



HALO™



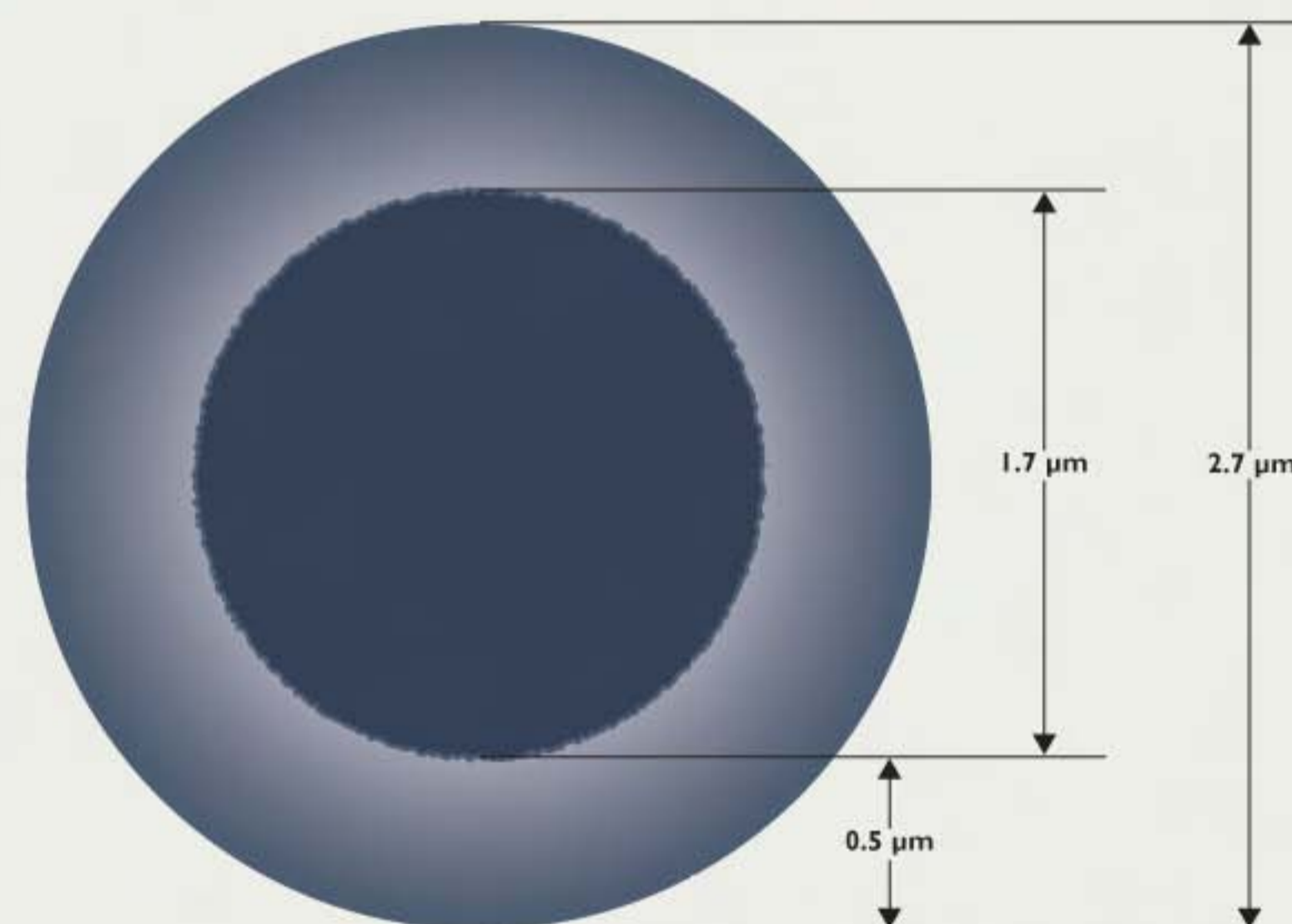
Fused-Core™ particle technology  
for hyper-fast and super-rugged  
HPLC Columns

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.** Fused-Core Particle Technology

