Low Cost Solution for Accelerating Gas Chromatographic Separations

Gary Stidsen, Stephen J. MacDonald, Frank Dorman and Brad Rightnour

Restek Corporation
www.restekcorp.com

RESTEK

Desires of GC Analysts

- ## Higher Sample Throughput
  - Lowers cost/sample
  - Increases sample capacity
  - Fewer instruments to accomplish same workload
- ## Better Resolution
  - Can allow for shorter run times
  - Improves quantitation
  - Can allow for analysis of very complex matrices

Methods to Improve Speed and/or Resolution "high-end" technology

- Fast GC/Flash GC
  - Short, narrow I.d. columns
  - Ballistic heating (resistive, microwave)
- Multicolumn GC
  - Bertsch, Guichon, Giddings
- Comprehensive 2D-GC
  - Begun by John Phillips – Southern Illinois Univ.
- Stop-Flow GC
  - Richard Sacks – Univ. of Michigan

Methods to Improve Speed and/or Resolution "lower-end" technology
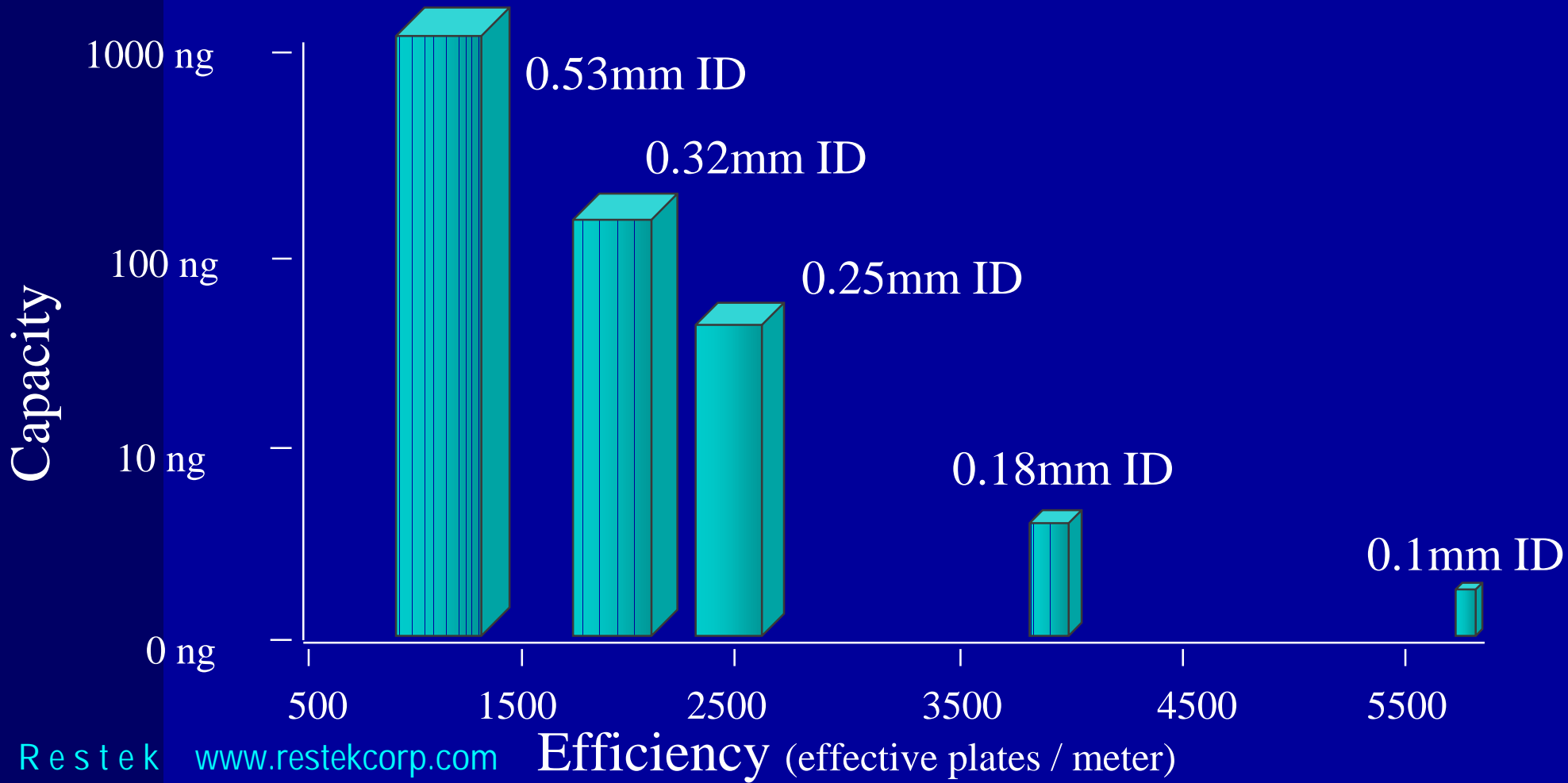
- Tuning Stationary Phase Selectivity
  - Design column to achieve specific separation
  - Users can send retention data for optimization
- Physical Parameter Optimization
  - Pro EZ-GC Software allows user optimization
- Hardware Modification
  - GC Racer allows common existing instrumentation to achieve increased temperature ramp rates

"Fast" GC Techniques

- How fast is fast?

    – 100 C/min, 100 C/sec ?

- How fast is necessary?

    – Partially depends on column dimensions

- Does the technique require different columns?

