Effect of Organic Solvent on Selectivity in LC Separations

Different organic mobile phase modifiers produce different chromatographic results, and the foundation of good separations is leveraging choices in mobile phase and stationary phase chemistries to create different degrees of interactions between them and the analytes of interest. In this work, we will explore how the differences in organic modifiers result in the chromatographic performance you observe when using acetonitrile or methanol with reversed-phase LC columns. Specifically, we will be looking at a classic C18-type stationary phase as well as another popular reversed-phase stationary phase, biphenyl. Let's start with the C18.

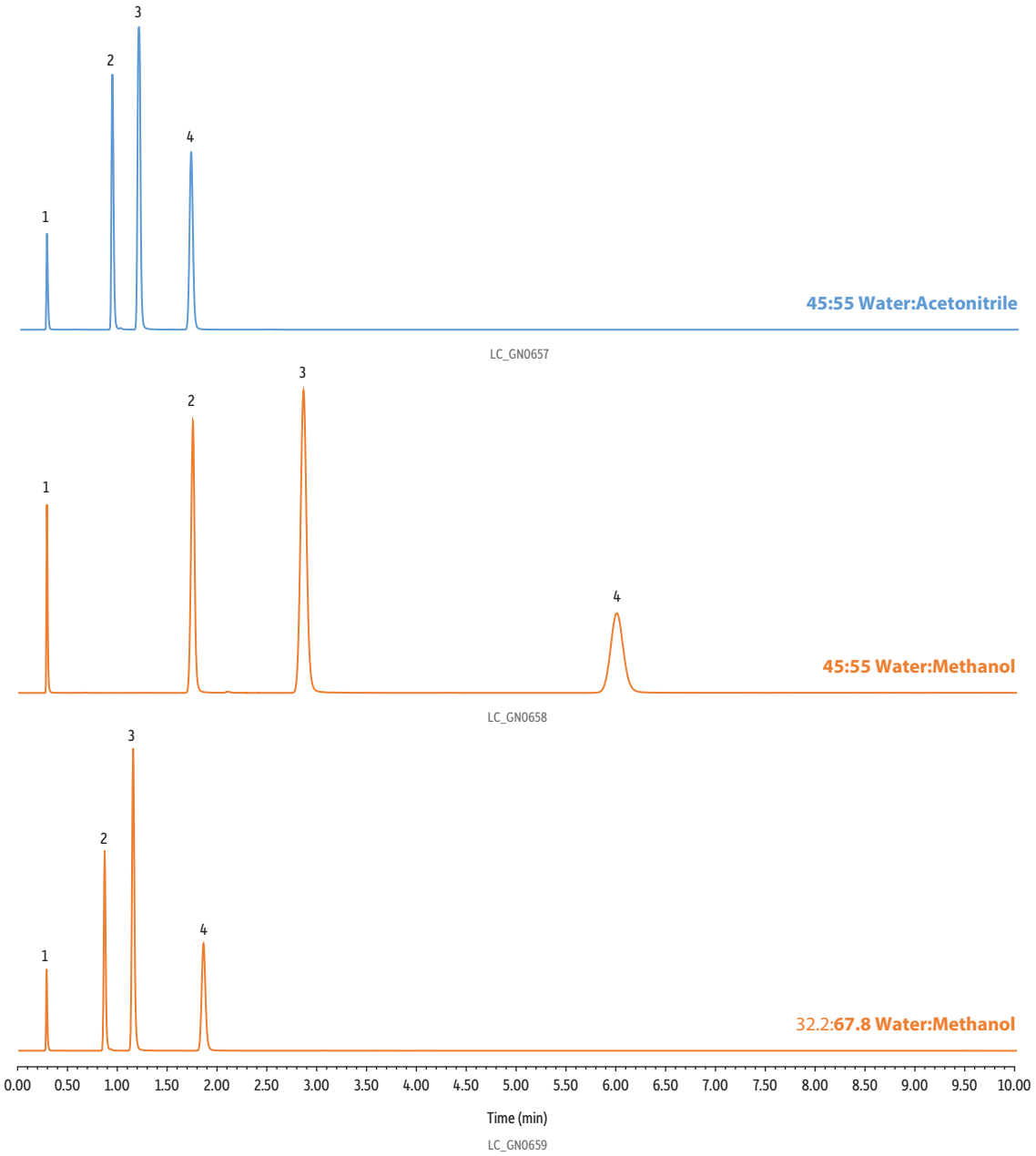
One of the first differences you often learn about organic modifiers is "elution strength," which is sometimes represented as an "eluotropic series." The eluotropic series is just a list of solvents in order of elution strength where a solvent with a strong elution strength is one that solutes have a high affinity for relative to the stationary phase. The consequence of this high affinity is that the analytes stay in the mobile phase more, reducing interactions with the stationary phase, which results in less retention. Analytes typically have lower affinity for organic modifiers with weaker elution strengths, and so, in this case, the same compounds would have more interactions with the stationary phase and exhibit greater retention, all other things being equal.

When it comes to an eluotropic series for reversed-phase chromatography, acetonitrile has a higher elution strength than methanol. Therefore, we would expect, as we see in Figure 1, that at the same percentage of organic modifier in the mobile phase, we would see less retention for the analytes with acetonitrile than we do with methanol.

But, there are times when someone may be interested in switching from one organic modifier to another while still trying to achieve the same separation in approximately the same time. The question is, can that be easily done?

To account for differences in elution strength between methanol and acetonitrile, you need to change the amount of the organic modifier in order to match retention times. When switching from acetonitrile to methanol, you will need to increase the overall elution strength of the mobile phase by increasing the percentage of methanol. There are tables (e.g., see Figure 4 in reference [1]) that give estimates of what percent of methanol, for instance, matches the elution strength of a given percent of acetonitrile. Using these tables, we were able to figure out a methanol mobile phase composition that matched the elution strength and chromatographic performance of the original acetonitrile conditions fairly well (Figure 1).

