Fast GC: Increase Sample Throughput without Sacrificing Quality

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Fast GC

Introduction: What is Fast GC?

Theory

Parameters that can be modified

Applications

Summary

Fast GC

- is 3 - 10 x faster than conventional GC
- allows for higher sample through-put (decreasing cost)
- provides faster method development
- increases accuracy of results by higher number of replications
- maintains quality/efficiency of the GC technology
- does not require additional capital equipment

Fast GC – columns

Conventional GC

- Column ID > 0.25 mm

Fast GC

- Different Column ID - 0.10 mm usually

UltraFast GC

- Column ID < 0.05 mm or thinner

Retention time in GC

$$t_r = \frac{L}{u}(k'+1)$$

t_r = retention time

L = length of the column

k' = retention factor

u = carrier gas velocity

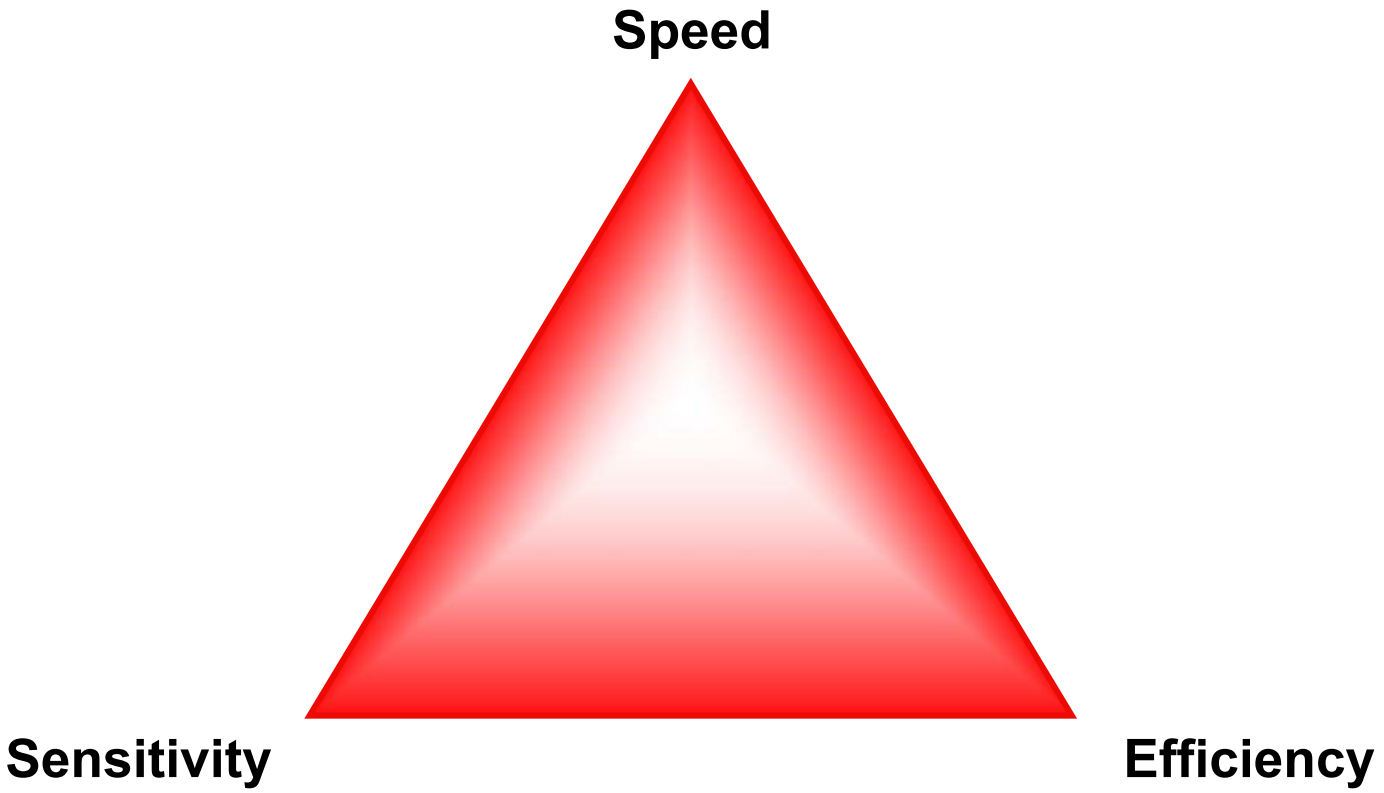
Principles of Fast GC

Decrease analysis time by using:

- Shorter column
- Quicker oven temperature ramp rate
- Higher carrier gas linear velocity

But these changes also decrease resolution!

Chromatography Triangle



Golay equation

$$H = \frac{2 D_G}{u} + \frac{2 k d_f}{3 (1+k)^2 D_L} + \frac{(1+6k+11k^2) r^2 u}{24 (1+k) 2 D_G}$$

Longitudinal Diffussion	Mass transfer into stat. phase	Mass transfer in mobile phase

H = Height of theoretical plate

d_f = Film thickness of stationary phase

r = Inner diameter of column

u = linear carrier gas velocity

Principles of Fast GC

Decrease analysis time by using:

- Shorter column
- Quicker oven temperature ramp rate
- Higher carrier gas linear velocity

But these changes also decrease resolution!

