

Polymer Matrix Columns



Polyamino HILIC
CarboPac H⁺ /Ca²⁺ /OA-6
LEC KS-1000/KS-10000
Protein SEC-400/SEC-1000
GFC SB-2000/SB-15000
GPC KF-150/KF-300/KF-500
GPC KF-1500/KF-5000



Dikma Technologies Inc.
www.dikmatech.com

Dikma Polyamino HILIC

Dikma Polyamino HILIC is bonded with amino functional groups on porous polyvinyl alcohol polymer particles, providing a wide pH range. In the analysis of monosaccharides and oligosaccharides, Dikma Polyamino HILIC exhibits superior durability and reproducibility compared to silica-based amino columns, making it particularly suitable for the analysis of carbohydrate substances.

- Polymer-based packing material provides excellent chemical stability and minimum deterioration over extended time period
- Particularly suitable for saccharides analysis
- Strong alkali resistance, can be washed with alkaline solutions
- Strong water resistance, suitable for high aqueous phase mobile phases
- Low bleed, suitable for ELSD, ESI and LC/MS
- Offers equivalent performance to NH₂P-50 2D, suitable for the determination of glyphosate and its metabolite residues according to SN/T 4655-2016
- Fulfills USP-NF L82 requirements

Dikma Polyamino HILIC Filler Specifications

Functional Group	Base Material	pH Range	Temperature Resistance Range (°C)	Flow Rate (mL/min)	Maximum Pressure (MPa/column)	Plate Number (TP/column)	Shipping Solvent
Amino	Polyvinyl alcohol	2-3	4-50	0-1.5	15	Above 7500	Acetonitrile: Water=75:25

* Usually used flow rate: 0.5-1.0 mL/min; When used frequently, it is recommended to use under normal flow rate.

Dikma Polyamino HILIC is very suitable for sugar analysis

Both amide and amino columns can be used to analyze carbohydrate substances through hydrophilic interactions. However, due to the non-alkaline environment inside amide-based columns, analysis must be conducted under high-temperature conditions. In contrast, Dikma Polyamino HILIC, which is bonded with weakly basic amino groups, creates an alkaline environment within the column. Therefore, even at room temperature, carbohydrate analysis can be performed without causing end-group isomer separation.

Column: Listed on chromatograms

Dimension: 250 x 4.6 mm, 5 μm

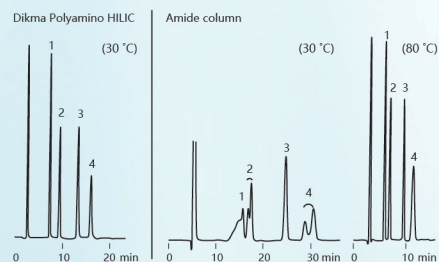
Mobile Phase: MeCN:H₂O = 75:25

Flow Rate: 1.0 mL/min

Detection: RI

Sample:

1. Fructose
2. Glucose
3. Sucrose
4. Maltose



Dikma Polyamino HILIC is a polymer-based packing material with strong alkali resistance. It does not undergo the time-dependent degradation observed in silica-based amino columns. Additionally, it can be regenerated by washing with alkaline solutions. The graph below illustrates the comparison of time-dependent changes between Dikma Polyamino HILIC and a silica-based amino column. Even after 180 hours of continuous flow, Dikma Polyamino HILIC shows no signs of degradation, while the silica-based amino column exhibits deteriorating peak shapes due to time-dependent degradation.

Column: Listed on chromatograms

Dimension: 250 x 4.6 mm, 5 μm

Mobile Phase: MeCN:H₂O = 75:25

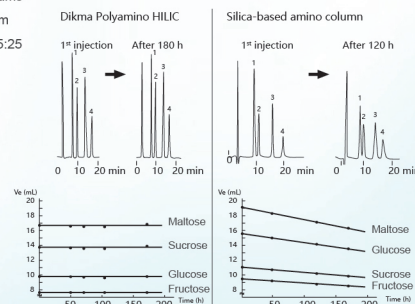
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 30 °C

Sample:

1. Fructose
2. Glucose
3. Sucrose
4. Maltose



Monosaccharides

Column: Dikma Polyamino HILIC 250 x 4.6 mm, 5 μm (Cat.No: 99301)

Mobile Phase: MeCN:H₂O: H₃PO₄ = 80:19:1 (Left)

MeCN:H₂O = 80:20 (Right)

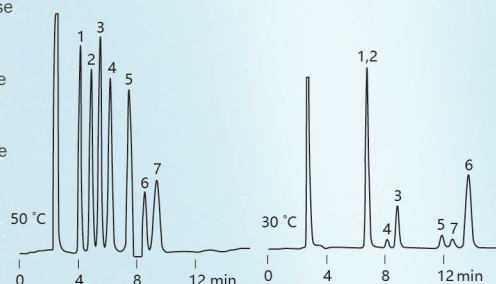
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 50 °C, 30 °C

Sample:

1. Rhamnose
2. Fucose
3. Xylose
4. Arabinose
5. Mannose
6. Glucose
7. Galactose



Maltooligosaccharides

Column: Dikma Polyamino HILIC 250 x 4.6 mm, 5 μm (Cat.No: 99301)