    – "caged" columns for resistive heating

    – Microwave heated columns
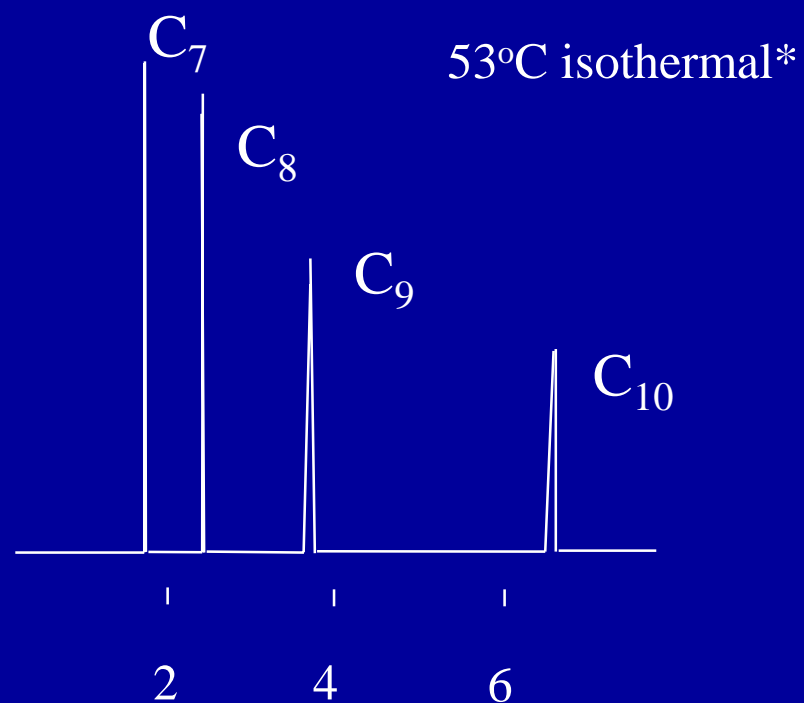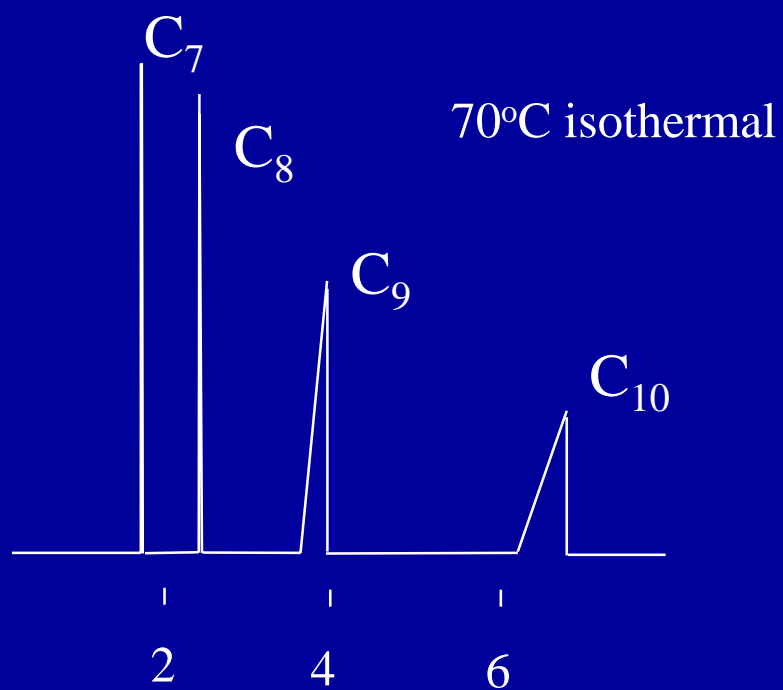
    – Narrow-bore columns

Column Selection
Typical Column Capacity vs. Efficiency

Capacity vs. Efficiency bar chart showing: 0.53mm ID (~1000 ng, ~1000 plates/meter), 0.32mm ID (~150 ng, ~1800 plates/meter), 0.25mm ID (~50 ng, ~2500 plates/meter), 0.18mm ID (~5 ng, ~3900 plates/meter), 0.1mm ID (~2 ng, ~5700 plates/meter).

Y-axis: Capacity — 1000 ng, 100 ng, 10 ng, 0 ng

X-axis: Efficiency (effective plates / meter) — 500, 1500, 2500, 3500, 4500, 5500

Effect of ID on Capacity

Rtx-1: 15m, <u>0.25mm ID</u>, 0.25μm   15m, <u>0.53mm ID</u>, 0.25μm

C_7

C_8

70°C isothermal

C_9

C_{10}

2   4   6

C_7

53°C isothermal*

C_8

C_9

C_{10}

2   4   6

*run at different temperatures to keep k values similar

Effect of Temperature Programming Rate
on Number of Theoretical Plates:
Area of the triangle Represents relative number of theoretical plates at different heating rates.

