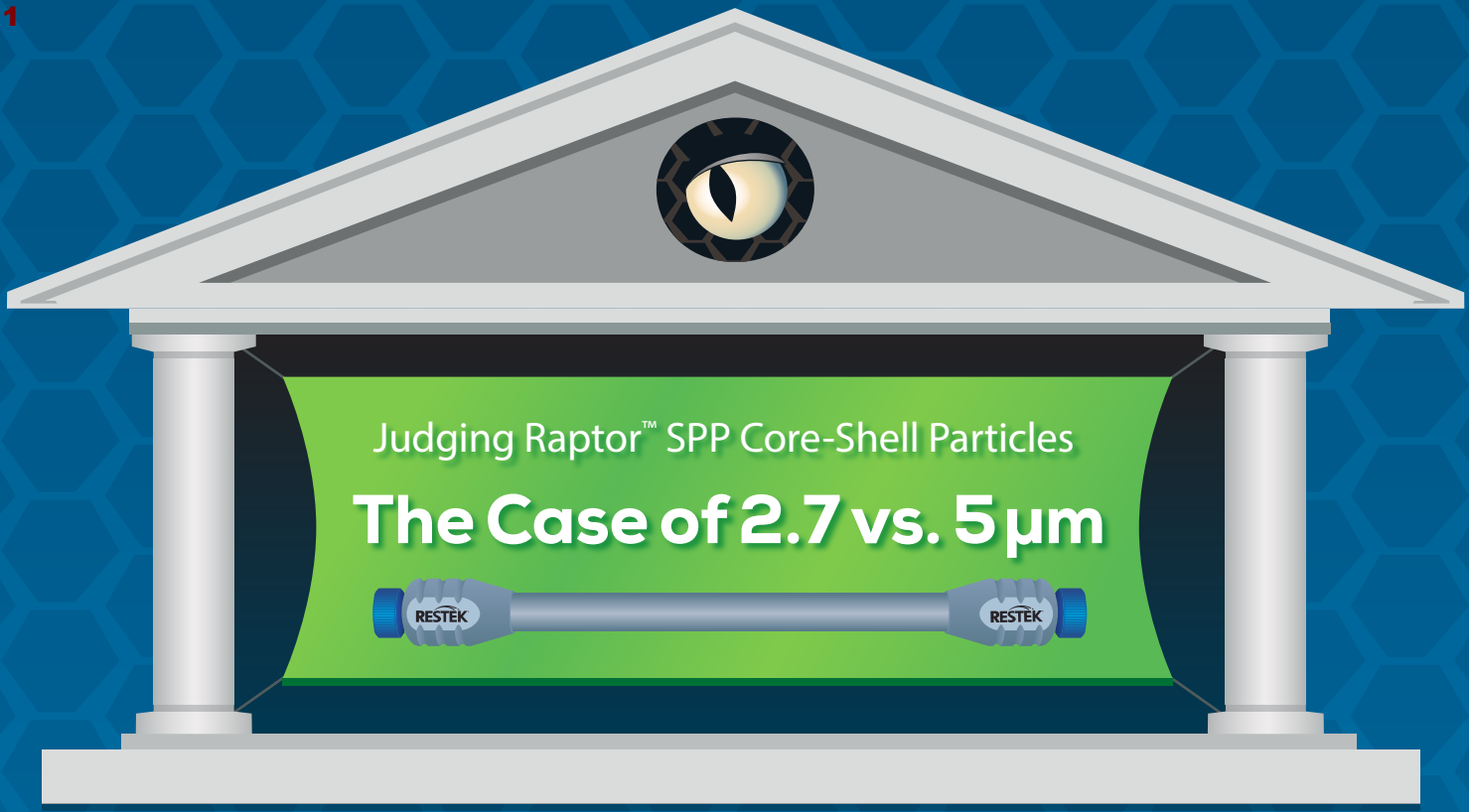
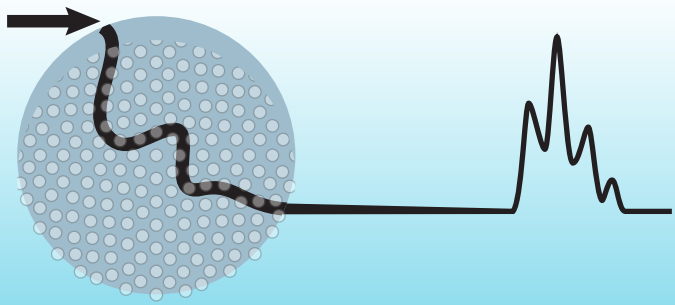



With traditional fully porous particles, the sample must take a slow journey through the entire particle.

## Fully Porous

***Slower; Poor Resolution***

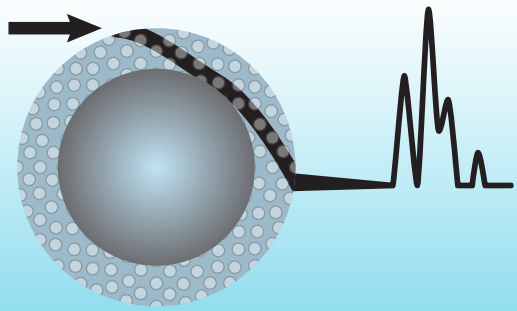


But with superficially porous particles (a.k.a. SPP or "core-shell" particles), your sample skips past a solid, impenetrable core and sprints for your detector.

But with superficially porous particles (a.k.a. SPP or "core-shell" particles), your sample skips past a solid, impenetrable core and sprints for your detector.

## Superficially Porous

***Faster; Better Resolution***



Add USLC® selectivity into the mix, and you get the shorter retention times and excellent resolution of a Raptor™ SPP column.

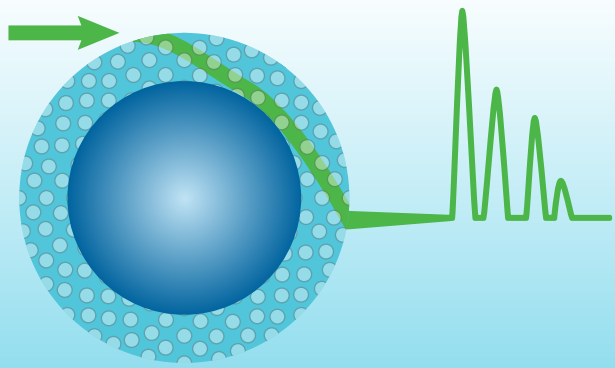
## Raptor™

**Superficially Porous**

w/USLC® Technology

***Faster; Excellent Resolution:***

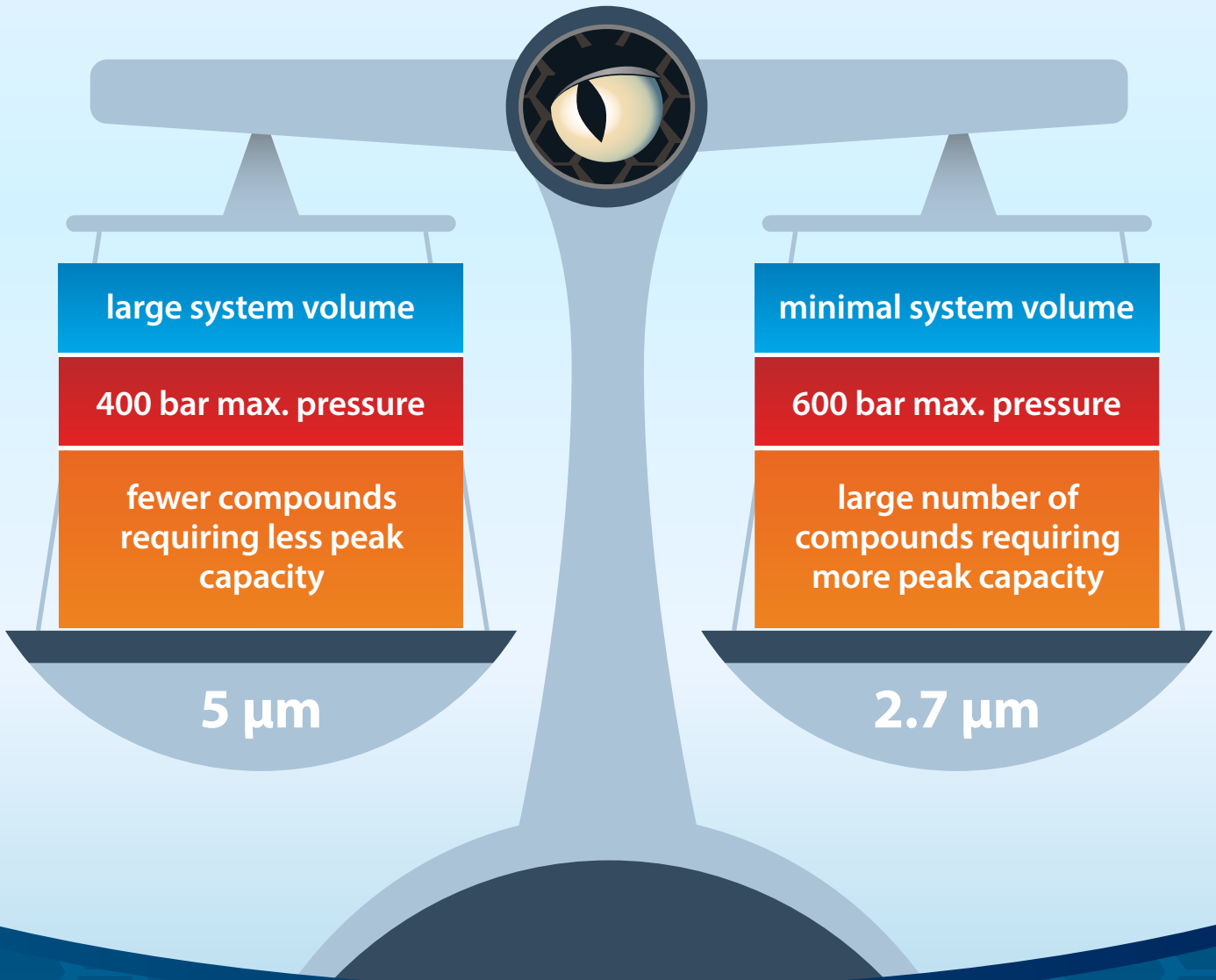
**Selectivity Accelerated!**



So, Raptor™ columns are an excellent choice for your methods, but you still have a decision to make: particle size. The right answer for you comes down to what's under the hood of your instrument, and what you're injecting into it...

# 2.7 vs. 5 µm Diameter Raptor™ Particles – Which Do You Choose?

Both 2.7 and 5 µm particles have a place in your laboratory—they are each great choices, but are ideal under different conditions.



# The Verdict

## 5 µm:

Boost analysis speed for existing methods on traditional LCs.

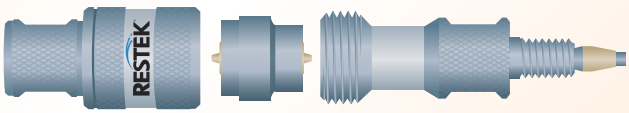
## 2.7 µm:

Supercharge efficiency and sensitivity with a modest increase in backpressure.

Order your Raptor™ columns today and experience ***Selectivity Accelerated.***

## TECH TIP: PROTECT YOUR INVESTMENT

Raptor™ EXP® guards help your analytical columns last longer. Better yet, you can change cartridges without breaking inlet/outlet fluid connections—and without tools.

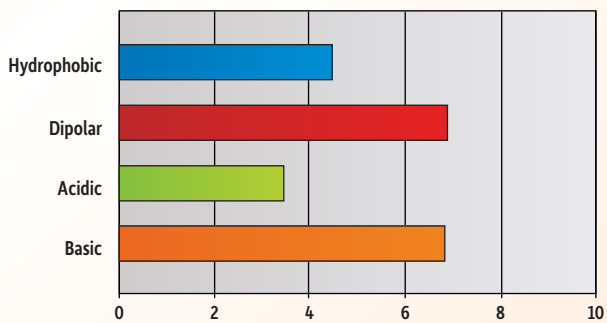



Want the details and data? Check out our technical note on this subject at

**www.restek.com/raptor**

## TECH TIP: CHOOSE WISELY

USLC® phases are optimized for different chemical interactions and solute types. Our easy-to-follow profiles make choosing the right Raptor™ column a snap.


RESTEK® Pure Chromatography

www.restek.com



GNOT2470-UNV

# The Dawn of an Era

Superficially porous particles (commonly referred to as SPP or "core-shell" particles) have been proven to provide fast separations without the need for expensive Ultra High Performance Liquid Chromatography (UHPLC) instruments, thereby increasing sample throughput without capital investment. These particles feature a solid, impermeable core enveloped by a thin, porous layer of silica that decreases the diffusion path and reduces peak dispersion. As a result, they offer significantly higher efficiency than traditional fully porous particles of similar dimensions—often rivaling the efficiency of smaller particles. Core-shell particles changed LC, but they were only the beginning...

## A New Species Has Evolved

Restek is proud to announce that SPP core-shell technology has evolved with the introduction of Raptor™ LC columns. Although column efficiency, which is boosted with superficially porous particles, considerably accelerates analysis time, it has little effect on resolution (i.e., peak separation). Selectivity, on the other hand, has a substantial impact on resolution, but shows minimal improvement in analysis times. New Raptor™ LC columns bond rugged 2.7 and 5 µm superficially porous particles with Restek's unique Ultra Selective Liquid Chromatography™ (USLC®) phases to offer chromatographers the best of both worlds.

By being the first to combine the speed of SPP with the resolution of highly selective USLC® technology, Raptor™ LC columns provide the practicing analyst with the most powerful tools available for fast and efficient method development. And because they are from Restek, Raptor™ LC columns are backed by the manufacturing and quality systems you've come to trust along with the best Plus 1 service in the industry. Choose them for all of your valued assays to experience *Selectivity Accelerated*.

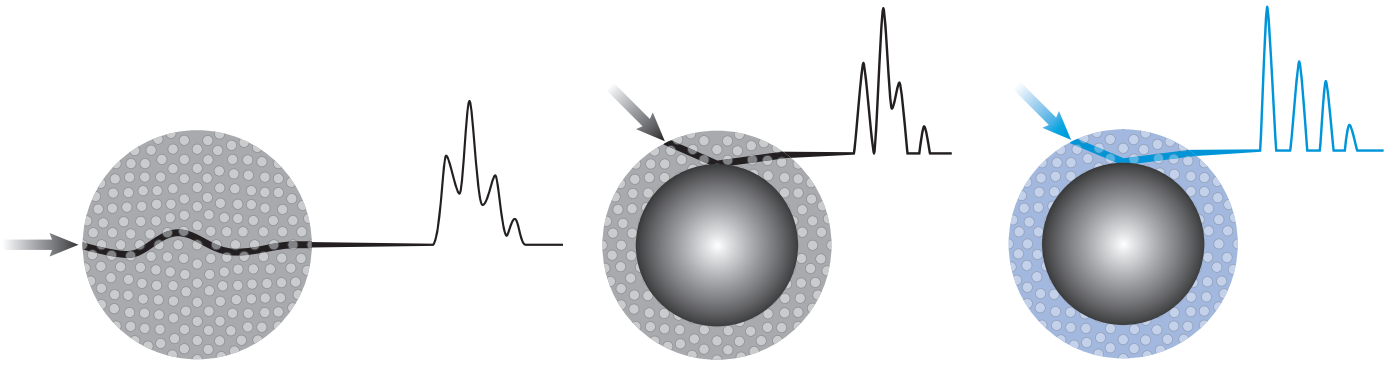
### The History of USLC® Technology

Restek extended the hydrophobic-subtraction model to describe orthogonal selectivity and then applied it to create our unique USLC® stationary phases.

Learn more at **www.restek.com/uslc**

RESTEK USLC®
Ultra Selective Liquid Chromatography

**Figure 1:** Only Raptor™ LC columns offer the higher efficiency of a superficially porous particle *plus* the improved resolution of USLC® phases.



Fully porous particles with typical stationary phases show longer retention times and less resolution.

Ordinary superficially porous particles (SPP) with typical stationary phases show shorter retention times than fully porous particles, but still exhibit less resolution.

Only Raptor™ LC columns with highly selective USLC® stationary phases show shorter retention times and greater resolution.

**Experience *Selectivity Accelerated*. Put Raptor™ LC columns and guards to the test today on your most challenging workflows.**

2 www.restek.com/raptor

RESTEK

# Evolutionary Chromatography

It is only possible to fully utilize the efficiency of superficially porous particle technology when it is united with the power of USLC® selectivity. With Raptor™ LC columns, you can speed up method development and enhance sample throughput—without investing in costly UHPLC equipment—to create faster, more reliable, and more sensitive analyses.

- Run faster and avoid lengthy gradient adjustments.
- Separate isobaric and hard-to-resolve compounds with ease.
- Avoid eluting compounds near the void volume and limit ion suppression.
- Skip the complex mobile phases and multiple method modifications.

# Dissecting Raptor™ LC Columns

*A closer look at a new species*

## Adaptive Traits: Raptor™ LC Column

Restek's dedicated R&D group studied every aspect of superficially porous particles (commonly referred to as SPP or "core-shell" particles) to develop the bonding chemistries that are best suited to both the SPP construction and our highly selective USLC® phases. But we didn't stop there. In addition to implementing a new, proprietary column-packing technique, we upgraded our LC column hardware. By looking at not only the particles, but also the packing and hardware, we have made sure that you will get repeatable, rugged performance from each and every Raptor™ LC column.

### Larger 2 µm Frit

Prevents clogging better than commonly used 0.5 µm frits; boosts column lifetime and helps maintain optimal pressures.

### Rugged Label

Clearly identifies both flow direction and column; resists solvents and tearing to last as long as your column does.


### Proprietary Column-Packing Technique

Provides greater pressure stability (600 bar for 2.7 µm; 400 bar for 5 µm); achieves higher linear velocities without sacrificing efficiency or lifetime.

### Raptor™ SPP Particles

**Robust 2.7 and 5 µm Particles**
Let you run high-speed analyses without UHPLC.

**Narrow Silica Distribution**
Ensures high efficiency and consistent flows.

**Updated Bonding and QC**
Guarantee retention time stability, run to run and column to column.

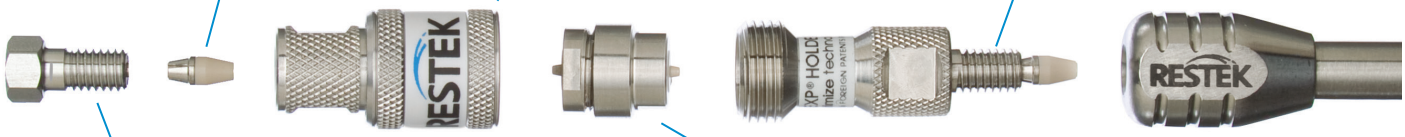
# Natural Protection: Raptor™ EXP® Guard Column

Regardless of its performance, lifespan, or frit size, we know the LC column is the most expensive consumable used for your chromatographic assay. To help protect your investment and further extend the life of our already-rugged Raptor™ LC columns, we have mated our new superficially porous particles with patent-pending guard column hardware developed by Optimize Technologies. A Raptor™ LC guard column cartridge in an EXP® direct connect holder is the ultimate in column protection.

**Patented Titanium Hybrid Ferrules**
Can be installed repeatedly without compromising high-pressure seal.

**Free-Turn® Architecture**
Allows you to change cartridges without breaking inlet/outlet fluid connections—and without tools.

**Auto-Adjusting Connection**
Provides ZDV (zero dead volume) connection to any 10-32 female port.




**Flexible Design**
Replace nut with longer or even tool-free options (below) to best suit your needs.

**Unidirectional Raptor™ Cartridge**

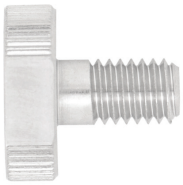
**In-Tandem Development**
Made to pair perfectly with Raptor™ LC columns.

**Superior Packing Technique**
Withstands 600 bar (2.7 µm) / 400 bar (5 µm) operating pressures.

**Restek® Quality**
Backed by the manufacturing and QC systems you trust.

View our full selection of Raptor™ EXP® guard column cartridges at **www.restek.com/raptor**

## Restek also recommends:



**Hand-Tight Nut** (cat.# 25937–25939)
Upgrade the supplied nut to install your Raptor™ EXP® guard column by hand—no tools needed.

**Long Hex-Head Nut** (cat.# 25934)
Extend the nut on your Raptor™ EXP® guard column for easier access in tight spaces—no more bumped knuckles.

**EXP® Hand-Tight Coupler** (cat.# 25940)
Achieve tool-free 8,700+ psi (600+ bar) seals anywhere in your LC system with EXP® hand-tight couplers and connectors.

Visit **www.restek.com/exp** for more EXP® hex-head fittings, couplers, replacement parts, and more!



RESTEK®
Pure Chromatography

**Questions about this or any other Restek® product?**
**Contact us or your local Restek® representative (www.restek.com/contact-us).**



**www.restek.com**

QUALITY ISO 9001 - 17025 - Guide 34

Lit. Cat.# GNTS1895C-UNV

General Applications

# The Effects of LC Particle Choice on Column Performance: Switching from 3 and 5 µm Fully Porous Particles (FPP) to 5 µm Superficially Porous Particles (SPP)

By Sharon Lupo, Ty Kahler, and Paul Connolly

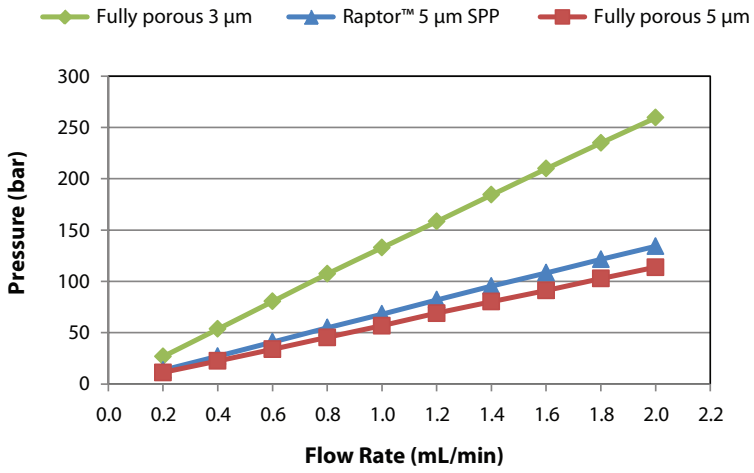
## Introduction

Superficially porous particles (commonly referred to as SPP or "core-shell" particles) have been proven to provide fast and efficient LC separations. These particles feature a solid, impermeable core enveloped by a thin, porous layer of silica that offers significantly higher efficiency and sensitivity than traditional fully porous particles (FPP). In this technical note, we will compare the performance of Raptor™ 5 µm SPP LC columns to traditional 3 and 5 µm FPP LC columns. We will demonstrate how faster, more efficient analyses can be attained with greater sensitivity and reduced system pressure by switching from fully porous particles to superficially porous particles—without changing instrumentation.

## Switching from FPP to SPP: Increased Efficiency, Decreased Pressure

One of the primary advantages of SPP is its ability to provide increased column efficiency, often with similar or even reduced backpressure, when compared to conventional FPP. By increasing efficiency while decreasing pressure, the user can achieve faster analysis times without changing instrumentation. As shown in Figure 1, column backpressure decreases by approximately 50% on average across the instrument flow rates tested (0.2 to 2 mL/min) when switching from a 3 µm FPP column to a Raptor™ 5 µm SPP column. Although the 5 µm FPP column displays comparable pressure to the Raptor™ 5 µm SPP column, it is at the expense of efficiency.

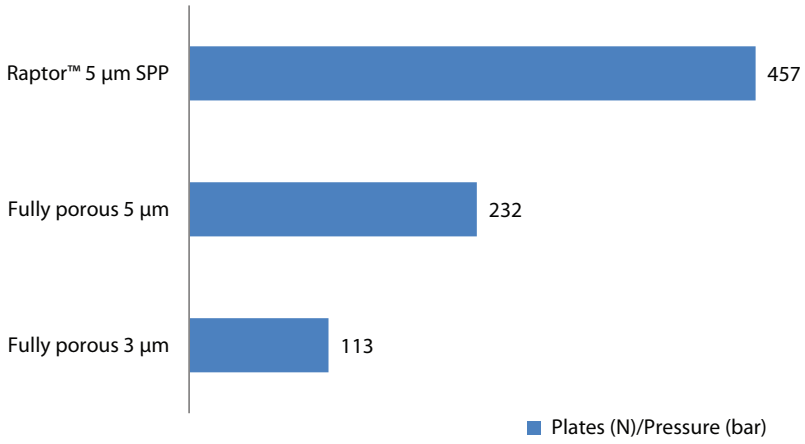
**Figure 1:** Switch from a 3 µm FPP column to a Raptor™ 5 µm SPP to cut backpressure in half.




**Column:** Dimensions: 150 mm x 4.6 mm ID; Temp.: 30 °C;
**Mobile Phase:** Water:Acetonitrile (45:55).

The ratio of theoretical plates (N) at optimal flow divided by pressure can be used as a measure of efficiency for a column. When compared for each column, the Raptor™ 5 µm SPP column has double the number of plates per unit pressure as the 5 µm FPP column, and four times the number of plates per unit pressure as the 3 µm FPP column (Figure 2).

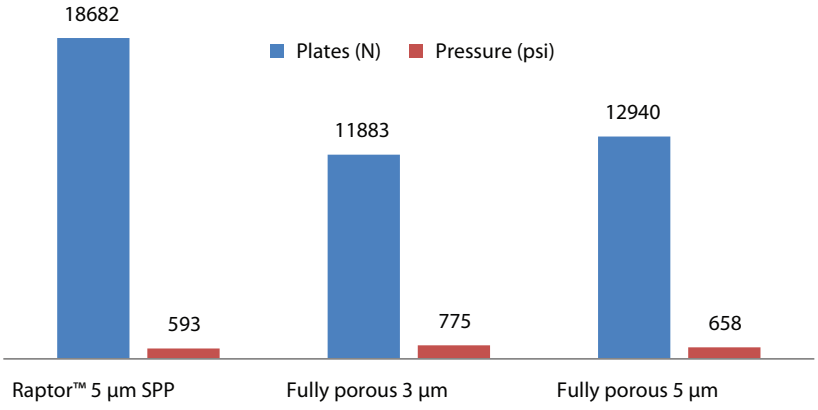
**Figure 2:** Focusing on plates per unit pressure, switching from 3 and 5 µm FPP columns to Raptor™ 5 µm SPP columns offers clear advantages.




**Column:** Dimensions: 150 mm x 4.6 mm ID; Temp.: 30 °C;
**Mobile Phase:** Water:Acetonitrile (45:55). **Detection:** 254 nm; **Test Probe:** Biphenyl.

Alternatively, the relationship between efficiency and pressure can be illustrated by comparing the theoretical plates of each column while holding pressure relatively constant (Figure 3). Again, the Raptor™ 5 µm SPP column shows a dramatic increase in efficiency at equivalent pressure.

**Figure 3:** With equivalent pressures, Raptor™ 5 µm superficially porous particles exhibit significantly more plates than 3 and 5 µm fully porous particles.



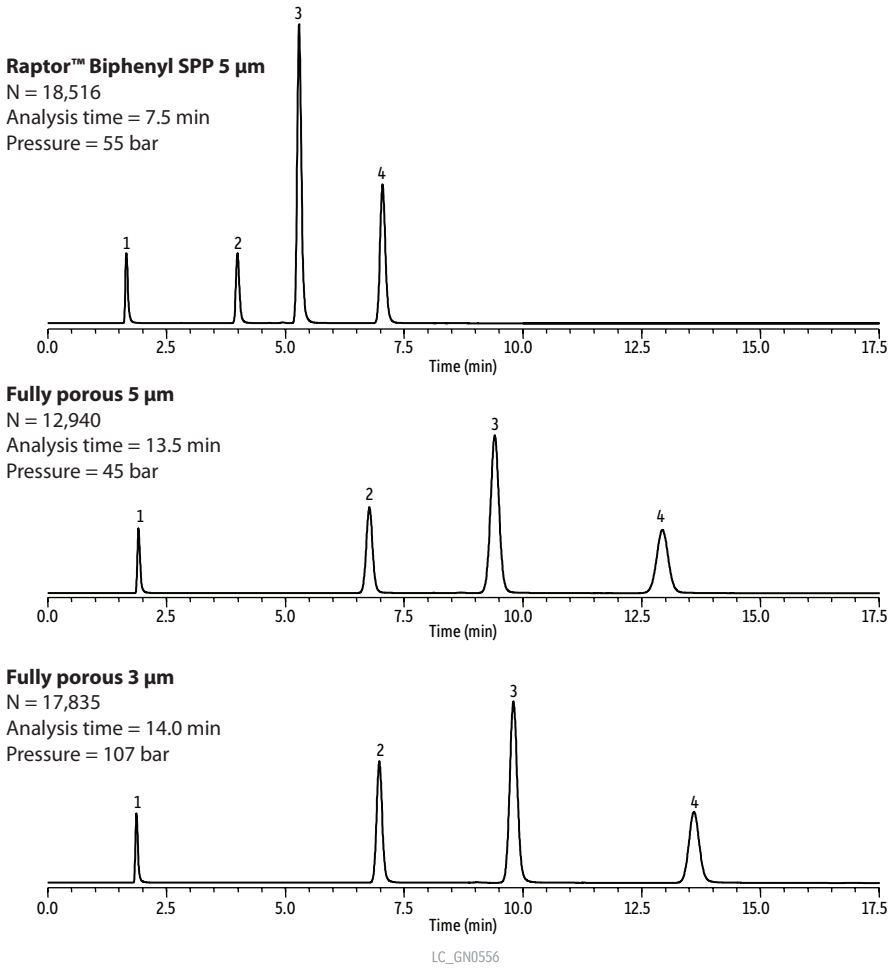

**Column:** Dimensions: 150 mm x 4.6 mm ID; Temp.: 30 °C;
**Mobile Phase:** Water:Acetonitrile (45:55); **Detection:** 254 nm; **Test Probe:** Biphenyl.