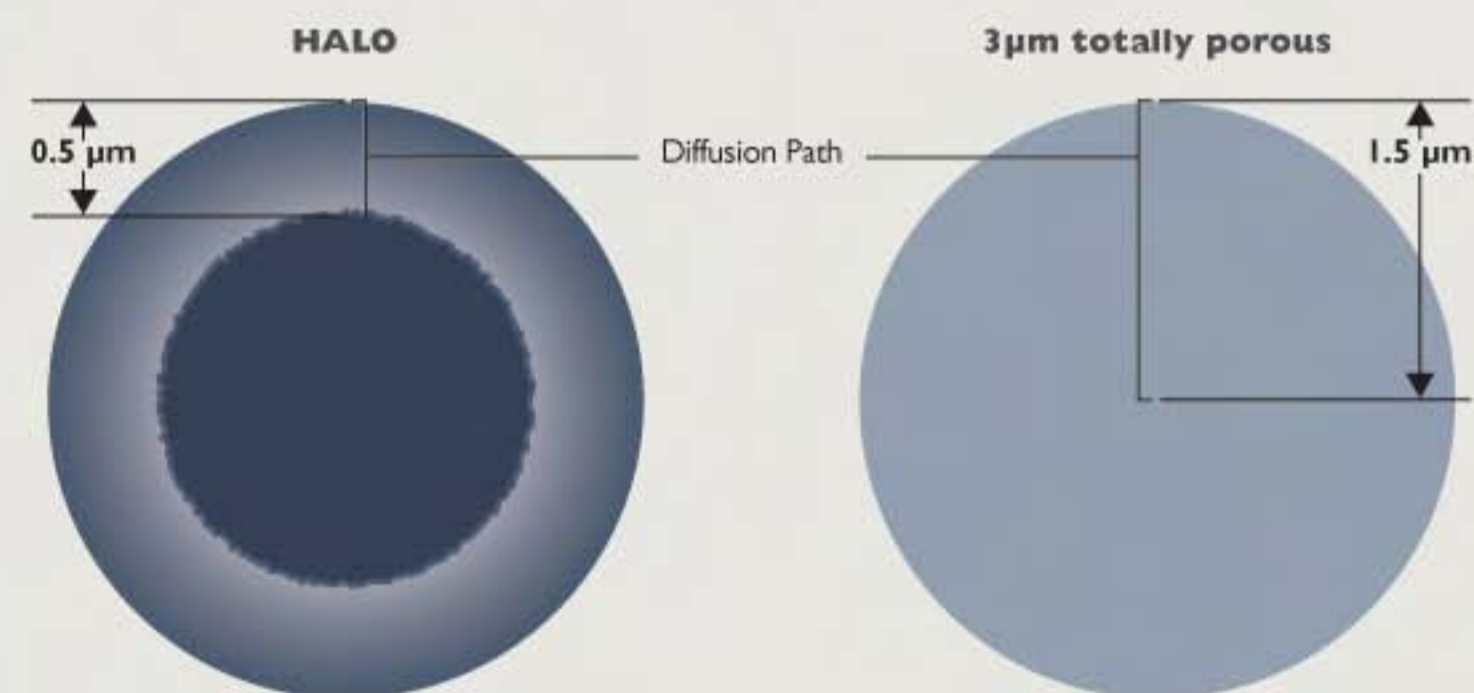


- Fused-Core particle technology was developed by Jack Kirkland to produce HPLC columns that provide faster separations and higher sample throughput without sacrificing column ruggedness and reliability. As the name implies, Fused-Core particles are manufactured by “fusing” a porous silica layer onto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

# HALO particles are designed for hyper-fast HPLC

Their ability to generate hyper-fast separations comes not only from their small particle size (2.7  $\mu\text{m}$ ) but also from the unique Fused-Core particle technology that creates a 0.5  $\mu\text{m}$  porous shell fused to a solid core particle. As you increase mobile phase flow rate to speed-up a separation, the slow mass transfer of solute molecules inside the particles can limit resolving power. Fused-Core particle technology addresses this limitation by providing an incredibly small path (0.5  $\mu\text{m}$ ) 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).

**Figure 2.** The shorter diffusion path of HALO reduces axial dispersion

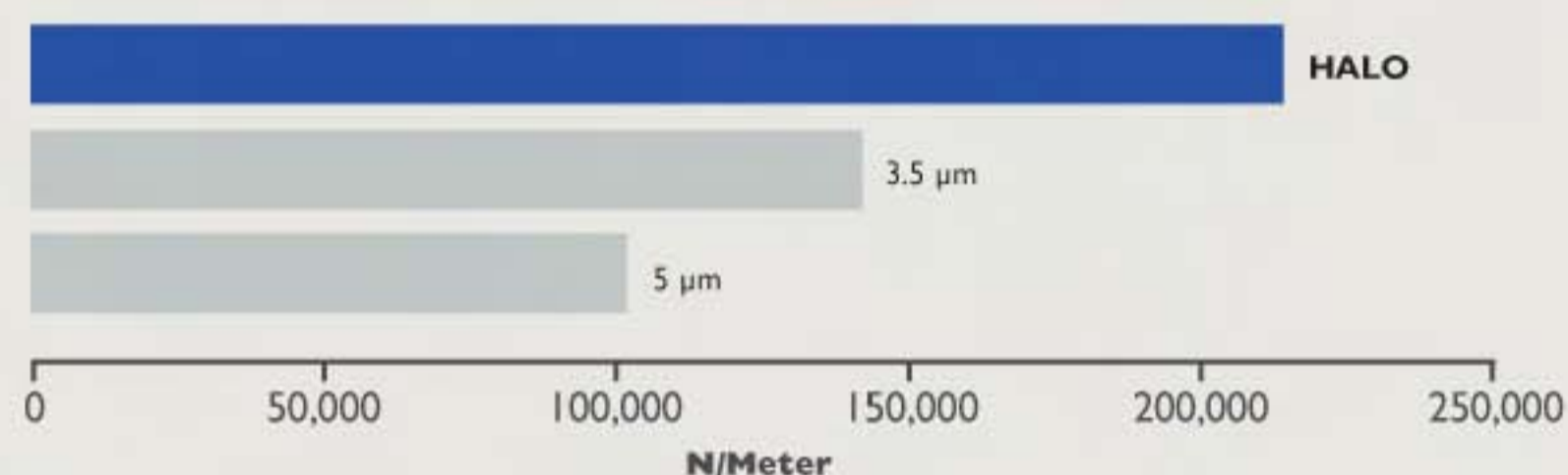


- The shorter diffusion path of HALO particles reduces axial dispersion of solutes and minimizes peak broadening. A Halo particle has only a 0.5  $\mu\text{m}$  diffusion path compared to the approximately 1.5  $\mu\text{m}$  diffusion path of a 3  $\mu\text{m}$  totally porous particle. Because of the 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.

