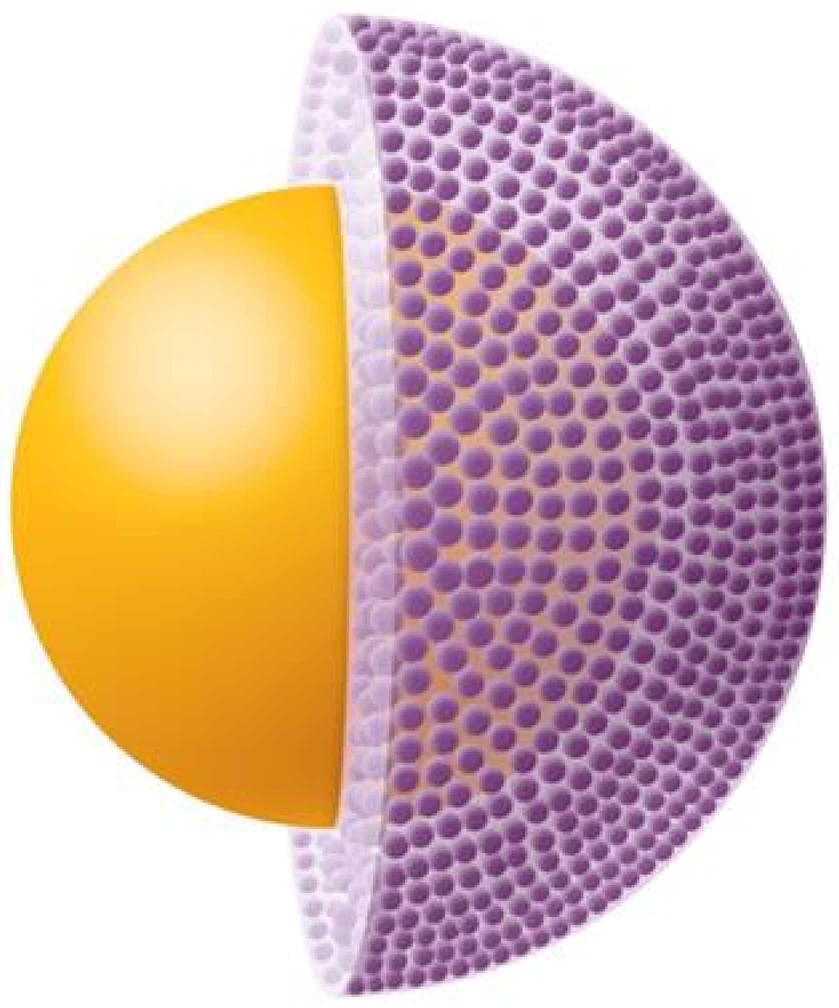
Practical Aspects of High Performance Column Selection in HPLC/UHPLC: Superficially Porous or Sub-Two Micron Porous

Rita Steed
Agilent Technologies
May 22, 2014

Outline



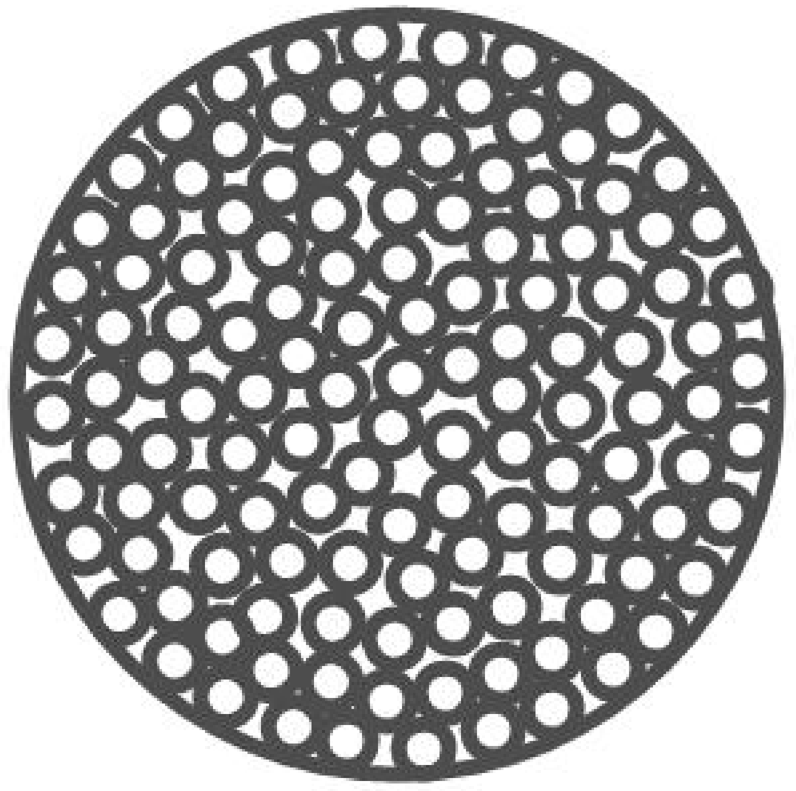
Newer particles/columns

HPLC particle development history

Particles used in HPLC/UHPLC

Intro to Superficially Porous Particles

Compare: Totally Porous <2-µm Particles (TPP) and Superficially Porous Particles (SPP)



- Efficiency
- Pressure
- Peak capacity
- Sample capacity
- Practical aspects; plugging, dimensions, method transfer, available phases, pressure, instrument requirements

Best for your application

History of Commercial HPLC Particle Development

Year of Acceptance	Particle Size	Nominal Size	~Plates/15 cm
1950s	Irreg. shape	100 µm	200
1967	Glass Bead	50 µm (pellicular)	1,000
1972		10 µm	6,000
1985		5 µm	12,000
1992		3-3.5 µm	22,000
1998*		1.5 µm* (non-porous)	33,000
1999		5.0 µm (pellicular)	8,000**
2000		2.5 µm	25,000
2003		1.8 µm	32,500
2007/2008		2.7 µm	32,000***
2013		1.6 µm (pellicular)	

* non-porous silica or resins, ** 300 A pore for proteins, *** 90-120 A pore

Superficially Porous Particles

Past

- Pellicular
- Porous Layer(ed) Beads
- Superficially Porous Particles

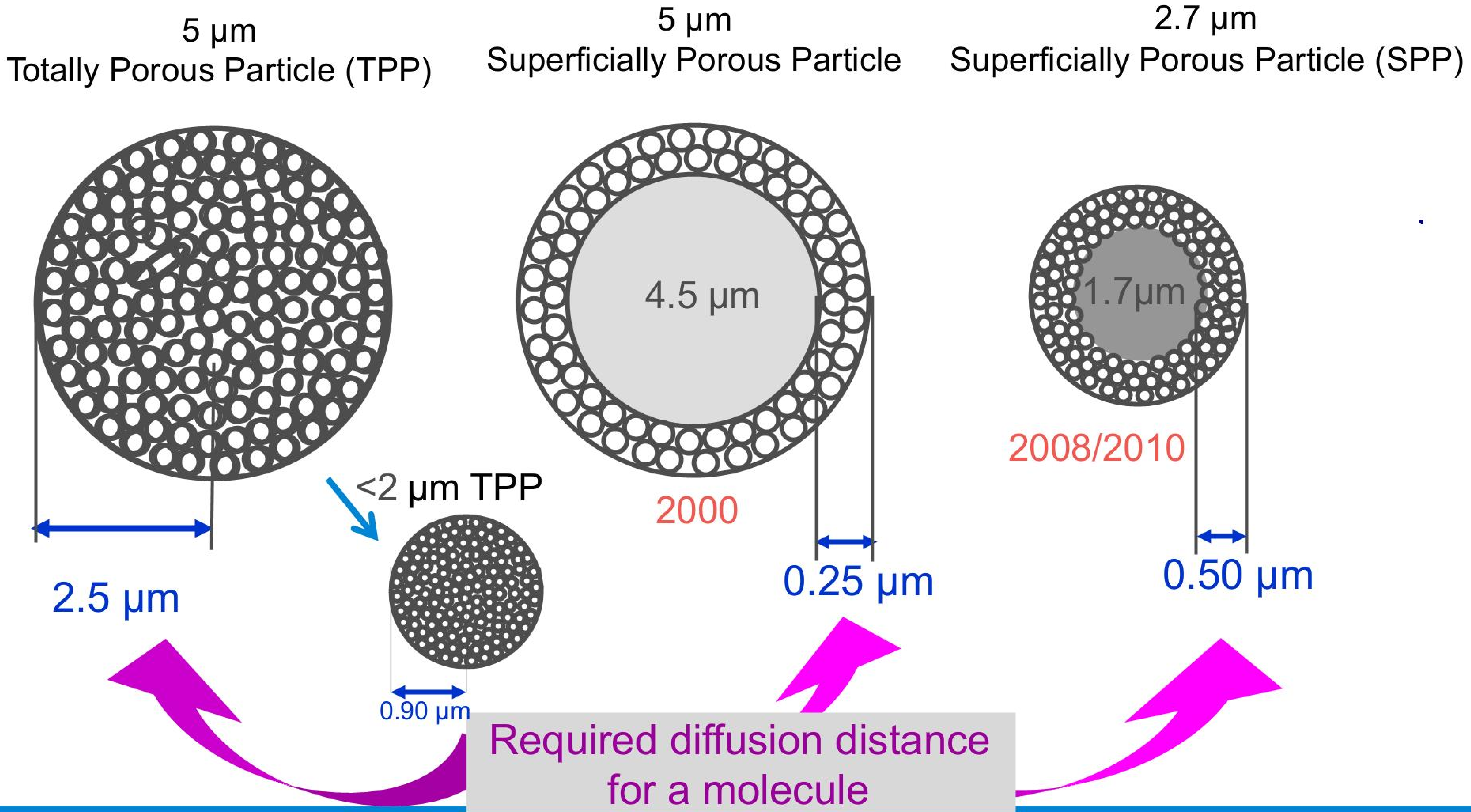
Current

- Superficially Porous Particles (SPP)
- Fused Core Particles
- (Core) Shell Particles
- Poroshell

Comparison of Different Particles

Diffusion Distances

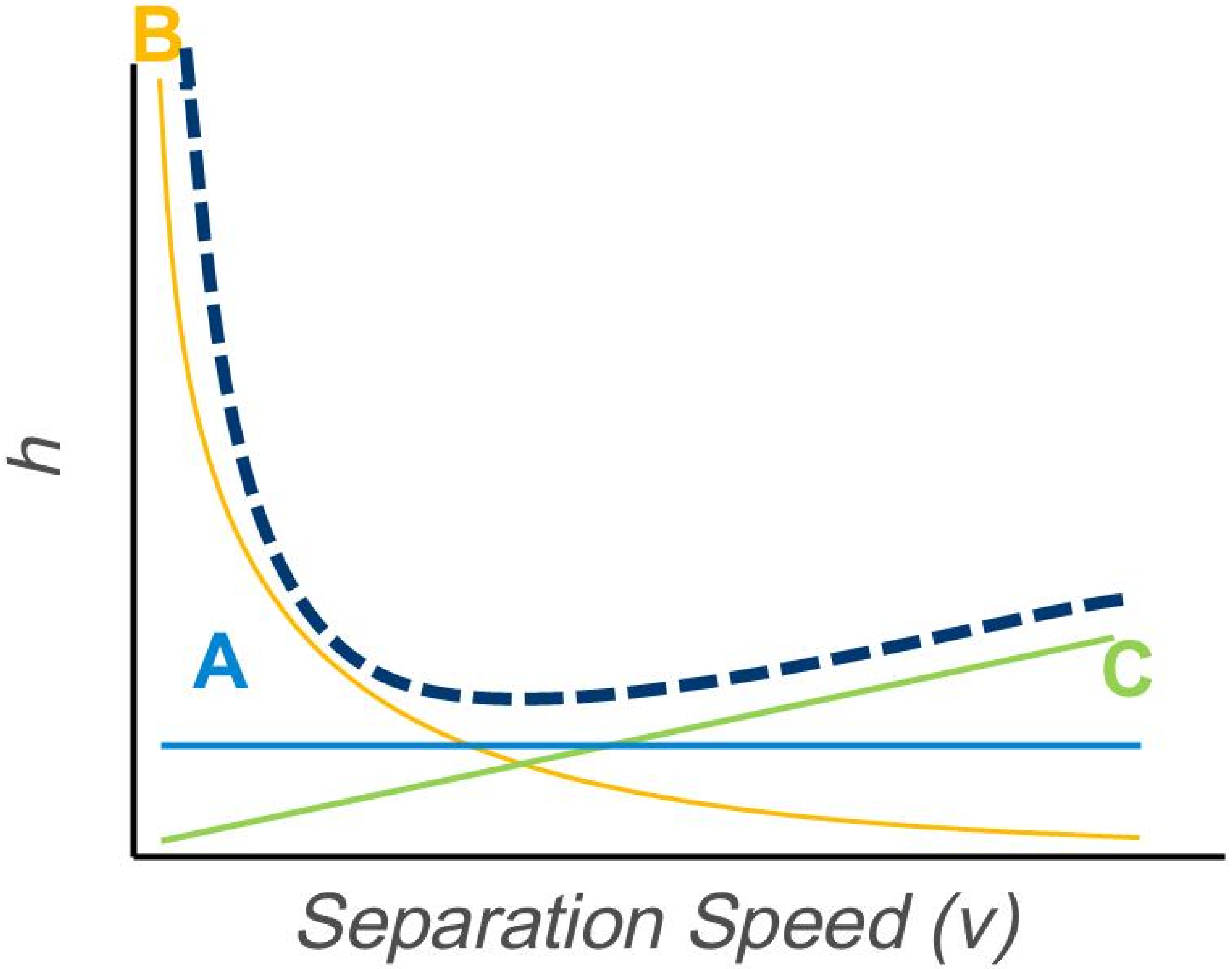
Totally porous silica versus superficially porous silicas



Efficiency Improvement with Superficially Porous Particles

van Deemter equation:

$$h = A + B/v + C \cdot v$$

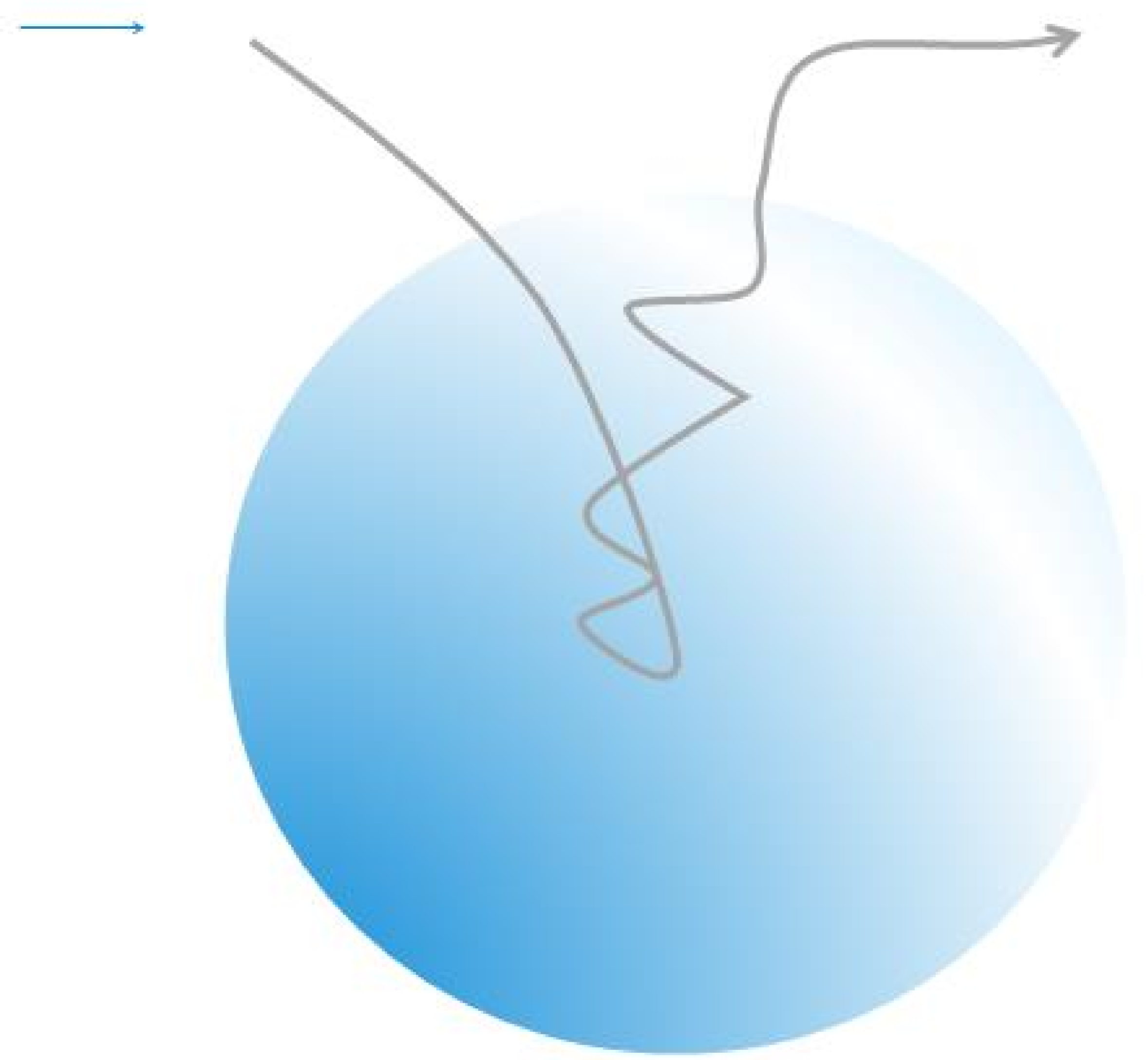


Lower *h* = higher efficiency!