The Raptor™ 5 µm column has nearly twice the plates (i.e., greater efficiency) as the fully porous 3 and 5 µm particle columns.

### Switching from FPP to SPP: Increased Efficiency, Faster Run Times

The invention of SPP has provided analysts with fast separations without the need for expensive Ultra High Performance Liquid Chromatography (UHPLC) instruments, thereby increasing sample throughput without capital investment. To investigate the increased speed and efficiency of superficially porous particles, the Raptor™ Biphenyl 5 µm SPP column was compared to columns packed with fully porous 3 and 5 µm particles by performing an assay using identical instrumentation and isocratic method conditions (Figure 4).

**Figure 4:** Cut analysis times almost in half by switching to 5 µm SPP with lower pressure over 3 µm FPP and far superior efficiency over 5 µm FPP.




| Peaks | Conc. (mg/mL) |
|---|---|
| 1. Uracil | 0.02 |
| 2. Benzene | 3.0 |
| 3. Naphthalene | 0.5 |
| 4. Biphenyl | 0.06 |

**Column**
Temp.: 30 °C
**Sample**
Diluent: LC Reversed Phase Test Mix #1 (cat.# 35005)
Inj. Vol.: Methanol:water (75:25)
2 µL
**Mobile Phase**
A: Water
B: Acetonitrile

| Time (min) | Flow (mL/min) | %A | %B |
|---|---|---|---|
| 0.00 | 0.8 | 45 | 55 |
| 20 | 0.8 | 45 | 55 |

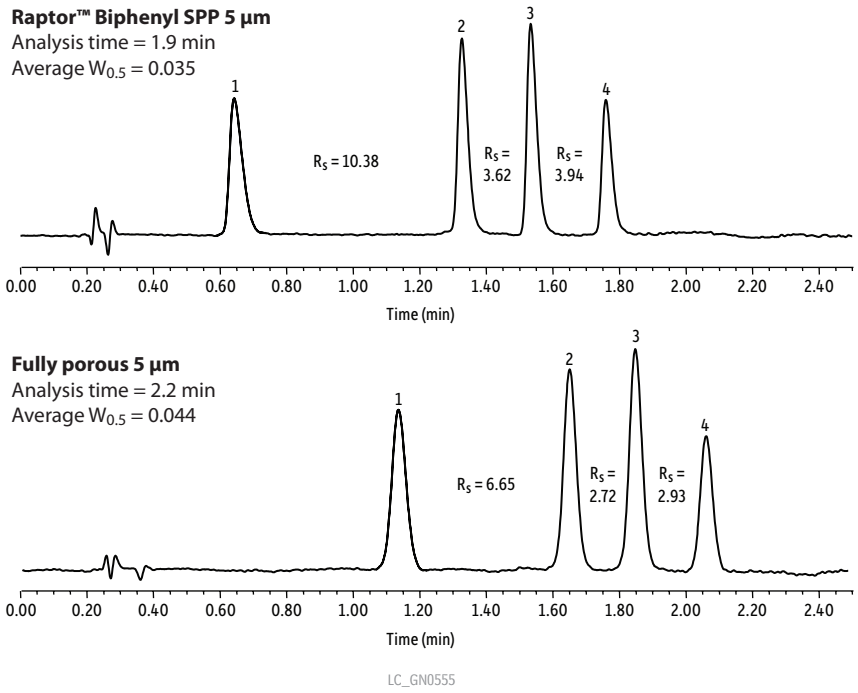
**Detector** DAD @ 254 nm
**Instrument** HPLC
**Notes** All columns were 150 mm x 4.6 mm ID. Values for efficiency (N) were calculated from the Biphenyl peak.

The last analyte eluted on the Raptor™ Biphenyl 5 µm column in 7.1 minutes resulting in a 45% decrease in analysis time compared to the 3 µm and 5 µm fully porous particle columns, which had run times of 13.6 and 12.9 minutes respectively. In addition, a 43% improvement in efficiency was observed for the Raptor™ Biphenyl 5 µm SPP column over the 5 µm FPP column. The 3 µm FPP column displayed only slightly less efficiency but nearly double the backpressure of the Raptor™ Biphenyl 5 µm SPP column.

### Switching from FPP to SPP: Increased Sensitivity, Better Performance

The performance of existing methods can be instantly improved by replacing conventional 3 µm or 5 µm FPP columns with the Raptor™ 5 µm column. Enhanced method efficiency, peak width, and analysis time can be achieved under gradient conditions, as demonstrated in Figure 5.

**Figure 5:** Increase resolution and decrease analysis time by switching from FPP to Raptor™ SPP columns.




**Peaks**
1. Norfentanyl
2. Acetyl fentanyl
3. Fentanyl
4. Sufentanyl

| | |
|---|---|
| **Column** | |
| Temp.: | 30 °C |
| **Sample** | |
| Diluent: | Water |
| Conc.: | 25 µg/mL |
| Inj. Vol.: | 1 µL |
| **Mobile Phase** | |
| A: | Water + 0.1% formic acid |
| B: | Methanol + 0.1% formic acid |

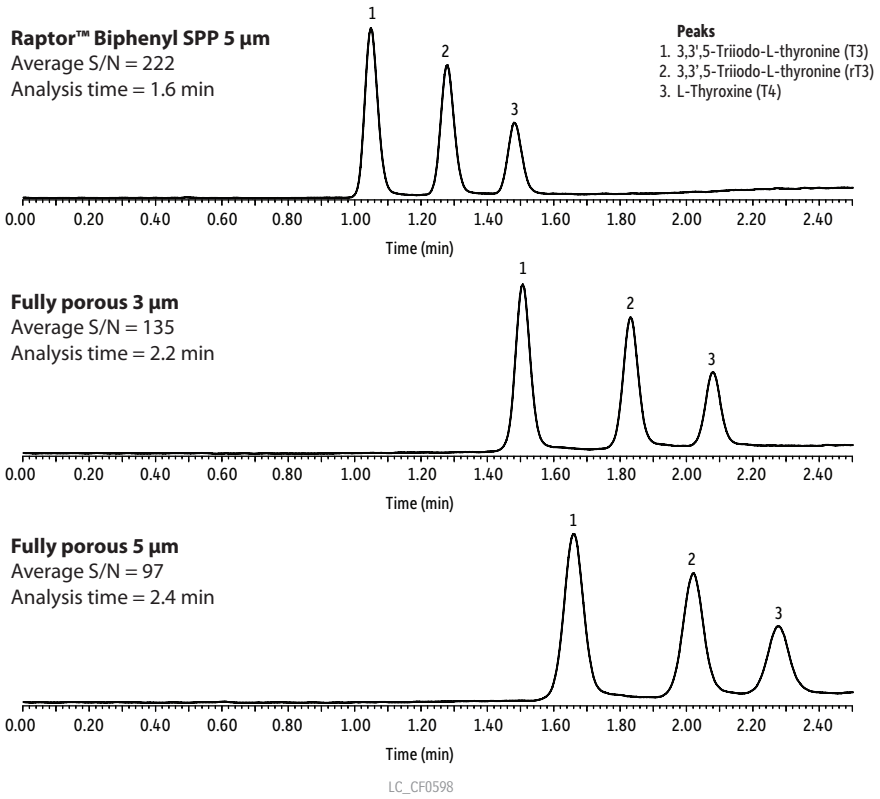
| Time (min) | Flow (mL/min) | %A | %B |
|---|---|---|---|
| 0.00 | 0.6 | 65 | 35 |
| 2.00 | 0.6 | 15 | 85 |
| 2.01 | 0.6 | 65 | 35 |
| 4.00 | 0.6 | 65 | 35 |

| | |
|---|---|
| **Detector** | PDA @ 210 nm |
| **Instrument** | HPLC |
| **Notes** | All columns were 50 mm x 2.1 mm ID. |

Average resolution values were 6.0 on the Raptor™ Biphenyl 5 µm SPP column and 4.1 on the 5 µm FPP column. In addition to a shorter run time, average analyte resolution increased 46% when switching to superficially porous particles of the same diameter.

In another example using gradient conditions and mass spectrometry, the analysis time decreased from 2.3 minutes on the 5 µm FPP column to 1.5 min on the Raptor™ Biphenyl SPP 5 µm column (Figure 6). Meanwhile, average sensitivity for the 5 µm SPP column increased by 64% over the 3 µm FPP column and 128% over the 5 µm FPP column.

**Figure 6:** Raptor™ 5 µm SPP columns also provide increased sensitivity over 3 or 5 µm FPP columns.




| | |
|---|---|
| **Column** | |
| Temp.: | 40 °C |
| **Sample** | |
| Diluent: | Water:methanol (35:65) |
| Conc.: | 1 ng/mL |
| Inj. Vol.: | 2 µL |
| **Mobile Phase** | |
| A: | 0.1% Formic acid in water |
| B: | 0.1% Formic acid in methanol |

| Time (min) | Flow (mL/min) | %A | %B |
|---|---|---|---|
| 0.00 | 0.4 | 35 | 65 |
| 2.00 | 0.4 | 20 | 80 |
| 2.01 | 0.4 | 35 | 65 |
| 3.50 | 0.4 | 35 | 65 |

| | |
|---|---|
| **Detector** | MS/MS |
| Ion Mode: | ESI+ |
| **Instrument** | HPLC |
| **Notes** | All columns were 100 mm x 2.1 mm ID. |

## Conclusion

Raptor™ 5 µm LC columns with superficially porous particles (SPP) display lower backpressure and increased efficiency when compared to columns packed with 3 and 5 µm fully porous particles (FPP) of similar dimension. When used in the development of new assays, Raptor™ 5 µm SPP LC columns offer fast run times and excellent method performance without upgrading instrumentation. When substituted into existing methodologies, switching from conventional 3 µm and 5 µm FPP columns to Raptor™ 5 µm SPP LC columns has the potential to dramatically decrease analysis times while improving efficiency and sensitivity. Certain assays may require some degree of method development to achieve optimal results, but Raptor™ 5 µm LC columns are compatible with most assays and offer an excellent way to increase performance without extra cost or labor.



RESTEK®

Lit. Cat.# GNAR2109-UNV

General Applications

# The Effects of LC Particle Choice on Column Performance: 2.7 vs. 5 µm Diameter Superficially Porous Particles (SPP)

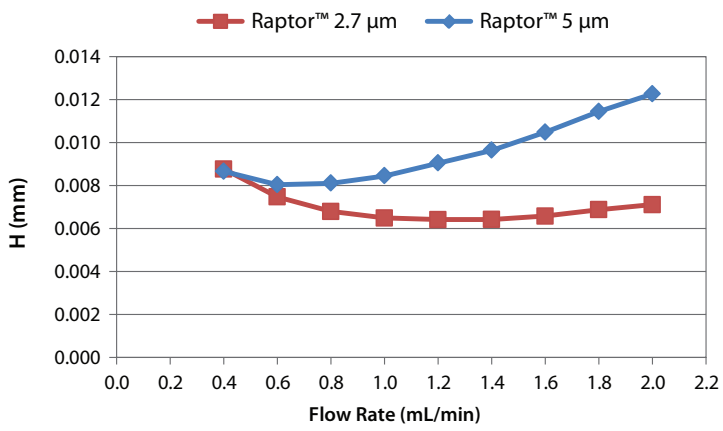
By Sharon Lupo, Ty Kahler, and Paul Connolly

Superficially porous particles (commonly referred to as SPP or "core-shell" particles) have been proven to provide fast and efficient LC separations. These particles feature a solid, impermeable core enveloped by a thin, porous layer of silica that offers significantly higher efficiency and sensitivity than traditional fully porous particles. Restek's Raptor™ SPP LC columns are available in both 2.7 and 5 µm diameter particle sizes, giving analysts the flexibility to select the most appropriate size for their specific assay. However, the best LC particle choice may not always be clear. In this technical note, we will examine the differences in efficiency, sensitivity, and pressure between Raptor™ LC columns packed with 2.7 vs. 5 µm diameter particles and provide advice on making the appropriate particle choice based on the intended experimental conditions and instrument capability.

## Efficiency

The relationship between column efficiency and linear velocity, or flow rate, can be illustrated using a van Deemter plot. Column efficiency is represented by plate height (H); the smaller the plate height at a given flow rate, the more efficient the column. The end result is sharper peaks and increased resolution. As shown in Figure 1, Raptor™ 2.7 µm columns display on average 25% more efficiency than Raptor™ 5 µm SPP columns across the flow rates tested. In addition, minimal loss in efficiency was observed at higher flow rates on the Raptor™ 2.7 µm column. For a 4.6 mm ID column, flow rates from 1.0 to 1.6 mL/min yielded the highest efficiency for our 2.7 µm diameter particle column; while flow rates ranging from 0.4 to 1.0 mL/min yielded the highest efficiency for our 5 µm diameter particle column.

**Figure 1:** Raptor™ 2.7 µm SPP columns maintain efficiency, even at elevated flow rates.

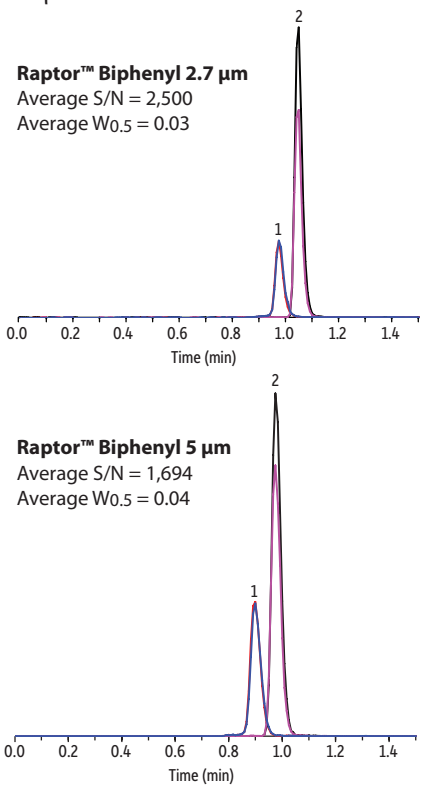



**Column:** Dimensions: 150 mm x 4.6 mm ID; Temp.: 30 °C;
**Mobile Phase:** Water:Acetonitrile (45:55); **Detection:** 254 nm;
**Test Probes:** Uracil and Biphenyl.

## Sensitivity

Sensitivity can be measured by comparing signal-to-noise ratios (S/N) for a particular peak. Signal response can be increased by reducing peak width, thereby making peaks sharper and increasing sensitivity. Since superficially porous particles are less porous due to their solid, impermeable core, they offer a more direct diffusion path over fully porous particles, which results in reduced peak dispersion and narrower peaks. To demonstrate the impact of LC particle choice on S/N, a common pharmaceutical and its metabolite were analyzed on separate Raptor™ Biphenyl columns packed with 2.7 vs. 5 µm particles. The resulting chromatograms, peak widths, and S/N are compared in Figure 2. The Raptor™ 2.7 µm diameter particle column displays an average increase in S/N of 32% accompanied by a 25% decrease in average peak width when compared to the Raptor™ 5 µm diameter particle column.

**Figure 2:** Our 2.7 µm particles offer an average 32% increase in signal-to-noise ratio (i.e., greater sensitivity) over 5 µm.




| Peaks | $t_R$ 2.7 µm (min) | $t_R$ 5 µm (min) | Precursor Ion | Product Ion 1 | Product Ion 2 |
|---|---|---|---|---|---|
| 1. Naltrexone | 0.98 | 0.90 | 342.4 | 270.1 | 267.1 |
| 2. 6-β-Naltrexol | 1.06 | 0.98 | 344.4 | 308.0 | 254.1 |

**Column**
Temp.: 30 °C
**Sample**
Conc.: Prepared 500 ng/mL in human urine. Diluted 5x in mobile phase A. Final conc. = 100 ng/mL
Inj. Vol.: 10 µL
**Mobile Phase**
A: Water + 0.1% formic acid + 2 mM ammonium formate
B: Water:methanol (5:95) + 0.1% formic acid + 2 mM ammonium formate

| Time (min) | Flow (mL/min) | %A | %B |
|---|---|---|---|
| 0.00 | 0.5 | 70 | 30 |
| 1.50 | 0.5 | 0 | 100 |
| 1.51 | 0.5 | 70 | 30 |
| 3.00 | 0.5 | 70 | 30 |

**Detector** MS/MS
Ion Mode: ESI+
**Instrument** HPLC
**Notes** Top: Raptor™ Biphenyl 50 mm x 2.1 mm, 2.7 µm (cat.# 9309A52)
Bottom: Raptor™ Biphenyl 50 mm x 2.1 mm, 5 µm (cat.# 9309552)

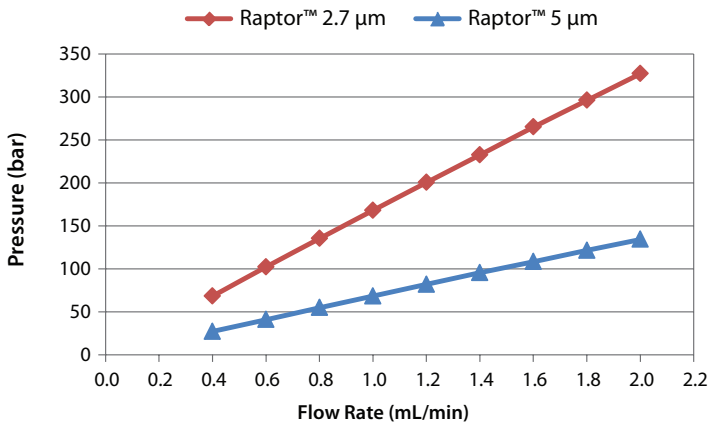
The S/N and $W_{0.5}$ calculations were made using Product Ion 1 (black trace).

LC_CF0597

## Pressure

One of the primary advantages of SPP is its ability to provide increased column efficiency, often with similar or even reduced backpressure, when compared to fully porous particles. By decreasing the size of superficially porous particles, efficiency improves and pressure increases at a rate inversely proportional to the square of the particle size. In Figure 3, column backpressure is shown to increase by approximately 150% on average across the instrument flow rates tested (0.4 to 2 mL/min) when switching from a 5 µm diameter Raptor™ particle to a 2.7 µm diameter particle. Additional parameters that contribute to operating pressure include column dimensions, mobile phase composition, and sources of flow restriction on the LC and detection systems.

**Figure 3:** Switching from a 5 µm to 2.7 µm Raptor™ particle increases backpressure approximately 150%.




**Column:** Dimensions: 150 mm x 4.6 mm ID; Temp.: 30 °C; **Mobile Phase:** Water:Acetonitrile (45:55).

## Conclusion

It is important to consider instrumentation and assay objectives when choosing between Raptor™ 2.7 vs. 5 µm diameter particle SPP LC columns.

### Raptor™ 5 µm columns:

Raptor™ 5 µm diameter particle columns display low backpressure as well as good efficiency and sensitivity. These columns can be substituted into existing methods to increase analysis speed on traditional LC systems, especially those with pressure limitations. Raptor™ 5 µm SPP is an ideal LC particle choice for fast assays containing fewer analytes.

- Large amount of system volume.
- Maximum operating pressure of 400 bar.
- Fewer compounds requiring less peak capacity.

### Raptor™ 2.7 µm columns:

Raptor™ 2.7 µm diameter particle columns exhibit greater efficiency and sensitivity than 5 µm SPP at the cost of higher pressures. Since extra-column effects are most pronounced on short, small-diameter columns packed with small particles, 2.7 µm columns are best suited for instrumentation with reduced system volume that can sustain pressures up to 600 bar. Raptor™ 2.7 µm SPP is the right LC particle choice for larger analyte lists that require additional peak capacity.

- Minimal system volume.
- Maximum operating pressure 600 bar.
- Large number of compounds requiring more peak capacity.



RESTEK®

Lit. Cat.# GNAR2079-UNV

Stationary Phase: **ARC-18**

# Raptor™ LC Columns

*Selectivity Accelerated*

## Ahead of the Curve for Large, Multiclass Lists by Mass Spec


RESTEK® Pure Chromatography www.restek.com/raptor

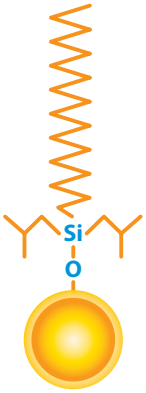
# The Raptor™ ARC-18 Column

With Raptor™ LC columns, Restek chemists became the first to combine the speed of superficially porous particles (also known as SPP or "core-shell" particles) with the resolution of highly selective USLC® technology. This new breed of chromatographic column allows you to more easily achieve peak separation and faster analysis times without expensive UHPLC instrumentation.

The birth of Restek's Raptor™ SPP LC column line began with the innovative Biphenyl phase, but it has quickly grown to include a new Restek® phase: the ARC-18. Designed and intended specifically for use on LC-MS/MS systems, the Raptor™ ARC-18 column features a well-balanced retention profile without the drawbacks of using an ordinary C18 in the harsh, acidic mobile phases needed for mass spectrometry (MS). Even after extended use in these low-pH (≤ 2.0) conditions, the sterically protected ARC-18 offers consistent retention, peak shape, and response for charged bases, neutral acids, small polar compounds, and more.

For the rapid analysis of large, multiclass assays by LC-MS/MS, the acid-resistant Raptor™ ARC-18 truly is *ahead of the curve.*

## Column Description:




**Stationary Phase Category:**
C18, octadecylsilane (L1)

**Ligand Type:**
Sterically protected C18

**Particle:**
2.7 µm or 5 µm superficially porous silica (SPP or "core-shell")

**Pore Size:**
90 Å

**Surface Area:**
150 $m^2/g$ (2.7 µm)
or 100 $m^2/g$ (5 µm)

**Recommended Usage:**
pH Range: 1.0–8.0

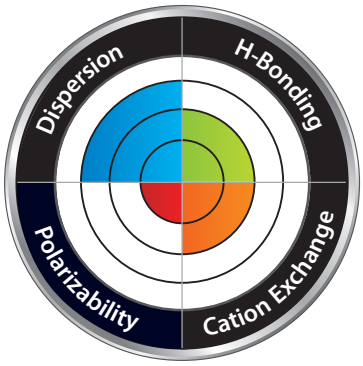
Maximum Temperature: 80 °C

Maximum Pressure: 600 bar / 8,700 psi (2.7 µm)
or 400 bar / 5,800 psi (5 µm)

**Properties:**
- Well-balanced retention profile.
- Sterically protected to resist harsh, low-pH mobile phases.
- Ideal for use with sensitive detectors like mass spec.

**Switch to an ARC-18 when:**
- You are analyzing large, multiclass lists by LC-MS/MS.
- Strongly acidic (pH 1–3) mobile phases are required.

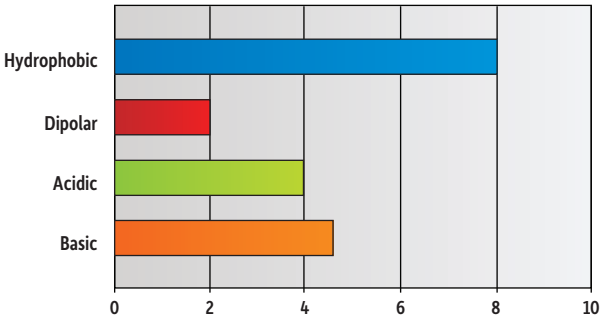
## Column Interaction Profile:


**Defining Solute Interaction:**
- Dispersion

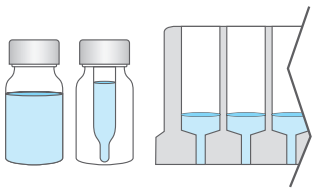
**Complementary Solute Interactions:**
- Hydrogen bonding
- Cation exchange

## Solute Retention Profile:




**Target Analyte Structure:**
- Hydrocarbons

**Target Analyte Functionalities:**
- Hydrophobic compounds
- Protonated bases

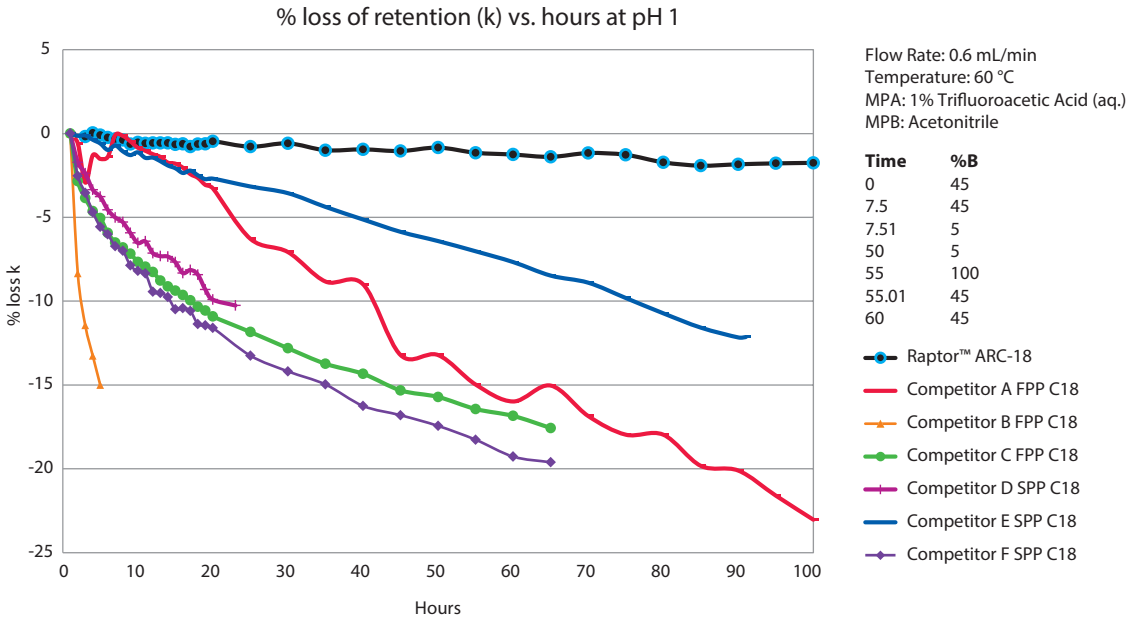


RESTEK

## A New Proprietary Bonded Phase Born for LC-MS/MS

The new Raptor™ ARC-18 column was designed to stand up to even the harshest acidic MS conditions. It utilizes a proprietary bonding procedure that arranges our sterically protected ligand to resist acid hydrolysis and, therefore, also resist phase degradation and bleed. This cutting-edge column lets you increase ionization and boost sensitivity in your mass spec by using low-pH mobile phases—without the fear of retention drift over time. ARC-18 columns maintain a stable retention profile (Figure 1) in mobile phases well under pH 2.0.

**Figure 1:** Steric protection helps the Raptor™ ARC-18 column endure low-pH MS mobile phases without sacrificing retention.