Figure 1: Comparing the retention times of various reversed-phase analytical probes (a) using acetonitrile as an organic modifier, (b) using methanol at the same mobile phase composition, and (c) using a percent methanol empirically determined to match the elution strength of the acetonitrile analysis. Column: Raptor ARC-18 (2.7 µm, 50 x 2.1 mm); Peaks: 1. uracil, 2. toluene, 3. naphthalene, 4. biphenyl.



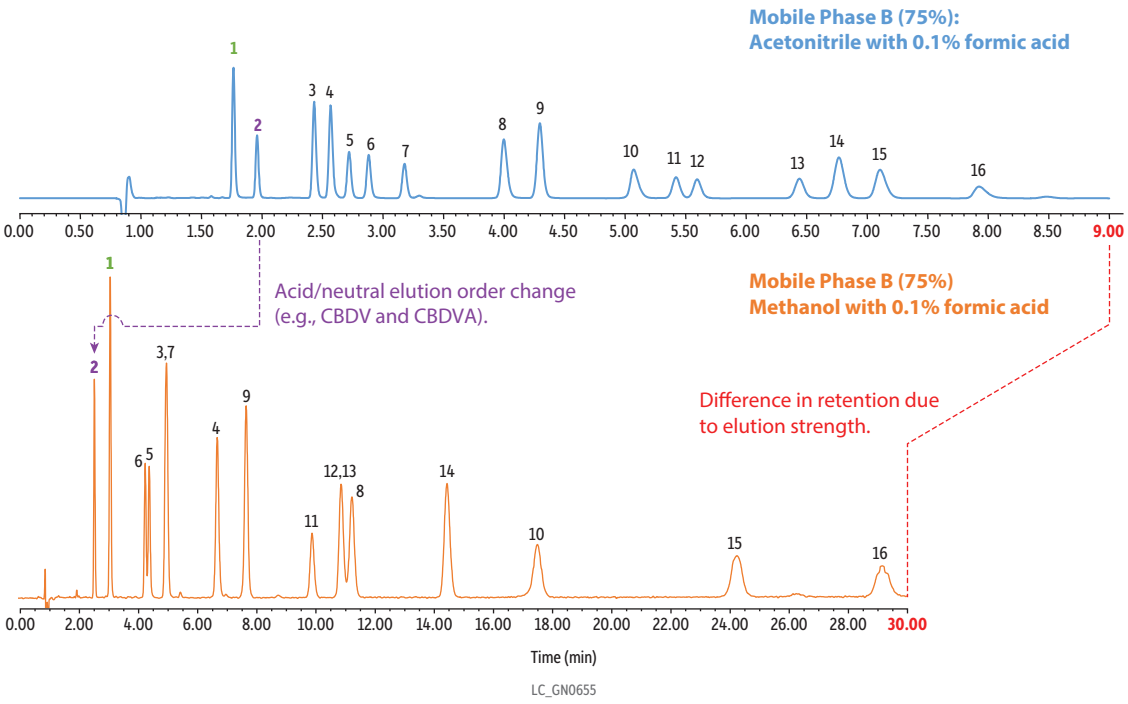
So, in this example, if you want to switch from acetonitrile to methanol (or vice versa), you can figure out the organic modifier composition that will match the elution strength of the method you are trying to convert. However, there are times when that approach does not work out so easily. The following cannabinoids analyses show that the effect of organic solvent on selectivity in LC is not always simple to predict.

Let's say we have a method in acetonitrile that we want to switch over to methanol. If we do the same experiment that we did in the example above, where we just switch modifiers and keep the percentage of organic modifier the same, we see our first clue that matching elution strengths alone might not work (Figure 2).

The initial thing you notice is that, as expected, the run is longer (a lot longer, in this case) with methanol. Methanol is the weaker elution strength solvent, so it is expected that compounds elute later. But, if you look carefully, you will see that a number of compounds in this example move significantly in relation to nearby compounds, and, in some cases, they even switch elution order all together! So, we don't just have a change in the retentive character of the chromatography (strong elution strength, less retention; weaker elution strength, more retention), we have a change in selectivity (how compounds elute in relation to each other).

The prominent examples of that, in this case, are instances where the acidic compounds (e.g., CBDVA, CBDA, THCVA, and CBNA) show greater retention than their neutral counterparts (e.g., CBDV, CBD, TCHV, CBN) when methanol is the organic modifier compared to when acetonitrile is used. Again, that *everything* would show greater retention is expected, because methanol is the weaker organic modifier, but some compounds are showing an even greater degree of retention than their neighbors when methanol is used when compared to acetonitrile at the same percent composition.

Figure 2: Comparison of the effect of organic solvent on selectivity in LC, where the percent composition is kept the same for both, on commonly monitored cannabinoids.



Peaks	Conc. (µg/mL)	Acetonitrile tR (min)	Methanol tR (min)
1. Cannabidivarinic acid (CBDVA)	50	1.877	3.117
2. Cannabidivarin (CBDV)	50	2.086	2.563
3. Cannabidiolic acid (CBDA)	50	2.592	5.003
4. Cannabigerolic acid (CBGA)	50	2.750	6.678
5. Cannabigerol (CBG)	50	2.912	4.373
6. Cannabidiol (CBD)	50	3.084	4.233
7. Tetrahydrocannabivarin (THCV)	50	3.391	4.904
8. Tetrahydrocannabivarinic acid (THCVA)	50	4.279	11.237
9. Cannabinol (CBN)	50	4.609	7.643
10. Cannabinolic acid (CBNA)	50	5.437	17.535
11. Δ9-Tetrahydrocannabinol (Δ9-THC)	50	5.815	9.866
12. Δ8-Tetrahydrocannabinol (Δ8-THC)	50	6.002	10.747
13. Cannabicyclol (CBL)	50	6.916	10.865
14. Cannabichromene (CBC)	50	7.263	14.387
15. δ-9-Tetrahydrocannabinolic acid-A (THCA-A)	50	7.612	23.975
16. Cannabichromenic acid (CBCA)	50	8.510	28.943

