High Resolution and Fast LC and LC/MS of Proteins and Peptides with Poroshell Columns

Agilent Technologies
The Path to Ultra-Fast HPLC Separations

- Superficially Porous Particles - 40µ
- 5 µm particles
- 150 mm length
- High Temp with Steric-Protection
- Non-Porous Particles
- Micro-Bore
- Capillary Columns
- Well-Plate Samplers
- 1.8 µm particles
- 10 µm particles
- 250 mm length
- Superficially Porous Particles - 5µ
- 3.5 µm particles
- 15 mm length
- Narrow-Bore
- High Flow Rates
- Overlapped Injections
- Nano HPLC

Small-Column HPLC Technology

Agilent Technologies
What Makes High Speed HPLC Possible?

Small particle sizes (< 5 µm)

Short columns (10 cm or less)

Low viscosity mobile phases

Optimized HPLC – minimal extra column volume, low volume flow cell

Detector set to fast response time

High diffusion coefficient of the sample molecules in the mobile phase = rapid diffusion = less band broadening = higher linear velocities with efficient peaks

But large molecules have small diffusion coefficients
Slower Diffusion of Large Molecules Broadens Peaks at High Flow Rates

Decrease the diffusion time for macromolecules!

How?

• Increase the Diffusion Rate
  - Elevate operating temperature
  - Decrease solvent viscosity

• Decrease the Diffusion Distance
  - Develop very small particles
  - Limit diffusion distance into a particle  
    Zorbax Poroshell Approach
Comparison of diffusion distance

Totally porous silica versus superficially porous silica

<table>
<thead>
<tr>
<th>5 µm</th>
<th>5 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totally Porous Particle</td>
<td>Superficially Porous Particle</td>
</tr>
</tbody>
</table>

Maximum diffusion depth for a macromolecule

2.5 µm

0.25 µm
What are Zorbax Poroshell 300SB and 300Extend?
A solid silica core with a superficially porous surface of smaller silica sol particles derivatized with a sterically-protected bonded phase.
Poroshell is Part of the ZORBAX StableBond Family of Sterically-Protected Silica Phases

Advantage of Monolayer Bonding:
Single Step, Reproducible Reaction
ZORBAX Extend-C18 - A Bidentate C18 Bonded Phase designed for Use at High pH

Now available as Zorbax Poroshell 300Extend-C18
ZORBAX StableBond-C18 shows exceptional stability at low pH and high temperatures (pH 0.8, 90°C)

ZORBAX Extend-C18 is Very Stable at High pH

Aging of Extend-C18 column in NH₄OH at pH 10.5

Consistent retention and plate heights over time indicate stable column at high pH.

Long column lifetime achieved.

Column: ZORBAX Extend-C18
4.6 x 150 mm, 5 µm
Mobile phase: 80% Methanol
20% 20 mM NH₄OH, pH 10.5
Flow Rate: 1.5 mL/min;
Aging at 24°C, tests at 40°C
Gradient Equation for Fast HPLC of Proteins

\[
k^* = \frac{t_G F}{S \Delta \Phi V_m}
\]

Because:
- \( S \) is a constant for a separation system.

Assuming:
- \( \Delta \Phi \) is set for maximum resolution.
- \( S \) and \( \Delta \Phi \) drop out of this equation.

\[
k^* = \frac{t_G F}{V_m} \sim \frac{V_G}{V_m}
\]

Because:
- \( t_G F = V_G \) or gradient volume.

\( k^* \) (relative retention) is dependent upon the ratio of \( V_G \) over \( V_m \).

1. If one keeps the same ratio of \( V_G/V_m \), then \( k^* \) and the peak elution pattern will stay the same.
2. Flow rates of 1 to 3 mL/min on a 2.1 mm i.d. Poroshell column are the equivalent of 5 to 15 mL/min on a 4.6 mm i.d. column!
3. When \( F \) is large, \( t_G \) should be reduced proportionally; therefore, the very short run times!
4. In comparison of larger columns to the Poroshell configuration, \( t_G \) and \( F \) are also adjusted.
How Do We Use Poroshell Columns?

