Building Blocks for a Robust GC Method

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Application Engineers
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Agilent
Trusted Answers

Things to Consider for a Successful Robust Method

The sample

Injection method

Inlet

Carrier gas

Column

Detector

Temperature program

The Sample

Will it fly?

Only 10–20% of all compounds are suitable for GC analysis.

The compounds must have:

- Sufficient volatility
- Thermal stability
- **No** inorganic acids, bases, or salts.

The Sample

Analyte Composition

What are my analytes?

- Isomers
- Polar versus nonpolar
- Organic acids
- Light gases
- Noble gases
- Halogens

The Sample

Matrix – residue or dirt?

Residue

- Semivolatile
  - Bake out
  - Back flush
- Nonvolatile
  - Frequent inlet maintenance
    - Liner, seal, trim column
  - Guard column
  - Back flush

Dirty samples

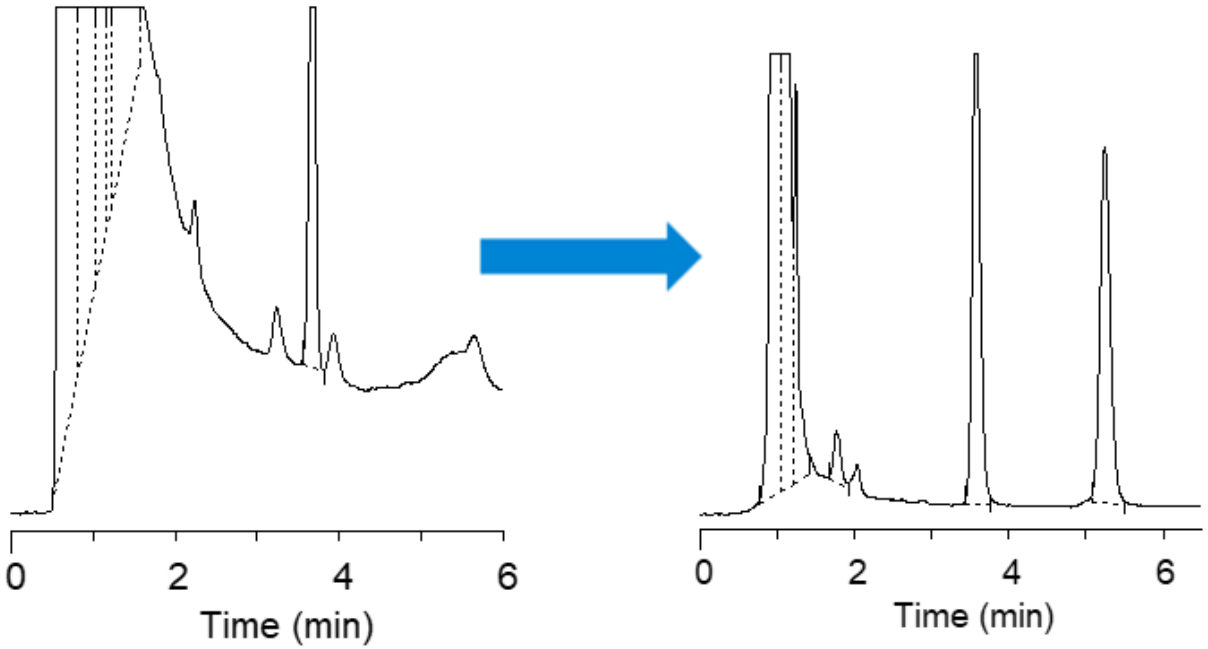
- Sample cleanup
- Back flush

Importance of the Correct Sample Preparation/Cleanup

Target analytes are the needle in the haystack of a matrix, sample preparation helps find the needle in the haystack.

- Protect the instrument detection system from contamination
- Improve the detection, method robustness, and reliability
- Reduces frequency of GC maintenance
  - *"Pay-me-now or pay-me-later"*

Sample **without** sample preparation



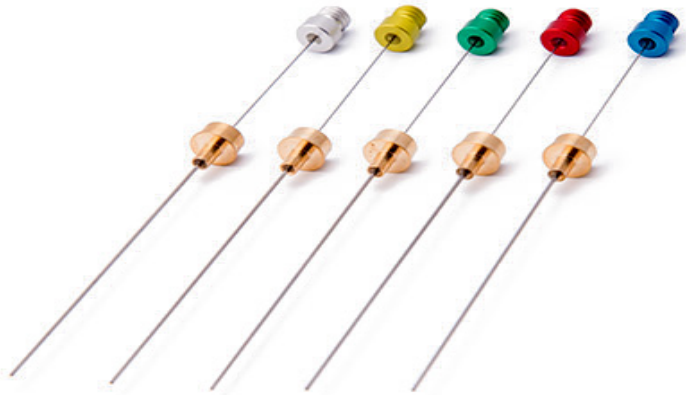
Sample *with* sample preparation

Offline Options for Sample Matrix Removal

Bond Elut Solid Phase Extraction cartridges and plates

Filter vials – Mini-Uni Prep

QuEChERS



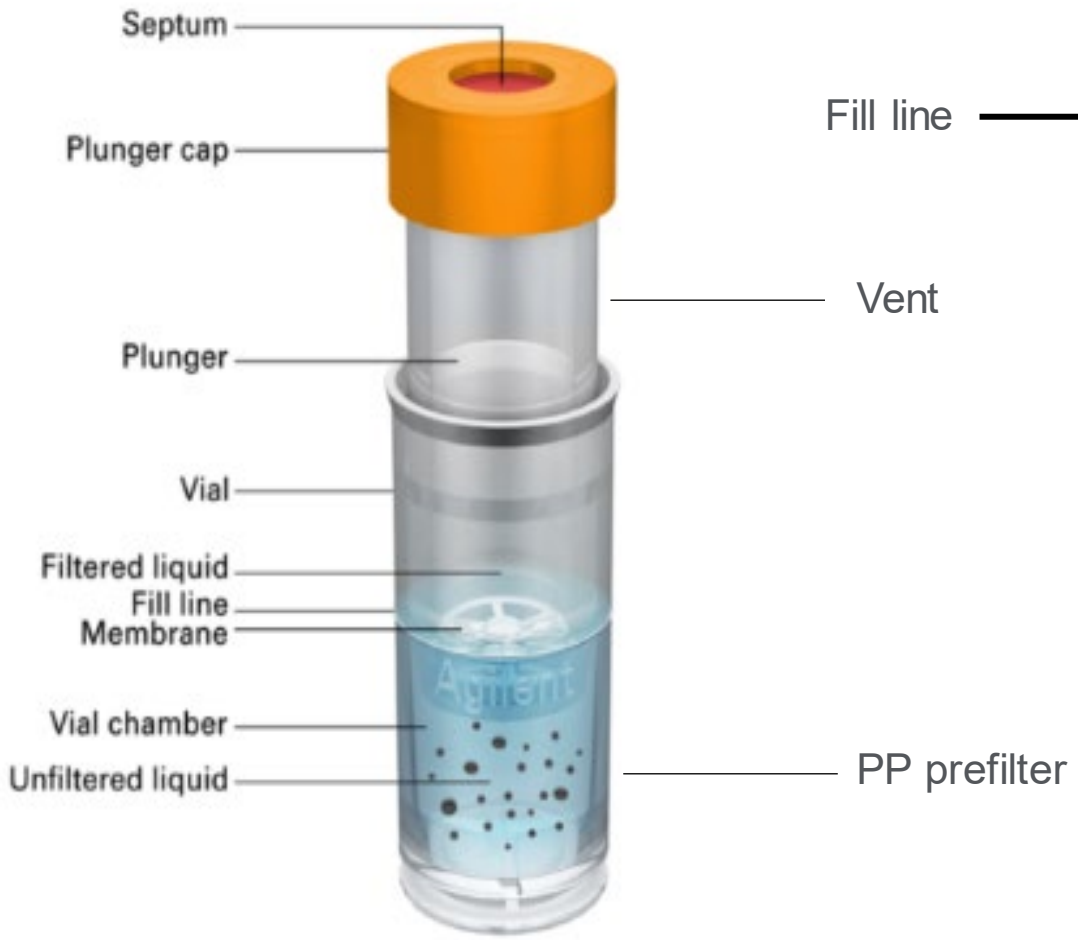
SPME (Arrows)

Captiva EMR-Lipid filtration cartridges and plates

Chem Elut S

Captiva syringe filters

Filtration – Captiva Filter Vials



Description	Part Number
PTFE filter vial, 0.45 µm, 100/pk	5191-5933
PTFE filter vial, 0.20 µm, 100/pk	5191-5934
Nylon filter vial, 0.45 µm, 100/pk	5191-5935
Nylon filter vial, 0.20 µm, 100/pk	5191-5936
RC filter vial, 0.45 µm, 100/pk	5191-5939
RC filter vial, 0.20 µm, 100/pk	5191-5940
PES filter vial, 0.45 µm, 100/pk	5191-5941
PES filter vial, 0.20 µm, 100/pk	5191-5942
Vial closure tool	5191-5943

See appendix for solvent compatibility poster request

www.agilent.com/chem/filtervials
Filter vials user guide: 5994-0814EN

Filtration – Targeted Filtration

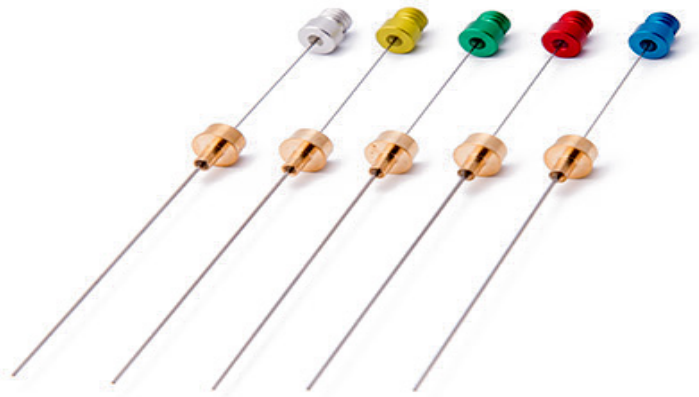
Captiva EMR-Lipid

- One of the newest Agilent sample cleanup products with the 2-in-1 benefit of removing proteins and lipids.
- It reduces ion suppression, increases analyte sensitivity, improves peak shape, and extends the lifetime of your analytical column.
- Simple pass-through format, 96-well plate, 1 mL, 3 mL, and 6 mL cartridges
- Solvent-retention frit in 1 mL cartridge/96-well plate for in-well protein precipitation
- Unique chemistry and filtration ensure protein and lipid removal
- Depth filtration design allows for smooth elution
- Received the Analytical Scientist Innovation Award (TASIA) of 2017

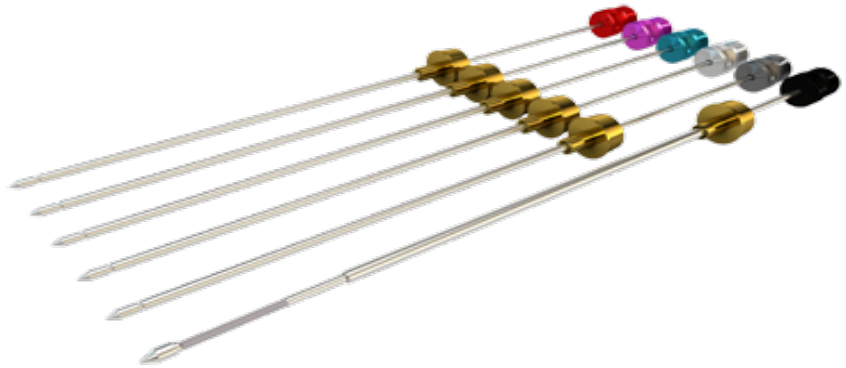
SPME Fiber and Arrow Offering from Agilent

Solid phase microextraction (SPME)

- Environmental analyses of water samples
- Odor analyses (ppt)
- Flavor analyses of food products
- Forensic analyses of arson/explosives samples
- Toxicology analyses: blood alcohol or drugs in urine/serum
- Surfactants, other industrial applications
- Trace analysis in food
- Drugs and pharmaceuticals
- Herbicides/pesticides
- Medical diagnostics
- Trace impurities in polymers and solid samples
- Solvent residue in raw materials
- Explosives



SPME fibers



SPME Arrows

SPME Fiber & Arrow Characteristics

Solid phase microextraction (SPME)

Parts of the SPME Arrow:

Injections

Method of Injection

Manual injection

Liquid injection

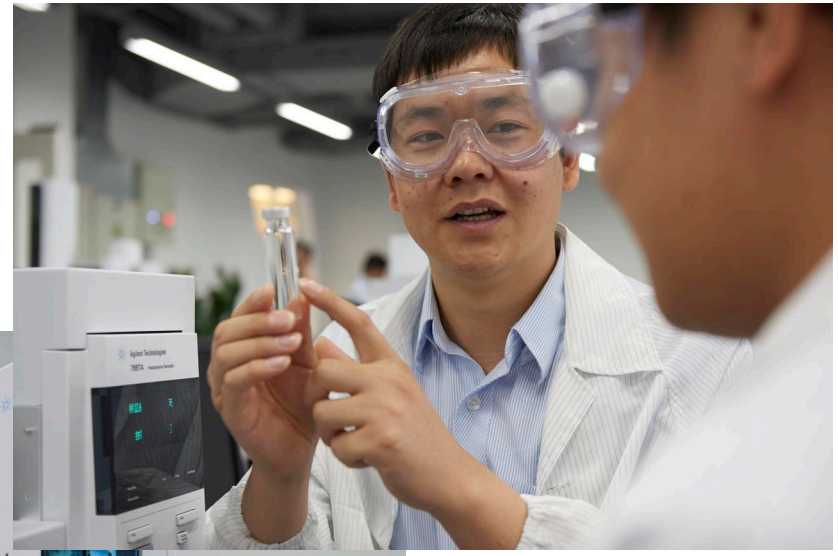
Headspace

Purge & trap

Gas sampling valve

SPME

Thermal desorption



Inlets

Liners

Purpose of liners

- Provide an “inert” space for liquid samples to vaporize

Key aspects

- Liner Volume
- Treatment or deactivation
- Special Characteristics (glass wool or frit, cup, taper, etc.)
- Type of Injection

Inlets

Liners - volume

Choose a liner with enough volume to accommodate the vaporized sample

- Especially important for polar solvents with large vapor volumes
- If vapor volume exceeds liner volume, samples may backflash.
  - May cause ghost peaks and reproducibility issues.

Agilent liners are primarily 2 or 4 mm in inner diameter and 78 mm long.

- Therefore:
  - 2 mm liners hold ~ 0.245 mL or 245 µL of vapor
  - 4 mm liners hold ~ 0.972 mL or 972 µL of vapor

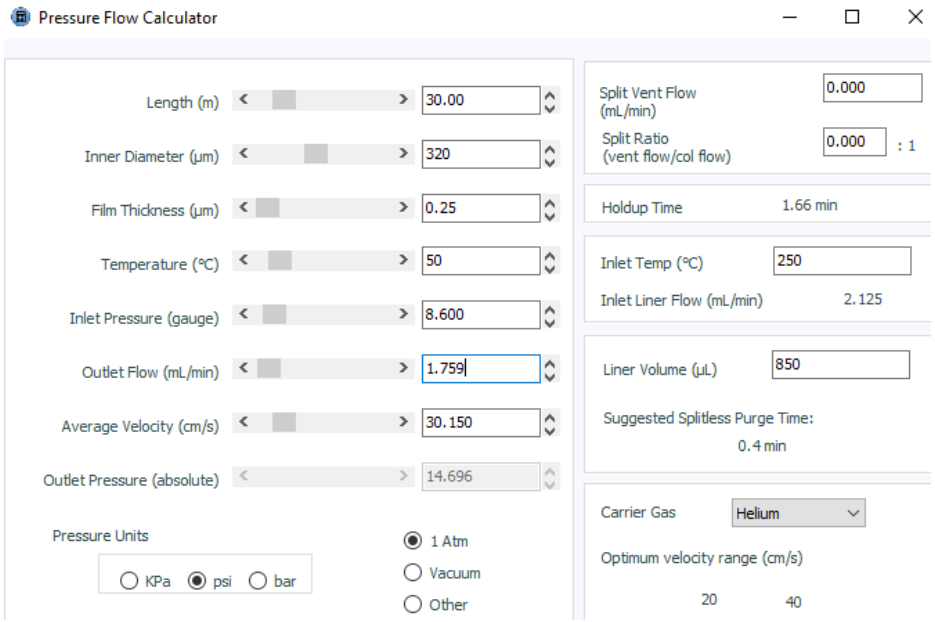
Recommended injection volumes are 1–2 µL or less for organic solvents and 0.5 µL for water.