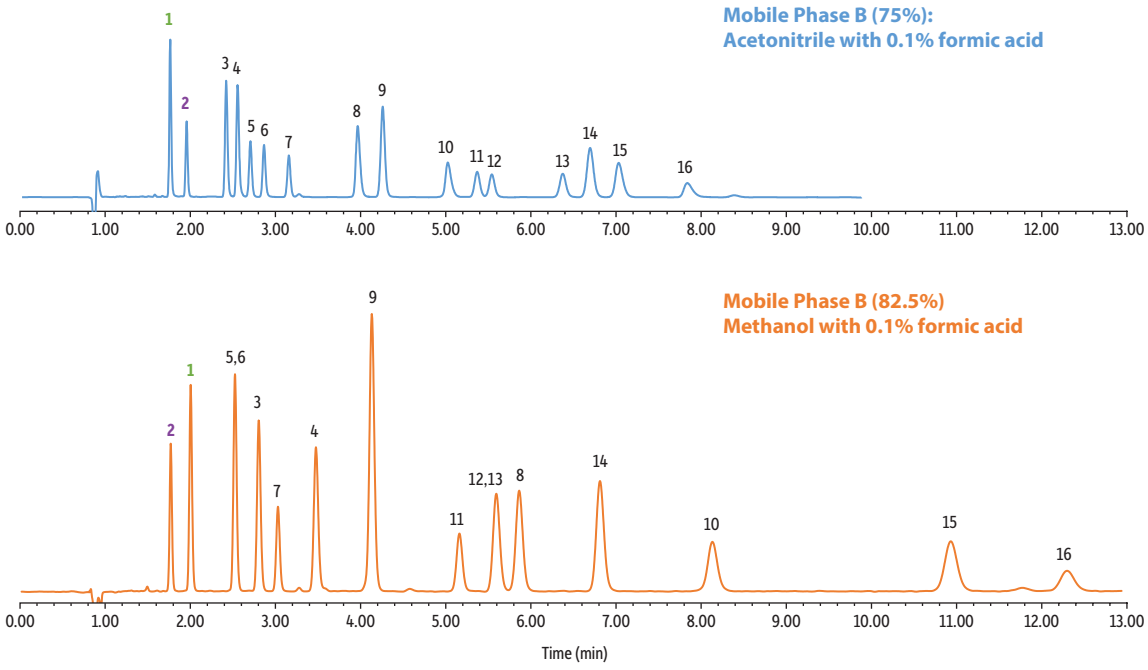
Column	Raptor ARC-18 (cat.# 9314A65)
Dimensions:	150 mm x 4.6 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Temp.:	30 °C
Inj. Vol.:	5 µL
Mobile Phase	
Flow:	1.5 mL/min
Detector	UV/Vis @ 228 nm
Instrument	Waters ACQUITY UPLC H-Class
Notes	**Mobile Phase Details**

Acetonitrile (top)
A: Water, 5 mM ammonium formate, 0.1% formic acid
B: Acetonitrile, 0.1% formic acid
9 min isocratic run (75%B)

Methanol (bottom)
A: Water, 5 mM ammonium formate, 0.1% formic acid
B: Methanol, 0.1% formic acid
30 min isocratic run (75%B)

Next, we will try to match elution strengths and see what happens. Figure 3 shows the results of that experiment (note that the concentration of the ammonium formate buffer is different in two conditions, but it was changed to keep the overall amount delivered on-column the same, like it is in Figure 2). We can see that in a few cases, CBN being a good example, we do get a pretty good match in analyte retention when we match elution strength, but the change in selectivity that we observed in Figure 2 is still there. The nature of the analyte itself has a lot to do with how effective an approach like matching elution strengths is going to be when it comes to trying to get similar results with different organic modifiers.

Figure 3: Comparison of the effect of using a different organic modifier, but at the same elution strength (via higher concentration), on cannabinoid selectivity.



Peaks	Conc. (µg/mL)	Acetonitrile t_R (min)	Methanol t_R (min)
1. Cannabidivarinic acid (CBDVA)	50	1.877	1.998
2. Cannabidivarin (CBDV)	50	2.086	1.700
3. Cannabidiolic acid (CBDA)	50	2.592	2.803
4. Cannabigerolic acid (CBGA)	50	2.750	3.479
5. Cannabigerol (CBG)	50	2.912	2.522
6. Cannabidiol (CBD)	50	3.084	2.522
7. Tetrahydrocannabivarin (THCV)	50	3.391	3.030
8. Tetrahydrocannabivarinic acid (THCVA)	50	4.279	5.876
9. Cannabinol (CBN)	50	4.609	4.137
10. Cannabinolic acid (CBNA)	50	5.437	8.158
11. Δ9-Tetrahydrocannabinol (Δ9-THC)	50	5.815	5.170
12. Δ8-Tetrahydrocannabinol (Δ8-THC)	50	6.002	5.605
13. Cannabicyclol (CBL)	50	6.916	5.605
14. Cannabichromene (CBC)	50	7.263	6.828
15. δ-9-Tetrahydrocannabinolic acid-A (THCA-A)	50	7.612	10.969
16. Cannabichromenic acid (CBCA)	50	8.510	12.399

Column	Raptor ARC-18 (cat.# 9314A65)
Dimensions:	150 mm x 4.6 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Temp.:	30 °C
Sample	
Diluent:	Methanol
Inj. Vol.:	5 µL
Mobile Phase	
Flow:	1.5 mL/min
Detector	UV/Vis @ 228 nm
Instrument	Waters ACQUITY UPLC H-Class
Notes	**Mobile Phase Details**

Acetonitrile (top)
A: Water, 5 mM ammonium formate, 0.1% formic acid
B: Acetonitrile, 0.1% formic acid
9 min isocratic run (75%B)

Methanol (bottom)
A: Water, 7.14 mM ammonium formate, 0.1% formic acid
B: Methanol, 0.1% formic acid
13 min isocratic run (82.5%B)

