



# HICHROM

Chromatography Columns and Supplies

## LC COLUMNS HALO and HALO-5

Catalogue 9

### Hichrom Limited

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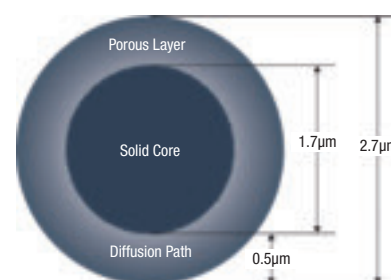
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- Silica-based Fused-Core® particle technology
- Use with conventional HPLC or UHPLC systems
- Highly robust columns
- Wide range of bonded phases
- Narrow particle size distribution
- Stable to 9000psi (600 bar)
- 2.7µm and 5µm particles

The HALO® 2.7µm materials from Advanced Materials Technology are the original phases manufactured using innovative Fused-Core particle technology. These particles comprise a 1.7µm solid core and a 0.5µm porous outer shell (see Figure 1). HALO columns provide the efficiency and separation speed of sub 2µm particles but at approximately half the back pressure for the same column length. This lower pressure means that HALO can be used with conventional HPLC and LC-MS systems, as well as with UHPLC systems. The newer HALO-5 columns consist of 5µm particles produced using the same Fused-Core technology. Please see page 128 for further details of HALO-5 columns.

Figure 1. Fused-Core particle technology



### HALO Phases<sup>3</sup>

HALO Phase	Particle Size (µm)	Pore Size (Å)	Surface Area (m <sup>2</sup> /g)	Carbon Load (%)	Endcapped	pH Range
C18	2.7 <sup>1</sup>	90	150	7.7	Yes	2 - 9
C8	2.7 <sup>1</sup>	90	150	5.4	Yes	2 - 9
HILIC (Silica)	2.7 <sup>1</sup>	90	150	-	No	1 - 8
RP-Amide	2.7 <sup>1</sup>	90	150	8.2	Yes	2 - 9
Phenyl-Hexyl	2.7 <sup>1</sup>	90	150	7.1	Yes	2 - 9
PFP	2.7 <sup>1</sup>	90	150	5.5	Yes	2 - 8
Peptide ES-C18	2.7 <sup>1</sup>	160	80	4.6	No	1 - 8
ES-CN	2.7 <sup>1</sup>	90	150	3.5	Yes	1 - 8
Penta-HILIC	2.7 <sup>1</sup>	90	150	3.2	No	2 - 9
HALO-5 C18	5 <sup>2</sup>	90	90	5.5	Yes	2 - 9
HALO-5 C8	5 <sup>2</sup>	90	90	3.7	Yes	2 - 9
HALO-5 PFP	5 <sup>2</sup>	90	90	3.9	Yes	2 - 9
HALO-5 Phenyl-Hexyl	5 <sup>2</sup>	90	90	5.2	Yes	2 - 9
HALO-5 ES-CN	5 <sup>2</sup>	90	90	2.5	Yes	2 - 9

<sup>1</sup> 1.7µm solid core particle with 0.5µm porous silica layer fused to surface

<sup>2</sup> Solid core particle with 0.6µm porous silica layer fused to surface

<sup>3</sup> Additional phases available – please enquire.

## Features of HALO 2.7µm Columns

### High Efficiency Separations

HALO and sub 2µm columns of the same dimensions give approximately the same number of theoretical plates, but HALO columns offer greatly reduced back pressures. These lower back pressures enable longer HALO columns to be used, thereby providing increased efficiency and improved resolving power, compared to sub 2µm columns. Fused-Core particles have a shorter diffusion path (0.5µm) compared to totally porous particles. This shorter diffusion path reduces axial dispersion of solutes and minimises peak broadening. The performance advantages of HALO become even more apparent when separating larger solute molecules and operating at faster eluent flow rates.

### Super-rugged Columns

HALO particles have a very narrow particle size distribution and a higher density than totally porous particles. This combination results in the production of rugged and reliable columns with excellent column-to-column reproducibility. The narrow particle size distribution also enables the use of 2µm porosity frits with HALO columns, thereby minimising the potential plugging problems often associated with sub 2µm columns (which generally require 0.5µm, or smaller, frits).