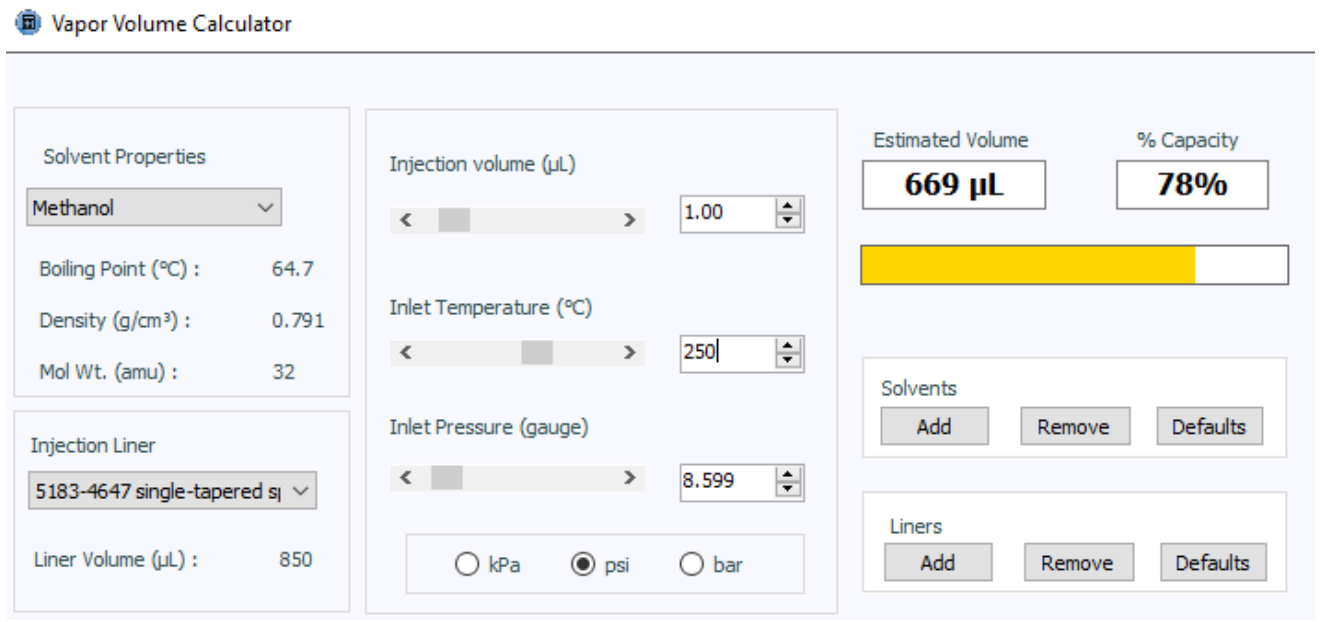
Inlets

Liners - volume

How do we calculate the vapor volume?

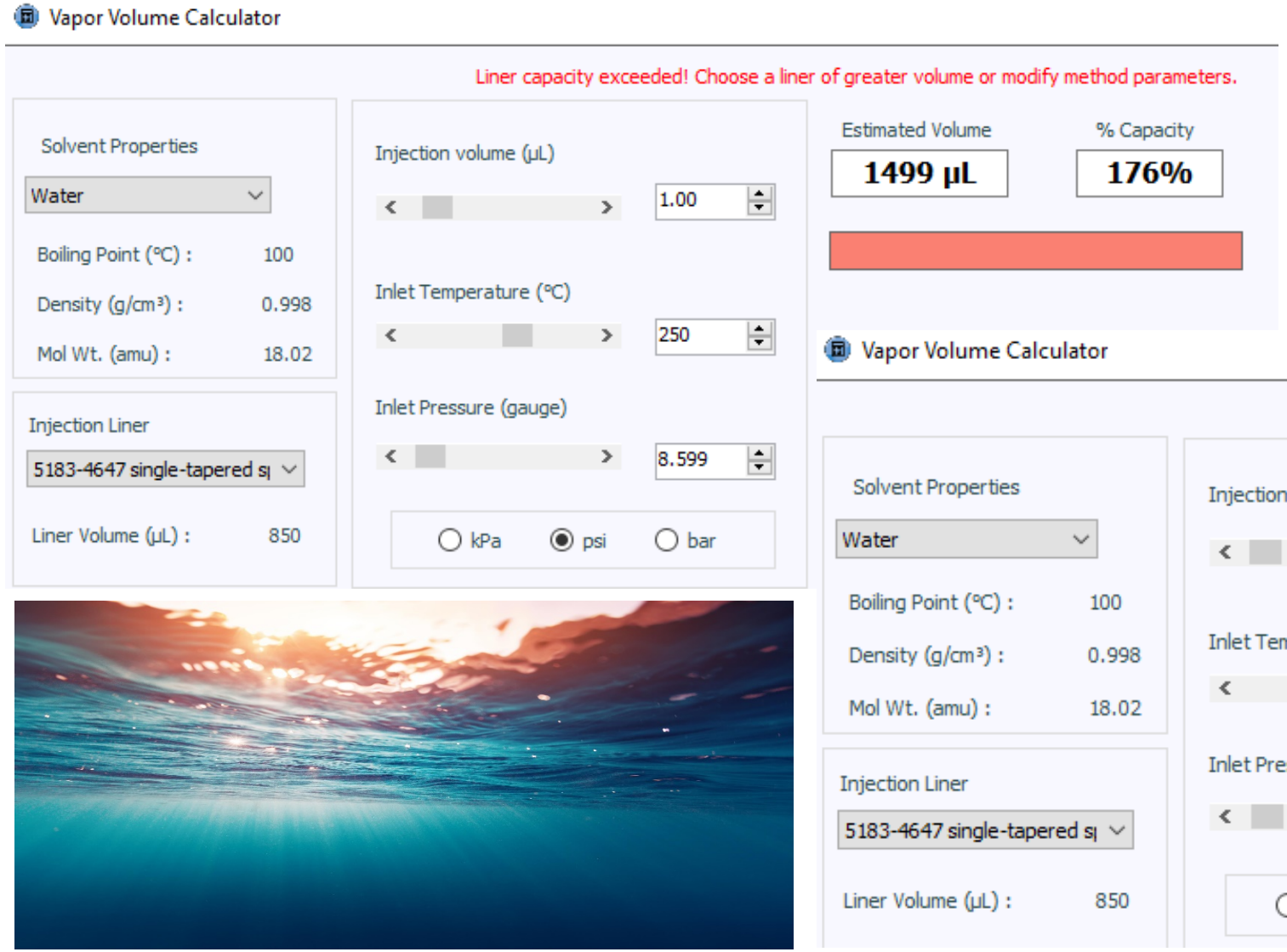
- Pressure / Flow calculator
  - Free download from https://www.agilent.com/en-us/support/gas-chromatography/gccalculators
  - Also built in to recent versions of Agilent GC software

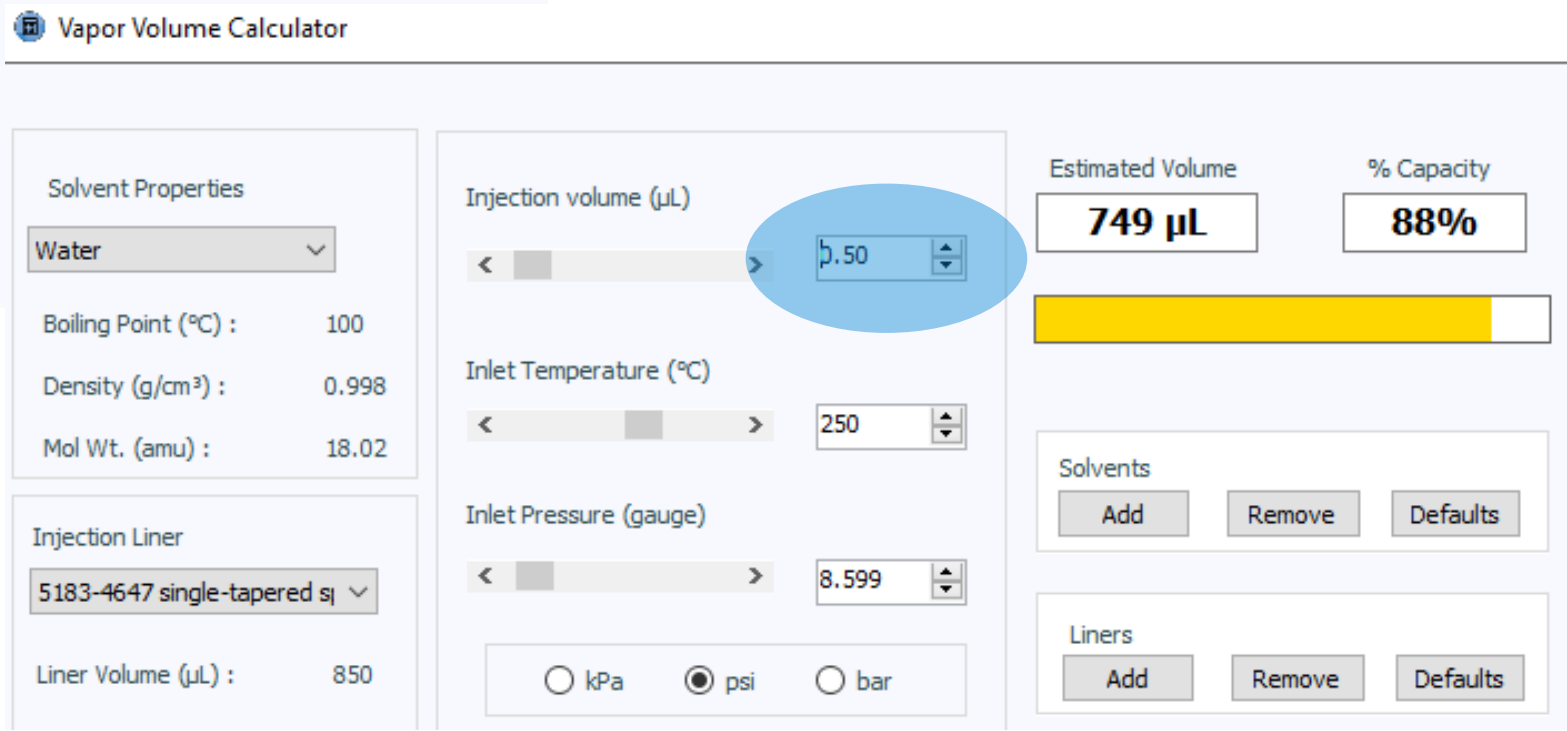




Inlets

Backflash





Water as a solvent:

Watch injection volumes, keep at 0.5 µL or less.

Inlet

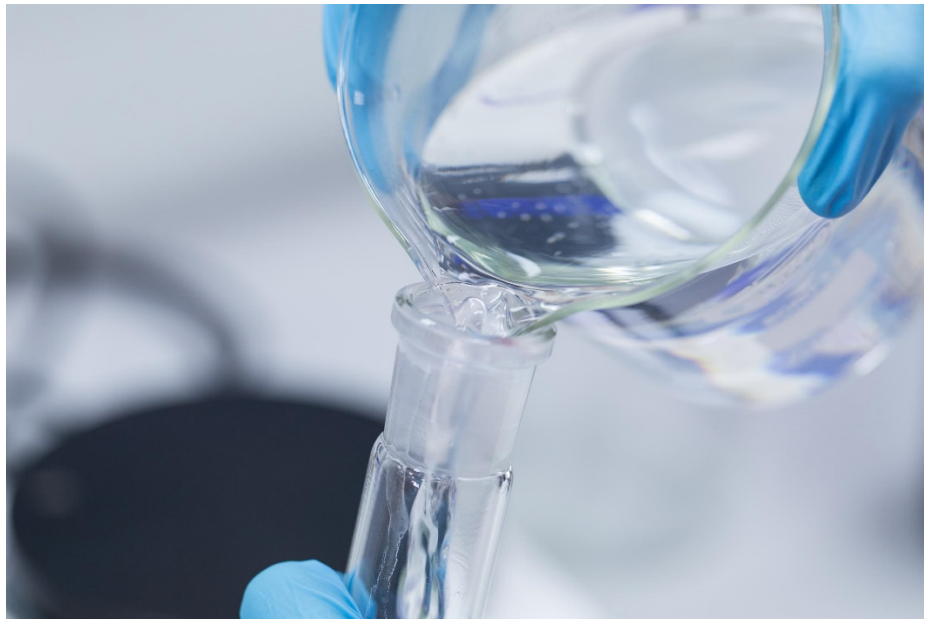
Liners - deactivation

Minimize adsorption of active compounds to surfaces

- Unwanted adsorption can lead to poor peak shape and lower response
  - Deactivated liners are usually treated with a silylating reagent

Agilent has a few different deactivation options:

- Ultra inert
- Original
- None



Inlet

Liners – Special Characteristics

Some liners have special features required for different injection techniques

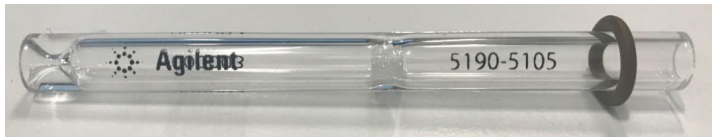
- Taper (gooseneck) – minimize sample contact with gold seal
- Dual taper – minimizes contact with gold sea, inlet weldment, and reduces potential for backflash
- Glass wool/frit – Prevents nonvolatiles from reaching column, helps with vaporization of heavier compounds, and can help to remove residual sample from needle (split liners)
- Jennings cup – Used for sample mixing in split inlets, reduces sample discrimination, prevents nonvolatiles from reaching the column. For clean samples
- Press fit (direct) connection – Bottom is designed to hold capillary column firmly (almost all sample goes onto the column). Side hole required for EPC with Direct Connect liners.
- Others
  - Baffles, spiral paths, laminar cups, column packings with stationary phase
    - All provide a turbulent sample flow path for mixing, a way to collect high molecular weight sample components or particles, surface area to allow efficient vaporization of sample components.