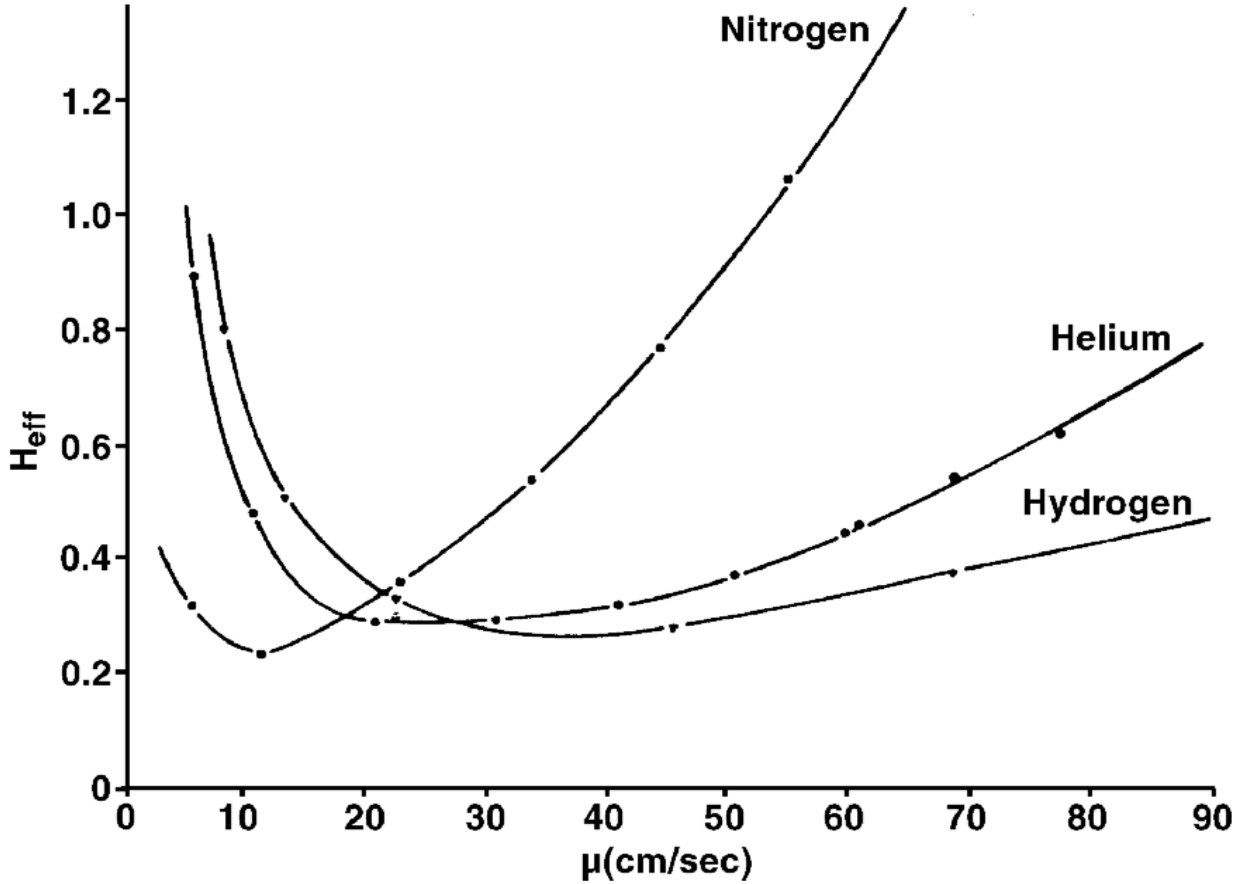
Offset the decrease in resolution by also using:

- Narrow I.D. column
- Hydrogen carrier gas
- Low film thickness

Properties of carrier gases

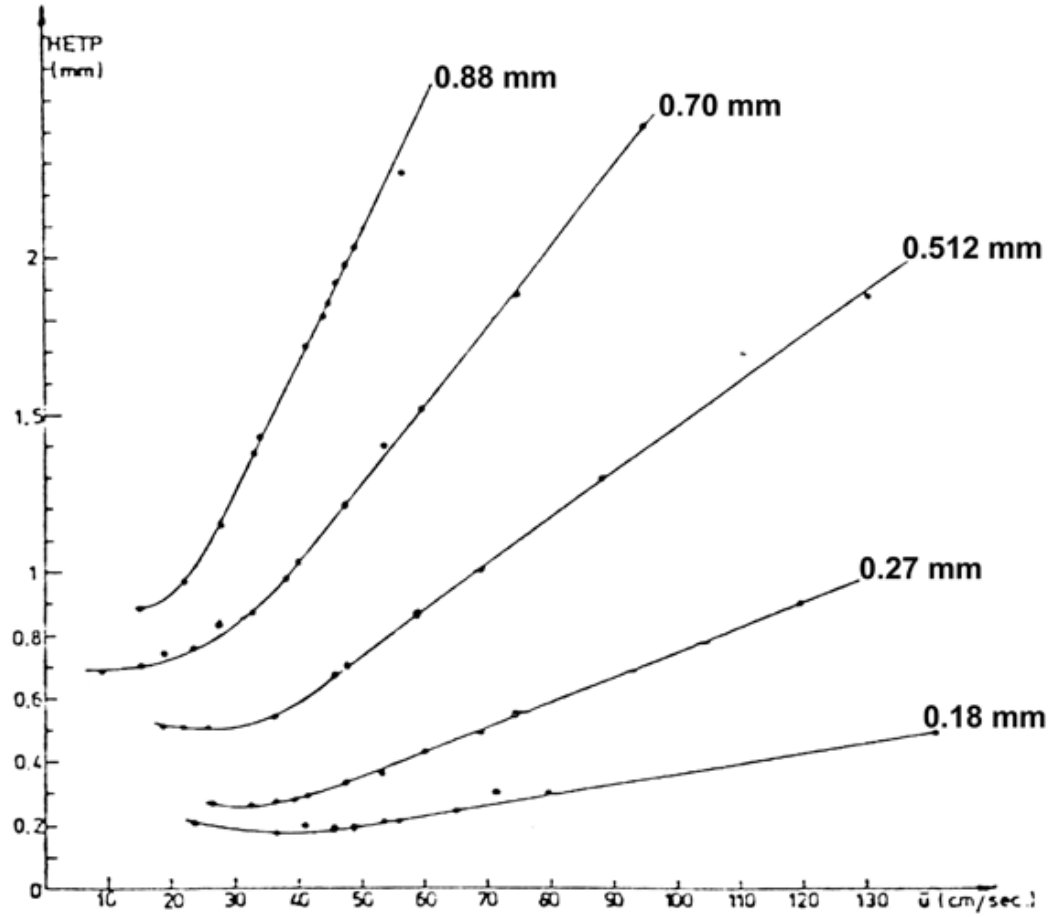
Carrier gas	Viskosity @ 50 °C [Kg/s m]	Diffusion of butane 100 °C [m^2/s]
Hydrogen	9.4	6×10^{-6}
Helium	20.8	5.5×10^{-6}
Nitrogen	18.8	1.5×10^{-6}

Fast GC and carrier gases



Columns for Fast GC with small inner diameter

- Flat H/μ curve
- optimal of range of μ quite large
- Opportunity for high carrier gas velocity



Prof Luigi Mondello, Messina

Comparison

Inner diameter – sample capacity - efficiency

Inner diameter	0.10mm	0.18mm	0.25mm	0.32mm	0.53mm
Sample capacity (ng)	5-10	10-20	50-100	400-500	1000-2000
He flow @20cm/sec.	0.1 mL/min.	0.3 mL/min.	0.7 mL/min.	1.0 mL/min.	2.6 mL/min.
H_2 flow @40cm/sec.	0.2 mL/min.	0.6 mL/min.	1.4 mL/min.	2.0 mL/min.	5.2 mL/min.
Efficiency (Plates/m)	8.600	5.300	3.300	2.700	1.600

Fast GC: Requirements on GC systems

Injection system:

- Fast transfer of sample → Split injection

Column:

- Small ID columns → Higher pressure
- Temperature programmed methods → Steeper temp. ramps
  → Fast cooling

