Continuing the Legacy of

HPLC Column Performance

Waters

THE SCIENCE OF WHAT'S POSSIBLE.®

Creating Exceptional Chromatography

Waters® reputation is based on chromatography, but we do not create chromatography — you do. Innovative thinking within your laboratory creates the chromatographic methods and assays that sustain your business. The metric of your success is monitored by the methods and results that you produce, and the HPLC column that you choose today needs to support your success for the future. Waters full line of state-of-the-art, reversed-phase and HILIC HPLC columns are chosen by scientists who understand that performance and innovation are linked and their success depends on them.

BEH Technology™

CSH™ Technology

HSS
HIGH STRENGTH SILICA

CORTECS®
COLUMNS

CORTECS

XBridge

XSelect

Atlantis

SunFire

Symmetry

XTerra

Waters Spherisorb

Nova-Pak

Resolve

Delta-Pak

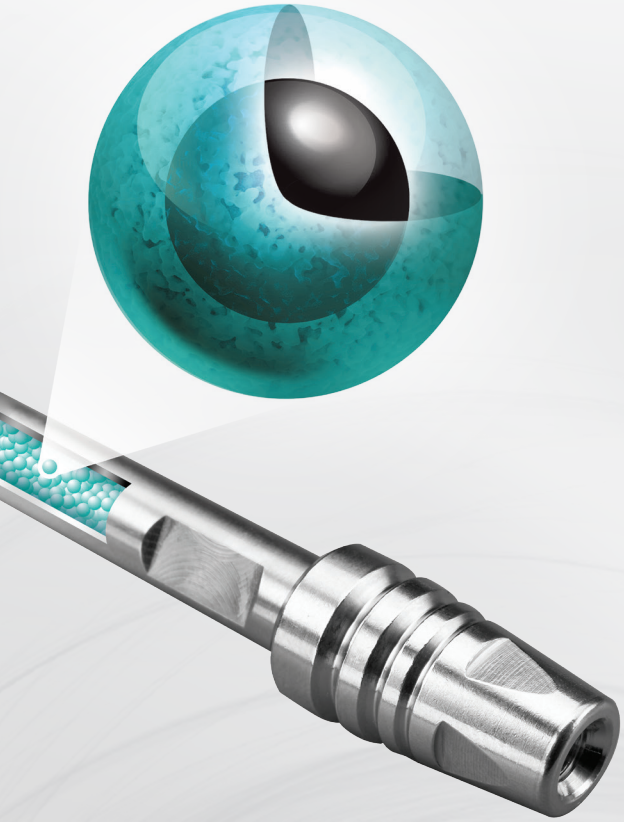
µBondaPak/BondaPak

µPorasil/Porasil

VanGuard

Waters Analytical
Standards and Reagents

CORTECS®
COLUMNS

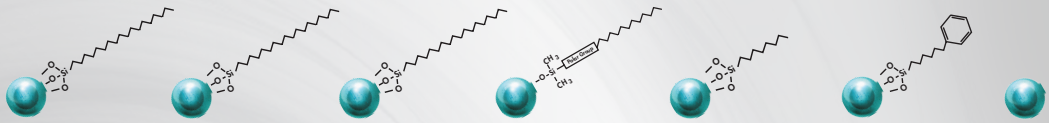


Solid-core particle packing materials combine a fully-porous surface layer that has been bonded to a solid-core substrate. This combination creates a highly efficient particle substrate that maintains chromatographic resolution while offering the advantage of lower column back pressures.

CORTECS® 2.7 µm Solid-Core Particle Columns maximize resolution and peak capacity for all LC separations and are optimized to extend HPLC or UHPLC instrument performance. The innovative solid-core technology and bonding chemistry used in CORTECS Columns helps you by:

- **Reducing Operational Backpressure:** Lower backpressure without sacrificing efficiency
- **Increasing Sensitivity:** Improved signal-to-noise performance for LC-MS applications
- **Simplifying Method Transfers:** Compatible with a wide range of chromatographic systems

The selection of CORTECS 2.7 µm Columns in both reversed-phase and HILIC phases gives you the flexibility to rapidly separate a wide range of compound classes. The improved efficiency of CORTECS 2.7 µm Solid-Core Columns produces sharper, narrower peaks compared to columns using fully-porous substrates and allows you to run faster flow rates to improve sample throughput.



CORTECS	C_{18}+	C_{18}	T3	Shield RP18	C_8	Phenyl	HILIC
Ligand Type	Trifunctional C_{18}	Trifunctional C_{18}	Trifunctional C_{18}	Monofunctional Embedded Polar	Trifunctional C_8	Trifunctional C_6 Phenyl	None
Ligand Density*	2.4 µmol/m²	2.7 µmol/m²	1.6 µmol/m²	3.2 µmol/m²	3.4 µmol/m²	3.2 µmol/m²	N/A
Carbon Load*	5.7%	6.6%	4.7%	6.4%	4.5%	5.9%	Unbonded
End-capped	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary	No
pH Range	2–8	2–8	2–8	2–8	2–8	2–8	1–5
Low pH Temp. Limit	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C
High pH Temp. Limit	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C
Pore Diameter	90Å	90Å	90Å	90Å	90Å	90Å	90Å
Surface Charge Modification	+	None	None	None	None	None	None
USP Classification	L1	L1	L1	L1	L7	L11	L3

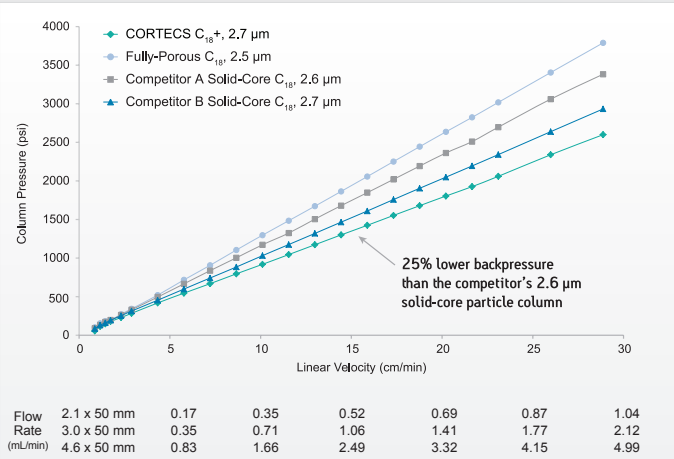
All CORTECS Columns are available in UPLC particle sizes.

* Expected or approximate values.

Reduced Backpressure

CORTECS Columns reduce operational backpressure allowing you to run methods using conventional LC instrumentation without compromising efficiency or resolution. Additionally, longer columns can be used to improve resolution for co-eluting peaks in complex sample mixtures.

Backpressure Advantages of CORTECS 2.7 µm Columns

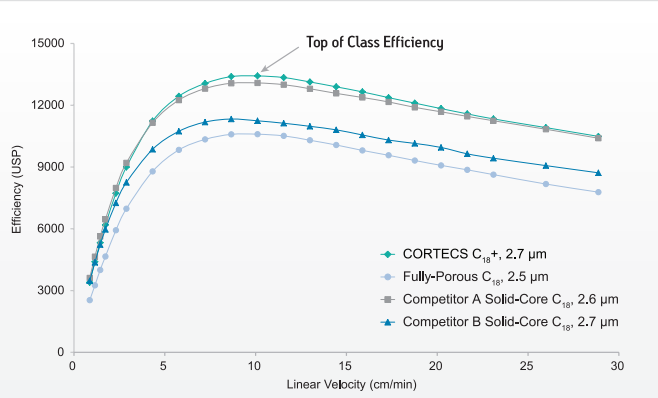


Flow Rate (mL/min)							
2.1 x 50 mm	0.17	0.35	0.52	0.69	0.87	1.04
3.0 x 50 mm	0.35	0.71	1.06	1.41	1.77	2.12
4.6 x 50 mm	0.83	1.66	2.49	3.32	4.15	4.99

Comparative separations may not be representative in all applications.

CORTECS 2.7 µm Columns offer a 25% reduction in operating backpressure—without sacrificing efficiency. Data conditions—Columns: 2.1 x 50 mm; Mobile phase: water/acetonitrile (25/75, v/v); Column temperature: 30 °C.

Efficiency Advantages of CORTECS 2.7 µm Columns



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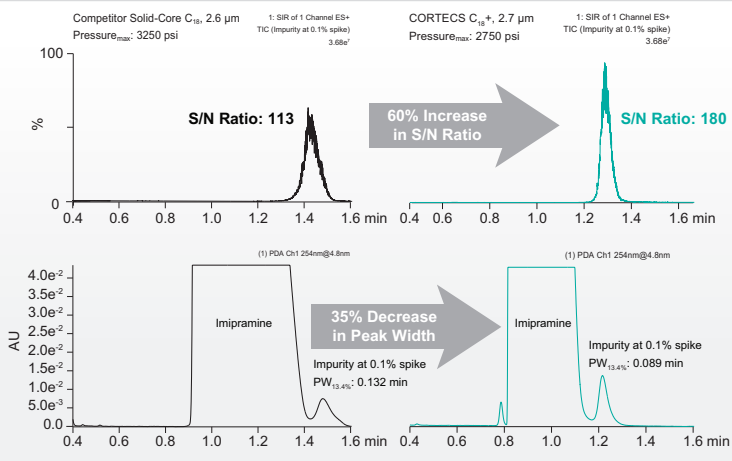
Comparative separations may not be representative in all applications.

