RESTEK environmental

Applications note

Fast Analyses of Aroclor® PCBs, Using the Zip Scientific GC Racer* Temperature Programming System

Introduction

Analytical chemists using traditional gas chromatographs (GC) have control of four fixed parameters (column length and internal diameter, phase type and film thickness) and three variable parameters (carrier gas composition and velocity, and temperature programming) that affect analytical run times. The maximum oven temperature ramp rate has been limited, however, based on chromatograph design. Now, the temperature-programming rate can be effectively increased, significantly shortening analysis time for Aroclor® PCBs and thereby reducing instrument operating time and increasing sample throughput.

Aroclor® PCBs

Aroclor® mixtures are mixtures of polychlorinated biphenyl (PCB) congeners, each phenyl ring of which contains 1–5 chlorine atoms. Since each PCB can contain up to 10 chlorine atoms, in any combination of positions, there are 209 PCB congeners. Environmental samples are commonly screened for seven Aroclor® mixtures that are or were widely used, but there are other Aroclor® mixtures and PCB mixtures are also manufactured under other tradenames.

The seven commonly analyzed Aroclor® mixtures are Aroclor® 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Other Aroclor® mixtures include "technical" Aroclor® 1254, Aroclor® 1262, and Aroclor® 1268. The Aroclors® contain mixes of congeners based on distillation fractions. The last two digits of the Aroclor® number indicate the content of chlorine, by weight (e.g., Aroclor® 1232 is 32% chlorine by weight). The exception is Aroclor® 1016, which is similar to Aroclor® 1242. The range of PCB congeners differs among Aroclor® mixtures (e.g., Aroclor® 1242 is made up mainly of congeners ranging from approximately dichlorobiphenyls to tetrachlorobiphenyls; late eluting Aroclor® 1260 is made up mostly of hexachlorobiphenyls to octachlorobiphenyls) and, since the mixtures were made to weight percent chlorine, not to specific composition standards, the exact mixture of congeners varies among various manufacture lots. All Aroclor® mixtures have some PCB congeners in common, so retention times among Aroclor® mixtures overlap, but each Aroclor® mixture has an identifiable fingerprint pattern.

Reducing Analysis Time

Because the chromatographic patterns of the various Aroclor® mixtures are easily differentiated, the chromatographer could accelerate the GC analysis, and thereby accomplish more analyses during a set period of time. To reduce analysis time without changing the column, the chromatographer has three options: change carrier gas (from helium to hydrogen), increase the velocity at which the carrier gas passes through the column, or increase the oven temperature program rate.

Changing the carrier gas might not be a practical option. To increase the velocity of the carrier gas the backpressure at the column inlet must be increased. Generally, 30m x 0.32mm columns are operated at a pressure of 5-10psig, but the pressure can be increased to 25 psig without a loss of column efficiency that would affect Aroclor® quantification.

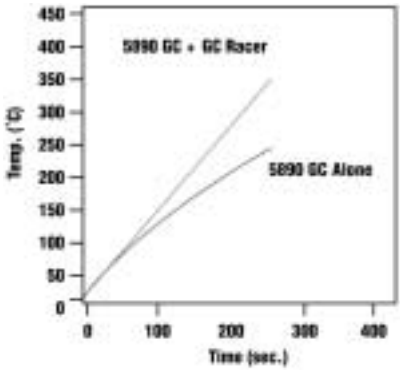
The third option, increasing the oven temperature program rate, has been a problem until now: oven temperature ramp rates are limited. Most older chromatograph models have a maximum reliable programming rate of 20°C/minute; newer models allow programming rates of up to 70°C/minute, but only to relatively low maximum temperatures.

Now, by using the Zip Scientific GC Racer auxiliary heating unit, temperature program rates of up to 70°C/min. can be maintained to temperatures up to 350°C—conditions that allow analyses of Aroclor® PCB mixtures to be accelerated.

