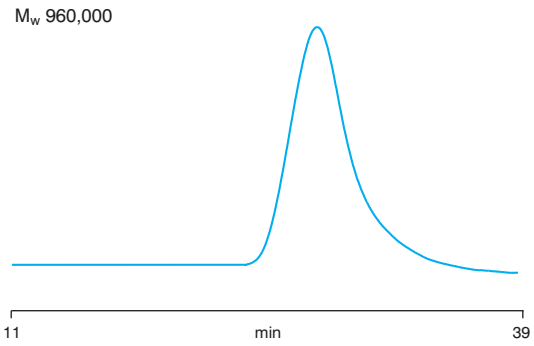
Columns: 2xPL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: 70% 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7, 30% Methanol
Flow Rate: 1.0ml/min
Detector: RI



PL aquagel-OH High MW Applications

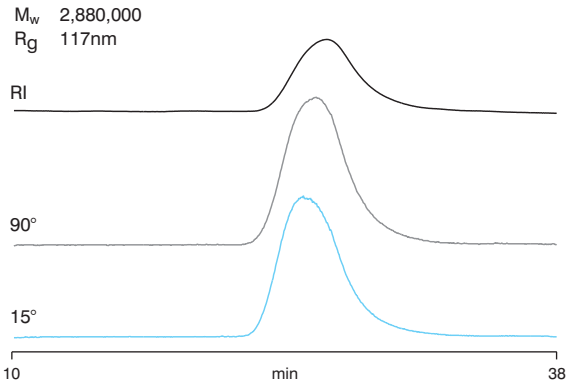
Polyacrylic Acid

Columns: PL aquagel-OH 60 15µm, 300x7.5mm (PL1149-6260)
PL aquagel-OH 40 15µm, 300x7.5mm (PL1149-6240)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 0.5ml/min
Detector: RI



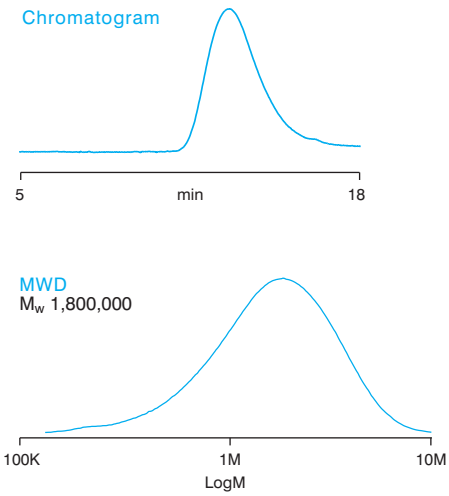
Guar Gum

Columns: PL aquagel-OH 60 15µm, 300x7.5mm (PL1149-6260)
PL aquagel-OH 40 15µm, 300x7.5mm (PL1149-6240)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 0.5ml/min
Detectors: RI / LS 15° / LS 90°



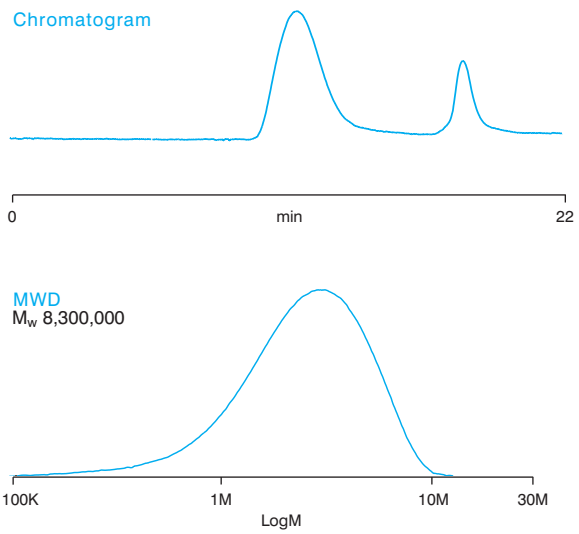
Hyaluronic Acid

Columns: PL aquagel-OH 60 15µm, 300x7.5mm (PL1149-6260)
PL aquagel-OH 40 15µm, 300x7.5mm (PL1149-6240)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Polyacrylamide

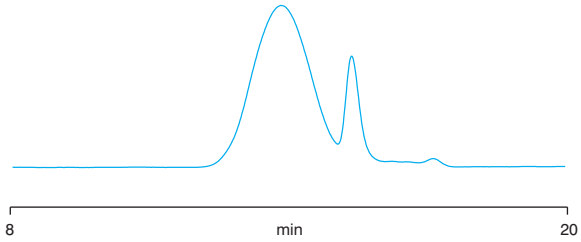
Columns: PL aquagel-OH 60 15µm, 300x7.5mm (PL1149-6260)
PL aquagel-OH 40 15µm, 300x7.5mm (PL1149-6240)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



PL aquagel-OH Miscellaneous Applications

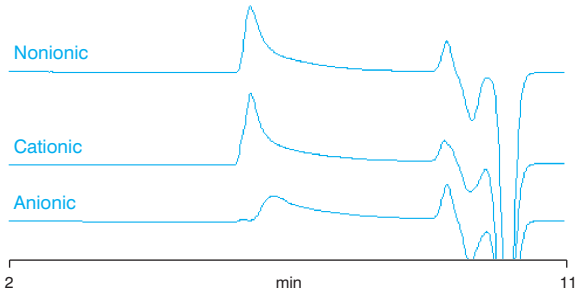
Sodium Polyacrylate

Columns: PL aquagel-OH 40 8µm, 300x7.5mm (PL1149-6840)
PL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



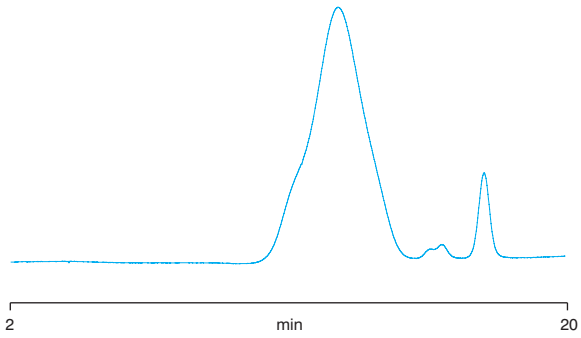
Residual Polyacrylamide in Reclaimed Water

Column: PL aquagel-OH 50 8µm, 300x7.5mm (PL1149-6850)
Eluent: 0.05M Na_2SO_4, adjusted to pH 3
Flow Rate: 1.0ml/min
Sample Loading: 0.1mg/ml, 200µl
Detector: UV, 208nm



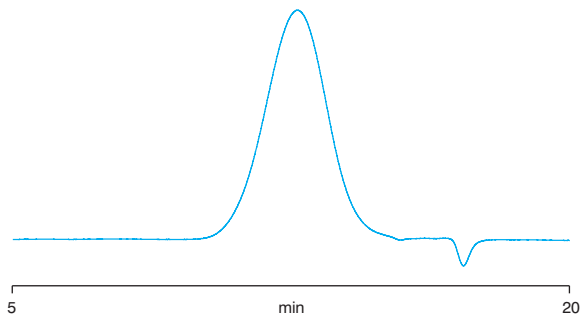
Dextrin Sulfate

Columns: PL aquagel-OH 40 8µm, 300x7.5mm (PL1149-6840)
PL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Dextran T40

Columns: PL aquagel-OH 40 8µm, 300x7.5mm (PL1149-6840)
PL aquagel-OH 30 8µm, 300x7.5mm (PL1120-6830)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



PL aquagel-OH Preparative Columns

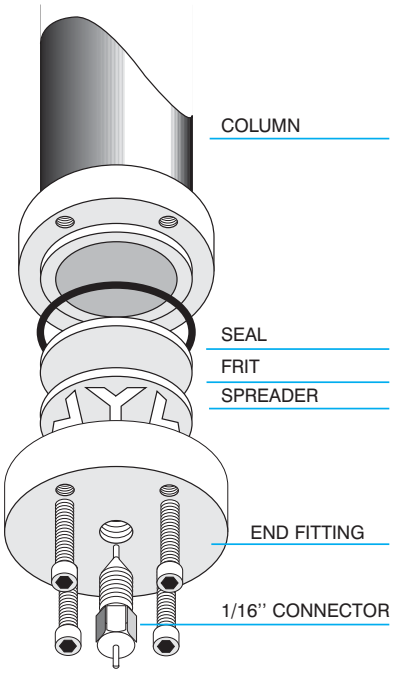
Preparative SEC can be used for the fractionation of a wide variety of water soluble samples based on their size in solution. The technique may be applied to the fractionation of disperse polymers or to isolate components in a polymer formulation.

Preparative PL aquagel-OH columns and associated guard columns have been specifically designed to enable rapid and convenient scale-up from analytical separations. The 25mm ID prep column offers at least a 10 x scale-up in loading from the 7.5mm ID analytical columns. Typically, a 10ml/min flow rate results in a separation time of 10 minutes with a 300mm column.

PL aquagel-OH preparative columns are packed with the same robust macroporous particles as the analytical column range. The 10μm particle size provides optimum resolution and loading characteristics with column efficiency >20,000 plates/m.

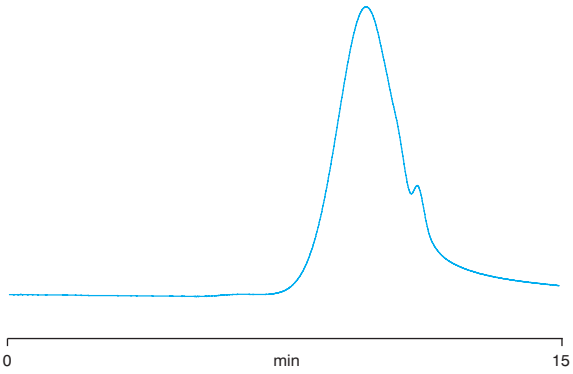
PL aquagel-OH preparative SEC columns are available in four individual pore sizes with column dimensions of 300x25mm. A 25x25mm preparative guard column is also available.

PL aquagel-OH Preparative Column Hardware



Polyvinyl Alcohol

Column: PL aquagel-OH 40 10μm, 300x25mm (PL1249-6140)
Eluent: 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 10.0ml/min
Loading: 10mg/ml, 2ml
Detector: RI



PL aquagel-OH Preparative Column Ordering Information

	Description (PEO/PEG)	MW Operating Range	Part No.
	PL aquagel-OH 30 10μm, 300x25mm	100 - 30,000	PL1220-6130
	PL aquagel-OH 40 10μm, 300x25mm	10,000 - 200,000	PL1249-6140
	PL aquagel-OH 50 10μm, 300x25mm	50,000 - 1,000,000	PL1249-6150
	PL aquagel-OH 60 10μm, 300x25mm	200,000 - >10,000,000	PL1249-6160
NEW	PL aquagel-OH MIXED 10μm, 300x25mm	100 - 10,000,000	PL1249-6100
	PL aquagel-OH Guard 10μm, 25x25mm	-	PL1249-1120
	Replacement Frit and End Fitting, 25mm ID	-	PL1310-0011

PL aquagel-OH Analytical Column Ordering Information

PL aquagel-OH Columns 300x7.5mm

Description	MW Operating Range (PEO/PEG)	Guaranteed Efficiency (plates/m)	Part No.
PL aquagel-OH 30 8µm	100 - 30,000	>35,000	PL1120-6830
PL aquagel-OH 40 8µm	10,000 - 200,000	>35,000	PL1149-6840
PL aquagel-OH 50 8µm	50,000 - 1,000,000	>35,000	PL1149-6850
PL aquagel-OH 60 8µm	200,000 - >10,000,000	>35,000	PL1149-6860
PL aquagel-OH MIXED 8µm	100 - 10,000,000	>35,000	PL1149-6800
PL aquagel-OH 40 15µm	10,000 - 200,000	>15,000	PL1149-6240
PL aquagel-OH 50 15µm	50,000 - 1,000,000	>15,000	PL1149-6250
PL aquagel-OH 60 15µm	200,000 - >10,000,000	>15,000	PL1149-6260

PL aquagel-OH Guard Columns

PL aquagel-OH guard columns are highly recommended to protect and prolong the lifetime of valuable high performance analytical columns. Packed with rigid low pore size material, the guard column traps out sample components which might otherwise contaminate the aqueous SEC columns. PL aquagel-OH guard columns are available in 50x7.5mm hardware and are compatible with all PL aquagel-OH analytical columns. Simply choose the 8µm or 15µm guard column to match the particle size of your analytical column.

Description	Part No
PL aquagel-OH Guard 8µm, 50x7.5mm	PL1149-1840
PL aquagel-OH Guard 15µm, 50x7.5mm	PL1149-1240

Column Repair Service

PL offers a rapid column repair service, please call for further details.

Column Design and Manufacture

PL has the expertize and flexibility to design and manufacture custom SEC columns for specialty applications. Please call to discuss your individual requirements.

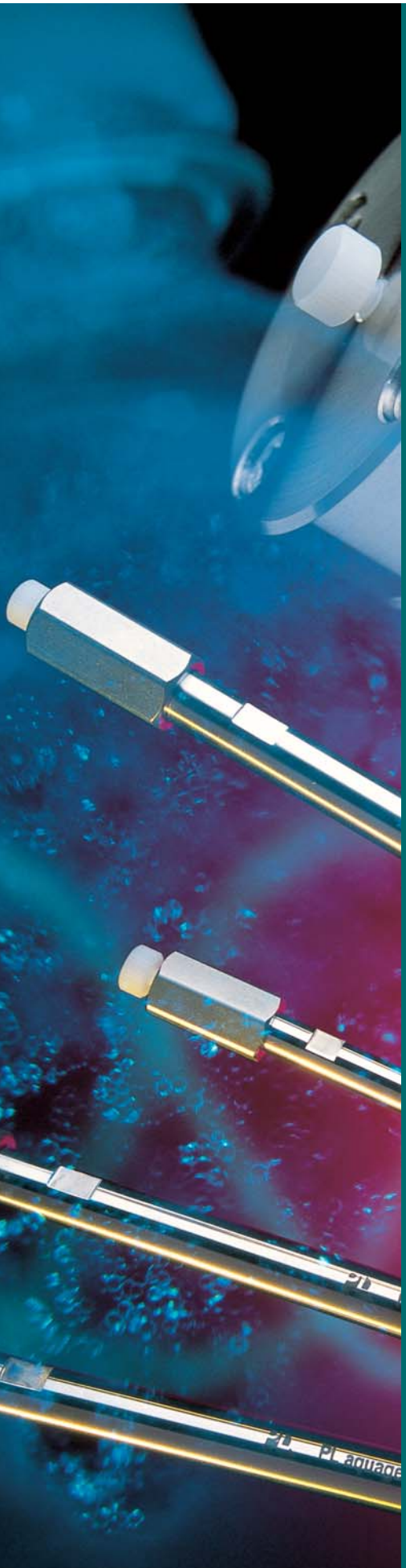
PL aquagel-OH Column Hardware

PL's own design of low dead volume hardware comprises a single piece end fitting which screws onto a threaded column. The frit porosity is matched to the particle size of the packing material, 2µm frit for 8µm columns and 5µm frit for 15µm columns.

PL aquagel-OH Accessories

Description	Part No.
Frit Removal Tool	PL1310-0001
End Fitting for threaded columns, 7.5mm ID	PL1310-0004
Frit(2µm) Kit (Pk of 5) for threaded columns, 7.5mm ID	PL1310-0002
Frit(5µm) Kit (Pk of 5) for threaded columns, 7.5mm ID	PL1310-0012
PL aquagel-OH 8µm Repair Gel	PL1449-0801
PL aquagel-OH 15µm Repair Gel	PL1449-0201
Column Connecting Nuts (Pk of 5), 1/16" tube	PL1310-0007
Tubing Ferrules (Pk of 5), 1/16" tube	PL1310-0008
LDV Intercolumn SS Connector	PL1310-0005
Column End Plugs (Pk of 10), 1/16"	PL1310-0003
Connecting Tubing (Pk of 10), 10cm length, 10 Thou ID	PL1310-0048
Connecting Tubing (Pk of 10) 5cm length, 10 Thou ID	PL1310-0047

PL Rapide Columns for Rapid Organic & Aqueous GPC/SEC



High speed polymer characterization can be used where very large numbers of samples need to be analysed, or where information is required rapidly for time-critical processes.

The PL Rapide range of rapid GPC/SEC columns can be used in high throughput screening and process monitoring to detect trends in average molecular weight and molecular weight distribution of synthetic polymers.

Polymer Laboratories' Approach to Rapid GPC/SEC

Rapid GPC is an excellent tool for screening polymer MWD for trend analysis. Short PL Rapide columns are used to reduce analysis times while maintaining the excellent solvent compatibility and mechanical stability of all Polymer Laboratories' GPC columns.

Two key parameters can be altered to reduce the analysis time of an experiment. Column length can be reduced *or* eluent flow rate increased. Using both methods in conjunction leads to a significantly higher sample throughput than can be obtained using a conventional GPC/SEC column set.

For high speed GPC/SEC applications where time is the most critical factor in the analysis, PL has launched new PL Rapide columns. Packed with high quality gels, these cover the complete spectrum of molecular weights and are available for the analysis of both organic and water soluble polymers.

Key Features of PL Rapide Columns

- 150x7.5mm and 100x10mm column dimensions
- High pore volume, high resolution packing materials
- No special system requirements
- Choice of molecular weight resolving range
- Wide solvent compatibility
- Excellent mechanical stability

Key Benefits of PL Rapide Columns

- Analysis in less than ten minutes
- Significantly increased sample throughput
- Reduced solvent consumption & disposal costs

PL Rapide Columns for the Analysis of High Viscosity Polymers

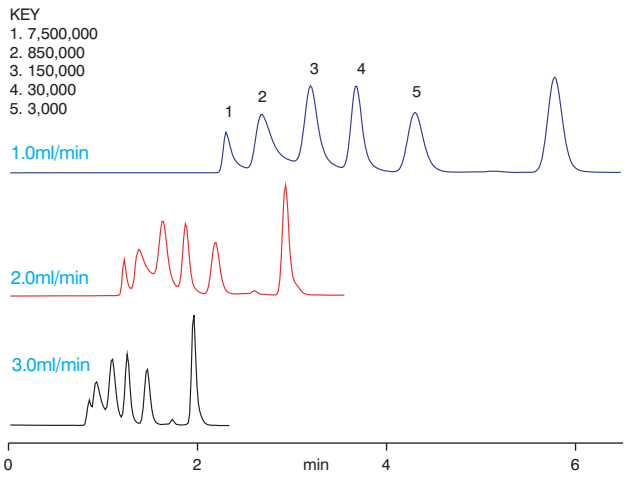
The analysis of high viscosity materials is a key factor in many materials discovery applications. With increasing molecular weight, diffusion of the polymer chains into and out of the pores of a GPC packing material during analysis is critical to obtaining good quality separations. This effect means that increasing the flow rate of an analysis to reduce the analysis time can have a detrimental effect on resolution and may damage the polymer chains through shear degradation. Polymer Laboratories' PL Rapide 150x7.5mm columns offer a 4-6 fold *decrease* in analysis time over conventional GPC columns at a typical flow rate of 1.0ml/min.

PL Rapide Columns for the Analysis of Intermediate and Low Viscosity Polymers

The analysis of intermediate and low viscosity polymers is less influenced by mass transfer effects, therefore increased flow rates can be used to further decrease the analysis time. For these applications, Polymer Laboratories' PL Rapide 100x10mm columns have the advantage of a 4-8 fold *decrease* in analysis time compared to a conventional analysis when running at 1.0ml/min. In addition, the expanded internal diameter allows the flow rate to be increased for further reduction in time without affecting the column resolution. PL Rapide 100x10mm columns can be used at flow rates as high as 3.0ml/min, which in conjunction with the short column lengths, gives a 10-15 fold *decrease* in total analysis time.

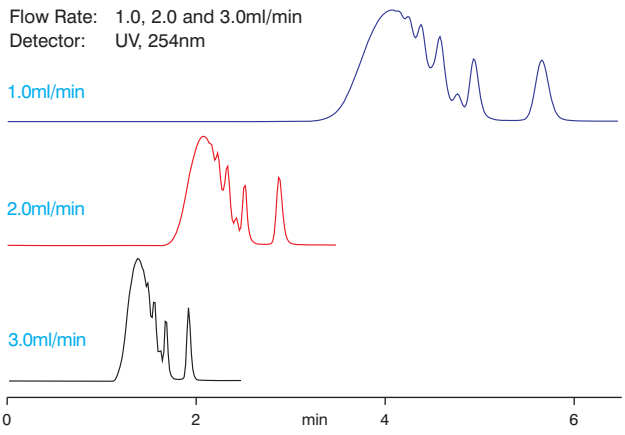
Effect of Flow Rate on Resolution – High Viscosity / High Molecular Weight

Sample: EasiCal PS-1 Polystyrene Standards
Column: PL Rapide M, 100x10mm (PL1013-2500)
Eluent: THF
Flow Rate: 1.0, 2.0 and 3.0ml/min
Detector: UV, 254nm



Resin Analysis by Rapid GPC

Sample: Epoxy resin
Column: PL Rapide L, 100x10mm (PL1013-2300)
Eluent: THF
Flow Rate: 1.0, 2.0 and 3.0ml/min
Detector: UV, 254nm



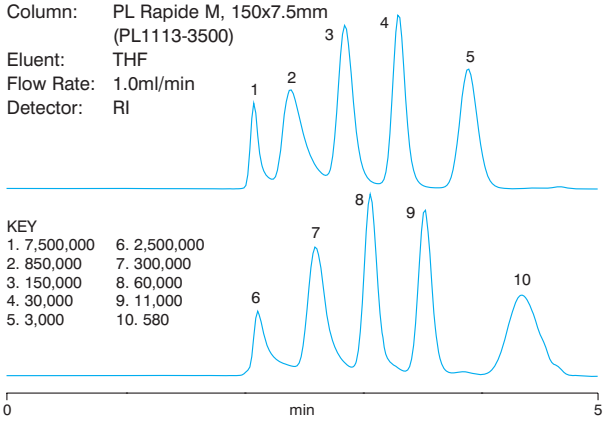
PL Rapide Applications

Polymer Analysis in Under 10 Minutes

Rapid GPC/SEC requires column calibration with the minimum number of injections. Polymer Laboratories' PL Rapide columns are packed with high pore volume, high efficiency media offering maximum resolution, and PL's pre-prepared polymer standards further simplify the calibration procedure.

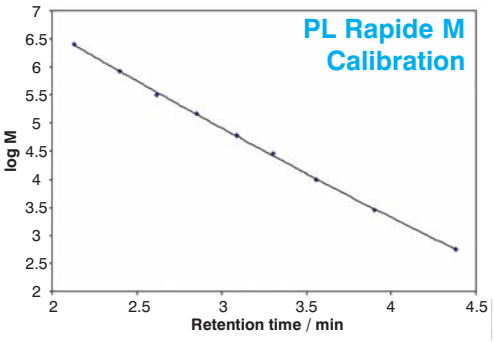
Rapid Calibration

Sample: EasiCal PS-1 Polystyrene Standards
Column: PL Rapide M, 150x7.5mm (PL1113-3500)
Eluent: THF
Flow Rate: 1.0ml/min
Detector: RI



KEY

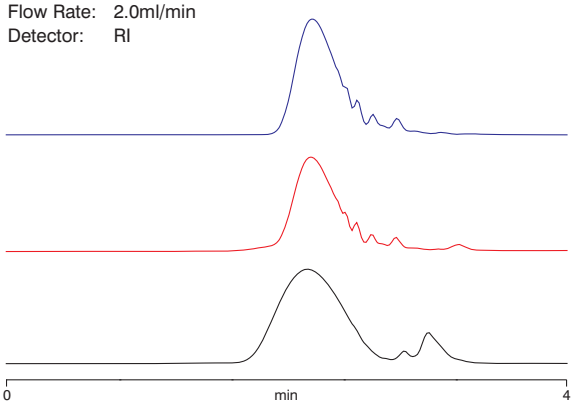
1. 7,500,000	6. 2,500,000
2. 850,000	7. 300,000
3. 150,000	8. 60,000
4. 30,000	9. 11,000
5. 3,000	10. 580



Rapid GPC/SEC permits easy differentiation between polymers which vary in both average molecular weight and MWD.

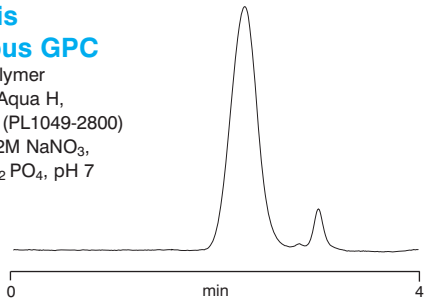
Polymer Analysis by Rapid GPC

Sample: Commercial Resin polymers
Column: PL Rapide L, 100x10mm (PL1013-2300)
Eluent: THF
Flow Rate: 2.0ml/min
Detector: RI



Polymer Analysis by Rapid Aqueous GPC

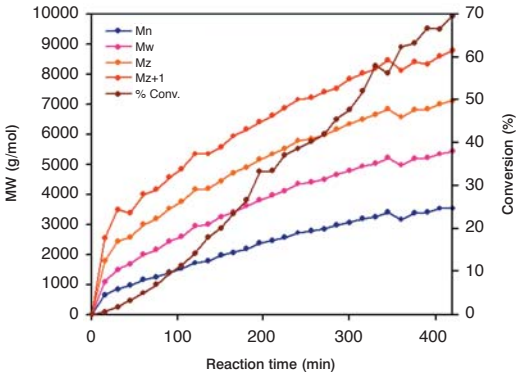
Sample: Acrylate polymer
Column: PL Rapide Aqua H, 100x10mm (PL1049-2800)
Eluent: Water + 0.2M $NaNO_3$, 0.01M NaH_2PO_4, pH 7
Flow Rate: 1.0ml/min
Detector: RI



Process Monitoring

Polymerization reactions can be monitored using rapid GPC/SEC methods to plot the trends in molecular weight and MWD. If the concentration detector response is also calibrated, conversion from monomer to polymer can also be monitored.

Monitoring Copolymerization of Styrene and Methacrylate by Atom Transfer Radical Polymerization (ATRP)



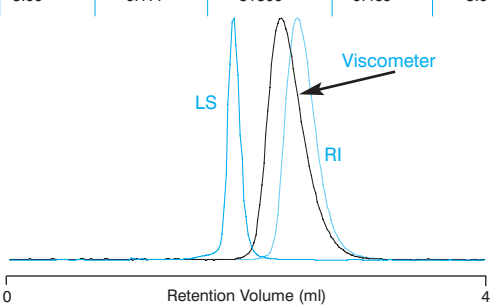
Polymer Flow Injection Analysis (FIA)

A GPC/SEC system fitted with light scattering and viscosity detection can be used to make a rapid determination of bulk properties (Mw and IV) using a rapid GPC column packed with low pore size media to simply separate the polymer from the additive region.

Polycarbonate Data by FIA

Column: PL Rapide F, 150x7.5mm (PL1113-3320)
Eluent: THF
Flow Rate: 1.5ml/min
Temp: 30°C
Detectors: RI, LS, Viscosity (PL-GPC 220)

Inj	Conc (mg/ml)	dn/dc (ml/g)	Mw (Daltons)	IV (dl/g)	Rg (nm)
1	3.00	0.175	32700	0.466	8.1
2	3.00	0.177	31300	0.469	8.0



PL Rapide Columns - Ordering Information

PL Rapide

Description	MW Range	Guaranteed Efficiency (plates/m)	Part No
PL Rapide H, 150x7.5mm	500 - 10,000,000	>35,000	PL1113-3100
PL Rapide H, 100x10mm	500 - 10,000,000	>35,000	PL1013-2100
PL Rapide M, 150x7.5mm	200 - 2,000,000	>60,000	PL1113-3500
PL Rapide M, 100x10mm	200 - 2,000,000	>60,000	PL1013-2500
PL Rapide L, 150x7.5mm	200 - 400,000	>80,000	PL1113-3300
PL Rapide L, 100x10mm	200 - 400,000	>80,000	PL1013-2300
PL Rapide F, 150x7.5mm	Up to 4,000	>40,000	PL1113-3120
PL Rapide F, 100x10mm	Up to 4,000	>40,000	PL1013-2120

PL Rapide Aqua

Description	MW Range	Guaranteed Efficiency (plates/m)	Part No
PL Rapide Aqua H, 150x7.5mm	100 - 10,000,000	>35,000	PL1149-3800
PL Rapide Aqua H, 100x10mm	100 - 10,000,000	>35,000	PL1049-2800
PL Rapide Aqua L, 150x7.5mm	100 - 30,000	>35,000	PL1120-3830
PL Rapide Aqua L, 100x10mm	100 - 30,000	>35,000	PL1020-2830

Custom GPC/SEC Columns

PL has the expertize and flexibility to design and manufacture custom GPC/SEC columns for specialty applications - call us to discuss your individual requirements for novel rapid GPC/SEC methodologies.

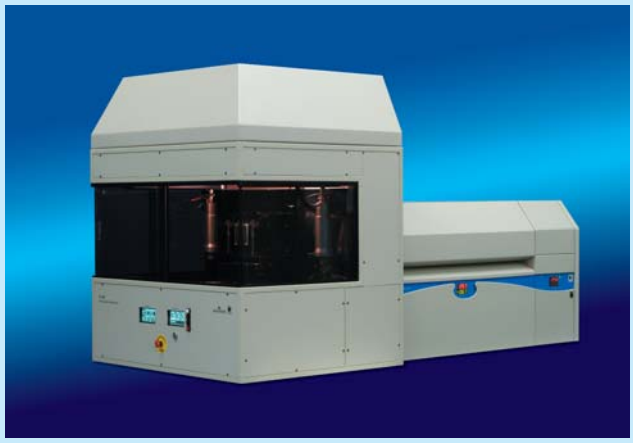
Polymer Laboratories' 100x10mm columns are manufactured under exclusive license from Symyx® US Patent No. 6,416,663. Use of these high-aspect ratio columns may also be covered by one or more of US Patent Numbers 6,406,632, 6,475,391, 6,491,823, 6,454,947, and 6,492,184. Additional US and foreign patents pending.

Symyx®

PL-XT 220

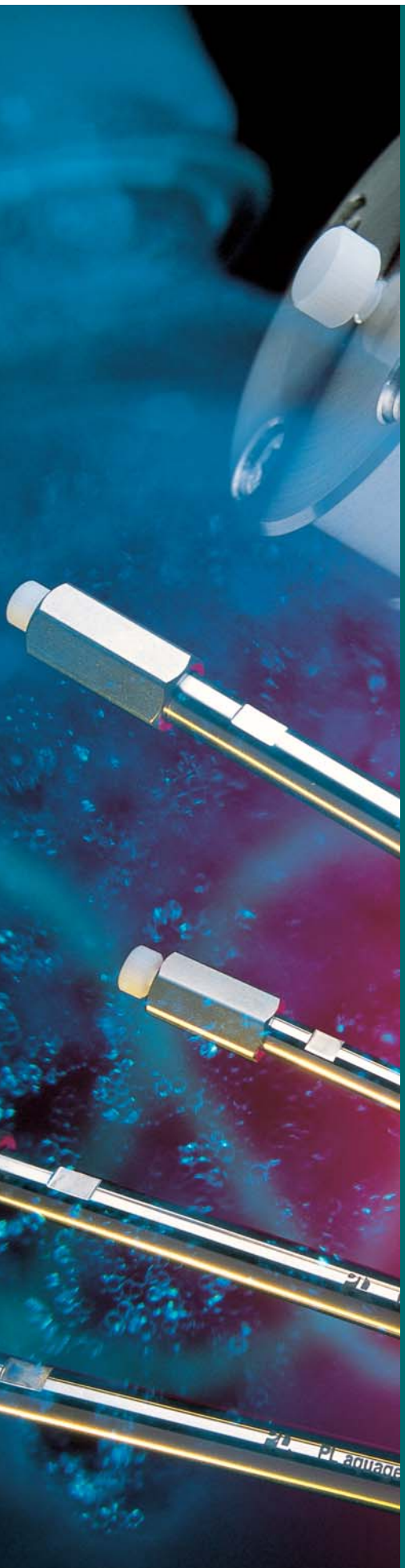
Polymer Laboratories manufactures the PL-XT 220 Rapid Analysis high temperature GPC System incorporating

- Sample Preparation
- Sample Injection
- Sample Analysis
- Fully Automated Instrument Control



- Contact us for further details.

PL Polymer Standards for GPC/SEC



Polymer Standards and specialty polymers used as reference materials are required for a number of different applications. Routinely, narrow polydispersity homopolymers with highly characterized molecular weights are used as calibration standards in GPC/SEC applications.

In addition, characterized specialty homopolymers and copolymers exhibiting specific characteristics are useful as model polymers for research purposes, and in the development of analytical techniques.

PL Polymer Standards for GPC/SEC

PL manufactures the highest quality Polymer Standards for GPC/SEC. With extremely narrow molecular weight distributions and extensive characterization data, PL offers a comprehensive range of polymer standards for both organic and aqueous GPC/SEC applications. PL's Polymer Standards are available in the widest range of molecular weights, and as kits and individual molecular weights for maximum choice.

Quality Counts...

Polymer Laboratories has over 31 years' experience in the synthesis and characterization of narrow polydispersity polymer standards. Our success relies fundamentally on expert knowledge and the use of stringently prepared and purified reagents and synthesis conditions. We have developed proprietary techniques using anionic polymerization to offer significantly improved standards across the molecular weight range.

Polymer Laboratories is an ISO 9001:2000 Quality Assessed Company to assure the User of the quality and reliability of our products and services. Polymer standards are characterized using a variety of independent techniques (eg light scattering and viscometry), and high performance GPC is carried out in order to verify polydispersity and to assign that all important peak molecular weight (Mp) for GPC/SEC applications.

All Polymer Laboratories' polymer standards are supplied with a comprehensive Certificate of Analysis detailing the characterization procedures employed and the results obtained, thus fulfilling the requirements of internationally recognised protocols for GPC/SEC, eg ISO 16014 and ASTM D5296.

Polymer Type	Individual MW	Calibration Kits	EasiCal	EasiVial	Type of GPC/SEC
Polystyrene	✓	✓	✓	✓	Organic
Polymethylmethacrylate	✓	✓		✓	Organic
Polyethylene	✓	✓			Organic
Polyethylene Glycol	✓	✓		✓	Organic/Aqueous
Polyethylene Oxide	✓	✓		✓	Organic/Aqueous
Polysaccharides	✓	✓			Organic/Aqueous
Polyacrylic Acid	✓	✓			Aqueous

Additional Polymer Standards

In addition to the PL Polymer Standards listed above, Polymer Laboratories can also supply other polymer types, as individual narrow molecular weights. PL also supplies broad distribution polymers for use in system validation or broad standard calibration procedures.
Please contact PL for further information on availability and price.

PL reserves the right to change the actual MWs supplied at the time of purchase.

EasiVial Pre-weighed Polymer Standards Kits

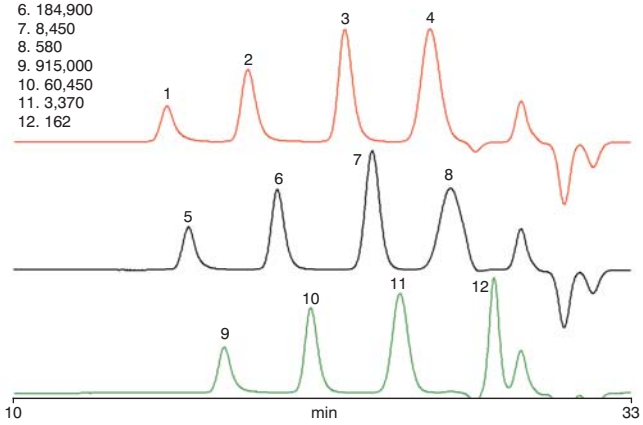
Polymer Laboratories' high quality, narrow polydispersity polymer standards are now available in a convenient new format. The EasiVial standards kit is a pre-prepared, time saving product for rapid and reliable GPC column calibration.

The EasiVial product consists of three vials, each containing a mixture of four accurately pre-weighed polymer standards, providing a 12 point GPC calibration in just three injections. The mass of each polymer in the vial is known, so that upon addition of a fixed volume of eluent the solution is prepared at a precise concentration, making the product ideal for both conventional **and multi detector GPC** calibration. EasiVials can be used simply for preparation of the polymer solution, followed by manual injection or transfer to alternative autosampler vial type, or placed directly in compatible autosamplers.

EasiVial PS-H

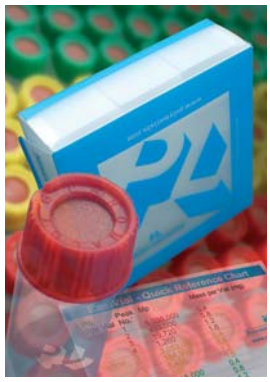
Columns: 2xPLgel 10μm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: THF
Flow Rate: 1.0ml/min
Temp: 40°C
Detector: RI (PL-GPC 220)

KEY
1. 6,035,000
2. 483,000
3. 19,720
4. 1,260
5. 3,053,000
6. 184,900
7. 8,450
8. 580
9. 915,000
10. 60,450
11. 3,370
12. 162

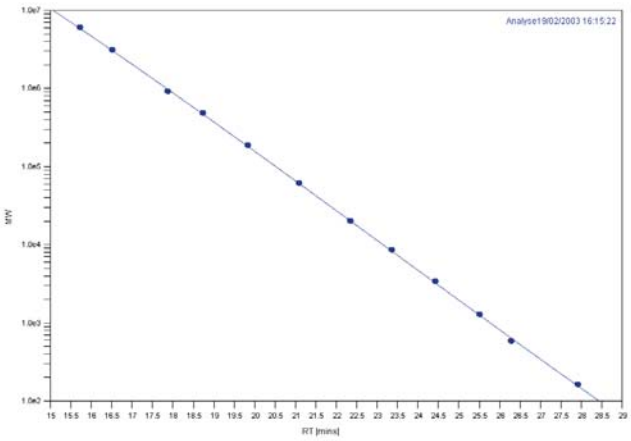


Each EasiVial kit contains 30 vials (10 of each type) which are color coded for easy identification and are available in either 4ml or 2ml vial formats. EasiVial kits are available for polystyrene (PS-H), polymethylmethacrylate (PM) and polyethylene glycol/oxide (PEG/PEO) standards. The benefits of EasiVial standards include:

- Easy to use
- Eliminates tedious weighing out of standards
- Reduces solvent dispensing
- Compatible with a variety of GPC column types
- Suitable for conventional and multi detector GPC analysis



Polystyrene Calibration Generated with EasiVials



EasiVial - Standards Kits

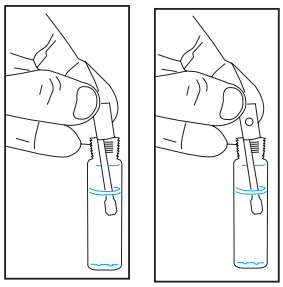
EasiVial Type	EasiVial PS-H	EasiVial PM	EasiVial PEG/PEO
	Nominal Mp	Nominal Mp	Nominal Mp
Red	6,035,000	2,000,000	1,200,000
	483,000	280,000	125,000
	19,720	30,000	12,000
	1,260	2,000	620
Yellow	3,053,000	790,000	965,000
	184,900	145,000	60,000
	8,450	15,000	4,000
	580	1,000	194
Green	915,000	500,000	460,000
	60,450	80,000	25,000
	3,370	6,000	1,500
	162	620	106
Part No. 4ml Vials	PL2010-0200	PL2020-0200	PL2080-0200
Part No. 2ml Vials	PL2010-0201	PL2020-0201	PL2080-0201

See page 49 for details of new Polystyrene Standards

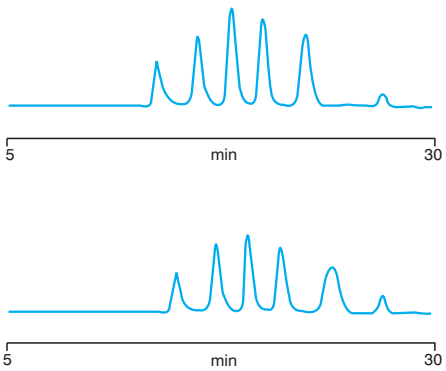
EasiCal® Pre-prepared Calibration Kits

Column calibration for GPC/SEC becomes as EASY as 1,2,3 ...

1. Place one spatula of each type in vial and add appropriate volume of solvent.

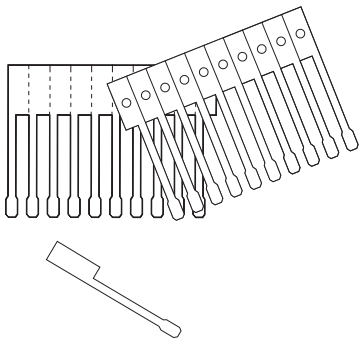


2. Chromatograph each solution, only two injections required

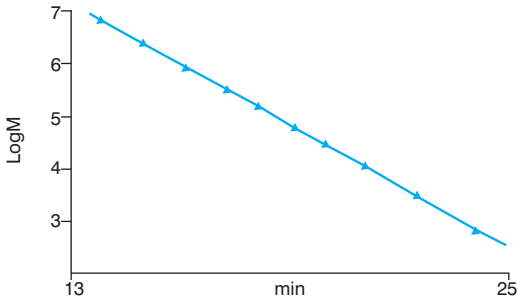


The EasiCal system consists of two different combs, each with 10 detachable spatulas supporting a mixture of 5 polymer standards.

The thin film of polymer (approx 5mg) on the tip of the PTFE spatulas rapidly dissolves when immersed in eluent to provide two GPC/SEC calibration solutions.



3. Generate a 10 point calibration



EasiCal polystyrene calibrants can be used with any GPC columns or systems. A single pack provides 10 spatulas of each type for 10 calibrations.

EasiCal Type	Polystyrene PS-1	Polystyrene PS-2
MW Range	580-7,500,000	580-400,000
Constituent Polymers	7,500,000	400,000
Spatula A	850,000	100,000
(nominal Mp)	150,000	20,000
	30,000	5,000
	3,000	1,300
Constituent Polymers	2,500,000	200,000
Spatula B	300,000	50,000
(nominal Mp)	60,000	10,000
	11,000	3,000
	580	580
Part No. Single Pack	PL2010-0501	PL2010-0601
Part No. Pack of 5	PL2010-0505	PL2010-0605

Polystyrene

Polystyrene standards are the first choice for many organic solvents, either for conventional GPC column calibration or for calibrating light scattering and viscosity detectors. PL's comprehensive Certificates of Analysis provide full information for the User, whatever the application.

Polystyrene Individual Molecular Weights

Part numbers are given for 1g quantities
(part numbers for 5g and 10g quantities are obtained by replacing the last two digits, 01, with 05 or 10 respectively):

Nominal M_p	M_w/M_n	Part No.
162	1.00	PL2012-1001
580	1.18	PL2012-2001
1,000	1.13	PL2012-3001
1,300	1.10	PL2012-4001
2,000	1.06	PL2012-5001
3,000	1.06	PL2012-6001
5,000	1.05	PL2012-7001
7,000	1.04	PL2012-8001
10,000	1.04	PL2012-9001
13,000	1.04	PL2013-0001
20,000	1.03	PL2013-1001
30,000	1.03	PL2013-2001
50,000	1.03	PL2013-3001
70,000	1.03	PL2013-4001

Nominal M_p	M_w/M_n	Part No.
100,000	1.03	PL2013-5001
130,000	1.03	PL2013-6001
200,000	1.03	PL2013-7001
300,000	1.04	PL2013-8001
500,000	1.05	PL2013-9001
700,000	1.06	PL2014-0001
1,000,000	1.06	PL2014-1001
1,500,000	1.06	PL2014-2001
2,000,000	1.06	PL2014-3001
2,500,000	1.06	PL2014-4001
3,000,000	1.06	PL2014-5001
4,000,000	1.06	PL2014-6001
7,000,000	1.15	PL2014-7001
10,000,000	1.30	PL2014-8001
15,000,000	1.30	PL2014-9001

Polystyrene Calibration Kits for GPC/SEC

Each kit contains 0.5g of ten different molecular weight standards

Kit Type	S-H-10	S-H2-10	S-M-10	S-M2-10	S-L-10
MW Range	300,000-15,000,000	1,000-15,000,000	580-3,000,000	580-300,000	162-20,000
Constituent	300,000	1,000	580	580	162
Polymers	460,000	3,000	1,450	1,400	580
(nominal Mp)	700,000	8,600	4,000	2,400	900
	1,100,000	25,000	10,000	4,750	1,400
	1,700,000	73,000	27,000	9,500	2,200
	2,600,000	210,000	66,000	19,000	3,400
	4,000,000	600,000	180,000	38,000	5,100
	6,200,000	1,780,000	460,000	75,000	8,100
	9,500,000	5,000,000	1,190,000	150,000	12,800
	15,000,000	15,000,000	3,000,000	300,000	20,000
Part No.	PL2010-0103	PL2010-0104	PL2010-0100	PL2010-0102	PL2010-0101

See page 49 for details of new Polystyrene Standards

Polymethylmethacrylate

Polymethylmethacrylate (PMMA) standards are extremely versatile as they can be used for organic GPC with a wide range of medium polarity eluents (eg THF, toluene, MEK, ethyl acetate), as well as the more polar organic eluents (eg dimethylformamide, dimethylacetamide, hexafluoroisopropanol).

