Enhancing Sensitivities and Peak Capacities for UHPLC-MS Fast Gradient Analyses When Exploiting the Properties of 2.6 µm Kinetex® Core-Shell Columns

James Rudge1, David Neville[2], Richard Houghton[2], Chris Message[1], and Jeremy Bierman[3]
[1] Phenomenex LTD, Queens Avenue, Hurdsfield Industrial Estate, Macclesfield, Cheshire, SK10 2BN, United Kingdom
[3] Phenomenex, Inc., 411 Madrid Ave., Torrance, CA 90501 USA
[2] Quotient Bioresearch Ltd., Newmarket Road, Fordham, Cambridgeshire, CB7 5WW, United Kingdom

When compared to 1.7 µm fully porous materials, the ultra-high efficiency and low backpressures provided by Kinetex core-shell 2.6 µm columns, provides users opportunities to go beyond what is traditionally accepted for UHPLC runs. To match backpressures exerted by 1.7 µm fully porous columns, large increases in core-shell column length and/or system flow rate is required. When gradient conditions are maintained, increases in flow rate and length result in an increase in peak capacity on the order of 26 %. When MS conditions are optimized to compensate for new flow rates, sensitivity increases of up to 3.5 times are observed and furthermore, peak capacity figures increase by almost 70 %.

Introduction

The introduction of Kinetex core-shell columns has brought dramatic benefits to chromatographers. The high efficiency shown from the 2.6 µm core-shell particle has allowed users to run ultra-high performance separations on HPLC and UHPLC systems alike. Moreover, the larger particle size of the Kinetex 2.6 µm material compared to 1.7 µm fully porous particles significantly reduces backpressures by a factor of ~40 %. This decrease in backpressure provides users an opportunity to exploit flow rates and/or column lengths to allow for faster UHPLC run times, higher peak capacities, and improvements in peak sensitivities.

Improvements in peak capacity can be realized if gradient rates are not changed and flow rates and/or column lengths are increased. The reason for this is that when the same gradient rate is applied, faster flow rates act to volumetrically lower gradients. However, if column length is increased and gradient time is also increased (with respect to the change in length) then it is known that again peak capacity values will increase due to the increased efficiency of the longer column, but this comes at the expense of increased run times.

Improved peak capacities observed over identical gradient windows are due to a reduction in peak widths. If smaller peak widths are observed, then this should give an opportunity for larger peak heights and hence better peak sensitivity. However, attention should be given to optimizing the detector to realize this benefit fully.

The work discussed in this technical note demonstrates performance advantages when operating 2.6 µm Kinetex core-shell particle columns under conditions that deliver backpressures matching that of a 50 x 2.1 mm fully porous 1.7 µm C18 column that is operated at traditional UHPLC flow rates (0.8 mL per minute) for a 2.1 mm ID column.

Materials and Methods

All analytes were purchased from Sigma-Aldrich.

Laboratory:
All work was carried out by Quotient Bioresearch Laboratories.

Columns Used:
A fully porous 1.7 µm C18, 50 x 2.1 mm column was compared with Kinetex 2.6 µm C18, 50 x 2.1 mm, 75 x 2.1 mm, and 100 x 2.1 mm columns from Phenomenex.

Instrumentation:
Waters ACQUITY® Binary UPLC®
AB SCIEX API 5000™

Mobile Phase Preparation:
Solutions of 0.1 % formic acid in water and acetonitrile

Standard Solution Preparation:
A 0.5 ng/mL solution containing the following analytes was prepared in water.

1. Haloperidol
2. Diltiazem
3. Terfenadine
4. Cimetidine
5. Acetaminophen
6. Sulfathiazole
7. Pindolol
8. Quinidine
9. Acebutolol
10. Chlorpheniramine
11. Tripolidine
12. Prednisolone
13. Nortriptyline
14. 2-Hydroxy-5-methyl benzaldehyde
15. Hexanophenone

Experiment 1 – Performance comparison between 2.6 µm Kinetex core-shell column and 1.7 µm fully porous column at the same flow rate and then at the same pressure on varying column lengths:
A 5 µL sample of all 15 components was injected with a gradient chromatographic separation using an initial flow rate of 0.8 mL/min over 2.5 minutes on a fully porous C18 1.7 µm, 50 x 2.1 mm column and then on a Kinetex C18 2.6 µm, 50 x 2.1 mm column. To match the backpressure of the fully porous column (531 bar, 7700 psi), the flow rate was then increased to 1.4 mL/min on the Kinetex column. Next a Kinetex C18 2.6 µm, 75 x 2.1 mm column

was taken and run at 1.1 mL/min, again to match the backpressure of the fully porous column. Finally, a Kinetex C18 2.6 µm, 100 x 2.1 mm Kinetex column was taken and run at 0.85 mL/min, again to run at the same backpressure of the fully porous 1.7 µm column at 0.8 mL per minute. All columns were maintained at 40 °C and data was collected using MS detection (For initial MS conditions see **Table 6**, column **2**).

Conditions are the same for all columns, except where noted.