HALO columns deliver over 50% more separating power (theoretical plates) than a column of the same length packed with 3.5  $\mu\text{m}$  particles and more than twice the plates of a column packed with 5  $\mu\text{m}$  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).

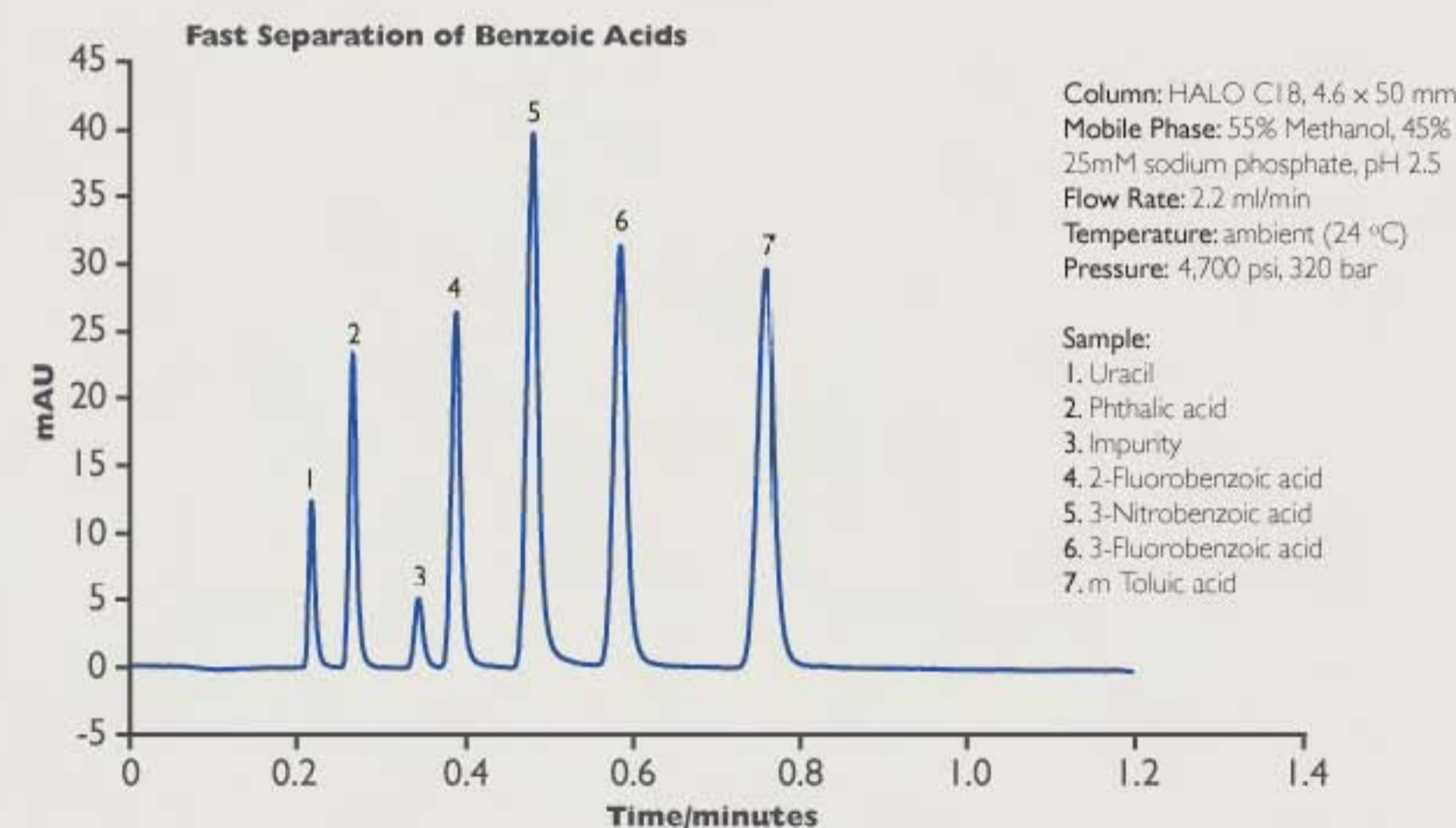
**Figure 3.** HALO columns deliver more separating power



- HALO columns deliver over 50% more separating power (plates) than columns of the same length packed with 3.5  $\mu\text{m}$  particles and more than twice the separating power of columns packed with 5  $\mu\text{m}$  particles.

Note: N/Meter values were calculated at the optimum mobile phase linear velocity for each of these stationary phases. Naphthalene was used as the test probe and the mobile phase conditions used were 60% acetonitrile and 40% water at 24  $^{\circ}\text{C}$ .

