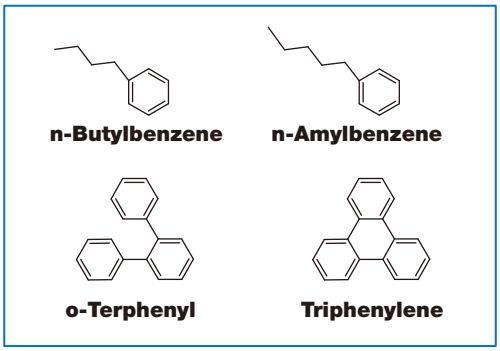
Comparison of Shodex Reversed Phase Chromatography (RPC) Column Features

ODS columns are the most popular reversed phase columns that are packed with silica-based octadecyl group. Shodex provides not only ODS columns but also polymer-based reversed phase columns with different functional groups. Please use following descriptions about the column features as guidelines to select suitable columns for your application purposes.

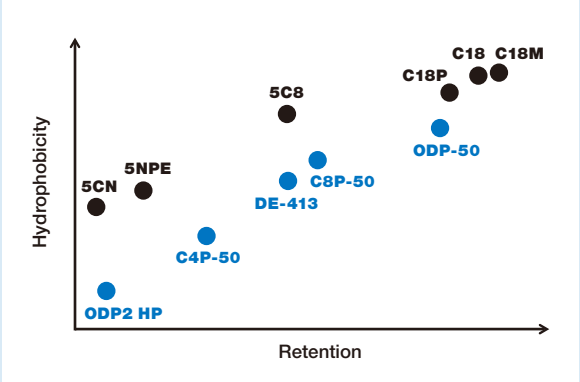
Features

ODP2 HP	• Provides a large theoretical plate number nearly twice as much as generally available polymer-based reversed phase columns do • Offers enhanced retention of high polar substances compared to ODS columns • Suitable for the analysis of small molecules such as pharmaceuticals in the presence of protein matrix • Ideal for LC/MS analysis of high polar compounds • Fulfills USP L39 requirements
ODP-50 **C8P-50** **C4P-50**	• Relatively large pore size is suitable for the analysis of amino acids, peptides, and proteins • Usable in a wide pH range from pH 2 to 13 • Usable in 100 % water and buffer solution • Best used for the analysis of basic substances • ODP-50 fulfills USP L67 requirements
ODP-40	• Higher performance type of ODP-50 series • Fulfills USP L67 requirements
RP18-415	• Large pore size is suitable for the analysis of proteins and peptides • Fulfills USP L21 requirements
DS-613 **DS-413**	• Suitable for reversed phase analysis of highly hydrophilic substances that are not well retained by ODS columns • Fulfill USP L21 requirements
DE-613 **DE-413** **DE-213**	• General purpose polymer-based column having similar polarity as ODS columns • Wide working pH range (from pH 2 to 12), usable in 100 % water and buffer solutions • Fulfill USP L71 requirements
DM-614	• Suitable for the analysis of amino acids and water-soluble vitamins • Fulfills USP L39 requirements
NN-814 **NN-614** **NN-414**	• The packing material modified with sulfo groups supports multimode (reversed phase and cation exchange) analysis • Ideal for the analysis of complex samples containing neutral and ionic substances
JJ-50	• The packing material is modified with trace amounts of quaternary ammonium groups, and supports multimode (reversed phase and anion exchange) analysis • Ideal for analysis of complex samples containing neutral and ionic substances
C18	• Fully end capped ODS column available at very reasonable price • Fulfills USP L1 requirements
C18M	• Monomeric type ODS column, fully end capped high purity silica (99.99 % or higher) • Fulfills USP L1 requirements
C18P	• Polymeric type ODS column, fully end capped high purity silica (99.99 % or higher) • Excellent acid tolerance • Advantageous for separating planar and nonplanar compounds from each other • Fulfills USP L1 requirements
New **C18U**	• UHPLC column (Maximum pressure: 100 MPa) • Achieves high performance analysis with sub-2 µm particles • Organic/inorganic silica hybrid particles provide excellent resolution and mechanical stability and improved alkali durability (from pH 1 to 12) • Usable in 100 % water and buffer solution • Fulfills USP L1 requirements
5C8	• Use when the retention capacity of C18 is too strong • Rapid mass transfer and fast equilibration allow its use as an ion-pair chromatography • Fulfills USP L7 requirements
5CN	• Utilizes reversed phase interaction and π-electron interaction to separate regioisomers, which typically cannot be separated with ODS or C8 columns • Fulfills USP L10 requirements
5NPE	• Utilizes several types of interactions based on π-electrons to separate structural isomers