Faster separations

- High flow rates for fast analysis with high resolution in comparison to totally porous silica
  - Polypeptides
  - Large proteins
  - Impurities

- High recovery of large proteins

Elevated temperature

Change selectivity

- Different bonded phases - Comparison to totally porous 300SB materials
- High resolution of proteins, heterogeneous proteins, and digests on different bonded phases

LC/MS

- Factors affecting LC/MS of proteins
- High resolution LC/MS of proteins
- Different bonded phases – comparisons to each other

- Peptide mapping at high and low pH
Ultra-Fast Analysis of High-Molecular Weight Protein and Impurities -- β-Amylase (200KDa)

Comparison of Zorbax Poroshell and Conventional Porous Particle

- Poroshell technology facilitates ultra-fast HPLC analysis of proteins
- Note the similar separation of minor impurities in the 2 and 20 min separations.
Poroshell Has Different Selectivity from Totally Porous 300SB

Poroshell and 300SB-C18 can have different selectivity due to the different ratios of bonded phase on the surface.
Temperature sharpens peaks and lowers back pressure in ultra-fast protein analysis

- Use of elevated temperature with temperature-resistant bonded phases, reduces viscosity and back pressure, sharpens peaks, increases sample solubility, and reduces retention times.
**Improved Peak Shape of IgG at Elevated Temperature**

**Intact IgG (15 µg) at 0.5 ml/min**

- Immunoglobulins have retention characteristics similar to very hydrophobic peptides – peaks are narrower at elevated temperatures and on shorter chain length columns

**Zorbax Poroshell 300SB-C18, 5µµ, 2.1 x 75 mm**

**Data courtesy of:**
Genentech, Inc
Analytical Chemistry, Baojen Shyong, Galahad DePeralta, and Victor Ling
Effect of Increasing Flow Rate in Protein Analysis with use of Totally Porous Silica

- Efficiency and resolution are lost at high flow rates on a totally porous 300Å RP column.

- 0.5 mL/min: 0-100%B in 4 min
- 1 mL/min: 0-100%B in 2 min
- 2 mL/min: 0-100%B in 1 min
- 3 mL/min: 0-100%B in 0.67 min

1. Neurotensin
2. Rnase A
3. Lysozyme
4. Myoglobin

Totally Porous 2.1x75mm, 5µm
High Efficiency at High Flow Rates for Ultra-Fast Protein Analyses with Poroshell

- Resolution is maintained at high flow rates with Poroshell, allowing for efficient peaks and rapid analysis times.

Agilent 1100 DAD
Agilent 1100 WPS with ADVR

**Column:** Poroshell 300SB-C18
2.1 x 75 mm, 5 mm

**Mobile Phase:**
A: 95% H$_2$O, 5% ACN with 0.1% TFA
B: 5% H$_2$O, 5% ACN with 0.1% TFA

**Temperature:** 70°C

**Detector:** UV 215 nm

**Sample:**
1. Neurotensin
3. Lysozyme
2. RNaseA
4. Myoglobin
Fast, High Resolution Separation of Peptides and Proteins With Poroshell 300SB-C18 . . . In Seconds

Columns: Poroshell 300SB-C18
2.1 x 75 mm, 5 mm
Mobile Phase: A: 0.1% TFA
B: 0.07% TFA in ACN
Gradient: 5 – 100% B in 1.0 min.
Flow Rate: 3.0 mL/min.
Temperature: 70°C
Pressure: 250 bar
Detection: UV 215 nm

Sample:
1. Angiotensin II
2. Neurotensin
3. RNAse
4. Insulin
5. Lysozyme
6. Myoglobin
7. Carbonic Anhydrase
8. Ovalbumin

- Only Poroshell can provide high efficiency at higher flow rates for extremely rapid separations of proteins and peptides.
- This is due to more rapid mass transfer of the superficially porous particle.
Break Number 1

For Questions and Answers
Press *1 on Your Phone to Ask a Question
How Do We Use Poroshell Columns?