Mobile Phase: MeCN:H₂O = 60:40

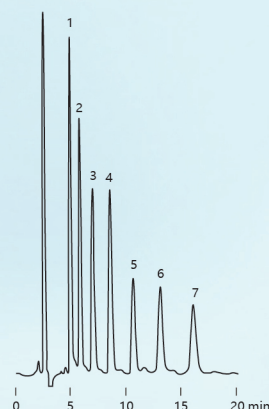
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 30 °C

Sample:

1. Glucose
2. Maltose
3. Maltotriose
4. Maltotetraose
5. Maltopentaose
6. Maltohexaose
7. Maltoheptaose



Dikma CarboPac H⁺

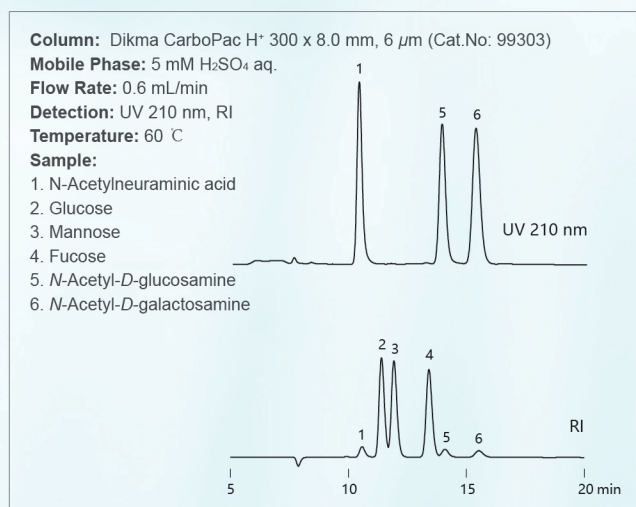
The Dikma CarboPac H⁺ column is packed with hydrogen-type sulfonated crosslinked styrene-divinylbenzene copolymer, utilizing a combination of size exclusion and ion exclusion methods to separate sugars and organic acids.

- Simultaneous analysis of saccharides and organic acids
- Separates neutral sugars by size exclusion mode and organic acids by ion exclusion mode
- Suitable for the analysis of uronic and aldonic acids
- Fulfill USP-NF L17 and L22 requirements

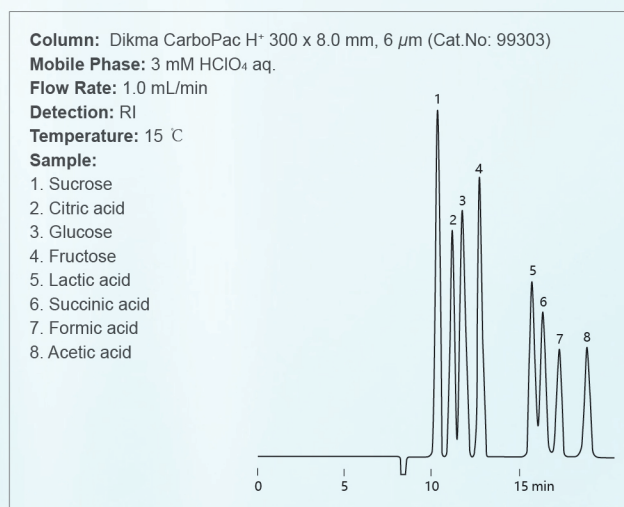
Dikma CarboPac H⁺ Filler Specifications

Base Material	Counter Ion	Separation Mode	Exclusion Limit	Operating Temperature (°C)	Flow Rate (mL/min)	Maximum Pressure (Mpa)	Plate Number (TP/column)	Shipping Solvent
Styrene divinylbenzene copolymer	Sulfo (H ⁺)	Size exclusion Ion exclusion	1000	≤95	0.5-1.0 Maximum usage flow rate 1.5	5	Above 17000	Water

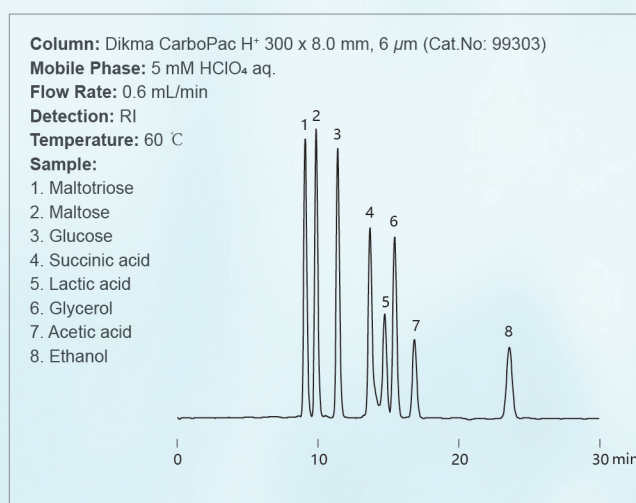
Monosaccharides Composing Sugar Chain



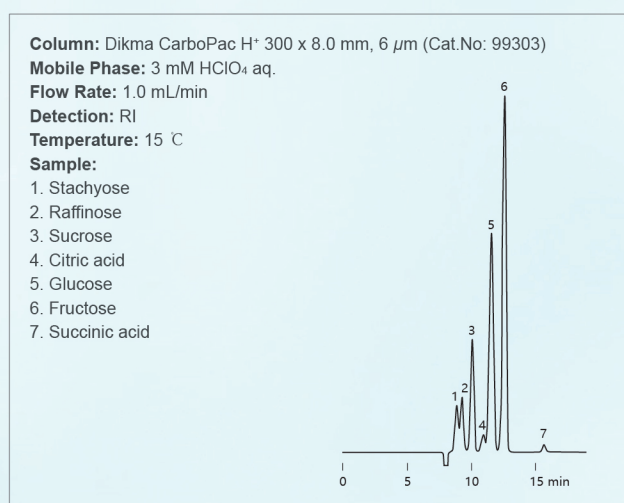
Saccharides and Organic Acids



Saccharides and Organic Acids



Soft Drink



Standard operating conditions:

Mobile phase: 0.01 N sulfuric acid Flow rate: 0.5~1.0 mL/min Column temperature: 50~60 °C

Mobile phase usage range: water~0.05 N sulfuric acid

Note: Do not use organic reagents such as methanol

Dikma CarboPac Ca²⁺

The Dikma CarboPac Ca²⁺ column is filled with calcium-type sulfonated crosslinked styrene-divinylbenzene copolymer. It utilizes a combination of ligand exchange and size exclusion methods to separate carbohydrate substances.

- Filled with calcium-type sulfonated crosslinked styrene-divinylbenzene copolymer
- Neutral sugars can be analyzed using water as the mobile phase
- Fulfills USP-NF L19 and L22 requirements

Dikma CarboPac Ca²⁺ Filler Specification

Base Material	Counter Ion	Separation Mode	Exclusion Limit	Operating Temperature (°C)	Flow Rate (mL/min)	Maximum Pressure(Mpa)	Plate Number (TP/column)	Shipping Solvent
Styrene divinylbenzene copolymer	Sulfo (Ca ²⁺)	Ligand exchange Size exclusion	1000	≤95	0.5-1.0 Maximum usage flow rate 1.5	4	Above 13000	Water

Associated Saccharides in Raffinose Synthetic Pathway

Column: Dikma CarboPac Ca²⁺ 300 x 8.0 mm, 6 μm (Cat.No: 99304)

Mobile Phase: H₂O

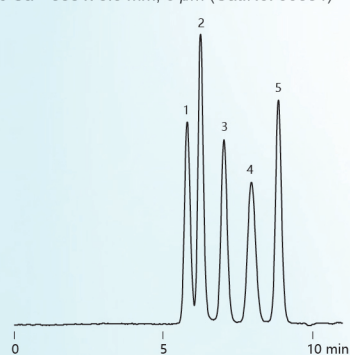
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 80 °C

Sample:

1. Raffinose
2. Sucrose
3. Galactinol
4. Galactose
5. *myo*-Inositol



Oligosaccharides

Column: Dikma CarboPac Ca²⁺ 300 x 8.0 mm, 6 μm (Cat.No: 99304)

Mobile Phase: H₂O

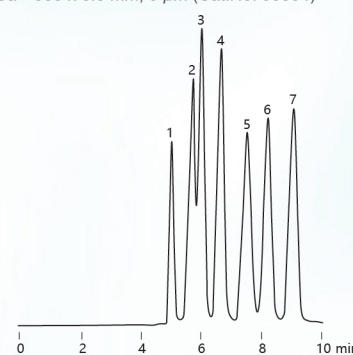
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 80 °C

Sample:

1. Dextran T10
2. Stachyose
3. Raffinose
4. Melibiose
5. Glucose
6. Galactose
7. Arabinose



Saccharides and Sugar alcohols

Column: Dikma CarboPac Ca²⁺ 300 x 8.0 mm, 6 μm (Cat.No: 99304)

Mobile Phase: H₂O

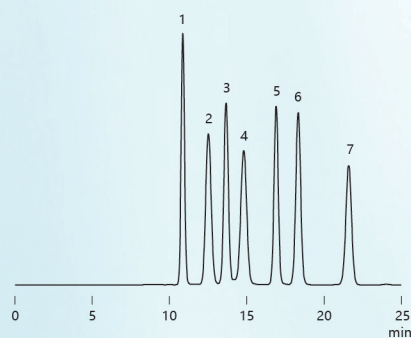
Flow Rate: 0.6 mL/min

Detection: RI

Temperature: 85 °C

Sample:

1. Sucrose
2. Glucose
3. Lactitol
4. Fructose
5. *meso*-Erythritol
6. Mannitol
7. Sorbitol



Apple Juice

Column: Dikma CarboPac Ca²⁺ 300 x 8.0 mm, 6 μm (Cat.No: 99304)

Mobile Phase: H₂O

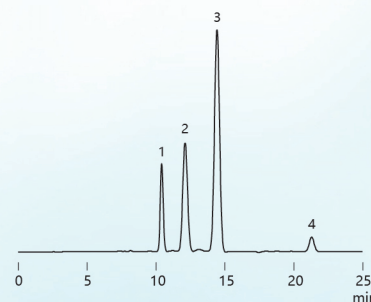
Flow Rate: 0.6 mL/min

Detection: RI

Temperature: 85 °C

Sample:

1. Sucrose
2. Glucose
3. Fructose
4. Sorbitol



Acesulfame K

Column: Dikma CarboPac Ca²⁺ 300 x 8.0 mm, 6 μm (Cat.No: 99304)

Mobile Phase: 10 mM CaSO₄ aq.

