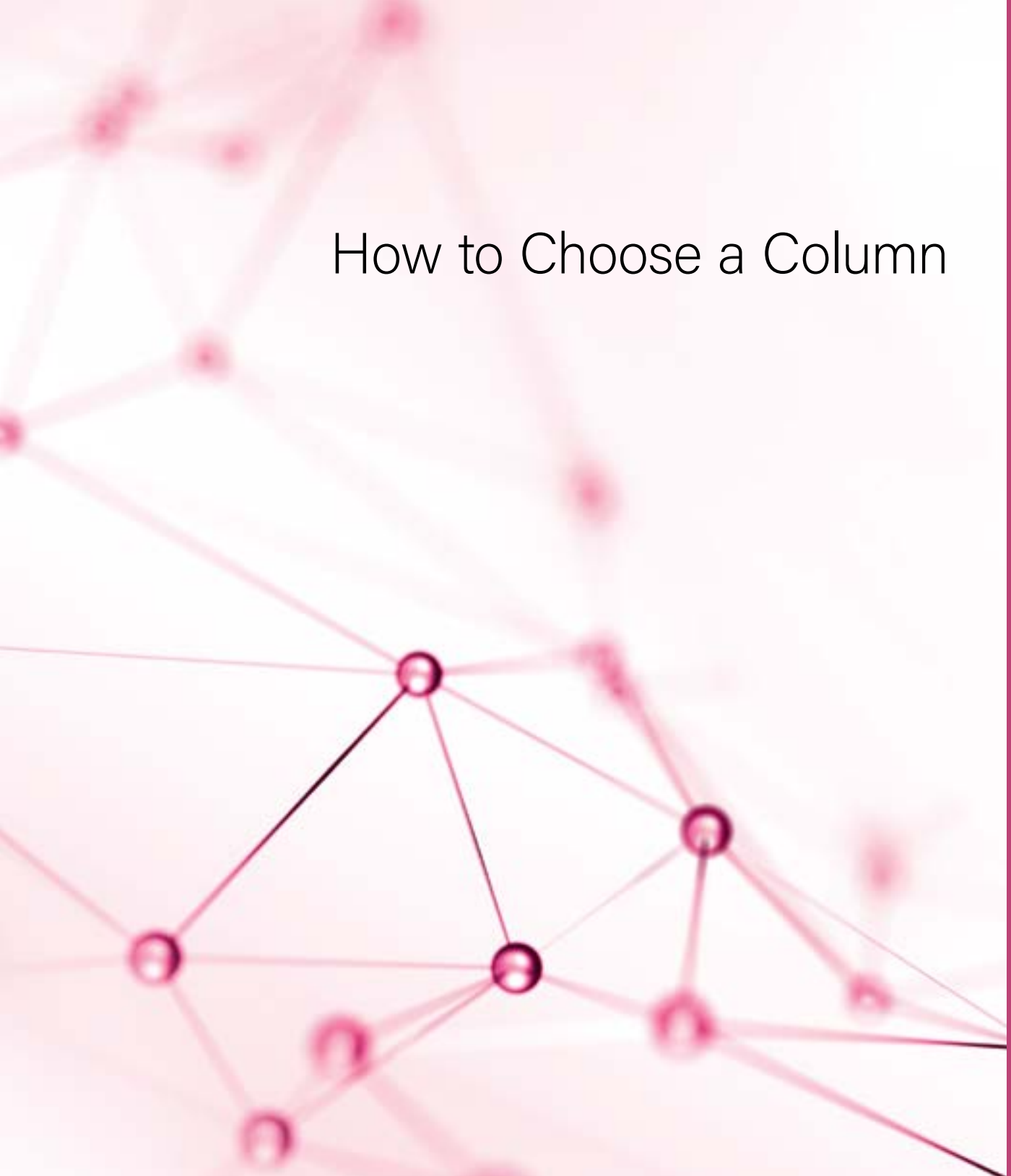
How to Choose a Column



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How to Choose a Column

Separation scientists continue to search for innovative solutions to improve chromatographic performance. With a wide array of column choices and formats, they have the ability to select the ideal column for their application. The following section introduces Waters' particle technologies and column formats to help you choose the best column to deliver throughput, resolution, and efficiency for your next chromatographic challenge.

Particle Technology

Reproducibility and transferability are the cornerstones of Waters' BEH, CSH,™ HSS, and solid-core particle technologies. Our extensive portfolio of scalable LC columns exhibit all of the chemical and physical characteristics you would expect from modern LC packing materials.