Faster separations

High flow rates for fast analysis with high resolution in comparison to totally porous silica
- Polypeptides
- Large proteins
- Impurities
High recovery of large proteins
Elevated temperature

Change selectivity

Different bonded phases - Comparison to totally porous 300SB materials
High resolution of proteins, heterogeneous proteins, and digests on different bonded phases

LC/MS

Factors affecting LC/MS of proteins
High resolution LC/MS of proteins
Different bonded phases – comparisons to each other
Peptide mapping at high and low pH
Separation of Seven Monoclonal Antibodies on Zorbax Poroshell 300SB-C8

Column: Zorbax Poroshell 300SB-C8, 2.1x75mm, 5u
Flow: 1.0 ml/min
Detection: 210nm
Mobile phase A: H2O-ACN (90:10) + 3 ml/L of MW 300 PEG
Mobile phase B: H2O-ACN (10:90) +3 ml/L of MW 300 PEG
Gradient: 0 min, 19% B; 12 min 41% B;
12.1 min, 19% B; 14 min, 19% B
Temperature: 70°C

Antibody Type:
1 = IgG1
2 = IgG1
3 = IgG1
4 = IgG4
5 = IgG1
6 = IgG1
7 = IgG1

Data courtesy of:
Novartis Pharma, Biotechnology, Basel
Dr. Kurt Forrer and Patrik Roethlisberger

• Zorbax Poroshell 30SB-C8 shows different selectivity for several pairs of monoclonal antibodies.
Separation of Seven Monoclonal Antibodies on Zorbax Poroshell 300SB-C3

Column: Zorbax Poroshell 300SB-C3, 2.1x75mm, 5μ
Flow: 1.0 ml/min
Detection: 210nm
Mobile phase A: H2O-ACN (90:10) + 3ml/L of MW 300 PEG
Mobile phase B: H2O-ACN (10:90) + 3ml/L of MW 300 PEG
Gradient: 0 min, 19% B; 12 min 41% B; 12.1 min, 19% B; 14 min, 19% B
Temperature: 70°C

Antibody Type:
1 = IgG1
2 = IgG1
3 = IgG1
4 = IgG4
5 = IgG1
6 = IgG1
7 = IgG1

Zorbax Poroshell 300SB-C3 shows different selectivity for several pairs of monoclonal antibodies.

Data courtesy of:
Novartis Pharma, Biotechnology, Basel
Dr. Kurt Forrer and Patrik Roethlisberger

High Res. & Fast LC & LC/MS of Proteins and Peptides with Poroshell
02/ 06/ 2004
Monoclonal IgG1 Chains on ZORBAX Poroshell 300SB-C8

It is known that the heavy chain is glycosylated. What is not yet known for certain is whether one or both peaks above are glycosylated initially and what the difference is between the two peaks after the glycosylation is removed. Current thought is that they are likely to be conformers but there is no real proof of this yet.

Data courtesy of:
Novartis Pharma, Biotechnology, Basel
Dr. Kurt Forrer and Patrik Roethlisberger
Monoclonal Antibody Chains on ZORBAX Poroshell 300SB-C8

Column: Zorbax Poroshell 300SB-C8, 2.1x75mm, 5μm  
Flow: 1.0 ml/min  
Detection: 210nm  
Mobile phase A: H2O-ACN (90:10) + 3 ml/L of MW 300 PEG  
Mobile phase B: H2O-ACN (10:90) + 3 ml/L of MW 300 PEG  
Gradient: 0 min, 20% B; 10 min 50% B; 10.1 min, 20% B; 14 min, 20% B  
Temperature: 70°C  

IgG1(Antibody 7) treated with:  
DTT  
Peptide-N-glycosidase F  
Carboxypeptidase F  