The interrelation between hydrophobicity and retention, and the interrelation between steric selectivity and retention were compared among Shodex columns for reversed phase chromatography.
The retention factor (k') of amylbenzene was used as the retention, the separation factor (α) between n-butylbenzene and n-amino benzene was used as the hydrophobicity. The separation factor between o-terphenyl and triphenylene was used as the steric recognition.
Larger separation factor means higher hydrophobicity and higher steric selectivity.

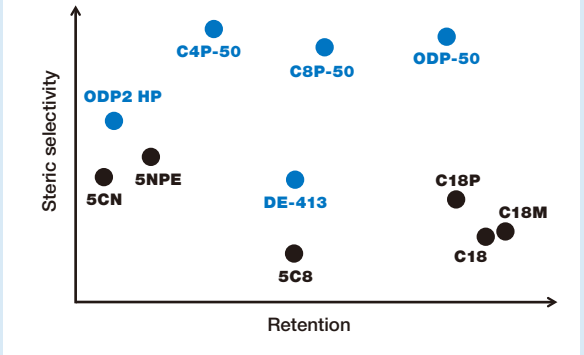


Hydrophobicity differences among Shodex RPCs



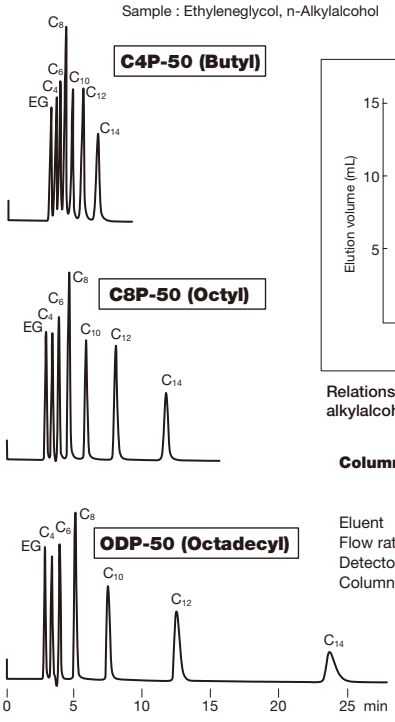
Column size : 4.6 mm I.D. x 150 mm each
Eluent : H_2O/CH_3OH=20/80
Flow rate : 1.0 mL/min
Detector : UV (254 nm)
Column temp. : 40 ℃

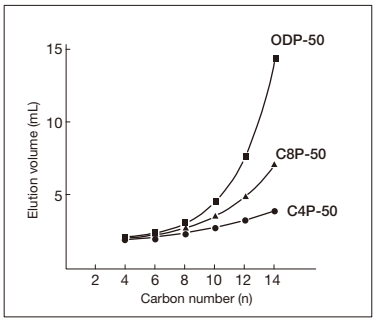
Steric selectivity differences among Shodex RPCs



Column size : 4.6 mm I.D. x 150 mm each
Eluent : H_2O/CH_3OH=20/80
Flow rate : 1.0 mL/min
Detector : UV (254 nm)
Column temp. : 40 ℃