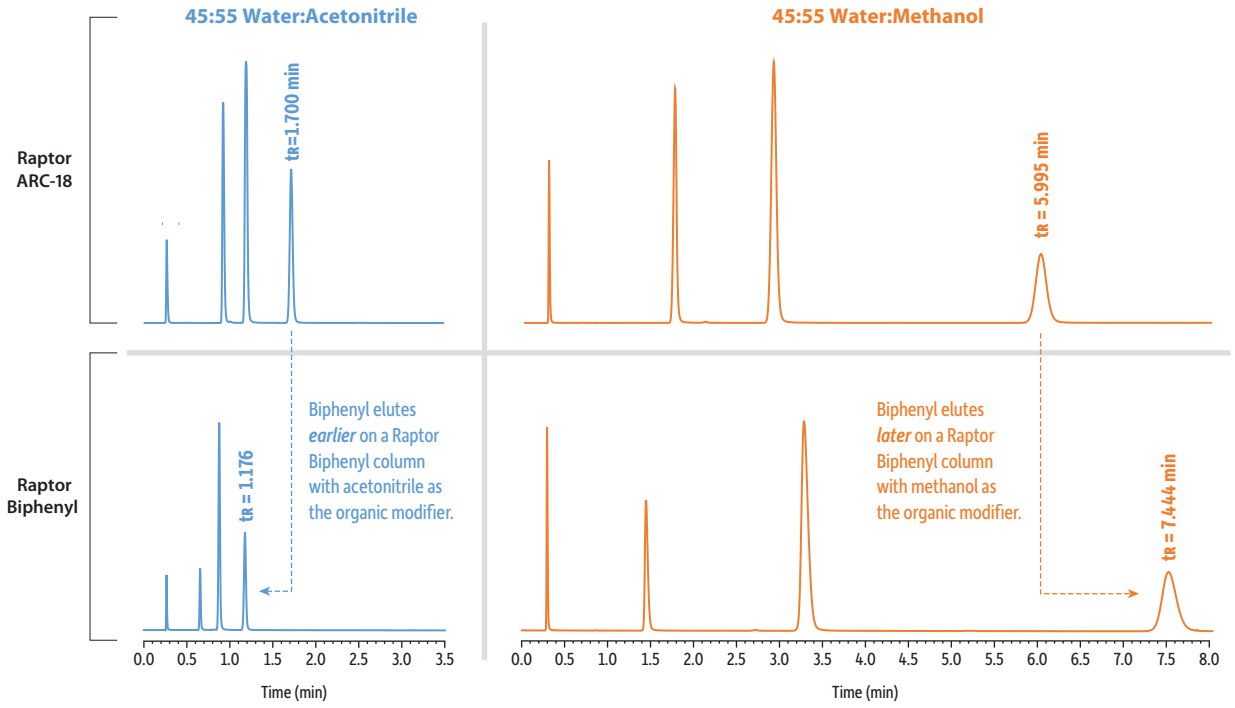
In our cannabinoid case, many of the compounds seeing the greatest change in relative retention are acidic in nature. And, that is what you might observe if you try this yourself. Some compounds are affected to a greater degree in relation to others, enough to change the selectivity of the chromatography. In a case like this, it is possible the cause is an additional interaction mechanism that exists between the organic modifier and the analyte itself based on the analyte's chemistry.

In our first example, we did not have any selective interaction affecting only one or two of the compounds based on organic modifier, so we could match elution strengths and adjust retention accordingly. As seen in the cannabinoids example, that will not be the case when there are compound-specific retention characteristics. In those circumstances, you cannot simply match elution strength and expect to produce similar chromatographic results.

It is true that the effect of organic solvent on selectivity may not compromise performance if you have the correct peak identification, but in our example, the change in selectivity causes coelutions that aren't acceptable for this LC-UV cannabis potency analysis.

But, does this hold true for other reversed-phase column chemistries? So far, we have only used a C18 column, but what about another popular reversed-phase stationary phase, such as biphenyl? To explore further, let's look at the first example shown on the C18-type column, the analysis of uracil, toluene, naphthalene, and biphenyl (Figure 1). This time, we will recreate the conditions on the biphenyl stationary phase instead.

Figure 4: Comparison of the effect of organic solvent on selectivity in LC on two different reversed-phase stationary phases using a matching percentage of organic modifier. All other things being equal, note how the last compound, biphenyl, moves when using acetonitrile compared to methanol. Columns: Raptor ARC-18 (2.7 µm, 50 x 2.1 mm), Raptor Biphenyl (2.7 µm, 50 x 2.1 mm); Peaks: 1. uracil, 2. toluene, 3. naphthalene, 4. biphenyl.



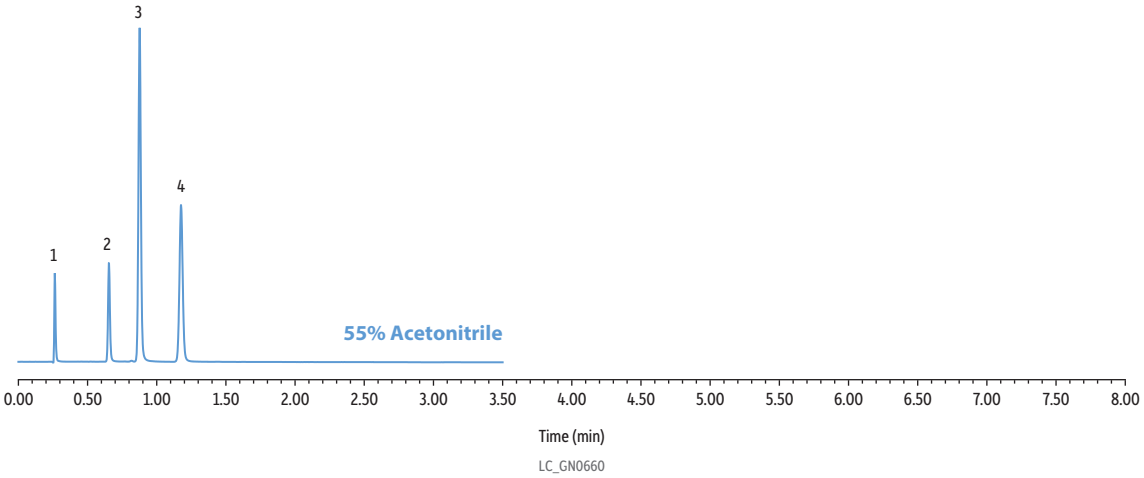
In Figure 4, we see as expected, an overall increase in retention time for all of the hydrophobic compounds (toluene, naphthalene, and biphenyl) when using methanol compared to acetonitrile (the first peak to elute is uracil, which is hydrophilic and is used as a void time marker in this reversed-phase analysis). What is not as immediately apparent, however, are the subtle retention time differences caused by the different solvents when compared to the C18 data. Take, for example, the final peak to elute in this example, which is the compound biphenyl (not the stationary phase biphenyl, but the analyte). When using a mobile phase with 55% acetonitrile on the C18 column, the biphenyl peak elutes at 1.7 minutes, but on the biphenyl column when using the same 55% acetonitrile mobile phase that same peak elutes at 1.176 minutes. So, there is less retention on the biphenyl column when using acetonitrile. If you compare the data using methanol as the organic modifier at 55%, you see on the C18 column the biphenyl peak elutes at 5.995 minutes compared to a retention time of 7.44 minutes of the biphenyl column. So, in this case, there is more retention on the biphenyl column when using methanol. Why is that?