The GC Racer consists of a program controller and a resistive heating element that is placed on the floor of the GC oven (Figure 1). The heating element is connected to the controller which, in turn, is plugged into the main PC board of the GC. When the GC Racer programmer detects that the factory heating elements are not keeping up with the programmed heating rate, the GC Racer heater is brought into the circuit to augment the heat being supplied to the oven. Oven temperature with and without supplementation from a GC Racer has been empirically tested with an Agilent 5890 chromatograph; results are shown in Figure 1.

Faster Aroclor® Analyses

Figure 1—The GC Racer allows a temperature program rate of up to 70°C/min. to be maintained up to 350°C.



GC: Agilent 5890; **Service:** 120V/15 amp; **Start Temp:** 20°C; set oven to 400°C and monitor oven temp.

The GC Racer consists of a control unit and a resistive heating element placed on the floor of the GC oven.

**Patent pending.*

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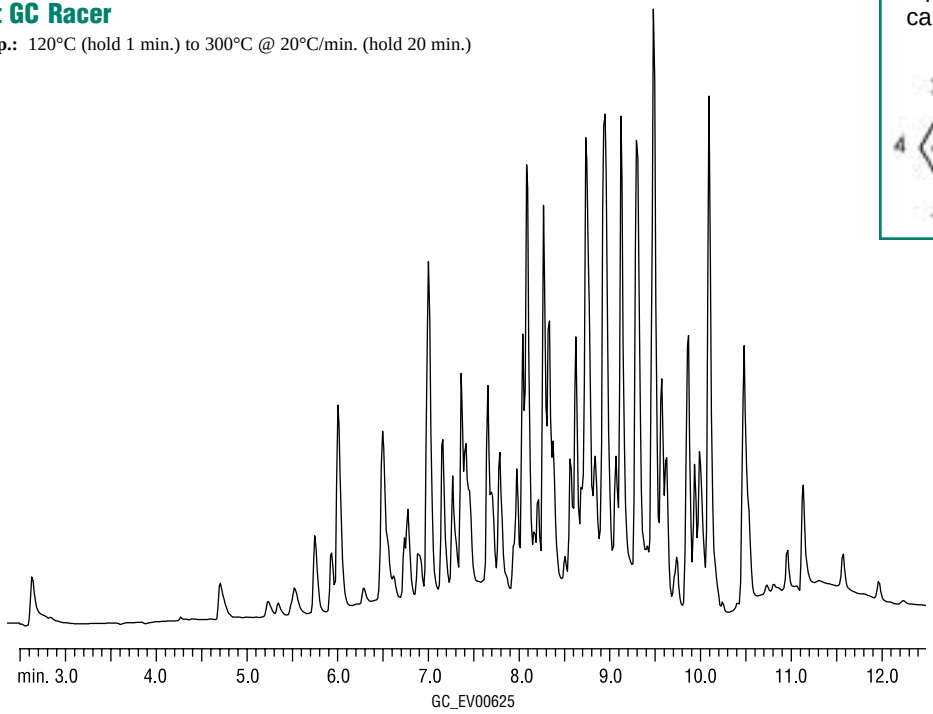
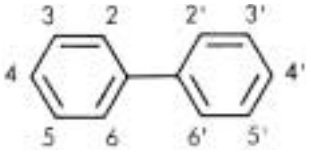
Figure 2—Analysis of mixed Aroclor® standards is significantly faster with the GC Racer temperature programmer.

Aroclor® 1221, 1242, 1254, 1260 Mix without GC Racer

Oven temp.: 120°C (hold 1 min.) to 300°C @ 20°C/min. (hold 20 min.)



Structure of polychlorinated biphenyls. Each molecule can have 1 to 10 chlorine atoms.



More than 40% reduction in analysis time with fast temperature programming!