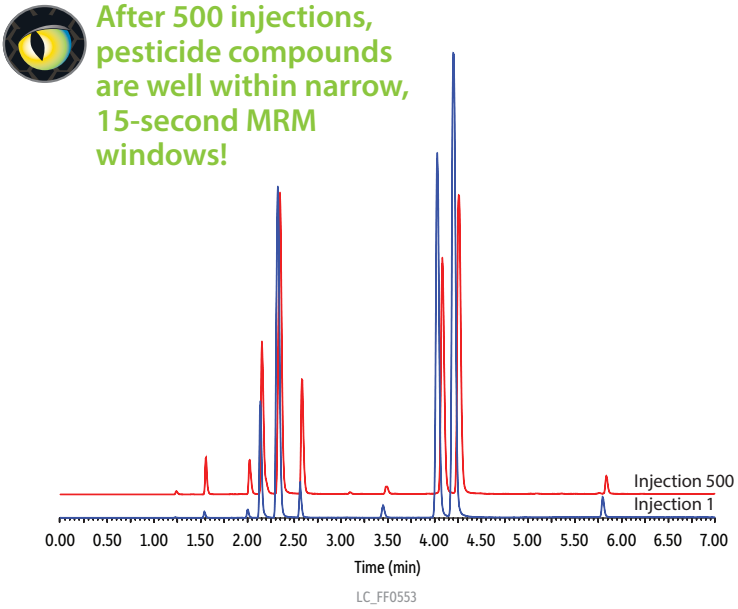


## The New Standard for Reproducibility for SPP Core-Shell Columns

To keep your productivity high and your lab expenses low, we know that Raptor™ ARC-18 columns must produce exceptional selectivity and fast analysis times not just once, but every time. Ruggedness and repeatability are essential, which is why from the silica and the bonding technique, to the packing process and upgraded hardware, every decision that went into creating this column was made to ensure superlative reproducibility, from injection to injection (Figure 2) and from lot to lot (Figure 3). We also adopted new quality control (QC) specifications to guarantee the retention time stability you need for worry-free analyses.

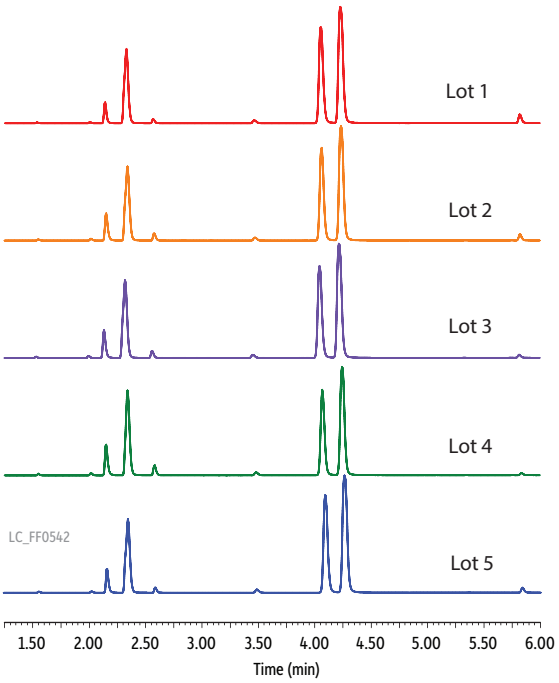
One of the greatest advantages of an SPP column is the ability to operate at higher linear velocities without losing efficiency as you would with a conventional fully porous particle column. But, these higher velocities can also generate higher backpressures that rob you of performance. Like all Raptor™ columns, our new ARC-18 can handle increased pressures, and handle them longer than other manufacturers' SPP columns, to help you achieve ***Selectivity Accelerated*** while offering outstanding reproducibility and maintaining efficiency—even in aggressive MS conditions.

**Figure 2:** Even after hundreds of injections with a highly acidic mobile phase like 0.2% formic acid, a Raptor™ ARC-18 column will provide consistent, reliable data.




**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 50 °C; **Sample:** LC multiresidue pesticide standard #1 (cat.# 31972); Diluent: Water; Conc.: 20 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: Water + 2 mM ammonium formate + 0.2% formic acid, B: Methanol + 2 mM ammonium formate + 0.2% formic acid; **Gradient (%B):** 0.00 min (5%), 2.00 min (60%), 4.00 min (75%), 6.00 min (100%), 7.00 (100%), 7.01 min (5%), 9.50 (5%); **Flow:** 0.4 mL/min; **Detector:** Waters Xevo TQ-S; Ion Source: Waters Zspray™ ESI; Ion Mode: ESI+; Mode: MRM; **Instrument:** Waters ACQUITY UPLC® I-Class

**Figure 3:** From one lot to the next, every Raptor™ ARC-18 column you purchase will perform the same.




Excellent lot-to-lot reproducibility helps ensure longevity for critical workflows.

**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 50 °C; **Sample:** LC multiresidue pesticide standard #1 (cat.# 31972); Diluent: Water; Conc.: 20 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: Water + 2 mM ammonium formate + 0.2% formic acid, B: Methanol + 2 mM ammonium formate + 0.2% formic acid; Max Pressure: 525 bar; **Gradient (%B):** 0.00 min (5%), 2.00 min (60%), 4.00 min (75%), 6.00 min (100%), 7.00 (100%), 7.01 min (5%), 9.50 (5%); **Flow:** 0.4 mL/min; **Detector:** Waters Xevo TQ-S; Ion Source: Waters Zspray™ ESI; Ion Mode: ESI+; Mode: MRM; **Instrument:** Waters ACQUITY UPLC® I-Class

RESTEK

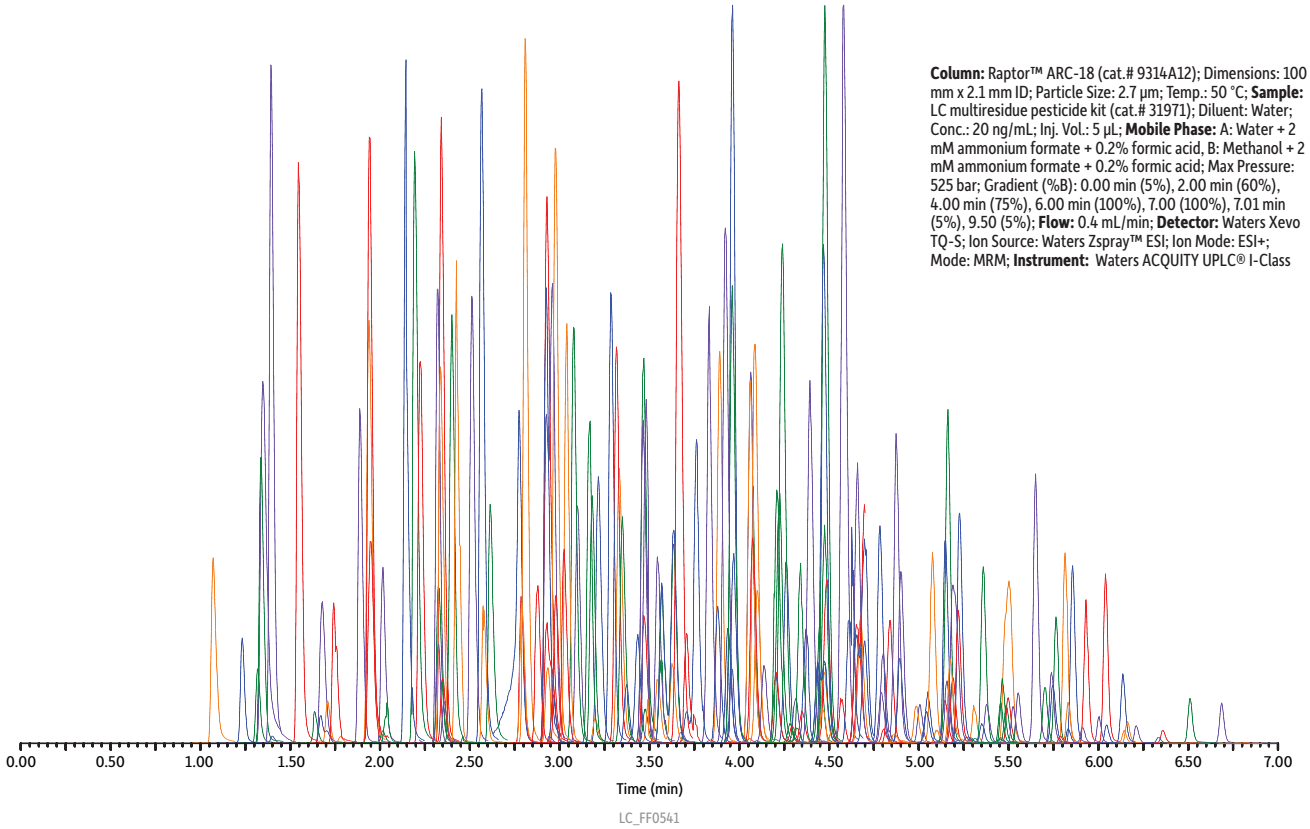
## Well-Balanced Retention to Quickly Separate Large, Multiclass Analyte Lists

In order to analyze large lists of compounds, especially across multiple classes, your column must be capable of spreading analytes out over the gradient to ensure accurate detector response and quantitation. In designing the Raptor™ ARC-18 column, we adjusted our bonding procedures to form an ideal ligand density that offers balanced retention for the rapid analysis of large, multiclass assays. As shown in Figure 4, even a 204-compound pesticide screen can be reliably completed in just 9.5 minutes. The Raptor™ ARC-18 column exhibits the balanced retention, selectivity, and performance needed for critical multiclass workflows in any industry or lab.

**Figure 4:** With its balanced retention profile, the Raptor™ ARC-18 column is ideally suited to analyze large, cross-class compound lists.

204 pesticides in just 9.5 minutes!

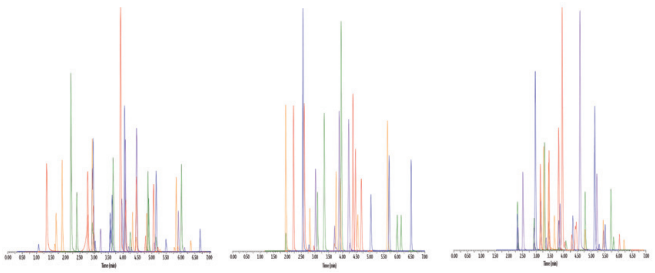
For a complete compound list, visit **www.restek.com/lc-multiresidue** select the LC Multiresidue Pesticide Kit (cat.# 31971).




**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 50 °C; **Sample:** LC multiresidue pesticide kit (cat.# 31971); Diluent: Water; Conc.: 20 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: Water + 2 mM ammonium formate + 0.2% formic acid, B: Methanol + 2 mM ammonium formate + 0.2% formic acid; Max Pressure: 525 bar; Gradient (%B): 0.00 min (5%), 2.00 min (60%), 4.00 min (75%), 6.00 min (100%), 7.00 (100%), 7.01 min (5%), 9.50 (5%); **Flow:** 0.4 mL/min; **Detector:** Waters Xevo TQ-S; Ion Source: Waters Zspray™ ESI; Ion Mode: ESI+; Mode: MRM; **Instrument:** Waters ACQUITY UPLC® I-Class

**Note:**
When combining a large number of compounds with different chemical functionalities, mix stability can be an issue. In formulating our LC multiresidue pesticide standard kit (cat.# 31971), we extensively studied the 204 compounds involved, then grouped them into as few mixes as possible while still ensuring maximum long-term stability and reliability. For quantitative analysis, we recommend analyzing each mix separately to ensure accurate results for every compound.

To view separate chromatograms of each mix, visit **www.restek.com/lc-multiresidue**



## Speed Up Challenging Analyses with Simple Mobile Phases and Methods

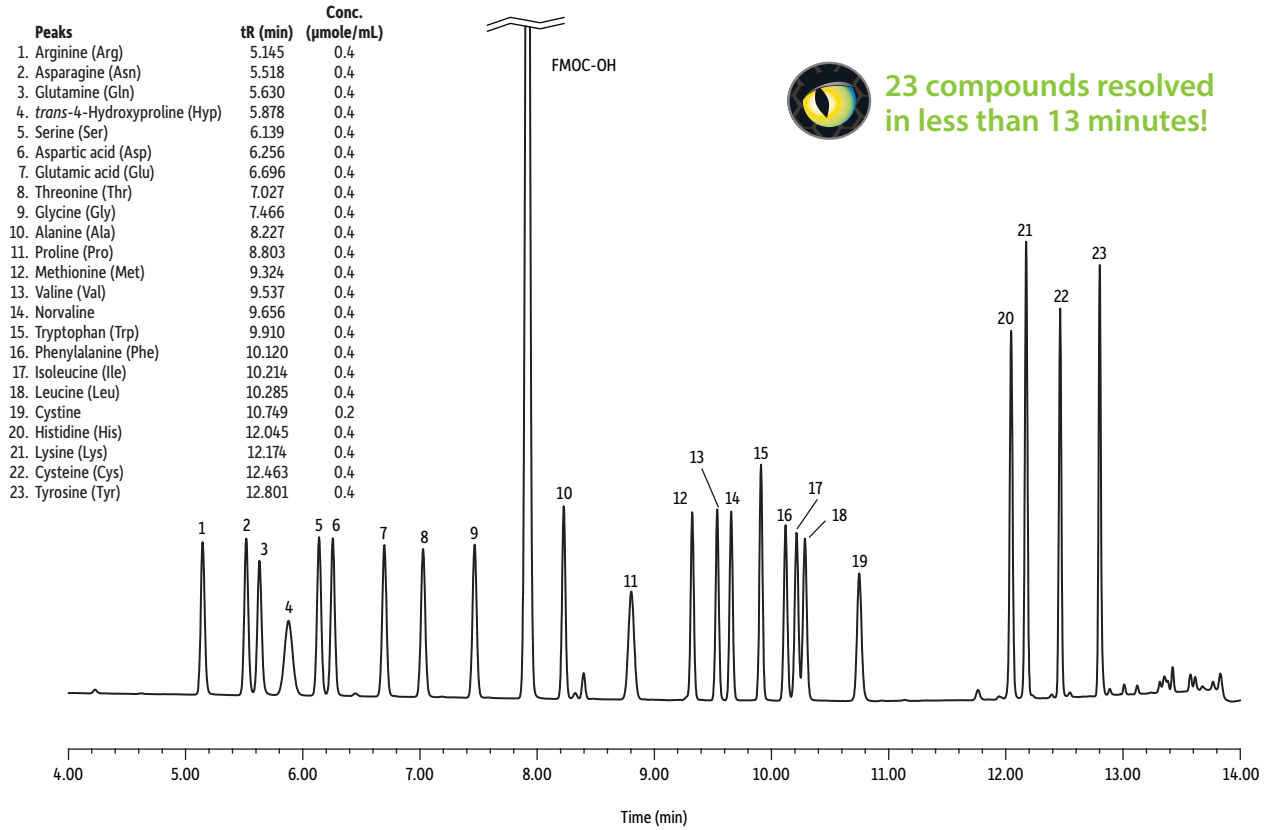
From food safety to bioanalytical work, getting reliable, reproducible data by LC often requires specialty instrumentation or columns, complex mobile phases, or long runs. Instead of wasting time and resources—and making your job harder in the process—you can greatly improve your productivity by selecting a better column for your existing instrumentation. By switching to a Raptor™ ARC-18 column for your LC-MS/MS analyses, you can increase your sample throughput and make your job easier by maintaining, or even improving, your data quality using simple mobile phases and a typical HPLC system. Put the ARC-18 to work in your lab today to experience ***Selectivity Accelerated!***

### Amino Acids with Standard Columns on UV or Mass Spec

Instead of purchasing specialty amino acid columns or dedicated analyzers, use Raptor™ ARC-18 columns with your standard HPLC and UV detector to perform routine analyses of 23 common amino acids. Using 9-fluorenylmethyl-chloroformate (FMOC) derivatization and simple mobile phases, you can separate, detect, and quantitate amino acids without specialty instrumentation (Figure 5). Because of the ARC-18's compatibility with MS-friendly mobile phases, these UV methods can also be easily transferred to your mass spectrometer. And since it is a Raptor™ column, it will hold up to extended use without losing selectivity or performance.

**Figure 5:** Raptor™ ARC-18 columns exhibit excellent retention and resolution of amino acids derivatized with FMOC, including isomers leucine and isoleucine.

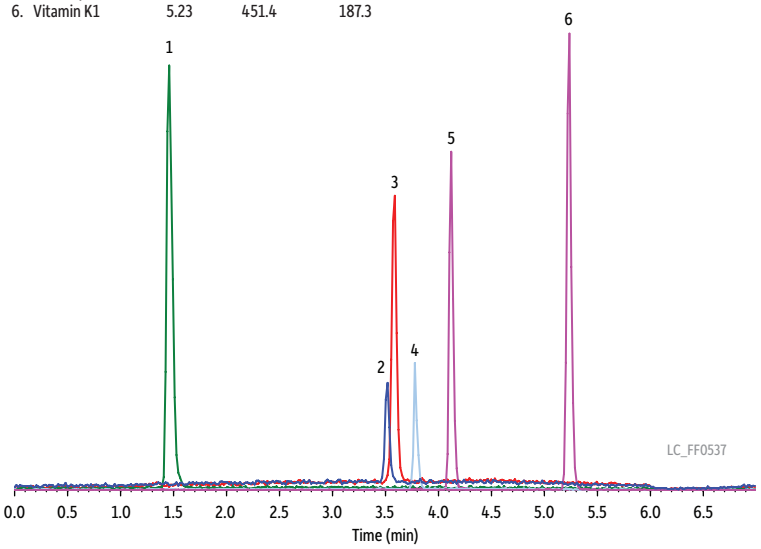
| Peaks | tR (min) | Conc. (µmole/mL) |
|---|---|---|
| 1. Arginine (Arg) | 5.145 | 0.4 |
| 2. Asparagine (Asn) | 5.518 | 0.4 |
| 3. Glutamine (Gln) | 5.630 | 0.4 |
| 4. *trans*-4-Hydroxyproline (Hyp) | 5.878 | 0.4 |
| 5. Serine (Ser) | 6.139 | 0.4 |
| 6. Aspartic acid (Asp) | 6.256 | 0.4 |
| 7. Glutamic acid (Glu) | 6.696 | 0.4 |
| 8. Threonine (Thr) | 7.027 | 0.4 |
| 9. Glycine (Gly) | 7.466 | 0.4 |
| 10. Alanine (Ala) | 8.227 | 0.4 |
| 11. Proline (Pro) | 8.803 | 0.4 |
| 12. Methionine (Met) | 9.324 | 0.4 |
| 13. Valine (Val) | 9.537 | 0.4 |
| 14. Norvaline | 9.656 | 0.4 |
| 15. Tryptophan (Trp) | 9.910 | 0.4 |
| 16. Phenylalanine (Phe) | 10.120 | 0.4 |
| 17. Isoleucine (Ile) | 10.214 | 0.4 |
| 18. Leucine (Leu) | 10.285 | 0.4 |
| 19. Cystine | 10.749 | 0.2 |
| 20. Histidine (His) | 12.045 | 0.4 |
| 21. Lysine (Lys) | 12.174 | 0.4 |
| 22. Cysteine (Cys) | 12.463 | 0.4 |
| 23. Tyrosine (Tyr) | 12.801 | 0.4 |




**Column:** Raptor™ ARC-18 (cat.# 9314A1E); Dimensions: 100 mm x 3 mm ID; Particle Size: 2.7 µm; Temp.: 30 °C; **Sample:** Diluent: 0.1 N HCl; Conc.: 0.4 µmole/mL for each amino acid (0.2 µmole/mL for cystine); Inj. Vol.: 1 µL; **Mobile Phase:** A: 0.1% Formic acid + 20 mM ammonium formate in water, B: 0.1% Formic acid + 10 mM ammonium formate in 90:10 acetonitrile:water; **Gradient (%B):** 0.00 min (20%), 6.25 min (40%), 9.00 min (60%), 10.00 min (60%), 13.00 (100%), 13.01 min (20%), 15.00 (20%); **Flow:** 0.8 mL/min; **Detector:** UV/Vis @ 265, 4.8 nm; **Instrument:** Waters Acquity® UPLC H-Class; **Notes:** Derivatization reaction: 50 µL amino acid mix + 100 µL 0.2 N borate buffer (pH 10.0) + 50 µL 15 mM 9-fluorenylmethyl-chloroformate solution + 50 µL acetonitrile; The injection can be performed after 5 minutes of reaction time.

**Figure 6:** The ARC-18 makes quick work of fat-soluble vitamins A, D, E, and K by LC-MS/MS

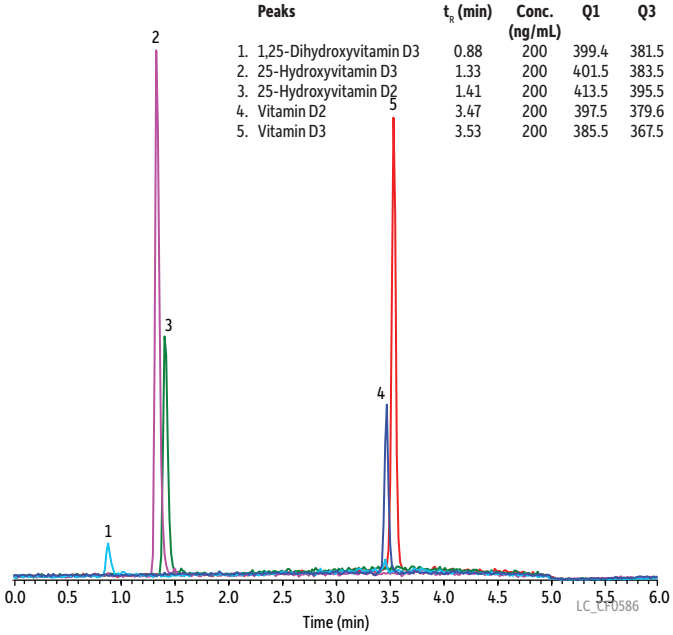
| Peaks | $t_R$ (min) | Precursor Ion | Product Ion |
|---|---|---|---|
| 1. Retinol | 1.46 | 269.4 | 93.3 |
| 2. Vitamin D2 | 3.52 | 397.5 | 379.6 |
| 3. Vitamin D3 | 3.58 | 385.5 | 367.5 |
| 4. γ-Tocopherol | 3.78 | 417.6 | 151.4 |
| 5. α-Tocopherol | 4.12 | 431.7 | 165.4 |
| 6. Vitamin K1 | 5.23 | 451.4 | 187.3 |




**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 40 °C; **Sample:** Diluent: Methanol; Conc.: 100 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid + 5 mM ammonium formate in water, B: 0.1% Formic acid + 5 mM ammonium formate in methanol; Max Pressure: 190 bar; **Gradient (%B):** 0.00 min (90%), 4.0 min (100%), 5.0 min (100%), 5.01 min (90%), 7.0 (90%); **Flow:** 0.5 mL/min; **Detector:** ABSCIEX API 4000™; Ion Source: TurboIonSpray®; Ion Mode: ESI+; Mode: MRM; **Instrument:** Shimadzu UFLCXR

**Figure 7:** The ARC-18 also resolves vitamin D metabolites by LC-MS/MS with the same column and mobile phases

| Peaks | $t_R$ (min) | Conc. (ng/mL) | Q1 | Q3 |
|---|---|---|---|---|
| 1. 1,25-Dihydroxyvitamin D3 | 0.88 | 200 | 399.4 | 381.5 |
| 2. 25-Hydroxyvitamin D3 | 1.33 | 200 | 401.5 | 383.5 |
| 3. 25-Hydroxyvitamin D2 | 1.41 | 200 | 413.5 | 395.5 |
| 4. Vitamin D2 | 3.47 | 200 | 397.5 | 379.6 |
| 5. Vitamin D3 | 3.53 | 200 | 385.5 | 367.5 |




**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 40 °C; **Sample:** Diluent: Methanol; Conc.: 200 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid + 5 mM ammonium formate in water B: 0.1% Formic acid + 5 mM ammonium formate in methanol; **Gradient (%B):** 0.00 min (90%), 4.00 min (100%), 4.01 min (90%), 6.00 (90%); **Flow:** 0.5 mL/min; **Detector:** ABSCIEX API 4000™; Ion Source: TurboIonSpray®; Ion Mode: ESI+; **Instrument:** Shimadzu UFLCXR

## Fat-Soluble Vitamins and Metabolites with Accelerated Run Times

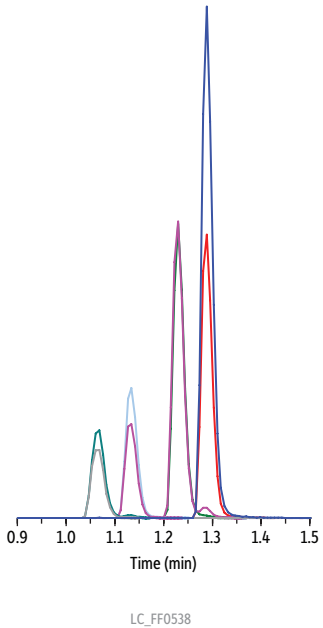
Separating fat-soluble vitamins by LC can be time-consuming. The Raptor™ ARC-18 column, however, can analyze these difficult compounds using reversed-phased chromatography (RPC) in less time than traditional columns to increase productivity. The ARC-18 also stands up to the low-pH, MS-friendly mobile phases that promote ionization and fast separation while providing the balanced retention profile necessary for this important food safety workflow (Figure 6). Plus, in the bioanalytical arena, the ARC-18 can quantitate the metabolites of vitamin D using the same column and mobile phases (Figure 7).

## Toxic Substances in Agricultural Matrices Using LC

When it comes to analyzing toxic substances in agricultural matrices (e.g., aflatoxins in wheat), speed is of paramount importance. A Raptor™ ARC-18 column retains *and* separates these compounds with simple mobile phases—in a rapid time frame that maximizes your productivity (Figure 8).

**Figure 8:** The ARC-18 elutes four common aflatoxins in under 1.5 minutes with an overall cycle time of 2.5 minutes!

| Peaks | $t_R$ (min) | Q1 | Q3 Quantifier | Q3 Qualifier |
|---|---|---|---|---|
| 1. Aflatoxin G2 | 1.07 | 331.1 | 245.1 | 189.1 |
| 2. Aflatoxin G1 | 1.13 | 329.0 | 243.1 | 200.1 |
| 3. Aflatoxin B2 | 1.23 | 315.0 | 259.1 | 287.1 |
| 4. Aflatoxin B1 | 1.29 | 313.0 | 285.1 | 241.1 |




**Column:** Raptor™ ARC-18 (cat.# 9314A5E); Dimensions: 50 mm x 3.0 mm ID; Particle Size: 2.7 µm; Temp.: 45 °C; **Sample:** Diluent: Acetonitrile:water (50:50); Conc.: 100 ng/mL; Inj. Vol.: 10 µL; **Mobile Phase:** A: 5 mM Ammonium formate + 0.1% formic acid in water; B: 0.1% Formic acid in methanol; Gradient (%B): 0.00 min (35%), 1.50 min (95%), 1.51 min (35%), 2.50 (35%); **Flow:** 0.700 mL/min; **Detector:** Applied Biosystems/MDS Sciex LC-MS/MS; Ion Source: TurboIonSpray®; Ion Mode: ESI+; **Instrument:** Shimadzu UFLCXR

# For Consistent Retention, Peak Shape, and Response with Mass Spec, Grab the Column that Thrives in Low pH Conditions

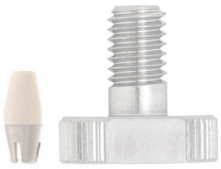
## Raptor™ ARC-18 LC Columns


| Length | 2.1 mm cat.# | 3.0 mm cat.# | 4.6 mm cat.# |
|---|---|---|---|
| **2.7 µm Columns** | | | |
| 30 mm | 9314A32 | 9314A3E | 9314A35 |
| 50 mm | 9314A52 | 9314A5E | 9314A55 |
| 100 mm | 9314A12 | 9314A1E | 9314A15 |
| 150 mm | 9314A62 | 9314A6E | 9314A65 |
| **5 µm Columns** | | | |
| 30 mm | — | 931453E | — |
| 50 mm | 9314552 | 931455E | 9314555 |
| 100 mm | 9314512 | 931451E | 9314515 |
| 150 mm | 9314562 | 931456E | 9314565 |
| 250 mm | — | — | 9314575 |

## EXP® Reusable Fittings for HPLC & UHPLC

for 10-32 fittings and 1/16" tubing

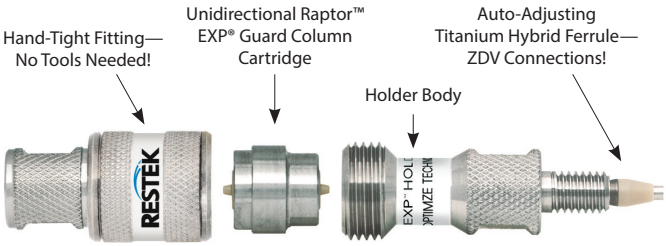
Effortlessly achieve 8,700+ psi HPLC seals by hand! (Wrench-tighten to 20,000+ psi.) Hybrid titanium/PEEK seal can be installed repeatedly without compromising your seal.



| Description | qty. | cat.# |
|---|---|---|
| EXP Hand-Tight Fitting (Nut w/Ferrule) | ea. | 25937 |
| EXP Hand-Tight Fitting (Nut w/Ferrule) | 10-pk. | 25938 |
| EXP Hand-Tight Nut (w/o Ferrule) | ea. | 25939 |

Hybrid Ferrule U.S. Patent No. 8201854, Optimize Technologies. Optimize Technologies EXP Holders are Patent Pending. Other U.S. and Foreign Patents Pending. The EXP, Free-Turn, and the Opti- prefix are registered trademarks of Optimize Technologies, Inc.