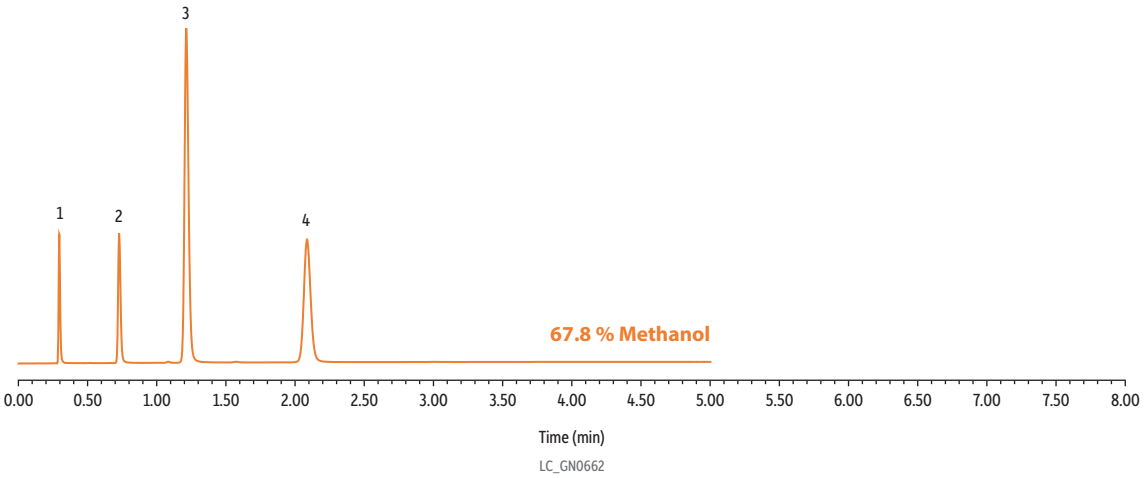
This difference that we see in retention and selectivity between the C18 and biphenyl phases when changing organic modifiers in the mobile phase has to do with the different retention mechanisms of the stationary phases themselves. The biphenyl stationary phase differs in selectivity from a C18 phase because its aromatic phenyl rings are capable of pi-pi interactions with the analytes of interest. The polarizability of the biphenyl phase allows it to change its electron distribution in the presence of an analyte and induce a dipole interaction. These interactions are most commonly seen in dipolar, unsaturated, or conjugated compounds. The unique selectivity of the biphenyl phase is affected differently than a C18 phase is by the choice of organic modifier.

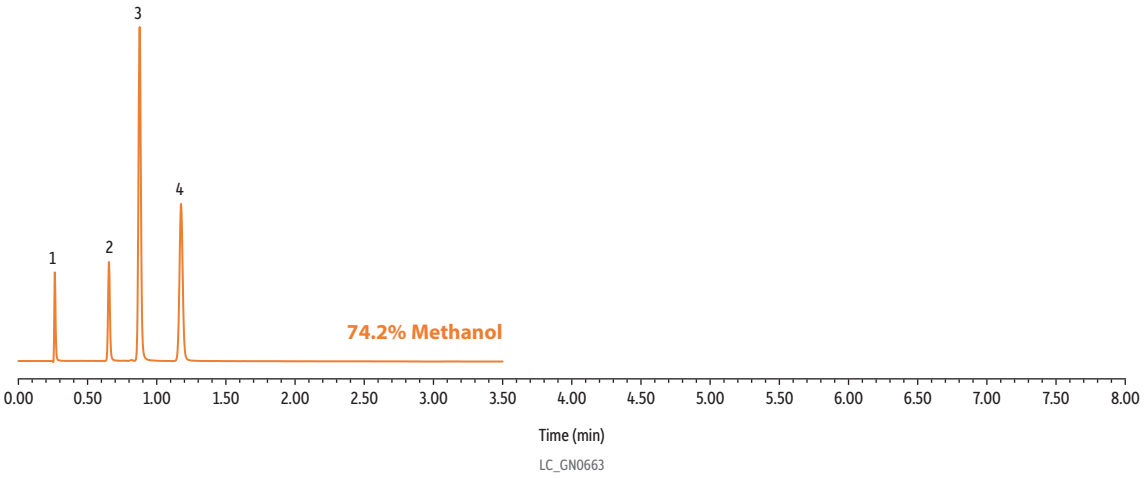
Structurally, acetonitrile has a central carbon atom that has a triple bond with a nitrogen atom. The triple bond is also capable of contributing to or interfering with pi interactions. So, when looking at the retention time of the biphenyl peak when using acetonitrile as the organic modifier, this results in less retention on the biphenyl column compared to the C18. However, when you switch to methanol, an organic solvent that does not have pi bonds, this results in an increased pi-pi interaction between the stationary phase and the analytes, resulting in a different selectivity and increased retention on the biphenyl column compared to the C18 for the biphenyl analyte, and to a lesser extent naphthalene. Acetonitrile has the capacity to have an additional interaction with the stationary phase that isn't present with methanol, and that additional interaction can fundamentally affect how the analytes interact with the phase, further enhancing the elution strength of acetonitrile beyond what the experience with the C18 would predict.