BEH Technology*

- High retentivity for basic compounds
- Exceptional peak shape at elevated pH
- Good universal column choice for a wide variety of compounds
- Stable across a wide pH range
- For separations at high temperatures (80 °C)

CSH Technology

- Good separations for basic compounds under low pH conditions
- Excellent MS performance with formic acid as a mobile phase modifier
- Fast pH switching and column equilibration

HSS Technology

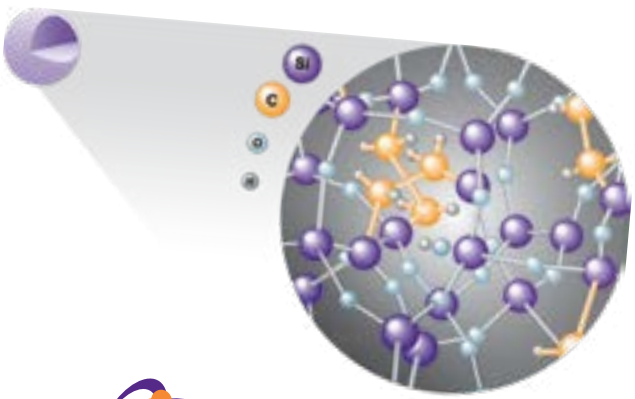
- High retentivity for polar organic compounds and metabolites
- Balanced retention of polar and hydrophobic analytes
- High strength silica for mechanical stability

Solid-Core Technology

- Maximum efficiency
- Increased sensitivity
- Seamless scalability from UPLC to UHPLC to HPLC

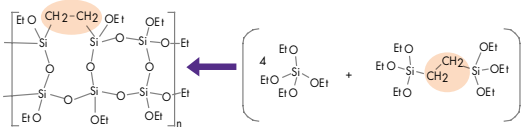
ETHYLENE BRIDGED HYBRID (BEH) PARTICLE TECHNOLOGY

Ethylene Bridged Hybrid (BEH) columns lead the industry for chromatographic versatility, chemical resistance, and mechanical stability. You can use them at extremes of pH and temperature to enhance retention and specificity for complex mixtures of acidic, basic, and neutral analytes. The BEH-particle family includes general-purpose and application-specific bonded phases that serve application areas.



BEH Technology™

Particle Synthesis



Polyethoxysilane (BPEOS) | Tetraethoxysilane (TEOS) | Bis(triethoxysilyl)ethane (BTEE)

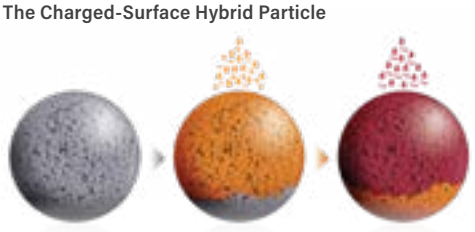
*US Patents 6,686,035; 7,223,473; 7,250,214.

Refer to "Ethylene-Bridged (BEH Technology™) Hybrids and Their Use in Liquid Chromatography" whitepaper (p/n: 720001159EN) for further detail.

CHARGED SURFACE HYBRID (CSH) PARTICLE TECHNOLOGY

Columns packed with charged surface hybrid (CSH) particles manifest the best attributes of BEH particles. CSH stationary phases provide chromatographic selectivity and superior performance in the presence of mobile phases of low ionic strength. The optimized surface charge, pore properties, and bonded phases make charged-surface, hybrid-based columns ideal for rapid method development.

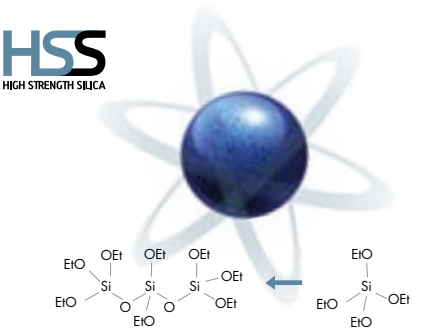
The Charged-Surface Hybrid Particle



Unbonded BEH Particle | Apply Controlled Surface Charge | Bond and End Cap

HIGH STRENGTH SILICA (HSS) PARTICLE TECHNOLOGY

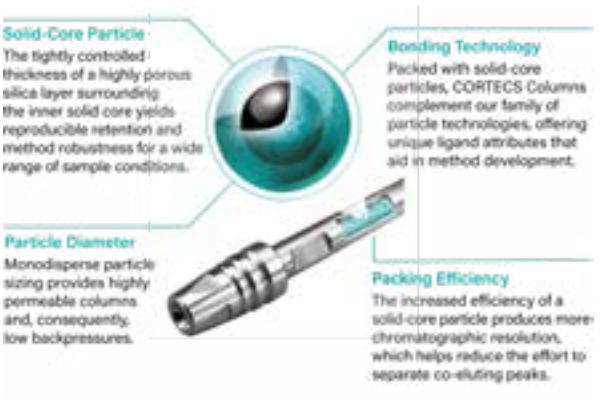
High strength silica (HSS) technology was developed specifically to complement the chromatographic performance of BEH and CSH particles. Compared with the ethylene-bridged BEH and CSH particles, the HSS particle's higher silanophilicity (100% silica) offers chromatographers significant advantages, including increased retention of polar compounds and significantly different selectivity. Additionally, as its name implies, the HSS particle possesses the mechanical strength to operate at pressures as high as 18,000 psi (1240 bar).