## Raptor™ EXP® Guard Cartridges




Protect your investment and extend the life of our already-rugged LC columns and change guard column cartridges by hand without breaking fluid connections—no tools needed!

### EXP® Direct Connect Holder

| Description | qty. | cat.# |
|---|---|---|
| EXP Direct Connect Holder for EXP Guard Cartridges (includes hex-head fitting & 2 ferrules) | ea. | 25808 |

### Raptor™ EXP® Guard Column Cartridges

| Description | Particle Size | qty. | 5 x 2.1 mm cat.# | 5 x 3.0 mm cat.# | 5 x 4.6 mm cat.# |
|---|---|---|---|---|---|
| Raptor ARC-18 EXP Guard Cartridge | 2.7 µm | 3-pk. | 9314A0252 | 9314A0253 | 9314A0250 |
| Raptor ARC-18 EXP Guard Cartridge | 5 µm | 3-pk. | 931450252 | 931450253 | 931450250 |

Maximum cartridge pressure: 600 bar / 8,700 psi (2.7 µm) or 400 bar / 5,800 psi (5 µm)

Raptor™ SPP LC columns combine the speed of SPP with the resolution of USLC® technology. Learn more at **www.restek.com/raptor**

Experience *Selectivity Accelerated.* Order the Raptor™ ARC-18 today at **www.restek.com/raptor**

RESTEK®
Pure Chromatography

**Questions about this or any other Restek® product?**
**Contact us or your local Restek® representative (www.restek.com/contact-us).**



**www.restek.com**

ISO 9001 • 17025 • Guide 34

Lit. Cat.# GNBR1970B-UNV

# Raptor™ C18 Columns

- A traditional end-capped C18 ideal for general-purpose use in reversed-phase chromatography.
- Wide pH range (2–8) provides excellent data quality for many applications, matrices, and compounds.
- Offers the highest hydrophobic retention of any Raptor™ phase.

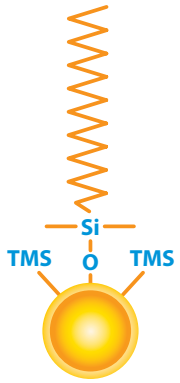
To lower costs and improve profitability, you need columns to last longer, data to be reproducible, and existing HPLC instrumentation to run faster. Get there with the only general-purpose C18 that gives you *Selectivity Accelerated.*

**Part of Restek's Raptor™ LC column line featuring 2.7 and 5 µm SPP core-shell silica:**

- *Higher efficiency and resolution for drastically faster analysis times.*
- *Increased sample throughput with existing HPLC instrumentation*
- *Long-lasting ruggedness for dependable reproducibility.*

Outfit your lab with Raptor™ C18s at **www.restek.com/raptor**

## Column Description:




**Stationary Phase Category:**
C18, octadecylsilane (L1)

**Ligand Type:**
End-capped C18

**Particle:**
2.7 µm or 5 µm superficially porous silica (SPP or "core-shell")

**Pore Size:**
90 Å

**Surface Area:**
150 $m^2/g$ (2.7 µm) or 100 $m^2/g$ (5 µm)

**Recommended Usage:**
pH Range: 2.0–8.0

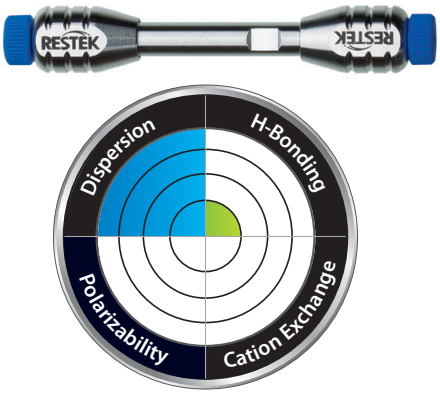
Maximum Temperature: 80 °C

Maximum Pressure: 600 bar / 8,700 psi (2.7 µm)
or 400 bar / 5,800 psi (5 µm)

**Properties:**
- Compatible with moderately acidic to neutral mobile phases (pH 2–8).
- Excellent data quality in food, environmental, bioanalytical, and other applications.

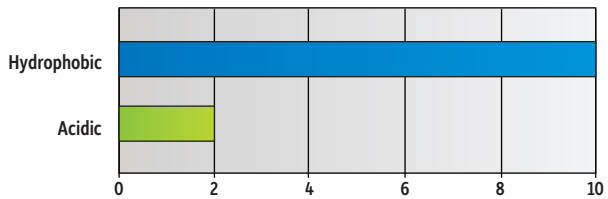
**Switch to a C18 when:**
- You need a general-purpose column for reversed-phase chromatography.
- You need to increase retention of hydrophobic compounds.

## Column Interaction Profile:



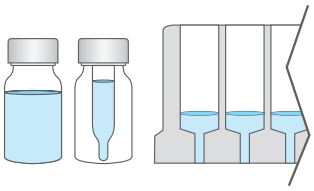

**Defining Solute Interaction:**
- Dispersion

## Solute Retention Profile:




**Target Analyte Structure:**
- Hydrocarbons

**Target Analyte Functionality:**
- Hydrophobic compounds





RESTEK

# Raptor™ C18 Performance: Speed, Efficiency, and Ruggedness in Action

**Figure 1:** Even at high pressures, long-lasting Raptor™ C18 columns maintain their stability and efficiency, so you can operate at higher linear velocities to achieve fast, accurate separations without UHPLC.

**Stable at high pressures for faster run times**

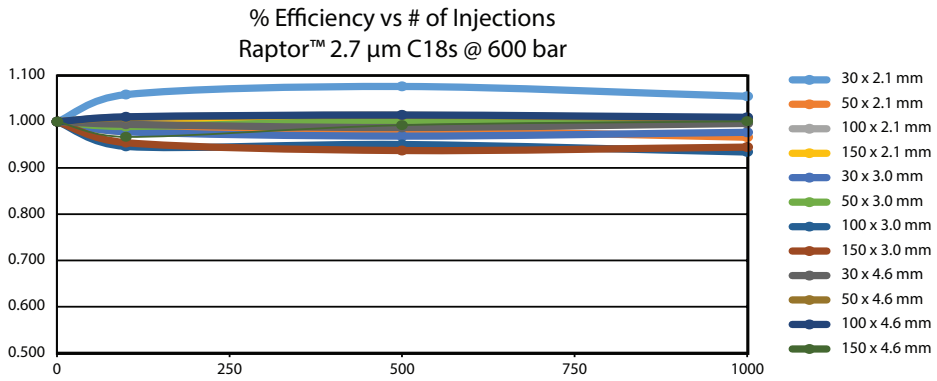
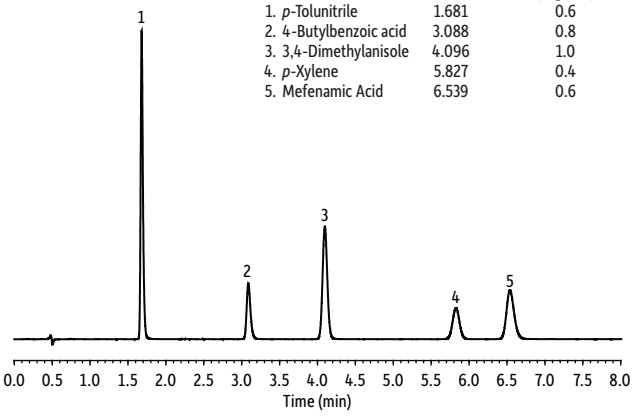



**Figure 2:** Raptor™ columns' stringent quality control (QC) specifications guarantee outstanding peak shape, even with active compounds, for superior data quality.

**Outstanding peak shapes for top-notch data**

| Peaks | tR (min) | Conc. (mg/mL) |
|---|---|---|
| 1. *p*-Tolunitrile | 1.681 | 0.6 |
| 2. 4-Butylbenzoic acid | 3.088 | 0.8 |
| 3. 3,4-Dimethylanisole | 4.096 | 1.0 |
| 4. *p*-Xylene | 5.827 | 0.4 |
| 5. Mefenamic Acid | 6.539 | 0.6 |

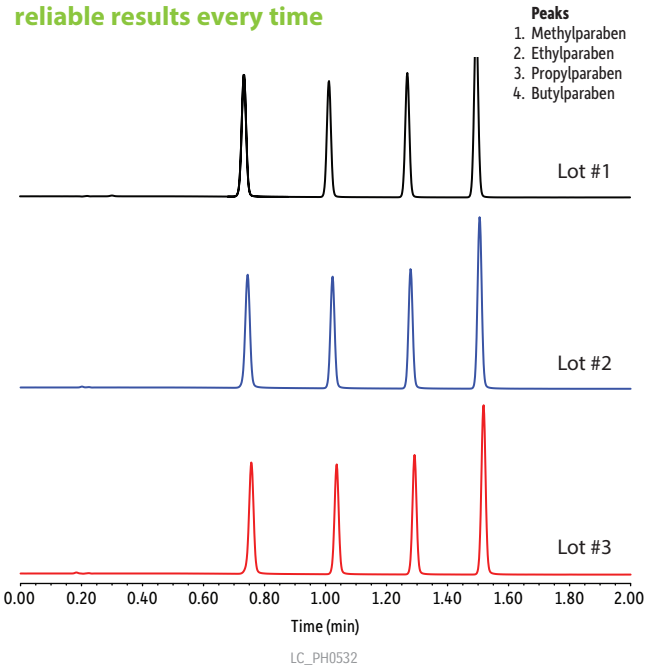



LC_GN0557

**Column:** Raptor™ C18 (cat.# 9304A1E); Dimensions: 100 mm x 3 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 30 °C; **Sample:** Diluent: Acetonitrile:water:phosphoric acid (65:34:1); Inj. Vol.: 1 µL; **Mobile Phase:** A: 0.05% Formic acid in water, B: 0.05% Formic acid in acetonitrile; **Gradient (%B):** 0.00 min (45% B), 8.00 min (45% B); **Flow:** 0.8 mL/min; **Detector:** UV/Vis @ 220 nm; Cell Temp: 40 °C; **Instrument:** HPLC.

**Figure 3:** Lot-to-lot reproducibility is the key to keeping your productivity high and budget low. You can expect the same exceptional performance from every Raptor™ C18 column you purchase.

**Lot-to-lot reproducibility for fast, reliable results every time**




LC_PH0532

**Column:** Raptor™ C18 (cat.# 9304512); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 5 µm; Temp.: 40 °C; **Sample:** Conc.: 100 µg/mL in water; Inj. Vol.: 1 µL; **Mobile Phase:** A: Water, B: Acetonitrile; **Gradient** (%B): 0.00 min (20% B), 2.00 min (80% B), 2.01 min (20% B), 3.50 min (20% B); **Flow:** 1.0 mL/min; **Detector:** PDA @ 254 nm; **Instrument:** UHPLC.

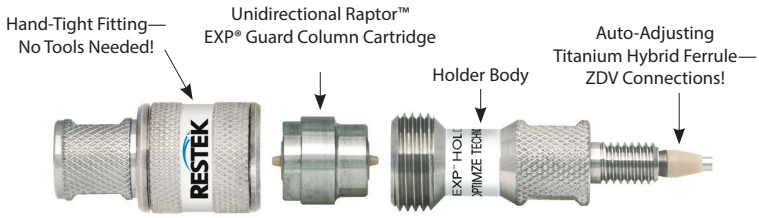
Experience *Selectivity Accelerated.* Order the Raptor™ C18 today at **www.restek.com/raptor**

# Lower Costs and Improve Profitability with the Only General-Purpose C18 That Gives You *Selectivity Accelerated*

## Raptor™ C18 LC Columns


| Length | 2.1 mm cat.# | 3.0 mm cat.# | 4.6 mm cat.# |
|---|---|---|---|
| **2.7 µm Columns** | | | |
| 30 mm | 9304A32 | 9304A3E | 9304A35 |
| 50 mm | 9304A52 | 9304A5E | 9304A55 |
| 100 mm | 9304A12 | 9304A1E | 9304A15 |
| 150 mm | 9304A62 | 9304A6E | 9304A65 |
| **5 µm Columns** | | | |
| 30 mm | — | 930453E | — |
| 50 mm | 9304552 | 930455E | 9304555 |
| 100 mm | 9304512 | 930451E | 9304515 |
| 150 mm | 9304562 | 930456E | 9304565 |
| 250 mm | — | — | 9304575 |

## Raptor™ EXP® Guard Cartridges




Protect your investment and extend the life of our already-rugged LC columns and change guard column cartridges by hand without breaking fluid connections—no tools needed!

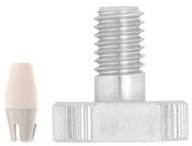
### EXP® Direct Connect Holder

| Description | qty. | cat.# |
|---|---|---|
| EXP Direct Connect Holder for EXP Guard Cartridges (includes hex-head fitting & 2 ferrules) | ea. | 25808 |

## EXP® Reusable Fittings for HPLC & UHPLC

for 10-32 fittings and 1/16" tubing

Effortlessly achieve 8,700+ psi HPLC seals by hand! (Wrench-tighten to 20,000+ psi.) Hybrid titanium/PEEK seal can be installed repeatedly without compromising your seal.



| Description | qty. | cat.# |
|---|---|---|
| EXP Hand-Tight Fitting (Nut w/Ferrule) | ea. | 25937 |
| EXP Hand-Tight Fitting (Nut w/Ferrule) | 10-pk. | 25938 |
| EXP Hand-Tight Nut (w/o Ferrule) | ea. | 25939 |

Hybrid Ferrule U.S. Patent No. 8201854, Optimize Technologies. Optimize Technologies EXP Holders are Patent Pending. Other U.S. and Foreign Patents Pending. The EXP, Free-Turn, and the Opti- prefix are registered trademarks of Optimize Technologies, Inc.

### Raptor™ EXP® Guard Column Cartridges

| Description | Particle Size | qty. | 5 x 2.1 mm cat.# | 5 x 3.0 mm cat.# | 5 x 4.6 mm cat.# |
|---|---|---|---|---|---|
| Raptor C18 EXP Guard Column Cartridge | 2.7 µm | 3-pk. | 9304A0252 | 9304A0253 | 9304A0250 |
| Raptor C18 EXP Guard Column Cartridge | 5 µm | 3-pk. | 930450252 | 930450253 | 930450250 |

Maximum cartridge pressure: 600 bar / 8,700 psi (2.7 µm) or 400 bar / 5,800 psi (5 µm)

Raptor™ SPP LC columns combine the speed of SPP with the resolution of USLC® technology. Learn more at **www.restek.com/raptor**

Experience *Selectivity Accelerated*. Order the Raptor™ C18 today at **www.restek.com/raptor**

RESTEK®
Pure Chromatography

**Questions about this or any other Restek® product?**
**Contact us or your local Restek® representative (www.restek.com/contact-us).**



**www.restek.com**

ISO 9001 · 17025 · Guide 34

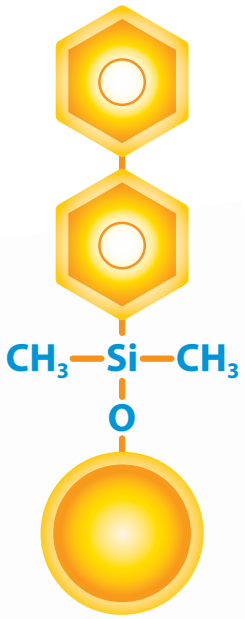
Lit. Cat.# GNSS2093B-UNV

Stationary Phase: **Biphenyl**

Raptor™ LC Columns

*Selectivity Accelerated*

# Fast, Rugged Raptor™ Columns with Time-Tested Selectivity





RESTEK® Pure Chromatography www.restek.com/raptor

# The Raptor™ Biphenyl Column

With Raptor™ LC columns, Restek chemists became the first to combine the speed of superficially porous particles (also known as SPP or "core-shell" particles) with the resolution of highly selective USLC® technology. This new breed of chromatographic column allows you to more easily achieve peak separation and faster analysis times without expensive UHPLC instrumentation.

Our top priority when developing our new SPP line was to create a version of our innovative Biphenyl. The industry-leading Biphenyl is Restek's most popular LC stationary phase because it is particularly adept at separating compounds that are hard to resolve or that elute early on C18 and other phenyl chemistries. As a result, the rugged Raptor™ Biphenyl column is extremely useful for fast separations in bioanalytical testing applications like drug and metabolite analyses, especially those that require a mass spectrometer (MS). Increasing retention of early-eluting compounds can limit ionization suppression, and the heightened selectivity helps eliminate the need for complex mobile phases that are not well suited for MS detection.

In 2005, Restek was the first to bring you the benefits of the Biphenyl ligand, and we have the experience to maximize the SPP performance of this premier phenyl chemistry for today's challenging workflows.

## Column Description:


**Stationary Phase Category:**
Phenyl (L11)

**Ligand Type:**
Biphenyl

**Particle:**
2.7 µm or 5 µm superficially porous silica (SPP or "core-shell")

**Pore Size:**
90 Å

**Surface Area:**
150 $m^2/g$ (2.7 µm)
or 100 $m^2/g$ (5 µm)

**Recommended Usage:**
pH Range: 1.5–8.0

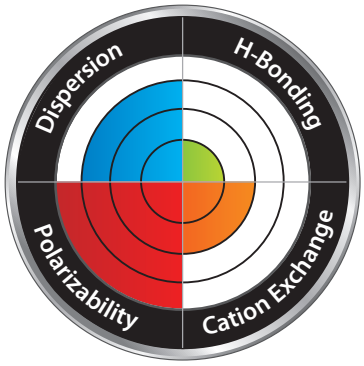
Maximum Temperature: 80 °C

Maximum Pressure: 600 bar / 8,700 psi (2.7 µm)
or 400 bar / 5,800 psi (5 µm)

**Properties:**
- Increased retention for dipolar, unsaturated, or conjugated solutes.
- Enhanced selectivity when used with methanolic mobile phase.
- Ideal for increasing sensitivity and selectivity in LC-MS analyses.

**Switch to a Biphenyl when:**
- Limited selectivity is observed on a C18.
- You need to increase retention of hydrophilic aromatics.

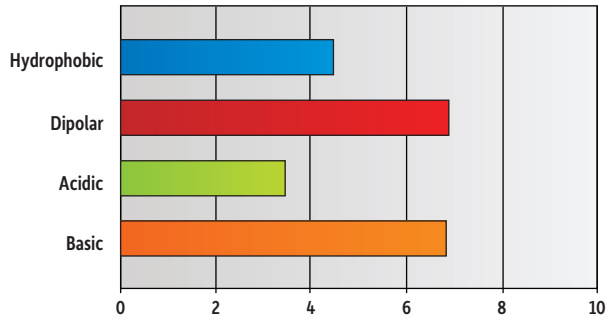
## Column Interaction Profile:

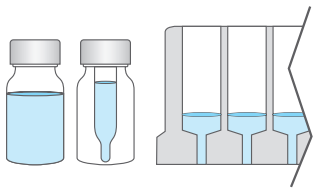

**Defining Solute Interactions:**
- Polarizability
- Dispersion

**Complementary Solute Interaction:**
- Cation exchange

## Solute Retention Profile:




**Target Analyte Structures:**
- Aromatic
- Dipolar



**Target Analyte Functionalities:**
- Hydrophilic aromatics
- Strong dipoles
- Lewis acids
- Dipolar, unsaturated, or conjugated compounds
- Fused-ring compounds with electron withdrawing groups

## More Aromatic Selectivity than Ordinary Phenyl-Hexyls

SPP core-shell columns commonly employ traditional phenyl-hexyl stationary phases, but the innovative Biphenyl ligand, developed by Restek's chemists, is the next generation of phenyl column chemistry. It provides greater aromatic selectivity than commercially available phenyl-hexyl columns [1] and a greater degree of dispersion than conventional phenyls. As a result, the Raptor™ Biphenyl allows you to more easily separate bioanalytical compounds like aromatics (Figures 1 and 2), which elute early or are hard to separate on C18 or other phenyl chemistries.

[1] In-house testing based on: M. R. Euerby, P. Petersson, W. Campbell, W. Roe, Chromatographic classification and comparison of commercially available reversed-phase liquid chromatographic columns containing phenyl moieties using principal component analysis, J. Chromatogr. A 1154 (2007) 138–151.

**Figure 1:** Raptor™ Biphenyl columns exhibit the highest aromatic selectivity compared to other SPP phenyl columns.

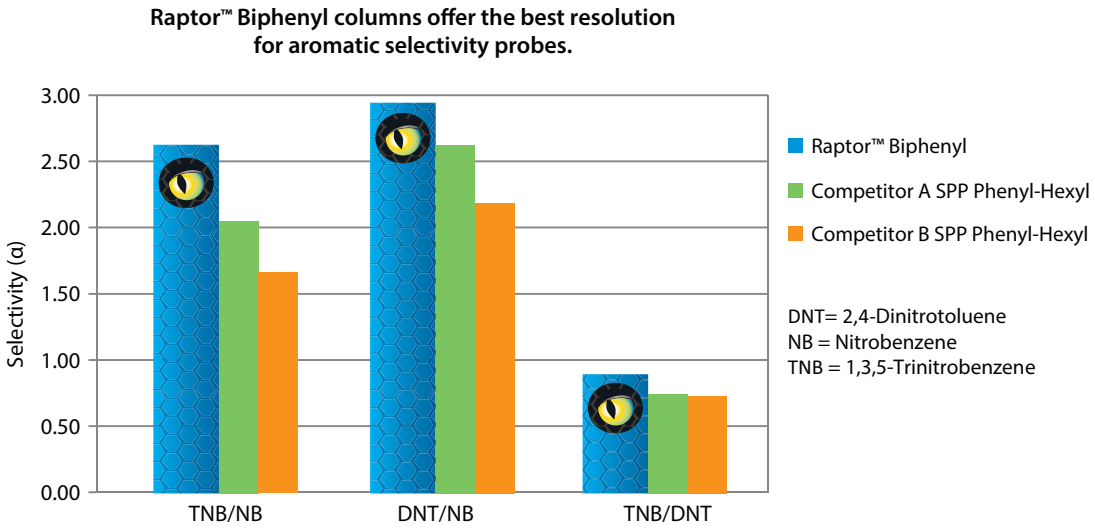
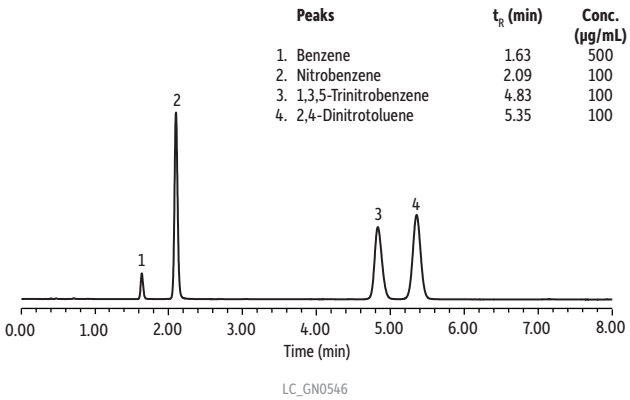



**Figure 2:** Raptor™ Biphenyl columns show increased retention for compounds containing electron withdrawing groups. Retention and elution order are dramatically different from a traditional C18.




**Column:** Raptor™ Biphenyl (cat.# 9309A55); Dimensions: 50 mm x 4.6 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 40 °C; **Sample:** Diluent: acetonitrile; Conc.: 100-500 µg/mL; Inj. Vol.: 1 µL **Mobile Phase:** water: methanol (50:50); Flow: 1.2 mL/min; **Detector:** Waters Acquity® PDA @ 254 nm; **Instrument:** Waters Acquity® UPLC H-Class.



www.restek.com/raptor

# The New Standard for Performance and Durability for SPP Core-Shell Columns

## Pressure Stability:

One of the greatest advantages of an SPP column is the ability to achieve fast, efficient separations by operating at higher linear velocities than are possible with a conventional fully porous particle column. However, these higher velocities can also result in higher back pressures. Raptor™ columns were designed to handle the increased pressures needed to achieve *Selectivity Accelerated*, and handle it far better than other SPP columns on the market (Figure 3).

## Reproducibility:

To help keep your productivity high and your lab budget low, we know that Raptor™ Biphenyl columns must produce exceptional selectivity and fast analysis times not just once, but every time. Ruggedness and repeatability are essential, which is why from the silica and the bonding technique, to the packing process and upgraded hardware, every decision that went into creating this column was made to ensure superlative reproducibility, from injection to injection (Figure 4) and from lot to lot (Figure 5). We also adopted new quality control (QC) specifications to guarantee the retention time stability you need for worry-free MRM analyses.

**Figure 3:** At high pressures, competitor phenyl-hexyl columns experience a quick and sharp drop-off in efficiency, but Raptor™ Biphenyl columns are unaffected to at least 3,000 injections.

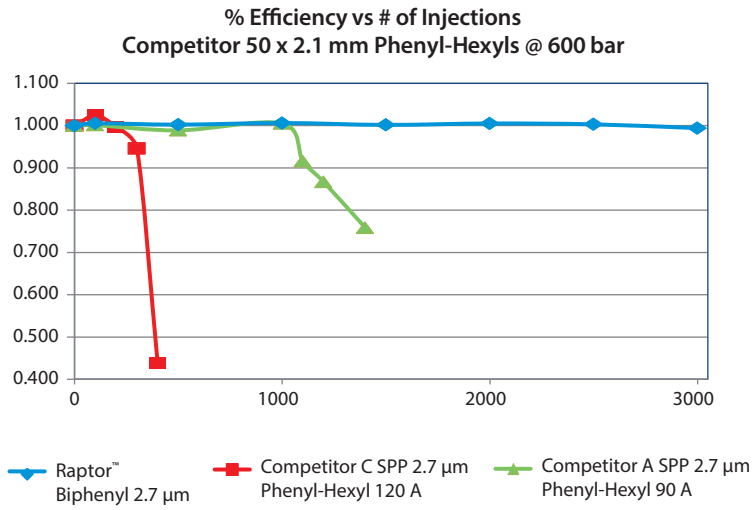
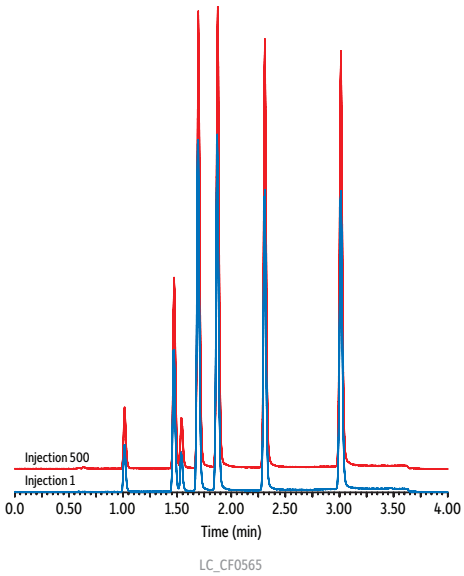


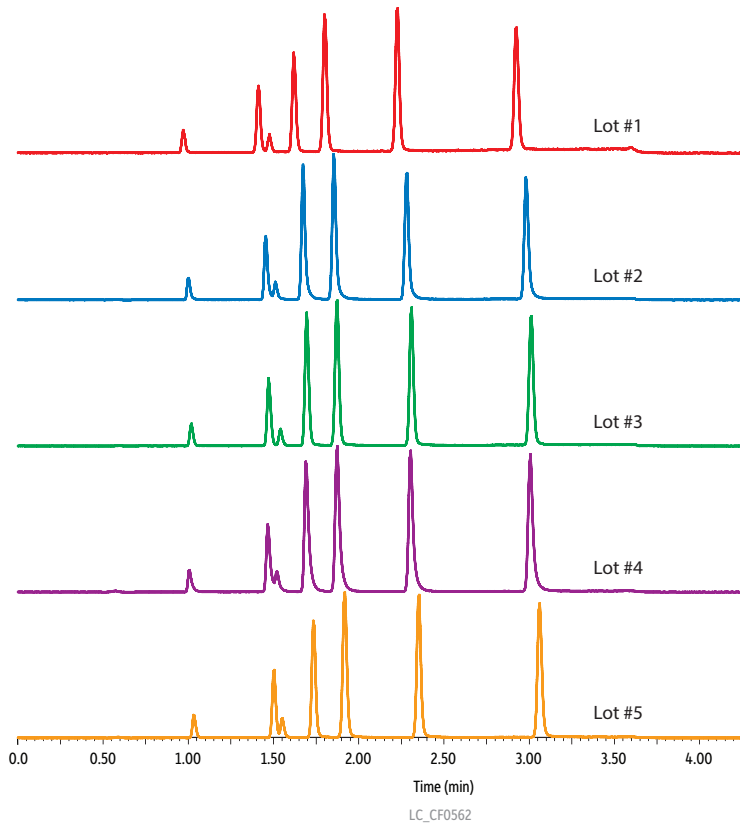

**Figure 4:** Even after hundreds of injections, a Raptor™ Biphenyl column will provide consistent, reliable data.




**Peaks**
1. Cortisol
2. 11-Deoxycortisol
3. Estradiol
4. Boldenone
5. Testosterone
6. Androstenedione
7. Progesterone

**Column:** Raptor™ Biphenyl (cat.# 9309A1E); Dimensions: 100 mm x 3.0 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 30 °C; **Sample:** Diluent: initial mobile phase; Conc.: 50 ng/mL; Inj. Vol.: 5 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (40%), 3.00 min (80%), 3.01 min (40%), 5.00 min (40%); **Flow:** 0.700 mL/min; **Detector:** Waters Xevo TQ-S; Ion Mode: ESI+; **Instrument:** Waters.