**Figure 4.** HALO columns are designed for hyper-fast HPLC separations

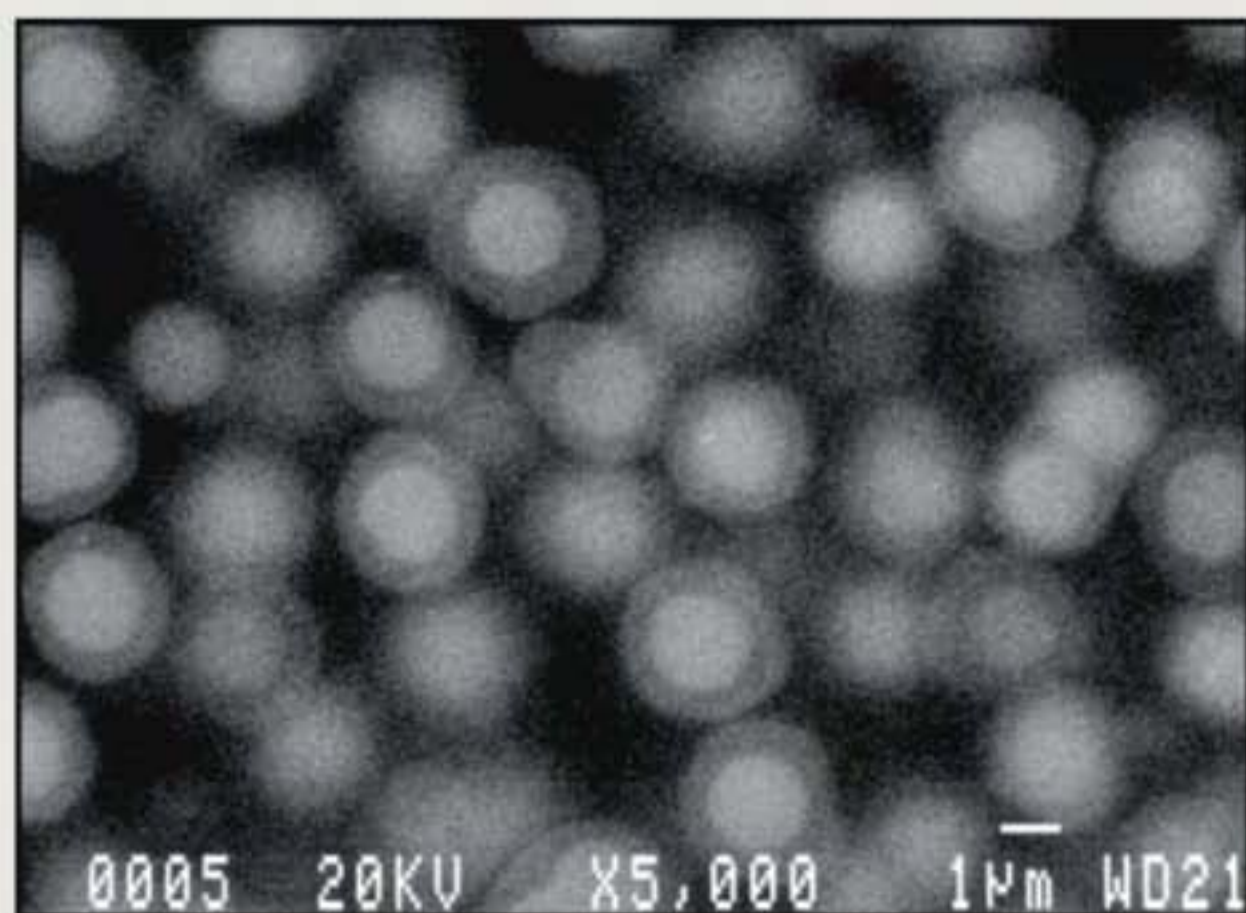


- HALO columns are designed for hyper-fast separations so that higher sample throughput can be achieved. In this example, the HALO column separated seven compounds in less than 48 seconds with better than baseline resolution for all peak pairs.