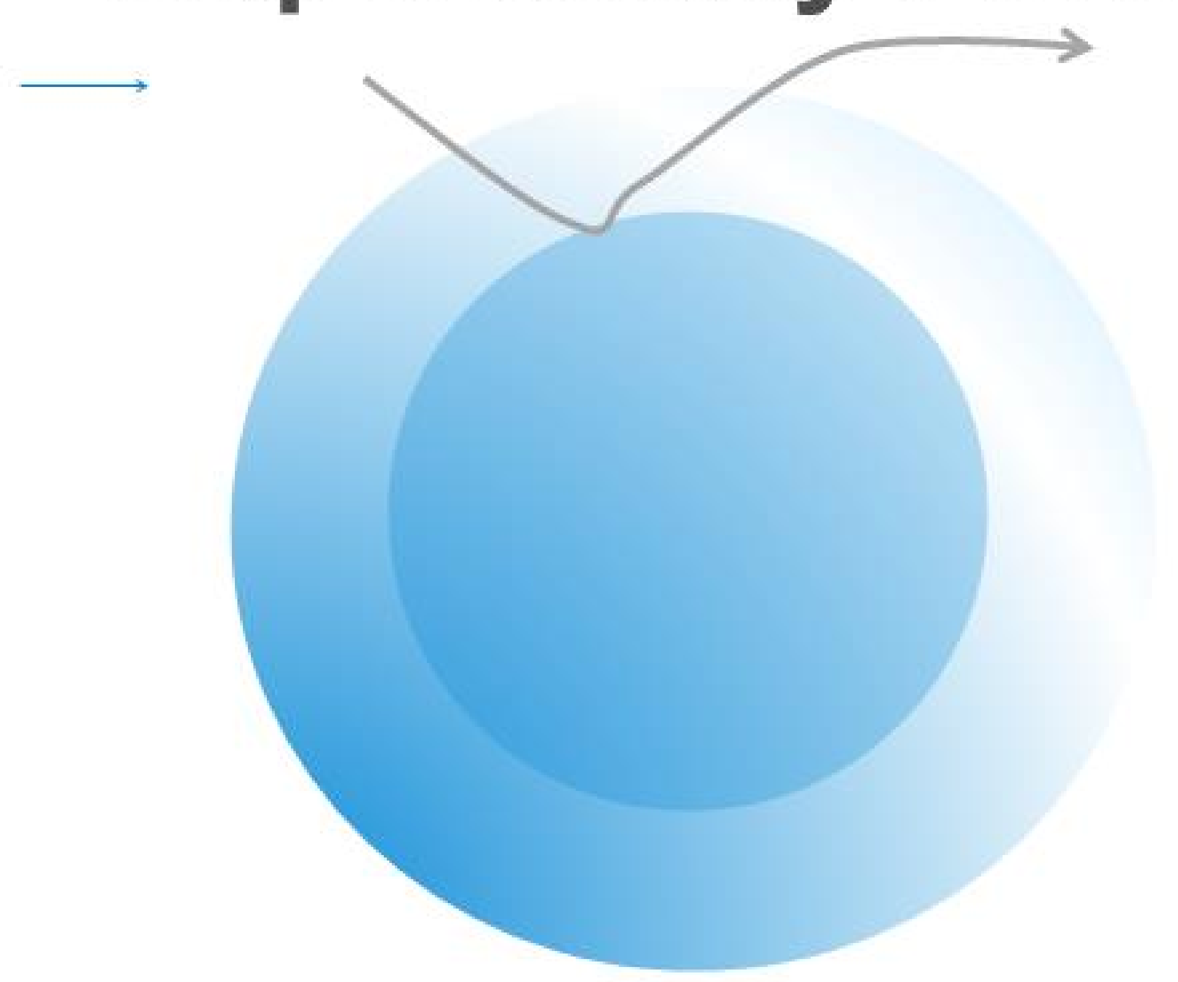
- **A term – eddy diffusion and flow distribution**
  - **particle size & packing quality important**
  - **narrow particle size distribution**
- **B term – longitudinal diffusion**
  - **Minimal impact to longitudinal diffusion**
- **C term – mass transfer**
  - **shorter diffusion paths**
  - **better with superficially porous particles**
  - **more effect on large molecules**

Analyte Mass Transfer Improvements through Lower Diffusion

Totally Porous



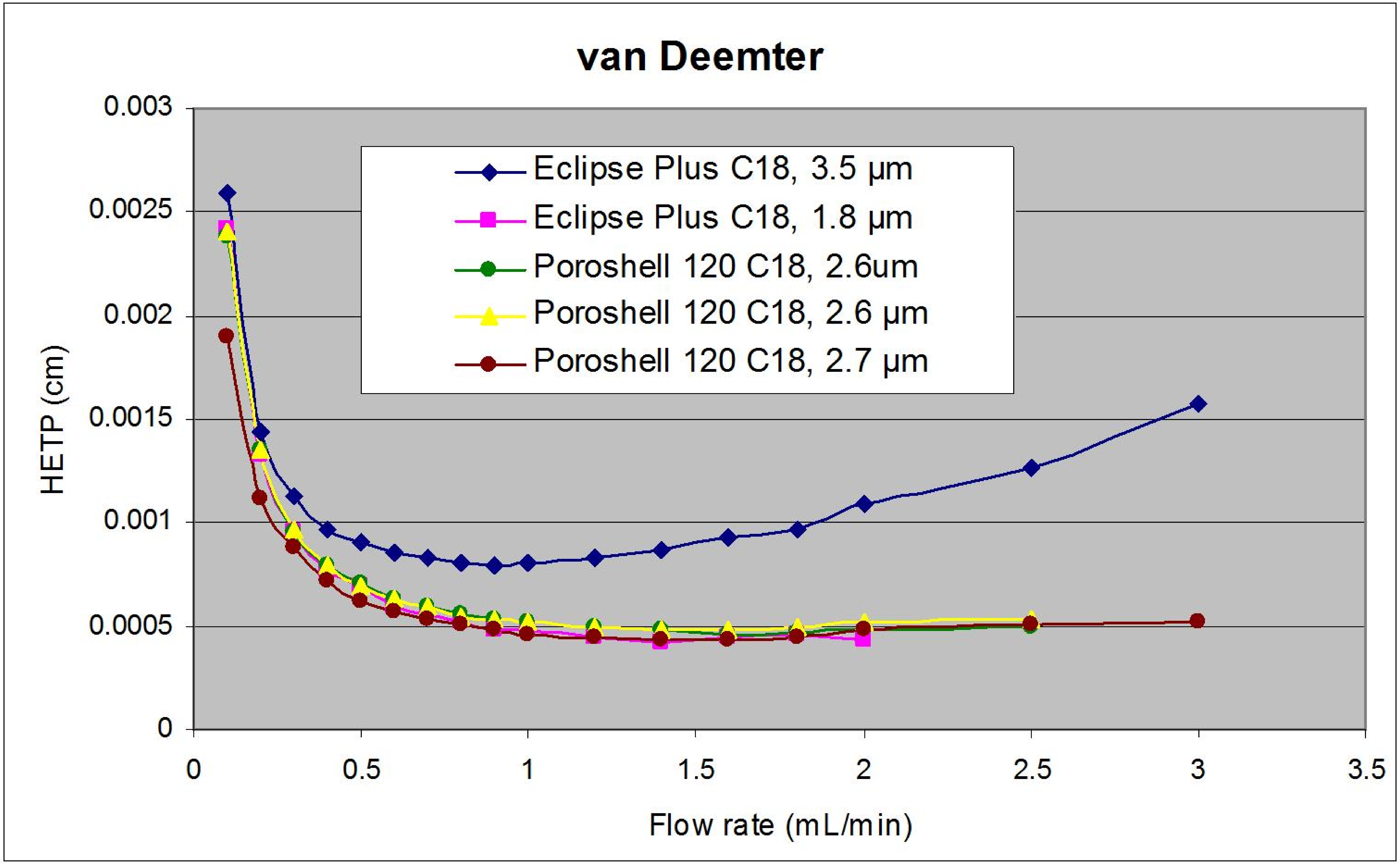
Superficially Porous



- Totally porous particles
  - diffusion throughout particle
- Poroshell 120
  - diffusion limited to outer shell

- Results:
  - Lower C term
  - Higher efficiency
- And
  - Higher flow rate with
  - Minimal impact on efficiency

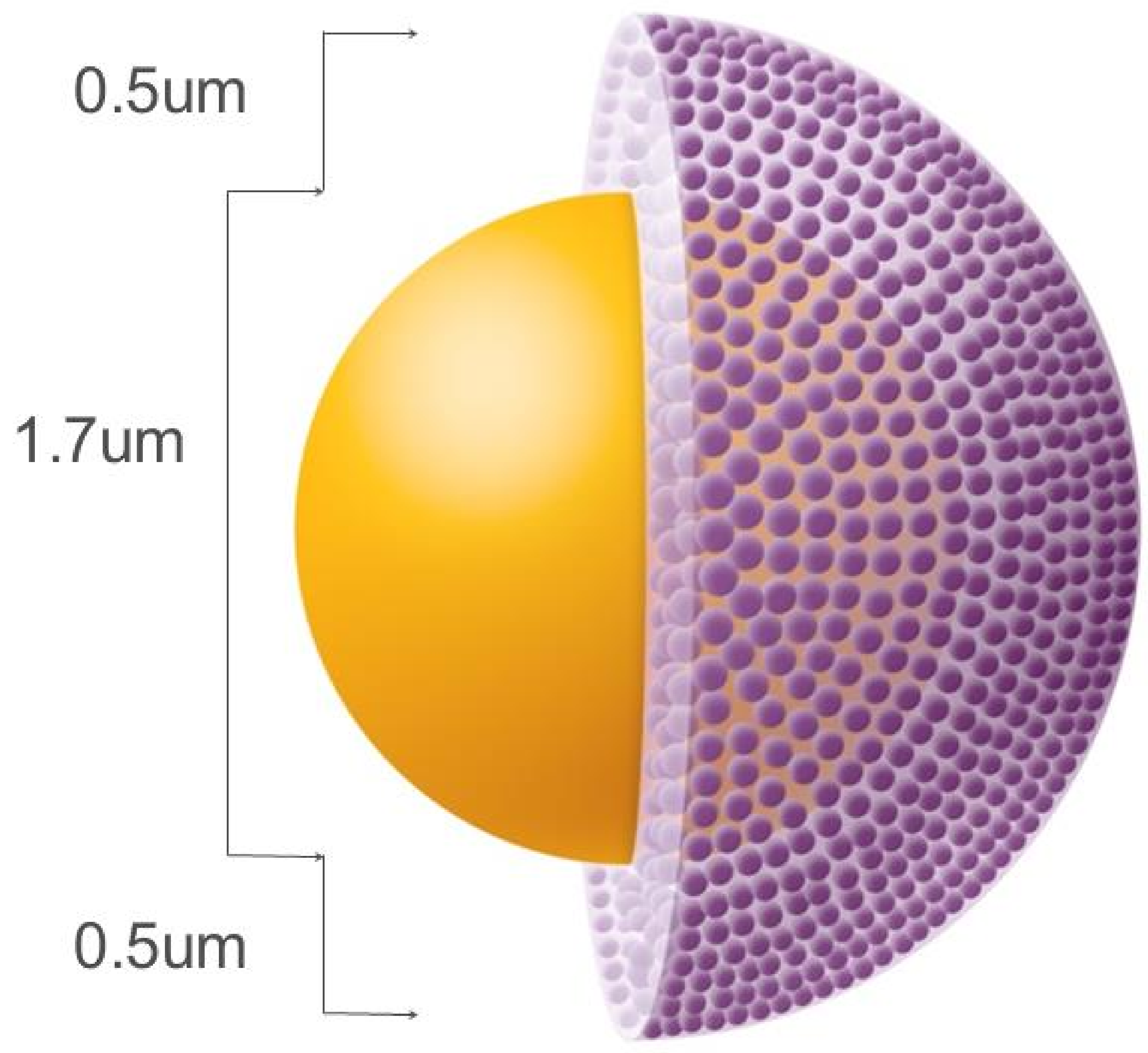
Superficially Porous (SPP)Column for Small Molecules Can Achieve Equal Performance to 1.8 µm (TPP)



Poroshell 120 SPP Columns for HPLC and UHPLC:

Poroshell 120 columns:

- 90-100% efficiency of sub 2 µm
- 2X efficiency of 3.5 µm (totally porous)
- A ~40-50% lower pressure
- A 2 µm frit to reduce clogging
- 600 bar pressure limit for HPLC or UHPLC use
- The particle has 2.7 µm outer diameter with a solid core (1.7 µm) and porous outer layer with a 0.5 µm diffusion path. The average pore diameter is 120 Å.

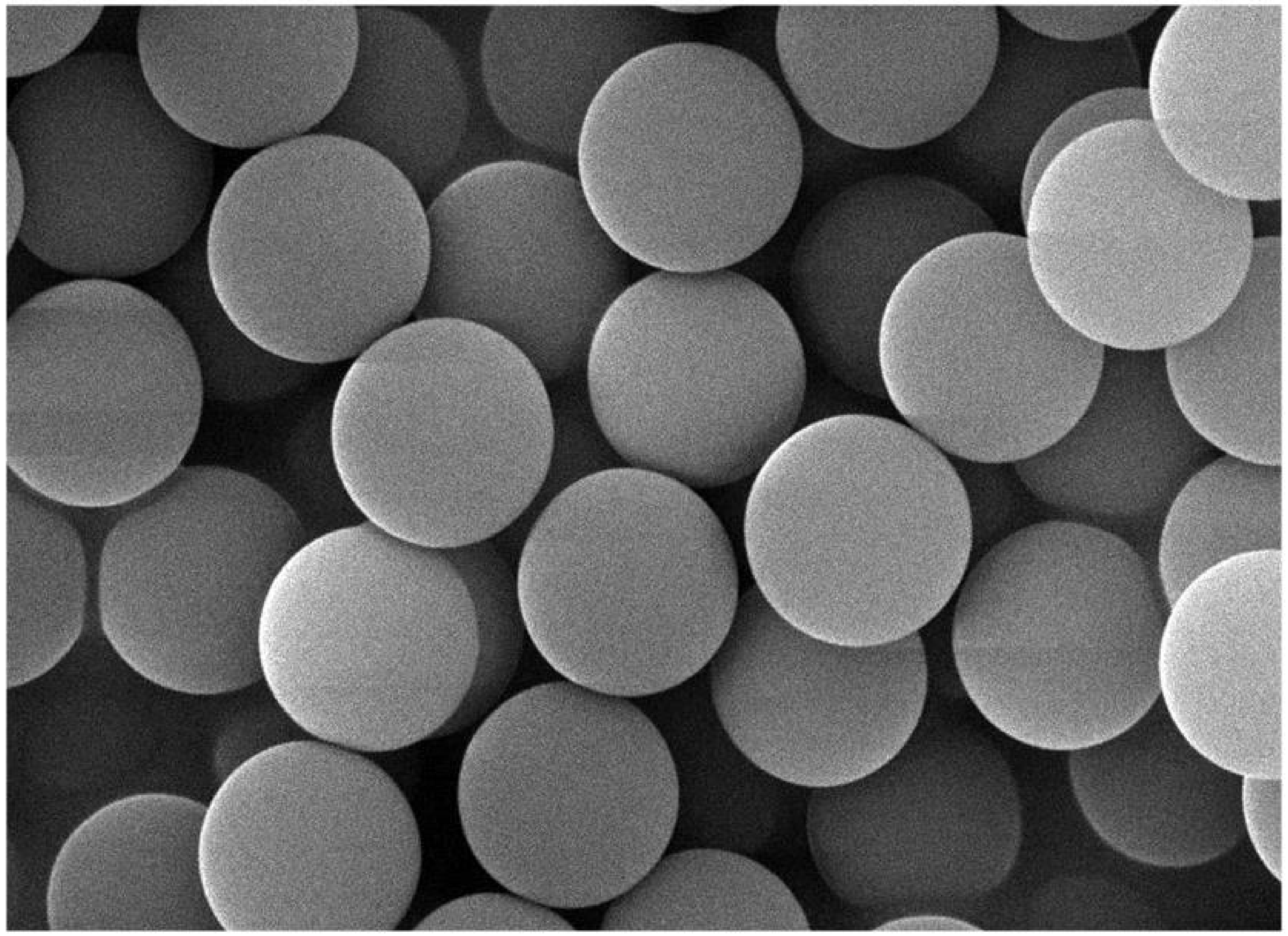


How is a Poroshell 120 Particle Made
Step 1 – Make the Solid Core

Cores uniform 1.7μm size with a smooth surface - monodisperse

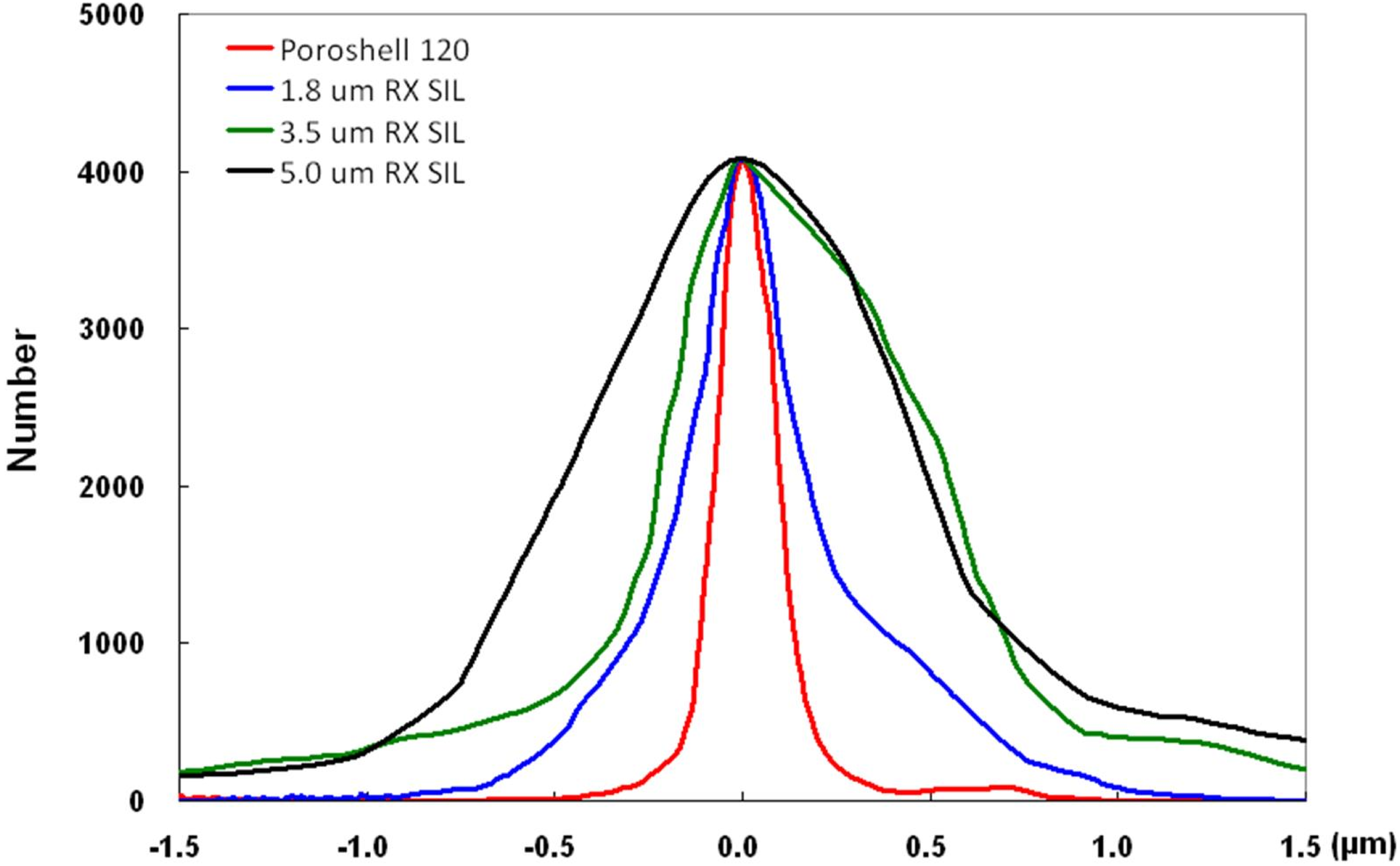
RSD of 7 batches of cores = 0.04%

Tight final particle size distribution (tighter than with totally porous particles)