Inlet

Liners – wool/glass frit

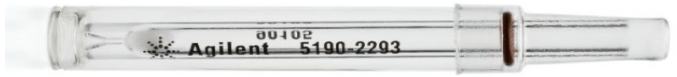
Placement

- Near the top
  - Wipes syringe needle
  - Can improve injector precision
  - Helps to prevent backflash
  - Assists in volatilization of heavy compounds in split injections



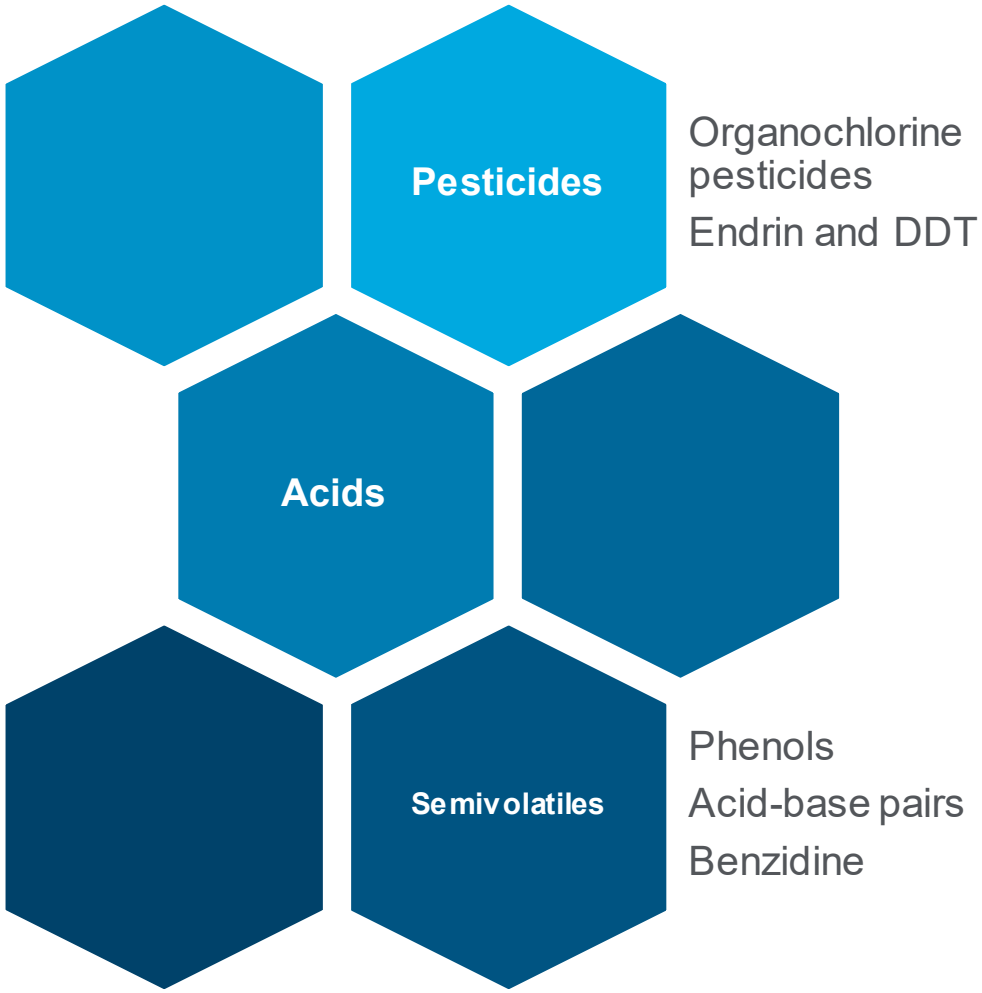
- Near the bottom
  - Helps in volatilization of heavy compounds in splitless injections
  - Increases mixing

- Both
  - Prevent particulates from getting onto the column head



The Benefits of the Glass Frit

Dislodged glass wool fibers expose active sites that interact with sensitive analytes



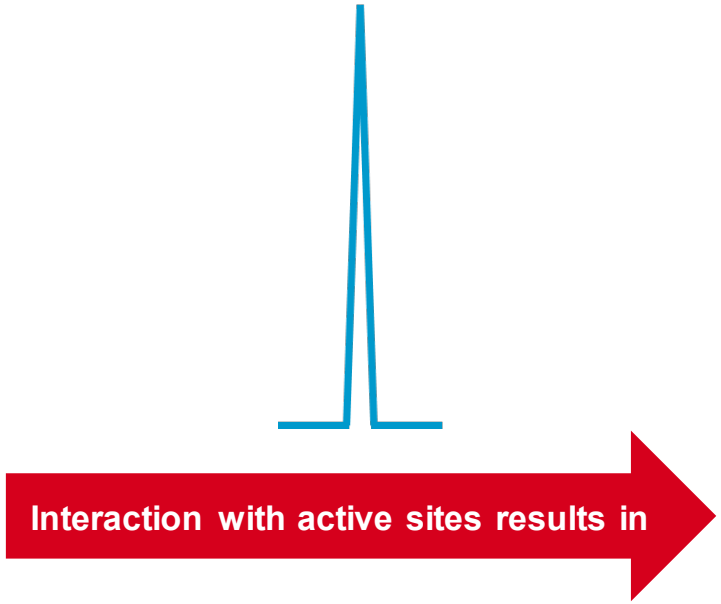
Organochlorine pesticides

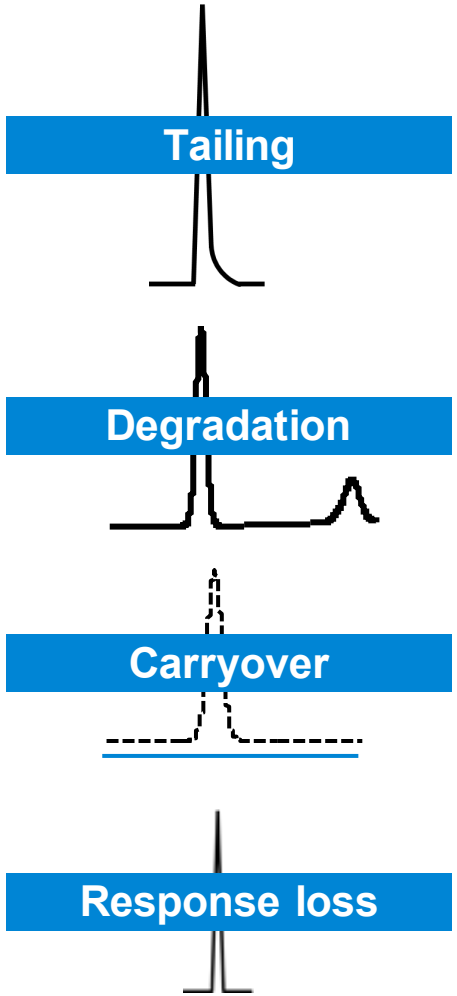
Endrin and DDT

Phenols

Acid-base pairs

Benzidine





Inlets

Inlet	Column	Mode	Sample Concentration	Comments	Sample to Column
Split/ Splitless	Capillary	Split Purged split Splitless Purged splitless	High High Low Low	Most commonly used inlet. Very flexible	Very little Very little All All
Cool-on-column	Capillary	N/A	Low or labile	Minimal discrimination and decomposition	All
Packed	Packed large capillary	N/A N/A	Any Any	OK if resolution is not critical	All All
Programmed temperature vaporization	Capillary	Split Pulsed split Splitless Pulsed splitless Solvent vent	High High Low Low Low	Not great for hot injections Can concentrate analytes and vent solvent	Very little Very little All All Most
Volatiles interface	Capillary	Direct Split Splitless	Low High Low	Purge and Trap/Headspace	All Very little All
Multimode	Capillary	Split Pulsed split Splitless Pulsed splitless Solvent vent	High High Low Low Low	Flexibility of standard SSL inlet and PTV	Very little Very little All All Most

Split Injection
Overview

Small Fraction of the sample is introduced into the column

Used for high concentration samples

Superior injection efficiency = narrow peaks = high resolution

Split Injection
Major variables

Split ratio – determines the fraction of sample on-column and efficiency of injection (sensitivity versus peak width)

Liner – influences efficiency of vaporization/discrimination

Temperature – hot enough to vaporize sample without degradation or causing backflash

Injection volume – typically 0.2–2 µL, increasing it does not have as much of an effect as one might think (smaller is usually always better provided you can meet RSD requirements)

Split Injection

Split ratios

- Too low
  - Poor peak shape
  - Column overload
  - Inlet shut down*
- Too high
  - Poor sensitivity
  - Wastes carrier gas (use gas saver!)
- Usually nonlinear
  - Cannot use split ratio as a “dilution factor”

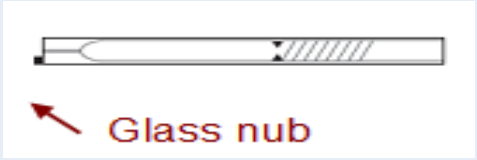
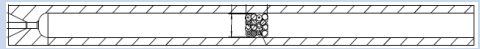
Higher flow rates

Id (mm)	Lowest ratio*
0.10	1:50 - 1:75
0.18 - 0.25	1:10 - 1:20
0.32	1:8 - 1:15
0.53	1:2 - 1:5

*keep total inlet flow ≥ ~20 ml/min to prevent inlet shut-down

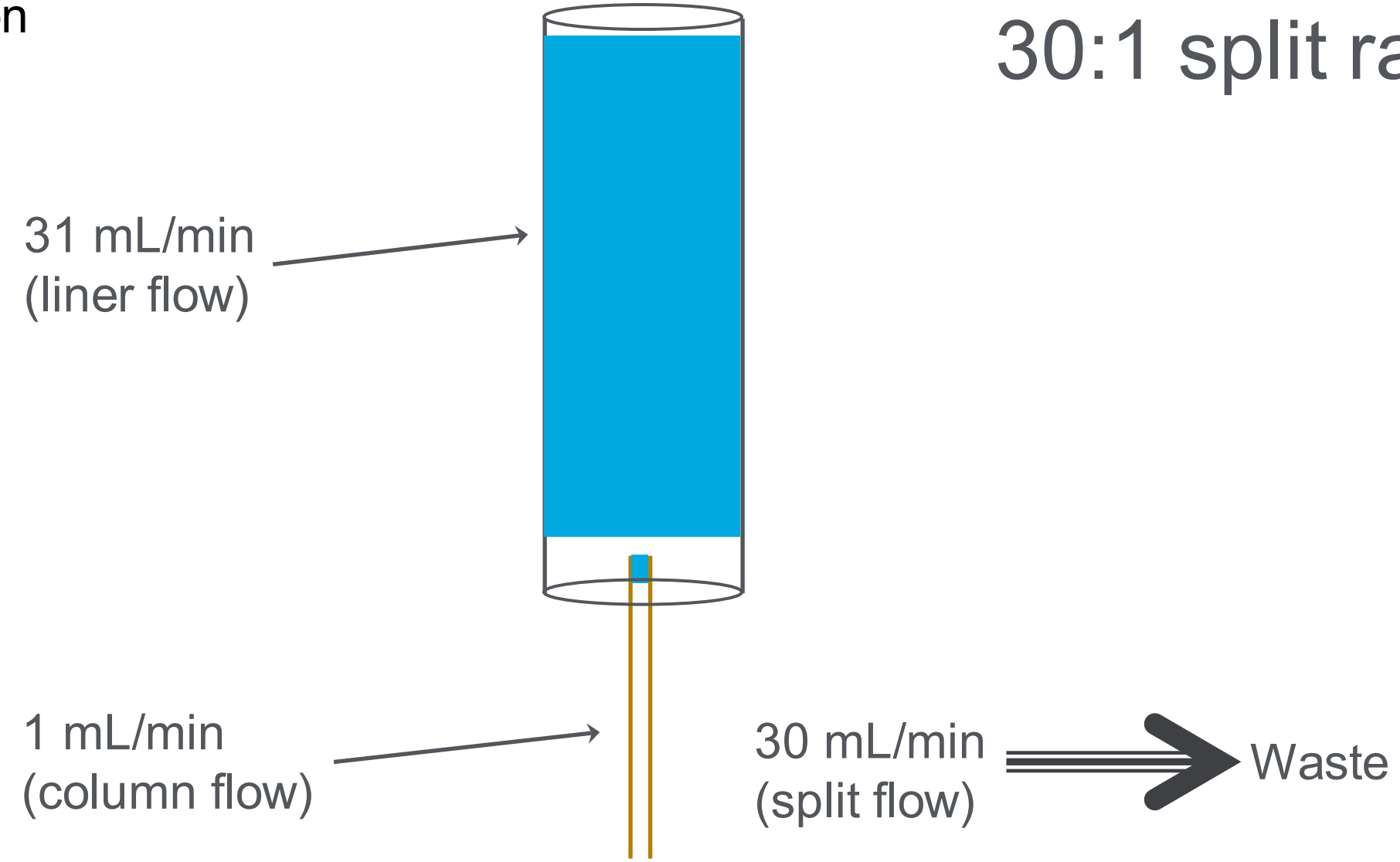
Inlet

Liners – split injection

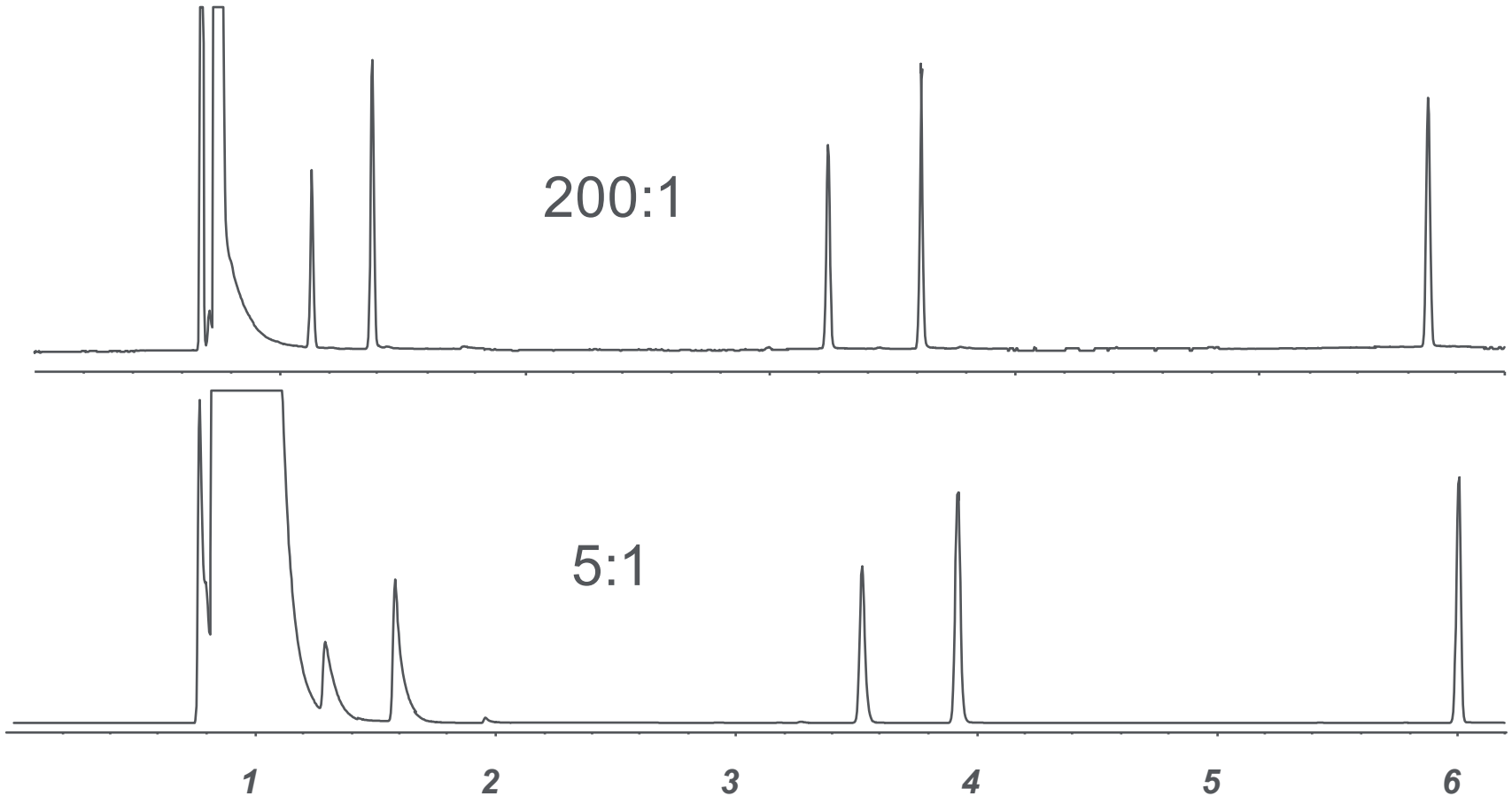
Liner	Part Number Each 5/pk 25/pk	Comments
	5190-2294 5190-3164 5190-3168	Simplest split liner, glass wool, UI deactivation, large volume (990 µL). Use for general purpose, can be used in splitless mode
	5190-2295 5190-3165 5190-3169	Glass wool, UI deactivation, 870 µL volume. Glass nub ensures that a gap remains below liner for split injection. Efficient for most applications
	5190-5105 5190-5105-005 5190-5105-025	Sintered glass frit, UI deactivation. Ideal for basic drugs analysis. Sintered glass frit more reproducible than glass wool.
	18740-80190	Liner with Jennings cup, no wool. 800 µL volume. Reduces inlet discrimination.

Split Injection

Animation



Split Injection - 200:1 versus 5:1



DB-1, 15 m x 0.25 mm id, 0.25 µm
60 °C for 1 min, 60–180 °C at 20°/min; Helium at 30 cm/sec
1. n-heptane 2. toluene 3. n-decane 4. n-butylbenzene 5. n-tridecane

Splitless Injection

More challenging the SPLIT

Most of the sample is introduced into the column

Used for low concentration samples

Poor injection efficiency = wider peaks = less resolution

Sample refocusing may be necessary

Splitless Injection

For trace level analysis

- Use split/splitless injection port in the splitless mode (split vent closed)
- The dilute sample is injected, the sample is volatilized, and most of the analytes and solvent are introduced to the column
- Later, the split vent is opened and residual solvent is vented (purge time/flow)
- Timing, carrier/split vent flows, and the oven temperature program are important
- Sample has longer residence time in the heated inlet giving more opportunity to vaporize high boiling sample components compared to split injection
- Typical splitless parameters:
  - Purge flow of 50 mL/min
  - Purge time of 0.5–2.0 minutes

Splitless Injection
Major variables

Purge activation time – determines amount of sample onto column and efficiency of injection (sensitivity versus peak shape)

Liner – preventing backflash more critical than vaporization properties (liner volume, tapers, and wool are less important…)

Injection volume – typically 1 µL or less (backflash: 0.5 µL max for water!)