# 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 other 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

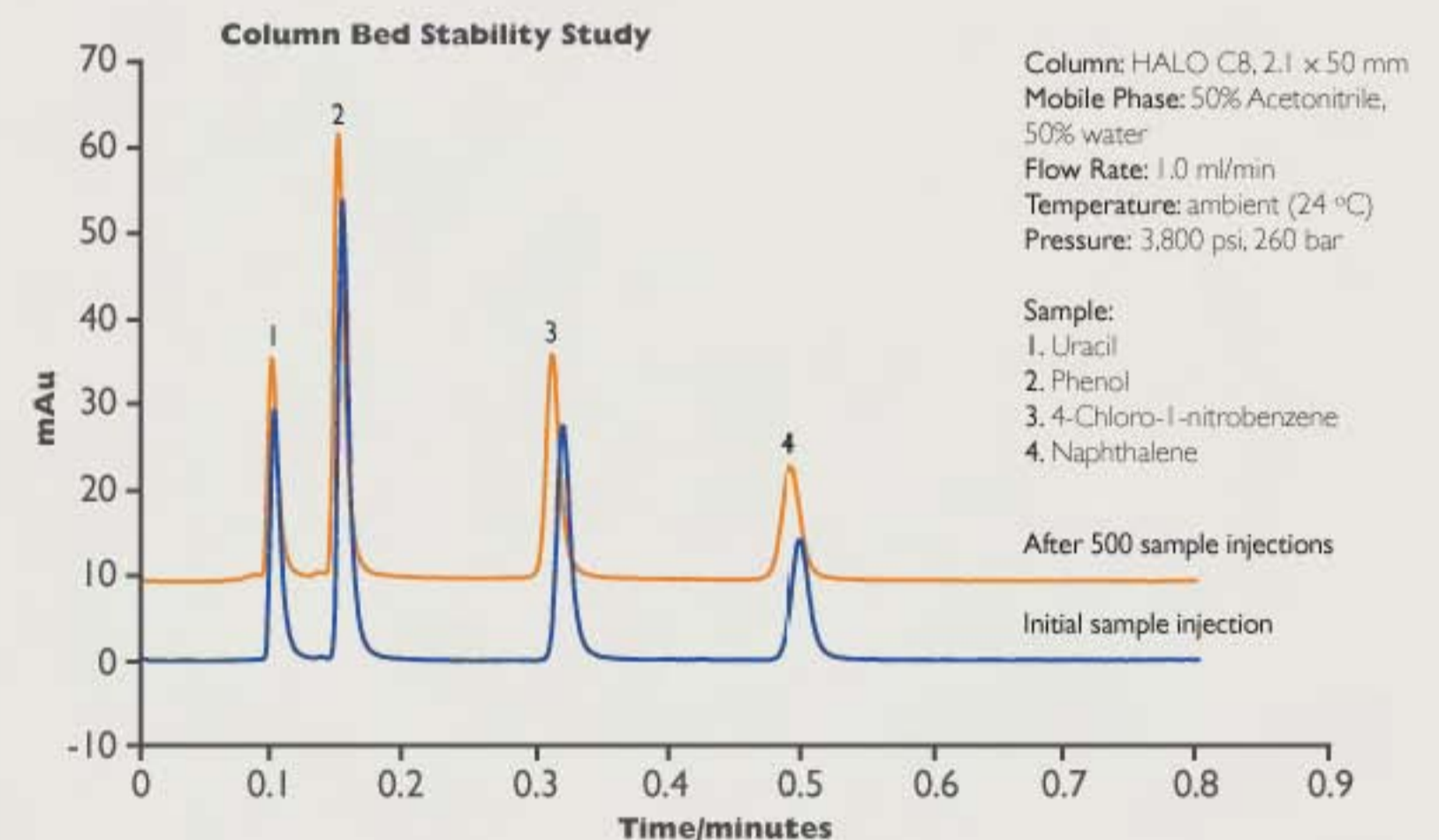


- This SEM photograph of HALO particles illustrates two important attributes of this unique column packing. First, the incredibly narrow particle size distribution is apparent. Second, this SEM photo shows some of the HALO particles "sliced in half" so that the solid core and the porous outer layer,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

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.

**Figure 6.** Stability testing of a HALO HPLC column

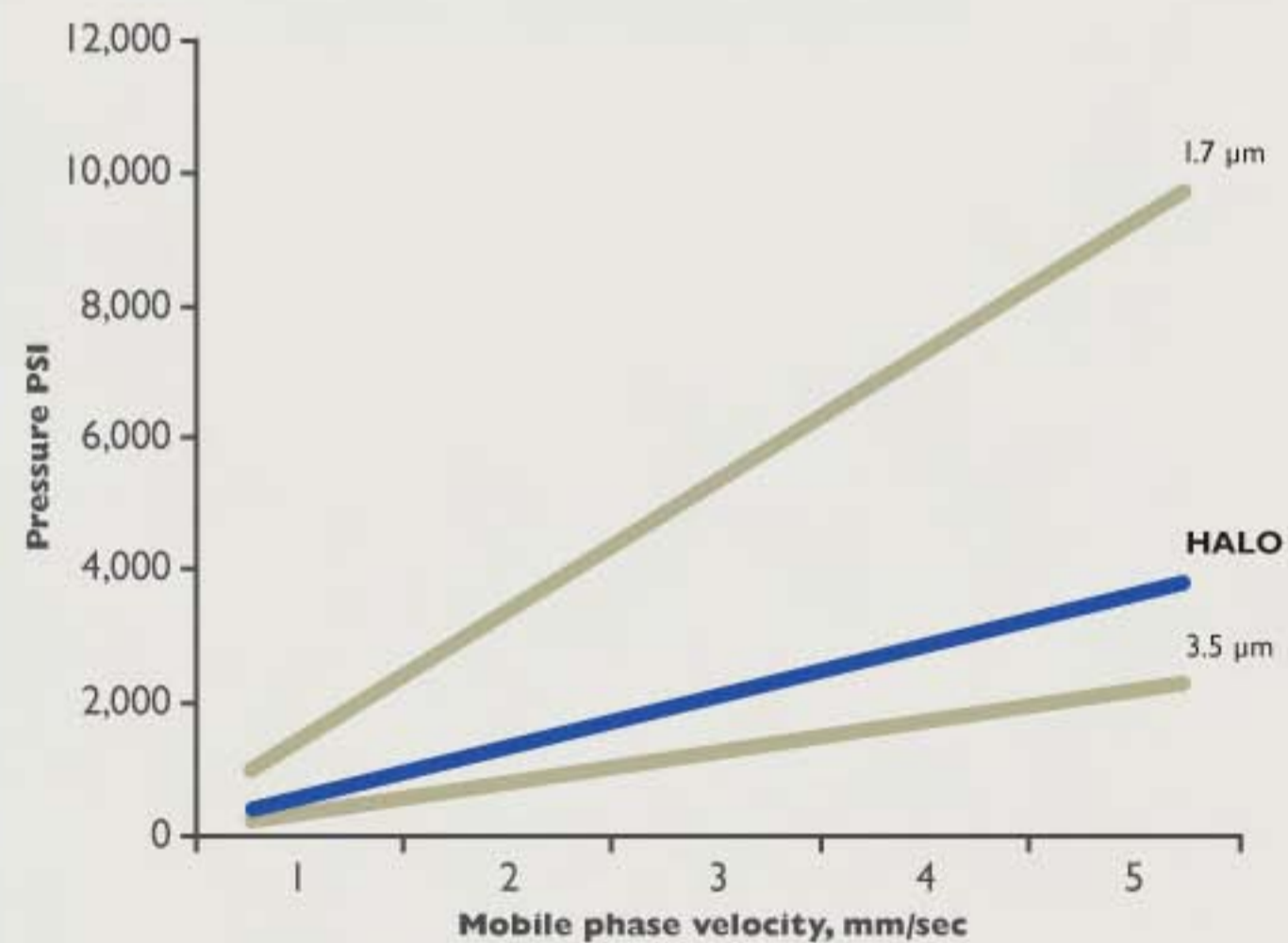


- A HALO column was run under high flow conditions to test bed stability. After 500 sample injections and over 40,000 column volumes, there was no evidence of any change to the packing bed.