PMMA Individual Molecular Weights

Part numbers are for 1g quantities (part numbers for 5g and 10g quantities are obtained by replacing the last two digits, 01, with 05 or 10 respectively):

Nominal M_p	M_w/M_n	Part No.
500	1.40	PL2022-2001
1,000	1.30	PL2022-3001
2,000	1.10	PL2022-5001
3,000	1.10	PL2022-6001
5,000	1.10	PL2022-7001
7,000	1.08	PL2022-8001
10,000	1.06	PL2022-9001
13,000	1.06	PL2023-0001
20,000	1.06	PL2023-1001
30,000	1.05	PL2023-2001
50,000	1.05	PL2023-3001
70,000	1.05	PL2023-4001
100,000	1.05	PL2023-5001
130,000	1.05	PL2023-6001
200,000	1.05	PL2023-7001
300,000	1.06	PL2023-8001
500,000	1.06	PL2023-9001
700,000	1.06	PL2024-0001
1,000,000	1.07	PL2024-1001
1,500,000	1.10	PL2024-2001

PMMA Calibration Kits for GPC/SEC

Each kit contains 0.5g of ten different molecular weight standards.

Kit Type	M-M-10	M-L-10
MW Range	1,000-1,500,000	600-50,000
Constituent	1,000	600
Polymers	2,200	840
(nominal Mp)	5,000	1,400
	11,200	2,350
	25,500	3,900
	58,000	6,400
	130,000	10,800
	290,000	18,000
	660,000	30,000
	1,500,000	50,000
Part No.	PL2020-0101	PL2020-0100

Calibration Kits contain a selection of 10 standards, covering a specific range of molecular weight.

NEW Linear Narrow Distribution Polyethylene Standards

An exciting new range of linear polyethylene standards is now available with low polydispersities (1.06 to 1.3) for GPC/SEC calibration. These have been configured into a calibration kit of ten standards from 540 to 1.5 Million molecular weight, which is supplied with comprehensive calibration data. This kit is the ideal standard for use with polyolefin polymers, and is designed for direct GPC/SEC column calibration in solvents such as TCB and oDCB at temperatures in the range 135-180°C. For examples of polyolefin analysis, see pages 52-53.

Polyethylene GPC Calibration Kit

(contains 0.2g of 10 different molecular weight standards)

Kit Type	MW Range	Part No.
E-MW-10	540-2,000,000	PL2650-0102
	Nominal Mp	Nominal Mw/Mn
Constituent	540	1.09
Polymers	750	1.18
	1,100	1.20
	2,155	1.14
	15,700	1.06
	30,600	1.07
	101,000	1.09
	278,000	1.20
	701,000	1.25
	1,510,000	1.30

Polyethylene Broad MWD Standard

A well characterized broad MWD polyethylene standard is also available for system verification.

Nominal Mw	Nominal Mw/Mn	Part No.
250,000	9.50	PL2660-7001

Short Chain Branching Standards

Determination of short chain branching (SCB) as a function of MWD in polyethylene is now possible using HTGPC coupled with FTIR (see page 57). This new series of well characterized polyethylene SCB standards can be used for FTIR calibration and is a useful reference set for TREF/CRYSTAF.

Polyethylene SCB Calibration Kit

(contains 0.2g of 10 different molecular weight standards)

Kit Type	SCB Range	Part No.
E-SCB	1.3 - 62.5	PL2650-0103
	Nominal Me/1000TC	Nominal Mp
Constituent	1.3	80,700
Polymers	1.4	94,000
	1.8	36,800
	2.4	27,800
	12.0	61,400
	14.0	66,900
	23.0	114,000
	40.0	703.40
	55.5	506.99
	62.5	450.88

Polyethylene Broad MWD/SCB Standard

Two well characterized broad MWD polyethylene standards with varying average degrees of SCB are also available for system verification:

Nominal Mw	Nominal Mw/Mn	SCB/ 1000TC	Part No.
35,000	5.0	0.0	PL2660-8001
400,000	5.0	4.0	PL2660-9001

Polyethylene Glycol/Oxide

These hydrophilic polymers are suitable for both aqueous SEC and organic GPC using the majority of polar organic solvents. The oxides are available in higher molecular weights, while the glycols cover the lower molecular weight range. The two types are chemically similar, and can be used together to cover a wider molecular weight range.

Polyethylene Glycol Individual Molecular Weights

Part numbers are for 1g quantities (part numbers for 5g and 10g quantities are obtained by replacing the last two digits, 01, with 05 or 10 respectively):

Nominal M_p	M_w/M_n	Part No.
106	1.00	PL2070-1001
194	1.00	PL2070-2001
400	1.10	PL2070-3001
600	1.08	PL2070-4001
1,000	1.07	PL2070-5001
1,500	1.05	PL2070-6001
4,000	1.03	PL2070-7001
7,000	1.03	PL2070-8001
10,000	1.03	PL2070-9001
13,000	1.04	PL2071-0001
20,000	1.06	PL2071-1001

Polyethylene Oxide Individual Molecular Weights

Part numbers are for 1g quantities (part numbers for 5g and 10g quantities are obtained by replacing the last two digits, 01, with 05 or 10 respectively):

Nominal M_p	M_w/M_n	Part No.
20,000	1.04	PL2083-1001
30,000	1.04	PL2083-2001
50,000	1.04	PL2083-3001
70,000	1.04	PL2083-4001
100,000	1.04	PL2083-5001
130,000	1.04	PL2083-6001
200,000	1.06	PL2083-7001
300,000	1.06	PL2083-8001
500,000	1.07	PL2083-9001
700,000	1.08	PL2084-0001
1,000,000	1.12	PL2084-1001
1,500,000	1.20	PL2084-2001

Polyethylene Glycol Calibration Kit

The kit contains 0.5g of 10 different molecular weight standards:

Kit Type	MW Range
PEG-10	106-22,000
Constituent	106
Polymers	194
(nominal Mp)	400
	600
	1,000
	2,100
	4,120
	7,100
	11,840
	22,800
Part No.	PL2070-0100

Polyethylene Oxide Calibration Kit

The kit contains 0.2g of 10 different molecular weight standards:

Kit Type	MW Range
PEO-10	20,000-1,000,000
Constituent	20,000
Polymers	29,000
(nominal Mp)	45,000
	70,000
	110,000
	170,000
	265,000
	410,000
	640,000
	1,000,000
Part No.	PL2080-0101

Polyacrylic Acid / Polysaccharides

Polysaccharides

Suitable for GPC using aqueous or polar organic eluents, this pullulan polysaccharide kit consists of several simple sugars together with some relatively narrow polydispersity linear macromolecules of maltotriose units.

Polysaccharide Calibration Kit

The kit contains 0.2g of 10 different molecular weight standards:

Kit Type	MW Range	Part No.
SAC-10	180-850,000	PL2090-0100
Constituent	180	
Polymers	738	
(nominal Mp)	5,900	
	11,800	
	22,800	
	47,300	
	112,000	
	212,000	
	404,000	
	788,000	

Polyacrylic Acid

The polydispersity of these polymers is not particularly narrow (typically between 1.30 - 1.75), however, they are very useful water soluble calibrants, as the M_p values are well characterized.

Polyacrylic Acid Individual Molecular Weights

Part numbers are for 0.2g quantities (part numbers for 1g are obtained by replacing the last two digits, 00, with 01):

Nominal M_p	Part No.
1,000	PL2142-3000
3,000	PL2142-6000
7,000	PL2142-8000
15,000	PL2143-0000
30,000	PL2143-2000
70,000	PL2143-4000
100,000	PL2143-5000
300,000	PL2143-8000
700,000	PL2144-0000
1,000,000	PL2144-1000

Polyacrylic Acid Calibration Kit

The kit contains 0.2g of 10 different molecular weight standards:

Kit Type	MW Range	Part No.
PAA-10	1,000-1,000,000	PL2140-0100
Constituent	1,250	
Polymers	2,925	
(nominal Mp)	7,500	
	16,000	
	28,000	
	62,900	
	115,000	
	272,900	
	782,200	
	1,100,000	

Specialty Polymers

Custom Synthesis

Polymer Laboratories has extensive knowledge and experience in ionic polymerization techniques. The expertize gained over 31 years' manufacturing PL Polymer Standards has been widely applied to many specialty polymers, both as proprietary development programs and as external Custom Synthesis projects. We are able to work very closely with the customer in order to deliver novel polymers which meet their specific requirements. Confidential enquiries for Custom Synthesis are welcomed; please contact your local PL office for further details.

Block Copolymers

PL manufactures a range of AB di-block copolymers and ABA tri-block copolymers with narrow polydispersities. Typical examples of copolymers, which illustrate the scope of our manufacturing capabilities, are listed below.

Polystyrene/Polymethylmethacrylate

Polystyrene/Polymethylmethacrylate-d_8

Polystyrene/Polyethylene Oxide

Polystyrene-d_8/Polymethylmethacrylate

Polystyrene/Polybutadiene

Polystyrene-d_8/Polymethylmethacrylate-d_8

A selection of copolymers is available from stock and specific copolymers can be made as Custom Synthesis projects. Please contact PL for further information.

Deuterated Polymers

PL offers a range of deuterated polymers which have a variety of applications, eg neutron scattering, NMR, etc. These polymers exhibit the same narrow molecular weight distribution characteristics as our protonated polymer standards, with typical polydispersities around 1.05.

Deuterated Polystyrene -d_8

Part numbers are for 1g quantities (part numbers for 5g and 10g quantities are obtained by replacing the last two digits, 01, with 05 or 10 respectively):

Nominal M_p	Part No.
5,000	PL2062-7001
7,000	PL2062-8001
10,000	PL2062-9001
30,000	PL2063-2001
50,000	PL2063-3001
70,000	PL2063-4001
100,000	PL2063-5001
200,000	PL2063-7001
500,000	PL2063-9001
700,000	PL2064-0001
1,000,000	PL2064-1001
3,000,000	PL2064-5001

Deuterated Polymethylmethacrylate -d_8

Part numbers are for 1g quantities (part numbers for 5g quantities are obtained by replacing the last two digits, 01, with 05):

Nominal M_p	Part No.
10,000	PL2112-9001
20,000	PL2113-1001
30,000	PL2113-2001
50,000	PL2113-3001
70,000	PL2113-4001
100,000	PL2113-5001
130,000	PL2113-6001
200,000	PL2113-7001

Please contact Polymer Laboratories for price and availability.

EasiVial™ PS-M and S-L2-10 Polystyrene Calibration Kits

With the launch of the two new polystyrene GPC/SEC calibration kits, Varian Polymer Laboratories extends its portfolio of polymer standards products for accurate and reliable GPC column calibration:

The EasiVial™ PS-M Polystyrene Calibration Kit is a pre-prepared, time-saving product for fast and reliable GPC column calibration.

Key benefits include:

- Wider molecular weight range options.
  The addition of the EasiVial PS-M Polystyrene Kit introduces a kit which is specifically designed for resins and condensation polymers.
- Rapid, reliable calibration
  The EasiVial PS-M Polystyrene Kit consists of pre-prepared mixtures of accurately pre-weighed standards, providing a practical, time-saving product for rapid column calibration.
- Ideal for multi detection techniques
  The Polymer Standards are accurately dispensed into the vials, for use with light scattering and viscometry.

The newest polymer standards kit for GPC/SEC comes in the form of the S-L2-10 Polystyrene Calibration Kit, targeted at oligomeric and low molecular weight samples.

Key benefits include:

- Facilitates highly accurate analysis
  The S-L2-10 Polystyrene Kit is targeted at oligomeric and low molecular weight samples <4,500 Daltons, allowing you the ability to yield a precise calibration when used in conjunction with PL's PlusPore™ column range and PLgel 100Å individual pore sized columns.
- Designed for use with OligoPore™ columns
  Specifically designed for use with PL's OligoPore columns, providing outstanding compatibility.
- Widest polystyrene calibration capability
  Addition of the S-L2-10 to PL's Polymer Standards product range provides you with the widest possible polystyrene calibration capability.

Ordering Information

Product	Part No.
EasiVial PS-M 4 mL Vials	PL2010-0300
EasiVial PS-M 2 mL Vials	PL2010-0301
EasiVial PS-M Tri-Pack 4 mL Vials	PL2010-0303
EasiVial PS-M Tri-Pack 2 mL Vials	PL2010-0302
S-L2-10 Calibration Kit	PL2010-0105

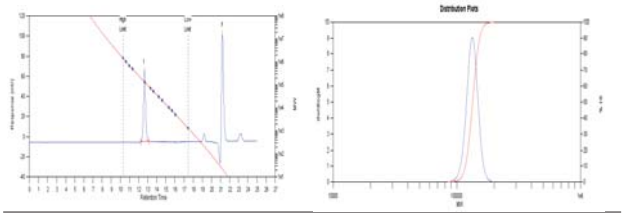
For further information, visit our websites, www.polymerlabs.com and www.varianinc.com.

CERTIFICATE OF ANALYSIS

Polystyrene **Batch Number 20136-8** **Mp 132,900**

	GPC	Light scattering	Viscometry
Mp (g/mol)	132,900		
Mn (g/mol)	131,400		
Mw (g/mol)	132,900	131,300	
Mv (g/mol)	132,700		
	Mw/Mn = 1.01		[η] = 0.4789 dl/g

Mp, Mn, Mw & Mv are the respective peak, number, weight and viscosity molecular weight averages
Mw/Mn = molecular weight distribution or polydispersity ratio [η] = Intrinsic viscosity



Analysis Conditions

	GPC	Light scattering	Viscometry
System	Cirrus GPC / SEC	PL-GPC 210R	PL-GPC 210R
Detector	Ultra Violet	PD 2000	PL-BV 400
Columns	2 x PLgel 5µm MIXED-C 300x7.5mm	PLgel 10µm MIXED-BLS 300x7.5mm	PLgel 10µm MIXED-BLS 300x7.5mm
Solvent	THF	THF	THF
Flow rate	1.0 ml / min	1.0 ml / min	1.0 ml / min
Injection volume	20µl	100µl	100µl
Sample concentration	0.05%	1.932 mg / ml	1.932 mg / ml
Temperature	Ambient	30°C	30°C
Calibrants	Polystyrene	Polystyrene	Polystyrene
Angle		15°	
dn/dc		0.185	

The above characterisation data has been measured according to *Polymer Laboratories* Quality Assurance procedures. Certificate of Analysis valid until expiry date – April 2014

P.J.Scott — *PL Quality Assurance.* — D.F. Scholes

Issue 03 15th November 2007 COA STANDARDS 1

UK (+44) 01694 723581
USA 413 253 9554
Benelux (+31) 011 8671500
Germany (+49) 06151 / 703292
France (+33) 01.69.86.38.64

Polymer Laboratories
Now a part of Varian, Inc.
www.polymerlabs.com

VARIAN

Varian Polymer Labs issues Certificates of Analysis with all its polymer standards.

Instrumentation & Software

To provide a complete solution, Polymer Laboratories designs, manufactures and supplies a range of sophisticated, versatile instrumentation and software for polymer and materials characterization.

PL-GPC 220 PL-GPC 120

Gel permeation chromatography (GPC) is the technique of choice for rapid and reliable characterization of polymer molecular weight and molecular weight distribution. Advances in polymer science and technology mean that a more diverse range of solvents and temperatures are required in the modern GPC laboratory, and with ever increasing workloads, the GPC system must deliver greater accuracy, reproducibility and reliability with automated high sample throughput.

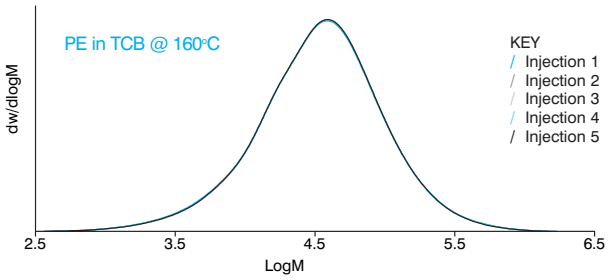
PL-GPC 220 system for use up to 220°C

PL-GPC 120 system for use up to 120°C

PL's advanced GPC instruments ensure excellent chromatographic performance across the full operational temperature range, from 30 to 220°C, whatever the application.

Unrivalled Reproducibility

PL's integrated GPC systems incorporate a high specification pump for the best pump performance available. Unbeatable flow reproducibility of 0.07% is achieved, not only in THF at near ambient temperature, but also in TCB at temperatures above 140°C. Advanced temperature control and detector technology also ensure excellent repeatability for consistent and precise GPC results.



Parameter	PE in TCB @ 160°C
RT of Marker	0.04%
Mn	0.62%
Mw	0.16%
Mz	0.45%
Area	0.24%

Enhanced RI Sensitivity and Stability

The improved Refractive Index detector includes a new photodiode and uses fiber optic technology to maximize sensitivity while minimizing baseline drift and noise, vital for good GPC. This RI ensures outstanding signal/noise ratio, even at 220°C.

Easy Access Oven with Uniform Temperature Distribution

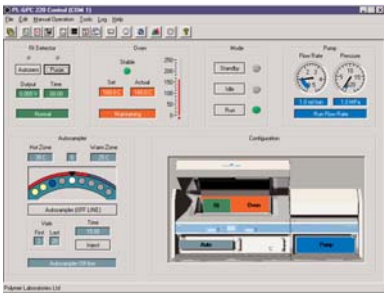
For ease of use and flexibility, the column oven can comfortably hold six 30cm GPC columns, RI detector and injection valve, as well as a viscometer and multi angle light scattering detector, if required.

PL's multi heater forced air oven accurately controls the temperature to less than 0.05°C variation per hour, minimizing detector baseline drift and ensuring the reproducible retention times so important in GPC.

PC Control - Easy to Program, Easy to Use

The PL-GPC 220 and PL-GPC 120 feature comprehensive PC control for full system management and monitoring, permitting truly unattended operation with the PL-GPC 220. Features include

- Color-coded graphics
- Time estimator to calculate solvent use
- Pump/flow rate ramping
- Automatic RI purging and baseline autozero



Safety First

PL's systems incorporate integral sensors which constantly monitor the system. An audit trail feature offers full status and error logging facility for system traceability.

Dual Zone Heated Autosampler - No Degradation of Samples Before Injection

The PL-GPC 220 autosampler design features dual zone heating to minimize thermal degradation. The Hot and Warm zones are independently programmable from ambient to 220°C, therefore the samples in the carousel waiting for injection are maintained at a lower holding temperature, then heated to analysis temperature immediately prior to injection. Injection precision has been measured at better than 1% RSD with no cross contamination between samples.

NOTE: The PL-GPC 120 comes with a manual injector as standard but can be operated with an external autosampler.

PL-GPC 220 PL-GPC 120 Applications

Thermostated Solvent Delivery

The PL-GPC 220 features a temperature controlled integral solvent module with a choice of solvent reservoir from 2 Ltr bottles up to a 13 Ltr stainless steel tank. This design ensures efficient, continuous and reproducible solvent delivery, even if the solvent is viscous or may be solid at near ambient temperature.

Interfacing to Other Techniques

The PL-GPC 120/220 can easily be interfaced to other instruments to provide maximum characterization information. PL offers a heated transfer line which can be custom made to the length required for the application. PL's instruments incorporate a convenient oven access port on the left side of the instrument and the heated transfer line can be directly controlled by the operating system.

Interfacing Options:
Viscometer, LALLS, MALLS, FTIR, ELSD, TREF

Adding Integrated Viscosity and Light Scattering - Easily

The PL-GPC 220 and PL-GPC 120 are the only systems designed for integrated triple detection. Viscosity and/or light scattering systems are available at the time of purchase, or can be added later.

PL's systems are factory-prepared to accept both a four capillary differential viscometer (Polymer Laboratories' PL-BV 400HT) and light scattering detectors (model PD2040 from Precision Detectors or HT-miniDAWN from Wyatt Technology Corporation).

For further applications data, or for your own sample evaluation, please contact your local PL office or distributor, or visit our website at www.polymerlabs.com/gpc. Full product information is available in a separate brochure entitled 'Advanced High Performance GPC/SEC Instrumentation for Polymer Characterization from 30-220°C'.

PL-GPC 220 Ordering Information

Product	Part No.
PL-GPC 220 Integrated GPC/SEC System	PL0820-0000
Autosampler Vials (pk of 500)	PL0810-0001
Autosampler Vial Caps and Seals (pk of 500)	PL0810-0002
Vial Crimping Tool	PL0810-0015
Magnetic Fleas (pk of 50)	PL0810-0003

PL-GPC 120 Ordering Information

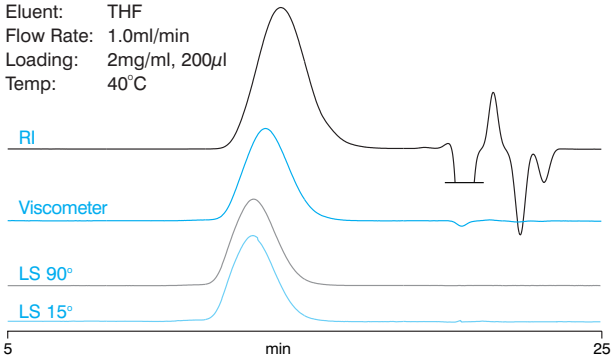
Product	Part No.
PL-GPC 120 Integrated GPC/SEC System	PL0830-0000
PL-AS MT Autosampler	PL0870-8180
Heated Transfer Line for PL-GPC 120/220	PL0810-1001

Contact us for ordering information for autosampler accessories.

Polystyrene

For many applications in routine solvents such as THF, elevated and constant temperature of operation can significantly improve resolution and detector performance.

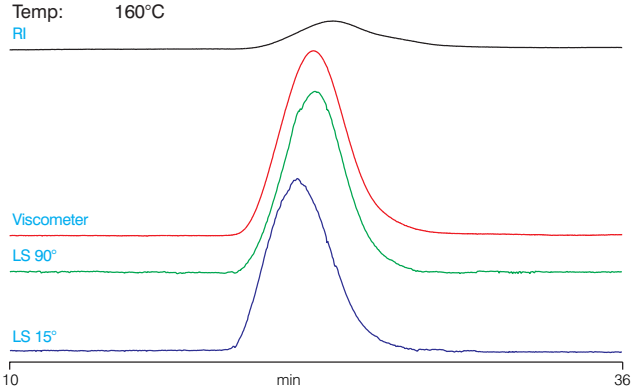
Columns: 2xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: THF
Flow Rate: 1.0ml/min
Loading: 2mg/ml, 200µl
Temp: 40°C



Polyethylene

A very common HTGPC application, the analysis of polyolefins is routinely performed at temperatures in the range 135-160°C. The addition of molecular weight sensitive detectors is ideal for studying long chain branching as a function of molecular weight.

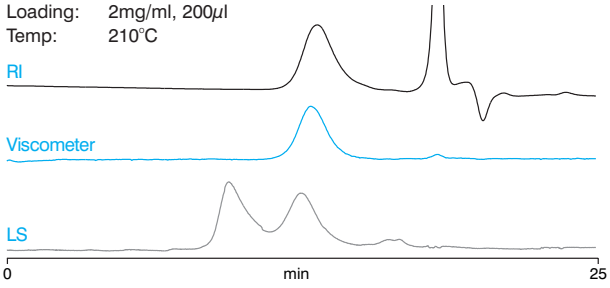
Columns: 4xPLgel 20µm MIXED-A LS, 300x7.5mm (PL1110-6200LS)
Eluent: TCB
Flow Rate: 1.0ml/min
Loading: 1mg/ml, 200µl
Temp: 160°C



Poly(phenylene sulfide)

Sample precipitation at around 190°C demands extremely high operating temperatures for analysis. Online viscosity and light scattering detectors provide very useful data for characterizing these engineering polymers.

Columns: 2xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: o-Chloronaphthalene
Flow Rate: 1.0ml/min
Loading: 2mg/ml, 200µl
Temp: 210°C



PL-XT 220 Rapid Analysis GPC System

Recent developments in combinatorial materials discovery and the growing need to rapidly obtain data for polymeric samples of all types has required a completely different approach to performing GPC analysis.

The PL-XT 220 from Polymer Laboratories (PL) is a sophisticated, fully featured, totally automated rapid high temperature GPC analysis system incorporating:

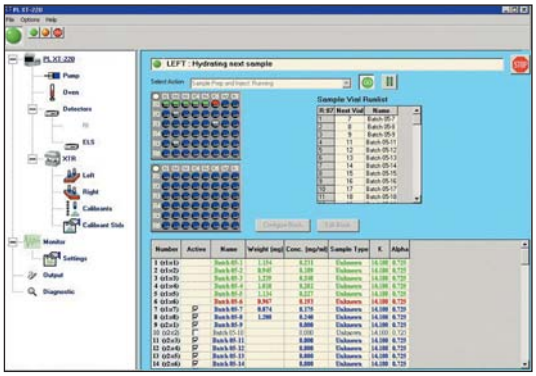
- Sample Preparation
- Sample Injection
- Sample Analysis
- Fully Automated Instrument Control

The PL-XT 220 consists of:

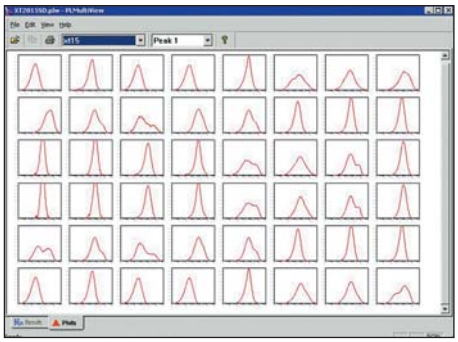
- Dual arm robotic sample preparation platform with two x 96 well autosampler capability for continuous operation
- Temperature controlled oven (30-220°C) containing columns and a range of optional detectors
- A precision solvent delivery system
- A specifically designed high temperature evaporative light scattering detector (ELSD)
- Sophisticated, flexible and intuitive system control software for complete automation
- Powerful and comprehensive data collection, analysis and 'rapid data review' software

Rapid GPC

The PL-XT 220 is capable of performing rapid, reproducible, automated GPC analysis in under 10 minutes. Purpose designed single columns or conventional multi column formats can be employed. To ensure maximum baseline stability and sample throughput, ELSD is standard in the chromatography system. However, the PL-XT 220 is compatible with all traditional GPC concentration and specific molecular weight detectors.



Automatic calibration of the system followed by sample data analysis can be achieved using PL's powerful Cirrus™ GPC software. Large sample data arrays can be reviewed through a flexible graphics package, allowing for visual assessment and detailed comparison of molecular weight properties.



Ordering Information

Product	Part No.
PL-XT 220 Rapid Analysis GPC System	PL0840-0000

Symyx®

Manufactured by PL under exclusive licence from Symyx® US Patent No. 6,260,407. Use of this instrument may also be covered by one or more of US Patent Numbers 6,406,632, 6,475,391, 6,265,226, and 6,454,947. Additional US and foreign patents pending.

PL-GPC 50 Plus

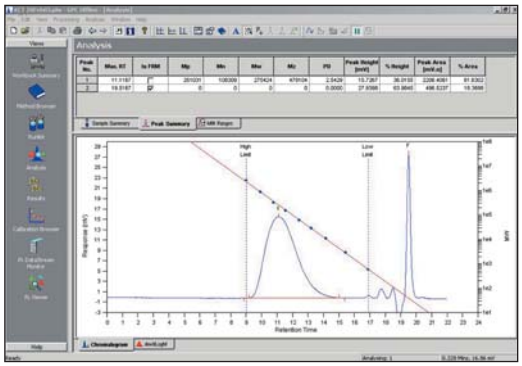
The PL-GPC 50 Plus is a high resolution, cost effective integrated GPC system designed for operation from ambient to 50°C. The standard system comprises a precision solvent delivery system, a manual injection valve, a high performance differential refractive index detector and column oven.

For maximum flexibility and applicability, a choice of system enhancements is available. Modules for:

- UV detection
- Viscosity detection (see page 56)
- Online degasser
- Autosampler

Designed for Ease of Use

The PL-GPC 50 Plus features onboard PC based system control and Cirrus™ data acquisition and analysis software – everything you need to get up and running in one integrated package. The simplicity of the PL-GPC 50 Plus design and the intuitive interface make it extremely easy to operate. This, combined with high performance and reliability, makes the PL-GPC 50 Plus the ideal choice for any laboratory.



Versatility and Performance

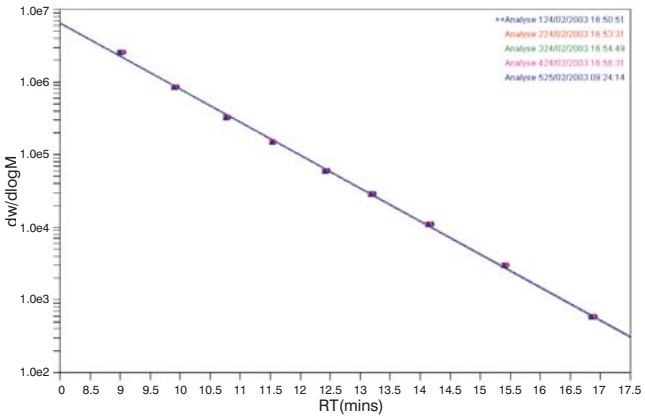
For optimized performance, the system is designed to significantly reduce extra column dispersion and band broadening effects, thereby maximizing resolution and accuracy for the GPC separation. The PL-GPC 50 Plus can accommodate up to four regular 300mm GPC columns with easy access for column exchange via the hinged front panel. The RI detector exhibits both high sensitivity and excellent baseline stability for a wide variety of organic GPC and aqueous based eluents.

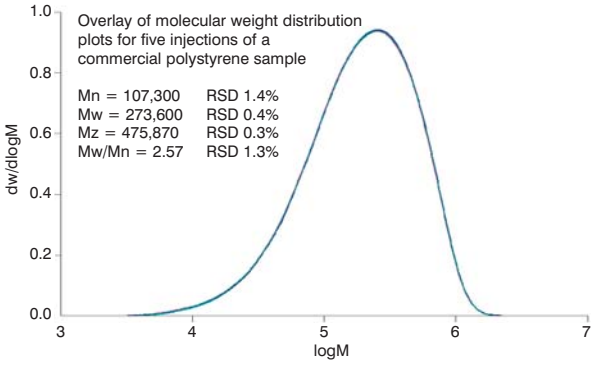
Excellent Reproducibility

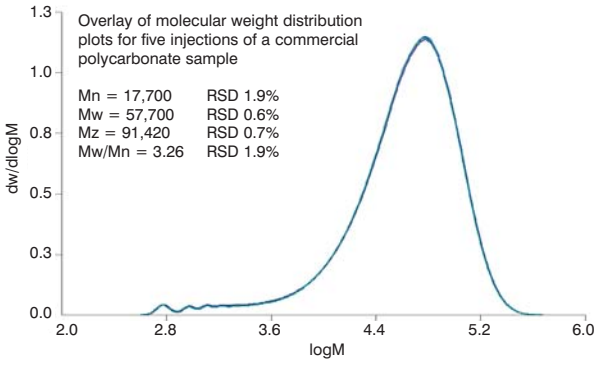
The flow rate precision of the solvent delivery system is fundamental to achieving the most reliable GPC data. The PL-GPC 50 Plus delivers flow reproducibility of better than 0.1%, resulting in repeatable calibration curves and accurately calculated polymer molecular weight data.

Columns: 2xPLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: THF
Flow Rate: 1.0ml/min

Overlay of five GPC calibration curves generated from five separate injections of each polystyrene standard (EasiCal PS-1 calibrants)







Ordering Information

Product	Part No.
PL-GPC 50 Plus Integrated GPC System	PL0870-8500
Degasser	PL0870-0100
Autosampler	PL0870-5000
Fixed Wavelength UV Detector	PL0870-1000
Variable Wavelength UV Detector	PL0870-1500
PL-BV 400RT	PL0810-3060

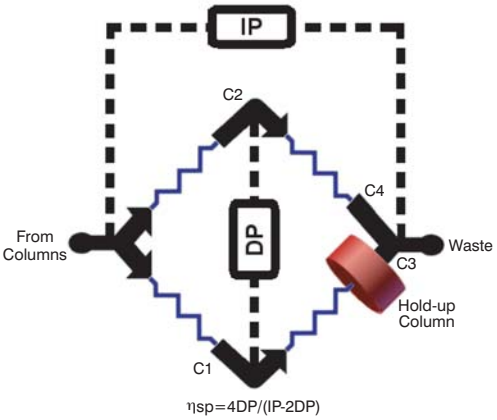
NEW PL-BV 400 - Online Integrated Viscometers for GPC/SEC

Based on the proven four capillary bridge design, the PL-BV 400 is a new detector from Polymer Laboratories for the online measurement of viscosity in GPC/SEC.

The combination of refractive index (RI) and viscosity detection provides accurate molecular weight determination for all polymer types based on the Universal Calibration principle, as well as valuable branching information not otherwise accessible from a concentration detector alone.

The detector consists of three components:

- Precision engineered 4-capillary bridge
- High sensitivity pressure transducers
- State of the art low noise electronics



A set of four identical capillaries is arranged in a fluid analog of a Wheatstone bridge. When pure solvent is flowing through the system, the differential pressure (DP) across the bridge will be zero because solvent will be in all four capillaries. When the polymer solution elutes from the column, the eluent enters capillaries C1, C2 and C4, while pure solvent from the hold-up column remains in capillary C3. The slightly higher viscosity of the eluent in C1, C2 and C4, compared to the pure solvent in C3, causes a pressure imbalance in the bridge, measured by the differential pressure transducer (DP). The inlet pressure (IP) and DP are directly proportional to the specific viscosity of the polymer solution.

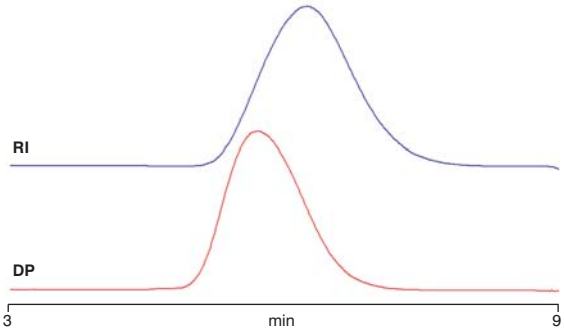
The PL-BV 400HT is designed to be incorporated into the PL-GPC 120 or PL-GPC 220 integrated high temperature GPC systems, while the PL-BV 400RT is designed for use in the PL-GPC 50 Plus system for use between ambient and 50°C.

Features of the PL-BV 400 include:

- High sensitivity
- Stable baseline
- Compatible with all solvents
- Operation over the temperature range 30-220°C

System Performance Data

Sample: Polystyrene
Column: PLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: THF
Flow Rate: 1.0ml/min
Temp: 40°C
Detectors: RI and PL-BV 400HT in PL-GPC 220



Three 1V analog outputs are available:

- inlet pressure (IP)
- differential pressure (DP)
- and a direct output of specific viscosity (ηsp)

Cirrus™ Multi Detector software is designed to acquire and analyse data from the RI/viscometer detector combination. Algorithms for Universal Calibration, molecular weight distribution and branching determination come as standard (see page 60).

Ordering Information

Product	Part No.
PL-BV 400HT	PL0810-3050
PL-BV 400RT	PL0810-3060
Cirrus™ Multi Detector Software	PL0570-2020

GPC-FTIR Characterization of Polymers from PL

Interfacing chromatographic methods with other analytical techniques can significantly increase the amount of information available for polymer characterization. Polymer Laboratories manufactures an innovative interface to couple gel permeation chromatography (GPC) with fourier transform infrared spectroscopy (FTIR), enabling rapid determination of compositional heterogeneity and its relationship to molecular weight from a single measurement.

The flow cell, which is supplied with a specific mounting bracket for individual FTIR instruments, fits directly onto the optical bench of the spectrometer and interfaces with any GPC system. The flow cell features low dispersion for minimum band broadening and is available with a choice of window materials for a variety of applications.

For high temperature GPC applications, the interface can be supplied with a temperature control module which enables the heated cell assembly and a heated transfer line to be controlled up to 175°C.

The GPC-FTIR combination provides spectral information for the polymer as a function of elution time from the GPC system. The spectrometer-based software records multiple spectra which can be used to derive both molecular weight distribution using PL's Cirrus™ suite of programs and composition distribution information (see page 60).

Conventional GPC Calculations from FTIR

PL has introduced the GPC-FTIR Data Import Module for its Cirrus suite of GPC software which allows time-resolved FTIR data to be imported into Cirrus for conventional GPC calculations. Compatible with most time-resolved FTIR data acquisition packages, the GPC-FTIR Data Import software easily converts time-resolved spectral profiles into standard Cirrus data files. Once converted, these files can be manipulated in Cirrus to allow calculations of molecular weight averages using either narrow or broad standard calibrations.

Using the GPC-FTIR Data Import software with the PL GPC-FTIR or PL HTGPC-FTIR Interfaces permits the powerful combination of compositional analysis by FTIR with the determination of molecular weight by GPC.

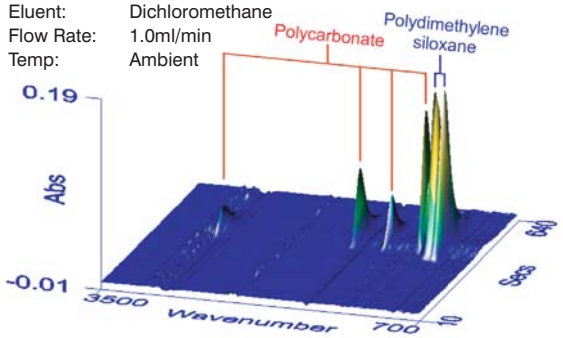
Ordering Information

Contact us for ordering information.

For more information about FT-IR from Varian, Inc., visit our web site at www.varianinc.com.

Applications:
Analysis of Copolymers and Polymer Blends

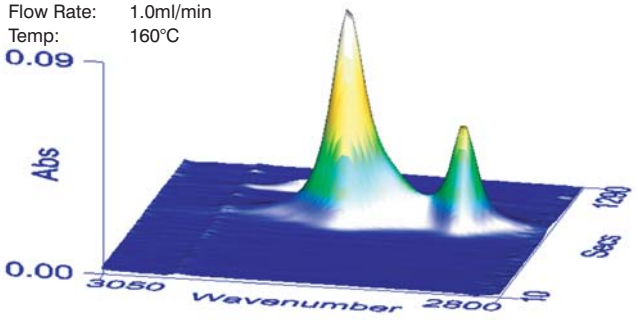
Sample: Polycarbonate/polydimethylsiloxane blend
Column: PLgel 5µm MIXED-C, 300x7.5mm (PL1110-6500)
Eluent: Dichloromethane
Flow Rate: 1.0ml/min
Temp: Ambient



Determination of Short Chain Branching in Polyolefins

For FTIR users, the PL HTGPC-FTIR interface is ideal for the study of short chain branching in polyethylene. Using PL's Cirrus™ GPC-FTIR SCB software in conjunction with the FTIR control and acquisition software, the short chain branching distribution can be mapped as a function of molecular weight distribution. The software incorporates a novel chemometrics approach which permits determination of the SCB/1000 carbon atoms as a function of molecular weight, as well as an error bar for each point.

Sample: Polyethylene
Columns: 2xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: Trichlorobenzene
Flow Rate: 1.0ml/min
Temp: 160°C



Ordering Information

Product	Part No.
Cirrus™ GPC-FTIR SCB Software	PL0570-2400
GPC-FTIR Data Import Module	PL0570-2300
Calcium Fluoride Cell Windows (1 pair)	PL0820-2300
Polyethylene SCB Calibration Kit (E-SCB)	PL2650-0103
Polyethylene Broad MWD/SCB Standard, Nom MW 35,000, 1g	PL2660-8001
Polyethylene Broad MWD/SCB Standard, Nom MW 400,000, 1g	PL2660-9001

NEW PL-SP 260VS Sample Preparation System

The PL-SP 260VS is a NEW Sample Preparation System designed for the manual dissolution and filtration of samples prior to GPC analysis. The unit combines controlled heating across a temperature range of 30-260°C*, with gentle agitation, user-selectable from speeds of between 85-230 rpm. With its temperature range and speed capabilities, the new PL-SP 260VS is ideal for a wide range of polymer types, including even the most difficult of samples.**

Variable Speed

During sample preparation, the vials can be agitated continuously or the shaker can be programmed to operate for specific periods of time. The new PL-SP 260VS provides variable, user-selectable speed of shaking, which is easily adjustable via the front panel of the instrument. For additional safety with noxious eluents, the extraction hood can be fitted during the dissolution stage, which also enables purging with nitrogen for air-sensitive samples.

Choice of Vial Types

The aluminium blocks for the heated compartment are available in several formats to accommodate a variety of vial types. The Standard Accessory Kit is designed to be used with standard sample preparation vials (supplied) and either PL-GPC 220 2ml autosampler vials or Waters' 4ml autosampler vials. The Custom Accessory Kits permit alternative vials to be specified by the customer.

Description	Sample Prep Block	Destination Block
Standard Accessory Kit	Standard 20ml	2 / 4ml vials
Custom Accessory Kit 1	Standard 20ml	Custom
Custom Accessory Kit 2	Custom	2 / 4ml vials
Custom Accessory Kit 3	Custom	Custom

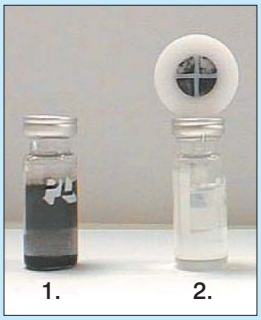
Efficient Dispensing

A unique pipettor device efficiently dispenses filtered sample solution from the sample preparation vial directly into destination (autosampler) vials, with minimal handling.

Choice of Filtration Media

Two filtration media are available:

- Glass fiber (nominal porosity 1μm) - *the preferred system for general applications*
- Porous stainless steel (nominal porosity 0.5μm, 2μm, 5μm or 10μm)



Carbon Black Filled Polyethylene Solution:

1. Without Filtration
2. After Filtration Using 1μm glass fiber filter

Each filter magazine houses four filters. Either type is suitable for the removal of crosslinked polymer 'gel' or insoluble additives. Porosity should be selected based on the molecular weight of the polymer under investigation. The glass fiber depth filter is particularly suitable for polymers containing very fine particulates (eg carbon black and other pigments), yet is suitable for use with even high molecular weight polymers.

Ordering Information

Product	Part No.
PL-SP 260VS Sample Preparation System, 220V	PL0810-4050/220
PL-SP 260VS Sample Preparation System, 110V	PL0810-4050/110
PL-SP 260VS Standard Accessory Kit	PL0810-4100
PL-SP 260VS Custom Accessory Kit 1	PL0810-4200
PL-SP 260VS Custom Accessory Kit 2	PL0810-4300
PL-SP 260VS Custom Accessory Kit 3	PL0810-4400
Filter Magazine, 1μm Glass Fiber (Pk of 50)	PL0810-4006
Filter Magazine, 0.5μm Stainless Steel (Pk of 50)	PL0810-4003
Filter Magazine, 2μm Stainless Steel (Pk of 50)	PL0810-4002
Filter Magazine, 5μm Stainless Steel (Pk of 50)	PL0810-4004
Filter Magazine, 10μm Stainless Steel (Pk of 50)	PL0810-4005
Standard Sample Preparation Vials, 20ml (Pk of 100)	PL094/33086
Standard Sample Preparation Vial Caps (Pk of 100)	PL094/33087
Autosampler Vials, 2ml (Pk of 500)	PL0810-0001
Autosampler Vial Caps and Seals (Pk of 500)	PL0810-0002
2ml Vial Crimping Tool	PL0810-0015

One of the above Accessory Kits must be ordered with each PL-SP 260VS Sample Preparation System

The above accessories are compatible with the PL-SP 260VS and its predecessor, the PL-SP 260.

* +/- 2°C

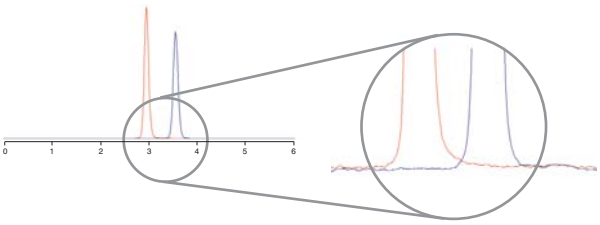
** +/- 10%

PL-XTR Robotic Sample Handling System for Automated GPC

The PL-XTR is an advanced sample handling system which is designed to be interfaced with any GPC system. A two arm robot performs both sample dilution and injection functions from ambient up to 220°C.

Sample filled vials are loaded into 48 capacity sample blocks in an X-Y array. The robotic arm dispenses a defined volume of solvent into the vials, which are then subjected to controlled heating and optional stirring for a programmed dissolution time. Once dissolution is complete, the solution is delivered to the GPC chromatograph via an on-board heated injection valve and compact heated transfer line.

The injection system incorporates heated needle assemblies which can be rinsed to avoid cross contamination of samples. A zoom in on the baseline of two consecutive injections of polystyrene standards shows absolutely no evidence of carry over from one injection to the next.



Features of the PL-XTR

- Fully automated for increased efficiency and high throughput
- Designed to provide operator safety
- Accommodates large number of samples
- Excellent repeatability
- Rugged and reliable workhorse system

Instrument Control

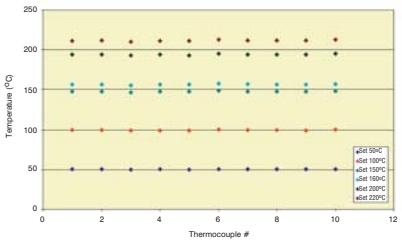
All the robotic functions, including solvent dispensing, sample delivery, sequencing and valve operation, are software controlled.

Operator Safety

The complete system is housed in an extracted enclosure, with robotic operation ensuring operator safety.

Temperature Control

The PL-XTR features precise and uniform temperature control across the sample blocks. The graphs indicate temperature profiles monitored in solvent filled vials at 10 different positions (indicated in red) in 2x48 sample blocks for six different set temperatures.



Ordering Information:

Product	Part No.
PL-XTR Robotic Sample Handling System for Automated GPC	PL0840-1000

Cirrus - The Universal GPC Solution

Cirrus is the powerful suite of GPC/Multi Detector software from Polymer Laboratories, suppliers of the industry standard GPC software since the 1980s. Cirrus makes GPC calculations easy, whether in conventional GPC using a concentration detector or for multi detector analysis with light scattering and viscosity.