Temperature – long residence times allow for lower temperatures

Inlet

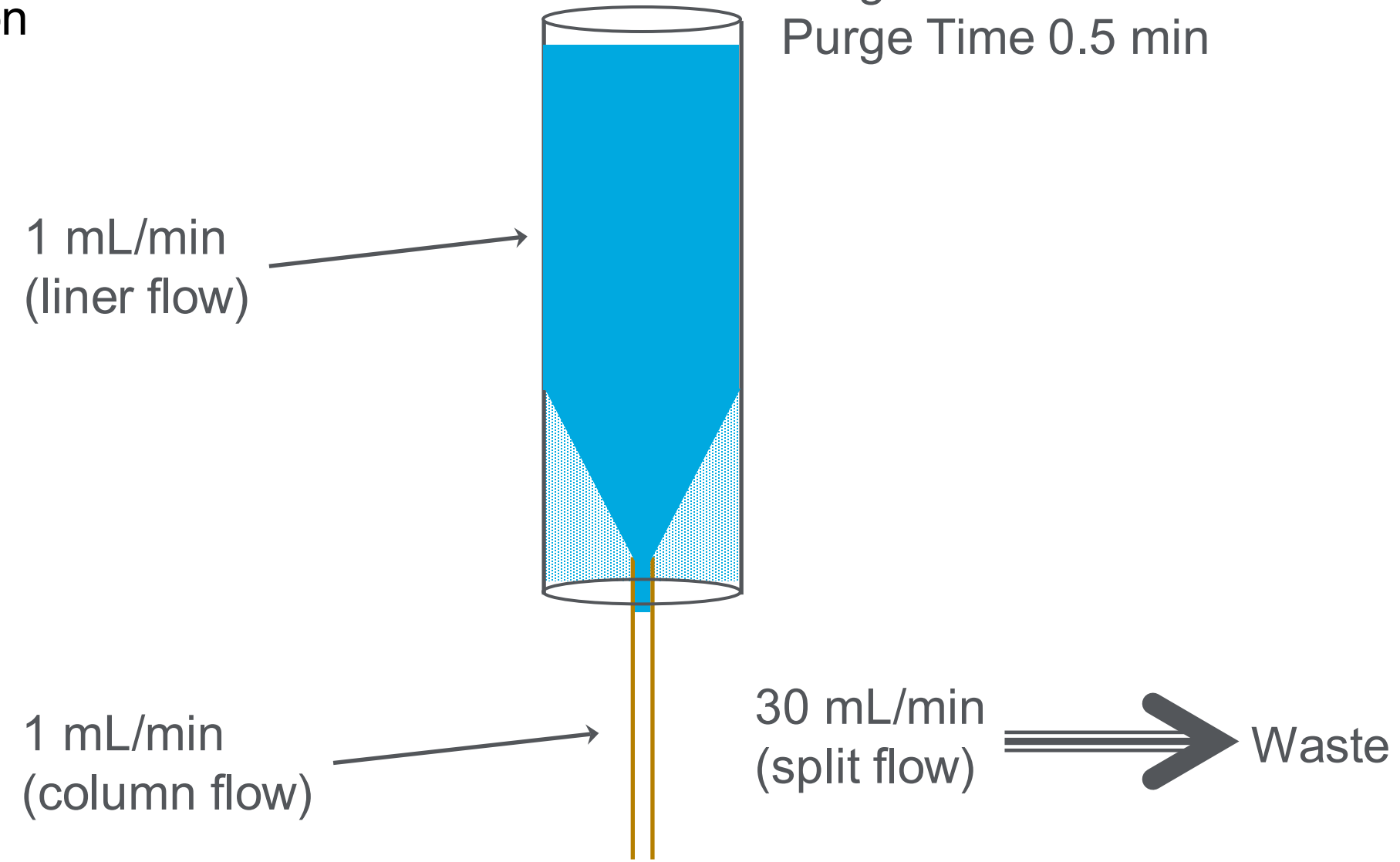
Liners – splitless injection

Liner	Part Number Each 5/pk 25/pk	Comments
	5190-2292 5190-3162 5190-3166	Single taper, UI deactivated, 900 µL volume. Taper isolates sample form gold seal, reducing breakdown of active compounds. Trace samples, general applications.
	5190-2293 5190-3163 5190-3167	Single taper, UI deactivated, glass wool, 900 µL volume. Glass wool aides with volatilization of heavier compounds and protects the column. Trace, dirty samples.
	5190-5112 5190-5112-005 190-5112-025	Singer taper, UI deactivated, sintered glass frit. Glass frit acts like glass wool but is more reproducible.
	5190-3983 5190-4007 ****_****	Double taper, UI deactivated, 800 µL volume. Taper on inlet reduces backflash. High efficiency for trace, active samples.
	5190-7011 (5/pk) 5190-7012 (5/pk) 5190-7013 (5/pk) 5190-7014 (5/pk) 5190-7020 (5/pk)	Direct Connect liners, single and dual taper, original deactivation. Column press fits into liner. Focuses almost all sample onto column and reduces exposure to inlet. Ultimate for trace, active samples. Various hole placements for use with EPC

Splitless Injection

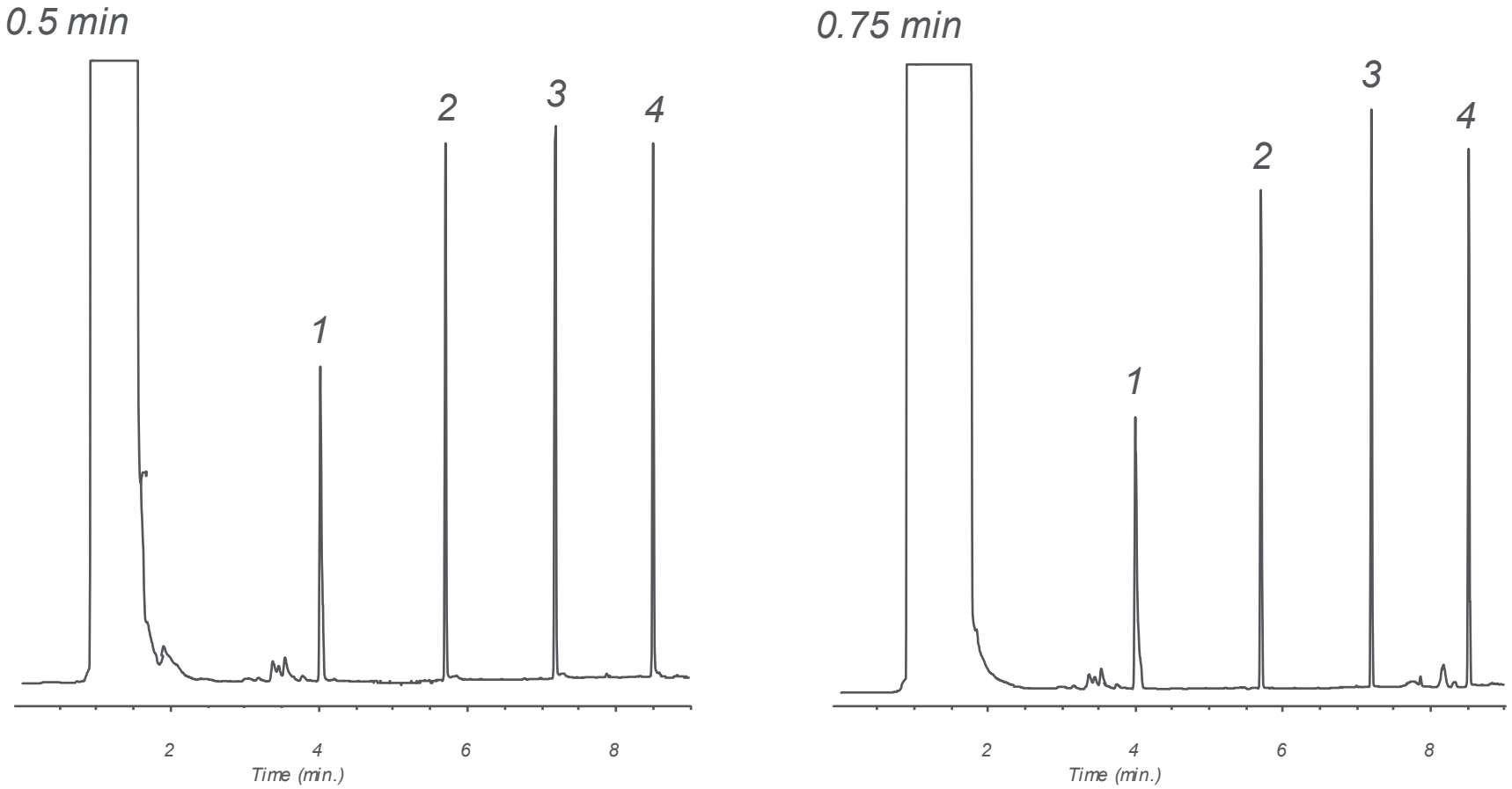
Animation

Purge flow 30 mL/min
Purge Time 0.5 min



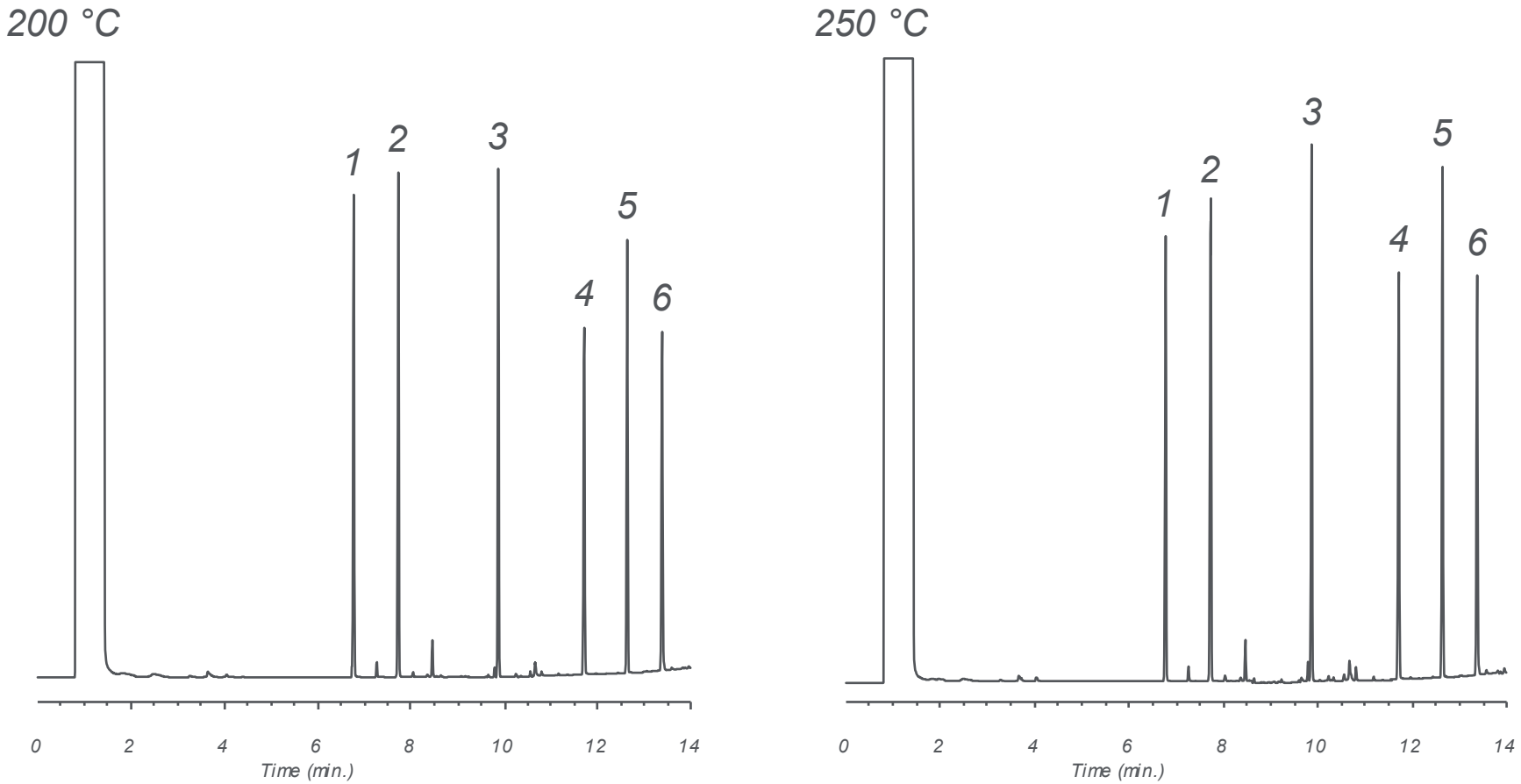
Splitless Injection

Purge activation time



DB-1, 15 m x 0.25 mm id, 0.25 µm
60 °C for 1 min, 60-180 °C at 20°/min; Helium at 30 cm/sec
1. n-decane 2. n-dodecane 3. n-tetradecane 4. n-hexadecane

Splitless injection
Injector temperature



DB-1, 15 m x 0.25 mm id, 0.25 µm
50 °C for 0.5 min, 50-325 °C at 20°/min; Helium at 30 cm/sec
Phthalates: 1. dimethyl 2. diethyl 3. dibutyl 4. benzyl butyl 5.bis(2-ethylhexyl) 6. dioctyl

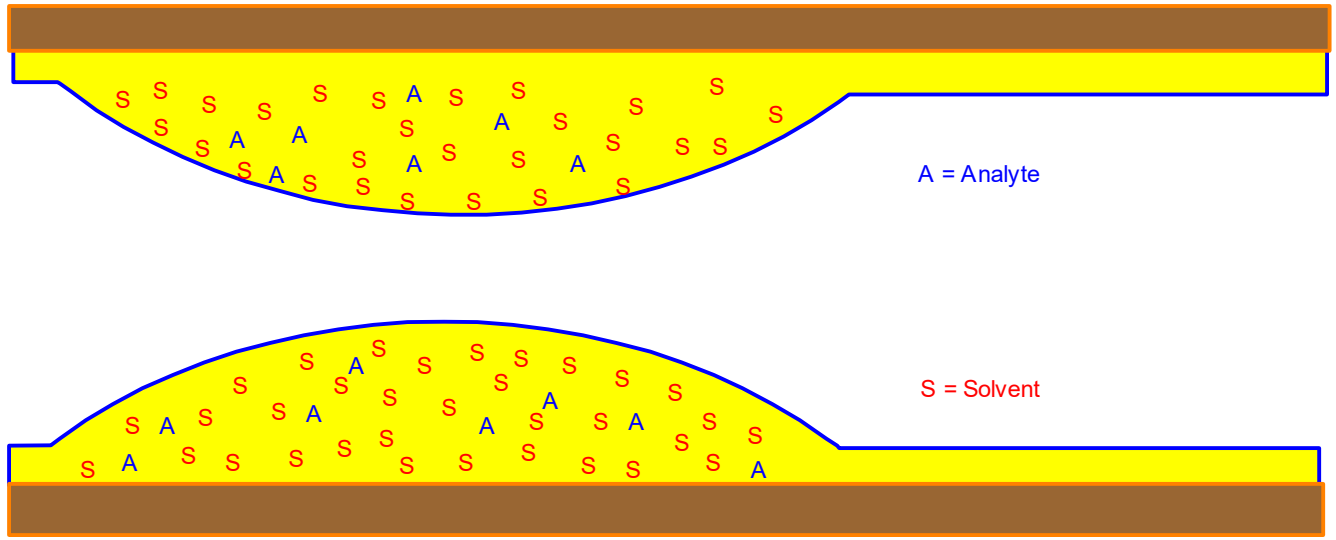
Splitless injection
Sample refocusing

Sample refocusing improves efficiency

Use low column temperature to refocus solvent - called the *solvent effect*

Use cold trapping

The Splitless “Solvent” Effect



The initial oven temperature is set below the boiling point of the solvent.