Light Chains differing by 2 amino acids

Data courtesy of:  
Novartis Pharma, Biotechnology, Basel  
Dr. Kurt Forrer and Patrik Roethlisberger
Separation of Large and Glycosylated Proteins on ZORBAX Poroshell 300SB-C18, C8, and C3

Column: Zorbax Poroshell 300SB-C18, C8 or C3, 1.0 x 75mm, 5µm
Flow: 0.454ml/min
Mobile phase A: 0.1% TFA in H2O
Mobile phase B: 0.07% TFA in ACN
Gradient: 5% B —> 100% B in 10 min
Detector: DAD, 212nm, 1.7 µl flow cell
<0.01 min peak width
Temperature: 70° C
Bypass mode, Binary Pump, no mixer

Peak widths, resolution, and analysis times are superior on Poroshell columns

- Mouse monoclonal IgG, MW = 150KDa
- Human α2-Macroglobulin, MW = 720KDa
- Human IgM, MW = 950KDa
- Human Glycophorin, MW ~ 50KDa, 60% carbohydrate

Aligned
5X Faster
Separation of Large and Glycosylated Proteins on ZORBAX Poroshell 300SB-C18, C8, and C3

Column: Zorbax Poroshell 300SB-C18, C8 or C3, 1.0x75mm, 5 µ and Zorbax 300SB-C18, 1.0x50mm, 3.5 µ
Flow: 0.454 ml/min
Mobile phase A: 0.1% TFA in H2O
Mobile phase B: 0.07% TFA in ACN
Gradient: 5% B → 100% B in 10 min
Detector: DAD, 212nm, 1.7 µl flow cell
<0.01 min peak width
Temperature: 70° C
Bypass mode, Binary Pump, no mixer

- Zorbax Poroshell C8 and C3 offer advantages over Zorbax 300SB-C18 for large and heavily glycosylated proteins
- Zorbax Poroshell C18 offers advantages for all but the most heavily glycosylated proteins
Chromatography of Thyroglobulin - a Doubly Heterogeneous Protein – on ZORBAX Poroshell C3, C8, and C18

Column: as shown  Flow: 0.454mL/min Mobile phase A: 0.1% TFA in H2O Mobile phase B: 0.07% TFA in ACN Gradient: 5% B ——> 100% B in 10 min  Detector: DAD, 212nm, 1.7 µl flow cell <0.01min peak width Temperature: 70° C  Bypass mode, Binary Pump, no mixer

Peakwidth at
Half Height (min.)

<table>
<thead>
<tr>
<th></th>
<th>ZORBAX Poroshell 300SB-C3, 1 x 75mm, 5µm</th>
<th>ZORBAX Poroshell 300SB-C8, 1 x 75mm, 5µm</th>
<th>ZORBAX Poroshell 300SB-C18, 1 x 75mm, 5µm</th>
<th>ZORBAX 300SB-C18, 1 x 50mm, 3.5µm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.173</td>
<td>0.242</td>
<td>0.258</td>
<td>0.252</td>
</tr>
<tr>
<td>Symmetry</td>
<td>0.911</td>
<td>0.872</td>
<td>0.827</td>
<td>0.759</td>
</tr>
</tbody>
</table>

•Best peak width and symmetry on Zorbax Poroshell 300SB-C3

Bovine Thyroglobulin
MW 670 KDa.
Glycosylated and Partially Iodinated

Agilent Technologies
High Speed HPLC Peptide Maps of a Monoclonal Antibody on Several ZORBAX Poroshell Phases

Conditions:
Mobile phase A = 0.1% TFA in water
Mobile phase B = 0.1% TFA in ACN;
Gradient: 0 min, 0% B; 20 min, 50% B; 20.5 min, 100% B; 21.5 min, 100% B
Temperature: 70°C;
Detection: VWD, 210nm;
Injection: 10 µl Lys-C digest of Human Monoclonal Antibody;
Flow: 1.0 ml/min