CORTECS 2.7 µm Columns exhibit excellent efficiency compared to similarly-sized, fully-porous and solid-core particle columns. Data conditions—Columns: 2.1 x 50 mm; Mobile phase: water/acetonitrile (25/75, v/v); Column temperature: 30 °C; Compounds: acenaphthene (200 µg/mL), octanophenone (100 µg/mL).

Increased Sensitivity

Charged surface technology improves peak shape and compound loading when using low-ionic strength mobile phases such as formic acid. The permanent low-level surface charge used during the C_{18}+ bonding process enhances signal-to-noise performance by eliminating ion-pairing reagents and additives that would otherwise negatively impact LC-MS applications.

Superior Peak Shape for Low Level Impurity Analysis



LC Conditions

Columns:	3.0 x 50 mm
Mobile phase A:	0.1% formic acid in water
Mobile phase B:	0.1% formic acid in acetonitrile
Gradient:	25 to 35% B in 4.6 min
Flow rate:	0.8 mL/min
Column temp.:	30 °C
Detection:	254 nm and ESI+ MS
Injection volume:	10 µL

Compounds

Imipramine (0.5 mg/mL)
Impurity at 0.1% spike (0.5 µg/mL)

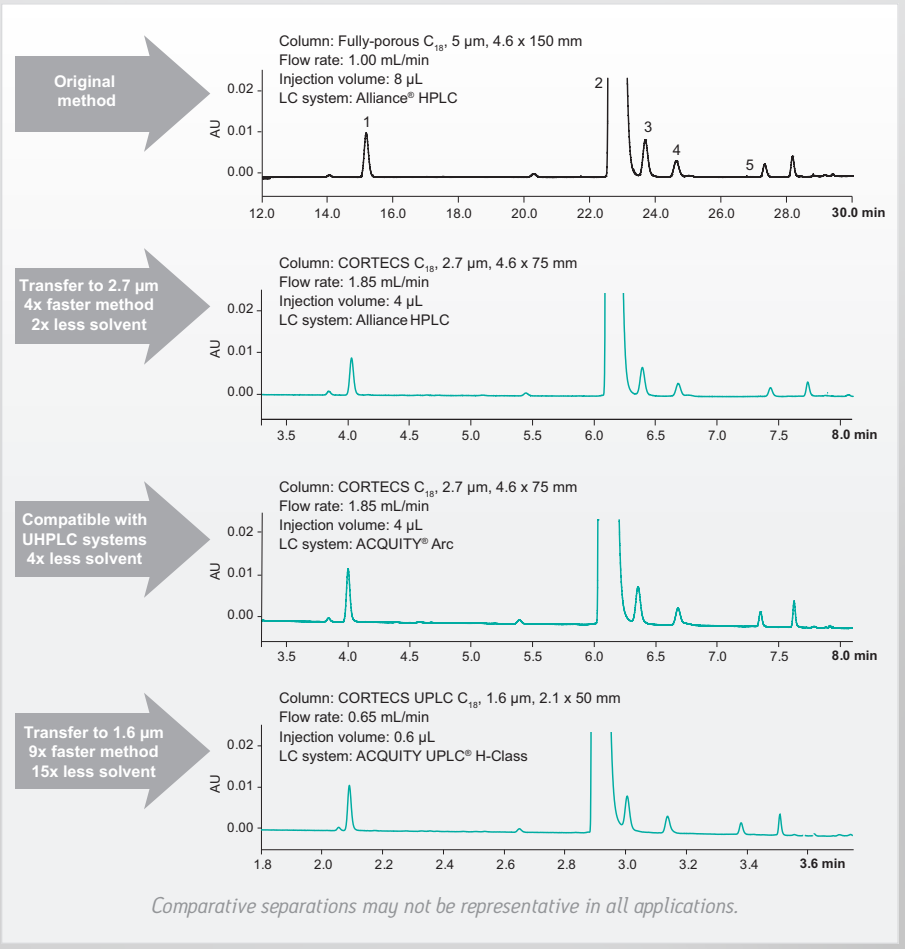
Comparative separations may not be representative in all applications.

HPLC-UV/MS analysis of the low-ionic basic antidepressant imipramine reveals a low level impurity. Using a CORTECS C_{18}+, 2.7 µm Column designed for use with low ionic strength acidic mobile phases results in narrower peaks and improved signal-to-noise.

The CORTECS Family

A dedicated selection of 7 phases can be used to separate a wide array of compound classes. CORTECS C_{18} provides a balanced retention profile for acidic, basic, and neutral compounds. CORTECS C_{18}+ gives the best peak shape and increased sensitivity of basic analytes when using low ionic strength mobile phases such as formic acid. CORTECS T3 is an excellent phase to use when separating compounds of various polarity. The lower C_{18} ligand density provides balance retention for both polar and nonpolar compounds and the 120Å pore diameter allows for the use of 100% aqueous mobile phase. CORTECS C_8, being less hydrophobic than a typical C_{18} bonded phase, is an excellent choice for the separation of strongly hydrophobic compounds. CORTECS Phenyl offers alternative selectivity to C_8 and C_{18} due to analyte interactions with the benzyl ring; selectivity differences for this phase are particularly noticed for aromatic compounds especially when using methanol as the organic modifier. The CORTECS Shield RP18 also provides alternative selectivity over typical C_8 and C_{18} bonded phases due to the embedded polar group, and is a great choice for method development, especially for phenolic and basic compounds. The orthogonal unbonded CORTECS HILIC phase provides superior peak shape and retention of polar analytes. With particle sizes that are compatible with HPLC, UPLC,® and UHPLC platforms, any method that you develop can be simply and seamlessly transferred without limitation to particle size, column configuration, or instrument manufacturer.

USP Method Transfer of Abacavir with Time and Solvent



Comparative separations may not be representative in all applications.

LC Conditions

Mobile phase A:	0.1% trifluoroacetic acid in water
Mobile phase B:	85% methanol in water
Column A:	Fully-Porous C_{18}, 5 µm, 4.6 x 150 mm
Column B:	CORTECS C_{18}, 2.7 µm, 4.6 x 75 mm
Column C:	CORTECS C_{18}, 2.7 µm, 3.0 x 75 mm
Column D:	CORTECS C_{18}, 1.6 µm, 2.1 x 50 mm

Geometrically-scaled gradients (i.e., same column volumes per gradient step):

Column A:	5 to 30% B in 23.6 min and 30 to 90% B in 14.8 min
Column B:	5 to 30% B in 6.4 min and 30 to 90% B in 4.0 min
Column C:	5 to 30% B in 6.4 min and 30 to 90% B in 4.0 min
Column D:	5 to 30% B in 2.5 min and 30 to 90% B in 1.6 min

Compounds

1. Dicyclopropyl Abacavir
2. Abacavir
3. 1R,4R trans-Abacavir
4. o-(4-Chloro-2,5-diaminopyimidnyl)-abacavir
5. o-t-Butyl-abacavir

Methods developed on 5 µm fully-porous columns can be scaled and transferred to shorter 2.7 µm columns. For further efficiency gains and productivity improvements, sub-2-µm UPLC columns can be used, enabling greater flexibility in method consistency when transitioning between laboratories within an organization or to contract partners.

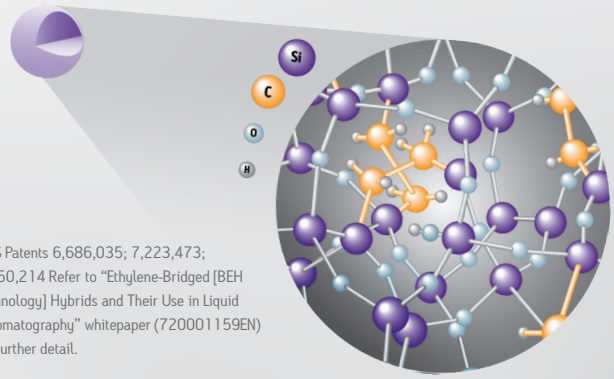
XBridge® BEH HPLC Columns are designed for one purpose, to maximize your productivity. Whether your goal is to create a quality control method or develop a leading edge LC-MS assay, XBridge BEH Columns are designed to help you by:

- **Improving pH Stability:** Increased column lifetime
- **Improving Column Reliability:** Assay ruggedness
- **Maximizing Particle Efficiency:** Unmatched peak shape and peak capacity

With a selection of 10 general purpose and application specific sorbents in the widest range of particle sizes available, no other HPLC column family gives you the tools you need for the most demanding chromatographic challenges. Whether you require robust HPLC methods, seamless UPLC transferability, or preparative scaling for product isolation, you can count on the versatility of an XBridge Column.

