

# HALO®

A BETTER PATH TO SEPARATIONS WITH FUSED-CORE®

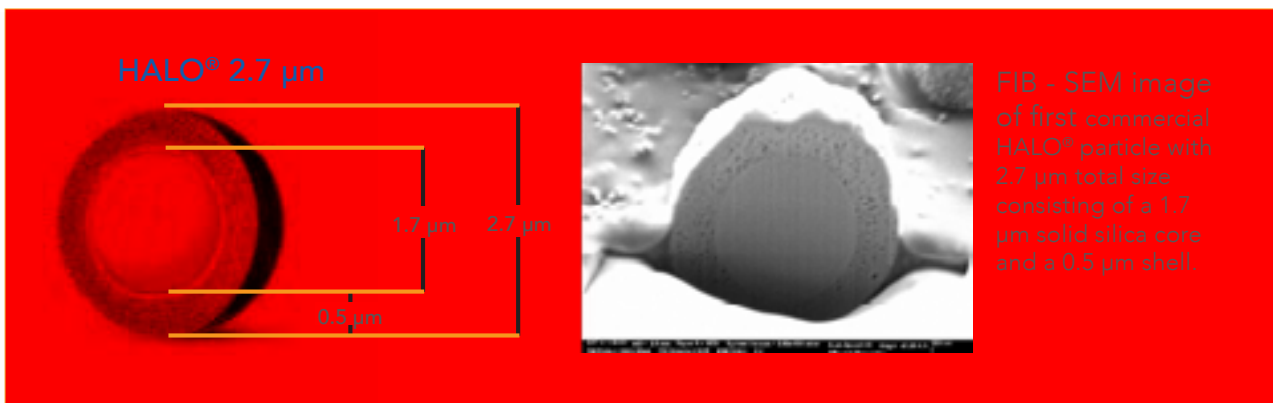


advancedmaterialstechnology

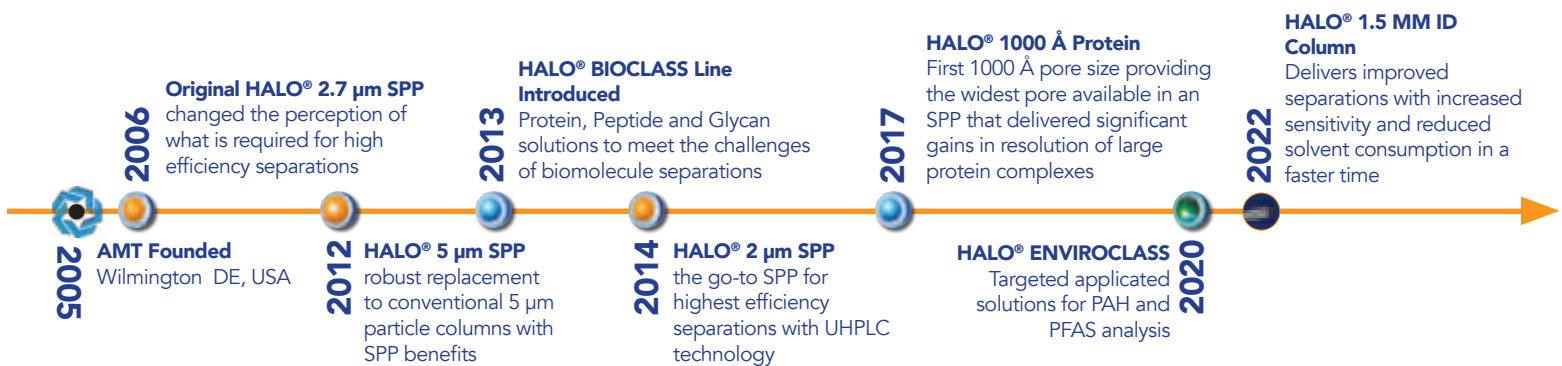
# HALO® – A BETTER PATH TO SEPARATIONS

Chromatographers continue to push separation limits due to increasing productivity demands. How can I achieve an improved separation in a faster time, or with less solvent consumption, increased sensitivity, or all of the above? The specific drivers may be different, but the overall goal is the same – *'I need more, but without sacrificing anything'*. This dilemma is not new and it gained prime attention back in the early 2000's when UHPLC instrumentation first arrived on the scene. Separation scientists were presented with a possibility to reduce run times by up to 70% and still maintain high resolution with the adoption of smaller particle size columns and new instrumentation that could accommodate the increase in back pressure generated by these smaller particles.

In 2006, Advanced Materials Technology took a different path towards this goal and introduced a novel technology where particles had a solid silica core surrounded by a porous layer that provided high efficiency separations without the backpressure consequence. This little HALO® Fused-Core® particle started one large revolution where superficially porous particle technology has been accepted as the new standard in high performance LC and LCMS separations!



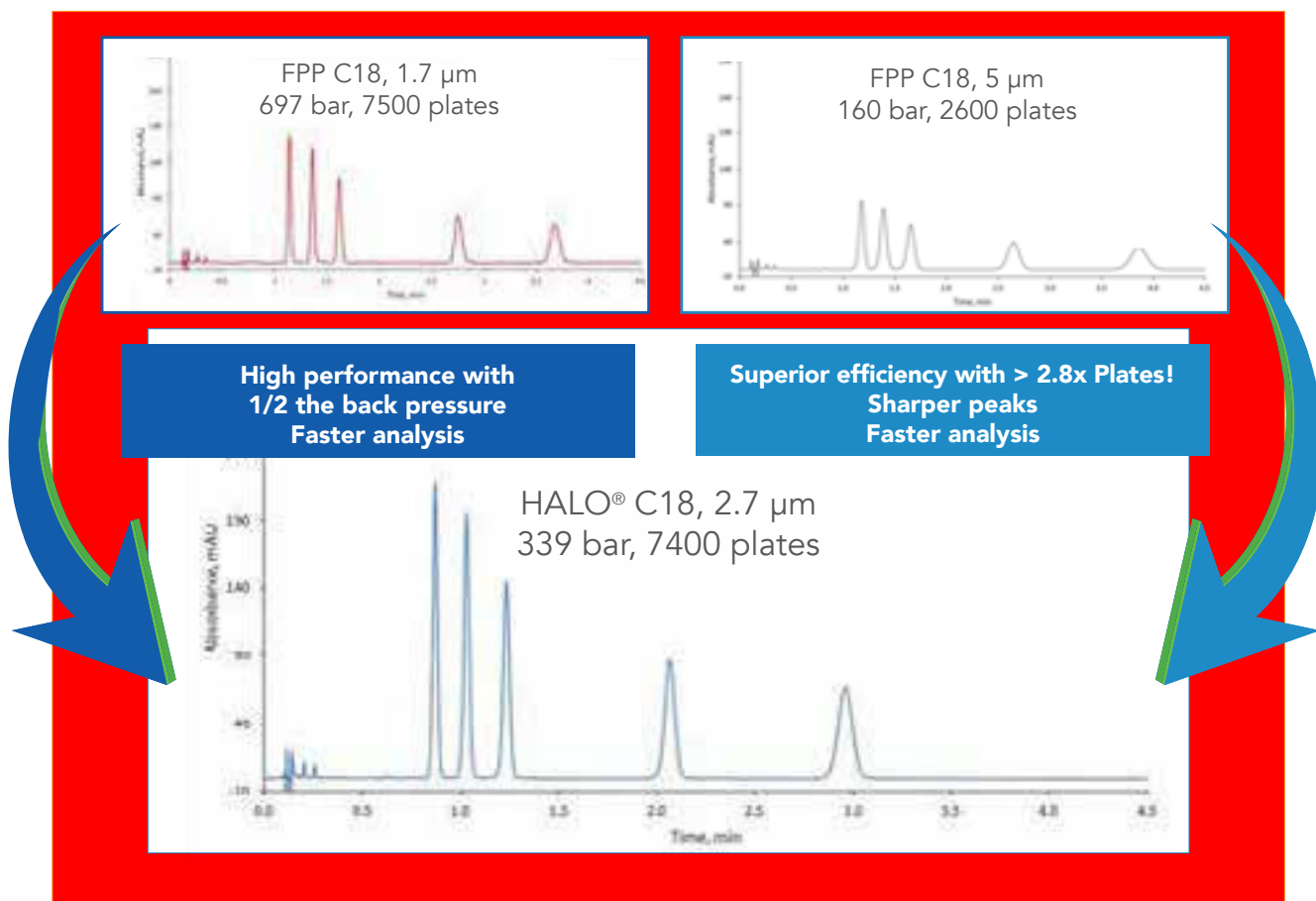
## AS SEPARATION DEMANDS EVOLVE SO DOES AMT'S INDUSTRY LEADING INNOVATION



# TECHNOLOGY OVERVIEW

## How HALO® Delivers Higher Efficiency

The original HALO® Fused-Core® columns are able to perform competitively versus sub-2  $\mu\text{m}$  fully porous columns and substantially outperform 3 and 5  $\mu\text{m}$  fully porous columns delivering the goal of increased performance without the consequence of high back pressures!



Ready to convert your FPP Methods to Fused-Core®?



Method Conversion Guidebook

# HALO® FOR SMALL MOLECULE ANALYSIS



HALO®

HALO® (U)HPLC/LCMS columns for small molecule analysis are designed for ultra-fast separations from a few compounds to more complex samples containing hundreds of analytes. HALO® columns for small molecule solutions provide an optimized 90 Å pore size, a wide breadth of bonded phase selectivities, particle size options and column hardware dimensions to accommodate micro through semi-prep LC and LCMS systems.



HALO®  
ENVIROCLASS

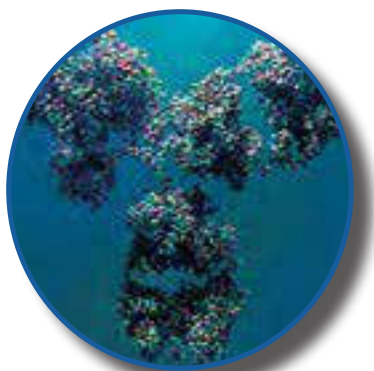
HALO® ENVIROCLASS columns are performance-designed application-specific phases to separate per- and polyfluorinated alkyl substances (PFAS) and polycyclic aromatic hydrocarbons (PAH). In addition, this line offers a suite of solutions for other persistent, high environmental-impact contamination agents such as pesticides, mycotoxins, herbicides, and more all based upon HALO's innovative and trusted technology with the understanding of the unique needs of the environmental laboratory in mind.

## DISCOVER MORE WITH FUSED-CORE® SMALL MOLECULE COLUMNS:

- Optimized 90 Å pore size for small molecules
- 2 µm, 2.7 µm and 5 µm particle sizes
- Reversed-phase and HILIC stationary phases
- Applied PFAS, PFAS delay, and PAH columns
- Available in micro through semi-prep formats



# HALO® FOR BIOPHARMACEUTICAL ANALYSIS



**HALO®**  
BIOCLASS

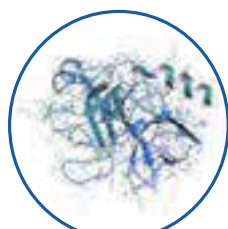
HALO® BioClass columns have been developed to simplify and promote a more comprehensive understanding of biomolecules – faster. Pore morphologies and chemistries have been optimized to promote both fast and high resolution separations of biomolecules to support the development of novel therapeutic proteins and peptides in pharmaceutical drug development, characterize protein post-translation modifications, and to fully assess subtle differences in biosimilars and other products of bioengineering and manufacturing.

From the innovative 1000 Å pore materials designed for intact proteins and monoclonal antibodies (mAbs) analysis to high resolution LCMS peptide columns and application assured glycan columns, HALO® offers a suite of tailored columns for the bio workflow.



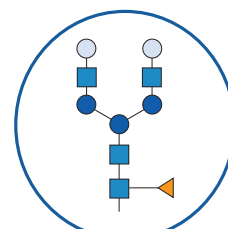
## PROTEIN

- Wide pore portfolios (1000 Å and 400 Å) for unrestricted bonded phase access capable of characterizing very large proteins with good peak shape and recovery
- Compatible chemistries for UHPLC, HPLC, and Mass Spectrometry
- Multiple bonded phase options for a tailored solution
- Particle morphology engineered for fast, high resolution separations



## PEPTIDE

- Optimized 160 Å pore size for fast, high resolution peptide separations
- High peak capacities delivering rugged, reliable performance for use with either UHPLC, HPLC, or LC-MS
- Extensive portfolio of particle sizes and chemistries



## GLYCAN

- Application-assured column for glycan analysis
- Improved retention of acidic and zwitterionic analytes
- Very low sensitivity to buffer concentration
- Able to separate isobaric oligosaccharides with different linkages



Bioanalysis  
Solutions  
Guidebook

# HALO® PRODUCT FAMILIES

The HALO® portfolio of products consists of varying particle morphologies to meet separation needs through the properties of particle size, core size, shell thickness and pore size. A wide range of bonded phase chemistries also provides selectivity options for small molecule and large molecule separation chemists.

**SMALL MOLECULE**

90 Å 2 micron particle      90 Å 2.7 micron particle      90 Å 5 micron particle

**ENVIROCLASS**

2.7 micron particle      2.7 micron particle

PAH      PFAS

**BIOCLASS**

1000 Å 2.7 micron particle      400 Å 3.4 micron particle      90 Å 2.7 micron particle

PROTEIN      GLYCAN

160 Å 2 micron particle      160 Å 2.7 micron particle      160 Å 5 micron particle

PEPTIDE

## HALO® PARTICLE SIZES AND PROPERTIES

	2 µm	2.7 µm	5 µm
<b>Best Uses</b>	complex separations when ultimate resolution is required with a low system volume UHPLC	best all-purpose rugged particle providing high efficiencies with minimal back pressure	when more performance or lower back pressures from 3 µm or 5 µm FPP methods are desired; samples with dirty matrices
<b>Performance Potential (plates/meter)</b>	300,000+	230,000+	160,000+
<b>Efficiency Comparison to FPP</b>	outperforms <2 µm FPP	performance of <2 µm FPP	performance of 3 µm FPP
<b>Instrumentation</b>	UHPLC/MS	UHPLC/HPLC/MS	HPLC

# HALO<sup>®</sup>

## MARKET SEGMENTS



PHARMACEUTICAL



BIO  
PHARMACEUTICAL



VITAMINS



ENVIRONMENTAL



FOOD/BEVERAGE



CLINICAL/TOXICOLOGY



CANNABIS



INDUSTRIAL

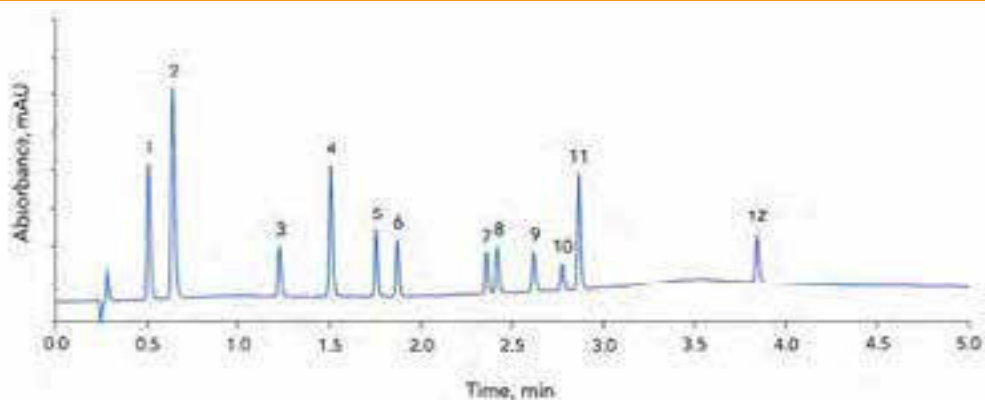


# PHARMACEUTICAL APPLICATIONS

Driven by data to ensure the safety and efficacy of life saving medicines and treatments, pharmaceutical science demands reproducibility, accuracy and quality of products during rigorous test regimes. HALO® columns are manufactured in our ISO 9001:2015 QMS certified facility where we begin with starting raw materials and quality control every processing step of the way resulting in products with lot to lot reproducibility that can be relied upon.

## HIGH EFFICIENCY SEPARATION USING HALO® 2 µm BIPHENYL

A mixture of twelve beta blockers is separated on a HALO® 2.0 µm Biphenyl column with excellent speed and resolution. Beta blockers are mainly used to treat irregular heart beats or complications with the heart such as heart attacks.



### PEAK IDENTITIES:

1. Atenolol
2. Sotalol
3. Nadolol
4. Pindolol
5. Acebutolol
6. Metoprolol
7. Bisoprolol
8. Oxprenolol
9. Labetalol
10. Alprenolol
11. Propranolol
12. Carvedilol

### TEST CONDITIONS:

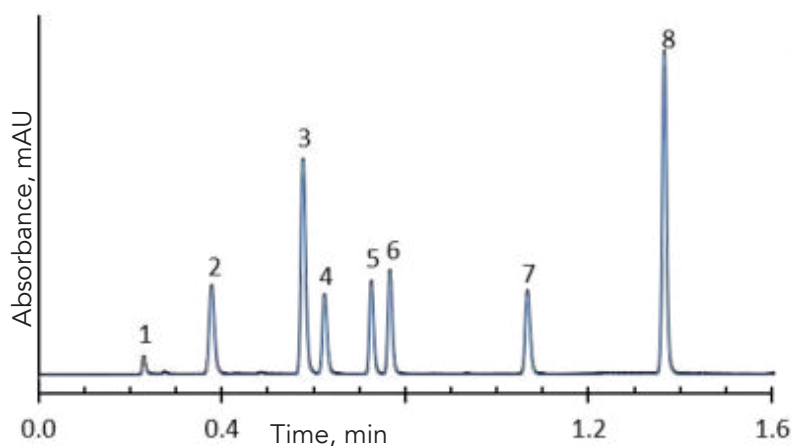
Column: HALO 90 Å Biphenyl, 2.0 µm, 2.1 x 50 mm  
 Part Number: 91812-411  
 Mobile Phase:  
 A: Water, 0.1% TFA  
 B: Acetonitrile, 0.05% TFA

Gradient:      Time (min)    %B  
                          0.0            10  
                          5.0            50  
 Flow Rate: 0.5 mL/min  
 Initial Pressure: 272 bar  
 Temperature: 35 °C  
 Detection: UV 220 nm, PDA

Injection Volume: 1.0 µL  
 Sample Solvent: Water  
 Response Time: 0.025 sec  
 Data Rate: 40 Hz  
 Flow Cell: 1.0 µL  
 LC System: Shimadzu Nexera X2

## ULTRA FAST SEPARATION OF ANTIBIOTIC AND ANTIFUNGAL DRUGS ON HALO® RP-AMIDE

The antimicrobial drug clofazimine and other antifungal drugs can be analyzed in under 1.5 minutes using a HALO® RP-Amide column with low back pressure which demonstrates the power of Fused-Core® technology.