The solvent condenses at the head of the column swelling the stationary phase and trapping the analyte.

Solvent	Boiling point (°C)	Initial oven temperature (°C)
Dichloromethane	40	**10–30**
Chloroform	61	**25-50**
Carbon disulfide	46	**10-35**
Diethyl ether	35	**10–25**
Pentane	36	**10–25**
Hexane	69	**40–60**
Iso-octane	99	**70–90**

Solvent and stationary phase must be compatible

Splitless injection

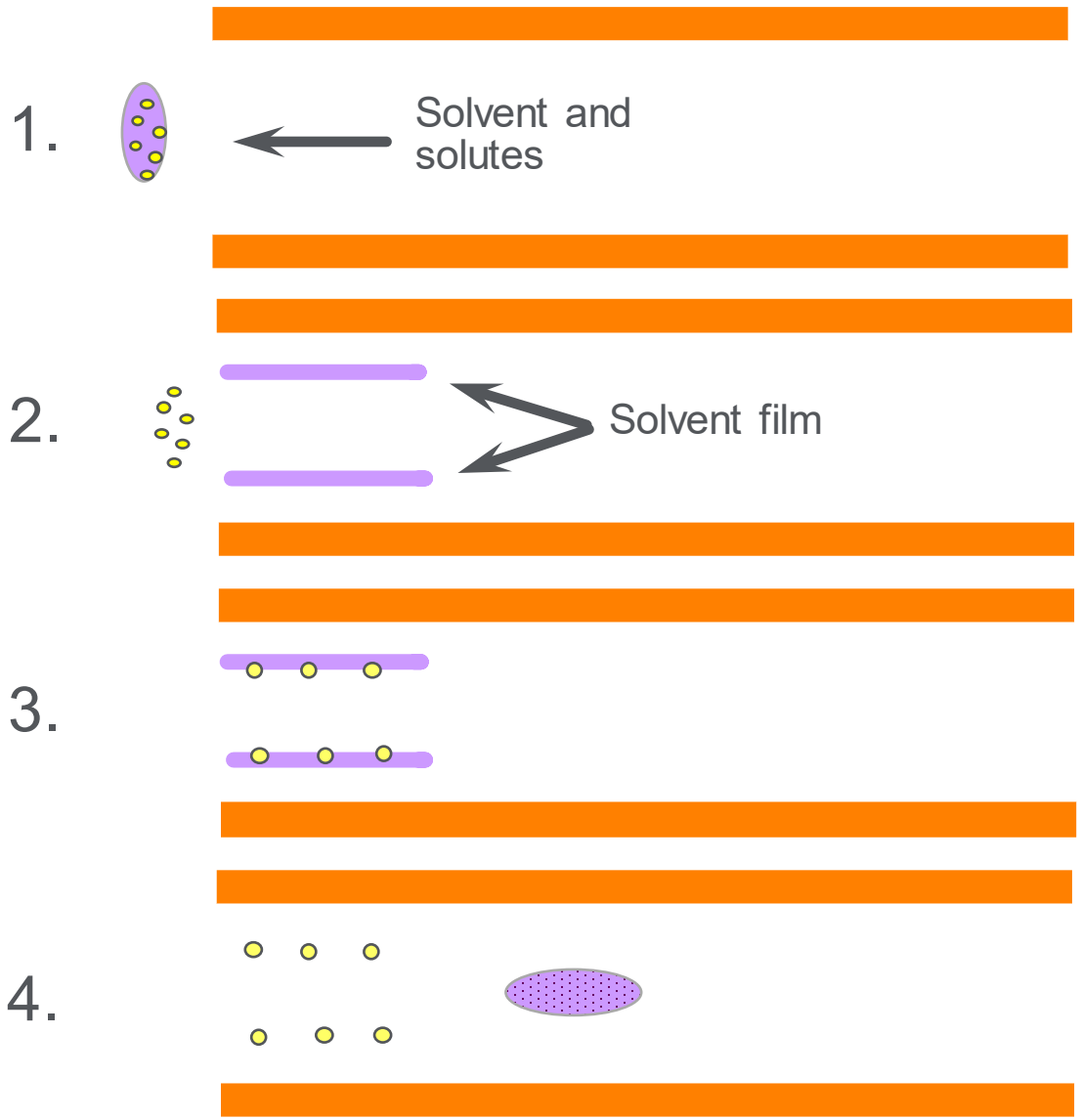
Solvent effect

Initial column temperature at least **10 to 20 °C below** sample solvent boiling point

Required to obtain good peak shapes unless cold trapping occurs

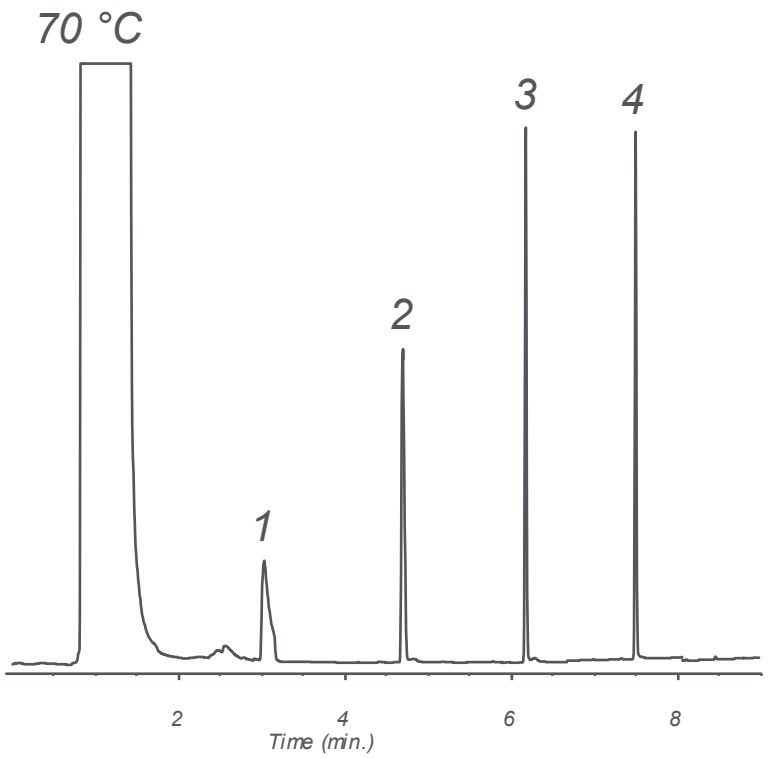
Rule of thumb, if solute boiling point > 150 °C above initial column temperature, the solute will cold trap

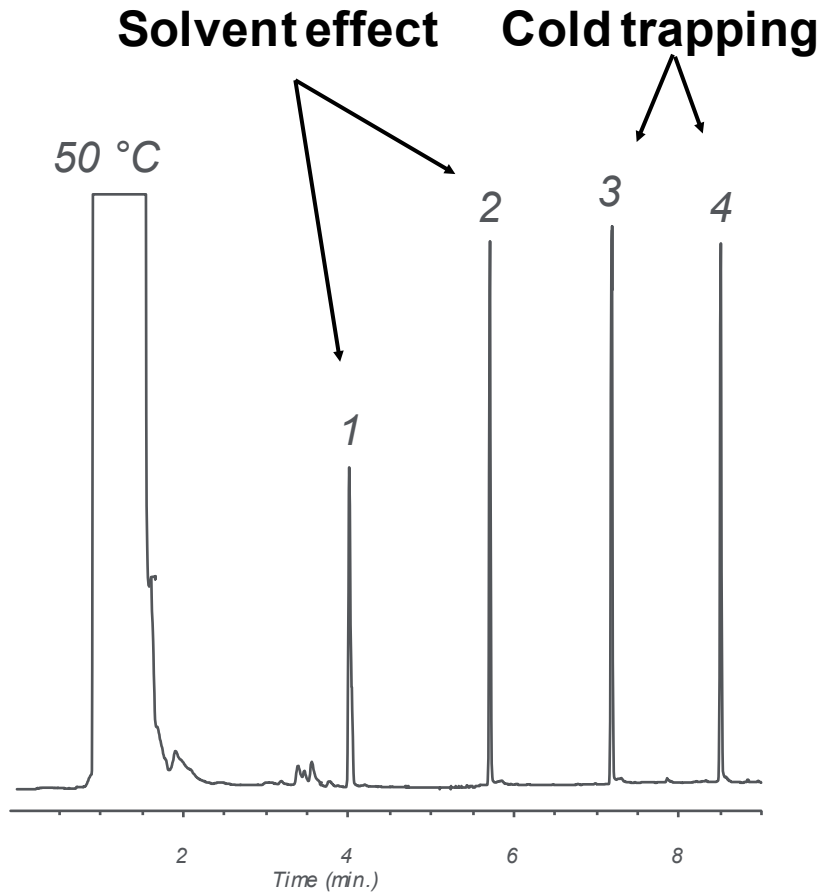
Cold trapping has greater efficiency than solvent effect



Splitless Injection
Initial column temperature

Hexane Solvent (boiling point = 68–69 °C)





DB-1, 15 m x 0.25 mm id, 0.25 µm
50 °C or 70 °C for 0.5 min, to 210 °C at 20 °C/min; Helium at 30 cm/sec
1. n-decane 2. n-dodecane 3. n-tetradecane 4. n-hexadecane

GC Column - Selectivity

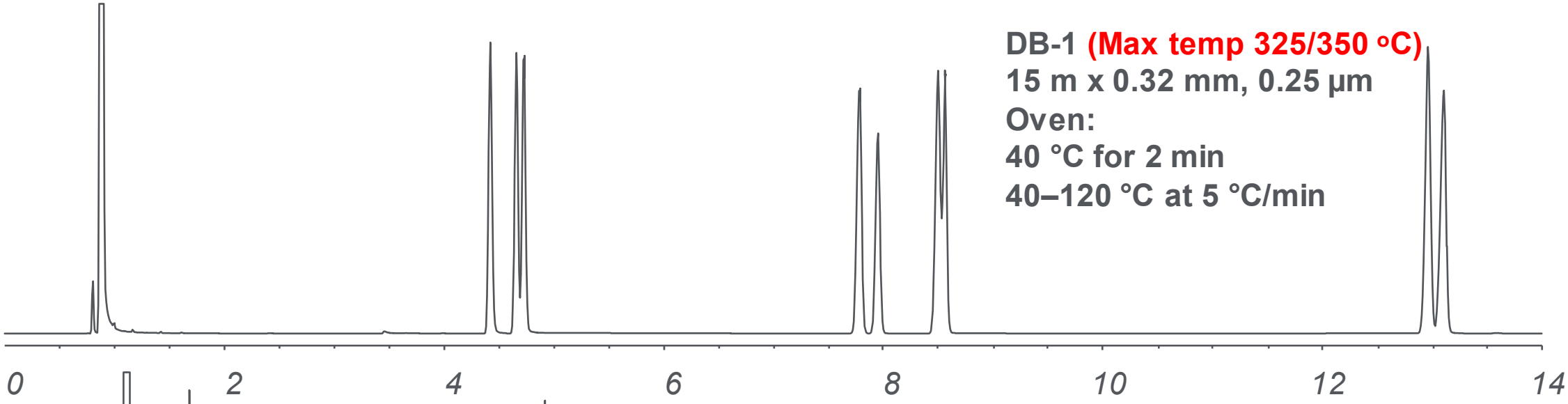
Selecting the correct column

- Use pre-existing methods as a reference
  - Application notes, posters, established methods
- Column temperature limits are a good indicator of over-all column stability (non-polar are more stable than polar)
- Choose the most non-polar/stable column available that will still resolve your analytes
- For more complex mixtures, match analyte polarity to column polarity (i.e. *"like dissolves like."*)
- For even tougher separations, look for unique interactions that analytes may have with a phase

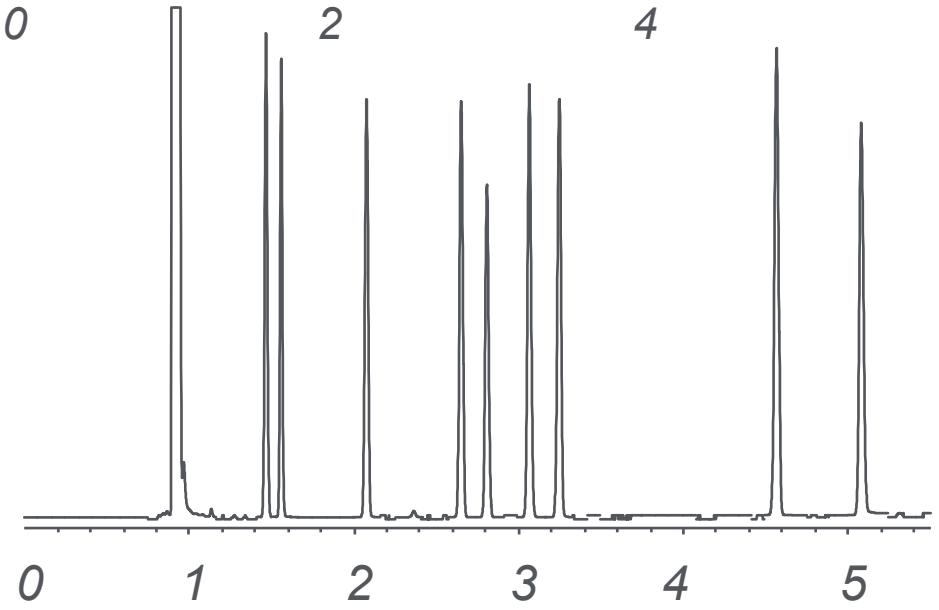
Use the Agilent GC Application Support Team

- gc-column-support@agilent.com
- 800-227-9770; options 3, 3, 1

Start with the Right Phase – “Like Dissolves Like”



DB-1 (Max temp 325/350 °C)
15 m x 0.32 mm, 0.25 µm
Oven:
40 °C for 2 min
40–120 °C at 5 °C/min



DB-Wax (Max Temp 250/260 °C)
15 m, 0.32 mm, 0.25 µm
Oven:
80–190 °C at 20 °C/min

Generally match analyte polarity to stationary phase polarity, but not always necessary

For tougher separations, take advantage of unique interactions between analyte and stationary phase functional groups

“New” J&W DB-HeavyWAX

The WAX Column You’ve Been Waiting For!