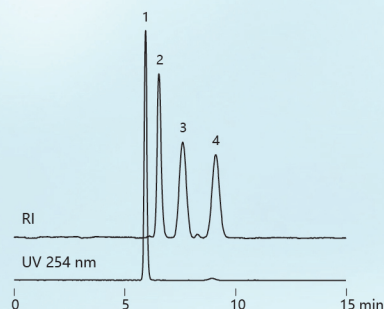
Flow Rate: 1.0 mL/min

Detection: RI, UV 254 nm

Temperature: 80 °C

Sample: 10 μL

1. Acesulfame K
2. Sucrose
3. Glucose
4. Fructose



Standard operating conditions:

Mobile phase: water Flow rate: 0.5~1.0 mL/min Column temperature: 70~80 °C Mobile phase usage range: water~20% acetonitrile/water

Dikma LEC KS-1000 / LEC KS-10000 ^{New}

Dikma LEC KS series is specifically designed for separation and analysis of sugars. A strong acidcation exchange type packing gel, prepared from a rigid resin of styrene divinylbenzene copolymer provides amixed separation mode. Smaller sugars, such as mono and disaccharides, are separated by a combination of ligand exchange and size exclusion modes. On the other hand, larger sugars, such as oligo saccharides and polysaccharides, are separated by size exclusion mode, and thus it is suitable for molecular weight analysis. Columns with diferent exclusion limits are available.

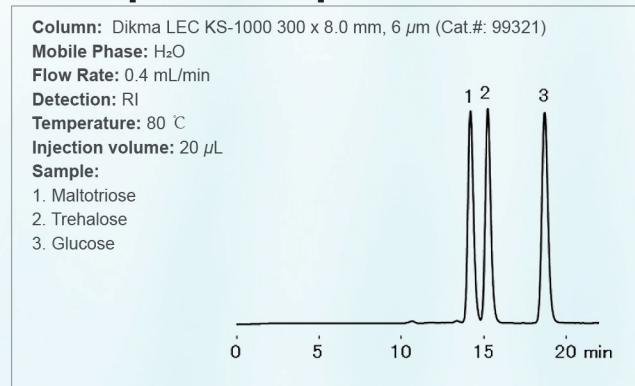
- Specifically designed for separation and analysis of sugars
- Separates saccharides by combination of ligand exchange and size exclusion modes
- Only water is required for the analysis of neutral sugars
- Dikma LEC KS-1000 is suitable for the determination of trehalose in the USP-NF Method
- Dikma LEC KS-10000 fulfill GB 5009.88-2023 requirements
- Dikma LEC KS-1000 and LEC KS-10000 fulfill USP-NF L22 and L58 requirements

Dikma LEC KS-1000 / LEC KS-10000 Filler Specification

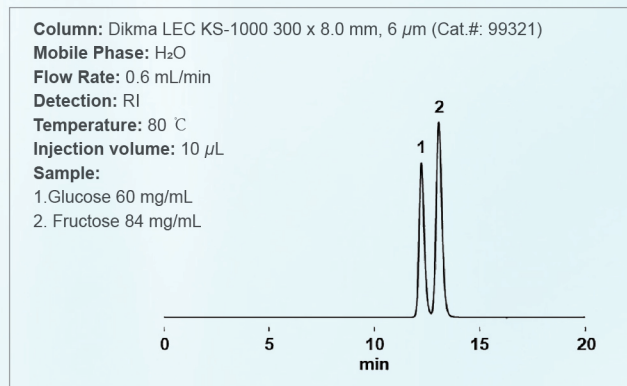
Column	Base Material	Functional Group (Counter Ion)	Separation Mode	Exclusion Limit (Pullulan)	Temperature Resistance °C	Flow Rate* mL/min	Maximum Pressure (MPa/column)	Plate Number (TP/column)	Shipping Solvent
LEC KS-1000	Styrene divinylbenzene copolymer	Sulfo (Na ⁺)	Combination of ligand exchange & Size exclusion	1,000	≤85	0-1.5	5.0	≥17000	H ₂ O
LEC KS-10000				10,000					

* Standard operating conditions: Mobile phase: H₂O Flow rate: 0.5~1.0 mL/min Column temperature: 50~85 °C

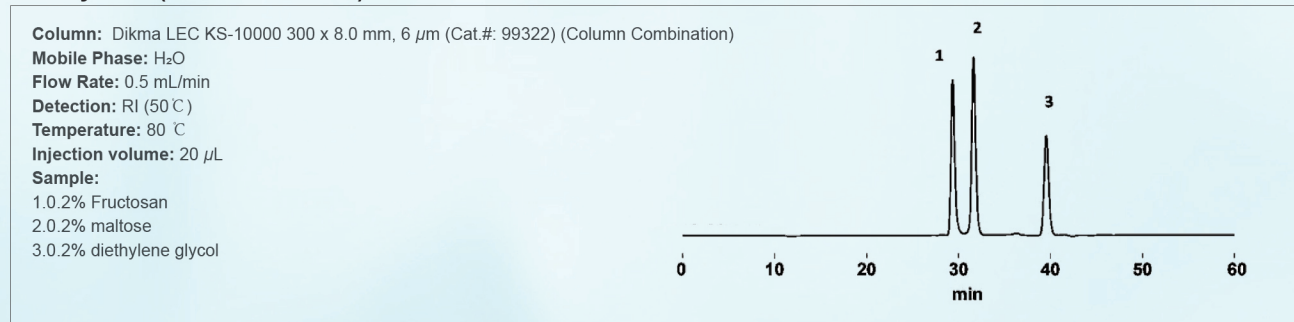
Trehalose [USP-NF Method]



Fructose Glucose Syrup (Japanese Pharmaceutical Excipients Method)



Dietary fiber (GB 5009.88-2023)



Standard operating conditions:

Mobile phase: water Flow rate: 0.5~1.0 mL/min Column temperature: 70~80 °C Mobile phase usage range: water~20% acetonitrile/water

Dikma CarboPac OA-6

The column, constructed using styrene-divinylbenzene copolymer as the filler material, operates on an ion exclusion and distribution adsorption separation mode. It is designed for the separation of low molecular weight organic acids, as well as water-soluble organic compounds like methanol, aldehydes, and nitriles.