1/32

1/16

1/8

1/4

1/2

1

Temperature
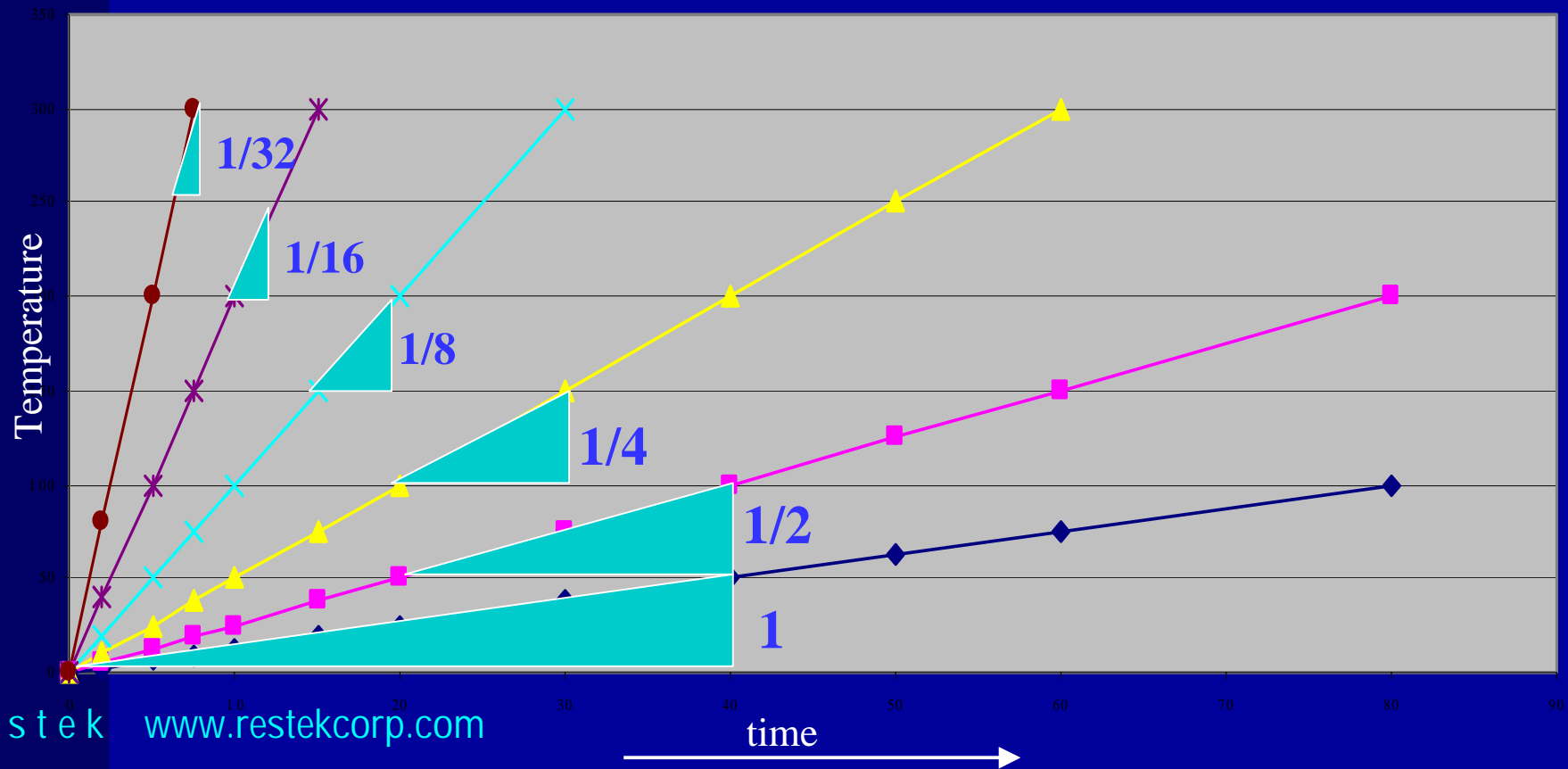
time

GC Racer

- Interfaces to existing GC's
  - 5890 A model available
  - 5890 Series 2 model available
  - 6890 Series available
- Operates using existing GC control
  - No software or firmware
- Allows for maximum ramp rates up to 440 C
- Can allow for 2-5 times speed enhancement for most methods

GC Racer Heater Installed in an Agilent 5890

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GC Racer Installed on an Agilent 5890

Versatility of HSGC Techniques

| HSGC Technique	GC Racer	Flash	Micro Bore	Others
Versatility Factor				
Injectors	All	Split/splitless	Most	?
Guard Columns	Yes	No	Yes	Yes
Retention Gap	Yes	No	Yes	Yes
Columns	All	5 or 10 m	< 0.1 mm i.d.	Small i.d.[1]
Sample Capacity	Full Range	Med - Low	Low	??
Temp Programming	Yes	Yes	Yes	Yes
Detectors	All	Most	All	?
EPC	Yes	No	High Pressure	All
RT Locking	Yes	No	Yes	Yes
Validation	None	Required	None	Required

Simplicity of HSGC Techniques

HSGC Technique	GC Racer	Flash	Micro Bore	Others
Simplicity Factor				
Installation	User	Professional	Not Applicable	Professional ?
Column changing	Plug and Play			
Column Purchase	Standard	Specialized	Standard	Standard?
User Training	Any Source	Sole Source	Any Source	?
Software	None	Yes	None	Yes
Bench space	None	Yes	None	Yes
Added Operational Requirements	No	Yes	No	??

Affordability of HSGC Techniques

HSGC Technique	GC Racer	Flash	Micro Bore	Others
Cost Factor				?
Purchase Price	3,800	20,000	400	
Installation Cost	0	3,000	0	
Maintenance Cost	0	??	0	
Training Cost	0	included in installation cost	0	
Number of Columns	GC dependent (1 – 4)	1	1	
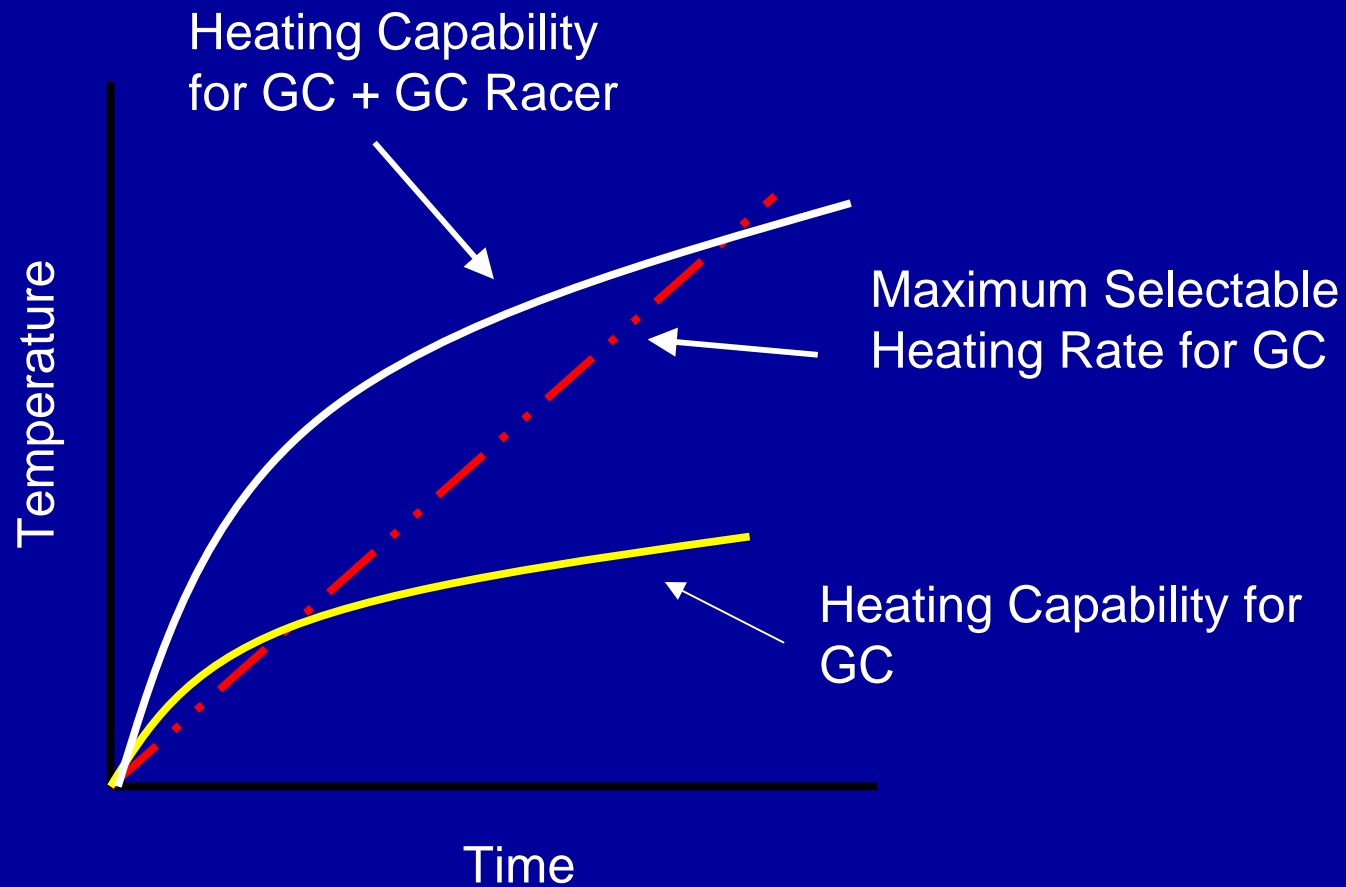
GC Racer: Allows use of fast heating rates throughout entire temperature range

