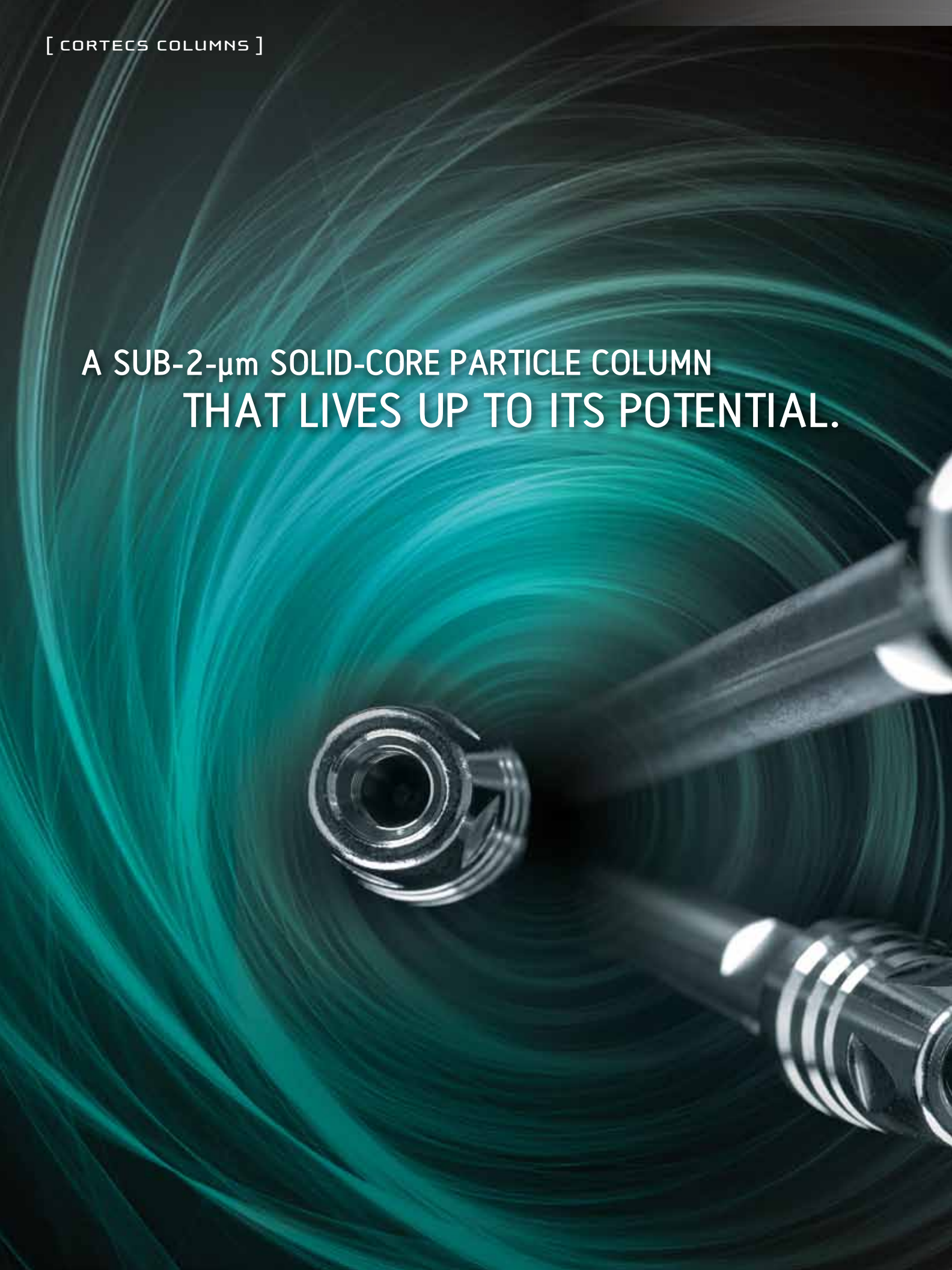
CORTECS™
COLUMNS

TRANSCEND THE LIMITS OF PERFORMANCE

Waters
THE SCIENCE OF WHAT'S POSSIBLE.™

A SUB-2-µm SOLID-CORE PARTICLE COLUMN THAT LIVES UP TO ITS POTENTIAL.



C_{18} | C_{18}+ | HILIC

SOLID-CORE PARTICLE COLUMNS THAT DELIVER ULTIMATE EFFICIENCY AND PERFORMANCE

With our unique understanding of how to harness the power of sub-2-µm particles, Waters brings you the latest addition to our family of sub-2-µm UltraPerformance LC® columns. Based on 1.6 µm solid-core particle technology, CORTECS™ Columns enable you to achieve new levels of efficiency and performance. Whether you're trying to resolve complex mixtures or maintain resolution while increasing throughput, CORTECS Columns will surpass ALL expectations.

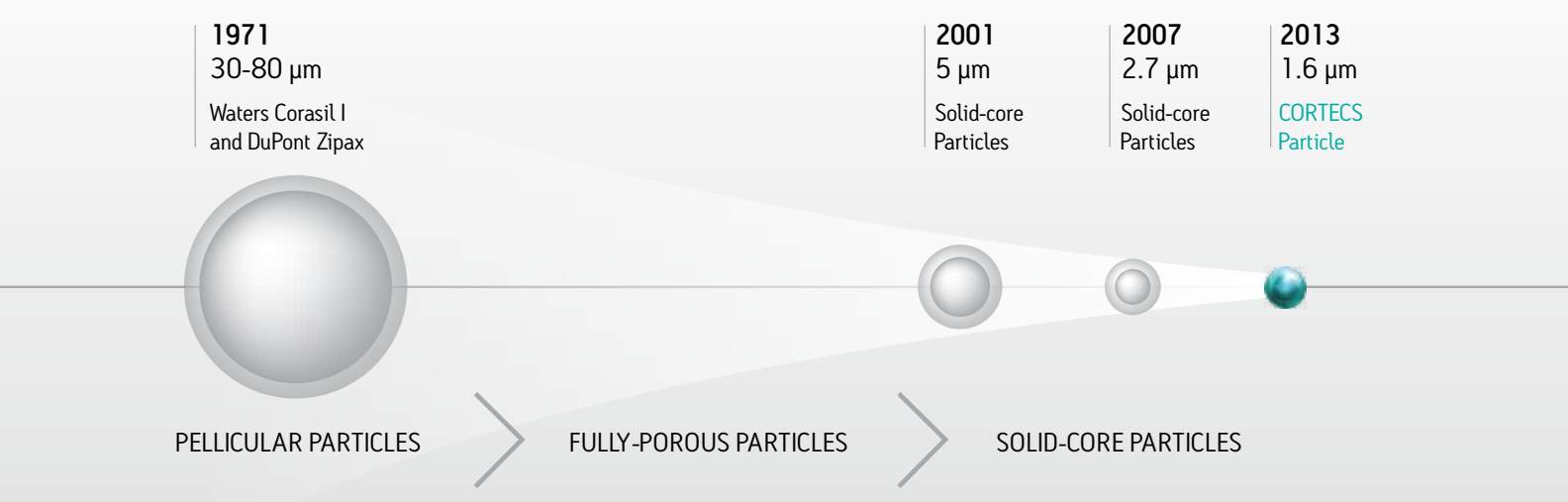
SOLID-CORE PARTICLES AND THE QUEST FOR ULTRA PEFORMANCE[1]

