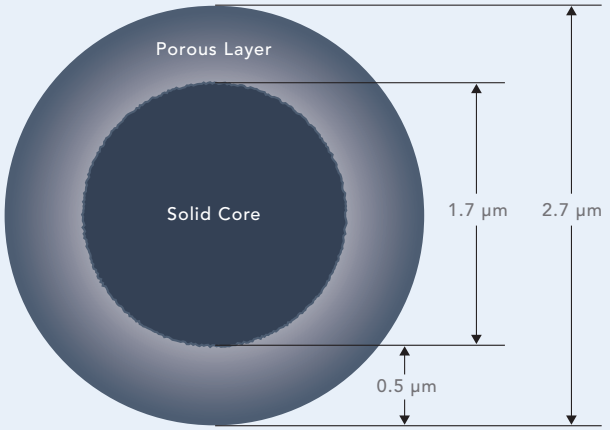

HALO®
PRODUCT BULLETIN
Fused-Core® particle technology
for hyper-fast and super-rugged
HPLC columns

HALO®

Not like other fast HPLC columns

HALO® column packings are not made the typical way. Instead, the particles packed into HALO columns are manufactured using Fused-Core® particle technology that was specially developed to deliver hyper-fast chromatographic separations while avoiding the reliability issues so often associated with fast HPLC (*Figure 1*).

FIGURE 1: HALO Fused-Core particle



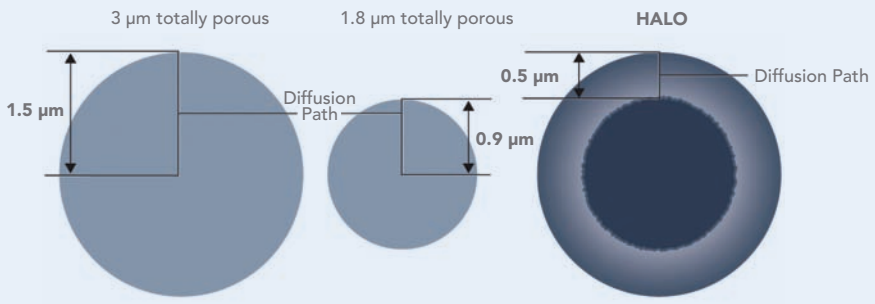
Fused-Core particle technology was developed by Jack Kirkland to produce HPLC columns that provide faster separations and higher sample throughput without sacrificing column ruggedness and reliability. As the name implies, Fused-Core particles are manufactured by "fusing" a porous silica layer onto a solid silica particle.

HALO® particles are designed for hyper-fast separations at modest column back pressure

The ability of HALO to generate hyper-fast separations comes not only from their small particle size (2.7 µm) but also from the unique Fused-Core® particle technology that creates a 0.5 µm porous shell fused to a solid core particle. As mobile phase flow rate is increased to speed up a separation, the slow mass transfer of solute molecules inside the particles limits resolving power. Fused-Core particle technology addresses this limitation by providing an incredibly small path (0.5 µm) for diffusion of solutes into and out of the stationary phase, thereby reducing the time solute molecules spend inside the particles and minimizing a major barrier to fast chromatographic separations (*Figure 2*).

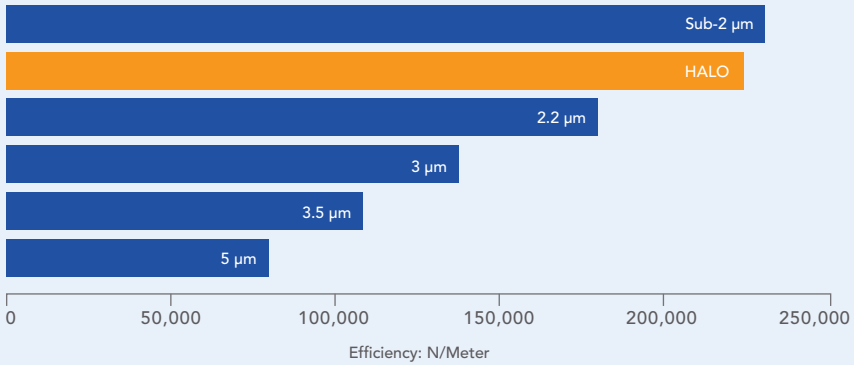
> *"The fused-core silica column providing the reduced diffusional mass transfer path allows the use of shorter columns and higher flow rates to achieve remarkably fast high-resolution separations."*
>
> Analytical Chemistry, August 2007

FIGURE 2: The shorter diffusion path of HALO reduces axial dispersion



The shorter diffusion path of HALO particles reduces axial dispersion of solutes and minimizes peak broadening. Because of the shorter diffusion path, the performance advantages of HALO become even more apparent when separating larger solute molecules and operating at faster mobile phase flow rates.