Column: Kinetex 2.6 µm C18 100 Å
Fully Porous 1.7 µm C18
Dimensions: Kinetex: 50 x 2.1 mm, 75 x 2.1 mm, and 100 x 2.1 mm
Fully Porous: 50 x 2.1 mm
Flow Rate: 0.8, 1.1, and 1.4 and 0.85 mL/min
Mobile Phase: A: 0.1% Formic acid in Water
B: 0.1% Formic acid Acetonitrile
Gradient:

Time (min)	% A
0.00	95
0.25	95
1.80	10
1.90	10
1.91	95
2.50	95

Temperature: 40 °C

Experiment 2 – Observed performance under optimized running conditions with an optimized MS detector:

Aliquots of 5 µL of the analyte mix were repeatedly injected with a gradient chromatographic separation using an initial flow rate of 0.8 mL/min on a Kinetex C18 2.6 µm, 50 x 2.1 mm column and the total run time was 2.5 minutes. Peak height, peak width, and peak capacity data was collected. Following this, the instrument flow rate was increased to 1.4 mL/min and the data was collected again. The columns were maintained at 40 °C with MS detection where the source was optimized for each flow rate (see "Opt 0.8 mL/min" and "Opt 1.4 mL/min" columns of **Table 2**). To increase the number of data points across each peak, subsets of analytes were grouped into 4 groups of 3 and MRM data was collected for three masses per run. **Table 1** lists each group and their respective parent and product ions.

Conditions are the same for all columns, except where noted.

Column: Kinetex 2.6 µm C18 100 Å
Fully Porous 1.7 µm C18
Dimensions: 50 x 2.1 mm
Flow Rate: 0.8 and 1.4 mL/min
Mobile Phase: A: 0.1% Formic acid in Water
B: 0.1% Formic acid Acetonitrile
Gradient:

Time (min)	% A
0.00	95
0.25	95
1.80	10
1.90	10
1.91	95
2.50	95

Temperature: 40 °C

Experiment 3 – Measured effect of optimized MS detector on observed performance under sub-optimal running conditions:
Aliquots of 5 µL of the analyte mix were repeatedly injected with a gradient chromatographic separation using an initial flow rate of 0.8 mL/min on a fully porous C18 1.7 µm, 50 x 2.1 mm column and on a Kinetex C18 2.6 µm, 50 x 2.1 mm column. The total run time was 2.5 minutes and peak height, peak width, and peak capacity data was collected at a flow rate optimized for 0.8 mL per minute (Program A). Using the Kinetex column, the instrument flow rate was increased to 1.4 mL/min (Program B) and the data was collected again. Finally, at 1.4 mL per minute, the gradient was adjusted with respect to the change in flow rate from 0.8 to 1.4 mL per minute. The columns were maintained at 40 °C with MS detection where the source was optimized for each flow rate (see "Opt 0.8 mL/min" and "Opt 1.4 mL/min" columns of **Table 2**). Like Experiment 2, to increase the number of data points across each peak, subsets of analytes were grouped into 4 groups of 3 and MRM data was collected for three masses per run. **Table 1** lists each group and their respective parent and product ions.

Conditions are the same for all columns, except where noted.

Column: Kinetex 2.6 µm C18 100 Å
Fully Porous 1.7 µm C18
Dimensions: 50 x 2.1 mm
Flow Rate: 0.8 and 1.4 mL/min
Mobile Phase: A: 0.1% Formic acid in Water
B: 0.1% Formic acid Acetonitrile
Gradient:

Program A (0.8 mL/min)		Program B (1.4 mL/min)	
Time (min)	% A	Time (min)	% A
0.00	95	0.00	95
0.25	95	0.25	95
1.80	10	1.80	10
1.90	10	1.90	10
1.91	95	1.91	95
2.50	95	2.50	95

Temperature: 40 °C

Table 1.
List of grouped analytes and their respective parent and product ions.

Group Number	Sample Name	Q1 mass (m/z)	Q3 mass (m/z)	Dwell time (ms)
Group 1	Acetaminophen	152.2	110.1	50
	Cimetidine	253.2	159.1	50
	Pindolol	249.3	116.1	50
Group 2	Sulfathiazole	256.1	91.9	50
	Chlorpheniramine	275.2	230	50
	Triprolidine	279.4	208.1	50
Group 3	Diltiazem	415.3	178.1	50
	Terfenadine	472.4	436.4	50
	Acebutolol	337.3	116.2	50
Group 4	Haloperidol	376.3	123	50
	Quinidine	325.3	79.1	50
	Nortriptyline	264.3	91.1	50

Mass Spectrometric Source Conditions:

Table 2.
Mass spectrometer (MS) source conditions

Parameter	Initial	Opt 0.8 mL/min	Opt 1.4 mL/min
CAD (PSI)	7	4	7
Curtain gas (PSI)	30	30	30
Gas1 (PSI)	50	40	50
Gas2 (PSI)	40	50	50
IS (eV)	5500	2000	2000
TEM (°C)	650	750	750

Opt = Optimized flow rate

Results and Discussion

Experiment 1

The fully porous and Kinetex® 50 x 2.1 mm columns were initially run at 0.8 mL per minute. The backpressures for both columns were recorded and adjusted gradient peak capacity values were then calculated.

Figures 1 and **2** illustrate that both the fully porous and Kinetex 50 x 2.1 mm columns gave comparable peak capacity figures (see **Table 3**). The small change was due to the difference in adjusted retention window (1.285 min for the fully porous column and 1.187 min for Kinetex). In fact, the average peak widths were slightly narrower for the Kinetex (0.036 min) compared to the fully porous column (0.037 min). As expected there was a large disparity in backpressure, 7700 psi for the fully porous column vs 4600 psi for Kinetex. This change in backpressure was exploited where the flow rate on the Kinetex column was increased to 1.4 mL/min to match the backpressure of the 1.7 µm fully porous column. **Figure 3** and **Table 3** shows that the resulting change in flow rate caused the average peak width to reduce by ~30 % and the peak capacity to increase by 26 %. The increase in performance was attributed to the fact that the number of column volumes had increased per percent of organic thus had volumetrically lowered the gradient.