How does this affect our ability to match elution strengths and get comparable chromatography? In Figure 5, we first evaluated the same conditions that gave a good match with the C18 (Figure 2). As we might expect, when we try to get the same performance on the biphenyl column using the same "matched-elution-strength" mobile phase conditions, we still have more retention when using methanol. With a greater degree of interaction between the biphenyl stationary phase and the organic mobile phase modifier, the effective elution strength of acetonitrile is greater on the biphenyl column than on the C18 column. To account for the difference in effective elution strength, we increased the methanol content beyond what is theoretically considered a matched percentage for the original acetonitrile conditions and produced very similar results in a similar amount of time.

Figure 5: Results of attempting to match the chromatographic separation on a biphenyl stationary phase using different mobile phases: (a) acetonitrile mobile phase, (b) methanol mobile phase using the same percent methanol that matched well on a C18-type column, and (c), a higher percent methanol mobile phase to account for the enhanced elution strength of acetonitrile on the biphenyl stationary phase. Columns: Raptor Biphenyl (2.7 µm, 50 x 2.1 mm); Peaks: 1. uracil, 2. toluene, 3. naphthalene, 4. biphenyl.



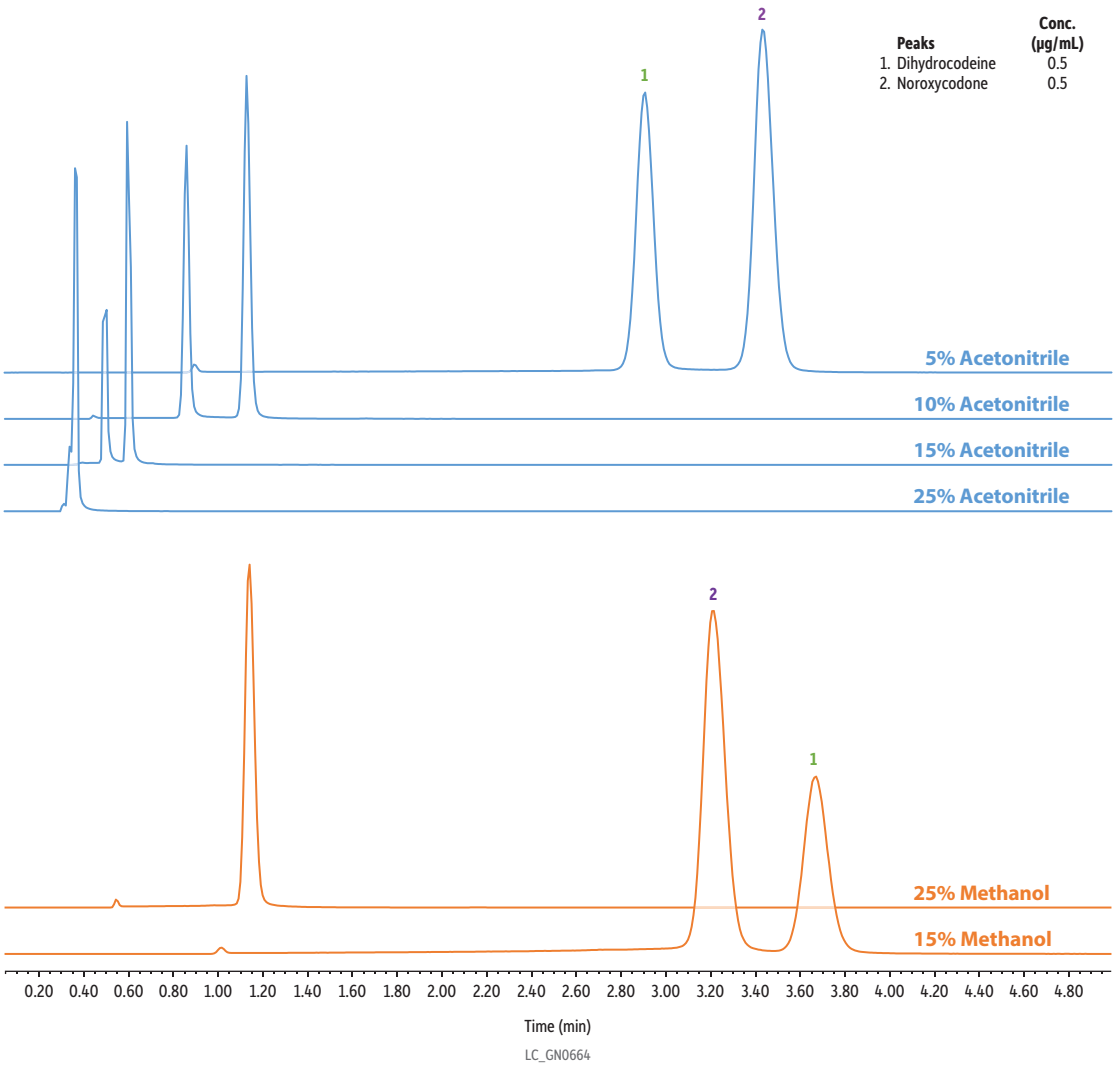




So, in the case of the biphenyl column compared to the C18, it was still possible to account for acetonitrile's enhanced elution strength, which stems from its interaction with the biphenyl phase itself, by increasing the amount of methanol beyond the matched elution strength percentage predicted for C18 columns.

To further explore the effect of organic solvent on selectivity in LC, we can look at the example of oxycodone's metabolite, noroxycodone, and the painkiller dihydrocodeine on the biphenyl column in Figure 6. These two compounds are structurally similar, and both have an aromatic ring. We see the expected difference in elution strength with more methanol being required to get similar retention to a given amount of acetonitrile. However, as we try to match elution strength we see a switch in elution order. In this case, the choice of organic modifier affects the interactions between the phase and the analytes, causing a change in selectivity.

Figure 6: The effect of organic modifier choice and organic modifier percent composition on selectivity for two pain-panel compounds.