Based on BEH Technology

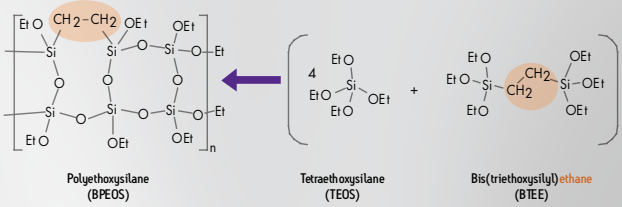
Ethylene Bridged Hybrid (BEH) Technology synthesis creates particles that ensure extreme column performance and long column lifetimes under harsh operating conditions. The particle is prepared from two high purity monomers: tetraethoxysilane (TEOS) and bis(triethoxysilyl) ethane (BTEE), which results in a highly stable, pH resistant, and mechanically strong particle.

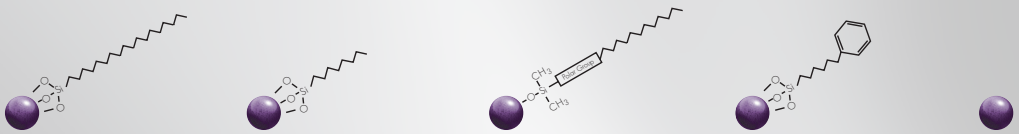


* US Patents 6,686,035; 7,223,473; 7,250,214 Refer to "Ethylene-Bridged [BEH Technology] Hybrids and Their Use in Liquid Chromatography" whitepaper (720001159EN) for further detail.

BEH Technology™

Particle Synthesis





XBridge	C_{18}	C_8	Shield RP18	Phenyl	HILIC
Ligand Type	Trifunctional C_{18}	Trifunctional C_8	Monofunctional Embedded Polar	Trifunctional Phenyl-Hexyl	Unbonded BEH Particle
Ligand Density*	3.1 µmol/m²	3.2 µmol/m²	3.3 µmol/m²	3.0 µmol/m²	N/A
Carbon Load*	18%	13%	17%	15%	Unbonded
End-capped	Proprietary	Proprietary	TMS	Proprietary	No
USP Classification	L1	L7	L1	L11	L3
pH Range	1–12	1–12	2–11	1–12	1–9
Low pH Temp. Limit	80 °C	60 °C	50 °C	80 °C	45 °C
High pH Temp. Limit	60 °C	60 °C	45 °C	60 °C	45 °C
Pore Diameter*	130Å	130Å	130Å	130Å	130Å
Surface Area*	185 m²/g	185 m²/g	185 m²/g	185 m²/g	185 m²/g
Particle Size	2.5, 3.5, 5, 10 µm	2.5, 3.5, 5, 10 µm	2.5, 3.5, 5, 10 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm

** Expected or approximate value.*

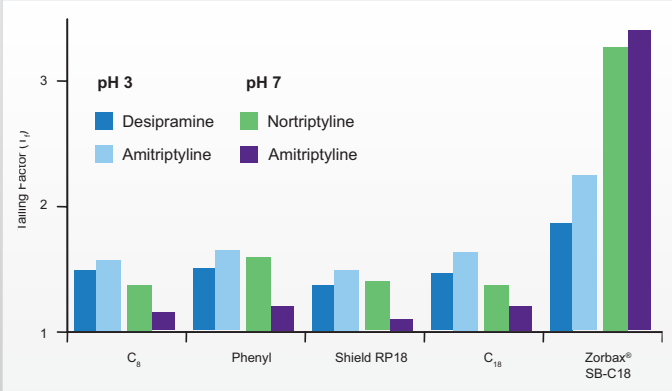
Column Reliability

Much of the cost when developing a chromatographic method is associated with the rigorous testing and validation of the final method. We understand that revalidation of your method is not an option, so we thoroughly test each batch of sorbent and final column product to ensure that you get the most reproducible columns available. With an XBridge BEH Column, you have the confidence that the method you develop today will be repeatable for the lifetime of your assay.

Particle Efficiency

BEH Technology™ offers many advantages over conventional silica-based particles, including the ability to control the silanol activity with great precision. By controlling the silanol activity, you control and reduce unwanted silanol interactions that increase peak tailing.

XBridge Family USP Tailing Factors



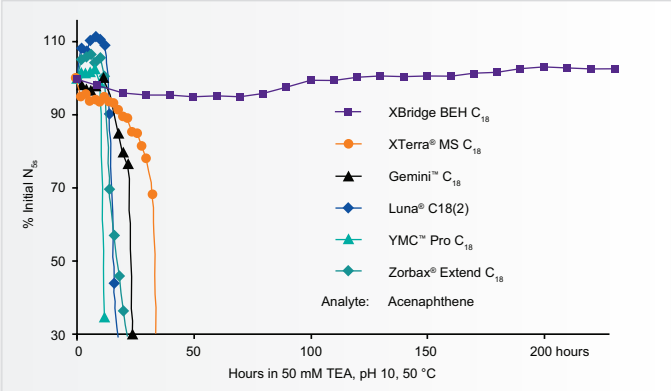
The combination of excellent particle and ligand stability as well as high chromatographic efficiencies makes XBridge BEH Columns an ideal choice for low and intermediate pH methods.

Amide	Peptide BEH C_{18}, 130Å	Peptide BEH C_{18}, 300Å	Protein BEH C_4, 300Å	Oligo BEH C_{18}	SEC
Amide	Trifunctional C_{18}	Trifunctional C_{18}	Monofunctional C_4	Trifunctional C_{18}	SEC
7.5 µmol/m²	3.1 µmol/m²	3.1 µmol/m²	2.4 µmol/m²	3.1 µmol/m²	N/A
12%	18%	12%	8%	18%	12%
No	Proprietary	Proprietary	No	Proprietary	No
N/A	L1	L1	L26	L1	L33
2–1	1–12	1–12	1–10	1–12	1–8
90 °C	80 °C	80 °C	80 °C	80 °C	45 °C
90 °C	60 °C	60 °C	50 °C	60 °C	45 °C
130Å	130Å	300Å	300Å	130Å	125, 200, 450Å
185 m²/g	185 m²/g	90 m²/g	90 m²/g	185 m²/g	220 m²/g
2.5, 3.5, 5 µm	3.5, 5, 10 µm	3.5, 5, 10 µm	3.5 µm	2.5 µm	3.5 µm

pH Stability

XBridge BEH Columns have been specifically designed to contain the most chemically-stable chromatographic sorbent available, allowing you to explore the full benefits of a wide pH (1–12) mobile-phase range. Chemical stability, especially for the extremes of pH, is built into the particle during the synthesis process and it cannot be duplicated using a conventional silica-based bonding process. No other column can match the chemical stability of an XBridge Column.

Accelerated High pH Stability Test of Competitive Columns

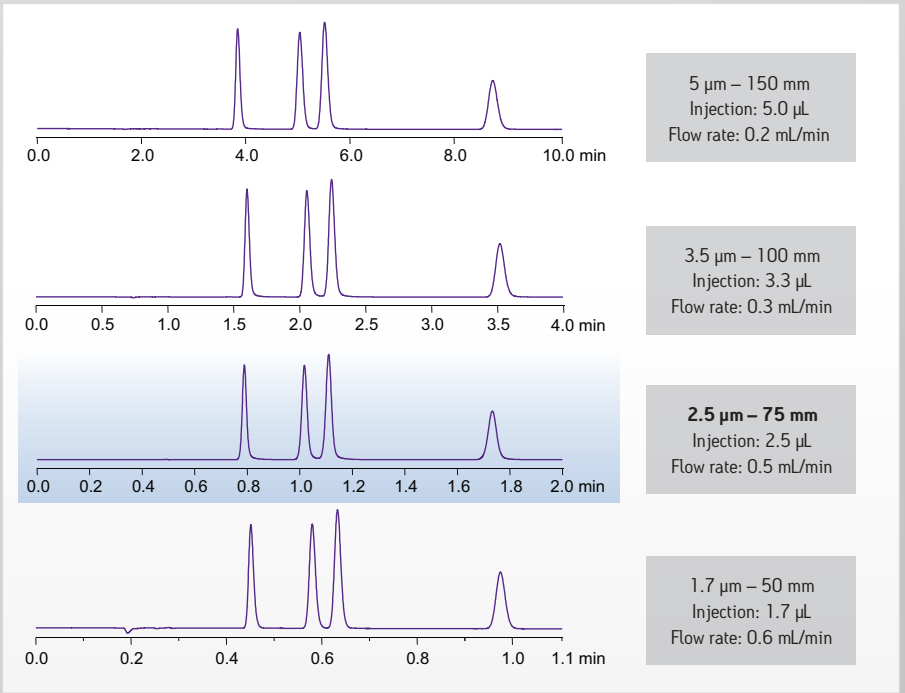


Chromatograms, run at regular intervals during the high-pH lifetime study, verify that 86% of the original XBridge Column efficiency remains after 300 hours at pH 10 and elevated temperature, with little change in peak shape or retention time.

Methods Transfer Using ***XP*** 2.5 µm Columns

All XBridge and XSelect® HPLC Columns (discussed on the next page) are offered in e***X***tended ***P***erformance [***XP***] 2.5 µm UHPLC column formats to help you transfer methods from HPLC to UPLC instrumentation. The ***XP*** 2.5 µm columns improve the performance of your current HPLC and UHPLC instrumentation and provide you with a pathway to gain maximum separation efficiency using sub-2-µm ACQUITY® UPLC Technology.