**Figure 5:** From one lot to the next, every Raptor™ Biphenyl column you purchase will perform the same.




**See Figure 4 for compound list and conditions.**

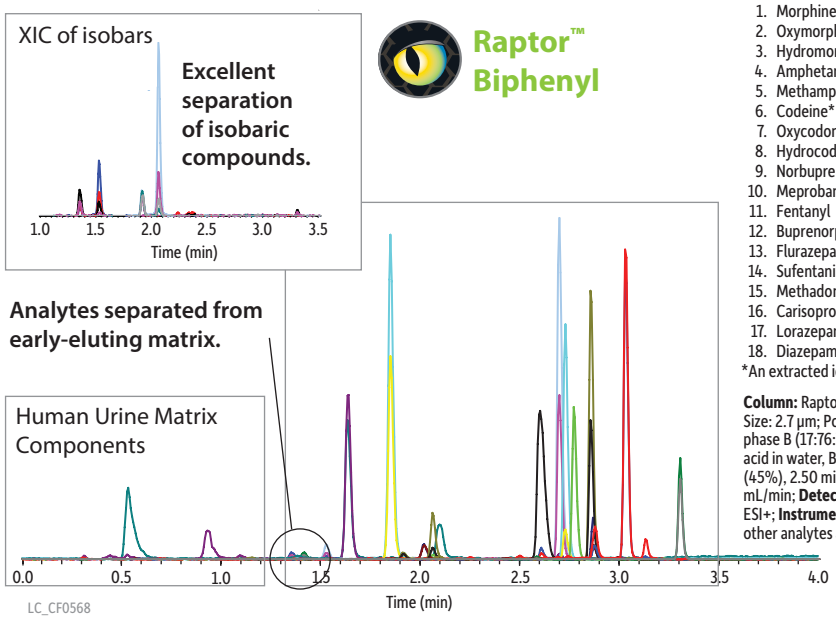
# Clinically Proven to Optimize Your Bioanalytical Workflows

For over a decade, the Restek® Biphenyl has been the column of choice for clinical testing because of its ability to provide highly retentive, selective, and rugged reversed-phase separations of drugs and metabolites. By bringing the speed of SPP to the Biphenyl family, the Raptor™ Biphenyl provides clinical labs with an even faster option for a wide variety of clinical assays.

## Rugged Pain Panels from Urine in Under 3.5 Minutes

Pain panels can be difficult to optimize and reproduce due to the limited selectivity of C18 and phenyl-hexyl phases, but not on the Raptor™ Biphenyl. Complete your pain panel analysis with a 5-minute cycle time and complete isobaric resolution using Raptor™ Biphenyl columns (Figure 6). Popular competitor columns offer tailing peaks, longer run times, and coelutions; the Raptor™ Biphenyl exhibits the selectivity and performance needed for this critical analysis.

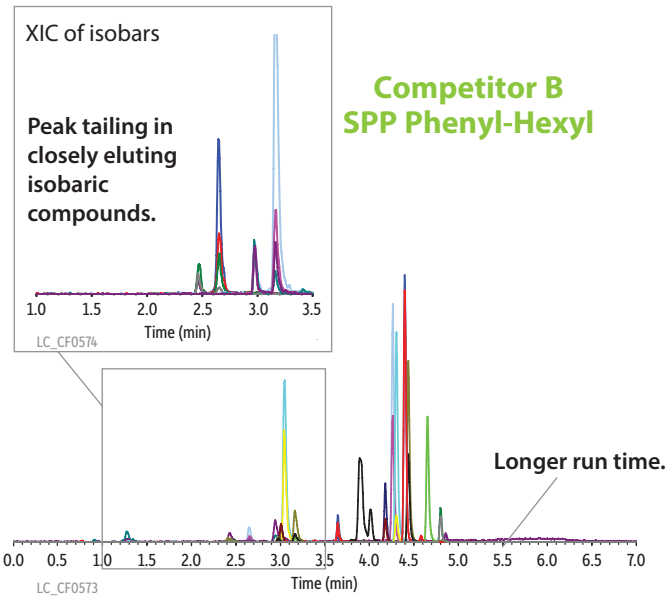
**Figure 6:** Raptor™ Biphenyl columns offer pain panel analyses with complete isobaric resolution in under 5 minutes!



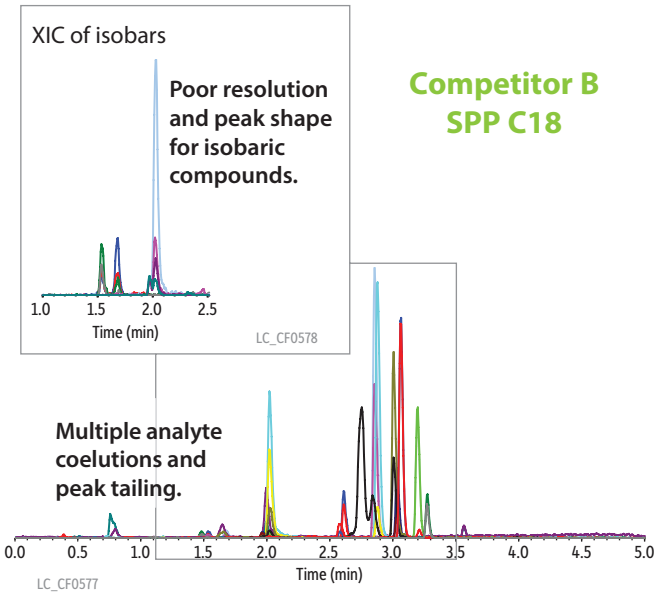

| | Peaks | $t_R$ (min) | Precursor ion | Product ion 1 | Product ion 2 |
|---|---|---|---|---|---|
| 1. | Morphine* | 1.34 | 286.2 | 152.3 | 165.3 |
| 2. | Oxymorphone | 1.40 | 302.1 | 227.3 | 198.2 |
| 3. | Hydromorphone* | 1.52 | 286.1 | 185.3 | 128.2 |
| 4. | Amphetamine | 1.62 | 136.0 | 91.3 | 119.2 |
| 5. | Methamphetamine | 1.84 | 150.0 | 91.2 | 119.3 |
| 6. | Codeine* | 1.91 | 300.2 | 165.4 | 153.2 |
| 7. | Oxycodone | 2.02 | 316.1 | 241.3 | 256.4 |
| 8. | Hydrocodone* | 2.06 | 300.1 | 199.3 | 128.3 |
| 9. | Norbuprenorphine | 2.59 | 414.1 | 83.4 | 101.0 |
| 10. | Meprobamate | 2.61 | 219.0 | 158.4 | 97.2 |
| 11. | Fentanyl | 2.70 | 337.2 | 188.4 | 105.2 |
| 12. | Buprenorphine | 2.70 | 468.3 | 396.4 | 414.5 |
| 13. | Flurazepam | 2.73 | 388.2 | 315.2 | 288.3 |
| 14. | Sufentanil | 2.77 | 387.2 | 238.5 | 111.3 |
| 15. | Methadone | 2.86 | 310.2 | 265.3 | 105.3 |
| 16. | Carisoprodol | 2.87 | 261.2 | 176.3 | 158.1 |
| 17. | Lorazepam | 3.03 | 321.0 | 275.4 | 303.1 |
| 18. | Diazepam | 3.31 | 285.1 | 193.2 | 153.9 |

*An extracted ion chromatogram (XIC) of the isobars is presented in the inset.

**Column:** Raptor™ Biphenyl (cat.# 9309A5E); Dimensions: 50 mm x 3.0 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 30 °C; **Sample:** Diluent: urine:mobile phase A:mobile phase B (17:76:7); Conc.: 10-100 ng/mL; Inj. Vol.: 10 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in methanol; **Gradient (%B):** 0.00 min (10%), 1.50 min (45%), 2.50 min (100%), 3.70 min (100%), 3.71 min (10%) 5.00 min (10%); **Flow:** 0.6 mL/min; **Detector:** AB SCIEX API 4000™ MS/MS; Ion Source: TurboIonSpray®; Ion Mode: ESI+; **Instrument:** API LC-MS/MS; **Notes:** Lorazepam was prepared at 100 ng/mL; all other analytes are 10 ng/mL.




**Column:** Competitor B SPP C18; Dimensions: 50 mm x 4.6 mm ID; Particle Size: 2.6 µm; Pore Size: 100 Å; Temp.: 22 °C; **Sample:** Diluent: urine:mobile phase A:mobile phase B (17:76:7); Conc.: 10-100 ng/mL; Inj. Vol.: 10 µL **Mobile Phase:** A: 10 mM ammonium formate in water, B: 0.1% formic acid in methanol; **Gradient (%B):** 0.00 min (5%), 4.00 min (100%), 5.00 min (100%), 5.10 min (5%), 7.00 min (5%); **Flow:** 0.6 mL/min; **Detector:** AB SCIEX API 4000™ MS/MS; Ion Source: TurboIonSpray®; Ion Mode: ESI+; **Instrument:** API LC-MS/MS; **Notes:** Lorazepam was prepared at 100 ng/mL; all other analytes are 10 ng/mL. **Note:** Column and conditions used were specifically recommended or published by the manufacturer for this assay.

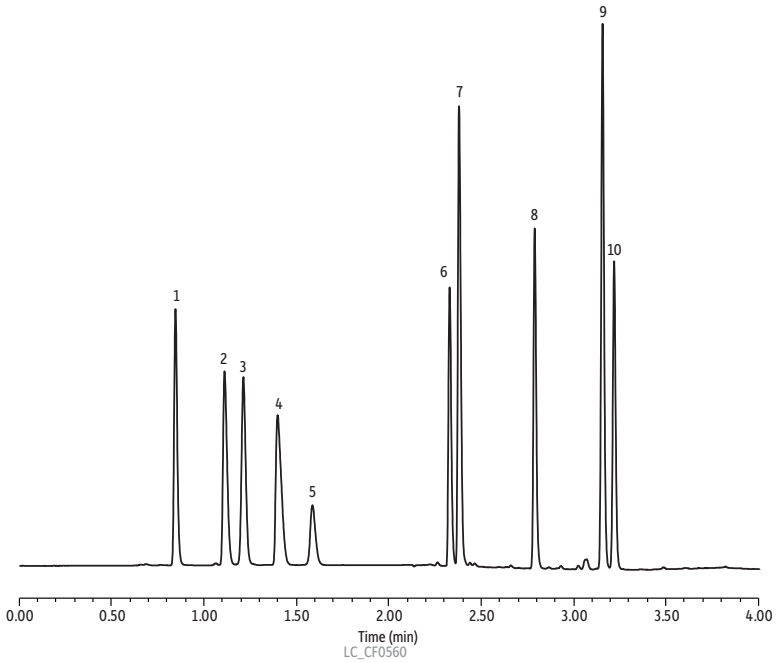



**Column:** Competitor B SPP C18; Dimensions: 50 mm x 3.0 mm ID; Particle Size: 2.6 µm; Pore Size: 100 Å; Temp.: 25 °C; **Sample:** Diluent: urine:mobile phase A:mobile phase B (17:76:7); Conc.: 10-100 ng/mL; Inj. Vol.: 10 µL **Mobile Phase:** A: 10 mM ammonium formate in water, B: 0.1% formic acid in methanol; **Gradient (%B):** 0.00 min (5%), 3.00 min (100%), 4.00 min (100%), 4.10 min (5%), 5.00 min (5%); **Flow:** 0.5 mL/min; **Detector:** AB SCIEX API 4000™ MS/MS; Ion Source: TurboIonSpray®; Ion Mode: ESI+; **Instrument:** API LC-MS/MS; **Notes:** Lorazepam was prepared at 100 ng/mL; all other analytes are 10 ng/mL. **Note:** Column and conditions used were specifically recommended or published by the manufacturer for this assay.

## Catecholamines and NSAIDs Without Ion Pairing, HILIC, or Complex Mobile Phases

Analyzing catecholamine compounds can be problematic by liquid chromatography and often forces chemists to turn to aqueous normal phase / HILIC or ion-pairing reagents that are not well suited for mass spectrometry (MS). Raptor™ Biphenyl columns easily retain and separate these difficult compounds using simple, MS-friendly mobile phases in a time frame that maximizes your productivity (Figure 7). Raptor™ Biphenyl also offers fast, efficient analysis of nonsteroidal anti-inflammatory drugs (NSAIDs) with LC-MS friendly solvents.

**Figure 7:** Separate catecholamine and other neurotransmitter compounds fast without ion pairing or HILIC.

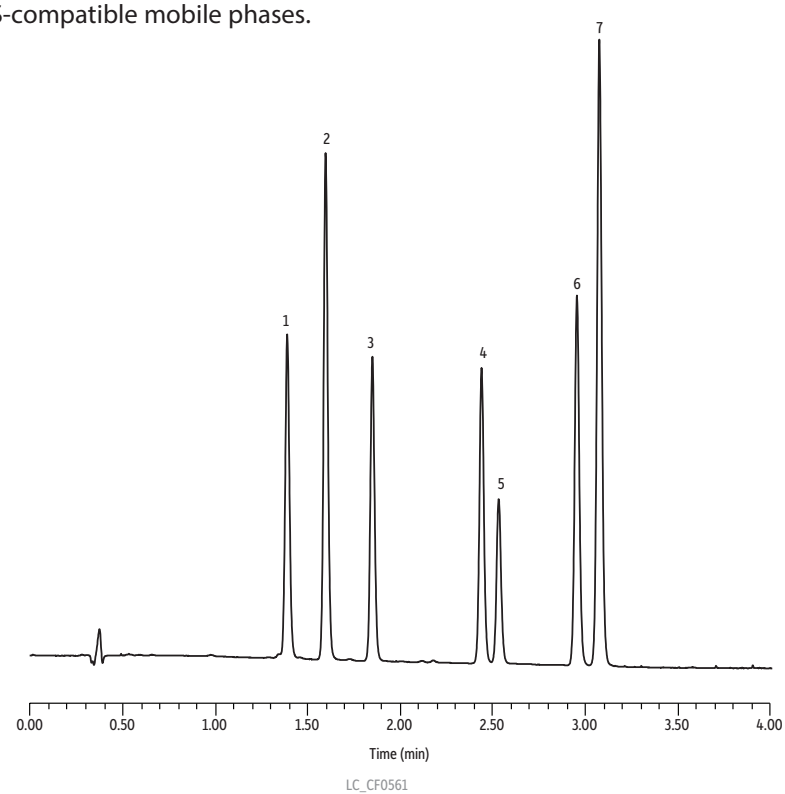



| Peaks | $t_R$ (min) |
|---|---|
| 1. Norepinephrine | 0.85 |
| 2. Epinephrine | 1.11 |
| 3. L-Dihydroxyphenylalanine | 1.21 |
| 4. Dopamine | 1.40 |
| 5. Tyrosine | 1.59 |
| 6. 3-Methoxytyramine* | 2.33 |
| 7. Serotonin | 2.38 |
| 8. (3,4-Dihydroxyphenyl)acetic acid* | 2.79 |
| 9. 5-Hydroxyindoleacetic acid** | 3.16 |
| 10. Homovanillic acid* | 3.22 |

* Dopamine metabolite, ** serotonin metabolite

**Column:** Raptor™ Biphenyl (cat.# 9309A62); Dimensions: 150 mm x 2.1 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 30 °C; **Sample:** Diluent: water; Conc.: 50 µg/mL; Inj. Vol.: 1 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (0%), 4.00 min (70%), 4.01 min (0%), 5.00 min (0%); **Flow:** 0.4 mL/min; **Detector:** Waters Acquity® PDA @ 280 nm; **Instrument:** Waters Acquity® UPLC H-Class.

**Figure 8:** Nonsteroidal anti-inflammatory drugs (NSAIDs) are also easily resolved with Raptor™ Biphenyl using UV- and MS-compatible mobile phases.



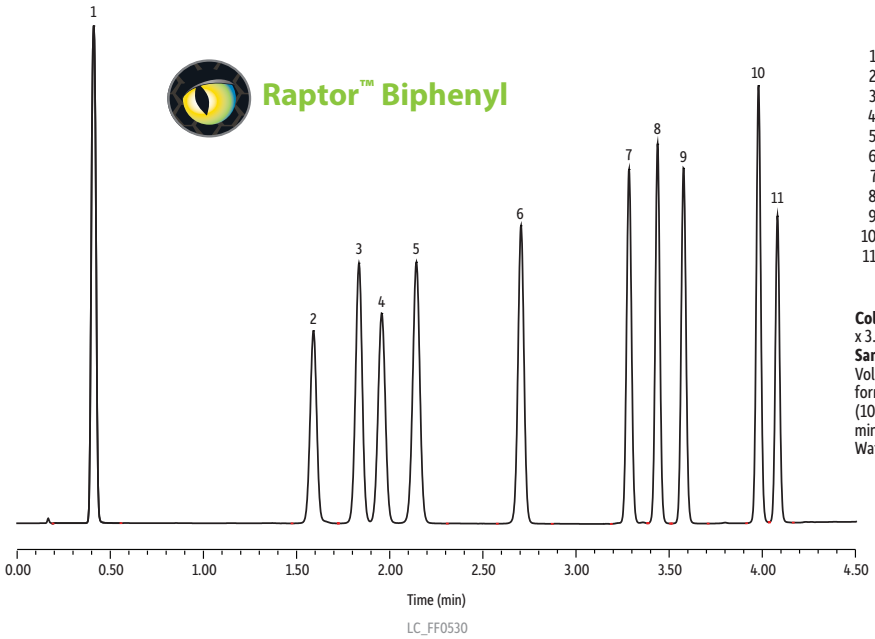

| Peaks | $t_R$ (min) | Conc. (µg/mL) |
|---|---|---|
| 1. Piroxicam | 1.39 | 25 |
| 2. Sulindac | 1.60 | 25 |
| 3. Naproxen | 1.85 | 25 |
| 4. Fenoprofen | 2.44 | 100 |
| 5. Ibuprofen | 2.54 | 200 |
| 6. Diclofenac | 2.96 | 25 |
| 7. Indomethacin | 3.08 | 25 |

**Column:** Raptor™ Biphenyl (cat.# 9309A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 40 °C; **Sample:** Diluent: water:acetonitrile (65:35); Conc.: 25-200 µg/mL; Inj. Vol.: 2 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (35%), 4.00 min (60%), 4.01 min (35%), 5.00 min (35%); **Flow:** 0.6 mL/min; **Detector:** Waters Acquity® PDA @ 270 nm; **Instrument:** Waters Acquity® UPLC H-Class.

## Fast Analysis of Sulfur Antibiotics Without Coelutions

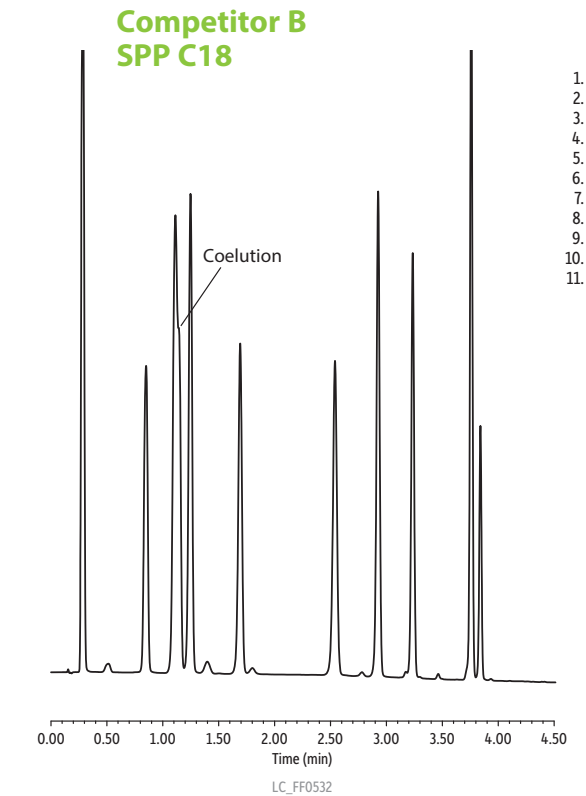
Even with high-efficiency UHPLC particles, C18 and ordinary phenyl columns fail to achieve baseline separation of sulfonamides. Not only does the Raptor™ Biphenyl have the selectivity to easily and completely separate these difficult compounds (Figure 9), it does so in well under 5 minutes!

**Figure 9:** Sulfonamides pose no problems for analysis, even at high linear velocities. Increased retention of early-eluting sulfanilamide also helps limit ionization suppression.



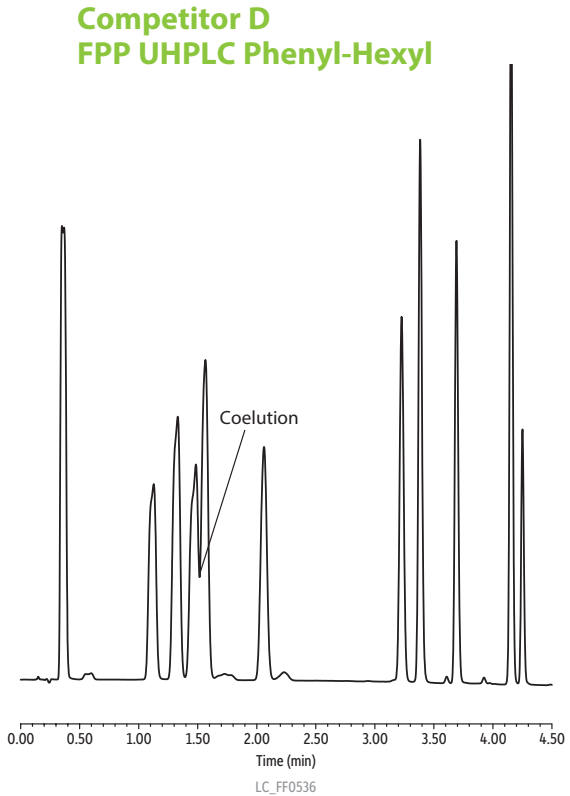

| Peaks | $t_R$(min) |
|---|---|
| 1. Sulfanilamide | 0.41 |
| 2. Sulfadiazine | 1.59 |
| 3. Sulfapyridine | 1.84 |
| 4. Sulfathiazole | 1.96 |
| 5. Sulfamerazine | 2.14 |
| 6. Sulfamethazine | 2.71 |
| 7. Sulfachlorpyridazine | 3.29 |
| 8. Sulfadoxine | 3.44 |
| 9. Sulfisoxazole | 3.58 |
| 10. Sulfadimethoxine | 3.98 |
| 11. Sulfaquinoxaline | 4.08 |

**Column:** Raptor™ Biphenyl (cat.# 9309A5E); Dimensions: 50 mm x 3.0 mm ID; Particle Size: 2.7 µm; Pore Size: 90 Å; Temp.: 20 °C; **Sample:** Diluent: 0.1% formic acid in water; Conc.: 50 µg/mL; Inj. Vol.: 5 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (5%), 2.00 min (10%), 4.50 min (35%), 4.51 min (5%), 5.50 min (5%); **Flow:** 1.5 mL/min; **Detector:** Waters Acquity® PDA @ 260, 4.8 nm; **Instrument:** Waters Acquity® UPLC H-Class.




**Peaks**
1. Sulfanilamide
2. Sulfadiazine
3. Sulfapyridine
4. Sulfathiazole
5. Sulfamerazine
6. Sulfamethazine
7. Sulfachlorpyridazine
8. Sulfadoxine
9. Sulfisoxazole
10. Sulfadimethoxine
11. Sulfaquinoxaline

**Column:** Competitor B SPP C18; Dimensions: 50 mm x 3.0 mm ID; Particle Size: 2.6 µm; Pore Size: 100 Å; Temp.: 20 °C; **Sample:** Diluent: 0.1% formic acid in water; Conc.: 50 µg/mL; Inj. Vol.: 5 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (5%), 2.00 min (10%), 4.50 min (35%), 4.51 min (5%), 5.50 min (5%); **Flow:** 1.5 mL/min; **Detector:** Waters Acquity® PDA @ 260, 4.8 nm; **Instrument:** Waters Acquity® UPLC H-Class.




**Column:** Competitor D FPP Phenyl-Hexyl; Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.7 µm; Temp.: 20 °C; **Sample:** Diluent: 0.1% formic acid in water; Conc.: 50 µg/mL; Inj. Vol.: 5 µL **Mobile Phase:** A: 0.1% formic acid in water, B: 0.1% formic acid in acetonitrile; **Gradient (%B):** 0.00 min (5%), 2.00 min (10%), 4.50 min (35%), 4.51 min (5%), 5.50 min (5%); **Flow:** 0.75 mL/min; **Detector:** Waters Acquity® PDA @ 260, 4.8 nm; **Instrument:** Waters Acquity® UPLC H-Class. **Note:** Flow rate scaled to particle size

www.restek.com/raptor

# Accelerated Performance and Time-Tested Biphenyl Selectivity for Clinical Diagnostic, Pain, Pharma, and Environmental Labs

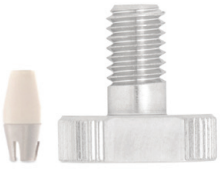
## Raptor™ Biphenyl LC Columns


| Length | 2.1 mm cat.# | 3.0 mm cat.# | 4.6 mm cat.# |
|---|---|---|---|
| **2.7 µm Columns** | | | |
| 30 mm | 9309A32 | 9309A3E | 9309A35 |
| 50 mm | 9309A52 | 9309A5E | 9309A55 |
| 100 mm | 9309A12 | 9309A1E | 9309A15 |
| 150 mm | 9309A62 | 9309A6E | 9309A65 |
| **5 µm Columns** | | | |
| 30 mm | — | 930953E | — |
| 50 mm | 9309552 | 930955E | 9309555 |
| 100 mm | 9309512 | 930951E | 9309515 |
| 150 mm | 9309562 | 930956E | 9309565 |
| 250 mm | — | — | 9309575 |

## EXP® Reusable Fittings for HPLC & UHPLC

for 10-32 fittings and 1/16" tubing

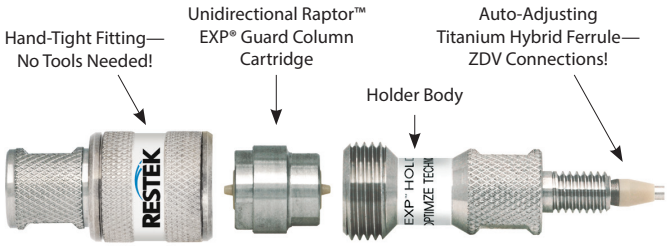
Effortlessly achieve 8,700+ psi HPLC seals by hand! (Wrench-tighten to 20,000+ psi.) Hybrid titanium/PEEK seal can be installed repeatedly without compromising your seal.



| Description | qty. | cat.# |
|---|---|---|
| EXP Hand-Tight Fitting (Nut w/Ferrule) | ea. | 25937 |
| EXP Hand-Tight Fitting (Nut w/Ferrule) | 10-pk. | 25938 |
| EXP Hand-Tight Nut (w/o Ferrule) | ea. | 25939 |

Hybrid Ferrule U.S. Patent No. 8201854, Optimize Technologies. Optimize Technologies EXP Holders are Patent Pending. Other U.S. and Foreign Patents Pending. The EXP, Free-Turn, and the Opti- prefix are registered trademarks of Optimize Technologies, Inc.