Column	Raptor Biphenyl (cat.# 9309A52)
Dimensions:	50 mm x 2.1 mm ID
Particle Size:	2.7 µm
Pore Size:	90 Å
Temp.:	Ambient
Inj. Vol.:	10 µL
Mobile Phase	
Flow:	0.8 mL/min
Detector	PDA @ 254 nm
Instrument	Waters ACQUITY UPLC H-Class
Notes	**Mobile Phase Details**

Acetonitrile (top)
Analysis run using 5, 10, 15, and 25% acetonitrile mobile phase.
A: Water, 0.1% formic acid
B: Acetonitrile, 0.1% formic acid

Methanol (bottom)
Analysis run using 15 and 25% methanol mobile phase.
A: Water, 0.1% formic acid
B: Methanol, 0.1% formic acid

In the end, switching the organic modifier and expecting the same chromatographic performance is not always a reasonable expectation to have. In cases where the switch in organic modifier only affects the overall retention of your compounds of interest, there is a good chance that adjusting the organic modifier composition to match the elution strength of the original mobile phase will get you close to your original performance. But, if the relative retentions of compounds—the selectivity of the chromatographic system—show significant differences, especially in cases where peaks are shown to change elution order, you have an excellent indication that trying to simply match elution strengths will not produce similar chromatography. Sometimes, the organic modifier plays specific roles in specific circumstances, having a greater affinity for some classes of compounds because of a particular mode of interaction that another organic modifier does not possess (or possess to the same degree).

So, if you are interested in finding out if a switch in organic modifier is a viable option for you, first try keeping the percent composition the same before you do any method development. If you have similar selectivity, but with greater overall retention, you may be able to empirically determine a conversion between organic modifier percent composition and elution strength, make the adjustment, and get very close to your target.

If you see not only a change in overall retention due to elution strength but you also observe changes in selectivity, you can be sure that by changing the organic modifier you are also fundamentally changing the way your method is separating your compounds of interest.

Don't shy away from trying to change organic mobile phase modifiers; if a change is what is right for your lab, just be aware of the effect of organic solvent on selectivity in LC and understand that the choice of organic solvent is a lever that can be used as you develop your methods.

References

[1] R.E. Majors, The continuing acetonitrile shortage: how to combat it or live with it, LCGC North America (2009) 27(6) 458-471. http://www.chromatographyonline.com/continuing-acetonitrile-shortage-how-combat-it-or-live-it?id=&pageID=1&sk=&date=

similar phases

Phenomenex Kinetex Biphenyl; Supelco/Millipore Sigma Ascentis Express Biphenyl (2.7 µm)

ordering notes

Certificates of analysis for new Restek LC columns are now provided electronically. To view and download, visit www.restek.com/documentation then enter your cat.# and serial #.

Stationary Phase Category: Phenyl (L11)
Ligand Type: Biphenyl
Particle: 1.8 µm, 2.7 µm, or 5 µm superficially porous silica (SPP or "core-shell")
Pore Size: 90 Å
Carbon Load: 7% (1.8 µm), 7% (2.7 µm), 5% (5 µm)
End-Cap: yes
Surface Area: 125 m^2/g (1.8 µm), 130 m^2/g (2.7 µm), or 100 m^2/g (5 µm)
Recommended Usage:
pH Range: 2.0 to 8.0
Maximum Temperature: 80 °C
Maximum Pressure: 1,034 bar/15,000 psi* (1.8 µm), 600 bar/8,700 psi (2.7 µm); 400 bar/5,800 psi (5 µm)

* For maximum lifetime, recommended maximum pressure for 1.8 µm particles is 830 bar/12,000 psi.

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.

Raptor Biphenyl LC Columns (USP L11)

- Ideal for bioanalytical testing applications like drug and metabolite analyses.
- Heightened selectivity and retention for compounds that are hard to resolve or elute early on C18 and other phenyl chemistries.
- Limits ionization suppression and allows simple, MS-friendly mobile phases.
- Part of Restek's Raptor LC column line featuring 1.8, 2.7, and 5 µm SPP core-shell silica.

The innovative 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.

ID	Length	qty.	cat.#
1.8 µm Particles			
2.1 mm	30 mm	ea.	9309232
	50 mm	ea.	9309252
	100 mm	ea.	9309212
	150 mm	ea.	9309262
3.0 mm	50 mm	ea.	930925E
	100 mm	ea.	930921E
2.7 µm Particles			
2.1 mm	30 mm	ea.	9309A32
	50 mm	ea.	9309A52
	100 mm	ea.	9309A12
	150 mm	ea.	9309A62
3.0 mm	30 mm	ea.	9309A3E
	50 mm	ea.	9309A5E
	100 mm	ea.	9309A1E
	150 mm	ea.	9309A6E
4.6 mm	30 mm	ea.	9309A35
	50 mm	ea.	9309A55
	100 mm	ea.	9309A15
	150 mm	ea.	9309A65
5 µm Particles			
2.1 mm	50 mm	ea.	9309552
	100 mm	ea.	9309512
	150 mm	ea.	9309562
3.0 mm	30 mm	ea.	930953E
	50 mm	ea.	930955E
	100 mm	ea.	930951E
	150 mm	ea.	930956E
4.6 mm	50 mm	ea.	9309555
	100 mm	ea.	9309515
	150 mm	ea.	9309565
	250 mm	ea.	9309575

Raptor ARC-18 LC Columns (USP L1)

- Ideal for high-throughput LC-MS/MS applications with minimal sample preparation.
- Well-balanced retention profile for better detection and integration of large, multiclass analyte lists.
- Sterically protected to endure low-pH mobile phases without sacrificing retention or peak quality.
- Part of Restek's Raptor LC column line featuring 1.8, 2.7, and 5 µm SPP core-shell silica.

Designed and intended specifically for use on LC-MS/MS systems, the Raptor ARC-18 column offers 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.

