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Aroclors, Homologs and Congeners – An Evaluation of the Options for PCB Analysis and a Comparison of the Interpretive Value

Chuck Neslund, Technical Director, Eurofins Lancaster Laboratories Environmental, LLC

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Polychlorinated Biphenyls - PCBs

- Most commonly known for use in transformers as dielectric fluids
- Also used in hydraulic fluids, lubricants, as plasticizers and in caulking compounds
- Primary manufacturer was Monsanto – product given the trade name Aroclor
- Aroclor nomenclature indicated the average % chlorine in the mixture

  i.e. Aroclor 1254 = approx 54% chlorine

Why are they important?

- PCBs bioaccumulate
- WHO (World Health Organization) has determined that some of the 209, ones referred to as “dioxin-like” PCBs, dl-PCBs, or coplanar PCBs, may be anticipated to cause cancer
- People can be exposed to PCBs through breathing in contaminated air, consuming contaminated food, and by skin contact with old electrical equipment that contains PCBs.

Polychlorinated Biphenyls - PCBs

PCBs can be grouped or identified by three common descriptions;

- Aroclor – a mixture of up to one hundred different congeners, grouped together based on an average percent weight chlorine basis
- Homolog – congeners of the same chlorination level. There are 10 chlorination groupings
- Congener – any of the individual chlorinated biphenyl compounds of which 209 are possible

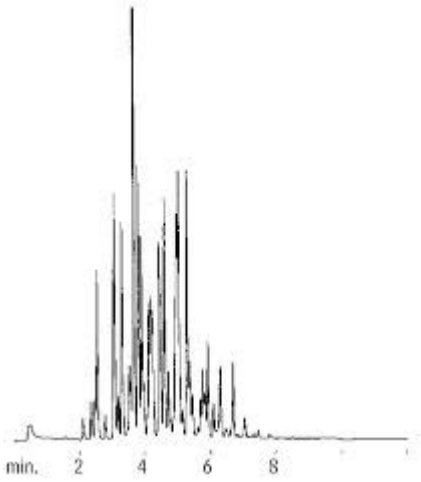
Polychlorinated Biphenyls - Aroclors

- The most common analysis technique is GC/ECD, SW-846 Method 8082
- Identifies and quantifies PCBs as an Aroclor

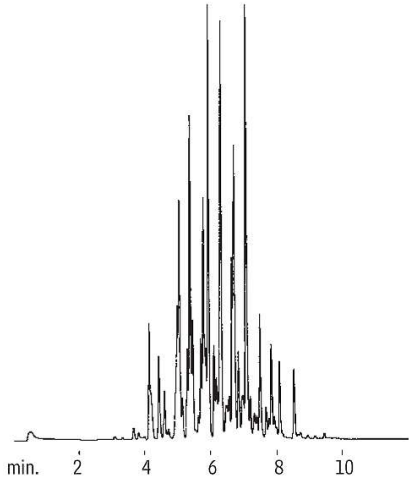
Aroclor 1016	Aroclor 1221	Aroclor 1232
Aroclor 1242	Aroclor 1248	Aroclor 1254
Aroclor 1260	Aroclor 1262	

- Limits are typically in the ug/kg and ug/l range
- Technique is prone to interferences

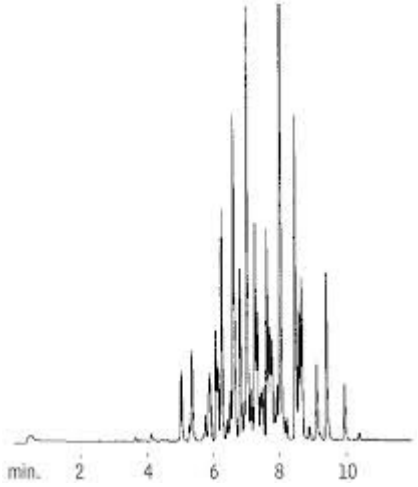
Polychlorinated Biphenyls - Aroclors



Aroclor 1242



Aroclor 1254



Aroclor 1260

Polychlorinated Biphenyls - Aroclors

- Each Aroclor mix consists of dozens of congeners
- Congeners with the same number of chlorines on the biphenyl ring are called homologs
- For example, Aroclor1254 contains;

  1% Trichlorobiphenyls

  15% Tetrachlorobiphenyls

  53% Pentachlorobiphenyls

  26% Hexachlorobiphenyls

  4% Heptachlorobiphenyls

Why are they important?