# HALO™ columns don't 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.

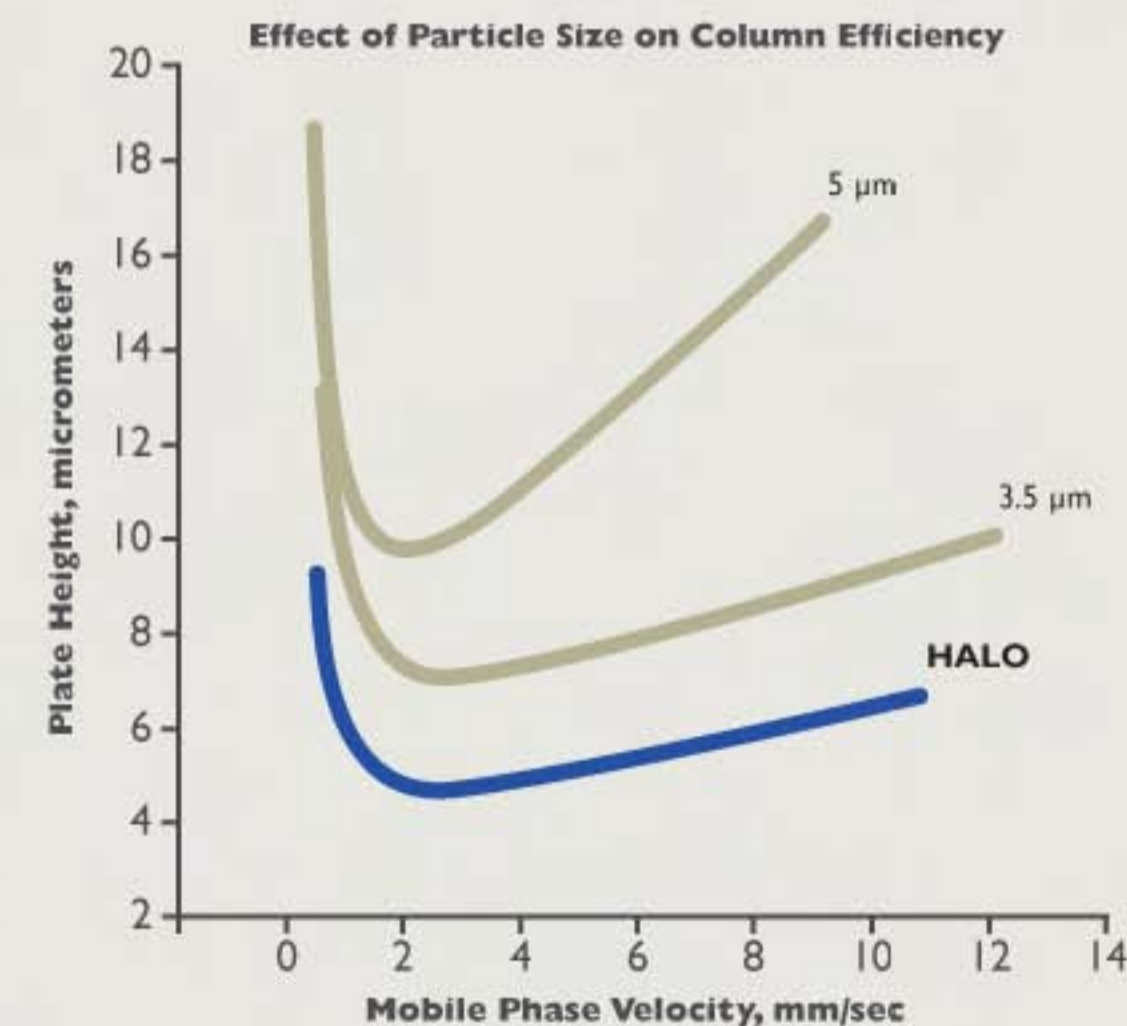
## The science behind HALO

The van Deemter equation describes the dependence of column efficiency on linear velocity of the mobile phase:

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

The 3rd term, the "C term," is directly proportional to mobile phase linear velocity and, therefore, important to consider in the design of stationary phases for fast HPLC.

**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:



## The science behind HALO (cont.)

In HPLC the movement of the mobile phase past the particles containing the stationary phase interferes with the equilibrium between the solute, mobile phase, and stationary phase. This non-equilibrium causes band spreading due to axial dispersion of the solute molecules. The higher the velocity of the mobile phase, the greater the axial dispersion and the broader the peak becomes. In addition, the longer the path a solute has to travel within the pores of the stationary phase, its diffusional mass transfer, the more detrimental will be the effect of mobile phase velocity on column efficiency. These factors affecting stationary phase efficiency are manifested in the C term of the van Deemter equation.