### TEST CONDITIONS:

Column: HALO 90 Å RP-Amide, 2.7 µm, 4.6 x 50 mm  
 Part Number: 92814-407  
 Mobile Phase:  
 A: 0.02 M phosphate buffer, pH 3.0  
 B: Acetonitrile

Gradient:      Time (min)    %B  
                          0.0            41  
                          1.0            80  
                          1.6            80

Flow Rate: 2.0 mL/min  
 Initial Pressure: 188 bar  
 Temperature: 35 °C  
 Detection: UV 230 nm, VWD  
 Injection Volume: 0.3 µL  
 Sample Solvent: 25/75 water/acetonitrile  
 Response Time: 0.02 sec  
 Flow Cell: 2.5 µL semi-micro  
 LC System: Shimadzu Prominence UFLC XR

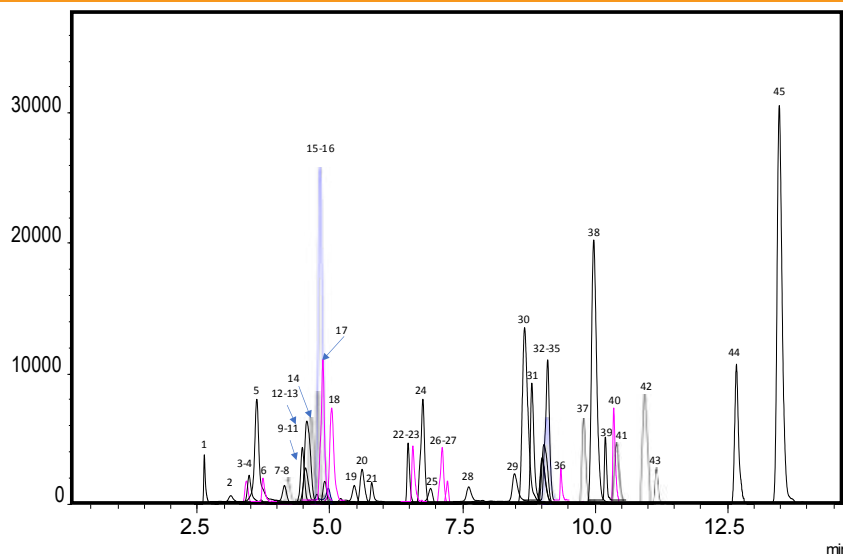
### PEAK IDENTITIES:

1. Unknown
2. Ketoconazole
3. Naftifine
4. Clotrimazole
5. Econazole
6. Sulconazole
7. Clofazimine
8. Tolnaftate



## HIGH RESOLUTION LCMS ANALYSIS OF VETERINARY DRUGS USING HALO® C18

Screening for the presence of veterinary drug residues in food is important to prevent possible allergic reactions, bacterial drug resistance, and accidental poisonings. A rapid separation of a complex mix of veterinary drugs is achieved using a HALO® C18 column which enables high through-put analysis.



### PEAK IDENTITIES:

- |                            |                         |
|----------------------------|-------------------------|
| 1. Ciprofloxacin           | 28. Tilmicosin          |
| 2. Sulfathiazole           | 29. Flumequin           |
| 3. Lincomycin              | 30. Nalidixic Acid      |
| 4. Sulfapyridine           | 31. Oxolinic Acid       |
| 5. Albendazole-2-amino     | 32. Kitasamycin         |
| 6. Trimethoprim            | 33. Tylosin             |
| 7. Ormetoprim              | 34. Florfenicol Amine   |
| 8. Tetracycline            | 35. Erythromycin A      |
| 9. Enrofloxacin            | 36. Malachite Green     |
| 10. Danofloxacin           | 37. Albendazole         |
| 11. Sulfaclozine           | 38. Cloxacillin         |
| 12. Sulfachloropyridazine  | 39. Dicloxacillin       |
| 13. Sulfamerazine          | 40. Leucocrystal Violet |
| 14. Diclofenac             | 41. Crystal Violet      |
| 15. Difloxacin             | 42. Brilliant Green     |
| 16. Amoxicillin            | 43. Dapsone             |
| 17. Chlortetracycline      | 44. Carprofen           |
| 18. Sulfadoxine            | 45. Ivermectin          |
| 19. Sulfaethoxyypyridazine |                         |
| 20. Penicillin G           |                         |
| 21. Neospiramycin          |                         |
| 22. Spiramycin             |                         |
| 23. Sulfadimethoxine       |                         |
| 24. Albendazole Sulfoxide  |                         |
| 25. Albendazole Sulfone    |                         |
| 26. Sulfaquinoxaline       |                         |
| 27. Phenylbutazone         |                         |

### TEST CONDITIONS:

Column: HALO 90 Å C18, 2.7 µm, 2.1 x 100 mm  
 Part Number: 92812-602  
 Mobile Phase A: Water, 0.1 % Formic Acid  
 Mobile Phase B: ACN, 0.1% Formic Acid  
 Flow Rate: 0.4 mL/min  
 Pressure: 228 bar  
 Temperature: 35 °C

Injection Volume: 2.0 µL  
 Sample Solvent: 50/50/ MEOH/H<sub>2</sub>O  
 Detection: +ESI MS/MS  
 LC System: Shimadzu Nexera X2  
 ESI LCMS System: Shimadzu LCMS-8040

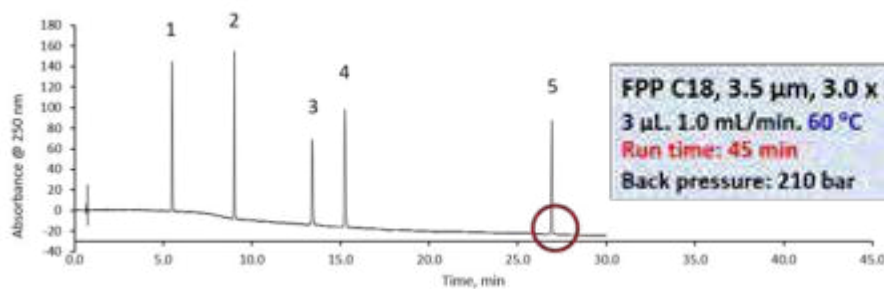
Gradient:	Time	%B
	0	10
	14	100
	16	100
	16.10	10
	19.0	stop

### MS Source Conditions:

ESI +  
 Spray Voltage: 3.0 kV  
 Nebulizing gas: 2 L/min  
 Drying gas: 15 L/min  
 DL temp: 250 °C  
 Heat Block: 400 °C

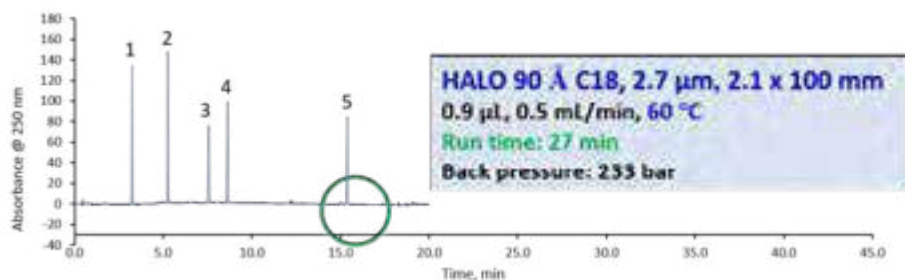
## COMPARISON OF THE ORIGINAL MONOGRAPH METHOD CONDITIONS TO THE MODERNIZED CONDITIONS USING A HALO® C18

Using HALO® C18 the sample elution run time can be reduced by 40%. Along with the reduction of run time, there is a reduction in solvent and sample usage. With the HALO® Fused-Core® technology the USP method for Rivaroxaban can be optimized for time, solvent savings, and sample usage, while adhering to the strict guidelines of the USP.



### PEAK IDENTITIES:

1. Rivaroxaban related compound B
2. Rivaroxaban related compound D
3. Rivaroxaban related compound G
4. Rivaroxaban
5. Rivaroxaban related compound J



\* to view the complete test conditions, [click here](#)

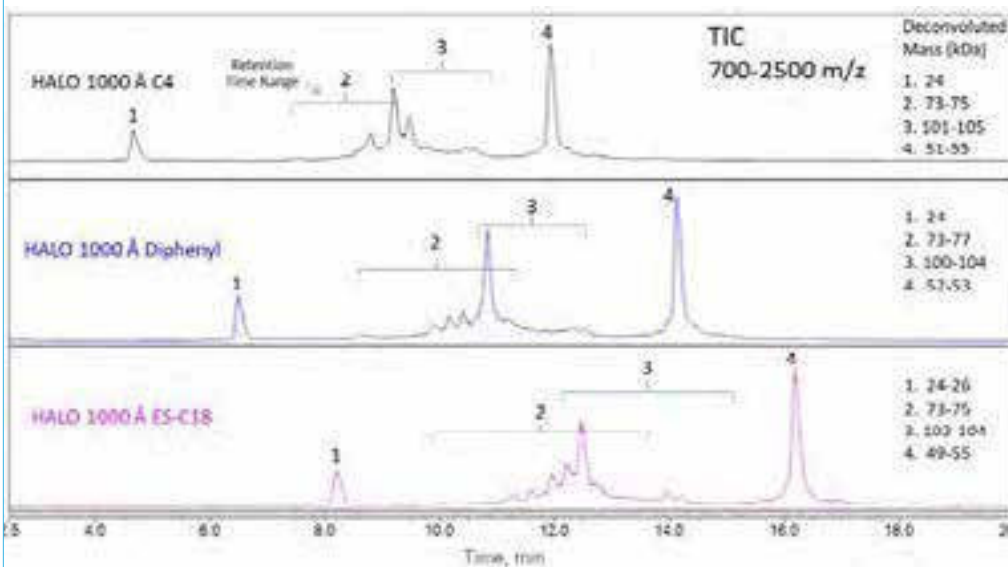


# BIOPHARMACEUTICAL APPLICATIONS

At the cutting edge of modern medicine, biologics are forging a path for better outcomes. Pushing the limits of drug development and design, biopharmaceuticals are subject to a battery of testing requirements, of which chromatography plays a significant part. HALO® BIOCLASS products have been designed with the particle morphologies to meet these demands.

## LC-MS ANALYSIS OF AN ADC MIMIC ON HALO 1000 Å PHASES

The three stationary phases available for HALO 1000 Å offer different selectivity for the analysis of an ADC mimic.



### PEAK IDENTITIES:

MWs as labeled on the TICs

### TEST CONDITIONS:

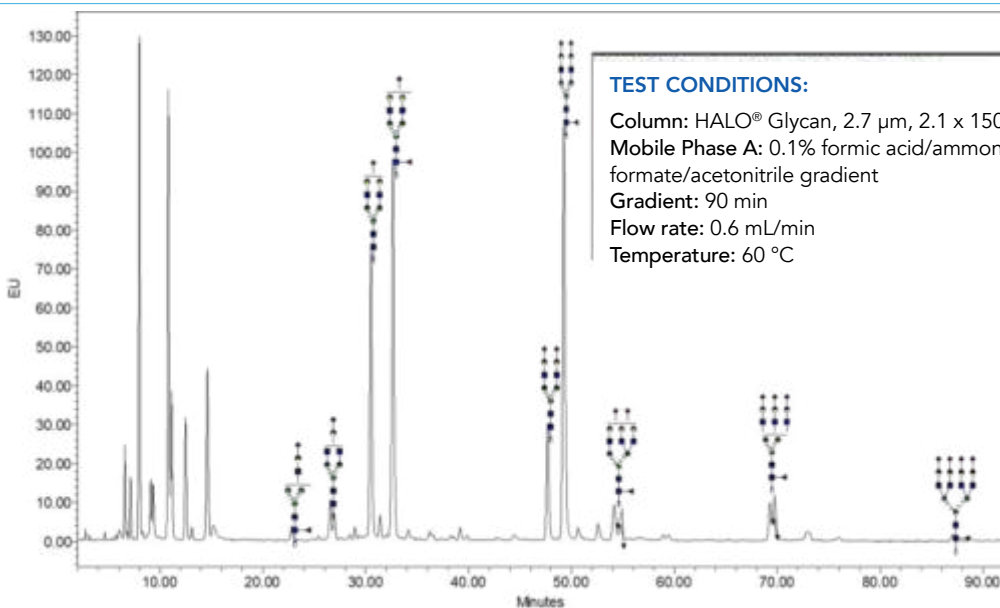
Column: HALO 1000 Å C4, 2.7 µm, 2.1 x 150 mm  
 Part Number: 92712-714  
 Column: HALO 1000 Å Diphenyl, 2.7 µm, 2.1 x 150 mm  
 Part Number: 92712-726  
 Columns: HALO 1000 Å ES-C18, 2.7 µm, 2.1 x 150 mm  
 Part Number: 92712-702  
 Mobile Phase A: Water/0.1% DFA  
 B: ACN/0.1% DFA  
 Gradient: 30-39 %B in 20 min  
 Flow Rate: 0.4 mL/min  
 Temperature: 75 °C  
 Detection: MS  
 Injection Volume: 5 µL  
 LC System: Shimadzu Nexera

### MS Conditions:

Detection: + ESI MS/MS  
 ESI LCMS System: Velos Pro Orbitrap  
 Spray Voltage: 4 kV  
 Capillary Temperature: 275 °C  
 Source Heater: 300 °C  
 Sheath Gas: 35  
 Aux Gas: 10  
 RF lens: 70

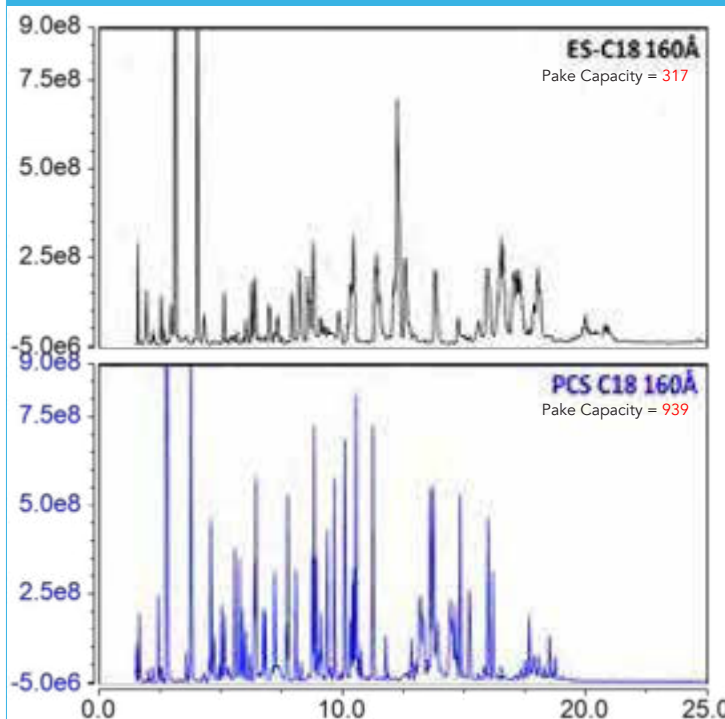
## HALO® GLYCAN COLUMN SEPARATING > 70 GLYCAN SPECIES WITH A PEAK CAPACITY OF ~200

The ability for a comprehensive characterization of the glycan species in a glycoprotein with high peak capacity is achieved using HILIC mode with the HALO® Glycan column.

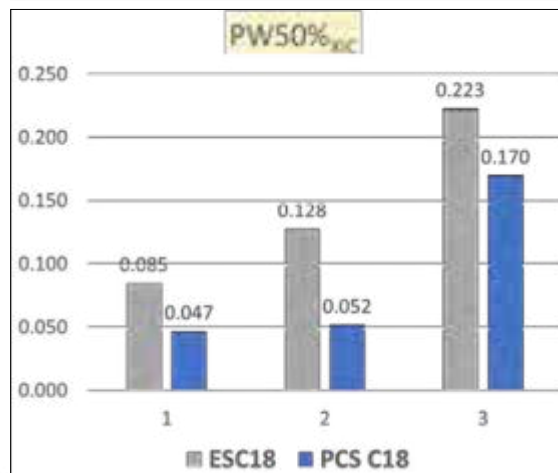


## INCREASED PEAK CAPACITY OF TRASTUZUMAB TRYPTIC DIGEST ON PCS C18

Using a positively charged stationary phase (PCS C18) with low ionic conditions allows for an alternative selectivity and better separation of the peptides. By measuring peak width @ 50% of 3 distinct peptides it can be seen how the effect of the PCS C18 phase can significantly improve peptide separations that require low ionic strength mobile phases such as formic acid.



#	Tryptic Peptide	PC	t <sub>R</sub> (min)
1	ARDTAVYIC/Carbamidomethyl/PT	667.2877	ES-C18: 6.45 PCS C18: 8.60
2	TPPEVTC/Carbamidomethyl(VVVQVSHZQPEVK	718.6807	ES-C18: 12.28 PCS C18: 10.11
3	TVAAPSVFPPSDEQLE	973.5171	ES-C18: 17.12 PCS C18: 14.47



### TEST CONDITIONS:

Column: HALO 160 Å ES-C18, 2.7 μm, 2.1 x 150 mm  
 Part Number: 92122-702  
 Column: HALO 160 Å PCS-C18, 2.7 μm, 2.1 x 150 mm  
 Part Number: 92112-717  
 Mobile Phase A: Water + 0.1% Formic Acid  
 Mobile Phase B: Acetonitrile + 0.1% Formic Acid

Gradient: Time %B  
 0.0 3  
 30.0 50  
 30.1 95  
 33.0 95  
 33.1 3  
 37.0 3

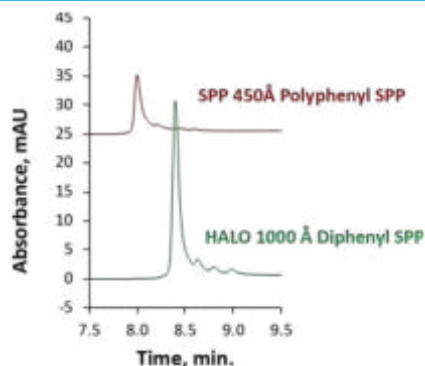
Flow Rate: 0.4 mL/min  
 Pressure: 465 bar  
 Temperature: 60 °C  
 Injection Volume: 1 μL  
 Sample: Trastuzumab Tryptic Digest (1.25 μg/μL)  
 Sample Solvent: Refer to Digestion Procedure  
 LC System: Shimadzu Nexera X2

### MS CONDITIONS:

System: QExactive HF  
 ESI positive polarity  
 300-2000 m/z  
 Source voltage: 3.2kV  
 Sheath Gas: 40  
 Aux Gas: 20  
 Aus Gas Temp: 275°C  
 Capillary Temp: 320°C  
 μscans: 1  
 Max Injection Time: 200 msec  
 S-Lens RF: 50

## HALO 1000 Å DIPHENYL PERFORMANCE AT LOWER TEMPERATURES

The HALO 1000 Å Diphenyl column exhibits improved resolution, retention and peak area under low temperature conditions.

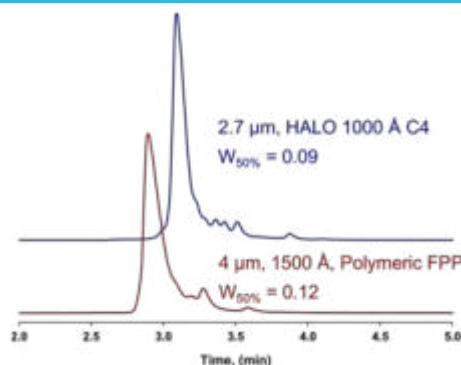


### TEST CONDITIONS:

Columns: 2.1 x 150 mm; Flow rate: 0.4 mL/min; Mobile Phase A: water/0.1% TFA; Mobile Phase B: ACN/0.1% TFA; Gradient: 30-45% B in 15 min; Injection Volume: 2 μL of 2 mg/mL trastuzumab in water/0.1% TFA; Temp: 40 °C; Detection: PDA at 280 nm

## SHARPER PEAK SHAPE WITH HALO 1000 Å C4 COMPARED TO A LARGER PORE SIZE PARTICLE COLUMN

HALO 1000 Å pore accessibility demonstrates superior resolution compared to 1500 Å FPP competitor for this intact trastuzumab separation.