- Everything you know about Aroclor PCBs applies in some part to PCB Congeners
- Not all PCB congeners are found in Aroclors
- Approximately 130 of the 209 congeners are detected in Aroclors
- Congeners are also categorized by the number of chlorines substituted on the biphenyl ring
- These categories are called homolog groups or isomer groups

Polychlorinated Biphenyls - Homologs

Homologs can be characterized by EPA Method 680 or EPA Method 1668.

EPA Method 680

- Gas Chromatography/Mass Spectrometry (low resolution)
- Can be operated full scan or selected ion monitoring (SIM)
- Therefore, sensitivities similar to what you have with 8270

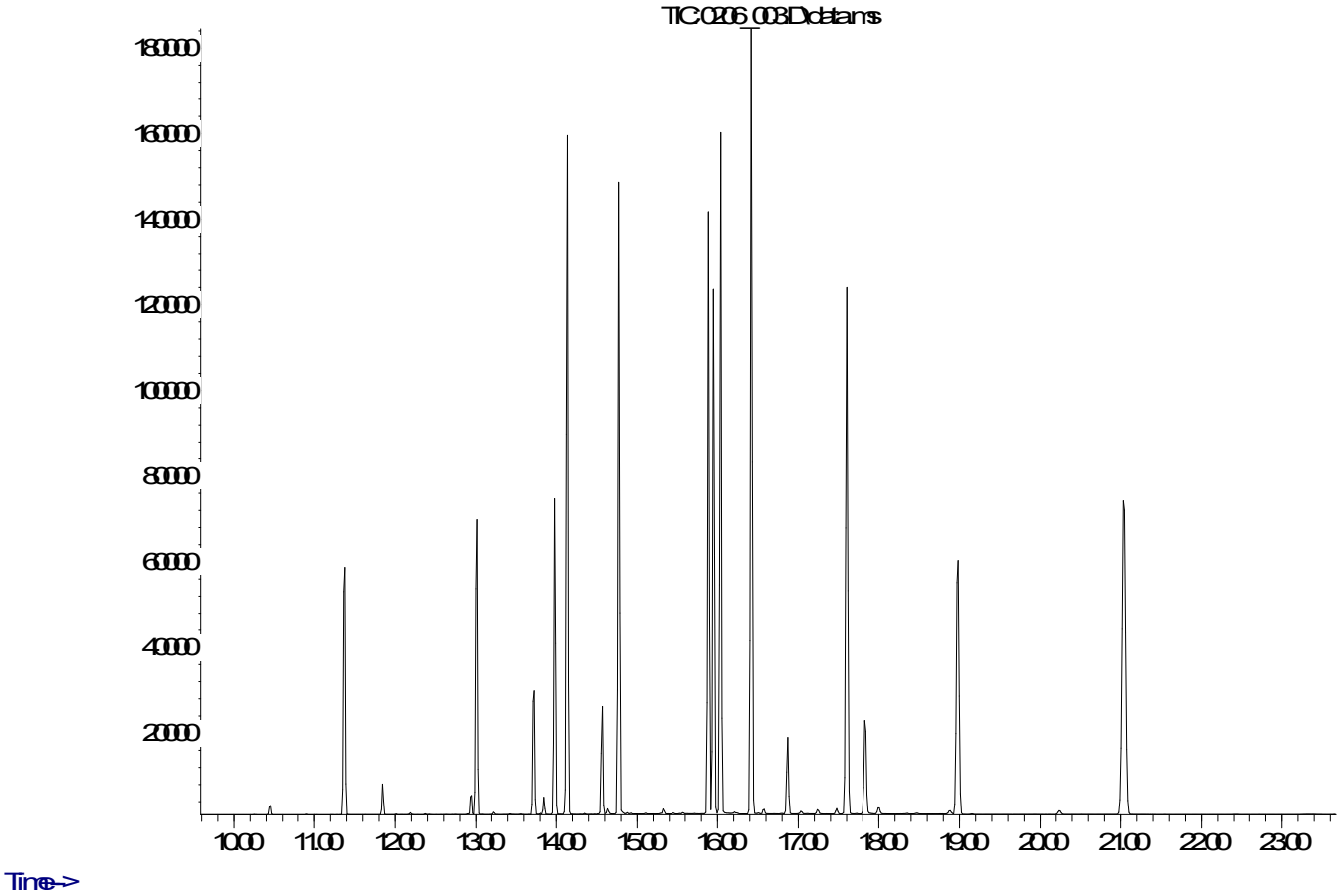
  0.1 ug/l for the lower chlorination homologs
  0.3-0.5 ug/l for the higher chlorination homologs
  Low/single digit ug/kg for soils/solids