The path a solute has to travel within the pores of a stationary phase 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 path lengths and, therefore, are less affected by increases in mobile phase velocity. HALO particles, by virtue of their 0.5  $\mu\text{m}$  porous shell, have reduced the diffusional mass transfer path by one third compared to 3  $\mu\text{m}$  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. This advantage grows as the molecular size of the compounds in the sample mix increases because of the slower diffusion of larger molecules.

## Fused-Core technology

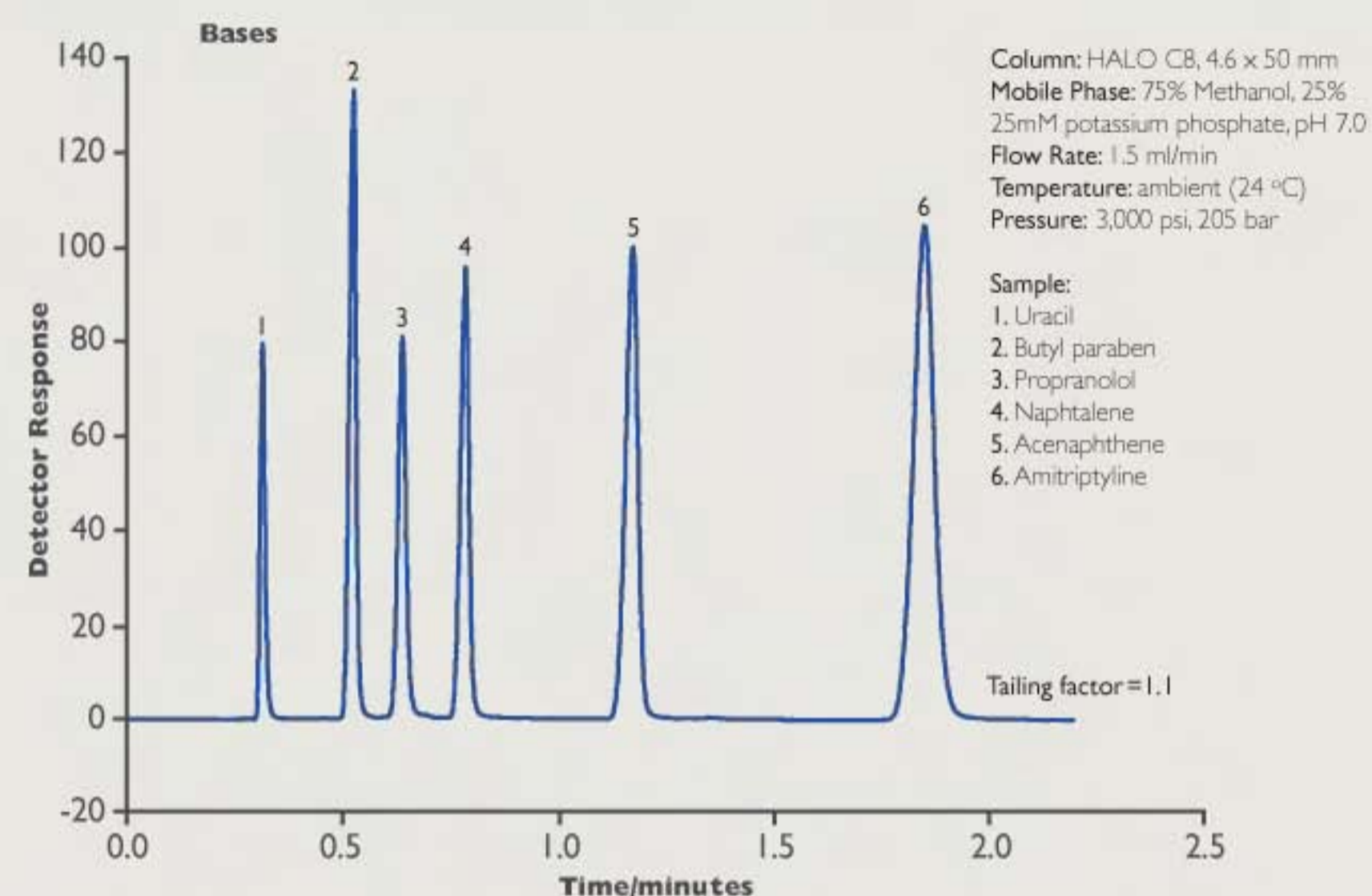


- *Fused-Core technology was developed by Jack Kirkland. Dr. Kirkland is widely regarded as one of the "founders" of HPLC and is well recognized for his research and contribution to the understanding of chromatography. He's authored over 150 major research publications, and 6 textbooks. Dr. Kirkland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