### TEST CONDITIONS:

Conditions: Columns: 2.1 x 100 mm; Mobile phase A: water (0.1% TFA); Mobile phase B: 80/20 ACN/water (0.085% TFA); Gradient: 40-47.5% B in 8 min; Flow rate: 0.4 mL/min; Temperature: 80 °C; Sample: trastuzumab; Injection volume: 2 μL of 2 mg/mL in water; Instrument: Shimadzu Nexera; Detection: UV at 280 nm with 350 nm reference wavelength

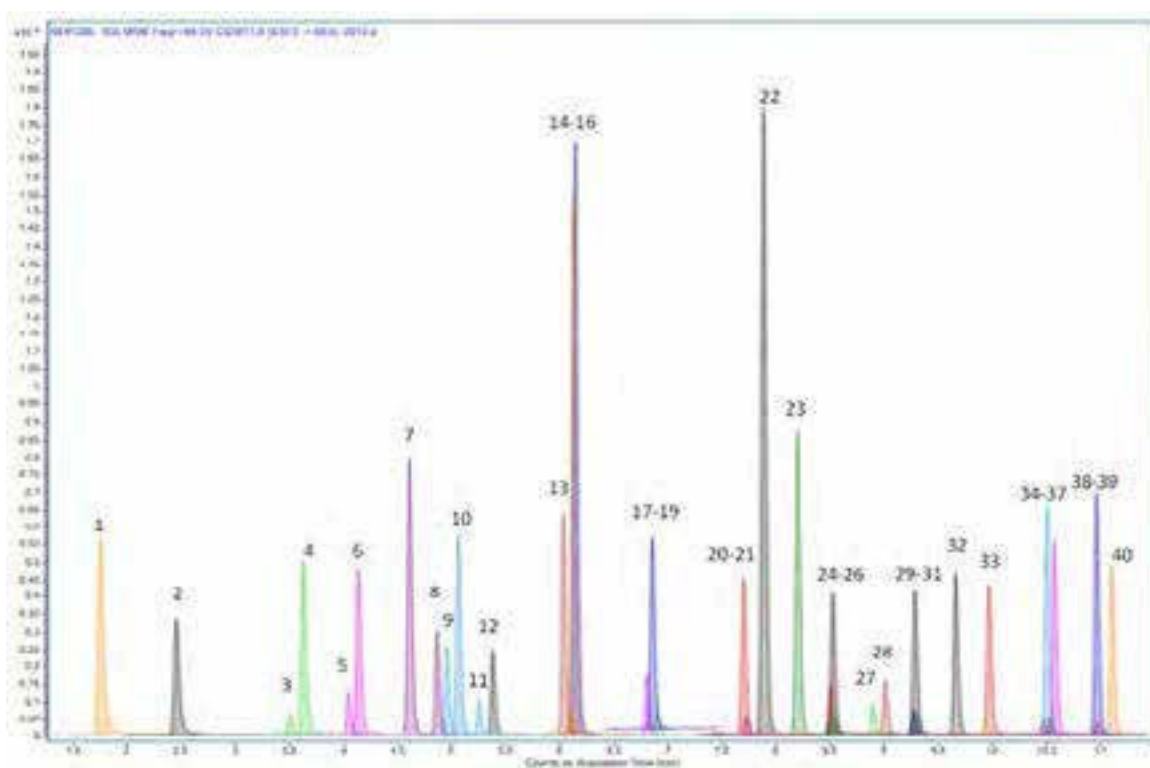


# ENVIRONMENTAL APPLICATIONS

Our Earth's most precious resources need protecting. Thanks to dedicated environmental scientists the challenge has been accepted. Following established and emerging testing requirements for some of the most challenging matrices requires rugged and reliable solutions. HALO® ENVIROCLASS is comprised of applied column solutions for PFAS and PAH applications and includes other small molecule chemistries to address environmental LC separations.

## FAST ANALYSIS OF PFAS FOLLOWING EPA METHOD 1633

In 2021 the EPA released method 1633 for the detection and quantification of 40 PFAS compounds in a wide variety of matrices, including aqueous, solid, biosolids, and tissue samples. Below is the HALO® PFAS solution for PFAS analysis using EPA method 1633. All of the analytes elute within 12 minutes making it a rapid analysis.



### PEAK IDENTITIES:

1. PFBA	11. PFPeS	21. PFOS	31. NETFOSAA
2. PFMPA	12. HFPO-DA	22. 7-3 FTCA	32. 11Cl-PF3OUdS
3. 3-3 FTCA	13. PFHpA	23. 9Cl-PF3ONS	33. PFDaA
4. PFPeA	14. PFHxS	24. 8-2FTS	34. NMeFOSA
5. PFBS	15. 5-3 FTCA	25. PFDA	35. NMeFOSE
6. PFMBA	16. ADONA	26. PFNS	36. PFDoS
7. PFEESA	17. 6-2FTS	27. NMeFOSAA	37. PFTrA
8. NFDHA	18. PFOA	28. PFOSA	38. NETFOSE
9. 4-2FTS	19. PFHpS	29. PFDS	39. NETFOA
10. PFHxA	20. PFNA	30. PFUnA	40. PFTeDA

### TEST CONDITIONS:

Analytical Column: HALO® PFAS, 2.7 µm, 2.1 x 100 mm  
 Part Number: 92812-613  
 Delay Column: HALO® PFAS Delay, 2.7 µm, 3.0 x 50 mm  
 Part Number: 92113-415  
 Mobile Phase A: 20 mM Ammonium Acetate  
 Mobile Phase B: Methanol  
 Gradient:

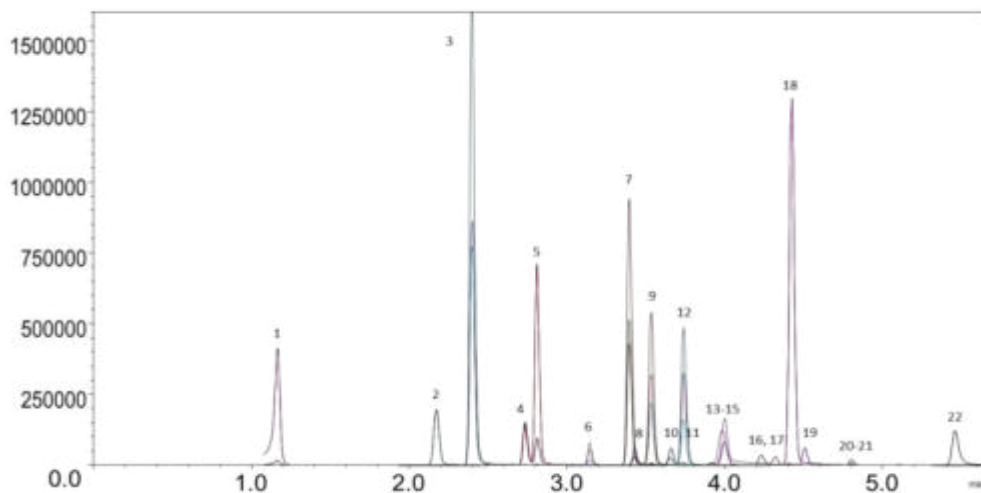
Time	%B
0.0	20
12	90
15	90
15.1	20
18	End

Flow Rate: 0.4 mL/min  
 Pressure: 505 bar  
 Temperature: 44 °C  
 Detection: -ESI MS/MS  
 Injection Volume: 2.0 µL  
 Sample Solvent: Methanol (96%) Water (4%)  
 MS System: Agilent 6400 series  
 LC System: Agilent 1200 series

**MS Conditions:**  
 Gas Temp: 130 °C  
 Nebulizer: 25 psi  
 Gas Flow: 11 L/min  
 Sheath Gas Heater: 250 °C  
 Capillary: 3500 V

## LCMS SEPARATION OF MYCOTOXINS ON HALO® PFP, 2.7 µm

The HALO 90 Å PFP can meet these challenges of environmental analysis, but exceed them by demonstrating high speed and sensitivity. The HALO 90 Å PFP is an ideal column to be used in environmental and mycotoxin analysis.



### PEAK IDENTITIES:

1. Nivalenol
2. Fusarenone X
3. Neosolaniol
4. 15- acetyldeoxynivalenol
5. 3- acetyldeoxynivalenol
6. Aflatoxin M1
7. Diacetoxyscripenol
8. Aflatoxin G2
9. Aflatoxin G1
10. HT2 Toxin
11. Aflatoxin B2
12. Aflatoxin B1
13. Ochratoxin B
14. Citrinin
15. T2 Toxin
16. Ochratoxin A
17. Zearalenone
18. Sterigmatocystin
19. Fumonisin B2
20. Fumonisin B3
21. Fumonisin B1
22. Beauvericin

### TEST CONDITIONS:

Column: HALO 90 Å PFP, 2.7 µm, 2.1 x 100 mm  
 Part Number: 92812-609  
 Mobile Phase A: Water, 2 mM Ammonium Formate, 0.1% Formic Acid  
 Mobile Phase B: Methanol, 2 mM Ammonium Formate, 0.1% Formic Acid

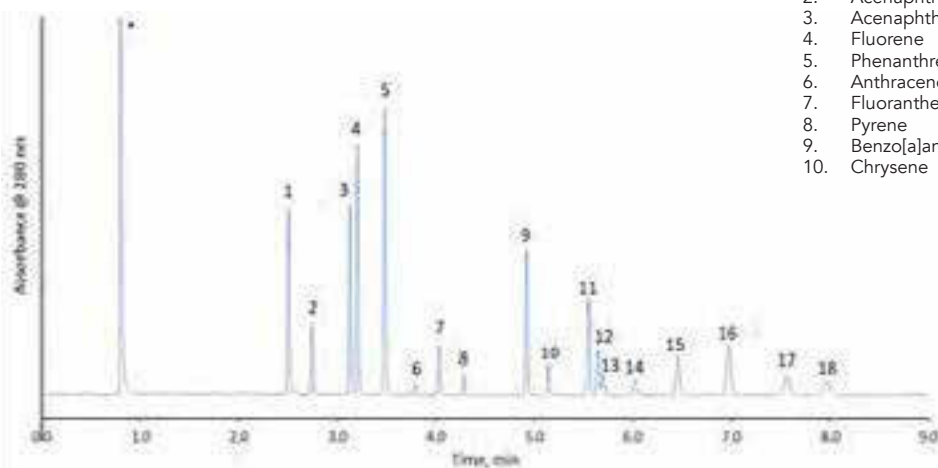
Gradient: Time %B  
 0.0 15  
 4.5 100  
 10.0 100

Flow Rate: 0.4 mL/min  
 Pressure: 280 bar

Temperature: 40 °C  
 Injection Volume: 7.0 µL  
 Sample Solvent: Methanol  
 Detection: +ESI MS/MS  
 LC System: Shimadzu Nexera X2

## SEPARATION OF EPA 610 + BENZO[E]PYRENE + PERYLENE USING HALO® PAH

Rapid separation of the 16 compounds specified in EPA 610 along with benzo[e]pyrene and perylene demonstrates excellent speed and resolution with the HALO® PAH column.



### PEAK IDENTITIES:

1. Naphthalene
  2. Acenaphthylene
  3. Acenaphthene
  4. Fluorene
  5. Phenanthrene
  6. Anthracene
  7. Fluoranthene
  8. Pyrene
  9. Benzo[a]anthracene
  10. Chrysene
  11. Benzo[e]pyrene
  12. Benzo[b]fluoranthene
  13. Perylene
  14. Benzo[k]fluoranthene
  15. Benzo[a]pyrene
  16. Dibenzo[a,h]anthracene
  17. Benzo[g,h,i]perylene
  18. Indeno[1,2,3-c,d]pyr
- \* acetone from sample solvent

### TEST CONDITIONS:

Column: HALO 90 Å PAH, 2.7 µm, 4.6 x 150 mm  
 Part Number: 92844-712  
 Mobile Phase A: Water

B: Acetonitrile  
 Gradient: Time %B  
 0.0 50  
 4.5 100  
 9.0 100  
 9.5 50  
 14.0 50

Flow Rate: 1.8 mL/min  
 Initial Back Pressure: 416 bar  
 Temperature: 30 °C  
 Detection: 280 nm  
 Injection Volume: 5 µL  
 Sample Solvent: 80/20 Methanol/Acetone  
 Data Rate: 40 Hz  
 Response Time: 0.05 sec.  
 Flow Cell: 1 µL  
 LC System: Shimadzu Nexera X2  
 ESI LCMS system: Shimadzu LCMS-8040



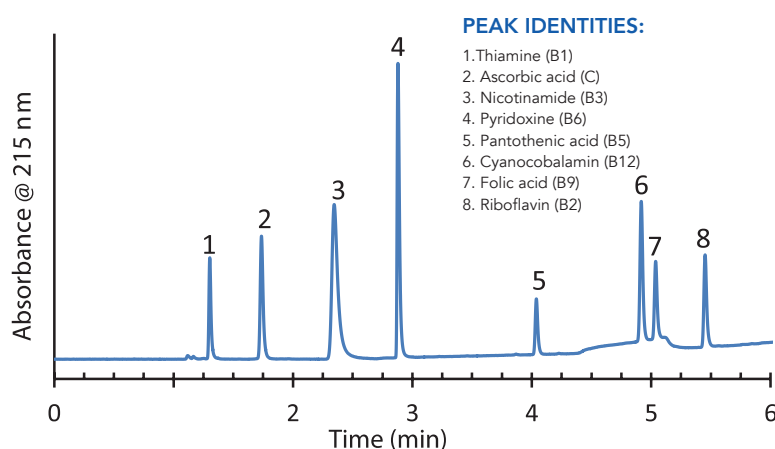


# VITAMIN APPLICATIONS

Analytical scientists are charged with formulating new combinations of vitamins and supplements in a variety of matrices and delivery mechanisms. Chromatography plays a critical role in this process. HALO® columns offer unique phase chemistries and properties designed for studying vitamins and their isomers.

## SEPARATION OF WATER-SOLUBLE VITAMINS ON HALO® AQ-C18

HALO® AQ-C18 columns can be used with totally or mostly aqueous mobile phases. In this application, eight water-soluble vitamins are well-separated using this phase in under six minutes using a gradient from 0-70% methanol, with a 1-minute initial hold.



### TEST CONDITIONS:

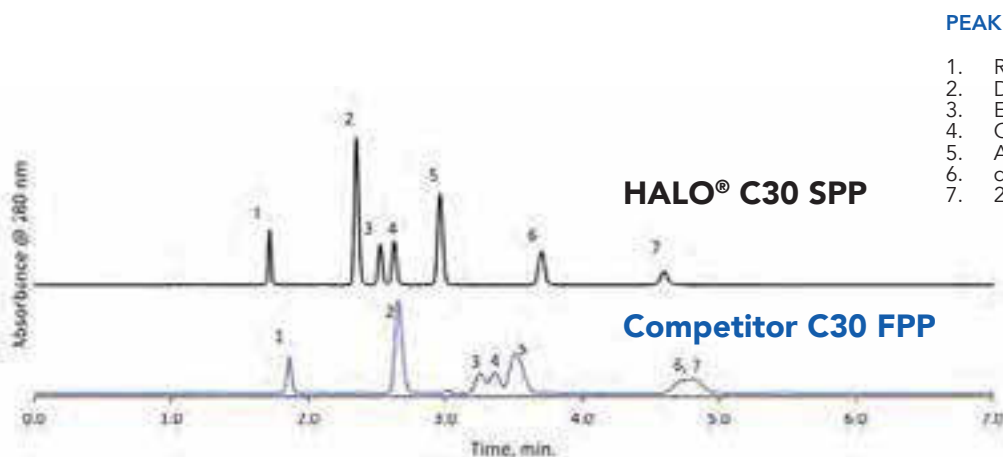
Column: HALO 90 Å AQ-C18, 2.7 µm, 4.6 x 150 mm  
 Part Number: 92814-722  
 Mobile Phase: A/B  
 A= 0.025 M, potassium phosphate in water, pH=2.5 B= Methanol  
 Gradient:

Time (min.)	%B
0.0	0
1.0	0
6.0	70
10.0	70

Flow Rate: 1.2 mL/min.  
 Initial Pressure: 243 bar  
 Temperature: 30°C  
 Injection Volume: 2.0 µL  
 Sample Solvent: water  
 Detection: 215 nm, VWD  
 Response Time: 0.02 sec.  
 Data Rate: 25 Hz  
 Flow Cell: 2.5 µL semi-micro  
 LC System: Shimadzu Prominence UFLC XR  
 ECV: ~14 µL

## SEPARATION OF FAT SOLUBLE VITAMINS: SPP VS. FPP

Sharper peaks and increased resolution are obtained on the HALO® C30 column compared to the competitor FPP C30 column.



### TEST CONDITIONS:

Column: HALO 160 Å C30, 2.7 µm, 4.6 x 150 mm  
 Part Number: 92114-730  
 Competitor FPP: C30, 3.0 µm, 4.6 x 150 mm  
 Isocratic: 100% Methanol  
 Flow Rate: 1.5 mL/min  
 Initial HALO Pressure: 262 bar  
 Initial Competitor FPP Pressure: 207 bar  
 Temperature: 30°C  
 Detection: UV 280 nm, PDA  
 Injection Volume: 2.0 µL  
 Sample Solvent: Methanol  
 Data Rate: 40 Hz  
 Response Time: 0.025 sec.  
 Flow Cell: 1 µL  
 LC System: Shimadzu Nexera X2

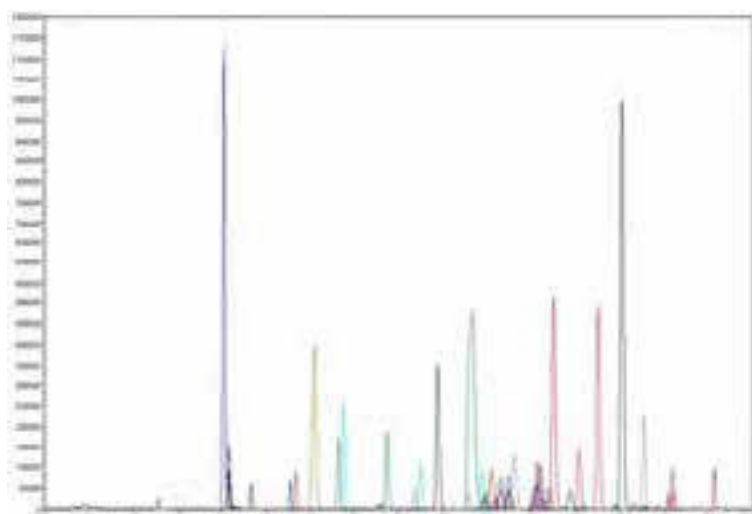
# CANNABIS APPLICATIONS

Chromatography aids in the discovery and identification of medicines derived from natural products such as cannabis. Cannabis plants provide a complex web of characteristics and attributes to alleviate pain and improve medical conditions. Analytical scientists are challenged with identifying, quantifying and formulating the proper characteristics for efficacy and delivery. HALO® columns with their Fused-Core® technology lend themselves to the challenging matrix of cannabis for rugged and efficient separations.



## LC-MS ANALYSIS OF THE OREGON PESTICIDE MIX ON HALO® AQ-C18

The Oregon pesticide list consists of 59 compounds and 2 of these are isomers (spinosad A and D and pyrethrin I and II). All of the compounds were run using positive ESI except fludioxinil and fipronil, which were run in negative mode since it is easier for these compounds to be oxidized.