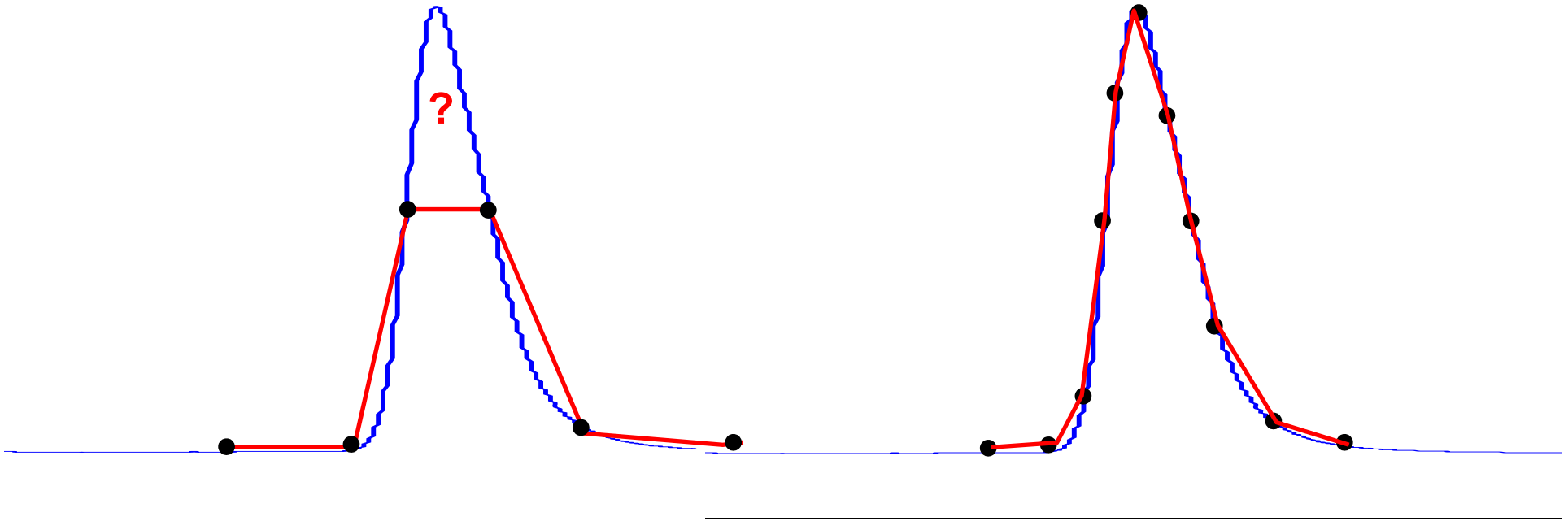
Detection:

- Narrow peaks → Fast Detection &
  → high data sampling rate

Detector: Data sampling rate

Slow data sampling rate

Fast data sampling rate

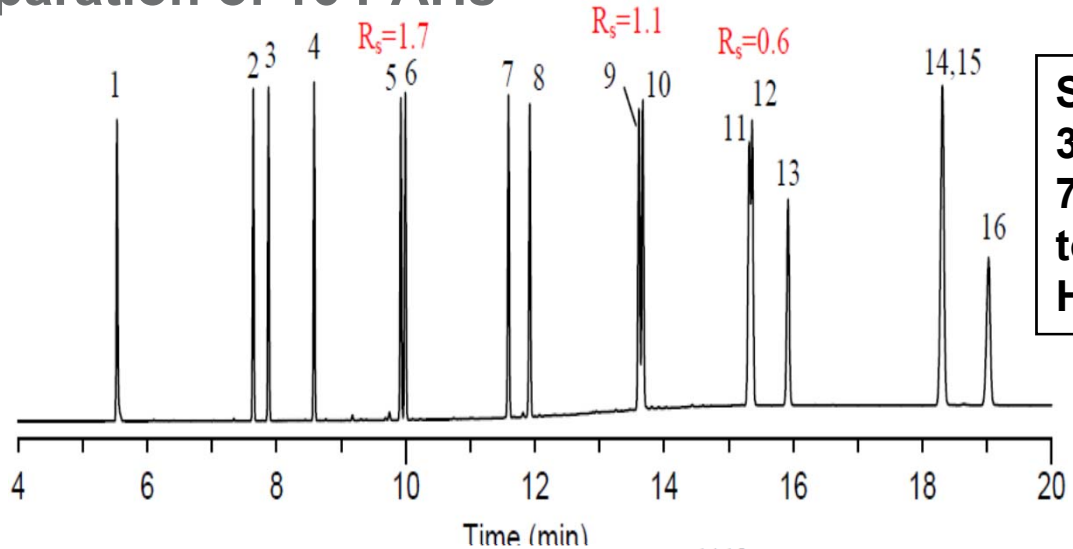


Implementation and application of Fast GC

Fast GC: Decrease column length

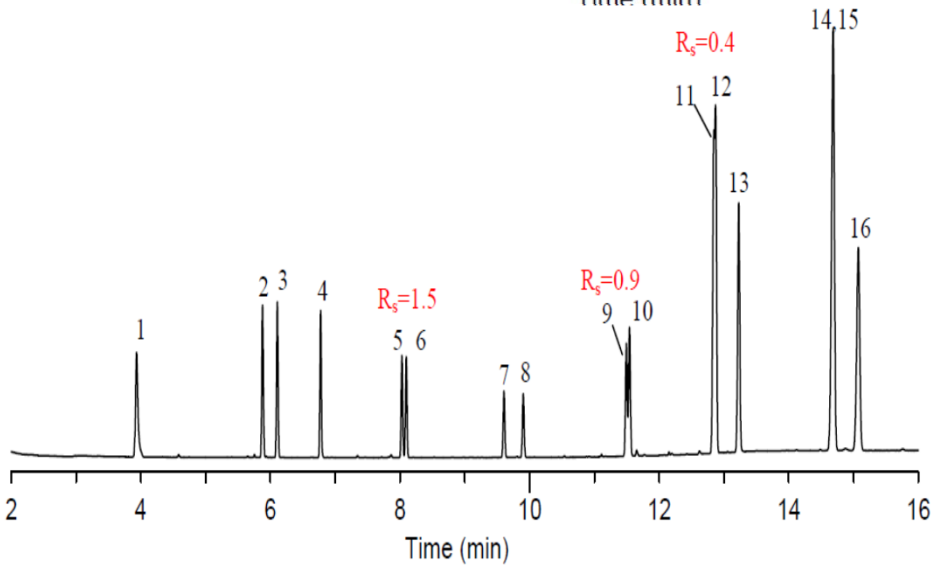
Separation of 16 PAHs

1



SLB-5ms
30 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Helium @ 25 cm/sec