Polyethoxysilane (PEOS) | Tetraethoxysilane (TEOS)

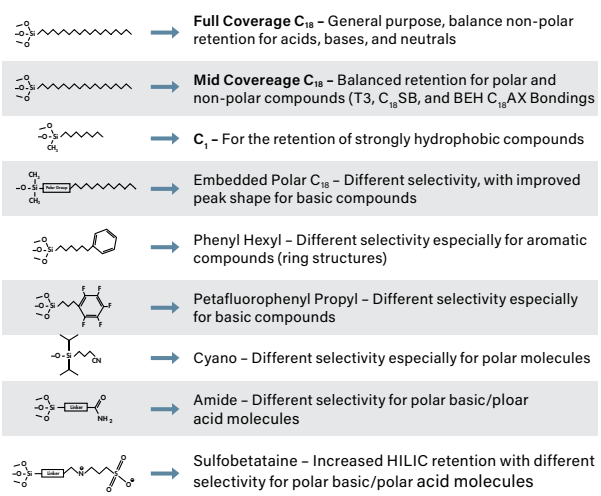
SOLID-CORE PARTICLE TECHNOLOGY

Compared to columns packed with fully porous particles, columns packed with solid-core particles demonstrate higher chromatographic efficiency and lower backpressures. The optimized porous layer that surrounds the solid-silica core gives rise to the key benefits of speed and efficiency. UPLC columns packed with CORTECS™ 1.6 µm particles yield maximum efficiency when used with the ultra-low dispersion ACQUITY UPLC instrument platform. CORTECS Columns packed with 2.7 µm particles offer maximum flexibility, providing increased efficiencies at the backpressure limits of UHPLC and HPLC operation.



REVERSED PHASE AND HILIC CHEMISTRIES

To maximize selectivity, which is critical for analytical methods development, Waters offers a wide range of chemistries to help you separate the most challenging of compounds. For both reversed-phase and HILIC applicators, Waters has the chemistry you need to get the job done. Rugged and robust ligands that ensure long column lifetimes and reproducible separations over the lifetime of you method. Highlighted are some of Waters chemistries used for reversed-phase and HILIC separations.



Full Coverage C_{18} – General purpose, balance non-polar retention for acids, bases, and neutrals

Mid Covereage C_{18} – Balanced retention for polar and non-polar compounds (T3, C_{18}SB, and BEH C_{18}AX Bondings

C_1 – For the retention of strongly hydrophobic compounds

Embedded Polar C_{18} – Different selectivity, with improved peak shape for basic compounds

Phenyl Hexyl – Different selectivity especially for aromatic compounds (ring structures)

Petafluorophenyl Propyl – Different selectivity especially for basic compounds

Cyano – Different selectivity especially for polar molecules

Amide – Different selectivity for polar basic/ploar acid molecules

Sulfobetataine – Increased HILIC retention with different selectivity for polar basic/polar acid molecules

Column Selection

Our quality mission is to ensure that the Waters' Columns you use today are the most reproducible and reliable LC columns available. As a primary manufacturer of silica and hybrid particles, scientists can be assured of consistent column performance, batch-to-batch reproducibility, and product availability over the life of the analytical method.

The following table lists all Waters Column Brands that are registered according to classifications prescribed in the United States Pharmacopeia (USP).