Comparison of different functional groups on the separation of alkylalcohols

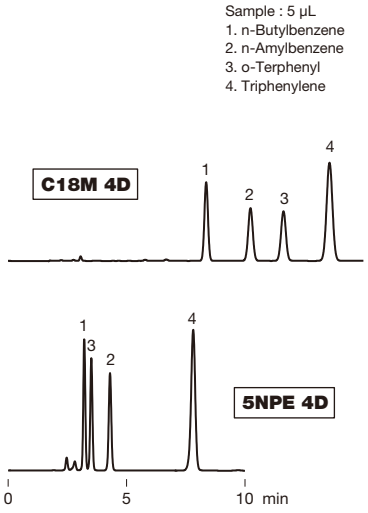




Relationship between the carbon number in alkylalcohols and elution volume

Column : Shodex Asahipak ODP-50 4D
Shodex Asahipak C8P-50 4D
Shodex Asahipak C4P-50 4D
Eluent : H_2O/CH_3OH=20/80
Flow rate : 0.6 mL/min
Detector : RI
Column temp. : 30 ℃

Effects of steric selectivity differences



Column : Shodex Silica C18M 4D
Shodex Silica 5NPE 4D
Eluent : H_2O/CH_3OH=20/80
Flow rate : 1.0 mL/min
Detector : UV (254 nm)
Column temp. : 40 ℃

Polymer-based Reversed Phase Chromatography Columns (RSpak)

Please refer to “Comparison of Shodex Reversed Phase Chromatography (RPC) Column Features” on page 6 and 7 for features.

Standard columns

Product Code	Product Name	Plate Number (TP/column)	Base Material	Particle Size (µm)	Pore Size (Å)	Column Size (mm) I.D. x Length	Shipping Solvent
F7009000	**RSpak RP18-415**	≥ 5,000	Styrene divinylbenzene copolymer	6	450	**4.6 x 150**	H_2O/CH_3CN=5/95
F6709558	**RSpak RP18-G**	(guard column)	Styrene divinylbenzene copolymer	6	–	**4.6 x 10**	H_2O/CH_3CN/THF=40/30/30
F7001001	**RSpak DS-613**	≥ 6,500	Styrene divinylbenzene copolymer	6	200	**6.0 x 150**	H_2O/CH_3CN/THF=30/40/30
F7001012	**RSpak DS-413**	≥ 11,000	Styrene divinylbenzene copolymer	3.5	200	**4.6 x 150**	H_2O/CH_3CN/THF=40/30/30
F6700140	**RSpak DS-G**	(guard column)	Styrene divinylbenzene copolymer	10	–	**4.6 x 10**	H_2O/CH_3CN/THF=30/40/30
F7001004	**RSpak DE-613**	≥ 7,000	Polymethacrylate	6	25	**6.0 x 150**	H_2O
F7001005	**RSpak DE-413**	≥ 11,000	Polymethacrylate	4	25	**4.6 x 150**	H_2O/CH_3CN=50/50
F7009030	**RSpak DE-413L**	≥ 17,000	Polymethacrylate	4	25	**4.6 x 250**	H_2O/CH_3CN=50/50
F6700150	**RSpak DE-G 4A**	(guard column)	Polymethacrylate	10	–	**4.6 x 10**	H_2O
F7001002	**RSpak DM-614**	≥ 4,500	Polyhydroxymethacrylate	10	200	**6.0 x 150**	5 mM H_3PO_4 aq.
F6700160	**RSpak DM-G 4A**	(guard column)	Polyhydroxymethacrylate	12	–	**4.6 x 10**	5 mM H_3PO_4 aq.

Semi-micro columns

Product Code	Product Name	Plate Number (TP/column)	Base Material	Particle Size (µm)	Pore Size (Å)	Column Size (mm) I.D. x Length	Shipping Solvent
F7001007	**RSpak DE-213**	≥ 8,000	Polymethacrylate	4	25	**2.0 x 150**	H_2O/CH_3CN=50/50
F6700151	**RSpak DE-G 2A**	(guard column)	Polymethacrylate	6	–	**2.0 x 10**	H_2O/CH_3CN=50/50