Columns containing solid-core particles made their debut in the chromatography market over 40 years ago. As researchers explored ways to increase the efficiency of liquid chromatography, they turned to a technology that Csaba Horváth described as "pellicular phases": non-porous glass-core particles with a thin coating of a solid-porous phase. Working with István Halász, Horváth's mentor, Waters commercialized the first of this type of product in 1970 as Corasil I. While these particles improved upon the efficiency and speed shortcomings of 30-80 µm fully-porous particles, they were limited in their analyte loading capacity because of low surface area. The subsequent development of 10 µm fully-porous particles (µPorasil™ and µBondapak®), in combination with higher pressure instrumentation and advanced packing techniques, eclipsed their popularity and performance.

In 2007, 2.7 µm solid-core particles packed into 4.6 mm i.d. columns were found to exhibit surprisingly low reduced plate heights. These columns were touted as a means to achieve the resolving power, sensitivity, and throughput of UPLC® Technology using only an HPLC instrument. While reducing the particle size did yield an improvement in efficiency vs. 3.5 and 5 µm particle columns, theory was shown to prevail [see Chapter 10 in Reference 1]. Even on a low-dispersion UPLC instrument, these new 2.7 µm solid-core particles could not achieve the peak capacities and efficiencies of sub-2-µm fully-porous particles, especially when packed in 2.1 mm i.d. columns.

[1] For a review of particle history, please reference: P.D. McDonald and U.D. Neue, The Quest for Ultra Performance in Liquid Chromatography, Waters, Milford [2007], part number 715002098

EVOLUTION OF SOLID-CORE PARTICLE USE



Over the years, chromatographers have employed particles of different morphologies as they searched for ways to maximize the efficiency and resolution of their separations.

HOW SOLID-CORE PARTICLES ACHIEVE HIGHER EFFICIENCY[2]

The initial explanation for the high efficiency of 2.7 µm solid-core particle columns was that the shorter diffusion path in solid-core vs. fully-porous particles resulted in faster mass transfer kinetics. However, it has been shown to account for a very small portion of the efficiency improvement for low molecular weight analytes, which have high diffusion rates. Current research suggests that solid-core particles may improve performance by lowering each of the three terms of the van Deemter equation:

- Solid-core particles may pack more uniformly—lowering the A term
- Their lower particle porosity reduces axial diffusion—lowering the B term
- Their solid core may improve heat transfer, diminishing radial temperature gradients—lowering the C term

$$HETP = A + \frac{B}{u} + C \bullet u$$

[2] *G. Guiochon and F. Gritti,* J. Chrom. A ***1218****, 2011, 1915 - 1938.*

Waters CORTECS Columns are designed to maximize efficiency, throughput and performance as well as to fulfill the promise of sub-2-µm solid-core particle columns.

CORTECS™ COLUMNS

PARTICLE CHARACTERISTICS

Particle Size	Rho[3]	Pore Volume	Pore Size	Surface Area	Chemistries
1.6 µm	0.70	0.26 cm^3/g	90 Å	100 m^2/g	C_{18} C_{18}+ HILIC

[3] *Rho (ρ) = ratio of the diameter of the solid core to the diameter of the particle.*