High Resolution Data Capture

The PL DataStream provides a 4 channel, high resolution, ultra low noise interface allowing each channel to be used for independent systems or linked together to collect data from multi detector systems.

Collection options within the software allow

- On the fly sample definition - 'inject & define'
- Pre-defined sample sequences
- Priority samples

Integration with Existing LC Software

Cirrus is available for standalone GPC or for integrating GPC with LC. Cirrus is compatible with Galaxie™ Chromatography Software from Varian, Inc.

Galaxie is comprehensive chromatographic data handling software for both standalone and client server applications. Galaxie features a series of plug ins and industry driven tools which provide custom calculations and advanced automation, including Cirrus GPC Software for Galaxie.

PL supplies seamless, integrated GPC packages for

- Varian's Galaxie Chromatography Software
- Thermo Electron Corporation's Atlas Chromatography Data System
- Agilent's LC ChemStation

In addition, Cirrus is compatible with most LC chromatography systems on the market today, including

- Varian
- Dionex
- Waters
- PE
- Shimadzu
- Beckman

For multi detector systems, Cirrus can directly process data collected from

- Precision Detectors
- Viscotek systems

Data collected from PL Caliber can easily be imported into Cirrus.

An ASCII import routine ensures that archived data can easily be read into Cirrus.

Cirrus utilizes the latest advances in software design to provide the following key features

- Powerful, yet easy to use and learn
- Flexible and expandable
- Comprehensive calculation options
- Customized reporting
- High resolution data capture with the PL DataStream

Modular, Flexible, Scaleable

Cirrus is designed to grow as your needs change. A suite of modules provides support for a variety of GPC techniques, such as multi detector GPC, online FTIR detection and short chain branching (SCB).

Cirrus can be run on a standalone PC or provide a networked GPC solution.

Technical Support

Registered Cirrus users have full access to comprehensive technical support, including PL's Support Website, downloads of all upgrades and Cirrus literature, plus access to the FAQs database.

Cirrus Capabilities & Features

Easy to Use Interface

Cirrus is designed around an intuitive graphical user interface, so easy to use that new users will be able to report results within an hour of installing the software. Cirrus is based on PL's Workbook concept to provide

- A simple 'container' for data, parameters and results
- Automatic archiving of chromatograms, calibrations and results
- Data traceability and data integrity
- Templates allowing predefinition of parameters and report content

Comprehensive Calibration Options

Cirrus provides a choice of calibration options

- Conventional calibration using Narrow Standards
- Universal calibration by viscometry or using Mark-Houwink coefficients
- Replicate entries of calibration points
- Three Broad Standard calibration methods

A Calibration Overlay facility allows you to view the effects of column performance over time.

Wide Range of Calculation Options

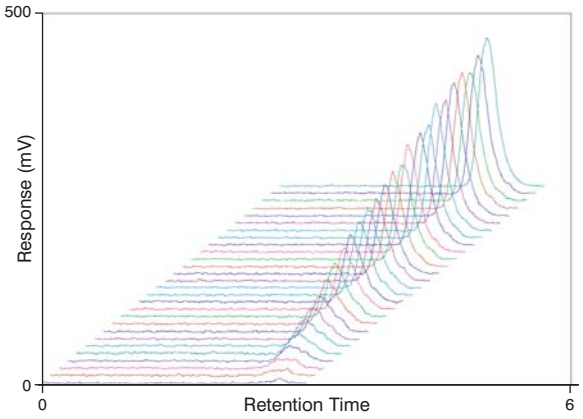
- Averages and Distributions can be calculated for any number of peaks in a chromatogram
- % of material can be reported for specific MW limits

Automation Options

Cirrus is designed to meet the requirements of both the QC/Routine and R&D environments, providing fully automated or interactive analysis.

Reviewing, Collating & Condensing Results

Cirrus provides a number of powerful options to review, compare and extract information from archived data and results for inclusion into final summary reports. Chromatograms and results can be reviewed both textually and graphically. This information can be exported in a variety of industry standard formats.



Comprehensive Reporting Options

A powerful Report Designer provides total flexibility in report content and presentation.

Accessing Data & Results

PL recognizes the importance of quick access to data and results. In Cirrus, all parameters relating to a chromatogram or results file are easily accessible via a comprehensive range of export options.

Customization

Cirrus can be quickly customized to a high level using the Cirrus Software Development Kit (SDK). The SDK allows you to easily access information from Cirrus using various programming environments and enables you to develop routines to address your specific needs.

Data Traceability

Cirrus ensures that data integrity and traceability is maintained throughout all operations.

Cirrus GPC/Multi Detector Polymer Characterization

GPC/Viscosity

This module allows the calculation of molecular weight based on the Universal Calibration using a viscometer in combination with a concentration detector. Using this approach, intrinsic viscosities can be calculated along with Mark-Houwink parameters. Long chain branching calculations can also be performed using the Mark-Houwink plot. Cirrus supports Polymer Laboratories' PL-BV 400 and Viscotek's four capillary bridge differential viscometers.

GPC/Light Scattering

This module allows the calculation of molecular weight based on light scattering calculations using a dual angle light scattering detector in combination with a concentration detector. Using this approach, radius of gyration can be calculated. Long chain branching calculations can also be performed using the Conformation plot. Cirrus supports 1 or 2 angles from the Precision Detectors' PD2000 series of light scattering detectors.

Triple Detection

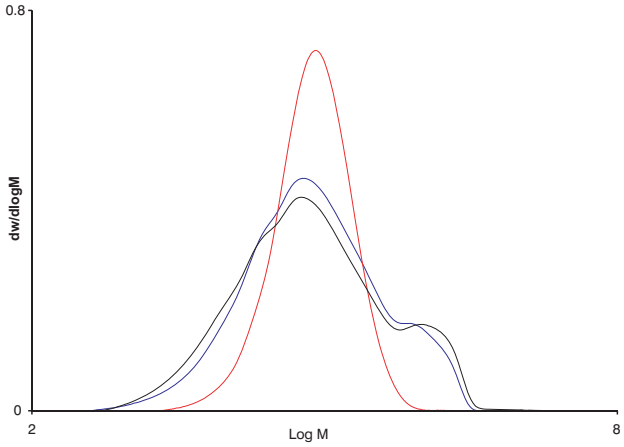
Cirrus also supports Triple Detection, the widest possible characterization option provided by simultaneous collection from a concentration detector with 1 or 2 angles of light scattering detection plus a differential viscometer.

Data from Precision Detectors' Discovery32 and Viscotek's TriSEC can be read into Cirrus, allowing calculations to be performed on data collected with either of these platforms.

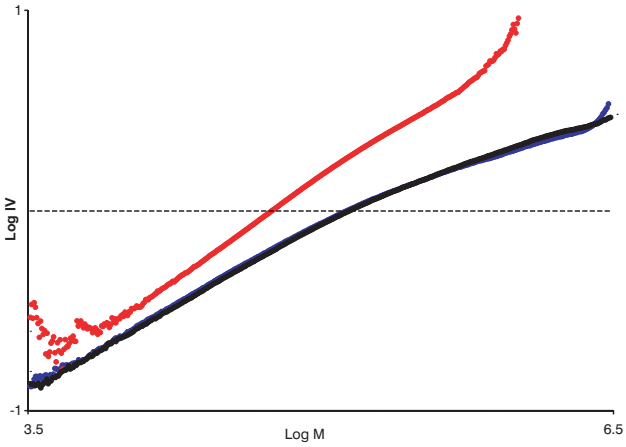
Interfacing to FTIR

Cirrus's new GPC-FTIR Data Import Module allows the calculation of MW distributions from time resolved FTIR spectra, and the Cirrus GPC-FTIR SCB Software supports the calculation of short chain branching distributions by FTIR (see page 57).

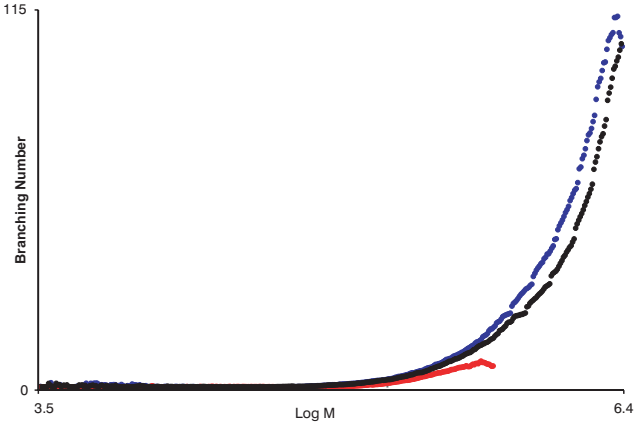
Distribution Plot of 3 Polyethylene Samples



Mark-Houwink Plot of 3 Polyethylene Samples



Branching Plot of 3 Polyethylene Standards



Cirrus - GPC Solutions for the ChemStation & Atlas

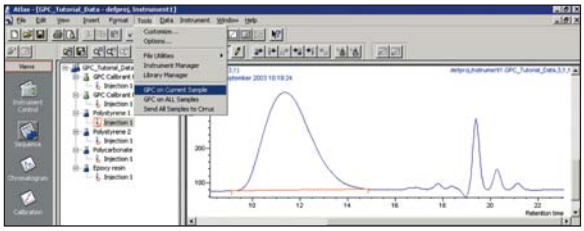
Cirrus GPC Software for the LC ChemStation

Polymer Laboratories produces a version of Cirrus GPC Software designed specifically as a seamless, drop in GPC capability for integration into Agilent Technologies' LC ChemStation.

Cirrus GPC Software for the Atlas Chromatography Data System

Polymer Laboratories has been working in partnership with Thermo Electron Corporation to provide a seamless, integrated GPC solution for the Atlas Chromatography Data System, with PL being selected as 'Best of Breed'.

Cirrus is very similar to Atlas in look and operation, with a similar Workbook approach and simple 'Task View' style user interface.



Cirrus is compatible with Thermo Electron Corporation's Atlas Chromatography Data System 2000 or above.

The Cirrus GPC solutions for the ChemStation and Atlas share many common features.

Data Acquisition

The Atlas Chromatography Data System and the LC ChemStation manage all instrument control, data acquisition and any LC data analysis. Cirrus can process chromatograms collected from the wide range of detector types supported by the LC ChemStation and Atlas. Cirrus provides simultaneous data capture with online or offline processing of data.

The system is quick and simple to use for routine analyses, yet has the versatility to handle more demanding separations.

GPC analysis can be performed as soon as a chromatogram is collected. Alternatively, chromatograms can be stored for later processing.

Single Entry Point

The Cirrus GPC solution provides a simple, integrated 'single entry point' for GPC processing parameters and sample information within the host systems. GPC specific processing parameters can be defined within the ChemStation and Atlas, and associated with an LC method. Sample details defined within the Atlas and ChemStation sample sequences remain with the sample in Cirrus, ensuring easy traceability of sample and results.

Peak Integration Options

For each chromatogram, Cirrus will use the peak integration information generated by the ChemStation or Atlas. Options allow the initial peak integration performed within the LC chromatography systems to be modified within Cirrus, or you can simply use the integration routines provided within Cirrus.

Flexible Configuration

Cirrus can be used with Atlas and the ChemStation in a variety of ways...

QC/Routine Environment

Fully Automated Analysis

R&D Environment

Fully Interactive Analysis

IQ OQ - Fit for Purpose

Installation and automated verification procedures ensure that Cirrus is correctly installed and ready to use.

Ordering Information

Product	Part No.
Cirrus™ GPC Software	PL0570-2000
Cirrus™ Multi Detector Software	PL0570-2020
Cirrus™ GPC-FTIR SCB Software	PL0570-2400
GPC-FTIR Data Import Module	PL0570-2300
Cirrus™ AIA GPC Software for LC Data Systems	PL0570-2000AIA
Cirrus™ GPC Software for the Agilent ChemStation	PL0570-2000AT
Cirrus™ GPC Software for Atlas (1pk)	PL0570-2000LS
Cirrus™ GPC Software for Atlas (5pk)	PL0570-2000LS5
Cirrus™ GPC Software for Atlas (10pk)	PL0570-2000LS10
PL DataStream	PL0570-2010

Galaxie LC Functionality for Cirrus™ GPC Users

Galaxie CDS provides a scalable solution for your chromatography data handling needs.

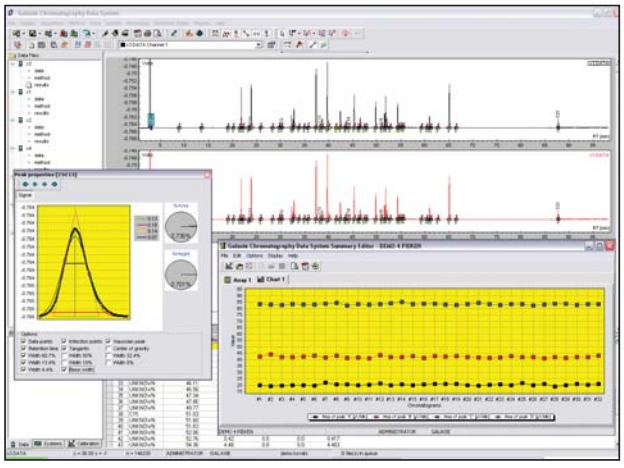
Galaxie provides all of the data handling and instrument control functions necessary for the modern chromatography laboratory. Both LCs and GCs from multiple vendors connect seamlessly with Galaxie and can all be controlled using a single graphical user interface.

Simply Powerful

Galaxie's single screen approach to building methods and sequences, as well as viewing and manipulating data, makes it very easy to use and learn.

Key features

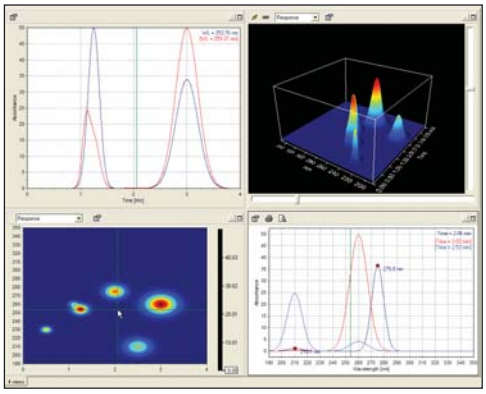
- Acquire & Process data from any LC & GC
- Control a large range of Varian's and other vendors' instruments
- Scalable from single PC Workstation to full client server system
- Powerful, yet easy to use
- Enables you to comply with regulatory requirements, such as 21CFR Part 11
- Interactive Graphic integration
- Multi-level calibration
- Customizable analysis reports
- Suitability testing & Summary reports



Chromatography Data Handling and More

Galaxie Chromatography software comes with many powerful features that will give you even more control over your application. After the concentration calculation you can use the following tools to increase productivity, ensure quality and comply with regulatory requirements.

- **Summary Reports** use results from any number of chromatograms. Calculate averages and standard deviations, and plot trends in data.
- **System Suitability** software determines the quality of a chromatographic analysis, calculating parameters such as peak asymmetry and column efficiency.
- **Diode Array** spectral processing software determines the identity and purity of peaks.
- **Column Tracker**, an integrated database, keeps track of the identity and usage of all system columns.
- **Print Manager** allows users to conveniently export reports and chromatograms, simplifying the ability to perform further calculations or modeling.
- **Galaxie Fusion AE** automates the processes of developing, optimizing and validating methods, significantly improving productivity in R&D and QC laboratories.
- **Regulatory Requirements** Galaxie Chromatography Data System allows you to comply with regulatory guidelines like GLP, GMP & 21CFR part 11.
- **The Plug-in Tool Kit** allows power users to develop customized calculation modules, which fully integrate with Galaxie.



Ordering Information

Product	Part No.
Galaxie Software single PC license including 1 instrument analog data acquisition	03-950000-91
Galaxie Software single PC license including 4 instrument analog data acquisition	03-950000-92
Galaxie Software single PC license including 1 instrument Varian LC control	03-950000-96
Galaxie Software single PC license including 4 instrument Varian LC control	03-950000-94

PL-PMC Series of Online Polymerization Monitoring & Control Systems

Within the polymer manufacturing industry, it is widely recognized that an accurate, reliable method of monitoring Molecular Weight Distribution (MWD) and the various molecular weight averages (Mw, Mn and Mz) in real time (or near real time) during the polymerization process is of significant importance for a successful and profitable product.

The PL-PMC series of online polymerization monitoring and control systems from Polymer Laboratories comprises versatile polymer molecular weight monitoring systems designed for the rapid, automated acquisition and analysis of real time data for polymerization processes.

The series incorporates state of the art developments in ultra-rapid molecular weight (MW) measurement techniques in the areas of Gel Permeation Chromatography (GPC) and Flow Injection Analysis (FIA).

GPC can provide information on MW, molecular weight distribution, copolymer composition and polymer content above/below the MW limits of interest, whereas FIA can provide polymer conversion and rapid measurements of MW and intrinsic viscosity.

The latest developments in high speed GPC and FIA capability provide the opportunity for feedback control of the reactor parameters and feedstock during the polymerization.

Online polymerization monitoring and control with the PL-PMC systems is a four stage process:

Polymer Sampling
- automatic and continuous extraction from polymerization vessel

Dilution and Sample Preparation
- controlled dilution of the extracted sample to a known concentration

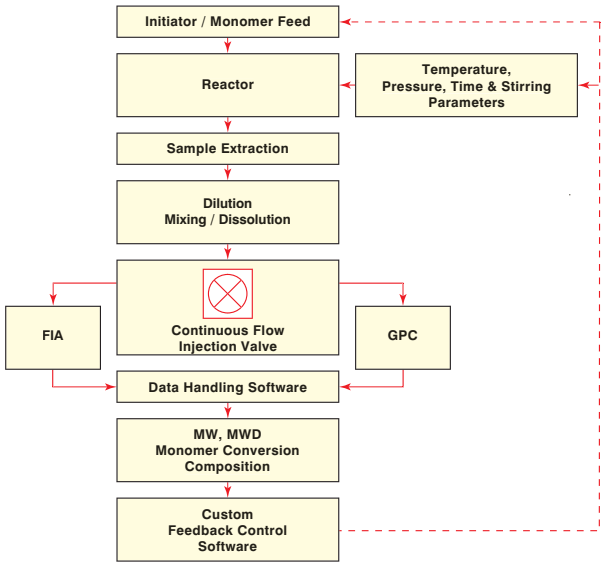
Measurement
- continuous measurements with 'absolute' detectors (LS or Viscometry) and/or concentration detectors (UV, RI, ELSD, etc)

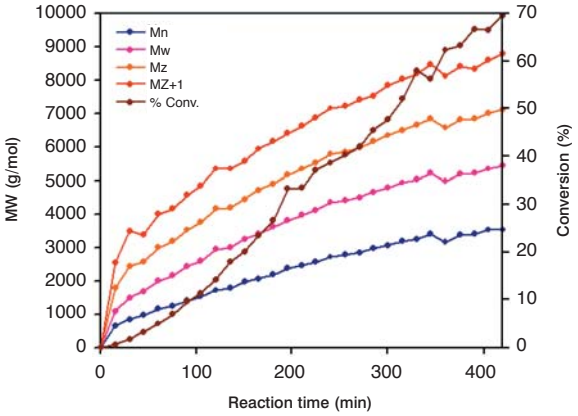
or
- discrete rapid or conventional chromatographic or FIA analysis

Data Monitoring or Feedback Control
- calculation of MW averages, MWD or reaction conversion rates gives ability to monitor and provide data for control of polymerization process

Use of the PL-PMC systems is essential for

- New polymer research and development
- Polymerization process development including
  - Reactor conditions
  - Reactor design
  - Initiator selection
  - Monomer feed/composition
- Production monitoring
- Production control





Monitoring of the evolution of molecular weight averages and monomer to polymer conversion as a function of reaction time for an atom-transfer radical polymerization of methyl methacrylate and styrene.

PL's engineers, polymer scientists and programmers work in conjunction with our customers to design and provide custom solutions for online polymerization monitoring and control. PL has more than 31 years' experience in polymer analysis and characterization. Call us to discuss your requirements.

Symyx®

Polymer Laboratories' polymer molecular weight analysers for process monitoring are based on exclusive licences to Symyx Technologies, Inc's proprietary technologies: US Patents 6,260,407, 6,265,266, 6,294,388, 6,175,409 and other patents pending.

PL-PSDA Particle Size Distribution Analyser

The PL-PSDA from Polymer Laboratories is an integrated, automated system for the rapid determination of particle size distribution of colloidal dispersions. Operating on the principle of packed column hydrodynamic chromatography (HDC), the PL-PSDA measures complex particle size distributions with high precision and accuracy, making it ideal for narrow distribution, multi-modal or polydisperse samples, irrespective of particle chemistry or density.

The automated features and user friendly software combine to deliver remarkable ease of operation which, together with the high resolution of the technique, provide an instrument suitable for both quality control and research applications.

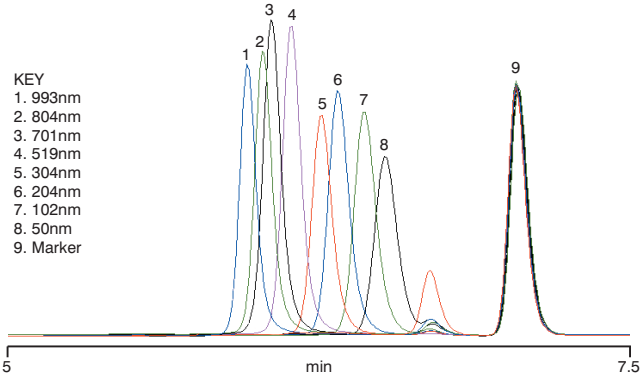
Key Application Areas

- Polymer Latex
- Emulsions and Dispersions
- Surfactants
- Fillers
- Dairy/Food Products
- Cosmetics

Principle of Operation

A proprietary eluent is continuously pumped through the system at a constant flow rate. The sample under investigation and a small molecule marker solution are introduced into the system via a two position, electrically actuated valve, such that the eluent flow is not interrupted. The sample components are separated by an HDC mechanism in a 'cartridge', and their concentration is measured by a UV detector. The system is calibrated using a series of particle size standards.

Typical Chromatograms of Latex Standards (Type 2 Cartridge)



Features

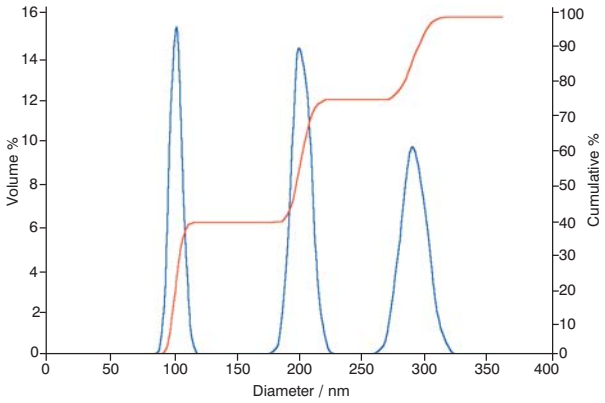
- Measures complex particle size distributions in the range 5nm – 2μm
- Makes no assumptions regarding the shape of the particle size distribution
- Results are independent of particle density
- Analysis time less than 10 minutes
- Automated sample analysis, integrated autosampler
- User friendly, intuitive software control
- High resolution, accuracy and precision

The particle size distribution of a sample under investigation is derived from the raw chromatographic data via a calibration procedure involving the parameter Retention Factor (Rf). A series of particle size standards is run and Rf, which is the ratio of marker RT/standard RT, is plotted against the square root of the diameter of the particle size standard. Using a suite of specifically designed software algorithms, the instrument thus provides a complete particle size distribution for a sample as well as a calculated mean, median and mode diameter values.

Resolution

Particle size distribution can be measured with a high degree of resolution as the PL-PSDA physically fractionates particles according to size, as illustrated for a blend of latex standards.

Particle Size Distribution of a Mixture of 102nm, 204nm and 304nm Latex Standards (Type 1 Cartridge)



Accuracy and Precision

The accuracy, precision and excellent repeatability of the PL-PSDA are shown in results obtained for six consecutive determinations of particle size for a Latex 519nm standard.

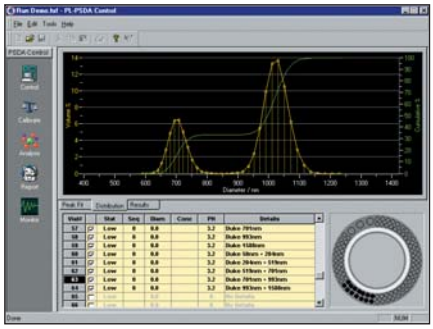
Run No.	Mean Diameter (nm)
1	518
2	518
3	517
4	517
5	517
6	518
Average (nm)	517.5
Variation (%)	0.1

PL-PSDA Particle Size Distribution Analyser

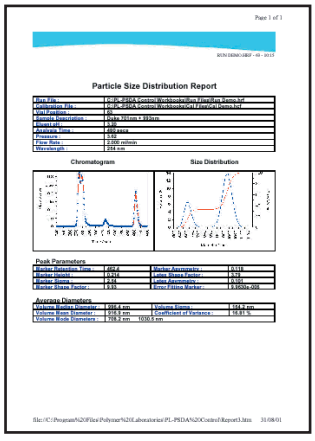
Instrument Control and Data Analysis

The PL-PSDA Windows compatible software provides system control, data acquisition, data analysis and reporting through one user friendly, intuitive graphical user interface. Individual screen views are easily accessed from the familiar style shortcuts toolbar.

The main Control view indicates the status of all the system components and facilitates the input of sample details for up to 87 vial positions in the autosampler carousel. Samples do not necessarily have to be run sequentially in the carousel, and urgent samples can be assigned higher priority at any time. The autosampler graphic in the Control view uses color coding to indicate the status of each vial position.

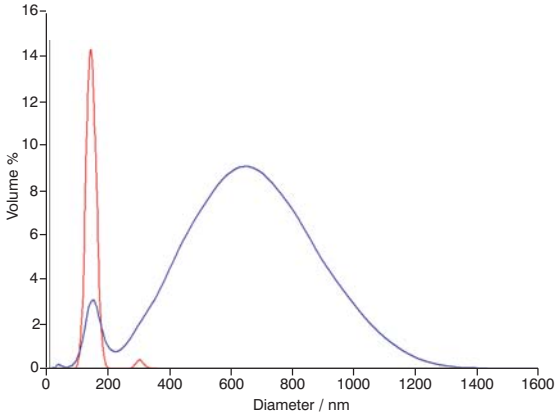


The Analysis view enables the User to produce results for samples currently being analysed or review stored data files. Simply enter the run file into the grid and select one of the three tab options to display the chromatogram, the particle size distribution or the calculated results.

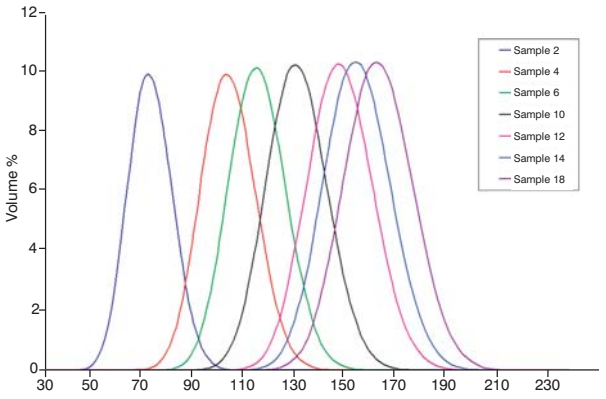


An HTML style sample results report is generated for every calculation which can be viewed or printed from the Report view. Several report templates are provided. For extra flexibility, the raw data and calculated particle size distribution data for individual samples can be exported in ASCII format for manipulation using other commercial packages, such as Windows Excel.

PVC Latex (Overlay of Two Sample Distributions) Type 2 Cartridge

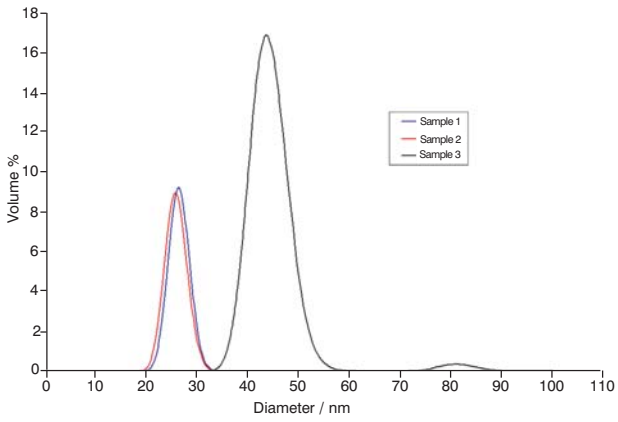


n-butyl acrylate Latex (Overlay of Sequential Samples taken from Reactor) Type 2 Cartridge



Samples courtesy of Dr B Hunt, The University of Sheffield, UK

Gold Colloids (Overlay of Three Sample Distributions) Type 1 Cartridge



Ordering Information

Product	Part No.
PL-PSDA Particle Size Distribution Analyser	PL0850-0000
Cartridge Type 1 (5nm to 300nm)	PL0850-1010
Cartridge Type 2 (20nm to 1200nm)	PL0850-1020
Cartridge Type 3 (500nm to 2000nm)	PL0850-1030
Eluent Concentrate (4x100ml)	PL0850-2000
Latex Particle Size Standards Kit	PL0850-2050
Torque Extension Tool	PL094/33244
Autosampler Vials, Screw Top (pk of 1000)	PL0120-0010
Autosampler Vials, Screw Caps (pk of 1000)	PL0120-0011
Autosampler Vials, Seals PTFE (pk of 1000)	PL0120-0012

Quality ELSDs from Polymer Laboratories

It is well recognised that Evaporative Light Scattering Detectors (ELSD) can outperform traditional detectors when analysing non-chromophoric samples by HPLC, as the detection method does not rely on the optical properties of the analyte. ELSD detectors detect all compounds less volatile than the mobile phase, and with the advantage of low temperature operation, the benefits of ELSD compared to UV or RI now apply to an even wider range of HPLC applications.

PL's Evaporative Light Scattering Detectors

Polymer Laboratories (PL) presents three models of ELSD, each offering high sensitivity for a wide range of analytes and analysis conditions, designed to address your particular application area. Choose from:

PL-ELS 2100 Ice

For HPLC analyses of low boiling point compounds

PL-ELS 2100

For a wide range of HPLC applications, with high sensitivity for semi-volatile compounds, at low temperature operation

PL-ELS 1000

For routine HPLC and GPC, including high boiling point solvents

Advantages and Benefits of PL's ELSDs

Designed and built to the highest standards, Polymer Laboratories' detectors offer considerable benefits compared to other ELSDs on the market:

- Extremely small footprints, maximize available bench space
- Wide gradient & solvent compatibility
- High sensitivity, extremely low limits of detection (LOD)
- Sub-ambient operation for low boiling point compounds
- Low dispersion, minimal peak broadening for maximum resolution
- Rapid equilibration, fast set-up and high productivity
- Advanced instrument control, easy to use with built-in safety

Application Areas

- Pharmaceuticals
- Nutraceuticals
- Combinatorial libraries
- Carbohydrates
- Lipids
- Phospholipids
- Triglycerides
- Fatty acids
- Amino acids
- Peptides
- Surfactants
- Polymers

Analytical Techniques

- HPLC - analytical, microbore, preparative
- SFC
- LC-MS
- High throughput screening
- 2D Chromatography
- GPC/SEC
- High temperature GPC
- TREF
- GPEC

	PL-ELS 2100 Ice	PL-ELS 2100	PL-ELS 1000
HPLC analysis:			
Non-volatile compounds	✔	✔	✔
Semi-volatile compounds	✔	✔	✘
Highly volatile compounds	✔	✘	✘
Ambient GPC analysis	✔	✔	✔
High temperature GPC analysis	✘	✘	✔

ELSD detectors from PL offer the widest flexibility and deliver optimum performance for all applications.

ELSD - *The Choice* for HPLC Detection

Evaporative light scattering detection is rapidly becoming the preferred concentration detection method for liquid chromatography, either as the ideal substitute for, or supplement to, traditional HPLC detectors. ELSDs offer the following key benefits over more conventional UV and RI detectors:

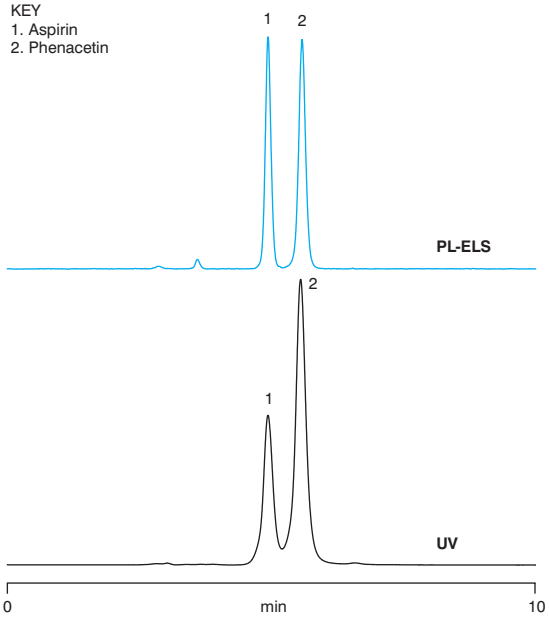
- Universal response, no chromophore required
- Full gradient & solvent compatibility
- No need for pre- or post-column derivatization
- Excellent baseline stability

Universal Response

PL's ELSDs are ideal detectors for many compounds, including those with no UV chromophore or widely differing extinction coefficients. When UV detection is used to monitor the separation of equal amounts of aspirin and phenacetin, different responses are recorded due to variable extinction coefficients at 280nm. Clearly a more uniform response is obtained when ELSD is used.

Column:	PLRP-S 100Å 5μm, 150x4.6mm (PL1111-3500)
Eluent:	0.1% TFA in 50% Water : 50% ACN
Flow Rate:	0.5ml/min
Detectors:	PL-ELS 1000 (neb=60°C, evap=65°C, gas=1.0 SLM)
	UV, 280nm

KEY
1. Aspirin
2. Phenacetin



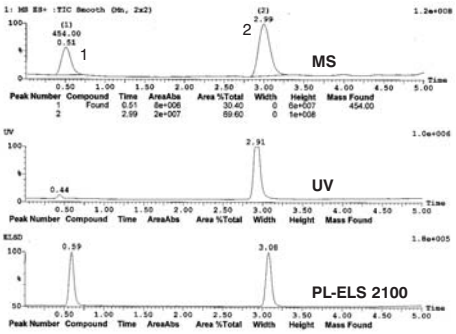
A Valuable Addition to Your LC-MS System

As the operational requirements for LC-MS and ELSD are very similar, PL ELSD methods can be directly transferred to MS, saving valuable LC-MS development time. Polymer Laboratories' evaporative light scattering detectors can be used in parallel with any standard LC-MS system to obtain concentration information for all compounds, irrespective of whether they are UV active.

Sample:	1:1 Mixture of Verapamil and Diazepam
Column:	C_8 3μm, 150x2.1mm column
Eluent A:	0.1% Formic acid in Water
Eluent B:	0.1% Formic acid in ACN
Gradient:	20-80% B in 5 mins
Flow Rate:	0.3ml/min
Inj Vol:	10μl
Detectors:	MS
	UV
	PL-ELS 2100 (neb=50°C, evap=50°C, gas=1.6 SLM)

KEY
1. Verapamil
2. Diazepam

- ***LC-MS trace shows 1:3 ratio***
- ***UV trace shows 1:10 ratio***
- ***ELS shows the true ratio of 1:1***

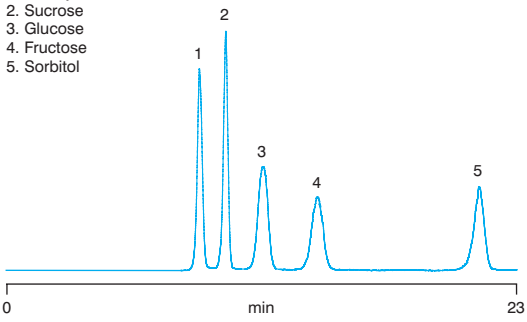


Improved Sensitivity and Baseline Stability

For the analysis of sugars, UV detection cannot be used. Carbohydrates have no UV chromophore, therefore for this type of isocratic separation, RI has been commonly used despite its drawbacks. ELSD detection is the perfect alternative to RI detection, providing higher sensitivity and dramatically improved baseline stability.

Column:	PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent:	Water
Flow Rate:	0.6ml/min
Inj Vol:	10μl
Sample Conc:	1mg/ml
Temp:	85°C
Detector:	PL-ELS 2100 (neb=30°C, evap=90°C, gas=1.6 SLM)

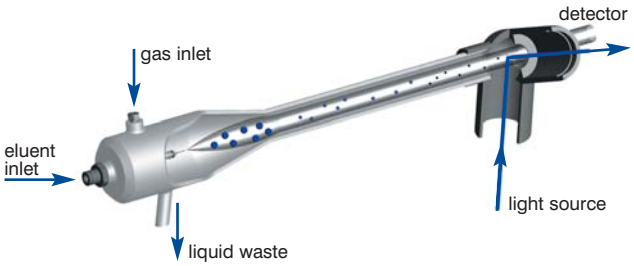
KEY
1. Stachyose
2. Sucrose
3. Glucose
4. Fructose
5. Sorbitol



ELSDs from Polymer Laboratories - *Better By Design*

Evaporative light scattering detection involves a three stage process:

- **Nebulization** - utilizing an inert gas stream to form a plume of uniformly sized droplets
- **Evaporation** - generating a plume of non-volatile solute particles by removal of solvent
- **Detection** - where the intensity of scattered light is proportional to the number of particles passing through the optical chamber



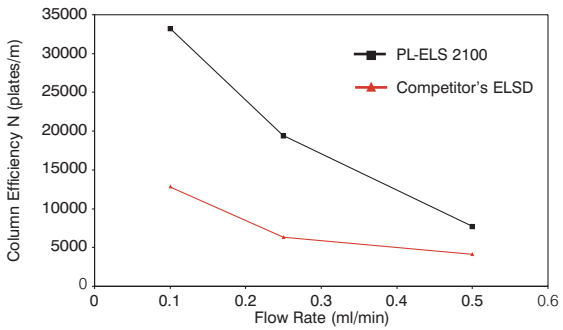
Nebulization

Efficient nebulization using low gas flow rates is a feature of PL's detectors. Independent nebulizer temperature control and digital gas flow control provide excellent stability and reproducibility.

Evaporation

The nebulized plume of droplets passes through an independently temperature-controlled evaporator tube where the solvent is removed, leaving a stream of less volatile solute particles. PL's detectors feature the shortest evaporator tubes which guarantee extremely low swept volume and minimum peak dispersion. The result is that PL's detectors deliver the maximum resolution from your separation, especially important for work with small column volumes.

Sample:	Caffeine
Column:	C_{18} 5µm, 50x2.1mm column
Eluent:	30% Water : 70% ACN
Flow Rate:	0.1-0.5ml/min
Inj Vol:	10µl
Temp:	40°C
Detector:	PL-ELS 2100 (neb=50°C, evap=50°C, gas=1.4 SLM)



- ***PL's ELSD detectors offer up to 3 times higher efficiency than competitors' instruments***

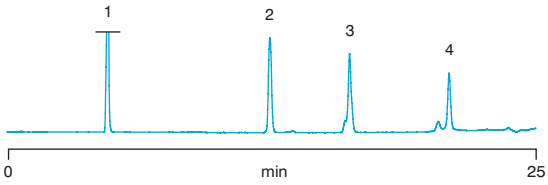
Efficient Evaporation of Complex Eluents

Resolution of phospholipids generally requires the use of complex gradients. PL's ELSDs easily evaporate the most complex eluent gradients, making them ideal detectors for this class of compound.

Sample:	Phospholipid mix at a concentration of 3.125mg/ml
Column:	Silica 100x4.6mm column
Eluent A:	99% 2,4,4-Trimethylpentane : 1% THF
Eluent B:	66.6% Acetone : 33.3% DCM
Eluent C:	15% Water : 85% Isopropanol 7.5mM Ethanolamine 7.5mM Acetic acid
Flow Rate/ Gradient:	See Table

KEY
1. Cholesterol
2. Phosphatidylserine
3. Phosphatidylethanolamine
4. Phosphatidylcholine

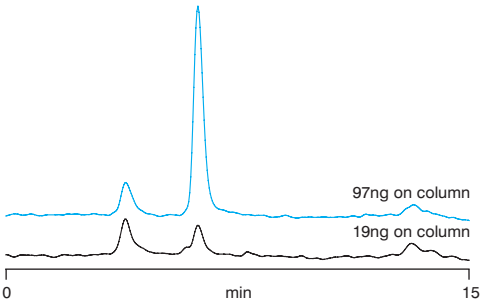
Time	%Solvent			Flow Rate
min	A	B	C	ml/min
0	100			1.6
4	90	10		1.6
7	70	30		1.6
7.1	40	50	10	1.6
20.4	39		61	1.6
20.5	40	60		2
22.6	100			2
25	100			2
25.1	100			2
30	100			2



Detection

The solute particles are detected as they pass through the optical chamber. The advanced design of the optical and electronic components ensures that PL's detectors deliver maximum sensitivity with minimum baseline noise.

Sample:	Caffeine
Column:	C_8 3µm, 50x4.6mm column
Eluent A:	5mM Ammonium acetate in Water
Eluent B:	5mM Ammonium acetate in ACN
Gradient:	10-100% B in 5 mins, 1 min hold in 100% B
Flow Rate:	1.0ml/min
Inj Vol:	10µl
Detector:	PL-ELS 2100 (neb=50°C, evap=50°C, gas=1.4 SLM)



- ***Achieve very low on-column limits of detection, even with 4.6mm columns***

PL-ELS 2100 and 2100 Ice - Leading The Way In HPLC Detection

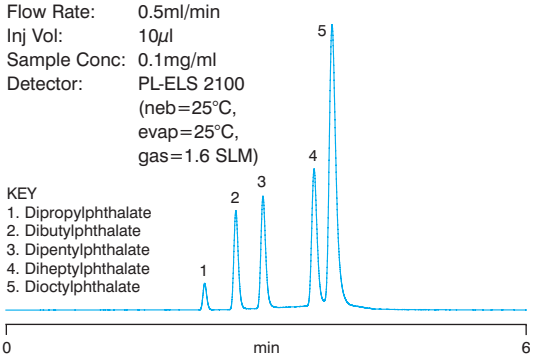
The PL-ELS 2100 series surpasses other ELSDs for low temperature HPLC applications with volatile compounds

The PL-ELS 2100 series represents the next generation of ELSD technology. Its innovative design provides optimum performance across a diverse range of HPLC applications. This patented design permits operation at very low temperatures, even sub-ambient, to facilitate the detection of semi-volatile compounds *missed by other ELSDs*.

Analysis of Phthalates at Ambient Temperature

Dialkyl phthalates are used as softeners of plastics, oily substances in perfumes, additives to hairsprays, lubricants and wood finishers. Due to their high volatility, dialkyl phthalates have always presented a challenge for detection by ELSD when analysed by HPLC methods.

Column: C_{18} 3.5µm, 30x2.1mm column
Eluent A: Water
Eluent B: ACN
Gradient: 0-100% B in 3.1 mins, hold for 0.7 min
Flow Rate: 0.5ml/min
Inj Vol: 10µl
Sample Conc: 0.1mg/ml
Detector: PL-ELS 2100 (neb=25°C, evap=25°C, gas=1.6 SLM)

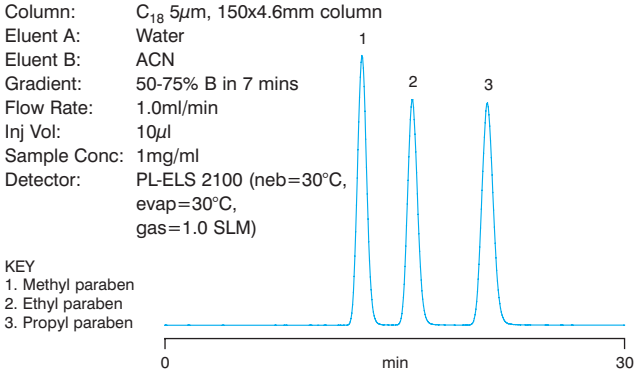


■ ***By operating the PL-ELS 2100 at near ambient conditions, it is possible to detect a wide range of dialkyl phthalates***

Analysis of Parabens

This application shows a separation of parabens, synthetic preservatives frequently used in cosmetics and personal care products and in pharmaceutical formulations. These low molecular weight compounds are relatively volatile but can easily be detected by operating the PL-ELS 2100 at very low temperatures, essentially ambient temperature.

Column: C_{18} 5µm, 150x4.6mm column
Eluent A: Water
Eluent B: ACN
Gradient: 50-75% B in 7 mins
Flow Rate: 1.0ml/min
Inj Vol: 10µl
Sample Conc: 1mg/ml
Detector: PL-ELS 2100 (neb=30°C, evap=30°C, gas=1.0 SLM)



■ ***Parabens are semi-volatile compounds; the PL-ELS 2100, with evaporation at 30°C, shows excellent response***

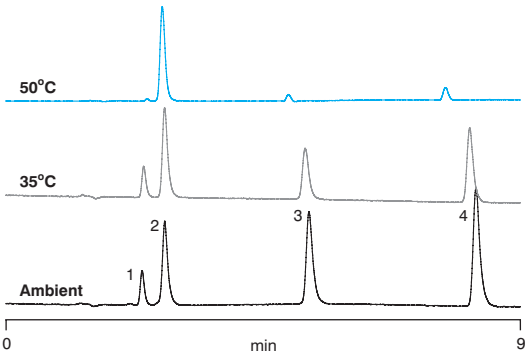
Analysis of Pharmaceutical Compounds

In this analysis, peak 2, indapamide, is essentially non-volatile but the remaining three peaks (acetanilide, ibuprofen and dibutylphthalate) are semi-volatile to different degrees. The effect of operating temperature on the recovery of these three semi-volatile compounds is clearly illustrated.