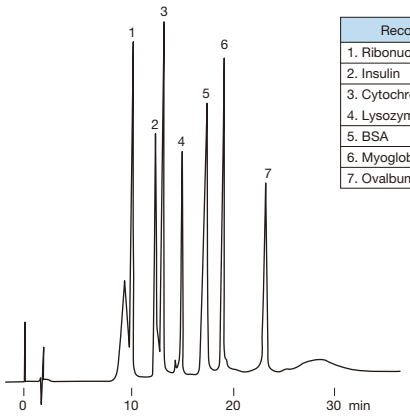
Standard columns

Product Code	Product Name	Plate Number (TP/column)	Functional Group	Base Material	Particle Size (μm)	Pore Size (Å)	Column Size (mm) I.D. x Length	Shipping Solvent
F7008140	**RSpak NN-814**	≥ 9,000	Sulfo	Polyhydroxymethacrylate	10	200	**8.0 x 250**	0.1 M Sodium phosphate buffer (pH3.0)
F7008150	**RSpak NN-614**	≥ 4,000	Sulfo	Polyhydroxymethacrylate	10	200	**6.0 x 150**	0.1 M Sodium phosphate buffer (pH 3.0)
F6700510	**RSpak NN-G**	(guard column)	Sulfo	Polyhydroxymethacrylate	10	–	**6.0 x 50**	0.1 M Sodium phosphate buffer (pH 3.0)
F7008160	**RSpak NN-414**	≥ 6,000	Sulfo	Polyhydroxymethacrylate	10	200	**4.6 x 150**	0.1 M Sodium phosphate buffer (pH 3.0)
F7008240	**RSpak JJ-50 4D**	≥ 4,500	Quaternary ammonium	Polyvinyl alcohol	5	100	**4.6 x 150**	H_2O/CH_3CN=40/60

Semi-micro columns

Product Code	Product Name	Plate Number (TP/column)	Functional Group	Base Material	Particle Size (μm)	Pore Size (Å)	Column Size (mm) I.D. x Length	Shipping Solvent
F7008220	**RSpak JJ-50 2D**	≥ 3,500	Quaternary ammonium	Polyvinyl alcohol	5	100	**2.0 x 150**	H_2O/CH_3CN=40/60

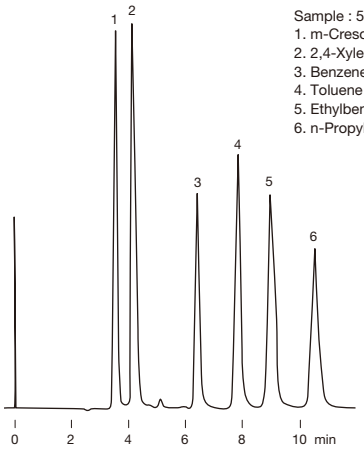
Separation and recovery rate of standard proteins



Recovery (%)	
1. Ribonuclease A	93
2. Insulin	98
3. Cytochrome C	100
4. Lysozyme	100
5. BSA	98
6. Myoglobin	108
7. Ovalbumin	–

Column : **Shodex RSpak RP18-415**
Eluent : (A); 0.1 % TFA aq./CH_3CN=99/1
(B); 0.1 % TFA aq./CH_3CN=5/95
Linear gradient; (B %) 20 % to 60 %, 20 min
Flow rate : 1.0 mL/min
Detector : UV (220 nm)
Column temp. : Room temp.

Alkylbenzenes

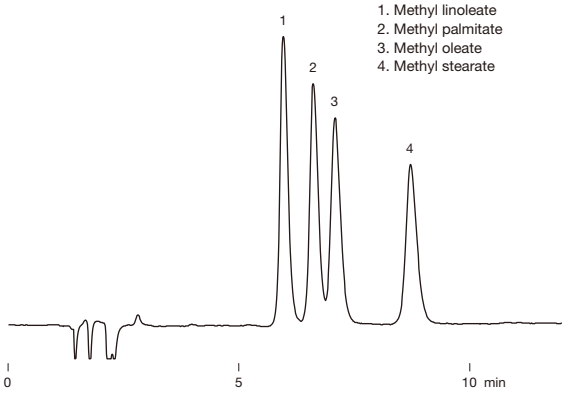


Sample : 5 µL

1. m-Cresol	0.1 %
2. 2,4-Xylenol	0.1 %
3. Benzene	0.5 %
4. Toluene	0.5 %
5. Ethylbenzene	0.5 %
6. n-Propylbenzene	0.5 %