Scalable Separations



5 µm – 150 mm
Injection: 5.0 µL
Flow rate: 0.2 mL/min

3.5 µm – 100 mm
Injection: 3.3 µL
Flow rate: 0.3 mL/min

2.5 µm – 75 mm
Injection: 2.5 µL
Flow rate: 0.5 mL/min

1.7 µm – 50 mm
Injection: 1.7 µL
Flow rate: 0.6 mL/min

LC Conditions

LC system:	ACQUITY UPLC with TUV Detector
Columns:	XBridge BEH C$_{18}$, 5 µm, 2.1 x 150 mm XBridge BEH C$_{18}$, 3.5 µm, 2.1 x 100 mm XBridge BEH C$_{18}$, ***XP***, 2.5 µm, 2.1 x 75 mm ACQUITY UPLC BEH C$_{18}$, 1.7 µm, 2.1 x 50 mm
Mobile phase A:	0.1% formic acid in water
Mobile phase B:	0.1% formic acid in acetonitrile
Isocratic:	95% A:5% B
Sample conc.:	25 µg/mL
Column temp.:	38 °C
Detection:	280 nm

Columns of different lengths and particle sizes were used to successfully reduce run times and maintain resolution.

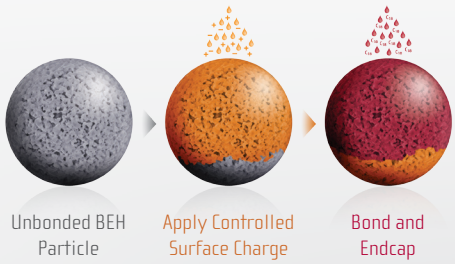
XSELECT® Columns

XSelect HPLC Columns are designed for the method development scientist who demands the most diverse selection of sorbents to easily separate the most difficult analyte co-elutions. XSelect Columns are tools that are:

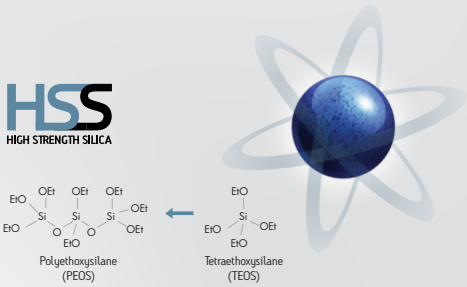
- **Designed for Selectivity:** Improve your ability to separate closely eluting peaks
- **Intended for Isolation and Purification:** Highest analyte mass loading available
- **Ideal for Rapid Method Development:** Reduce the time and cost spent developing methods

The XSelect HPLC Column family features two base particles with a unique blend of optimized ligands to provide highly selective chromatographic phases while maintaining the reproducibility expected from modern high performance LC columns. With more than 500 column configurations that combine 8 selectivity-optimized bonded phases and 3 scalable particles sizes, XSelect Columns are your first choice for method development.

The Charged-Surface Particle



Charged Surface Hybrid (CSH™) particles incorporate a low level surface charge that improves sample loading and peak symmetry when using low ionic strength mobile phases. The CSH particle is the next evolution of hybrid particle technology that maintains the mechanical and chemical stability inherent in BEH particle technology.



Many silica-based particles do not have the mechanical stability to withstand the high operational pressures used with modern LC instrumentation. High Strength Silica (HSS) is the first and only 100% silica-based particle substrate that has been designed and tested for mechanical stability up to 18,000 psi (1240 bar).

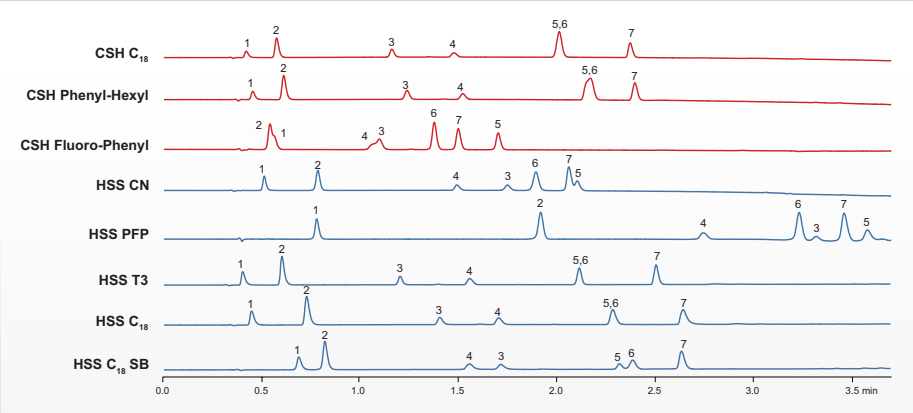
XSelect	CSH C_{18}	CSH Phenyl-Hexyl	CSH Fluoro-Phenyl	HSS T3	HSS C_{18}	HSS C_{18} SB	HSS PFP	HSS CN
Ligand Type	Trifunctional C_{18}	Trifunctional C_6 Phenyl	Trifunctional Propylfluoro-phenyl	Trifunctional C_{18}	Trifunctional C_{18}	Trifunctional C_{18}	Trifunctional Pentafluoro-phenyl	Monofunctional Cyano-propyl
Ligand Density*	2.3 µmol/m²	2.3 µmol/m²	2.3 µmol/m²	1.6 µmol/m²	3.2 µmol/m²	1.6 µmol/m²	3.2 µmol/m²	2.0 µmol/m²
Carbon Load*	15%	14%	10%	11%	15%	8%	7%	5%
End-capped	Proprietary	Proprietary	No	Proprietary	Proprietary	No	No	No
USP Classification	L1	L11	L43	L1	L1	L1	L43	L10
pH Range	1–11	1–11	1–8	2–8	1–8	2–8	2–8	2–8
Low pH Temp. Limit	80 °C	80 °C	60 °C	45 °C	45 °C	45 °C	45 °C	45 °C
High pH Temp. Limit	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C	45 °C
Pore Diameter*	130Å	130Å	130Å	100Å	100Å	100Å	100Å	100Å
Surface Area*	185 m²/g	185 m²/g	185 m²/g	230 m²/g	230 m²/g	230 m²/g	230 m²/g	230 m²/g
Particle Size	2.5, 3.5, 5, 10 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm	2.5, 3.5, 5 µm

** Expected or approximate value.*

Enhanced Selectivity

Selectivity and retentivity are the most powerful tools a method developer has to influence chromatographic behavior. The XSelect family offers a diverse range of reversed-phase C_{18} columns (e.g., CSH C_{18}, HSS C_{18}, HSS C_{18} SB) for general purpose separations; as well as columns that offer improved polar retention (T3) and greater selectivity options (phenyl-hexyl, fluoro-phenyl, and cyano) for method development.

XSelect Columns Provide Diverse Analyte Selectivity



Observed selectivity differences for a mixture of basic analytes. Compounds: [1] aminopyrazine, [2] pindolol, [3] quinine, [4] labetalol, [5] verapamil, [6] diltiazem, [7] amitriptyline.

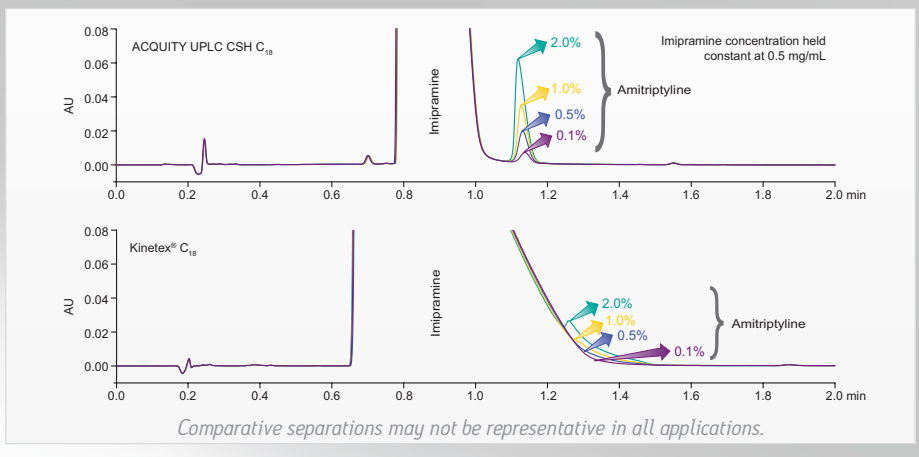
LC Conditions

LC system:	ACQUITY UPLC with ACQUITY UPLC PDA Detector
Columns:	2.1 x 50 mm
Mobile phase A:	10 mM ammonium formate, pH 3.0
Mobile phase B:	Methanol
Flow rate:	0.4 mL/min
Injection volume:	1 µL
Sample diluent:	Water
Column temp.:	30 °C
Gradient:	Time (min) %A %B 0.00 70 30 3.00 15 85 3.50 15 85 3.51 70 30 4.50 70 30
Detection:	260 nm

Isolation and Purification

High mass loading applications like compound purification, impurity profiling, and dissolution testing demand superior column performance. For these types of applications, column loading is limited by its inability to maintain symmetrical peak shape. This manifests itself as severe broadening of the main compound peak, which often overwhelms the trace impurities that you are trying to remove in the purification. XSelect CSH Columns consistently provide narrow peaks under high loading conditions that allow the chromatographer the ability to separate trace-level impurities or degradants giving you more loading capacity with less time and solvent.