As the temperature of operation is lowered, significant improvement of response is observed for all peaks, with excellent baseline stability maintained.

Column: C_{18} 5µm, 150x4.6mm column
Eluent A: 0.1% TFA in Water
Eluent B: 0.1% TFA in ACN
Gradient: 60-90% B in 5 mins
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Sample Conc: 1mg/ml
Detector: PL-ELS 2100 (gas=1.6 SLM)

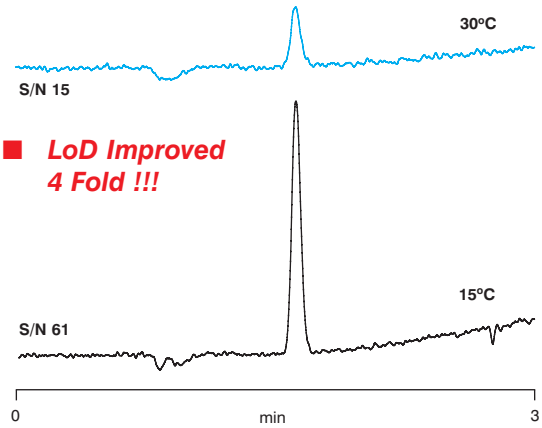
KEY
1. Acetanilide
2. Indapamide
3. Ibuprofen
4. Dibutylphthalate



Improve the Limit of Detection for Low Molecular Weight Compounds

The limit of detection for thermally sensitive analytes, such as acetanilide (MW 135.2) and Polyethylene Glycol (MW 106), is often limited by their volatility. Using the PL-ELS 2100 Ice, the detection limit for these types of compounds can be dramatically improved.

Sample: 200µg/ml Acetanilide
Column: C_{18} 5µm, 150x4.6mm
Eluent A: Water + 0.1% TFA
Eluent B: ACN + 0.1% TFA
Gradient: 60-90% B in 5 mins
Flow Rate: 1.0ml/min
Inj Vol: 20µl
Detector : PL-ELS 2100 Ice (neb= 30°C, gas=1.6 SLM)



■ ***LoD Improved 4 Fold !!!***

PL-ELS 1000 - Ideal For Routine HPLC and GPC Analyses

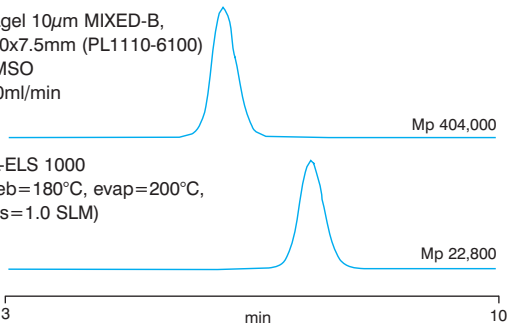
The PL-ELS 1000 For HPLC and GPC Applications, Ambient to High Temperature

The PL-ELS 1000 is renowned for its rugged design and ability to deliver high performance, even for very demanding HPLC or GPC applications. The nebulizer and evaporator can be controlled at very high temperatures to efficiently handle high boiling point solvents commonly used in GPC that other ELSDs simply cannot manage. A custom designed heated transfer line, controlled from the PL-ELS 1000, permits easy coupling to any GPC system, especially valuable for use in high temperature GPC applications.

Polar Solvents

Dimethyl sulfoxide (DMSO) is widely used as an eluent for the analysis of polysaccharides by GPC. An RI detector lacks sensitivity for this application as the refractive index difference between polysaccharides and DMSO is small. In addition, DMSO is normally run at elevated temperature to reduce solvent viscosity, which can result in RI detector instability. The PL-ELS 1000 can be used with high boiling solvents such as DMSO with the benefits of improved detector response and excellent baseline stability with no baseline drift. Typical raw data chromatograms for two pullulan polysaccharide standards illustrate the excellent signal to noise and baseline stability of the PL-ELS 1000.

Column: PLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: DMSO
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=180°C, evap=200°C, gas=1.0 SLM)

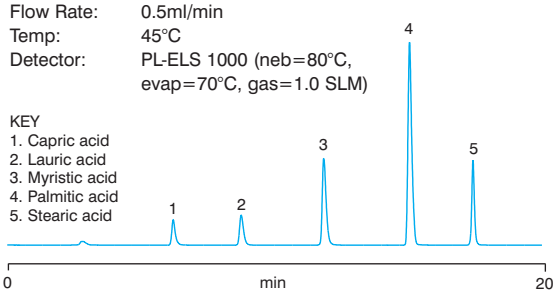


Fatty Acids

ELSD is ideal for the analysis of both saturated and unsaturated fatty acids, as these compounds have no UV chromophore and require gradient elution.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 60mM Acetic acid
Eluent B: ACN
Eluent C: THF
Gradient: 35/60/5 A/B/C to 0/90/10 A/B/C in 20 mins
Flow Rate: 0.5ml/min
Temp: 45°C
Detector: PL-ELS 1000 (neb=80°C, evap=70°C, gas=1.0 SLM)

KEY
1. Capric acid
2. Lauric acid
3. Myristic acid
4. Palmitic acid
5. Stearic acid

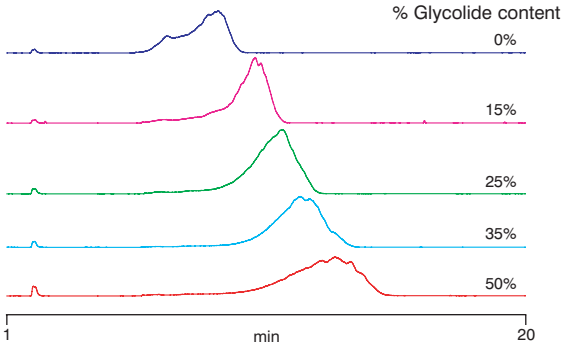


■ *Working at low pH to maximize resolution and minimize analysis time, the ELSD provides good sensitivity and a stable, drift free baseline*

Copolymer Characterization by GPEC

Copolymers are often characterized for composition using interactive HPLC methods, usually employing gradient elution with a wide variety of solvents depending on the application.

Sample: Random poly(lactide-*co*-glycolide) polymers with varying glycolide content
Column: PLRP-S 1000Å 8µm, 150x4.6mm (PL1512-3802)
Eluent A: MeOH
Eluent B: THF
Gradient: 2 min hold in 99% A, 1-99% B in 10 mins
Flow Rate: 1.0ml/min
Detectors: PL-ELS 1000 (neb=70°C, evap=80°C, gas=1.0 SLM)

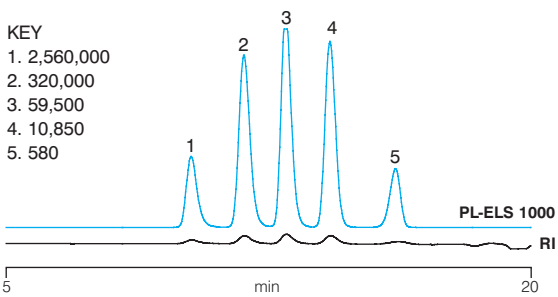


High Temperature GPC

Polyolefins are typically analyzed by GPC using trichlorobenzene (TCB) at 160°C. As the dn/dc of polyolefins and polystyrene standards in TCB is relatively small, RI detector performance must be maximized to obtain acceptable signal to noise ratio. The polystyrene response in TCB using the PL-ELS 1000 is greatly improved compared to a typical RI chromatogram, illustrating the increased sensitivity of the PL-ELS 1000 for high temperature GPC applications.

Sample: Polyethylene
Columns: 2xPLgel 10µm MIXED-B, 300x7.5mm (PL1110-6100)
Eluent: TCB
Flow Rate: 1.0ml/min
Inj Vol: 200µl
Sample Conc: 1mg/ml
Temp: 160°C
Detector: PL-ELS 1000 (neb=160°C, evap=270°C, gas=1.5 SLM)

KEY
1. 2,560,000
2. 320,000
3. 59,500
4. 10,850
5. 580



■ *The PL-ELS 1000 is the ONLY ELSD on the market which operates at this temperature*

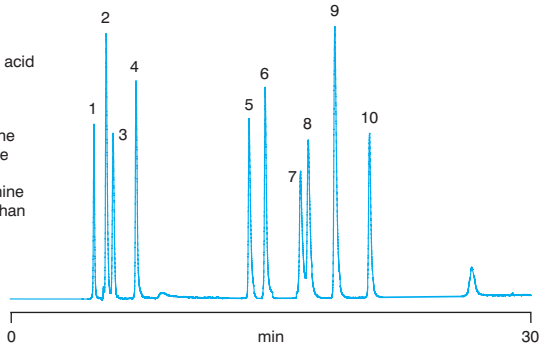
General ELSD Applications

Underivatized Amino Acids

There are numerous methods involving gas and liquid chromatography coupled with pre- and post- column derivatization for the analysis of amino acids. These methods are well established and can offer low detection limits, however, they are time consuming and the products resulting from the derivatization step can be unstable.

Column:	C_{18} 5µm, 250x4.6mm column
Eluent A:	0.1% TFA in Water
Eluent B:	0.1% TFA in ACN
Gradient:	100% A 5 min hold, 0-40% B in 15 mins
Flow Rate:	1.0ml/min
Inj Vol:	10µl
Sample Conc:	1mM
Detector:	PL-ELS 2100 (neb=50°C, evap=50°C, gas=1.6 SLM)

KEY
1. Serine
2. Glutamic acid
3. Arginine
4. Proline
5. Valine
6. Methionine
7. Isoleucine
8. Leucine
9. Phenylanine
10. Tryptophan

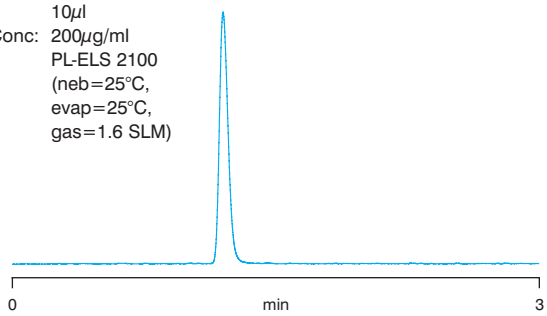


■ ***ELSD is ideal for the detection of amino acids as no derivatization step is required, thus reducing the time and cost for sample preparation and analysis***

Analgesics

Acetaminophen was approved by the FDA in 1951, and has since been used in many over the counter medication brands. PL's ELSD easily permits the determination of low levels of acetaminophen; shown here is a chromatogram for an on column loading of 2µg.

Sample:	Acetaminophen
Column:	C_{18} 5µm, 150x4.6mm column
Eluent A:	90% Water : 9% MeOH : 1% Acetic acid
Eluent B:	ACN
Isocratic:	60/40% A/B
Flow Rate:	1.5ml/min
Inj Vol:	10µl
Sample Conc:	200µg/ml
Detector:	PL-ELS 2100 (neb=25°C, evap=25°C, gas=1.6 SLM)



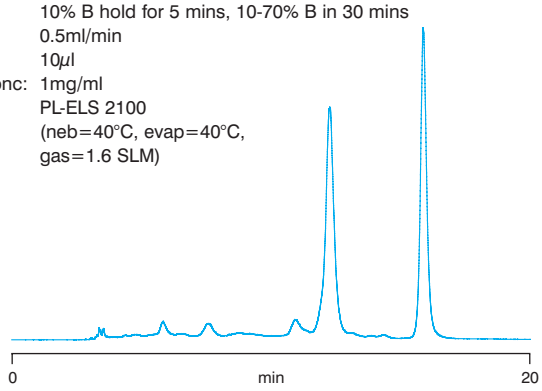
■ ***The PL-ELSD provides excellent sensitivity for the analysis of semi-volatiles at room temperature***

For further information, request a copy of PL's brochure 'High Sensitivity, State of the Art, Evaporative Light Scattering Detectors'

Triglycerides in Cooking Oil

In order to develop a high resolution HPLC separation of complex triglycerides, gradient elution is required. ELSD using the PL-ELS 2100 is the ideal detection method for complex gradients.

Column:	PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A:	ACN
Eluent B:	Dichloromethane
Gradient:	10% B hold for 5 mins, 10-70% B in 30 mins
Flow Rate:	0.5ml/min
Inj Vol:	10µl
Sample Conc:	1mg/ml
Detector:	PL-ELS 2100 (neb=40°C, evap=40°C, gas=1.6 SLM)

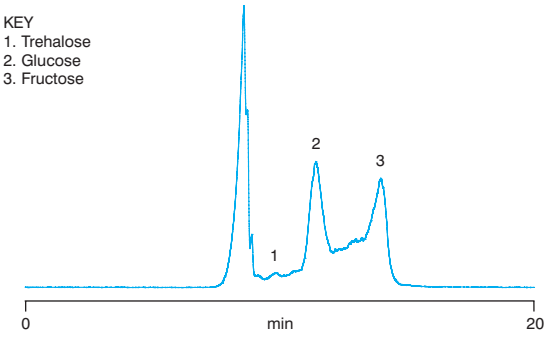


Sugars in Aloe Juice

Studies in the field of glycomics suggest that the monosaccharide content in aloe juice contributes significantly towards its anti-inflammatory activity.

Column:	PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent:	Water
Flow Rate:	0.6ml/min
Inj Vol:	20µl
Sample Conc:	1mg/ml
Temp:	80°C
Detector:	PL-ELS 2100 (neb=50°C, evap=90°C, gas=1.6 SLM)

KEY
1. Trehalose
2. Glucose
3. Fructose



■ ***The ELSD offers significant improvements over the RI for the analysis of a sample of aloe juice which contains glucose and fructose (monosaccharides) and trehalose (disaccharide), as it has increased sensitivity and more stable baseline stability***

Ordering Information

Product	Part No.
PL-ELS 2100 Ice (110V)	PL0860-1110
PL-ELS 2100 Ice (230V)	PL0860-1240
PL-ELS 2100 (110V)	PL0860-0110
PL-ELS 2100 (230V)	PL0860-0240
PL-ELS 1000 (110V)	PL091/24797/110
PL-ELS 1000 (230V)	PL091/24797/220
Heated Transfer Line (110V)	PL091/24629/110
Heated Transfer Line (230V)	PL091/24629/220

PL Network Interface

Using the PL Network Interface, Polymer Laboratories' instrumentation can easily be connected across a company's local area network (LAN) or wide area network (WAN) to obtain instant 'anywhere, anytime access' for remote monitoring, control and data collection.

Polymer Laboratories' instrumentation uses standard serial port or USB connections for control and data collection by a PC. In circumstances where...

...the physical location of the equipment poses logistical problems

...in hazardous environments where health and safety requirements pose access restrictions

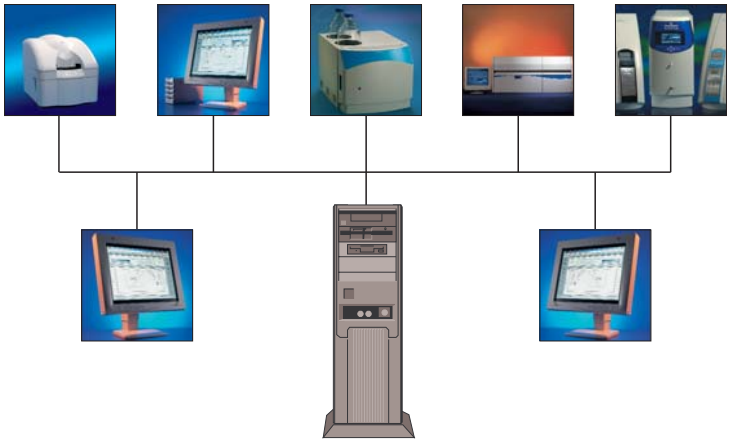
...or where there is a requirement to access the instrumentation by multiple users situated in different labs or even sites

...connection using the PL Network Interface is the solution.

Connecting PL instrumentation is easy

- Connect the instruments to the PL Network Interface using the standard serial port connections
- Connect the PL Network Interface to your Company's LAN

The PL instrumentation can now be accessed remotely from any network enabled PC configured to use the instruments with no changes required to the instrument or the PL control software being used.



Applications of the PL Network Interface

- Remote Data Collection
- Remote Control & Monitoring

The PL Network Interface allows you to control and collect data from your system located in your laboratory direct from your office workstation.

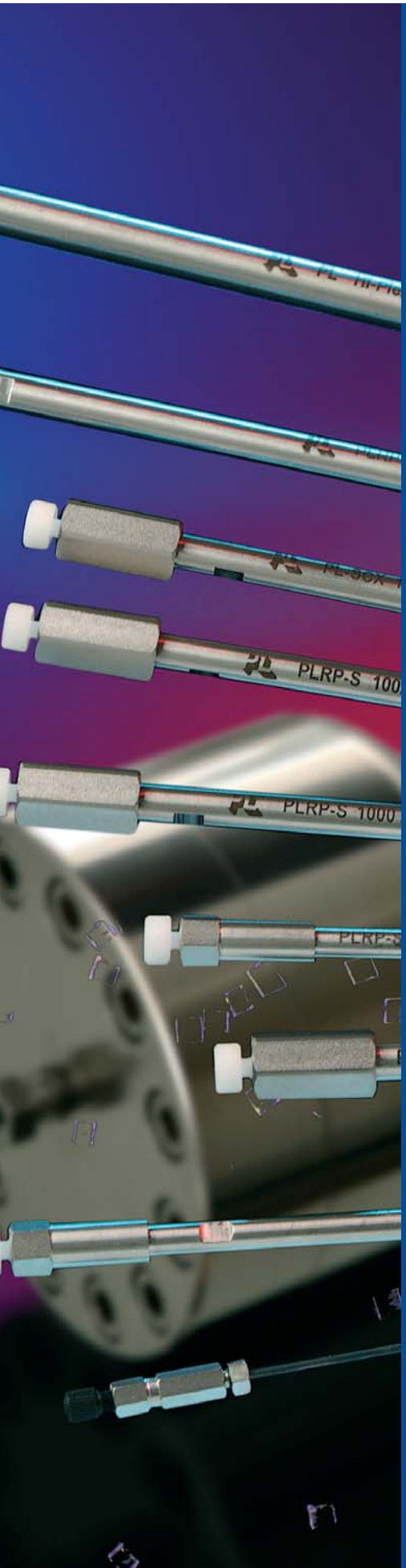
For seamless networking of the range of GPC/HPLC instrumentation from Polymer Laboratories, the PL Network Interface provides remote access and control of

- PL DataStream data capture unit
- PL-ELS 2100 and PL-ELS 1000 evaporative light scattering detectors
- PL-GPC 120 & PL-GPC 220 integrated GPC/SEC systems
- PL-XT 220 rapid analysis GPC/SEC system
- PL-XTR robotic sample handling system
- PL-PSDA particle size distribution analyser

Ordering Information

Product	Part No.
PL-Network Interface, 8 port	PL0870-0200
PL-Network Interface, 1 port	PL0870-0300

Polymeric Columns for Pharmacopeia Methods



For use in Pharmacopeia methods, Polymer Laboratories manufactures macroporous polystyrene/divinylbenzene HPLC materials in a full range of pore and particle sizes plus sulfonated low crosslinked polystyrene/divinylbenzene cation exchange materials with the full range of counter ions.

Polymeric Columns for Pharmacopeia Methods

Various international bodies including the US, British and European Pharmacopeia Commissions produce compendiums of approved, validated methods of analysis, including HPLC methods. These methods are an invaluable reference for Quality Assurance departments and/or analytical laboratories.

Polymer Laboratories is the only manufacturer of macroporous polystyrene/divinylbenzene HPLC materials in a full range of pore sizes from 100Å to 4000Å, and particle sizes from 3µm to 10µm for use in Pharmacopeia methods. Advantages of PL's reversed phase PLRP-S columns include

- chemical stability, pH 1-14
- high pressure capability
- gradients from 1 to 100% organic modifier
- can be easily regenerated, sanitized and sterilized

In addition to these rigid polymers, Polymer Laboratories also manufactures PL Hi-Plex sulfonated low crosslinked polystyrene/divinylbenzene cation exchange materials with the full range of counter ions. PL Hi-Plex monodisperse sulfonated packings provide the benefits of

- improved column efficiencies
- reduced band broadening
- lower column pressures
- increased column lifetimes
- assured batch to batch reproducibility

The Pharmacopeia methods define the type of HPLC media and column dimensions approved for validated methods. To enable the correct selection of the appropriate media/column for a given analytical method, each type of HPLC packing is identified by a code.

USP Classification

Media Type L21: A rigid, spherical styrene/divinylbenzene copolymer, 5 to 10µm particle size
PLRP-S 100Å, 300Å, 1000Å, 4000Å

Media Type L17: Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the hydrogen form, 7 to 11µm in diameter
PL Hi-Plex H

Media Type L19: Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the calcium form, ~ 9µm in diameter
PL Hi-Plex Ca

Media Type L34: Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the lead form, ~ 9µm in diameter
PL Hi-Plex Pb

Media Type L58: Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the sodium form, ~ 7-11µm in diameter
PL Hi-Plex Na

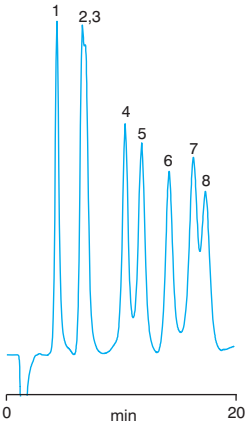
The food and drink industry is a prime user of Pharmacopeia methods for product quality control. The strong cation exchange resins consisting of sulfonated crosslinked styrene/divinylbenzene copolymer with a range of counter ions are the column packings of choice for sugar and sugar alcohol quantitation.

Sugar Alcohols - USP Method

Sugar alcohols occur naturally in fruit, vegetables and cereals. Their pleasant sweet taste allows them to be used as an alternative sweetening agent to sucrose, particularly in reduced calorie and diabetic food.

Column:	PL Hi-Plex Ca, 250x4.0mm (PL1570-5810)
Eluent:	70% Water : 30% ACN
Temp:	60°C
Flow Rate:	0.3ml/min
Detector:	RI

KEY
1. Penta-erythritol
2. Erythritol
3. Adonitol
4. Arabitol
5. Mannitol
6. Xylitol
7. Dulcitol
8. Sorbitol



Polymeric Columns for Pharmacopeia Methods

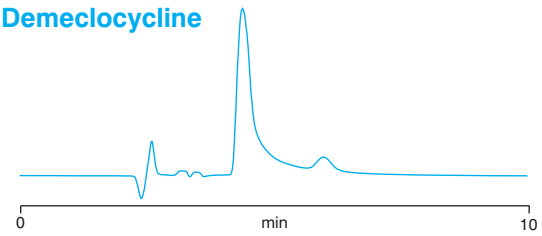
Manufacturers of drugs and other pharmaceutical compounds must comply with stringent regulations before a compound can be passed as fit for human or veterinary use.

Several methods using the PLRP-S L21 polymeric media exist, and a number of examples are given below.

Demeclocycline, Doxycycline Hyclate & Oxytetracycline

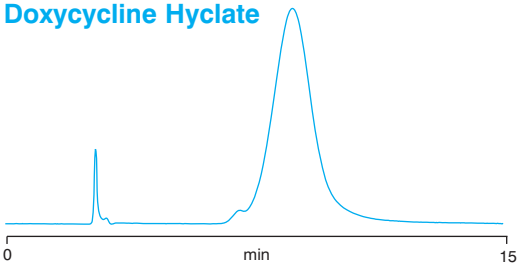
These compounds are part of the wide range of broad spectrum tetracycline-based antibiotics used in the treatment of a wide range of infections.

Demeclocycline

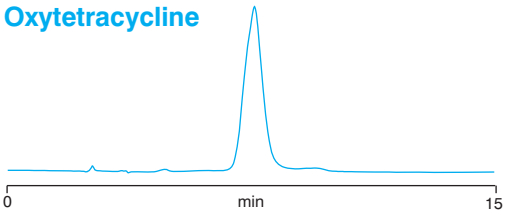


Column: PLRP-S 100Å 8μm, 250x4.6mm (PL1512-5800)
Eluent: 92% 20mM K_2HPO_4, 3mM Bu_4NHSO_4, 1mM EDTA (disodium salt), pH 9.0 : 8% *t*-butanol (for Demeclocycline assay)
Eluent: 92% 20mM K_2HPO_4, 1.5mM Bu_4NHSO_4, 1mM EDTA (disodium salt), pH 9.0 : 8% *t*-butanol (for Doxycycline Hyclate assay)

Doxycycline Hyclate



Oxytetracycline

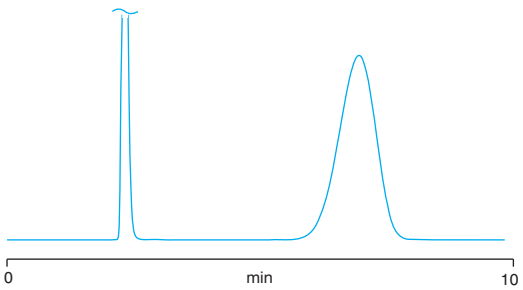


Eluent: 94% 20mM K_2HPO_4, 1.5mM Bu_4NHSO_4, 0.01mM EDTA (disodium salt), pH 9.0 : 6% *t*-butanol (for Oxytetracycline assay)
Flow Rate: 1.0ml/min
Temp: 60°C
Detector UV, 210nm

Enalapril Maleate

Enalapril Maleate (brand name Vasotec) is a commonly used drug for treatment of heart failure and hypertension. Tablets contain quantities of the maleate salt which undergoes hydrolysis to the active metabolite - an Angiotensin Converting Enzyme (ACE) inhibitor. Manufacturers of this compound are required to analyse purity by reversed phase HPLC using a polystyrene-based column (media type L21) according to the US Pharmacopeia procedures.

Column: PLRP-S 100Å 8μm, 250x4.6mm (PL1512-5800)
Eluent: 80% 18mM NaH_2PO_4, pH 6.8 : 20% ACN
Flow Rate: 1.0ml/min
Temp: 70°C
Detector UV, 210nm

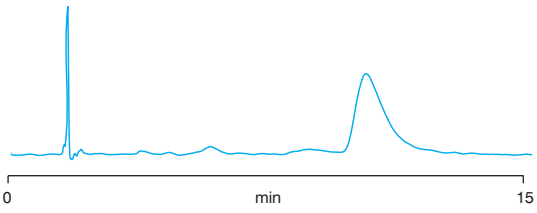


Erythromycin

Erythromycin, the antibiotic, comprises a number of closely related substances (the most significant usually being referred to as Erythromycin A, B and C and Erythromycin A enol ether). These contain slightly differing substituents at key positions within the molecule : either hydrogen, hydroxyl or methoxy groups are present. The US Pharmacopeia requires identification and quantification of these impurities from the main Erythromycin A product using a polystyrene-based column (media type L21) with 1000Å pores.

The PLRP-S 1000Å 8μm uniquely provides the selectivity for this analysis.

Column: PLRP-S 1000Å 8μm, 250x4.6mm (PL1512-5802)
Eluent: 80.5% 7.5mM K_2HPO_4, pH 9.0 : 16.5% *t*-butanol : 3% ACN
Flow Rate 2.0ml/min
Temp: 70°C
Detector UV, 215nm



Reference: Paesen, Roets and Hoogmartens, Chromatographia, Vol 32, 3/4, 1991.

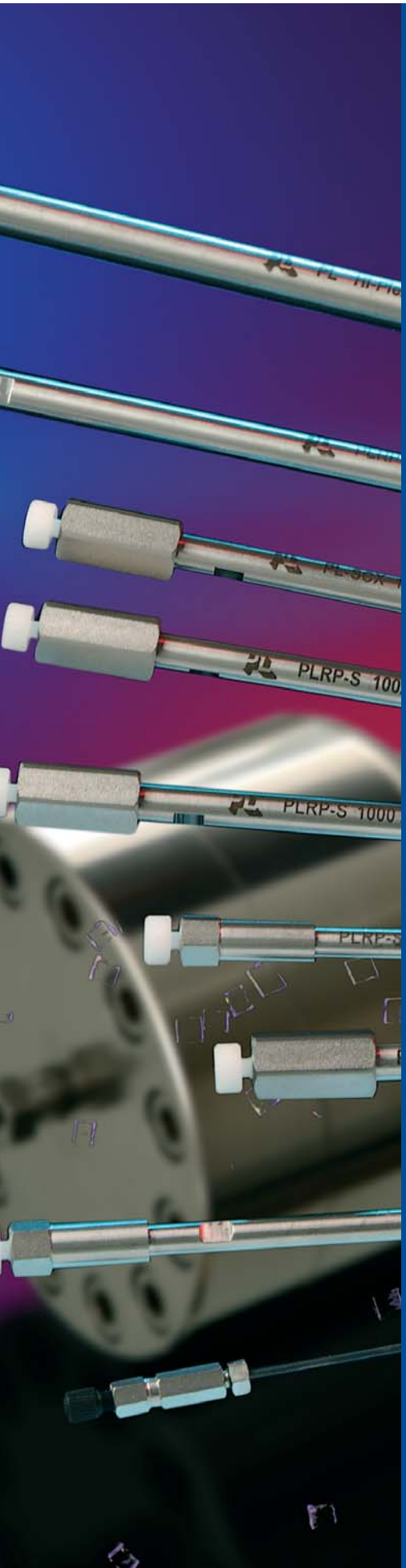
Polymeric Columns for Pharmacopeia Methods

Polymeric Columns

Product	Part No.
PLRP-S 100Å 5µm, 250x4.6mm	PL1512-5500
PLRP-S 100Å 8µm, 250x4.6mm	PL1512-5800
PLRP-S 300Å 5µm, 250x4.6mm	PL1512-5501
PLRP-S 300Å 8µm, 250x4.6mm	PL1512-5801
PLRP-S 1000Å 8µm, 250x4.6mm	PL1512-5802
PLRP-S 1000Å 10µm, 250x4.6mm	PL1512-5102
PLRP-S 4000Å 8µm, 150x4.6mm	PL1512-3803
PL Hi-Plex H, 300x7.7mm	PL1170-6830
PL Hi-Plex Ca, 300x7.7mm	PL1170-6810
PL Hi-Plex Ca USP Column, 250x4.0mm	PL1570-5810
PL Hi-Plex Pb, 300x7.7mm	PL1170-6820
PL Hi-Plex Na, 300x7.7mm	PL1171-6140

For the complete product range, please see page 108 (PLRP-S) and page 132 (PL Hi-Plex).

Rigid Polymerics - High Performance Columns



Rigid polymeric particles are ideal for small scale chromatography.

By optimization of the production process, it is now possible to produce rigid polymeric particles with the required robustness to pack stable high performance nano/capillary/micro columns. Control of particle production gives very narrow particle size distributions with no “fines” to leach and cause spiking, even during the most sensitive LC-MS analyses.

Rigid Polymerics - High Performance Columns

Polymer Laboratories offers a range of capillary/micro columns packed with the highest performance polymeric materials available. Small pore 3µm particles are available for small molecule analysis and wide pore 5µm particles for large biomolecules.

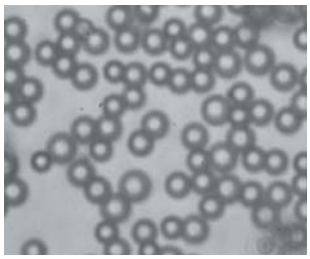
Key Features of Polymeric Particles

Chemically stable polymeric particles are ideal for small scale chromatography and in particular LC-MS applications, as they are chemically stable and do not leach either soluble or particulate species. They can therefore be used for the most demanding of high sensitivity separations.

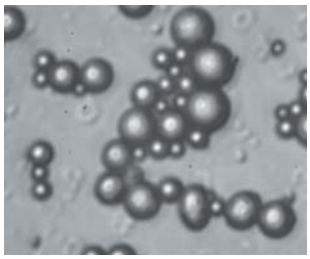
The optical micrograph shows a very narrow particle size distribution with no "small" particles to disrupt the column packed bed, so ensuring a stable packed column.

Optical Micrograph (x100) Illustrating Particle Size Distributions

PLRP-S 100Å 3µm



Competitor's Polymeric 3µm



Reversed phase PLRP-S is a styrene/divinylbenzene copolymer with an inherently hydrophobic surface. No bonded phase is required for reversed phase chromatography. These rigid macroporous particles can be coated/derivatized to give a range of functionalities, including weak and strong cation and anion exchangers.

Column Hardware

To obtain the best column efficiency, the column hardware used must be of the highest possible standard. As the column internal diameter decreases so wall effects increase, therefore it is essential that the internal finish of the column wall is the best available. For the microbore 1mm ID columns, Isolation Technology's Modular column system with ISOBORE™ ID surface finish is used, and for the capillary columns, polyetheretherketone (PEEK) hardware is used with 0.5µm titanium frits.

All Polymer Laboratories' columns are individually tested and are supplied with a unique test certificate. This ensures the best possible column performance and reproducibility.

Column Choice

Nano, capillary or micro columns are used where increased sensitivity is required or where analyte availability is limited.

Nano columns are best suited to sample sizes of less than a pg and are used with nl/min flow rates.

Capillary columns are best suited to sample sizes in the range pg to ng, and are used with flow rates around 4µl/min.

Micro columns are ideally suited to sample sizes in the range ng to mg, and typically operate at flow rates in the range of 40µl/min.

Rigid Polymerics - High Performance Columns

Application Areas

- Proteomics
- Combinatorial chemistry
- High throughput screening
- ADME

Packing Materials

When a column is required for robust HPLC with high sensitivity, polymeric packings provide the solution - the preferred alternative to conventional silica based HPLC materials. Polymer Laboratories manufactures the following small particle, high efficiency materials:

Reversed Phase

PLRP-S 100Å 3µm
PLRP-S 300Å 3µm
PLRP-S 1000Å 5µm
PLRP-S 4000Å 5µm

Anion Exchange

PL-SAX 1000Å 5µm
PL-SAX 4000Å 5µm
PL-WAX 1000Å 5µm
PL-WAX 4000Å 5µm

Cation Exchange

PL-SCX 1000Å 5µm
PL-SCX 4000Å 5µm
PL-WCX 1000Å 5µm
PL-WCX 4000Å 5µm

4000Å gigaporous particles are ideal for applications requiring increased speed. The capacity of these materials is significantly higher than monoliths or solid particles, and does not decrease as the flow rate is increased, due to the open pore structure.

High Sensitivity, LC-MS Applications

Two internal column diameters are available as standard, 1.0mm and 300µm, to cover flow rates from 40µl/min to 4µl/min. In addition, Polymer Laboratories can provide columns in custom dimensions for specific applications, if required.

2D Chromatography/Sample Preparation

Polymer Laboratories offers the complementary chemistries that are required for 2D chromatography and sample preparation: reversed phase (PLRP-S) materials and both strong and weak cation (PL-SCX, PL-WCX) and anion (PL-SAX, PL-WAX) exchangers.

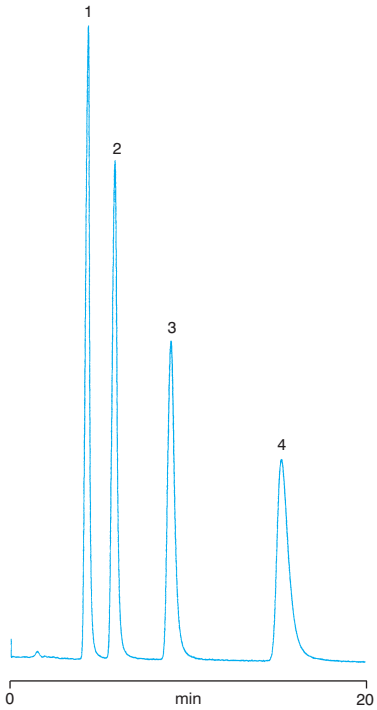
1.0mm internal diameter columns are available to complement the capillary and analytical columns.

The small pore, high capacity PLRP-S materials are included in the product range together with the wide pore packings for larger biomolecule analyses. The gigaporous 4000Å reversed phase and ion exchange materials are the preferred option when ultra high speed analyses are required.

Typical Small Molecule Test Chromatogram

Column: PLRP-S 100Å 3µm, 150x300µm (PL1A12-3300)
Eluent: 60% Water : 40% ACN
Flow Rate: 5.0µl/min
Detector UV

KEY
1. Methyl paraben
2. Ethyl paraben
3. Propyl paraben
4. Butyl paraben



High Performance Columns - Ordering Information

The following items are the core stock products available from Polymer Laboratories, however, other lengths and internal diameters are available by request. Please contact us if the column you require is not listed below.

Capillary HPLC (300μm ID)

Part No.	
PLRP-S 100Å 3μm, 50x300μm	PL1A12-1300
PLRP-S 100Å 3μm, 150x300μm	PL1A12-3300
PLRP-S 300Å 3μm, 50x300μm	PL1A12-1301
PLRP-S 300Å 3μm, 150x300μm	PL1A12-3301
PLRP-S 1000Å 5μm, 50x300μm	PL1A12-1502
PLRP-S 4000Å 5μm, 50x300μm	PL1A12-1503
PL-SAX 1000Å 5μm, 50x300μm	PL1A51-1502
PL-SAX 4000Å 5μm, 50x300μm	PL1A51-1503
PL-SCX 1000Å 5μm, 50x300μm	PL1A45-1502
PL-SCX 4000Å 5μm, 50x300μm	PL1A45-1503
PL-WAX 1000Å 5μm, 50x300μm	PL1A52-1502
PL-WAX 4000Å 5μm, 50x300μm	PL1A52-1503
PL-WCX 1000Å 5μm, 50x300μm	PL1A46-1502
PL-WCX 4000Å 5μm, 50x300μm	PL1A46-1503

Micro HPLC (1.0mm ID)

	Part No
PLRP-S 100Å 3μm, 50x1.0mm	PL1312-1300
PLRP-S 100Å 3μm, 150x1.0mm	PL1312-3300
PLRP-S 300Å 3μm, 50x1.0mm	PL1312-1301
PLRP-S 300Å 3μm, 150x1.0mm	PL1312-3301
PLRP-S 1000Å 5μm, 50x1.0mm	PL1312-1502
PLRP-S 4000Å 5μm, 50x1.0mm	PL1312-1503
PL-SAX 1000Å 5μm, 50x1.0mm	PL1351-1502
PL-SAX 4000Å 5μm, 50x1.0mm	PL1351-1503
PL-SCX 1000Å 5μm, 50x1.0mm	PL1345-1502
PL-SCX 4000Å 5μm, 50x1.0mm	PL1345-1503
PL-WAX 1000Å 5μm, 50x1.0mm	PL1352-1502
PL-WAX 4000Å 5μm, 50x1.0mm	PL1352-1503
PL-WCX 1000Å 5μm, 50x1.0mm	PL1346-1502
PL-WCX 4000Å 5μm, 50x1.0mm	PL1346-1503

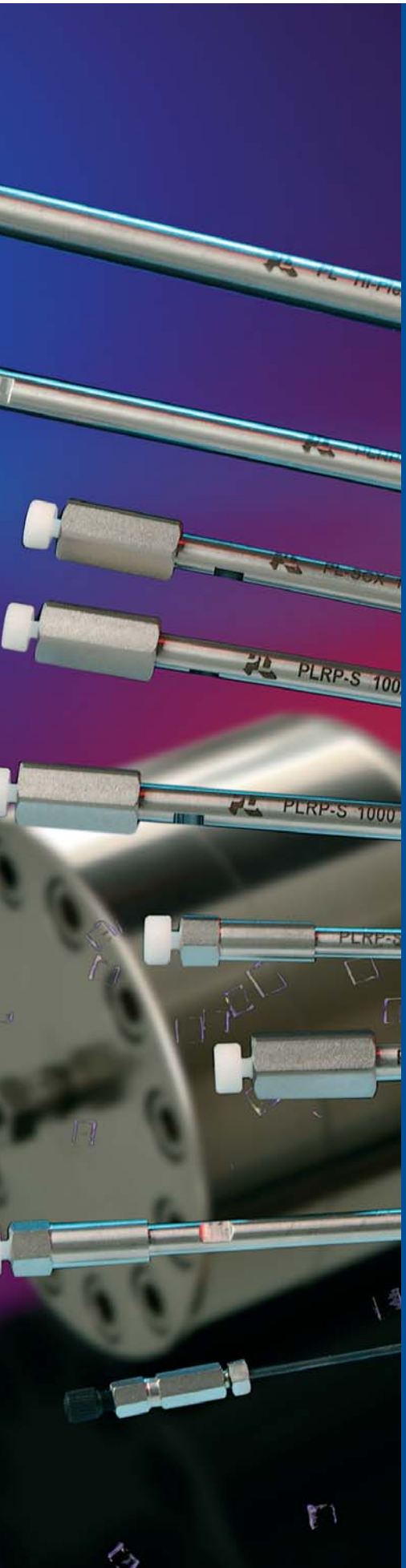
Sample Concentration/Prep

	Part No.
PLRP-S 100Å 3μm, 5x1.0mm	PL1C12-1300
PLRP-S 100Å 3μm, 10x1.0mm	PL1C12-2300
PLRP-S 300Å 3μm, 5x1.0mm	PL1C12-1301
PLRP-S 300Å 3μm, 10x1.0mm	PL1C12-2301
PLRP-S 1000Å 5μm, 10x1.0mm	PL1C12-2502
PLRP-S 4000Å 5μm, 10x1.0mm	PL1C12-2503
PL-SAX 1000Å 5μm, 10x1.0mm	PL1C51-2502
PL-SAX 4000Å 5μm, 10x1.0mm	PL1C51-2503
PL-SCX 1000Å 5μm, 10x1.0mm	PL1C45-2502
PL-SCX 4000Å 5μm, 10x1.0mm	PL1C45-2503
PL-WAX 1000Å 5μm, 10x1.0mm	PL1C52-2502
PL-WAX 4000Å 5μm, 10x1.0mm	PL1C52-2503
PL-WCX 1000Å 5μm, 10x1.0mm	PL1C46-2502
PL-WCX 4000Å 5μm, 10x1.0mm	PL1C46-2503

Nano HPLC (75μm ID)

	Part No
PLRP-S 100Å 3μm, 150x75μm	PL1B12-3300
PLRP-S 300Å 3μm, 150x75μm	PL1B12-3301

Analytical PLRP-S Columns



PLRP-S is a rigid macroporous styrene/divinylbenzene (PS/DVB) HPLC phase, ideal for the analysis of small molecules through to the largest biological macromolecules.

Analytical PLRP-S Product Range and Characteristics

PLRP-S is a rigid macroporous styrene/divinylbenzene (PS/DVB) HPLC phase which has outstanding chemical and physical stability. PLRP-S HPLC media is inherently hydrophobic and reproducible, and does not require a bonded alkyl chain, eg C_8, C_{18}, to confer hydrophobicity.

Advantages of PLRP-S

- Outstanding Chemical Stability, pH 1-14
- High Pressure Capability (>8000psi for 100Å)
- Highly Reproducible
- Easily Regenerated, Sanitized and Sterilized
- Designed for Reproducible Scale-up
- Durable and Resilient for Long Lifetimes
- Temperature Stability (>200°C)
- Gradients from 1 to 100% Organic Modifier
- Unlimited Buffer Concentration

PLRP-S Quality

PLRP-S is manufactured by Polymer Laboratories using state-of-the-art manufacturing techniques. The process is tightly controlled and monitored throughout, ensuring product quality and reproducibility at the manufacturing stage.

The media undergoes rigorous QC for

- particle size
- pore size
- swell and physical stability
- leachables
- capacity factors
- resolution
- permeability

The columns are individually tested for

- efficiency
- asymmetry
- pressure

The PLRP-S family of products consists of a wide range of pore and particle sizes, all with the identical fundamental adsorptive characteristics and chemistry.

Four Pore Sizes

- 100Å - Small Molecule, Peptide and Oligonucleotide Analysis
- 300Å - Large Peptides and Globular Proteins
- 1000Å - Large Biomolecules
- 4000Å - 'Gigaporous' for high speed biochromatography

Range of Particle Sizes

- Pre-packed Columns - 3µm*, 5µm, 8µm

*3µm particle size available in 100Å and 300Å pore sizes only

Range of Pre-packed Columns

- Analytical - 2.1mm, 4.6mm and 7.5mm ID

Polymer Laboratories manufactures pre-packed columns from capillary through process scale, from 300µm ID capillary columns up to 100cm ID columns packed with process media in conventional or axial/radial compression hardware.

The result is assured reproducibility and quality.

Analytical PLRP-S Product Range and Characteristics

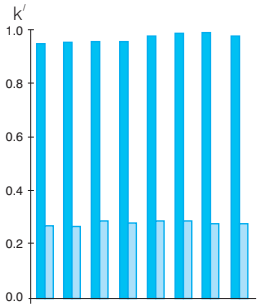
Batch to Batch Reproducibility

PL's proprietary manufacturing processes and use of high purity polymer systems provide reliable, stable and clean polymeric platforms for analytical to process scale chromatography. Residual monomer and surfactant are removed using rigorous cleansing procedures to ensure batch to batch homogeneity. The result is an entirely pure reversed phase surface without the possibility of leachables or changing retention characteristics.