FIGURE 3: HALO columns deliver more separating power



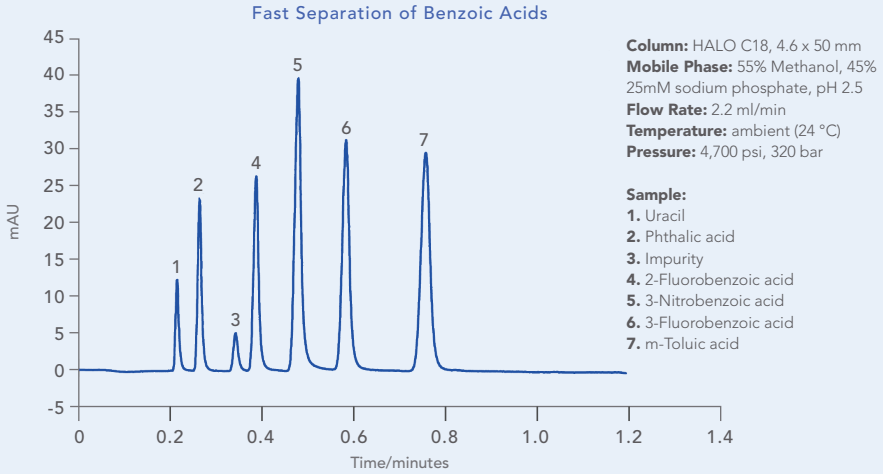
HALO columns deliver over 90% more separating power (theoretical plates) than columns of the same length packed with 3.5 µm particles and almost three times the separating power of columns packed with 5 µm particles.

Note: N/Meter values were calculated at the optimum mobile phase linear velocity for each of these stationary phases.

HALO columns deliver over 90% more separating power (theoretical plates) than a column of the same length packed with 3.5 µm particles and almost three times the plates of a column packed with 5 µm particles (*Figure 3*).

And, because of Fused-Core particle technology, HALO columns maintain their resolving power at high flow rates. This means that shorter columns and higher flow rates can be used to achieve remarkably fast high resolution separations (*Figure 4*).

FIGURE 4: HALO columns are designed for hyper-fast HPLC separations.



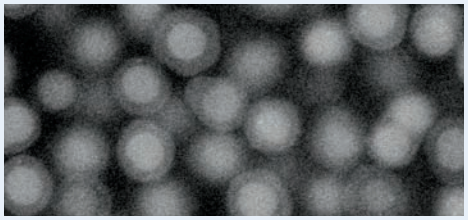
HALO columns are designed for hyper-fast separations so that higher sample throughput can be achieved. In this example, the HALO column separated seven compounds in less than 48 seconds with better than baseline resolution for all peak pairs.

> *"The unusually high efficiency for columns of these particles is believed to be a feature of the very narrow particle size distribution and the higher particle density."*
>
> American Laboratory, April 2007

HALO® columns are designed to be super-rugged

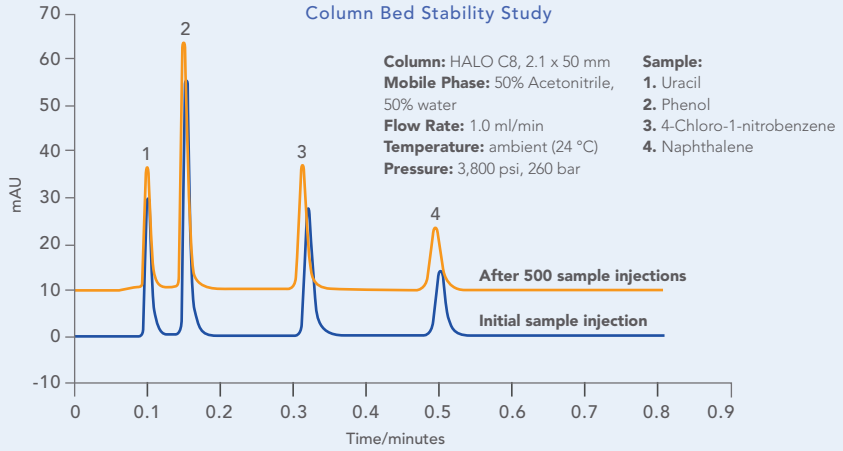
Packing HPLC columns can be as much art as it is science. There are many variables that have to be optimized in order to pack a column well for even non-high throughput applications. But, the demands placed upon columns used in high speed applications, i.e., high flow rate and high pressure, make it especially difficult to pack a column that will hold-up for a satisfactory period of time. HALO particles facilitate the packing process in two ways. First, the unique Fused-Core® particle technology produces particles that have extremely narrow size distribution. Second, these particles are significantly more dense than conventional totally porous particles, allowing them to be more easily packed into stable and efficient columns. This combination of extremely narrow particle size distribution and very dense particles allows the production of columns that are incredibly rugged and reliable, as well as very reproducible from column to column (*Figure 5*).

FIGURE 5: Scanning electron microscope (SEM) photograph of HALO particles



This SEM photograph of HALO particles illustrates two important attributes of this unique column packing. First, the incredibly narrow particle size distribution is apparent. Second, this SEM photo shows some of the HALO particles "sliced in half" so that the solid core and the porous outer layer, the "halo" of the particles, is evident.

FIGURE 6: Stability testing of a HALO HPLC column



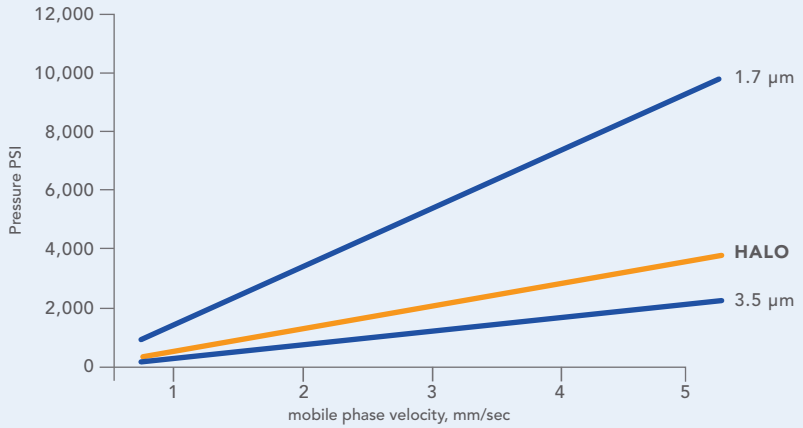
A HALO column was run under high flow conditions to test bed stability. After 500 sample injections and over 40,000 column volumes, there was no evidence of any change to the packing bed.