When the column length of the Kinetex was increased to 75 mm and the flow rate was altered to 1.1 mL per minute such that the backpressure matched the 50 x 2.1 mm fully porous column at 0.8 mL per minute, a performance gain was again seen (see **figure 4**, **table 3**). In fact, the increase in peak capacity (n = 42.3) almost matched the peak capacity of the Kinetex 50 x 2.1 mm column run at 1.4 mL per minute (n = 43.5). However, the reason behind this gain was not due to a volumetric lowering of the gradient, but due to the increased efficiency manifested in the longer column length. The volumetric gradient remained almost identical to the 50 x 2.1 mm column run at 0.8 mL/min.

To see if increasing the length to 100 mm provided any further benefits, a Kinetex 2.6 µm, 100 x 2.1 mm was then run at 0.85 mL per minute to match the backpressure of the 50 x 2.1 mm, 1.7 µm fully porous column. The resulting peak capacity (n = 34.6) was almost the same as the fully porous material (see **Table 3**). The reason for this was that there were almost half the number of column volumes passed down the longer column. So although the 100 mm length column would have been a lot more efficient than the 50 mm length 1.7 µm fully porous column, the gradient had been volumetrically steepened and so any gains in performance due to efficiency would have been negated by a contraction of the gradient.

Figure 1.
LC/MS chromatogram of the fully porous 1.7 µm, C18, 50 x 2.1 mm at 0.8 mL/min