Retention Characteristics

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 10% Water : 90% ACN
Flow Rate: 1.0ml/min
Detector: UV, 254nm

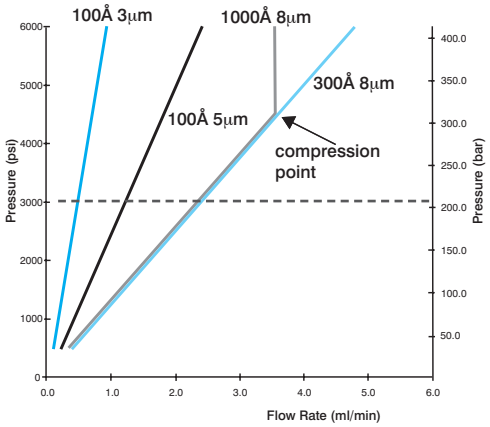
Diethylphthalate
Toluene



The graph illustrates the minimal batch to batch variation of PLRP-S media.

High Mechanical Stability

All the pore sizes in the PLRP-S product range are mechanically stable to pressures in excess of 3000psi. This enables columns to be run under HPLC conditions of pressure and flow rate.

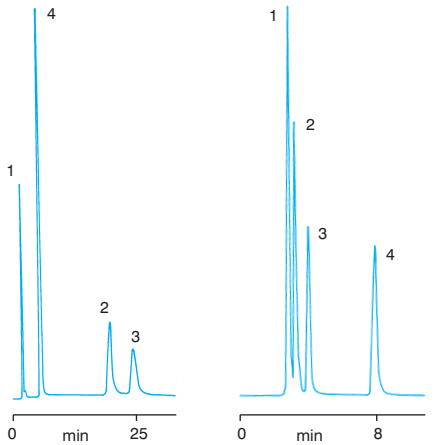


Unsurpassed pH Stability

PLRP-S columns are designed for easy use across the pH spectrum from 1 to 14, with none of the eluent restrictions associated with silica packings. Polymeric packings offer the convenience of separations at the extremes of pH. The separation of Sulfanilic drugs at pH 2.2 and 9.3 illustrates the effective use of pH to control retention and selectivity. This is outside the normally accepted range in which a silica column could be continuously run.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Flow Rate: 1.0ml/min
Detector: UV, 254nm

KEY
1. Sulfanilic acid
2. Sulfadiazine
3. Sulfamethazine
4. Sulfanilamide



Eluent: Potassium sulfate: ACN 7:1, pH 2.2

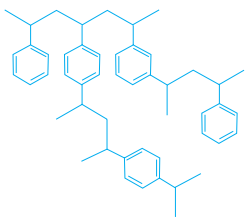
Eluent: Disodium tetraborate: ACN 6:1, pH 9.3

Outstanding Chemical Stability

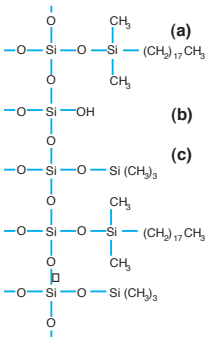
PS/DVB macroporous packings, such as PLRP-S, are inherently and uniformly hydrophobic, and do not necessitate bonded ligands[a], unlike alkyl-functionalized silica reversed phase materials.

Polymeric PLRP-S materials do not possess residual surface functionalities, and do not therefore suffer from the typical silica problems of acidic silanol groups[b] or other ionic species, which can interfere with the separation performance of the matrix and are difficult to remove entirely and reproducibly by endcapping[c] :

Chemical Structure of PLRP-S



Chemical Structure of C_{18} Reversed Phase Silica



Analytical PLRP-S Product Range and Characteristics

Long Lifetimes

PLRP-S media, being a macroporous poly(styrene/divinylbenzene) polymer with no bonded phase, has no residual reactive sites which often arise in silica-based products and is free from silanols and heavy metal ions. The polymeric nature of PLRP-S prevents dissolution of the stationary phase. Columns therefore last significantly longer as voids are unlikely to form and no ligand is leached. This feature even allows the use of high temperature (>200°C) superheated water as an eluent without fear of damage to the stationary phase.

Column Regeneration

A wide range of clean-up procedures can be used to regenerate the original separation characteristics and prolong the use of the column for analytical or process applications. Theoretically *and* in practice, there can be no leakage or ageing due to removal of bonded ligands.

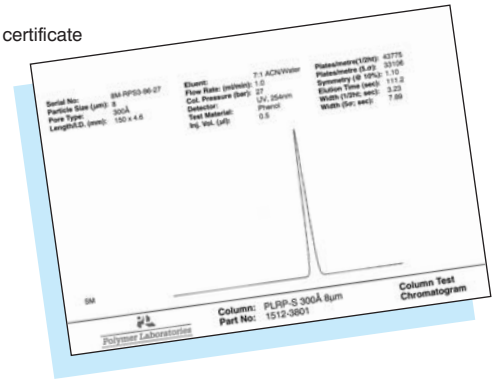
Easily Sterilized

PLRP-S columns can easily be sterilized using sodium hydroxide or other reagents. Media can also be autoclaved if required.

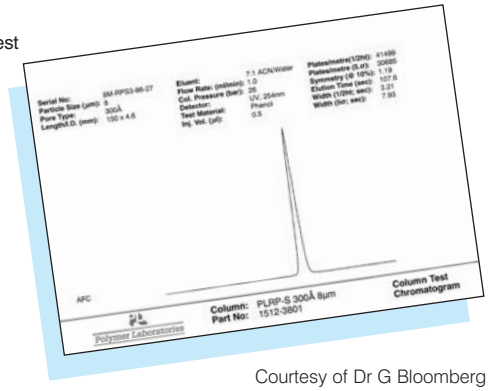
Illustration of Extended Column Lifetime

The comparison of column test certificates below shows the continued performance of a PLRP-S 300Å 8µm column after 5 years' continuous daily use.

Original test certificate



Column Re-test

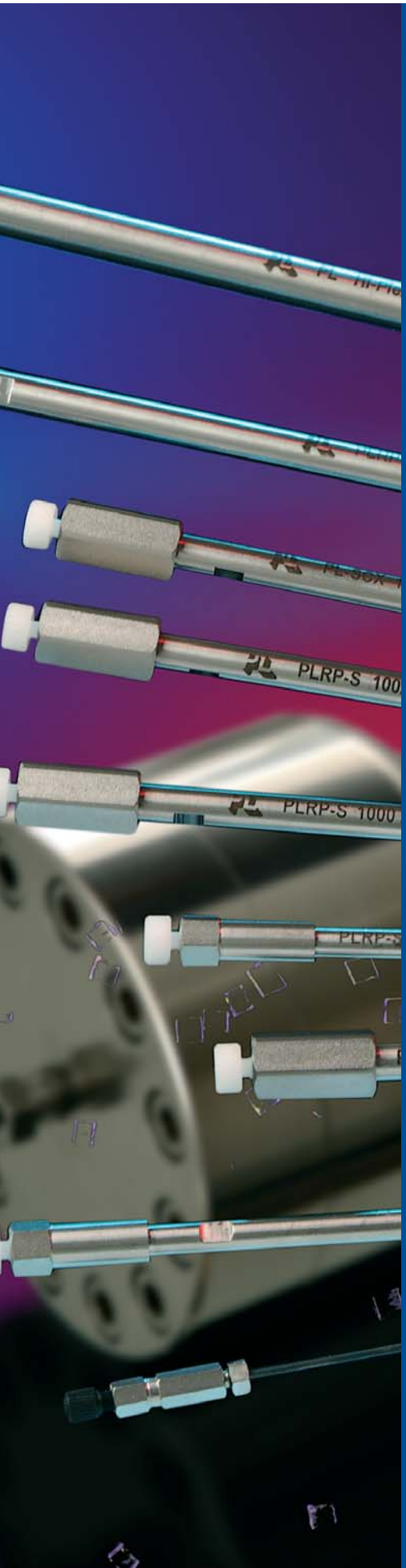


Courtesy of Dr G Bloomberg,
Department of Biochemistry, Medical School, University of Bristol, UK.

Specification

pH Range	1-14
Buffer Content	Unlimited
Organic Modifier	1-100%
Temperature (max)	200°C
Pressure (max) 5-8µm:	3000psi/210 bar
Pressure (max) 3µm:	4000psi/300 bar

PLRP-S Columns for Small Molecule Analysis



PLRP-S Columns are designed for the high performance analysis of small molecules.

PLRP-S Columns for Small Molecule Analysis

PLRP-S columns are ideally suited for the analysis of many small molecules. The 100Å pore size has an exceptionally high surface area which is accessible to the solutes. It is more retentive for small molecules than the majority of alkyl bonded silicas.

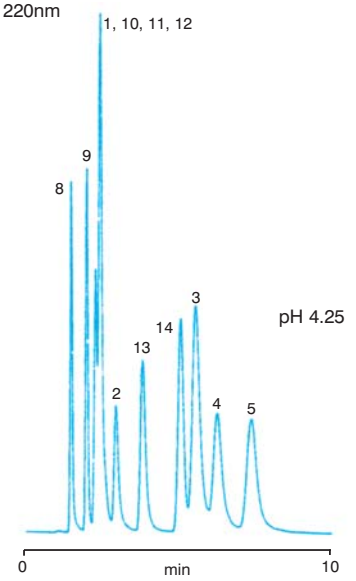
Higher Retentivity

PLRP-S media possesses a much greater surface area than alkyl bonded silicas and therefore even polar molecules such as carboxylic acids may be retained much longer, resulting in greater resolution.

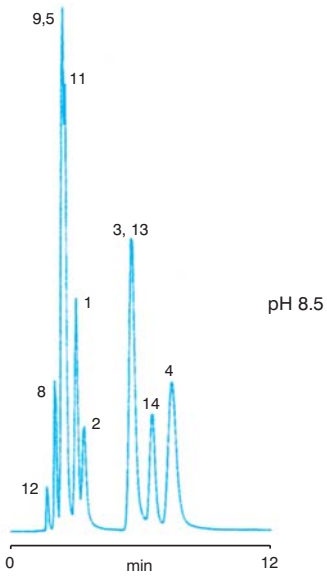
The separation can be further enhanced by the use of ion pairing agents.

Nucleosides and Bases

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 99% Ammonium formate : 1% ACN
Flow Rate: 1.0ml/min
Detector: UV, 220nm



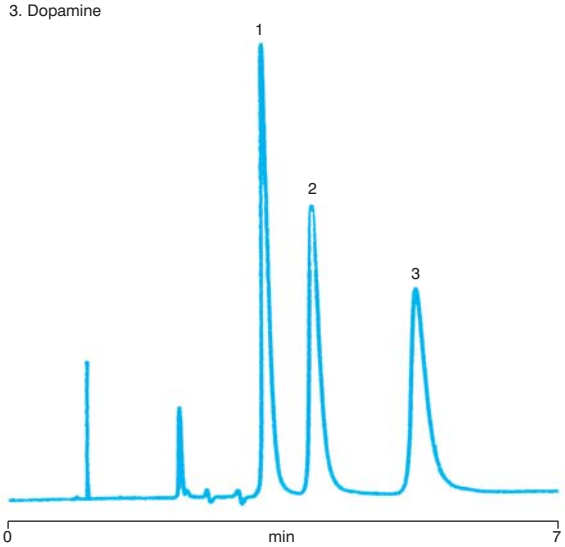
KEY
1. Cytidine
2. Uridine
3. Inosine
4. Guanosine
5. Xanthosine
8. Cytosine
9. Uracil
10. Guanine
11. Hypoxanthine
12. Xanthine
13. Adenine
14. Thymine



Catecholamines

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 95% 25mM Citric acid, 25mM Na_2HPO_4,
1mM Heptane Sulfonic acid : 5% ACN, pH 2.85
Flow Rate: 1.0ml/min
Detector: UV, 280nm

KEY
1. Noradrenaline
2. Adrenaline
3. Dopamine



Small Molecules can be analysed by:

- Isocratic Elution
- Gradient Elution
- Ion Suppression Chromatography
- Ion Pairing Chromatography

PLRP-S offers almost limitless operating boundaries for HPLC.

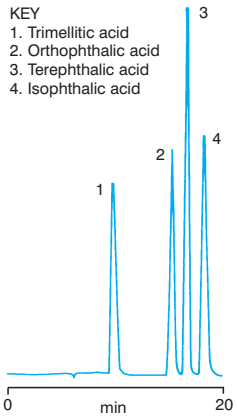
PLRP-S Columns for Small Molecule Analysis - Chemicals

Aromatic Carboxylic Acids

PLRP-S columns are particularly suitable for Ion Suppression Chromatography for the analysis of ionizable compounds, eg Organic acids. This separation was run using a pH of 2.0.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 80% 50mM Phosphoric acid : 20% ACN, pH 2.0
Flow Rate: 0.5ml/min
Detector: UV, 229nm

KEY
1. Trimellitic acid
2. Orthophthalic acid
3. Terephthalic acid
4. Isophthalic acid

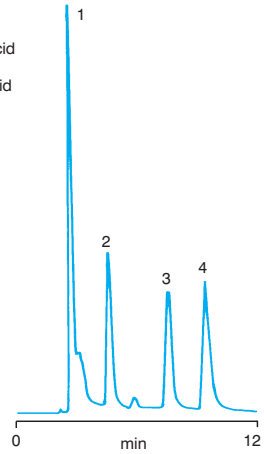


Aliphatic Carboxylic Acids

For acidic compounds, the mobile phase pH can be adjusted below the pKa of the solutes, suppressing ionization to selectively increase retention.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 30mM Perchloric acid, pH 2.6
Flow Rate: 0.5ml/min
Detector: RI

KEY
1. Oxalic acid
2. DL-Malic acid
3. Citric acid
4. Fumaric acid

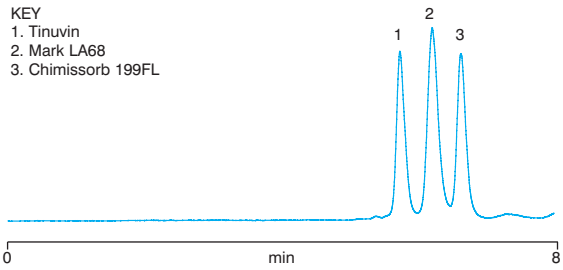


Antioxidants and Stabilizers

Molecules which act as free radical scavengers are used to stabilize plastics and polymer products. It is possible to quantify the amount of these compounds after extraction with a suitable solvent. Baseline separation of three such compounds is shown below.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 10% Water : 90% THF
Flow Rate: 0.5ml/min
Detector: PL-ELS 2100
(neb=30°C, evap=70°C, gas=1.4 SLM)

KEY
1. Tinuvin
2. Mark LA68
3. Chimissorb 199FL

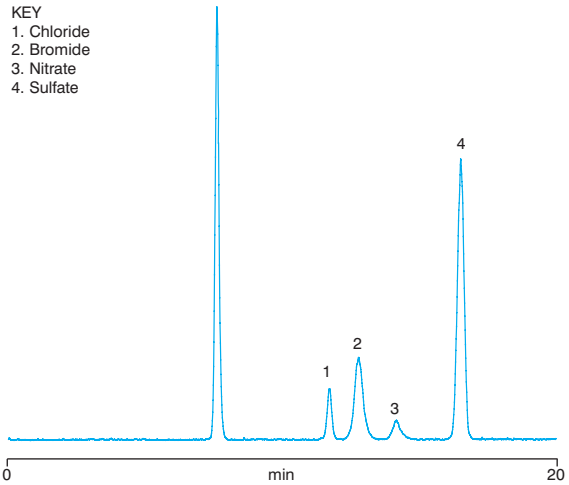


Dynamic Ion Exchange Chromatography

The PLRP-S 100Å material is hydrophobic and has a high surface area, making it ideal for separations using mobile phase additives. This separation shows the analysis of four common inorganic anions achieved using the additives pentylamine and formic acid. These volatile modifiers were used so that detection could be accomplished using an evaporative light scattering detector, the PL-ELS 1000, which gives an exceptionally stable baseline.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 98% 10mM Pentylamine, 10mM Formic acid : 2% ACN
Flow Rate: 0.4ml/min
Detector: PL-ELS 1000 (neb=90°C, evap=100°C, gas=1.0 SLM)

KEY
1. Chloride
2. Bromide
3. Nitrate
4. Sulfate



PLRP-S Columns for Small Molecule Analysis - Medical/Pharmaceutical

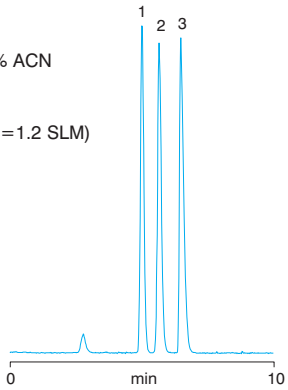
Analgesics

Aspirin was a widely used analgesic which had largely been superseded by other more effective treatments. It has found renewed interest due to its blood-thinning properties and implications in reducing the risk of heart attack or thrombosis.

Aspirin is the acetyl derivative of salicylic acid. Phenacetin, a second analgesic, is often incorporated in aspirin-based preparations, but has a much stronger UV absorbance. This leads to detection and resolution difficulties of these three compounds when using a UV detector. The PL-ELS 2100 evaporative light scattering detector eliminates this problem as the phenacetin peak is no longer grossly exaggerated.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 0.1% TFA in 50% Water : 50% ACN
Flow Rate: 0.5ml/min
Detector: PL-ELS 2100 (neb=40°C, evap=80°C, gas=1.2 SLM)

KEY
1. Acetylsalicylic acid (aspirin)
2. Acetophenetidin (phenacetin)
3. Salicylic acid

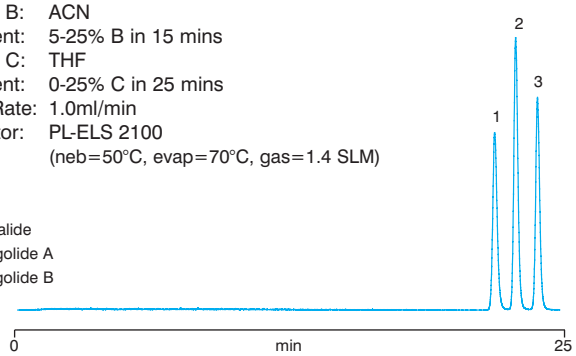


Active Components from *Ginkgo biloba* Leaves

Infusions and extracts from the leaves of the *Ginkgo biloba* tree are important phytopharmaceuticals. The amount of active components in such preparations may vary due to changes in the content of the extract. A reversed phase HPLC method has been developed to quantify the bilobalide and ginkgolides A and B using the PLRP-S 100Å column and the PL-ELS 1000 evaporative light scattering detector.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: Water
Eluent B: ACN
Gradient: 5-25% B in 15 mins
Eluent C: THF
Gradient: 0-25% C in 25 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 2100 (neb=50°C, evap=70°C, gas=1.4 SLM)

KEY
1. Bilobalide
2. Ginkgolide A
3. Ginkgolide B

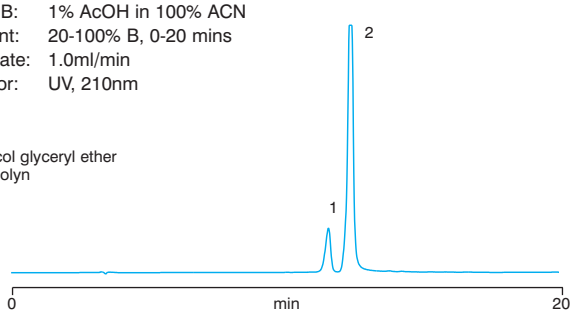


Anti-Asthmatic Drug

Cromolyn is an anti-asthmatic drug which is normally administered through an inhaler. The quality control procedures require quantification using an internal reference standard. Resolution between the chosen reference material and the drug itself has been found to be a problem with alkyl-bonded silica columns, yet baseline resolution is achieved with the PLRP-S reversed phase material.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 1% AcOH in 99% Water : 1% ACN
Eluent B: 1% AcOH in 100% ACN
Gradient: 20-100% B, 0-20 mins
Flow Rate: 1.0ml/min
Detector: UV, 210nm

KEY
1. Guaicol glyceryl ether
2. Cromolyn



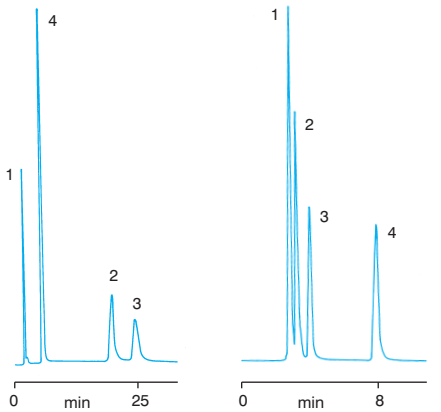
Sulfa Drugs

The wide pH operating range of PLRP-S columns can be utilized for the analysis of acidic compounds, where the mobile phase pH can be adjusted below the pKa of the solutes, suppressing ionization to selectively increase retention.

The solute retention order can also be changed, as in the separation below. At pH 2.2, the sulfa drugs, 2 and 3 below, are not ionized and therefore are retained, however, at pH 9.3, they become fully ionized and retention is reduced. The chemical stability of the PLRP-S media allows routine operation at elevated pH without a reduction in column lifetime.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Flow Rate: 1.0ml/min
Detector: UV, 254nm

KEY
1. Sulfanilic acid
2. Sulfadiazine
3. Sulfamethazine
4. Sulfanilamide



Eluent: Potassium sulfate: ACN 7:1, pH 2.2

Eluent: Disodium tetraborate: ACN 6:1, pH 9.3

PLRP-S Columns for Small Molecule Analysis - Medical/Pharmaceutical

Tryptophan Metabolites

Tryptophan metabolism is of significant biological importance, since altered levels have been seen in patients suffering from a range of disorders, including depression, schizophrenia, Downs Syndrome and alcoholism.* The major and minor routes of tryptophan catabolism lead to a wide range of related compounds which may be acidic, basic or zwitterionic.

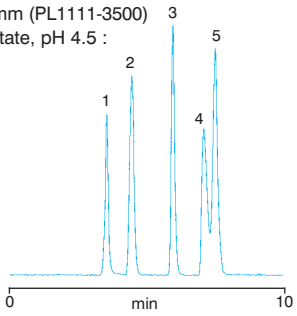
The use of polymeric reversed phase columns, PLRP-S 100Å, offers a difference in selectivity compared to conventional alkyl-bonded silica columns. The absence of residual silanols eliminates potential band broadening of basic components.

Using a PLRP-S column in conjunction with PL's evaporative light scattering detectors, all of the compounds may be analysed without the need for derivatization and with similar response factors - leading to easier, reliable quantification.

*A M Krstuulovic, M J Friedman, H Colin, G Guiochon, M Gasper and K A Pajer, J. Chrom., 297, (1984), 271-281.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 93% 40mM Ammonium acetate, pH 4.5 : 7% ACN
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=85°C, evap=90°C, gas=1.0 SLM)

KEY
1. Quinolinic Acid
2. 3-Hydroxykynurenine
3. Kynurenine
4. Kynurenic Acid
5. Tryptophan

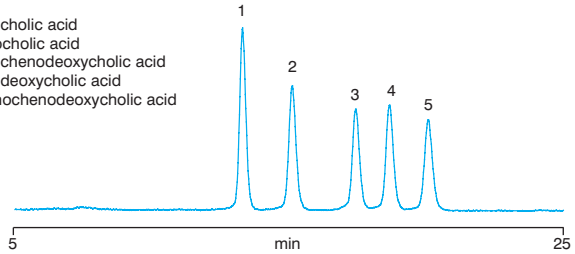


Bile Acid Analysis

Physiologically important steroids include the bile acids which are derivatives of cholesterol. They present a challenge to the chromatographer as they contain both polar and non polar regions and do not have a strong UV chromophore. A gradient HPLC method has been developed which will resolve the conjugated bile acid salts.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A: 39% 58mM Ammonium acetate : 58% MeOH : 3% Isopropanol, pH 5.3
Eluent B: THF
Gradient: 0-15% B in 20 mins
Flow Rate: 0.5ml/min
Detector: PL-ELS 1000 (neb=85°C, evap=60°C, gas=1.0 SLM)

KEY
1. Taurocholic acid
2. Glycocholic acid
3. Taurochenodeoxycholic acid
4. Taurodeoxycholic acid
5. Glychochenodeoxycholic acid



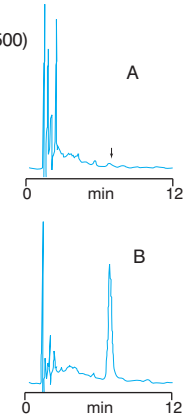
Morphine

Due to the problems of silica instability, use of an aqueous-alkaline eluent requires a pH resistant polymeric column. Using PLRP-S, the remarkable selectivity, efficiency and peak shape can be seen in this analysis. It has been reported* that this level of performance can still be achieved after more than one year of continuous daily use, demonstrating the durability of the PLRP-S polymeric column.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 85% 50mM, Na_2HP0_4 : 15% ACN, pH 9.5
Flow Rate: 1.0ml/min
Detector: Amperometric
Temp: 65°C

KEY
A. Extract of a control hair sample
B. Hair sample from an heroin addict, containing 0.5ng/mg (The arrow indicates morphine retention time).

* Ref: F Tagliaro et al, Chromatographia, 26 (1988), 163-167. Separation courtesy of Dr F Tagliaro et al, Institute of Forensic Medicine, University of Verona, Italy



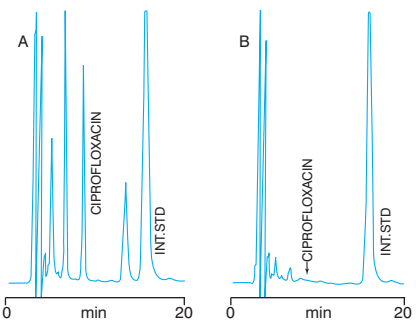
Analysis of Ciprofloxacin and Ciprofloxacin Metabolites

A PLRP-S 100Å column is ideal for the analysis of ciprofloxacin and three metabolites in body fluids. The higher retentivity of PLRP-S allows for the simple isocratic analysis of ciprofloxacin and its broad range of polar metabolites. Silica based columns do not have this range of retentivity with respect to less polar materials.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 74% 20mM TCA : 22% ACN : 4% MeOH adjusted to pH 3
Flow Rate: 1.0ml/min
Detector: UV, 277nm

KEY
A. Blank urine sample containing known concentrations of internal standard, ciprofloxacin and its metabolites

B. Blank urine sample containing only internal standard.



Reprinted from the Journal of Liquid Chromatography, 9(13), 1986, G J Kroll, A J Noe, D Beerman, *Liquid Chromatographic Analysis of Ciprofloxacin and Ciprofloxacin Metabolites in Body Fluids,* with permission from Marcel Dekker, Inc.

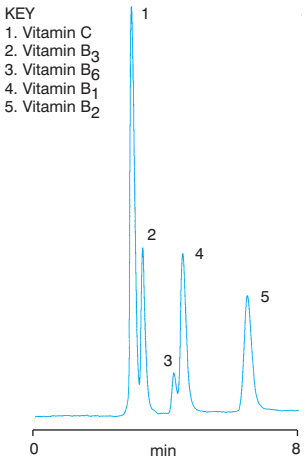
PLRP-S Columns for Small Molecule Analysis - Food

The versatility of the PLRP-S 100Å packing for polar and non-polar compounds is illustrated by the analysis of both water and fat soluble vitamins.

Water Soluble Vitamins

Low pH and a low percentage of organic modifier allow rapid isocratic separation of water soluble vitamins.

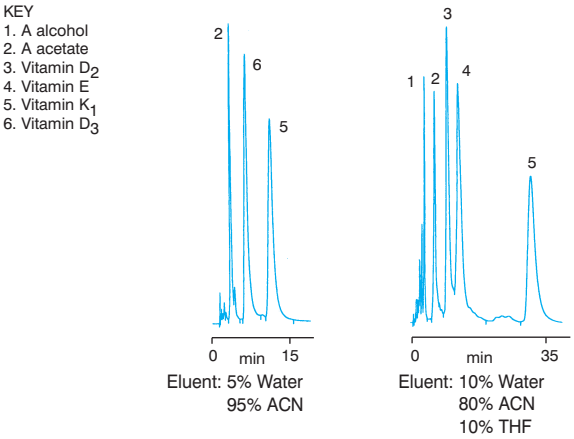
Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent: 89% 0.1M Perchloric acid : 11% ACN
Flow Rate: 0.5ml/min
Detector: UV, 254nm



Fat Soluble Vitamins

Fat soluble vitamins may also be separated isocratically. In this case, a high organic content is required in the eluent for solute solubility and elution.

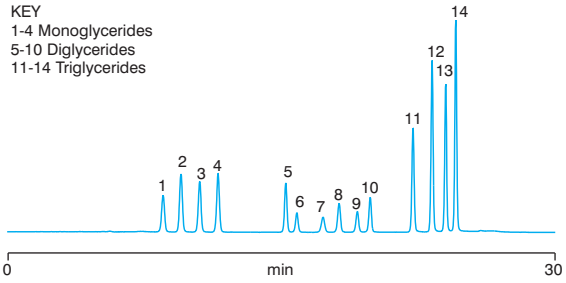
Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Flow Rate: 1.0ml/min
Detector: UV, 266nm



Acylglycerides

Triacylglycerides, or more commonly, triglycerides, are derived from glycerol with a fatty acid esterified to each hydroxyl group. Mono and diacylglycerides have one and two fatty acid esterified hydroxyl groups respectively. Fingerprinting of acylglycerides is required for many food products, and in particular fats and oils.

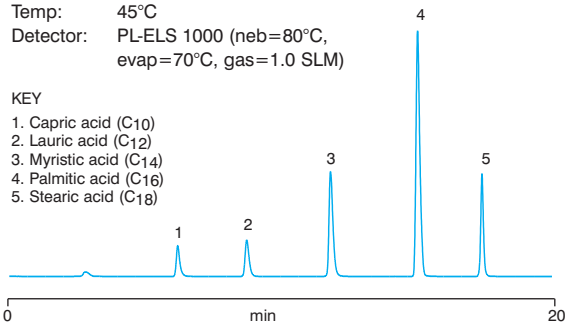
Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A: 42% Water : 10% MeOH : 48% THF
Eluent B: 5% Water : 10% MeOH : 85% THF
Gradient: 0-100% B in 20 mins
Flow Rate: 0.5ml/min
Detector: PL-ELS 1000 (neb=75°C, evap=65°C, gas=1.0 SLM)



Fatty Acid Analysis

Fatty acids are important building blocks for acylglycerides, lipids, phospholipids and sphingolipids. They are long chain hydrocarbons, 10 to 24, with terminal carboxylate groups. The hydrocarbon chain can contain one or more cis configuration double bond. Quantitation of fatty acids after hydrolysis is used for structural analysis and solute identification.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 60mM Acetic acid
Eluent B: ACN
Eluent C: THF
Gradient: 35:60:5 to 0:90:10 in 20 mins
Flow Rate: 0.5ml/min
Temp: 45°C
Detector: PL-ELS 1000 (neb=80°C, evap=70°C, gas=1.0 SLM)



PLRP-S Columns for Small Molecule Analysis - Food

Flavonoids

Research has shown that increased flavonoid consumption may help to reduce the risk of death by coronary heart disease.

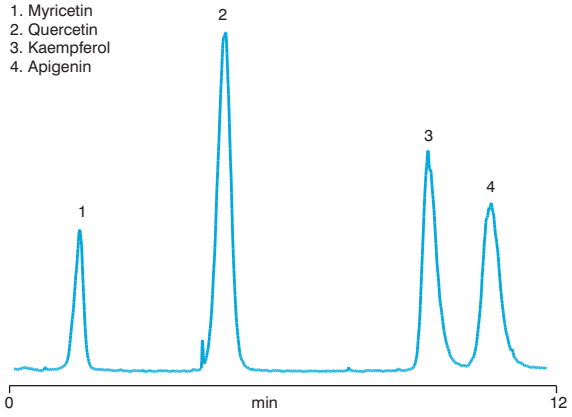
Flavonoids are receiving particular interest in their role as antioxidants. They are polyphenolic compounds, occuring naturally in a great many vegetables, fruit and beverages.

Quantification of flavonoid content of foodstuffs is complicated by the need to hydrolyse the flavonoid glycosides to the parent flavonoid.

PLRP-S polymeric reversed phase columns are particularly suited to the analysis of these types of compound by offering physical and chemical stability over the complete pH range. These features may be exploited by reducing the number of steps required to prepare a sample for analysis. Any strongly retained contaminants can be effectively removed by rigorous clean-up without detrimental effect on column lifetime.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A: 5mM Acetic acid
Eluent B: ACN
Gradient: 30-80% B in 20 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=80°C, evap=85°C, gas=1.0 SLM)

KEY
1. Myricetin
2. Quercetin
3. Kaempferol
4. Apigenin

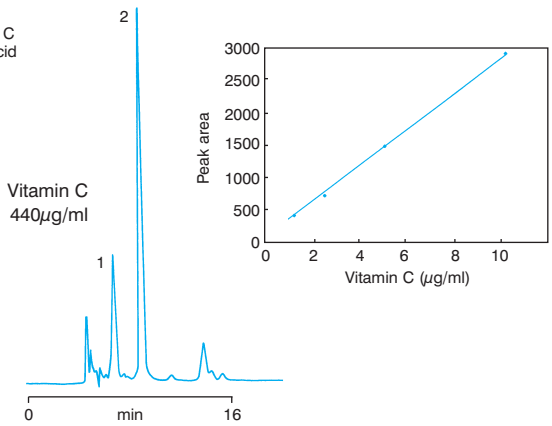


Quantification and Qualification of Vitamin C and Citric Acid in Fresh Grapefruit Juice

Utilizing low pH/high salt mobile phases allows quantitative determination of vitamins and citric acid levels in pure, concentrated and freshly extracted fruit juices without the need for tedious and time-consuming sample preparation.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 0.2M NaH_2PO_4, pH 2.14
Flow Rate: 0.5ml/min
Detector: UV, 220nm
Sample: Diluted 1:50 in eluent

KEY
1. Vitamin C
2. Citric acid

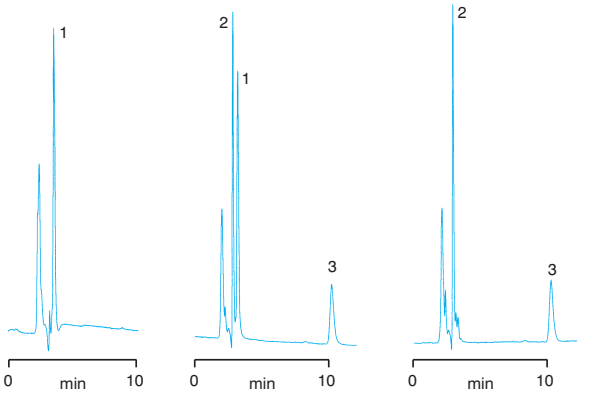


Carbonated Soft Drink Analysis

Often, simple isocratic conditions can be used for quantification of components in commercially available foods and drinks as routine QC/QA techniques.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent: 70% 15mM Phosphoric acid : 30% ACN
Flow Rate: 1.0ml/min
Detector: UV, 210nm

KEY
1. Caffeine
2. Aspartame
3. Benzoic acid



NEW PLRP-S Columns for High Resolution/High Speed Separations

The latest addition to the PLRP-S product range is a 3µm packing in 100Å and 300Å pore sizes, designed to address the area of high resolution/high speed separations.

PLRP-S 3µm is the ideal choice for a single column to operate across the entire range of HPLC eluents. It is chemically stable and physically robust, which means that it is possible to switch between organic modifiers such as methanol and tetrahydrofuran, and eluent pH, 0 to 14, on a single column.

The high performance PLRP-S 3µm materials are ideally suited to those applications which require a higher resolution than the 5µm particle offers but without an increase in analysis time, or where the 5µm equivalent resolution is required in a shorter analysis time. To address these two areas, the 3µm material is available packed in both 150mm and 50mm column lengths.

As with the other PLRP-S materials, the 3µm packing has the advantage of being completely polymeric, with no base particle to dissolve or fragment, and no bonded phase to strip. This ensures complete stability and robustness of performance. The stringent production process, documented by Polymer Laboratories' enhanced ISO 9001:2000 quality system, ensures reproducibility of product and maintenance of quality.

Typical Application Areas

100Å

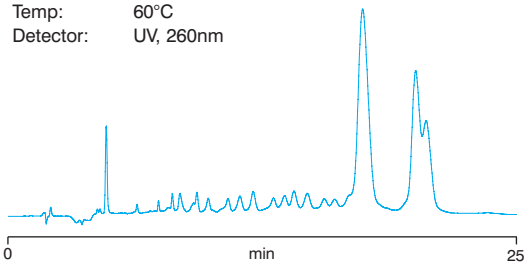
Peptides
Oligonucleotides
ADME Drug Discovery

300Å

Proteins
Larger Oligonucleotide Fragments

Bio-Pharmaceutical Oligonucleotide

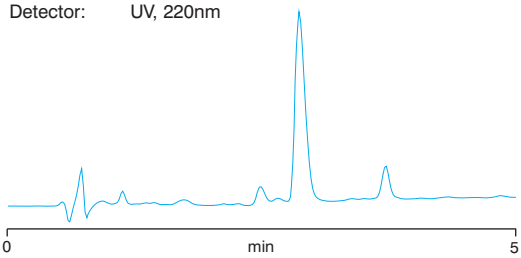
Column:	PLRP-S 100Å 3µm, 150x4.6mm (PL1512-3300)
Eluent A:	25mM TBuABr in 90% Water : 10% ACN
Eluent B:	25mM TBuABr in 10% Water : 90% ACN
Gradient:	0-60% B in 5 mins
	60-80% B in 20 mins
Flow Rate:	1.0ml/min
Temp:	60°C
Detector:	UV, 260nm



■ ***PLRP-S 3µm permits the high resolution analysis of a typical product from the synthesis of a 20mer, showing the separation of the trityl-on/trityl-off oligomer and failure sequences***

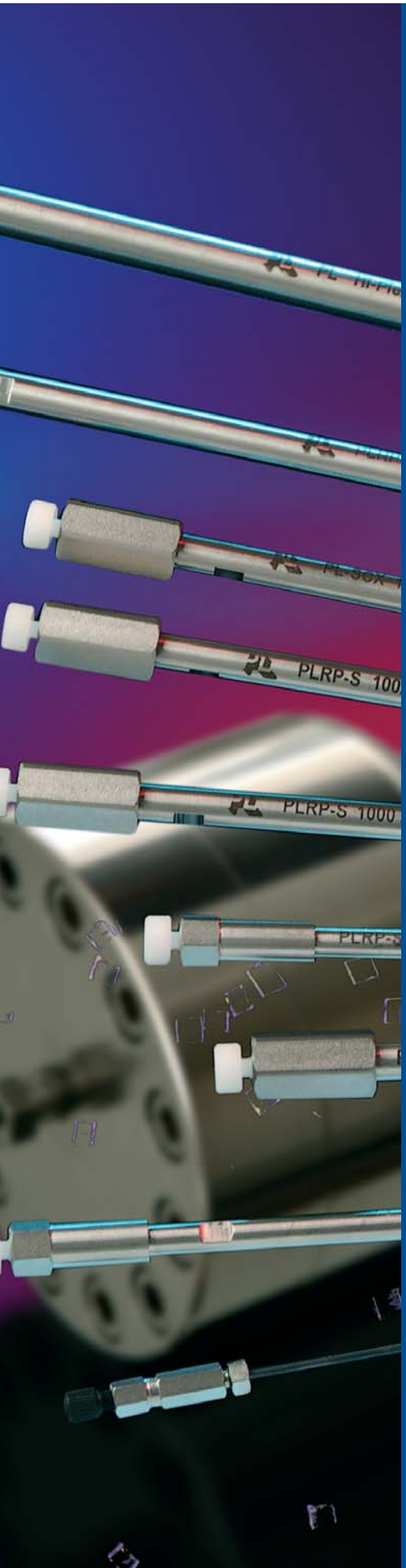
Synthetic Peptide - High Speed Screening

Sample:	Ac-Lys-Tyr-Ala-Leu-Lys-Ala-Leu-Lys-Gly-Leu-Lys-acid
Column:	PLRP-S 100Å 3µm, 50x4.6mm (PL1512-1300)
Eluent A:	0.1% TFA in 99% Water : 1% ACN
Eluent B:	0.1% TFA in 50% Water : 50% ACN
Gradient:	40-80% B in 5 mins
Flow Rate:	1.0ml/min
Detector:	UV, 220nm



■ ***Use of a 50mm length PLRP-S 100Å 3µm column permits the rapid analysis of a synthetic peptide using a 5 minute gradient***

PLRP-S Columns for Synthetic Oligomer/Polymer Analysis



PLRP-S columns can be used for synthetic oligomer analysis by reversed phase HPLC (RPHPLC) and polymer type separations by gradient polymer elution chromatography (GPEC).

PLRP-S Columns for Synthetic Oligomer/Polymer Analysis

Traditionally, molecular size information has been obtained using GPC which utilizes an isocratic system with RI detection. However, GPC provides insufficient resolution for the quantitation of individual oligomers. An alternative approach is to use reversed phase HPLC, where elution order is determined by relative hydrophobicity. For an homologous series this correlates with degree of polymerization – the longer the oligomer, the longer the retention time.

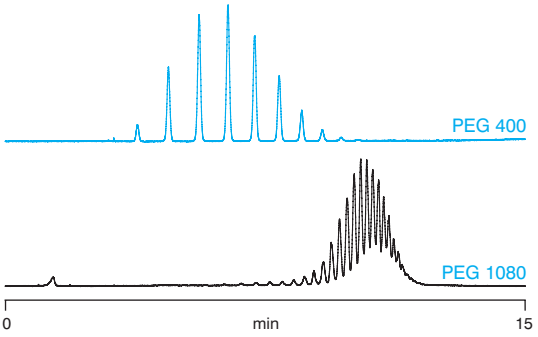
PLRP-S 100Å : Pore size is suitable for the analysis of small neutral oligomers without restricted diffusion.

Polyethylene Glycols

Polyethylene glycols (PEGs) are low molecular weight polymers widely used as excipients or drug delivery agents in the pharmaceutical industry, and as additives in cosmetics and home care products. Oligomeric separation of low molecular weight PEGs by gradient reversed phase HPLC is widely used to verify the composition of the polymer. However, PEG has no UV chromophore and is not suitable for UV detection and, as gradient elution is required, RI detection is not a viable alternative.

Using the highly retentive PLRP-S 100Å material with the PL-ELS 2100 evaporative light scattering detector and gradient elution, baseline resolution of the individual oligomers is achieved.

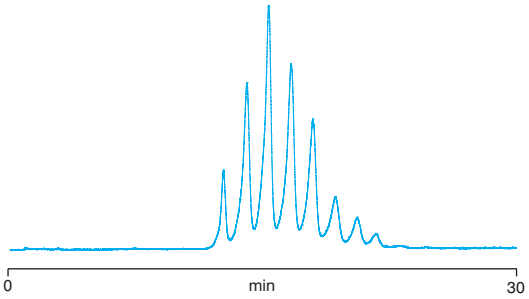
Column:	PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A:	Water
Eluent B:	ACN
Gradient:	10-30% B in 12 mins held at 30% B for 3 mins
Flow Rate:	1.0ml/min
Inj Vol:	10µl
Sample Conc:	1mg/ml
Detector:	PL-ELS 2100 (neb=50°C, evap=70°C, gas=1.6 SLM)



Polystyrene Oligomers

Polystyrene is hydrophobic and is therefore not soluble in water. Using the high surface area PLRP-S 100Å material, reversed phase HPLC can be used to obtain an oligomeric profile with THF as the organic modifier. Baseline drift, which would be observed with a UV detector due to changes in absorbance of the eluent gradient, is eliminated by using the PL-ELS 1000 detector.

Sample:	PS 580
Column:	PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A:	Water
Eluent B:	THF
Gradient:	65-85% B in 40 mins
Flow Rate:	0.5ml/min
Detector:	PL-ELS 1000 (neb=60°C, evap=85°C, gas=0.8 SLM)



PLRP-S Columns for Synthetic Oligomer/Polymer Analysis

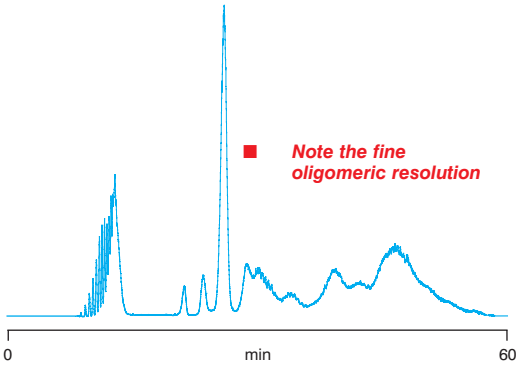
Surfactants

Surfactants are complex mixtures of molecules, often with no UV chromophore, with a wide range of hydrophobicities. The PLRP-S material is suited to this type of analysis as it can be used over a wide range of organic modifier compositions and with one or more organic modifiers.

Tween 20®

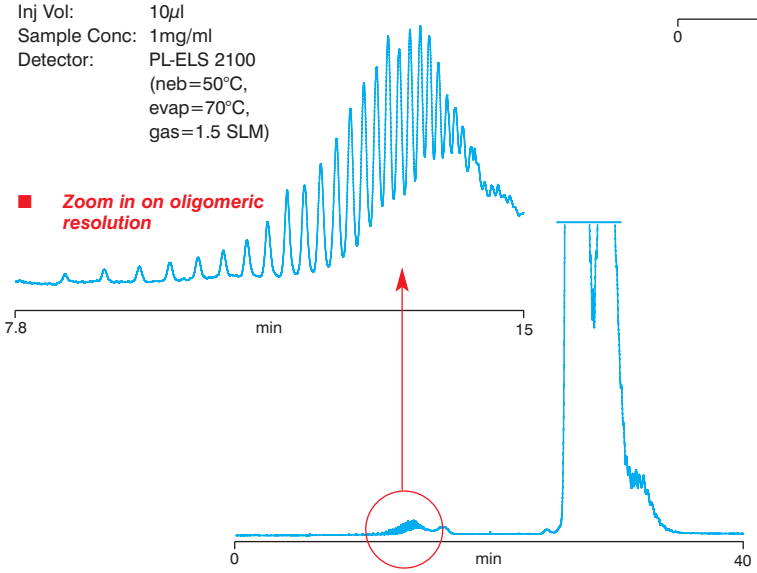
In the separation of the surfactant Tween 20, also known generically as Polysorbate 20, the absence of a usable UV chromophore and the requirement for gradient elution mean that neither RI nor UV detection can be used for HPLC separation.