SEM of Cores

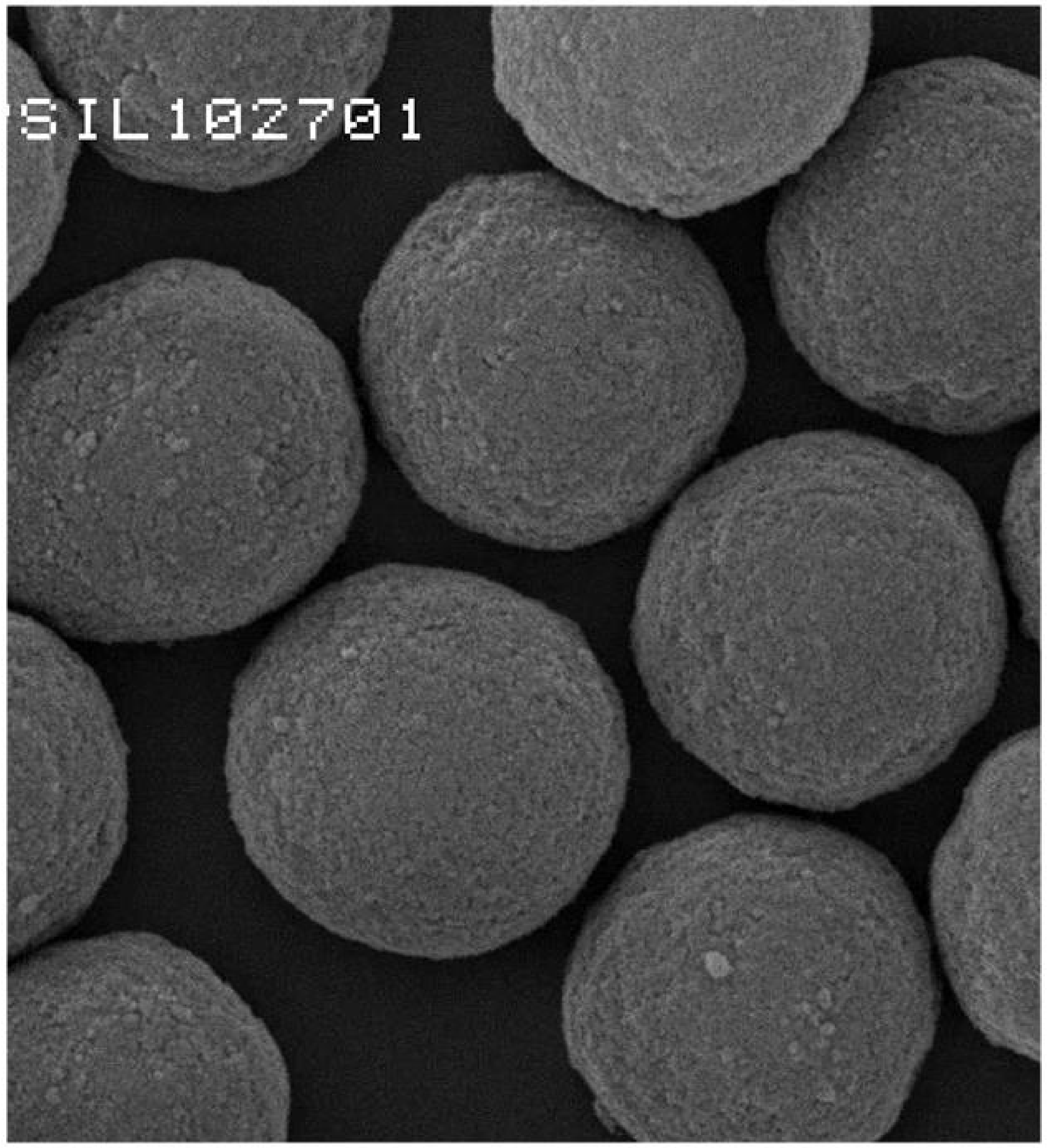
Particle Size Distributions
Totally Porous and Poroshell 120 Particles



Step 2 – The Porous Outer Layer

Poroshell 120 differs from other processes for superficially porous particles

- Single step coacervation process used versus multi-layering
  - Coacervation - The process by which small sol particles come together to form the porous particle
- 1 step reduces variability = more reproducible



Step 3 – Attach the Bonded Phase

- Poroshell 120 EC-C18 & EC-C8
  - Endcapped for best peak shape
  - C18 is also used for peptide mapping
- Poroshell 120 Stablebond SB-C18 & SB-C8
  - Great alternate selectivity – non-endcapped
  - Best performance at low pH, i.e. longest lifetime
- Additional selectivities for method optimization
  - EC-CN, Phenyl-Hexyl, SB-Aq, Bonus-RP, HILIC
- *New* Phases
  - PFP
  - HPH-C18 & C8
    - Poroshell 120 based
    - 110 A pore size

Comparison

Efficiency

- Totally Porous Particles (TPP)
- Superficially Porous Particles (SPP)

Sub 2-µm Short Totally Porous Particle (TPP) Columns Provide Efficiency of Longer Columns with Larger Particles

Column Length (mm)	Efficiency N(5 µm)	Efficiency N(3.5 µm)	Efficiency N(1.8 µm)	Typical Pressure Bar (1.8 µm)	Analysis Time*
150	12,500	21,000	32,500	580	
100	8,500	14,000	24,000	420	-33%
75	6000	10,500	17,000	320	-50%
50	4,200	7,000	12,500	210	-67%
30	N.A.	4,200	6,500	126	-80%
15	N.A.	2,100	2,500	55	-90%

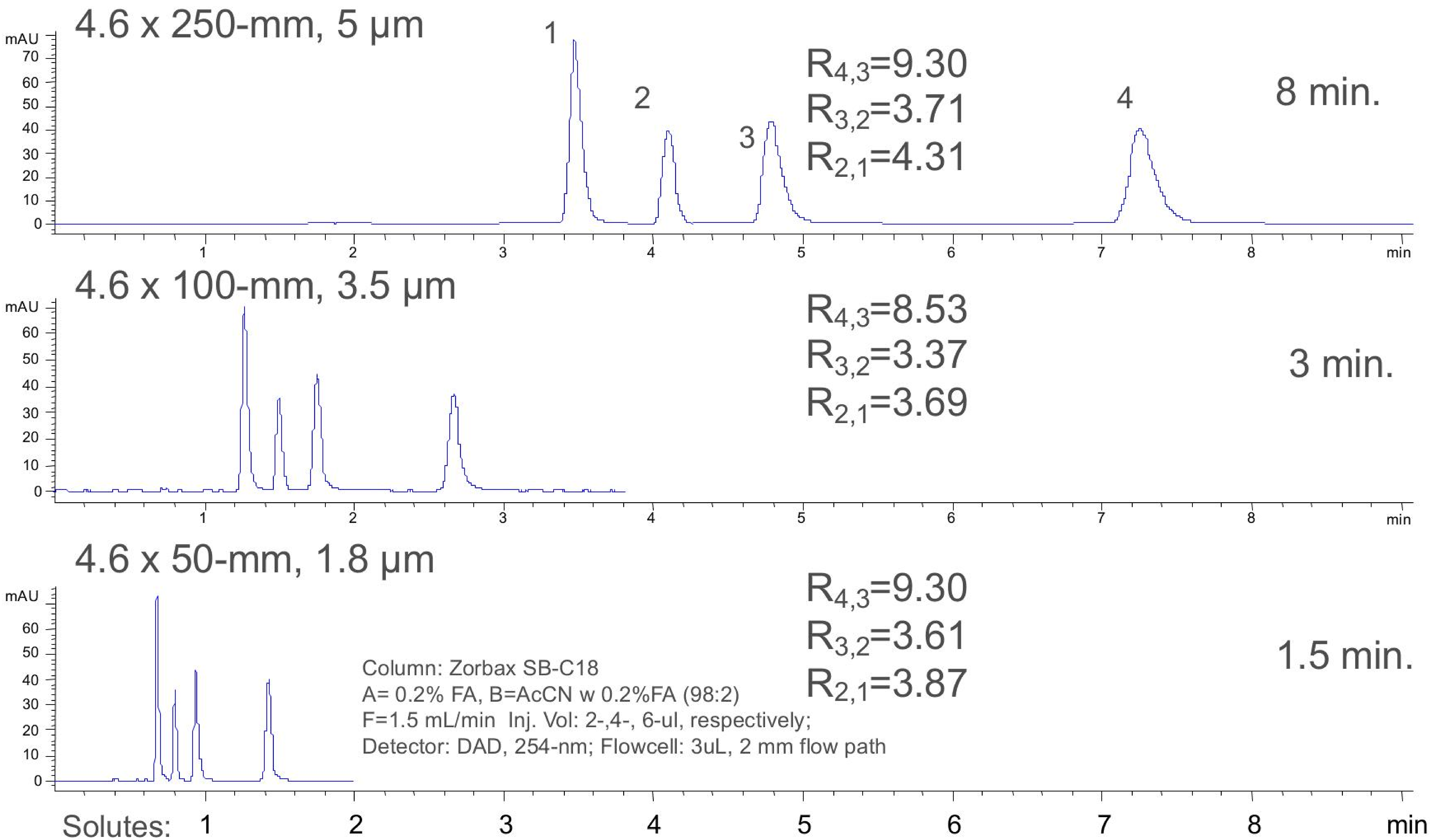
Analysis Time
Peak Volume
Solvent Usage

* Reduction in analysis time compared to 150 mm column

- pressure determined with 60:40 MeOH/water, 1mL/min, 4.6mm ID

TPP Column Scalability

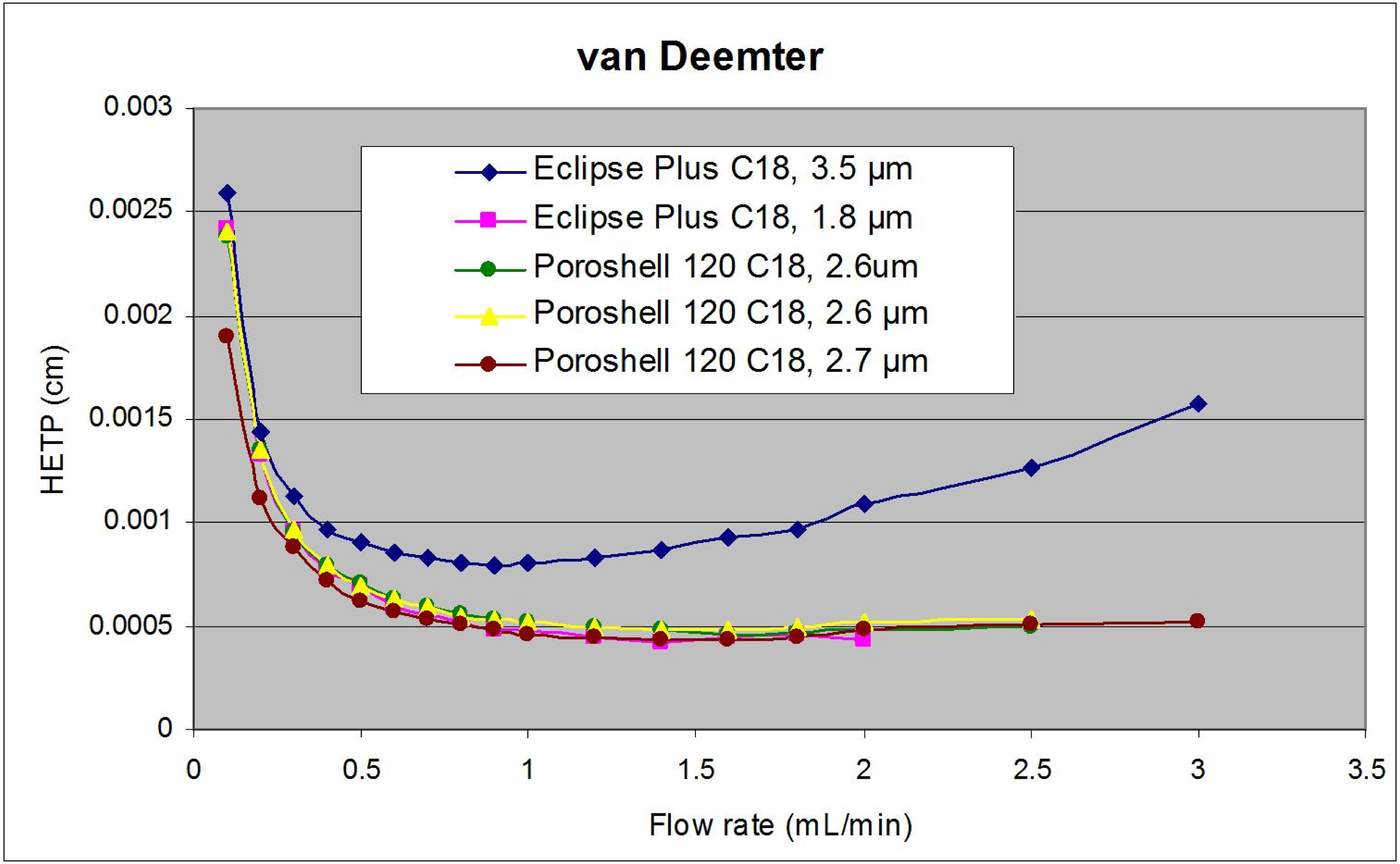
Change Dimensions & d_p to Increase Speed; Maintain Resolution



Solutes:

1-methylxanthine; 2) 1,3-dimethyluric acid; 3) 3,7-dimethylxanthine; 4) 1,7-dimethylxanthine

Small Molecules
SPP Similar Performance to 1.8 µm TPP

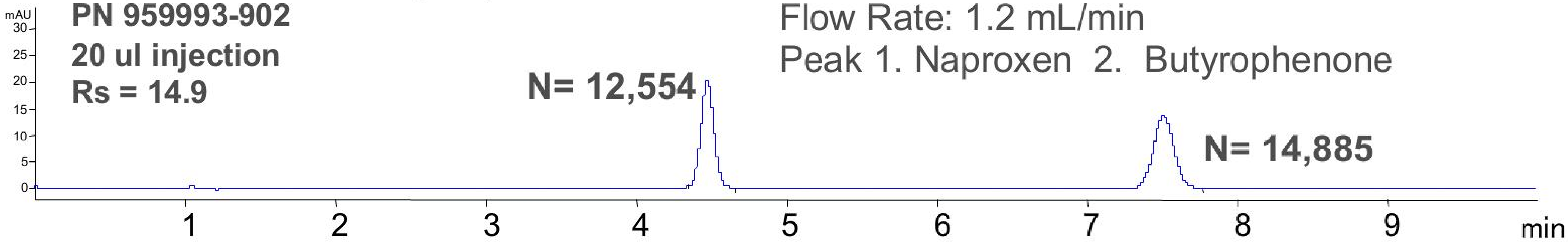


Naproxen Tablets - USP Method
Faster Analysis on Poroshell 120

Method Requirement N > 4000, Rs better than 11.5

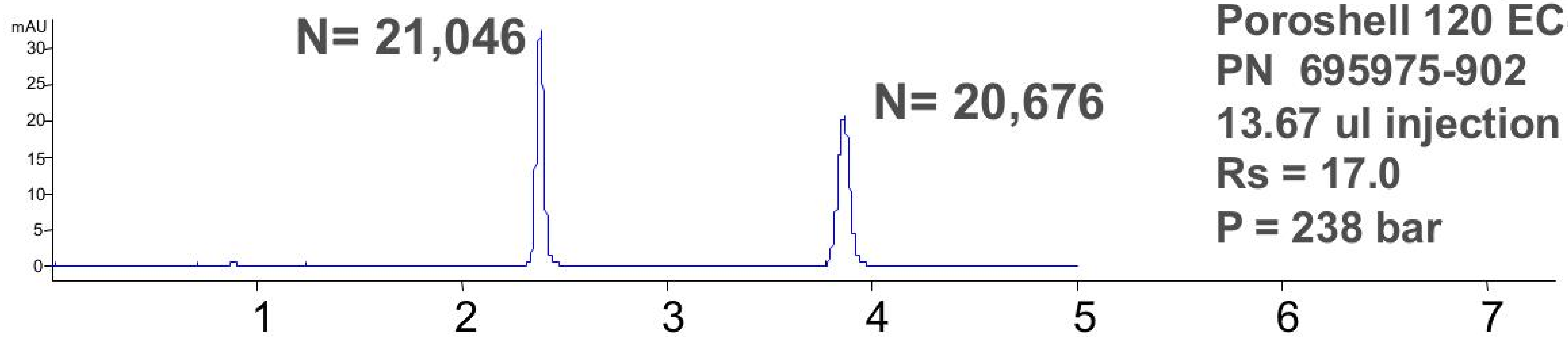
Common Conditions:
Mobile Phase: 50:49:1 MeCN:H2O Acetic Acid
Flow Rate: 1.2 mL/min
Peak 1. Naproxen 2. Butyrophenone

4.6 x 150 mm (L1)
Eclipse Plus C18, 5um (TPP)
PN 959993-902
20 ul injection
Rs = 14.9



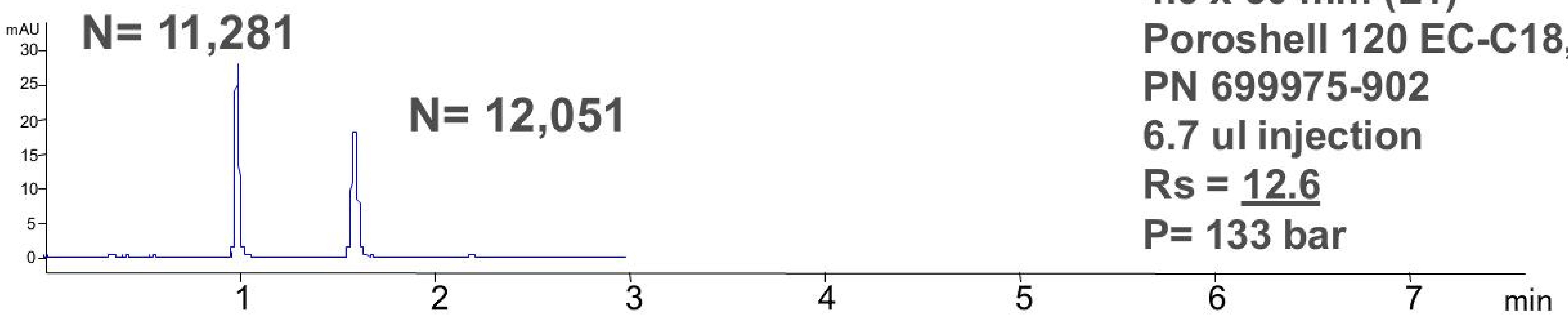
4.6 x 100 mm (L1)
Poroshell 120 EC-C18, 2.7 um
PN 695975-902
13.67 ul injection
Rs = 17.0
P = 238 bar

2X Faster



4.6 x 50 mm (L1)
Poroshell 120 EC-C18, 2.7 um
PN 699975-902
6.7 ul injection
Rs = 12.6
P= 133 bar

4.5X Faster



Comparison

Pressure

But What About Pressure?