Aroclor® 1221, 1242, 1254, 1260 Mix with GC Racer

Oven temp.: 120°C (hold 0.5 min.) to 300°C @ 60°C/min. (hold 6.5 min.)
Zip Scientific GC Racer for Agilent 5890 Series II (cat.# 23024)

Column:	Rtx®-CLPesticides2 30m, 0.32mm ID, 0.25µm (cat.# 11324)
Sample:	400ng/mL Aroclor® 1221, 1242, 1254, 1260 mix in hexane
Inj.:	1.0µL direct, Uniliner® inlet liner (cat.# 20335)
Inj. temp.:	210°C
Carrier gas:	helium, constant pressure
Linear velocity:	46cm/sec. @ 120°C
Det.:	ECD @ 310°C
Guard Column:	Siltek™-Deactivated 5m, 0.32 ID (cat.# 10027)
Connector:	Universal Angled Press-Tight® (cat.# 20446)

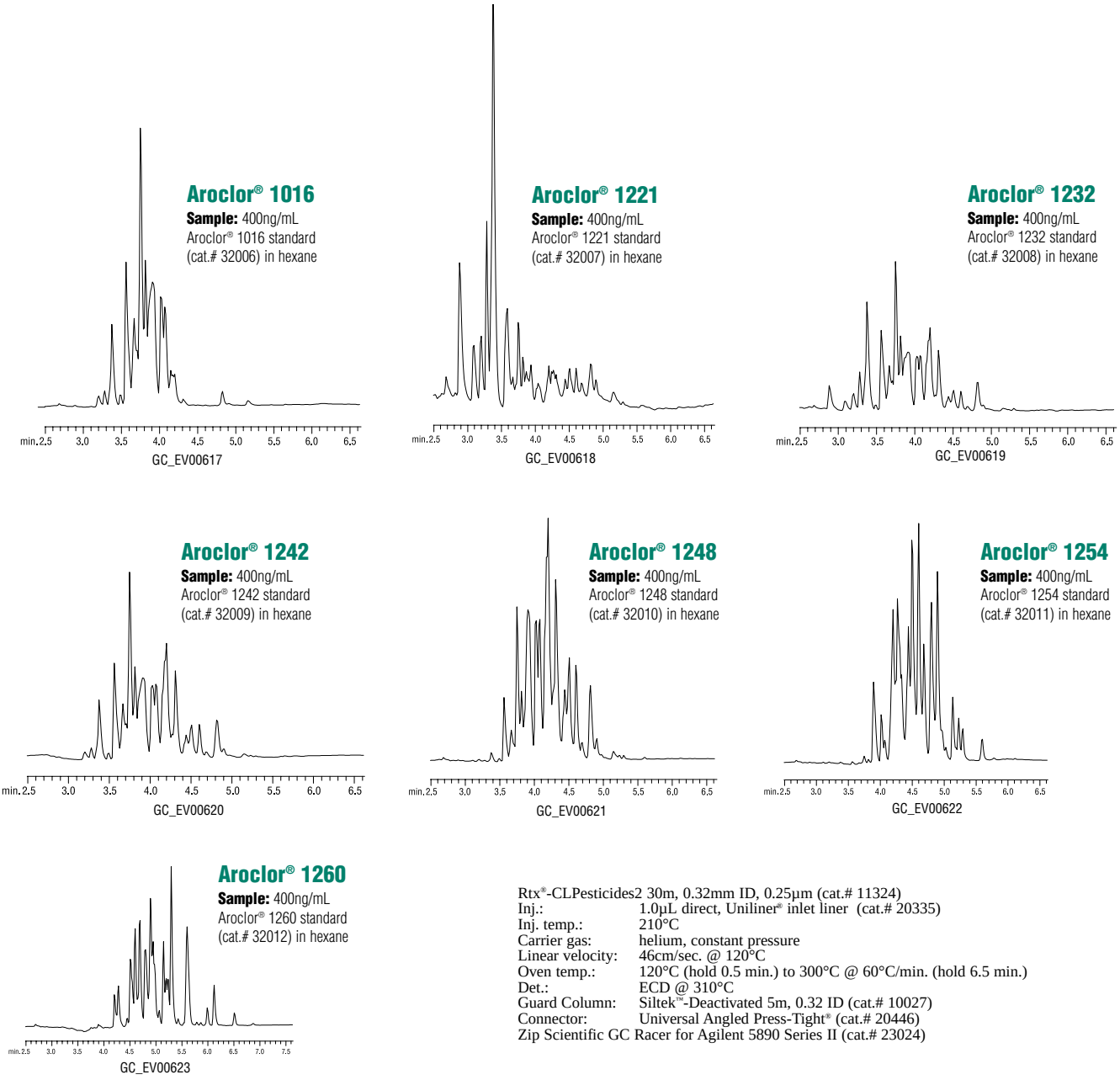
Using a GC Racer, the oven temperature program for an Agilent 5890 chromatograph can be tripled, from 20°C/min. to 60°C/min. With all other chromatographic parameters the same, analysis time will be reduced significantly. Figure 2 shows chromatograms of a mixture of Aroclor® standards analyzed at both programming rates. Time savings that accrue from the five-minute shorter analysis are significant. Using a common GC cool-down time of two minutes, total cycle times at the two programming rates are 14 minutes and 9 minutes. In an 8-hour period 34 cycles can be made at a 14-minute cycle time, versus 53 cycles with the GC Racer—**a 56% increase in sample throughput!**

