Making a Grand Entrance: Techniques for Efficient Sample Introduction, Inlet Types, and Maintenance

Mark Sinnott – Application Engineer
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Sample Injection Goals

• Introduce sample into the column
• Reproducible
• Minimize efficiency losses
• Representative of sample
Influence of Injection Efficiency

Short concentrated

Long diffuse

Solute bands

Same column, same chromatographic conditions

March 18, 2019
Techniques for Efficient Sample Introduction
Agilent Restricted
## Inlet Choices

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Split/Splitless Inlet Schematic and Operation Modes

Modes
- Split
- Pulsed split (useful for small number of applications)
- Splitless
- Pulsed splitless
Split Injections – Considerations

Dirty samples are less problematic (compared to splitless) – backflushing
Wide analyte boiling range
Solvent properties
  – Wide boiling point range
  – Wide polarity range

Discrimination can be due to liner or inlet temperature
Most efficient sample transfer = nice sharp peaks
Split Injections – Inertness

More inert than splitless
• Higher velocity through the inlet
• Less exposure to inlet hardware/consumables
  – Shorter inlet residence time

Glass wool is a compromise
• Exhibits some activity (even if deactivated) – high surface area
• Greatly improves fluidic performance – mixing of the vaporized sample is important for uniform splitting
• Thermal mass/high surface area aides vaporization
Split Liners: Recommended Liner
Split/splitless liner with glass wool, low pressure drop

Split injections have higher carrier gas flow through liner
• Faster transfer onto column
• Split liners have a smaller outer diameter than splitless liners to accommodate high flow to split vent

If potential exists for sample discrimination between low and high boiling components
• Use a liner with wool

**Agilent Ultra Inert** liners enable excellent peak shapes for tricky analytes
• 5190-2295 is recommended liner; single taper, low pressure drop

**Glass wool** plug in upper position wipes needle, avoids sample discrimination improves P&A, and collects septum particulate

**Low pressure drop** bead promotes better carrier gas flow for split injections

Touchless packaging ensures contamination-free installation
Preinstalled O-ring
Split flow path

Smaller liner OD with *split* liners accommodates the higher flow to the split vent
What Does Mass Discrimination Look like?

No glass wool

Glass wool added to liner
What Does Mass Discrimination Look like?

No glass wool

Glass wool added to liner
Split Injections - Maximizing Sensitivity

Increase injection volume
• Liner dependent (use the pressure-volume calculator)
• 2 μL maximum

Reduce split ratio
• Go from 50:1 to 10:1
• 10:1 practical lower limit for liquid injections (for 250 – 320 μm id columns)
• 1:1 possible for gas injections with larger diameter columns and correct liner
• Keep total inlet flow at 20 mL/min or higher
Split Injector: Injection Volumes

Agilent J&W DB-1, 15 m x 0.25 mm id, 0.25 µm
60 °C for 1 min, 60-180 °C at 20 °C/min; helium at 30 cm/s
1. n-heptane 2. toluene 3. n-decane 4. n-butylbenzene 5. n-tridecane
## Minimum Recommended Split Ratio

<table>
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<th>mm id</th>
<th>Lowest ratio</th>
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<td>0.10</td>
<td>1:50 - 1:75</td>
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<td>0.18 - 0.25</td>
<td>1:10 - 1:20</td>
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<tr>
<td>0.32</td>
<td>1:8 - 1:15</td>
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<tr>
<td>0.53</td>
<td>1:2 - 1:5</td>
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Higher flow rates
Split Injections – Troubleshooting

Column pressures <10 psi
• The pressure pulse from evaporating solvent can cause discrimination and poor precision

Liner residence times <0.5 s (>200 mL/min)
• Poor mixing will cause discrimination

No glass wool

Solvents with high expansion volume

Column position – top to bottom, side to side

Large bore, short columns with a high split ratio
## Split Ratio Comparison

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<th>Low Ratio</th>
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<td>Sample into column</td>
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<td>Efficiency</td>
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<td>Discrimination</td>
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<tr>
<td>Carrier gas use</td>
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Splitless Injection Overview

• For trace level analysis

• Use split/splitless injection port in the splitless mode (split vent temporarily closed).