Also of importance, the extremely narrow particle size distribution permits the use of 2 µm porosity inlet frits on the HALO columns. This is the same inlet frit porosity typically found on columns packed with 5 µm particles. The result is a column capable of delivering incredibly high sample throughput, much higher than 3 µm packed columns, but with the ease of use and durability of a column packed with 5 µm particles (*Figure 6*). Who says you can't have both high speed and ruggedness? HALO delivers both.

HALO® columns do not require ultra-high pressure

Fused-Core® particle technology produces hyper-fast columns that can be used on practically all HPLC systems. Figure 7 provides a comparison of system back pressure for the HALO column versus other fast HPLC columns. Columns packed with stationary phases smaller than 2 µm often require pressures in excess of what is achievable with typical HPLC instrumentation. A very real bonus that comes with using a HALO column is that expensive ultra-high pressure instrumentation does not have to be purchased and new laboratory protocols do not have to be developed. HALO columns can turn almost any HPLC system into a high speed workhorse for your lab.

FIGURE 7: Comparison of column back pressure



Most HPLC systems have operating pressure limits of 6,000 psi (400 bar), or less. As the column packing particle size decreases, the column back pressure increases rapidly. To use columns packed with sub-2 µm size particles at their optimum flow rate, pressure that exceeds 6,000 psi is often encountered.This necessitates purchasing very expensive "ultra-pressure" equipment to achieve optimum performance. HALO columns, even though they do generate slightly higher back pressure than columns packed with 3.5 µm particles, can be used with most existing HPLC equipment.

The science behind HALO

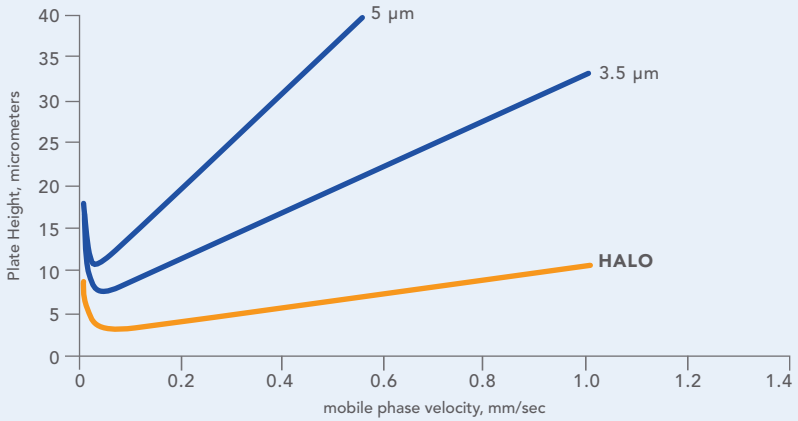
The well known van Deemter equation identifies the three main sources of band broadening.

$$H = A + B/\mu + C\mu$$

The value of the A term, eddy diffusion, reflects the multiple flow paths through a column. Packing particle size, particle size distribution, and the uniformity of the packed bed all determine the value of A. Because of the high density and extremely narrow size distribution of Fused-Core particles, HPLC columns can be packed with well ordered beds that have A term values significantly smaller than what is typically seen with columns packed with totally porous particles. This is one of the reasons that HALO columns deliver column plate numbers that are much higher than what would normally be expected from their particle size.

The C term of the van Deemter equation, the coefficient of mass transfer, reflects the time it takes for analyte to diffuse in and out of the stationary phase. The C term is directly related to mobile phase velocity because higher velocity interferes with the equilibrium between the analyte, mobile phase and stationary phase. The longer the path an analyte has to travel within the pores of the stationary phase support particles, the more detrimental the effect of mobile phase velocity will be on column efficiency.

FIGURE 8: Comparison of van Deemter plots



Van Deemter plots are a convenient way to compare the efficiency of HPLC columns. In this comparison we see that HALO columns are more efficient than columns packed with 5 µm or 3.5 µm particles and that they can be run at higher mobile phase linear velocity and still maintain their resolving power.

FUSED-CORE TECHNOLOGY

Fused-Core technology was developed by Jack Kirkland. Dr. Kirkland is widely regarded as one of the "founders" of HPLC and is well recognized for his research and contribution to the understanding of chromatography. He's authored over 150 major research publications, and 6 textbooks. Dr. Kirkland holds over 30 patents, and has received several prestigious awards within the field of chromatography.

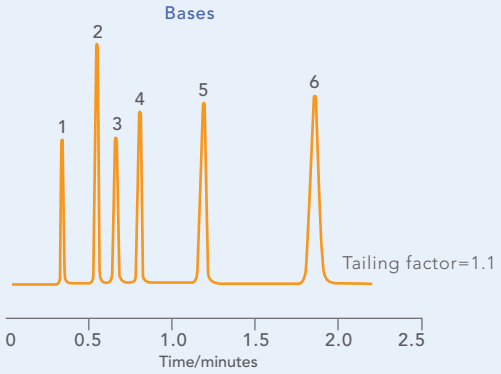
The path a solute has to travel within the pores of a stationary phase support particle can be reduced by using smaller size particles and this is typically the strategy that is used by column manufacturers when making columns for fast HPLC. Smaller particles have shorter diffusion path lengths and, therefore, are less affected by increases in mobile phase velocity. HALO particles, by virtue of their 0.5 µm porous shell, have reduced the diffusional mass transfer path by one third compared to 3 µm particles. As the molecular size of the solute increases, its diffusion rate slows, making this effect even greater. The result is a column that can achieve faster separations and higher sample throughput.