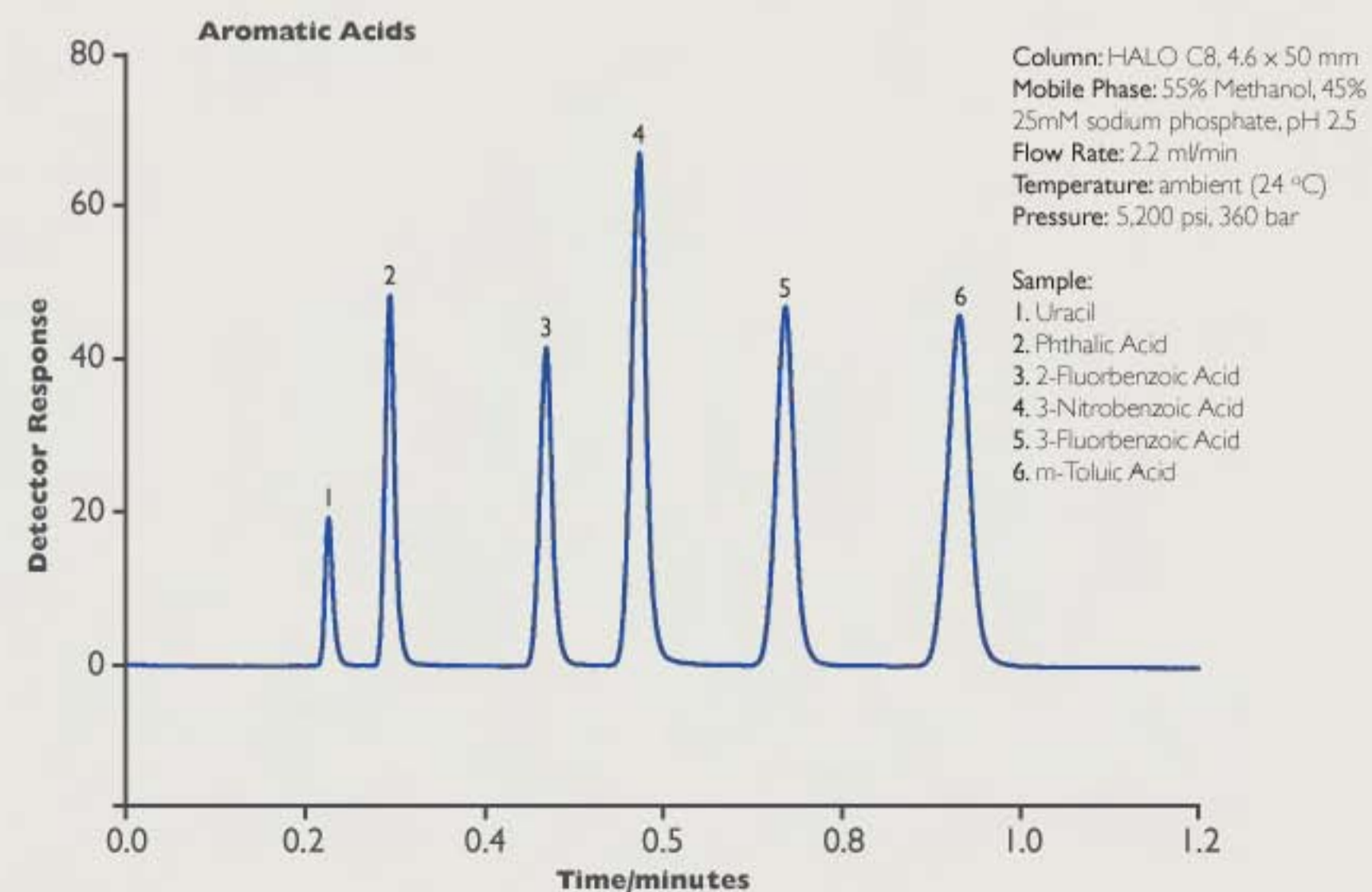
# HALO™ is base-deactivated for excellent peak shape

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



- 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.



# HALO™ specifications

## Stationary Phase Support

- Ultra-pure, "Type B" silica
- 1.7  $\mu\text{m}$  solid core particle with a 0.5  $\mu\text{m}$  porous silica layer fused to the surface
- 150  $\text{m}^2/\text{gram}$  surface area
- 90  $\text{\AA}$  pore size

## Bonded Phase

- Monomeric bonding chemistry
- Densely bonded phase
- Maximized endcapping
- C18: Octadecyldimethylsilane, 3.5  $\mu\text{moles}/\text{m}^2$
- C8: Octyldimethylsilane, 3.7  $\mu\text{moles}/\text{m}^2$
- pH Range: 2 to 9

Maximum Pressure: 9,000 psi, 600 Bar

## HALO Ordering Information

Column Dimensions	Halo C18	Halo C8
2.1 x 30mm	92812-302	92812-308
2.1 x 50mm	92812-402	92812-408
2.1 x 75mm	92812-502	92812-508
2.1 x 100mm	92812-602	92812-608
2.1 x 150mm	92812-702	92812-708
3.0 x 30mm	92813-302	92813-308
3.0 x 50mm	92813-402	92813-408
3.0 x 75mm	92813-502	92813-508
3.0 x 100mm	92813-602	92813-608
3.0 x 150mm	92813-702	92813-708
4.6 x 30mm	92814-302	92814-308
4.6 x 50mm	92814-402	92814-408
4.6 x 75mm	92814-502	92814-508
4.6 x 100mm	92814-602	92814-608
4.6 x 150mm	92814-702	92814-708



## HALO™ HPLC Columns are Built to be Hyper-fast and Super-rugged.

If the demands on your lab require increased sample throughput, choose HALO HPLC columns. Their hyper-fast speed, superior ruggedness, and reasonable back-pressure are the sensible way to increase lab sample throughput.

HALO HPLC columns are faster than columns packed with 3  $\mu\text{m}$  particles, but are just as rugged and easy to use as columns containing 5  $\mu\text{m}$  particles.

Contact your distributor today, for additional details on HALO HPLC column availability and pricing.

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Advanced Materials Technology, Inc.



**HALO™**  
the sensible way to do fast HPLC.