2

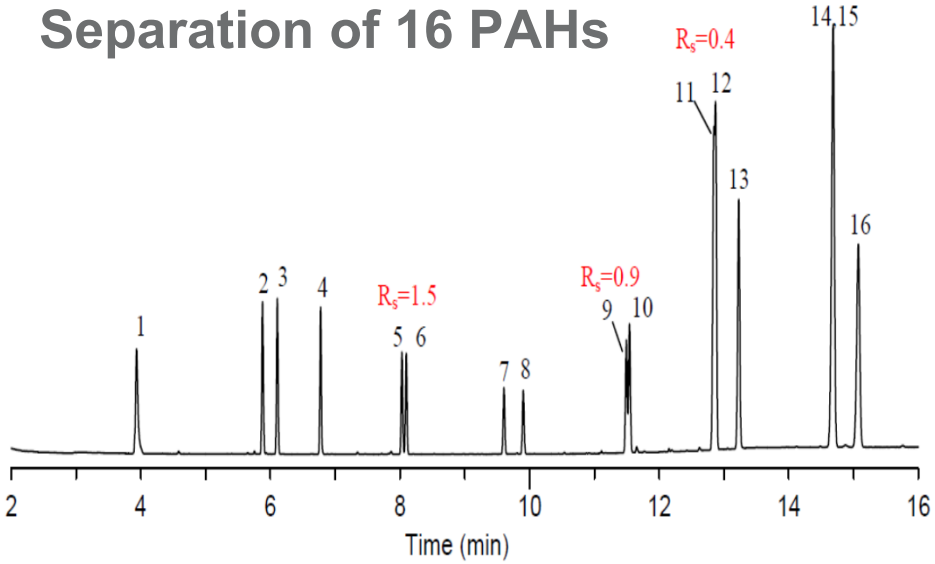


SLB-5ms
15 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Helium @ 25 cm/sec

Fast GC: Change to hydrogen as carrier gas

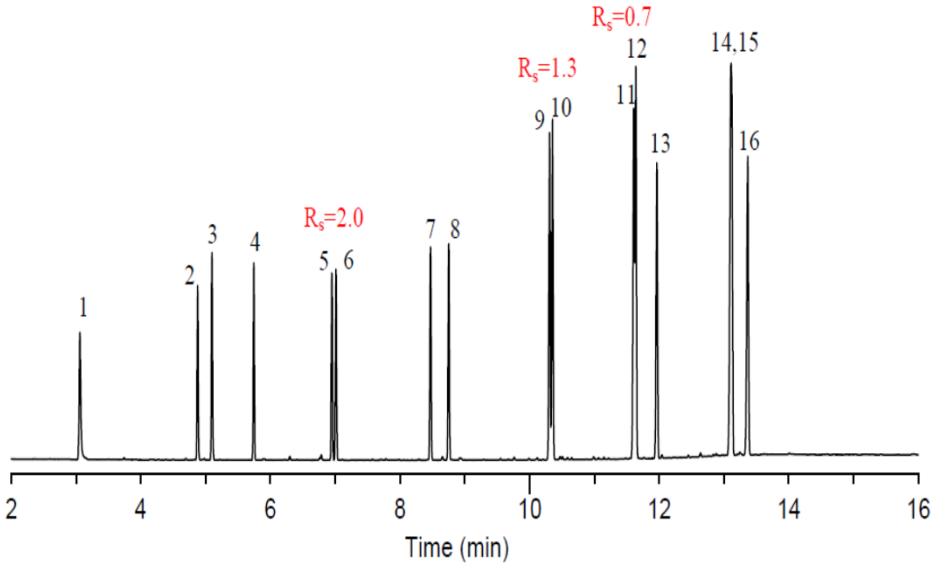
Separation of 16 PAHs

2



SLB-5ms
15 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min.
to 325 °C (3 min.)
Helium @ 25 cm/sec

3

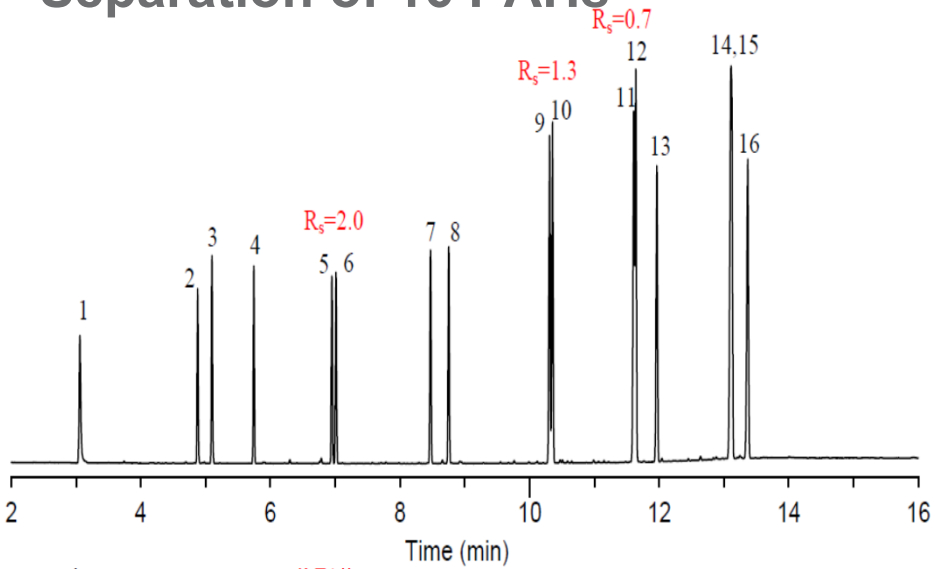


SLB-5ms
15 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min.
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