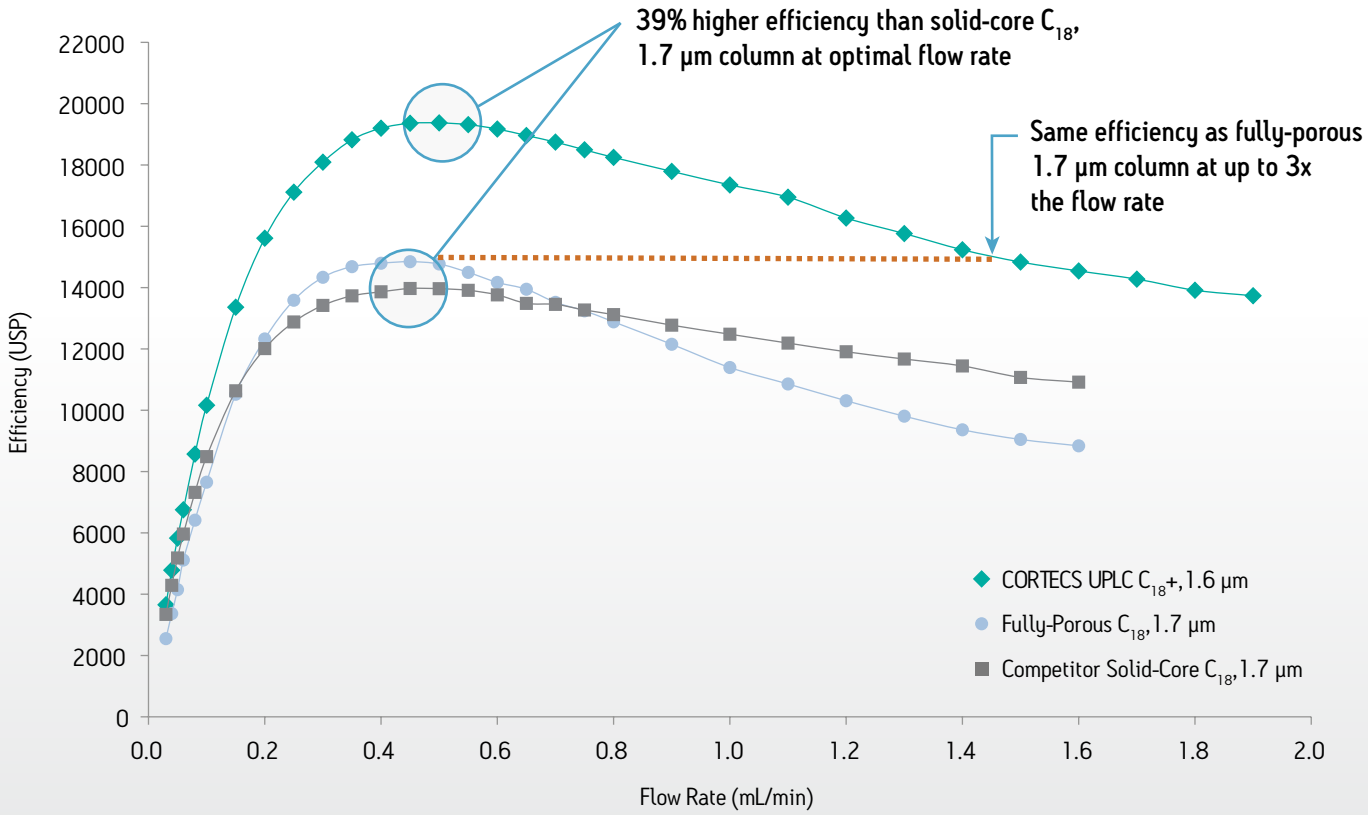
REQUISITES FOR ACHIEVING A NEW EFFICIENCY STANDARD

Due to the characteristic duality of their morphology, solid-core particles hold the potential for higher efficiency when compared to fully-porous particles of a similar particle size. However, achievement of this theoretical potential requires the use of ultra-low dispersion column hardware and optimal packing techniques. Packing difficulty is inversely proportional to particle size and column diameter. By using unique column hardware and proprietary packing equipment and methodologies, Waters has set the efficiency standard for UPLC Columns.

Backed by over a decade of knowledge and expertise in sub-2-µm particle columns, CORTECS UPLC Columns deliver the full benefit of solid-core particle technology.

DESIGNED AND CONSTRUCTED FOR MAXIMUM EFFICIENCY AND THROUGHPUT

Efficiency Advantage of CORTECS UPLC Columns



Comparative separations may not be representative in all applications.

CORTECS Columns offer higher efficiency than columns containing sub-2-µm fully-porous particles as well as those containing 1.7 µm competitor solid-core particles. They also give chromatographers the option to more than double the throughput of their current sub-2-µm column separation while maintaining a similar efficiency. Data conditions - Columns: 2.1 x 50 mm; Analyte: acenaphthene; Mobile phase: 75:25 (v/v) acetonitrile/water; Temperature: 30 °C.

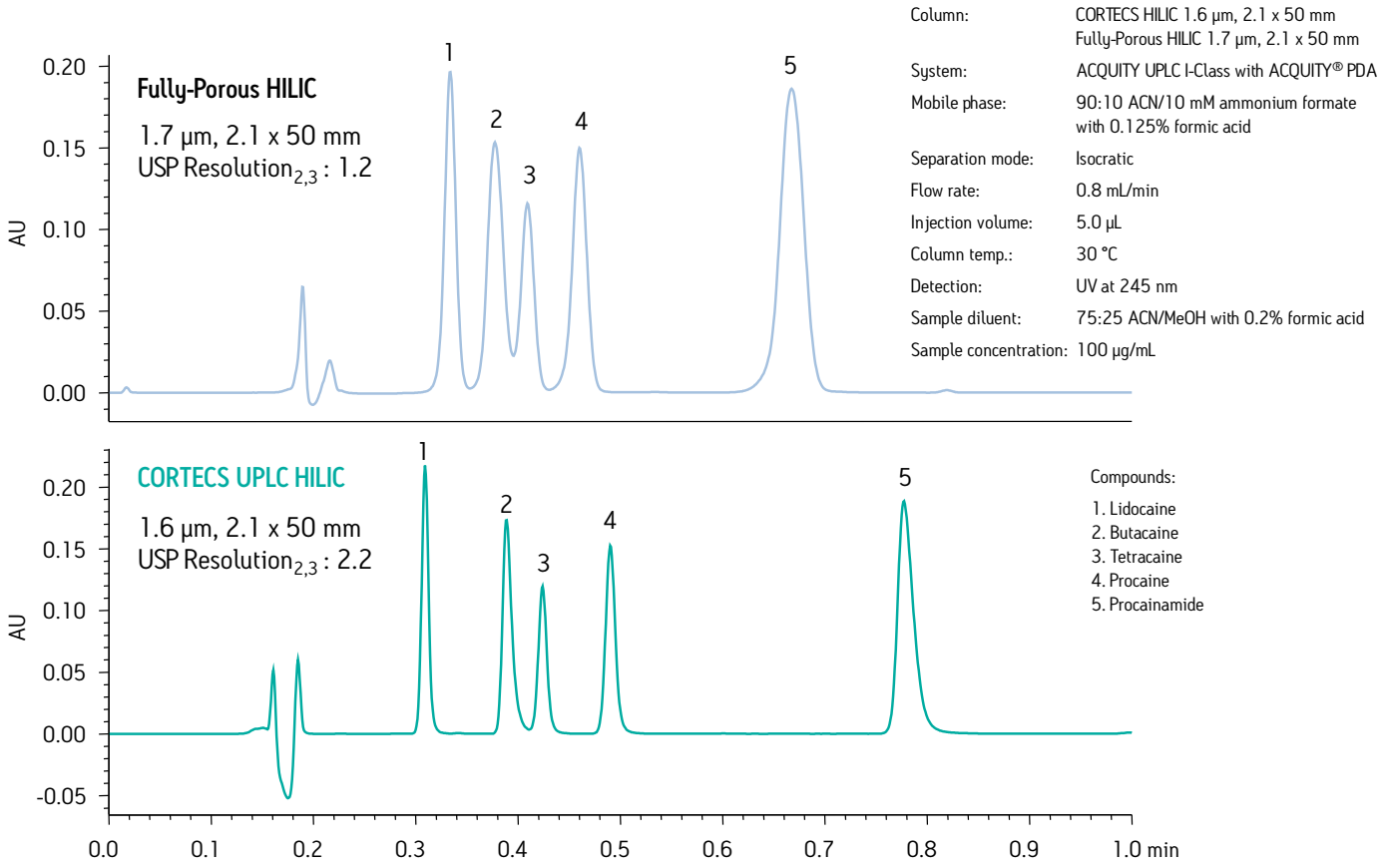
MAXIMUM EFFICIENCY FOR MAXIMUM RESOLUTION