Maintaining Peak Shape with High Mass Loading



The improved mass loading of XSelect Columns permits the separation, identification, and quantification of closely eluting impurities or degradants.

LC Conditions

LC system:	ACQUITY UPLC H-Class with ACQUITY UPLC PDA Detector
Columns:	2.1 x 50 mm
Mobile phase A:	Water
Mobile phase B:	Acetonitrile
Mobile phase C:	2% formic acid in water
Gradient:	Time (min) Flow (mL/min) %A %B %C Initial 0.6 70 25 5 2.0 0.6 60 35 5 5.0 0.6 70 25 5
Injection volume:	5 µL
Sample diluent:	Water
Sample conc.:	Imipramine: 0.5 mg/mL; amitriptyline: as indicated (% of imipramine)
Column temp.:	40 °C
Detection:	254 nm

Method Development and Transfer

When developing methods, skilled chromatographers realize that any method developed using uniquely selective columns must be easily transferable across laboratories, independent of the LC system platform used. XSelect Columns are engineered for method development and are fully compatible with all modern detection modes.

Reproducible and Scalable Separations

Reproducibility and scalability for gradient separations on 2.1 x 50 mm columns containing nine different batches of CSH fluoro-phenyl representing three (1.7,- 3.5,- and 5-µm) particle sizes.

LC Conditions

LC system:	ACQUITY UPLC with ACQUITY UPLC PDA Detector
Columns:	2.1 x 50 mm
Flow rate:	0.5 mL/min
Mobile phase A:	15.4 mM ammonium formate, pH 3.0
Mobile phase B:	Acetonitrile
Gradient:	5 to 90% B linear in 5 minutes
Injection volume:	5 µL
Column temp.:	30 °C
Detection:	254 nm

Compounds

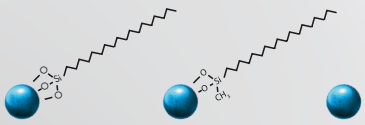
1. Thiourea
2. Resorcinol
3. Metoprolol
4. 3-Nitrophenol
5. 2-Chlorobenzoic acid
6. Amitriptyline
7. Diethylphthalate
8. Fenoprofen
9. Dipropylphthalate
10. Pyrenesulfonic acid

Atlantis® Columns

Atlantis® HPLC Columns provide exceptional performance, versatility, and retention for polar compounds, while also affording balanced retention for broad analyte mixtures.

Compatibility with 100% Aqueous Mobile Phases

To maximize polar compound retention in reversed-phase methods, it is possible to use Atlantis Reversed-phase HPLC Columns with highly aqueous mobile phases and buffers without the risk of pore dewetting and hydrophobic collapse of the stationary phase.



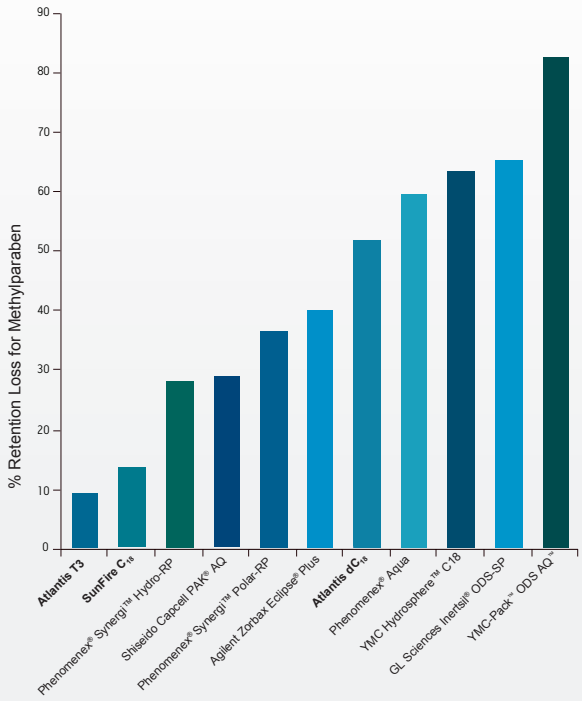
Atlantis	T3	dC_{18}	HILIC Silica
Ligand Density*	1.6 µmol/g	1.6 µmol/g	N/A
Carbon Load*	14%	12%	N/A
End-capped	Proprietary	Proprietary	No
USP Classification	L1	L1	L3
pH Range	2–8	3–7	1-5
Low pH Temp. Limit	45 °C	45 °C	45 °C
High pH Temp. Limit	45 °C	45 °C	45 °C
Pore Diameter*	100Å	100Å	100Å
Surface Area*	330 m^2/g	330 m^2/g	330 m^2/g
Particle Size	3, 5, 10 µm	3, 5, 10 µm	3, 5, 10 µm

** Expected or approximate value.*

Long Column Lifetimes Using Low-pH Mobile Phases

Atlantis Columns resist ligand hydrolysis when using strongly acidic mobile phases, thus maintaining method efficiency, compound retention, and critical analyte selectivity.

20 Hour Exposure to 0.5% TFA at 60 °C



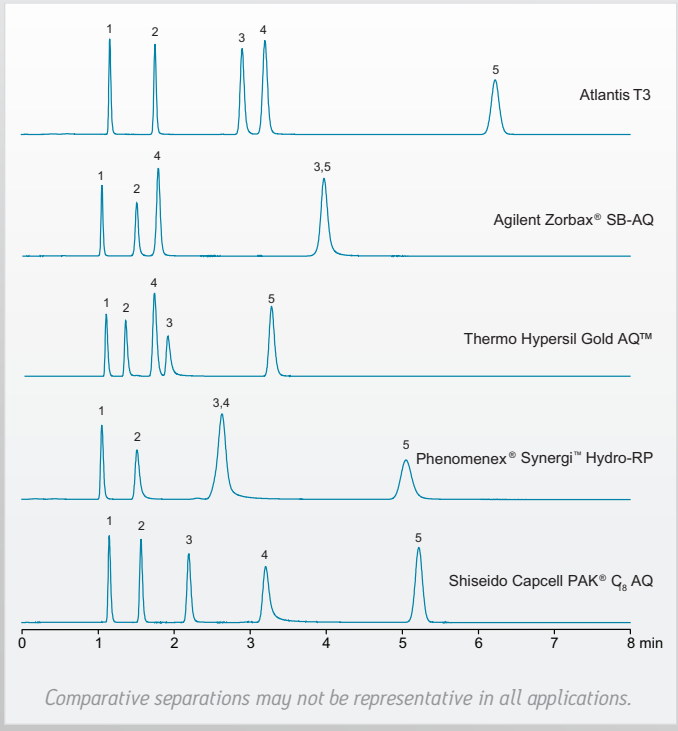
Comparative separations may not be representative in all applications.

During this accelerated test, the columns were exposed to low pH and high temperature conditions to determine the affect of ligand loss due to hydrolysis. The Atlantis T3 bonding resists ligand hydrolysis to maintain analyte retention using extremely harsh mobile-phase conditions.

Polar Compound Retention without Ion-Pairing Reagents

Eliminating ion-pairing reagents improves detection limits, method reproducibility, and robustness, while reducing instrument maintenance due to harsh mobile-phase environments.

Polar Compound Retention



Comparative separations may not be representative in all applications.

Separating highly polar analytes on the Atlantis T3 Column compared to competitive brands. Scientists rely on the uncompromised peak shape and retention that only Atlantis Columns provide.

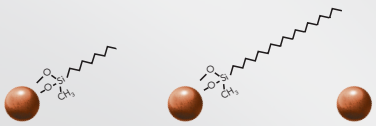
LC Conditions

LC system:	Alliance 2695 with 2487 Dual-Wavelength Absorbance Detector
Column:	4.6 x 150 mm
Mobile phase:	10 mM ammonium formate, pH 3.0
Flow rate:	1.3 mL/min for 3 µm
Injection volume:	2.0 µL
Column temp.:	30 °C
Detection:	254 nm

Compounds

1. Thiourea
2. 5-Fluorocystine
3. Adenine
4. Guanosine-5'-monophosphate
5. Thymine

SunFire™ Columns set the standard for state-of-the-art bonded C_{18}- and C_8- silica HPLC columns. Benefiting from years of research and product development, SunFire Columns represent the best in particle and bonding expertise and deliver industry-leading levels of chromatographic performance.