Fast GC: Decrease inner diameter of column

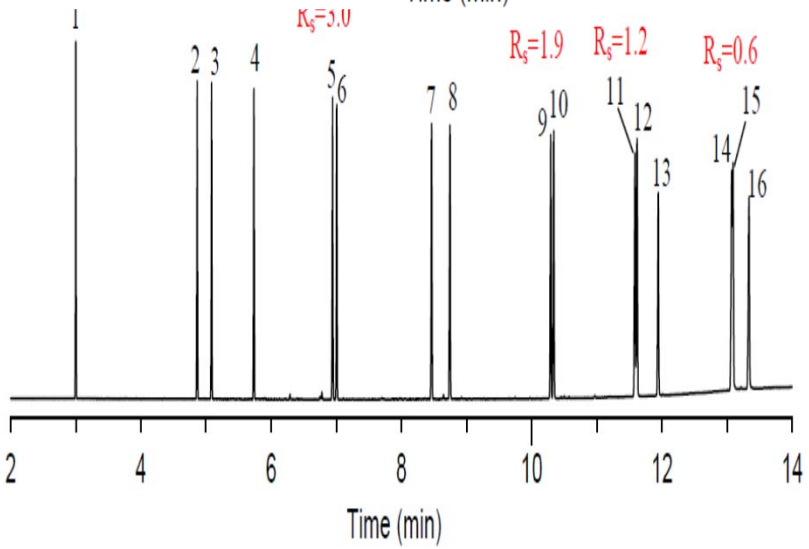
Separation of 16 PAHs

3



SLB-5ms
15 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

4

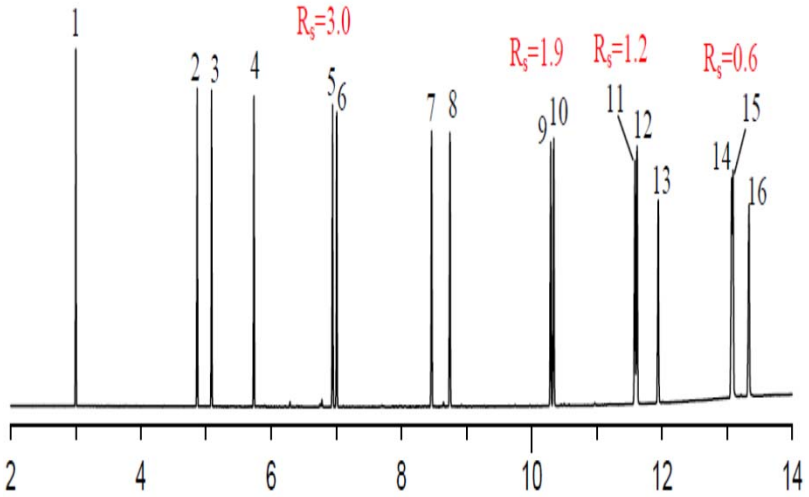


SLB-5ms
15 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

Fast GC: Further decrease of column length

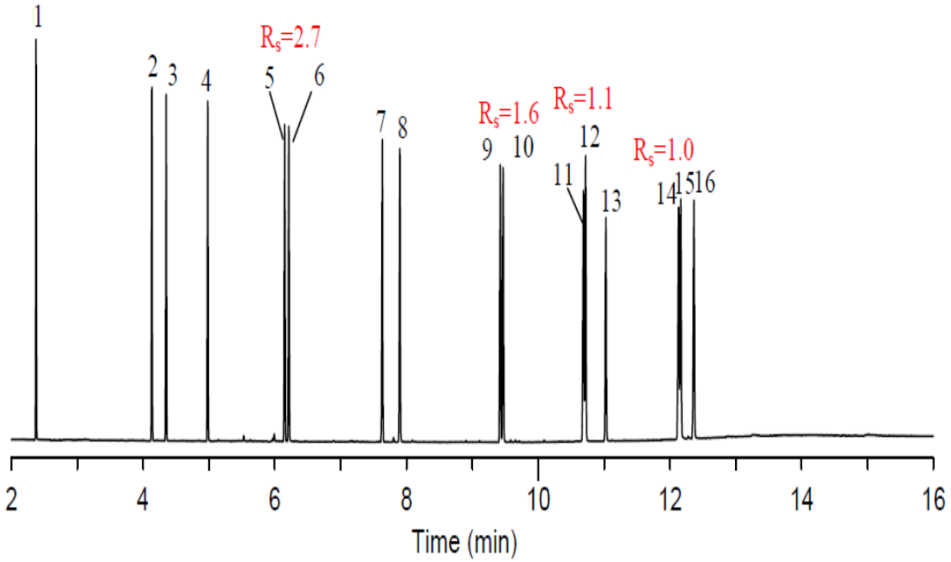
Separation of 16 PAHs

4



SLB-5ms
15 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

5

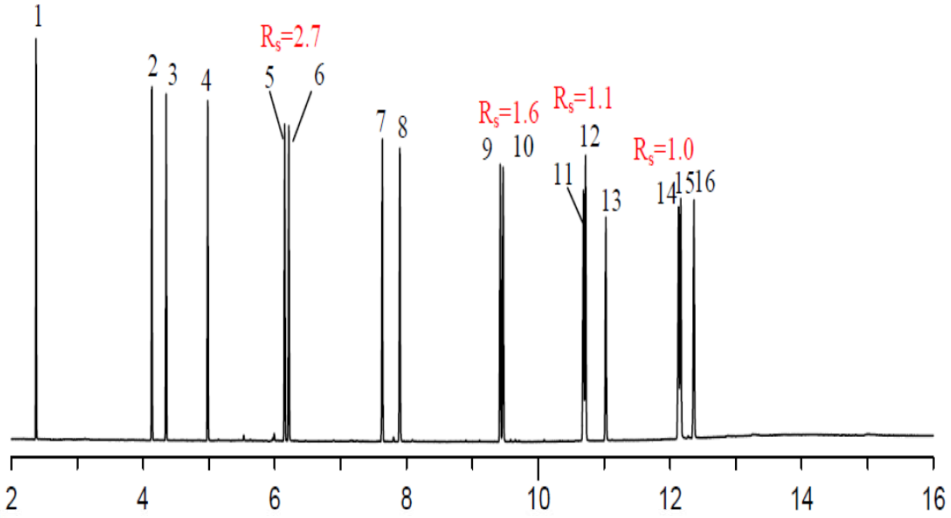


SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

Fast GC: Increase of linear velocity

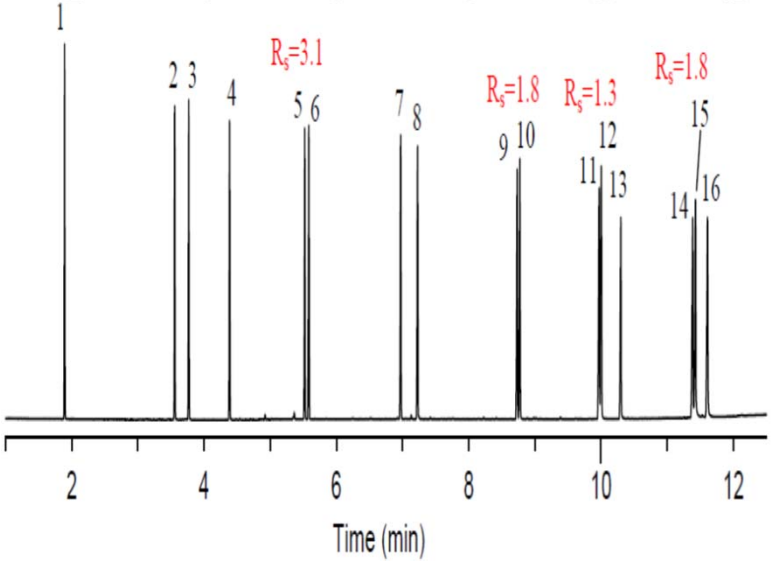
Separation of 16 PAHs

5



SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 40 cm/sec