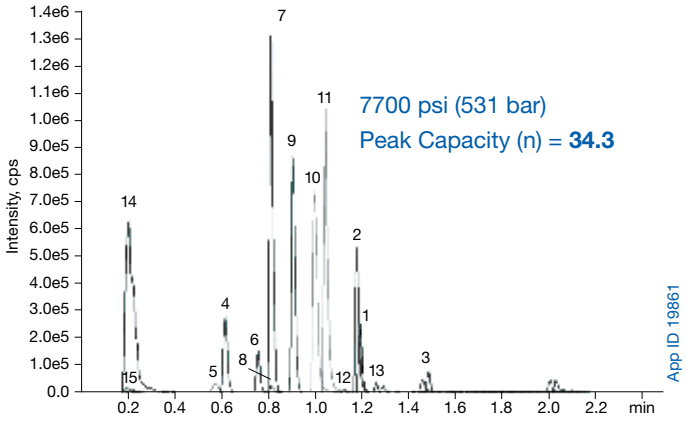

Figure 2.
LC/MS chromatogram of Kinetex 2.6 µm C18, 50 x 2.1 mm at 0.8 mL/min

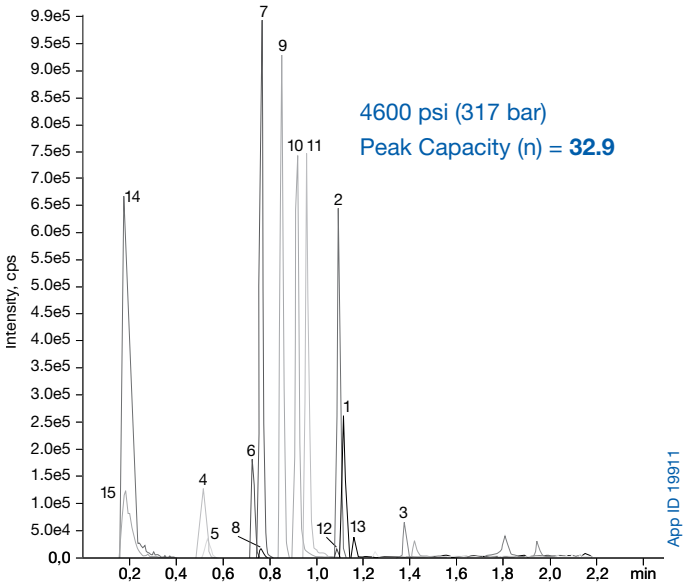

Figure 3.
LC/MS chromatogram of Kinetex® 2.6 µm C18, 50 x 2.1 mm at 1.4 mL/min

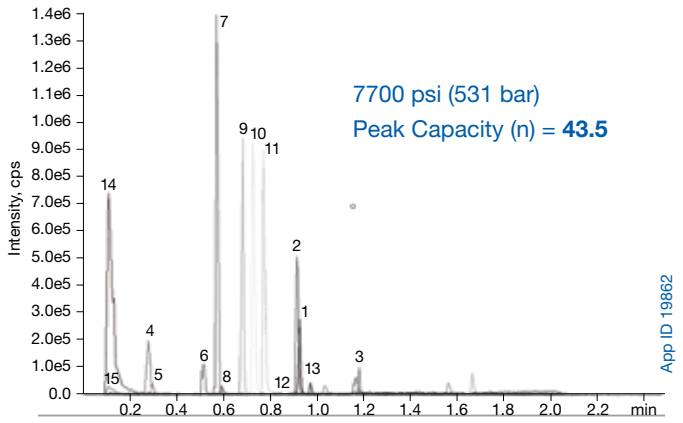

Figure 4.
LC/MS chromatogram of Kinetex 2.6 µm C18, 75 x 2.1 mm at 1.1 mL/min

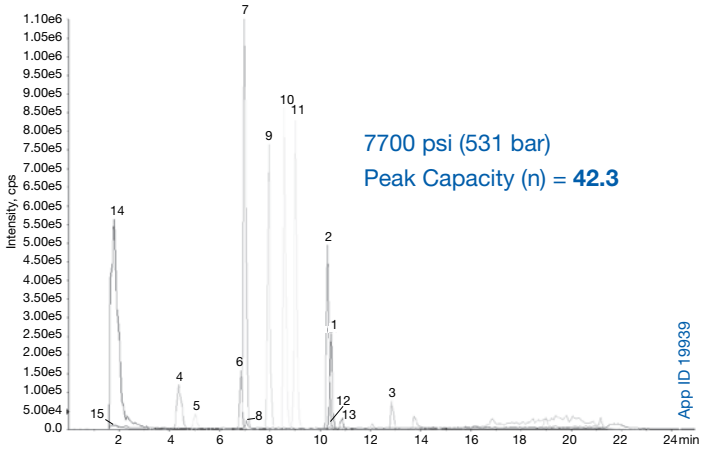

Figure 5.
LC/MS chromatogram of Kinetex 2.6 µm C18, 100 x 2.1 mm at 0.85 mL/min

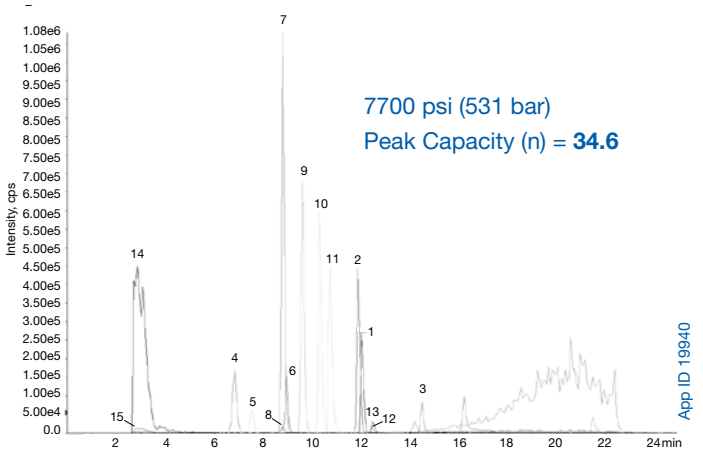

Table 3.
Performance comparison summary of Kinetex 2.6 µm vs. 1.7 µm fully porous columns for Experiment 1

Sample Name	PW_{ave} (min)	dRT (min)	Peak Capacity (n)
Fully Porous C18 1.7 µm, 50 x 2.1 mm @ 0.8 mL/min	0.037	1.29	34.4
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 0.8 mL/min	0.036	1.19	32.9
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 1.4 mL/min	0.025	1.08	43.6
Kinetex C18 2.6 µm, 75 x 2.1 mm @ 1.1 mL/min	0.026	1.12	42.4
Kinetex C18 2.6 µm, 100 x 2.1 mm @ 0.85 mL/min	0.034	1.17	34.6

From the above results it was concluded that Kinetex 2.6 µm core-shell columns run at 1.4 mL per minute was optimal in terms of peak width and peak capacity. Nevertheless, it was noticed that although column performance had improved, peak sensitivities had dropped. It was hypothesized that the reason for this drop in sensitivity was due to the fact that the MS had not been optimized for the change in flow rate and hence source modifications would be required to rectify this. Moreover it was also concluded that an increase in the mass dwell time per MRM may also improve peak sensitivity. Work was then done to optimize the MS and acquire masses in small groups to allow for an increase in the mass dwell time.

Experiment 2

To observe if peak sensitivity is recovered when running under more optimal MS conditions for the faster flow rate, it was decided to run just the basic analytes in the mix (9) as these provided the best peak sensitivity and peak shape in Experiment 1 (**Figure 6**, **7**, and **8**). The results (see **Table 4**) indicated again a big increase in peak capacity (52 %), however, unexpectedly peak heights increased too, ranging from a 7 % increase to around 3.5 times increase (**Figure 9**). It was concluded that the MS optimization allowed for more effective desolvation thus allowing more ions into the MS source. Furthermore, due to running small groups, the MS was able to detect the peak apexes more effectively under the optimized conditions.

Figure 6.
Group 1 analytes on Kinetex® C18 2.6 µm, 50 x 2.1 mm at 0.8 and 1.4 mL/min respectively under optimal MS conditions for each flow rate.