SunFire	C_8	C_{18}	Silica
Ligand Density*	3.5 µmol/g	3.5 µmol/g	N/A
Carbon Load*	12%	16%	N/A
End-capped	Proprietary	Proprietary	No
USP Classification	L7	L1	L3
pH Range	2–8	2–8	2–8
Low pH Temp. Limit	40 °C	50 °C	55 °C
High pH Temp. Limit	40 °C	40 °C	45 °C
Pore Diameter*	100Å	100Å	100Å
Surface Area*	340 m^2/g	340 m^2/g	340 m^2/g
Particle Size	2.5, 3.5, 5, 10 µm	2.5, 3.5, 10 µm	2.5, 3.5, 10 µm

** Expected or approximate value.*

Excellent Low-pH Stability

Under low-pH mobile-phase conditions, SunFire Columns exhibit superior column lifetimes that exceed many silica-based HPLC column brands.

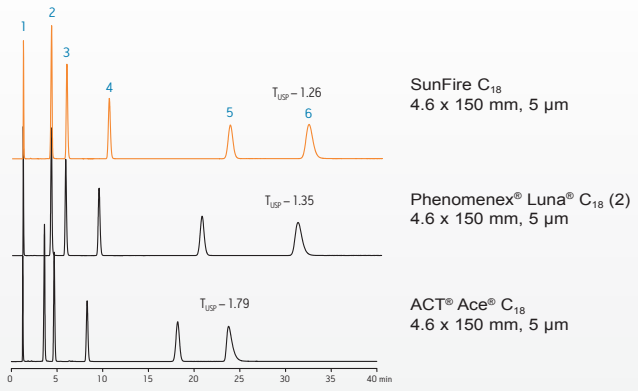
High Efficiency

A synergistic combination of particle synthesis, packing technology, and hardware engineering is required for high efficiency. SunFire Intelligent Speed™ (*IS*™) and Optimum Bed Density (OBD™) Columns were developed specifically from this knowledge.

Superior Peak Shapes

SunFire Columns provide symmetrical peaks for improved resolution of acidic, neutral and basic compounds at low and moderate pH ranges (2–8).

Peak Shape Comparison of SunFire Columns



Comparative separations may not be representative in all applications.

Isocratic Separation

LC system:	Alliance 2695 with 2487 Dual-Wavelength Absorbance Detector
Mobile phase A:	35% 20 mM dipotassium phosphate/ 20 mM monopotassium phosphate pH 7.0
Mobile phase B:	65% methanol
Wavelength:	254 nm
Flow rate:	1.0 mL/min
Injection vol.:	14 µL
Column temp.:	23 °C

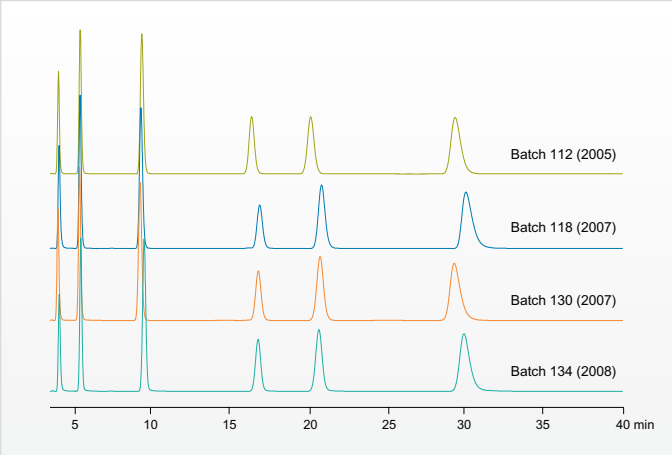
Compounds

1. Uracil
2. Propranolol
3. Butylparaben
4. Naphthalene

Batch-to-Batch Reproducibility

Waters is dedicated to maintain the tightest specifications in the HPLC industry. Controlled manufacturing processes and column packing procedures ensure that you receive the best, most reproducible HPLC column available.

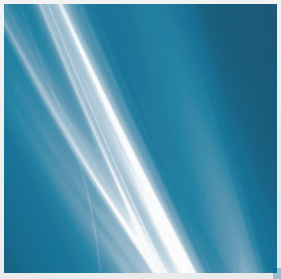
Batch-to-Batch Reproducibility of SunFire Columns



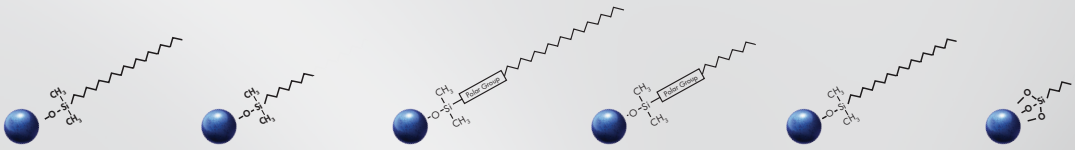
This excellent reproducibility is a result of our commitment to maintaining the tightest specifications in the HPLC column industry. SunFire Columns start with high purity raw materials, and are produced using controlled manufacturing processes and column packing procedures that provide today's scientists with the best, most reproducible HPLC columns available.

Symmetry® Columns

Symmetry® Columns are manufactured using high purity silica and tightly controlled manufacturing processes to ensure that you receive a column that exceeds the standards for HPLC column performance. No other silica-based LC column brand can match the column-to-column and batch-to-batch reproducibility of the Symmetry family. Symmetry Columns are available in column, cartridge, and guard formats:



- **Symmetry and SymmetryPrep™ Columns:** Deliver maximum reproducibility
- **SymmetryShield™ RP18 and RP8 Columns:** Provide superior peak shape
- **Symmetry300™ C_{18} and C_4 Columns:** Offer high recoveries of peptides and proteins

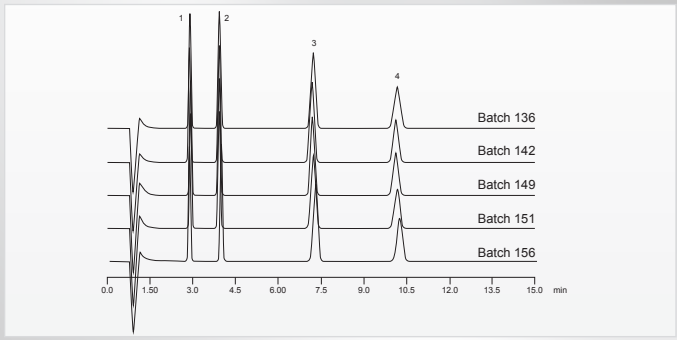


Symmetry	Symmetry and SymmetryPrep C_{18}	Symmetry and SymmetryPrep C_8	SymmetryShield RP18	SymmetryShield SymmetryPrep RP8	Symmetry300 C_{18}	Symmetry300 C_4
Particle Size	3.5, 5, 7 µm	3.5, 5, 7 µm	3.5, 5, 7 µm	3.5, 5, 7 µm	3.5, 5 µm	3.5, 5 µm
Particle Shape	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical
Pore Size	100Å	100Å	100Å	100Å	300Å	300Å
Carbon Load	19%	12%	17%	15%	8.5%	2.8%
End-capped	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary

Symmetry Columns for Reproducibility

You can rely on a Symmetry HPLC Column for rugged and reproducible performance. Narrow column specification ranges minimize variation giving you the confidence that the methods you use today will continue to be used in the future.

Batch-to-Batch Reproducibility of Symmetry Columns



Unmatched year-to-year reproducibility.

LC Conditions

Column:	Symmetry C_{18}, 5 µm, 4.6 x 150 mm
Mobile phase A:	Water
Mobile phase B:	Acetonitrile
Mobile phase C:	pH 3.75; 100 mM ammonium formate in water
Flow rate:	1.4 mL/min
Isocratic:	30% A; 60% B; 10% C
Injection vol.:	5.0 µL
Column temp.:	30 °C
Detection:	233nm

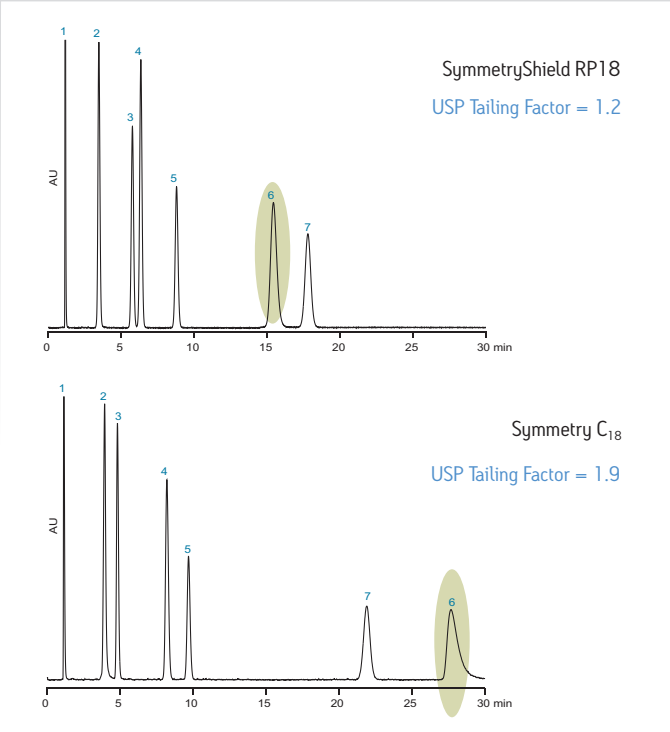
RSD's for retention times

1. Terbinafine HCl	0.7%
2. Ibuprofen	0.8%
3. Lovastatin	0.6%
4. Simvastatin	0.7%

Symmetry Columns for Superior Peak Shape

SymmetryShield Columns feature Waters' patented Embedded Polar Group Technology that shields the silica's residual silanols from highly basic analytes that improves overall peak shape. Additionally, by placing the embedded polar group close to the silica surface, the activity of the surface silanols is further reduced. This imparts selectivity and retention that is different compared to the Symmetry C_{18} ligand.