Conditions:
Mobile phase A = 0.1% TFA in water
Mobile phase B = 0.1% TFA in ACN;
Gradient: 1 min, 0% B; 10 min, 0% B; 110 min, 50% B; 115 min, 70% B; 120 min, 70% B; 125 min, 0% B; 135 min, 0% B
Temperature: ambient;
Detection: VWD, 210nm; Injection: 50 µl Lys-C digest of Human Monoclonal Antibody;
Flow: 0.3 ml/min
Ultra High Speed HPLC Peptide Maps of a Monoclonal Antibody on Several ZORBAX Poroshell Phases

ZORBAX Poroshell technology facilitates ultra-fast HPLC analysis of peptides.
Peaks detected in peptide maps of a Lys-C digest of a monoclonal antibody

<table>
<thead>
<tr>
<th>Column</th>
<th># of Peaks recognized (120 min. run)</th>
<th># of Peaks recognized (20.5 min. runs)</th>
<th># of Peaks recognized (5.6 min. runs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitor V C18</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poroshell-C18</td>
<td>55</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Poroshell-C8</td>
<td>58</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Poroshell-C3</td>
<td>54</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>
Separation of a Tryptic Digest on Poroshell Capillary HPLC Column

Column: ZORBAX Poroshell 300SB-C18, 150 x 0.5 mm, 5µ
Solvent: 0.1% TFA in water/
0.1% TFA in acetonitrile, gradient 5-65% in 15’
Flow: 20 µL/min
Detection: 214 nm
Temp.: 25 °C
Sample: 0.1 µL, 1.5 pmol, digest of horse skeletal myoglobin
System: Agilent 1100 Series Capillary LC System

Agilent Technologies
More Poroshell Bonded Phases Provide Selectivity Options to Enhance Resolution

Conditions: columns – as listed
Mobile Phase: A 0.1% TFA/H2O, B 0.07% TFA/MeCN; Gradient: 5-100% B in 3.0 min
Temperature: 70°C
Flow rate: 0.5 ml/min
Detector: UV 215 nm

Poroshell 300SB-C3, 2.1 x 75 mm, 5 µm

Poroshell 300SB-C18, 2.1 x 75 mm, 5 µm

• Poroshell 300SB-C3 provides complete resolution of Insulin and Cytochrome C, whereas the 300SB-C18 does not.
Break Number 2

For Questions and Answers
Press *1 on Your Phone to Ask a Question
How Do We Use Poroshell Columns?

Faster separations

- High flow rates for fast analysis with high resolution in comparison to totally porous silica
  - Polypeptides
  - Large proteins
  - Impurities
- High recovery of large proteins
- Elevated temperature

Change selectivity

- Different bonded phases - Comparison to totally porous 300SB materials
- High resolution of proteins, heterogeneous proteins, and digests on different bonded phases

LC/MS

- Factors affecting LC/MS of proteins
- High resolution LC/MS of proteins
- Different bonded phases – comparisons to each other
- Peptide mapping at high and low pH
Poroshell Columns for LC/MS of Proteins

High resolution separations of proteins

Formic or acetic acid containing mobile phases for better LC/MS sensitivity

Optimize and balance LC and MS parameters for high sensitivity

<table>
<thead>
<tr>
<th>MS Parameters</th>
<th>LC Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate</td>
<td>Flow Rate</td>
</tr>
<tr>
<td>Scan speed</td>
<td>Resolution</td>
</tr>
<tr>
<td>Peak width</td>
<td>Peak width</td>
</tr>
<tr>
<td>Step size</td>
<td></td>
</tr>
</tbody>
</table>

Excellent elution and recovery of proteins improves LC/MS
Effect of LC/MS Acid Modifier on Peak Width using Poroshell

Column: Poroshell 300SB-C18, 2.1 x 75 mm, 5 µm
Mobile Phase Gradient: 20-100% B in 5.5 min. A: water + 0.1% TFA or FA B: ACN + 0.1% FA or TFA
Flow Rate: 500 µL/min
Temperature: 60°C
Injector: 1 µL
DAD: 220, 4 nm

FA = formic acid
TFA = trifluoroacetic acid

- Formic acid gives high efficiency with only slightly larger peak widths on Poroshell
Effect of Modifier on MS Response: 10 pmol BSA
**Good Sensitivity with Formic Acid**

**Mass Spectra of Several Proteins**

**5 pmol Insulin**
MW 5733

**5 pmol Myoglobin**
MW 16950

**10 pmol Carbonic anhydrase**
MW 29022

- Both small and large proteins generate clear mass spectra using Poroshell with formic acid.