Versatility of Zip GC Racer

Versatility Factor		
Injectors	All	S/SS, Direct, PTV, SPME, 3RD Party
Columns	All	Every size, every manufacturer, every length - Fused silica, metal, packed.
Guard Columns	Yes	
Retention Gap	Yes	
Sample Capacity		From microbore to packed column capacity
Temp Programming		HP 5890: 70 °C/min up to 350 °C.
		HP 6890: 70 °C/min up to 400 °C.
Detectors	Full Range	FID, MSD, FPD, PID, TCD, HID, … every make, model, manufacturer.
EPC	All	original EPC and third party EPC accessories
RT Locking	Yes	Seamless addition to existing system

Simplicity of Zip GC Racer

Simplicity Factor	
Installation	Simple; 3 plug in connections. Plug and Play
Column changing	Standard method, no special columns, interfaces, or tools.
Column Purchase	User continues to buy from vendor of choice.
User Training	None
Software	None
Bench space	None
Added Operational Requirements	None

Ruggedness of Zip GC Racer

The Zip GC Racer is based on the same heating technology used by GC manufacturers for the past 25+ years. Most GCs go to the junkyard without ever having oven failures. MTBF for GC oven heaters is a long, long, very long time.

Alpha Site	U Mass		
Beta Sites		Woods Hole Environmental Group	Restek Corp
Host GC	HP 5890 Series II	HP 5890	HP 5890
Application	Tenn/Miss DRO	Extractable HC	SimDis PCB's
Comments	Blew a few fuses – nobody got hurt.		
Problems encountered	Typical Design Issues	None	None

Tenn/Miss DRO Mix with GC Racer
Temp Program: 50°C (0.33 min hold), 70°C/min to 300°C, hold 0.1 min

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GC Racer RT Stability over 7 Days/900 Runs

Retention Time (min)

Tenn/Miss DRO (Peak Number)

Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Series11
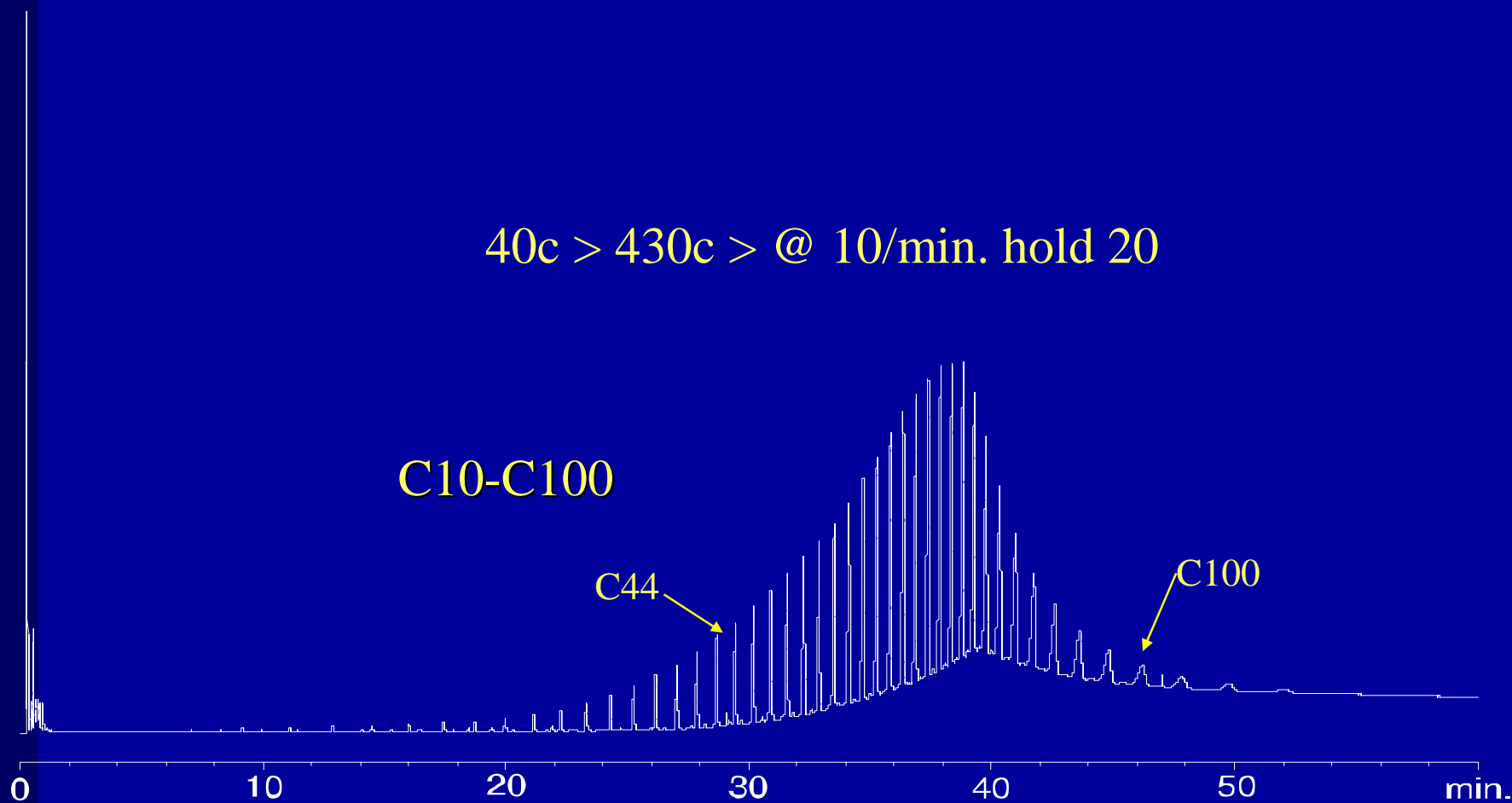
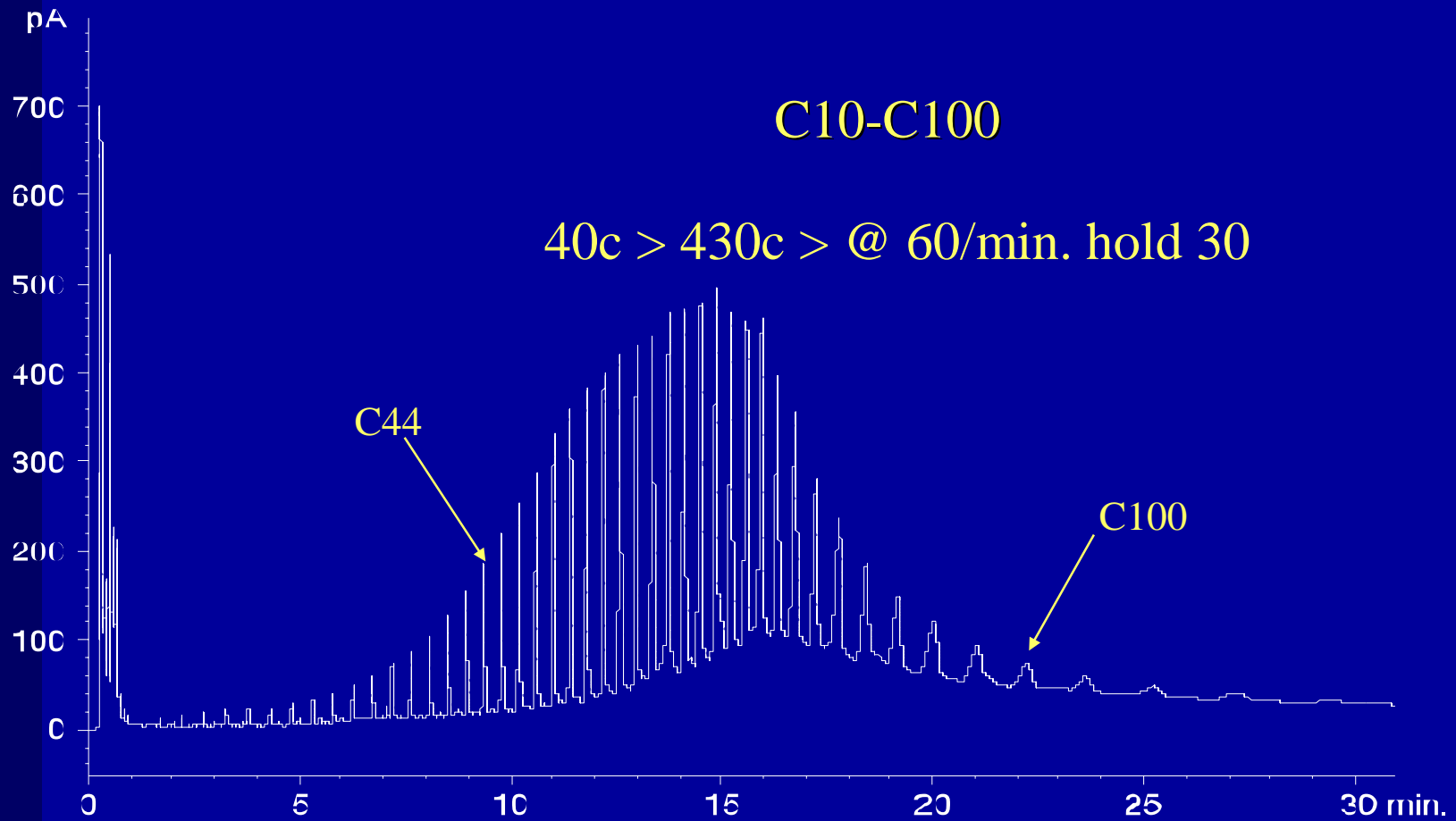R e s t e k   www.restekcorp.com
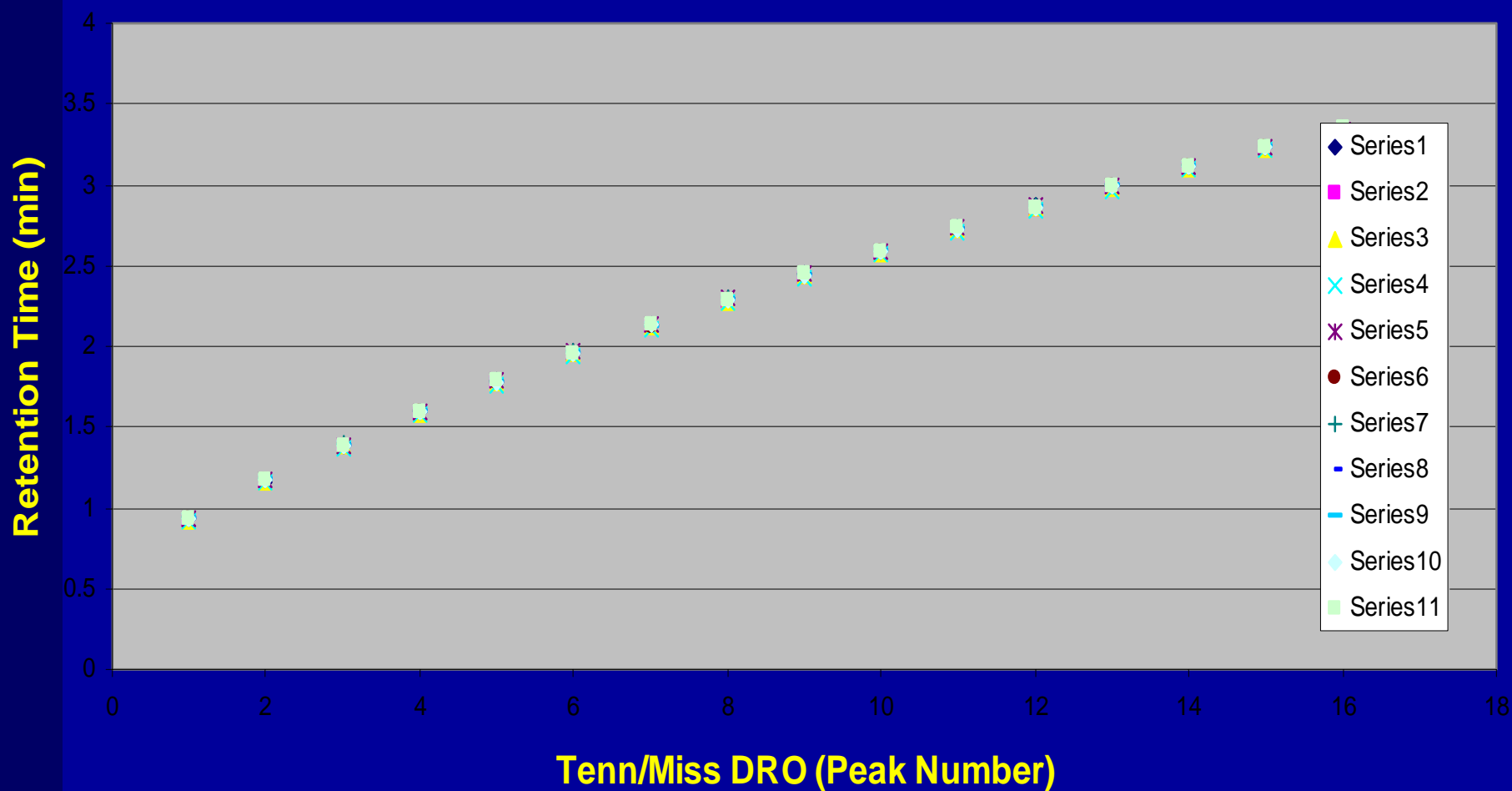
Polywax 1000