Column : **Shodex RSpak DS-613**
Eluent : $H_2O/CH_3CN/THF$=30/40/30
Flow rate : 1.0 mL/min
Detector : UV (254 nm)
Column temp. : 40 ℃

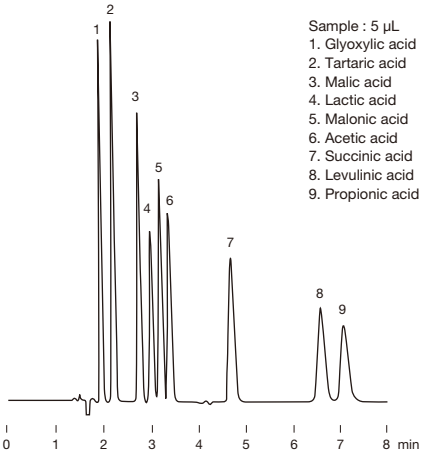
Fatty acid methyl esters



Sample : 0.2 % each, 20 µL
1. Methyl linoleate
2. Methyl palmitate
3. Methyl oleate
4. Methyl stearate

Column : **Shodex RSpak DS-413**
Eluent : $H_2O/CH_3CN/THF$=25/45/30
Flow rate : 1.0 mL/min
Detetor : RI
Column temp. : 40 ℃

Organic acids

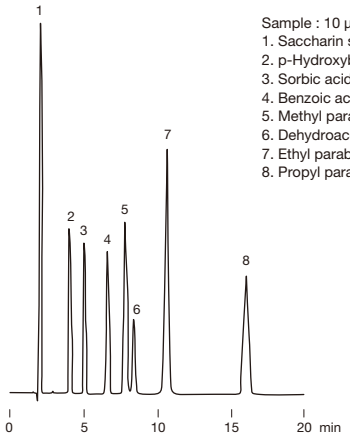


Sample : 5 µL

1. Glyoxylic acid	1.78 mg/mL
2. Tartaric acid	1.95 mg/mL
3. Malic acid	2.06 mg/mL
4. Lactic acid	2 µL/mL
5. Malonic acid	1.95 mg/mL
6. Acetic acid	2 µL/mL
7. Succinic acid	2.05 mg/mL
8. Levulinic acid	1.95 mg/mL
9. Propionic acid	2 µL/mL

Column : **Shodex RSpak DE-413**
Eluent : 10 mM H_3PO_4 aq.
Flow rate : 1.0 mL/min
Detector : RI
Column temp. : 50 ℃

Food additives (Preservatives)

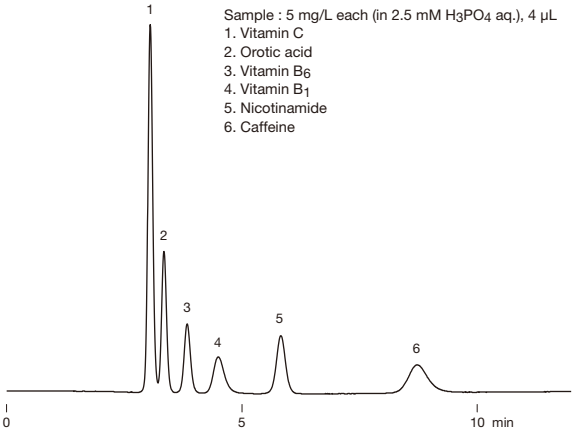


Sample : 10 µL

1. Saccharin sodium	0.005 %
2. p-Hydroxybenzoic acid	0.005 %
3. Sorbic acid	0.02 %
4. Benzoic acid	0.02 %
5. Methyl paraben	0.01 %
6. Dehydroacetic acid	0.01 %
7. Ethyl paraben	0.02 %
8. Propyl paraben	0.02 %