As described in this equation, resolution depends on three variables: the efficiency of the column/system (N), the selectivity between compounds (α) and the retention factor (k) of the analyte.

$$R_S = \frac{\sqrt{N}}{4} \frac{(\alpha-1)}{\alpha} \frac{k}{(k+1)}$$

Resolution increases in proportion to the square root of efficiency. So, the higher efficiency of CORTECS Columns gives you increased resolution for the analysis of complex samples. For gradient separations, this improvement in efficiency can be measured by peak capacity, the upper limit of the number of peaks that can be separated in a given retention window. As peak widths decrease and peak capacity increases, peak heights increase, resulting in improved sensitivity and signal-to-noise ratios.

Improved Resolution of Local Anesthetics on CORTECS HILIC Columns



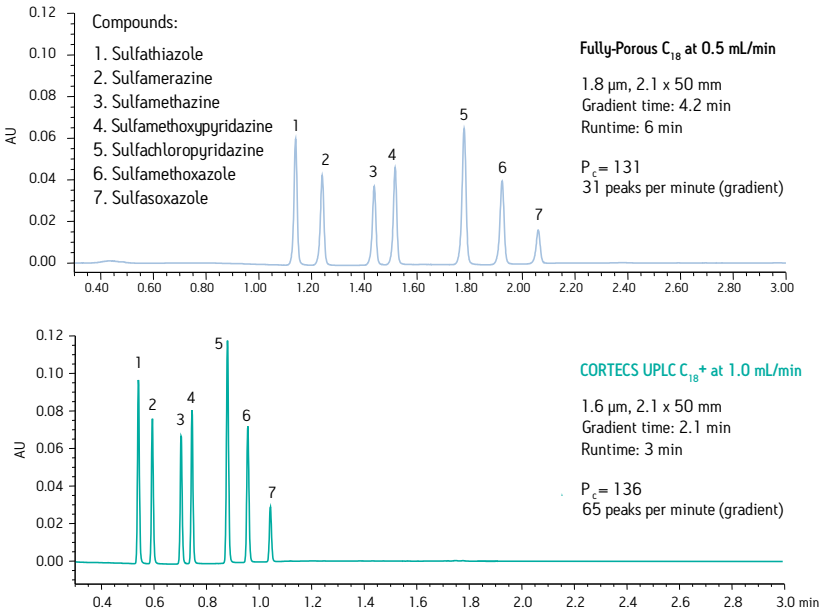
Comparative separations may not be representative in all applications.

Improved resolution for a separation of local anesthetics using a CORTECS UPLC HILIC Column compared to a fully-porous column, using the same method conditions.

FASTER SEPARATIONS FOR GREATER THROUGHPUT

Another benefit of CORTECS Columns is that they enable you to increase sample throughput with comparable or better peak capacities, simply by raising the flow rate of the method. Alternatively, the high efficiency of CORTECS Columns can enable the use of a shorter column length compared to the original separation, while maintaining similar peak capacities and providing faster re-equilibration time. This increased speed of analysis without sacrificing separation performance gives you the option to run more samples in the same amount of time or to get results faster, decreasing the costs of analysis and lab operation.

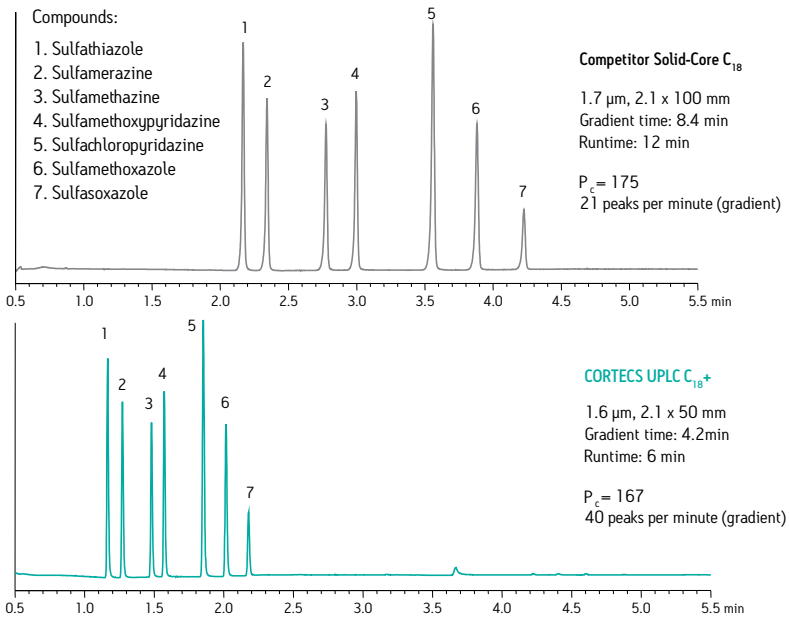
Faster Separation and Similar Peak Capacity at Double the Flow Rate



Comparative separations may not be representative in all applications.

Faster separation with similar peak capacity for sulfa drugs using a CORTECS UPLC C_{18}+ Column at double the flow rate, compared to a fully-porous column. Data conditions: System: ACQUITY UPLC H-Class; UV detection: 254 nm, scaling the gradient to account for the change in flow rate; Sample concentration: 10 µg/mL.

Higher Throughput With Shorter Column Length



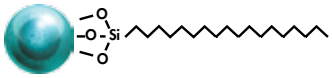
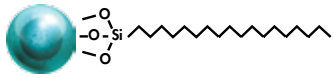
Comparative separations may not be representative in all applications.

Higher throughput with similar peak capacity for sulfa drugs using a 50 mm length CORTECS UPLC C_{18}+ Column, compared to a 100 mm length competitor solid-core column. Data conditions: System: ACQUITY UPLC H-Class; UV detection: 254 nm, scaling the method to account for the change in column length; Sample concentration: 10 µg/mL.