> *"Columns packed with the shell HALO particles exhibit most impressive performance and prove most advantageous for the analysis of low and moderate weight compounds."*
>
> Journal of Chromatography A, May 2007

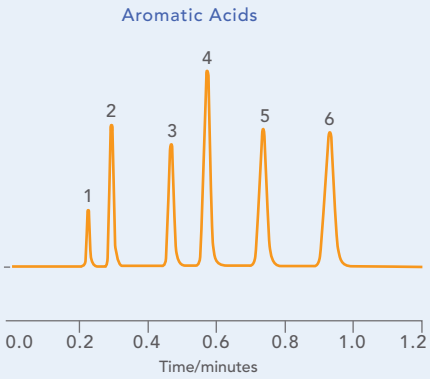
HALO is base-deactivated for excellent peak shape

HALO stationary phases are made using ultra-pure reagents and "Type B" silica. The peak shapes for bases and acids are excellent on HALO columns because metal contamination has been virtually eliminated and interference from silanol groups has been minimized (*Figure 9*). Because of the elimination of "secondary retention" of solutes from metal contamination or silanol interaction, column-to column reproducibility is also excellent.

FIGURE 9. Separations of bases and acids on HALO



Column: HALO C8, 4.6 x 50 mm
Mobile Phase: 75% Methanol, 25% 25mM potassium phosphate, pH 7.0
Flow Rate: 1.5 ml/min
Temperature: ambient (24 oC)
Pressure: 3,000 psi, 205 bar
Sample:
1. Uracil
2. Butyl paraben
3. Propranolol
4. Naphtalene
5. Acenaphthene
6. Amitriptyline

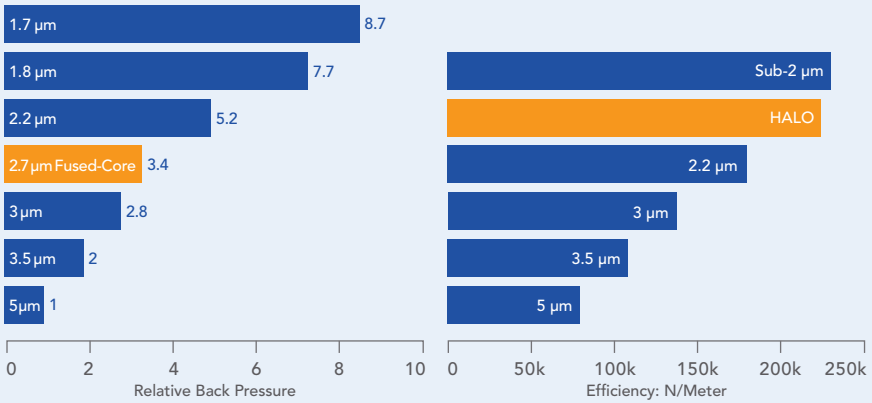


Column: HALO C8, 4.6 x 50 mm
Mobile Phase: 55% Methanol, 45% 25mM sodium phosphate, pH 2.5
Flow Rate: 2.2 ml/min
Temperature: ambient (24 oC)
Pressure: 5,200 psi, 360 bar

Sample:
1. Uracil
2. Phthalic Acid
3. 2-Fluorbenzoic Acid
4. 3-Nitrobenzoic Acid
5. 3-Fluorbenzoic Acid
6. m-Toluic Acid

Peak tailing due to trace metals or silanol groups is essentially non-existent on HALO stationary phases. The examples here show the excellent peak shape that can be achieved for either bases or acids when using a HALO column. The conditions used for the bases were chosen to encourage any potential silanol interference. Note the excellent peak shape for amitriptyline under these conditions.

FIGURE 10: HALO columns exhibit UHPLC-like performance at conventional HPLC pressure



HALO columns packed with Fused-Core particles provide over 80% of the efficiency (theoretical plates, N) and 90% of the resolving power of sub-2-µm columns, but require less than half the back pressure. This lower pressure permits HALO columns to be used with conventional 400 bar-limit HPLC equipment and achieve speed and resolution very similar to UHPLC.

> *"This fast HPLC technology is comparable with ultrahigh-pressure liquid chromatography (UHPLC) in terms of chromatographic performance but demands neither expensive ultra-high-pressure instrumentation nor new laboratory protocols."*
>
> Analytical Chemistry, August 2007

HALO® RP-AMIDE

- Alternate, complementary selectivity to C18 and C8 bonded phases
- Particularly recommended for samples containing acidic and basic compounds
- Compatible with highly aqueous mobile phases to facilitate the retention and separation of polar compounds
- Enhanced bonded-phase stability for durable, long-lived performance plus minimum bleed for LC/MS applications
- Base-deactivated for good peak shape when separating basic compounds
- Moderate back pressure allows for UHPLC-like performance with conventional HPLC equipment
- The use of 2 µm porosity column inlet frits reduces the inconvenience caused by pressure increases from plugged fits and makes HALO columns more forgiving and easier to use

HALO columns are available packed with a polar-embedded phase that offers a powerful alternate selectivity to HALO C18 and C8. HALO RP-Amide columns provide enhanced selectivity for samples containing acidic and basic compounds and are an excellent choice when a C18 or C8 phase fails to provide an adequate separation. The HALO RP-Amide columns are also particularly well suited for the separation of highly water soluble compounds that require high aqueous mobile phases, since the polar amide group ensures that the stationary phase is fully "wettable", even when using 100% aqueous mobile phases.