**Column:** Poroshell 300SB-C18, 2.1 x 75 mm, 5 µm
**Mobile Phase Gradient:** 20-100% B in 5.5 min. A: water + 0.1% formic acid. B: ACN + 0.1% formic acid
**Flow Rate:** 500 µL/min
**Temperature:** 60°C
**Injector:** 1 µL
**DAD:** 220/4 nm
**LC/MS:** Pos. Ion ESI –, Vcap 6000 V, Drying gas flow: 12 l/min, Drying gas temperature: 350°C, Nebulizer: 45 psi, Fragmentor voltage: 140 V
**Scan:** 600 – 2500
**Stepsize:** 0.15
**Peakwidth:** 0.06 min
Impact of Protein Heterogeneity on Mass Spectra

100 pmol phosphorylase B

5 pmol BSA
Optimize LC/MS Separation: Effect of Flow Rate

Column: Poroshell 300SB-C18, 1.0 x 75 mm, 5 µm  
Mobile Phase Gradient: 20-100% B in 5.5 min.  
A: water + 0.1% formic acid  
B: ACN + 0.1% formic acid  
Flow Rate: as shown  
Temperature: 80°C  
Injection volume: 1 µL  
Sample: insulin, lysozyme, cytochrome C, myoglobin, BSA, carbonic anhydrase  
LC/MS: Pos. Ion ESI –, Vcap 6000 V, Drying gas flow: 12 l/min, Drying gas temperature: 350°C, Nebulizer: 45 psi, Fragmentor voltage: 140 V, Scan: 600–2500, Stepsize: 0.15 amu, Peakwidth: 0.06 min

- The flow rate is more critical to the chromatographic separation than the MS.
Effect of Flow Rate on Mass Spectra

- Flow rate changes have almost no impact on the mass spectra from 300 – 600 µL/min.
Impact of Scan Speed on Sensitivity

- A slower scan speed as defined by MS settings, allows for better peak definition for better sensitivity
Effect of MS Settings on TIC Signal

Pw=0.1
Stepsize = 0.15
Loose chromatographic resolution

Pw=0.06
Stepsize = 0.15
Best compromise of speed, chromatographic behavior and MS results

Pw=0.04
Stepsize = 0.15
Scanspeed override ON
Sacrifices MS signal (ion transmission)

Pw=0.04
Stepsize = 0.25
Better chromatographic resolution
but loss of MS signal
Effect of MS Settings on Spectral Quality

- **Pw=0.1**
  - Stepsize = 0.15
  - Lose chromatographic resolution

- **Pw=0.06**
  - Stepsize = 0.15
  - Best compromise of speed, chromatographic behavior and MS results

- **Pw=0.04**
  - Stepsize = 0.15
  - Scanspeed override ON
  - Sacrifices MS signal (ion transmission)

- **Pw=0.04**
  - Stepsize = 0.25
  - Better chromatographic resolution but loss of MS signal
High Flow Rates and High Sensitivity LC/MS Using 1.0 mm ID Zorbax Poroshell

Mobile Phase Gradient: 20-100% B in 5.5 min.
A: water + 0.1% formic acid
B: ACN + 0.1% formic acid
Flow Rate: 600 mL/min
Temperature: 80°C
Injection volume: 1 mL,
LC/MS: Pos. Ion ESI
Vcap 6000 V
Drying gas flow: 12 L/min
Drying gas temperature: 350°C
Nebulizer: 45 psi
Fragmentor voltage: 140 V
Scan: 600 – 2500
Stepsize: 0.15 amu
Peakwidth: 0.06 min