### Hyper-fast Separations

Compared to sub 2µm particles, the HALO 2.7µm particles generate approximately half the back pressure. This enables longer columns and faster flow rates to be used. Hyper-fast separations that have efficiency and resolution equal to sub 2µm particle columns can therefore be achieved on HALO at increased flow rates, but with similar back pressures. Figure 2 shows the separation of benzoic acids in less than 1 minute.

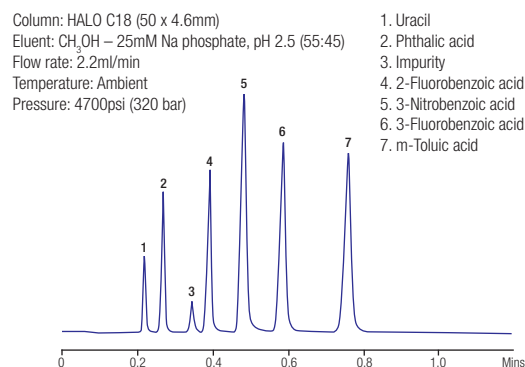


Figure 2. Fast separation of benzoic acids

## Features of HALO® 2.7µm Columns (continued)

### Pressure Considerations

As particle size decreases, the column back pressure increases rapidly. The use of sub 2µm particle size columns at their optimum flow rate often leads to pressures  $\geq 6000$  psi, therefore requiring specialised UHPLC instrumentation. Due to their Fused-Core® technology HALO® columns can not only be used with UHPLC equipment but can also be used with most existing HPLC equipment. In figure 3, Advanced Materials Technology have illustrated the low back pressure typically seen with a HALO 2.7µm Fused-Core technology column, compared to a sub 2µm particle size column.

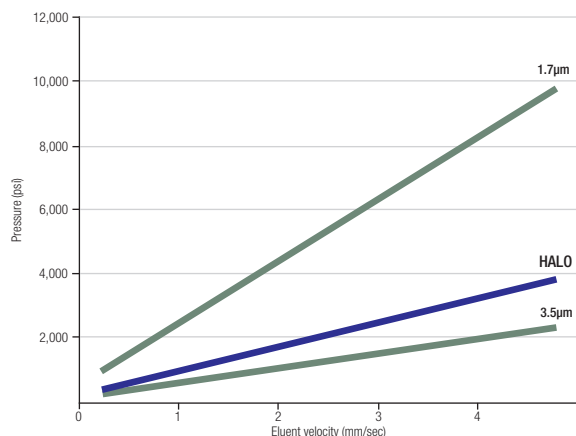


Figure 3. Comparison of column back-pressure\*

\*The comparative data presented here may not be representative for all applications.

## HALO 2.7µm Phases

### HALO C18 and HALO C8

HALO C18 and HALO C8 show excellent performance for a broad range of analyte polarities. Separations are due primarily to hydrophobic interactions and differences in hydrophobicity between analytes.

### HALO RP-Amide

HALO RP-Amide columns offer complementary selectivity to HALO C18 and C8 and are recommended for samples containing acidic and basic compounds that require high aqueous eluents. Separations are influenced by both hydrophobic interaction with the alkyl chains and hydrogen bonding with the embedded amide group (see Figure 4). Proprietary bonding chemistry leads to excellent stability and extremely low bleed characteristics, making HALO RP-Amide particularly well suited for LC-MS applications. Figure 5 illustrates the alternative selectivity offered by HALO RP-Amide compared to HALO C18.

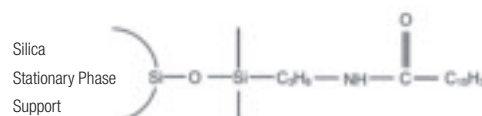


Figure 4. Structure of HALO RP-Amide

### HALO Phenyl-Hexyl

HALO Phenyl-Hexyl can retain analytes via several separation mechanisms including  $\pi$ - $\pi$  interactions and hydrophobic interactions. It is particularly recommended for compounds containing aromatic groups and for compounds requiring high aqueous eluents.