Pressure Increases Dramatically with Decreasing Particle Size

Pressure Drop across an HPLC column

$$\Delta P = \frac{\eta \cdot L \cdot v}{\theta \cdot d_p^2}$$

ΔP = Pressure Drop

η = Fluid Viscosity

L = Column Length

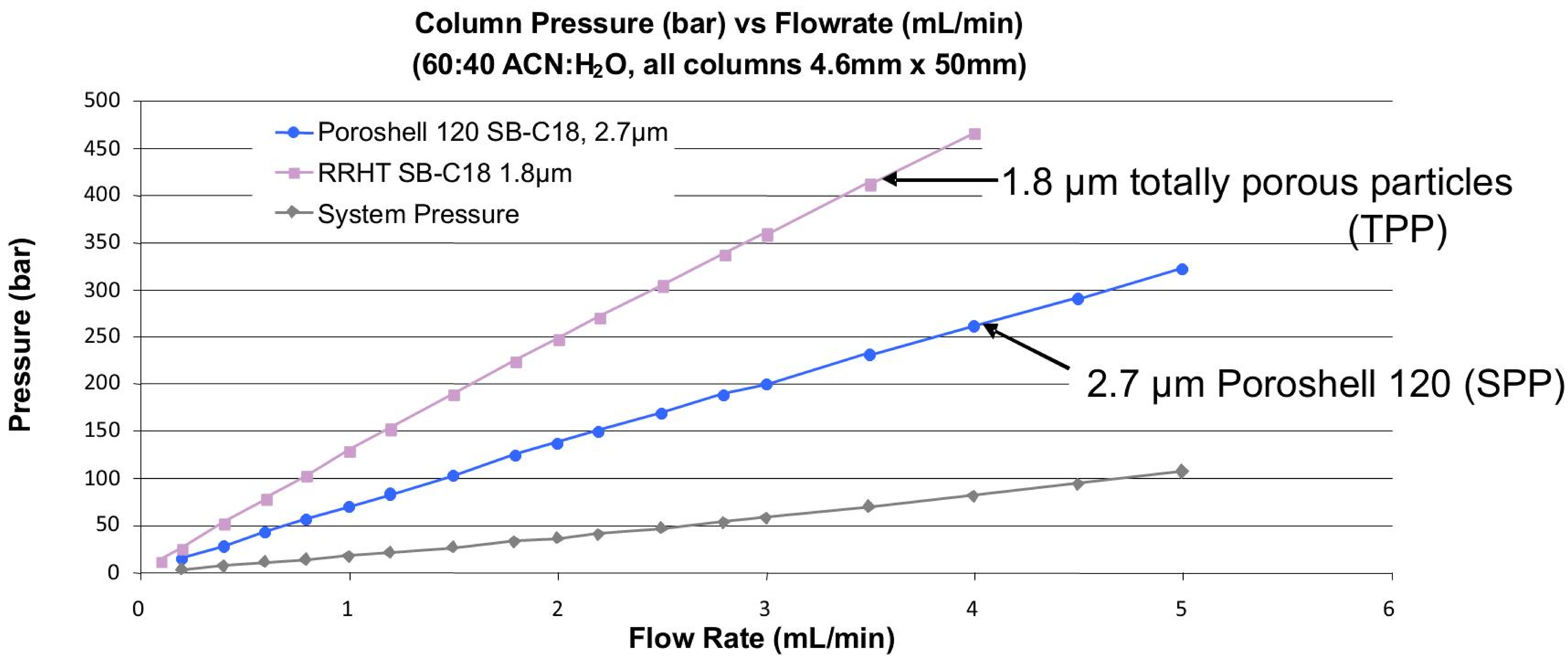
v = Flow Velocity

d_p = Particle Diameter

θ = Dimensionless structural constant

- ✓ Many parameters influence column pressure
  - Particle size and column length are most critical
- ✓ Long length and smaller particle size = more resolution and pressure

Backpressure: Comparison of 2.7 μm Poroshell 120 with 1.8μm Totally Porous Particles



- Superficially porous particles have ~40% lower backpressure than 1.8 μm totally porous particles when used under the same conditions.

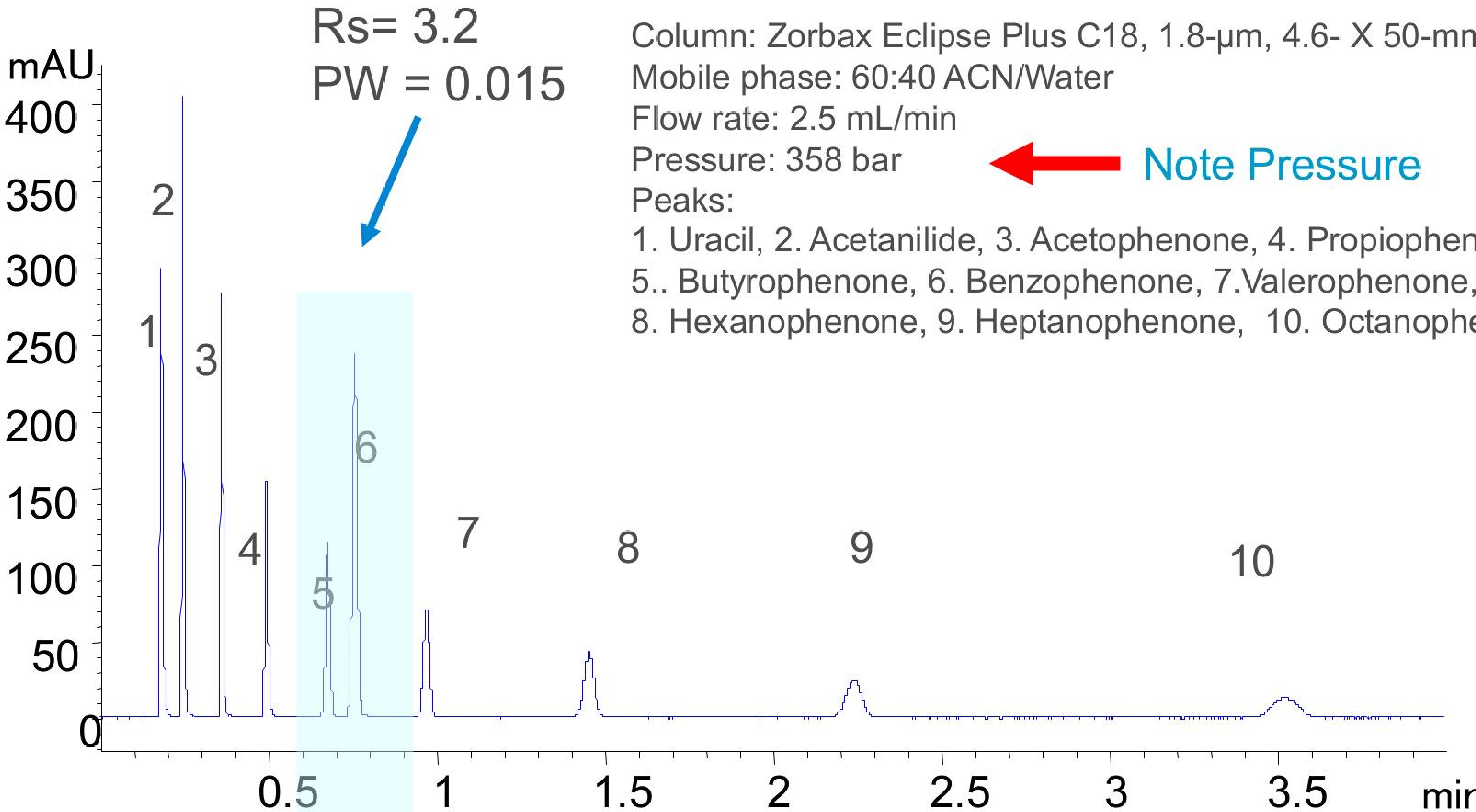
Efficiency and Pressure Tradeoffs

Totally Porous Sub-2-µm Columns (TPP) and 2.7-µm Superficially Porous Particle (SPP) Columns

- **High Throughput (Speed)**
- **High Efficiency (Plate Number)**

Eclipse Plus C18 Totally Porous 1.8-µm

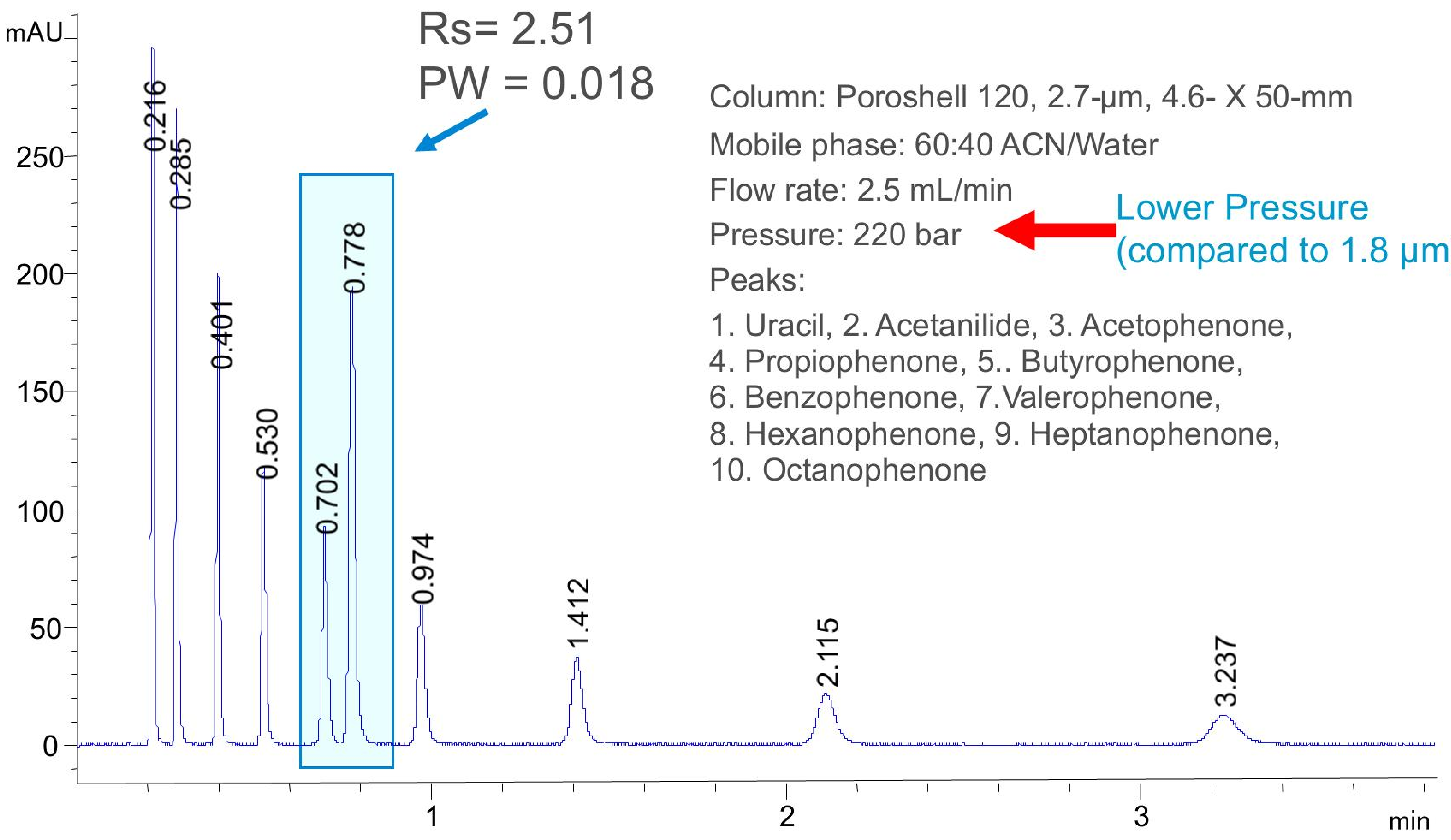
Isocratic Separation of Alkylphenones



Column: Zorbax Eclipse Plus C18, 1.8-µm, 4.6- X 50-mm
Mobile phase: 60:40 ACN/Water
Flow rate: 2.5 mL/min
Pressure: 358 bar ← Note Pressure
Peaks:
1. Uracil, 2. Acetanilide, 3. Acetophenone, 4. Propiophenone,
5.. Butyrophenone, 6. Benzophenone, 7.Valerophenone,
8. Hexanophenone, 9. Heptanophenone, 10. Octanophenone

Poroshell 120 Superficially Porous Particle (2.7-µm) (SPP)

Isocratic Separation of Alkylphenones



Column: Poroshell 120, 2.7-µm, 4.6- X 50-mm

Mobile phase: 60:40 ACN/Water

Flow rate: 2.5 mL/min

Pressure: 220 bar

Peaks:

1. Uracil, 2. Acetanilide, 3. Acetophenone,
4. Propiophenone, 5.. Butyrophenone,
6. Benzophenone, 7.Valerophenone,
8. Hexanophenone, 9. Heptanophenone,
10. Octanophenone

Comparing Efficiency and Pressure Different Types of Columns

Particle Size/Type	Pressure	Efficiency	LC Compatibility
3.5µm – Totally Porous	123 bar	7,800	All 400 bar instruments
2.7µm – Poroshell 120* (Superficially Porous)	180 bar	12,000	All LCs/UHPLCs (up to 600 bar)
1.8µm – Totally Porous	285 bar	12,500	All LCs/UHPLCs (up to 1200 bar)

Columns: 4.6 x 50mm, Mobile Phase: 60% ACN:40% Water   Flow Rate: 2 mL/min

12 Phenols on SPP Under 400 bar

Column: Poroshell 120 EC-C18, 4.6 x 50mm, 2.7µm
Mobile Phase A: Water w/0.1% Formic Acid
B: Acetonitrile

Gradient	**Time**	**%B**
	0.8	5%
	6.8	60%

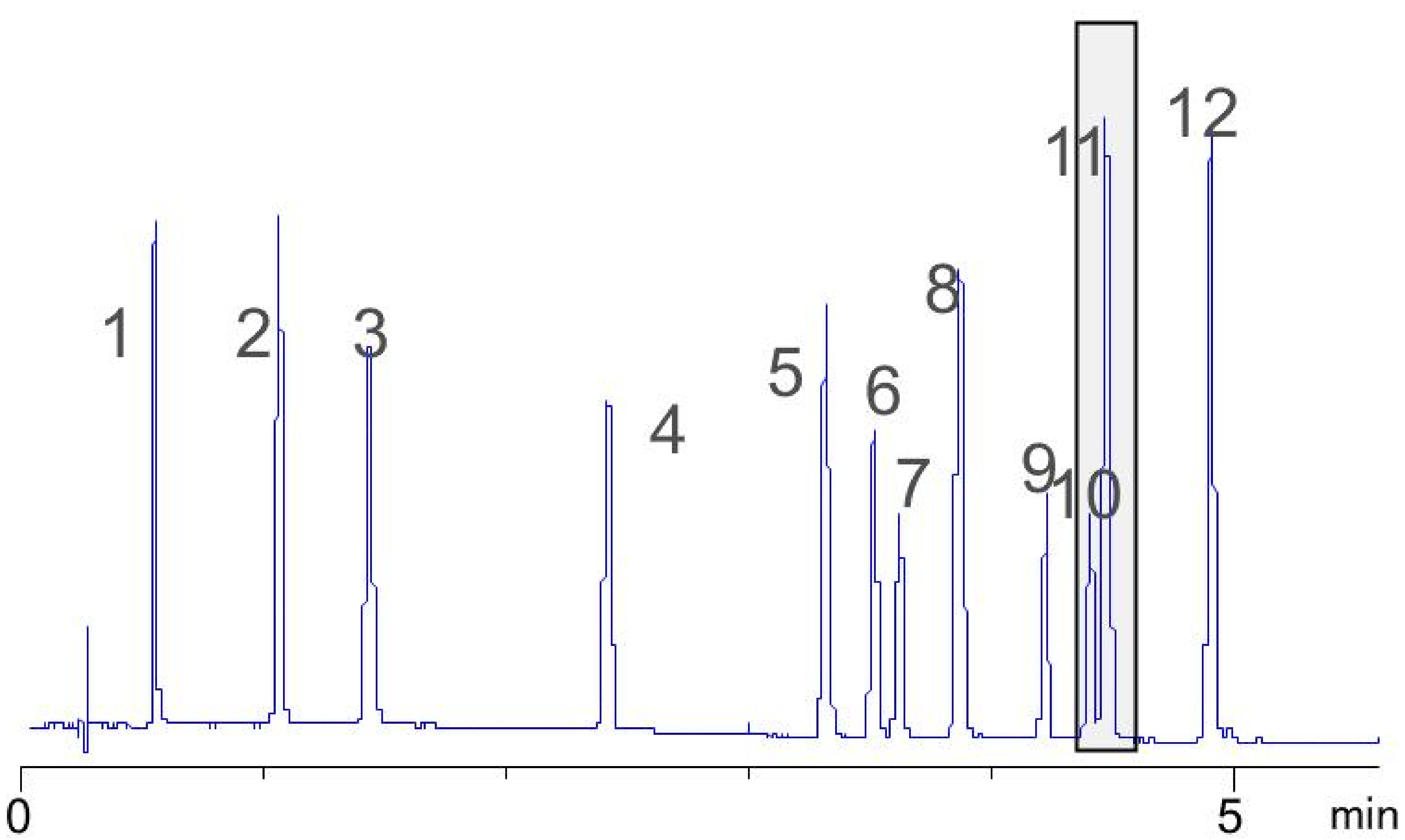
Instrument: 1200 SL; 2 mm flow cell;
Temp: 25 C