Sample: Mixture of insulin, lysozyme, cytochrome C, myoglobin, BSA, carbonic anhydrase

These TIC’s show good sensitivity with only 0.5 pmoles on column.
Selectivity, Resolution Options with Multiple Poroshell Bonded Phases

**Column:** Poroshell 300SB, 2.1 x 75 mm, 5 µm
Mobile Phase Gradient: 20-100% B in 5.5 min.
Mobile Phase: A: water +0.1% Formic Acid  B: ACN + 0.1% Formic acid
Flow Rate: 500 µL/min
Temperature: 60°C
Injection: 1 mL
Sample: Phosphorylase B, BSA, Ovalbumin, Carbonic anhydrase, Soybean trypsin inhibitor, alpha-lactalbumin and sucrose
Detection: Electrospary ionization: positive ion
Vcap: 6000V
Drying Gas: 12L/min 350°C
Nebulizer: 45 psi
Scan: 600-2500 amu
Step size: 0.15 amu
Peak width: 0.06 min
Pharmacia pl 3-10 Standard run on Poroshell 300SB-C18

Contents of sample:
- amylglucosidase 65 kD
- soybean trypsin inhibitor 21.5 kD
- beta-lactoglobulin A 18.3 kD
- bovine carbonic anhydrase B 29 kD
- human carbonic anhydrase B 28.8 kD
- horse myoglobin 16.95 kD
- lentil lectin 23.3 kD
- trypsinogen 24 kD
- sucrose
- methyl red

- Myoglobin
  - expected MW 16950.97
  - measured MW 16950.91

- Human carbonic anhydrase
  - expected MW 28780.36
  - measured MW 28779.94

- Bovine carbonic anhydrase
  - expected MW
  - measured MW 29023.20

- Trypsinogen
  - expected MW 23980.36
  - measured MW 23981.02

No end of document reached.
Comparison of Speed in Peptide Mapping by LC-MS using ZORBAX Extend-C18 and Poroshell Extend-C18

ZORBAX Extend-C18 (2.1 x 150mm, 3.5µm)
Flow= 0.2mL/min, Gradient 0 – 100%B in 40 min
Mobile Phase A = 10mM NH₄OH, H₂O; B = 10mM NH₄OH, MeOH
Agilent 1100 LC-MSD, Scan 200-1500m/z, Drying Gas= 10L/min; 35psig; Temp= 350°C
POS ESI mode, 4500V, Fragmentor Ramp 70 @ 50m/z to 120 @ 1500m/z
Sample: myoglobin tryptic digest 50 pmol in 5µL

ZORBAX Poroshell Extend-C18 (2.1 x 75mm, 5µm)
Flow= 1.0mL/min, Gradient 0 – 100%B in 4 min
Mobile Phase A = 10mM NH₄OH, H₂O; B = 10mM NH₄OH, MeOH
Agilent 1100 LC-MSD, Scan 200-1500m/z, Drying Gas= 13L/min; 60psig; Temp= 350°C
POS ESI mode, 4500V, Fragmentor Ramp 70 @ 50m/z to 120 @ 1500m/z
Sample: myoglobin tryptic digest 50 pmol in 5µL
Comparison of Peptide Mapping by LC-MS using Poroshell 300Extend-C18 and Poroshell 300SB-C18 at high and low pH

**ZORBAX Poroshell 300Extend-C18 (2.1 x 75mm, 5µm)**
Flow = 1.0mL/min, Gradient 0 – 100%B in 4 min
Mobile Phase A = 10mM NH₄OH, H₂O; B = 10mM NH₄OH, MeOH
Agilent 1100 LC-MSD, Scan 200-1500m/z
Drying Gas = 13L/min; 60psig; Temp = 350°C, POS ESI mode, 4500V
Fragmentor Ramp 70 @ 50m/z to 120 @ 1500m/z, 0.52 sec/cycle
Sample: myoglobin tryptic digest: 50 pmol in 5µL