SELECTIVITY FOR METHOD DEVELOPMENT

While high efficiency is an important factor in generating resolution, selectivity has an even more significant impact. There are many variables that you may use to optimize selectivity: mobile-phase pH, organic modifier, buffer selection, temperature and gradient slope. Since varying column stationary phases has a prominent effect on the selectivity of a separation, methods can be developed faster using columns designed with different substrate properties and innovative particle-surface modifications.

CORTECS UPLC CHEMISTRY CHARACTERISTICS

	C_{18}	C_{18}+	HILIC
Chemistry			
Intended Use	General purpose, high-efficiency, reversed-phase column. Balanced retention of acids, bases and neutrals at low and mid-range pH.	General purpose, high-efficiency, reversed-phase column. A positively charged surface delivers excellent peak shape for basic compounds at low pH.	High-efficiency column designed for retention of extremely polar analytes. Offers orthogonal selectivity vs. C_{18} columns.
Ligand Type	Trifunctional C_{18}	Trifunctional C_{18}	None
Surface Charge Modification	None	+	None
Endcap Style	Proprietary	Proprietary	None
Carbon Load	6.6%	5.7%	Unbonded
Ligand Density	2.7 µmol/m^2	2.4 µmol/m^2	N/A
pH Range	2-8	2-8	1-5
Temperature Limits[1]	Low pH = 45 °C High pH = 45 °C	Low pH = 45 °C High pH = 45 °C	Low pH = 45 °C High pH = 45 °C

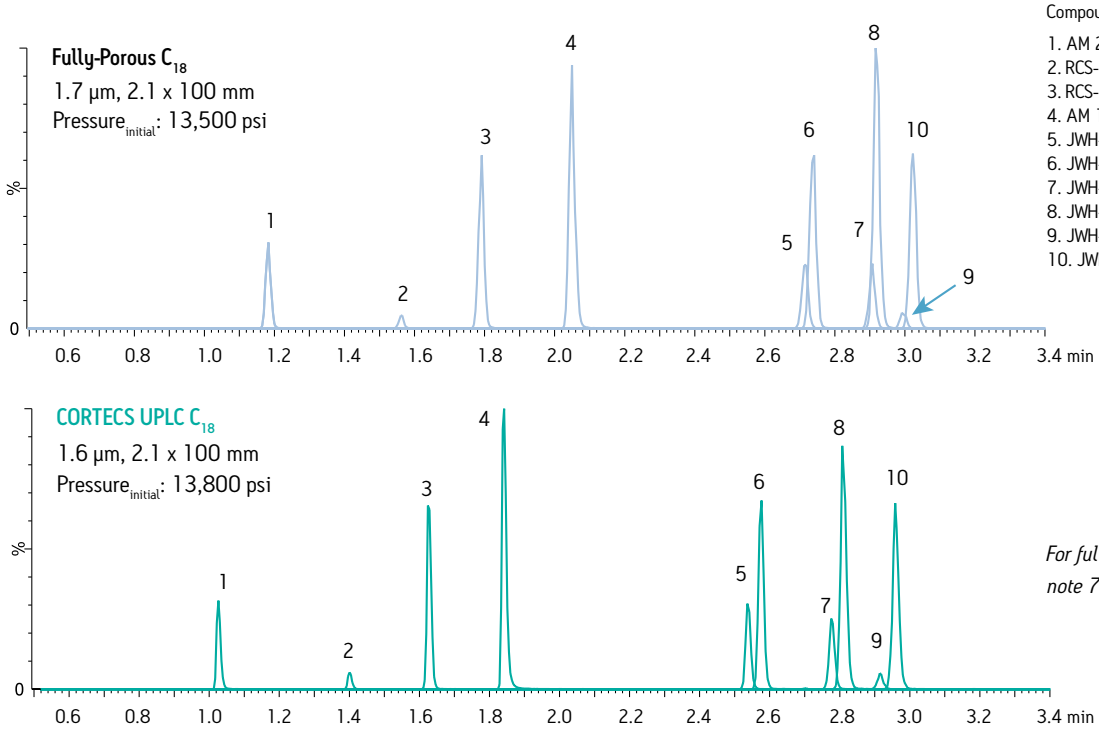
[1] *Recommended temperature limits when operating at the extremes of the pH range. Higher temperatures may be used when the pH is not near the limits.*

For information about the Waters Reversed-Phase Column Selectivity Chart, visit **www.waters.com/selectivitychart**

EXCELLENT RESOLUTION AND RETENTION WITH CORTECS C_{18} COLUMNS

Chromatographers prefer C_{18} ligands for excellent retention and stability. Waters offers two complementary C_{18} chemistries in our CORTECS family of columns. CORTECS C_{18} is a traditional C_{18}-bonded phase while CORTECS C_{18}+ features a charged-surface particle. CORTECS C_{18} Columns exhibit balanced retention of acids, bases and neutrals at low- and mid-range pH, and provide superb efficiency, resolution and retention for complex analyte mixtures.

Greater Resolution for Synthetic Cannabinoids on a CORTECS C_{18} Column



Compounds:

1. AM 2223
2. RCS-4, M10
3. RCS-4, M11
4. AM 1248
5. JWH-073 4-butanoic acid metabolite
6. JWH-073 4-hydroxybutyl metabolite
7. JWH-018 5-pentanoic acid metabolite
8. JWH-073 (+/-) 3-hydroxybutyl metabolite
9. JWH--10 50hydroxypentyl metabolite
10. JWH-018 (+/-) 4-hydroxypentyl metabolite

For full conditions, reference application note 720004726EN at ***www.waters.com***