- Polyethylene (even numbers) with average molecular weight of 1000 daltons
- Requires high temperature for elution of homologous series
- Good candidate for faster technique

MXT-1HT   Polywax 1000 C10-C100

40c > 430c > @ 10/min. hold 20

C10-C100

C44

C100

0   10   20   30   40   50   min.

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Polywax 1000 60ᶜ/ minute ramp rate

C10-C100

40c > 430c > @ 60/min. hold 30
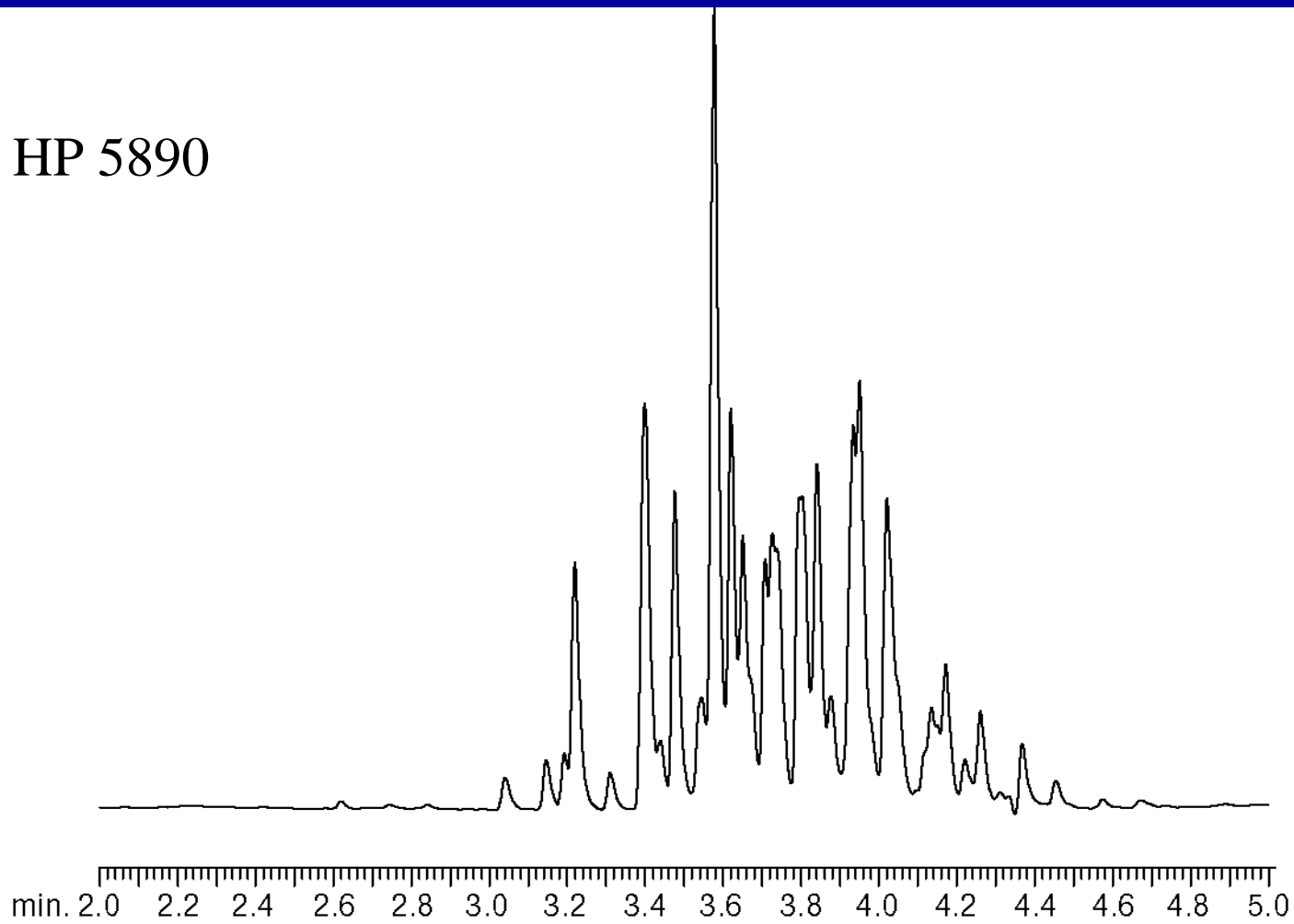
C44

C100

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PCB Aroclors

- Screening or analysis of PCB Aroclors can be performed quickly since complete separation is not a factor

- One of the most common tests required at remediation sites or for waste oil disposal