ID	Length	qty.	cat.#
1.8 µm Particles			
2.1 mm	30 mm	ea.	9314232
	50 mm	ea.	9314252
	100 mm	ea.	9314212
	150 mm	ea.	9314262
3.0 mm	50 mm	ea.	931425E
	100 mm	ea.	931421E
2.7 µm Particles			
2.1 mm	30 mm	ea.	9314A32
	50 mm	ea.	9314A52
	100 mm	ea.	9314A12
	150 mm	ea.	9314A62
3.0 mm	30 mm	ea.	9314A3E
	50 mm	ea.	9314A5E
	100 mm	ea.	9314A1E
	150 mm	ea.	9314A6E
4.6 mm	30 mm	ea.	9314A35
	50 mm	ea.	9314A55
	100 mm	ea.	9314A15
	150 mm	ea.	9314A65
5 µm Particles			
2.1 mm	50 mm	ea.	9314552
	100 mm	ea.	9314512
	150 mm	ea.	9314562
3.0 mm	30 mm	ea.	931453E
	50 mm	ea.	931455E
	100 mm	ea.	931451E
	150 mm	ea.	931456E
4.6 mm	50 mm	ea.	9314555
	100 mm	ea.	9314515
	150 mm	ea.	9314565
	250 mm	ea.	9314575

similar phases

Agilent Poroshell 120 SB-C18; Phenomenex Kinetex XB-C18; Supelco/Millipore Sigma Ascentis Express Peptide ES-C18; Thermo Fisher Scientific Accucore XL C18

ordering notes

Certificates of analysis for new Restek LC columns are now provided electronically. To view and download, visit www.restek.com/documentation then enter your cat.# and serial #.

Stationary Phase Category: C18, octadecylsilane (L1)
Ligand Type: Sterically protected C18
Particle: 1.8 µm, 2.7 µm, or 5 µm superficially porous silica (SPP or "core-shell")
Pore Size: 90 Å
Carbon Load: 7% (1.8 µm), 7% (2.7 µm), 5% (5 µm)
End-Cap: no
Surface Area: 125 m^2/g (1.8 µm), 130 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: 1,034 bar/15,000 psi* (1.8 µm), 600 bar/8,700 psi (2.7 µm); 400 bar/5,800 psi (5 µm)

* For maximum lifetime, recommended maximum pressure for 1.8 µm particles is 830 bar/12,000 psi.

Properties:

- Well-balanced retention profile.
- Sterically protected and acid-resistant 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.

Raptor EXP Guard Column Cartridges

- 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.# 25937–25938) for tool-free installation.

To help protect your investment and further extend the life of our already-rugged LC columns, Restek offers the patent-pending guard column hardware developed by Optimize Technologies. A Restek LC guard cartridge in an EXP direct connect holder is the ultimate in column protection, especially when using dilute-and-shoot or other minimal sample preparation techniques.

ordering notes

Certificates of analysis for new Restek LC columns are now provided electronically. To view and download, visit www.restek.com/documentation then enter your cat.# and serial #.

Description	Particle Size	Size	qty.	cat.#
Raptor C18 EXP Guard Column Cartridge	UHPLC	5 x 2.1 mm	3-pk.	9304U0252
	UHPLC	5 x 3.0 mm	3-pk.	9304U0253
	2.7 µm	5 x 2.1 mm	3-pk.	9304A0252
	2.7 µm	5 x 3.0 mm	3-pk.	9304A0253
	2.7 µm	5 x 4.6 mm	3-pk.	9304A0250
	5 µm	5 x 2.1 mm	3-pk.	930450252
	5 µm	5 x 3.0 mm	3-pk.	930450253
	5 µm	5 x 4.6 mm	3-pk.	930450250
Raptor ARC-18 EXP Guard Column Cartridge	UHPLC	5 x 2.1 mm	3-pk.	9314U0252
	UHPLC	5 x 3.0 mm	3-pk.	9314U0253
	2.7 µm	5 x 2.1 mm	3-pk.	9314A0252
	2.7 µm	5 x 3.0 mm	3-pk.	9314A0253
	2.7 µm	5 x 4.6 mm	3-pk.	9314A0250
	5 µm	5 x 2.1 mm	3-pk.	931450252
	5 µm	5 x 3.0 mm	3-pk.	931450253
	5 µm	5 x 4.6 mm	3-pk.	931450250
Raptor Biphenyl EXP Guard Column Cartridge	UHPLC	5 x 2.1 mm	3-pk.	9309U0252
	UHPLC	5 x 3.0 mm	3-pk.	9309U0253
	2.7 µm	5 x 2.1 mm	3-pk.	9309A0252
	2.7 µm	5 x 3.0 mm	3-pk.	9309A0253
	2.7 µm	5 x 4.6 mm	3-pk.	9309A0250
	5 µm	5 x 2.1 mm	3-pk.	930950252
	5 µm	5 x 3.0 mm	3-pk.	930950253
	5 µm	5 x 4.6 mm	3-pk.	930950250
Raptor FluoroPhenyl EXP Guard Column Cartridge	UHPLC	5 x 2.1 mm	3-pk.	9319U0252
	UHPLC	5 x 3.0 mm	3-pk.	9319U0253
Raptor FluoroPhenyl EXP Guard Column Cartridges	2.7 µm	5 x 2.1 mm	3-pk.	9319A0252
	2.7 µm	5 x 3.0 mm	3-pk.	9319A0253
	2.7 µm	5 x 4.6 mm	3-pk.	9319A0250
	5 µm	5 x 2.1 mm	3-pk.	931950252
	5 µm	5 x 3.0 mm	3-pk.	931950253
	5 µm	5 x 4.6 mm	3-pk.	931950250
Raptor HILIC-Si EXP Guard Column Cartridge	2.7 µm	5 x 2.1 mm	3-pk.	9310A0252
	2.7 µm	5 x 3.0 mm	3-pk.	9310A0253
	2.7 µm	5 x 4.6 mm	3-pk.	9310A0250
Raptor Polar X EXP Guard Column Cartridge	2.7 µm	5 x 2.1 mm	3-pk.	9311A0252 NEW!

Maximum cartridge pressure: 1,034 bar/15,000 psi* (UHPLC), 600 bar/8,700 psi (2.7 µm); 400 bar/5,800 psi (5 µm)
* For maximum lifetime, recommended maximum pressure for UHPLC particles is 830 bar/12,000 psi.
Intellectual Property: optimizetech.com/patents

RESTEK
Pure Chromatography

Questions? Contact us or your local Restek representative (www.restek.com/contact-us).

www.restek.com

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