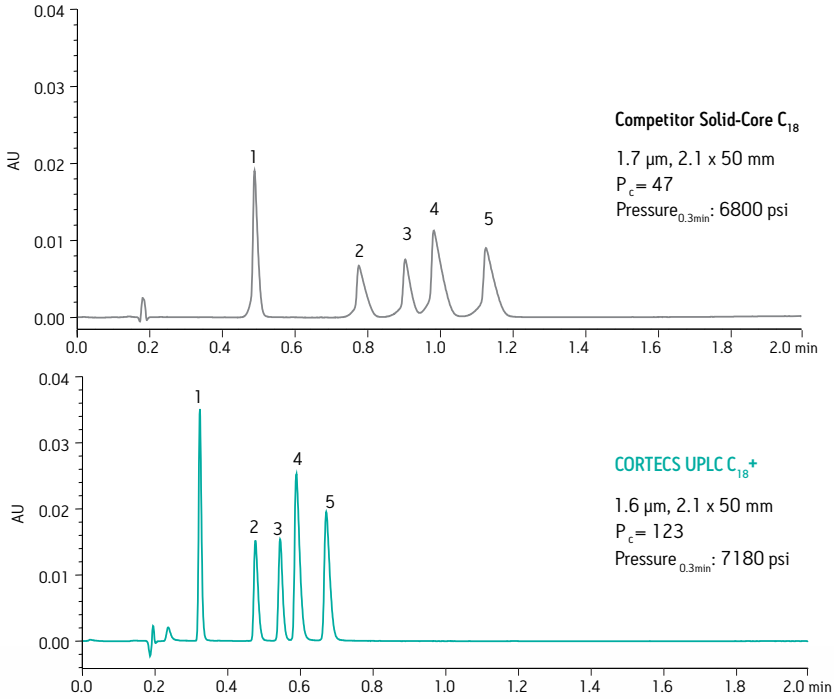
Comparative separations may not be representative in all applications.

UPLC-MS/MS analysis of synthetic cannabinoids and metabolites at 10 ng/mL using a CORTECS UPLC C_{18} Column, compared to a fully-porous C_{18} 1.6 µm, 2.1 x 100 mm Column at 0.6 mL/min. The analysis was performed on an ACQUITY UPLC System with a Xevo® TQD Mass Spectrometer, using the same method for both columns. Co-elution is evident on the fully-porous column for peaks 5/6, 7/8 and 9/10 (isobaric), but these are sufficiently resolved for quantitation on the CORTECS C_{18} Column.

ENHANCED PEAK SHAPE AND LOADING CAPACITY FOR BASIC ANALYTES WITH CORTECS C_{18}+ COLUMNS

In 2010, Waters introduced novel Charged Surface Hybrid (CSH™) Technology that imparts a low-level positive charge to the particle surface. This patent-pending technology enables you to use low-ionic strength mobile phases such as formic acid for the analysis of basic compounds while obtaining improved peak shape, loading capacity and signal-to-noise performance in mass spectrometry for these analytes. The charged surface particle also allows you to substitute formic acid for an ion-pairing reagent such as trifluoroacetic acid (TFA) while maintaining good peak shape for charged analytes.

Improved Loading Capacity and Peak Shape of Basic Analytes with CORTECS C_{18}+



Comparative separations may not be representative in all applications.

Column:	CORTECS UPLC C_{18}+ 1.6 µm, 2.1 x 50 mm Competitor Solid-Core C_{18} 1.7 µm, 2.1 x 50 mm
System:	ACQUITY UPLC H-Class with ACQUITY PDA
Mobile phase A:	0.1% formic acid in H_2O
Mobile phase B:	0.1% formic acid in ACN
Gradient:	28-35% B over 3 minutes
Flow rate:	0.6 mL/min
Injection volume:	1.0 µL
Column temp.:	40 °C
Detection:	UV at 254 nm
Sample concentration:	10 µg/mL

Compounds:

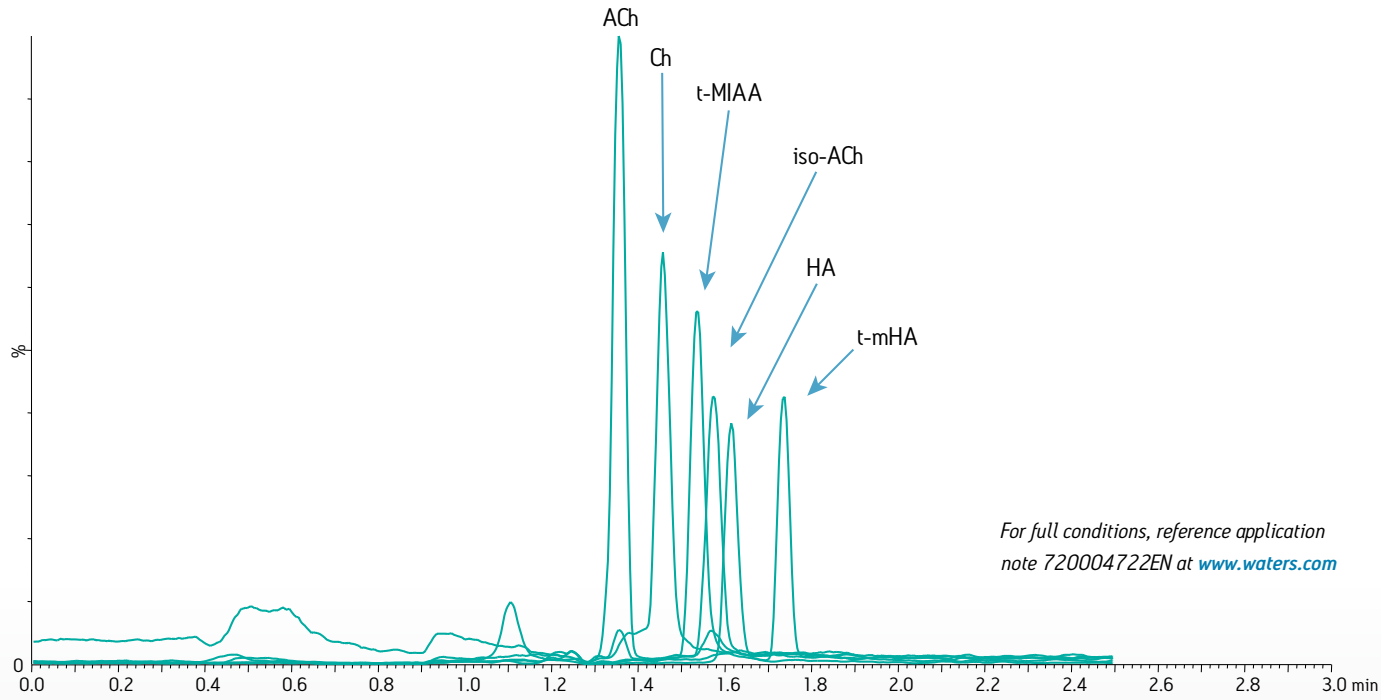
1. Nordoxepin
2. Protriptyline
3. Nortriptyline
4. Amitriptyline
5. Trimipramine

Improved loading and peak shape of basic compounds using a CORTECS UPLC C_{18}+ Column, compared to a competitor solid-core C_{18} column results in much higher peak capacity for the CORTECS Column separation using the same method conditions.