## Raptor™ EXP® Guard Cartridges




Protect your investment and extend the life of our already-rugged LC columns and change guard column cartridges by hand without breaking fluid connections—no tools needed!

### EXP® Direct Connect Holder

| Description | qty. | cat.# |
|---|---|---|
| EXP Direct Connect Holder for EXP Guard Cartridges (includes hex-head fitting & 2 ferrules) | ea. | 25808 |

### Raptor™ EXP® Guard Column Cartridges

| Description | Particle Size | qty. | 5 x 2.1 mm cat.# | 5 x 3.0 mm cat.# | 5 x 4.6 mm cat.# |
|---|---|---|---|---|---|
| Raptor Biphenyl EXP Guard Cartridge | 2.7 µm | 3-pk. | 9309A0252 | 9309A0253 | 9309A0250 |
| Raptor Biphenyl EXP Guard Cartridge | 5 µm | 3-pk. | 930950252 | 930950253 | 930950250 |

Maximum cartridge pressure: 600 bar / 8,700 psi (2.7 µm) or 400 bar / 5,800 psi (5 µm)

Raptor™ SPP LC columns combine the speed of SPP with the resolution of USLC® technology. Learn more at **www.restek.com/raptor**

Experience *Selectivity Accelerated.* Order the Raptor™ Biphenyl today at **www.restek.com/raptor**

RESTEK®
Pure Chromatography

**Questions about this or any other Restek® product?**
**Contact us or your local Restek® representative (www.restek.com/contact-us).**



**www.restek.com**

ISO 9001 · 17025 · Guide 34

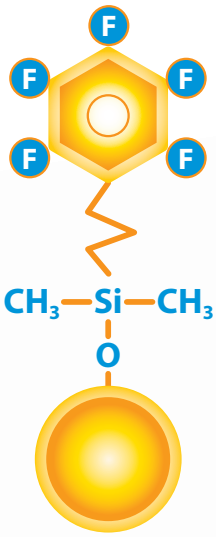
Lit. Cat.# GNBR1891A-UNV

Stationary Phase: **FluoroPhenyl**

Raptor™ LC Columns

*Selectivity Accelerated*

# Get the Power of HILIC and RP Modes in One LC Column




RESTEK® Pure Chromatography www.restek.com/raptor

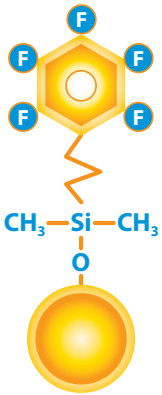
# The Raptor™ FluoroPhenyl Column

Restek chemists became the first to combine the speed of superficially porous particles (also known as SPP or "core-shell" particles) with the resolution of highly selective USLC® technology. This new breed of chromatographic column allows you to more easily achieve peak separation and faster analysis times without expensive UHPLC instrumentation. Learn more about Raptor™ LC columns at **www.restek.com/raptor**

Restek has now extended the speed and reliability of Raptor™ column technology into the HILIC realm with the addition of Raptor™ FluoroPhenyl columns. Restek's Raptor™ FluoroPhenyl phase offers chromatographers the ability to run in reversed-phase or HILIC mode for a variety of compounds. The Restek® Raptor™ FluoroPhenyl column is also amenable to LC-MS because it is extremely reliable and efficient with acidic mobile phases.

Switch to a Raptor™ FluoroPhenyl LC column for reliable performance in *both* reversed-phase and HILIC modes.

## Column Description:




**Stationary Phase Category:**
Pentafluorophenyl propyl (L43)

**Ligand Type:**
Fluorophenyl

**Particle:**
2.7 µm or 5 µm superficially porous silica (SPP or "core-shell")

**Pore Size:**
90 Å

**Surface Area:**
150 $m^2/g$ (2.7 µm) or 100 $m^2/g$ (5 µm)

**Recommended Usage:**
pH Range: 2.0–8.0

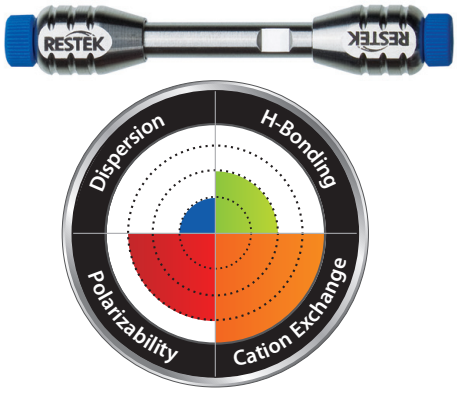
Maximum Temperature: 80 °C

Maximum Pressure: 600 bar/8,700 psi (2.7 µm)
or 400 bar/5,800 psi (5 µm)

**Properties:**
- Capable of both reversed-phase and HILIC separations.
- Ideal for increasing sensitivity and selectivity in LC-MS analyses.
- Offers increased retention for charged bases.

**Switch to a Raptor™ FluoroPhenyl LC column when:**
- Limited retention and selectivity are observed on a C18 for basic compounds.
- You need increased retention of hydrophilic compounds.

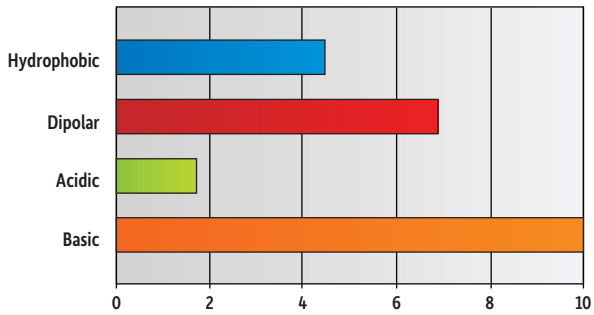
## Column Interaction Profile:




**Defining Solute Interaction:**
- Cation exchange

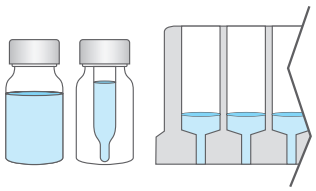
**Complementary Solute Interactions:**
- Polarizability
- Dispersion

## Solute Retention Profile:




**Target Analyte Structures:**
- Nitrogen

**Target Analyte Functionalities:**
- Protonated amines
- Quaternary ammonium compounds
- Positively charged moieties
- Lewis bases



RESTEK

## Raptor™ FluoroPhenyl Columns: Rugged, Check—Reproducible, Double Check.

Of course, Raptor™ FluoroPhenyl columns are rugged, that is to be expected. And they are exceptionally reproducible as well. Reproducibility can be an issue for fluorinated phenyl phases, which is why we engineered all our columns for dependable performance. Lot to lot, column to column, and injection to injection, every Raptor™ FluoroPhenyl column gives a consistent performance that you can count on. Consider it done.

**Figure 1:** Raptor™ FluoroPhenyl columns maintain efficiency in any dimension—even at the maximum recommended operating pressure of 600 bar—so you can run at high linear velocities with confidence.

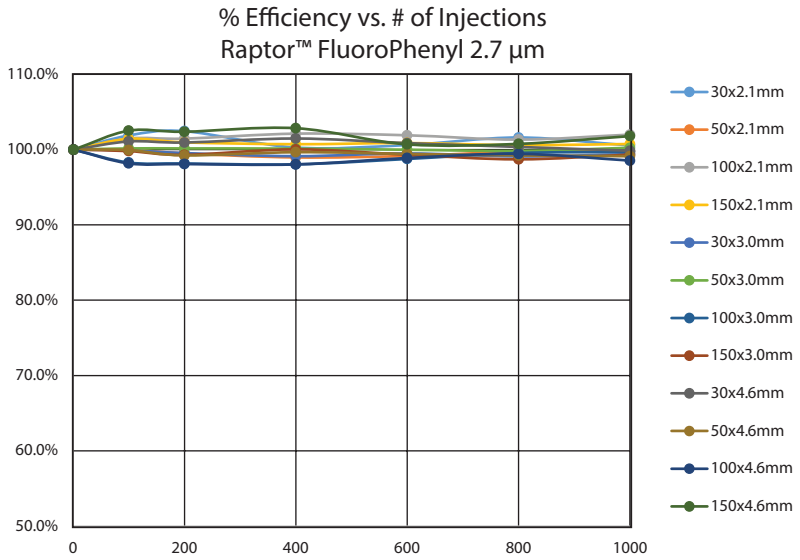
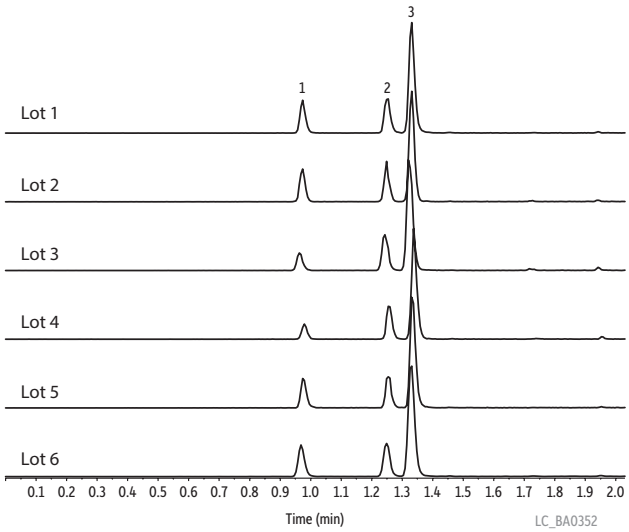



**Figure 2:** Strict quality control ensures Raptor™ FluoroPhenyl columns are exceptionally reproducible, so you get predictable performance from every column.

**Reliable, reproducible fluorophenyl column performance.**

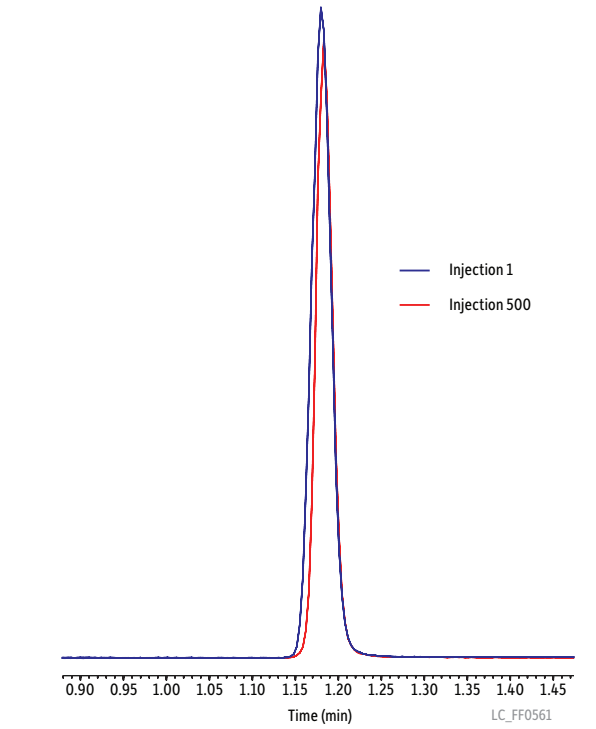
| Peaks | $t_R$ (min) | Precursor Ion | Product Ion 1 | Product Ion 2 |
|---|---|---|---|---|
| 1. Baccatin III | 0.97 | 587.0 | 405.1 | 105.0 |
| 2. Docetaxel | 1.25 | 808.1 | 527.3 | 226.1 |
| 3. Paclitaxel | 1.33 | 854.1 | 569.3 | 286.2 |




**Column:** Raptor™ FluoroPhenyl (cat.# 931955E); Dimensions: 50 mm x 3 mm ID, Particle Size: 5 µm; Temp.: 35 °C; **Sample:** Diluent: Water; Conc.: 100 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: 0.1% Formic acid in acetonitrile; **Gradient (%B):** 0.00 min (25% B), 2.00 (95% B), 2.01 (25% B), 3.50 (25% B); **Flow:** 0.8 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC

**Figure 3:** From start to finish, Raptor™ FluoroPhenyl columns provide accurate, reproducible results.

| Peaks | $t_R$ (min) | Precursor Ion | Product Ion |
|---|---|---|---|
| 1. 4-Methylimidazole (4-MEI) | 1.19 | 83 | 56 |



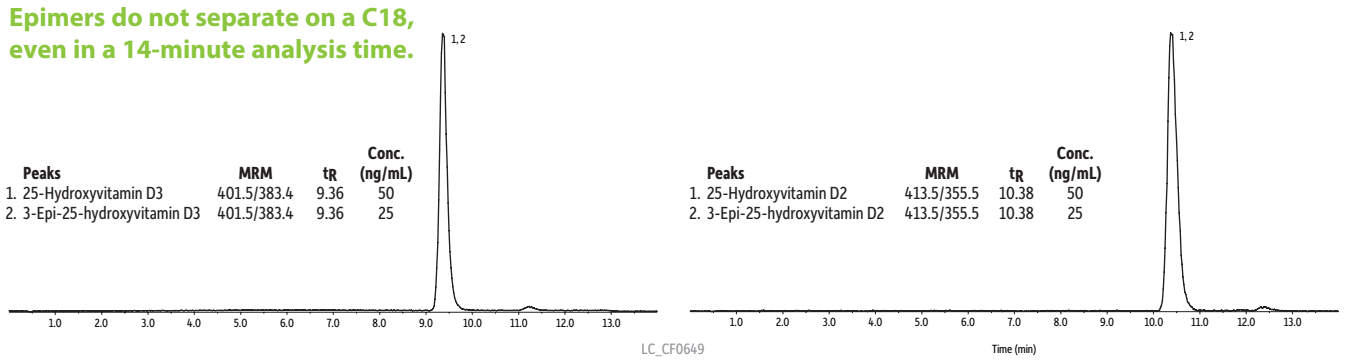

**Column:** Raptor™ FluoroPhenyl (cat.# 9319A52); Dimensions: 50 mm x 2.1 mm ID, Particle Size: 2.7 µm; Temp.: 35 °C; **Sample:** Diluent: Acetonitrile; Conc.: 100 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: 0.1% Formic acid in acetonitrile; **Gradient (%B):** 0.00 min (95% B), 2.00 (30% B), 2.01 (95% B), 3.50 (95% B); Flow: 0.6 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC

www.restek.com/raptor

## More Separating Power than a C18

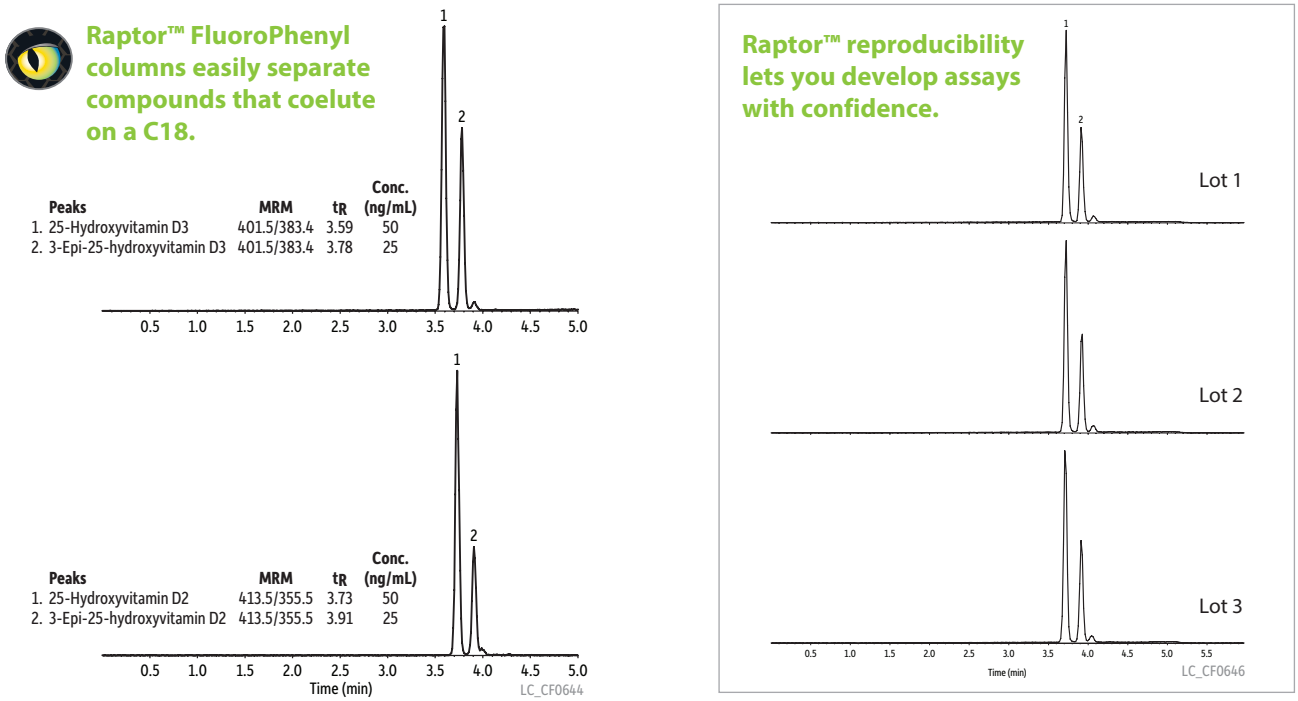
C18 columns work well for many compounds, but they just don't work for everything. Raptor™ FluoroPhenyl columns can provide greater selectivity and retention for analytes that are not easily separated by C18 phase chemistry. For example, interest in vitamin D status is on the rise in clinical diagnostics, but accurate analysis is only possible if the epimeric forms of both vitamin D2 and D3 25-hydroxy metabolites can be distinguished. Typical reversed-phase C18 columns cannot separate these isobaric epimers, which differ in bioactivity, but the new Raptor™ FluoroPhenyl column provides adequate chromatographic resolution so accurate results are generated and the proper diagnosis can be made.

**Figure 4:** Reversed-phase C18 columns do not have the right selectivity or retention mechanism to separate the epimers of vitamin D2 and D3 25-hydroxy metabolites.




**Column:** Raptor™ ARC-18 (cat.# 9314A12); Dimensions: 100 mm x 2.1 mm ID, Particle Size: 2.7 µm; Temp.: 30 °C; **Sample:** Diluent: Water:methanol (50:50); Conc.: 25-50 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: Methanol; **Gradient (%B):** 0.00 min (75% B), 4.00 (80% B), 12.00 (80% B), 12.10 (75% B); 14.00 (75% B); **Flow:** 0.5 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument**: HPLC

**Figure 5:** Raptor™ FluoroPhenyl columns have the selectivity and retention you need to quickly and easily separate compounds that coelute on a C18, such as the epimeric forms of vitamin D2 and D3 25-hydroxy metabolites.




**Column:** Raptor™ FluoroPhenyl (cat.# 9319A1E); Dimensions: 100 mm x 3 mm ID, Particle Size: 2.7 µm; Temp.: 30 °C; **Sample:** Diluent: Water:methanol (50:50); Conc.: 25-50 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: Methanol; **Gradient (%B):** 0.00 min (75% B), 4.00 (85% B), 4.10 (100% B), 5.00 (100% B), 5.01 (75% B), 7.00 (75% B); **Flow:** 0.6 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument**: HPLC

RESTEK

www.restek.com/raptor

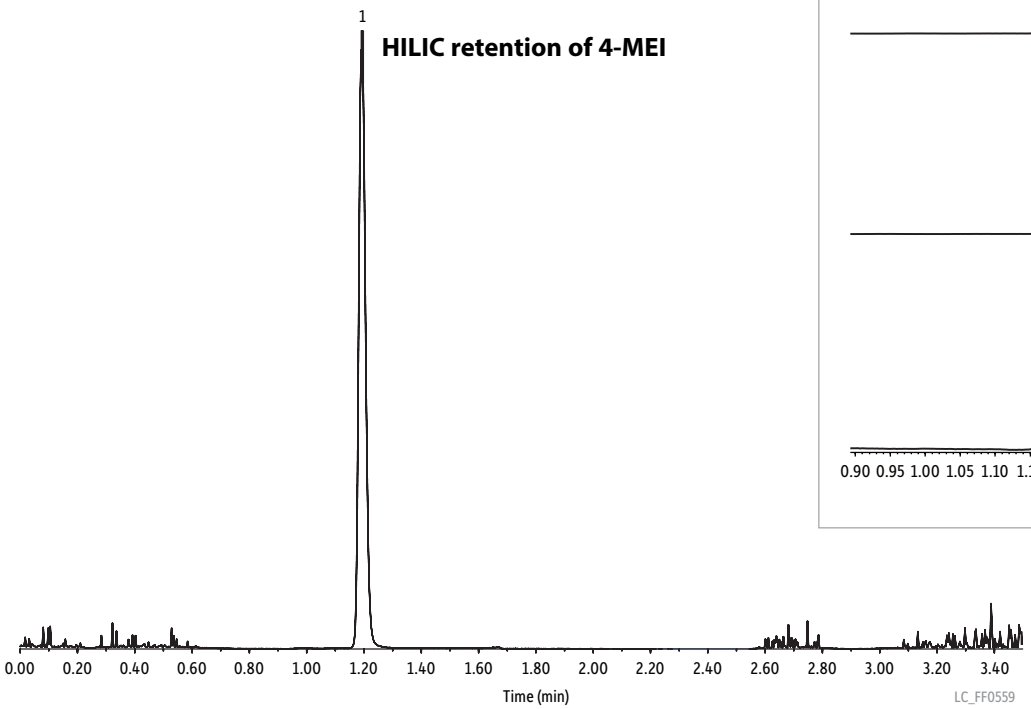
# Get the Power of HILIC and RP Modes in One LC Column

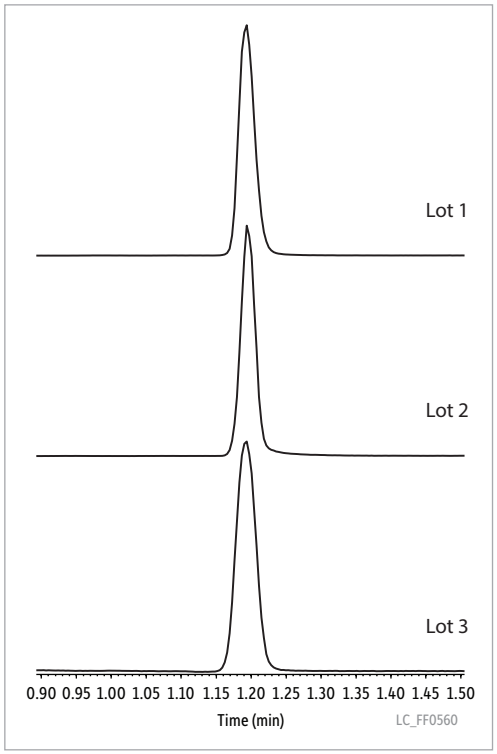
HILIC chromatography is becoming the go-to solution for compounds that are difficult to retain on a C18. The Raptor™ FluoroPhenyl column gives chromatographers the flexibility to evaluate compound retention in both reversed-phase and HILIC modes. The analysis of 4-methylimidazole (4-MEI), which is a byproduct of caramel coloring in foods and beverages, can be problematic by reversed-phase chromatography due to very limited retention. However, 4-MEI is well retained on a Raptor™ FluoroPhenyl column and can easily be analyzed using HILIC mode and simple LC and LC-MS/MS compatible mobile phases.

**Figure 6:** Sometimes adequate retention cannot be obtained with a C18. The Raptor™ FluoroPhenyl column performs dependably in either HILIC or RP mode, so you can use the mode that is best for your analytes.

**Raptor™ FluoroPhenyl columns give you the flexibility to work in both reversed-phase and HILIC modes.**

| Peaks | $t_R$ (min) | Precursor Ion | Product Ion |
|---|---|---|---|
| 1. 4-Methylimidazole (4-MEI) | 1.19 | 83 | 56 |




**Column:** Raptor™ FluoroPhenyl (cat.# 9319A52); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 35 °C; **Sample:** Diluent: Acetonitrile; Conc.: 100 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: 0.1% Formic acid in acetonitrile; **Gradient (%B):** 0.00 min (95% B), 2.00 (30% B), 2.01 (95% B), 3.50 (95% B); **Flow:** 0.6 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC

RESTEK

www.restek.com/raptor

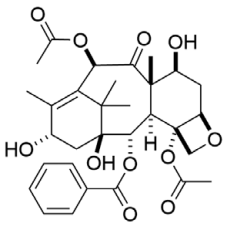
## Fast, Accurate Analysis of Basic Compounds

Taxane drugs—such as paclitaxel, docetaxel, and their precursor baccatin III—are early chemotherapy treatment options. Accurate analysis is critical because these drugs are used for many types of metastatic cancers. As shown here, the selectivity of the Raptor™ FluoroPhenyl column provides excellent retention and resolution of these structurally similar compounds. Reliable results for these basic compounds can be obtained in fast analysis times using LC-MS/MS friendly solvents.

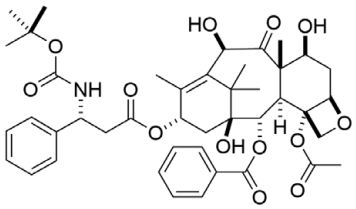
**Figure 7:** Raptor™ FluoroPhenyl columns allow taxane drugs and other basic compounds to be separated quickly and effectively.