USP "L" COLUMN LISTING

L1	Octadecyl silane chemically bonded to porous or non-porous silica or ceramic micro-particles, 1.5 to 10 µm in diameter, or monolithic rod		
Brand	**Particle Size**	**Type**	**Page**
AccQTag Ultra RP C_{18}	1.7 µm	Spherical	347
ACQUITY UPLC BEH C_{18}	1.7 µm	Spherical	118, 373
ACQUITY UPLC BEH Shield RP18	1.7 µm	Spherical	118
ACQUITY UPLC CSH C_{18}	1.7 µm	Spherical	114
ACQUITY UPLC HSS C_{18}	1.7 µm	Spherical	121
ACQUITY UPLC HSS C_{18} SB	1.7 µm	Spherical	121
ACQUITY UPLC HSS T3	1.7 µm	Spherical	122
ACQUITY UPLC Oligonucleotide C_{18}	1.7 µm	Spherical	377
ACQUITY UPLC Peptide BEH C_{18}	1.7 µm	Spherical	377
ACQUITY Premier BEH C_{18}	1.7 µm	Spherical	99
ACQUITY Premier HSS T3	187 µm	Spherical	99
ACQUITY Premier Peptide BEH C_{18}	1.7 µm	Spherical	100
ACQUITY Premier Oligonucleotide C_{18}	1.7 µm	Spherical	100
ACQUITY Premier Shield RP18	1.7 µm	Spherical	99
ACQUITY Premier CSH C_{18}	1.7 µm	Spherical	99
XBridge Premier C_{18}	2.5 µm	Spherical	101
XBridge Premier Shield RP18	2.5 µm	Spherical	101
XBridge Premier Peptide 130 Å	2.5 µm	Spherical	377
XBridge Premier Peptide 300 Å	2.5 µm	Spherical	377
XBridge Premier Oligonucleotide C_{18}	2.5 µm	Spherical	377
XSelect Premier CSH C_{18}	2.5 µm	Spherical	101
XSelect Premier HSS T3	2.5 µm	Spherical	102
Atlantis dC_{18}	3, 5, 10 µm	Spherical	209
Atlantis T3	3, 5, 10 µm	Spherical	208
CORTECS C_{18}	2.7 µm	Spherical	241
CORTECS C_{18}+	2.7 µm	Spherical	241
CORTECS Shield RP18	2.7 µm	Spherical	241
CORTECS T3	2.7 µm	Spherical	241
CORTECS UPLC C_{18}	1.6 µm	Spherical	110

L1	Octadecyl silane chemically bonded to porous or non-porous silica or ceramic micro-particles, 1.5 to 10 µm in diameter, or a monolithic rod		
Brand	**Particle Size**	**Type**	**Page**
CORTECS UPLC C_{18}+	1.6 µm	Spherical	110
CORTECS UPLC Shield RP18	1.6 µm	Spherical	111
CORTECS UPLC T3	1.6 µm	Spherical	111
Delta-Pak C_{18}	5 µm	Spherical	301
µBondapak C_{18}	10 µm	Irregular	300
µBondapak C_{18} Radial-Pak	10 µm	Irregular	307
Nova-Pak C_{18}	4, 6 µm	Spherical	299
Prep Nova-Pak HR C_{18}	6 µm	Spherical	308
Radial-Pak C_{18}	Spherical	Spherical	307
Resolve C_{18}	5, 10 µm	Spherical	244, 307
Spherisorb ODS1	3, 5, 10 µm	Spherical	295
Spherisorb ODS2	3, 5, 10 µm	Spherical	295
Spherisorb ODS-B	5 µm	Spherical	228
SunFire C_{18}	2.5, 3.5, 5, 10 µm	Spherical	172, 277
Symmetry C_{18}	3.5, 5 µm	Spherical	291
SymmetryPrep C_{18}	5, 7 µm	Spherical	217, 292
Symmetry 300 C_{18}	3.5, 5 µm	Spherical	293
SymmetryShield RP18	3.5, 5 µm	Spherical	292, 293
XBridge C_{18}	2.5, 3.5, 5, 10 µm	Spherical	255
XBridge Peptide BEH, 130 Å	3.5, 5, 10 µm	Spherical	260
XBridge Peptide BEH, 300 Å	3.5, 5, 10 µm	Spherical	261
XBridge BEH C_{18}	2.5, 3.5, 5, 10 µm	Spherical	254
XBridge Oligonucleotide C_{18}	2.5 µm	Spherical	262
XBridge Shield RP18	2.5, 3.5, 5, 10 µm	Spherical	256
XSelect CSH C_{18}	2.5, 3.5, 5 µm	Spherical	267
XSelect HSS C_{18}	2.5, 3.5, 5 µm	Spherical	270
XSelect HSS C_{18} SB	2.5, 3.5, 5 µm	Spherical	270
XSelect HSS T3	2.5, 3.5, 5 µm	Spherical	271
XTerra MS C_{18}	2.5, 3.5, 5, 10 µm	Spherical	286
XTerra RP18	3.5, 5, 10 µm	Spherical	288, 289

( ) - Denotes particle sizes available outside of L class.

Source: United States Pharmacopeia.

L2 Octadecyl silane chemically bonded to silica gel of a controlled surface porosity that has been bonded to a solid spherical core, 30 to 50 µm in diameter

Brand	Particle Size	Type	Page
Bondapak Prep C_{18}	15–20 µm	Irregular	236

L3 Porous silica particles, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
ACQUITY UPLC BEH HILIC	1.7 µm	Spherical	118,119
Atlantis HILIC Silica	3, 5 µm	Spherical	284
CORTECS HILIC	2.7 µm	Spherical	134
CORTECS UPLC HILIC	1.6 µm	Spherical	112
µPorasil	10 µm	Spherical	237, 244
Nova-Pak Silica	4, 6 µm	Spherical	299
Prep Nova-Pak HR Silica	6 µm	Spherical	308
Resolve Silica	5, 10 µm	Spherical	244, 307
Spherisorb Silica	3, 5, 10 µm	Spherical	230, 295
SunFire Silica	5, 10 µm	Spherical	172, 279
XBridge BEH HILIC	2.5, 3.5, 5, 10 µm	Spherical	265