- Columns suitable for the analysis of organic acids
- Separates compounds by ion exclusion mode and reversed phase mode
- Highly selective when used with post column method
- Fulfills USP-NF L17 and L22 requirements

Dikma CarboPac OA-6 Filler Specifications

Base Material	Bonded Phase	Separation Mode	Temperature Range (°C)	Flow Rate (mL/min)	Maximum Pressure (MPa)	Plate Number (TP/column)	Shipping Solvent
Styrene divinylbenzene copolymer	Sulfonyl group	Ion exclusion Distributive adsorption	40-85	0-1.5	5.0	Above 17000	0.1% phosphoric acid aqueous solution

Organic Acids

Column: Dikma CarboPac OA-6 300 x 8.0 mm, 6 μ m (Cat.No: 99306) x 2

Mobile Phase: 6 mM HClO₄ aq.

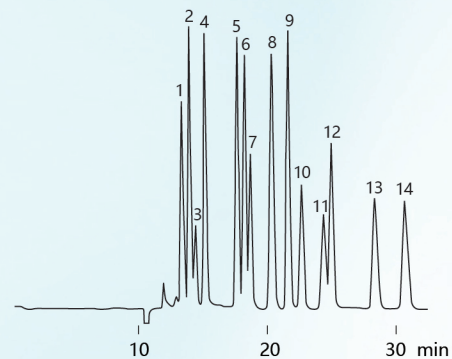
Flow Rate: 1.0 mL/min

Detection: VIS 430 nm (for post-column method)

Temperature: 50 °C

Sample:

- | | |
|------------------|-----------------------|
| 1. Citric acid | 8. Fumaric acid |
| 2. Tartaric acid | 9. Acetic acid |
| 3. Pyruvic acid | 10. Levulinic acid |
| 4. Malic acid | 11. Pyroglutamic acid |
| 5. Succinic acid | 12. Propionic acid |
| 6. Glyconic acid | 13. Isobutyric acid |
| 7. Lactic acid | 14. n-Butyric acid |



Dikma IEC SP-8-5000

- Suitable for the analysis of large molecules such as proteins, peptides, DNA, and RNA
- Polymer-based packing material, pH range 2 - 12
- Suitable for the detection of Thaumatin in food additives, GB 1886.321-2021

Dikma IEC SP-8-5000 Filler Specifications

Substrate	Ion Exchange Group	Ion Exchange Capacity (meq/g)	Maximum Pressure (MPa)	Maximum Flow Rate (mL/min)	Available Temperature	Available pH Range	Available Organic Solvent Concentration	Available Salt Concentration	Storage Solvent
Strong cation exchange resin	Sulfopropyl	0.4	2.0	1.5	10 ~ 50	2 ~ 12	≤ 20 %	20 mM ~ 1.0 M	50 mM Na ₂ SO ₄ aq.

Standard Proteins

Column: Dikma IEC SP-8-5000 75 x 8.0mm (Cat.No: 99310)

Mobile Phase: A: 20 mM Sodium phosphate buffer (pH 7.0) B: A+0.5 M NaCl

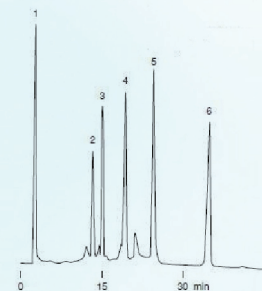
Gradient: 0-60 min (A to B)

Detection: UV 280 nm

Temperature: Ambient

Sample:

- | | |
|-------------------|---------------------------------|
| 1. Myoglobin | 4. α -Chymotrypsinogen A |
| 2. Trypsinogen | 5. Cytochrome c |
| 3. Ribonuclease A | 6. Lysozyme |



Dikma Protein SEC-400 / SEC-1000

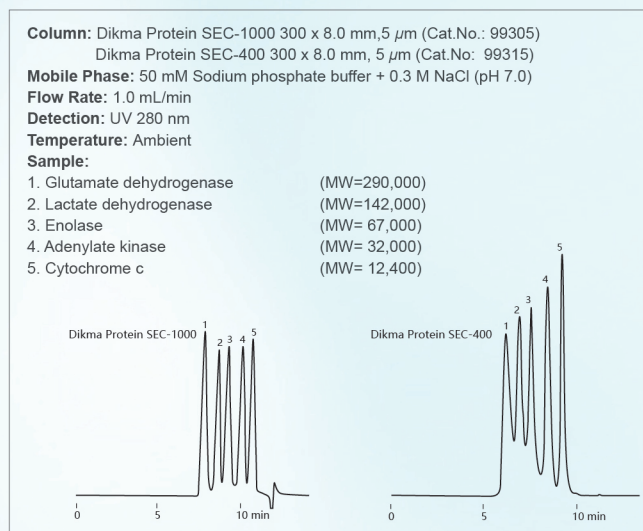
The Dikma Protein SEC series features silica-based aqueous gel columns that operate on a size exclusion separation mode. These columns are suitable for separating proteins, enzymes, and peptides.