Polychlorinated Biphenyls - Homologs

Nine congeners are used to “characterize” the homolog groups

PCB 1	Monochlorobiphenyls
PCB 5	Dichlorobiphenyls
PCB 29	Trichlorobiphenyls
PCB 50	Tetrachlorobiphenyls
PCB 87	Pentachlorobiphenyls
PCB 154	Hexachlorobiphenyls
PCB 188	Heptachlorobiphenyls
PCB 200	Octachlorobiphenyls
PCB 209	Nona- and decachlorobiphenyl

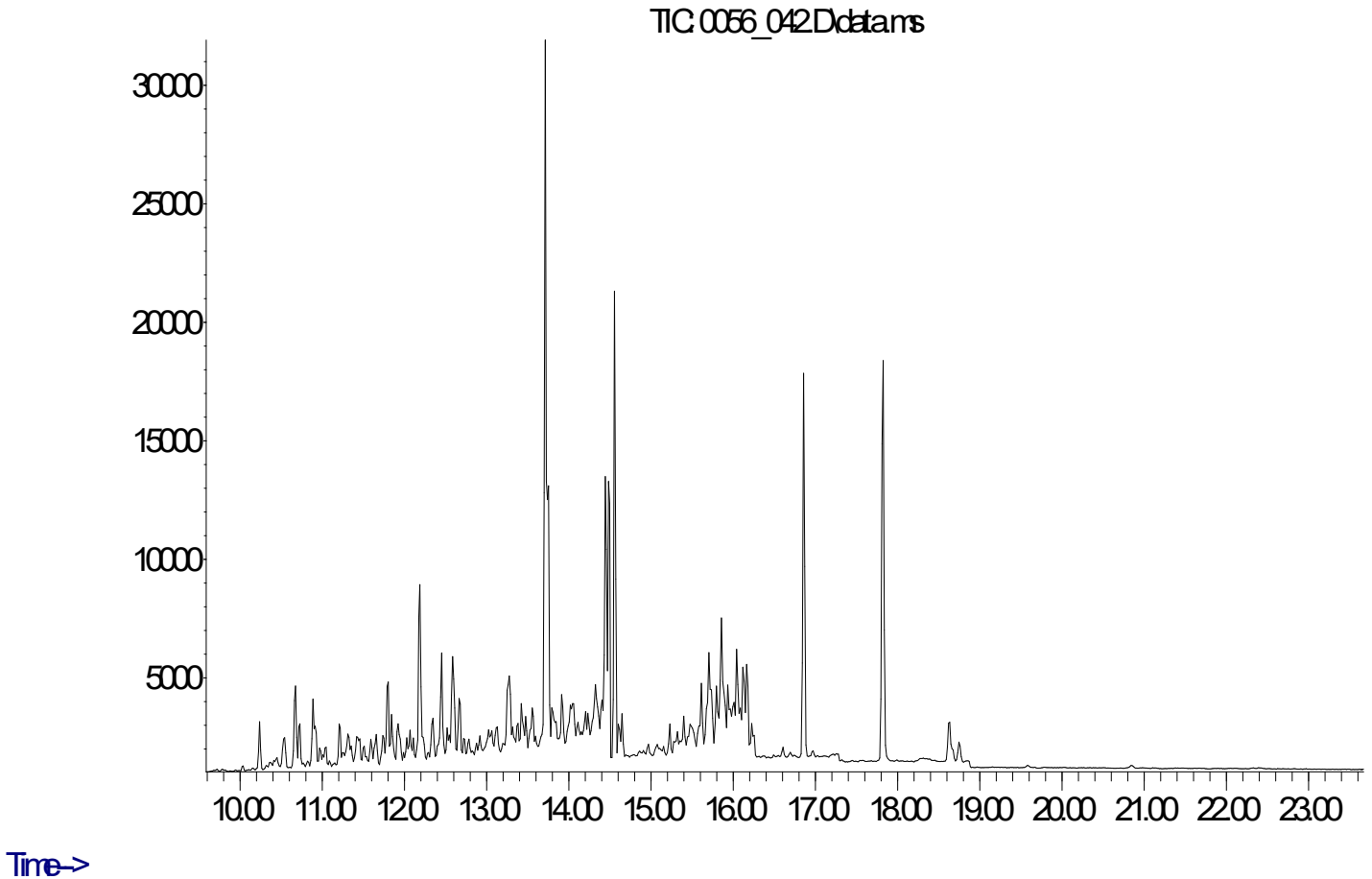
Total Ion Chromatogram of 680 CCAL



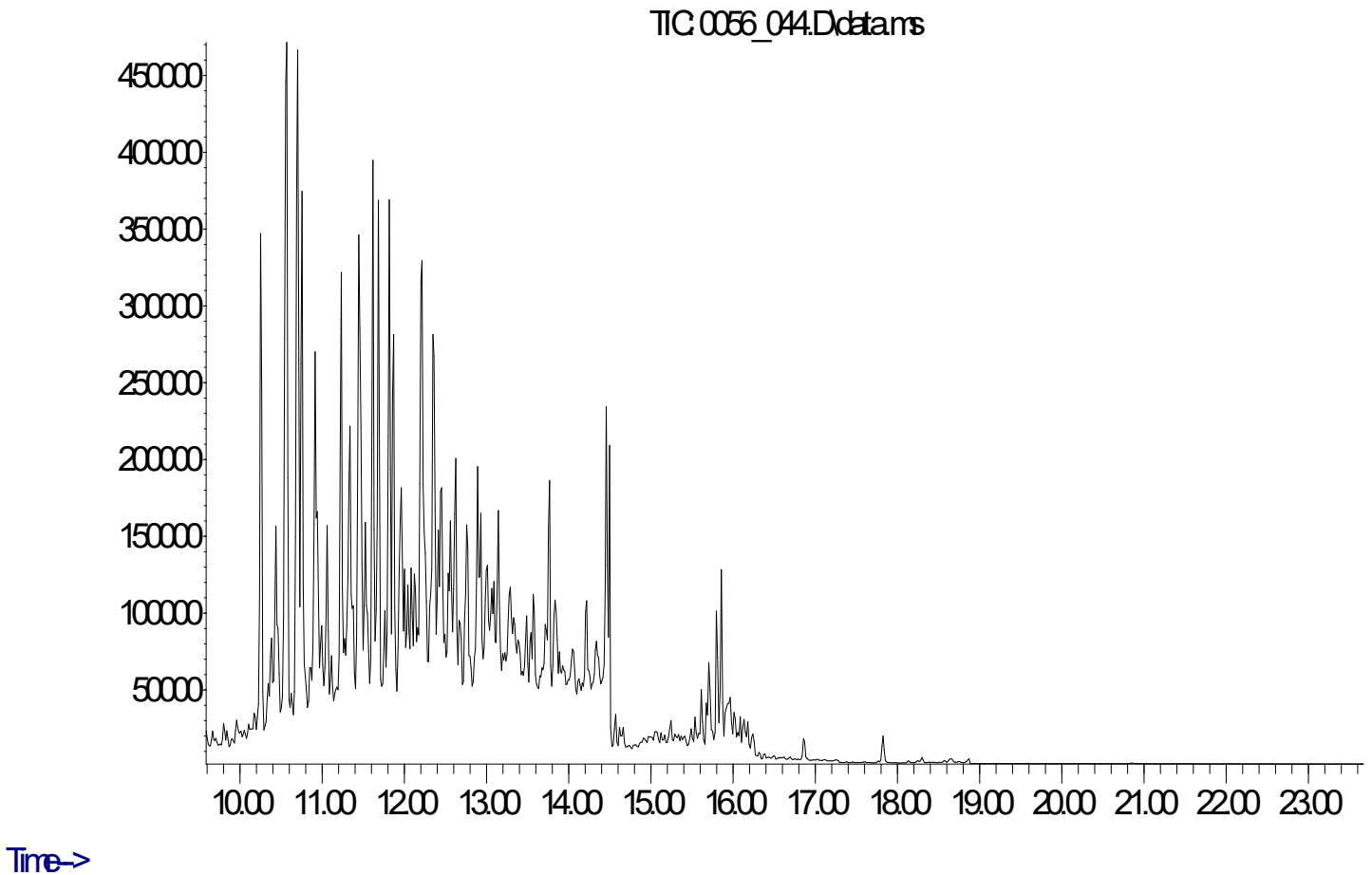
Polychlorinated biphenyls - Homologs

- Quantitation is achieved with internal standard calibration using deuterated PAHs, like 8270
- Homolog group is determined by summing the areas of all peaks within a given retention time, that have the same mass
- Even though a select few congeners are used for the calibration response, data does not yield congener information
- Results will consist of a value for each of the homolog groups and a sum of the homolog groups for a PCB total