Column: Poroshell 120 EC-C18, 4.6 x 100mm, 2.7µm
Mobile Phase A: Water w/0.1% Formic Acid
B: Acetonitrile

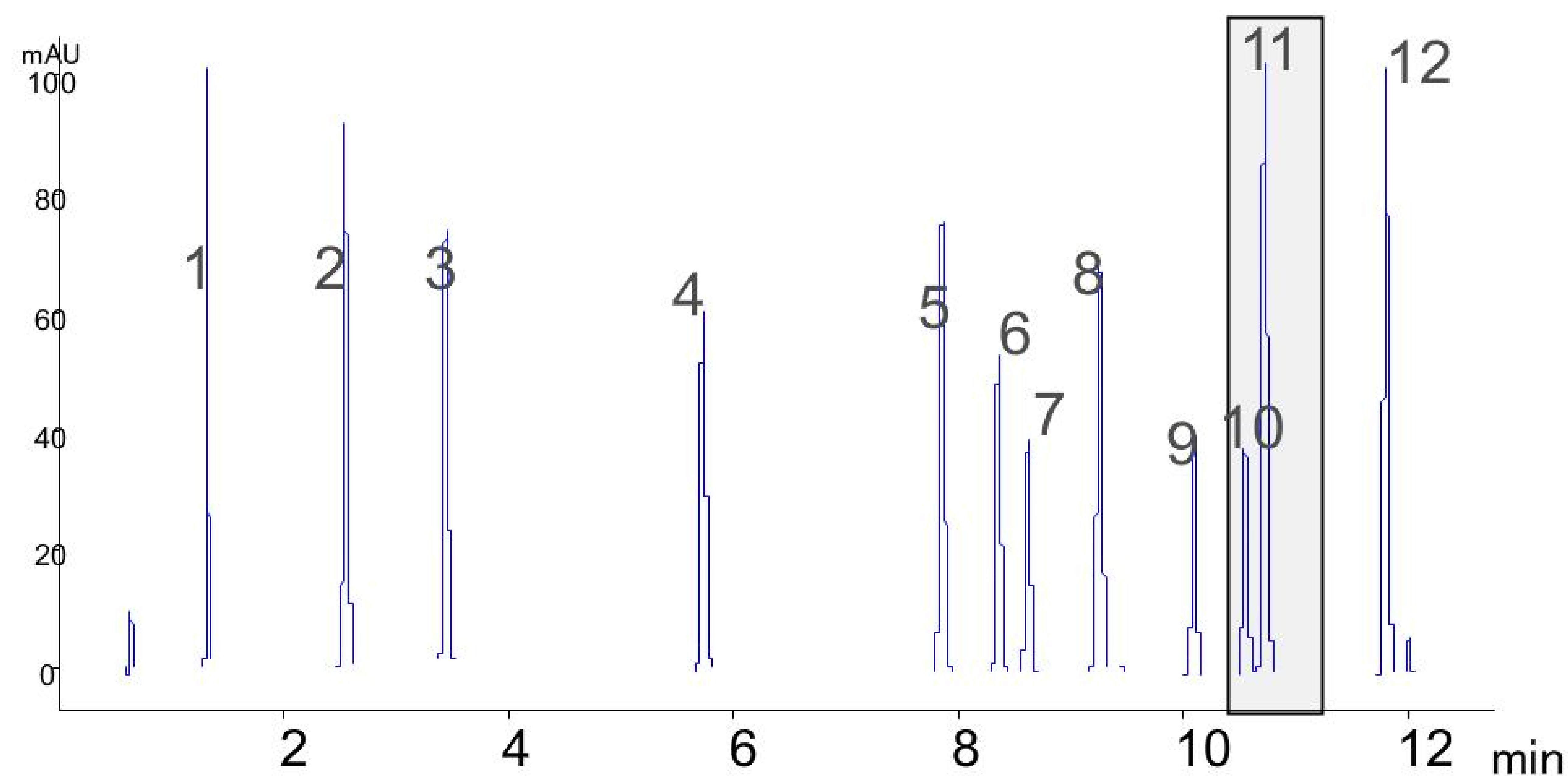
Gradient	**Time**	**%B**
	2.0	5%
	17	60%

Instrument: 1200 SL; 2 mm flow cell;
Temp: 25 C

274 bar 2.5 ml/min



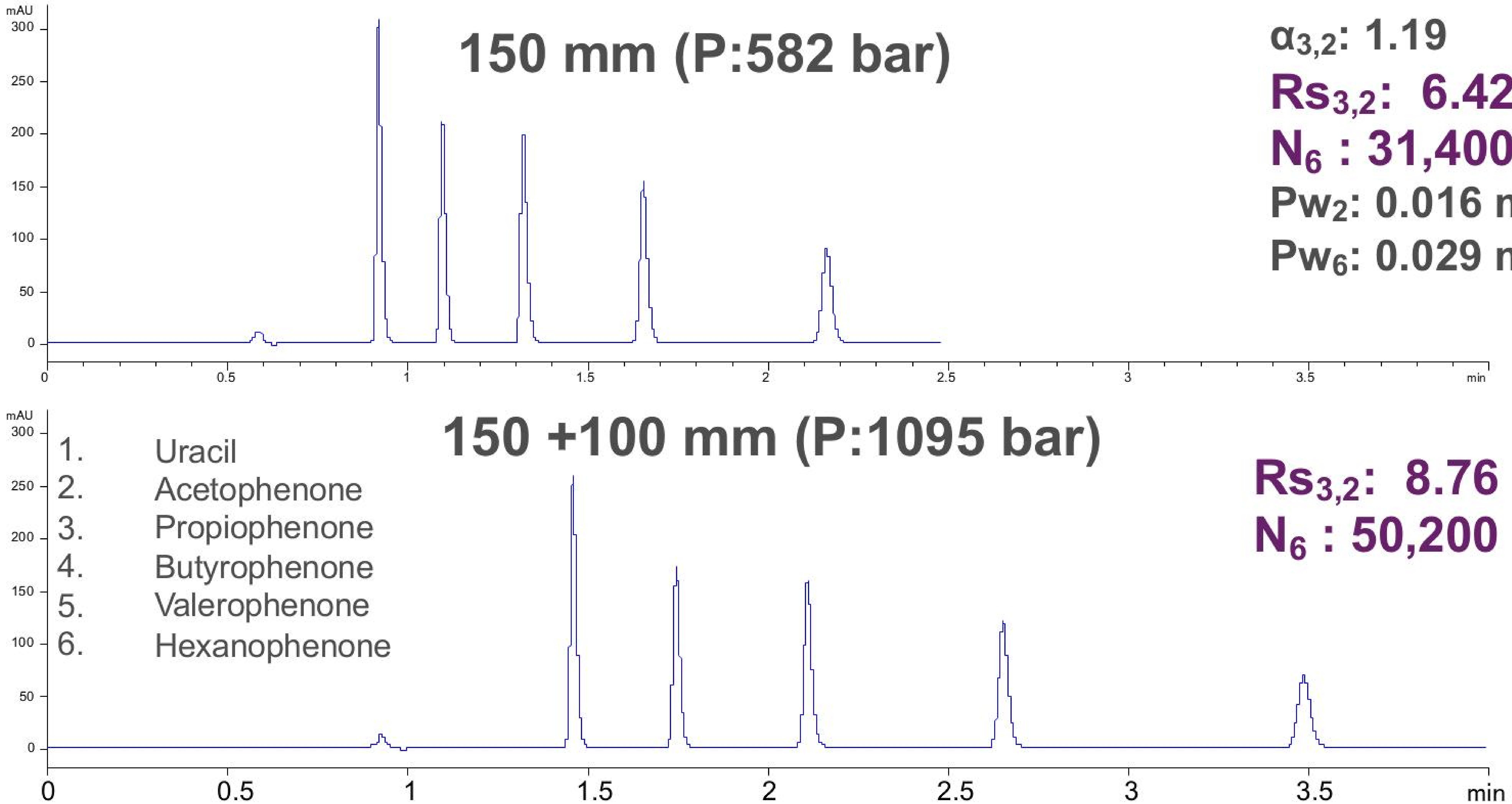
Improve Resolution with 100mm
2.0 ml/min, 394 bar



Sample: 1. Hydroquinone, 2. Resourcinol, 3. Catechol, 4. Phenol, 5. 4-Nitrophenol, 6. p-cresol, 7.o-cresol, 8. 2-Nitrophenol, 9. 3,4 di methyl phenol, 10. 2,3 di methyl phenol, 11. 2,5 di methyl phenol, 12. 1-napthol

Gain Efficiency and Resolution1.8µm TPP

Mobile Phase 25:75 water:acetonitrile, Flow Rate: 0.5 mL/min, ambient temperature, ZORBAX RRHD SB-C18, 1.8um columns



$\alpha_{3,2}$: 1.19
$Rs_{3,2}$: 6.42
N_6 : 31,400
Pw_2: 0.016 min
Pw_6: 0.029 min

$Rs_{3,2}$: 8.76
N_6 : 50,200

High Rs in 3.5 minutes, 250mm, 1.8um at 1100 bar
Resolution is fine on 150mm column, but longer column has even more

High Throughput: Sub 30 Second Separations with Short 1.8-µm (TPP) Columns

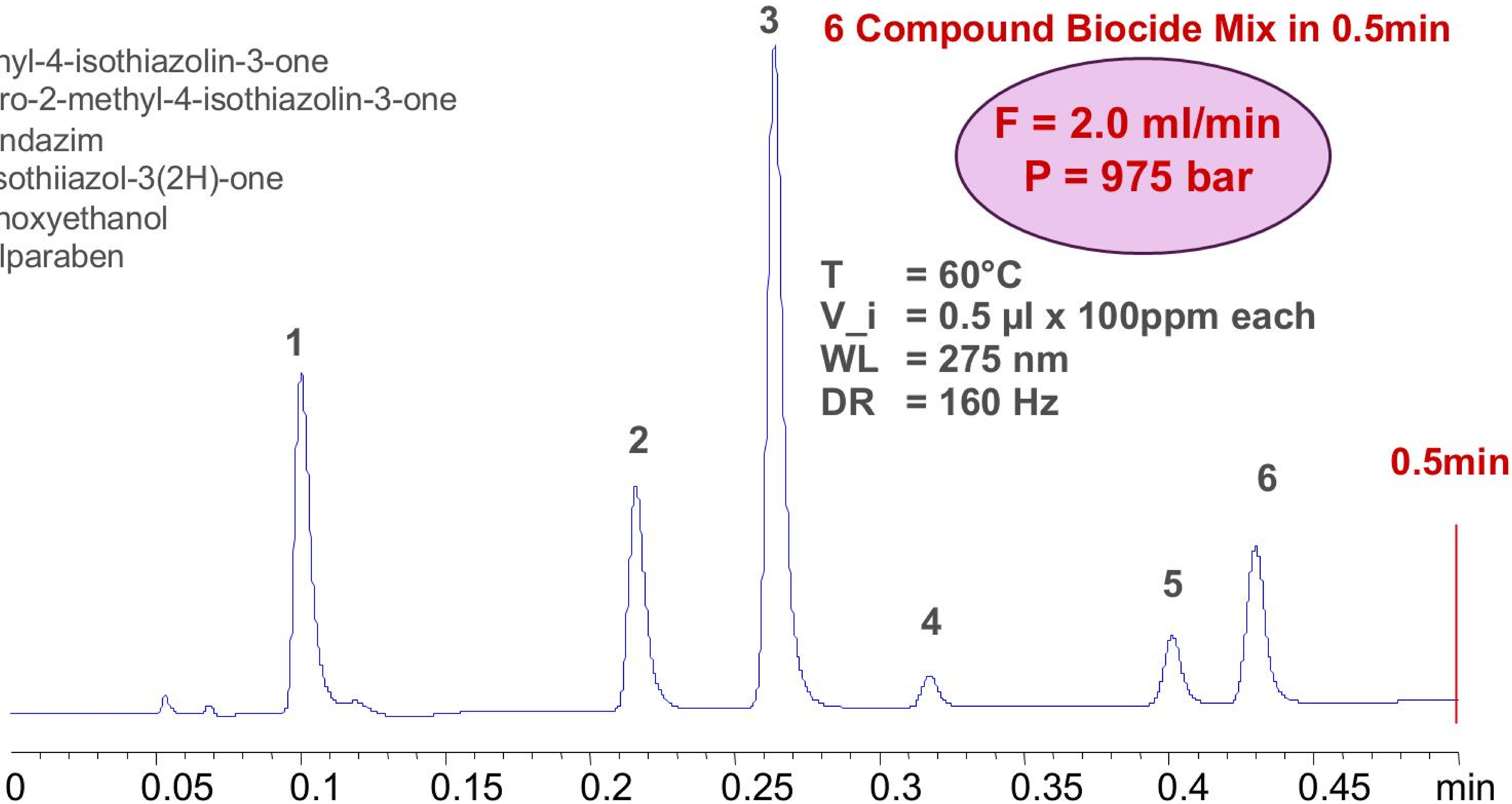
Column: ZORBAX RRHD SB-C18 2.1 x 50mm 1.8 µm
Gradient: H_2O (0.05% TFA) / 10-40 % ACN; 1min

1. 2-methyl-4-isothiazolin-3-one
2. 5-chloro-2-methyl-4-isothiazolin-3-one
3. Carbendazim
4. Benzisothiiazol-3(2H)-one
5. 2-phenoxyethanol
6. Methylparaben

6 Compound Biocide Mix in 0.5min

F = 2.0 ml/min
P = 975 bar

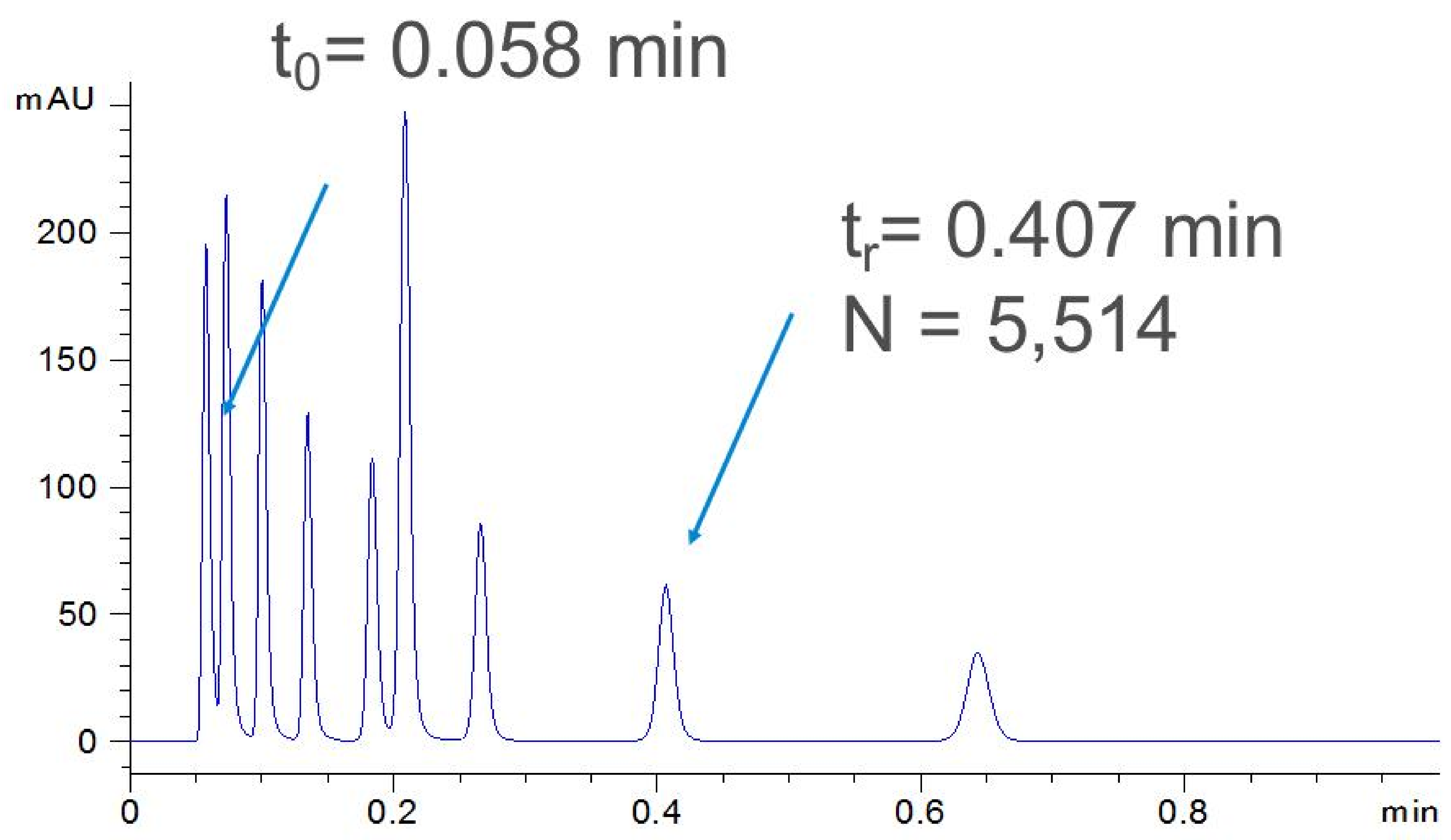
T = 60°C
V_i = 0.5 µl x 100ppm each
WL = 275 nm
DR = 160 Hz