**Raptor™ FluoroPhenyl columns have the retention needed for fast, accurate analysis of basic compounds.**

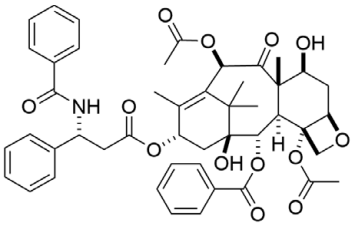
| Peaks | $t_R$ (min) | Precursor Ion | Product Ion 1 | Product Ion 2 |
|---|---|---|---|---|
| 1. Baccatin III | 0.97 | 587.0 | 405.1 | 105.0 |
| 2. Docetaxel | 1.25 | 808.1 | 527.3 | 226.1 |
| 3. Paclitaxel | 1.33 | 854.1 | 569.3 | 286.2 |



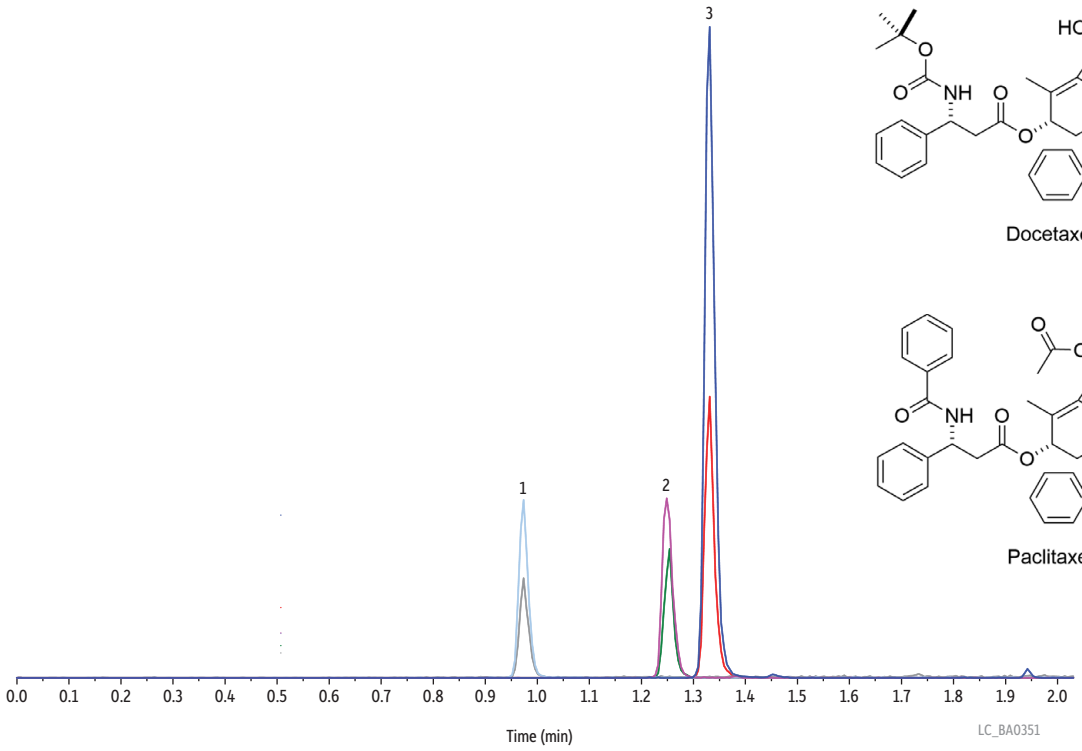
Baccatin III



Docetaxel



Paclitaxel




**Column:** Raptor™ FluoroPhenyl (cat.# 931955E); Dimensions: 50 mm x 3 mm ID, Particle Size: 5 µm; Temp.: 35 °C; **Sample:** Diluent: Water; Conc.: 100 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.1% Formic acid in water; B: 0.1% Formic acid in acetonitrile; **Gradient (%B):** 0.00 (25% B), 2.00 (95% B), 2.01 (25% B), 3.50 (25% B); **Flow:** 0.8 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument**: UHPLC

RESTEK

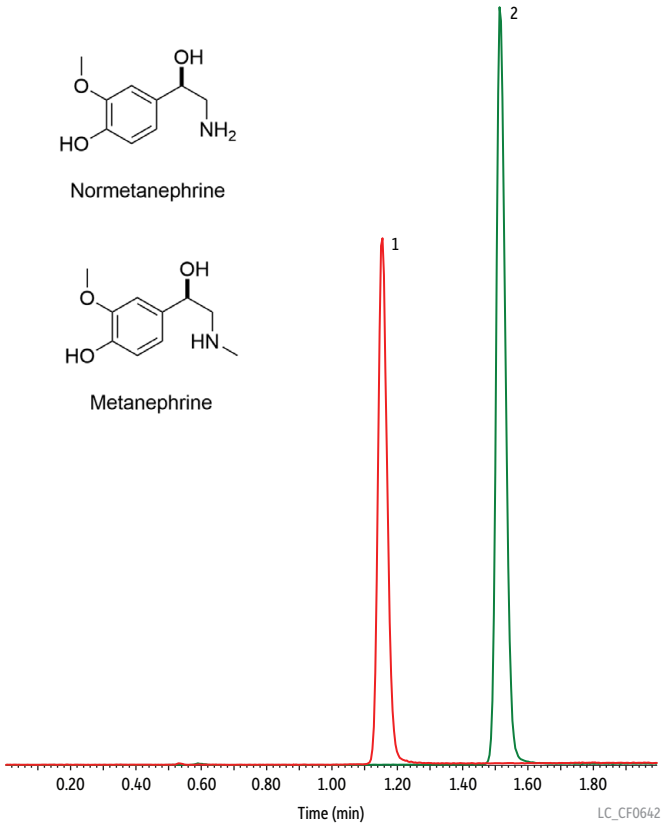
www.restek.com/raptor

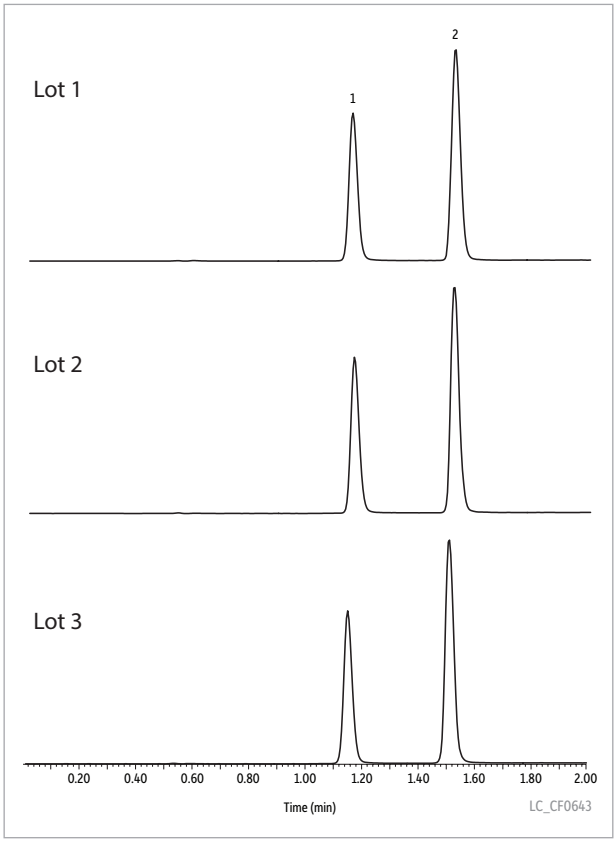
## Exceptional Selectivity for Clinical Analyses

The analysis of normetanephrine and metanephrine provides another example of the power of Raptor™ FluoroPhenyl columns for analyzing basic compounds. Accurately determining these metabolites of epinephrine/norepinephrine in plasma or urine is one of the best diagnostic tests for neuroendocrine tumors (pheochromocytomas). Normetanephrine and metanephrine are difficult to retain by typical C18 reversed-phase chromatography; however, the Raptor™ FluoroPhenyl column provides a simple, fast chromatographic solution to this challenging assay. The Raptor™ FluoroPhenyl column's unique combination of aromatic retention and cation exchange mechanisms are not provided by a C18 column and result in reliable, high-quality separations.

**Figure 8:** Rapid analysis of metanephrine and normetanephrine on a Raptor™ FluoroPhenyl column.

| Peaks | $t_R$ (min) | Precursor Ion | Product Ion 1 | Product Ion 2 |
|---|---|---|---|---|
| 1. Normetanephrine | 1.15 | 166.1 | 121.1 | 134.0 |
| 2. Metanephrine | 1.52 | 180.1 | 165.1 | 148.3 |




**Column:** Raptor™ FluoroPhenyl (cat.# 9319A12); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 2.7 µm; Temp.: 30 °C; **Sample:** Diluent: Water; Conc.: 20 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A: 0.2% Formic acid in water; B: Methanol; **Gradient (%B):** 0.00 min (2% B), 2.00 (40% B), 2.01 (2% B), 6.00 (2% B); Flow: 0.4 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC

# Dependable Raptor™ FluoroPhenyl Columns Give You the Flexibility to use both HILIC and RP Modes

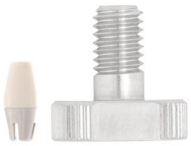
## Raptor™ FluoroPhenyl LC Columns (USP L43)


| Length | 2.1 mm cat.# | 3.0 mm cat.# | 4.6 mm cat.# |
|---|---|---|---|
| **2.7 µm Columns** | | | |
| 30 mm | 9319A32 | 9319A3E | 9319A35 |
| 50 mm | 9319A52 | 9319A5E | 9319A55 |
| 100 mm | 9319A12 | 9319A1E | 9319A15 |
| 150 mm | 9319A62 | 9319A6E | 9319A65 |
| **5 µm Columns** | | | |
| 30 mm | — | 931953E | — |
| 50 mm | 9319552 | 931955E | 9319555 |
| 100 mm | 9319512 | 931951E | 9319515 |
| 150 mm | 9319562 | 931956E | 9319565 |
| 250 mm | — | — | 9319575 |

## EXP® Reusable Fittings for HPLC & UHPLC

for 10-32 fittings and 1/16" tubing

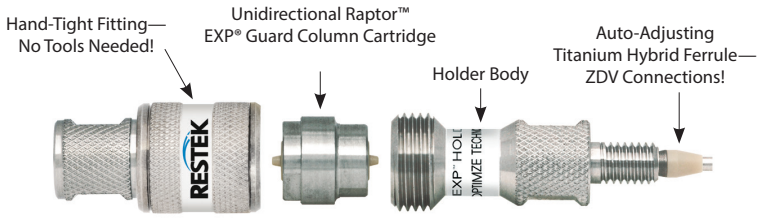
Effortlessly achieve 8,700+ psi HPLC seals by hand! (Wrench-tighten to 20,000+ psi.) Hybrid titanium/PEEK seal can be installed repeatedly without compromising your seal.



| Description | qty. | cat.# |
|---|---|---|
| EXP Hand-Tight Fitting (Nut w/Ferrule) | ea. | 25937 |
| EXP Hand-Tight Fitting (Nut w/Ferrule) | 10-pk. | 25938 |
| EXP Hand-Tight Nut (w/o Ferrule) | ea. | 25939 |

Hybrid Ferrule U.S. Patent No. 8201854, Optimize Technologies. Optimize Technologies EXP Holders are Patent Pending. Other U.S. and Foreign Patents Pending. The Opti- prefix is a registered trademark of Optimize Technologies, Inc.

## Raptor™ EXP® Guard Cartridges




Protect your investment and extend the life of our already-rugged LC columns and change guard column cartridges by hand without breaking fluid connections—no tools needed!

### EXP® Direct Connect Holder

| Description | qty. | cat.# |
|---|---|---|
| EXP Direct Connect Holder for EXP Guard Cartridges (includes hex-head fitting & 2 ferrules) | ea. | 25808 |

Maximum holder pressure: 20,000 psi (1,400 bar)

### Raptor™ EXP® Guard Column Cartridges

| Description | Particle Size | qty. | 5 x 2.1 mm cat.# | 5 x 3.0 mm cat.# | 5 x 4.6 mm cat.# |
|---|---|---|---|---|---|
| Raptor FluoroPhenyl EXP Guard Column Cartridges | 2.7 µm | 3-pk. | 9319A0252 | 9319A0253 | 9319A0250 |
| Raptor FluoroPhenyl EXP Guard Column Cartridges | 5 µm | 3-pk. | 931950252 | 931950253 | 931950250 |

Maximum cartridge pressure: 600 bar/8,700 psi (2.7 µm) or 400 bar/5,800 psi (5 µm).
Raptor™ SPP LC columns combine the speed of SPP with the resolution of USLC® technology. Learn more at **www.restek.com/raptor**

Experience *Selectivity Accelerated.* Order the Raptor™ FluoroPhenyl today at **www.restek.com/raptor**

RESTEK®
Pure Chromatography

**Questions about this or any other Restek® product?**
**Contact us or your local Restek® representative (www.restek.com/contact-us).**



**www.restek.com**

Lit. Cat.# GNBR2368-UNV

Restek LC

FORCE™
PERFORMANCE LC COLUMNS

# Apply Force to Your LC Methods

- **Long-lasting and reproducible**—even with rapid cycling and elevated UHPLC pressures.
- **Fully scalable between HPLC and UHPLC**—easily transfer and optimize methods
- **Premium quality**—backed by our 100% Pure Satisfaction guarantee.


RESTEK® Pure Chromatography www.restek.com

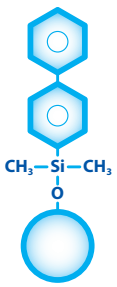
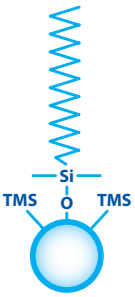
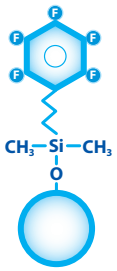
# Force Performance LC Columns from Restek

Restek's new Force performance LC columns give you the power to maximize instrument uptime, increase productivity, and transfer methods across your entire lab, from your trusted-but-aged HPLC to the cutting-edge UHPLC you just plumbed last week. This incredibly rugged and supremely consistent column line represents the culmination of our twenty-plus years in LC dedicated to continually improving our phase chemistries, our lot and lifetime testing, and our bonding and packing procedures.

- Long-lasting and reproducible—maintain stable retention times and peak shapes, even under the stress of elevated UHPLC pressures and rapid cycling.
- Fully scalable between 3 or 5 µm HPLC and 1.8 µm UHPLC—easily transfer and optimize methods without extensive calculations.
- Premium quality ensured by strict manufacturing and QC procedures—backed by the strength of our 100% Pure Satisfaction guarantee.

Meet today's workflow needs—and prepare for tomorrow's—by applying Force LC columns to all of your instrument platforms. Order yours today at **www.restek.com/force**

## Available with Restek's most-popular and highly selective Biphenyl and FluoroPhenyl phases, as well as a general-purpose C18.

| | Biphenyl | C18 | FluoroPhenyl |
|---|---|---|---|
| |  |  |  |
| **USP Phase Code** | L11 | L1 | L43 |
| **Stationary Phase Category** | Phenyl | C18, octadecylsilane | Pentafluorophenyl propyl |
| **Ligand Type** | Biphenyl | End-capped C18 | Fluorophenyl |
| **Particle Size** | 1.8 µm, 3 µm, or 5 µm fully porous | 1.8 µm, 3 µm, or 5 µm fully porous | 1.8 µm, 3 µm, or 5 µm fully porous |
| **Pore Size** | 100 Å | 100 Å | 100 Å |
| **Surface Area** | 300 $m^2/g$ | 300 $m^2/g$ | 300 $m^2/g$ |
| **Carbon Load** | 15% | 20% | 10% |
| **End-Cap** | yes | yes | no |
| **pH Range** | 2.0 to 8.0 | 2.0 to 8.0 | 2.0 to 8.0 |
| **Maximum Temperature** | 80 °C | 80 °C | 80 °C |

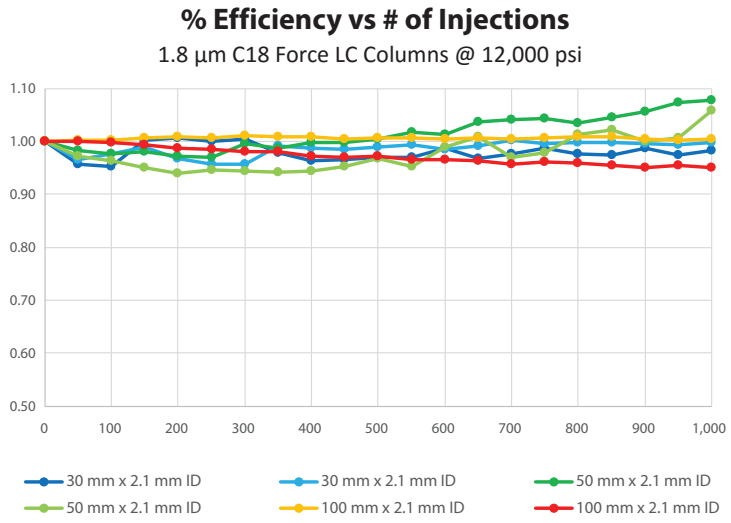
RESTEK

# Apply Force to Your LC Methods...

## ... for Longer Column Life

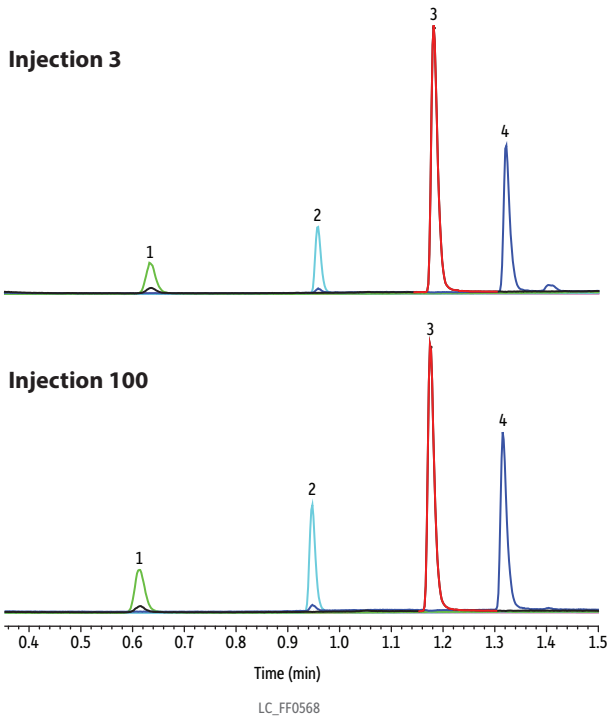
Elevated pressures and rapid pressure cycling put extreme stress on your LC column and shorten its life. And when the demand to increase lab productivity meets the growing pressure limits of modern LCs and the faster cycle times of new methods, many competitor columns simply can't survive. Force LC columns from Restek are designed and manufactured to handle high-pressure, high-stress conditions. Whether you're running a 3 or 5 µm column on an older HPLC or a 1.8 µm on the newest UHPLC in your lab (Figures 1 & 2), your method will give you the same separation from one injection to the next when you trust your workflow to the extended lifetime of a Force LC column.

**Figure 1:** At over 10,000 psi, you may be used to seeing a drop in efficiency, but Force LC columns will take the pressure.




**1,000 injections and still going strong at high pressure.**

**Figure 2:** Rapid changes in pressure place more stress on a column than even high pressures can, but Force LC columns will handle repeated analyses with no change in separation.




**Stable retention times and peak shapes even with rapid cycling!**

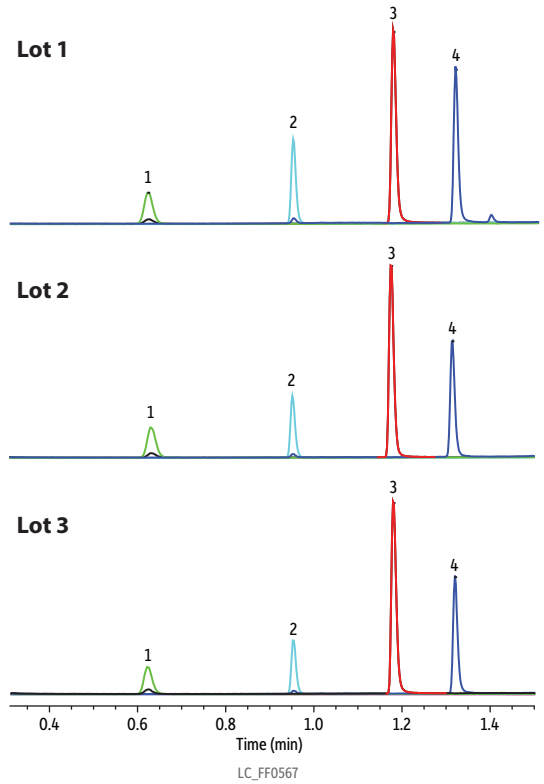
| | Peaks | SIR (m/z) |
|---|---|---|
| 1. | Daidzin | 417.2 |
| 2. | Genistin | 433.2 |
| 3. | Daidzein | 255.1 |
| 4. | Genistein | 271.1 |

**Column:** Force C18 (cat.# 9634252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Guard Column: UltraShield UHPLC precolumn filter 0.2 µm (cat.# 25810); Temp.: 50 °C; **Sample:** Custom mix; Diluent: Water; Conc.: 500 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 0.1% formic acid, B. Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (15%), 1.50 min (95%), 1.51 min (15%), 3.00 min (15%); **Flow:** 0.6 mL/min; Max Pressure: 500 bar; **Detector:** MS; Interface: ESI+; **Instrument:** UHPLC.

# ... for Improved Reproducibility

Once you set up and validate a workflow, you move on to developing the next new method. You don't have time to repeatedly revisit past methods because your chosen column is giving you different results with each lot. Peak shapes and retention times need to be maintained over the lifetime of your workflow to ensure consistent results, reduce unplanned downtime, and preserve your own productivity. Force LC columns have the lot-to-lot reproducibility you need to rely on (Figure 3)—backed by Restek's strict QC system and our 100% Pure Satisfaction guarantee—so that you are free to focus your energy on what's next.

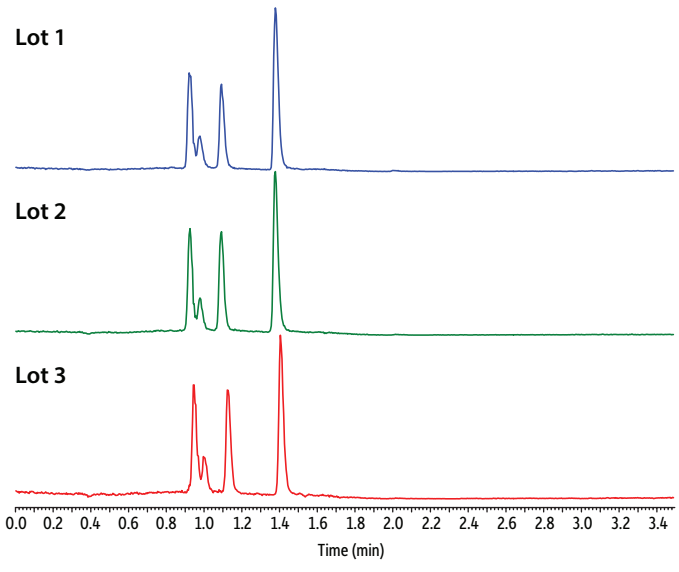
**Figure 3:** Whether a standard C18 or our FluoroPhenyl with its innovative new bonding process, each subsequent Force column you order will give you the same outstanding performance as the first.




**C18**

| | Peaks | SIR (m/z) |
|---|---|---|
| 1. | Daidzin | 417.2 |
| 2. | Genistin | 433.2 |
| 3. | Daidzein | 255.1 |
| 4. | Genistein | 271.1 |

**Column:** Force C18 (cat.# 9634252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 50 °C; **Sample:** Custom mix; Diluent: Water; Conc.: 500 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 0.1% formic acid, B. Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (15%), 1.50 min (95%), 1.51 min (15%), 3.00 min (15%); **Flow:** 0.6 mL/min; Max Pressure: 500 bar; **Detector:** MS; Interface: ESI+; **Instrument:** UHPLC.




**FluoroPhenyl**

| | Peaks | Precursor Ion | Product Ion | Product Ion |
|---|---|---|---|---|
| 1. | Nitrofurantoin | 239.1 | 121.9 | 95.0 |
| 2. | Nitrofurazone | 199.1 | 107.9 | 54.0 |
| 3. | Furazolidone | 226.2 | 95.0 | 67.0 |
| 4. | Nifuroxazide | 276.2 | 121.0 | 93.0 |

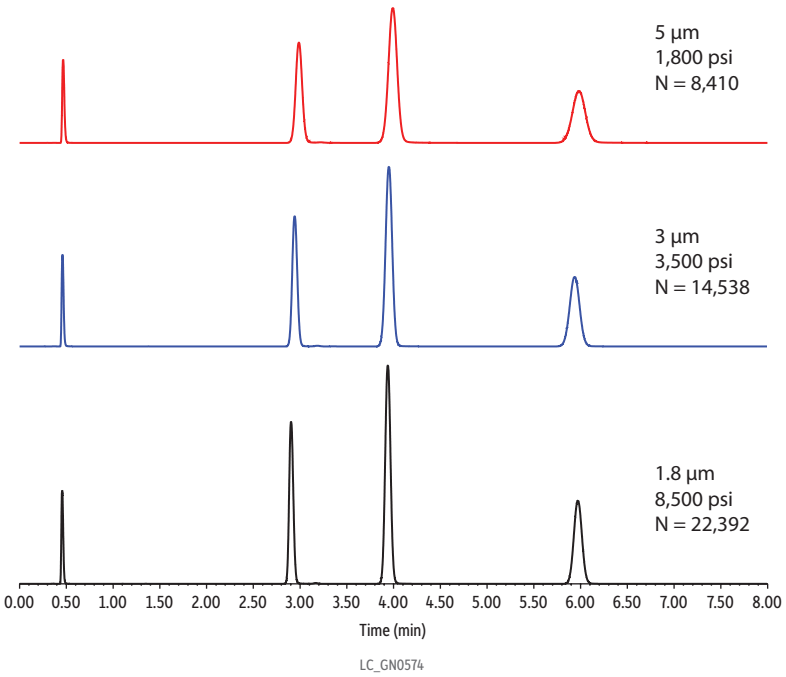
**Column:** Force FluoroPhenyl (cat.# 9639252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 40 °C; **Sample:** Diluent: Water; Conc.: 50 ng/mL; Inj. Vol.: 5 µL; Mobile Phase: A. 0.1% Acetic acid in water, B. Methanol; **Gradient (%B):** 0.00 min (30%), 1.50 min (95%), 1.51 min (30%), 3.50 min (30%); **Flow:** 0.4 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC.

## ... for Complete Scalability

To accelerate time to market, analysts will often develop methods on fast UHPLC instruments using sub-2 µm particle columns. But, the methods must then be scaled to match the analysis time and pressure limitations of the traditional HPLCs and the 3 or 5 µm columns that will actually be doing the work. To make this transition easier and ensure consistent results, Force LC columns are available in three particle sizes that are manufactured on the same silica support with the same properties to reliably and easily provide the same separation on any instrument platform (Figure 4).

And, of course, it works both ways: fully scalable Force LC columns also make it easy to update conventional HPLC methods to UHPLC instruments to increase sample throughput and reduce solvent consumption and waste disposal costs.

**Figure 4:** With identical isocratic flow rates, 5, 3, and 1.8 µm Force columns still offer the same results. (If using a gradient, simple equations can help you adjust slope and time points.) Scaling doesn't get easier than that!

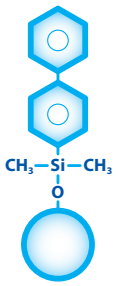



**Peak shape and plate number improve as particle size decreases—ideal for increased MS sensitivity!**

| Peaks | $t_R$ (min) |
|---|---|
| 1. Uracil | 0.456 |
| 2. Toluene | 2.904 |
| 3. Naphthalene | 3.939 |
| 4. Biphenyl | 5.971 |

**Column:** Force, 100 x 2.1 mm (see above for particle sizes); Temp.: 30 °C; **Sample:** UHPLC RP test mix; Diluent: Water: acetonitrile (50:50); Inj. Vol.: 2 µL; **Mobile Phase:** A. Water, B. Acetonitrile; **Gradient (%B):** 0.00 min (55%), 8.00 min (55%); **Flow:** 0.4 mL/min; **Detector:** PDA @ 254 nm; **Instrument:** UHPLC.

# Force LC Columns at Work: *Time-Tested Restek Biphenyl Phase*




## The established choice for pharmaceutical testing since 2005

- Separates compounds that other phenyl and C18 chemistries can't.
- Allows the use of simple, MS-friendly mobile phases.
- Restek's most popular LC phase.

### Properties:

- Increased retention for dipolar, unsaturated, or conjugated solutes.
- Enhanced selectivity when used with methanolic mobile phase.
- Ideal for increasing sensitivity and selectivity in LC-MS analyses.

### Switch to a Biphenyl when:

- Limited selectivity is observed on a C18.
- You need to increase retention of hydrophilic aromatics.

## Column Interaction Profile:

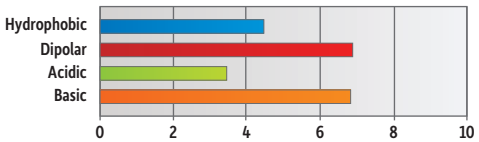

### Defining Solute Interactions:

- Polarizability
- Dispersion

### Complementary Solute Interaction:

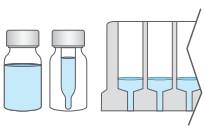
- Cation exchange

## Solute Retention Profile:




### Target Analyte Structures:

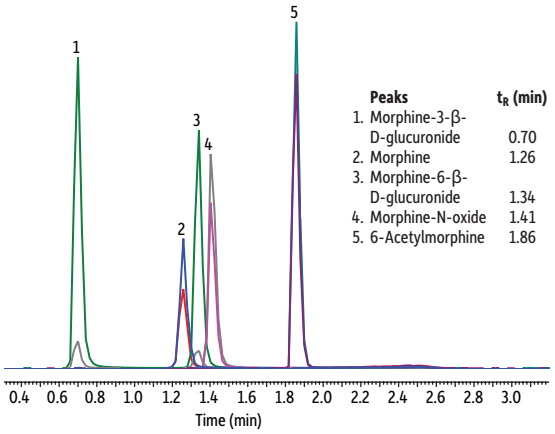
- Aromatic
- Dipolar



### Target Analyte Functionalities:

- Hydrophilic aromatics
- Strong dipoles
- Lewis acids
- Dipolar, unsaturated, or conjugated compounds
- Fused-ring compounds with electron withdrawing groups

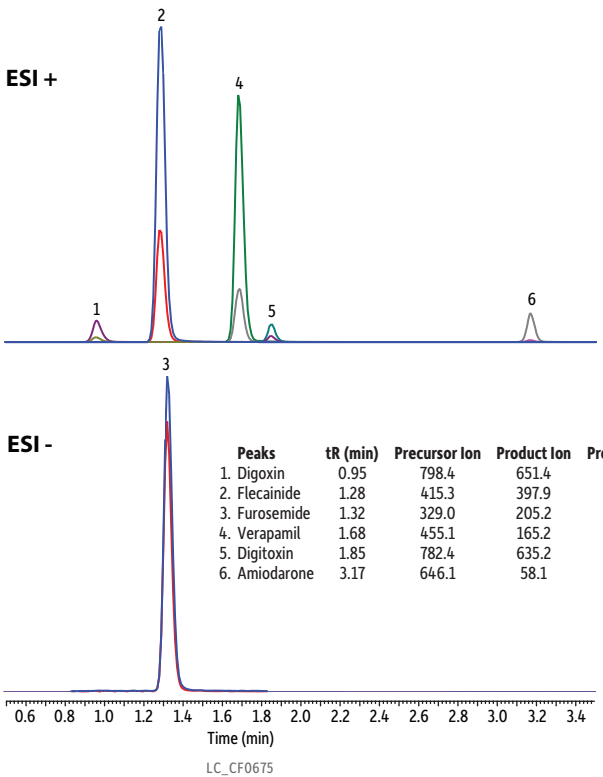
**Figure 5:** Whether for therapeutic drug monitoring or toxicology, Force Biphenyl columns were made for applications where fast, reliable identification of drugs and metabolites could be a matter of life and death.




| Peaks | $t_R$ (min) | Precursor Ion | Product Ion | Product Ion |
|---|---|---|---|---|
| 1. Morphine-3-β-D-glucuronide | 0.70 | 462.1 | 286.0 | 152.1 |
| 2. Morphine | 1.26 | 286.1 | 164.9 | 152.0 |
| 3. Morphine-6-β-D-glucuronide | 1.34 | 462.1 | 286.0 | 152.1 |
| 4. Morphine-N-oxide | 1.41 | 302.1 | 284.9 | 161.9 |
| 5. 6-Acetylmorphine | 1.86 | 328.1 | 211.1 | 165.0 |

**Column:** Force Biphenyl (cat.# 9629252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 35 °C; **Sample:** Diluent: 0.1% Formic acid in water; Conc.: 50 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A. 0.1% Formic acid in water, B. 0.1% Formic acid in methanol; **Gradient (%B):** 0.00 min (15%), 0.50 min (15%), 2.00 min (70%), 2.01 min (15%), 4.00 min (15%); **Flow:** 0.5 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC.