• The dilute sample is injected, the sample is volatilized, and majority of analytes transfer to the column

• Later, the split vent is opened and residual solvent is vented

• Timing, carrier and split vent flows, and 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 (less discrimination)

• Longer residence time in inlet will give more time for active compounds to interact with active sites (effectively making splitless less inert)
Splitless Injections – Considerations

Dirty samples can be an issue – better if you have backflushing capabilities

Analyte boiling range – wide

Early eluters need bp difference versus solvent

Solvent properties
• Wide boiling point range
  – But consider bp of earliest eluting analyte
• Wide polarity range (but narrower than split)
  – Water and methanol worst choices
• Longer sample residence time (actives)
  – Lower inlet temperatures can be used
    • Better for labile compounds
Splitless Injections - Inertness

Less inert than Cool-on-column (cool-on-column is most inert)
- Liner and inlet interaction

Less inert than split
- Longer residence time in inlet and on glass wool
- Used for trace analysis, so there's a greater chance of analyte loss for actives
Splitless Liners

Single taper with or without wool

Splitless has lower flows through liner

- Splitless liners are typically wider for a more snug fit
  - Ensures all available flow funnels through the liner, not around
- You can do split injections with a split liner as long as split ratio is not too high
  - Poor reproducibility, not enough room for high flows to the vent

**Agilent Ultra Inert** liners enable excellent peak shapes for tricky analytes

- 5190-2293 is recommended splitless liner; single taper, with wool

In low carrier gas flow splitless analysis, a **bottom taper** helps focus analytes onto head of column

Small plug of **glass wool** near bottom of liner filters matrix
Splitless Injections – Discrimination

Improper purge time
– Short purge times cause loss of late eluters (not enough time to vaporize)
– Long purge times cause solvent tail interference with early eluters

Improper initial oven temperature (solvent effect – refocusing)
– Too high of a temperature prevents solvent effect and a loss of early eluters
Splitless Injections – Splitless Time (Purge Time On)

Purge time too long results in large solvent tail

0.75 min purge time clips solvent tail
Splitless Injector: Injection Volume

Agilent J&W DB-1, 15 m x 0.25 mm id, 0.25 µm
60 °C for 1 min, 60-180 °C at 20 °C/min; helium at 30 cm/s
1. n-decane  2. n-dodecane  3. n-tetradecane  4. n-hexadecane
Splitless Injector: Injector Temperature

Agilent J&W DB-1, 15 m x 0.25 mm id, 0.25 µm
50 °C for 0.5 min, 50-325 °C at 20 °C/min; helium at 30 cm/s
Phthalates: 1. dimethyl  2. diethyl  3. dibutyl  4. benzylbutyl  5.bis(2-ethylhexyl)  6. dioctyl
Sample refocusing improves efficiency

Use low column temperature to refocus solvent (10 – 30 °C less than solvent BP)

• Called the solvent effect

Use cold trapping
Splitless Sample Refocusing

- **Sample refocusing**
  - Also known as the “solvent effect”
  - Condenses sample as a thin film on the head of the column
  - Initial oven temperature must be at least 10 °C below the solvent BP
    - this results in better peak shape
    - results in smaller injection band than would other-wise occur (improves resolution)
    - improved peak shape (especially for low boiling analytes)

- “Cold trapping” is a version of sample refocusing for high boiling analytes
  - Occurs when the starting oven temperature is ~150 °C below the boiling point of analytes of interest
  - Condenses the analytes on the head of the column
  - Results in better peak shapes

- Solvent effect and cold trapping can occur in same sample
  - When looking at analytes with a wide distribution of BP s
Splitless Injector: Solvent Effect

1. Initial column temperature at least 10°C below sample solvent boiling point

2. Required to obtain good peak shapes unless cold trapping occurs

3. Generally, if solute BP >150 °C above initial column temperature, the solute will cold trap

4. Cold trapping has greater efficiency than solvent effect
Splitless Injector

Initial column temperature
Hexane solvent (BP = 68-69 °C)

70°C

Solvent effect

Cold trapping

50°C

Agilent J&W 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/s
1. n-decane 2. n-dodecane 3. n-tetradecane 4. n-hexadecane
Splitless Injector
Reverse solvent effect/polarity mismatch