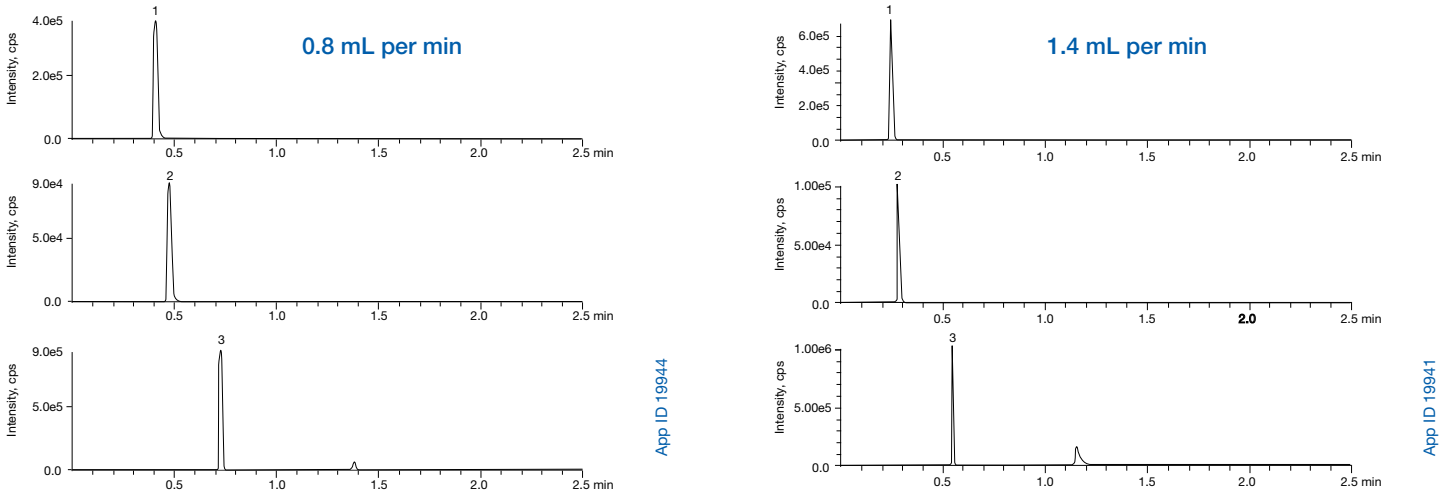

Figure 7.
Group 2 analytes on Kinetex C18 2.6 µm, 50 x 2.1 mm at 0.8 and 1.4 mL/min respectively under optimal MS conditions for each flow rate.

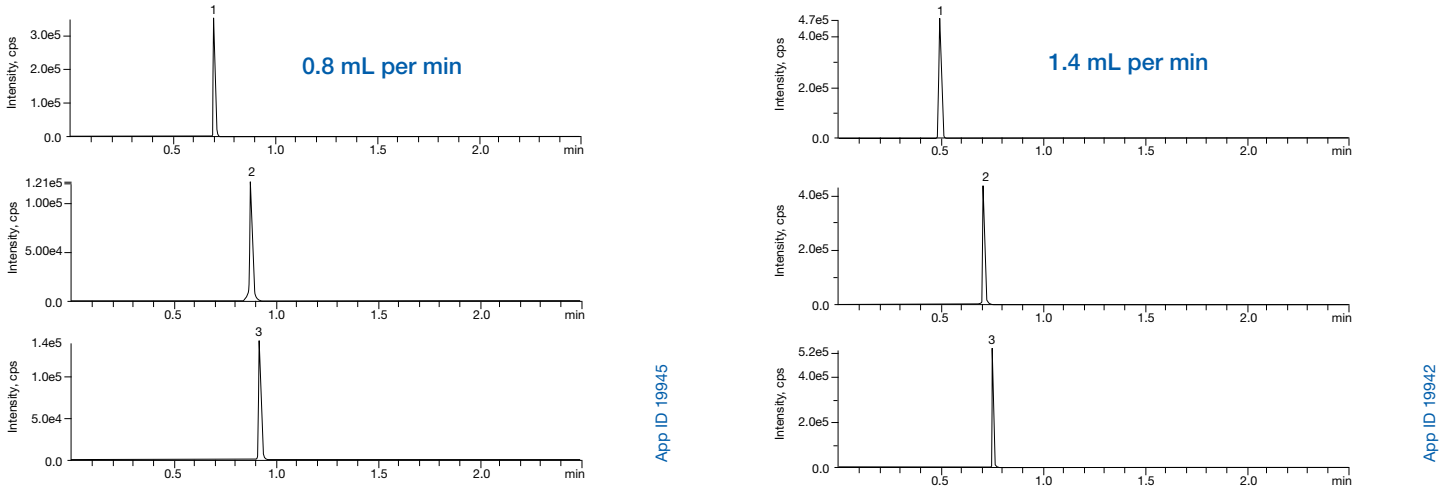

Figure 8.
Group 3 analytes on Kinetex C18 2.6 µm, 50 x 2.1 mm at 0.8 and 1.4 mL/min respectively under optimal MS conditions for each flow rate.

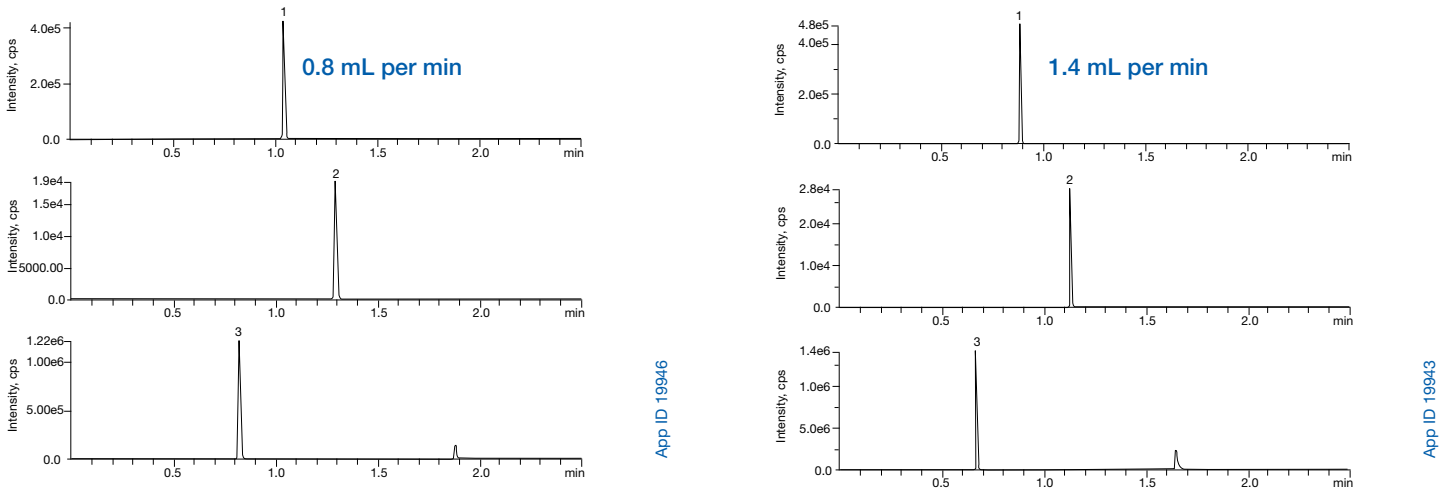

Figure 9.
Peak height data for all analytes tested under optimized MS conditions for each flow rate. (The 0.8 mL per minute data was normalized to 1.)