6

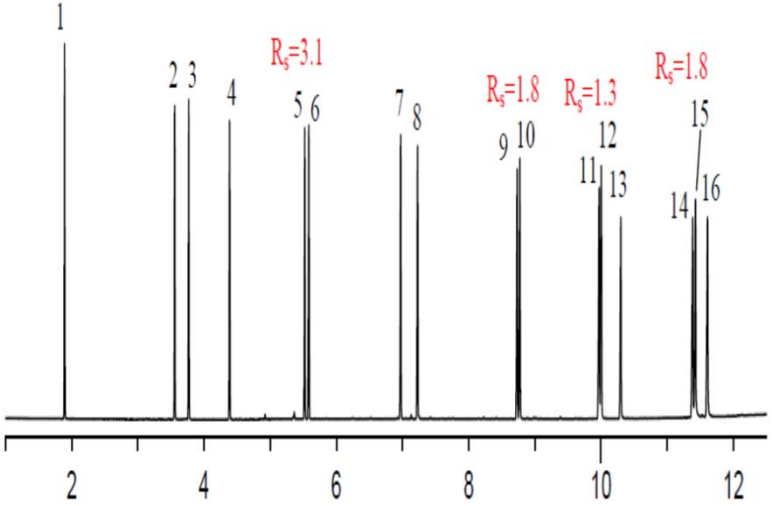


SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min
to 325 °C (3 min.)
Hydrogen @ 60 cm/sec

Fast GC: Steeper temperature ramp

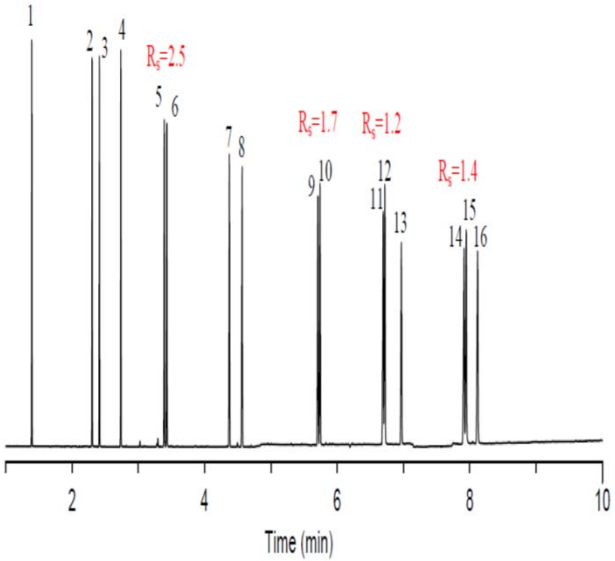
Separation of 16 PAHs

6



SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 20 °C/min to 325 °C (3 min.)
Hydrogen @ 60 cm/sec

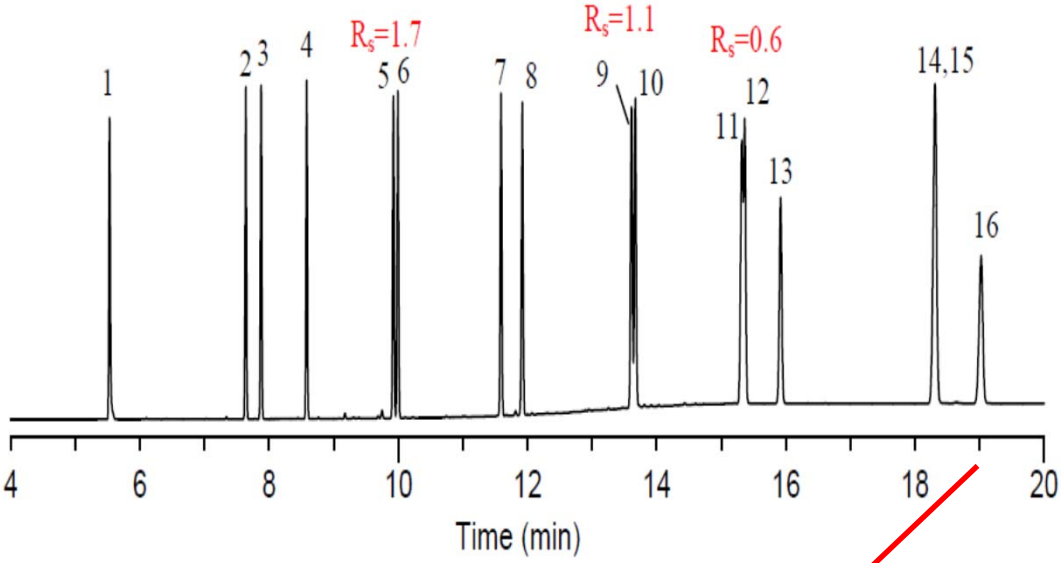
7



SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 40 °C/min to 175 °C, 25 °C/min to 270 °C, 20 °C/min to 325 °C
Hydrogen @ 60 cm/sec

Summary – Separation of 16 PAHs

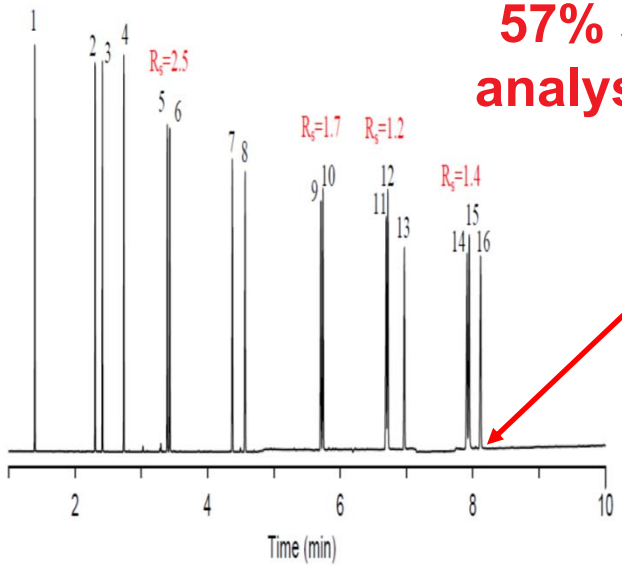
1



SLB-5ms
30 m x 0.25 mm, 0.25 µm
70 °C (0.2 min.), 20 °C/min to 325 °C (3 min.)
Helium @ 25 cm/sec

57% shorter analysis time!