Column:	PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A:	Water
Eluent B:	ACN
Gradient:	10-100% B in 45 mins hold at 100% B for 10 mins 100% B-100% C in 5 mins
Flow Rate:	1.0ml/min
Inj Vol:	10µl
Sample Conc:	1mg/ml
Detector:	PL-ELS 2100 (neb=50°C, evap=50°C, gas=1.6 SLM)



Brij 35®

Column:	PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A:	Water
Eluent B:	ACN
Gradient:	0-100% B in 40 mins
Flow Rate:	0.8ml/min
Inj Vol:	10µl
Sample Conc:	1mg/ml
Detector:	PL-ELS 2100 (neb=50°C, evap=70°C, gas=1.5 SLM)

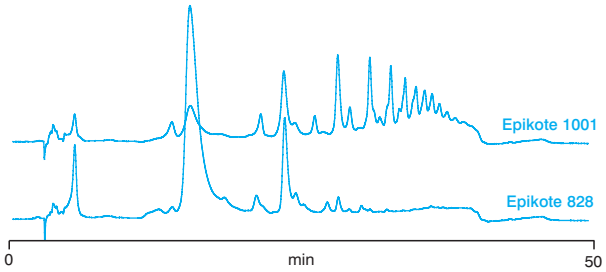


Where samples contain larger oligomers or polymeric material it is necessary to use a larger pore size media to prevent peak broadening occuring due to restricted solute diffusion.

Epoxy Resin Analysis

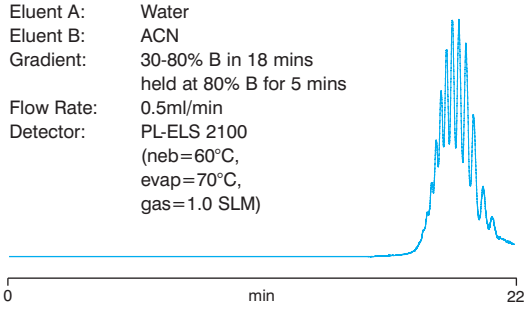
Oligomeric fingerprints of epoxy resins can be obtained using reversed phase HPLC with the PLRP-S 300Å material. The fingerprints of Epikote 1001 and 826 are compared below.

Column:	PLRP-S 300Å 8µm, 250x4.6mm (PL1512-5801)
Eluent A:	Water
Eluent B:	90% ACN : 10% THF
Gradient:	Stepped gradient B 55% to 98%
Detector:	UV, 254nm



Triton™ X

Column:	PLRP-S 100Å 3µm, 150x4.6mm (PL1512-3300)
Eluent A:	Water
Eluent B:	ACN
Gradient:	30-80% B in 18 mins held at 80% B for 5 mins
Flow Rate:	0.5ml/min
Detector:	PL-ELS 2100 (neb=60°C, evap=70°C, gas=1.0 SLM)

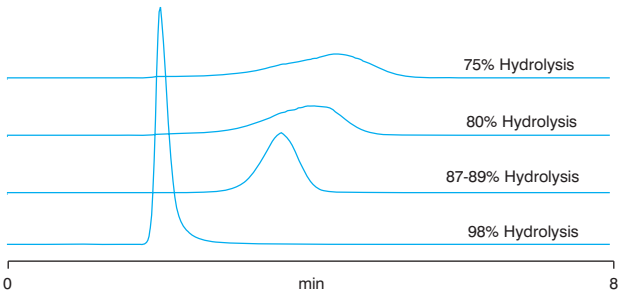


PLRP-S Columns for Polymer Compositional Analysis

Chemical Composition

Copolymer systems exhibit molecular weight and chemical composition heterogeneity which can be investigated by GPC/SEC and reversed phase, either independently or as a coupled column, orthogonal, chromatographic technique. The example illustrates four poly(vinyl alcohol) samples with different degrees of hydrolysis from the parent poly(vinyl acetate) separated by reversed phase using the very large pore PLRP-S 4000Å. The 4000Å pore size provides maximum permeation and interaction of the polymer molecules with the packing, with minimal size exclusion characteristics. This ensures the separation is based only on chemical type and is not a combination of chemical type and solution size.

Column: PLRP-S 4000Å 8µm, 50x4.6mm (PL1512-1803)
Eluent A: 99% Water : 1% THF
Eluent B: THF
Gradient: 0-70% B in 5 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=80°C, evap=85°C, gas=1.0 SLM)

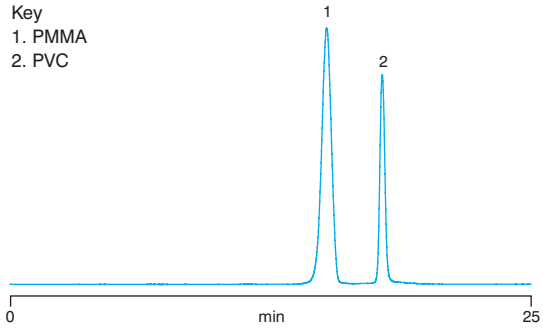


Polymer Chemical Type

Gradient polymer elution chromatography (GPEC) coupled to the PL-ELS 1000 has been developed for the characterization of polymers based on their chemical composition. In this separation of polyvinyl chloride (PVC) and polymethyl methacrylate (PMMA), a PLRP-S 100Å reversed phase column is used. The two polymers are dissolved in a good solvent before being injected into a water/tetrahydrofuran eluent – a poor solvent. As the percentage of THF is increased, the polymers will redissolve and PMMA and PVC will be separated.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A: Water
Eluent B: THF
Gradient: 40-100% B in 20 mins
Flow Rate: 0.5ml/min
Detector: PL-ELS 1000 (neb=85°C, evap=75°C, gas=1.0 SLM)

Key
1. PMMA
2. PVC

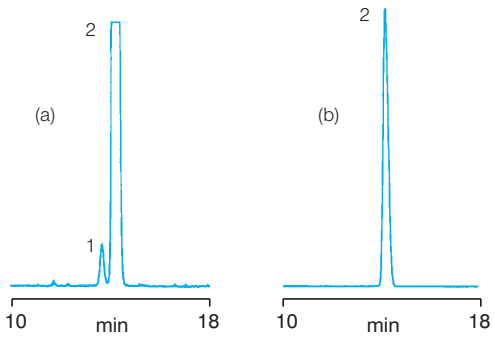


Polymer End Groups

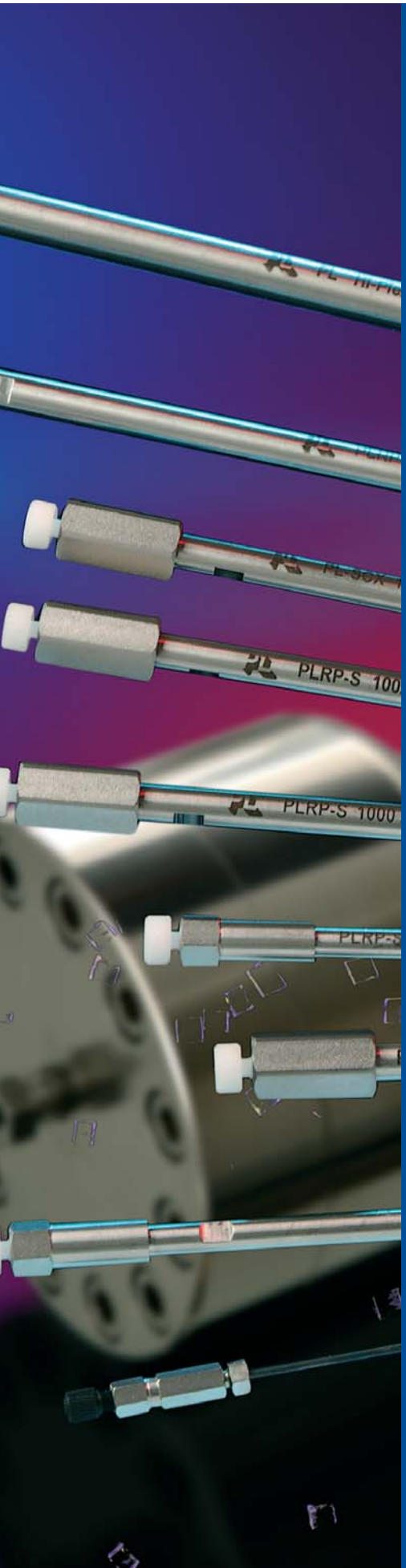
Monofunctional polyethylene oxides (PEO), which have a single terminal hydroxyl group, are used in the pharmaceutical industry. Reversed phase HPLC using the PLRP-S 300Å column can be used to resolve PEO samples with one or two terminal hydroxyl groups. The separations show the analysis of monofunctional PEO spiked with 5% of the difunctional polymer (a), and the absence of the difunctional polymer in pure monofunctional pharmaceutical grade PEO (b).

Column: PLRP-S 300Å 5µm, 150x4.6mm (PL1512-3501)
Eluent A: 99% Water : 1% ACN
Eluent B: ACN
Gradient: 30-50% B in 20 mins
Flow Rate: 0.5ml/min
Detector: PL-ELS 1000 (neb=80°C, evap=85°C, gas=1.0 SLM)

KEY
1. Difunctional PEO
2. Monofunctional PEO



PLRP-S Columns for Biomolecule Analysis



PLRP-S columns are ideally suited to biomolecule analysis. The range of pore sizes enables high capacity/high resolution separations from the smallest peptide to the largest protein.

PLRP-S Columns for Biomolecule Analysis

Reversed phase HPLC has become the method of choice for the analysis and purification of synthetic peptides and proteins. The PLRP-S materials, with a range of optimized pore sizes, are ideally suited to this application area. Accessibility and high permeability of the molecules to the internal surface of the porous particle give excellent selectivity and capacity. The high chemical and physical stability of polymeric PLRP-S columns enable reproducible resolution with greatly extended column lifetimes, for thousands of injections over years of use. The PLRP-S packing is completely insoluble, and will not contaminate isolated fractions with leachable bonded phase. The ability to operate over the entire pH range and virtually all mobile phase compositions enables greater selectivity and unrestricted clean-up procedures to be used.

PLRP-S Advantages

PLRP-S macroporous styrene/divinylbenzene media does not suffer from the same problems and limitations as silica based particles with bonded phases.

■ NO residual acidic silanol groups:

NO peak tailing/loss of resolution due to interaction with basic amino acid residues - lysine, arginine
NO ion pairing agent (eg TFA) needed to mask silanol interactions
NO loss of basic peptides/proteins due to non-specific interactions

■ NO stripping of hydrophobic bonded phase:

NO change in retention/selectivity as a function of column age
NO contamination of valuable peptide/protein with hydrophobic ligand

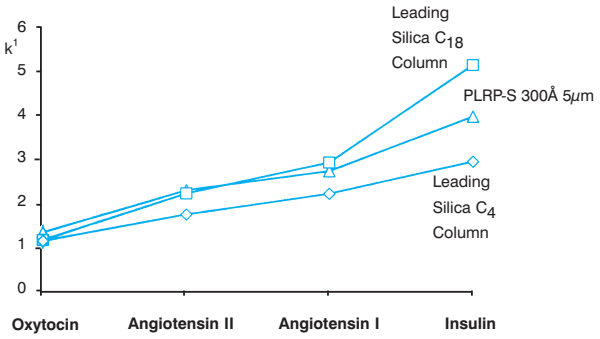
■ NO dissolution of base particle:

NO loss of column performance - voiding
NO contamination of valuable peptide/protein with silica

■ The underlying hydrophobic retention characteristics of the PLRP-S media are comparable to RP-Silica based packings. However, subtle differences due to the potential for additional pi-pi bond interactions can be utilized to further improve the resolution.

Gradient Elution of 4 Peptide Hormones

Columns: 250x4.6mm
Eluent A: 0.1% TFA in 80% Water : 20% ACN
Eluent B: 0.1% TFA in 50% Water : 50% ACN
Gradient: 0-100% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm



■ The observed absolute retention for four peptides on leading C_{18} and C_4 silica columns and PLRP-S indicates the similarity of the interaction. The retention characteristics of the PLRP-S column offer excellent performance over a wide range of peptides and proteins.

PLRP-S Columns for Biomolecule Analysis

Choice of Pore Size

A range of pore sizes is available in the PLRP-S product range to maximize selectivity and capacity across the whole molecular size range from di-, tri- peptides up to large proteins.

In order to maximize selectivity and capacity, the HPLC media requires the maximum available surface area, yet with sufficiently large pores so that access is not restricted.

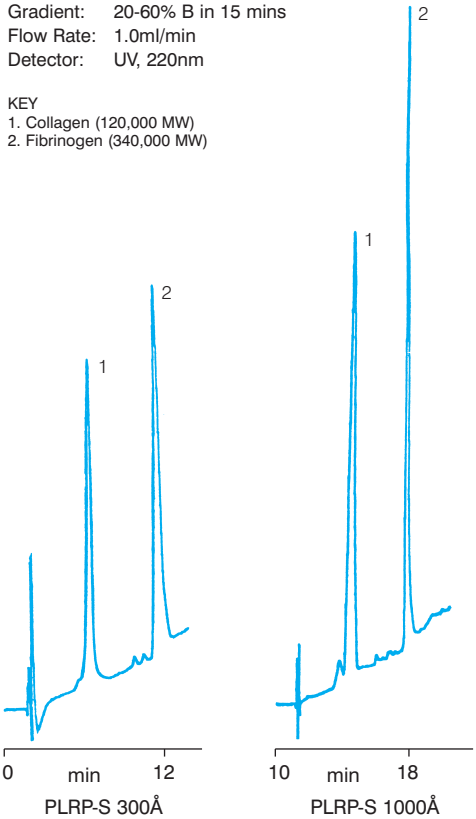
- The PLRP-S 100Å has the optimum pore size for the analysis of peptides and oligonucleotides.
- The PLRP-S 300Å is best suited to the analysis of polypeptide/globular proteins.
- The PLRP-S 1000Å is required for large fibrous proteins and large DNA/RNA oligomers.
- The PLRP-S 4000Å gigaporous material is designed for the analysis of very large biomolecules or for high speed/high resolution separations.

Large Fibrous Proteins

Improved peak shape and increased peak height are obtained with the larger pore PLRP-S 1000Å column.

Columns: PLRP-S 8µm, 150x4.6mm
Eluent A: 0.25% TFA in Water
Eluent B: 0.25% TFA in 5% Water : 95% ACN
Gradient: 20-60% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Collagen (120,000 MW)
2. Fibrinogen (340,000 MW)



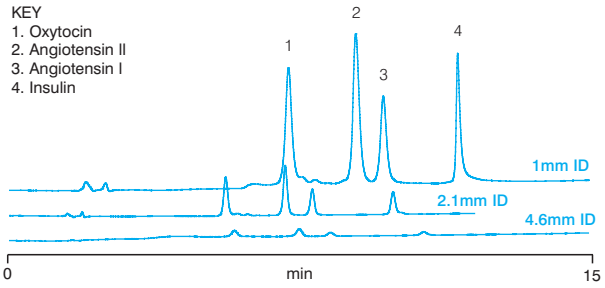
Choice of Column Size

- Analytical and Semi-Prep
- Range of Microbore

All the PLRP-S materials are sufficiently robust and mechanically stable to permit these to be packed into efficient capillary and microbore columns, 300µm and 1.0mm ID. The improvement in sensitivity which can be gained by using microbore columns compared to traditional 4.6mm analytical columns is clearly seen in the standard peptide separation.

Columns: PLRP-S 100Å 5µm, 150mm
Eluent A: 0.1% TFA in 80% Water : 20% ACN
Eluent B: 0.1% TFA in 50% Water : 50% ACN
Gradient: 0-100% B in 15 mins
Flow Rate: 4.6mm ID 1.0ml/min
2.1mm ID 200µl/min
1.0mm ID 47µl/min
Detector: UV

KEY
1. Oxytocin
2. Angiotensin II
3. Angiotensin I
4. Insulin



Preparative - Easy Scale-up

PLRP-S media is manufactured to the same specifications regardless of particle size. Separations developed on an analytical scale column can be transferred to a preparative scale column with minimal method re-development.

The ability of the media to withstand extremes of pH, thus allowing sanitization both on-column (clean in place or CIP), or on a batch basis, is a fundamental advantage for the PLRP-S materials. Ensuring that the media is free from bacterial or similar contamination will assist in validation, particularly under GMP or regulated procedures.

PLRP-S media is available in packed preparative HPLC columns in 25mm, 50mm and 100mm ID dimensions, and as loose media as detailed in pages 115-124.

The media offers exceptional loading capacity due to the high surface area, and the clean, purely hydrophobic surface functionality ensures a very high recovery.

PLRP-S Columns for Biomolecule Analysis - Peptides

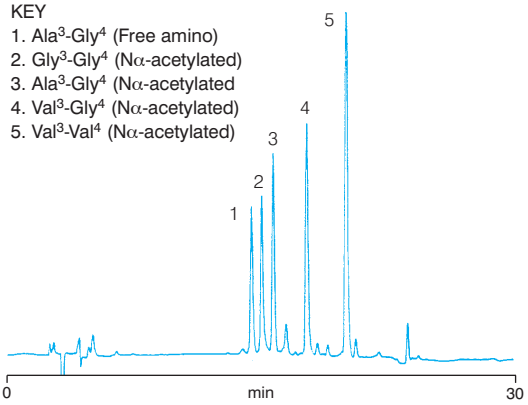
Reversed phase HPLC is routinely used for high resolution separations of peptides. The PLRP-S media, with its inherent hydrophobicity and unsurpassed chemical stability is ideal for such separations.

The mixture, RPS-P0010, produced by Alberta Peptide Institute, is designed to monitor reversed phase column performance. It contains 5 C-terminal amide decapeptides, 4 of which are Nα-acetylated and the fifth contains a free Nα-amino group.

The PLRP-S 100Å column resolves the five major peptides to baseline and also shows the presence of several minor components. The peaks are sharp and symmetrical.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 0.1% TFA in 99% Water : 1% ACN
Eluent B: 0.1% TFA in 70% Water : 30% ACN
Gradient: 0-100% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Ala^3-Gly^4 (Free amino)
2. Gly^3-Gly^4 (Nα-acetylated)
3. Ala^3-Gly^4 (Nα-acetylated
4. Val^3-Gly^4 (Nα-acetylated)
5. Val^3-Val^4 (Nα-acetylated)

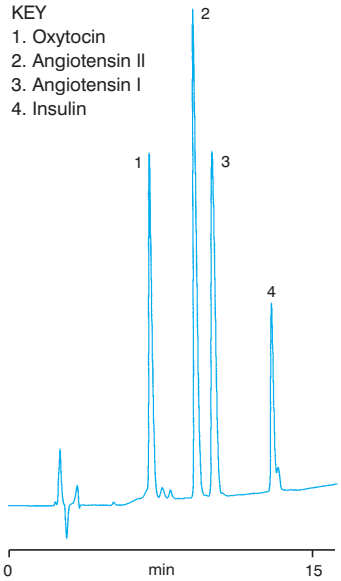


QC Separation of Peptide Standards

Very small proteins and peptides can be chromatographed on the 100Å pore size with significant advantages for loading capacity.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 0.1% TFA in 80% Water : 20% ACN
Eluent B: 0.1% TFA in 50% Water : 50% ACN
Gradient: 0-100% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Oxytocin
2. Angiotensin II
3. Angiotensin I
4. Insulin

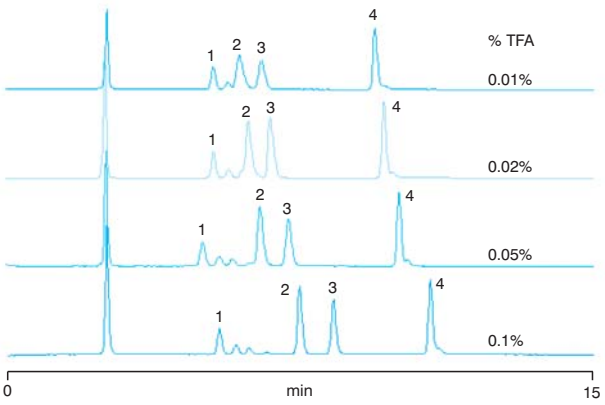


Low Levels of TFA

Peptide peaks are symmetrical, even with low levels of the ion pairing agent, TFA. There are no residual silanols on the surface of the PLRP-S which need to be masked to prevent peak tailing. Performing the analysis with low levels of TFA can be a significant advantage in LC/MS, as the presence of TFA will reduce the MS sensitivity.

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)
Eluent A: TFA (various %) in Water
Eluent B: TFA (various %) in ACN
Gradient: 20-50% B in 15 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 2100 (neb=85°C, evap=80°C, gas=1.0 SLM)

KEY
1. Oxytocin
2. Angiotensin II
3. Angiotensin I
4. Insulin



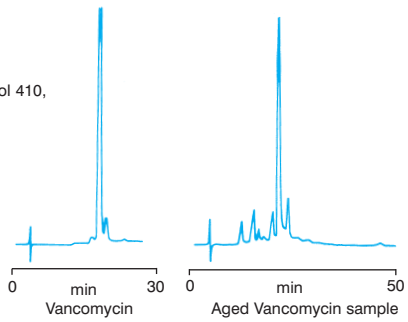
PLRP-S Columns for Biomolecule Analysis - Peptides

Glycopeptide Stability

Vancomycin is a bactericidal antibiotic. Reversed phase HPLC is ideal for measuring concentration levels, composition and stability of Vancomycin.

Column: PLRP-S 100Å 8µm, 150x4.6mm (PL1512-3800)
Eluent A: 92% 20mM Borate buffer : 8% ACN, pH 8.0
Eluent B: 84% 20mM Borate buffer : 16% ACN, pH 8.0
Gradient: 0-100% B in 17.5 mins
Flow Rate: 0.5ml/min
Detector: UV, 235nm

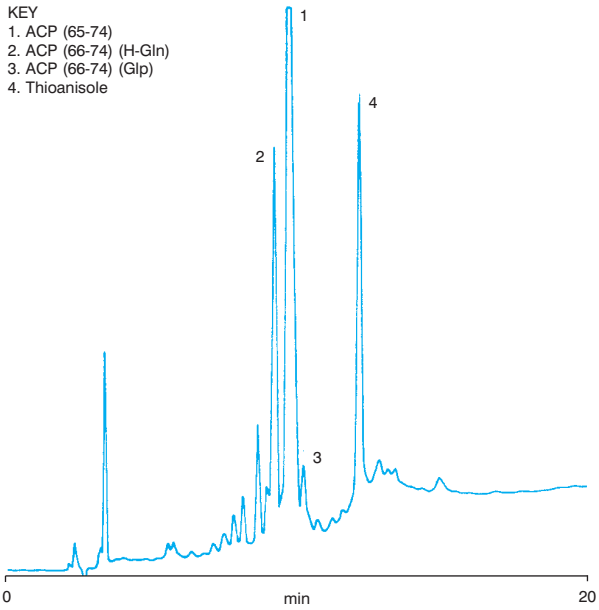
Reprinted from the Journal of Chromatography, Vol 410, A H Thomas and P Newland, *Chromatographic Methods for the Analysis of Vancomycin,* 1987, with permission from Elsevier Science.



Synthetic Peptide Purification

PLRP-S is ideal for the purification of synthetic peptides as it exhibits high selectivity for the peptide and truncated sequences. In the example below, peaks 2 and 3 are the truncated sequences due to incomplete coupling of valine, amino acid 65.

Sample: Synthetic acyl carrier protein (ACP) residues 65-74
Column: PLRP-S 100Å 8µm, 150x4.6mm (PL1512-3800)
Eluent A: 0.1% TFA in 99% Water : 1% ACN
Eluent B: 0.1% TFA in 1% Water : 99% ACN
Gradient: 10-60% B in 20 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm



Peptides carry a charge, the type and magnitude of which is dependent on the eluent pH.

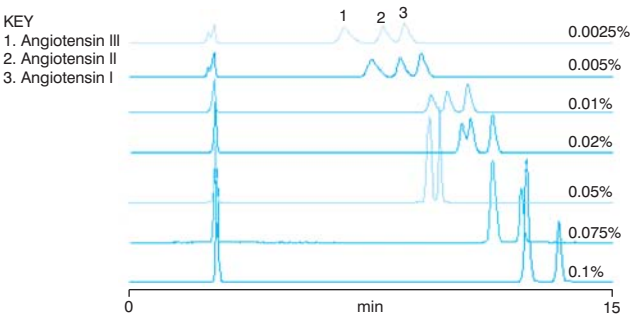
Optimization of the separation through pH control of the eluent is feasible due to the chemical stability of the PLRP-S material, across pH 1-14.

The separation of angiotensin I, II and III can be achieved by decreasing the concentration of TFA in the eluent, while improved peak shapes are observed if alkaline pH is used, >pH 10. This is due to the additional C-terminal aspartyl residue of angiotensin II, which has an acidic side chain and is ionized at pH 10.

Exploiting Chemical Stability

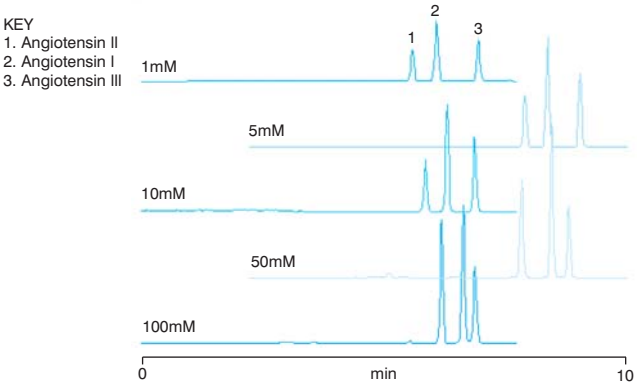
TFA Concentration

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: TFA (various %) in Water
Eluent B: TFA (various %) in ACN
Gradient: Linear 12-40% B in 15 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=75°C, evap=85°C, gas=1.0 SLM)



Ammonium Hydroxide Concentration

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: NH_4OH (various mM) in Water
Eluent B: NH_4OH (various mM) in ACN
Gradient: Linear 10-100% B in 15 mins
Flow Rate: 1.0ml/min
Detector: PL-ELS 1000 (neb=80°C, evap=85°C, gas=1.0 SLM)



PLRP-S columns can be continuously operated at high pH without having a detrimental effect on column lifetime/performance, unlike silica based columns.

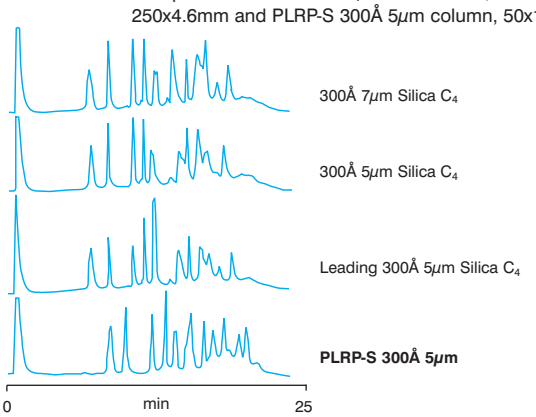
PLRP-S Columns for Biomolecule Analysis - Proteins

Indicator Test Proteins

The retention of the PLRP-S 300Å media for many proteins is only slightly greater than a Silica C_4, as illustrated below. The following extract from a detailed independent study confirms many of the virtues of PLRP-S.

Polymeric packings are recognized as being superior in terms of resolution, sample recovery and minimization of 'ghosting'. In this comparison*, polymeric supports such as the 300Å 5µm PLRP-S packing...offered clear advantages in terms of reduced tailing and improved recoveries, as well as significantly increased column stability over a much wider range of operating conditions.

Columns: Comparison of 3 x 300Å C_4 silica columns, 250x4.6mm and PLRP-S 300Å 5µm column, 50x1.0mm



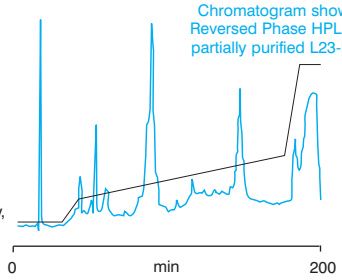
Reprinted from the Journal of Chromatography, Vol 443, W G Burton, K D Nugent, T K Slattery, B R Summers and L R Snyder, **Separations of Proteins by Reversed-Phase High-Performance Liquid Chromatography, 1. Optimizing The Column*, 1988, with permission from Elsevier Science.

Ribosomal Proteins

Ribosomes comprise of RNA and protein, and occur in the cytoplasma of all cells. In this analysis, two crosslinked protein pairs consisting of L23-L29 and L3-L19 proteins are resolved.

In a comparison* between polymeric and silica columns, polymeric PLRP-S columns were found to yield the highest purity in the purification of the crosslinked protein pair L23-L29. For the protein pair L3-L19, size exclusion and re-chromatography on PLRP-S columns was found to be the most suitable.

Column: PLRP-S 300Å 10µm, 300x7.5mm
Eluent A: 0.1% TFA in 85% Water : 15% ACN
Eluent B: 0.1% TFA in 20% Water : 80% ACN
Gradient: 0 mins 10% B, 30 mins 10% B, 40 mins 20% B, 175 mins 40% B, 185 mins 80% B, 195 mins 80% B, 200 mins 50% B
Flow Rate: 0.5ml/min
Detector: UV, 220nm



Chromatogram showing Reversed Phase HPLC of partially purified L23-L29.

*Extracted from Preparation and Comparison of RP-HPLC of Crosslinked Ribosomal Protein Pairs by Chromatography on PLRP-S and Vydac-Columns, S Herwig, Max-Planck-Institut für Molekulare Genetik, Berlin, Germany, Chromatographia, 30, No. 11/12, 1990, 696 - 702.

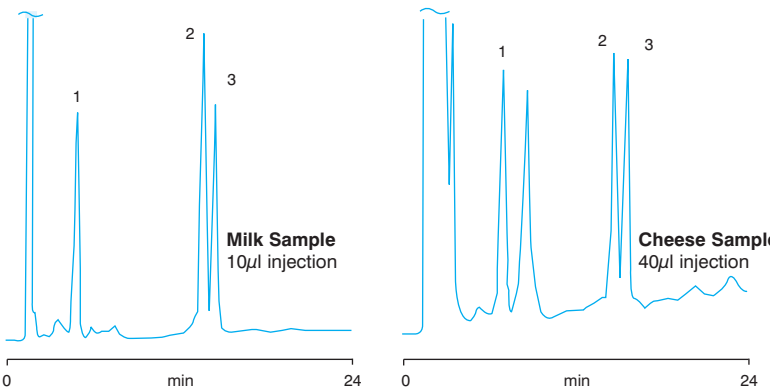
Whey Proteins in Dairy Products

The major whey protein in cows' milk is ß-lactoglobulin, although it is absent in many other animals.
The PLRP-S 300Å 8µm, 150x4.6mm column is able to successfully separate the A and B chains from each other and from other proteins such as α-lactalbumin, and is used for the recommended method:

Method: International Milk Federation, Brussels, 178, 1996

Column: PLRP-S 300Å 8µm, 150x4.6mm (PL1512-3801)
Eluent A: 0.1% TFA in 99% Water : 1% ACN
Eluent B: 0.1% TFA in 1% Water : 99% ACN
Gradient: 36-48% B, 0-24 mins; 48-100% B, 24-30 mins; 100% B, 30-35 mins; 100-36% B, 35-40 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

Peak Identification
1. α-Lactalbumin
2. ß-Lactoglobulin (B chain)
3. ß-Lactoglobulin (A chain)

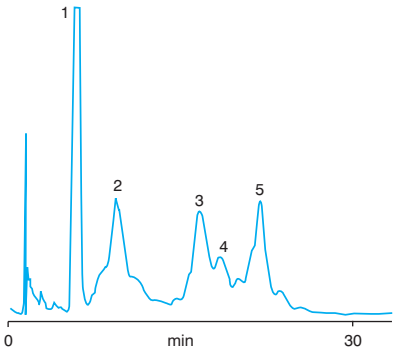


Haemoglobin Fingerprinting

Polymeric reversed phase chromatography in denaturing conditions is ideal for the analysis of haemoglobin. Haemoglobin chains will dissociate, enabling reversed phase chromatography to identify abnormal haemoglobin traits.

Column: PLRP-S 300Å 5µm, 50x4.6mm (PL1512-1501)
Eluent A: 0.1% TFA in 95% Water : 5% ACN
Eluent B: 0.1% TFA in 5% Water : 95% ACN
Gradient: Linear 31-48% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 280nm

KEY
1. heme
2. ß
3. α
4. G_δ
5. A_δ



Oligonucleotides

PLRP-S columns are ideal for oligonucleotide analysis due to their chemical and thermal stability and excellent selectivity. PLRP-S columns can be used for either trityl on/trityl off separations prior to deprotection of the oligonucleotides, and for ion pairing separations of the deprotected oligos.

Ion Pair Chromatography

For dynamic ion pair chromatography, the small particle size, high performance PLRP-S materials provide high surface area and exceptional resolution.

For small oligonucleotides, typically 20-30 mer, the PLRP-S 100Å material has the optimum pore size to give maximum surface area without restriction to mass transfer. Increasing the pore size decreases the available surface area and hence capacity; increasing the temperature increases the capacity when TBuABr is used as the ion pairing agent.

Oligonucleotide Capacity (mg/ml packed bed) Effect of Pore Size when TBuABr is used as the Ion Pairing Agent

Eluent	Column			
	PLRP-S 100Å	PLRP-S 300Å	PLRP-S 1000Å	PLRP-S 4000Å
TBuABr				
Ambient	63	46	29	11
60°C	72	54	34	11

Choice of Ion Pairing Agent

Although TBuABr provides high capacity when used as the ion pairing agent, resolution is improved further when TEAA is used as the eluent.

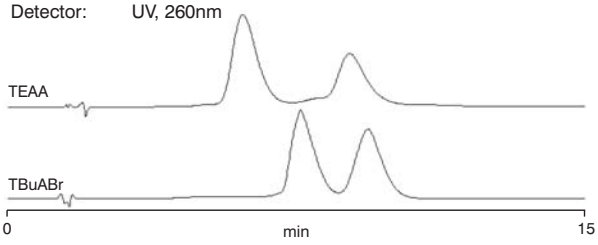
Separation of Two PS Oligomers

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)

TEAA Ion Pairing Agent
Eluent A: 0.1M TEAA in 99% Water : 1% ACN, pH 7.0
Eluent B: 0.1M TEAA in 1% Water : 99% ACN, pH 7.0
Gradient: 15 to 25% B in 20 mins

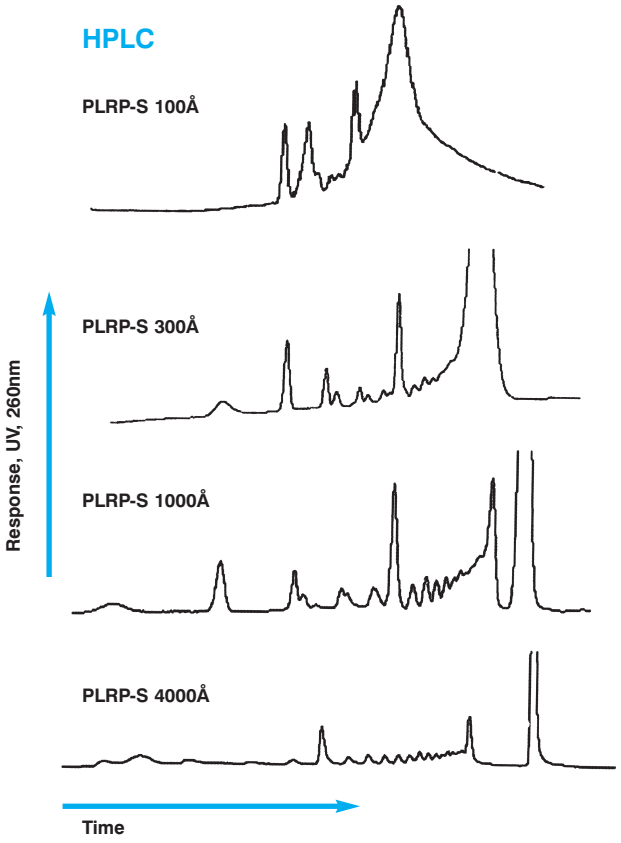
TBuABr Ion Pairing Agent
Eluent A: 0.025M TBuABr in 99% Water : 1% ACN
Eluent B: 0.1M TBuABr in 1% Water : 99% ACN
Gradient: 60 to 70% B in 20 mins

Flow Rate: 1.0ml/min
Temp: 60°C
Detector: UV, 260nm



One of the most challenging separation issues for oligonucleotides is the analysis of large oligomers, >30 mer. As the PLRP-S material is available in pore sizes from 100Å to 4000Å, it is possible to analyse even very large oligomers. The chromatograms below show the separation of a 25 bp double stranded DNA ladder using the four pore sizes. The small pore PLRP-S 100Å resolves up to 50-75 bp, the 300Å 250-300 bp, the 1000Å 400-450 bp and the 4000Å in excess of 500 bp.

Column: PLRP-S, 150x2.1mm
Eluent A: 0.1M TEAA
Eluent B: 0.1M TEAA in 50% Water : 50% ACN
Gradient: 12.5 to 50% B in 150 mins
Flow Rate: 200µl/min



Reprinted from the Journal of Chromatography, Vol 1009, Lloyd et al, "Rigid Polymerics...," pp223-230, Copyright (2003), with permission from Elsevier.

PLRP-S Columns for Biomolecule Analysis - Gigaporous Particles

High Speed Biochromatography

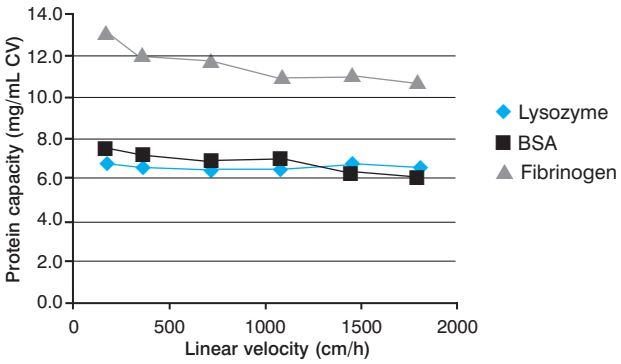
The very open pore structure of the PLRP-S 4000Å polymeric media has unique mass transfer characteristics of great significance for ultra high speed chromatography. Conventional porous adsorbents designed for the HPLC of biomolecules experience a dramatic loss of resolution with rapid steep gradients. Conversely, currently available non-porous packings specifically designed for fast separations show very poor sample capacity with their low surface area.

The PLRP-S 4000Å gigaporous packing operated at high flow rates achieves high resolution with steep gradients in typically 1 to 3 minutes. Since no reduction in sample capacity is observed, high speed/high resolution separations can be carried out at conventional sample loading using unmodified analytical and preparative HPLC instrumentation.

Loading Capacity

With the gigaporous materials the capacity, as determined by frontal loading, changes only slightly with increasing linear velocity - even for very large proteins such as fibrinogen. This enables high throughput purifications to be achieved.

Column: PLRP-S 4000Å, 50x4.6mm
Eluent: 0.1% TFA in Water : ACN

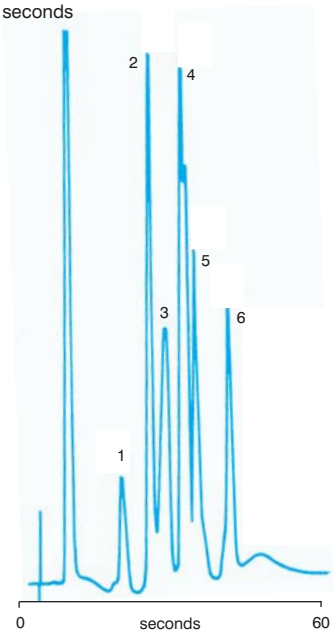


Standard Proteins by Reversed Phase

The 6 commonly used reversed phase standard protein probes are resolved in 60 seconds using the high speed PLRP-S 4000Å 8µm column. The separation is achieved at ambient temperature using a UV detector with a 10µl cell volume and 10mm path length.

Column: PLRP-S 4000Å 8µm, 50x4.6mm (PL1512-1803)
Eluent A: 0.1% TFA in 95% Water : 5% ACN
Eluent B: 0.1% TFA in 5% Water : 95% ACN
Gradient: Linear 18-60% B in 60 seconds
Flow Rate: 4.0ml/min
Detector: UV, 280nm

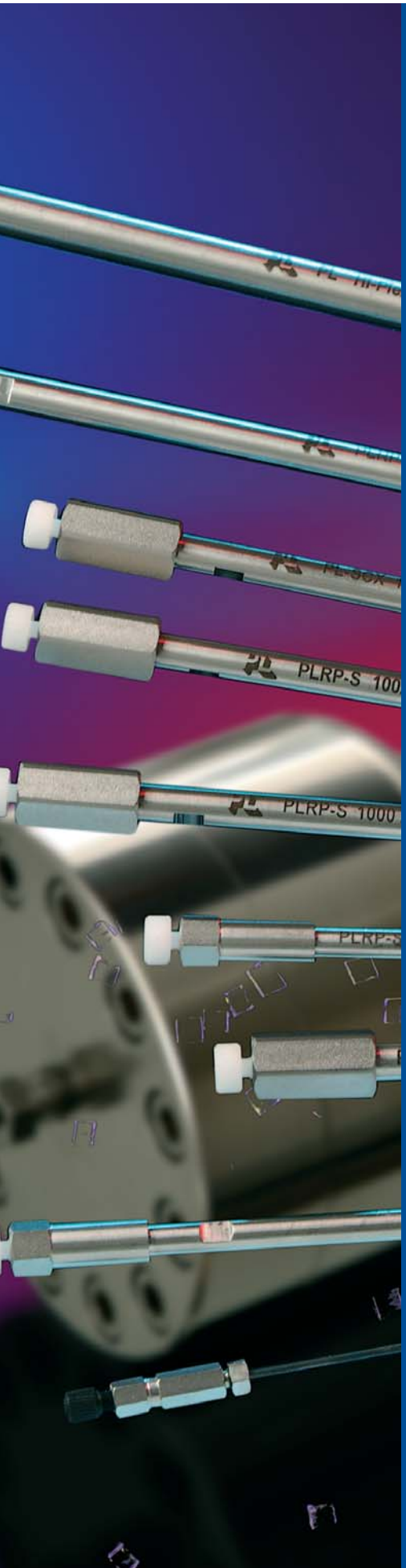
KEY
1. Ribonuclease A
2. Cytochrome c
3. Lysozyme
4. BSA
5. Myoglobin
6. Ovalbumin



Application Areas

- Rapid screening of complex samples
- High speed QC
- Fast fractionation of labile biomolecules
- Rapid method optimization
- High throughput purification

PLRP-S Ordering Information



PLRP-S Columns - Ordering Information

PLRP-S 100Å

Efficiency plates/m **Dimensions**	3µm >70,000* **Part No.**	5µm >50,000* **Part No.**	8µm >30,000 **Part No.**
50x2.1mm*	PL1912-1300	PL1912-1500	
150x2.1mm*	PL1912-3300	PL1912-3500	
250x2.1mm*		PL1912-5500	
50x4.6mm	PL1512-1300	PL1512-1500	
150x4.6mm	PL1512-3300	PL1111-3500	PL1512-3800
250x4.6mm		PL1512-5500	PL1512-5800
300x7.5mm			PL1112-6800

PLRP-S 300Å

Efficiency plates/m **Dimensions**	3µm >60,000* **Part No.**	5µm >50,000* **Part No.**	8µm >30,000 **Part No.**
50x2.1mm*	PL1912-1301	PL1912-1501	PL1912-1801
150x2.1mm*	PL1912-3301	PL1912-3501	PL1912-3801
250x2.1mm*		PL1912-5501	PL1912-5801
50x4.6mm	PL1512-1301	PL1512-1501	PL1512-1801
150x4.6mm	PL1512-3301	PL1512-3501	PL1512-3801
250x4.6mm		PL1512-5501	PL1512-5801
300x7.5mm			PL1112-6801

PLRP-S 1000Å

Efficiency plates/m **Dimensions**	5µm >40,000* **Part No.**	8µm >30,000 **Part No.**
50x2.1mm*	PL1912-1502	PL1912-1802
150x2.1mm*		PL1912-3802
50x4.6mm	PL1512-1502	PL1512-1802
150x4.6mm		PL1512-3802
250x4.6mm		PL1512-5802
50x7.5mm		PL1112-1802
150x7.5mm		PL1112-3802
300x7.5mm		PL1112-6802

PLRP-S 4000Å

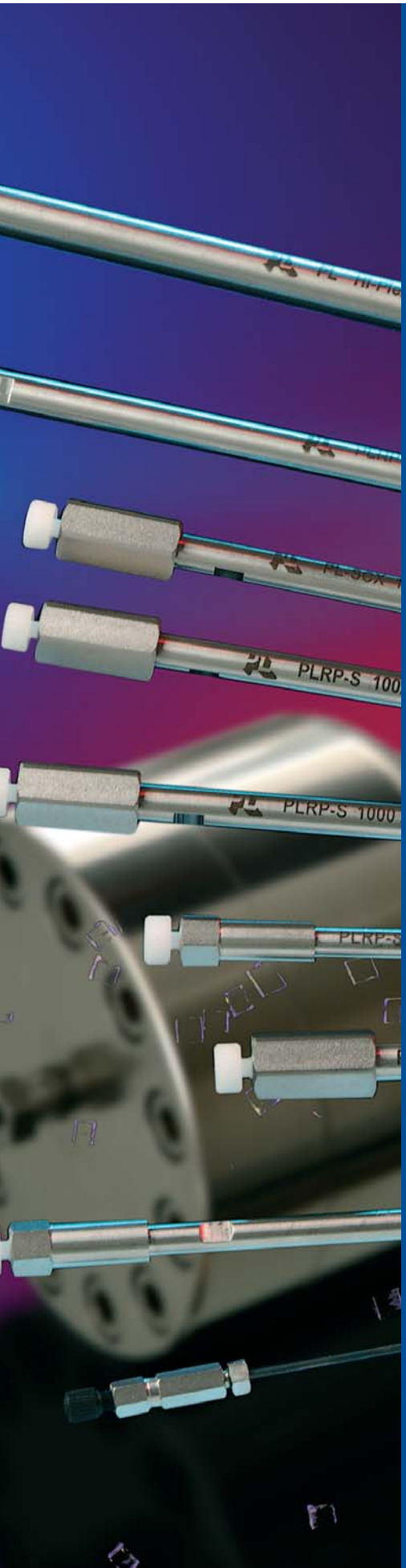
Efficiency plates/m **Dimensions**	5µm >40,000* **Part No.**	8µm >30,000 **Part No.**
50x2.1mm*	PL1912-1503	PL1912-1803
150x2.1mm*		PL1912-3803
50x4.6mm	PL1512-1503	PL1512-1803
150x4.6mm		PL1512-3803
50x7.5mm		PL1112-1803

PLRP-S Guard Cartridges

	Part No.
Guard Cartridge Holder	PL1310-0016
PLRP-S Guard Cartridges (x2) 5x3mm	PL1612-1801

*These plate counts apply to optimized systems. 2.1mm column efficiencies are generally lower.