### HALO ES-CN

HALO ES-CN is a moderately polar phase for alternative selectivity, showing increased retention of polar compounds. It features Extra Stable (ES) bonding.

### HALO PFP

HALO PFP is particularly well suited for the separation of halogenated compounds, nitro-aromatic compounds and polar bases, with separations being primarily influenced by hydrogen bonding and dipole-dipole interactions. It has low bleed and is ideal for LC-MS applications. In addition, polar compounds that are poorly retained in the reversed-phase mode can be separated using the HILIC mode with HALO PFP. Figure 6 illustrates the HILIC separation of basic drugs using higher organic content eluent.

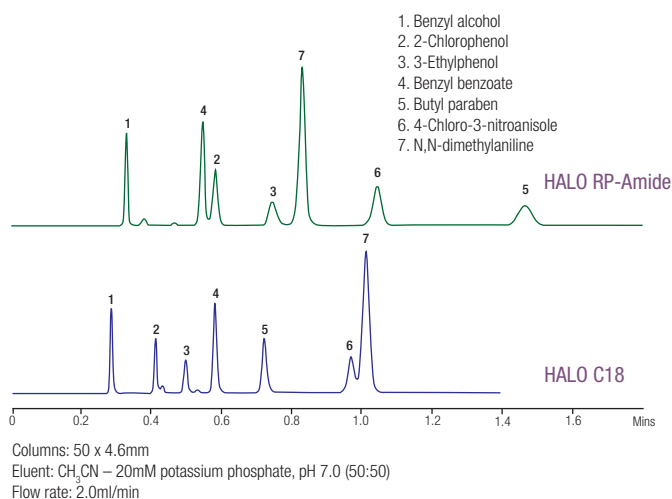


Figure 5. Comparison of selectivity of HALO RP-Amide and HALO C18

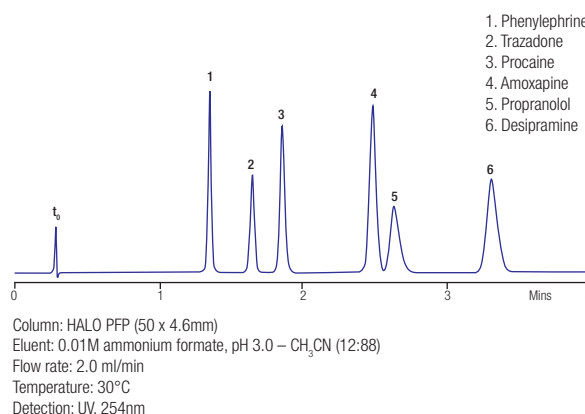


Figure 6. HILIC separation on HALO PFP

## HALO® 2.7µm Phases (continued)

### HALO Peptide ES-C18

HALO® Peptide ES-C18 columns are specifically designed for ultra-fast and ultra-high resolution separation of peptides. A larger pore size (160Å) and Extra Stable (ES) bonding chemistry provides optimum separation of peptides up to 20kDa. This extra stable bonding is achieved by bonding the silica surface with organosilanes with bulky side groups. These bulky side groups sterically protect the siloxane bond from acid hydrolysis (see Figure 7). Figure 8 illustrates the high speed separation of 9 peptides and 2 proteins in less than a minute with HALO Peptide ES-C18. For high resolution separations, longer HALO Peptide ES-C18 columns can be used. Additionally, due to the lower back pressures offered by Fused-Core particles, two columns can be connected in series for the separation of complex mixtures such as tryptic digests, as demonstrated in Figure 9.