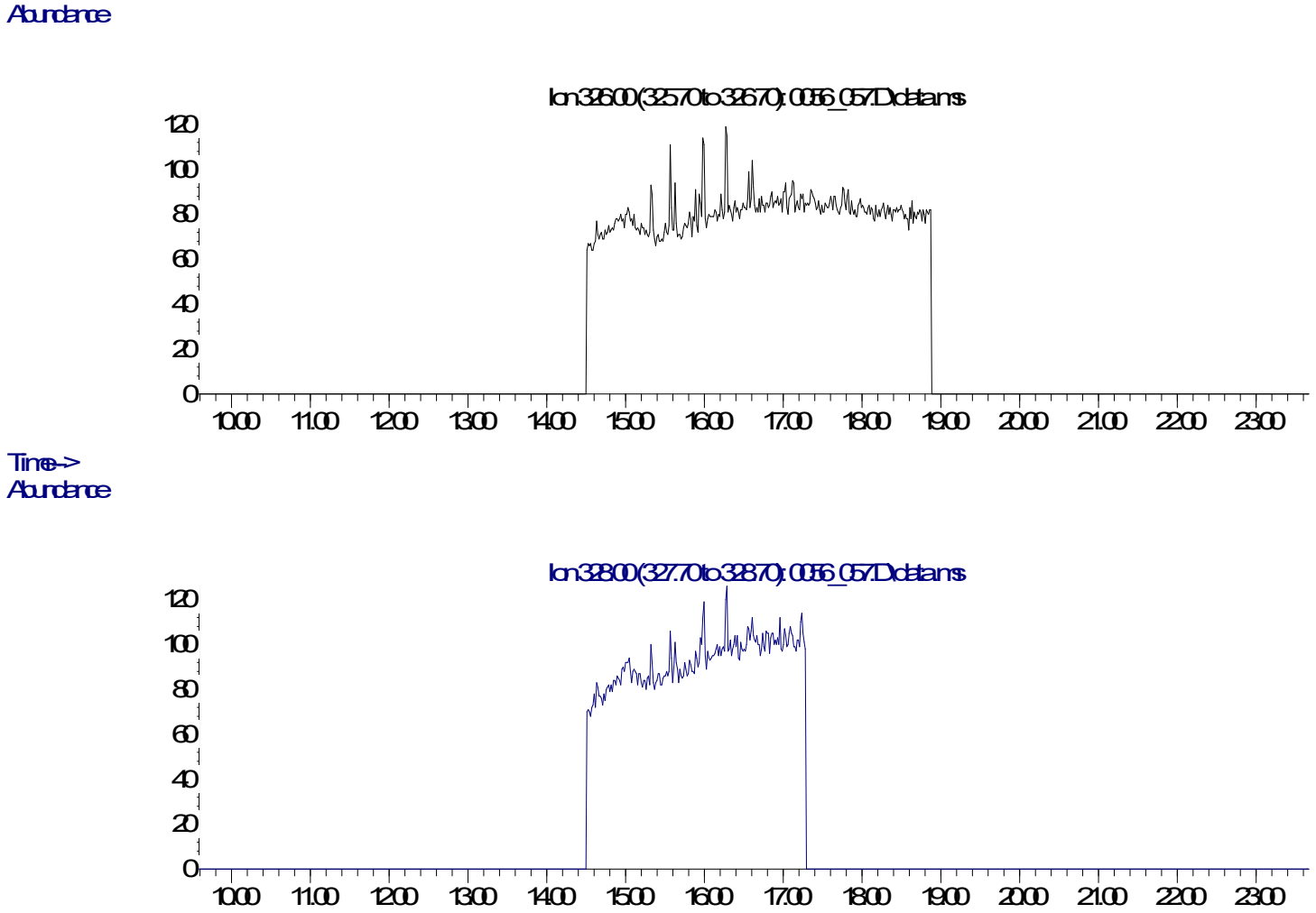
TIC of Typical Sample



TIC of Contaminated Sample



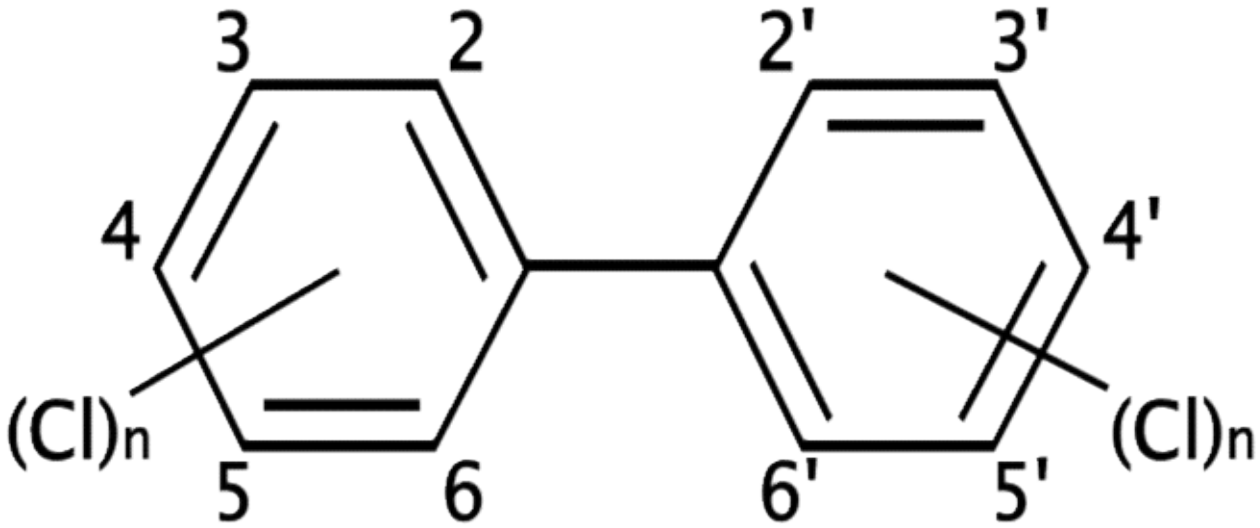
Extracted Ion for Pentachlorobiphenyl



What are PCB Congeners?

A congener is a specific chlorine substitution pattern on a biphenyl ring.