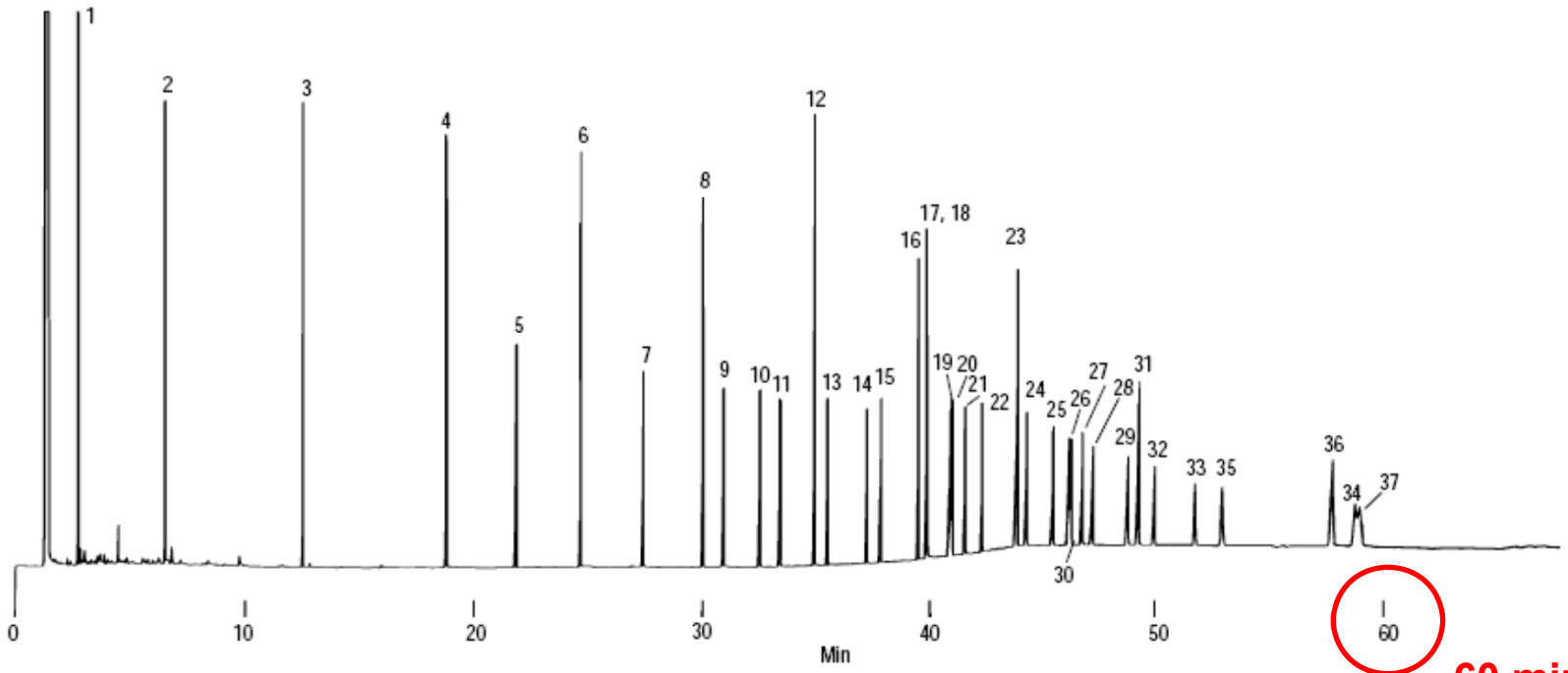
7



Improved resolution!

SLB-5ms
10 m x 0.10 mm, 0.10 µm
70 °C (0.2 min.), 40 °C/min to 175 °C, 25 °C/min to 270 °C, 20 °C/min to 325 °C
Hydrogen @ 60 cm/sec

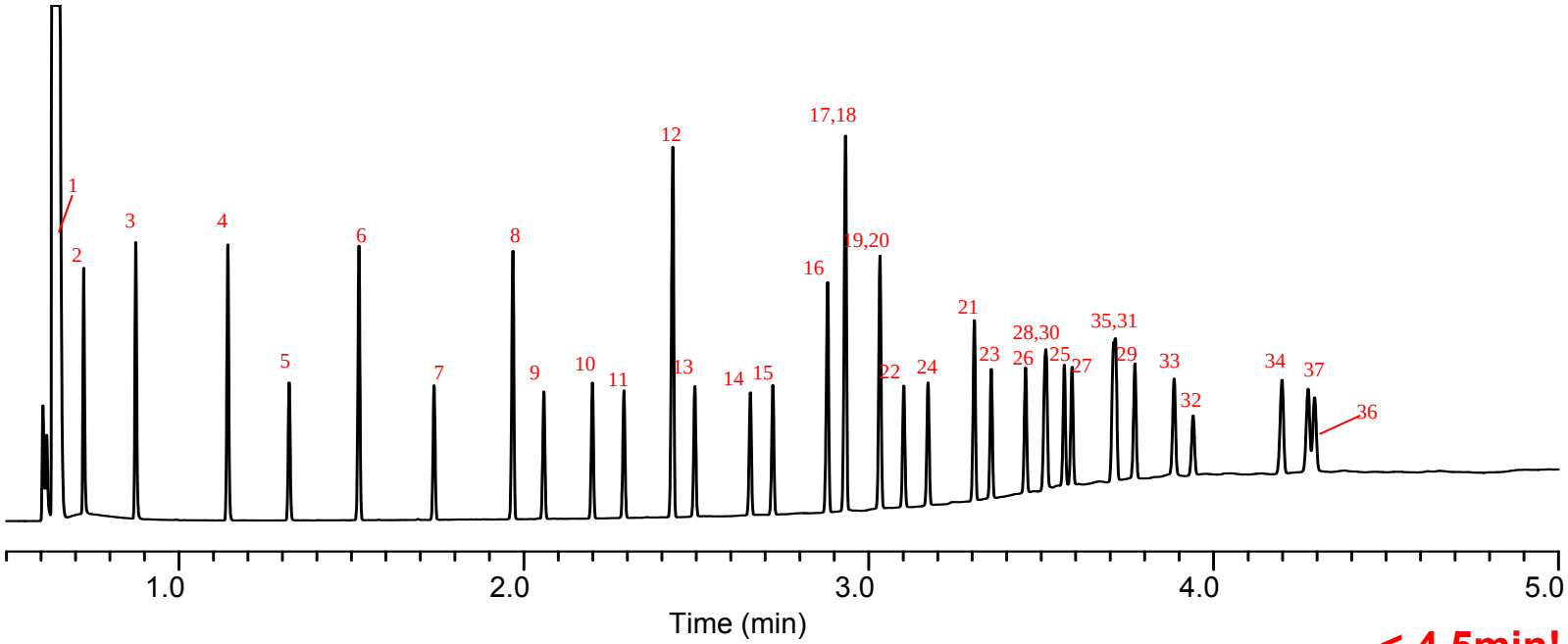
Fatty acid methyl esters (FAMEs) on Omegawax (conventional GC)



60 min!