HALO RP-Amide should not be confused with other amide embedded phases that exhibit weak hydrolytic stability. Proprietary bonding chemistry is used in the production of the HALO RP-Amide phase to achieve excellent stability and long column life. The extremely low bleed characteristics of the HALO RP-Amide phase make it particularly well suited for LC/MS applications.

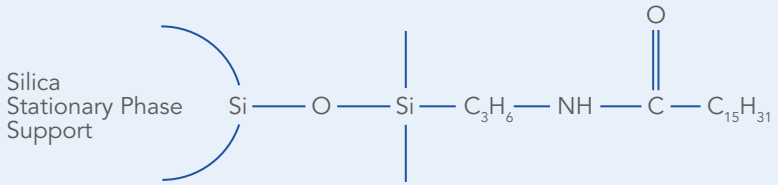
As with the HALO C18 and C8 phases, ultra-pure reagents, "Type B" silica, dense bonding technology, and exhaustive endcapping generate a base-deactivated stationary phase that provides excellent peak shape for polar compounds.

Mechanism of separation

Separations on HALO RP-Amide columns are influenced by both hydrophobic interaction with the alkyl chain and hydrogen bonding with the embedded amide group. (*See Figure 11 for structure of the RP-Amide bonded phase.*) Analytes with hydrogen bond donor characteristics can be expected to be more retained on the HALO RP-Amide phase. An example of this can be seen in Figure 12 where 2-chlorophenol, 3-ethylphenol and butyl paraben are more strongly retained on the HALO RP-Amide than the HALO C18. In general, acids will be retained more, bases will be retained slightly less and neutral analytes will have approximately the same retention on the HALO RP-Amide as they will on the HALO C18.

This different selectivity provided by the HALO RP-Amide makes it a very useful alternative phase to a C18 phase. Compounds that are poorly separated on a C18 phase may be well separated on the HALO RP-Amide. Figure 13 is a good example. Here, 2-nitroaniline, 4-bromoacetanilide and 2, 2'-biphenol co-elute on a C18 phase, but are baseline separated on the HALO RP-Amide.

FIGURE 11: Structure of bonded phase of HALO RP-Amide

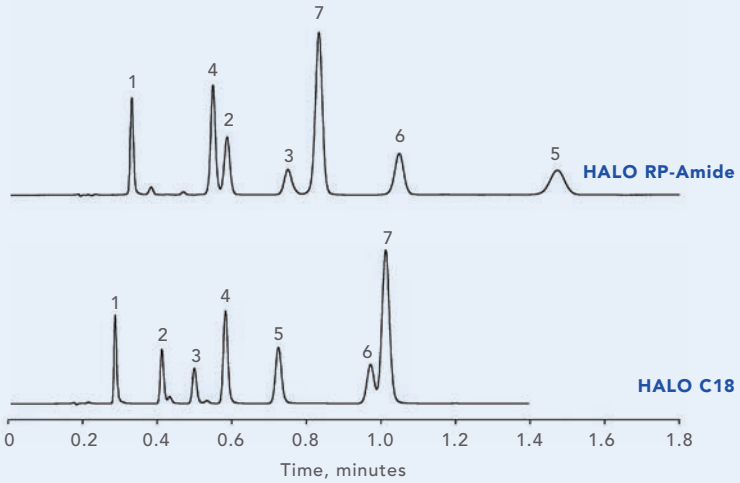


A stable amide group embedded in an 18-carbon chain is the bonded phase used for the HALO RP-Amide phase.

FIGURE 12 : HALO RP-Amide offers an alternate selectivity to C18

Conditions:
Columns: 4.6 x 50 mm
Mobile Phase: 50/50 ACN/ 20 mM potassium phosphate buffer (pH = 7.0)
Flowrate: 2.0 ml/min
Pressure: ~175 bar

Sample: 1µL of solution containing:
1. benzyl alcohol
2. 2-chlorophenol
3. 3-ethylphenol
4. benzylbenzoate
5. butyl paraben
6. 4-chloro-3-nitroanisole
7. N,N-dimethylaniline

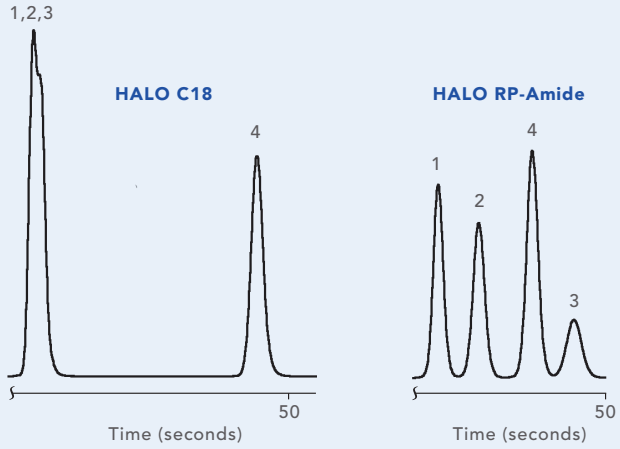


Hydrogen bond donors, like 2-chlorophenol, 3-ethylphenol, and butyl paraben are more strongly retained on the HALO RP-Amide phase than on the HALO C18 phase. Basic compounds, like N, N-dimethylaniline, are slightly less retained on the HALO RP-Amide phase. This difference in selectivity makes HALO RP-Amide an extremely useful alternate selectivity to the HALO C18 phase.