SymmetryShield Columns Deliver Unique Selectivity



Embedded Polar Group Technology improves chromatographic peak shape and selectivity.

LC Conditions

Columns:	SymmetryShield RP18, 5 µm, 3.9 x 150 mm Symmetry C_{18}, 5 µm, 3.9 x 150 mm
Mobile phase:	65% methanol; 35% 20 mM monopotassium phosphate/ dipotassium phosphate at pH 7
Flow rate:	1.0 mL/min
Detection:	254 nm
Column temp.:	23 °C

Compounds

1. Uracil
2. Propranolol
3. Butylparaben
4. Dipropyl phthalate
5. Naphthalene
6. Amitriptyline
7. Acenaphthene

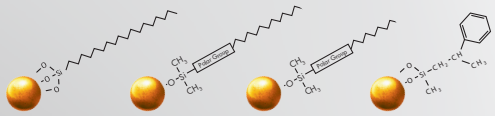
www.waters.com/symmetry

XTerra® MS, Shield RP, and Phenyl Columns combine the best properties of silica and polymeric bonded phases with patented Hybrid Particle Technology that replaces one out of every three silanols with a methyl group during particle synthesis. This can only be achieved during the initial particle synthesis and the inclusion of this methyl group is an integral part of the base particle backbone. The result is a mechanically strong particle that can be used for high pH separations that will improve loading and peak shapes for basic compounds.

The Efficiency of Silica with Stability of Polymers

The vast majority of reversed-phase HPLC separations take place on silica-based stationary phases. Silica has long enjoyed such attributes as high efficiency and mechanical strength. However, silica suffers from poor peak shape for bases and a limited pH range. One way that chromatographers have attempted to overcome these limitations is by turning to polymer-based stationary phases. Polymers, however, have not enjoyed the acceptance of silica due to poor efficiency, low mechanical strength, and unpredictable peak elution order when transferring methods from polymeric to silica-based columns.

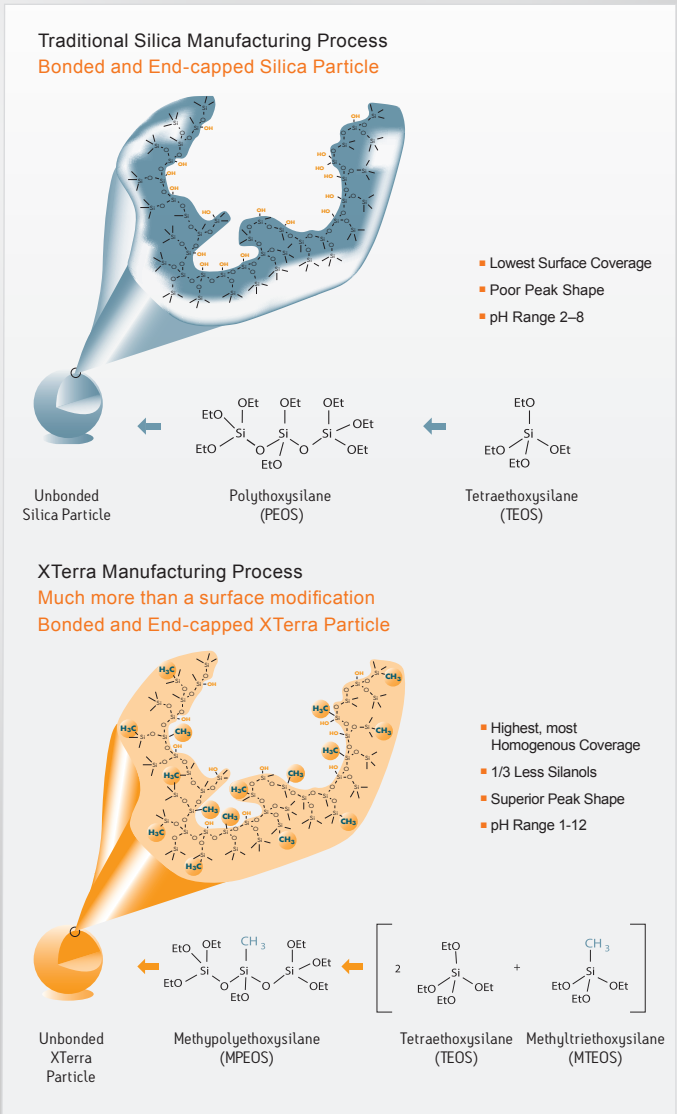
Hybrid Particle Technology overcomes these limitations and combines the best attributes of both these materials while overcoming each material's weaknesses. The result is a rugged material that has high mechanical strength, high efficiency, excellent peak shape for bases, and easy scale-up from analytical to preparative chromatography.



XTerra	MS C_{18}	Shield RP18	Shield RP8	Phenyl
Particle Size	2.5, 3.5, 5, 10 µm	3.5, 5, 10 µm	3.5, 5, 10 µm	3.5, 5 µm
Particle Shape	Spherical	Spherical	Spherical	Spherical
Pore Size	125Å	125Å	125Å	125Å
Carbon Load	15.5%	15.0%	13.5%	12.0%
End-capped	Proprietary	Proprietary	Proprietary	Proprietary

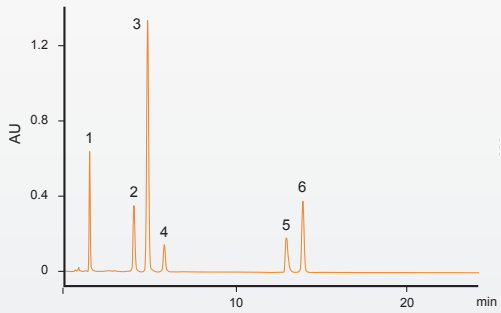
** Expected or approximate value.*

Traditional Silica versus XTerra Manufacturing Process

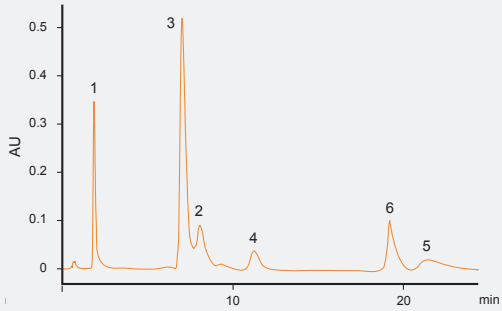


Silica Separations at Polymer pH

XTerra Shield RP18: 4.6 x 150 mm
pH 10.7



Polymer Column: 4.1 x 150 mm
pH 10.7



LC Conditions

LC system:	Alliance 2690 with 996 PDA Detector
Mobile phase A:	20 mM ammonium hydroxide, pH 10.7
Mobile phase B:	Acetonitrile
Flow rate:	3 mL/min
Gradient:	Time Profile
	(min) %A %B
	0.0 70 30
	25.0 40 60
Injection vol.:	5 µL
Column temp.:	Ambient
Detection:	220 nm

Compounds

1. Codeine
2. Yohimbine
3. Thebaine
4. Cocaine
5. Resperine
6. Methadone

WATERS SPHERISORB COLUMNS

Waters Spherisorb® Columns are one of the most widely referenced HPLC columns in the scientific literature. There are over 2,000 analytical abstracts published using Waters Spherisorb Columns, providing a tremendous range of validated methods and applications to assist in your method development process.

Waters Spherisorb Columns are produced in a wide range of particle sizes (3-, 5-, and 10- µm) and bonded phases to meet your chromatographic needs. In addition, Waters Spherisorb Columns' high quality bonded phases give many different and unique separation selectivities. Waters Spherisorb Analytical Columns are supplied with industry-standard Parker-style column end fittings.