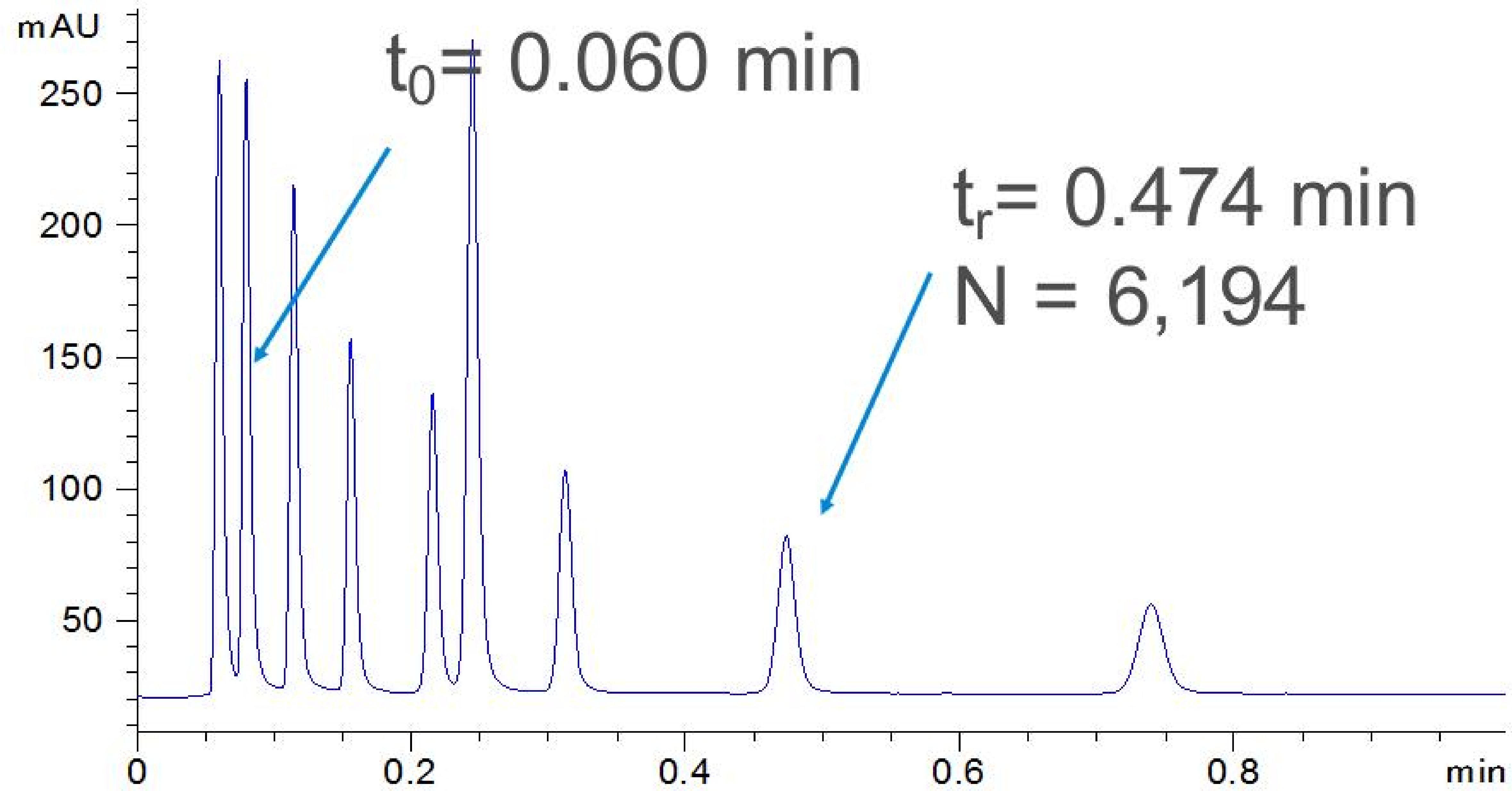
Achieving this speed takes advantage of the higher pressure limits of the UHPLC Systems (like Agilent 1290 Infinity)

TPP v SPP for Ultra-Fast Analysis on 50 mm Columns

2.7µm Poroshell 120
EC-C18
2.1 x 50 mm
F = 1.94 mL/min, 40°C
56% ACN, 44% Water
549 bar



1.8µm ZORBAX RRHD
Eclipse Plus C18
2.1 x 50 mm
F = 1.82 mL/min, 40°C
59% ACN, 41% Water
1003 bar

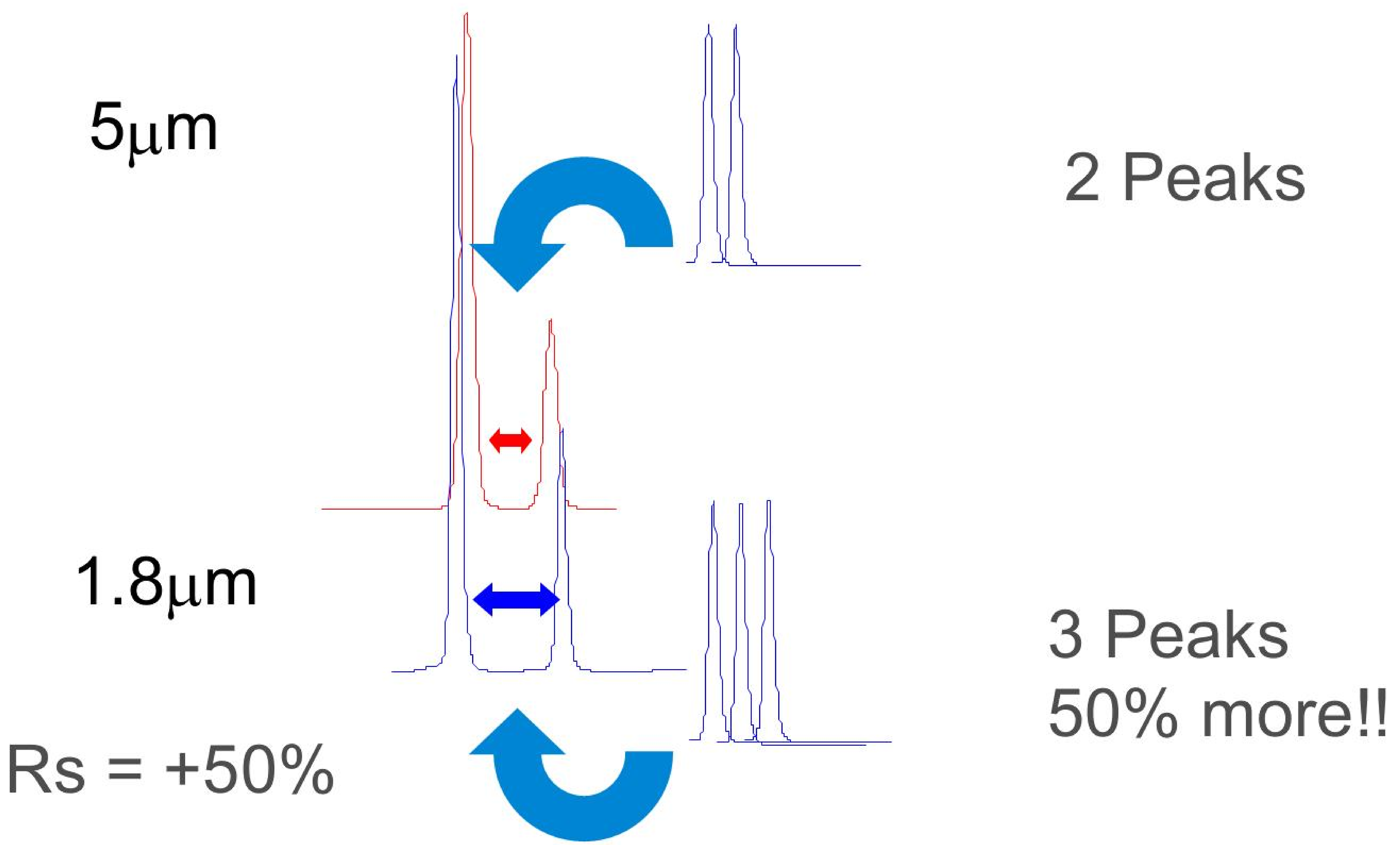


Comparison

Peak Capacity

Defining Peak Capacity

- *Peak capacity is the number of peaks which can be separated with defined resolution (example: R=1) in a certain period of time for a given system (column length and particle size)*
- *Peak capacity is another measure of separation efficiency (esp. for gradients) and is especially useful for complex chromatograms.*



Calculating Peak Capacity - Equations

Peak Capacity (P_c) - Gradient Elution Equations

1. $$P_C = 1 + \frac{t_g}{\frac{1}{n}\sum_1^n w} = 1 + \frac{t_g}{w_{av}}$$

Pc = peak capacity
tg = gradient time (min)
w = peak width (min)

$t_{R,n}$ = last peak
$t_{R,m}$ = first possible peak (unretained)
$t_{R,1}$ = first actual peak

2. $$P_c = 1 + \frac{t_{R,n} - t_{R,m}}{W_{av}}$$

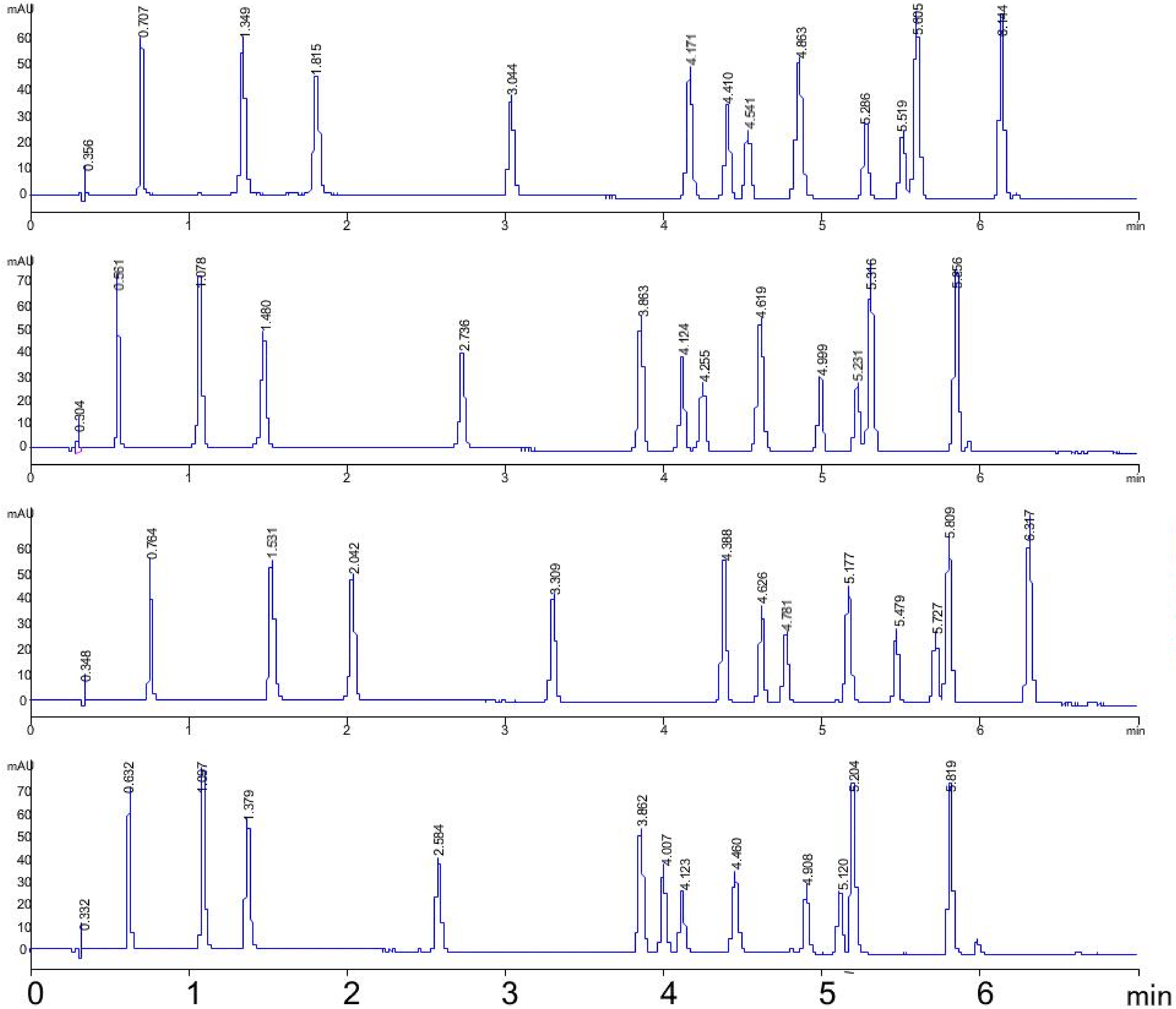
3. $$P_c = 1 + \frac{t_{R,n} - t_{R,1}}{W_{av}}$$

W impacted by N, which includes column length and particle size

Peak Capacity

(P_c) of TPP (1.8 µm) Slightly Higher Than SPP

Columns: 4.6 x 50mm Flow Rate: 2 mL/min



Poroshell 120 EC C18
2 ml/min 220 Bar (SPP)
Pc Ave=54

Other C18
2 ml/min 210 Bar (SPP)
Pc Ave=55

Eclipse Plus C18 RRHT
2 ml/min 364 Bar
Pc Ave=61 (TPP)

Other C18 (2.6um)
2 ml/min 232 Bar (SPP)
Pc Ave=50

All compounds prepared at 1 mg/ml (prepared at 0.1 mg/ml) in water. Compounds were combined in equal volumes to yield approximately 0.1 mg/ml
10ul injection volume , 4.6 x 50 mm
A: 0.1 % Formic Acid in Water
B: Acetonitrile
Flow rate: 2 mL/min

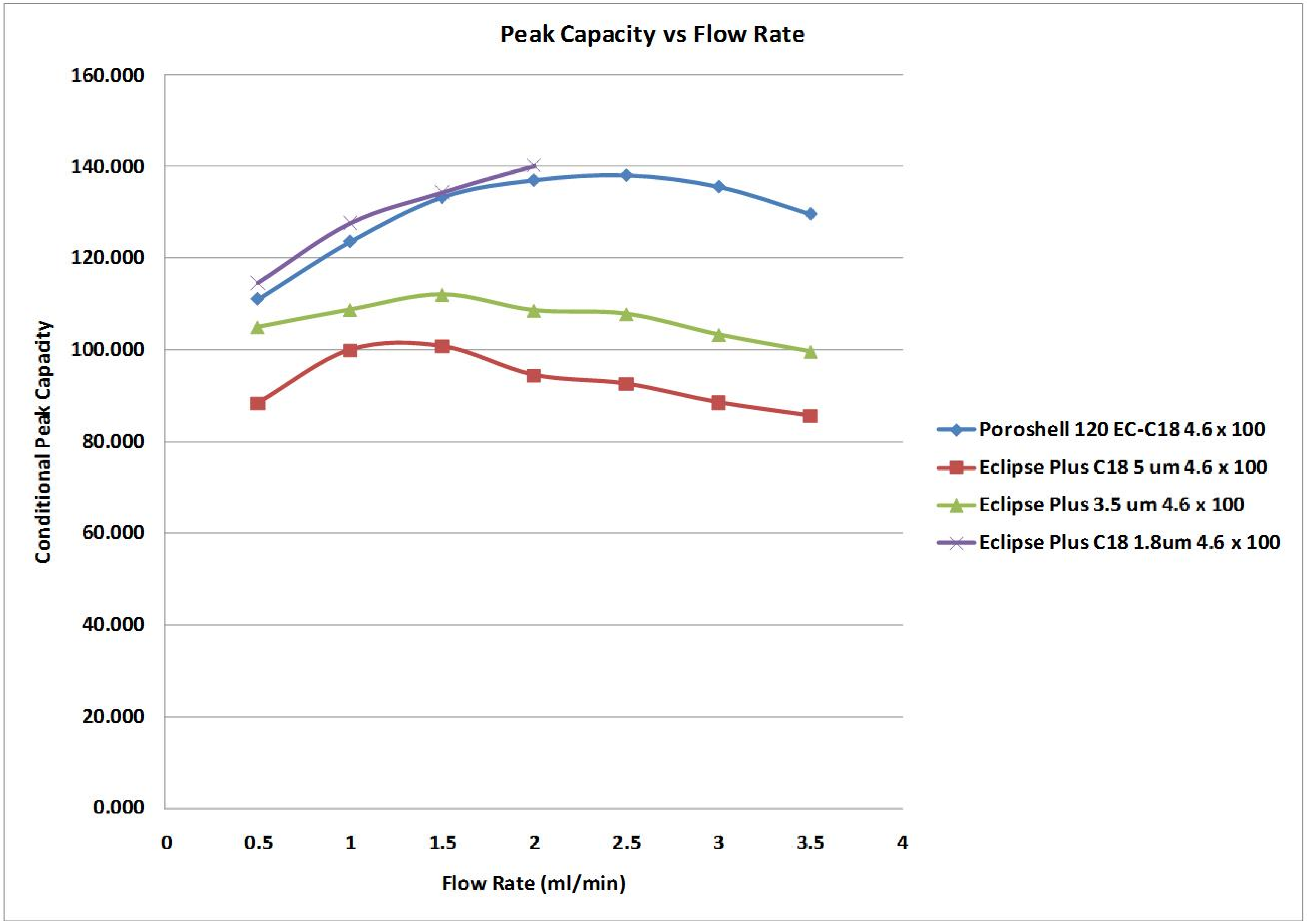
270 nm, no reference

1. **Hydroquinone**
2. **Resourcinol**
3. **Catechol**
4. **Phenol**
5. **4-Nitrophenol**
6. **p-cresol**
7. **o-cresol**
8. **2-Nitrophenol**
9. **3,4 di methyl phenol**
10. **2,3 di methyl phenol**
11. **2,5 di methyl phenol**
12. **1-napthol**

Gradient Profile

	Time	% B
1	1	5
2	8.5	60
3	10	60
4	11	5

Comparison of Peak Capacity
Poroshell 120 (SPP) vs. Totally Porous 1.8µm, 3.5µm and 5µm Columns