- Silica-based packed columns for aqueous SEC (GFC) analysis
- Suitable for the analysis of proteins, enzymes and peptides
- Fulfills USP-NF L20, L33, and L59 requirements

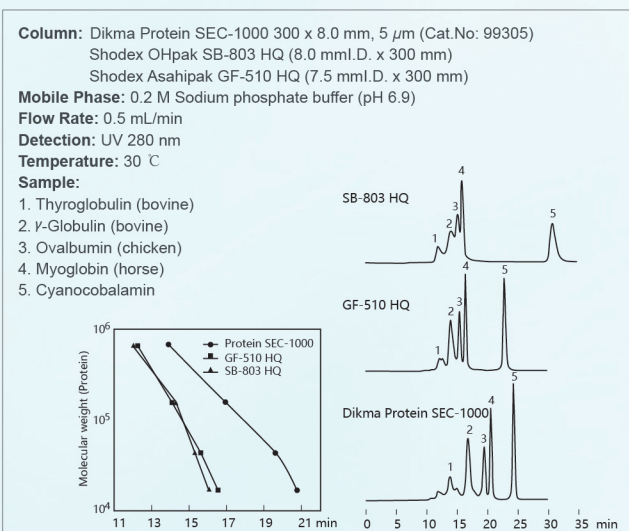
Dikma Protein SEC-400 / SEC-1000 Filler Specification

Product Name	Pore Size (Å)	Separation Mode	Exclusion Limit	pH Range	Operating Temperature (°C)	Flow Rate (mL/min)	Maximum Pressure (Mpa)	Plate Number (TP/column)	Shipping Solvent
Protein SEC-400	400	Size exclusion	Prulan 60000 Protein 150000	3-7.5	45	1.0 Maximum usage flow rate 1.5	5	Above 21000	Water
Protein SEC-1000	1000		Prulan 170000 Protein 700000						

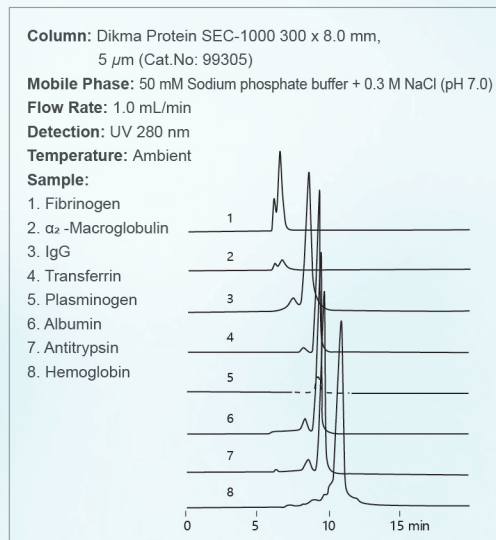
Standard Proteins



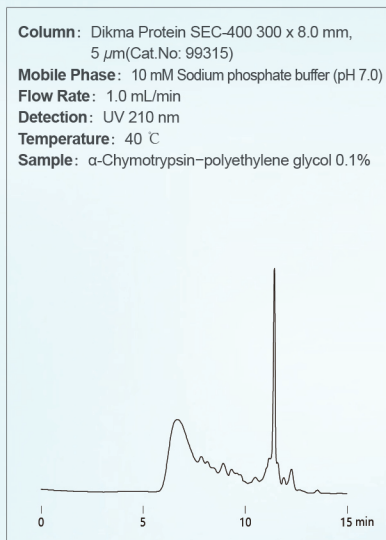
Comparison of Chromatograms of Proteins



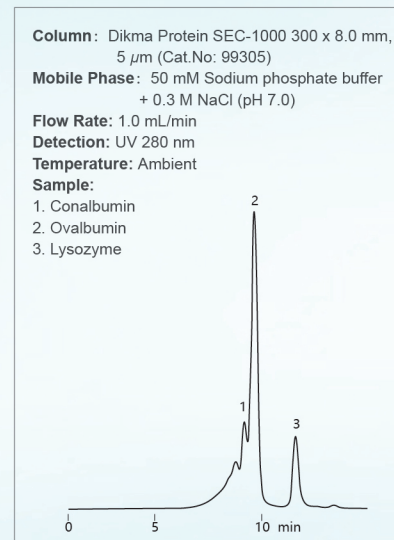
Proteins from Human Serum



PEG-modified Chymotrypsin



Crude Albumin from Chicken Egg



Standard operating conditions:

Mobile phase: phosphate buffer, acetic acid buffer, etc. (maximum salt concentration 0.3 M) Flow rate: 1.0 mL/min
Column temperature: room temperature Column number: commonly used in series with 2-4 columns

Dikma GFC SB-2000^{New} / GFC SB-15000

A water-soluble SEC (GFC) chromatographic column filled with polyhydroxymethacrylate, with a size exclusion separation mode, is suitable for the determination of molecular weight over a wide range.