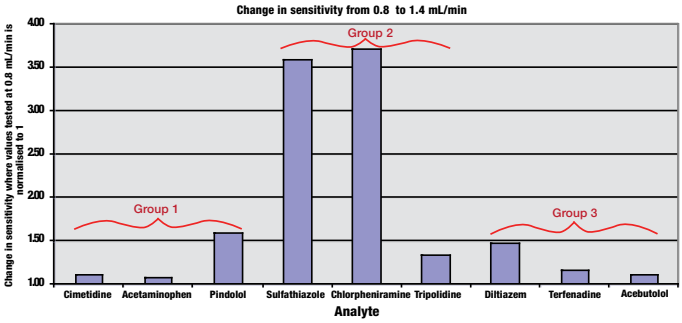

Table 4.
Performance comparison summary of Kinetex run at 0.8 and 1.4 mL per minute respectively

Conditions	PW_{ave} (min)	dRT (min)	Peak Capacity (n)
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 0.8 mL/min	0.024	0.88	36.0
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 1.4 mL/min	0.016	0.89	54.9

It was concluded that the MS optimization allowed for more effective desolvation and this helped to improve peak sensitivities. Furthermore, as the peak widths were so narrow the MS was able to detect the peak apexes more effectively under the optimized conditions. Thus it was decided to compare the fully porous 1.7µm column with Kinetex 2.6 µm under optimized MS conditions.

Experiment 3

Kinetex® C18 2.6 µm, 50 x 2.1 mm columns were compared with fully porous 1.7 µm columns at 0.8 mL/min under optimal mass spec conditions for that flow rate. It was found that the Kinetex columns gave a slightly, but not significantly, higher peak capacity. However, when the Kinetex columns were run at 1.4 mL per minute significant increases in peak capacity (around 70 %) were observed (see **Figure 11** and **Table 5**). Finally, when the gradient rate was increased such that the number of column volumes matched the run at 0.8 mL/min, the consequence was to reduce the run time to 1.5 minutes. This resulted in reducing the peak capacity to the same level as the fully porous column run at 0.8 mL/min over the original 1.5 minutes. Furthermore, as shown in **Figure 10**, sensitivity improvements were again observed when the Kinetex column was run at the faster 1.4 mL per minute flow rate.

Figure 10.
Sensitivity results for Experiment 3

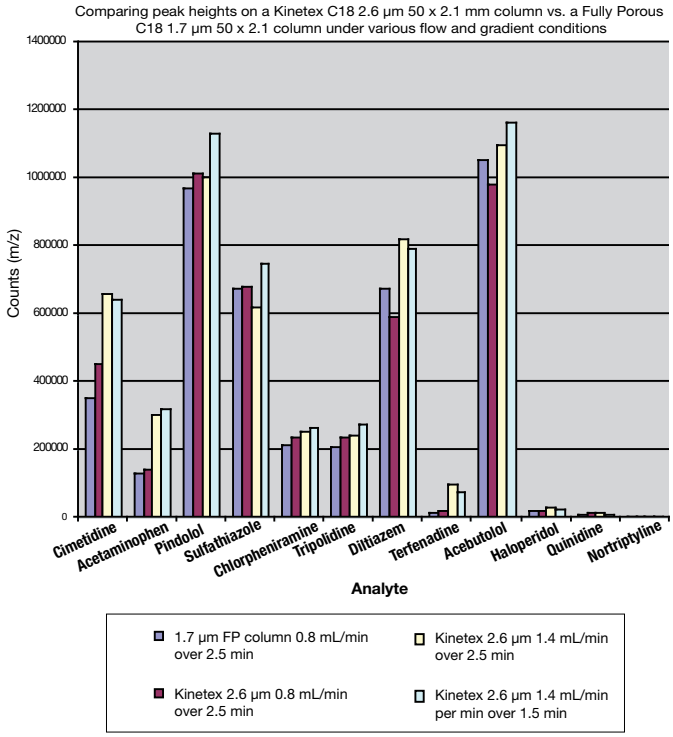

Figure 11.
Peak Capacity Data for Experiment 3

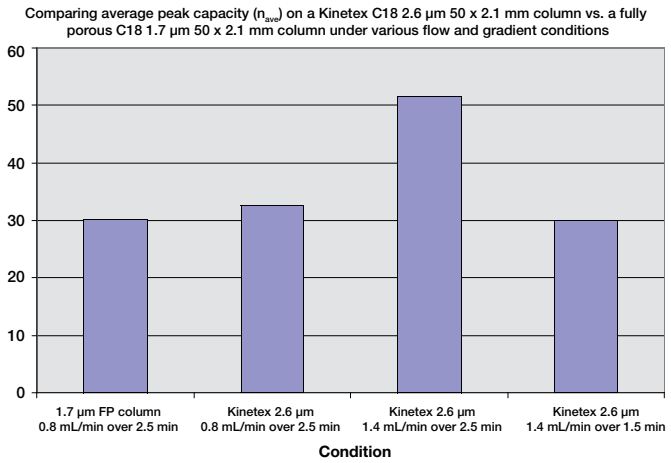

Table 5.
Summary of peak capacity data for Experiment 3

Conditions	PW_{ave} (min)	dRT (min)	Peak Capacity (n)
Fully Porous C18 1.7 µm, 50 x 2.1 mm @ 0.8 mL/min (2.5 min)	0.029	0.87	30.1
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 0.8 mL/min (2.5 min)	0.027	0.88	32.5
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 1.4 mL/min (2.5 min)	0.017	0.89	51.6
Kinetex C18 2.6 µm, 50 x 2.1 mm @ 1.4 mL/min (1.5 min)	0.017	0.50	30.0