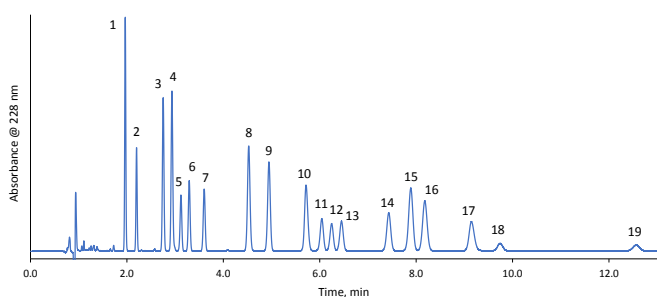


### PEAK IDENTITIES:

- |                         |                        |
|-------------------------|------------------------|
| 1. Daminozide           | 32. Bifenazate         |
| 2. Acephate             | 33. Pyrethrin I        |
| 3. Oxamyl               | 34. Fipronil           |
| 4. Flonicamid           | 35. Fenoxycarb         |
| 5. Methomyl             | 36. Tebuconazole       |
| 6. Thiamethoxam         | 37. Kresoxim-methyl    |
| 7. Imidacloprid         | 38. Propiconazole      |
| 8. Dimethoate           | 39. Diazinon           |
| 9. Acetamiprid          | 40. Spinosad A         |
| 10. Aldicarb            | 41. MGK 264            |
| 11. Thiacloprid         | 42. Prallethrin        |
| 12. Dichlorvos          | 43. Spinosad D         |
| 13. Propoxur            | 44. Pyrethrin II       |
| 14. Carbofuran          | 45. Chlorfenapyr       |
| 15. Carbaryl            | 46. Trifloxystrobin    |
| 16. Imazalil            | 47. Clofentazine       |
| 17. Metalaxyl           | 48. Piperonyl butoxide |
| 18. Naled               | 49. Hexythiazox        |
| 19. Parathion methyl    | 50. Chlorpyrifos       |
| 20. Chlorantraniliprole | 51. Spiromesifen       |
| 21. Spiroxamine         | 52. Etoxazole          |
| 22. Phosmet             | 53. Fenpyroximate      |
| 23. Methiocarb          | 54. Cyfluthrin         |
| 24. Azoxystrobin        | 55. Cypermethrin       |
| 25. Paclobutrazol       | 56. Pyridaben          |
| 26. Boscalid            | 57. Abamectin          |
| 27. Fludioxinil         | 58. Permethrin         |
| 28. Malathion           | 59. Etofenprox         |
| 29. Myclobutanil        | 60. Bifenthrin         |
| 30. Spirotetramat       | 61. Acequinocyl        |
| 31. Ethoprophos         |                        |

\* to view the complete test conditions, [click here](#)

## SEPARATION OF 19 CANNABINOIDS USING HALO® LPH-C18



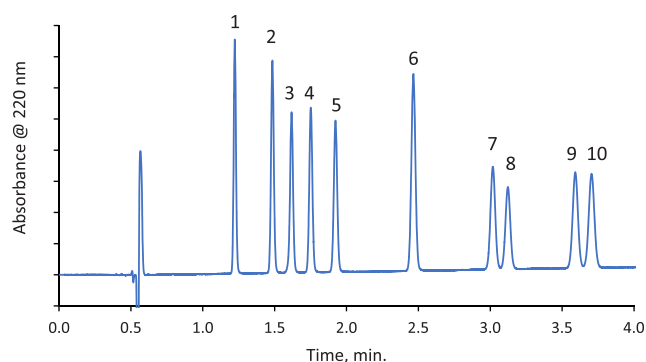
### TEST CONDITIONS:

Column: HALO 90 Å LPH-C18, 2.7 µm, 4.6 x 150mm  
 Part Number: 92824-716  
 Mobile Phase A: 5 mM Ammonium Formate, 0.1% Formic Acid  
 Mobile Phase B: Acetonitrile, 0.05% Formic Acid  
 Isocratic: 75% B  
 Flow Rate: 1.5 mL/min  
 Pressure: 232 bar  
 Temperature: 30°C  
 Detection: PDA, UV: 228 nm  
 Injection Volume: 1 µL  
 Sample Solvent: 75/25 MeOH/ Water  
 Data Rate: 100 Hz  
 Response Time: 0.025 sec.  
 Flow Cell: 1 µL  
 LC System: Shimadzu Nexera X2

### PEAK IDENTITIES:

1. Cannabidivarinic acid (CBDVA)
2. Cannabidivarin (CBDV)
3. Cannabidiolic acid (CBDA)
4. Cannabigerolic acid (CBGA)
5. Cannabigerol (CBG)
6. Cannabidiol (CBD)
7. Tetrahydrocannabivarin (THCV)
8. Tetrahydrocannabivarinic acid (THCVA)
9. Cannabinol (CBN)
10. Cannabinolic acid (CBNA)
11. Exo-tetrahydrocannabinol (EXO-THC)
12. delta 9- Tetrahydrocannabinol (D9-THC)
13. delta 8- Tetrahydrocannabinol (D8-THC)
14. Cannabicycol (CBL)
15. Cannabichromene (CBC)
16. Tetrahydrocannabinolic acid A (THCA-A)
17. Cannabichromenic acid (CBCA)
18. Cannabicyclolic acid (CBLA)
19. Cannabitrinol (CBT)

## HIGH SPEED SEPARATION OF TEN KEY CANNABINOIDS



### TEST CONDITIONS:

Column: HALO 90 Å C18, 2.7 µm, 4.6 x 100 mm  
 Part Number: 92814-602  
 Mobile Phase A: Water/0.1% formic acid  
 Mobile Phase B: Acetonitrile/0.085% formic acid  
 Gradient: 77-85% B in 4 min  
 Flow Rate: 1.5 mL/min  
 Initial Pressure: 197 bar  
 Temperature: 38 °C  
 Detection: UV 220 nm, PDA  
 Injection Volume: 1.3 µL  
 Dwell Volume: 0.471 mL  
 Sample Solvent: 75/25 methanol/water  
 Response Time: 0.025 sec  
 Data Rate: 100 Hz  
 Flow Cell: 1.0 µL  
 LC System: Shimadzu Nexera X2

### PEAK IDENTITIES:

1. Cannabidivarin (CBDV)
2. Cannabidiolic acid (CBDA)
3. Cannabigerol (CBG)
4. Cannabidiol (CBD)
5. Tetrahydrocannabivarin (THCV)
6. Cannabinol (CBN)
7. delta-9-Tetrahydrocannabinol (Δ9-THC)
8. delta-8-Tetrahydrocannabinol (Δ8-THC)
9. Cannabichromene (CBC)
10. delta-9-Tetrahydrocannabinolic acid A (THCA)

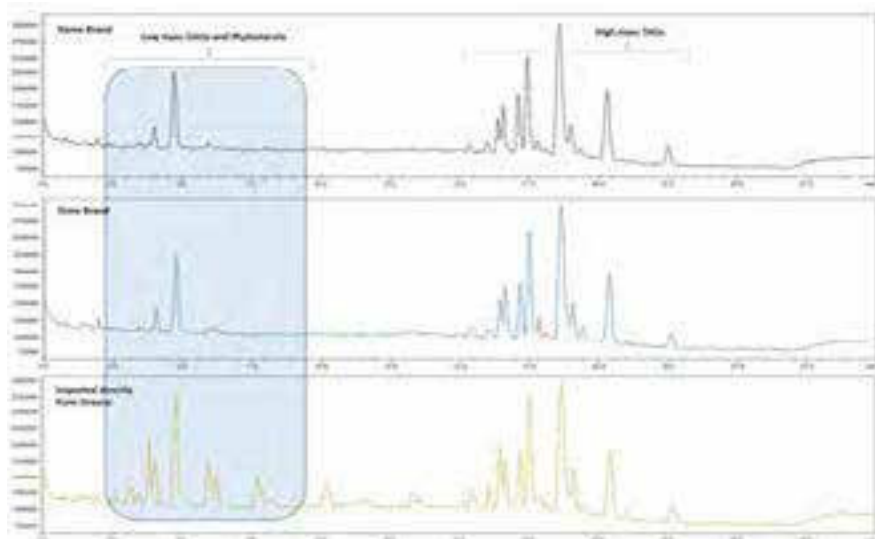


# FOOD AND BEVERAGE APPLICATIONS

Nutrition is critical for life itself, and through food and beverages humans have derived enjoyment of life. Food scientists depend on chromatography to develop new formulations and ensure the safety of the products we enjoy every day. Matrices of food applications can pose several analytical challenges. HALO® columns are designed to withstand dirtier matrices than their fully porous counterparts.

## LCMS PROFILING OF OLIVE OILS USING THE HALO® C30 COLUMN

Using the HALO® C30 HPLC column, complex separations of glycerols, such as olive oils, can be achieved and used for product quality testing.



### TEST CONDITIONS:

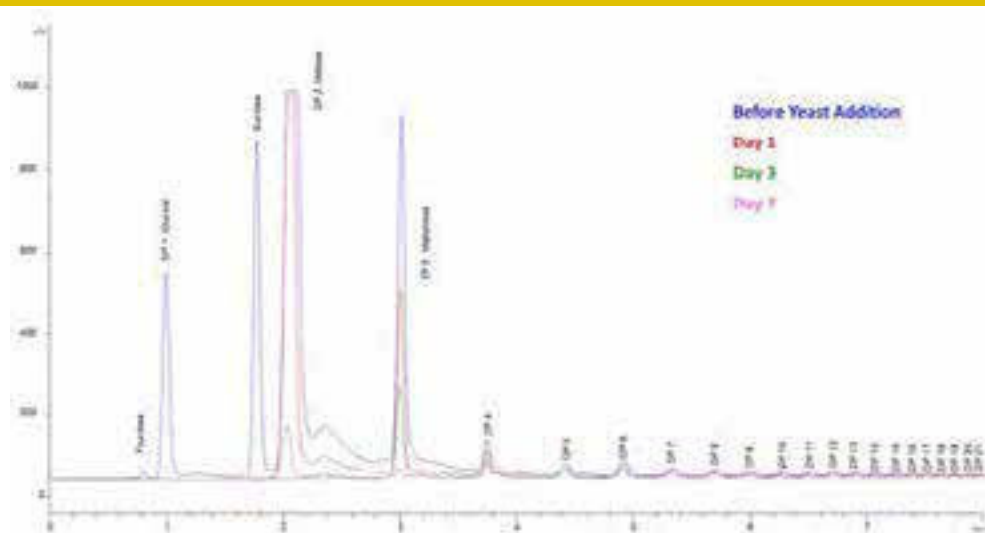
Column: HALO 160 Å C30, 2.7µm, 2.1 x 150 mm  
 Part Number: 92112-730  
 Mobile Phase A: Methanol  
 Mobile Phase B: IPA/0.1% Formic Acid

Gradient:	Time	%B
	0.00	10
	10.00	10
	14.00	40
	25.00	40
	25.01	10
	30.00	10

Flow Rate: 0.3 mL/min  
 Temperature: Ambient  
 Injection Volume: 2 µL  
 Sample Solvent: MeOH  
 LC System: Shimadzu Nexera X2  
 MS System: Shimadzu 2020

## BEER FERMENTATION ANALYSIS USING HALO® PENTA-HILIC

The Penta-HILIC/ELSD combination is a great way to perform rapid sugar analysis providing high resolution and good peak shape at elevated temperatures



### TEST CONDITIONS:

Column: HALO 90 Å Penta-HILIC, 2.7 µm, 3.0 x 50 mm  
 Part Number: 92813-405  
 Mobile Phase A: Water  
 Mobile Phase B: Acetonitrile

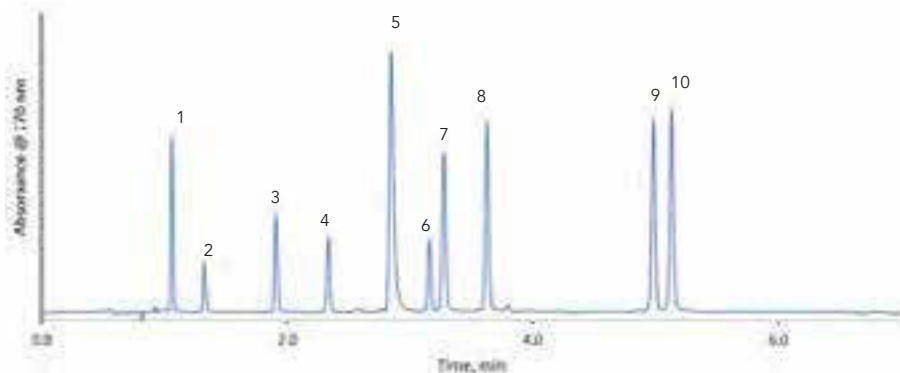
Gradient:	Time	%B
	0.0	92
	8.0	52

Flow Rate: 0.75 mL/min  
 Temperature: 65 °C  
 Detection: ELSD, 40°C, 45 psi  
 Injection Volume: 2 µL  
 Data Rate: 10 Hz, 2 sec filter

Data Courtesy of Merlin K. L. Bicking, Ph. D. (ACCTA, Inc.)

## SEPARATION OF COMMON CATECHINS AND CAFFEINE FOUND IN TEA VIA LC-UV

A UV separation of catechin and caffeine standards shows excellent resolution on a HALO® LPH-C18 column. This column is ideal for low pH separations due to its sterically protected ligand, preventing acid hydrolysis and reducing retention drift over time.



### PEAK IDENTITIES:

1. Gallic Acid
2. Gallocatechin
3. Epigallocatechin
4. Catechin
5. Caffeine
6. Epicatechin
7. Epigallocatechin Gallate
8. Gallocatechin Gallate
9. Epicatechin Gallate
10. Catechin Gallate

### TEST CONDITIONS:

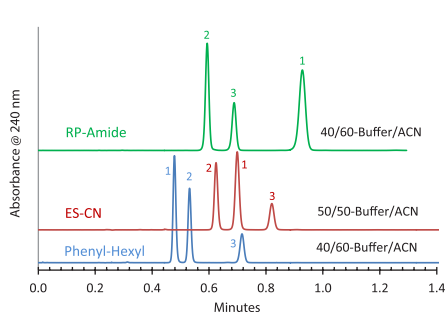
Column: HALO 90 Å LPH-C18 2.7 µm, 4.6 x 150 mm  
 Part Number: 92824-716  
 Mobile Phase A: Water, 0.2% Formic Acid (pH: 2.45)  
 Mobile Phase B: Acetonitrile, 0.2% Formic Acid  
 Gradient:

Time	%B
0.0	10
0.5	10
6.0	23
7.0	23

Flow Rate: 1.8 mL/min  
 Pressure: 395 bar  
 Temperature: 40 °C  
 Detection: PDA, UV 270 nm  
 Injection Volume: 5 µL  
 Sample Solvent: 90/10 Water/ Acetonitrile  
 LC System: Shimadzu Nexera X2

## SEPARATION OF THREE FLAVONOIDS ON HALO® RP-AMIDE, ES-CN AND PHENYL-HEXYL, 2.7 µm

These phase choices allow flexibility during method development and optimization. Note the short separation time and modest back pressure.



### PEAK IDENTITIES:

1. Biochanin A
2. Flavone
3. Flavanone

### TEST CONDITIONS:

Columns:

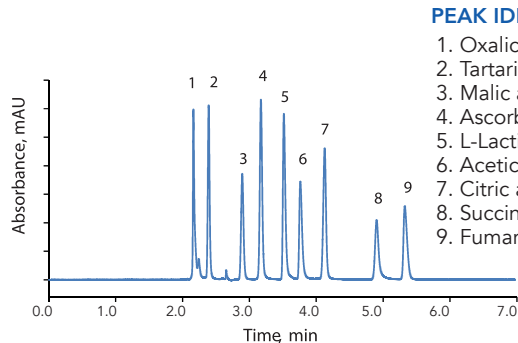
- 1) HALO 90 Å RP-Amide, 2.7 µm, 4.6 x 50 mm  
 Part Number: 92814-407
- 2) HALO 90 Å ES-CN, 2.7 µm, 4.6 x 50 mm  
 Part Number: 92814-404
- 3) HALO 90 Å Phenyl-Hexyl, 2.7 µm, 4.6 x 50 mm  
 Part Number: 92814-406

Mobile Phase: A/B - See chart  
 A: 0.02 M Potassium phosphate buffer, pH 2.9  
 B: Acetonitrile

Flow Rate: 2.0 mL/min  
 Pressure: ~170 bar  
 Temperature: 30 °C  
 Detection: UV 240 nm, VWD  
 Injection Volume: 1.0 µL  
 Sample Solvent: 50/50 water/acetonitrile  
 Response Time: 0.02 sec  
 Data Rate: 25 Hz  
 Flow Cell: 2.5 µL semi-micro  
 LC System: Shimadzu Prominence UFLC XR  
 Extra Column Volume: ~14 µL

## SEPARATION OF POLAR ORGANIC ACIDS ON HALO® AQ-C18

Nine polar organic acids are separated using a HALO® AQ-C18 column with 100% aqueous mobile phase at low pH.



### PEAK IDENTITIES:

1. Oxalic acid
2. Tartaric acid
3. Malic acid
4. Ascorbic acid
5. L-Lactic acid
6. Acetic acid
7. Citric acid
8. Succinic acid
9. Fumaric acid

### TEST CONDITIONS:

Column: HALO 90 Å AQ-C18, 2.7 µm, 4.6 x 250 mm  
 Part Number: 92814-922  
 Isocratic: 20 mM potassium phosphate buffer, pH 2.7  
 Flow Rate: 1.0 mL/min  
 Pressure: 307 bar  
 Temperature: 40 °C  
 Detection: UV 214 nm, PDA  
 Injection Volume: 20 µL  
 Sample Solvent: Mobile phase  
 Response Time: 0.025 sec  
 Data Rate: 100 Hz  
 Flow Cell: 1.0 µL  
 LC System: Shimadzu Nexera X2

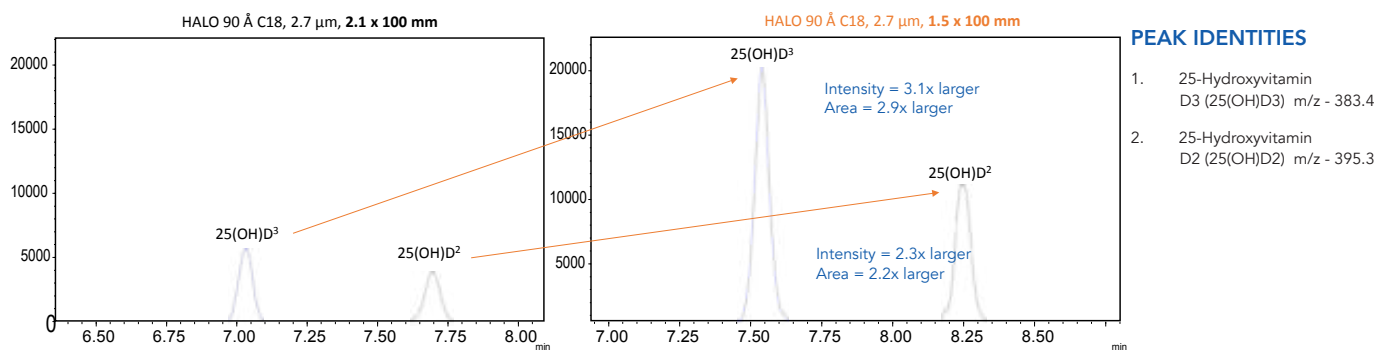


# CLINICAL APPLICATIONS

Understanding our biological systems and the impacts from natural and unnatural sources to it, provides scientists a clearer picture of causality and effects. Obtaining this knowledge requires state of the art tools as demands for sensitivity increase. HALO® (U)HPLC/MS columns are designed for fast, high efficiency separations making them an ideal choice for high throughput clinical laboratory applications where time and accuracy are critical.