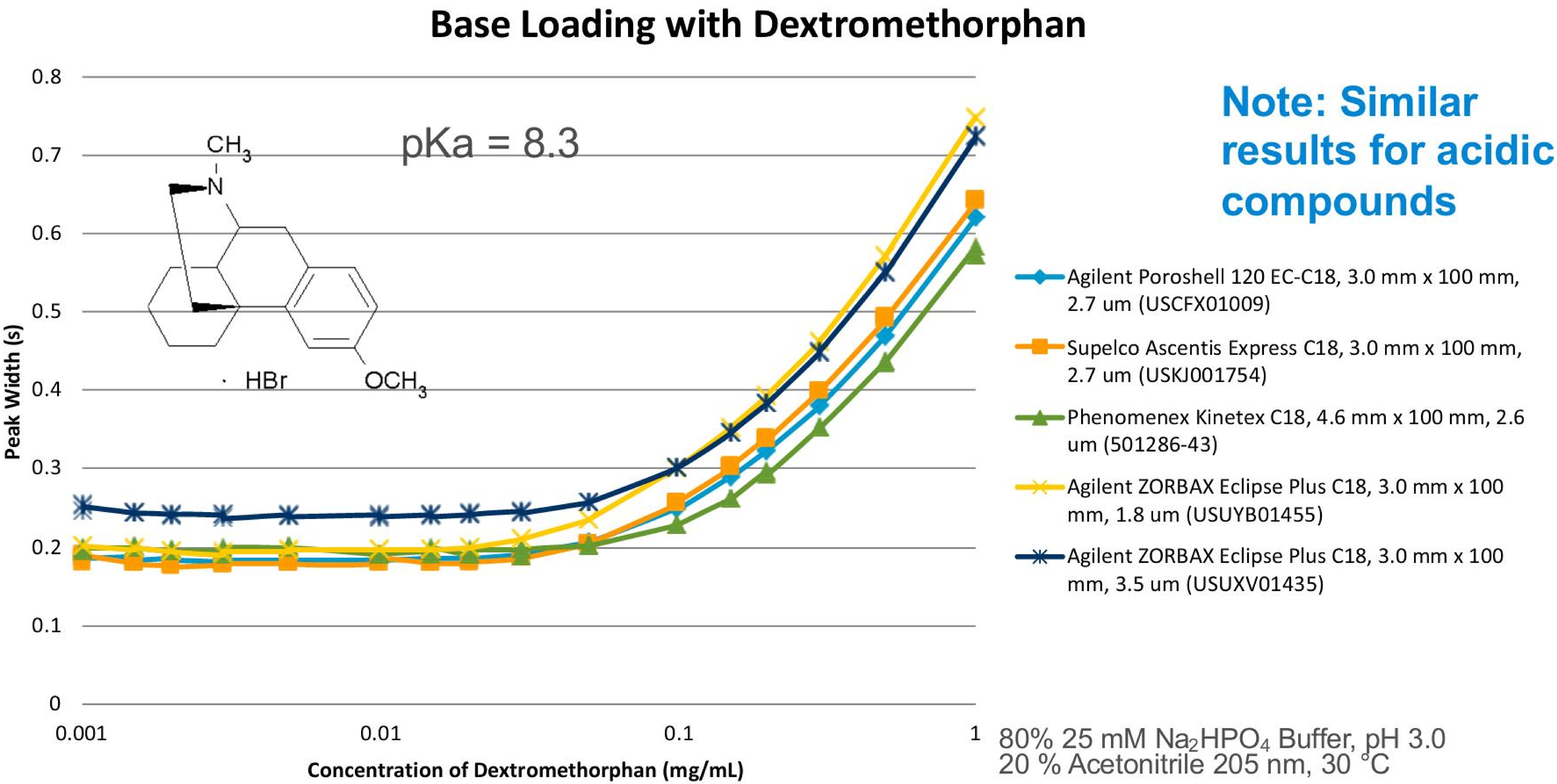


Peak capacity is similar on Poroshell 120 2.7 µm to 1.8 µm column of same size and higher than 3.5- or 5-µm columns of similar size.

Comparison

Sample (Loading) Capacity

Sample Loading of Basic Compounds on Poroshell 120 (SPP) Comparable to sub-2 micron Columns



Note: Similar results for acidic compounds

80% 25 mM Na_2HPO_4 Buffer, pH 3.0
20 % Acetonitrile 205 nm, 30 °C

The increase in peak width for the Poroshell 120 is at the same loading as the 1.8µm.

Compare

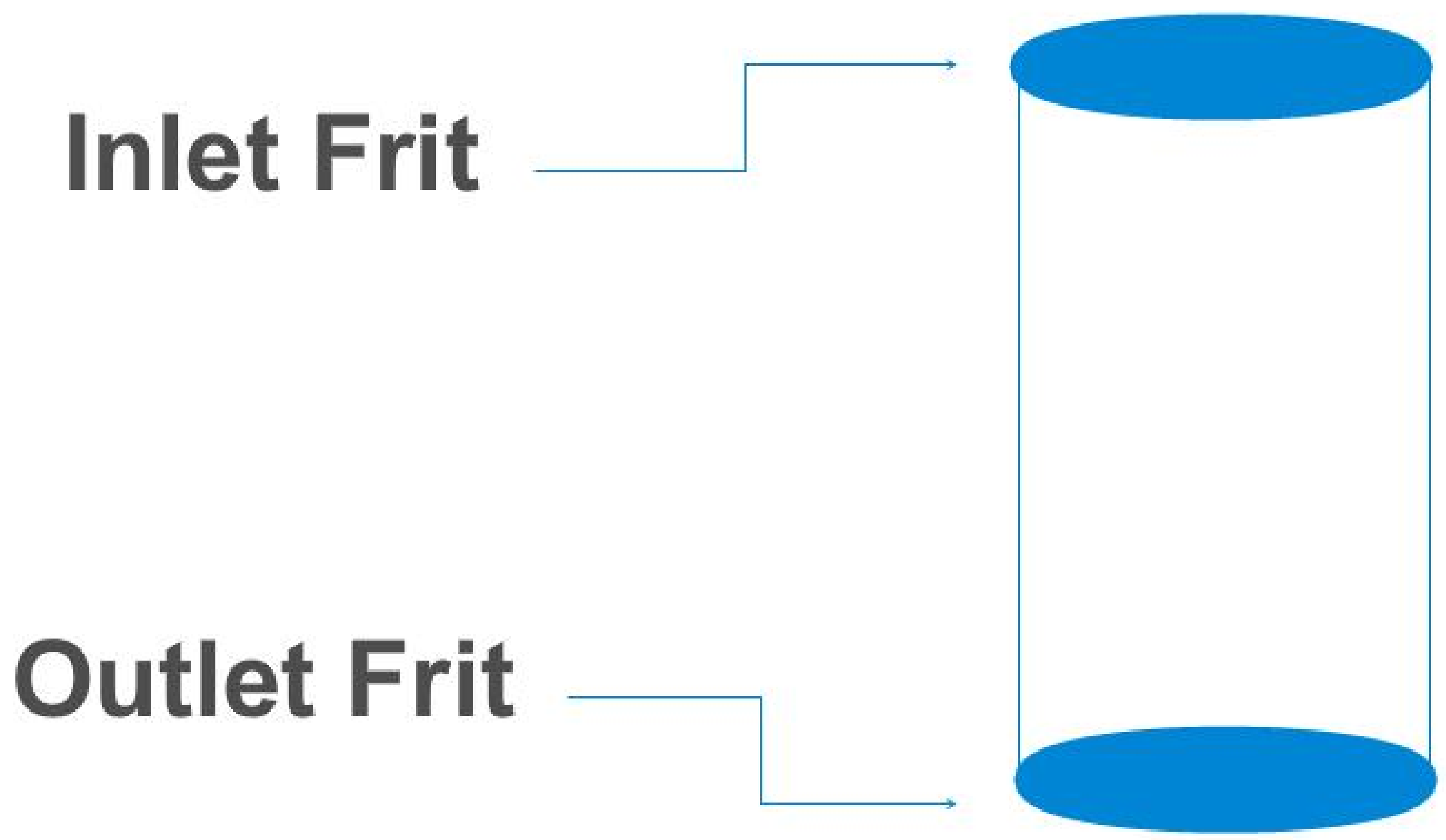
Practical Aspects

-Tolerance for Dirty Samples (Plugging)

- Available Phases
- Method transfer
  - See Appendix
- Instrument

Most Column Pressure Problems in HPLC/UHPLC…
Caused by Sample/Mobile Phase Matter Plugging Inlet Frit

- Filter sample and buffers
- Use in-line filter to keep particulates out of inlet frit
- Outlet frit must be smaller than smallest particles in column packing



Quick Summary of Families and Bonded Phases

Poroshell 120

Particle size: 2.7um

EC-18, EC-C8, SB-C18, SB-C8, Phe-Hex, SB-Aq, PFP, EC-CN, Bonus-RP, HPH-C18, HPH-C8, HILIC

Eclipse Plus

Particle sizes: 5, 3.5, 1.8um

Available phases: C18, C8, Phenyl-Hexyl, PAH, HILIC

StableBond

Particle sizes: 7, 5, 3.5, 1.8um

Pore sizes 80Å & 300Å

Available phases: C18*, C8*, Phenyl, CN, C3, Aq*

*Also available in Poroshell 120

Eclipse XDB

Particle sizes: 7, 5, 3.5, 1.8um

Available phases: C18, C8, Phenyl, CN

Also available in Poroshell 120

Bonus-RP

Particle sizes: 5, 3.5, 1.8um

Also available in Poroshell 120

Additional Phases

Extend-C18

Particle sizes: 5, 3.5, 1.8um

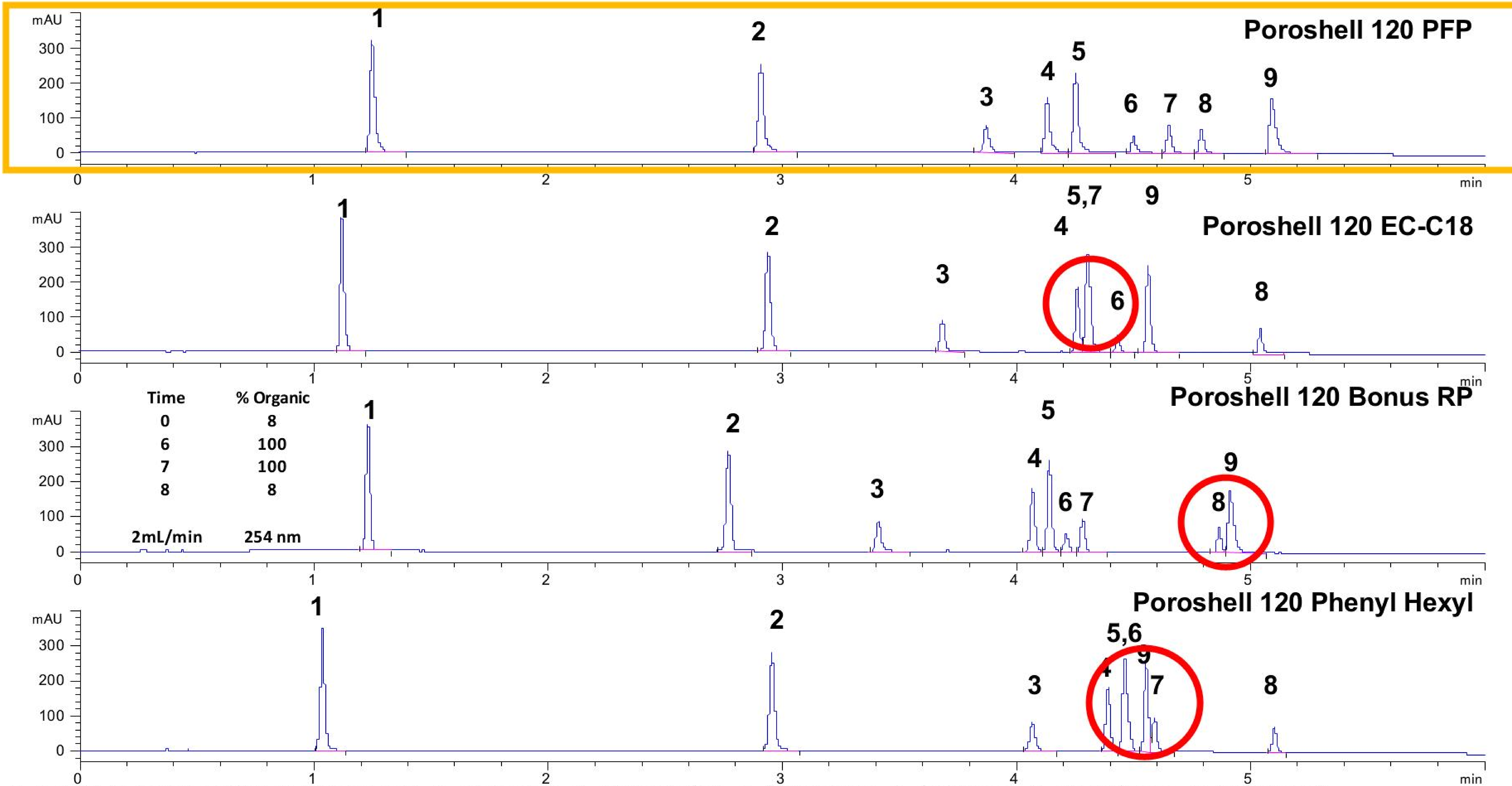
Pore sizes 80Å & 300Å

300-Diphenyl

Particle size: 1.8um

NSAID Separation
Poroshell 120 MeOH Gradient

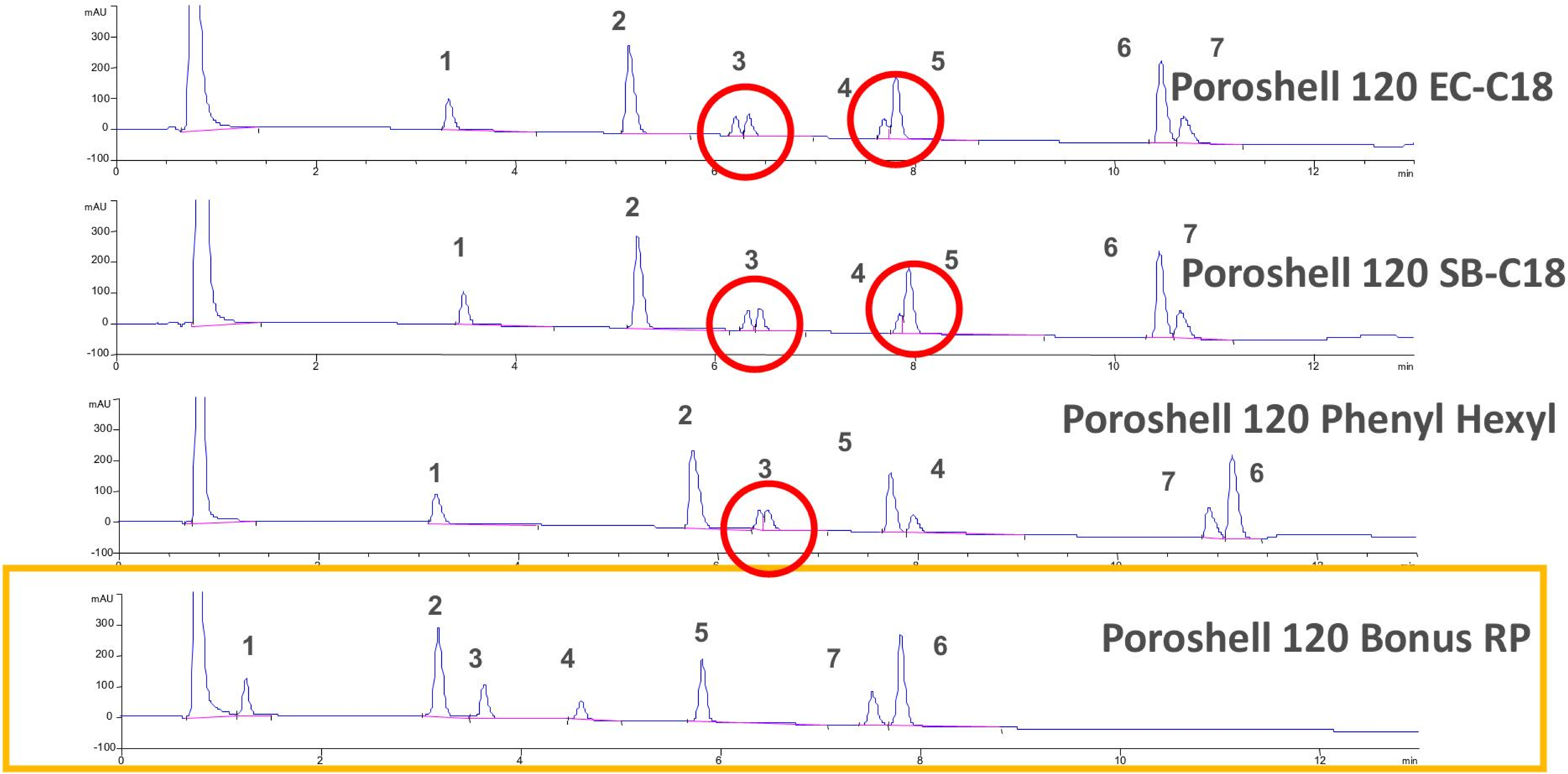
Best Resolution of all analytes with Poroshell 120 PFP