- Good candidate for accelerated separation
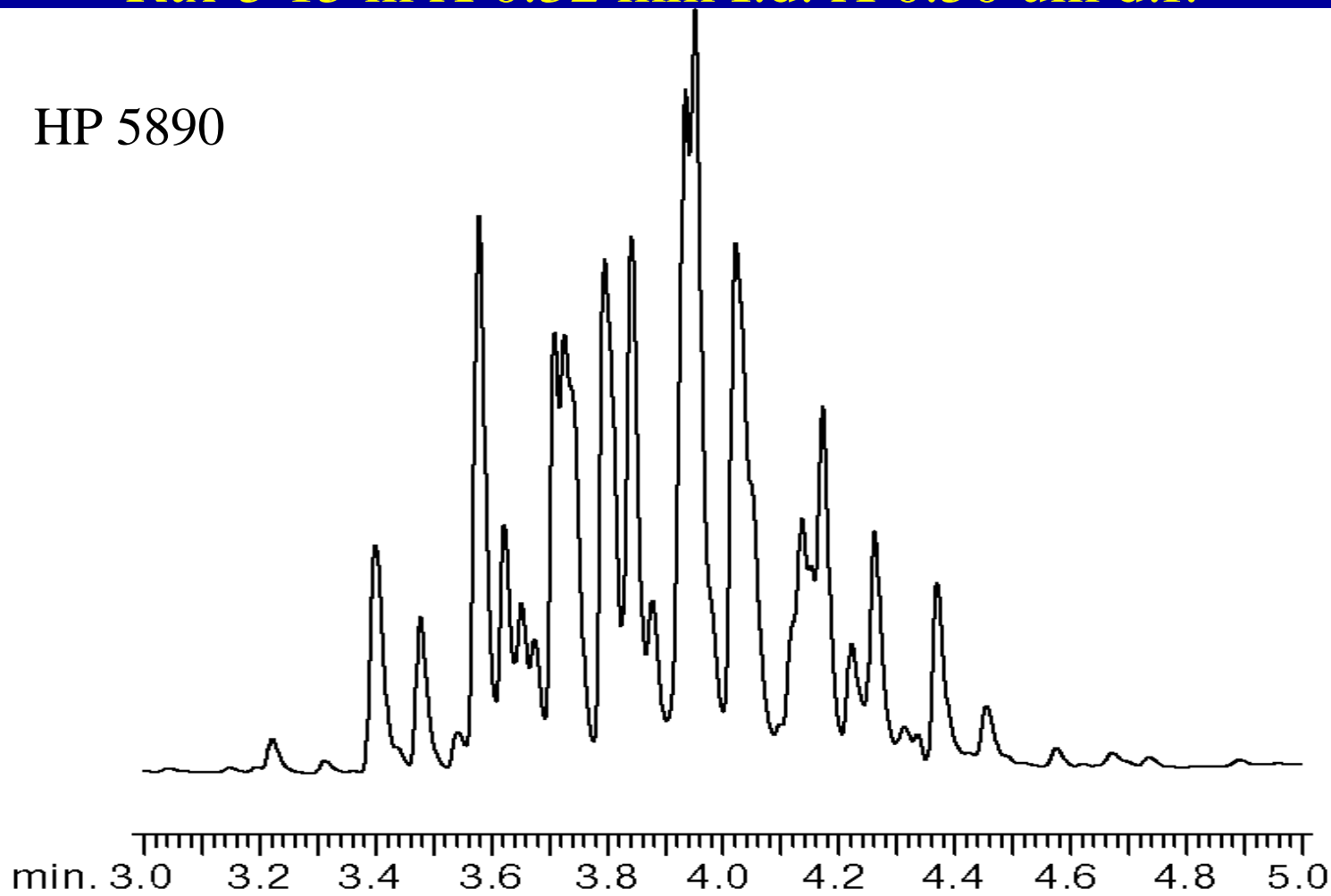
Rtx-5 15 m X 0.32 mm I.d. X 0.50 um d.f.

HP 5890

min. 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0

Aroclor 1242 with Zip Racer 110 C (Hold 1 min) to 300 C at 60 C/min (hold 5 min)

Rtx-5 15 m X 0.32 mm I.d. X 0.50 um d.f.

HP 5890

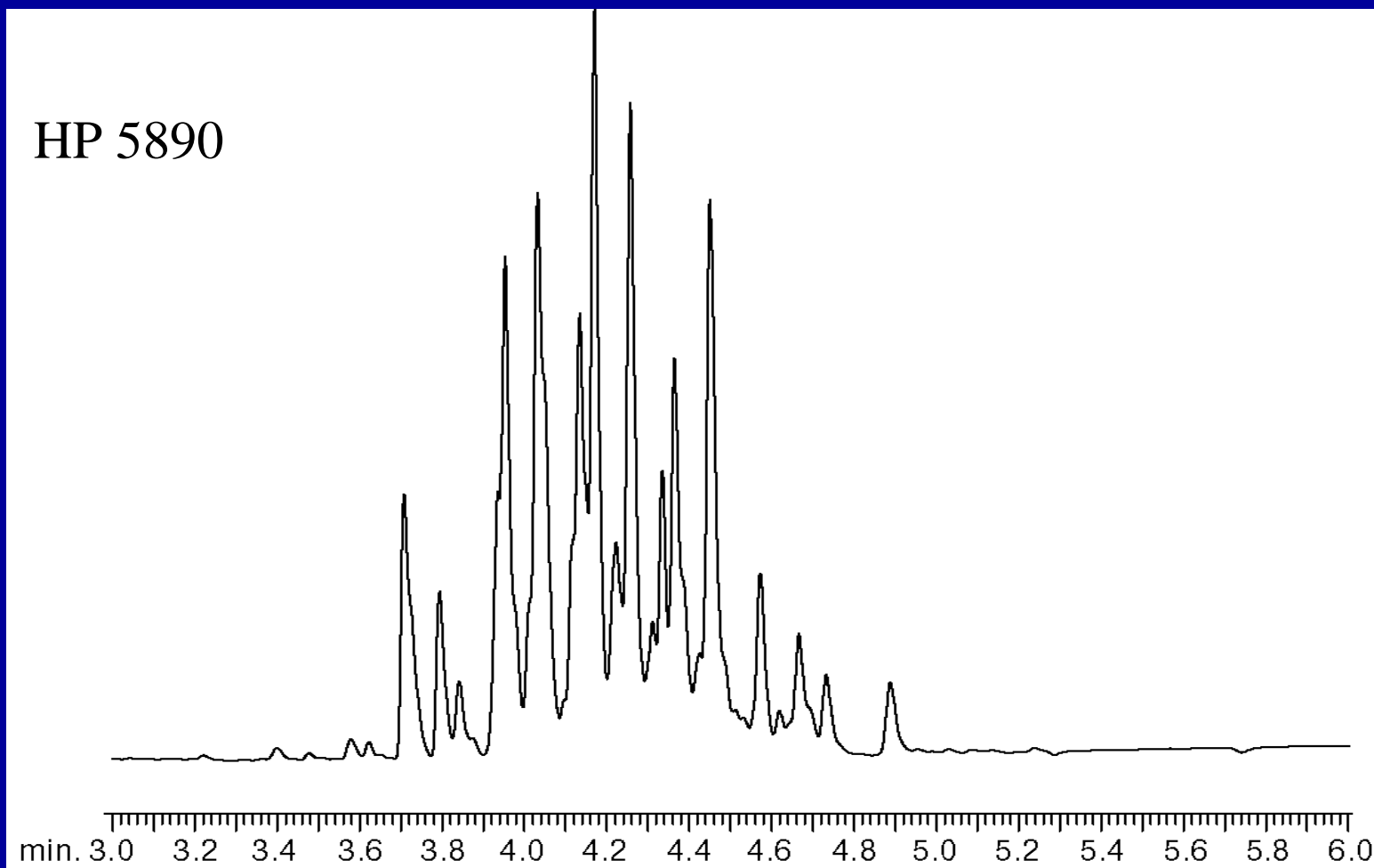min. 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0