FIGURE 13: The alternate selectivity of HALO RP-Amide often provides a better separation

Conditions:
Columns: 4.6 x 50 mm
Mobile Phase: 35/65 ACN/20 mM phosphate buffer, pH = 7.0
Flowrate: 3.0 ml/min
Pressure: 310 bar
Temperature: Ambient at 26 °C

Peak Identities:
1. 2-Nitroaniline
2. 4-Bromoacetanilide
3. 2,2′-Biphenol
4. Benzylbenzoate

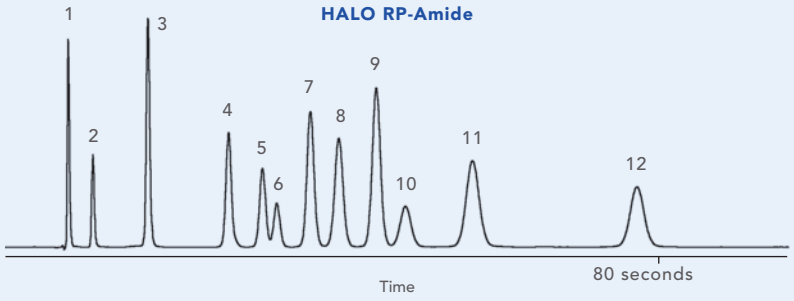


Three compounds in this sample mix do not separate on a C18 phase. Under identical mobile phase conditions, they are baseline separated on the HALO RP-Amide.

FIGURE 14 : Ultra-fast separation of a 12 component mixture on a HALO RP-Amide column

Conditions:
Columns: 4.6 x 50 mm
Mobile Phase: 35/65 ACN/20 mM phosphate buffer, pH = 7.0
Flowrate: 3.0 ml/min
Pressure: 310 bar
Temperature: Ambient at 26 ˚C

Peak Identities:
1. Uracil
2. Benzamide
3. Aniline
4. Cinnamyl Alcohol
5. Dimethylphthalate
6. Phenylacetonitrile
7. 2-Nitroaniline
8. 4-Bromoacetanilide
9. Benzylbenzoate
10. 2,2′-Biphenol
11. 4,4′-Biphenol
12. N,N-dimethylaniline



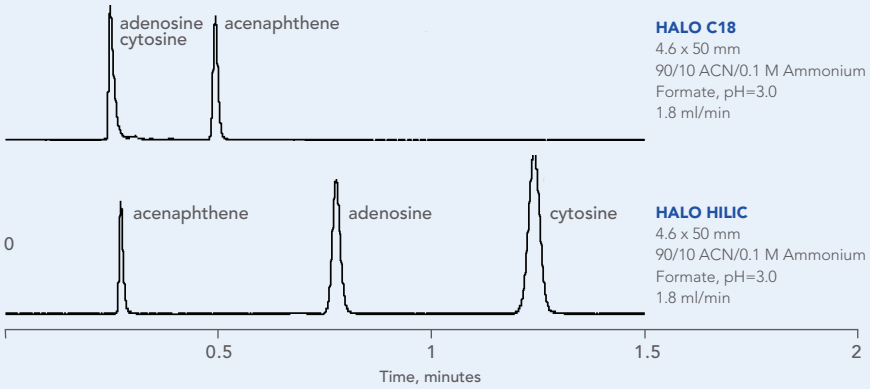
The selectivity offered by the alkyl amide phase combined with the high efficiency and high speed of the HALO Fused-Core particles facilitates the separation of these 12 compounds in under 80 seconds.

HALO® HILIC

- Separate highly polar compounds that are poorly retained on reversed-phase columns
- Complementary selectivity to reversed-phase
- Increase LC/MS sensitivity

HILIC, or hydrophilic interaction liquid chromatography, is especially suitable for separating polar compounds. HALO HILIC columns can be particularly useful for separating acidic and basic compounds that are either not retained or poorly retained on reversed-phase columns. In addition, the complementary selectivity of HILIC may provide a better separation than that achieved by reversed-phase. Since typical mobile phases used with HILIC are composed of a large fraction of volatile organic solvent, such as acetonitrile, HILIC separations can offer significant increases in sensitivity when interfaced to mass spectrometry.

FIGURE 15: Complementary selectivity of reversed-phase and hydrophilic interaction liquid chromatography (HILIC).



Retention mechanism

Retention in HILIC appears to be a combination of hydrophilic interaction, ion-exchange and some reversed-phase retention. The aqueous layer which forms on the polar surface of HILIC particles promotes interaction with polar solutes. Retention in HILIC as a function of the mobile phase is just opposite from that in reversed-phase. The strongest mobile phase has a high percentage of water and the weakest has a high percentage of organic solvent. For gradient separations, the initial mobile phase has a high percentage of organic solvent and the gradient is formed by increasing percentage of the aqueous component. The greatest retention for basic and acidic analytes is found when using more than about 70% organic (e.g., acetonitrile) in acidic mobile phases. Since high organic concentrations are used in the mobile phases, HILIC is especially favorable for separations using mass spectrometry (MS) detection.