- ✓ Increased temperature range
  - ✓ **280°C Isothermal**
  - ✓ **290 °C Programmed**
- ✓ Increased Thermal stability
- ✓ Lower Bleed

www.agilent.com/chem/db-heavywax

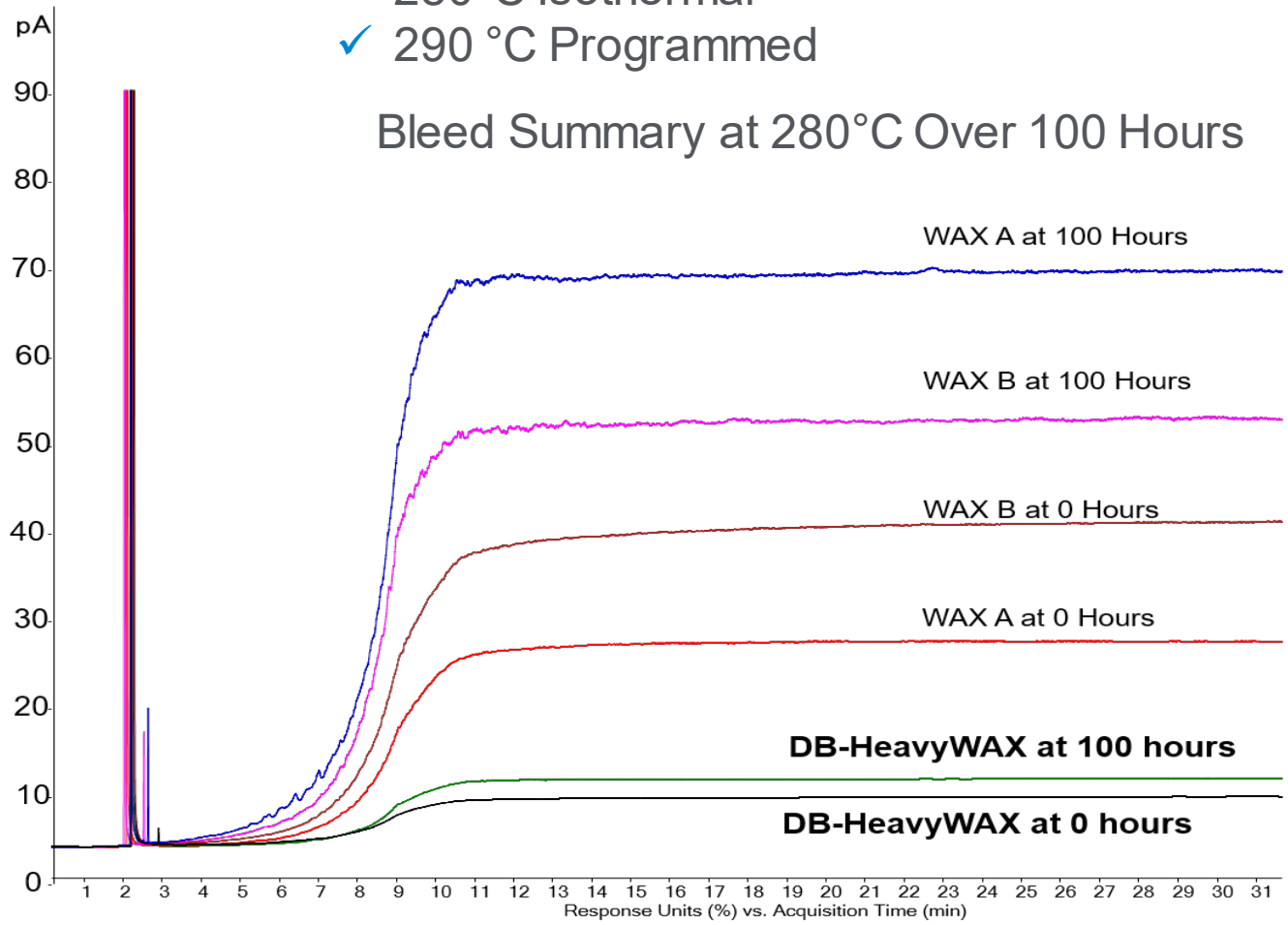
Benefits of the J&W DB-HeavyWAX

- Increased Thermal Stability
  - Stable Retention Times
  - Consistent Peak Order
- Deceased Column Bleed
  - Greater sensitivity for “heavier” compounds
  - Increase analyte range
  - Decrease analysis time
  - Safely bake out column
    - Up to 290°C
- Behaves like a WAX because it is a WAX
  - Simpler method translation

Increased Temperature Range

- ✓ 280°C Isothermal
- ✓ 290 °C Programmed

Bleed Summary at 280°C Over 100 Hours



Increased Thermal Stability + Decreased Column Bleed = Longer Lifetime

GC Column - Dimensions

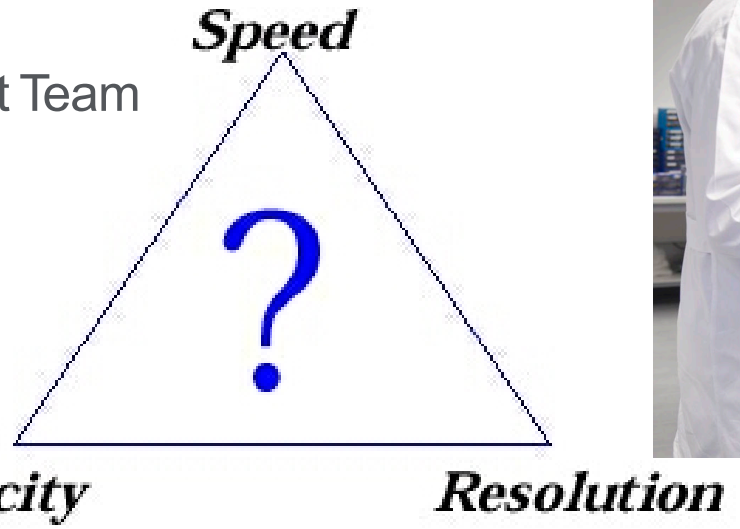
Selecting the correct column

- Larger diameters columns have more capacity, but they are less efficient (wider peaks = less resolution)
- Longer columns are more efficient, but result in longer run-times
- Narrower columns are more efficient, but have less capacity
- Thicker film columns will help resolve volatiles/early eluting analytes

Again, use the Agilent GC Application Support Team

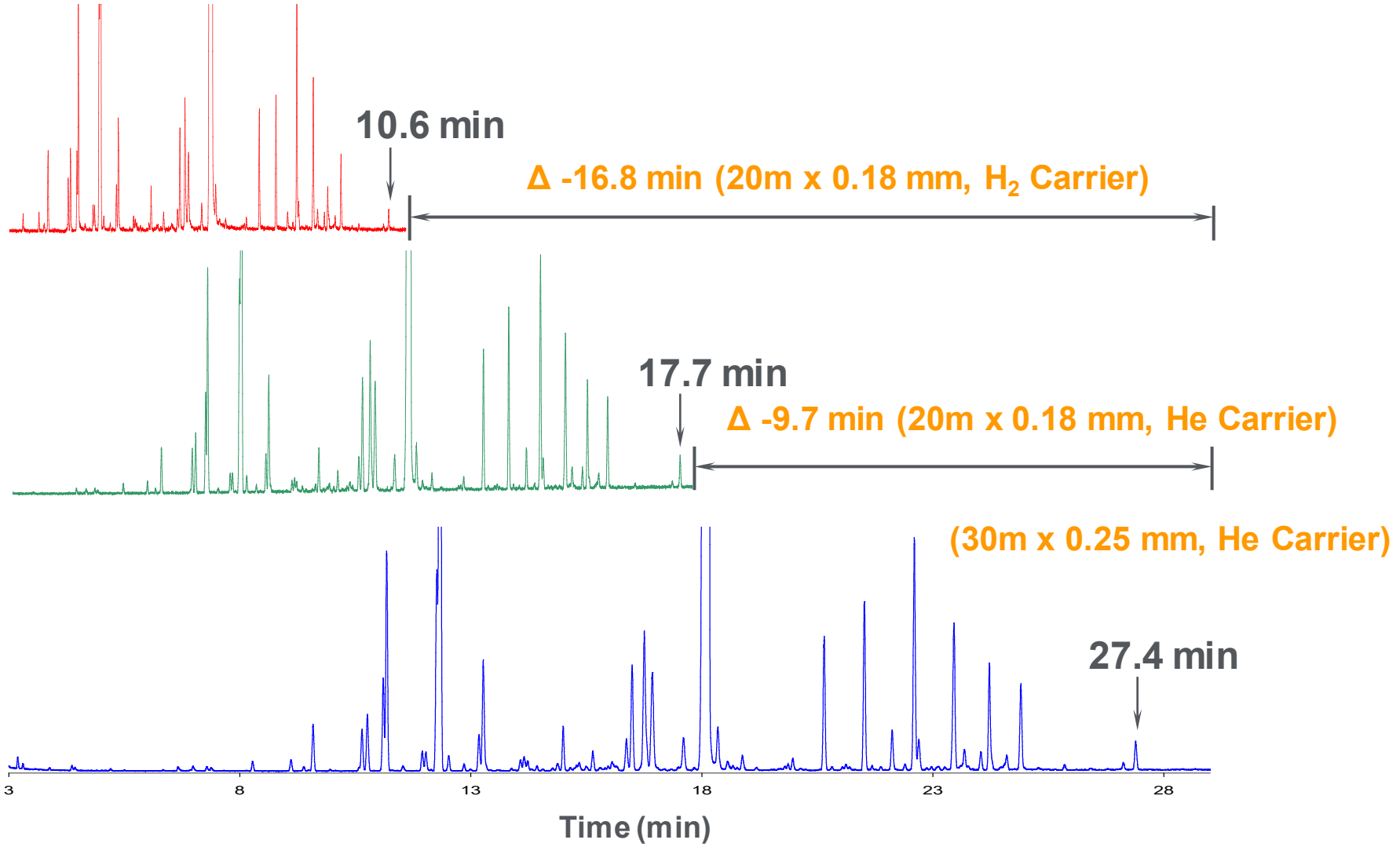
- gc-column-support@agilent.com

- 800-227-9770; options 3, 3, 1.



Column dimensions webinar:
https://agilenteseminar.webex.com/agilenteseminar/lsr.php?RCID=b21639d8d4abf46753fe3a1af3d2743b
Fast GC Webinar:
https://agilenteseminar.webex.com/agilenteseminar/lsr.php?RCID=bbe62a3a03e5d36464af090a64e4db61

The power of manipulating column dimensions/carrier gas



https://agilenteseminar.webex.com/agilenteseminar/onstage/playback.php?RCID=87b891d4848654caf821c246b26918fd

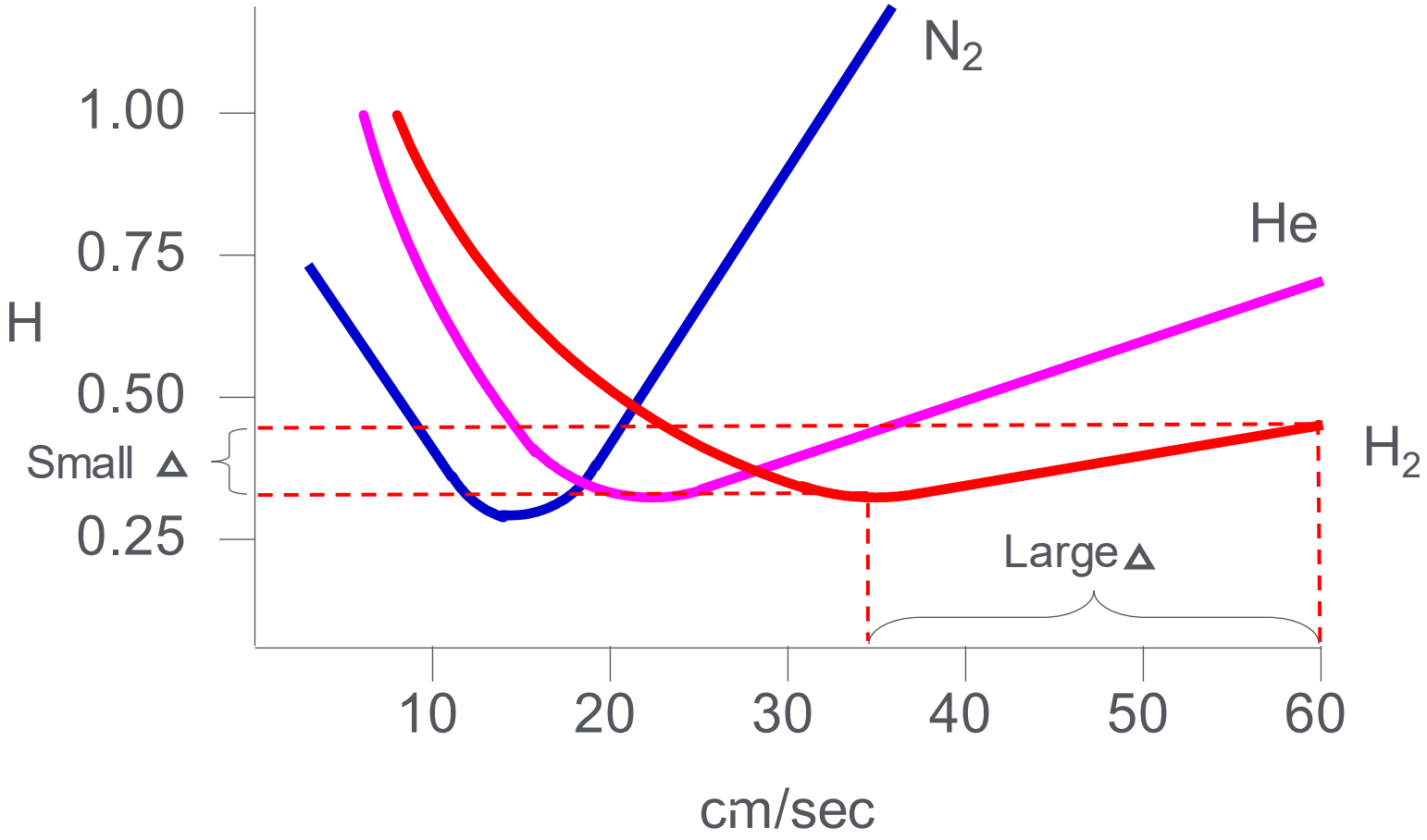
https://agilenteseminar.webex.com/agilenteseminar/onstage/playback.php?RCID=2e666bb9c62e4f623b44061a3480f748

Carrier Gas Considerations

Carries the solutes down the column

Selection and velocity influences efficiency and retention time

Van Deemter Curves

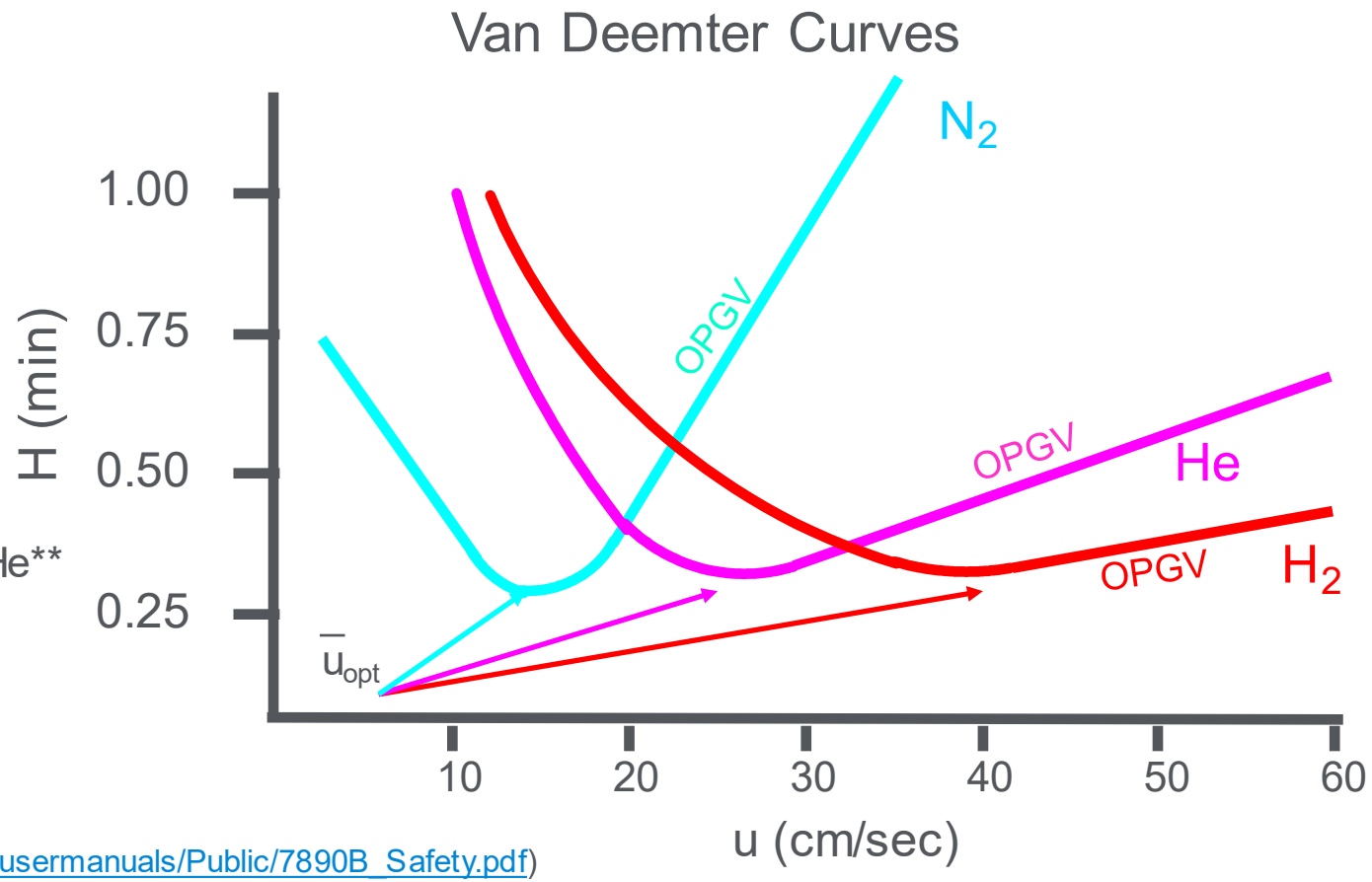


Carrier Gas

Helium
- Reasonably fast analysis
- Good sensitivity with mass spec
- Relatively expensive