PL-SAX/PL-SCX 1000Å/4000Å



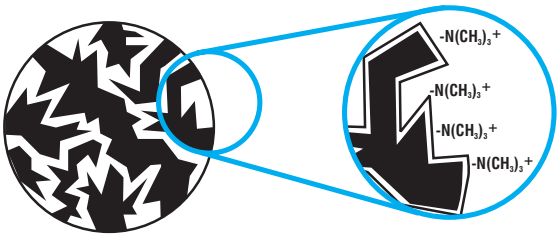
PL-SAX and PL-SCX strong anion and cation exchange resins are designed for the analysis of proteins and oligonucleotides with high capacity and high recovery.

PL-SAX/PL-SCX 1000Å/4000Å Technical Information

Polymer Laboratories has developed and manufactures two high performance resin-based ion exchange packings, PL-SAX and PL-SCX, for the analysis, separation and purification of biomolecules. They are available in a wide range of analytical and preparative scale columns. All media and columns, analytical through preparative, are manufactured in our ISO 9001:2000 facility to the same high operational specifications, to allow for scale-up with confidence.

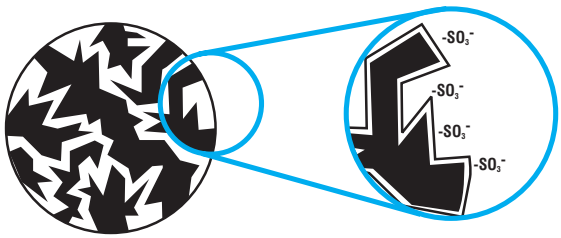
PL-SAX -$N(CH_3)_3^+$

PL-SAX is a hydrophilic strong anion exchange chromatographic packing material. The combination of the rigid macroporous PS/DVB polymer matrix and chemically stable quaternized PEI coating allows the analysis of biomolecules over a wide range of mobile phase conditions and pH. The media's physical stability allows it to be used with high eluent flow rates and high speed gradients for very rapid separations. This excellent stability ensures both rapid equilibration between separations and the ability to use aggressive clean-up procedures employing high salt, NaOH, mineral and organic acids, and a wide range of organic solvents.



PL-SCX -SO_3^-

PL-SCX is a macroporous PS/DVB matrix with a very hydrophilic strong cation exchange coating. This process is controlled to provide the optimum density of strong cation exchange moeties for the analysis, separation and purification of a wide range of biomolecules, from small peptides to large proteins.



PL-SAX/PL-SCX Gradient Elution within:

- pH 1-14
- Buffer/Salt Concentration 8M (limited only by solubility)
- Polar Organics 0-100%
- Pressure 3000psi (200 bar)

PL-SAX/PL-SCX Pore Sizes: 1000Å and 4000Å

For globular protein analysis and purification, the 1000Å material has the optimum pore size for maximum loading with low band broadening. The more open pore structure of the 4000Å is preferred for high resolution and high speed applications or for the separation of very large biomolecules.

Outstanding Chemical Stability

Polymer Laboratories' polymeric based PL-SAX and PL-SCX columns combine the robust, durable chemical stability characteristics of our PLRP-S range of reversed phase HPLC columns with precisely-controlled surface modification to produce very high resolution ion exchange columns for the analysis of biomolecules. As a result, PL-SAX and PL-SCX also deliver extended operational column lifetimes by allowing the use of harsh clean-up and depyrogenation procedures to clean and regenerate the column surface.

Protein Loading

Pore Size	Typical Binding Capacity	
	BSA	Lysozyme
PL-SAX 1000Å	80mg/ml	-
PL-SAX 4000Å	35mg/ml	-
PL-SCX 1000Å	-	60mg/ml
PL-SCX 4000Å	-	30mg/ml

PL-SAX Applications

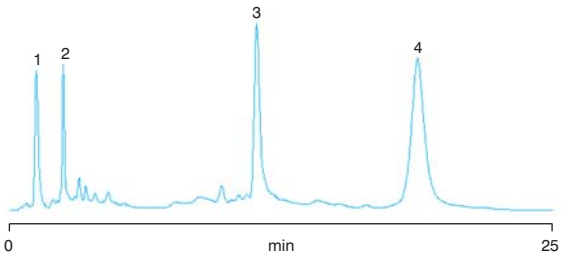
Standard Protein Separation

The large and open pore size PL-SAX 1000Å gives excellent mass transfer without compromising loading capacity, up to 80mg BSA per ml of column volume for the 5μm material.

NEW

Column: PL-SAX 1000Å 5μm, 50x4.6mm (PL1551-1502)
Eluent A: 10mM Tris HCl, pH 8.0
Eluent B: A + 0.35M NaCl, pH 8.0
Gradient: 0-100% B in 20 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Myoglobin
2. Bovine Carbonic Anhydrase
3. Ovalbumin
4. Soybean Trypsin Inhibitor

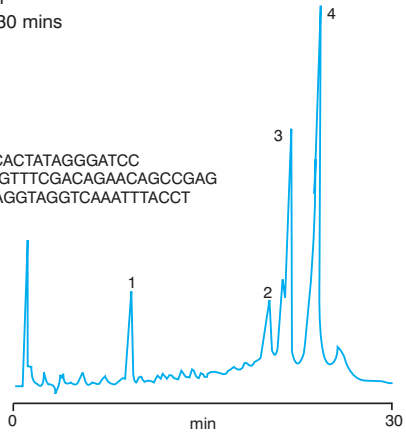


Synthetic Oligonucleotides
24mer: ATTATGCTGAGTGATATCCCTAGG

Oligonucleotides produced using a commercial synthesizer were deprotected and the purity assessed using the PL-SAX strong anion exchanger. Purification from the shorter chain length failure sequences can be accomplished. Urea was added to the mobile phase to prevent self hybridization and the production of secondary structure of palindromic single stranded oligonucleotides. Note the reversal in expected elution order for numbers 3 and 4, the 30 mer and 29 mer.

Column: PL-SAX 1000Å 8μm, 50x4.6mm (PL1551-1802)
Eluent A: 20mM KH_2PO_4, pH 5.5, 5M Urea
Eluent B: A + 1.0M KCl
Gradient: 0-100% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 260nm

KEY
1. 6 mer : GGATCC
2. 24 mer : TAATAGGACTCACTATAGGGATCC
3. 30 mer : GCGCTTTACGGTTTCGACAGAACAGCCGAG
4. 29 mer : GATCCATTTGAGGTAGGTCAAATTTACCT

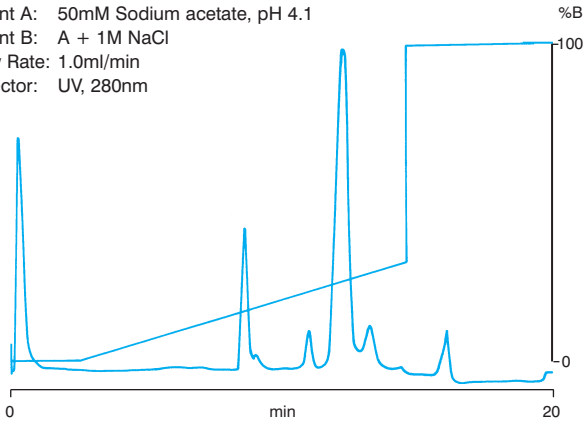


Pepsins in Human Gastric Juice

The PL-SAX can be routinely used for the identification of pepsins 1, 5, 3a, 3b and 3c in peptic ulcer disease. Excellent resolution facilitates quantitation, if required.

Sample: 250μl human gastric juice dialyzed against 0.05M sodium acetate, pH 4.1. Filtered 0.45μm.

Column: PL-SAX 1000Å 8μm, 50x4.6mm (PL1551-1802)
Eluent A: 50mM Sodium acetate, pH 4.1
Eluent B: A + 1M NaCl
Flow Rate: 1.0ml/min
Detector: UV, 280nm

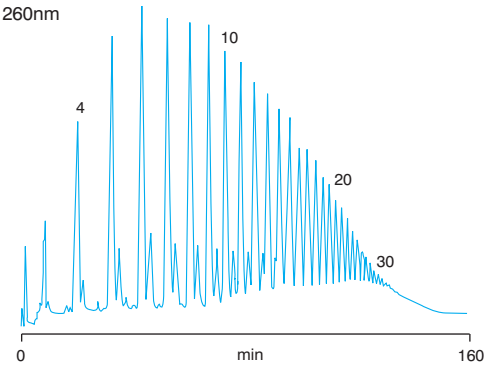


Separation courtesy of NB Roberts, Royal Liverpool Hospital, UK

Separation of Oligoribonucleotides-Oligo(rA)n

A sample of oligoribonucleotides was prepared by alkaline hydrolysis of the homopolymer, poly(rA).

Column: PL-SAX 4000Å 8μm, 150x4.6mm (PL1551-3803)
Eluent A: 20mM KH_2PO_4, pH 5.5, 5M urea
Eluent B: A+1.0M KCl
Gradient: 0-100% B in 200 mins
Flow Rate: 2.0ml/min
Detector: UV, 260nm



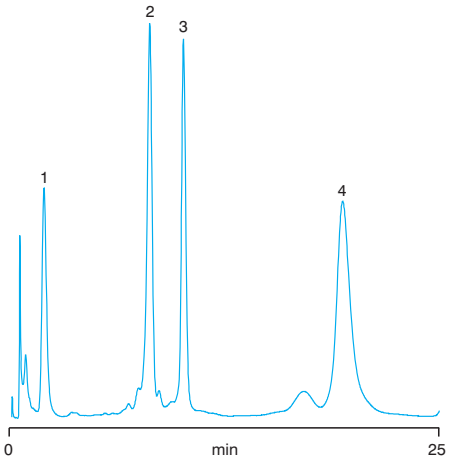
PL-SCX Applications

Standard Protein Separation

Proteins which have a +ve charge at pH 6.0 will be retained by the cation exchanger. The more basic the protein, such as lysozyme (pI 11.8), the longer the elution time from the column under a typical NaCl gradient.

Column:	PL-SCX 1000Å 8µm, 50x4.6mm (PL1545-1802)
Eluent A:	20mM KH_2PO_4, pH 6.0
Eluent B:	A + 1M NaCl
Gradient:	0-100% B in 20 mins
Flow Rate:	1.0ml/min
Detector:	UV, 280nm

KEY
1. Myoglobin
2. Chymotrypsinogen A
3. Cytochrome C
4. Lysozyme

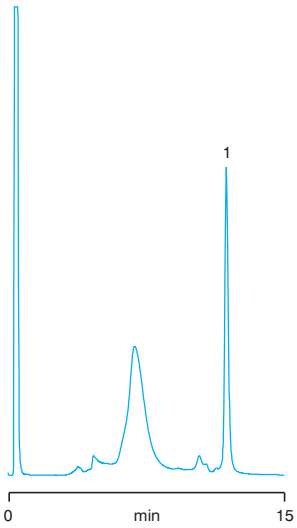


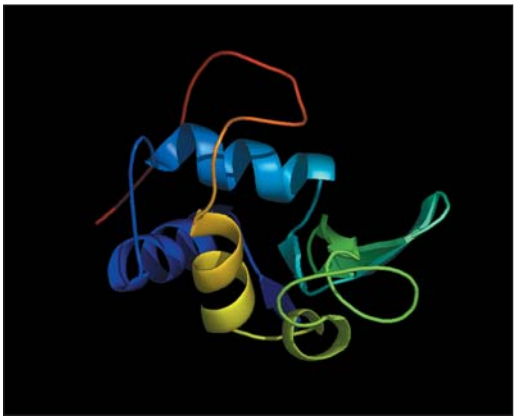
Analysis of Egg White

Lysozyme is an enzyme with an isoelectric point (pI) of >11, and is therefore particularly suitable for separation by cation exchange chromatography on the PL-SCX column. PL-SCX exhibits no secondary hydrophobic interactions. Since it is a polymeric stationary phase, it can tolerate extremes of pH should clean-up be required.

Column:	PL-SCX 1000Å 8µm, 50x4.6mm (PL1545-1802)
Eluent A:	10mM MES, pH 6.0
Eluent B:	A + 1M NaCl
Gradient:	0-75% B in 20 mins
Flow Rate:	1.0ml/min
Detector:	UV, 280nm

KEY
1. Lysozyme

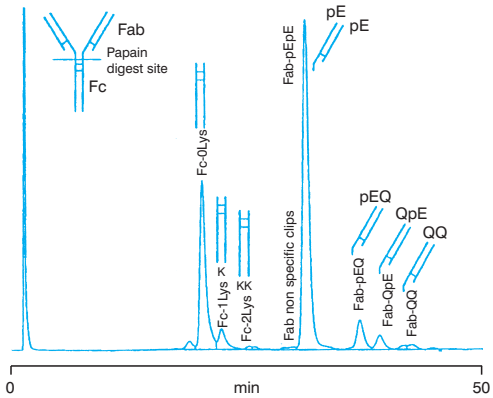




Typing Recombinant Monoclonal Antibody

Cation exchange chromatography following papain fragmentation was used to determine the purity with respect to the charge variant distribution of a recombinant monoclonal antibody.

Column:	PL-SCX 1000Å 8µm, 150x4.6mm (PL1545-3802)
Eluent A:	10mM MES, pH 6.0
Eluent B:	0.2M NaCl, 10mM MES, pH 6.0
Gradient:	5% B for 5 min followed by linear 5-85% B over 40 min
Flow Rate:	1.0ml/min
Detector:	UV, 280nm



Reprinted from Journal of Pharmaceutical & Biomedical Analysis, Vol 16, K G Moorhouse, W Nashabeh, J Deveney, N S Bjork, M G Mulkerrin and T Ryskamp, *Validation of an HPLC method for the analysis of the charge heterogeneity of the recombinant monoclonal antibody IDEC-C2B8 after papain digestion,* 1997, with permission from Elsevier Science.

PL-SAX/PL-SCX 4000Å High Speed Gigaporous Packings

The high speed analysis and purification of biomolecules can now be achieved using either non-porous or flow through 'gigaporous' packings to overcome diffusion restrictions in biochromatography. PL has developed the PL-SAX and PL-SCX 4000Å 'gigaporous' packings to combine high speed and high resolution. These offer the distinct advantages over non-porous packings of high protein capacity and low operating pressures.

Loading Dynamics

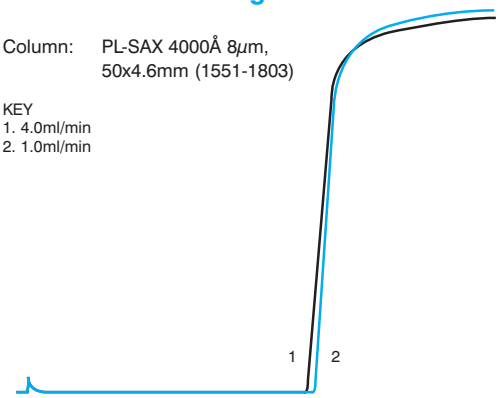
The flow through pores and diffusive pore structure of the PL-SAX and PL-SCX 4000Å media offer excellent permeation and binding efficiencies for separation and purification, even at high flow rates. The frontal loading/binding curves show a very clean, sharp breakthrough, allowing most of the column bed to be utilized before valuable product is detected in the eluent stream.

The capacity of the PL-SAX 4000Å material was determined as 34mg BSA/mlCV at 1.0ml/min and 32mg/mlCV at 4.0ml/min with a minimal change in the shape of the breakthrough curve.

BSA Frontal Loading Curves

Column: PL-SAX 4000Å 8µm, 50x4.6mm (1551-1803)

KEY
1. 4.0ml/min
2. 1.0ml/min

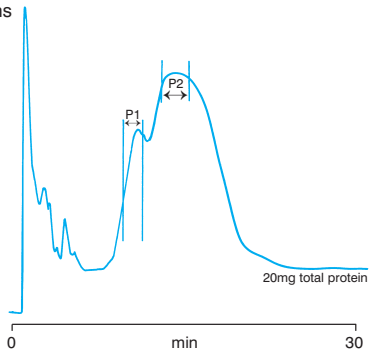


[timescales normalized for comparison]

QC of an HPLC Fractionation

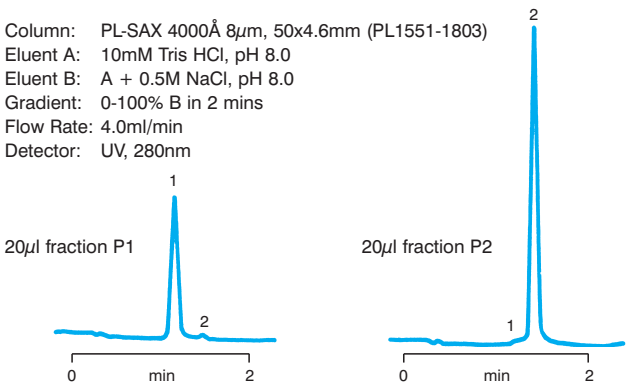
The HPLC fractionation of *Aspergillus niger* cell culture filtrate to isolate the 2 isoenzymes of amyloglucosidase, 1 and 2, was quality controlled using the high speed column. Approximately 95% purity was achieved for a 20mg protein load fractionated on an analytical 50x4.6mm column.

Sample: Amyloglucosidase from *Aspergillus niger* cell culture filtrate
Column: PL-SAX 1000Å 8µm, 50x4.6mm (PL1551-1802)
Eluent A: 10mM NaH_2PO_4, pH 7.0
Eluent B: A + 0.5M NaCl, pH 7.0
Gradient: 0-100% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 280nm



Fractions P1 and P2 were analysed using the PL-SAX 4000Å high speed column.

Column: PL-SAX 4000Å 8µm, 50x4.6mm (PL1551-1803)
Eluent A: 10mM Tris HCl, pH 8.0
Eluent B: A + 0.5M NaCl, pH 8.0
Gradient: 0-100% B in 2 mins
Flow Rate: 4.0ml/min
Detector: UV, 280nm

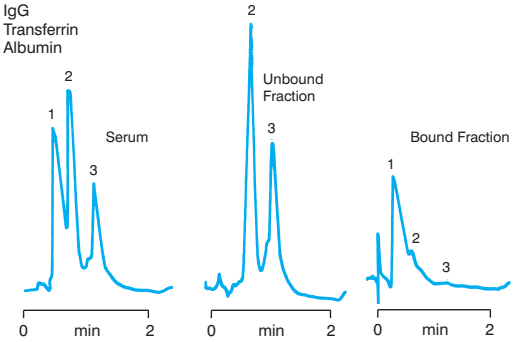


Purity Assessment of an Affinity Separation

Quality control of the affinity HPLC separation of polyclonal antibodies can be completed in under 2 minutes using the PL-SAX 4000Å column. The fractions were collected, the pH adjusted and an aliquot immediately analysed. Resolution of IgG, transferrin and albumin for QC purposes is obtained in 90 seconds.

Column: PL-SAX 4000Å 8µm, 50x4.6mm (PL1551-1803)
Eluent A: 10mM Tris HCl, pH 8.0
Eluent B: A + 0.5M NaCl, pH 8.0
Gradient: 0-100% B in 2 mins
Flow Rate: 4.0ml/min
Detector: UV, 280nm

Peaks: 1. IgG
2. Transferrin
3. Albumin



PL-SAX/PL-SCX Columns - Ordering Information

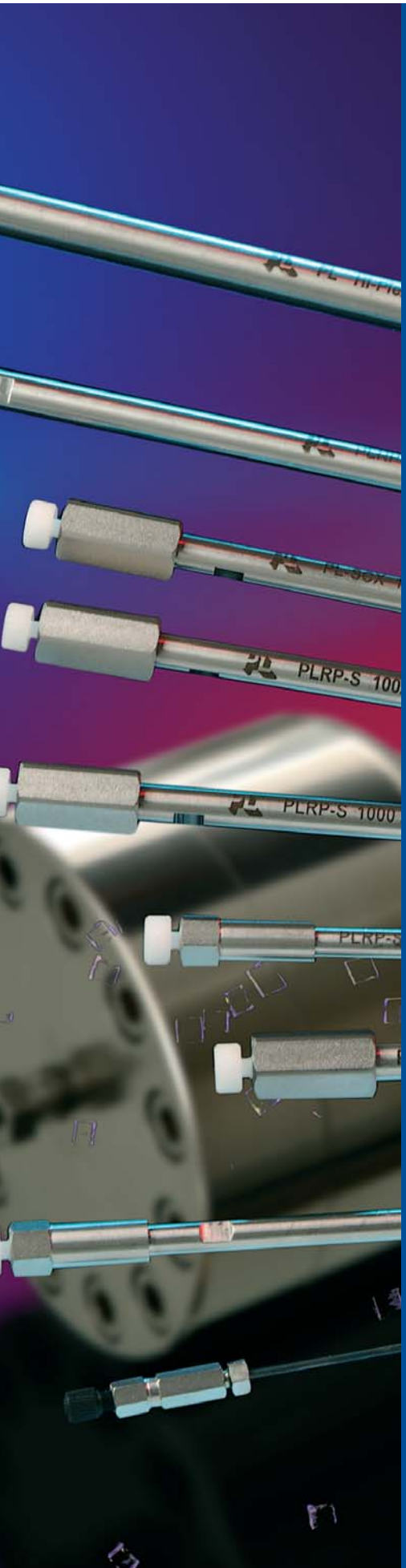
PL-SAX Columns

Dimensions **PL-SAX**	5µm 1000Å **Part No.**	8µm 1000Å **Part No.**	5µm 4000Å **Part No.**	8µm 4000Å **Part No.**
50x2.1mm	PL1951-1502	PL1951-1802	PL1951-1503	PL1951-1803
150x2.1mm		PL1951-3802		PL1951-3803
50x4.6mm	PL1551-1502	PL1551-1802	PL1551-1503	PL1551-1803
150x4.6mm		PL1551-3802		PL1551-3803
50x7.5mm		PL1151-1802		PL1151-1803
150x7.5mm		PL1151-3802		PL1151-3803

PL-SCX Columns

Dimensions **PL-SCX**	5µm 1000Å **Part No.**	8µm 1000Å **Part No.**	5µm 4000Å **Part No.**	8µm 4000Å **Part No.**
50x2.1mm	PL1945-1502	PL1945-1802	PL1945-1503	PL1945-1803
150x2.1mm		PL1945-3802		PL1945-3803
50x4.6mm	PL1545-1502	PL1545-1802	PL1545-1503	PL1545-1803
150x4.6mm		PL1545-3802		PL1545-3803
50x7.5mm		PL1145-1802		PL1145-1803

High Performance Columns & Media



Rigid polymeric particles are ideal for prep/process chromatography.

By optimization of the production process, Polymer Laboratories manufactures rigid polymeric particles with the same mechanical stability as silica based particles, yet with the chemical stability previously only associated with the semi-rigid polymers used for low/medium pressure process chromatography.

High Performance Columns & Media

Rigid Polymerics

Polymer Laboratories manufactures packed columns and loose media for high performance preparative and process purification in the pharmaceutical and biopharmaceutical industries.

Rigid polymerics are ideal for the purification of peptides, proteins and oligonucleotides and where extreme conditions are required for sample solubility and/or separation selectivity.

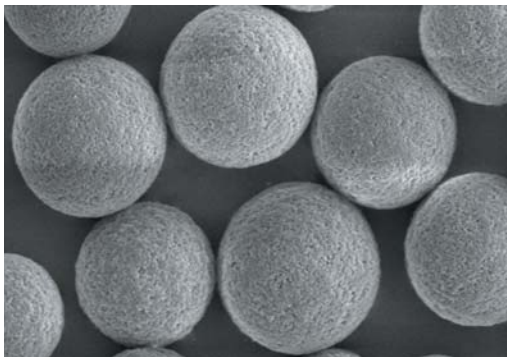
- Particle Sizes 8μm - 30μm
- Pore Sizes 100Å - 4000Å
- Reversed Phase & Ion Exchange

Rigid Macroporous Polymer Particles From PL Provide *Improved Economics* Through	
Chemical, Physical & Thermal Stability →	*Unsurpassed Column Lifetimes*
Chemical & pH Stability →	*Enhanced Selectivity & CIP*
Optimized Pore Structure →	*Increased Capacity*
No Leachables →	*Cleaner Product*

Physical Features

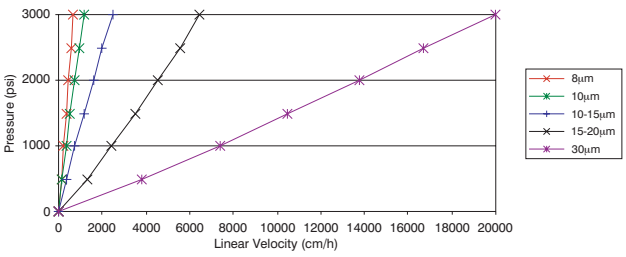
Spherical Uniform Particles

Polymer Laboratories' production process yields spherical uniform particles which are free from fines.



Particle Rigidity

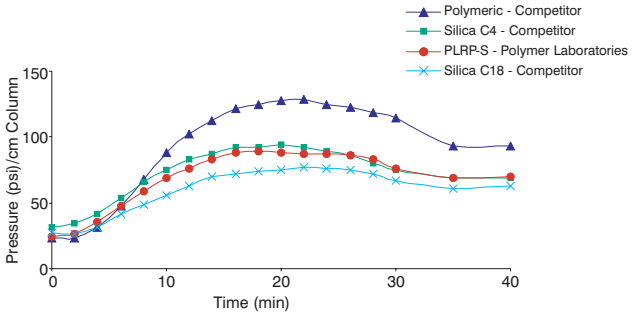
The rigid polymeric particles are mechanically stable to pressures in excess of 6000 psi. Simple packing procedures are available for packing conventional HPLC columns or DAC hardware. Minimal media slurry preparation is required.



Mechanical Stability

PL's rigid polymeric particles are highly crosslinked and therefore demonstrate minimal swell in organic solvents. When the pressure of a typical reversed phase gradient is monitored, the profile through an aqueous/organic gradient is identical to a silica based reversed phase particle of the same size. The pressure maximum is much lower than observed with a conventional polymeric process media where the swell is dependent upon the organic content of the gradient. This is clearly evident from the pressure plots shown below.

Pressure Through Aqueous/Organic Gradient

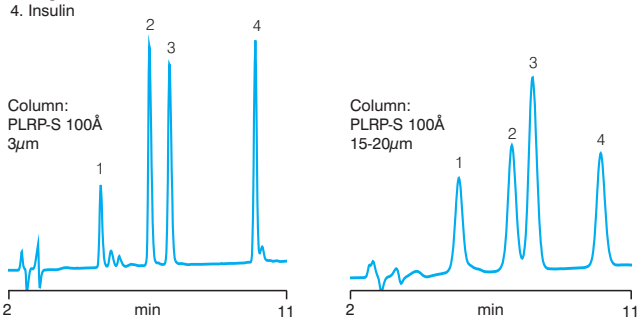


Ease of Scale Up

The separation selectivity is independent of the media particle size. This enables scale up from prep of ng using 3μm analytical columns to the purification of multi-kg using prep/process columns packed with the 8-30μm media.

Eluent A: 0.1% TFA in 80% Water : 20% ACN
Eluent B: 0.1% TFA in 50% Water : 50% ACN
Gradient: 0-100% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Oxytocin
2. Angiotensin II
3. Angiotensin I
4. Insulin



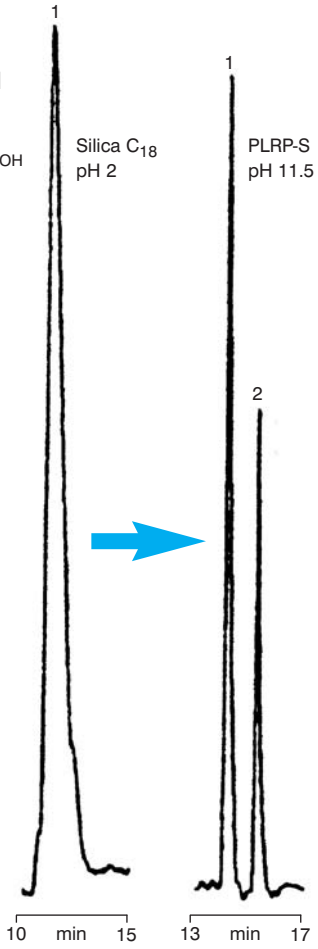
High Performance Columns & Media

Chemical Stability

One of the main advantages of rigid polymerics is their chemical stability. The base particle is stable from pH 1-14, therefore the chromatographic operating range can be extended from that available with conventional silica based materials.

- Move to polymerics for improved selectivity at high pH

KEY
1. H-Asp-Arg-Val-Tyr-Ile-His-Pro-Phe-OH
2. H-Arg-Val-Tyr-Ile-His-Pro-Phe-OH



Reversed Phase and Ion Exchange

Complementary separation techniques are available - reversed phase for peptides/oligos and stable proteins, and ion exchangers for labile proteins, peptides and oligonucleotides.

Process Evaluation Columns

Polymer Laboratories supplies process evaluation columns in 250x4.6mm and 150x4.6mm column dimensions packed with prep/process media for rapid method development.

Regulatory Support & Quality Assurance

PL offers comprehensive, confidential support for its preparative and process media.

PL's team of scientists specialising in biopurification will assist with your initial application and separation optimization, through process development and scale up to production implementation.

- Choice of Media
- DMF
- RSF

Polymer Laboratories is an ISO 9001:2000 Quality Assessed Company to assure you of the quality and reliability of our products and service to you. Customers are invited to audit our manufacturing and QC/QA facilities.

PL - Your Partner in Purification

PL has complete control over the manufacturing process for its full range of prep/process media. This means that where no commercially available material with the required characteristics for a process scale purification exists, PL will work with you to design and manufacture a suitable material. This could involve increasing the load and/or changing the surface chemistry/functionality to improve selectivity and resolution.

No Leachables

The larger particle high performance prep/process media undergoes the same rigorous clean up procedure as do the analytical products. This ensures that there are no leachables, either soluble or solid, which could contaminate product or cause packed bed instability/frit blocking.

Batch Sizes up to 600L/200kg of Product

Polymer Laboratories manufactures large batches of up to 600L/200kg. Customers are therefore able to minimize validation procedures by using the same batch of media for single or multi column packing.

High Performance Columns & Media

Media Selection Guide

PL's BioProcess media product range consists of a series of pore and particle sizes optimized for solute size and system pressure.

In the small pore reversed phase materials, PLRP-S 100Å and 300Å, a high performance 8µm particle is available as these materials are designed for the purification of peptides and oligonucleotides which require high efficiency to resolve closely related impurities. The larger pore reversed phase materials are available in a slightly larger, 10µm, particle size. In addition to the high performance particles, larger sizes are available for use with systems with lower pressure maxima.

PLRP-S Reversed Phase Product Range

	Analytical		Prep/Process					
Pore Size	3µm	5µm	8µm	10µm	10-15µm	15-20µm	30µm	50µm*
100Å	✔	✔	✔	✔	✔	✔		✔
300Å	✔	✔	✔	✔	✔	✔		✔
1000Å		✔	✔	✔			✔	
4000Å		✔	✔	✔			✔	

*Also available as 200Å.

PL-SAX & PL-SCX Ion Exchange Product Range

	Analytical		Prep/Process	
Pore Size	5µm	8µm	10µm	30µm
1000Å	✔	✔	✔	✔
4000Å	✔	✔	✔	✔

Low Pressure Media

For reversed phase applications, Polymer Laboratories produces a PLRP-S 50µm particle in 100Å, 200Å, 300Å and a PLRP-S 50-70µm 1000Å pore sizes. This is a high performance material with no particulate or soluble leachables. Unlike most large particle polymeric materials produced for low pressure applications, the PLRP-S materials are manufactured to the same exacting standards as the smaller high efficiency particles. This ensures reproducibility from batch to batch and a narrow particle size distribution. There are no 'fines' to clog frits or contaminate product, and no pre-washing/sedimentation is required prior to use. These materials are ideal for both low pressure chromatography and batch processes.

Prep/Process Media Characteristics

	PLRP-S	PL-SAX	PL-SCX
Matrix	PS/DVB	fully polymeric	fully polymeric
Pore Size	100Å to 4000Å	1000Å, 4000Å	1000Å, 4000Å
Particle Sizes (100Å, 300Å)	8µm to 15-20µm		
Particle Sizes (1000Å, 4000Å)	10µm, 30µm	10µm, 30µm	10µm, 30µm
Bead Form	rigid, spherical	rigid, spherical	rigid, spherical
Functionality	reversed phase	quaternary amine	sulfonic acid
Pressure Stability	>3000psi	>3000psi	>3000psi
Temperature Stability	200°C	80°C	80°C
pH Range	1 to 14	1 to 14	1 to 14
Eluent Compatibility	all common RP organics all RP ion pairing agents	all anion exchange buffers	all cation exchange buffers
Packed Bed Density	0.33g/ml	0.39g/ml	0.39g/ml

Maximum Throughput

To maximize throughput it is essential that the chromatographic media has maximum loading capacity under the purification conditions used. Loading will be influenced by the pore size, pore size distribution and pore volume of the media as these parameters determine the available surface area. The size of the molecule to be purified will determine the minimum pore diameter of the media to be used.

Capacity mg/ml CV

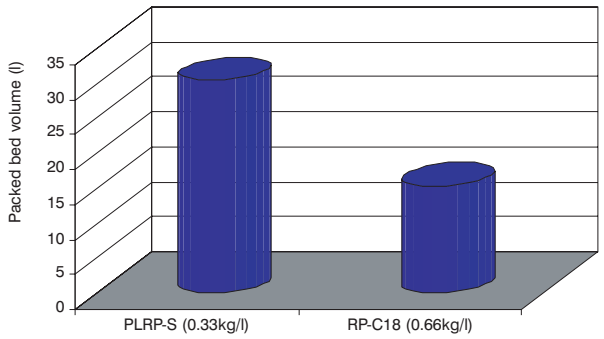
	PLRP-S		PL-SAX		PL-SCX	
	100Å	300Å	1000Å	4000Å	1000Å	4000Å
Insulin	95	60	-	-	-	-
Lysozyme	55	45	-	-	60	30
BSA	5	25	80	35	-	-
Oligonucleotide	72	54	20	14	-	-

Preparative/Process Columns

Scale Up Potential

PL's robust production process and state of the art chemical engineering plant enable single batch sizes ranging from 1kg to 200kg to be produced. Full support documentation exists, and a team of dedicated scientists and engineers is available to assist with method development and scale up issues.

Chart showing the volume of column that can be packed using 10kg of media



The packed bed density of rigid polymeric materials is less than that of silica based HPLC packings and therefore it is possible to pack more column volume from a given weight of particles.

Easy Scale Up for Preparative Applications

PLRP-S media is manufactured to the same specifications regardless of particle size. Separations developed on an analytical scale column can be transferred to a preparative scale column with minimal method re-development.

PL media can be packed into all commercially available process column hardware such as Varian Load & Lock and other systems, up to 1m ID.

Column Packing Procedures

Media is supplied with universal packing instructions. Custom packing methods can be designed by our BioPurification Team.

Preparative Column Hardware

Polymer Laboratories uses high quality 316 stainless steel mirror finish tubing for its column range for the highest efficiency and corrosion resistance.

Preparative/Process Columns

25, 50 to 100mm ID

PL's preparative and process columns offer the highest performance, no compromise column efficiency and loading using a bolted one-piece end fitting/flange design.

The 25mm ID columns use 1/16" tubing connections for maximum efficiency with the smaller column volume, whereas the 50 and 100mm ID columns have 1/8" tubing connections for higher flow throughput.

Pressure Rating and Certification

The 25, 50 and 100mm columns are machined from a solid blank of 316SS, and tested for continuous use up to 3000 psi.

50 and 100mm ID columns are individually pressure tested for complete safety.

The columns are designed to exceed pressure vessel regulations and are CE marked to comply with European standards.

Synthetic Peptides

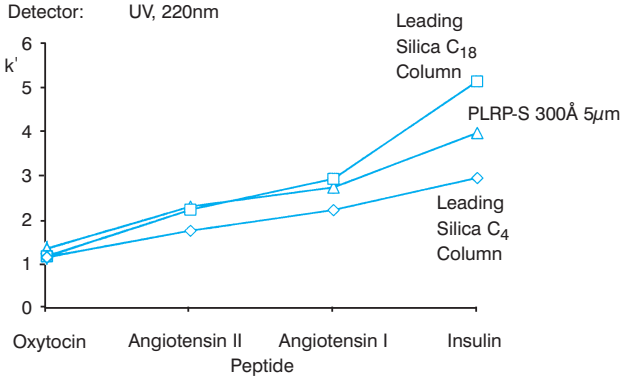
Rigid polymerics have a number of advantages for the purification of synthetic peptides:

- Exceptional Selectivity
- Ease of Scale Up, ng - multi-kg
- High Efficiency at Every Scale
- Chromatography across the Entire pH Range

The underlying retention characteristics of the PLRP-S media are comparable to RP-silica based packings. However, subtle differences due to the potential pi - pi bond interactions can be utilized to further improve the resolution.

Comparison of Retention Characteristics - PLRP-S and Commercial Silica-Based Packings

Columns: 250x4.6mm
Eluent A: 0.1% TFA in 20% ACN : 80% Water
Eluent B: 0.1% TFA in 50% ACN : 50% Water
Gradient: 0-100% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm



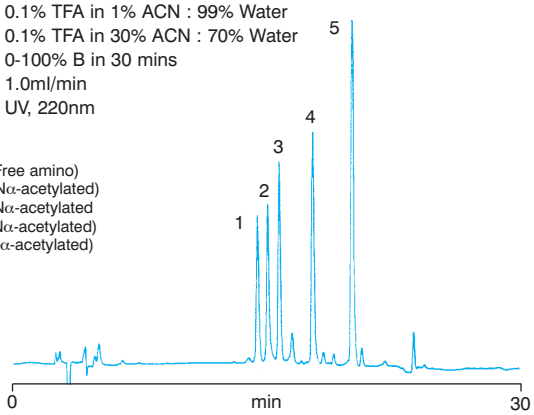
High Resolution Separation of Peptides

PLRP-S media, with its inherent hydrophobicity and unsurpassed chemical stability, is ideal for the high resolution separation of peptides. The mixture, RPS-P0010, produced by Alberta Peptide Institute, is designed to monitor reversed phase column performance. It contains 5 C-terminal amide decapeptides, 4 of which are Nα-acetylated and the fifth contains a free Nα-amino group.

The PLRP-S 100Å column resolves the five major peptides to baseline and also shows the presence of several minor components. The peaks are sharp and symmetrical.

Column: PLRP-S 100Å 5µm, 250x4.6mm (PL1512-5500)
Eluent A: 0.1% TFA in 1% ACN : 99% Water
Eluent B: 0.1% TFA in 30% ACN : 70% Water
Gradient: 0-100% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

KEY
1. Ala^3-Gly^4 (Free amino)
2. Gly^3-Gly^4 (Nα-acetylated)
3. Ala^3-Gly^4 (Nα-acetylated
4. Val^3-Gly^4 (Nα-acetylated)
5. Val^3-Val^4 (Nα-acetylated)

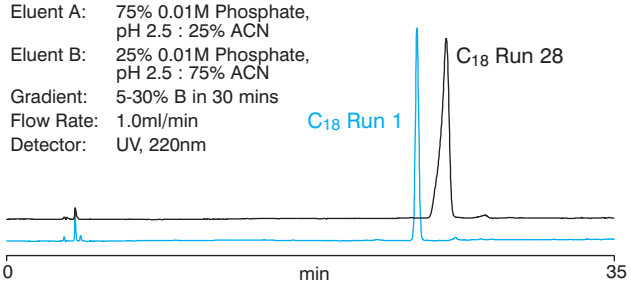


Stable Polymeric Particles - Cleaner Bio-Product

PL's media does not suffer from base particle degradation or bonded phase stripping, unlike conventional silica reversed phase material. The result is no contamination of your product with silica and/or alkyl ligands, and guaranteed run to run reproducibility.

Silica Degradation with a Basic Peptide Solution

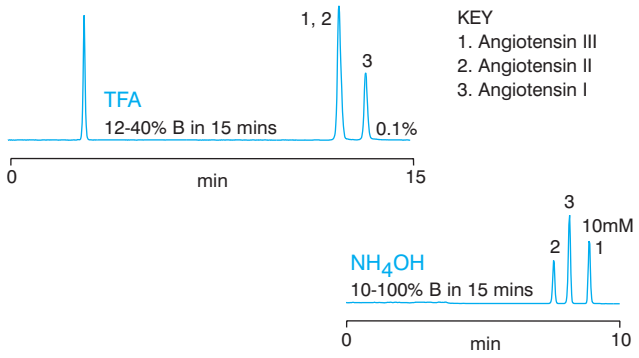
Column: Silica C_{18} 250x4.6mm
Eluent A: 75% 0.01M Phosphate, pH 2.5 : 25% ACN
Eluent B: 25% 0.01M Phosphate, pH 2.5 : 75% ACN
Gradient: 5-30% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm



Effect of pH on Peptide Selectivity

Traditionally, peptide separations have been performed at acidic pH, within the limited pH stability range of silica-based materials. Exploiting the pH stability of PLRP-S packings, separations can be performed under neutral and basic pH, improving the resolution and loading of the purification.

Column: PLRP-S 100Å 10-15µm, 250x4.6mm (PL1512-5400)
Flow Rate: 1.0ml/min
Detector: UV, 220nm



Recombinant Peptides and Proteins

Peptides and proteins produced by recombinant technology are biologically active, and so any purification regime must maintain the bioactivity, or a method must be available to re-activate the peptide/protein after purification. The sample matrix will contain a far wider range of impurities than would be present from a peptide synthesis, including host cell impurities and endotoxins. The concentration of the target compound in the feedstock is often low.

Rigid polymerics have a number of advantages for the purification of recombinant products:

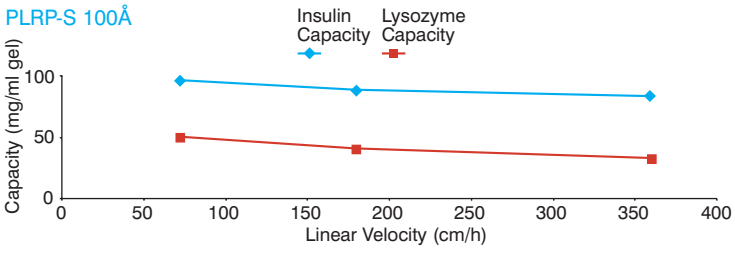
- High Resolution for Final Product Polishing
- Inert Media Resistant to Fouling
- Depyrogenation/Clean Up with 1M NaOH
- Sanitizable/Autoclavable
- Ion Exchange & Reversed Phase Functionalities
- Range of Pore Sizes to Maximize Capacity

Capacity mg/ml CV

	PLRP-S 100Å	PLRP-S 300Å	PL-SAX 1000Å	PL-SAX 4000Å
Insulin	95	60	-	-
Lysozyme	55	45	-	-
BSA	5	25	80	35

The optimized pore structure of the media ensures excellent mass transfer characteristics. Feedstock can be loaded at high linear velocity with minimal reduction in dynamic capacity.

Capacity Dependency on Linear Velocity



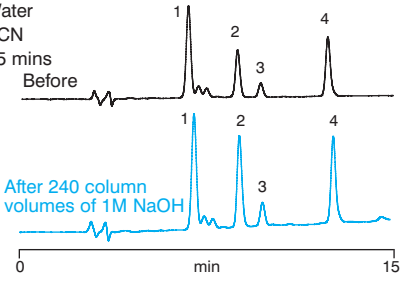
Cleaning in Place

PL's media is chemically robust and can withstand extremely aggressive sanitizing/cleaning protocols. Media can be cleaned in a packed column (CIP), or in bulk, using a range of solubilizing agents such as sodium hydroxide to ensure unsurpassed column/media lifetimes.