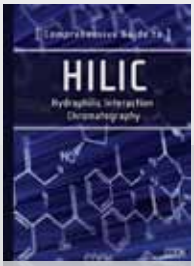
RETENTION OF POLAR ANALYTES WITH CORTECS HILIC COLUMNS

Hydrophilic Interaction Chromatography (HILIC) is a mode that retains extremely polar analytes when reversed phase may not. CORTECS HILIC Columns contain unbonded solid-core particles that will retain polar compounds. Whereas reversed-phase chromatography uses a highly aqueous mobile phase in an attempt to retain polar analytes, HILIC utilizes mobile phases with a high concentration of organic solvent. The high concentration of organic solvent in the mobile phase makes this technique directly compatible with SPE eluates, thereby streamlining sample preparation for higher throughput. Higher concentrations of organic solvent also enable more effective desolvation of analytes in the MS source, resulting in improved MS response and sensitivity.

Retention and Resolution of Neurotransmitters on CORTECS HILIC Column



UPLC-MS/MS analysis of neurotransmitters at 280-1100 pg/mL in artificial Cerebrospinal Fluid (aCSF) using a CORTECS UPLC HILIC 1.6 µm, 2.1 x 100 mm Column and a Xevo TQ-S Mass Spectrometer. These compounds are highly polar and will typically be poorly retained in reversed-phase LC. Iso-ACh is an isobaric endogenous interference of ACh in CSF that needs to be chromatographically resolved.



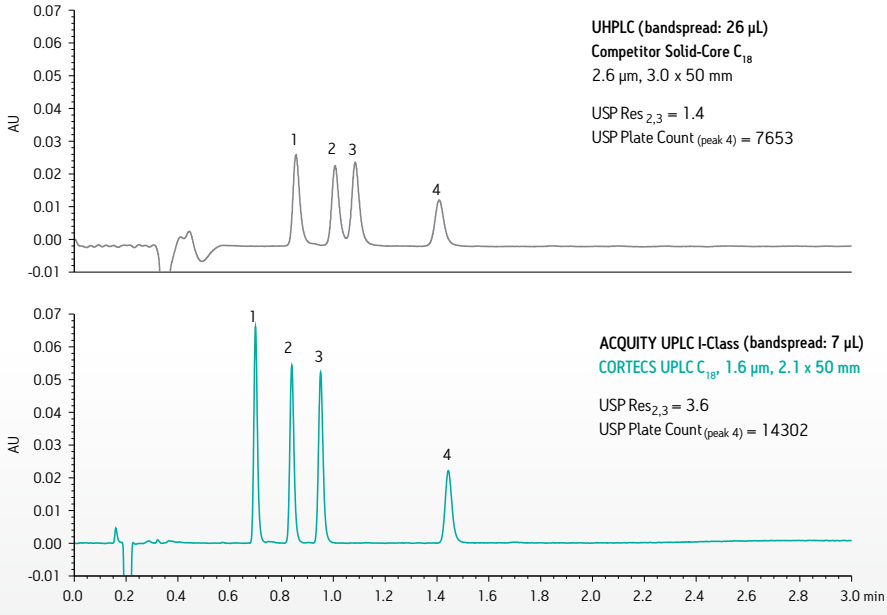
To learn more about Waters Comprehensive Guilde to HILIC (Hydrophilic Interaction Chromatography), visit www.waters.com/hilic

ACHIEVE ULTIMATE PEAK CAPACITY WITH SUB-2-µm PARTICLE COLUMNS AND LOWEST DISPERSION SYSTEMS

When sub-3-µm solid-core particle columns were introduced in 2007, one of the primary claims was that these columns run on an HPLC system would offer similar performance to columns containing sub-2-µm fully-porous particles run on a UPLC System, despite the difference in particle size. In fact, smaller size particles generate lower plate heights, and thereby, higher plate counts (consistent with theory). This results in higher column efficiencies for a sub-2-µm particle column as compared to a sub-3-µm particle column, on any system.

As with all small particle columns, the dispersion (extra-column band spreading) of the system on which a CORTECS Column is operated will have considerable impact on the observed performance of the column. As system dispersion decreases, peaks become narrower and the peak capacity of a separation increases. High-efficiency CORTECS Columns paired with ultra-low dispersion instruments such as ACQUITY UPLC I-Class Systems result in new levels of UPLC performance.

Impact of Particle Size and System Dispersion on Peak Capacity



Column:	CORTECS UPLC C_{18}+ 1.6 µm, 2.1 x 50 mm Competitor Solid-Core C_{18} 2.6 µm, 3.0 x 50 mm
System:	ACQUITY UPLC I-Class with ACQUITY PDA; Competitor UHPLC
Separation mode:	Isocratic
Mobile phase:	55:45 H_2O/ACN with 0.1% formic acid
Flow rate:	0.5 mL/min (1.6 µm, 2.1 x 50 mm) 0.69 mL/min (2.6 µm, 3.0 x 50 mm)
Injection volume:	1.0 µL (1.6 µm, 2.1 x 50 mm) 2.0 µL (2.6 µm, 3.0 x 50 mm)
Column temp.:	30 °C
Detection:	UV at 220 nm
Sample concentration:	20 µg/mL

Compounds:

1. Estradiol
2. Ethinyl estradiol
3. Estrone
4. Levonorgestrel

Comparative separations may not be representative in all applications.

The separation of estradiols on a 2.6 µm competitor solid-core particle column using a UHPLC system with 26 µL system bandspread, compared to the same separation on a CORTECS 1.6 µm Column using an ACQUITY UPLC I-Class System with 7 µL system bandspread. Data conditions - Isocratic method: 45% acetonitrile in water with 0.1% formic acid; 3 mm column i.d. scaled to a flow rate of 0.69 mL/min with a 2 µL injection; 2 mm column i.d. scaled to a flow rate of 0.5 mL/min with a 1 µL injection; UV detection: 220 nm.

The ACQUITY UPLC Columns Calculator can be downloaded from the ACQUITY UPLC Online Community at **www.waters.com/myuplc**

VERSATILITY IN SUB-2-µm PARTICLE DESIGN

Scientists are often challenged by the need to analyze mixtures of compounds that vary in their polarity, molecular weight, functionality and complexity. While screening columns with different ligands is an essential strategy in method development, choosing the particle with the appropriate attributes for the separation is even more crucial. This is why we have added CORTECS solid-core particles to our growing family of particles.