Agilent J&W DB-1, 15 m x 0.25 mm id, 0.25 µm
50 ºC for 1 min, 50-210 ºC at 20 ºC/min; helium at 30 cm/s
1. 1,3-DCP 2. 3-hexanol 3. butyl acetate 4. 1-heptanol 5. 3-octanone 6. 1,2-dichlorobenzene
Retention Gap
Also called a guard column

Usually 2-10 m long and same diameter as the column (or larger if needed)
Splitless Injector
3 m x 0.25 mm id retention gap

No retention gap

With retention gap

Methanol

Agilent J&W DB-1, 15 m x 0.25 mm id, 0.25 µm
50 °C for 1 min, 50-210 °C at 20 °C/min; helium at 30 cm/s
1. 1,3-DCP 2. 3-hexanol 3. butyl acetate 4. 1-heptanol 5. 3-octanone 6. 1,2-dichlorobenzene
EPC for Pulsed Splitless Injection

Pressure pulse contains sample expansion and transfers analytes to the column faster

Pulsed splitless
• Sample containment more critical than split injection
• Sharper peaks than in traditional splitless injection
• Two new parameters to set: pulse pressure and pulse time

Typical starting point
• Pulse pressure = double resting pressure
• Tie pulse time to purge time (Pulse time slightly longer than purge time)
Benefits of the Pulsed Splitless Mode

% Recovery of each labile pesticide relative to cool on-column injection

- Methamidophos
- Acephate
- Azobenzene
- Omethoate
- Diazinon
- Dimethoate
- Chlorpyrifos

On column

70 psi Pulsed splitless

22.5 psi Pulsed splitless

Splitless

High column flow

Normal column flow

March 18, 2019

Techniques for Efficient Sample Introduction

Agilent Restricted
Splitless Injections – Starting Parameters

Injection volume = 1 µL (if water 0.5 ul !)
• Check the pressure-volume calculator
Initial oven temp = 10 °C < solvent boiling point
Purge flow = 20 to 60 mL/min
Purge time = 0.75 min
• Sweep with two liner volumes of carrier gas
No pulse
Try to avoid water and methanol as solvents
Splitless Injections – Troubleshooting Tips

Injecting too much
- Column overload = poor peak shape
- Inlet overload = poor reproducibility (Back-flash)
  • Ghost peaks in subsequent blanks are possible

No glass wool
- Poor mixing
- More matrix on column

Glass wool
- Has the potential to react with trace components (high surface area)
- May not be necessary if your samples are reasonably clean
Splitless Injections – Troubleshooting Tips

If you think you have an inlet issue related to splitless injections:

- Run a 10:1 split injection
- Make up a standard at 10x concentration and run a 10:1 split injection

What if….when I changed from split to splitless, I don’t see an increase in response…

Verify that the purge time is not set to 0 min. Try increasing the purge time (“pseudo” split injection).
**MMI Inlet: Split/Splitless + PTV**

**Hot split/splitless (also pulsed)**
- Similar to the S/SL inlet using the **same liners**
- All previous S/SL discussions apply here

**Cold split/splitless**
- Significantly more inert than hot splitless (for thermally labile)
- Can inject 3-5 µL with no solvent venting
- Better sensitivity than hot splitless because large vapor cloud is not formed which travels outside the liner and portions are lost

**LVI-Solvent vent**
- An extension of cold splitless
- Large volume injection for maximum sensitivity

**Direct mode**
- Uses a direct connect liner – simulates COC (no purge)
Multi-Mode (MMI) Inlet Features

Temperature range of -160 °C to 450 °C
Heating at 15 °C/s (900 °C/min)
Septum/liner easily exchangeable using Turn Top Inlet
Injection modes: hot S/SL, cold S/SL, pulsed mode, solvent vent mode, residue removal mode
Support for single stroke injections from 0.1 μL to 250 μL
Multimode Inlet Solves Many Problems

Performing large volume injection (LVI) of relatively clean samples?
• Programmable injection slows solvent evaporation and maximizes analyte transfer into the column/detector
• Decrease MDL by injecting more sample

Injecting dirty samples?
• Matrix vent, backflush, and easy liner changing minimize dirty sample effects