1M Sodium Hydroxide Stability

Column: PLRP-S 300Å 10-15µm, 250x4.6mm (PL1512-5401)
Eluent A: 0.1% TFA in Water
Eluent B: 0.1% TFA in ACN
Gradient: 20-50% B in 15 mins
Flow Rate: 1.0ml/min
Detector: UV, 220nm

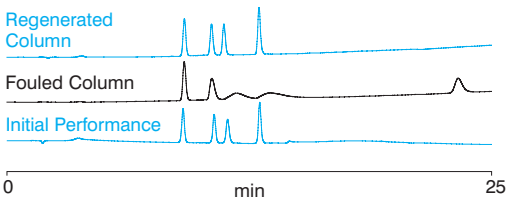
KEY
1. Oxytocin
2. Angiotensin II
3. Angiotensin I
4. Insulin



Bio Fouling

A PLRP-S column was deliberately fouled by repeat injections of an E-coli lysate. The column performance was monitored by injecting a standard peptide solution, measuring the plate count and assessing operating pressure at regular intervals.

	Pressure	Plate Count	Peptide
Initial	36 bar	33,930	good
72 inj	41 bar	26,548	good
95 inj	78 bar	18,316	poor
After reg	38 bar	34,369	good



The plot shows the peptide separation at the beginning of the experiment and after 92 injections of E-coli lysate when the performance was deemed unacceptable. The column was regenerated by flushing with 1M NaOH, THF and ACN, and the separation, pressure and plate count are as the original.

Oligonucleotides

Rigid polymerics have a number of advantages for the purification of oligonucleotides

Reversed Phase, PLRP-S

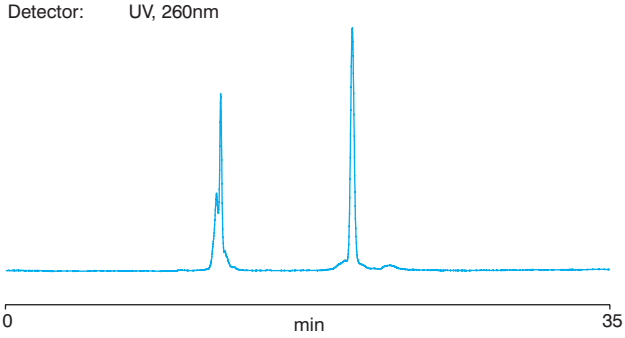
- Trityl on/Trityl off
- Ion Pair Chromatography
- Thermal Stability

Anion Exchange, PL-SAX

- HPLC at High pH
- Large Pore Size
- Thermal Stability

Reversed Phase Separation of Protected DMT on Oligonucleotide Product from Deprotected DMT off Failure Sequences

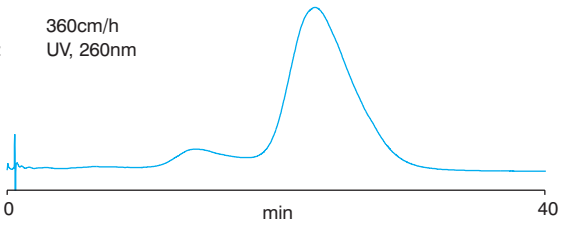
Sample: 40 mer oligo
5' d(TTTTTCAGTACAGGAGATCTTT - GAGGTGGATAACTTTTTT) 3'
Column: PLRP-S 100Å 10µm, 150x4.6mm (PL1512-3100)
Eluent A: 1% ACN : 99% 200mM Sodium acetate, pH 7.2
Eluent B: 50% ACN : 50% 200mM Sodium acetate, pH 7.2
Gradient: 0% B hold for 5 mins, 0-100% B in 30 mins
Flow Rate: 1.0ml/min
Detector: UV, 260nm



Thiolated Oligonucleotide

Using PL-SAX material, a high pH eluent can be used to separate a fully thiolated oligonucleotide from an impurity where thiolation is incomplete.

Column: PL-SAX 1000Å 10µm
Eluent A: 1M NaOH
Eluent B: 1M NaOH, 2M NaCl
Gradient: 75-100% B in 25 mins, hold at 100% B for 15 mins
Linear Velocity: 360cm/h
Detector: UV, 260nm



- ***The strong anion exchange functionality on a chemically inert polymeric matrix gives charge differentiation even in 1M NaOH***

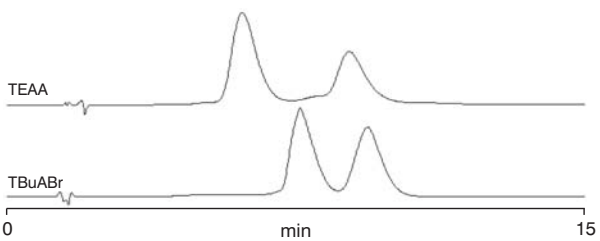
Separation of De-protected 18 mer and 20 mer PS Oligonucleotides with a Small PO Contaminant

Column: PLRP-S 100Å 5µm, 150x4.6mm (PL1111-3500)

TEAA Ion Pairing Agent
Eluent A: 0.1M TEAA in 99% Water : 1% ACN, pH 7.0
Eluent B: 0.1M TEAA in 1% Water : 99% ACN, pH 7.0
Gradient: 15 to 25% B in 20 mins

TBuABr Ion Pairing Agent
Eluent A: 0.025M TBuABr in 99% Water : 1% ACN
Eluent B: 0.1M TBuABr in 1% Water : 99% ACN
Gradient: 60 to 70% B in 20 mins

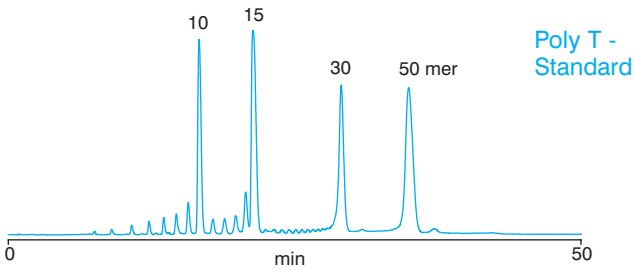
Flow Rate: 1.0ml/min
Temp: 60°C
Detector: UV, 260nm



Thermal Stability

PL's media is thermally stable for separations which require elevated temperatures, such as oligonucleotide separations which are routinely run at 60°C.

Column: PL-SAX 1000Å 8µm, 50x4.6mm (PL1551-1802)
Eluent A: 93% 0.1M TEAA, pH 8.5 : 7% ACN
Eluent B: 93% 0.1M TEAA, 1M Ammonium chloride, pH 8.5 : 7% ACN
Gradient: 0-40% B in 10 mins, 40-70% B in 14 mins, 70-100% B in 25 mins
Flow Rate: 1.5ml/min
Temp: 60°C



Ordering Information

PLRP-S 100Å/300Å Columns & Media

	8µm		10µm	
	100Å **Part No**	300Å **Part No.**	100Å **Part No.**	300Å **Part No.**
Prep/Process Evaluation Columns				
150x4.6mm	PL1512-3800	PL1512-3801	PL1512-3100	PL1512-3101
250x4.6mm	PL1512-5800	PL1512-5801	PL1512-5100	PL1512-5101
Prep/Process Columns				
150x25mm	PL1212-3800	PL1212-3801	PL1212-3100	PL1212-3101
300x25mm	PL1212-6800	PL1212-6801	PL1212-6100	PL1212-6101
150x50mm	PL1712-3800	PL1712-3801	PL1712-3100	PL1712-3101
300x50mm	PL1712-6800	PL1712-6801	PL1712-6100	PL1712-6101
300x100mm	PL1812-6800	PL1812-6801	PL1812-6100	PL1812-6101
Media				
10g			PL1412-2100	PL1412-2101
100g			PL1412-4100	PL1412-4101
1kg	PL1412-6800	PL1412-6801	PL1412-6100	PL1412-6101

	10-15µm		15-20µm	
	100Å **Part No.**	300Å **Part No.**	100Å **Part No.**	300Å **Part No.**
Prep/Process Evaluation Columns				
150x4.6mm	PL1512-3400	PL1512-3401	PL1512-3200	PL1512-3201
250x4.6mm	PL1512-5400	PL1512-5401	PL1512-5200	PL1512-5201
Prep/Process Columns				
300x25mm	PL1212-6400	PL1212-6401	PL1212-6200	PL1212-6201
150x50mm	PL1712-3400	PL1712-3401	PL1712-3200	PL1712-3201
300x50mm	PL1712-6400	PL1712-6401	PL1712-6200	PL1712-6201
300x100mm	PL1812-6400	PL1812-6401	PL1812-6200	PL1812-6201
Media				
10g	PL1412-2400	PL1412-2401	PL1412-2200	PL1412-2201
100g	PL1412-4400	PL1412-4401	PL1412-4200	PL1412-4201
1kg	PL1412-6400	PL1412-6401	PL1412-6200	PL1412-6201

PLRP-S 1000Å/4000Å Columns & Media

	10µm		30µm	
	1000Å **Part No.**	4000Å **Part No.**	1000Å **Part No.**	4000Å **Part No.**
Prep/Process Evaluation Columns				
150x4.6mm	PL1512-3102	PL1512-3103	PL1512-3702	PL1512-3703
250x4.6mm	PL1512-5102	PL1512-5103	PL1512-5702	PL1512-5703
Prep/Process Columns				
50x25mm	PL1212-1102	PL1212-1103		
150x25mm	PL1212-3102	PL1212-3103	PL1212-3702	PL1212-3703
150x50mm	PL1712-3102	PL1712-3103	PL1712-3702	PL1712-3703
300x100mm	PL1812-2102	PL1812-2103	PL1812-3102	PL1812-3103
Media				
10g	PL1412-2102	PL1412-2103	PL1412-2702	PL1412-2703
100g	PL1412-4102	PL1412-4103	PL1412-4702	PL1412-4703
1kg	PL1412-6102	PL1412-6103	PL1412-6702	PL1412-6703

For multi-kilo applications, bulk discounts and call-off orders, please call to discuss your requirements.

Ordering Information

PL-SAX 1000Å/4000Å Columns & Media

	10µm		30µm	
	1000Å **Part No.**	4000Å **Part No.**	1000Å **Part No.**	4000Å **Part No.**
Prep/Process Evaluation Columns				
150x4.6mm	PL1551-3102	PL1551-3103	PL1551-3702	PL1551-3703
250x4.6mm	PL1551-5102	PL1551-5103	PL1551-5702	PL1551-5703
Prep/Process Columns				
50x25mm	PL1251-1102	PL1251-1103		
150x25mm	PL1251-3102	PL1251-3103	PL1251-3702	PL1251-3703
150x50mm	PL1751-3102	PL1751-3103	PL1751-3702	PL1751-3703
300x100mm	PL1851-2102	PL1851-2103	PL1851-3102	PL1851-3103
Media				
10g	PL1451-2102	PL1451-2103	PL1451-2702	PL1451-2703
100g	PL1451-4102	PL1451-4103	PL1451-4702	PL1451-4703
1kg	PL1451-6102	PL1451-6103	PL1451-6702	PL1451-6703

PL-SCX 1000Å/4000Å Columns & Media

	10µm		30µm	
	1000Å **Part No.**	4000Å **Part No.**	1000Å **Part No.**	4000Å **Part No.**
Prep/Process Evaluation Columns				
150x4.6mm	PL1545-3102	PL1545-3103	PL1545-3702	PL1545-3703
250x4.6mm	PL1545-5102	PL1545-5103	PL1545-5702	PL1545-5703
Prep/Process Columns				
50x25mm	PL1245-1102	PL1245-1103		
150x25mm	PL1245-3102	PL1245-3103	PL1245-3702	PL1245-3703
150x50mm	PL1745-3102	PL1745-3103	PL1745-3702	PL1745-3703
300x100mm	PL1845-2102	PL1845-2103	PL1845-3102	PL1845-3103
Media				
10g	PL1445-2102	PL1445-2103	PL1445-2702	PL1445-2703
100g	PL1445-4102	PL1445-4103	PL1445-4702	PL1445-4703
1kg	PL1445-6102	PL1445-6103	PL1445-6702	PL1445-6703

PLRP-S Process Media 50µm

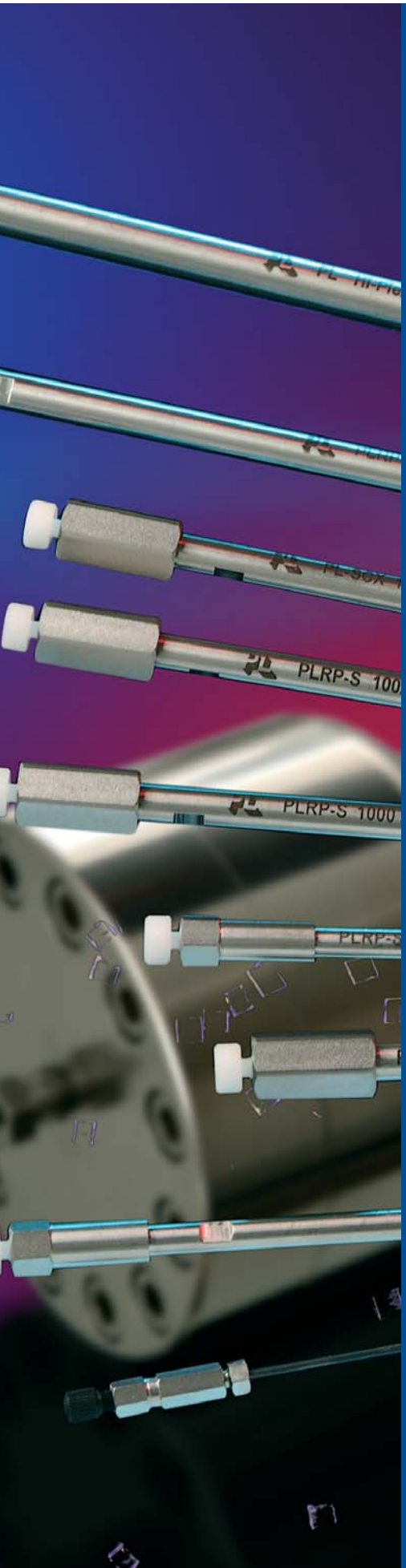
	100Å **Part No.**	200Å **Part No.**	300Å **Part No.**
10g	PL1412-2K00	PL1412-2K05	PL1412-2K01
100g	PL1412-4K00	PL1412-4K05	PL1412-4K01
1kg	PL1412-6K00	PL1412-6K05	PL1412-6K01
10kg	PL1412-7K00	PL1412-7K05	PL1412-7K01
100kg	PL1412-8K00	PL1412-8K05	PL1412-8K01

PLRP-S 50-70µm

	1000Å **Part No**
10g	PL1412-2602
100g	PL1412-4602
1kg	PL1412-6602

For multi-kilo applications, bulk discounts and call-off orders, please call to discuss your requirements.

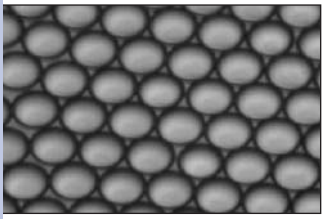
PL Hi-Plex Columns



Resin-Based Columns for the Analysis of Carbohydrates, Saccharides, Alcohols and Organic Acids.

Monodisperse Packing: Improved Chromatography and Reproducibility.

PL Hi-Plex Technical Information



Optical Microscope image of Monodisperse particles

Naturally occuring materials such as carbohydrates, organic acids and alcohols have been analysed using 'soft' microporous sulfonated resins for many years, however, their inherent low crosslink density and wide particle size distribution brought problems of high back pressures and low efficiencies. In search of improved performance, Polymer Laboratories has used its extensive knowledge of chromatography column packing production to create the solution, a sulfonated resin, but with a fundamental improvement in performance. PL has introduced *monodisperse* sulfonated packings to overcome the problems of low efficiencies and high back pressures encountered with 'soft' gels.

Analysis of Carbohydrates / Alcohols / Acids

Crosslink content controls the molecular weight range of the analysis, governing the size exclusion properties of the resin. Using this technology, PL has designed a series of three basic column types...

Ca, Pb

Resins incorporating 8% w/w divinylbenzene exclude large molecular weight oligosaccharides. Mono- and disaccharides permeate the individual beads and are separated by secondary ligand exchange interactions with the metal ion associated with the sulfonated resin. Different counter ion forms (eg calcium and lead) offer differences in selectivity due to varying strengths of interaction with the numerous hydroxyl groups present on sugar molecules.

H

PL Hi-Plex columns are available in hydrogen form for the analysis of sugar alcohols and sugar molecules using water as the mobile phase. The PL Hi-Plex H is also the column of choice for the analysis of organic acids, using dilute mineral acid as eluent.

Na

For higher molecular weight oligosaccharides (degree of polymerization, Dp, 5 and above) lower crosslinked gels are required. PL has produced a 4% crosslinked resin, available in sodium form.

Typical Operating Conditions

Column Type	Temp	Flow Rate	Eluent
PL Hi-Plex Ca & Pb	80-90°C	0.6ml/min	Water
PL Hi-Plex H for Sugars	60-70°C	0.6ml/min	Water
PL Hi-Plex H for Organic Acids	40-60°C	0.6ml/min	<0.01M H^+
PL Hi-Plex Na	80-90°C	0.3ml/min	Water

Exact operating conditions should be adjusted for optimum performance and resolution. Please refer to the User's Guide for further details.

Monodisperse Packings

Monodisperse particles provide significant advantages over traditional polydisperse sulfonated resins:

- Improved column efficiencies
- Reduced band broadening
- Lower column pressures
- Increased column lifetimes
- Assured batch to batch reproducibility

Reproducible Quality *Assured*

To eliminate the major problem of column to column variation, Polymer Laboratories' proprietary manufacturing process is strictly monitored and quality controlled, *ensuring* product reproducibility from batch to batch. Each column is individually computer-tested under normal operating conditions, and evaluated for peak efficiency, symmetry, retention and pressure. A comprehensive User's Guide and test certificate, showing full column test data, including plate count and pressure, are issued with each column.

Column Clean-up for *Extended Column Lifetimes*

PL Hi-Plex columns can often be regenerated after contamination with simple clean-up procedures *to restore the original separation characteristics.* Flushing of the column with the appropriate salt solution to replace the counter ion or the addition of organic modifier to remove hydrophobic contamination can often regenerate the resin.

PL Hi-Plex Column Choice

Column Selection Guide

Application Areas	Suitable Column Type(s)
Adulteration of Food & Beverages	PL Hi-Plex Ca or Pb
Alcohols	PL Hi-Plex Ca or H
Anomer Separation	PL Hi-Plex Ca
Carbohydrate Analysis	PL Hi-Plex Ca, Na, Pb
Confectionery Analysis	PL Hi-Plex Ca or Pb
Corn Syrup	PL Hi-Plex Na
Dairy Products	PL Hi-Plex Ca or H
Disaccharide Analysis	PL Hi-Plex Ca or Pb
Fermentation Analysis	PL Hi-Plex Ca or H
Food Additives	PL Hi-Plex Ca or Pb
Fruit Juice Analysis	PL Hi-Plex Ca or Pb
Glycoprotein Constituents	PL Hi-Plex H
Monosaccharides	PL Hi-Plex Ca or Pb
Oligosaccharides	PL Hi-Plex Na
Organic Acids	PL Hi-Plex H
Wine Analysis	PL Hi-Plex Ca or H

Pharmacopeia methods specify the type of HPLC column which should be used. The PL Hi-Plex product range features three materials which comply with USP definitions:

Media Type L17 : Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the hydrogen form with 7-11μm particle diameter - **PL Hi-Plex H**

Media Type L19 : Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in calcium form with 9μm particle diameter - **PL Hi-Plex Ca**

Media Type L34 : Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the lead form with 9μm particle diameter - **PL Hi-Plex Pb**

Media Type L58 : Strong cation exchange resin consisting of sulfonated crosslinked styrene/divinylbenzene copolymer in the sodium form with ~ 7-11μm particle diameter - **PL Hi-Plex Na**

USP Method for Mannitol Analysis (Sugar Alcohol)
The PL Hi-Plex Ca material (**Media Type L19**) is available packed into a 250x4.0mm ID column to fulfill the criteria of the USP method for the analysis of sugar alcohols.

Column Choice

For appropriate column selection, retention times of commonly occurring neutral sugars, sugar alcohols and organic acids are shown below:

Saccharide	H	Ca	Pb
Adonitol	11.5	14.9	20.4
Arabinose	11.4	13.6	19.4
Erythritol	12.7	15.6	20.3
Fructose	10.6	13.5	19.3
Fucose	12.2	13.7	17.1
Galactose	10.7	12.2	15.6
Glucose	9.9	11.1	13.9
Glycerol	14.1	16.1	19.5
Lactose	8.6	9.7	12.8
Maltose	8.4	9.5	12.5
Maltotriose	7.7	8.7	11.9
Mannitol	11.0	17.3	28.9
Mannose	10.5	12.5	16.7
Raffinose	*8.2	8.6	11.4
Rhamnose	11.6	12.7	18.0
Sorbitol	11.1	20.7	N/A
Stachyose	7.4	8.2	10.8
Sucrose	*9.8	9.4	11.9
Xylose	10.6	12.0	15.0

An asterisk denotes partial hydrolysis.

Retention times (in minutes) were recorded under conditions as follows:

Columns:	PL Hi-Plex, 300x7.7mm Ca @ 85°C Pb @ 80°C H @ 75°C
Eluent:	Water
Flow Rate:	0.6ml/min
Detector:	RI

By using PL Hi-Plex H columns at higher operating temperatures, closely eluting compounds can be resolved. Acid catalyzed hydrolysis of some oligosaccharides may occur

Organic Acid	H
Acetic acid	15.8
Citric acid	9.1
Formic acid	14.9
Fumaric acid	16.1
Lactic acid	13.8
Malic acid	10.6
Oxalic acid	7.2
Pyruvic acid	10.3
Succinic acid	13.0
Tartaric acid	9.6

Retention times (in minutes) were recorded under conditions as follows:

Columns:	PL Hi-Plex H, 300x7.7mm
Eluent:	0.005M H_2SO_4
Temp:	55°C
Flow Rate:	0.6ml/min
Detector:	UV, 210nm

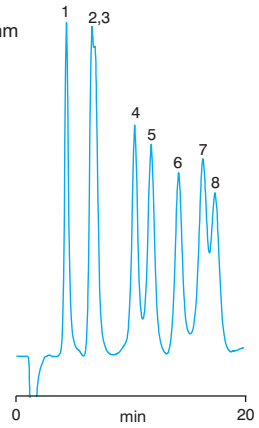
Sugar Alcohols - USP Method

Sugar alcohols occur naturally in fruit, vegetables and cereals. Their pleasant sweet taste allows them to be used as an alternative sweetening agent to sucrose, particularly in reduced calorie and diabetic food.

Analysis of Sugar Alcohols

Column:	PL Hi-Plex Ca, 250x4.0mm (PL1570-5810)
Eluent:	70% Water : 30% ACN
Temp:	60°C
Flow Rate:	0.3ml/min
Detector:	RI

KEY
1. Penta-erythritol
2. Erythritol
3. Adonitol
4. Arabitol
5. Mannitol
6. Xylitol
7. Dulcitol
8. Sorbitol



PL Hi-Plex Applications - Mono-, Disaccharides

The PL Hi-Plex series of 8µm crosslinked materials is recommended for the analysis of mono- and disaccharides. For monosaccharides, the PL Hi-Plex Pb material is most retentive, and shows improved resolution for some disaccharides. The PL Hi-Plex Ca columns are preferred for rapid profiling of monosaccharides in the presence of oligosaccharide material.

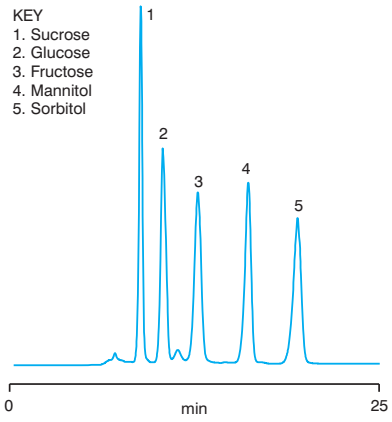
The PL Hi-Plex Ca columns are ideal for the analysis of most sweeteners, monosaccharides (glucose and fructose), disaccharide (sucrose) and sugar alcohols. Rapid profiles of these components in food products can be achieved and compositions quantified for authenticity checks.

Chewing Gum Analysis

Some chewing gums are sugar free, others contain sucrose. In addition, they contain sugar alcohols which sweeten the product and also act as stabilizers.

Column: PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 85°C
Detector: RI

KEY
1. Sucrose
2. Glucose
3. Fructose
4. Mannitol
5. Sorbitol

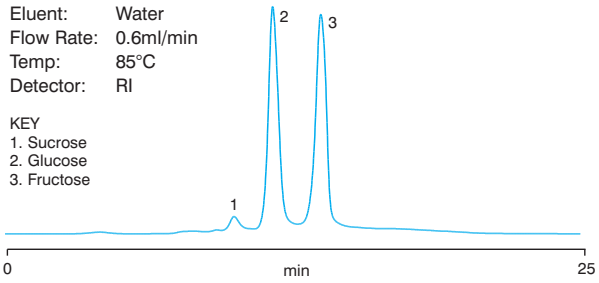


Analysis of Raisins

Drying grapes to produce raisins is a simple way of preserving a short lived fruit. This chromatogram indicates the sugars found in raisins (sucrose, glucose and fructose), and shows how the analysis could be used to check for the addition of sugar to inferior raisins to improve their sweetness.

Column: PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 85°C
Detector: RI

KEY
1. Sucrose
2. Glucose
3. Fructose



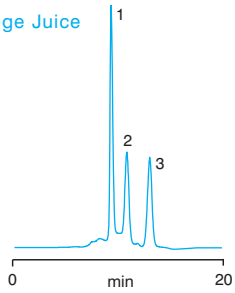
Analysis of Fruit Juice

PL Hi-Plex Ca columns are ideal for the determination of the major sugars in fruit juices. A comparison of orange, apple and tomato juice identifies the varying proportions of sucrose, glucose and fructose present in each pure juice.

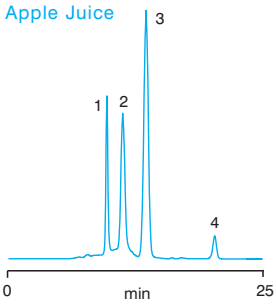
Column: PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 85°C
Detector: RI

KEY
1. Sucrose
2. Glucose
3. Fructose
4. Sorbitol

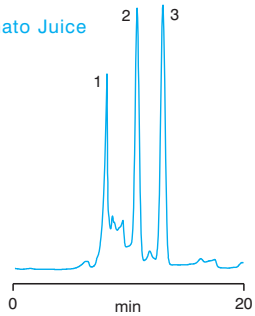
Orange Juice



Apple Juice



Tomato Juice

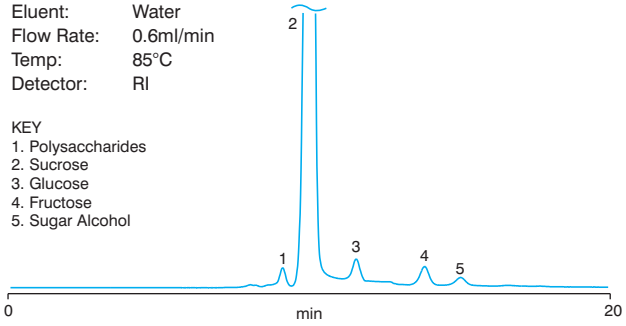


Analysis of Maple Syrup

The main sugar present in this popular American syrup is sucrose. Sucrose gives the syrup its sweet taste.
PL Hi-Plex Ca gives a good separation of sucrose from the more minor components of fructose, glucose and larger polymeric material, in a relatively short time.

Column: PL Hi-Plex Ca, 300x7.7mm (PL1170-6810)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 85°C
Detector: RI

KEY
1. Polysaccharides
2. Sucrose
3. Glucose
4. Fructose
5. Sugar Alcohol



PL Hi-Plex Applications - Mono-, Disaccharides

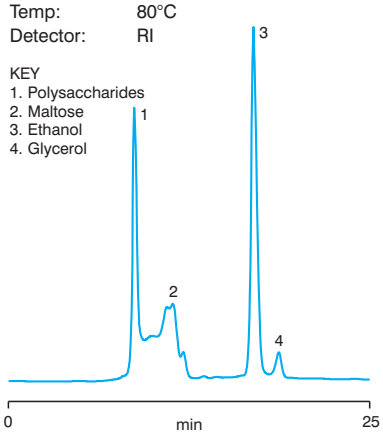
Alcohol Levels in Beer

The taste of a beer is partly determined by the combination of sugars and alcohols present.

PL Hi-Plex Pb columns, also based on an 8μm crosslinked resin, are used to separate mono-, di- and polysaccharides and the alcohol. Sweeter beers contain more monosaccharides, whereas stronger beers will contain more alcohol.

Column: PL Hi-Plex Pb, 300x7.7mm (PL1170-6820)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 80°C
Detector: RI

KEY
1. Polysaccharides
2. Maltose
3. Ethanol
4. Glycerol



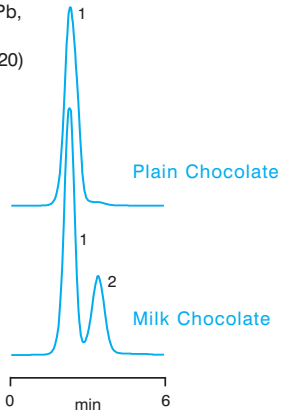
The PL Hi-Plex Pb column is ideally suited to the analysis of dairy-based food products. The analysis of the milk disaccharide lactose can be quantified in the presence of the sweetener sucrose.

Sugars in Plain and Milk Chocolate

Using the PL Hi-Plex Pb column, it is possible to identify the sugars present in milk and plain chocolate. The major sugar is sucrose, however in the milk chocolate, the milk sugar lactose contributes to the carbohydrate content. Lactose is not found in the plain, dark chocolate where no milk is used in its production.

Column: PL Hi-Plex Pb, 300x7.7mm (PL1170-6820)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 80°C
Detector: RI

KEY
1. Sucrose
2. Lactose



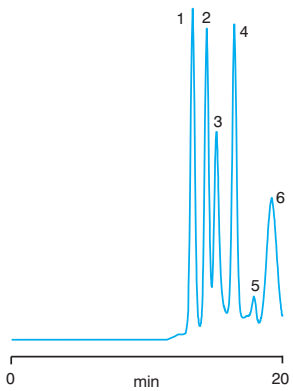
The PL Hi-Plex Pb column also provides improved monosaccharide resolution compared to the calcium counter ion, but with longer analysis times. It can therefore be used for samples which contain several monosaccharides.

Wood Pulp Hydrolysates

The main constituent of wood is cellulose, with hemicellulose and lignin in addition. For complete characterization, the large polysaccharides need to be hydrolyzed to monosaccharides, which can then be identified and quantified.

Column: PL Hi-Plex Pb, 300x7.7mm (PL1170-6820)
Eluent: Water
Flow Rate: 0.6ml/min
Temp: 70°C
Detector: RI

KEY
1. Glucose
2. Xylose
3. Galactose
4. Arabinose
5. Rhamnose
6. Mannose



PL Hi-Plex Applications - Organic Acids

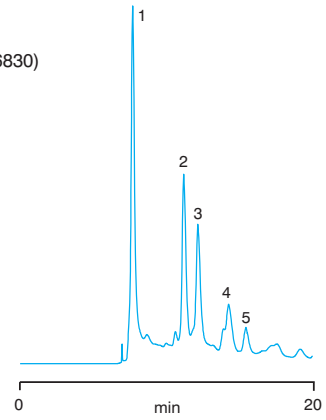
Where the samples to be analysed contain organic acids or acids in the presence of neutral mono- or disaccharides, the PL Hi-Plex H column is preferred. The column can be run with either water for the carbohydrate analysis or dilute acid if carbohydrate and organic acid analysis is required. The most commonly used eluent is dilute sulfuric acid.

Analysis of Organic Acids in Wine

The composition of the organic acids can be indicative of the age and state of the wine. Some wines are affected by secondary fermentations which may modify the taste and quality of the wine. These secondary fermentations can be spontaneous, such as the malo-lacto fermentation, or as with the conversion of ethanol to acetic acid caused by bacteria from the genus *Gluconobacter* or *Acetobacter.*

Sample: Chardonnay
Column: PL Hi-Plex H, 300x7.7mm (PL1170-6830)
Eluent: 5mM H_2SO_4
Flow Rate: 0.6ml/min
Detector: UV, 210nm

KEY
1. Anthocyanins
2. Tartaric acid
3. Malic acid
4. Succinic acid
5. Acetic acid

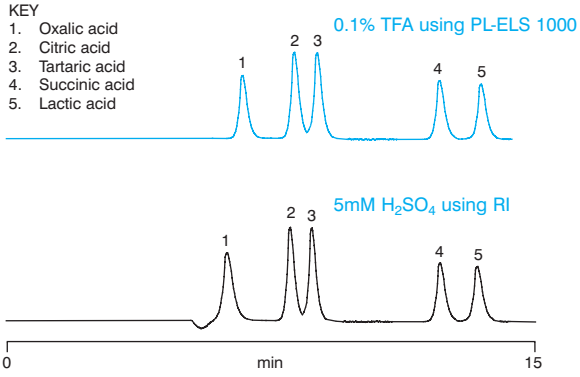


Organic Acid Analysis

The use of trifluoroacetic acid (TFA), a volatile acid, was investigated as an alternative to sulfuric acid for the analysis of organic acids. Comparison of the separations of 5 standard organic acids achieved with a 5mM sulfuric acid eluent and a 0.1% TFA eluent demonstrated similarities of elution times, peak symmetry and width. Use of an evaporative light scattering detector (PL-ELS 1000) is therefore feasible with a volatile modifier such as TFA.

Column: PL Hi-Plex H, 300x7.7mm (PL1170-6830)
Eluent: Water with acid as specified
Flow Rate: 0.6ml/min
Temp: 60°C
Detectors: PL-ELS 1000, RI
(neb=80°C, evap=90°C, gas=0.7 SLM)

KEY
1. Oxalic acid
2. Citric acid
3. Tartaric acid
4. Succinic acid
5. Lactic acid



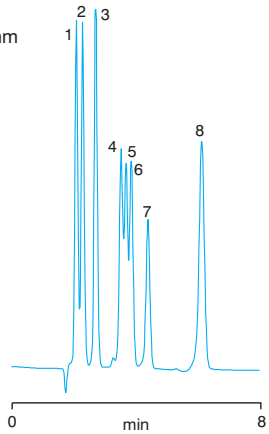
Fermentation Analysis - Rapid Profiling

The progress of a fermentation requires monitoring to ensure that there are sufficient substrates for the fermentation to continue at its optimum level, or prevent the build-up of toxic products which can slow down or even halt a fermentation. The build-up of a fermentation product in the culture media can have a negative feed-back effect on its production, therefore it is particularly important to obtain data quickly.

Using the PL Hi-Plex H Fast Acid Column in 100x7.7mm column dimensions, regular sampling can be done of both sugar alcohol and acid content, and results produced in just a few minutes.

Column: PL Hi-Plex H Fast Acid Column, 100x7.7mm (PL1170-2823)
Eluent: 1mM H_2SO_4
Flow Rate: 0.7ml/min
Temp: 57°C
Detector: RI

KEY
1. Maltotriose
2. Maltose
3. Glucose
4. Succinic acid
5. Lactic acid
6. Glycerol
7. Acetic acid
8. Ethanol



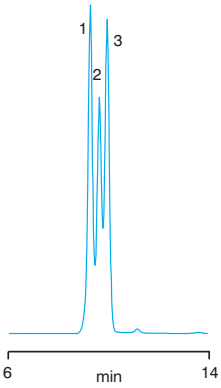
Glucose/Fructose/Malic Acid Analysis

To analyse the sugar content of wine, it is necessary to separate glucose, fructose and malic acid: if the malic acid co-elutes with the glucose, it results in a false indication of sweetness. Analysis of malic acid can also show the age of a wine or the occurance of malo-lacto fermentation.

Analysis conditions, particularly temperature and flow rate, must be carefully optimized to ensure separation. The strength of the acid eluent also affects the resolution.

Column: PL Hi-Plex H, 300x7.7mm (PL1170-6830)
Eluent: 5mM H_2SO_4
Flow Rate: 0.6ml/min
Temp: 76°C
Detector: RI

KEY
1. Glucose
2. Malic acid
3. Fructose



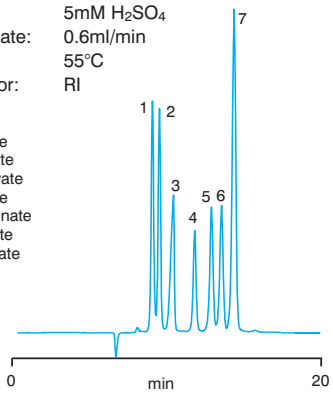
PL Hi-Plex Applications
Bio / Higher Oligosaccharides

Compounds of Physiological Significance

Analysis of blood serum can be an important indicator of health: diabetes can be identified by high blood lactate levels, and heavy metal poisoning by elevated pyruvate levels. PL Hi-Plex H is the column of choice for the analysis of complex biological fluids, as samples can often be analysed after minimal sample clean-up.

Column: PL Hi-Plex H, 300x7.7mm (PL1170-6830)
Eluent: 5mM H_2SO_4
Flow Rate: 0.6ml/min
Temp: 55°C
Detector: RI

KEY
1. Citrate
2. Tartrate
3. Pyruvate
4. Borate
5. Succinate
6. Lactate
7. Formate



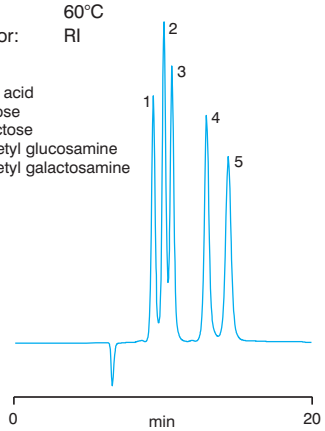
In addition to the analysis of neutral monosaccharides and organic acids, the PL Hi-Plex H column can also be used to identify and quantify acetylated amino sugars.

Protein Sugars Analysis

The carbohydrate and amino acid chains of membrane glycoproteins are often linked via acetylated amino sugars. Separation of these linkage molecules in hydrolyzed glycoprotein samples can be acheived using PL Hi-Plex H columns.

Column: PL Hi-Plex H, 300x7.7mm (PL1170-6830)
Eluent: 5mM H_2SO_4
Flow Rate: 0.6ml/min
Temp: 60°C
Detector: RI

KEY
1. Sialic acid
2. Glucose
3. Galactose
4. N-Acetyl glucosamine
5. N-Acetyl galactosamine



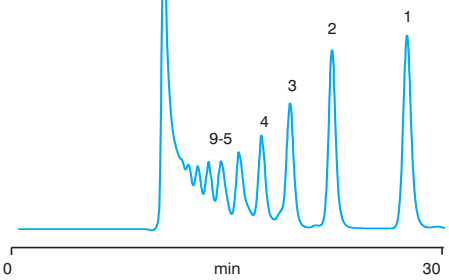
For rapid oligosaccharide profiling, the 4% crosslinked material is used. The PL Hi-Plex Na is suitable for the rapid analysis of up to approx. Dp 9.

Corn Syrup

The sweetness of corn syrup depends on the proportion of glucose in the syrup; the greater the degree of hydrolysis, the greater the proportion of glucose, and the sweeter the corn syrup.

Eluent: Water
Flow Rate: 0.3ml/min
Temp: 80°C
Detector: RI

KEY
1. Dp1
2. Dp2
3. Dp3
4. Dp4
5. Dp5
6. Dp6
7. Dp7
8. Dp8
9. Dp9
10. Dp10
11. Dp11
12. Dp12
13. Dp13
14. Dp14



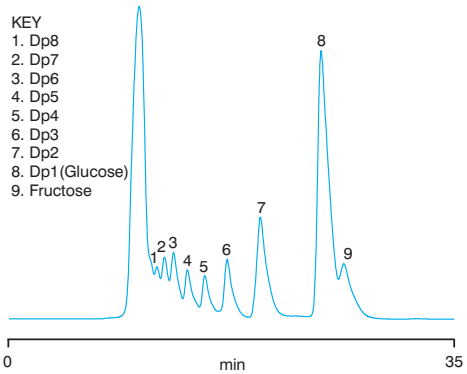
PL Hi-Plex Na,
300x7.7mm, 11 bar

Sports Drink

Beverages designed to give instant energy for sporting activity are becoming increasingly popular. They are intended to be absorbed more quickly than conventional beverages because they are in balance with the body's fluids, thereby eliminating osmotic factors in their uptake.

Sample: High energy orange flavor non-carbonated sports drink
Column: PL Hi-Plex Na, 300x7.7mm (PL1171-6140)
Eluent: Water
Flow Rate: 0.3ml/min
Temp: 80°C
Detector: RI

KEY
1. Dp8
2. Dp7
3. Dp6
4. Dp5
5. Dp4
6. Dp3
7. Dp2
8. Dp1 (Glucose)
9. Fructose



PL Hi-Plex Columns - Ordering Information

PL Hi-Plex Resin Based Columns

Product Name	Crosslink Content	Particle Size	Counter Ion	Dimensions	Part No.
PL Hi-Plex Ca	8%	8µm	Ca^{2+}	300x7.7mm	PL1170-6810
PL Hi-Plex Ca USP Column	8%	8µm	Ca^{2+}	250x4.0mm	PL1570-5810
PL Hi-Plex Pb	8%	8µm	Pb^{2+}	300x7.7mm	PL1170-6820
PL Hi-Plex H	8%	8µm	H^{+}	300x7.7mm	PL1170-6830
PL Hi-Plex H Fast Acid Column	8%	8µm	H^{+}	100x7.7mm	PL1170-2823
PL Hi-Plex Na	4%	10µm	Na^{+}	300x7.7mm	PL1171-6140

PL Hi-Plex Guard Cartridges

Product Name	Dimensions	Part No.
PL Hi-Plex Ca	5x3mm (x2)	PL1670-0810
PL Hi-Plex Pb	5x3mm (x2)	PL1670-0820
PL Hi-Plex H	5x3mm (x2)	PL1670-0830
PL Hi-Plex Na	5x3mm (x2)	PL1671-0140
Guard Cartridge Holder	for 5x3mm cartridges	PL1310-0016

PL Hi-Plex Guard Columns

Product Name	Dimensions	Part No.
PL Hi-Plex Ca	50x7.7mm	PL1170-1810
PL Hi-Plex Pb	50x7.7mm	PL1170-1820
PL Hi-Plex H	50x7.7mm	PL1170-1830
PL Hi-Plex Na	50x7.7mm	PL1171-1140

PL Hi-Plex Accessories

Product Name	Part No.
Frit (2µm) Kit (Pk of 5) for swaged columns, 7.7mm ID, Ca, H, Pb	PL1310-0006
Frit (5µm) Kit (Pk of 5) for swaged columns, 7.7mm ID, Na	PL1310-0013
Column Connecting Nuts (Pk of 5), 1/16" tube	PL1310-0007
Tubing Ferrules (Pk of 5), 1/16" tube	PL1310-0008
Swaged End Fitting, 7.7mm ID	PL1310-0009

Technical Bulletins for Applications Data

Request a copy of our Technical Bulletin CD from your local PL office.

Chromatography Products from Polymer Laboratories

This catalog has been designed as an easy to use guide to Polymer Laboratories' range of chromatographic columns, standards, media, instrumentation and software.

For further information, please visit our website at www.polymerlabs.com.

Polymer Laboratories, now a part of Varian, Inc. A Customer Orientated Company

ISO 9001:2000 Standard

Polymer Laboratories has recently been recognized as a customer-focussed company by the receipt of the enhanced customer satisfaction standard, ISO 9001:2000 Standard.

State of the Art Chemical Engineering

To meet customer demand, Polymer Laboratories opened its new, state of the art chemical engineering production plant in 2002, and established its place as one of the world's largest suppliers of high performance polymeric particles. This ensures consistent, reliable supply of top quality chromatographic products to our customers.

Polymer Laboratories
Now a part of Varian, Inc.

VARIAN

UK / International
Polymer Laboratories
(for GPC/instrumentation)
Now a part of Varian, Inc.
Church Stretton, UK
Tel: (+44) 01694 723581
Email: Sales@polymerlabs.com

Varian Ltd
(for HPLC columns & media)
Yarnton, UK
Tel: (+44) 01865 291500
Email: uk.consumablesales@varianinc.com

For your local sales office, please contact Varian Polymer Laboratories at Church Stretton or Varian Export Department at Varian B.V., Middelburg, NL.

North America
Polymer Laboratories
Varian, Inc.
(for GPC/instrumentation)
Amherst, USA
Tel: toll free 800 767 3963
Or tel: 413 253 9554
Email: SalesUS@polymerlabs.com

Varian, Inc.
(for HPLC columns & media)
Lake Forest, USA
Tel: 800 854 0277
Or tel: 949 770 9381
Email: helpdesk.us@varianinc.com

Australia
Varian Australia Pty. Ltd
Tel: (+61) 03 9560 7133
Email: sales.Australia@varianinc.com

Belgium
Varian Belgium NV SA
Tel: (+32) 015 556460
Email: varian.belgie@varianinc.com

France
Varian S.A.
Tel: (+33) 01 69 86 38 64
Email: fr.consommables@varianinc.com

Germany
Varian Deutschland GmbH
Tel: (+49) 06151 703292
Email: analyticalsupplies.de@varianinc.com

Italy
Varian S.p.A
Tel: (+39) 011 997 9317
Email: consumable.products.it@varianinc.com

The Netherlands
Varian B.V.
Tel: (+31) 011 8671500
Email: varian.nederland@varianinc.com

Spain
Varian Ibérica S.L.
Tel: (+34) 091 472 7612
Email: consumibles.es@varianinc.com

Sweden
Varian AB
Tel: (+46) 08 555 36 200
Email: se.info@varianinc.com

CS304/E/11.07 SI-1086/E/11.07

Your local distributor is:

Smart Products for Synthesis, Analysis & Purification

Since 1976