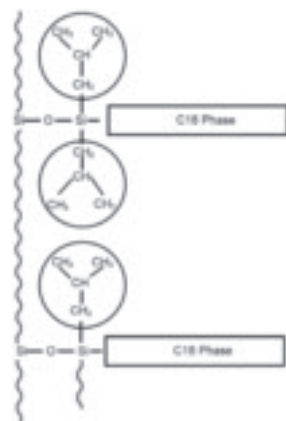


Figure 7. Extra Stable (ES) bonded phase

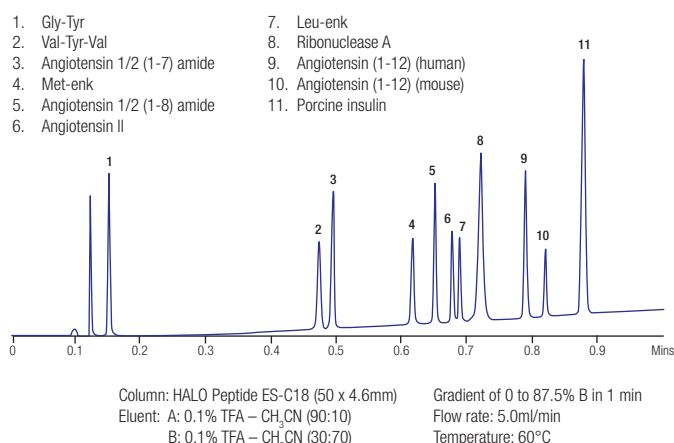


Figure 8. High speed separation using HALO Peptide ES-C18

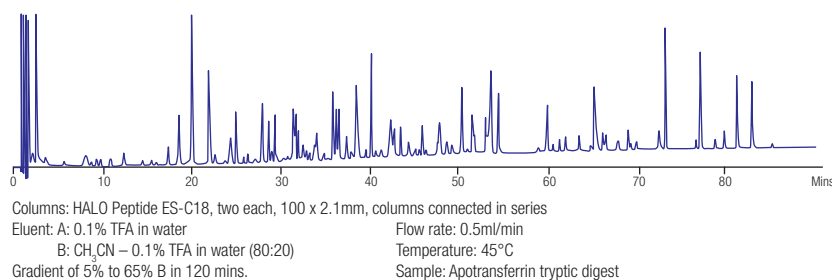


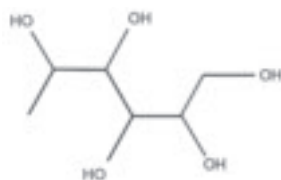
Figure 9. High resolution separation with HALO Peptide ES-C18

### HALO HILIC (Silica)

HALO HILIC can be used in both HILIC and normal-phase modes. It shows enhanced sensitivity and peak shape for LC-MS analyses of basic analytes.

### HALO Penta-HILIC

HALO Penta-HILIC is particularly well suited for the separation of highly polar compounds that are poorly retained under typical reversed-phase conditions. Columns are compatible with LC-MS eluents and exhibit low bleed. HALO Penta-HILIC uses proprietary bonding chemistry that includes five hydroxyl groups on the bonded ligand. The phase is not endcapped, in order to maintain the high polarity of the material surface. The high density and polarity of the bonded phase minimise ion-exchange effects with residual silanols. Figure 10 shows the separation of four strongly basic anti-ulcer drugs in less than 2 minutes on HALO Penta-HILIC.



Structure of HALO Penta-HILIC

Column: HALO Penta-HILIC (100 x 4.6mm)  
Eluent: 0.04M ammonium formate, pH 3.0 – CH<sub>3</sub>CN (10:90)  
Flow rate: 3.0ml/min  
Temperature: 30°C  
Detection: UV, 254nm

1. Cimetidine
2. Nizatidine
3. Famotidine
4. Ranitidine

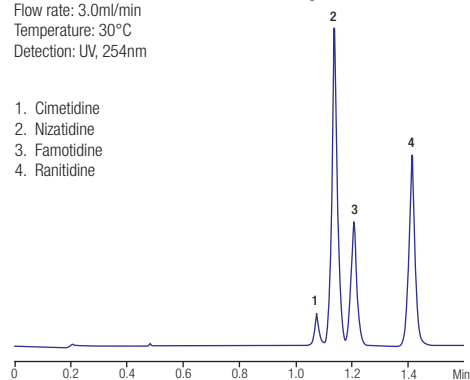


Figure 10. Fast separation on HALO Penta-HILIC

### Microbore and Capillary Columns

HALO columns with 1.0mm i.d. and capillary dimensions of 75, 100, 200 and 300µm i.d. are also available. Please contact Hichrom for ordering details.