Due to the highly polar mobile phases used in HILIC, both acidic and basic compounds often exhibit highly symmetrical peak shapes, often superior to those obtained in reversed-phase. In addition, sample loading effects often are more favorable for HILIC. When optimized, HALO HILIC columns show efficiency that is competitive with results obtained with reversed-phase. Although increased column operating temperatures can improve efficiency and peak shape in reversed-phase chromatography, temperatures above 60 °C generally are not recommended with HILIC.

Mobile phase solvents

Acetonitrile is commonly used as the weak mobile phase component in HILIC separations. With this solvent, 95% is typically the upper limit, and 60% the lower limit for adequate retention. At least 5% of the mobile phase should be a highly polar solvent such as water or methanol. If buffers are used, water is preferred for improved buffer solubility. As in reversed-phase, the organic solvent type can be varied to change retention and separation selectivity. Solvent strength (from weakest to strongest) for HILIC generally is tetrahydrofuran < acetone < acetonitrile < isopropanol < ethanol < methanol < water.

When using a gradient to scout for optimum mobile phase conditions, 90 - 95% acetonitrile is suggested as the initial solvent composition and 50 - 60% acetonitrile as the ending composition. The resulting elution characteristics can be used to estimate the appropriate mobile phase composition for isocratic elution in much the same way as for reversed-phase. To further increase retention in HILIC, replacing some of the water in the mobile phase with another polar solvent such as methanol or isopropanol is sometimes effective.

Mobile phase buffers

For optimum column efficiency and reproducibility, buffers in the range of 10 - 20 mM concentration or additives in the 0.5% range can be used in the mobile phase. Phosphate buffers are not recommended because of their poor solubility in highly organic mobile phases and incompatibility with MS detection. Additives such as formic acid, trifluoroacetic acid and phosphoric acid at concentrations up to about 1% can be used in the mobile phase. Volatile ammonium formate/formic acid buffers up to a final concentration of about 20 mM and pH 3 are especially effective for separating both basic and acidic compounds when interfacing the liquid chromatograph to a mass spectrometer. Acetonitrile/formate mobile phases seem to be a good starting point for many separations of both basic and acidic compounds. Ammonium acetate at pH ~5 has also been used at concentrations of 5 - 20 mM, but is generally less effective for separating stronger basic and acidic compounds. Buffers or additives above pH 6 usually are not recommended because they may enhance the slow dissolution of the silica support.

Sample conditions

As with reversed-phase, the solvent used to inject the sample is an important consideration with HILIC. The sample solvent should, as closely as possible, resemble the strength and type of the mobile phase. The sample solvent can contain a higher amount of organic than the mobile phase, but if it contains a higher amount of polar solvent (e.g., water), peak shape will be compromised, especially with early-eluting compounds. A mixture of 75:25 (v/v) acetonitrile/methanol is sometimes useful as the sample solvent, if for some reason it is not possible to inject the sample dissolved in the mobile phase.

Very strong solvents, such as dimethylformamide or dimethylsulfoxide, will usually result in poor peak shapes and are not recommended. These solvents will generally have to be diluted with a weaker solvent, such as acetonitrile, before satisfactory peak shape can be obtained.

HALO® Specifications

Stationary Phase Support

- Ultra-pure, "Type B" silica
- 1.7 µm solid core particle with a 0.5 µm porous silica layer fused to the surface
- 150 m^2/gram surface area
- 90 Å pore size

Bonded Phase

- C18: Octadecyldimethylsilane, 3.5 µmoles/m^2
- C8: Octyldimethylsilane, 3.7 µmoles/m^2
- RP-Amide: Alkylamide, 3.0 micromoles/m^2
- Densely bonded phase
- Maximized endcapping
- pH Range: 2 to 9

Maximum Pressure: 9,000 psi, 600 Bar

HALO® Ordering Information

Part Number	Description	
92812-302	2.7 µm HALO C18	2.1 x 30 mm
92812-402	2.7 µm HALO C18	2.1 x 50 mm
92812-502	2.7 µm HALO C18	2.1 x 75 mm
92812-602	2.7 µm HALO C18	2.1 x 100 mm
92812-702	2.7 µm HALO C18	2.1 x 150 mm
92813-302	2.7 µm HALO C18	3.0 x 30 mm
92813-402	2.7 µm HALO C18	3.0 x 50 mm
92813-502	2.7 µm HALO C18	3.0 x 75 mm
92813-602	2.7 µm HALO C18	3.0 x 100 mm
92813-702	2.7 µm HALO C18	3.0 x 150 mm
92814-302	2.7 µm HALO C18	4.6 x 30 mm
92814-402	2.7 µm HALO C18	4.6 x 50 mm
92814-502	2.7 µm HALO C18	4.6 x 75 mm
92814-602	2.7 µm HALO C18	4.6 x 100 mm
92814-702	2.7 µm HALO C18	4.6 x 150 mm
92812-308	2.7 µm HALO C8	2.1 x 30 mm
92812-408	2.7 µm HALO C8	2.1 x 50 mm
92812-508	2.7 µm HALO C8	2.1 x 75 mm
92812-608	2.7 µm HALO C8	2.1 x 100 mm
92812-708	2.7 µm HALO C8	2.1 x 150 mm
92813-308	2.7 µm HALO C8	3.0 x 30 mm
92813-408	2.7 µm HALO C8	3.0 x 50 mm
92813-508	2.7 µm HALO C8	3.0 x 75 mm
92813-608	2.7 µm HALO C8	3.0 x 100 mm
92813-708	2.7 µm HALO C8	3.0 x 150 mm
92814-308	2.7 µm HALO C8	4.6 x 30 mm
92814-408	2.7 µm HALO C8	4.6 x 50 mm
92814-508	2.7 µm HALO C8	4.6 x 75 mm
92814-608	2.7 µm HALO C8	4.6 x 100 mm
92814-708	2.7 µm HALO C8	4.6 x 150 mm
92812-401	2.7 µmHALO HILIC	2.1 x 50 mm
92812-601	2.7 µmHALO HILIC	2.1 x 100 mm
92812-701	2.7 µmHALO HILIC	2.1 x 150 mm
92814-401	2.7 µmHALO HILIC	4.6 x 50 mm
92814-601	2.7 µmHALO HILIC	4.6 x 100 mm
92814-701	2.7 µmHALO HILIC	4.6 x 150 mm
	other dimensions available upon request	