## INCREASED RESPONSE OF VITAMIN D METABOLITES USING LCMS

A separation of two vitamin D metabolites are performed on both a 1.5 mm and 2.1 mm ID column. The 1.5mm column gives an increase in response over the 2.1 mm column. With higher ionization efficiencies the 1.5 mm ID column can help reach the LOD of these vitamin D metabolites.



### TEST CONDITIONS:

Column: HALO 90 Å C18, 2.7µm, 2.1x100 mm  
Part Number: 92812-602  
Column: HALO 90 Å C18, 2.7µm, 1.5x100 mm  
Part Number: 9281X-602  
Tubing (Column to Source): AMT MarvelXACT™ 50 µm x 600 mm  
Part Number: PS7050600  
Mobile Phase A: Water, 0.1 % Formic Acid  
Mobile Phase B: ACN, 0.1 % Formic Acid

Gradient:

Time	%B
0.00	50
10.80	92.5
11.48	95
12.75	100
13.75	100
14.25	50
20.00	End

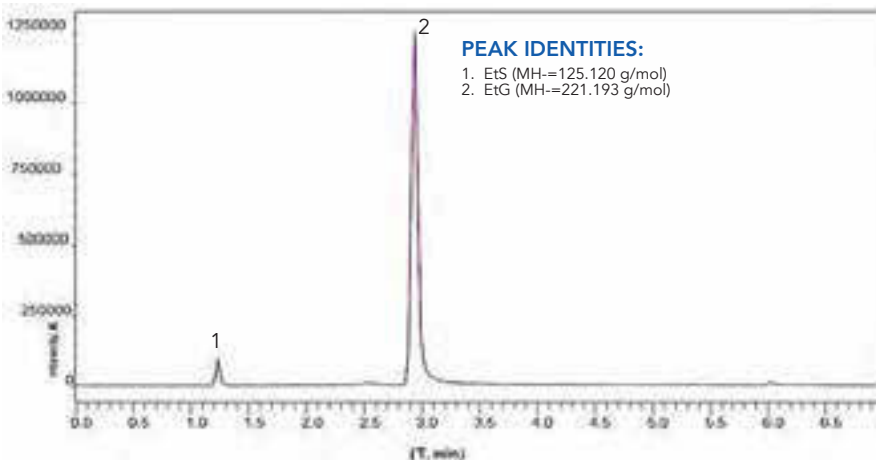
Flow Rate: 0.4 mL/min for 2.1 mm  
0.2 mL/min for 1.5 mm  
Pressure: 370 bar for 2.1 mm  
229 bar for 1.5 mm  
Temperature: 40 °C  
Injection Volume: 1.0 µL @ 500 ppb  
Sample Solvent: 50/50/ ACN/H<sub>2</sub>O  
Detection: +ESI/APCI MS/MS  
LC System: Shimadzu Nexera X2  
ESI LCMS System: Shimadzu LCMS-8040

### MS CONDITIONS:

Detection: ESI +/APCI  
Spray Voltage: 4.5 kV  
Nebulizing gas: 2 L/min  
Drying gas: 15 L/min  
DL temp: 250 °C  
Heat Block: 300 °C

## LCMS SEPARATION OF ETG/ETS FROM URINE ON HALO® PENTA-HILIC, 2 µm

Ethyl glucuronide (EtG) and ethyl sulfate (EtS) are metabolites of ethanol that are found in urine. The presence of these can be used to determine if an alcoholic beverage was ingested. Zero tolerance programs often use this test.



### TEST CONDITIONS:

Column: HALO 90 Å Penta-HILIC, 2 µm 2.1 x 100mm  
Part Number: 91812-605

Mobile Phase A: 5 mM ammonium formate/  
0.1% formic acid in 95:5 ACN/water

Mobile Phase B: 5mM ammonium formate/  
0.1% formic acid in 80:20 ACN/water

Gradient:	Time	%B
	0.00	0
	1.00	100
	5.00	100
	5.01	0
	7.00	END

### MS CONDITIONS:

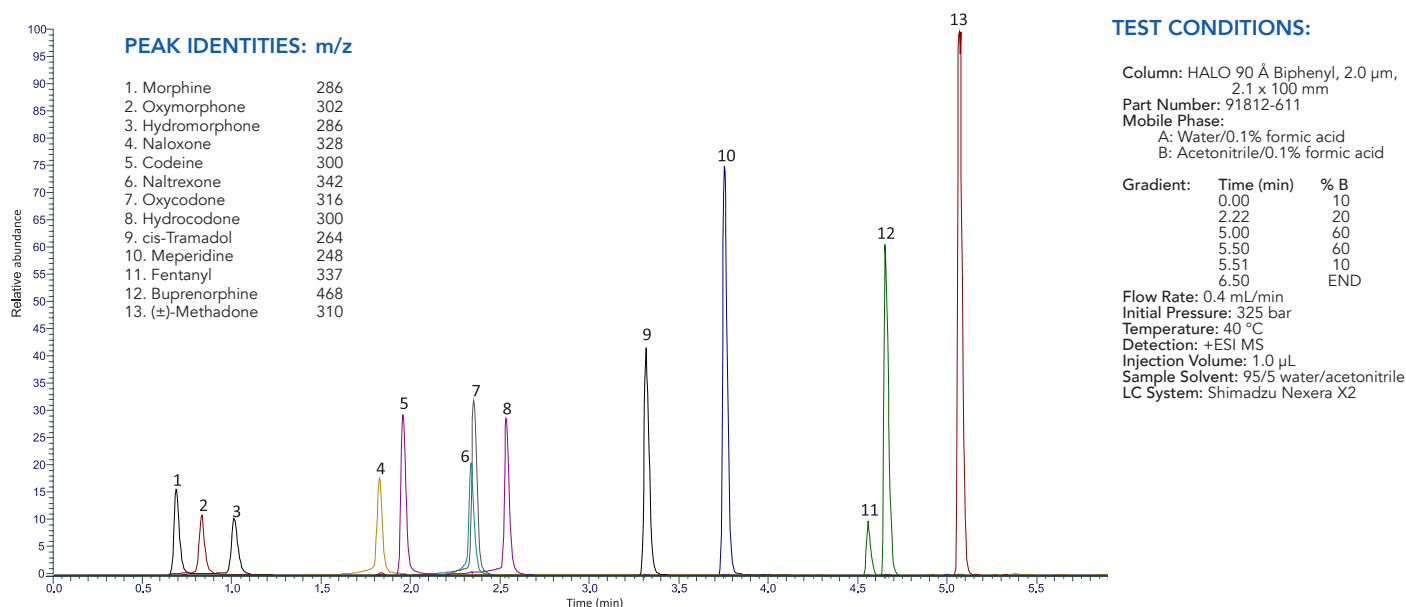
Flow Rate: 0.4 mL/min  
Initial Pressure: 325 bar  
Temperature: 40 °C  
Injection Volume: 2 µL  
Sample prep: 5ng/mL EtG/EtS in 20 µL of synthetic urine.  
10 fold dilution with mobile phase A.

LCMS system: Shimadzu LCMS-2020  
Detection: -ESI MS  
Spray voltage: 4.50 kV  
Drying line temp: 300 °C  
Heat Block: 450 °C



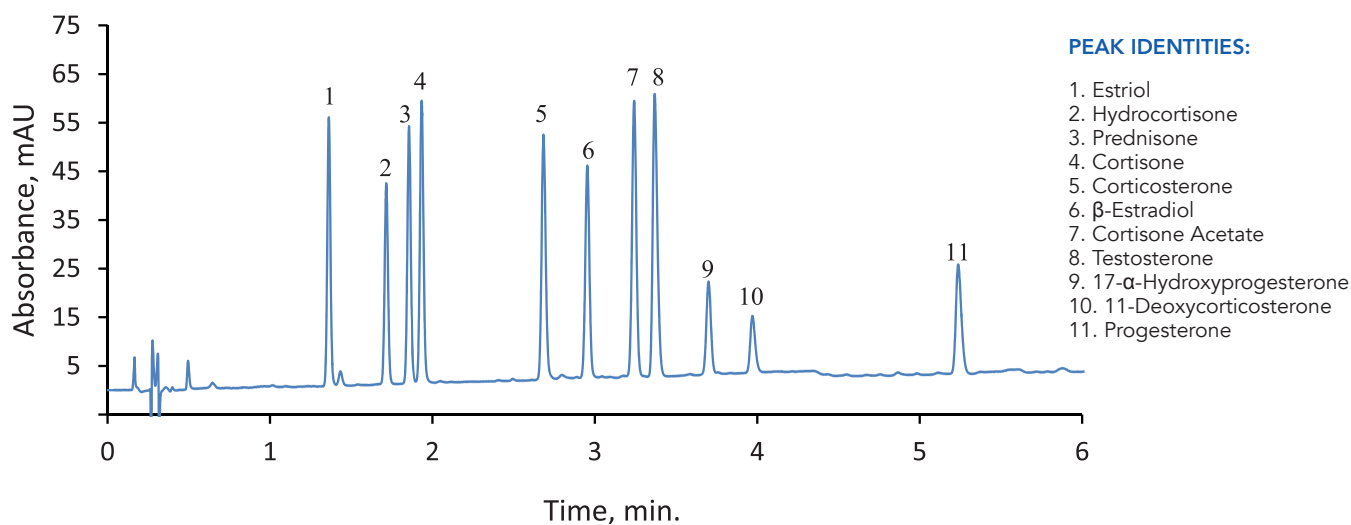
## LC-MS SEPARATION OF PAIN MANAGEMENT OPIATES ON HALO® BIPHENYL, 2.0 µm

The 2.0 µm HALO® Biphenyl is an ideal choice for high throughput analysis of drug panels, in which isobaric species separation is needed. Note the resolution between codeine and hydrocodone, (peaks 1 and 3, respectively) and morphine and hydromorphone (peaks 5 and 8, respectively).



## SEPARATION OF STEROIDS ON HALO® BIPHENYL

A mixture of eleven steroids is separated using a 6-minute gradient on a HALO 90 Å Biphenyl column. The chromatogram shows very good resolution between all peak pairs with excellent peak shape and high efficiency.



### TEST CONDITIONS:

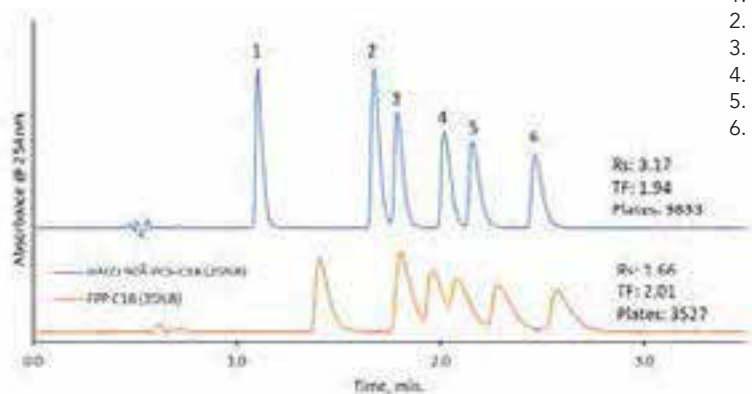
Column: HALO 90 Å Biphenyl, 2.0 µm, 2.1 x 100 mm  
 Part Number: 91812-611  
 Mobile Phase:  
 A: Water/0.1% formic acid  
 B: Acetonitrile/0.1% formic acid

Gradient:	Time (min)	% B
	0.00	10
	2.22	20
	5.00	60
	5.50	60
	5.51	10
	6.50	END

Flow Rate: 0.4 mL/min  
 Initial Pressure: 325 bar  
 Temperature: 40 °C  
 Detection: +ESI MS  
 Injection Volume: 1.0 µL  
 Sample Solvent: 95/5 water/acetonitrile  
 LC System: Shimadzu Nexera X2

## SEPARATION OF ANTIDEPRESSANTS USING HALO 90 Å PCS C18

The positive charged surface (PCS) stationary phase is ideal for basic analytes when using low ionic strength mobile phases such as formic acid. Sample loading is also improved compared to more traditional C18 columns on the market.



### PEAK IDENTITIES:

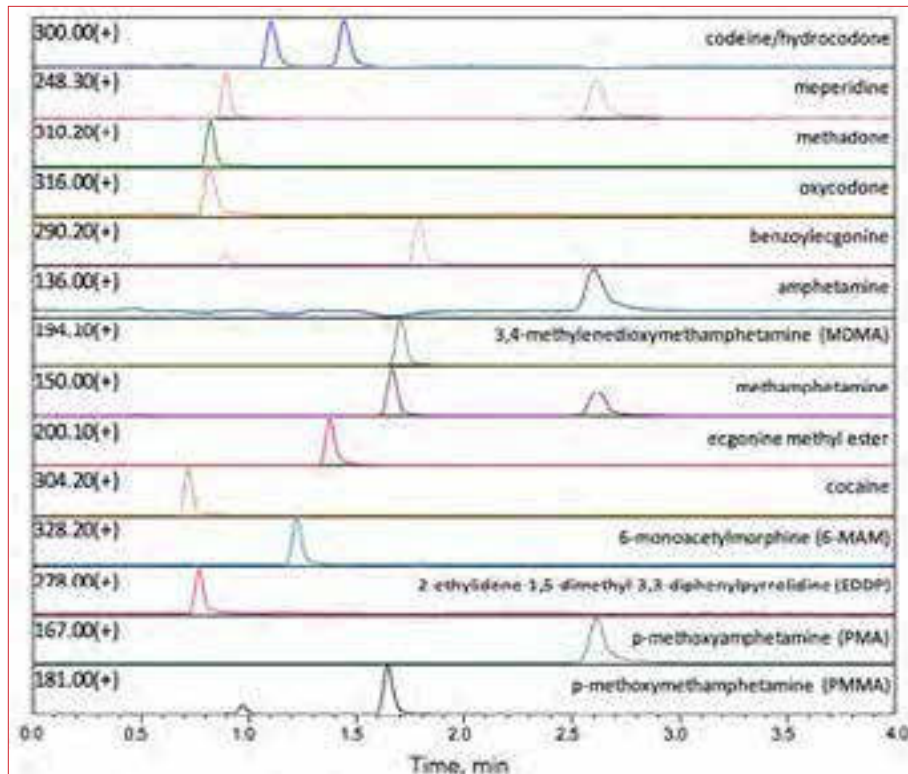
1. Doxepin
2. Desipramine
3. Imipramine
4. Nortriptyline
5. Amitriptyline
6. Trimipramine

### TEST CONDITIONS:

Column: HALO 90 Å PCS C18, 2.7  $\mu$ m, 2.1 x 100 mm  
 Part Number: 92812-617  
 Competitor Column: FPP C18, 3  $\mu$ m, 2.1 x 100 mm  
 Mobile Phase A: Water, 0.1% Formic Acid  
 Mobile Phase B: Acetonitrile, 0.1% Formic Acid  
 Isocratic: HALO<sup>®</sup> PCS C18: 25 %B  
 FPP C18: 35 %B  
 Flow Rate: 0.4 mL/min  
 Back Pressure: 267 bar  
 Temperature: 35 °C  
 Injection: 0.5  $\mu$ L (40  $\mu$ g)  
 Sample Solvent: 75/25 Water/ ACN  
 Wavelength: PDA, 254 nm  
 Flow Cell: 1  $\mu$ L  
 Data Rate: 100 Hz  
 Response Time: 0.025 sec.  
 LC System: Shimadzu Nexera X2

## LC-MS SEPARATION OF DRUGS OF ABUSE AND METABOLITES ON HALO<sup>®</sup> PENTA-HILIC

This mixture of drugs of abuse and metabolites is quickly identified using a HALO<sup>®</sup> PENTA-HILIC column and selected ion monitoring (SIM) for improved sensitivity. Adapted from J. Pharm. Anal. 2013; 3 (5): 303-311.



### TEST CONDITIONS:

Column: HALO 90 Å Penta-HILIC, 2.7  $\mu$ m, 2.1 x 100 mm  
 Part Number: 92812-605  
 Mobile Phase:  
 A: 5 mM Ammonium formate, pH 3.0  
 B: Acetonitrile  
 Isocratic: Pre-mixed 5/95 - A/B  
 Flow Rate: 0.5 mL/min  
 Pressure: 149 bar  
 Temperature: 60 °C  
 Detection: Selected Ion Monitoring as indicated  
 Injection Volume: 1.0  $\mu$ L  
 Sample Solvent: 90/10 ACN/water  
 MS Parameters: Positive ion mode, 2 kV, 400 °C heat block 225 °C capillary  
 LC-MS System: Shimadzu Nexera and LCMS-2020 (single quadrupole MS)

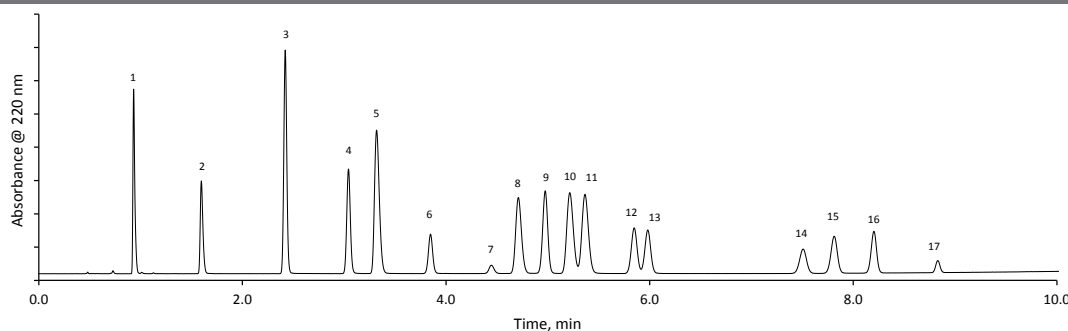


# INDUSTRIAL APPLICATIONS

Industrial scientists are faced with complex challenges which involves multiple modes of analysis. Chromatography is one of these tools relied upon to produce meaningful data. LC and LCMS separations often compliment the commonly used GC and GCMS techniques for industrial applications. The range of particle size, pore size, and available bonded phases make HALO® columns a useful option for LC method development.

## UHPLC SEPARATION OF EXPLOSIVES ON 2 µm HALO® C18

The determination of explosives in the environment is outlined in EPA method 8330B. 17 explosive compounds are separated on a HALO 90 Å 2 µm C18 column in less than 10 minutes using a water/methanol gradient.