Column : **Shodex RSpak DE-413**
Eluent : 50 mM KH_2PO_4 + 0.1 % H_3PO_4 aq./CH_3CN =65/35
Flow rate : 1.0 mL/min
Detector : UV (210 nm)
Column temp. : 40 ℃

Vitamins

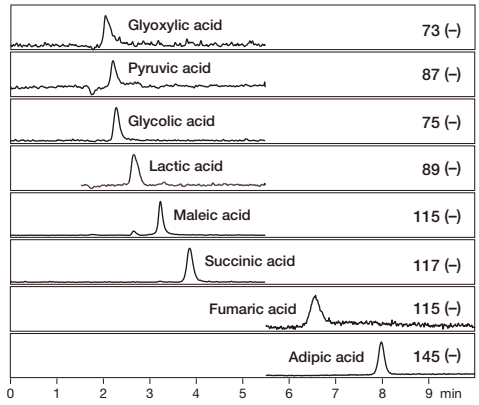


Sample : 5 mg/L each (in 2.5 mM H_3PO_4 aq.), 4 µL
1. Vitamin C
2. Orotic acid
3. Vitamin B_6
4. Vitamin B_1
5. Nicotinamide
6. Caffeine

Column : **Shodex RSpak DM-614**
Eluent : 0.055 M Na_2HPO_4 + 0.045 M KH_2PO_4 aq.
Flow rate : 1.0 mL/min
Detector : UV (254 nm)
Column temp. : 30 ℃

LC/MS analysis of organic acids

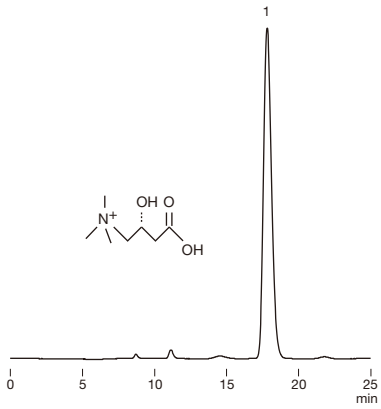
Sample : 50 ng/mL each, 10 µL



Column : **Shodex RSpak DE-213**
Eluent : (A); 0.1 % (v/v) Formic acid aq./(B); CH_3CN
Linear gradient; (B %) 5 % (0 min) → 5 % (2 min) → 15 % (2.5 min) → 15 % (10 min)
Flow rate : 0.2 mL/min
Detector : ESI-MS (SIM)
Column temp. : 30 ℃

Carnitine

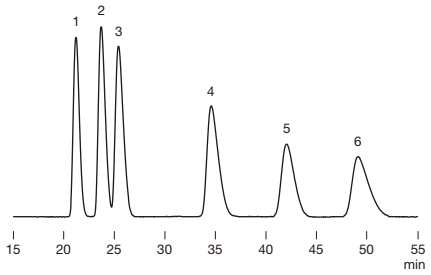
Sample : 20 µL
1. L-Carnitine 0.1 %



Column : **Shodex RSpak NN-814**
Eluent : 0.1 M H_3PO_4 aq.
Flow rate : 1.0 mL/min
Detector : UV (210 nm)
Column temp. : 25 ℃

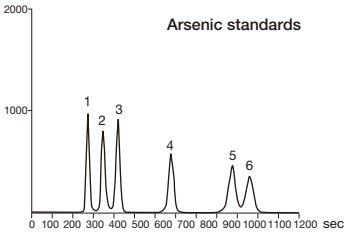
Amino acids

Sample : 0.1 % each, 20 µL
1. Aspartic acid
2. Glycine
3. Alanine
4. Valine
5. Methionine
6. Isoleucine