**Figure 6:** Accurate quantification is critical for cardiac drugs due to their narrow therapeutic range, and the Restek Biphenyl phase on a Force LC column is the ideal choice.



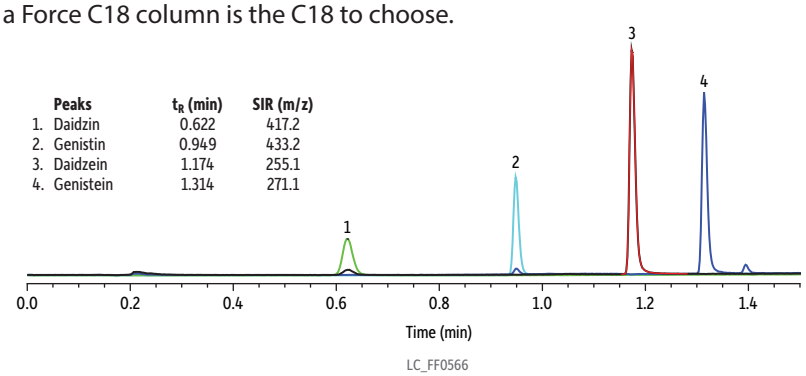

| Peaks | tR (min) | Precursor Ion | Product Ion | Product Ion | Polarity |
|---|---|---|---|---|---|
| 1. Digoxin | 0.95 | 798.4 | 651.4 | 355.1 | + |
| 2. Flecainide | 1.28 | 415.3 | 397.9 | 300.9 | + |
| 3. Furosemide | 1.32 | 329.0 | 205.2 | 285.1 | - |
| 4. Verapamil | 1.68 | 455.1 | 165.2 | 150.0 | + |
| 5. Digitoxin | 1.85 | 782.4 | 635.2 | 243.1 | + |
| 6. Amiodarone | 3.17 | 646.1 | 58.1 | 86.2 | + |

**Column:** Force Biphenyl (cat.# 9629252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 40 °C; **Sample:** Diluent: Water:acetonitrile (90:10); Conc.: 100 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 5 mM ammonium formate + 0.1% formic acid, B: Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (40%), 3.50 min (95%), 3.51 min (40%), 5.5 min (40%); **Flow:** 0.3 mL/min; **Detector:** MS/MS; Ion Mode: ESI+/ESI-; Mode: Scheduled MRM; **Instrument:** UHPLC.

RESTEK

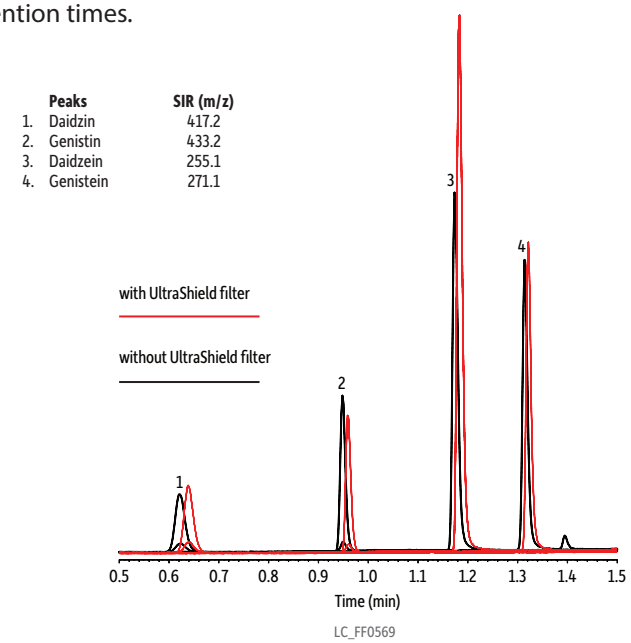
# Force LC Columns at Work: *General-Purpose Restek C18 Phase*

**Figure 7:** A C18 is a common first choice for method developers, and as shown here for these isoflavones commonly found in nutraceuticals, a Force C18 column is the C18 to choose.




**Column:** Force C18 (cat.# 9634252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 50 °C; **Sample:** Custom mix; Diluent: Water; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 0.1% formic acid, B. Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (15%), 1.50 min (95%), 1.51 min (15%), 3.00 min (15%); **Flow:** 0.6 mL/min; Max Pressure: 500 bar; **Detector:** MS; Interface: ESI+; **Instrument:** UHPLC.

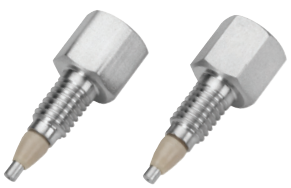
**Figure 8:** You can pair a 1.8 µm Force column with an UltraShield pre-column filter to prolong column lifetime—without significantly altering retention times.

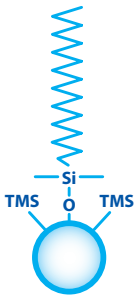



**Column:** Force C18 (cat.# 9634252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Guard Column: UltraShield UHPLC precolumn filter 0.2 µm (cat.# 25810); Temp.: 50 °C; **Sample:** Custom mix; Diluent: Water; Conc.: 500 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 0.1% formic acid, B. Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (15%), 1.50 min (95%), 1.51 min (15%), 3.00 min (15%); **Flow:** 0.6 mL/min; Max Pressure: 500 bar; **Detector:** MS; Interface: ESI+; **Instrument:** UHPLC.

## Small-Particle Column Protection

Protecting your column is always recommended. Restek offers EXP guard column cartridges for our 3 and 5 µm Force LC columns, but for 1.8 µm columns, where the additional volume of a guard is an issue, reach for the UltraShield UHPLC PreColumn filter with 0.2 µm frit. Its minimal dead volume (1 µL) makes it recommended for UHPLC up to 15,000 psi.






## Force column dependability, scalability, and quality in a C18

- Wide pH range provides excellent data quality for many applications.
- Offers high hydrophobic retention.

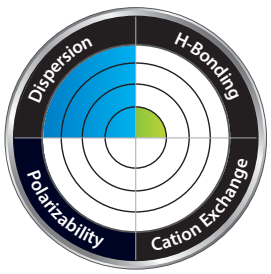
### Properties:

- Compatible with moderately acidic to neutral mobile phases (pH 2–8).
- Excellent data quality in food, environmental, bioanalytical, and other applications.

### Switch to a C18 when:

- You need a general-purpose column for reversed-phase chromatography.
- You need to increase retention of hydrophobic compounds.

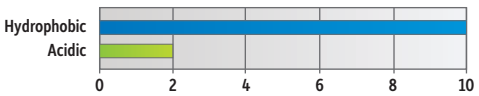
### Column Interaction Profile:




### Defining Solute Interaction:

- Dispersion

### Solute Retention Profile:

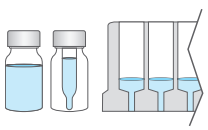



### Target Analyte Structure:

- Hydrocarbons

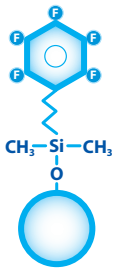
### Target Analyte Functionality:

- Hydrophobic compounds



RESTEK

# Force LC Columns at Work: *Reliably Versatile Restek FluoroPhenyl Phase*




## Get the power of HILIC and RP modes in one LC column

- Capable of both reversed-phase and HILIC separations.
- Ideal for increasing sensitivity and selectivity in LC-MS analyses.
- Offers increased retention for charged bases.

### Properties:

- Capable of both reversed-phase and HILIC separations.
- Ideal for increasing sensitivity and selectivity in LC-MS analyses.
- Offers increased retention for charged bases.

### Switch to FluoroPhenyl when:

- Limited retention and selectivity are observed on a C18 for basic compounds.
- You need increased retention of hydrophilic compounds.

## Column Interaction Profile:

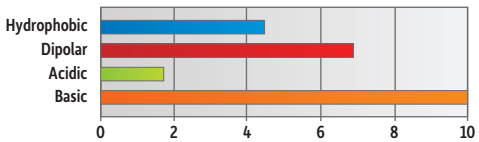

### Defining Solute Interactions:

- Cation exchange

### Complementary Solute Interaction:

- Polarizability
- Dispersion

## Solute Retention Profile:




### Target Analyte Structures:

- Nitrogen

### Target Analyte Functionalities:

- Protonated amines
- Quaternary ammonium compounds
- Positively charged moieties
- Lewis bases

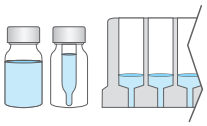
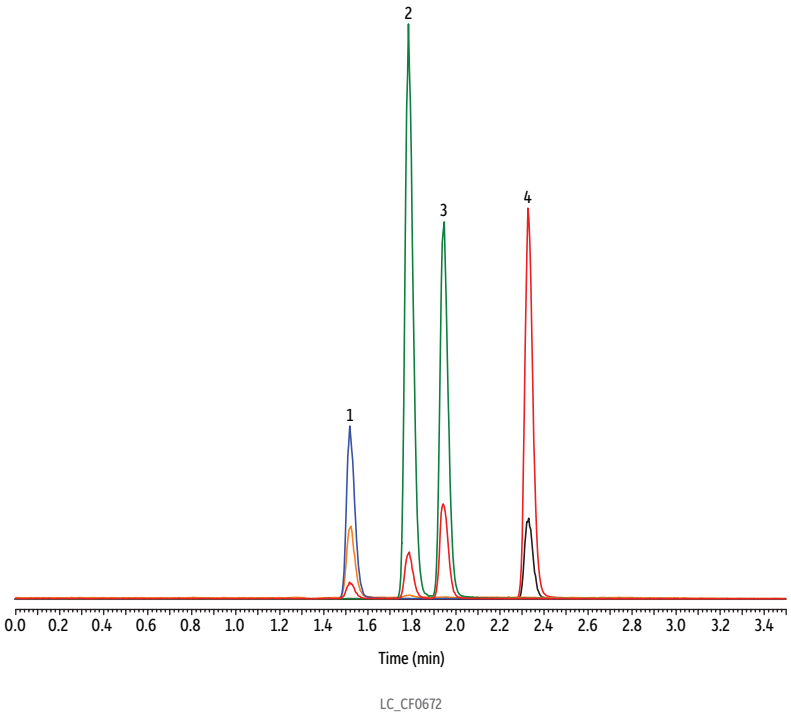


**Figure 9:** Xanthine analysis can be performed in clinical settings, in sports to target misuse, or even in food analyses. A Force FluoroPhenyl column offers fast, simultaneous analysis of multiple compounds including isobars paraxanthine and theophylline.

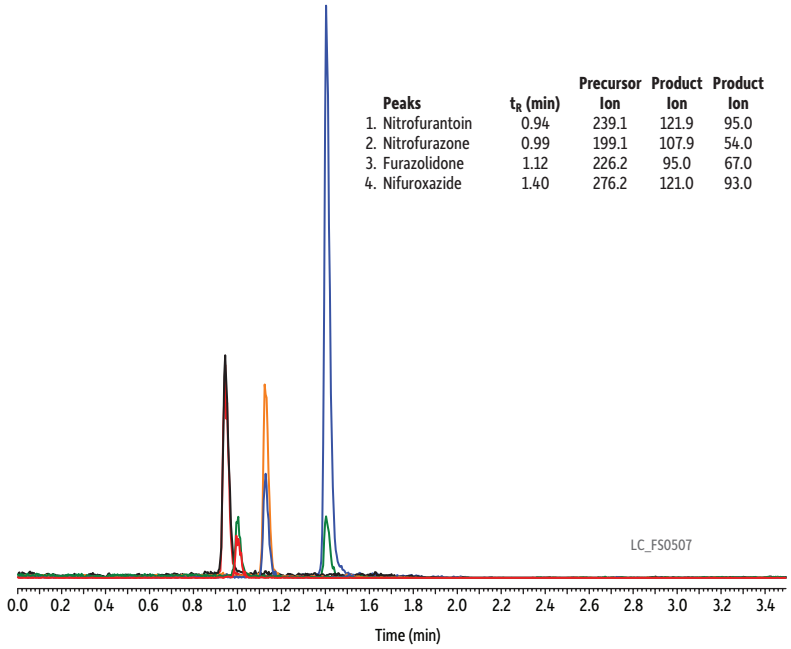
| Peaks | $t_R$ (min) | Conc. (µg/mL) | Precursor Ion | Product Ion | Product Ion |
|---|---|---|---|---|---|
| 1. Theobromine | 1.53 | 50 | 181.13 | 137.95 | 163.01 |
| 2. Theophylline | 1.79 | 50 | 181.13 | 124.02 | 96.03 |
| 3. Paraxanthine | 1.95 | 50 | 181.13 | 124.02 | 96.03 |
| 4. Caffeine | 2.33 | 50 | 195.09 | 138.01 | 110.03 |




**Column:** Force FluoroPhenyl (cat.# 9639212); Dimensions: 100 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 40 °C **Sample:** Diluent: 70:30 Water:methanol; Conc.: 50 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A. 0.1% Formic acid in water, B. Methanol; **Gradient (%B):** 0.00 min (30%), 2.5 min (70%), 3.0 min (100%), 3.01 min (30%), 5.0 min (30%); **Flow:** 0.3 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC.

RESTEK

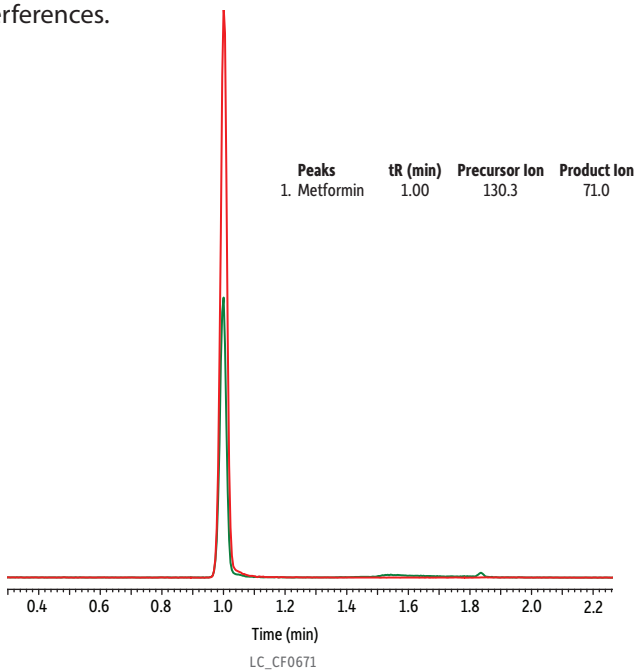
**Figure 10:** Restek's Force FluoroPhenyl column makes quick and effective work of nitrofurans, which are often used in animal feed as antibiotics/antimicrobials but are also banned in many regions.




| Peaks | $t_R$ (min) | Precursor Ion | Product Ion | Product Ion |
|---|---|---|---|---|
| 1. Nitrofurantoin | 0.94 | 239.1 | 121.9 | 95.0 |
| 2. Nitrofurazone | 0.99 | 199.1 | 107.9 | 54.0 |
| 3. Furazolidone | 1.12 | 226.2 | 95.0 | 67.0 |
| 4. Nifuroxazide | 1.40 | 276.2 | 121.0 | 93.0 |

**Column:** Force FluoroPhenyl (cat.# 9639252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 40 °C; **Sample:** Diluent: Water; Conc.: 50 ng/mL; Inj. Vol.: 5 µL; **Mobile Phase:** A. 0.1% Acetic acid in water, B. Methanol; **Gradient (%B):** 0.00 min (30%), 1.50 min (95%), 1.51 min (30%), 3.50 min (30%); **Flow:** 0.4 mL/min; **Detector:** MS/MS: Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC.

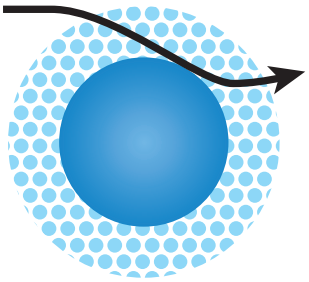
**Figure 11:** A common antidiabetic, metformin is difficult to retain using typical reversed-phase conditions, but with its HILIC capability, a Force FluoroPhenyl column provides suitable results in less than 3 minutes and reduces potential ion suppression caused by early-eluting matrix interferences.



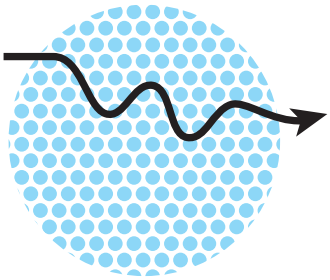

| Peaks | tR (min) | Precursor Ion | Product Ion | Product Ion |
|---|---|---|---|---|
| 1. Metformin | 1.00 | 130.3 | 71.0 | 60.1 |

**Column:** Force FluoroPhenyl (cat.# 9639252); Dimensions: 50 mm x 2.1 mm ID; Particle Size: 1.8 µm; Temp.: 40 °C; **Sample:** Diluent: Acetonitrile; Conc.: 100 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. 0.1% Formic acid in water, B. 0.1% Formic acid in acetonitrile; **Gradient (%B):** 0.00 min (70%), 1.5 min (10%), 1.51 min (70%), 2.5 min (70%); **Flow:** 0.6 mL/min; **Detector:** MS/MS; Ion Mode: ESI+; Mode: MRM; **Instrument:** UHPLC.

## SPP or FPP?



Superficially porous particles (SPP) are becoming increasingly popular for providing faster, more efficient analyses without UHPLC pressures. And when speed is your goal, Restek recommends the Raptor line of LC columns (**www.restek.com/raptor**).



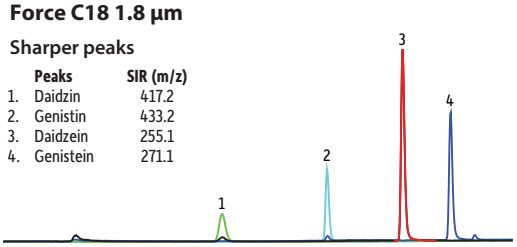
However, retention is often just as important to sharpen peaks and increase sensitivity for mass spec, and when that is the case, fully porous particle (FPP) Force LC columns are ready to be put to work.

Either way, Restek has a high-performing, reliable LC column for you.

**Force C18 1.8 µm**

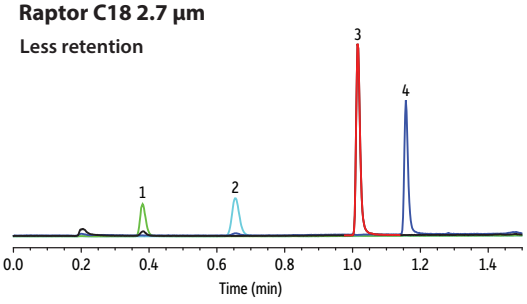
**Sharper peaks**

| Peaks | SIR (m/z) |
|---|---|
| 1. Daidzin | 417.2 |
| 2. Genistin | 433.2 |
| 3. Daidzein | 255.1 |
| 4. Genistein | 271.1 |




**Raptor C18 2.7 µm**

**Less retention**




**Columns:** Force C18 1.8 µm, 50 x 2.1 mm (cat# 9634252), max pressure = 500 bar and Raptor C18 2.7 µm, 50 x 2.1 mm (cat# 9304A52), max pressure = 225 bar; Temp.: 50 °C; **Sample:** Custom mix; Diluent: Water; Conc.: 500 ng/mL; Inj. Vol.: 2 µL; **Mobile Phase:** A. Water + 0.1% formic acid, B. Acetonitrile + 0.1% formic acid; **Gradient (%B):** 0.00 min (15%), 1.50 min (95%), 1.51 min (15%), 3.00 min (15%); **Flow:** 0.6 mL/min; **Detector:** MS; Interface: ESI+; **Instrument:** UHPLC.

# Product Listing

## Force Biphenyl LC Columns (USP L11)

| Length | 2.1 mm | 3.0 mm | 4.6 mm |
|---|---|---|---|
| **1.8 µm Columns** | | | |
| 30 mm | 9629232 | — | — |
| 50 mm | 9629252 | 962925E | — |
| 100 mm | 9629212 | 962921E | — |
| **3 µm Columns** | | | |
| 30 mm | 9629332 | — | — |
| 50 mm | 9629352 | 962935E | — |
| 100 mm | 9629312 | 962931E | 9629315 |
| 150 mm | 9629362 | 962936E | 9629365 |
| **5 µm Columns** | | | |
| 50 mm | 9629552 | 962955E | — |
| 100 mm | 9629512 | 962951E | 9629515 |
| 150 mm | 9629562 | 962956E | 9629565 |
| 250 mm | — | — | 9629575 |

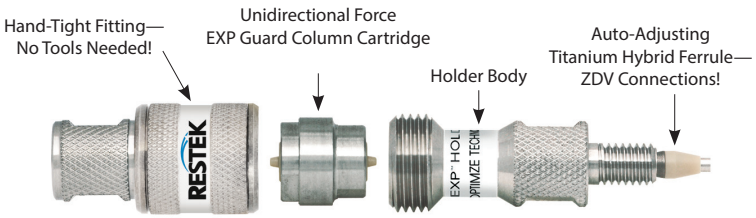
## Force C18 LC Columns (USP L1)

| Length | 2.1 mm | 3.0 mm | 4.6 mm |
|---|---|---|---|
| **1.8 µm Columns** | | | |
| 30 mm | 9634232 | — | — |
| 50 mm | 9634252 | 963425E | — |
| 100 mm | 9634212 | 963421E | — |
| **3 µm Columns** | | | |
| 30 mm | 9634332 | — | — |
| 50 mm | 9634352 | 963435E | — |
| 100 mm | 9634312 | 963431E | 9634315 |
| 150 mm | 9634362 | 963436E | 9634365 |
| **5 µm Columns** | | | |
| 50 mm | 9634552 | 963455E | — |
| 100 mm | 9634512 | 963451E | 9634515 |
| 150 mm | 9634562 | 963456E | 9634565 |
| 250 mm | — | — | 9634575 |

## Force FluoroPhenyl LC Columns (USP L43)

| Length | 2.1 mm | 3.0 mm | 4.6 mm |
|---|---|---|---|
| **1.8 µm Columns** | | | |
| 30 mm | 9639232 | — | — |
| 50 mm | 9639252 | 963925E | — |
| 100 mm | 9639212 | 963921E | — |
| **3 µm Columns** | | | |
| 30 mm | 9639332 | — | — |
| 50 mm | 9639352 | 963935E | — |
| 100 mm | 9639312 | 963931E | 9639315 |
| 150 mm | 9639362 | 963936E | 9639365 |
| **5 µm Columns** | | | |
| 50 mm | 9639552 | 963955E | — |
| 100 mm | 9639512 | 963951E | 9639515 |
| 150 mm | 9639562 | 963956E | 9639565 |
| 250 mm | — | — | 9639575 |

## Force EXP Guard Cartridges — *for 3 and 5 µm Force Columns*




Protect your investment and extend the life of our already-rugged LC columns and change guard column cartridges by hand without breaking fluid connections—no tools needed!

- Free-Turn architecture lets you change cartridges by hand without breaking inlet/outlet fluid connections—no tools needed.
- Patented titanium hybrid ferrules can be installed repeatedly without compromising high-pressure seal.
- Auto-adjusting design provides ZDV (zero dead volume) connection to any 10-32 female port.
- Guard column cartridges require EXP direct connect holder (cat.# 25808).
- Pair with EXP hand-tight fitting (cat.# 25937–25939) for tool-free installation.
- For use with 3 or 5 µm Force LC columns. For 1.8 µm Force columns, use a 0.2 µm UltraShield Filter.

### Force EXP Guard Column Cartridges

| Description | qty. | 5 x 2.1 mm cat.# | 5 x 3.0 mm cat.# | 5 x 4.6 mm cat.# |
|---|---|---|---|---|
| Force Biphenyl EXP Guard Column Cartridge | 3-pk. | 962950252 | 962950253 | 962950250 |
| Force C18 EXP Guard Column Cartridge | 3-pk. | 963450252 | 963450253 | 963450250 |
| Force FluoroPhenyl EXP Guard Column Cartridge | 3-pk. | 963950252 | 963950253 | 963950250 |

Maximum cartridge pressure: 600 bar/8,700 psi.
Apply Force LC columns to all of your HPLC and UHPLC instrument platforms at www.restek.com/force

### EXP Direct Connect Holder

| Description | qty. | cat.# |
|---|---|---|
| EXP Direct Connect Holder for EXP Guard Cartridges (includes hex-head fitting & 2 ferrules) | ea. | 25808 |

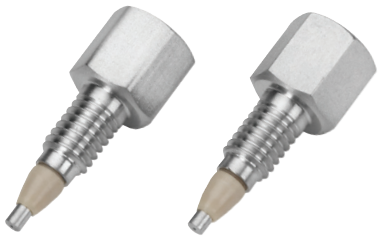
Maximum holder pressure: 20,000 psi (1,400 bar)

Apply Force to Your LC Methods at
**www.restek.com/force**

## UltraShield UHPLC PreColumn Filter — *for 1.8 µm Force Columns*

- Cost-effective protection for UHPLC systems.
- Reliable way to extend column lifetime.
- Universal fit—connects easily to any brand column.
- Leak-tight to 15,000 psi (1,034 bar).
- 0.5 µm or 0.2 µm titanium frit in a stainless steel body with PEEK ferrule.

**Specifications:**
Inlet/Outlet: Female/Male 10-32
Port Geometry: Parker ($^{1}/_{16}$ CPI)
Material: Titanium, stainless steel, PEEK ferrule
Filter: 0.2 µm stainless steel
Pressure Rating: 15,000 psig (1,034 bar)
Wrench Flat: $^{5}/_{16}$"



| Description | Filter Porosity | qty. | cat.# |
|---|---|---|---|
| UltraShield UHPLC PreColumn Filter | 0.2 µm frit | ea. | 25809 |
| | | 5-pk. | 25810 |
| | | 10-pk. | 25811 |

**EXP Reusable Fittings for HPLC & UHPLC** for 10-32 fittings and $^{1}/_{16}$" tubing

EXP Hand-Tight Fittings

- Hand-tight fitting style achieves effortless HPLC seals—no tools needed for a 8,700+ psi seal.
- Both hand-tight and hex-head styles wrench-tighten for reliable UHPLC use up to 20,000+ psi!
- Patented ferrule can be installed repeatedly without compromising high-pressure seal.
- Hybrid design combines the durability of titanium with the sealing ability of PEEK.
- Cutting-edge system provides ZDV (zero dead volume) connection to any 10-32 female port.
- Compatible with $^{1}/_{16}$" PEEK and stainless steel tubing.

**WARNING:** Do not use EXP ferrules with standard nuts. Failure to use EXP fittings according to the included instructions may result in unsafe UHPLC connections and/or non-ZDV connections.

| Description | qty. | cat.# |
|---|---|---|
| EXP Hand-Tight Fitting (Nut w/Ferrule) | ea. | 25937 |
| EXP Hand-Tight Fitting (Nut w/Ferrule) | 10-pk. | 25938 |
| EXP Hand-Tight Nut (w/o Ferrule) | ea. | 25939 |

Hybrid Ferrule U.S. Patent No. 8201854, Optimize Technologies. Optimize Technologies EXP Holders are Patent Pending. Other U.S. and Foreign Patents Pending. The Opti- prefix is a registered trademark of Optimize Technologies, Inc.

FORCE™
PERFORMANCE LC COLUMNS

Apply Force to Your LC Methods at
**www.restek.com/force**

RESTEK®
Pure Chromatography

**Questions about this or any other Restek product?**
**Contact us or your local Restek representative (www.restek.com/contact-us).**



**www.restek.com**

Lit. Cat.# GNBR2599-UNV