APPLICATIONS

Conclusion

Kinetex columns packed with 2.6 µm core-shell particles offer big advantages over fully porous 1.7 µm columns. The lower back-pressure can be utilized to run columns at flow rates which would normally be impossible to reach on UHPLC instruments due to instrument and material pressure limits. The observed reduced resistance to flow of Kinetex compared to 1.7 µm columns, but comparable efficiency can be used to gain much higher peak capacities when run under fast gradient conditions. Moreover, by steepening the gradient conditions with respect to the change in flow rate, then run times can be reduced without loss of performance. When MS conditions are optimized to the change in flow rate, then significant sensitivity improvements are also observed.

2.6 µm Material Characteristics

Packing Material	Total Particle Size (µm)	Porous Shell (µm)	Solid Core (µm)	Pore Size (Å)	Effective Surface Area (m^2/g)	Effective Carbon Load %	pH Stability	Pressure Stability
Kinetex XB-C18	2.6	0.35	1.9	100	200	10	1.5 - 8.5**	1000/600* bar
Kinetex C18	2.6	0.35	1.9	100	200	12	1.5 - 8.5**	
Kinetex C8	2.6	0.35	1.9	100	200	8	1.5 - 8.5**	
Kinetex PFP	2.6	0.35	1.9	100	200	9	1.5 - 8.5**	
Kinetex HILIC	2.6	0.35	1.9	100	200	0	2.0 - 7.5	
Kinetex Phenyl-Hexyl	2.6	0.35	1.9	100	200	11	1.5 - 8.5**	

** Columns are pH stable from 1.5-10 under isocratic conditions. Columns are pH stable 1.5-8.5 under gradient conditions.

* 2.1 mm ID Kinetex columns are pressure stable up to 1000 bar.

1.7 µm Material Characteristics

Packing Material	Total Particle Size (µm)	Porous Shell (µm)	Solid Core (µm)	Pore Size (Å)	Effective Surface Area (m^2/g)	Effective Carbon Load %	pH Stability	Pressure Stability
Kinetex XB-C18	1.7	0.23	1.25	100	200	10	1.5 - 8.5**	1000 bar
Kinetex C18	1.7	0.23	1.25	100	200	12	1.5 - 8.5**	
Kinetex C8	1.7	0.23	1.25	100	200	8	1.5 - 8.5**	
Kinetex PFP	1.7	0.23	1.25	100	200	9	1.5 - 8.5**	
Kinetex HILIC	1.7	0.23	1.25	100	200	0	2.0 - 7.5	
Kinetex Phenyl-Hexyl	1.7	0.23	1.25	100	200	11	1.5 - 8.5**	

When using Kinetex 1.7 µm, increased performance can be achieved, however higher pressure-capable instrumentation is required.

Kinetex® Ordering Information

2.6 µm Analytical Columns (mm)

	30 x 4.6	50 x 4.6	75 x 4.6	100 x 4.6	150 x 4.6	SecurityGuard ULTRA Cartridges 3/pk
XB-C18	—	00B-4496-E0	00C-4496-E0	00D-4496-E0	00F-4496-E0	AJ0-8768
C18	00A-4462-E0	00B-4462-E0	00C-4462-E0	00D-4462-E0	00F-4462-E0	AJ0-8768
C8	—	00B-4497-E0	00C-4497-E0	00D-4497-E0	00F-4497-E0	AJ0-8770
PFP	00A-4477-E0	00B-4477-E0	00C-4477-E0	00D-4477-E0	00F-4477-E0	AJ0-8773
HILIC	00A-4461-E0	00B-4461-E0	00C-4461-E0	00D-4461-E0	00F-4461-E0	AJ0-8772
Phenyl-Hexyl	—	00B-4495-E0	—	00D-4495-E0	00F-4495-E0	AJ0-8774
						for 4.6 mm ID

1.7 µm Minibore Columns (mm)

	30 x 2.1	50 x 2.1	100 x 2.1	150 x 2.1	SecurityGuard ULTRA Cartridges* 3/pk
XB-C18	00A-4498-AN	00B-4498-AN	00D-4498-AN	00F-4498-AN	AJ0-8782
C18	00A-4475-AN	00B-4475-AN	00D-4475-AN	00F-4475-AN	AJ0-8782
C8	00A-4499-AN	00B-4499-AN	00D-4499-AN	00F-4499-AN	AJ0-8784
PFP	00A-4476-AN	00B-4476-AN	00D-4476-AN	00F-4476-AN	AJ0-8787
HILIC	00A-4474-AN	00B-4474-AN	00D-4474-AN	—	AJ0-8786
Phenyl-Hexyl	—	00B-4500-AN	00D-4500-AN	00F-4500-AN	AJ0-8788
					for 2.1 mm ID

2.6 µm MidBore™ Columns (mm)