Aroclor 1248 with Zip Racer 110 C (Hold 1 min) to 300 C at 60C/min (hold 5 min)

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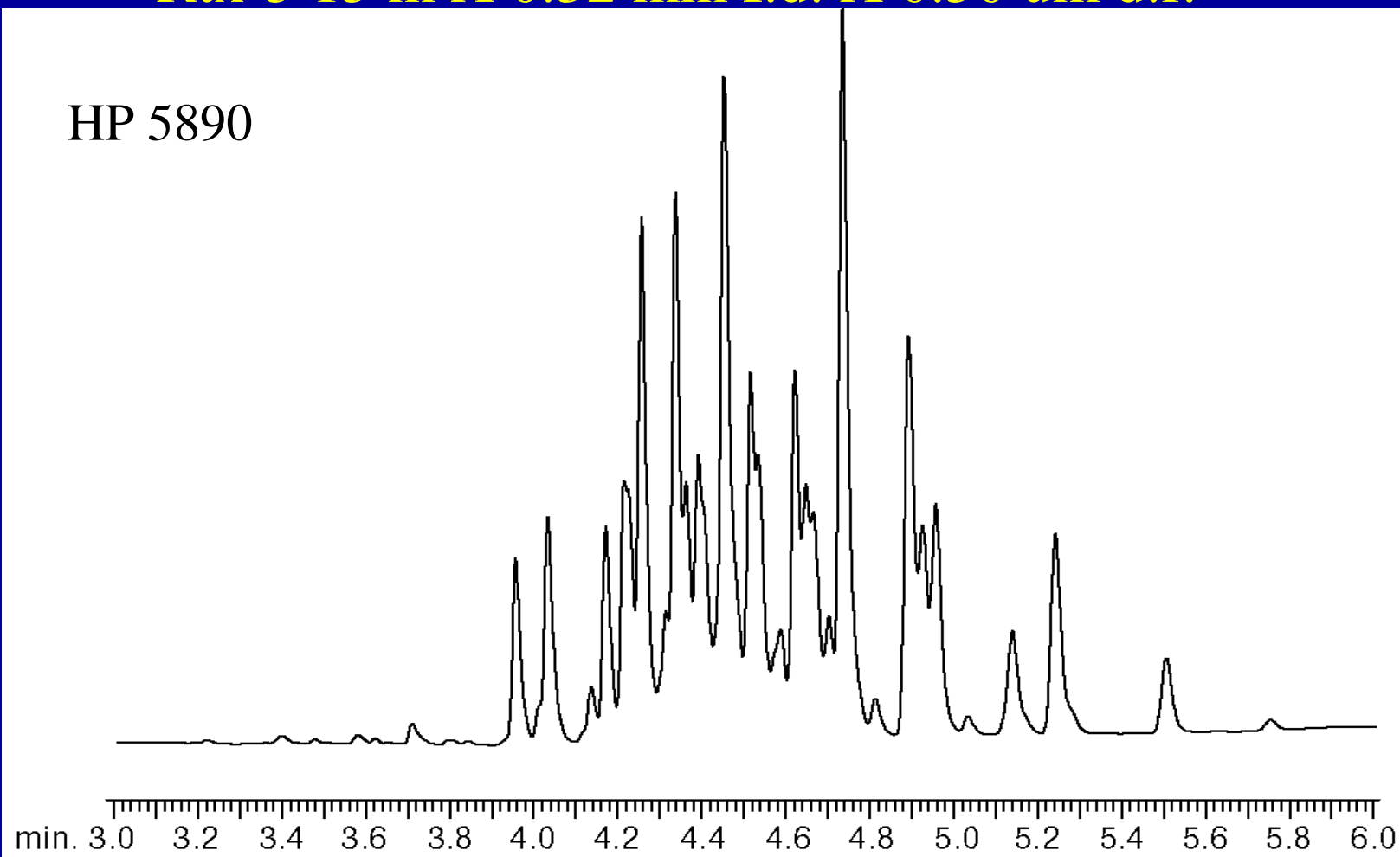
Rtx-5 15 m X 0.32 mm I.d. X 0.50 um d.f.

HP 5890

Aroclor 1254 with Zip Racer 110 C (Hold 1 min) to 300 C at 60C/min (hold 5 min)

Rtx-5 15 m X 0.32 mm I.d. X 0.50 um d.f.

HP 5890

min. 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0 5.2 5.4 5.6 5.8 6.0

Aroclor 1260 with Zip Racer 110 C (Hold 1 min) to 300 C at 60C/min (hold 5 min)

Affordability of Zip GC Racer

Purchase Price	Small fraction of the cost of existing technology.
Installation Cost	User installed in less than 30 min.
Maintenance Cost	No Preventative Maintenance Required
Training Cost	None - No Training Required
Number of Columns	GC dependent; 1 or 2

Summary
For the Routine User:

- GC Racer is simple to install

- No training necessary

- Allows improvement in oven ramp rates
  - Many methods can benefit

- No re-qualification necessary

- No software to learn

- Uses existing GC instrumentation