CORTECS SOLID-CORE PARTICLE

- Higher efficiency
- Increased throughput at similar efficiency
- Higher performance at same backpressure

CSH TECHNOLOGY

- Superior peak shape for basic analytes
- Exceptional loading capacity
- Seamless UPLC to HPLC scalability

BEH TECHNOLOGY

- Unparalleled pH stability
- Mobile phase and temperature versatility
- Seamless UPLC to HPLC scalability

HSS TECHNOLOGY

- Maximum retention
- Enhanced selectivity
- Seamless UPLC to HPLC scalability

ORDERING INFORMATION

CORTECS UPLC Columns

Chemistry	Particle Size	Dimension	Part No. 1 Pack	Part No. 3 Pack
CORTECS UPLC C_{18}	1.6 µm	2.1 x 30 mm	186007092	176003146
CORTECS UPLC C_{18}	1.6 µm	2.1 x 50 mm	186007093	176003147
CORTECS UPLC C_{18}	1.6 µm	2.1 x 75 mm	186007094	176003148
CORTECS UPLC C_{18}	1.6 µm	2.1 x 100 mm	186007095	176003149
CORTECS UPLC C_{18}	1.6 µm	2.1 x 150 mm	186007096	176003150
CORTECS UPLC C_{18}	1.6 µm	3.0 x 30 mm	186007097	176003151
CORTECS UPLC C_{18}	1.6 µm	3.0 x 50 mm	186007098	176003152
CORTECS UPLC C_{18}	1.6 µm	3.0 x 75 mm	186007099	176003153
CORTECS UPLC C_{18}	1.6 µm	3.0 x 100 mm	186007100	176003154
CORTECS UPLC C_{18}	1.6 µm	3.0 x 150 mm	186007102	176003155
CORTECS UPLC HILIC	1.6 µm	2.1 x 30 mm	186007103	176003156
CORTECS UPLC HILIC	1.6 µm	2.1 x 50 mm	186007104	176003157
CORTECS UPLC HILIC	1.6 µm	2.1 x 75 mm	186007105	176003158
CORTECS UPLC HILIC	1.6 µm	2.1 x 100 mm	186007106	176003159
CORTECS UPLC HILIC	1.6 µm	2.1 x 150 mm	186007107	176003160
CORTECS UPLC HILIC	1.6 µm	3.0 x 30 mm	186007108	176003161
CORTECS UPLC HILIC	1.6 µm	3.0 x 50 mm	186007109	176003162
CORTECS UPLC HILIC	1.6 µm	3.0 x 75 mm	186007110	176003163
CORTECS UPLC HILIC	1.6 µm	3.0 x 100 mm	186007111	176003164
CORTECS UPLC HILIC	1.6 µm	3.0 x 150 mm	186007112	176003165
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 30 mm	186007113	176003166
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 50 mm	186007114	176003167
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 75 mm	186007115	176003168
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 100 mm	186007116	176003169
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 150 mm	186007117	176003170
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 30 mm	186007118	176003171
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 50 mm	186007119	176003172
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 75 mm	186007120	176003173
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 100 mm	186007121	176003174
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 150 mm	186007122	176003175

VanGuard Pre-Columns 3-Packs (Guard Columns)

Chemistry	Particle Size	Dimension	Part No.
CORTECS UPLC C_{18}	1.6 µm	2.1 x 5 mm	186007123
CORTECS UPLC HILIC	1.6 µm	2.1 x 5 mm	186007124
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 5 mm	186007125

CORTECS UPLC Columns Method Validation Kits (MVK)*

Chemistry	Particle Size	Dimension	Part No.
CORTECS UPLC C_{18}	1.6 µm	2.1 x 30 mm	186007156
CORTECS UPLC C_{18}	1.6 µm	2.1 x 50 mm	186007157
CORTECS UPLC C_{18}	1.6 µm	2.1 x 75 mm	186007158
CORTECS UPLC C_{18}	1.6 µm	2.1 x 100 mm	186007159
CORTECS UPLC C_{18}	1.6 µm	2.1 x 150 mm	186007160
CORTECS UPLC C_{18}	1.6 µm	3.0 x 30 mm	186007161
CORTECS UPLC C_{18}	1.6 µm	3.0 x 50 mm	186007162
CORTECS UPLC C_{18}	1.6 µm	3.0 x 75 mm	186007163
CORTECS UPLC C_{18}	1.6 µm	3.0 x 100 mm	186007164
CORTECS UPLC C_{18}	1.6 µm	3.0 x 150 mm	186007165
CORTECS UPLC HILIC	1.6 µm	2.1 x 30 mm	186007166
CORTECS UPLC HILIC	1.6 µm	2.1 x 50 mm	186007167
CORTECS UPLC HILIC	1.6 µm	2.1 x 75 mm	186007168
CORTECS UPLC HILIC	1.6 µm	2.1 x 100 mm	186007169
CORTECS UPLC HILIC	1.6 µm	2.1 x 150 mm	186007170
CORTECS UPLC HILIC	1.6 µm	3.0 x 30 mm	186007171
CORTECS UPLC HILIC	1.6 µm	3.0 x 50 mm	186007172
CORTECS UPLC HILIC	1.6 µm	3.0 x 75 mm	186007173
CORTECS UPLC HILIC	1.6 µm	3.0 x 100 mm	186007174
CORTECS UPLC HILIC	1.6 µm	3.0 x 150 mm	186007175
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 30 mm	186007176
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 50 mm	186007177
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 75 mm	186007178
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 100 mm	186007179
CORTECS UPLC C_{18}+	1.6 µm	2.1 x 150 mm	186007180
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 30 mm	186007181
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 50 mm	186007182
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 75 mm	186007183
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 100 mm	186007184
CORTECS UPLC C_{18}+	1.6 µm	3.0 x 150 mm	186007185

*Each kit contains three columns from three batches of material.

Waters Part Selector & Selectivity Chart for iPad®

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The quality management system of Waters' manufacturing facilities in Taunton, Massachusetts and Wexford, Ireland complies with the International Standard ISO 9001 Quality Management and Quality Assurance Standards. Waters' quality management system is periodically audited by the registering body to ensure compliance.

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