### PEAK IDENTITIES:

1. HMX
2. RDX
3. 1,3,5-Trinitrobenzene
4. 1,3-Dinitrobenzene
5. 3,5-Dinitroaniline
6. Nitrobenzene
7. Nitroglycerin
8. Tetryl
9. 2,4,6-Trinitrotoluene
10. 2-Amino-4,6-dinitrotoluene
11. 4-Amino-2,6-dinitrotoluene
12. 2,4-Dinitrotoluene
13. 2,6-Dinitrotoluene
14. 2-Nitrotoluene
15. 4-Nitrotoluene
16. 3-Nitrotoluene
17. PETN (pentaerythritol tetranitrate)

### TEST CONDITIONS:

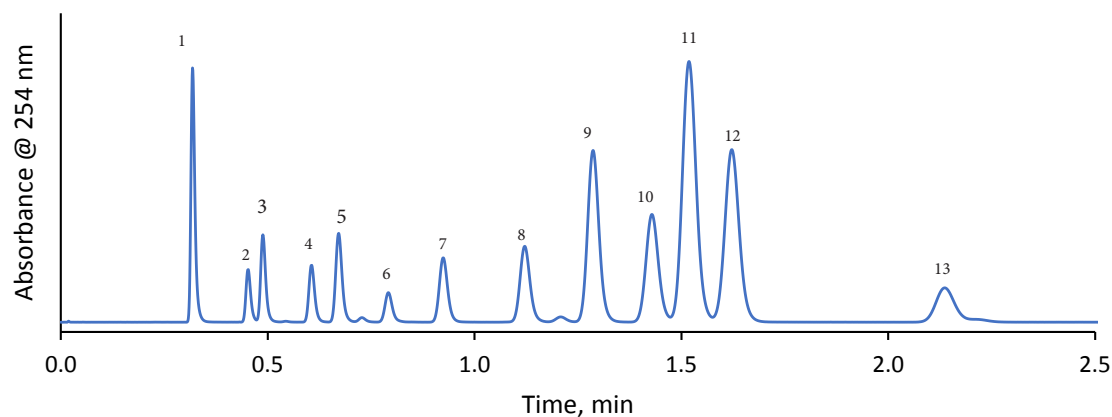
Column: HALO 90 Å C18, 2 µm, 3.0 x 100 mm  
 Part Number: 91813-602  
 Mobile Phase A: Water  
 Mobile Phase B: Methanol  
 Gradient: 

Time	%B
0.0	25
6.9	35
9.9	62

Flow Rate: 0.85 mL/min  
 Initial Back Pressure: 571 bar  
 Temperature: 43°C  
 Detection: 220 nm  
 Injection Volume: 0.2 µL  
 Sample Solvent: Methanol  
 Data Rate: 100 Hz  
 LC System: Shimadzu Nexera X2

## SEPARATION OF PHTHALATES AND NEUTRAL COMPOUNDS ON HALO® C8

A separation of phthalates and neutral compounds are separated on a HALO® C8 column with excellent speed and resolution.



### PEAK IDENTITIES:

1. Uracil
2. 1-Indanol
3. Dimethyl phthalate
4. Anisole
5. Diethyl phthalate
6. Benzophenone
7. Naphthalene
8. Dipropyl phthalate
9. Hexanophenone
10. Phenanthrene
11. Anthracene
12. 3-phenyltoluene
13. Dibutyl phthalate

### TEST CONDITIONS:

Column: HALO 90 Å C8, 2.7 µm, 4.6 x 50mm  
 Part Number: 92814-408  
 Mobile Phase:  
 A: Water  
 B: 70/30 Acetonitrile/ Methanol  
 Isocratic: 68%  
 Flow Rate: 1.5 mL/min  
 Pressure: 136 bar

Temperature: 27 °C  
 Detection: UV 254 nm, VWD  
 Injection Volume: 1.0 µL  
 Sample Solvent: Acetonitrile  
 Response Time: 0.02 sec  
 Flow Cell: 2.5 µL semi-micro  
 LC System: Shimadzu Prominence UFLC XR

# THE NEW HALO® 1.5 – DEFINING A NEW DIMENSION IN CHROMATOGRAPHY

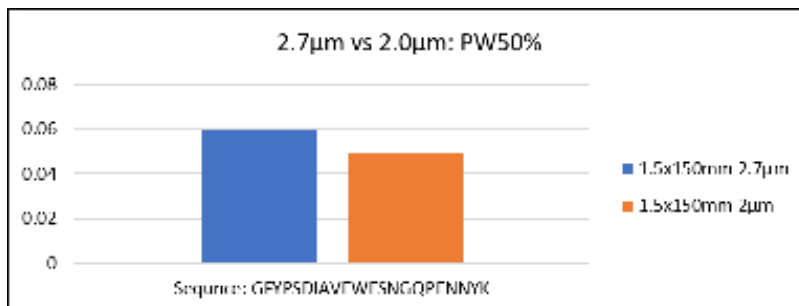
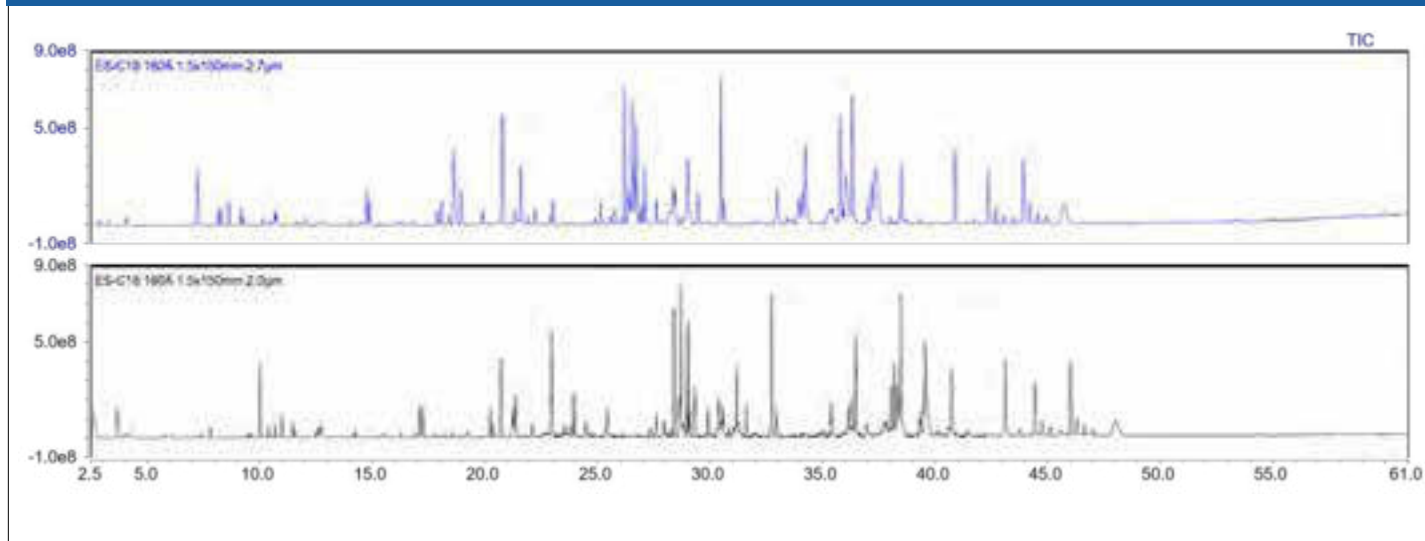
AMT broke new ground again with a 1.5 mm internal diameter HALO® column to push the boundaries of adopted UHPLC systems. Founded on all of the benefits of Fused-Core® particles, the HALO® 1.5 delivers increased sensitivity and reduced solvent consumption, allowing scientists to experience the benefits of capillary columns without the pains of specialized microflow systems.

## DELIVERING MORE PERFORMANCE

- ✓ More Sensitivity from conventional UHPLC Systems
- ✓ Higher Ionization Efficiencies from LCMS systems
- ✓ Reduced Solvent Consumption compared to 2.1 mm ID columns
- ✓ Easy to Implement microflow solution

## TRASTUZUMAB DIGEST SENSITIVITY IMPROVEMENT USING A 2µm PARTICLE SIZE IN A 1.5 MM ID FORMAT

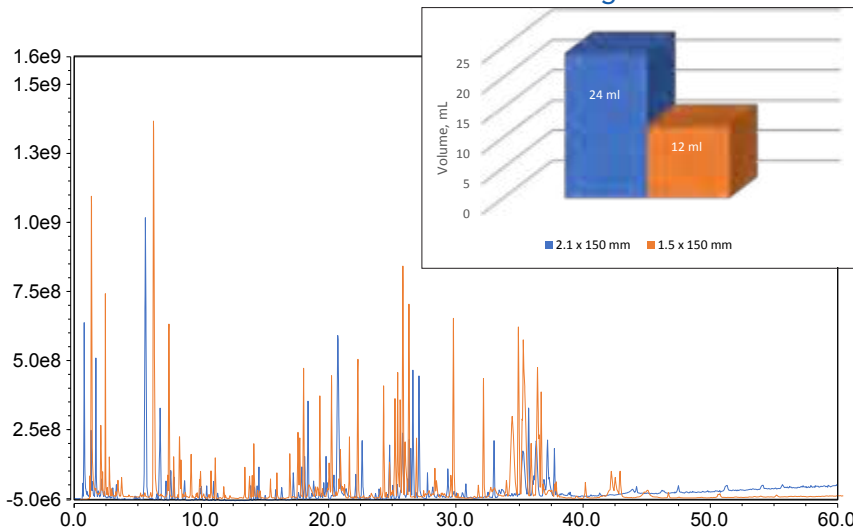
A full MS scan of a peptide map is separated on two different HALO® columns. This comparison features both the 1.5 mm 2.7µm ES-C18 column and the 1.5 mm 2µm ES-C18 column.



## PEPTIDE MAP SOLVENT SAVINGS USING HALO 160 Å ES-C18 IN 1.5 MM ID

When a 1.5 mm ID column is used in comparison to a 2.1 mm ID column for a peptide map of trastuzumab, 50% of the solvent is saved since the 1.5 mm ID column is run at 0.2 mL/min compared to 0.4 mL/min for the 2.1 mm ID column. For a 60 minute analysis, only 12 mL of solvent is used vs. 24 mL of solvent for the 2.1 mm ID column. Not only is solvent saved, but the cost of waste disposal is also reduced.

### Solvent Savings



### TEST CONDITIONS:

Column: HALO 160 Å ES-C18, 2.7 µm, 1.5 x 150 mm  
 Column: HALO 160 Å ES-C18, 2.7 µm, 2.1 x 150 mm  
 Mobile Phase A: Water/0.1% DFA  
 B: Acetonitrile/0.1% DFA  
 Gradient: 2-50 %B in 60 min  
 Flow Rate: 0.2 mL/min for 1.5 mm ID  
 0.4 mL/min for 2.1 mm ID  
 Back Pressure: 310 bar (1.5 mm)  
 444 bar (2.1 mm)  
 Temperature: 60 °C  
 Detection: ESI +  
 Injection Volume: 2 µL of 1.25 mg/mL Trastuzumab tryptic digest  
 Sample Solvent: 1.5 M Guanidine HCl/0.5% Formic Acid  
 LC System: Shimadzu Nexera X2  
 MS System: ThermoFisher Q Exactive

## OPTIONS FOR OPTIMIZING THE USP MONOGRAPH FOR ESTRADIOL

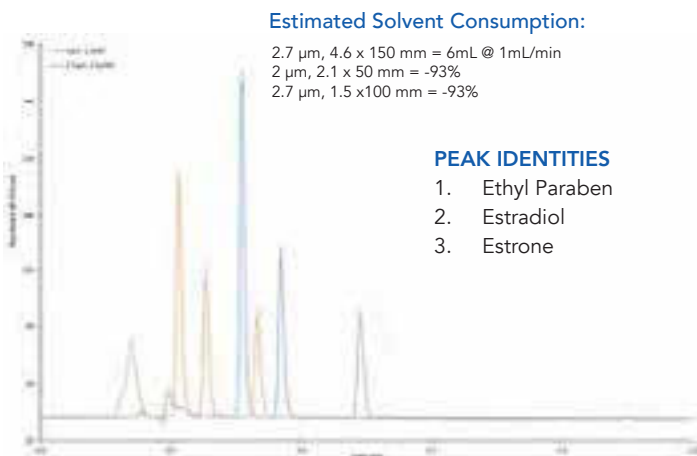
The USP monograph method for Estradiol can be optimized to save time, reduce solvent consumption, and reduce sample needed.

### Estimated Solvent Consumption:

2.7 µm, 4.6 x 150 mm = 6mL @ 1mL/min  
 2 µm, 2.1 x 50 mm = -93%  
 2.7 µm, 1.5 x 100 mm = -93%

### PEAK IDENTITIES

1. Ethyl Paraben
2. Estradiol
3. Estrone



### TEST CONDITIONS:

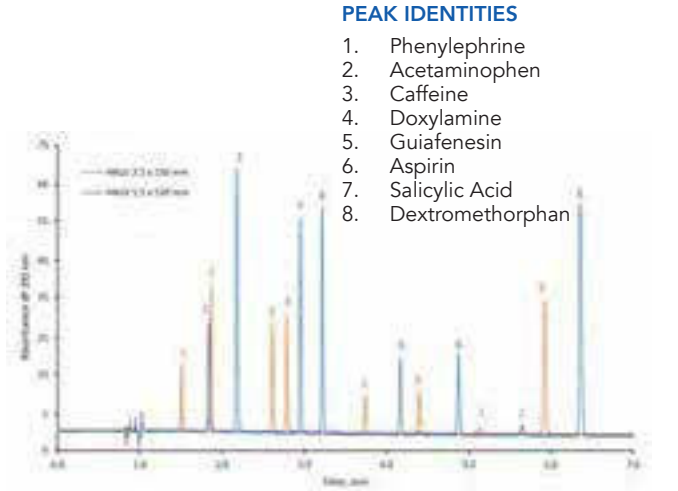
Column: HALO 90Å C18, 2 µm, 2.1 x 50 mm  
 Part #: 91812-402  
 Column: HALO 90Å C18, 2.7 µm, 1.5 x 100 mm  
 Part #: 9281X-602  
 Mobile Phase A: Water  
 Mobile Phase B: ACN  
 Isocratic: 45/55 Water/ACN  
 Flow Rate: 0.3 mL/min for 2.1 mm  
 0.2 mL/min for 1.5 mm  
 Pressure: 335 bar/2.1 mm  
 313 bar/1.5 mm  
 Temperature: 22 °C for 2.1 mm  
 25 °C for 1.5 mm  
 Detection: UV 205 nm, PDA  
 Injection Volume: 1.0 µL  
 Sample Solvent: 45/55 Water/MeOH  
 Data Rate: 100 Hz  
 Response Time: 0.025 sec.  
 Flow Cell: 1µL  
 Instrument: Shimadzu Nexera X2

## INCREASED RESPONSE IN SMALL MOLECULE APPLICATIONS WITH COUGH & COLD MEDICATIONS

A separation of eight different small molecules commonly found in cough and cold medicines is performed on a HALO 90 Å C18 column using 1.5 mm ID column.

### PEAK IDENTITIES

1. Phenylephrine
2. Acetaminophen
3. Caffeine
4. Doxylamine
5. Guaifenesin
6. Aspirin
7. Salicylic Acid
8. Dextromethorphan



### TEST CONDITIONS:

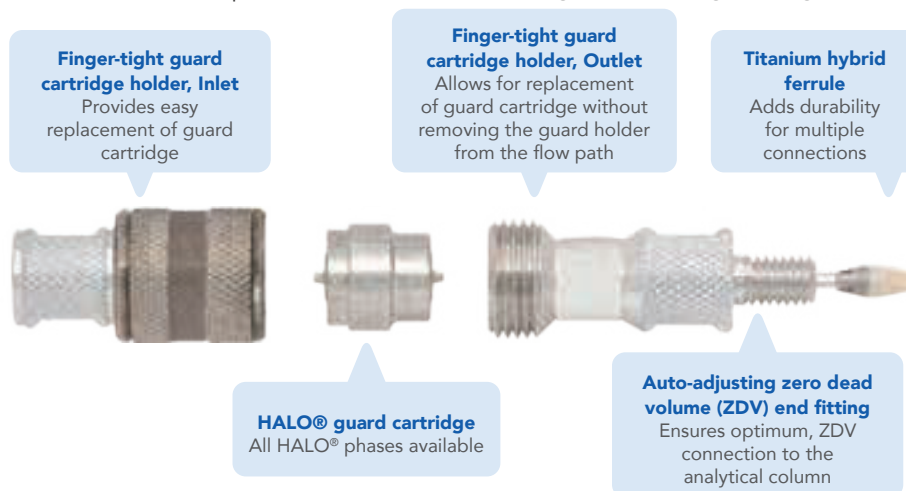
Column: HALO 90 Å C18, 2.7 µm, 1.5 x 150 mm  
 Part Number: 9281X-702  
 Column: HALO 90 Å C18, 2.7 µm, 2.1 x 150 mm  
 Mobile Phase A: Water/ 0.15% TFA  
 Mobile Phase B: ACN/ 0.1% TFA  
 Gradient: Time(min) %B  
 0.0 5  
 8.0 50  
 9.0 100  
 9.5 5  
 13.0 5  
 Flow Rate: 0.2 mL/min for 1.5 mm  
 0.4 mL/min for 2.1 mm  
 Pressure: 425 bar/1.5 mm  
 470 bar/2.1 mm  
 Temperature: 35 °C  
 Detection: UV 280 nm, PDA  
 Injection Volume: 0.5 µL  
 Data Rate: 100Hz  
 Response Time: 0.025 sec.  
 Flow Cell: 1 µL  
 Instrument: Shimadzu Nexera X2



# HALO® UHPLC AND HPLC GUARD COLUMNS

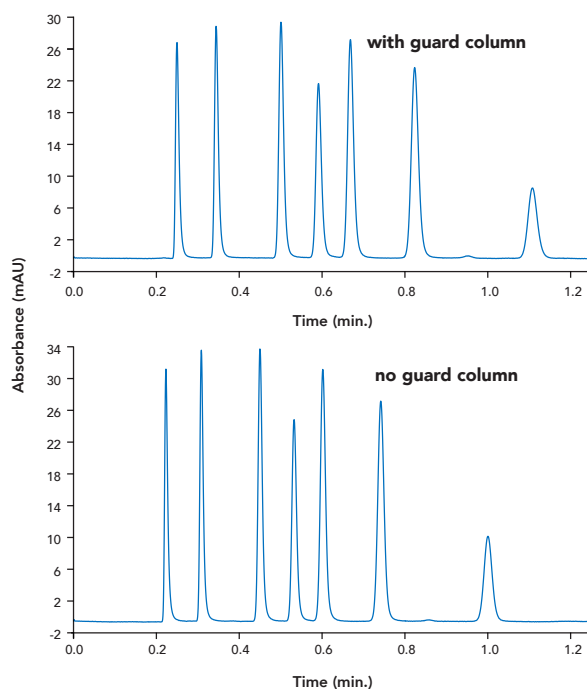
- Collect strongly retained compounds from the sample and minimizes column fouling
- Ultra-low dispersion, easy to use, operate at pressures up to 1000 bar
- Finger-tight, direct-connect units that auto-adjust to any column with a 10–32 inlet port
- Easily replace guard cartridge without removing guard holder from the flow path
- Available for all HALO® analytical geometries (2.1, 3.0 and 4.6 mm ID) and phases

See below for an exploded view of the HALO® guard cartridge and guard holder.



## HALO® GUARD COLUMNS: PROTECTION + PERFORMANCE

HALO® guard columns provide optimum protection for your HALO® HPLC and UHPLC columns without sacrificing column efficiency.



### TEST CONDITIONS:

Column: HALO 90 Å C18, 2.7 μm, 4.6 x 50 mm  
 Mobile Phase: 60/40 ACN/water  
 Flow Rate: 1.8 mL/min.  
 Temperature: 30 °C  
 Detection: 254 nm  
 Injection Volume: 1 μL  
 Pressure: 158 bar with guard column  
 146 bar without guard column  
 Instrument: Optimized Agilent 1100 bypassed semi-micro flow cell  
 0.05" ID tubing  
 14 Hz data rate

The Optimize Technologies EXP® Direct Connect Holder: U.S. Patent No. 8,201,854 & 8,696,902 and Foreign Patents Pending.