Performing analyses of high mol wt or thermally labile compounds?
• Temperature programming of multimode inlet elutes analytes at the lowest possible temperature, minimizing breakdown and absorption
• Discrimination of high mol wt compounds is minimal allowing HT GC
MultiMode GC Inlet – Cold Injections

• No syringe-needle discrimination; minimal inlet discrimination
• No special syringes, liners, or consumables
• Large volume injection (5 µL to 250 µL) – lower detection limits
  – Sensitivity is better, but also introduces that much more matrix!
• Solvent vent/matrix vent – decrease interference/maintenance
• Flexibility (hot/cold split/splitless, temperature programmed vaporization)
• Cold trapping in liner – improves chromatographic peak shape, resolution
• Capillary column backflush with CFT – decreases cycle time, maintenance
MMI Column Installation

Set to 12-15.5 mm
Trim the column

Thread the column into the column adapter – stabilize the column adapter with a 5/16-inch wrench

Tighten the column nut with a ¼-inch wrench – continue to hold the column adapter with a 5/16-inch wrench

• Graphite ferrules are recommended over Vespel
Inlet Degradation and Maintenance
Root Causes of Inlet Performance Degradation, and Consequences

Accumulation of sample residues
- Loss of response, tailing on active analytes, split vent trap fouling and inaccurate EPC flow control

Accumulation of consumables wear particles
- Same as accumulation of sample residues, plus "bleed peaks"

Leak in septum nut, septum
- Damage to O₂ sensitive detectors, irreversible damage to column

Nonoptimized setup
- O-ring, gold seal, ferrules, column nuts
- Faster inlet performance degradation between maintenance sessions
Inlet Liner Troubleshooting

• Many chromatographic problems are blamed on the column
• Often, a dirty liner is the culprit

Evidence of a dirty liner:

• Poor peak shape
• Irregular baselines
• Poor resolution
• Poor response
Dirty Liners
Silylated glass wool

• Traps nonvolatile materials and mixes sample

• Peak shape and discrimination affected by amount, location, and packing density
Liner Maintenance

• Liners become contaminated with use, collecting nonvolatiles, salts, excess reagents, and so on, or become damaged/cracked

• Should inspect and replace liners often

• Handle with gloves and forceps

• Insert into or remove liners only from cool injection ports

• Replacing with a new liner is recommended, to ensure reproducibility
Leak in Septum

Using septa beyond lifetime/temperature conditions
• Use environments that decrease lifetime include manual injections, wrong syringe tip type, larger gauge syringes, non-Agilent autosamplers (Agilent autosamplers are precisely aligned)
• Septum nut too tight
• Septum type and syringe needle type mating are essential to minimizing leak rate
• Typical cost of 1 premium septa ($1.25)
• Typical cost of 1 GC column ($600)
• Proactively change inlet septa
Septum Maintenance: Septum Coring

- After many injections, pieces of rubber from the septum may break off and fall into the inlet liner
  - This is called septa coring
  - Replace the inlet septa and liner frequently to prevent septa contamination
  - Use a cone tipped syringe to reduce the chance of tearing the septum

Septum core placed in a clean liner, and a blank injection performed.

- Inlet: 320 °C, split mode, 10:1 split ratio
- Oven: 35 °C to 300 °C at 20 °C/min
- Detector: Single quadrupole EI scan, 35 to 500 Da
Septum Maintenance: Deconvoluted Inlet Septa Spectrum

- Decamethyl cyclopentasiloxane
- Dodecamethyl cyclohexasiloxane
- Tetradecamethyl cycloheptasiloxane
- Hexadecamethyl cyclooctasiloxane
- Octadecamethyl cyclononasiloxane
- Eicosamethyl cyclodecasiloxane
Main Siloxane Peak Bandit

Multiple injections from same vial can dissolve silicone into the sample
Tips to Maximize Septum Life, Minimize Septum Leaks

- Use Agilent Gold Standard, 23-26 gauge, HP point taper syringes
  - Point style cores septa significantly less when used with CenterGuide Septa
  - Taper minimizes septum coring/wear
- Use Agilent CenterGuide Septa
  - Molded hole minimizes septa coring

![HP-point style](image)