	30 x 3.0	50 x 3.0	75 x 3.0	100 x 3.0	150 x 3.0	SecurityGuard ULTRA Cartridges 3/pk
XB-C18	00A-4496-Y0	00B-4496-Y0	00C-4496-Y0	00D-4496-Y0	00F-4496-Y0	AJ0-8775
C18	00A-4462-Y0	00B-4462-Y0	00C-4462-Y0	00D-4462-Y0	00F-4462-Y0	AJ0-8775
C8	00A-4497-Y0	00B-4497-Y0	00C-4497-Y0	00D-4497-Y0	00F-4497-Y0	AJ0-8777
PFP	00A-4477-Y0	00B-4477-Y0	00C-4477-Y0	00D-4477-Y0	00F-4477-Y0	AJ0-8780
HILIC	00A-4461-Y0	—	—	—	00F-4461-Y0	AJ0-8779
Phenyl-Hexyl	—	—	—	—	—	AJ0-8781
						for 3.0 mm ID

1.7 µm MidBore Columns (mm)

	30 x 3.0	50 x 3.0	100 x 3.0	SecurityGuard ULTRA Cartridges 3/pk
XB-C18	00A-4498-Y0	00B-4498-Y0	00D-4498-Y0	AJ0-8775
C18	—	00B-4475-Y0	00D-4475-Y0	AJ0-8775
C8	00A-4499-Y0	00B-4499-Y0	00D-4499-Y0	AJ0-8777
PFP	—	—	00D-4476-Y0	AJ0-8780
HILIC	—	00B-4474-Y0	—	AJ0-8779
Phenyl-Hexyl	—	—	—	AJ0-8781
				for 3.0 mm ID

2.6 µm Minibore Columns (mm)

	30 x 2.1	50 x 2.1	75x 2.1	100 x 2.1	150 x 2.1	SecurityGuard ULTRA Cartridges 3/pk
XB-C18	00A-4496-AN	00B-4496-AN	00C-4496-AN	00D-4496-AN	00F-4496-AN	AJ0-8782
C18	00A-4462-AN	00B-4462-AN	00C-4462-AN	00D-4462-AN	00F-4462-AN	AJ0-8782
C8	00A-4497-AN	00B-4497-AN	00C-4497-AN	00D-4497-AN	00F-4497-AN	AJ0-8784
PFP	00A-4477-AN	00B-4477-AN	00C-4477-AN	00D-4477-AN	00F-4477-AN	AJ0-8787
HILIC	00A-4461-AN	00B-4461-AN	00C-4461-AN	00D-4461-AN	00F-4461-AN	AJ0-8786
Phenyl-Hexyl	—	00B-4495-AN	—	00D-4495-AN	—	AJ0-8788
						for 2.1 mm ID

* SecurityGuard ULTRA cartridges require holder, Part No. AJ0-9000

APPLICATIONS

Australia
t: 02-9428-6444
f: 02-9428-6445
auinfo@phenomenex.com

Austria
t: 01-319-1301
f: 01-319-1300
anfrage@phenomenex.com

Belgium
t: +31 (0)30-2418700
f: +31 (0)30-2383749
beinfo@phenomenex.com

Canada
t: (800) 543-3681
f: (310) 328-7768
info@phenomenex.com

Denmark
t: 4824 8048
f: 4810 6265
nordicinfo@phenomenex.com

Finland
t: +358 (0)9 4789 0063
f: +45 4810 6265
nordicinfo@phenomenex.com

France
t: 01 30 09 21 10
f: 01 30 09 21 11
franceinfo@phenomenex.com

Germany
t: 06021-58830-0
f: 06021-58830-11
anfrage@phenomenex.com

India
t: 040-3012 2400
f: 040-3012 2411
indiainfo@phenomenex.com

Ireland
t: 01 247 5405
f: +44 1625-501796
eireinfo@phenomenex.com

Italy
t: 051 6327511
f: 051 6327555
italiainfo@phenomenex.com

Luxembourg
t: +31 (0)30-2418700
f: +31 (0)30-2383749
nlinfo@phenomenex.com

Mexico
t: 001-800-844-5226
f: 001-310-328-7768
tecnicomx@phenomenex.com

The Netherlands
t: 030-2418700
f: 030-2383749
nlinfo@phenomenex.com

New Zealand
t: 09-4780951
f: 09-4780952
nzinfo@phenomenex.com

Norway
t: +47 810 02 005
f: +45 4810 6265
nordicinfo@phenomenex.com

Puerto Rico
t: (800) 541-HPLC
f: (310) 328-7768
info@phenomenex.com

United Kingdom
t: 01625-501367
f: 01625-501796
ukinfo@phenomenex.com

All other countries:
Corporate Office USA
t: (310) 212-0555
f: (310) 328-7768
info@phenomenex.com

www.phenomenex.com
Phenomenex products are available worldwide. For the distributor in your country, contact Phenomenex USA, International Department at international@phenomenex.com

If Kinetex analytical columns do not provide at least an equivalent separation as compared to a competing column of the same phase and dimensions, return the column with comparative data within 45 days for a FULL REFUND.

Terms and Conditions
Subject to Phenomenex Standard Terms & Conditions, which may be viewed at www.phenomenex.com/TermsAndConditions

Trademarks
Kinetex is a registered trademark of Phenomenex, Inc. in the United States, European Union, and other jurisdictions. MidBore is a registered trademark of Phenomenex, Inc. Waters, ACQUITY, and UPLC are registered trademarks of Waters Corporation. API 5000 is a trademark of AB Sciex Pte. Ltd. AB SCIEX™ is being used under license.

Disclaimers
Comparative separations may not be representative of all applications. Phenomenex is not affiliated with Waters Corporation.

TN891908111_L