There are a total of 209 possible substitution patterns ranging from 1 chlorine up to 10 chlorines



Polychlorinated Biphenyls – Congeners

- To monitor and analyze for the more toxic congeners, High Resolution Mass Spectrometry (HRMS) is employed
- EPA Method 1668

  HRGC/HRMS

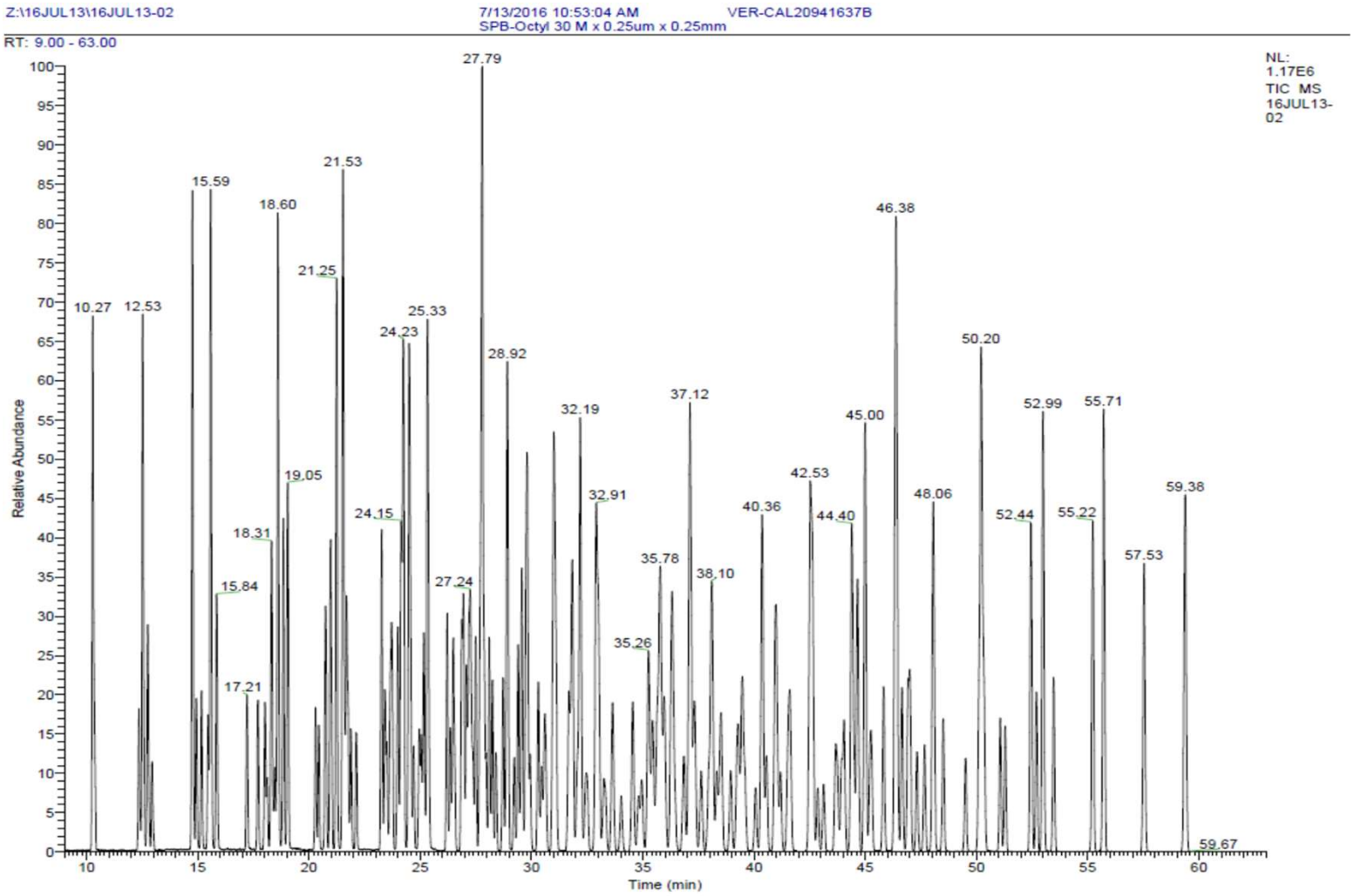
  Capillary column to resolve many of the congeners