# COLUMN FORMAT OFFERINGS

FORMAT	Available ID	Available Length
<b>GUARD</b> <small>*to be used with analytical columns</small>	2.1	5
	3.0	5
	4.6	5
<b>CAPILLARY</b> (<1.0 mm)	0.3	50
	0.3	100
	0.3	150
	0.5	50
	0.5	100
<b>SEMI-MICRO</b> (1.0 - 1.5 mm)	1.0	50
	1.0	100
	1.0	150
	1.5	50
	1.5	100
<b>ANALYTICAL</b> (2.1 - 4.6 mm)	2.1	20
	2.1	30
	2.1	50
	2.1	75
	2.1	100
	2.1	150
	2.1	250
	3.0	20
	3.0	30
	3.0	50
	3.0	75
	3.0	100
	3.0	150
	3.0	250
	4.6	20
	4.6	30
	4.6	50
	4.6	75
4.6	100	
4.6	150	
4.6	250	
<b>SEMI-PREP</b> (10 mm)	10.0	50
	10.0	75
	10.0	100
	10.0	150
	10.0	250

Looking for a dimension which is not listed? [Contact us](#) for a custom column request.

# PRODUCT SPECIFICATIONS

## SMALL MOLECULE SPECIFICATIONS: REVERSED PHASE

Bonded Phase	C18	LPH C18	PCS C18	AQ-C18	C8
USP Designation	L1	L1	L1	L1	L7
Particle Size(s) (µm)	2 2.7 5	2 2.7	2.7	2 2.7 5	2 2.7 5
Pore Size (Å)	90	90	90	90	90
Carbon Load (%)	7.2 7.7 5.4	6.5	7.5	6.5 6.7 5.6	4.8 5.4 3.7
Surface Area (m <sup>2</sup> /g)	125 125 90	125 125	125	125 125 90	125 125 90
Low pH/T Limit	2/60 °C	1/90 °C	2/60 °C	2/60 °C	2/60 °C
High pH/T Limit	9/40 °C	8/40 °C	7/40 °C	9/40 °C	9/40 °C
Endcapped	Yes	No	Yes	Yes	Yes

## SMALL MOLECULE SPECIFICATIONS: HILIC

Bonded Phase	HILIC	PENTA-HILIC
USP Designation	L60	L95
Particle Size(s) (µm)	2 2.7 5	2 2.7 5
Pore Size (Å)	90	90
Carbon Load (%)	unbonded	2.8 3.2 2.1
Surface Area (m <sup>2</sup> /g)	125 125 90	125 125 90
Low pH/T Limit	1/60 °C	2/60 °C
High pH/T Limit	8/40 °C	9/40 °C
Endcapped	N/A	No

## ENVIROCLASS SPECIFICATIONS

Bonded Phase	PFAS	PFAS Delay	PAH
USP Designation	-		L1
Particle Size(s) (µm)	2.7	2.7	2.7
Pore Size (Å)	90	-	90
Carbon Load (%)	-	-	-
Surface Area (m <sup>2</sup> /g)	125	-	125
Low pH/T Limit	2/60 °C	2/60 °C	2/60 °C
High pH/T Limit	9/40 °C	9/40 °C	9/40 °C
Endcapped	Yes	Yes	No

ES-CN	Phenyl-Hexyl	Biphenyl	PFP	RP-Amide	C30
L10	L11	L11	L43	L60	L62
2 2.7 5	2 2.7 5	2 2.7 5	2 2.7 5	2 2.7 5	2.7
90	90	90	90	90	160
3.4 3.5 2.5	6.3 7.1 5.2	6.7 7.0 5.5	5.3 5.5 3.9	7.3 8.2 5.1	4.5
125 125 90	125 125 90	125 125 90	125 125 90	125 125 90	75
1/80 °C	2/60 °C	2/60 °C	2/60 °C	2/60 °C	2/60 °C
8/40 °C	9/40 °C	9/40 °C	8/40 °C	9/40 °C	9/40 °C
Yes	Yes	Yes	Yes	Yes	Yes

## BIOCLASS SPECIFICATIONS

Bonded Phase	PROTEIN			PEPTIDE				GLYCAN
	C4	ES-C18	Diphenyl	ES-C18	ES-CN	PHENYL-HEXYL	PCS C18	Proprietary Poly-Hydroxy
USP Designation	L26	L1	L11	L1	L10	L11	L1	L95
Particle Size(s) ( $\mu\text{m}$ )	2.7 3.4	2.7 3.4	2.7 3.4	2 2.7 5	2.7 5	2.7	2.7	2.7
Pore Size ( $\text{\AA}$ )	1000 400	1000 400	1000 400	160	160	160	160	90
Carbon Load (%)	0.6 0.4	1.4 1.0	1.0 0.7	4.0 4.6 4.0	2.2 1.5	4.7	5.09	3.2
Surface Area ( $\text{m}^2/\text{g}$ )	22 15	22 15	22 15	68 75 60	75 60	75	75	125
Low pH/T Limit	2/90 °C	1/90 °C	2/90 °C	1/90 °C	1/90 °C	2/90 °C	2/60 °C	2/65 °C
High pH/T Limit	9/40 °C	8/40 °C	9/40 °C	8/40 °C	8/40 °C	9/40 °C	7/40 °C	9/40 °C
Endcapped	Yes	Yes	Yes	No	Yes	Yes	Yes	No

# COMMITMENT TO QUALITY

Since our founding in 2005, Advanced Materials Technology has been focused on one mission – Improving the presentation of the sample to the detector. Using our novel Fused-Core® particle design, we have challenged conventional wisdom and engineered innovative solutions for the separations community. Our quality procedures and practices are integrated into every HALO® column delivered ensuring your success – every time.



## AMT QUALITY POLICY

AMT is committed to providing world-class innovative products that uniquely fill the growing needs of small molecule and large molecule separation scientists. We take pride in delivering products that exceed customers' expectations on quality and delivery time and collaborate to break down any barriers that would prevent an exceptional customer experience. We continually strive to improve our organization to stay focused on safety, quality, and cost. We embrace ISO 9001 standards in our work systems and daily work. We pledge to have dynamic leadership promoting culture of excellence embedded in every employee.

**ADVANCED MATERIALS TECHNOLOGY IS AN  
ISO 9001:2015 CERTIFIED COMPANY**

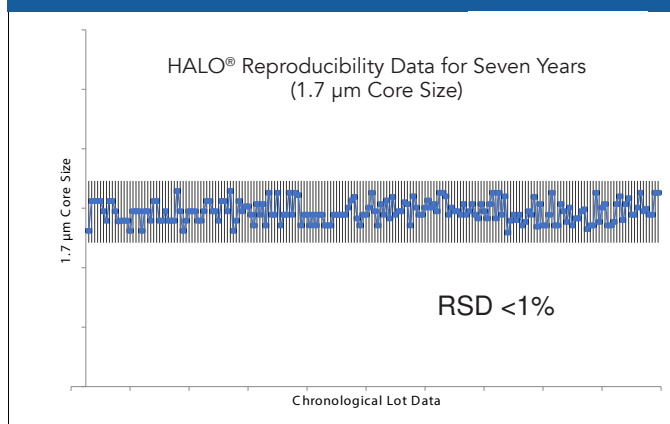




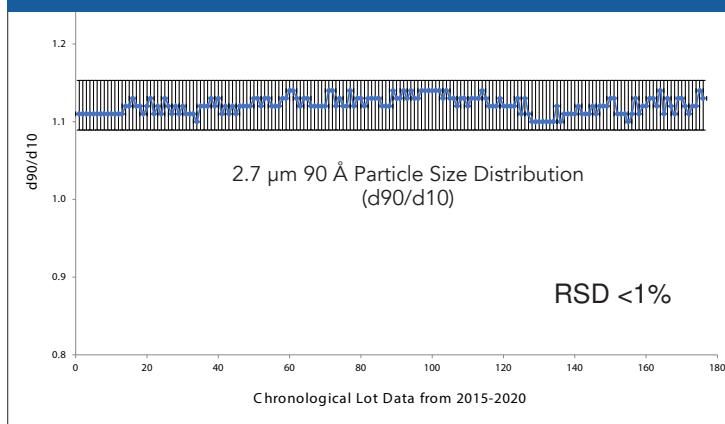
## INNOVATION YOU CAN TRUST – PERFORMANCE YOU CAN RELY ON

The quality of AMT products stems from our complete control over the entire manufacturing process – from incoming raw materials to the final particle and ultimately the box packaged for shipping, quality controls and measurements are built into every process. Cores and shells are carefully controlled resulting in tight particle size distributions for optimized loading parameters culminating in highly efficient performance packed columns. Rigorous quality assurance testing is completed for every lot. This result contributes greatly to our commitment for customers' long-term repeatability of separations utilizing AMT powered HPLC columns.

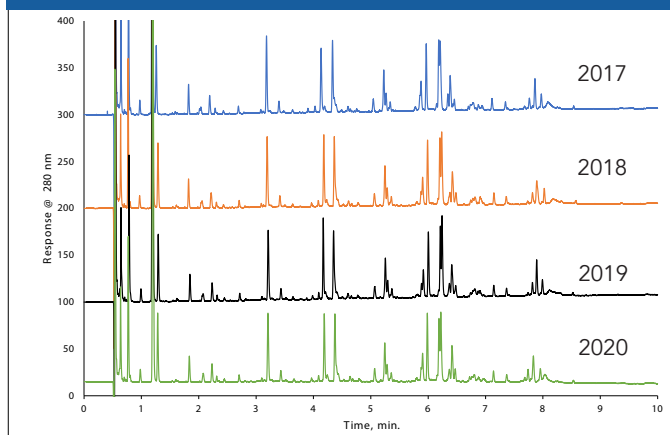
The solid silica core is the foundation of HALO® Fused-Core® particles. In this chronological run chart over the last seven years notice the impressive RSD of <1% of core control for our hallmark 2.7 µm particle.



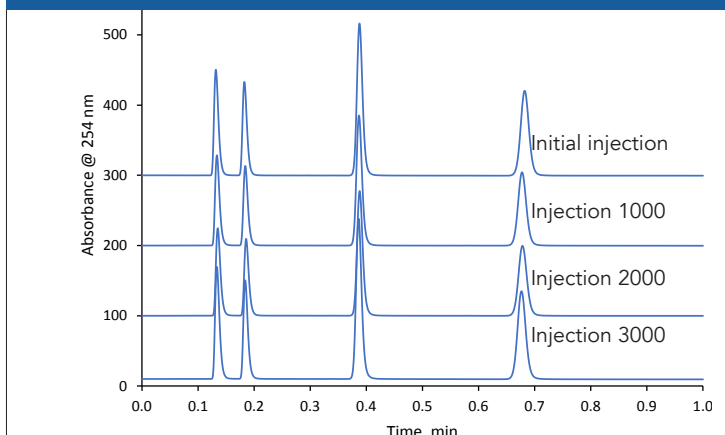
AMT's tight control of particle size distribution to RSD's of <1% highlights the quality control in our manufacturing processes. This narrow distribution ensures delivery of highly efficient columns.



Multi-year and multi-lot comparison of an Adalimumab digest with HALO® Peptide ES-C18. Note the excellent reproducibility of the separation profile attributes from multiple lots and manufacturing years representing AMT's commitment to delivering quality you can count on.



All new HALO® products are subject to stability testing. In this example the test required at least 1,000 injections at high temperature to demonstrate repeatability and performance. As shown, at 3,000 injections (approximately 23,000 column volumes) the results illustrated no significant changes in peak shape or retention.



# HALO 90 Å 2 μm COLUMNS

The part numbers for HALO 90 Å 2 μm columns are presented below and available in 2.1 and 3.0 mm internal diameters. Guard columns are also available for these IDs for UHPLC to provide additional protection when necessary.

Dimensions ID x Length (in mm)	C18	AQ-C18	LPH-C18	C8	Biphenyl	Phenyl-Hexyl	RP-Amide	PPF	ES-CN	Penta-HILIC	HILIC
2.1 x 20	91812-202	91812-222		91812-208	91812-211	91812-206	91812-207	91812-209	91812-204	91812-205	91812-201
2.1 x 30	91812-302	91812-322		91812-308	91812-311	91812-306	91812-307	91812-309	91812-304	91812-305	91812-301
2.1 x 50	91812-402	91812-422	91822-416	91812-408	91812-411	91812-406	91812-407	91812-409	91812-404	91812-405	91812-401
2.1 x 75	91812-502	91812-522		91812-508	91812-511	91812-506	91812-507	91812-509	91812-504	91812-505	91812-501
2.1 x 100	91812-602	91812-622	91822-616	91812-608	91812-611	91812-606	91812-607	91812-609	91812-604	91812-605	91812-601
2.1 x 150	91812-702	91812-722	91822-716	91812-708	91812-711	91812-706	91812-707	91812-709	91812-704	91812-705	91812-701
2.1 x 250	91812-902	91812-922		91812-908	91812-911	91812-906	91812-907	91812-909	91812-904	91812-905	91812-901
3.0 x 20	91813-202	91813-222		91813-208	91813-211	91813-206	91813-207	91813-209	91813-204	91813-205	91813-201
3.0 x 30	91813-302	91813-322		91813-308	91813-311	91813-306	91813-307	91813-309	91813-304	91813-305	91813-301
3.0 x 50	91813-402	91813-422	91823-416	91813-408	91813-411	91813-406	91813-407	91813-409	91813-404	91813-405	91813-401
3.0 x 75	91813-502	91813-522		91813-508	91813-511	91813-506	91813-507	91813-509	91813-504	91813-505	91813-501
3.0 x 100	91813-602	91813-622	91823-616	91813-608	91813-611	91813-606	91813-607	91813-609	91813-604	91813-605	91813-601
3.0 x 150	91813-702	91813-722	91823-716	91813-708	91813-711	91813-706	91813-707	91813-709	91813-704	91813-705	91813-701
3.0 x 250	91813-902	91813-922		91813-908	91813-911	91813-906	91813-907	91813-909	91813-904	91813-905	91813-901
2 μm, 90 Å Guard Columns, 3-Pack											
Dimensions ID x Length (in mm)	C18	AQ-C18	LPH-C18	C8	Biphenyl	Phenyl-Hexyl	RP-Amide	PPF	ES-CN	Penta-HILIC	HILIC
2.1 x 5	91812-102	91812-122	91822-116	91812-108	91812-111	91812-106	91812-107	91812-109	91812-104	91812-105	91812-101
3.0 x 5	91813-102	91813-122	91823-116	91813-108	91813-111	91813-106	91813-107	91813-109	91813-104	91813-105	91813-101
Guard Column Holder 94900-001											

Looking for a column that is not listed? [Contact us](#) for a custom column request.

# HALO 90 Å 2.7 µm COLUMNS

HALO® 2.7 µm columns are available in nano, capillary and analytical diameters, as well as in a 10 mm semi-preparative diameter. Guard columns are available for analytical diameters of 2.1, 3.0 and 4.6 mm to provide additional protection when necessary.

\*C30 made as 160 Å pore size

Dimensions ID x L (in mm)	C18	AQ-C18	LPH-C18	PCS C18	C8	C30*	Phenyl-Hexyl	Biphenyl	RP-Amide	PFP	ES-CN	Penta-HILIC	HILIC
0.3 x 50	98216-402	98216-422			98216-408	91216-402	98216-406	98216-411	98216-407	98216-409	98216-404	98216-405	98216-401
0.3 x 100	98216-602	98216-622			98216-608	91216-602	98216-606	98216-611	98216-607	98216-609	98216-604	98216-605	98216-601
0.3 x 150	98216-702	98216-722			98216-708	91216-702	98216-706	98216-711	98216-707	98216-709	98216-704	98216-705	98216-701
0.5 x 50	98215-402	98215-422			98215-408	91215-402	98215-406	98215-411	98215-407	98215-409	98215-404	98215-405	98215-401
0.5 x 100	98215-602	98215-622			98215-608	91215-602	98215-606	98215-611	98215-607	98215-609	98215-604	98215-605	98215-601
0.5 x 150	98215-702	98215-722			98215-708	91215-702	98215-706	98215-711	98215-707	98215-709	98215-704	98215-705	98215-701
1.0 x 50	92811-402	92811-422			92811-408	92111-402	92811-406	92811-411	92811-407	92811-409	92811-404	92811-405	92811-401
1.0 x 100	92811-602	92811-622			92811-608	92111-602	92811-606	92811-611	92811-607	92811-609	92811-604	92811-605	92811-601
1.0 x 150	92811-702	92811-722			92811-708	92111-702	92811-706	92811-711	92811-707	92811-709	92811-704	92811-705	92811-701
1.5 x 50	9281X-402	9281X-422	9282X-416	9281X-417								9281X-405	
1.5 x 100	9281X-602	9281X-622	9282X-616	9281X-617								9281X-605	
1.5 x 150	9281X-702	9281X-722	9282X-716	9281X-717								9281X-705	
2.1 x 20	92812-202	92812-222			92812-208	92112-230	92812-206	92812-211	92812-207	92812-209	92812-204	92812-205	92812-201
2.1 x 30	92812-302	92812-322			92812-308	92112-330	92812-306	92812-311	92812-307	92812-309	92812-304	92812-305	92812-301
2.1 x 50	92812-402	92812-422	92822-416	92812-417	92812-408	92112-430	92812-406	92812-411	92812-407	92812-409	92812-404	92812-405	92812-401
2.1 x 75	92812-502	92812-522			92812-508	92112-530	92812-506	92812-511	92812-507	92812-509	92812-504	92812-505	92812-501
2.1 x 100	92812-602	92812-622	92822-616	92812-617	92812-608	92112-630	92812-606	92812-611	92812-607	92812-609	92812-604	92812-605	92812-601
2.1 x 150	92812-702	92812-722	92822-716	92812-717	92812-708	92112-730	92812-706	92812-711	92812-707	92812-709	92812-704	92812-705	92812-701
2.1 x 250	92812-902	92812-922			92812-908	92112-930	92812-906	92812-911	92812-907	92812-909	92812-904	92812-905	92812-901
3.0 x 20	92813-202	92813-222			92813-208	92113-230	92813-206	92813-211	92813-207	92813-209	92813-204	92813-205	92813-201
3.0 x 30	92813-302	92813-322			92813-308	92113-330	92813-306	92813-311	92813-307	92813-309	92813-304	92813-305	92813-301
3.0 x 50	92813-402	92813-422	92823-416	92813-417	92813-408	92113-430	92813-406	92813-411	92813-407	92813-409	92813-404	92813-405	92813-401
3.0 x 75	92813-502	92813-522			92813-508	92113-530	92813-506	92813-511	92813-507	92813-509	92813-504	92813-505	92813-501
3.0 x 100	92813-602	92813-622	92823-616	92813-617	92813-608	92113-630	92813-606	92813-611	92813-607	92813-609	92813-604	92813-605	92813-601
3.0 x 150	92813-702	92813-722	92823-716	92813-717	92813-708	92113-730	92813-706	92813-711	92813-707	92813-709	92813-704	92813-705	92813-701
3.0 x 250	92813-902	92813-922			92813-908	92113-930	92813-906	92813-911	92813-907	92813-909	92813-904	92813-905	92813-901
4.6 x 20	92814-202	92814-222			92814-208	92114-230	92814-206	92814-211	92814-207	92814-209	92814-204	92814-205	92814-201
4.6 x 30	92814-302	92814-322			92814-308	92114-330	92814-306	92814-311	92814-307	92814-309	92814-304	92814-305	92814-301
4.6 x 50	92814-402	92814-422	92824-416	92814-417	92814-408	92114-430	92814-406	92814-411	92814-407	92814-409	92814-404	92814-405	92814-401
4.6 x 75	92814-502	92814-522			92814-508	92114-530	92814-506	92814-511	92814-507	92814-509	92814-504	92814-505	92814-501
4.6 x 100	92814-602	92814-622	92824-616	92814-617	92814-608	92114-630	92814-606	92814-611	92814-607	92814-609	92814-604	92814-605	92814-601
4.6 x 150	92814-702	92814-722	92824-716	92814-717	92814-708	92114-730	92814-706	92814-711	92814-707	92814-709	92814-704	92814-705	92814-701
4.6 x 250	92814-902	92814-922		92814-917	92814-908	92114-930	92814-906	92814-911	92814-907	92814-909	92814-904	92814-905	92814-901
10.0 x 50	92810-402	92810-422			92810-408	92110-402	92810-406	92810-411	92810-407	92810-409	92810-404	92810-405	92810-401
10.0 x 100	92810-602	92810-622			92810-608	92110-602	92810-606	92810-611	92810-607	92810-609	92810-604	92810-605	92810-601
10.0 x 150	92810-702	92810-722			92810-708	92110-702	92810-706	92810-711	92810-707	92810-709	92810-704	92810-705	92810-701
2.7 µm, 90 Å Guard Columns, 3-Pack													
Dimensions ID x Length (in mm)	C18	AQ-C18	LPH-C18	PCS C18	C8	C30	Phenyl-Hexyl	Biphenyl	RP-Amide	PFP	ES-CN	Penta-HILIC	HILIC
2.1 x 5	92812-102	92812-122	92822-116	92812-117	92812-108	92112-130	92812-106	92812-111	92812-107	92812-109	92812-104	92812-105	92812-101
3.0 x 5	92813-102	92813-122	92823-116	92813-117	92813-108	92113-130	92813-106	92813-111	92813-107	92813-109	92813-104	92813-105	92813-101
4.6 x 5	92814-102	92814-122	92824-116	92814-117	92814-108	92114-130	92814-106	92814-111	92814-107	92814-109	92814-104	92814-105	92814-101
Guard Column Holder 94900-001													

Looking for a column that is not listed? [Contact us](#) for a custom column request.