![Solid Septum](image)

![CenterGuide Septum](image)
Leaks Due to Septum Nut

- With repeated use, conical needle guide gets worn (out of round) and needs replacement, as septum can begin to “bulge” out, especially with excessive tightening
- Septa fail faster because needle is not guided with as much precision
- Under or over tightening – tighten nut until c-clamp on top stops turning, then ½ to ¾ turn more
- Non-Agilent septa may be too thin, too thick, or out of round like die-cut septa and may not seal as well
- Use environments that decrease lifetime, like using non-Agilent autosamplers (ours are precisely aligned), manual injection, larger gauge syringes
- Replace septum nut annually for peace of mind
Examples of Non-Optimized Operation

Typical cause: re-use and misinstallation

- Leak from O-ring, gold seal, ferrules, column nuts
- O-rings are elastomer compression fittings, designed for one use, not perfectly elastic
- Gold seals are designed for one use; knife edge cuts into gold layer giving leak tight seal without shrinkage or potential organic contaminants from polyimide outgassing/degradation
- Re-using could result in overlap in seal rings, resulting in a leak
Split Vent Trap

What is it?
Split Vent Trap

What is it?
Split Vent Trap

What is it?

Where is it?
Split Vent Trap

What is it?

Where is it?
Split Vent Trap

What is it?

Where is it?
Split Vent Trap

What is it?

Where is it?
Split Vent Trap Changed (Column Bleed)
Example Of Gross Contamination

This is **not** a normal column bleed

Agilent J&W DB-624, 30 m megabore
Temperature program: 35 °C, hold 1.50 min, 30 °C/min to 65 °C, hold 15 min, 20 °C/min to 260 °C, hold 50 min
Cleaning the Split/Splitless Injector

1. Carrier gas flow off
2. Disconnect split vent line and replace split vent trap
3. Injector body
4. Remove column, reducing nut, gold seal, washer and liner
5. Cotton swab
6. MeCl₂
7. Ace tone
8. MeOH

GC Off
*Temperature program: 35 °C, hold for 1.50 min; 30 °C/min to 65 °C, hold 15 min; 20 °C/min to 260 °C for 5 min
Agilent Bond Elut Sample Cleanup Products

Solid Phase Extraction cartridges and plates

Filtration cartridges and plates

Captiva EMR Lipid
Agilent Bond Elut Sample Cleanup Products

Solid Phase Extraction cartridges and plates

Filtration cartridges and plates

Captiva EMR Lipid
Enhanced Matrix Removal: Agilent Captiva EMR-Lipid

EMR-Lipid sorbent technology effectively traps lipids through two mechanisms:

- Size exclusion – unbranched hydrocarbon chains (lipids) enter the sorbent; bulky analytes do not
- Sorbent chemistry – lipid chains that enter the sorbent are trapped by hydrophobic interactions

Triglycerides
Free fatty acids
Phospholipids
Lipid
Fluoroquinolones
EMR sorbent
Analyte
### Application Case – Pesticides in Edible Oil by GC/MS/MS

<table>
<thead>
<tr>
<th>Classification</th>
<th>Pesticides</th>
<th>Classification</th>
<th>Pesticides</th>
<th>Classification</th>
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<tbody>
<tr>
<td><strong>Organophosphate</strong></td>
<td><strong>Organochlorine</strong></td>
<td><strong>Organophosphate</strong></td>
<td><strong>Pyrethroid</strong></td>
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<td>Sulphamide</td>
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<td>Dichlorfluanid</td>
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<td>Trichlorfon</td>
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<td>Tolylfluanid</td>
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<td>Sulfotep</td>
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<td>Endrin</td>
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<td>Captan</td>
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<td>Endosulfan</td>
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<td>Mirex</td>
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<td>2-Phenylphenol</td>
<td>Dicarboximide</td>
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<tr>
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<td>Iprodione</td>
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<td>Fenamiphos</td>
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<tr>
<td><strong>Oxazole</strong></td>
<td>Vinclozolin</td>
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<td><strong>Uracil</strong></td>
<td>Bromacil</td>
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</tbody>
</table>