## HALO®-5

- 5µm phases based on Fused-Core® particle technology
- High efficiencies
- Low back pressure (for use with any HPLC instrument)
- Scalable from UHPLC separations developed on 2.7µm HALO columns
- Stable to 9000psi (600 bar)

The original 2.7µm HALO® columns were designed as 'UHPLC-like' columns suitable for use with both UHPLC and HPLC instruments. The same proven Fused-Core® particle technology has now been used in the creation of a new generation of 5µm HALO HPLC columns, suitable for use with traditional HPLC equipment.

HALO-5 particles are based on ultra-pure silica consisting of a solid core particle with a 0.6µm porous silica layer fused to the surface. C18, C8, PFP, Phenyl-Hexyl and ES-CN bonded phases are initially available. These superficially porous technology columns show extremely high plate numbers compared with conventional porous 5µm phases and the equivalent or higher plate numbers compared with conventional 3µm columns, but with half the pressure (as illustrated by Advanced Materials Technology in Figure 11). HALO-5 was developed to boost the speed and resolution capability of HPLC to near-UHPLC levels.

In general, columns packed with larger particles produce higher efficiency per unit of column back pressure than columns packed with smaller particles. HALO-5 Fused-Core particle columns have been shown to have a plates-per-pressure ratio significantly higher than seen with other columns packed with totally porous particles of the same (5µm) particle size. For a given operating pressure, HALO-5 columns will deliver approximately twice the efficiency of a column packed with 5µm totally porous particles. This feature is particularly useful when developing a separation of a very complex mixture.

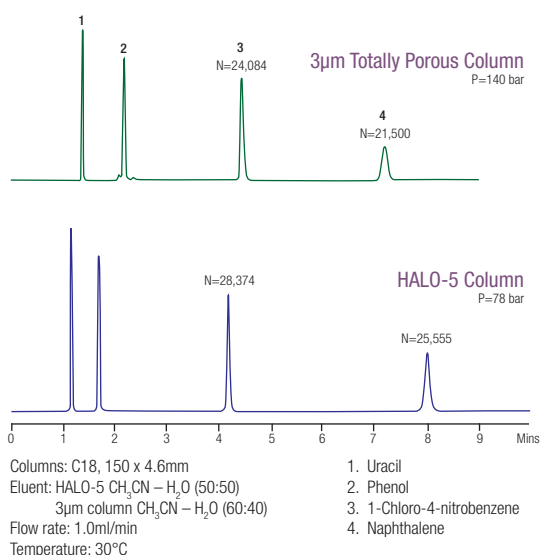


Figure 11. Higher efficiency at lower pressure\*

\*The comparative separations presented here may not be representative for all applications.

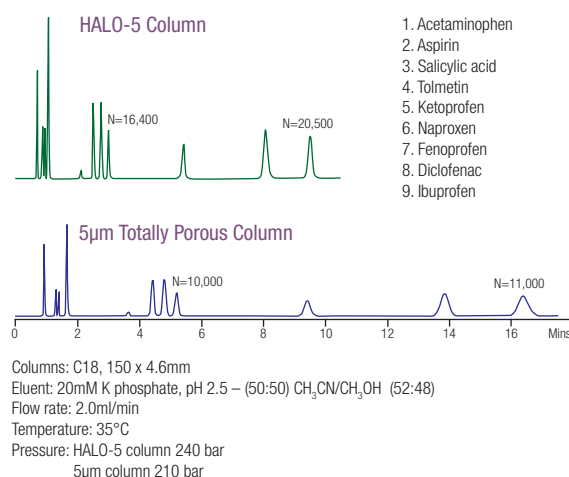


Figure 12. Fast separation and high resolution\*

\*The comparative separations presented here may not be representative for all applications.