# HALO 90 Å 5 µm COLUMNS

HALO 90 Å 5 µm columns are available in analytical diameters, and in a 10 mm semi-preparative diameter.

Guard columns are available for analytical diameters of 2.1, 3.0 and 4.6 mm.

Dimensions ID x Length (in mm)	C18	AQ-C18	C8	Biphenyl	Phenyl-Hexyl	RP-Amide	PFP	ES-CN	Penta-HILIC	HILIC
2.1 x 20	95812-202	95812-222	95812-208	95812-211	95812-206	95812-207	95812-209	95812-204	95812-205	95812-201
2.1 x 30	95812-302	95812-322	95812-308	95812-311	95812-306	95812-307	95812-309	95812-304	95812-305	95812-301
2.1 x 50	95812-402	95812-422	95812-408	95812-411	95812-406	95812-407	95812-409	95812-404	95812-405	95812-401
2.1 x 75	95812-502	95812-522	95812-508	95812-511	95812-506	95812-507	95812-509	95812-504	95812-505	95812-501
2.1 x 100	95812-602	95812-622	95812-608	95812-611	95812-606	95812-607	95812-609	95812-604	95812-605	95812-601
2.1 x 150	95812-702	95812-722	95812-708	95812-711	95812-706	95812-707	95812-709	95812-704	95812-705	95812-701
2.1 x 250	95812-902	95812-922	95812-908	95812-911	95812-906	95812-907	95812-909	95812-904	95812-905	95812-901
3.0 x 20	95813-202	95813-222	95813-208	95813-211	95813-206	95813-207	95813-209	95813-204	95813-205	95813-201
3.0 x 30	95813-302	95813-322	95813-308	95813-311	95813-306	95813-307	95813-309	95813-304	95813-305	95813-301
3.0 x 50	95813-402	95813-422	95813-408	95813-411	95813-406	95813-407	95813-409	95813-404	95813-405	95813-401
3.0 x 75	95813-502	95813-522	95813-508	95813-511	95813-506	95813-507	95813-509	95813-504	95813-505	95813-501
3.0 x 100	95813-602	95813-622	95813-608	95813-611	95813-606	95813-607	95813-609	95813-604	95813-605	95813-601
3.0 x 150	95813-702	95813-722	95813-708	95813-711	95813-706	95813-707	95813-709	95813-704	95813-705	95813-701
3.0 x 250	95813-902	95813-922	95813-908	95813-911	95813-906	95813-907	95813-909	95813-904	95813-905	95813-901
4.6 x 20	95814-202	95814-222	95814-208	95814-211	95814-206	95814-207	95814-209	95814-204	95814-205	95814-201
4.6 x 30	95814-302	95814-322	95814-308	95814-311	95814-306	95814-307	95814-309	95814-304	95814-305	95814-301
4.6 x 50	95814-402	95814-422	95814-408	95814-411	95814-406	95814-407	95814-409	95814-404	95814-405	95814-401
4.6 x 75	95814-502	95814-522	95814-508	95814-511	95814-506	95814-507	95814-509	95814-504	95814-505	95814-501
4.6 x 100	95814-602	95814-622	95814-608	95814-611	95814-606	95814-607	95814-609	95814-604	95814-605	95814-601
4.6 x 150	95814-702	95814-722	95814-708	95814-711	95814-706	95814-707	95814-709	95814-704	95814-705	95814-701
4.6 x 250	95814-902	95814-922	95814-908	95814-911	95814-906	95814-907	95814-909	95814-904	95814-905	95814-901
10.0 x 50	95810-402	95810-422	95810-408	95810-411	95810-406	95810-407	95810-409	95810-404	95810-405	95810-401
10.0 x 100	95810-602	95810-622	95810-608	95810-611	95810-606	95810-607	95810-609	95810-604	95810-605	95810-601
10.0 x 150	95810-702	95810-722	95810-708	95810-711	95810-706	95810-707	95810-709	95810-704	95810-705	95810-701
10.0 x 250	95810-902	95810-922	95810-908	95810-911	95810-906	95810-907	95810-909	95810-904	95810-905	95810-901
5 µm, 90 Å Guard Columns, 3-Pack										
Dimensions ID x Length (in mm)	C18	AQ-C18	C8	Biphenyl	Phenyl-Hexyl	RP-Amide	PFP	ES-CN	Penta-HILIC	HILIC
2.1 x 5	95812-102	95812-122	95812-108	95812-111	95812-106	95812-107	95812-109	95812-104	95812-105	95812-101
3.0 x 5	95813-102	95813-122	95813-108	95813-111	95813-106	95813-107	95813-109	95813-104	95813-105	95813-101
4.6 x 5	95814-102	95814-122	95814-108	95814-111	95814-106	95814-107	95814-109	95814-104	95814-105	95814-101
Guard Column Holder	94900-001									

Looking for a column that is not listed? [Contact us](#) for a custom column request.

# HALO 1000 Å & 400 Å PROTEIN COLUMNS

Part numbers for nano, capillary, analytical and semi-preparative HALO 1000 and 400 Å in 2.7 and 3.4 µm phases are provided below. Guard columns are available in 2.1, 3.0 and 4.6 mm IDs for UHPLC and HPLC applications to provide additional column protection when desired.

Dimensions ID x Length (in mm)	400 Å, 3.4 µm			1000 Å, 2.7 µm		
	C4	ES-C18	Diphenyl	C4	ES-C18	Diphenyl
0.3 x 50	94316-414	94316-402	94316-426	97216-414	97216-402	97216-426
0.3 x 100	94316-614	94316-602	94316-626	97216-614	97216-602	97216-626
0.3 x 150	94316-714	94316-702	94316-726	97216-714	97216-702	97216-726
0.5 x 50	94315-414	94315-402	94315-426	97215-414	97215-402	97215-426
0.5 x 100	94315-614	94315-602	94315-626	97215-614	97215-602	97215-626
0.5 x 150	94315-714	94315-702	94315-726	97215-714	97215-702	97215-726
1.0 x 50	93411-414	93411-402	93411-426	92711-414	92711-402	92711-426
1.0 x 100	93411-614	93411-602	93411-626	92711-614	92711-602	92711-626
1.0 x 150	93411-714	93411-702	93411-726	92711-714	92711-702	92711-726
1.5 x 50				9271X-414		9271X-426
1.5 x 100				9271X-614		9271X-626
1.5 x 150				9271X-714		9271X-726
2.1 x 20	93412-214	93412-202	93412-226	92712-214	92712-202	92712-226
2.1 x 30	93412-314	93412-302	93412-326	92712-314	92712-302	92712-326
2.1 x 50	93412-414	93412-402	93412-426	92712-414	92712-402	92712-426
2.1 x 75	93412-514	93412-502	93412-526	92712-514	92712-502	92712-526
2.1 x 100	93412-614	93412-602	93412-626	92712-614	92712-602	92712-626
2.1 x 150	93412-714	93412-702	93412-726	92712-714	92712-702	92712-726
2.1 x 250	93412-914	93412-902	93412-926	92712-914	92712-902	92712-926
3.0 x 20	93413-214	93413-202	93413-226	92713-214	92713-202	92713-226
3.0 x 30	93413-314	93413-302	93413-326	92713-314	92713-302	92713-326
3.0 x 50	93413-414	93413-402	93413-426	92713-414	92713-402	92713-426
3.0 x 75	93413-514	93413-502	93413-526	92713-514	92713-502	92713-526
3.0 x 100	93413-614	93413-602	93413-626	92713-614	92713-602	92713-626
3.0 x 150	93413-714	93413-702	93413-726	92713-714	92713-702	92713-726
3.0 x 250	93413-914	93413-902	93413-926	92713-914	92713-902	92713-926
4.6 x 20	93414-214	93414-202	93414-226	92714-214	92714-202	92714-226
4.6 x 30	93414-314	93414-302	93414-326	92714-314	92714-302	92714-326
4.6 x 50	93414-414	93414-402	93414-426	92714-414	92714-402	92714-426
4.6 x 75	93414-514	93414-502	93414-526	92714-514	92714-502	92714-526
4.6 x 100	93414-614	93414-602	93414-626	92714-614	92714-602	92714-626
4.6 x 150	93414-714	93414-702	93414-726	92714-714	92714-702	92714-726
4.6 x 250	93414-914	93414-902	93414-926	92714-914	92714-902	92714-926
10.0 x 50	93410-414	93410-402	93410-426	92710-414	92710-402	92710-426
10.0 x 100	93410-614	93410-602	93410-626	92710-614	92710-602	92710-626
10.0 x 150	93410-714	93410-702	93410-726	92710-714	92710-702	92710-726
Guard Columns, 3-Pack						
Dimensions ID x Length (in mm)	C4	ES-C18	Diphenyl	C4	ES-C18	Diphenyl
2.1 x 5	93412-114	93412-102	93412-126	92712-114	92712-102	92712-126
3.0 x 5	93413-114	93413-102	93413-126	92713-114	92713-102	92713-126
4.6 x 5	93414-114	93414-102	93414-126	92714-114	92714-102	92714-126
Guard Column Holder 94900-001						

# HALO 90 Å GLYCAN COLUMNS

HALO® Glycan columns are available in 2.1 and 4.6 mm diameters in the following lengths as a 2.7 µm particle size. Guard columns are available for UHPLC and HPLC applications if additional protection is desired.

Dimensions ID x Length (in mm)	HALO® Glycan
0.3 x 150	99226-705
2.1 x 50	92922-405
2.1 x 100	92922-605
2.1 x 150	92922-705
4.6 x 50	92924-405
4.6 x 100	92924-605
4.6 x 150	92924-705
Guard Columns, 3-Pack	
Dimensions ID x Length (in mm)	HALO® Glycan
2.1 x 5	92922-105
4.6 x 5	92924-105
Guard Column Holder 94900-001	

Looking for a column that is not listed?

[Contact us](#) for a custom column request.

# HALO 160 Å PEPTIDE COLUMNS

The part numbers are provided below for the nano, capillary, analytical and semi-preparative HALO 160 Å 2, 2.7 and 5 µm phases. Guard columns are available for 2.1, 3.0 and 4.6 mm internal diameters for UHPLC and HPLC applications, if additional protection is desired.

	160 Å, 2 µm		160 Å, 2.7 µm			160 Å, 5 µm	
Dimensions ID x Length (in mm)	ES-C18	ES-C18	ES-CN	Phenyl-Hexyl	PCS C18	ES-C18	ES-CN
0.3 x 50		91226-402	91226-404	91216-406			
0.3 x 100		91226-602	91226-604	91216-606			
0.3 x 150		91226-702	91226-704	91216-706			
0.5 x 50		91225-402	91225-404	91215-406			
0.5 x 100		91225-602	91225-604	91215-606			
0.5 x 150		91225-702	91225-704	91215-706			
1.0 x 50		92121-402	92121-404	92111-406			
1.0 x 100		92121-602	92121-604	92111-606			
1.0 x 150		92121-702	92121-704	92111-706			
1.0 x 250							
1.5 x 50	9112X-402	9212X-402			9211X-417		
1.5 x 100	9112X-602	9212X-602			9211X-617		
1.5 x 150	9112X-702	9212X-702			9211X-717		
2.1 x 20	91122-202	92122-202	92122-204	92112-106		95122-202	95122-204
2.1 x 30	91122-302	92122-302	92122-304	92112-206		95122-302	95122-304
2.1 x 50	91122-402	92122-402	92122-404	92112-306	92112-417	95122-402	95122-404
2.1 x 75	91122-502	92122-502	92122-504	92112-406		95122-502	95122-504
2.1 x 100	91122-602	92122-602	92122-604	92112-506	92112-617	95122-602	95122-604
2.1 x 150	91122-702	92122-702	92122-704	92112-606	92112-717	95122-702	95122-704
2.1 x 250	91122-902	92122-902	92122-904	92112-706		95122-902	95122-904
3.0 x 20	91123-202	92123-202	92123-204	92113-106		95123-202	95123-204
3.0 x 30	91123-302	92123-302	92123-304	92113-206		95123-302	95123-304
3.0 x 50	91123-402	92123-402	92123-404	92113-306	92113-417	95123-402	95123-404
3.0 x 75	91123-502	92123-502	92123-504	92113-406		95123-502	95123-504
3.0 x 100	91123-602	92123-602	92123-604	92113-506	92113-617	95123-602	95123-604
3.0 x 150	91123-702	92123-702	92123-704	92113-606	92113-717	95123-702	95123-704
3.0 x 250	91123-902	92123-902	92123-904	92113-706		95123-902	95123-904
4.6 x 20		92124-202	92124-204	92114-106		95124-202	95124-204
4.6 x 30		92124-302	92124-304	92114-206		95124-302	95124-304
4.6 x 50		92124-402	92124-404	92114-306	92114-417	95124-402	95124-404
4.6 x 75		92124-502	92124-504	92114-406		95124-502	95124-504
4.6 x 100		92124-602	92124-604	92114-506	92114-617	95124-602	95124-604
4.6 x 150		92124-702	92124-704	92114-606	92114-717	95124-702	95124-704
4.6 x 250		92124-902	92124-904	92114-706		95124-902	95124-904
10.0 x 50		92120-402	92120-404	92110-406		95120-402	95120-404
10.0 x 100		92120-602	92120-604	92110-606		95120-602	95120-604
10.0 x 150		92120-702	92120-704	92110-706		95120-702	95120-704
10.0 x 250						95120-902	95120-904
Guard Columns, 3-pack							
Dimensions ID x Length (in mm)	ES-C18	ES-C18	ES-CN	Phenyl-Hexyl	PCS C18	ES-C18	ES-CN
2.1 x 5	91122-102	92122-102	92122-104	92122-106	92112-117	95122-102	95122-104
3.0 x 5	91123-102	92123-102	92123-104	92123-106	92113-117	95123-102	95123-104
4.6 x 5	-	92124-102	92124-104	92124-106	92114-117	95124-102	95124-104
Guard Column Holder 94900-001							

Looking for a column that is not listed? [Contact us](#) for a custom column request.



# HALO® 1.5 PRODUCT OFFERINGS

## HOW TO SELECT THE BEST CONNECTORS FOR ACHIEVING OPTIMAL 1.5 MM ID PERFORMANCE

- In general, use the shortest length and smallest ID tubing that will work for your system
- Are you running isocratic or gradient?
  - If isocratic, then pre-column tubing is most impactful - reduce length and ID of tubing before the column
  - If gradient, then post-column tubing is most impactful reduce the length and ID of tubing after the column
- Does your system have a heat exchanger?
  - If so, consider bypassing it as long as you are able to operate your method without it
- Is there a smaller volume flow cell available for your system?
  - If so, consider switching to it

### STEPS FOR SELECTING CONNECTING TUBING

1. Measure the length in mm from the injector to the column and from the column to the detector or MS source
2. Select ID tubing and length that will fit according to the table below being mindful of your system back pressure limits:

L(mm)	ID (µm)	volume (µL)	
150	25	0.07	Red
	50	0.29	Orange
	75	0.66	Green
	100	1.18	Green

L(mm)	ID (µm)	volume (µL)	
350	25	0.17	Red
	50	0.69	Red
	75	1.55	Green
	100	2.75	Green

L(mm)	ID (µm)	volume (µL)	
600	25	0.29	Red
	50	1.18	Red
	75	2.65	Orange
	100	4.71	Green

Green = minimal extra back pressure (<15 bar)

Orange = may generate too much back pressure (>40 bar)

Red = not recommended (>100 bar)

### AMT MARVEL XACT™ PEEK LINED STAINLESS TUBING

DESCRIPTION	VOLUME	PART NUMBER
AMT MarvelXACT™ PLS 25µm x 150mm	75 nl	PL7025150
AMT MarvelXACT™ PLS 25µm x 350mm	170 nl	PL7025350
AMT MarvelXACT™ PLS 25µm x 600mm	295 nl	PL7025600
AMT MarvelXACT™ PLS 50µm x 150mm	295 nl	PL7050150
AMT MarvelXACT™ PLS 50µm x 350mm	685 nl	PL7050350
AMT MarvelXACT™ PLS 50µm x 600mm	1178 nl	PL7050600
AMT MarvelXACT™ PLS 75µm x 150mm	665 nl	PL7075150
AMT MarvelXACT™ PLS 75µm x 350mm	1545 nl	PL7075350
AMT MarvelXACT™ PLS 75µm x 600mm	2650 nl	PL7075600
AMT MarvelXACT™ PLS 100µm x 150mm	1178 nl	PL7100150
AMT MarvelXACT™ PLS 100µm x 350mm	2750 nl	PL7100350
AMT MarvelXACT™ PLS 100µm x 600mm	4710 nl	PL7100600

### AMT MARVEL XACT™ PEEKSIL™ TUBING

DESCRIPTION	VOLUME	PART NUMBER
AMT MarvelXACT™ PEEKsil™ 25µm ID x 150mm	75 nl	PS7025150
AMT MarvelXACT™ PEEKsil™ 25µm ID x 350mm	170 nl	PS7025350
AMT MarvelXACT™ PEEKsil™ 25µm ID x 600mm	295 nl	PS7025600
AMT MarvelXACT™ PEEKsil™ 50µm ID x 150mm	295 nl	PS7050150
AMT MarvelXACT™ PEEKsil™ 50µm ID x 350mm	685 nl	PS7050350
AMT MarvelXACT™ PEEKsil™ 50µm ID x 600mm	1178 nl	PS7050600
AMT MarvelXACT™ PEEKsil™ 75µm ID x 150mm	665 nl	PS7075150
AMT MarvelXACT™ PEEKsil™ 75µm ID x 350mm	1545 nl	PS7075350
AMT MarvelXACT™ PEEKsil™ 75µm ID x 600mm	2650 nl	PS7075600
AMT MarvelXACT™ PEEKsil™ 100µm ID x 150mm	1178 nl	PS7100150
AMT MarvelXACT™ PEEKsil™ 100µm ID x 350mm	2750 nl	PS7100350
AMT MarvelXACT™ PEEKsil™ 100µm ID x 600mm	4710 nl	PS7100600



# HALO®

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