Nitrogen
- Cheapest carrier gas
- Can use nitrogen generator
- Slowest speed of analysis
- Smaller Van-Deemter “sweet-spot”
- Can't use with MSD analysis
  - Can be used for periods of non-use to conserve He**

Hydrogen
- Fastest speeds possible
- Can use hydrogen generator
- Fairly inexpensive
- Safety concerns in labs (https://www.agilent.com/cs/library/usermanuals/Public/7890B_Safety.pdf)
- Lower sensitivity with mass spec, possible poor peak shape
- Can be used with MSD, but need to be very careful and generally not recommended**

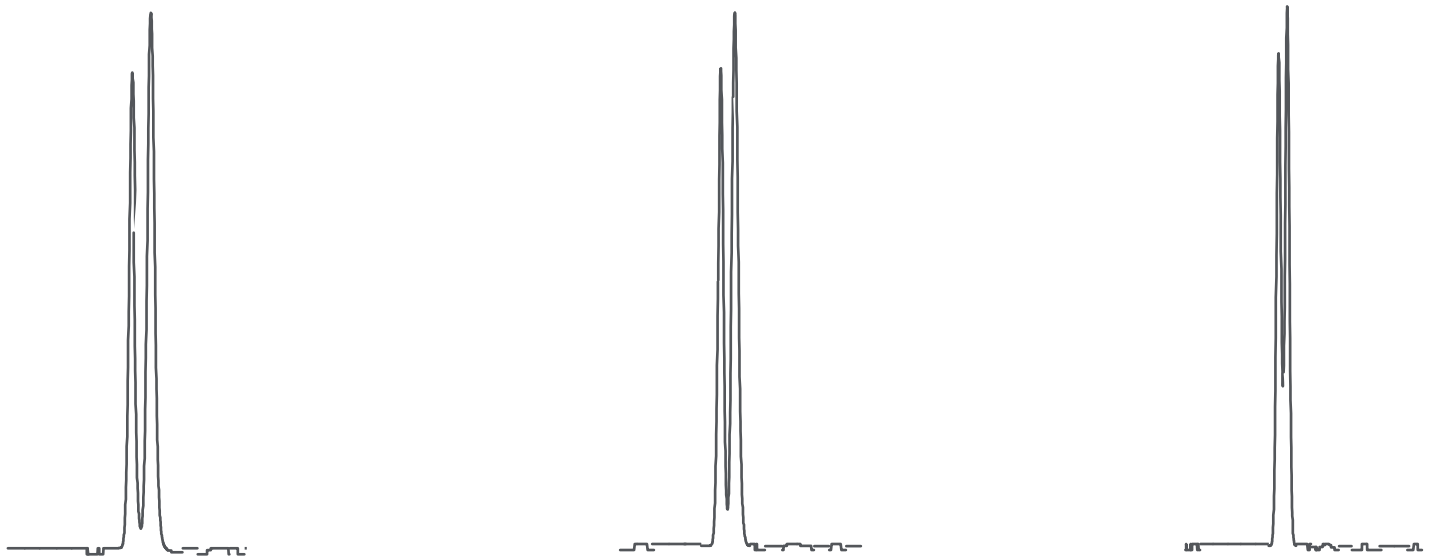


** https://agilenteseminar.webex.com/agilenteseminar/lsr.php?RCID=66ddb3db99b251c776ed947233c8b84b

Resolution versus Linear Velocity

Helium

Resolution of 1.5 = baseline resolution



R = 1.46	R = 1.31	R = 0.97
30 cm/sec	35 cm/sec	40 cm/sec
4.4 psig	5.1 psig	5.8 psig

DB-1, 15 m x 0.32 mm ID, 0.25 um
60 °C isothermal
1,3- and 1,4-Dichlorobenzene

Detectors

A quick overview

Detector	Dynamic Range	Type of Detection	MDL
TCD	10^5	Universal	400 pg Tridecane
FID *	10^7	Responds to C-H bonds	1.8 pg Tridecane
ECD	$5x10^5$	Responds to free electrons	6 fg/mL Lindane
NPD	10^5	Specific to N or P	0.4 pgN/s 0.06 pg P /s
FPD	10^3S, 10^4P	Specific to S or P	60 fg P/s 3.6 pg S/s
SCD	10^4	Specific & Selective to S	0.5 pg S/s
NCD	10^4	Specific & Selective to N	3 pg N/s
MSD		Universal	S/N 400:1 1 pg/µL OFN

* Better sensitivity with N_2 make-up over He

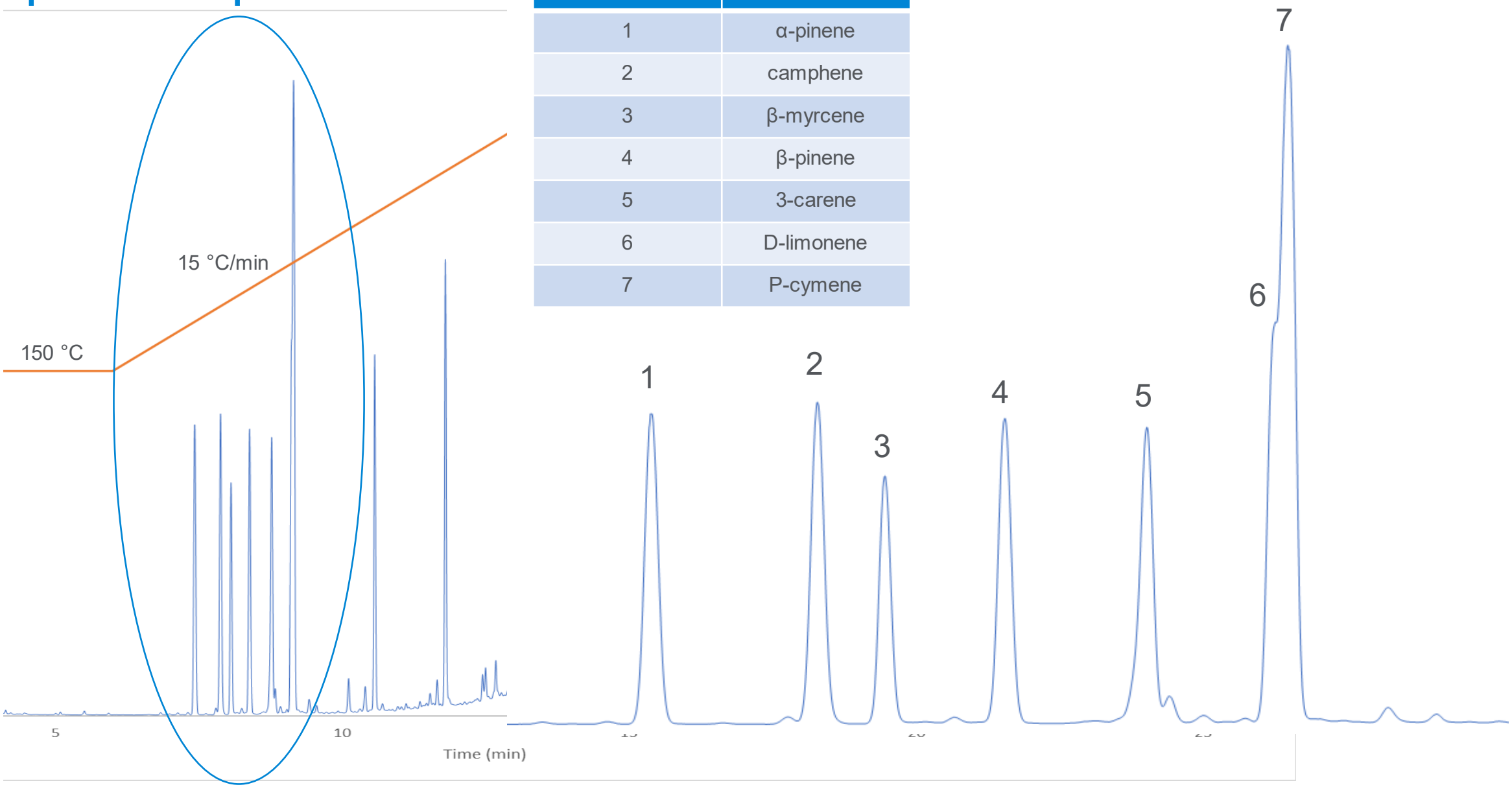
Developing a Temperature Program

Compound List

Peak Id	Terpenes
1	α-pinene
2	camphene
3	β-myrcene
4	β-pinene
5	3-carene
6	D-limonene
7	P-cymene

Terpene Separation

Peak Id	Terpenes
1	α-pinene
2	camphene
3	β-myrcene
4	β-pinene
5	3-carene
6	D-limonene
7	P-cymene



Terpene Separation

Peak id	Terpenes
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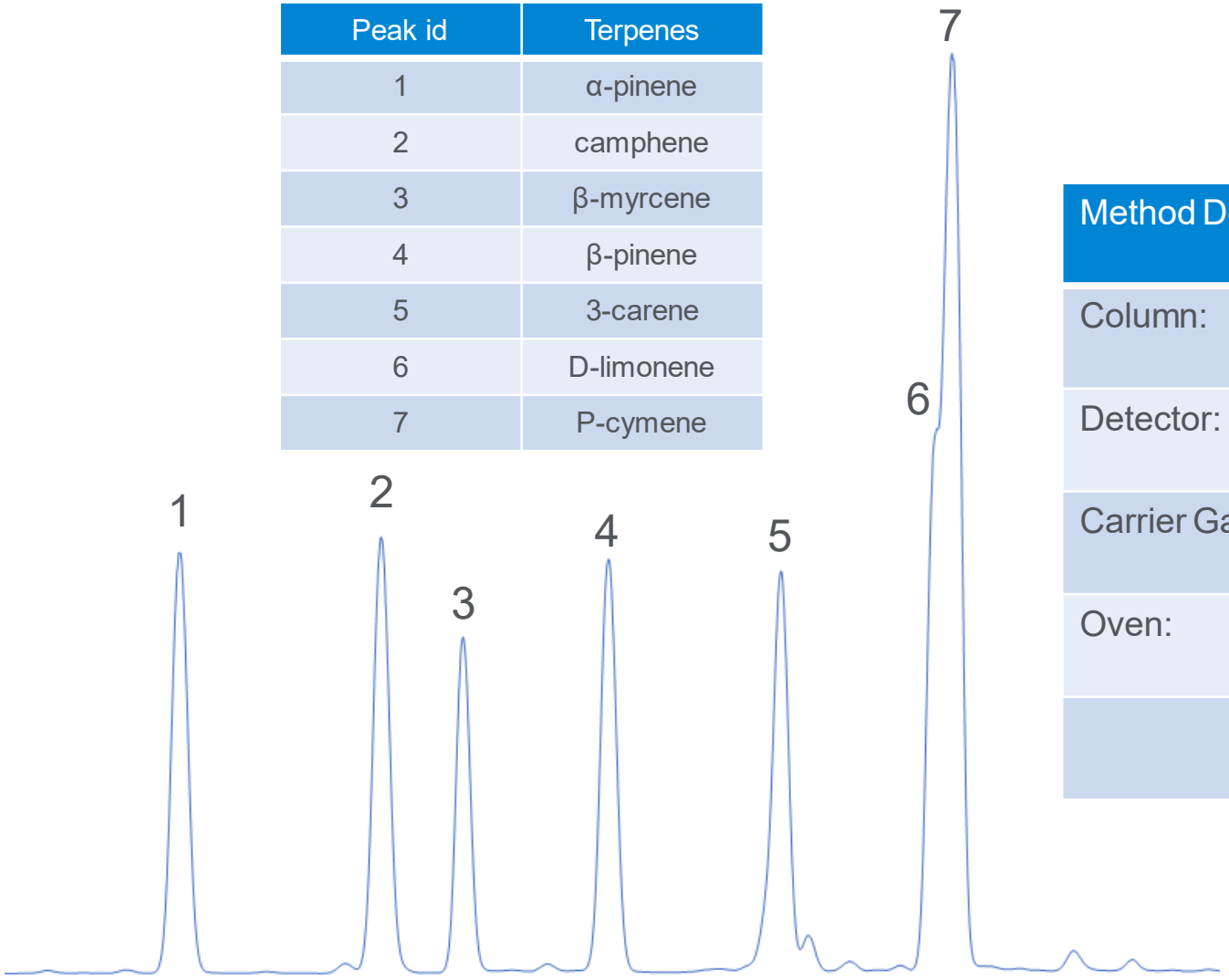
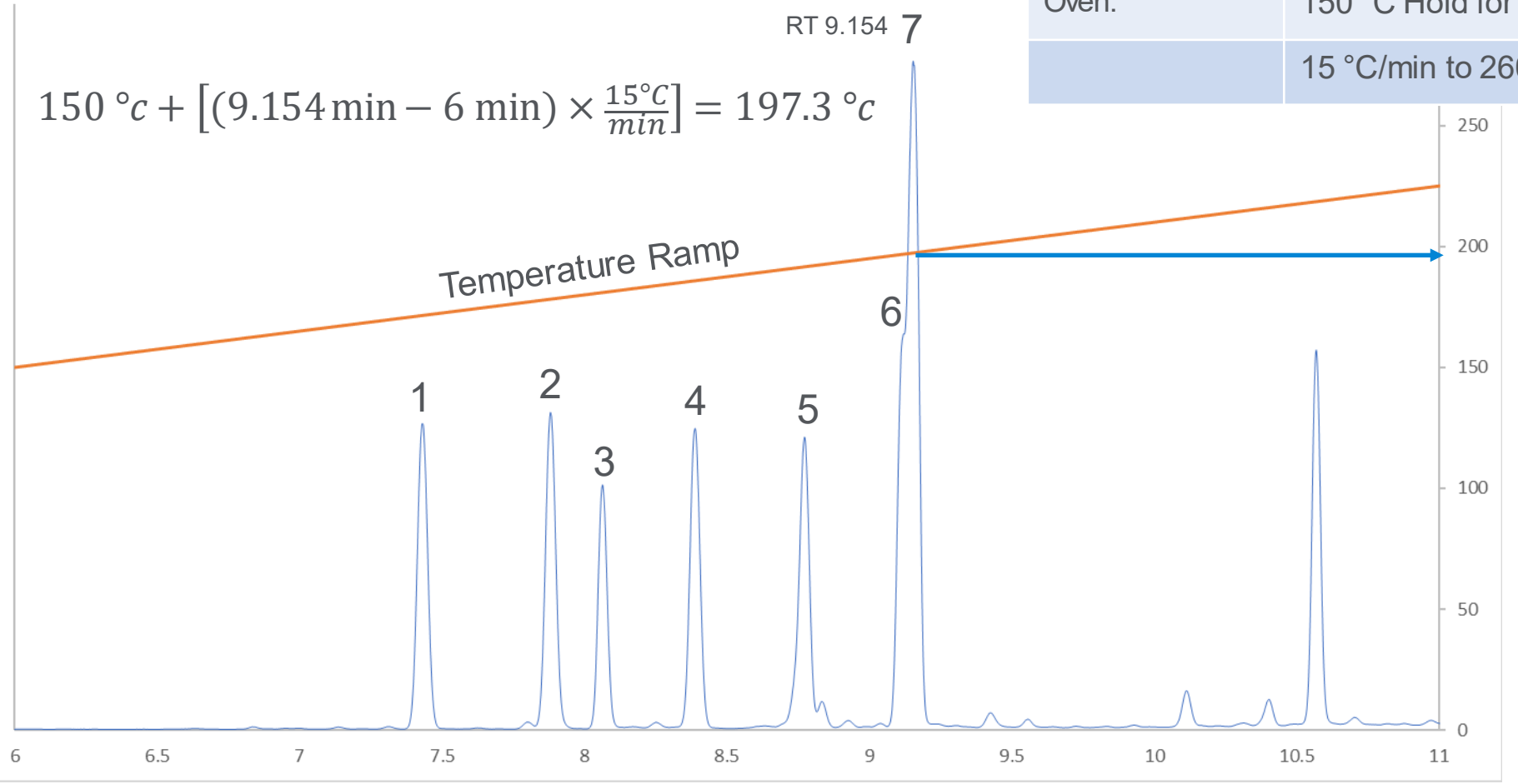


Method Details	
Column:	DB-Select 624UI, 30 m x 0.25 mm x 1.4 µm
Detector:	MSD
Carrier Gas:	Helium at 47.6 cm/sec
Oven:	150 °C hold for 6 min
	15 °C/min to 260 °CHold for 10 min