L4 Silica gel controlled surface porosity bonded to a solid spherical core, 30 to 50 µm in diameter

Brand	Particle Size	Type	Page
Porasil Prep Silica	15–20 µm	Spherical	303

L7 Octylsilane chemically bonded to totally or superficially porous silica particles, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
ACQUITY UPLC BEH C_8	1.7 µm	Spherical	118
CORTECS C_8	2.7 µm	Spherical	123
CORTECS UPLC C_8	1.6 µm	Spherical	111
CORTECS Phenyl	2.7 µm	Spherical	112
CORTECS UPLC Phenyl	1.6 µm	Spherical	124
Nova-Pak C_8	4, 6 µm	Spherical	299
Resolve C_8	10 µm	Spherical	307
Spherisorb C_8	3, 5, 10 µm	Spherical	229, 296
SunFire C_8 Silica	3.5, 5, 10 µm	Spherical	173, 280
Symmetry C_8	3.5, 5, 7 µm	Spherical	292
SymmetryPrep C_8	7 µm	Spherical	213
SymmetryShield RP8	3.5, 5 µm	Spherical	293
XBridge BEH C_8	2.5 3.5, 5, 10 µm	Spherical	102, 185
XTerra MS C_8	2.5 3.5, 5, 10 µm	Spherical	223, 287
XTerra Shield RP8	3.5, 5, 10 µm	Spherical	225, 289

L8 An essentially monomolecular layer of aminopropylsilane chemically bonded to totally porous silica gel support, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
High Performance Carbohydrate Analysis	3, 5 µm	_	495
µBondapak NH_2	10 µm	Irregular	236
Spherisorb NH_2	3, 5, 10 µm	Spherical	229, 297

L9 Irregular or spherical, totally porous silica gel having a chemically bonded, strongly acidic cation-exchange coating, 3 to 10 µm in diameter

Brand	Particle Size	Type	Page
Spherisorb SCX	5, 10 µm	Spherical	231, 298

L10 Nitrile groups chemically boned to porous silica particles, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
ACQUITY UPLC HSS CN	1.7 µm	Spherical	122
µBondapak CN	10 µm	Irregular	236, 300
NovaPak CN HP	4 µm	Spherical	299
Resolve CN	10 µm	Spherical	307
Spherisorb CN	3, 5, 10 µm	Spherical	230, 297
Spherisorb CN RP	3, 5, 10 µm	Spherical	230, 298
XSelect HSS CN	2.5, 3.5, 5 µm	Spherical	206

L11 Phenyl groups chemically bonded to porous silica particles, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
ACQUITY UPLC BEH Phenyl	1.7 µm	Spherical	119
ACQUITY UPLC CSH Phenyl-Hexyl	1.7 µm	Spherical	114
ACQUITY Premier CSH Phenyl-Hexyl	1.7 µm	Spherical	99
XSelect Premier CSH Phenyl-Hexyl	1.7 µm	Spherical	102
CORTECS Phenyl	2.7 µm	Spherical	136
CORTECS UPLC Phenyl	1.6 µm	Spherical	112
µBondapak Phenyl	10 µm	Irregular	236
NovaPak Phenyl	4 µm	Spherical	233
Spherisorb Phenyl	3, 5, 10 µm	Spherical	230
XBridge BEH Phenyl	2.5, 3.5, 5 µm	Spherical	147
XSelect CSH Phenyl-Hexyl	2.5, 3.5, 5 µm	Spherical	158
XTerra Phenyl	3.5, 5 µm	Spherical	177

L12 A strong anion-exchange packing made by chemically bonding a quaternary amine to a solid silica spherical core, 30 to 50 µm in diameter

Brand	Particle Size	Type	Page
AccellPlus QMA	40 µm	Irregular	450

( ) - Denotes particle sizes available outside of L class.

Source: United States Pharmacopeia.