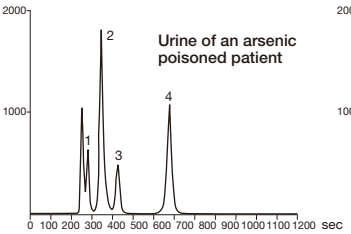


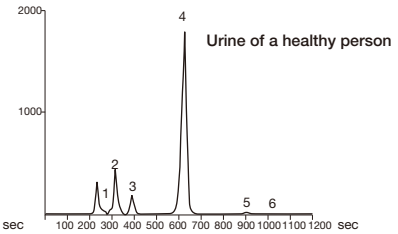
Column : **Shodex RSpak NN-814**
Eluent : 40 mM H_3PO_4 aq.
Flow rate : 1.0 mL/min
Detector : RI
Column temp. : 40 ℃

Speciation of arsenic



Sample : Arsenic standards, 50 µL
1. Monomethylarsonic acid
2. Arsinic acid
3. Dimethylarsinic acid
4. Arsenobetaine
5. Tetramethylarsonium
6. Trimethylarsine oxide



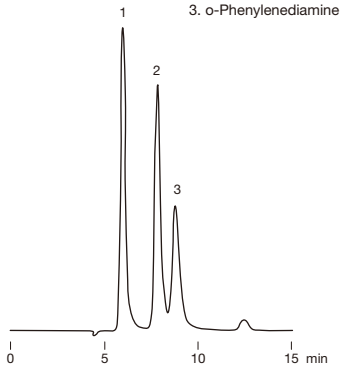


Column : **Shodex RSpak NN-614**
Eluent : 5 mM HNO_3/8 mM NH_4NO_3 aq.
Flow rate : 0.8 mL/min
Detector : ICP-MS (SIM m/z 75)

Source:
Noriko Tsunoda,
Pharmacia. 1998, vol.34, No.12, p.1237-1241

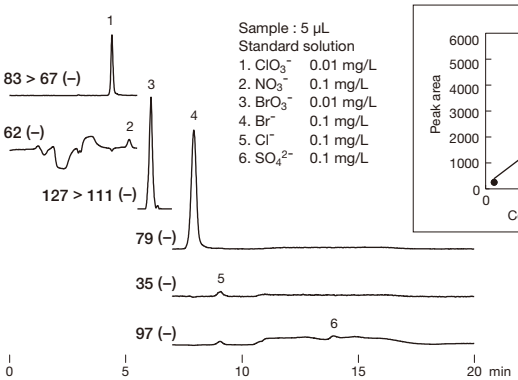
Phenylenediamine isomers

Sample : 100 mg/L each, 20 µL
1. p-Phenylenediamine
2. m-Phenylenediamine
3. o-Phenylenediamine

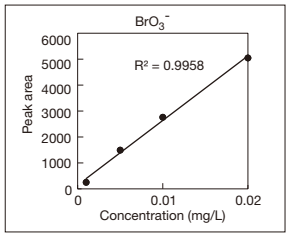


Column : **Shodex RSpak JJ-50 4D**
Eluent : 25 mM Ammonium acetate buffer (pH 9.2)/CH_3CN=70/30
Flow rate : 0.4 mL/min
Detector : UV (254 nm)
Column temp. : 30 ℃

High sensitive analysis of bromate by LC/MS/MS



Sample : 5 µL
Standard solution
1. ClO_3^- 0.01 mg/L
2. NO_3^- 0.1 mg/L
3. BrO_3^- 0.01 mg/L
4. Br^- 0.1 mg/L
5. Cl^- 0.1 mg/L
6. SO_4^{2-} 0.1 mg/L



Column : **Shodex RSpak JJ-50 2D**
Eluent : (A); 200 mM $HCOONH_4$ aq./(B); CH_3CN
Linear gradient (High pressure);
(B %) 85 % (0 min) → 85 % (8 min) → 50 % (9 min) → 50 % (14 min)
→ 85 % (15 min) → 85 % (20 min)
Flow rate : 0.3 mL/min
Detector : ESI-MS/MS (MRM) for ClO_3^-, BrO_3^-
ESI-MS (SIM) for NO_3^-, Br^-, Cl^-, SO_4^{2-}
Column temp. : 50 ℃