**Captiva EMR-Lipid**

6 mL cartridge
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil

LLE x2
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil

LLE x2

Transfer supernatant

Olive oil extract
Pesticides in Edible Oil by GC/MS/MS

Sample preparation procedure visual

Olive oil

LLE x2

Transfer supernatant

Mix w/ 20% water

Olive oil extract
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil

LLE x2

Transfer supernatant

Mix w/ 20% water

Captiva EMR-Lipid cleanup
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

1. Olive oil
2. LLE x2
3. Transfer supernatant
4. Mix w/ 20% water
5. Olive oil extract
6. Captiva EMR-Lipid cleanup
7. Olive oil extract EMR-Lipid eluent
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil

LLE x2

Olive oil extract

Transfer supernatant

Mix w/ 20% water

Captiva EMR-Lipid cleanup

Captiva EMR-Lipid cleanup

Olive oil extract

EMR - Lipid eluent

MgSO₄ salt partition

Olive oil extract

EMR-Lipid eluent

March 18, 2019
Techniques for Efficient Sample Introduction
Agilent Restricted
Pesticides in Edible Oil by GC/MS/MS
Sample preparation procedure visual

Olive oil

LLE x2

Transfer supernatant

Mix w/ 20% water

Supernatant for GC/MS/MS analysis

Olive oil extract

Captiva EMR-Lipid cleanup

Olive oil extract EMR-Lipid eluent

MgSO₄ salt partition
Captiva EMR-Lipid Cleanup Improves Analytes S/N Ratio and Integration Accuracy on GC/MS(/MS)

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Captan</th>
<th>Permethrin</th>
<th>Deltamethrin</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMR-Lipid cleanup</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>Zirconia sorbent cleanup</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>C18/PSA cleanup</td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
</tbody>
</table>

March 18, 2019
Techniques for Efficient Sample Introduction
Agilent Restricted
A New Portfolio of GC Consumables

- UI inlet liners
- Guard Chip
- Intuvo Flow Chips
- No-trim column
- Smart keys
- Tools and accessories
# When Do I Change Each Part?

<table>
<thead>
<tr>
<th>Item</th>
<th>Typical Schedule</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septum nut</td>
<td>3-6 months</td>
<td>Septum nut can get warn and shed metal particle into the liner. Replace to minimize activity in the inlet/liner.</td>
</tr>
<tr>
<td>Syringe</td>
<td>Every 3 months</td>
<td>Check movement of plunger and replace if it does not move freely and cannot be cleaned.</td>
</tr>
<tr>
<td>Gold seal</td>
<td>Monthly</td>
<td>At a minimum, replace when trimming the front end of the column</td>
</tr>
<tr>
<td>Split vent trap</td>
<td>6 months - 1 year</td>
<td>Often forgotten. Can also cause retention instability.</td>
</tr>
<tr>
<td>Liner</td>
<td>Weekly</td>
<td>The liner takes the brunt of the sample load/residues. Replace often to help prevent unwanted down time.</td>
</tr>
<tr>
<td>Trim/replace column</td>
<td>Weekly - monthly</td>
<td>When experiencing chromatographic problems trim 1/2 to 1 meter of the front end of the column. Replace liner, septum, and gold seal.</td>
</tr>
<tr>
<td>Inlet septa</td>
<td>100-200 injections</td>
<td>Depends on septum type and manual/auto injections.</td>
</tr>
</tbody>
</table>

This schedule is an approximation of average use requirements. Actual frequency is application and sample specific. Use your chromatography as a guide to developing a normal maintenance schedule.
Conclusions

• Start off with good inlet parameters
• Develop a maintenance schedule that fits your application and sample load
• Don’t skimp out on replacing your inlet consumables
• Use the same type of liner for the same type of application
• Trim more than 2 in from the front of the column (back end of the column is clean)
Contact Agilent Chemistries and Supplies Technical Support

1-800-227-9770 option 3, option 3:
Option 1 for GC or GC/MS columns and supplies
Option 2 for LC or LC/MS columns and supplies
Option 3 for Sample preparation, filtration and QuEChERS
Option 4 for Spectroscopy supplies
Available in the U.S. 8-5 all time zones

gc-column-support@Agilent.com
lc-column-support@agilent.com
spp-support@agilent.com
spectro-supplies-support@agilent.com