**2-D GC/MS and the Deans Switch: Theory and Applications**

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### Introduction

- Simplified 2-D GC can be used to accomplish the separation of specific analytes from very complex matrices.
- In complex sample matrices, there are often too many overlapping compounds to allow resolution of the compound(s) of interest, even with the highest resolution columns available.
- On any single column, the analytes co-elute with several other compounds, making their analysis difficult or impossible.
- This approach can solve difficult analytical problems with a relatively low cost, easy to use system that is very robust and easy to maintain.

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### Multidimensional (2-D) GC

- Very old (>25 yrs) but powerful separation technique.
- Based on cutting peak(s) from one GC column onto another with stationary phase of different selectivity (polarity).
- Compounds that co-elute with analyte on the first column separate from the analyte(s) of interest on the second column of different polarity.
  - THC in Hair
  - NIDA drugs in Oral Fluids
  - THC in Blood
- Especially useful at ultra-trace concentrations (<1 ng/ml)

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### Why 2-D GC now? What’s Changed?

- 6890 Simplified 2-D GC systems are much easier to use
  - Micro-fluidics Deans Switch
  - Column connections are easier, zero dead volume, inert, and reliable.
  - Setting gas flows done with EPC and Flow Calculator.
  - Retention time drift greatly reduced with modern oven and EPC.
  - Inertness problems with switch hardware eliminated with surface coatings.
  - RT control is very tight and the new switch is very quick.

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### “Simplified” 2-Dimensional GC

- 7683 Auto-sampler
- 6890n GC
- Deans Switch System:
  Used to “heart cut” individual peaks from DB-17ms to DB-1ms column

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### Deans Switch System:

- FID
- S/S Inlet
- MS
- Oven Wall
- PCM
- Solenoid valve
- Restrictor 0.1 mm UDFS
- DB-17ms 15m x 0.25 x 0.25 um
- DB-1ms 15m x 0.25 x 0.25 um
- T1
- T2
- T3
- FID1
- FID2
- Column 1
- Column 2
Deans Switch System
Used to “heart cut” peak from DB-17MS to DB-1MS

Deans Switch System
Switch off, DB-17MS effluent goes to monitor FID (no cut)

Deans Switch System
Switch on, DB-17MS effluent is cut to DB-1MS

Deans Switch System (after the cut)
Switch off, DB-17MS effluent goes to monitor FID

EPC Backflush to save time and clean out first column!
Program Inlet pressure down to 0.5 psi after the last cut, then after the last analyte elutes from column 2, program the PCM to 60 psi so heavies are backflushed out split vent.

New Micro-fluidics Deans Switch
Deans Switch column connections

Simple Run Table Entry Cuts Sample onto Column 2

Method Developers
Tools

Cryo Trap Re-focuses Sample on Column

First Application Example

- 0.1 pg/mg THC in Hair
- DB-35ms ➔ DB-5ms
- 2002 at Northwest Toxicology in Salt Lake City
  - Using Finnigan TSQ 7000 Triple Quadrupole MS
  - Same samples analyzed with Deans switch

Low Level Detection Required

- SAMSHA guidelines set confirmatory cutoff at 0.05 pg/mg
- 20 mg sample size used
  - washed, cut up, digested, extracted
  - derivitized with PFPA/PFPOH
- 50 ul final extract volume (in toluene)
- THC-COOH concentration in final extract = 20 fg/ul
**GC/MS Conditions**

- Agilent 6890N - 5973N
- Negative chemical ionization (NCI) mode - Autotuned
- Source temperature 160°C
- SIM ions (5 ions):
  - THC-COOH 620, 492, 472
  - d3-THC-COOH 623, 495
- Ammonia reagent (buffer) gas (5X increase in sensitivity vs methane)

**Ideal Conditions (2 ul unextracted standard)**

**Hair Matrix Effect: 0.1 pg/mg**

**Deans Switch System (THC in Hair)**
Heartcut THC peak from DB-35MS to DB-5MS

**Deans Switch System**
Switch off, DB-35MS effluent goes to monitor FID (no cut)

**Deans Switch System**
Switch on, DB-35MS effluent is cut to DB-5MS
Results: 0.1 pg/mg THC-COOH in Hair

**Second Application Example**

- THC in Oral Fluid
- TMS derivative
- DB-17ms 😊 DB1ms
  - Both are 15m x 0.25 x 0.25

**Deans Switch System**

*Used to “heart cut” peak from DB-17MS to DB-1MS*

**Method Developers**

*Tools:
  - Calculator to correctly set flows and restrictor size*

**THC parent drug in Oral Fluid**

**Third Application Example**

- THC parent and THCA in Blood
- Arizona DPS
- TMS derivative
- RTX-200 😊 DB17ms
Example of Inadequate Resolution
DB-17ms → DB-1ms

FID channel of the Deans Switch with no cuts to the secondary column

Cut Times determined from FID

0.5 ng/ml THC-TMS in Blood
Summary

• Developments in GC hardware in recent years have made Deans switch systems easier to use and maintain.
• 2D GC is a powerful tool that can be used by itself or combined with other selective techniques to solve difficult separation problems.
• 2D GCMS (GC/GC/MS) can be used instead of GC/MS/MS in many applications.