In figure 12 Advanced Materials Technology demonstrate the faster separation achieved using a HALO-5 superficially porous C18 column compared to a 5µm totally porous column, for a mixture of non-steroidal anti-inflammatory drugs.

Figure 13 illustrates the comparable selectivity shown by HALO-5 Phenyl-Hexyl and 2.7µm HALO Phenyl-Hexyl for a mixture of anticoagulants, illustrating the ease of method transfer between the two particle size phases. The slight adjustment in flow rate is to compensate for differences in packed column volume.

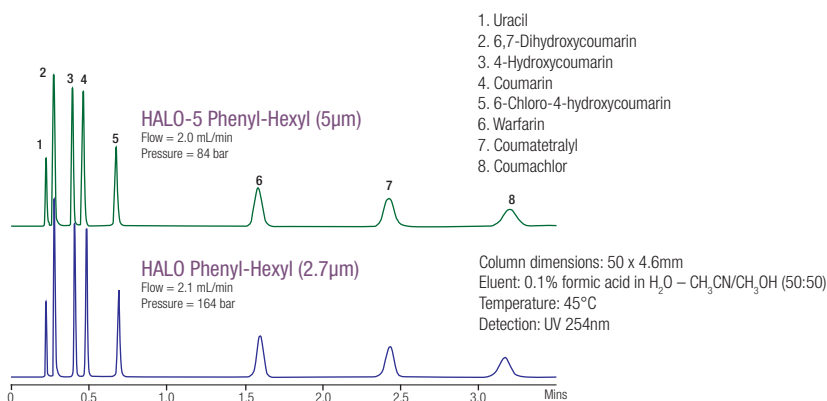


Figure 13. Comparable selectivity of HALO-5 Phenyl-Hexyl and 2.7µm HALO Phenyl-Hexyl

**Ordering Information – HALO® and HALO-5 Columns**
**HALO 2.7µm Columns**

HALO 2.7µm Phase	Column Dimensions <sup>1</sup> (mm)						Guard Cartridges <sup>2</sup> (3/pk)
	20 x 2.1	30 x 2.1	50 x 2.1	75 x 2.1	100 x 2.1	150 x 2.1	
C18	92812-202	92812-302	92812-402	92812-502	92812-602	92812-702	92812-102
C8	92812-208	92812-308	92812-408	92812-508	92812-608	92812-708	92812-108
HILIC (Silica)	92812-201	92812-301	92812-401	92812-501	92812-601	92812-701	92812-101
Phenyl-Hexyl	92812-206	92812-306	92812-406	92812-506	92812-606	92812-706	92812-106
PFP	92812-209	92812-309	92812-409	92812-509	92812-609	92812-709	92812-109
Peptide ES-C18	92122-202	92122-302	92122-402	92122-502	92122-602	92122-702	92122-102
ES-CN	92812-204	92812-304	92812-404	92812-504	92812-604	92812-704	92812-104
Penta-HILIC	92812-205	92812-305	92812-405	92812-505	92812-605	92812-705	92812-105

RP-Amide	92812-207	92812-307	92812-407	92812-507	92812-607	92812-707	92812-107
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HALO 2.7µm Phase	Column Dimensions (mm)						Guard Cartridges <sup>2</sup> (3/pk)
	20 x 3.0	30 x 3.0	50 x 3.0	75 x 3.0	100 x 3.0	150 x 3.0	
C18	92813-202	92813-302	92813-402	92813-502	92813-602	92813-702	92813-102
C8	92813-208	92813-308	92813-408	92813-508	92813-608	92813-708	92813-108
HILIC (Silica)	92813-201	92813-301	92813-401	92813-501	92813-601	92813-701	92813-101
Phenyl-Hexyl	92813-206	92813-306	92813-406	92813-506	92813-606	92813-706	92813-106
PFP	-	92813-309	92813-409	92813-509	92813-609	92813-709	92813-109
Peptide ES-C18	-	92123-302	92123-402	92123-502	92123-602	92123-702	92123-102
ES-CN	-	92813-304	92813-404	92813-504	92813-604	92813-704	92813-104
Penta-HILIC	-	92813-305	92813-405	92813-505	92813-605	92813-705	92813-105