L13 Trimethylsilane chemically bonded to porous silica particles, 3 to 10 µm in diameter

Brand	Particle Size	Type	Page
Spherisorb C_1	3, 5, 10 µm	Spherical	229, 296

L14 Silica gel having a chemically bonded strongly basic quaternary ammonium anion-exchange coating, 5 to 10 µm in diameter

Brand	Particle Size	Type	Page
Spherisorb SAX	5, 10 µm	Spherical	231, 298

L15 Hexylsilane chemically bonded to totally porous silica particles, 3 to 10 µm in diameter

Brand	Particle Size	Type	Page
Spherisorb C_6	3, 5, 10 µm	Spherical	229, 296

L17 Strong cation-exchange resin consisting of sulfonated cross-linked styrene-divinylbenzene copolymer in the hydrogen form, 6 to 12 µm in diameter

Brand	Particle Size	Type	Page
Fast Fruit Juice	N/A	N/A	497
IC-Pak Cation	10 µm	Irregular	500
IC-Pak Ion Exclusion	7 µm	Spherical	497
Shodex RSpak DC-613	6 µm	Spherical	237

L19 Strong cation-exchange resin consisting of sulfonated cross-linked styrene-divinylbenzene copolymer in the calcium form, 5 to 15 µm in diameter

Brand	Particle Size	Type	Page
Shodex Sugar SC-1011	7 µm	Spherical	496
Sugar-Pak 1	9 µm	Spherical	496

L20 Dihydroxypropane groups chemically bonded to porous silica or hybrid particles, 1.5 to 10 µm in diameter, or a monolithic silica rod

Brand	Particle Size	Type	Page
ACQUITY BEH200SEC	1.7 µm	Spherical	119
BioSuite 125, 250, 450 series	4, 5, 8, 10, (13), (17) µm	Spherical	433
Insulin HMWP	–	N/A	429
Protein-Pak 60	10 µm	Spherical	433
Protein-Pak 125	10 µm	Spherical	433
Protein-Pak 200SW and 300SW	10 µm	Spherical	433
XBridge Protein BEH SEC, 125 Å	3.5 µm	Spherical	466
XBridge Protein BEH SEC, 200 Å	3.5 µm	Spherical	466
XBridge Protein BEH SEC, 450 Å	3.5 µm	Spherical	466

( ) - Denotes particle sizes available outside of L class.

Source: United States Pharmacopeia.

L21 A rigid, spherical styrene-divinylbenzene copolymer, 3 to 30 µm in diameter

Brand	Particle Size	Type	Page
Styragel HR 0.5, 1, 2, 3 and 4	–	Spherical	406
Styragel HR 4E	–	Spherical	406
Styragel HR 5E	–	Spherical	406

L22 A cation-exchange resin made of porous polystyrene gel with sulfonic acid groups, 5 to 15 µm in diameter

Brand	Particle Size	Type	Page
IC-Pak Ion Exclusion	7 µm	Spherical	500
Shodex RSpak DC-613	6 µm	Spherical	237
Shodex Sugar SP0810	8 µm	Spherical	496

L23 An anion-exchange resin made of porous polymethacrylate or polyacrylate gel with quaternary ammonium groups, 7 to 12 µm in size

Brand	Particle Size	Type	Page
BioSuite DEAE	(2.5), 10, 13 µm	Spherical	446
BioSuite Q AXC	10, 13 µm	Spherical	446
BioSuite Q-PEEK	10 µm	Spherical	446
IC-Pak Anion	10 µm	Spherical	500
IC-Pak A HC	10 µm	Spherical	500
Protein-Pak Q 8HR	8 µm	Spherical	447

L25 Packing having the capacity to separate compounds with a molecular weight range from 100–5000 (as determined by polyethylene oxide), applied to neutral, anionic, and cationic water-soluble polymers. A polymethacrylate resin base, cross-linked with polyhydroxylated ether (surface contained some residual carboxyl functional groups) was found suitable

Brand	Particle Size	Type	Page
Ultrahydrogel DP, +120	10 µm	Spherical	473

L26 Butyl silane chemically bonded to totally porous or superficially porous silica particles, 1.5 to 10 µm in diameter

Brand	Particle Size	Type	Page
ACQUITY UPLC BEH300 C_4	1.7 µm	Spherical	416
Delta-Pak C_4	5 µm	Spherical	234
Symmetry300 C_4	3.5, 5 µm	Spherical	241, 242
XBridge BEH300 C_4	3.5, 5, 10 µm	Spherical	241

L27 Porous silica particles, 30 to 50 µm in diameter

Brand	Particle Size	Type	Page
Porasil	37–55 µm	Spherical	303, 307

L33 Packing having the capacity to separate dextrans by molecular size over a range of 4000 to 500,000 Da. It is spherical, silica-based, and processed to provide pH stability

Brand	Particle Size	Type	Page
ACQUITY UPLC Protein BEH SEC, 125 Å	1.7 µm	Spherical	427

L34 Strong cation-exchange resin consisting of sulfonated cross-linked styrene-divinylbenzene copolymer in the lead form, 7 to 9 µm in diameter

Brand	Particle Size	Type	Page
Shodex Sugar SP-0810	N/A	Spherical	496

L37 Packing having the capacity to separate proteins by molecular size over a range of 2000 to 40,000 Da. It is a polymethacrylate gel