Typical chromatographic patterns for the seven common Aroclor® mixtures analyzed under fast temperature programming are shown in Figure 3.

Conclusion

The Zip Scientific GC Racer system is a highly effective, easily installed tool that enhances the performance of a gas chromatograph. By decreasing run time and increasing sample throughput, the higher analysis speeds that can be achieved can lead to significant long-term savings of time and money. PCB analyses are shown here, but this example application is a good model for analyses of long-chain hydrocarbons, high molecular weight compounds, low-volatility molecules, and other late eluting analytes that require long analysis times at slow temperature program rates.

Figure 3—Typical chromatographic patterns for Aroclor® PCBs analyzed under fast temperature programming.



Rtx®-CLPesticides2 30m, 0.32mm ID, 0.25µm (cat.# 11324)
Inj.: 1.0µL direct, Uniliner® inlet liner (cat.# 20335)
Inj. temp.: 210°C
Carrier gas: helium, constant pressure
Linear velocity: 46cm/sec. @ 120°C
Oven temp.: 120°C (hold 0.5 min.) to 300°C @ 60°C/min. (hold 6.5 min.)
Det.: ECD @ 310°C
Guard Column: Siltek™-Deactivated 5m, 0.32 ID (cat.# 10027)
Connector: Universal Angled Press-Tight® (cat.# 20446)
Zip Scientific GC Racer for Agilent 5890 Series II (cat.# 23024)

GC Racer by Zip Scientific*

Operate Your Agilent 5890 as fast as a 6890!

CE pending

Description		qty.	cat.#
GC Racer for Agilent 5890 Series II (only) GC	120 volt	ea.	23024
GC Racer for Agilent 5890A (only) GC	120 volt	ea.	23025
GC Racer for Agilent 6890 (only) GC	120 volt	ea.	23028

**Patent pending.*

PCB Kit #1

32006: Aroclor® 1016
32007: Aroclor® 1221
32008: Aroclor® 1232
32009: Aroclor® 1242
32010: Aroclor® 1248
32011: Aroclor® 1254
32012: Aroclor® 1260

1,000µg/mL each in hexane, 1mL/ampul

Kit	Kit w/Data Pack
32089	32089-500

PCB Kit #2

32064: Aroclor® 1016
32065: Aroclor® 1221
32066: Aroclor® 1232
32067: Aroclor® 1242
32068: Aroclor® 1248
32069: Aroclor® 1254
32070: Aroclor® 1260

200µg/mL each in isooctane, 1mL/ampul

Kit	Kit w/Data Pack
32090	32090-500

PCB Kit #3

32007: Aroclor® 1221
32008: Aroclor® 1232
32009: Aroclor® 1242
32010: Aroclor® 1248
32011: Aroclor® 1254
32039: Aroclor® 1016/1260

1,000µg/mL each in hexane, 1mL/ampul

Kit	Kit w/Data Pack
32400	32400-500

PCB Kit #4

32065: Aroclor® 1221
32066: Aroclor® 1232
32067: Aroclor® 1242
32068: Aroclor® 1248
32069: Aroclor® 1254
32299: Aroclor® 1016/1260