RP-Amide	92813-207	92813-307	92813-407	92813-507	92813-607	92813-707	92813-107
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HALO 2.7µm Phase	Column Dimensions (mm)						Guard Cartridges <sup>2</sup> (3/pk)
	20 x 4.6	30 x 4.6	50 x 4.6	75 x 4.6	100 x 4.6	150 x 4.6	
C18	92814-202	92814-302	92814-402	92814-502	92814-602	92814-702	92814-102
C8	92814-208	92814-308	92814-408	92814-508	92814-608	92814-708	92814-108
HILIC (Silica)	92814-201	92814-301	92814-401	92814-501	92814-601	92814-701	92814-101
Phenyl-Hexyl	92814-206	92814-306	92814-406	92814-506	92814-606	92814-706	92814-106
PFP	-	92814-309	92814-409	92814-509	92814-609	92814-709	92814-109
Peptide ES-C18	-	92124-302	92124-402	92124-502	92124-602	92124-702	92124-102
ES-CN	-	92814-304	92814-404	92814-504	92814-604	92814-704	92814-104
Penta-HILIC	-	92814-305	92814-405	92814-505	92814-605	92814-705	92814-105

RP-Amide	92814-207	92814-307	92814-407	92814-507	92814-607	92814-707	92814-107
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<sup>1</sup> Other column dimensions available    <sup>2</sup> Use with guard cartridge holder 94900-001

**HALO-5 5µm Columns**

HALO-5 5µm Phase	Column Dimensions (mm)							Guard Cartridges <sup>1</sup> (3/pk)
	20 x 2.1	30 x 2.1	50 x 2.1	75 x 2.1	100 x 2.1	150 x 2.1	250 x 2.1	
C18	95812-202	95812-302	95812-402	95812-502	95812-602	95812-702	95812-902	95812-102
C8	95812-208	95812-308	95812-408	95812-508	95812-608	95812-708	95812-908	95812-108
PFP	95812-209	95812-309	95812-409	95812-509	95812-609	95812-709	95812-909	95812-109
Phenyl-Hexyl	95812-206	95812-306	95812-406	95812-506	95812-606	95812-706	95812-906	95812-106
ES-CN	95812-204	95812-304	95812-404	95812-504	95812-604	95812-704	95812-904	95812-104
	<b>20 x 3.0</b>	<b>30 x 3.0</b>	<b>50 x 3.0</b>	<b>75 x 3.0</b>	<b>100 x 3.0</b>	<b>150 x 3.0</b>	<b>250 x 3.0</b>	

C18	-	95813-302	95813-402	95813-502	95813-602	95813-702	95813-902	95813-102
C8	-	95813-308	95813-408	95813-508	95813-608	95813-708	95813-908	95813-108
PFP	-	95813-309	95813-409	95813-509	95813-609	95813-709	95813-909	95813-109
Phenyl-Hexyl	-	95813-306	95813-406	95813-506	95813-606	95813-706	95813-906	95813-106
ES-CN	-	95813-304	95813-404	95813-504	95813-604	95813-704	95813-904	95813-104

	<b>20 x 4.6</b>	<b>30 x 4.6</b>	<b>50 x 4.6</b>	<b>75 x 4.6</b>	<b>100 x 4.6</b>	<b>150 x 4.6</b>	<b>250 x 4.6</b>	
C18	-	95814-302	95814-402	95814-502	95814-602	95814-702	95814-902	95814-102
C8	-	95814-308	95814-408	95814-508	95814-608	95814-708	95814-908	95814-108
PFP	-	95814-309	95814-409	95814-509	95814-609	95814-709	95814-909	95814-109
Phenyl-Hexyl	-	95814-306	95814-406	95814-506	95814-606	95814-706	95814-906	95814-106
ES-CN	-	95814-304	95814-404	95814-504	95814-604	95814-704	95814-904	95814-104

<sup>1</sup> Use with guard cartridge holder 94900-001