**ZORBAX Poroshell 300SB-C18 (2.1 x 75mm, 5µm)**
Flow = 1.0mL/min, Gradient 0 – 100%B in 4 min
Mobile Phase A = 0.1% Formic Acid, H₂O; B = 0.1% Formic Acid, MeOH
Agilent 1100 LC-MSD, Scan 200-1500m/z
Drying Gas = 13L/min; 60psig; Temp = 350°C, POS ESI mode, 4500V
Fragmentor Ramp 70 @ 50m/z to 120 @ 1500m/z, 0.52sec/cycle
Sample: myoglobin tryptic digest: 50 pmol in 5µL

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**Graphs and Data**

- **EIC=408 (mw 408.2)**
  - Fragment 4 (43-45) FDK
- **EIC=636 (mw 1270.7)**
  - Fragment 3 (32-42) LFTGHPETLEK
- **EIC=661 (mw 661.3)**
  - Fragment 8 (57-62) ASEDLK
- **EIC=748 (mw 747.4)**
  - Fragment 18 (134-139) ALELFR
- **EIC=804 (mw 1606.1)**
  - Fragment 2 (17-31) VEADIAGHGQEVLIR
Summary

- Poroshell columns have a porous shell and solid core to reduce the diffusion distance and time for proteins.
- This allows for fast analysis of proteins – including very large proteins with high recovery.
- It also allows for high efficiency and good resolution of protein impurities.
- Use of sterically protected 300SB and 300 Extend phases further allows these columns to be operated at very high temperature and low or high pH.
- These columns are ideal for LC/MS of proteins and peptides because they give high resolution of complex samples.
Bibliography


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2) Novartis Pharma, Biotechnology, Basel (Dr. Kurt Forrer and Patrik Roethlisberger) for their data and discussions on the analysis of monoclonal antibodies and their fragments.
HPLC Column Technical Support

800-227-9770 (phone: US & Canada)*
302-993-5304 (phone)*
* Select option 4, then option 2.
916-608-1964 (fax)
www.agilent.com/chem
Q & A for breaks 1 & 2

Break 1

Q1: When you show the speed capabilities of Poroshell you have an implied assumption that everything in the LC is optimized for it. What happens if the system is set up for standard columns?

A1: What happens is not necessarily pretty. You will see less of an advantage for high speed columns. To optimize means to install narrow bore tubing throughout, eliminate as much extra column volume as possible, choose the best flow cell for your column diameter, and optimize the speed of data collection of your detectors. Once this is done, the advantages of Poroshell are obvious.

Q2: When you show data for column lifetime, you do it in terms of column volumes and run standards at regular intervals. Why don’t you do it in terms of number of injections?

A2: With the number of columns to be checked and samples to be run, it simply takes too long; so, we run it the other way. The examples shown are really only for comparing one column to another not for running against an absolute standard. Every manufacturer wants to know how well they do relative to their competition. This helps improve products.

Break 2

Q1: I noticed that PEG 300 was included in the mobile phases during the monoclonal antibody chromatograms. Why?

A1: It turns out that antibodies are very ‘sticky’ on reversed phase columns and always leave some molecules bound to the column. After several runs an increase in backpressure becomes very noticeable. If PEG 300 is included in the mobile phase, this buildup does not happen. I should note, however, that you must not use PEG 300 when running into your LC/MS; you will see PEG forever as a background contaminant. The buildup can be washed off by running at 100% ACN until the pressure returns to initial conditions.

Q2: C3 seems to be better than C18 on the biggest molecules. I do not understand why.

A2: C3 was better on the very heterogeneous large molecules studied. We think that this is because C3 has the lowest retention; i.e., it has fewer ways to interact with a large complicated molecule and thus will show less broadening due to interaction than the long chain, C18. It is not absolutely certain that it will be best on all large molecules.