Brand	Particle Size	Type	Page
Ultrahydrogel 250	N/A	Spherical	473

L38 A methacrylate-based size-exclusion packing for water-soluble samples

Brand	Particle Size	Type	Page
Ultrahydrogel series	N/A	Spherical	473

L39 A hydrophilic polyhydroxymethacrylate gel of totally porous spherical resin

Brand	Particle Size	Type	Page
Ultrahydrogel series	N/A	Spherical	473

L43 Pentafluorophenyl groups chemically bonded to silica particles by a propyl spacer, 1.5 to 10 µm in diameter

Brand	Particle Size	Type	Page
ACQUITY UPLC CSH Fluoro-Phenyl	1.7 µm	Spherical	114
ACQUITY UPLC HSS PFP	1.8 µm	Spherical	122
XSelect CSH Fluoro-Phenyl	2.5, 3.5, 5 µm	Spherical	157, 160, 161
XSelect HSS PFP	2.5, 3.5, 5 µm	Spherical	165, 167

L52 A strong cation exchange resin made of porous silica with sulfopropyl or sulfoethyl groups, 1 to 10 µm in diameter

Brand	Particle Size	Type	Page
IC-Pak Cation	10 µm	Irregular	500

L55 A strong cation exchange resin made of porous silica coated with polybutadiene-maleic acid copolymer, about 5 µm in diameter

Brand	Particle Size	Type	Page
IC-Pak C M/D	N/A	N/A	500

L59 Packing for the size-exclusion separations of proteins (separation by molecular weight) over the range of 5 to 7000 kDa. The packing is spherical 1.5 to 10 µm, silica or hybrid packing with a hydrophilic coating

Brand	Particle Size	Type	Page
ACQUITY BEH200 SEC	1.7 µm	Spherical	119
BioSuite 125, 250, 450 series	4–17 µm	Spherical	433
Protein-Pak 60	10 µm	Spherical	433, 471
Protein-Pak 300SW	10 µm	Spherical	433, 471

L68 Spherical, porous silica, 10 µm or less in diameter, the surface of which has been covalently modified with alkyl amide groups and not endcapped

Brand	Particle Size	Type	Page
ACQUITY UPLC Glycan BEH Amide	1.7 µm	Spherical	119
ACQUITY UPLC BEH Amide	1.7 µm	Spherical	118
ACQUITY Premier Glycan BEH Amide	1.7 µm	Spherical	369
ACQUITY Premier BEH Amide	1.7 µm	Spherical	383
XBridge Premier Glycan BEH Amide	2.5 µm	Spherical	338
XBridge BEH Amide	2.5, 3.5, 5 µm	Spherical	338
XBridge Premier BEH Amide	2.5 µm	Spherical	101
XBridge BEH Amide Glycan	2.5, 3.5 µm	Spherical	370

L78 A silane ligand that consists of both reversed-phase (an alkyl chain longer than C_8) and anion-exchange (primary, secondary, tertiary, or quartenary amino groups) functional groups chemically bonded to porous or non-porous silica or ceramic micro-particles, 1.0 to 50 µm in diameter, or a monolithic rod.

Brand	Particle Size	Type	Page
Atlantis Premier BEH C_{18} AX	1.7, 2.5, 5 µm	Spherical	104

L122 Sulfobetaine graft-polymerized to totally or superficially porous hydrophilic polymer particles, 1.0 to 10 µm in diameter, or a monolithic rod. Packing having densely bonded zwitterionic groups with 1:1 charge balance

Brand	Particle Size	Type	Page
Atlantis Premier BEH Z-HILIC	1.7, 2.5, 5 µm	Spherical	104

( ) - Denotes particle sizes available outside of L class.

Source: United States Pharmacopeia.

Column Configurations for Any LC System

COLUMN NOMENCLATURE

Our fully scalable particle technologies ensure that our LC columns perform with a broad range of chromatographic instrumentation. Depending on the goals of a separation, the instrument platform used, or the sample type, you can choose the most suitable column that is matched to your system's configuration without adversely affecting the chromatographic result.

The following table serves as a guide for selecting an appropriate LC column according to instrument classification.

Nano/Micro	UPLC	UHPLC	HPLC	Preparative
ACQUITY UPLC M-CLASS BEH (1.7 µm)	ACQUITY UPLC BEH (1.7 µm)	XBridge BEH ***XP*** (2.5 µm)	XBridge BEH (3.5, 5 µm)	XBridge BEH OBD™ (5, 10 µm)
ACQUITY UPLC M-CLASS CSH (1.7 µm)	ACQUITY UPLC CSH (1.7 µm)	XSelect CSH ***XP*** (2.5 µm)	XSelect CSH ***XP*** (3.5, 5 µm)	XSelect CSH OBD (5, 10 µm)
ACQUITY UPLC M-CLASS HSS (1.8 µm)	ACQUITY UPLC HSS (1.8 µm)	XSelect HSS ***XP*** (2.5 µm)	XSelect HSS ***XP*** (3.5, 5 µm)	XSelect HSS OBD (5 µm)
—	CORTECS UPLC (1.6 µm)	CORTECS (2.7 µm)	—	—