Continued

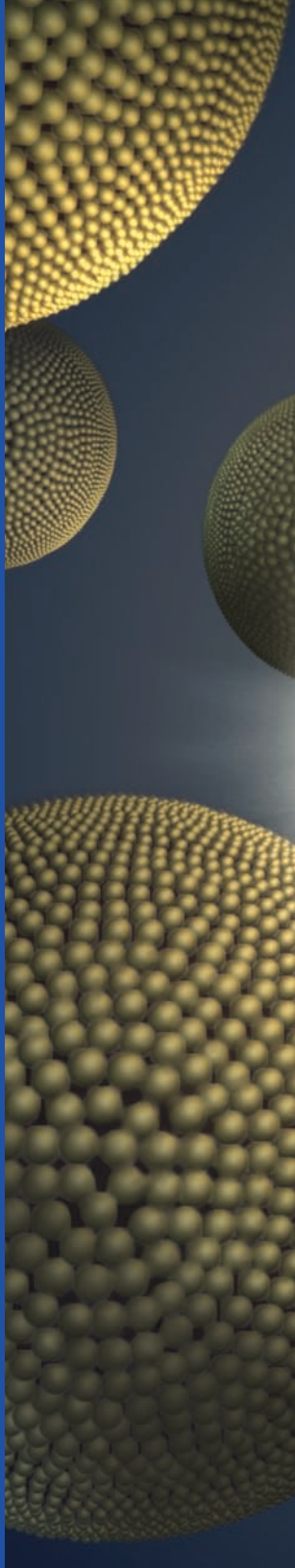
HALO® Ordering Information

Part Number	Description	
92812-307	2.7 µm HALO RP-Amide	2.1 x 30 mm
92812-407	2.7 µm HALO RP-Amide	2.1 x 50 mm
92812-507	2.7 µm HALO RP-Amide	2.1 x 75 mm
92812-607	2.7 µm HALO RP-Amide	2.1 x 100 mm
92812-707	2.7 µm HALO RP-Amide	2.1 x 150 mm
92813-307	2.7 µm HALO RP-Amide	3.0 x 30 mm
92813-407	2.7 µm HALO RP-Amide	3.0 x 50 mm
92813-507	2.7 µm HALO RP-Amide	3.0 x 75 mm
92813-607	2.7 µm HALO RP-Amide	3.0 x 100 mm
92813-707	2.7 µm HALO RP-Amide	3.0 x 150 mm
92814-307	2.7 µm HALO RP-Amide	4.6 x 30 mm
92814-407	2.7 µm HALO RP-Amide	4.6 x 50 mm
92814-507	2.7 µm HALO RP-Amide	4.6 x 75 mm
92814-607	2.7 µm HALO RP-Amide	4.6 x 100 mm
92814-707	2.7 µm HALO RP-Amide	4.6 x 150 mm
Capillary Columns		
98219-408	2.7 µm HALO C8	0.075 x 50 mm
98219-708	27 µm HALO C8	0.075 x 150 mm
98218-408	2.7 µm HALO C8	0.1 x 50 mm
98218-708	2.7 µm HALO C8	0.1 x 150 mm
98217-408	2.7 µm HALO C8	0.2 x 50 mm
98217-708	2.7 µm HALO C8	0.2 x 150 mm
98216-408	2.7 µm HALO C8	0.3 x 50 mm
98216-708	2.7 µm HALO C8	0.3 x 150 mm
98219-402	2.7 µm HALO C18	0.075 x 50 mm
98219-702	2.7 µm HALO C18	0.075 x 150 mm
98218-402	2.7 µm HALO C18	0.1 x 50 mm
98218-702	2.7 µm HALO C18	0.1 x 150 mm
98217-402	2.7 µm HALO C18	0.2 x 50 mm
98217-702	2.7 µm HALO C18	0.2 x 150 mm
98216-402	2.7 µm HALO C18	0.3 x 50 mm
98216-702	2.7 µm HALO C18	0.3 x 150 mm
1.0 mm ID Columns		
92811-402	2.7 µm HALO C18	1.0 x 50 mm
92811-602	2.7 µm HALO C18	1.0 x 100 mm
92811-702	2.7 µm HALO C18	1.0 x 150 mm

HALO HPLC columns made with Fused-Core® particle technology are hyper-fast and super-rugged. Their low back pressure allows them to be used with conventional HPLC equipment as well as ultra-high pressure systems.

HALO columns can turn almost any HPLC into a high speed workhorse for your laboratory.

LC503



advancedmaterialstechnology

www.advanced-materials-tech.com