Terpene Separation

Method Details	
Column:	DB-Select 624UI, 30 m x 0.25 mm x 1.4 µm
Detector:	MSD
Carrier Gas:	Helium at 47.6 cm/sec
Oven:	150 °C Hold for 6 min
	15 °C/min to 260 °C Hold for 10 min

$$150\ °c + \left[(9.154\,\text{min} - 6\,\text{min}) \times \frac{15°C}{min}\right] = 197.3\ °c$$



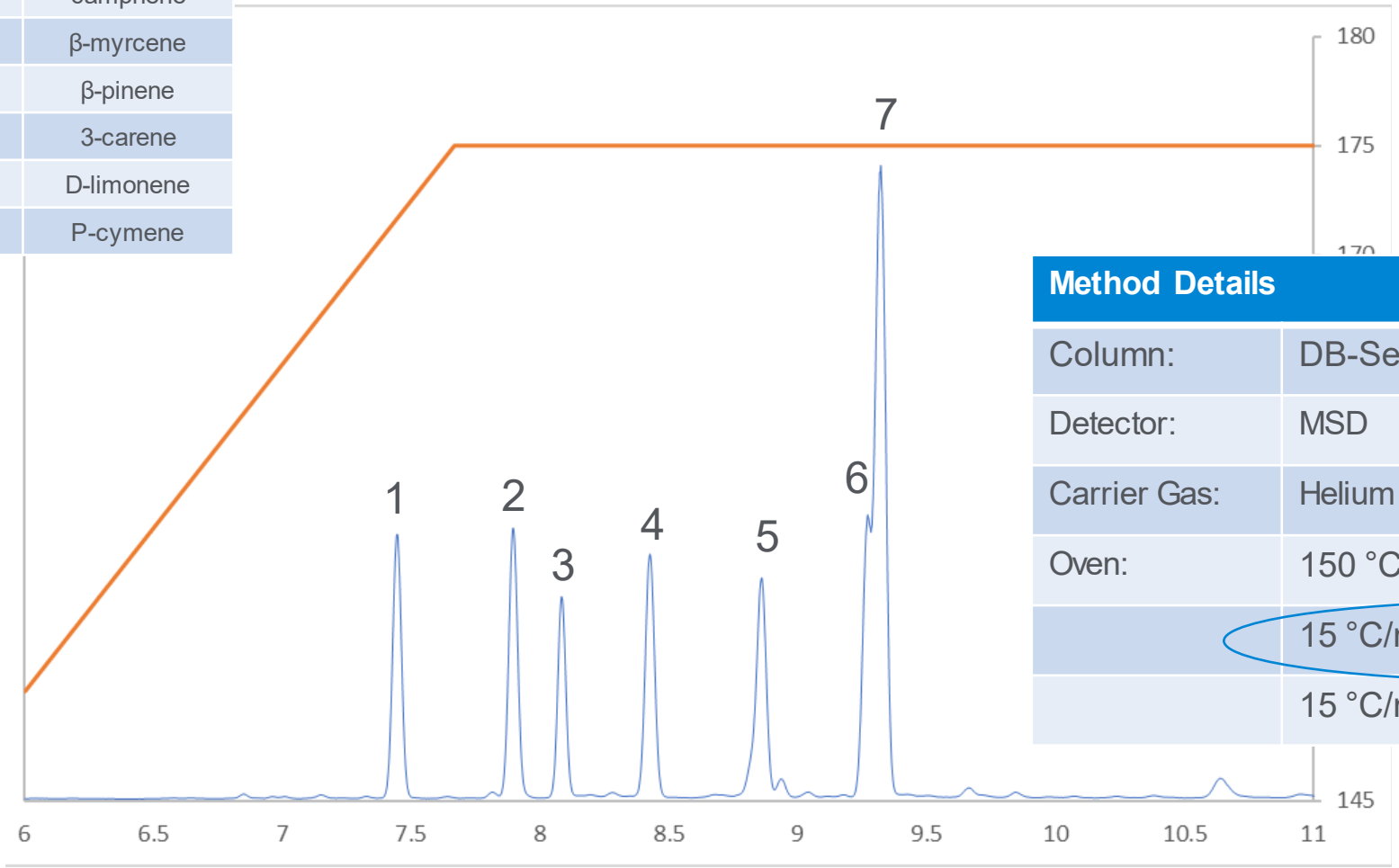
Elution Temp: 197.3 ° C

Peak id	Terpenes
1	α-pinene
2	camphene
3	β-myrcene
4	β-pinene
5	3-carene
6	D-limonene
7	P-cymene

Terpene Separation - Optimization

Peak Id	Terpenes
1	α-pinene
2	camphene
3	β-myrcene
4	β-pinene
5	3-carene
6	D-limonene
7	P-cymene

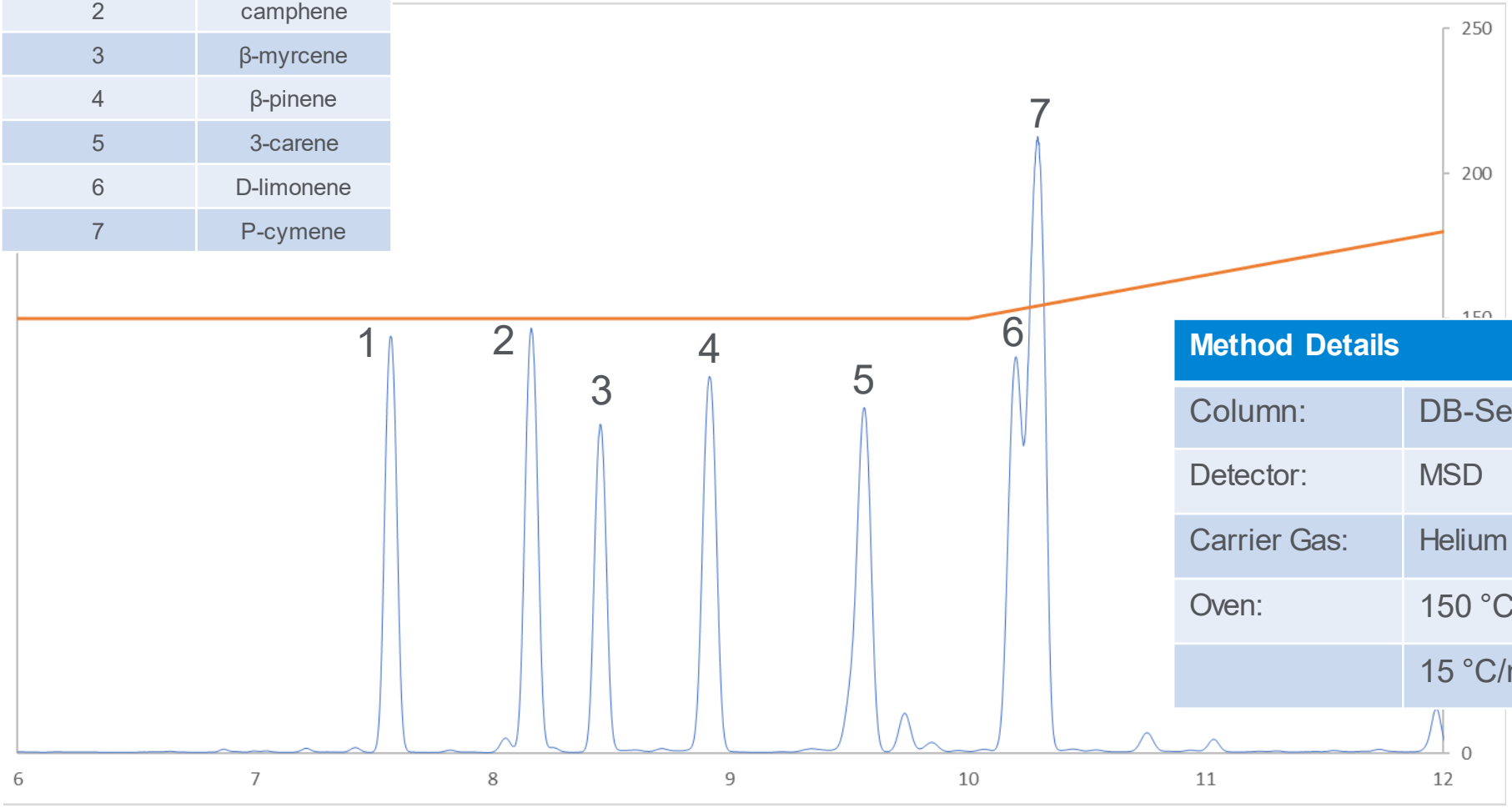
Temperature hold at ~20 - 30 °C less than elution temperature



Method Details	
Column:	DB-Select 624UI, 30 m x 0.25 mm x 1.4 µm
Detector:	MSD
Carrier Gas:	Helium at 47.6 cm/sec
Oven:	150 °C hold for 6 min
	15 °C/min to 175 °C hold for 4 min
	15 °C/min to 260 °C

Terpene Separation - Optimization

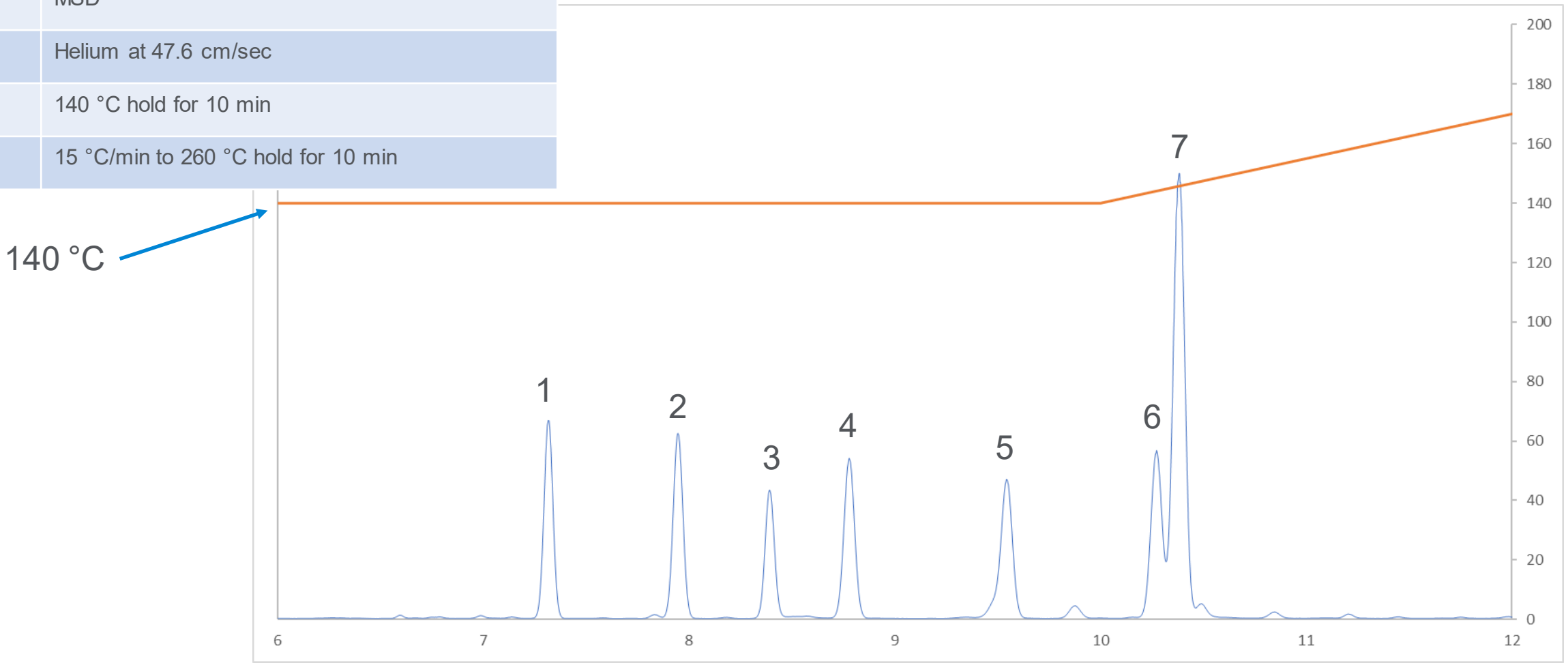
Peak Id	Terpenes
1	α-pinene
2	camphene
3	β-myrcene
4	β-pinene
5	3-carene
6	D-limonene
7	P-cymene



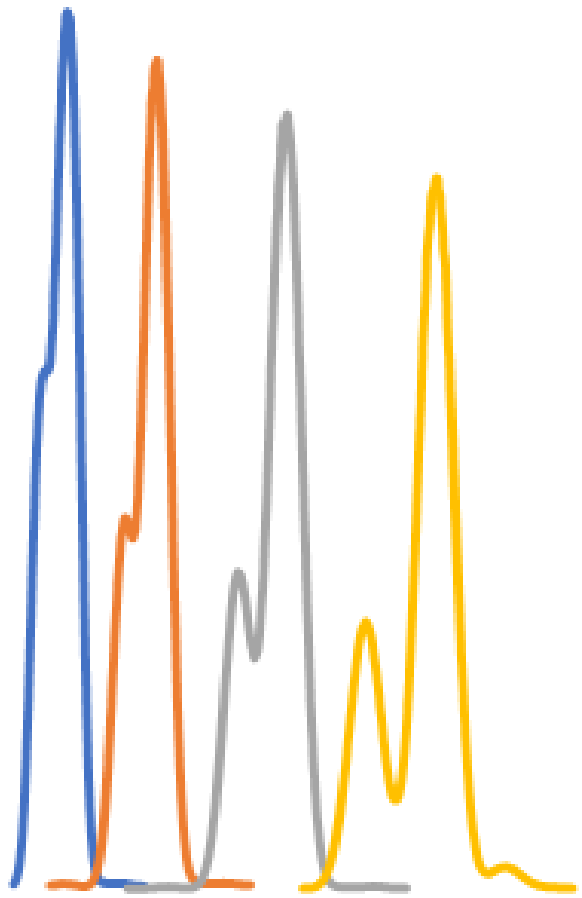
Method Details	
Column:	DB-Select 624UI, 30 m x 0.25 mm x 1.4 µm
Detector:	MSD
Carrier Gas:	Helium at 47.6 cm/sec
Oven:	150 °C hold for 10 min
	15 °C/min to 260 °C hold for 10 min

Terpene Separation - Optimization

Method Details	
Column:	DB-Select 624UI 30m X 0.25mm X 1.4um
Detector:	MSD
Carrier Gas:	Helium at 47.6 cm/sec
Oven:	140 °C hold for 10 min
	15 °C/min to 260 °C hold for 10 min



Terpene Separation - Optimization



Method Details	
Oven:	150 °C hold for 6 min
	15 °C/min to 260 °C hold for 10 min

Method Details	
Oven:	150 °C hold for 6 min
	15 °C/min to 175 °C hold for 4 min
	15 °C/min to 260 °C

Method Details	
Oven:	150 °C hold for 10 min
	15 °C/min to 260 °C hold for 10 min

Method Details	
Oven:	140 °C hold for 10 min
	15 °C/min to 260 °C hold for 10 min

Conclusions

Think about the sample first

- Is it “GC-able”?
  - Volatile? Stable?
- Sample composition
- Sample matrix/cleanup: *“Pay-me-now or pay-me-later”*

Choose inlet parameters based on detection limit requirements

Use information sources first when choosing a column

Choose the most stable column that will still resolve your analytes

Use appropriate carrier gas and optimum velocity

Calculate elution temperature and adjust oven program with appropriate ramps/holds

Make use of Technical Support…we are here to help!! ☺

Contact Agilent Chemistries and Supplies Technical Support

1-800-227-9770 option 3, option 3: webinars

Option 1 for GC and GC/MS columns and supplies

Option 2 for LC and LC/MS columns and supplies

Option 3 for sample preparation, filtration, and QuEChERS

Option 4 for spectroscopy supplies

Option 5 for chemical standards

Available in the USA and Canada 8–5, all time zones

gc-column-support@agilent.com

lc-column-support@agilent.com

spp-support@agilent.com

spectro-supplies-support@agilent.com

chem-standards-support@agilent.com

All webinars:

https://www.agilent.com/en/training-events/eseminars/gc-gc-ms-webinars

ScanView:

https://community.agilent.com/docs/DOC-2118-software-supported-method-development-the-scanview-program