- Polymer-based packed columns for aqueous SEC (GFC) analysis
- Supports a wide range of molecular weight sample analysis
- The eluent can be replaced with DMF enabling the analysis of polar polymers
- Method using GFC SB-2000 for gelatin's mean molecular weight determination is comparable with PAG method (Ver. 10, Japan)
- Fulfills USP-NF L38 and L39 requirements

Dikma GFC SB-2000^{New} / GFC SB-15000 Filler Specification

Column	Base Material	Separation Mode	Exclusion Limit (pullulan)	pH Range	Temperature Resistance °C	Flow Rate* mL/min	Maximum Pressure (MPa/column)	Plate Number (TP/column)	Shipping Solvent	Maximum Usable Concentration
GFC SB-2000N	Polyhydroxymethacrylate	Size exclusion	1,000,000	3-10	4-70	0-1.2	5.0	≥16000	0.02%NaN ₃ aqueous solution	Below 0.5M(boric acid buffersolution is not recommended)
GFC SB-15000			20,000,000				3.0	≥12000		

*Usually used flow rate: 0.5-1.0 mL/min, flow rate during solvent displacement: < 0.3 mL/min

Heparin

Column: Dikma GFC SB-2000 300 x 8.0 mm, 10 μm

Cat.No.: 99313

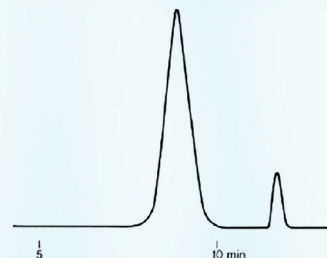
Mobile Phase: 10.1 M NaCl

Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 40 °C

Sample: Heparin



Colominic acid sodium salt, Poly[2,8-(N-acetylneuraminic acid)]

Column: Dikma GFC SB-2000 300 x 8.0 mm, 10 μm

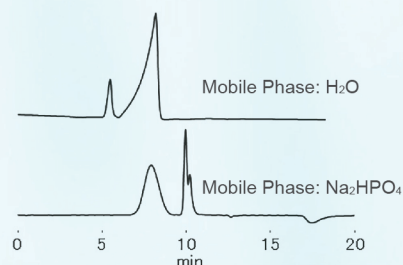
Cat.No.: 99313

Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 30 °C

Sample: Colominic acid sodium salt



Polyadenylic acid

Column: Dikma GFC SB-15000 300 x 8.0 mm, 13 μm (Cat.No: 99307)

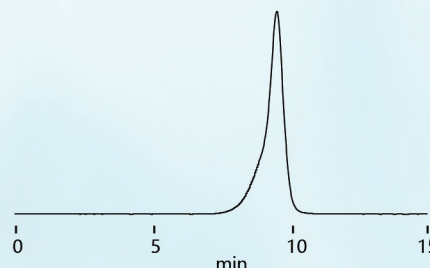
Mobile Phase: 10 mM Sodium phosphate buffer (pH 4.6)

Flow Rate: 1.0 mL/min

Detection: UV 260 nm

Temperature: 30 °C

Sample: Polyadenylic acid, poly[A]_n 0.1 %



Permissible addition amount of polar organic solvent:

Methanol: 75%

Acetonitrile: 75%

N, N-Dimethylformamide: 100%

Dikma GPC KF-150 / KF-300 / GPC KF-500 / GPC KF-1500 / GPC KF-5000

The organic-phase gel column, filled with styrene-divinylbenzene copolymer, operates on a size exclusion separation mode. It is suitable for separating organic compounds and oligosaccharides in organic solvent systems. Additionally, it is well-suited for determining the molecular weight distribution of high-molecular-weight substances.

- Standard organic solvent SEC (GPC) column
- Base Material: Styrene divinylbenzene copolymer
- Suitable for separating organic compounds and oligosaccharides in organic solvent systems, as well as determining the molecular weight distribution of high-molecular-weight substances
- Can be used in multi-column series
- Fulfills USP-NF L21 requirements

Dikma KF-150 / GPC KF-300 / GPC KF-500 / GPC KF-1500 / GPC KF-5000 Filler Specifications

Product Name	Base Material	Pore Size (Å)	Separation Mode	Exclusion Limit (Polystyrene)	Maximum Temperature	Flow Rate* mL/min	Maximum Pressure (MPa)	Plate Number (TP/column)	Shipping Solvent
GPC KF-150	Styrene divinylbenzene copolymer	150	Size exclusion	5000	<60 Commonly used 40	0.5-1.0	3.5	Above 1800	Tetrahydrofuran (THF)
GPC KF-300		300		20000					
GPC KF-500		500		70000					
GPC KF-1500		1500		400000					
GPC KF-5000		5000		4000000				Above 11000	

* Maximum flow rate: 2.0 mL/min

PPG, Poly(propylene glycol)

Column: Dikma GPC KF-300 300 x 8.0 mm, 6 µm (Cat.No: 99308)

Mobile Phase: C₄H₈O

Flow Rate: 1 mL/min

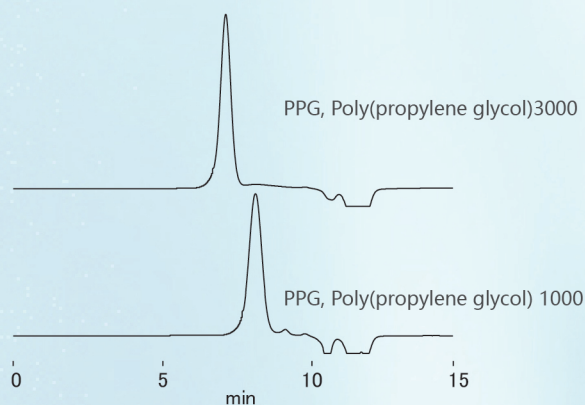
Detection: RI

Temperature: 30 °C

Sample:

PPG, Poly(propylene glycol) 3000

PPG, Poly(propylene glycol) 1000



Glyceryl stearate

Column: Dikma GPC KF-150 300 x 8.0 mm, 6 µm (Cat.No: 99316) *2

Mobile Phase: C₄H₈O

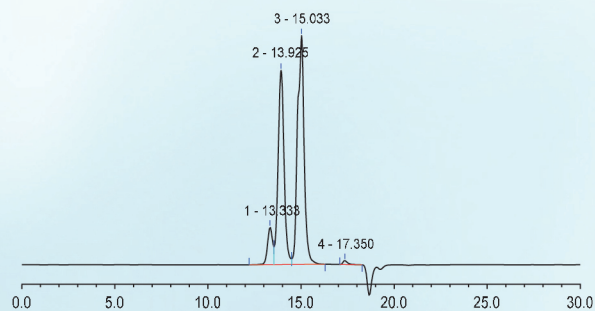
Flow Rate: 1.0 mL/min

Detection: RI

Temperature: 40 °C

Sample:

1. Triglycerides
2. Diglycerol ester
3. Monoglycerides+free fatty acids
4. Glycerol



Standard Operating Conditions:

Mobile Phase: Tetrahydrofuran (Please do not use water, ethanol, hexane, or any solvent that may cause shrinkage of the polystyrene filler.)

Flow Rate: 1.0 mL/min Column Temperature: Approximately 40 °C

Number of Columns: Depending on the experimental purpose and the nature of the sample, typically choose to use 2-4 columns in series



Column selection

Polymer Matrix Columns	Applications	USP No
Dikma Polyamino HILIC	Suitable for the analysis of carbohydrates, with better durability and reproducibility than silica gel based amino columns	L82
Dikma CarboPac H ⁺	Suitable for the analysis of uronic acid and uronic acid, enabling simultaneous analysis of sugars and organic acids	L17 L22
Dikma CarboPac Ca ²⁺	Neutral sugars can be analyzed using water as the mobile phase	L19 L22
Dikma LEC KS-1000	Specifically designed for separation and analysis of sugars	L22
Dikma LEC KS-10000		L58
Dikma Protein SEC-400	Applicable to the analysis of proteins, enzymes, and peptides	L20 L33 L59
Dikma Protein SEC-1000		
Dikma CarboPac OA-6	Suitable for the separation of low molecular weight organic acids and water-based organic compounds such as methanol, aldehydes, and nitriles	L17 L22
Dikma GFC SB-2000	Suitable for measuring molecular weight over a wide range	L38 L39
Dikma GFC SB-15000		
Dikma GPC KF-150	Suitable for the separation of organic compounds and oligomers in organic solvent systems, and for testing the molecular weight distribution of high molecular weight substances	L21
Dikma GPC KF-300		
Dikma GPC KF-500		
Dikma GPC KF-1500		
Dikma GPC KF-5000		

Ordering Information

Polymer Matrix Columns	Cat No	Similar with TSK	Similar with Shodex
Dikma Polyamino HILIC 250 x 4.6 mm, 5 μm	99301	TSKgel Amide-80 or TSKgel NH ₂ -100	NH ₂ P-50 4E
Dikma Polyamino HILIC 150 x 2.0 mm, 5 μm	99302		NH ₂ P-50 2D*
Dikma CarboPac H ⁺ 300 x 8.0 mm, 6 μm	99303	TSKgel SCX (H ⁺)	SUGAR SH1011
Dikma CarboPac Ca ²⁺ 300 x 8.0 mm, 6 μm	99304	—	SUGAR SC1011
Dikma Protein SEC-400 300 x 8.0 mm, 5 μm	99315	TSKgel G2000SWXL	KW-802.5
Dikma Protein SEC-1000 300 x 8.0 mm, 5 μm	99305	TSKgel G3000SWXL	KW-803
Dikma CarboPac OA-6 300 x 8.0 mm, 6 μm	99306	TSKgel SCX	RSpak KC-811
Dikma GFC SB-15000 300 x 8.0 mm, 13 μm	99307	TSKgel G6000PWXL	SB-806HQ
Dikma GFC SB-2000 300 x 8.0 mm, 10 μm	99313	TSKgel G4000PWXL	SB-804HQ
Dikma GPC KF-150 300 x 8.0 mm, 6 μm	99316	TSKgel G2000HXL	GPC KF-802
Dikma GPC KF-300 300 x 8.0 mm, 6 μm	99308	TSKgel G2500HXL	GPC KF-802.5
Dikma GPC KF-500 300 x 8.0 mm, 6 μm	99309	TSKgel G3000HXL	GPC KF-803
Dikma GPC KF-1500 300 x 8.0 mm, 7 μm	99311	TSKgel G4000HXL	GPC KF-804
Dikma GPC KF-5000 300 x 8.0 mm, 10 μm	99312	TSKgel G5000HXL	GPC KF-805
Dikma IEC SP-8-5000, 75 x 8.0 mm, 8 μm	99310	—	—
Dikma LEC KS-1000 300 x 8.0 mm, 6 μm	99321	—	KS-801
Dikma LEC KS-10000 300 x 8.0 mm, 6 μm	99322	—	KS-802

*NH₂P-50 2D is a designated chromatographic column by the SN/T 4655-2016 Determination of glyphosate and its metabolite residues in foodstuffs for export- HPLC-MS/MS method . Dikma Polyamino HILIC has the same performance and can act as substitutes.

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