Column: **Omegawax 250, 30m x 0.25mm ID x 0.25µm film** (Cat. No.: 24136)
Inj.: 1µL of split 100:1, 250°C
Det.: FID (2 x 10-11), 260°C
Oven: 50° C (2 min) to 220°C at 4°C/min, hold 15 min
Carrier: helium, 30cm/sec, 205°C
Sample: 10mg/mL Supelco 37 Component FAME Mix

Fatty acid methyl esters (FAMEs) on Omegawax (Fast GC)



< 4.5min!

Column: **15m x 0.10mm ID x 0.10µm Omegawax (Custom)**
Inj: 250° C
Det. 260° C (FID)
Oven: 140° C, 40° C/min to 280° C (2 min)
Carrier: H2, 50 cm/sec, constant
Injection: 0.2 ul, 200:1 split
Sample: 37-Component FAME Mix (cat. # 47885-U), 2-4% by wt. in methylene chloride
Liner: 4mm ID, cup split

Fast GC Application: Method 8270 semivolatiles

Typical analysis time: 20 to 45 minutes

Reduce run time, try….

- Shorter, narrow bore column
- Fast oven ramp rate

Result 

1. Analysis time < 9 min.
2. NO critical coelutions
3. 10-20 scans across each peak
4. Benzo (b)/(k) fluoranthenes: resolution of 66%

Short, narrower bore column

Column: SLB-5ms, 20 m x 0.18 mm I.D., 0.18 µm

Oven: 40 ° C (0.7 min.), 55 ° C/min. to 240 ° C, 28 ° C/min. to 330 ° C (2 min.)

Fast oven ramp rates

Inj.: 250 ° C

MSD interface: 330 ° C

Scan range: m/z 40-450

Carrier gas: Helium, 40 cm/sec, constant ← fast linear velocity

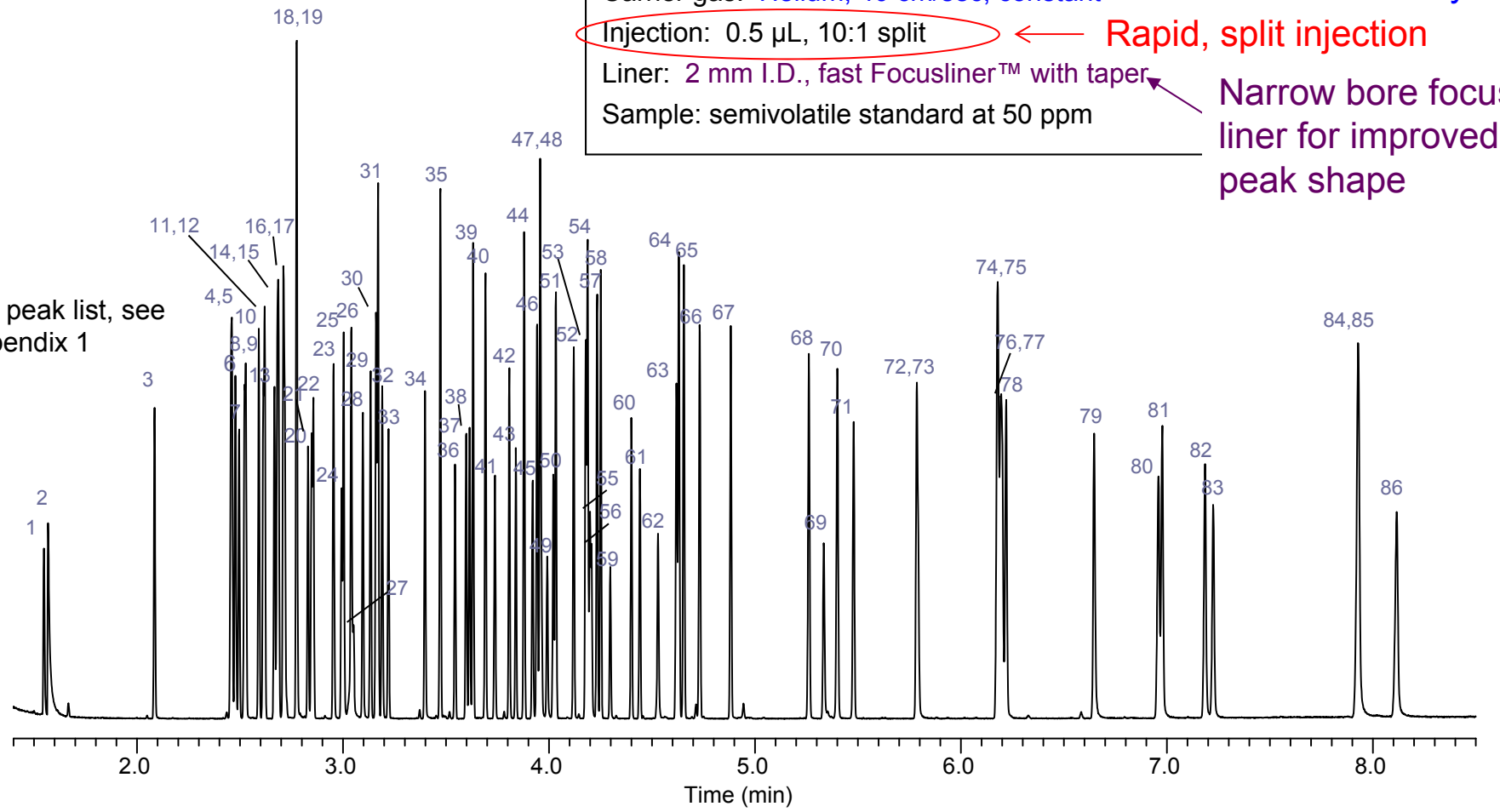
Injection: 0.5 µL, 10:1 split ← Rapid, split injection

Liner: 2 mm I.D., fast Focusliner™ with taper

Narrow bore focus liner for improved peak shape

Sample: semivolatile standard at 50 ppm

For peak list, see appendix 1



SIGMA-ALDRICH®

Columns for Fast GC

EQUITY-1

SLB-5ms (different dimensions), EQUITY-5

EQUITY-1701

SUPELCOWAX-10 (different dimensions)

SP-2560

Ionic Liquid GC columns

VOCOL

SPB-624

TCEP

Summary

Fast GC usually 0.10 mm ID columns.

Hydrogen is the preferred carrier gas.

Steep temperature ramps.

Advantages

- **Short analysis times**
- **Keeping efficiency**
- **Reduction of cost**

Considerations

- **Sample capacity**
- **Requirements on the instrument (pressure, heating, detection)**

Thank you!