1. APAP, 2. Phenacetin, 3. Piroxicam, 4. Tolmetin, 5. Ketoprofen, 6. Naproxen, 7. Sulindac, 8. Diclofenac, 9. Diflunisal

Comparison of Bonded Phases - Beta Blockers

Best Resolution of all analytes with Poroshell Bonus-RP

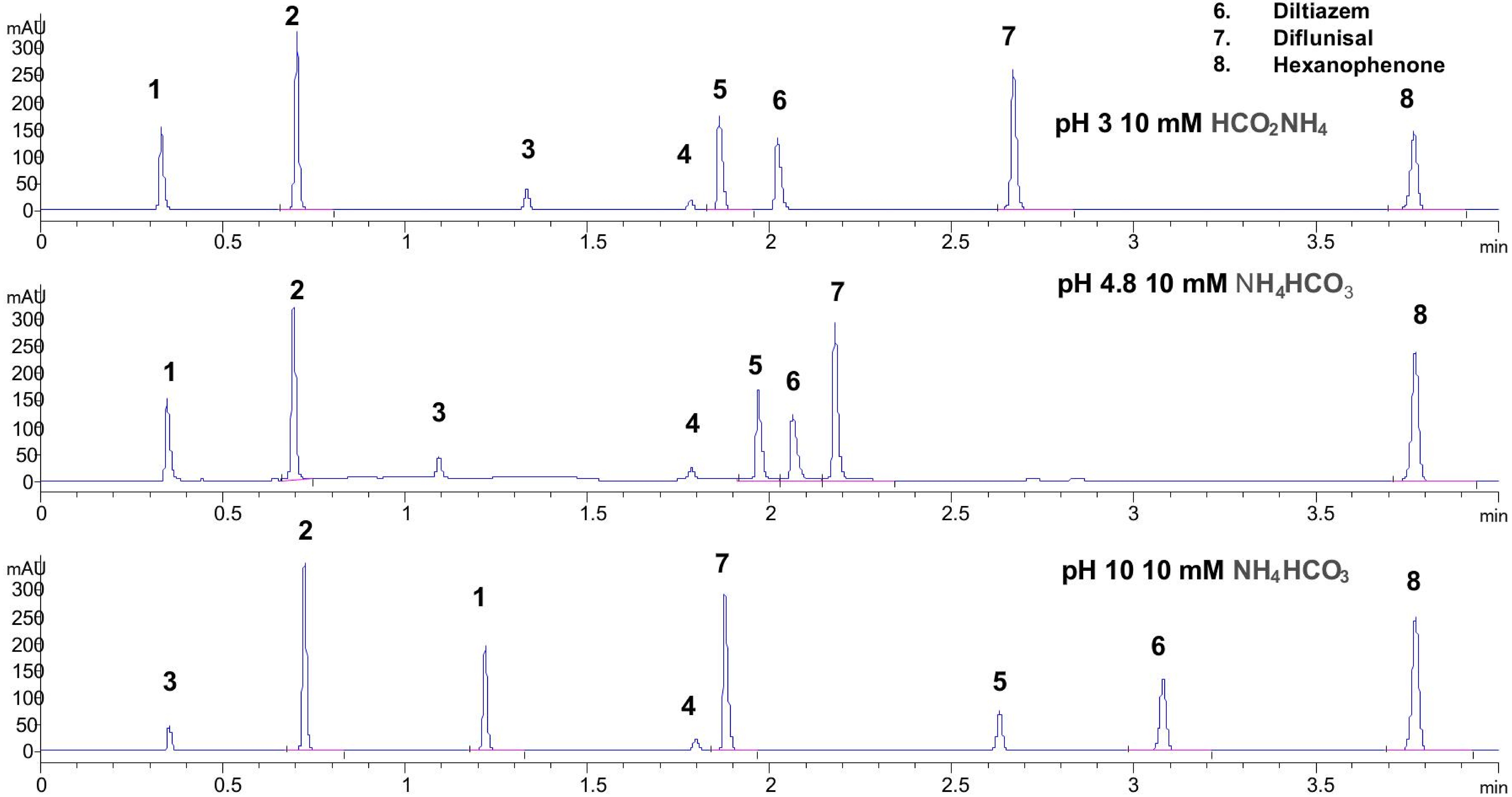


1.Atenolol, 2. Pindolol, 3. Naldolol, 4. Metoprolol, 5. Acebutolol, 6. Propranolol, 7. Alprenolol

Poroshell HPH Low, Mid, & High pH with Acetonitrile

Why use multiple pH's?

1. Procainamide
2. Caffeine
3. Acetyl Salicylic Acid
4. Hexanophenone Deg.
5. Dipyrimadole
6. Diltiazem
7. Diflunisal
8. Hexanophenone



Column/Instrument Compatibility

Particle Size/Type	Pressure	Efficiency	LC Compatibility
3.5µm – Totally Porous	123 bar	7,800	All 400 bar instruments
2.7µm – Poroshell 120* (Superficially Porous)	180 bar	12,000	All LCs/UHPLCs (up to 600 bar)
1.8µm – Totally Porous	285 bar	12,500	All LCs/UHPLCs (↑1200 bar)

Columns: 4.6 x 50mm, Mobile Phase: 60% ACN:40% Water   Flow Rate: 2 mL/min

Comparison

TPP sub-2 µm and SPP, 2.7 µm

Parameter	TPP (sub-2-µm)	SPP (2.7-µm)	Conclusion
Efficiency	12,500 pl/50 mm	12,000 pl/50 mm	Similar
Pressure	~ 2X SPP	~ ½ TPP	SPP lower
Selectivity (bonded phase)	Same particle size to particle size	Only slightly different for same phase for TPP	Transfer of method from TPP ⟷ SPP
Particle size distribution	1.47 (90%/10% ratio)	1.20 (90%/10% ratio)	SPP 25% narrower; helps packing efficiency; “A” term
Peak capacity	About the same as SPP	About the same as TPP	May be compound dependent
Plugging	0.5 micron porosity frit	2 micron porosity frit	SPP less prone
Sample capacity	Same	Same	SPP 75% of surface volume; particles pack more densely so a “wash”
Scale-up for prep (particle sizes)	1.8, 3.5, 5.0 (7.0)	Only 2.7-µm	TPP better
Pressure limit	Up to 1200 bar	Up to 600 bar	TPP goes higher; hardware different
Column diameters	2.1, 3.0 (1200 bar) 2.1, 3.0, 4.6 (600 bar)	2.1, 3.0, 4.6	Highest pressure (1200 bar) columns have one less id
Number of phases	Largest (17)	Large (12)	TPP wins out here since SPP newer

Agilent Technical Support

LC or GC Column Support

800-227-9770 (US & Canada)

Select opt. 3, opt. 3, then option 1 for GC or option 2 for LC.

Email: lc-column-support@agilent.com,

gc-column-support@agilent.com

Website: www.agilent.com/chem

Questions?

Appendix

New Phases on Poroshell 120

Poroshell 120 PFP

- A USP L43 bonded chemistry consisting of a perfluorophenyl ring attached with a propyl linker
- Excellent choice for polar analytes and analytes with pi-character due to it's ability to have unique pi-pi interactions
- Position as an alternative phase chemistry for unique selectivity that is orthogonal to C18 chemistries
- **Recommended operating range**
  - **pH 2-8**
  - **Maximum temp: 60°C**

Poroshell HPH-C18 (June 1) and HPH-C8 (July 1)

- A chemically modified Poroshell 120 particle using proprietary technology designed to give high pH stability
- Utilizes the same bonding chemistry as EC-C18 and EC-C8
- **Recommended operating range**
  - **pH 3-11**
  - **Maximum temp: 60°C**

Columns are available in 2.1, 3.0, and 4.6mm ID's, and in lengths of 50, 100, and 150mm; Other dimensions available through the custom columns process.

Poroshell 120 Bonded Phases

EC-C18
EC-C8
EC-CN

- Endcapped for best peak shape
- **EC-C18 – 1st choice for most separations, use C8 for less retention**
- EC-CN similar to Zorbax Eclipse XDB -CN; alternate selectivity for normal and reversed-phase

SB-C18
SB-C8

- Non-endcapped
- **Best performance and longest lifetime at low pH (1 -2)**
- Poroshell 120 SB-C8 enables method transfer from existing Zorbax SSB-C8 columns in many established USP methods

NEW
HPH-C18
HPH-C8

- Chemically modified Poroshell 120 particle using proprietary technology to give high pH stability
- **Recommended operating range: pH 3-11**
- .Alternate selectivity to other C18 and C8 phases

Bonus-RP

- Embedded polar group provides unique selectivity for polar compounds
- **Often changes elution order of acidic and basic compounds**
- Small polar acids can be separated on Bonus -RP with 0.1% TFA mobile phases

Poroshell 120 Bonded Phase, cont'd

Phenyl-Hexyl

- Utilizes the same bonding process utilized in ZORBAX Eclipse Plus Phenyl -Hexyl
- **Excellent choice for resolution of analytes such as aromatic compounds**, due to unique pi-pi interactions, or when other phenyl type columns are recommended
- Alternative selectivity to EC-C18 or SB-C18

PFP

- USP L43
- **Can give extra retention and selectivity for positional isomers of halogenated compounds**
- Use for the separation of aromatic compounds and polar molecules containing hydroxyl, carboxyl, nitro and other polar groups

SB-Aq

- Proprietary bonded phase is an excellent choice for polar analytes that don't retain well on C18, and when LC-UV is used
- StableBond chemistry enhances low-pH stability, for the most acidic mobile phases
- Good choice for small, polar compounds where 100% aqueous mobile phase is needed.

HILIC

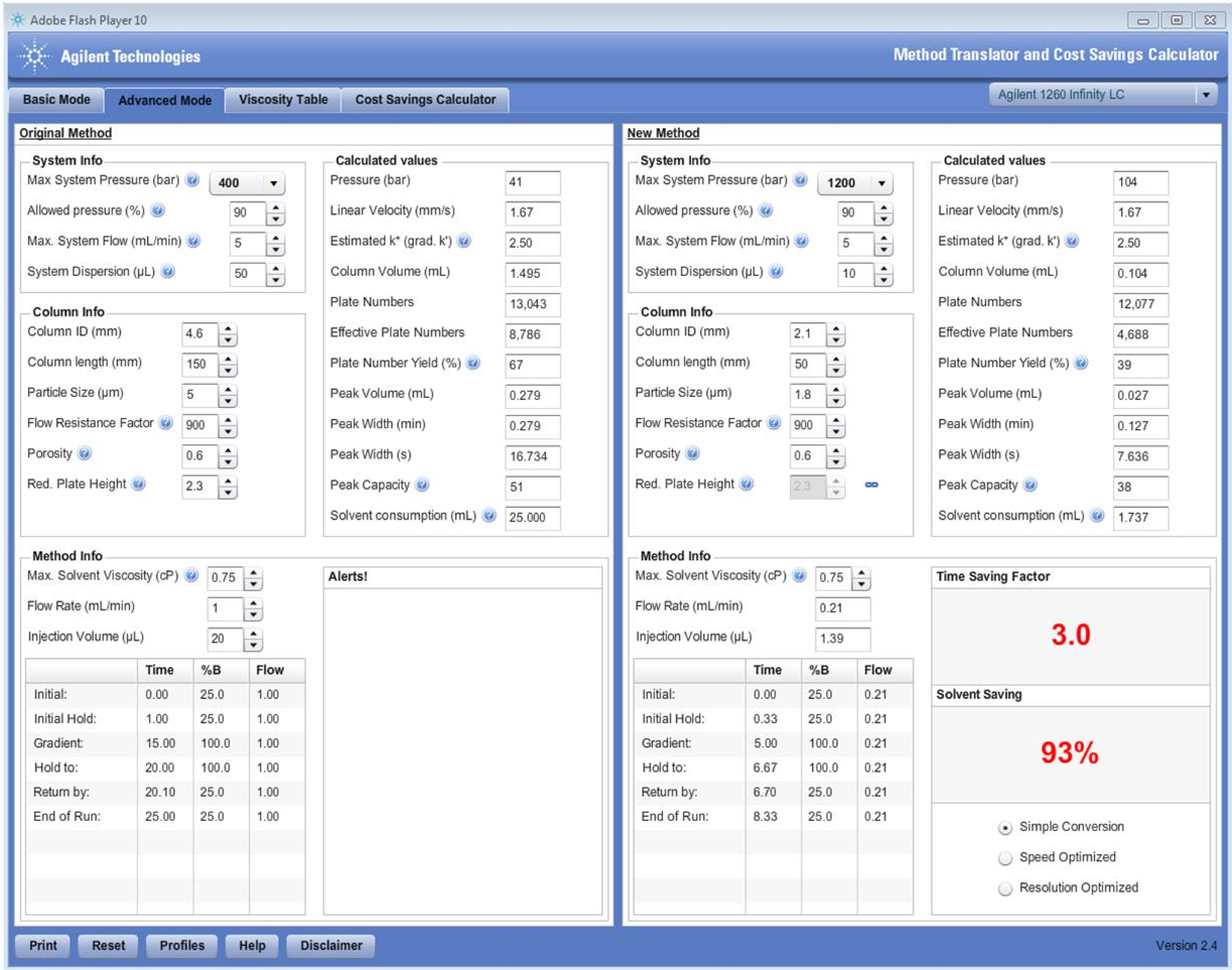
- Bare silica HILIC (ships in HILIC solvents) for separations of polar compounds
- Ideal for retention and analysis of polar compounds by LC/MS in high organic for maximum sensitivity

How To “Match” a Column to ZORBAX RRHT/RRHD

General Phase Type	Starting ZORBAX Choice
Typical “endcapped” C18 or C8 bonded phases, newer columns	Eclipse Plus C18 or C8
Endcapped C18 or C8 columns, older generation	Eclipse XDB-C18 or C8
Non-endcapped columns	StableBond C18
Older types of columns	StableBond C18, C8 etc.
Aqueous “type” columns	SB-Aq
CN or Phenyl	Eclipse Plus Phe-Hex, SB-Phenyl, SB-CN

Phenyl-Hexyl and Bonus-RP are for general method development use for alternate selectivity
Use SB-AQ for LC-UV and HILIC for LC/MS of polar, difficult to retain analytes

Method Translation Software



http://www.chem.agilent.com/en-US/Products-Services/Instruments-Systems/Liquid-Chromatography/pages/1200infinity_cost_calculator.aspx

New Method Development Kits

Choose from a variety of kits to suit your needs

• **Poroshell 120 L1, L7, and L10 USP Kits** make it easier to improve speed and sample throughput – without sacrificing resolution – by transferring your 5µm USP methods to Poroshell 120 columns

• **Poroshell 120 Selectivity Kits** provide a variety of column chemistries to help quickly adjust your analyte retention & selectivity

• **ZORBAX RRHD and Poroshell 120 Aqueous Method Development Kits** are ideal for polar compounds and 100% aqueous conditions, so you can achieve greater analyte retention without the phase collapse that can occur with C18 chemistries

Method Development Kits	Description (One of each)	Dimension	Part No.
Poroshell 120 Selectivity	EC-C18, Phenyl-Hexyl, Bonus-RP	2.1 x 50 mm	5190-6155
Poroshell 120 Selectivity	EC-C18, Phenyl-Hexyl, Bonus-RP	4.6 x 50 mm	5190-6156
Poroshell 120 Aqueous	SB-Aq, Phenyl-Hexyl, Bonus-RP	2.1 x 50 mm	5190-6157
Poroshell 120 Aqueous	SB-Aq, Phenyl-Hexyl, Bonus RP	4.6 x 50 mm	5190-6158
Poroshell 120 L1, L7, and L10 USP	EC-C18, EC-C8, EC-CN	4.6 x 100 mm	5190-6159
Poroshell 120 L1, L7, and L10 USP	EC-C18, EC-C8, EC-CN	3.0 x 100 mm	5190-6160
ZORBAX RRHD pH	SB-C18, Eclipse Plus C18, and Extend-C18	2.1 x 50 mm	5190-6152
ZORBAX RRHD Eclipse Plus	Eclipse Plus C18, Eclipse Plus C8, Eclipse Plus Phenyl-Hexyl	2.1 x 50 mm	5190-6153
ZORBAX RRHD Aqueous	SB-Aq, Bonus RP, Eclipse Plus Phenyl-Hexyl	2.1 x 50 mm	5190-6154

Validation Kits Available

Same column (dimensions, bonded phase, particle size); different mfg. lots

Agilent ZORBAX Rapid Resolution High Definition (RRHD) Method Validation Kits

Size (mm)	Particle Size (µm)	Eclipse Plus C18	Eclipse Plus C8	Eclipse XDB-C18	Extend-C18	Eclipse Plus Phenyl-Hexyl	Bonus-RP	SB-C18	SB-C8	SB-Phenyl	SB-Aq
3.0 x 150	1.8	959759-302K	959759-306K	981759-302K				859700-302K	859700-306K		
3.0 x 100	1.8	959758-302K	959758-306K	981758-302K	758700-302K	959758-312K		858700-302K	858700-306K	858700-312K	858700-314K
3.0 x 50	1.8	959757-302K	959757-306K	981757-302K	757700-302K	959757-312K		857700-302K	857700-306K	857700-312K	857700-314K
2.1 x 150	1.8	959759-902K	959759-906K	981759-902K	759700-902K	959759-912K	859768-901K	859700-902K	859700-906K	859700-912K	859700-914K
2.1 x 100	1.8	959758-902K	959758-906K	981758-902K	758700-902K	959758-912K	858768-901K	858700-902K	858700-906K	858700-912K	858700-914K
2.1 x 50	1.8	959757-902K	959757-906K	981757-902K	757700-902K	959757-912K	857768-901K	857700-902K	857700-906K	857700-912K	857700-914K

Agilent ZORBAX Method Validation Kits

Size (mm)	Particle Size (µm)	Eclipse Plus C18	Eclipse Plus C8	Eclipse XDB-C18	Eclipse XDB-C8	Extend-C18	Eclipse Plus Phenyl-Hexyl	Bonus-RP	SB-Aq	SB-C18	SB-C8	SB-Phenyl
4.6 x 250	5	959990-902K	959990-906K	990967-902K	990967-906K	770450-902K	959990-912K	880668-901K	880975-914K	880975-902K	880975-906K	880975-912K
4.6 x 150	5	959993-902K	959993-906K	993967-902K	993967-906K	773450-902K		883668-901K	883975-914K	883975-902K	883975-906K	883975-912K
3.0 x 150	5	959993-302K										
4.6 x 250	3.5									884950-567K		
4.6 x 150	3.5	959963-902K	959963-906K	963967-902K	963967-906K	763953-902K	959963-912K	863668-901K	863953-914K	863953-902K	863953-906K	863953-912K
4.6 x 100	3.5	959961-902K	959961-906K	961967-902K	961967-906K	764953-902K	959961-912K	864668-901K	861953-914K	861953-902K	861953-906K	861953-912K
4.6 x 50	3.5	959943-902K	959943-906K	935967-902K	935967-906K	735953-902K	959943-912K	835668-901K	835975-914K	835975-902K	835975-906K	835975-912K
4.6 x 150	1.8	959994-902K							829975-914K	829975-902K	829975-906K	829975-912K
4.6 x 100	1.8	959964-902K	959964-906K	928975-902K	928975-906K	728975-902K	959964-912K	828668-901K	828975-914K	828975-902K	828975-906K	828975-912K
4.6 x 50	1.8	959941-902K	959941-906K	927975-902K	927975-906K	727975-902K	959941-912K	827668-901K	827975-914K	827975-902K	827975-906K	827975-912K
3.0 x 100	1.8				928975-306K			828668-301K				
3.0 x 50	1.8				927975-306K			827668-301K				
2.1 x 100	1.8				928700-906K							
2.1 x 50	1.8				927700-906K							