200µg/mL each in isooctane, 1mL/ampul

Kit	Kit w/Data Pack
32401	32401-500

Rtx®-CLPesticides2 Columns (Fused Silica)

ID	df (µm)	temp. limits	15-Meter	20-Meter	30-Meter	60-Meter
0.10mm	0.10	-60 to 310/330°C		43302		
0.18mm	0.14	-60 to 310/330°C		42302		
0.25mm	0.20	-60 to 320/340°C	11320		11323	11326
0.32mm	0.25	-60 to 320/340°C	11321		11324	
0.53mm	0.42	-60 to 300/320°C	11337		11340	

Rtx®-5 Columns (Fused Silica)

(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter
0.25mm	0.25	-60 to 330/350°C	10220	10223	10226
	0.50	-60 to 330/350°C	10235	10238	10241
	1.00	-60 to 320/340°C	10250	10253	10256
0.32mm	0.25	-60 to 330/350°C	10221	10224	10227
	0.50	-60 to 330/350°C	10236	10239	10242
	1.00	-60 to 330/350°C	10251	10254	10257
0.53mm	0.25	-60 to 320/340°C	10222	10225	10228
	0.50	-60 to 310/330°C	10237	10240	10243
	1.00	-60 to 310/330°C	10252	10255	10258
	1.50	-60 to 310/330°C	10267	10270	10273

**The maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.*

Restek offers GC columns in virtually any bore, film thickness, and length. Also, we stock thousands of inlet liners for all major GC models for immediate shipment! For a complete product listing, request our annual Chromatography Products Guide.

Uniliner® Inlet Liner For Agilent GCs

(for 0.32/0.53mm ID columns)

(4.0mm ID, 6.3mm OD, 78.5mm length)	
20335 (ea.)	20336 (5-pk.)

Aroclor® Solutions

Compound Packaged 1mL/ampul	Solvent	µg/mL	Individual	Individual w/data pack	5-pk.	5-pk. w/data pack	10-pk. w/data pack
Aroclor® 1016	hexane	1,000	32006	32006-500	32006-510	32006-520	32106
Aroclor® 1221	hexane	1,000	32007	32007-500	32007-510	32007-520	32107
Aroclor® 1232	hexane	1,000	32008	32008-500	32008-510	32008-520	32108
Aroclor® 1242	hexane	1,000	32009	32009-500	32009-510	32009-520	32109
Aroclor® 1248	hexane	1,000	32010	32010-500	32010-510	32010-520	32110
Aroclor® 1254	hexane	1,000	32011	32011-500	32011-510	32011-520	32111
Aroclor® 1260	hexane	1,000	32012	32012-500	32012-510	32012-520	32112
Aroclor® 1016/1260	hexane	1,000	32039	32039-500	32039-510	32039-520	32139
Aroclor® 1262	hexane	1,000	32409	32409-500	32409-510	32409-520	32509
Aroclor® 1268	hexane	1,000	32410	32410-500	32410-510	32410-520	32510

Compound Packaged 1mL/ampul	Solvent	µg/mL	Individual	Individual w/data pack	5-pk.	5-pk. w/data pack	10-pk. w/data pack
Aroclor® 1016	isooctane	200	32064	32064-500	32064-510	32064-520	32164
Aroclor® 1221	isooctane	200	32065	32065-500	32065-510	32065-520	32165
Aroclor® 1232	isooctane	200	32066	32066-500	32066-510	32066-520	32166
Aroclor® 1242	isooctane	200	32067	32067-500	32067-510	32067-520	32167
Aroclor® 1248	isooctane	200	32068	32068-500	32068-510	32068-520	32168
Aroclor® 1254	isooctane	200	32069	32069-500	32069-510	32069-520	32169
Aroclor® 1260	isooctane	200	32070	32070-500	32070-510	32070-520	32170
Aroclor® 1016/1260	isooctane	200	32299	32299-500	32299-510	32299-520	32399

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Restek should be your first choice for custom-made reference materials. Our inventory of over 3,000 compounds ensures you of maximum convenience, maximum value, and minimum time spent blending mixtures in your lab.

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