Spherisorb **www.waters.com/spherisorb**

Ligand Type	ODS2 (C_{18})	ODS1 (C_{18})	ODSB (C_{18})	C_8	C_6	C_1	NH_2 (Amino)
Particle Size	3, 5, 10 µm	3, 5, 10 µm	5 µm	3, 5, 10 µm	3, 5, 10 µm	3, 5, 10 µm	3, 5, 10 µm
Surface Area	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g
Particle Shape	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical
Pore Size	80Å	80Å	80Å	80Å	80Å	80Å	80Å
Carbon Load	11.5%	6.2%	11.5%	7.75%	4.7%	2.15%	1.9%
Ligand Coverage	2.98 µmol/m^2	1.49 µmol/m^2	2.98 µmol/m^2	3.12 µmol/m^2	3.36 µmol/m^2	2.97 µmol/m^2	2.64 µmol/m^2
End-capped	Proprietary	No	Proprietary	Proprietary	Proprietary	No	No

Ligand Type	Phenyl	CN (Nitrile)	OD/CN	W (Silica)	SCX	SAX
Particle Size	3, 5, 10 µm	3, 5, 10 µm	5 µm	3, 5, 10 µm	5, 10 µm	5, 10 µm
Surface Area	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g	220 m^2/g
Particle Shape	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical
Pore Size	80Å	80Å	80Å	80Å	80Å	80Å
Carbon Load	2.5%	3.1%	5%	N/A	4%	4%
Ligand Coverage	2.72 µmol/m^2	3.29 µmol/m^2	1.15 µmol/m^2	N/A	N/A	N/A
End-capped	No	No	Proprietary	No	No	No

NOVA-PAK COLUMNS

The bonded phases of Nova-Pak® Columns are available in 4 µm and 6 µm particle sizes that offer high resolution as well as faster and more efficient chromatography. The smaller particle size in conjunction with shorter column lengths can be used to reduce solvent consumption while maintaining resolution for complex mixtures. Analytical columns with 4 µm particle size packing are available in 75, 150, and 300 mm length steel columns. Semi-preparative Prep Nova-Pak HR Columns are packed with 6 µm particle-size packings and provide an unparalleled range of separation possibilities. The high-efficiency packing of Prep Nova-Pak HR Columns provides faster separations using less solvent with the added advantage of more concentrated fractions, all of which reduce preparative chromatography cost. All Nova-Pak Columns are packed to stringent QC procedures in our cGMP manufacturing facility to ensure batch-to-batch reproducibility.

Nova-Pak www.waters.com/nova-pak

Chemistry	C_{18}	C_8	Phenyl	CN	Silica	Prep HR C_{18}	Prep HR Silica
Particle Size	4 µm	4 µm	4 µm	4 µm	4 µm	6 µm	6 µm
Particle Shape	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical	Spherical
Pore Size	60Å	60Å	60Å	60Å	60Å	60Å	60Å
Carbon Load	7%	4%	5%	2%	N/A	7%	N/A
End-capped	Proprietary	Proprietary	Proprietary	Proprietary	No	Proprietary	No

RESOLVE COLUMNS

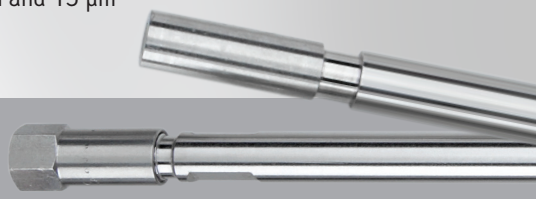
The non-endcapped Resolve™ packing is significantly different from Waters other packing materials. The change in chromatographic behavior is most commonly noticed with polar compounds which are typically more retained. Basic compounds can be chromatographed using mobile phase modifiers, such as ion-pairing reagents, which reduce excessive tailing.

Resolve www.waters.com/**resolve**

Ligand Type	Silica	C_{18}	C_8	CN
Particle Size	5, 10 µm	5, 10 µm	10 µm	10 µm
Particle Shape	Spherical	Spherical	Spherical	Spherical
Pore Size	90Å	90Å	90Å	90Å
Carbon Load	10 %	10%	5%	3%
End-capped	No	No	No	No

DELTA-PAK COLUMNS

Delta-Pak™ Columns are ideal for separation and isolation of peptides, proteins, and natural products and are available in two different pore sizes that are optimized for large molecule separations. Delta-Pak Columns are known for consistent and predicable scaling between column formats, allowing purification scientists the ability to isolate target compounds from the milligram to gram quantities. The highly stable Delta-Pak bonded silica is available in 5 µm and 15 µm particle sizes.



Delta-Pak www.waters.com/**delta-pak**

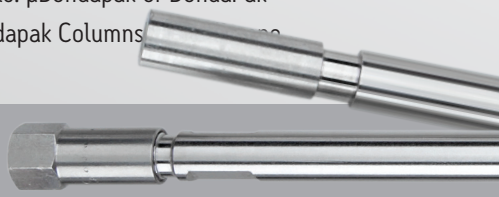
Ligand Type	C_{18}	C_{18}	C_4	C_4
Particle Size	5, 15 µm	5, 15 µm	5, 15 µm	5, 15 µm
Particle Shape	Spherical	Spherical	Spherical	Spherical
Pore Size	100Å	300Å	100Å	300Å
Carbon Load	17%	7%	7%	3%
End-capped	Proprietary	Proprietary	Proprietary	Proprietary

Irregular Particle Technology

The first HPLC packing materials were comprised of non-spherical and irregularly shaped particles. Typically, these columns have reduced mechanical stability and lower efficiency compared to a column packed with spherical particles. However, even with these limitations, there are many methods that require the use of these sorbents. As a primary manufacture of sorbents and bonded materials, Waters has demonstrated consistent and reliable column performance for over 40 years and we will continue to support these brands for the future.

µBONDAPAK/BONDAPAK COLUMNS

If your method calls for a µBondapak® Column, there is only one column that contains µBondapak C_{18} packing material. Many companies claim "µBondapak-like" selectivity, but none have passed Waters stringent QC batch tests. µBondapak or BondaPak® packing materials have demonstrated reproducibility from year-to-year since 1973, allowing µBondapak Columns [illegible] of the most widely referenced HPLC column brands.



µBondapak/ Bondapak **www.waters.com/bondapak**

Ligand Type	C_{18}	Phenyl	CN	NH_2
Particle Size	10 µm	10 µm	10 µm	10 µm
Particle Shape	Irregular	Irregular	Irregular	Irregular
Pore Size	125Å	125Å	125Å	125Å
Carbon Load	10%	8%	6%	3.5%
End-capped	Proprietary	Proprietary	Proprietary	No

µPORASIL/PORASIL COLUMNS

µPorasil™ and Porasil™ particles were one of the first commercially available fully porous packing materials used for LC separations. In contrast to the reversed-phase separation ability of µBondapak C_{18}, the non-bonded, silica-based material in µPorasil Columns was produced to provide normal-phase separations for a wide array of sample types.

µPorasil/Porasil **www.waters.com/porasil**

Ligand Type	Silica
Particle Size	10, 15-20 µm
Particle Shape	Irregular
Pore Size	125Å
Carbon Load	N/A
End-capped	No

How Do You Know Your Chromatographic System is in Proper Working Order?

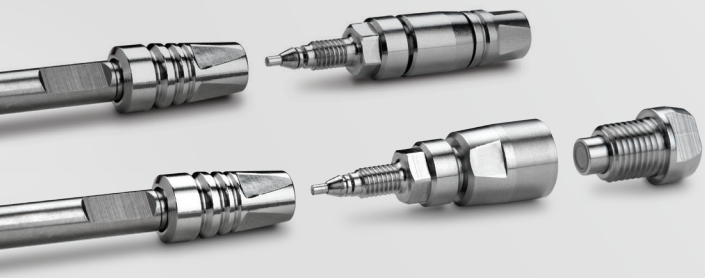
Quality Control (QC) Reference Materials contain mixtures of standards specifically chosen to provide an easy and reliable way to monitor the performance of any chromatographic system. By using a QC Reference Materials, you can be assured that your column and system are ready to analyze your samples. Regular use of QC Reference Materials also provides an opportunity to benchmark your chromatographic systems and trend performance over time, making it easier to proactively identify problems and resolve them faster.

Since chromatographic analyses are complex and depend on many different variables, such as mobile-phase composition, column type, and detection method, Waters has formulated specific QC Reference Material mixtures designed to test systems with these differences in mind.

To locate additional information for standards specific to calibration, qualification, and tuning of instruments and detectors, as well as a more comprehensive list of available standards and reagents, visit **asr.waters.com**

Column Performance Monitoring	Intended Use	Detector Performance Monitoring	Intended Use
Neutrals QC Reference Material	Provides chromatographic performance information under isocratic conditions using 3 neutral probes.	**QDa QC Reference Material**	Provides chromatographic and mass spectrometer information using an 8 component mixture in an optimized format for the ACQUITY QDa® Detector. This solution contains 1 critical pair to measure chromatographic performance.
Reversed-Phase QC Reference Material	Provides reversed-phase chromatographic performance information under gradient conditions using 1 void marker, 3 neutral, 1 acidic, and 2 basic probes.	**Quad LCMS QC Reference Material**	Provides chromatographic and mass spectrometer information using a 9 component mixture in a format optimized for quadrupole MS Systems. This solution contains 2 critical pairs to measure chromatographic performance.
HILIC QC Reference Material	Provides chromatographic performance information inclusive of mobile-phase pH in HILIC mode using 1 void marker, 1 polar neutral, and 2 polar basic probes.	**LCMS QC Reference Material**	Provides chromatographic and mass spectrometer information using a 9 component mixture in a format optimized for the highest resolution Tof/QTof MS Systems. This solution contains 2 critical pairs to measure chromatographic performance.

VANGUARD™
COLUMN PROTECTION



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VanGuard™ Pre-columns and Cartridges are optimized to protect and prolong analytical column lifetimes without compromising chromatographic performance. They are available in a wide selection of particle sizes and stationary phases, making them ideally suited for the physical and chemical protection for all Waters analytical columns.

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