COLUMN CONFIGURATION

System dispersion is inherent in every chromatographic system. It is the instrument's contribution to chromatographic band broadening and is dependent on the system's tubing volume, valve fittings, column fittings, and flow cell volume. System dispersion, in combination with column dispersion, makes up the total dispersion of a given separation. Therefore, it is important to understand the system's impact on chromatographic band broadening when choosing your column configuration. Systems that have high dispersion values will obtain the best column performance using columns that have larger volumes; and, systems that have low dispersion values are able to obtain excellent column performance using columns that have smaller volumes.

The following table summarizes the characteristics of Waters LC Systems and matches the column configuration that maintains chromatographic efficiency.

System	Nano/Micro	UPLC	UHPLC	HPLC	Preparative
Dispersion	1 µL	<20 µL	22–29 µL	>30 µL	—
Routine Pressure	<15,000 psi	<18,000 psi	<10,000 psi	<10,000 psi	<4000 psi
Particle Size	<2 µm	<2 µm	2–3 µm	3–5 µm	>5 µm
Column I.D.	75–300 µm	2.1 mm (1.0 mm)	3.0 mm (2.1 mm)	4.6 mm (3.0 mm)	>7.8 mm
Column Length	50–250 mm	<150 mm	50–150 mm	75–300 mm	50–300 mm

When you transfer LC methods, instrument dispersion is one of the most practical LC-instrument parameters to determine. Knowing the bandspread value helps you develop your own compatible methods, allowing you to seamlessly scale column dimensions or transfer methods between different instrumentation platforms and laboratory functions. The following table recommends column configurations based on nominal instrument bandspread values.

System	Bandspread*	Recommended Column Particle Sizes and I.D.s
Shimadzu Prominence UFLC	41 µL	CORTECS 2.7 µm XBridge 3.5, 5 µm XSelect 3.5, 5 µm **3.0–4.6 mm I.D.**
Alliance 2695 HPLC	29 µL	
Agilent 1260 UHPLC (600 bar)	28 µL	
ACQUITY Arc	23 µL	XBridge 2.5, 3.5, 5 µm XSelect 2.5, 3.5, 5 µm CORTECS 2.7 µm **3.0 mm I.D.**
Thermo Accela UHPLC	21 µL	XBridge 2.5, 3.5, 5 µm XSelect 2.5, 3.5, 5 µm CORTECS 2.7 µm **3.0 mm I.D.**
Agilent 1290 UHPLC (1200 bar)	17 µL	

System	Bandspread*	Recommended Column Particle Sizes and I.D.s
ACQUITY UPLC	12 µL	ACQUITY UPLC BEH 1.7 µm ACQUITY UPLC CSH 1.7 µm ACQUITY UPLC HSS 1.8 µm CORTECS UPLC 1.6 µm **2.1 mm I.D.**
ACQUITY UPLC H-Class with Column Manager	12 µL	
ACQUITY UPLC H-Class	9 µL	
ACQUITY UPLC I-Class (FTN)	7.5 µL	ACQUITY UPLC BEH 1.7 µm ACQUITY UPLC CSH 1.7 µm ACQUITY UPLC HSS 1.8 µm CORTECS UPLC 1.6 µm **1.0–2.1 mm I.D.**
ACQUITY UPLC I-Class (FL)	5.5 µL	

*These data are based on nominal values for unmodified systems. As such, they are intended for reference only. Any adjustment to a system's plumbing, connectivity, and configuration will change the instrument's bandspread, affecting the quality of chromatography.

L/d_p COMPARISON CHART FOR LC COLUMNS

To convert an HPLC method to a UPLC or UHPLC method with no loss in resolution, select columns that have equivalent length-to-particle-size (L/d_p) ratio.

Waters uses this ratio to compare the resolving power of columns. If you keep the L/d_p ratio the same for two columns, you will obtain the same resolution. Therefore, for two columns with the same L/d_p ratio, the more efficient, shorter column (packed with smaller particles) will provide the same resolution in less time.

EXAMPLE: $\frac{150\text{ mm}}{5\text{ µm}} = \frac{150{,}000\text{ µm}}{5\text{ µm}} = 30{,}000$

L/d_p			Column length (mm)						
			20	30	50	75	100	150	250
Particle size (µm)	Fully porous	1.7	–	17,600	29,400	44,100	58,000	88,200	–
		2.5	8,000	12,000	20,000	30,000	40,000	60,000	–
		3.5	5,700	8,600	14,300	21,400	28,600	42,900	71,400
		5.0	4,000	6,000	10,000	15,000	20,000	30,000	50,000