  Special clean-up techniques
- Reporting limits of ng/kg and pg/l

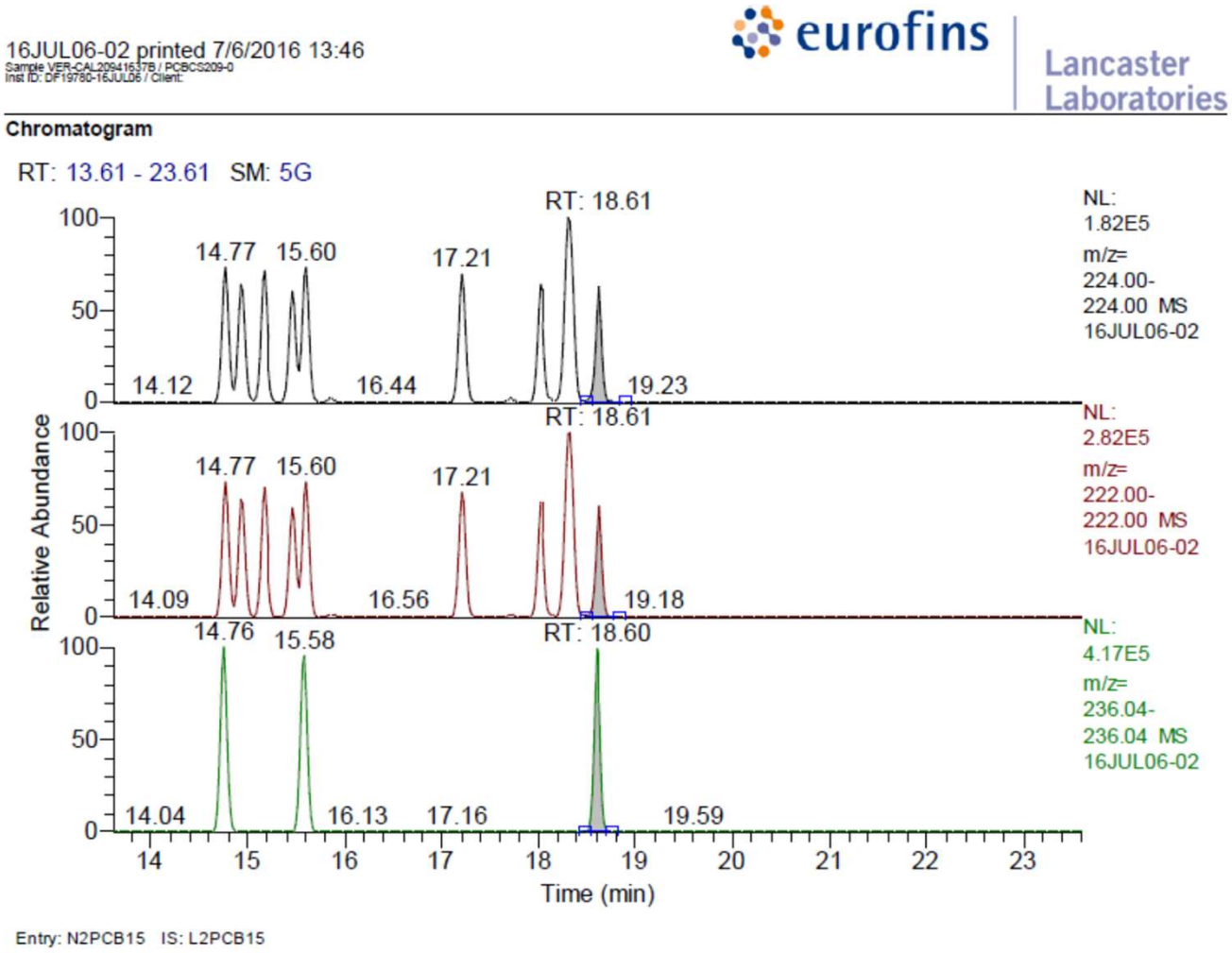
Polychlorinated Biphenyls – Congeners

- Able to calibrate for all 209 congeners
- Calibration is also mostly internal standard except that the compounds used as internal standards are isotopically labeled PCB congeners
- Able to differentiate between congeners that are constituents of Aroclors and those that are not.
- Able to differentiate contribution of dl-PCBs from total PCB content

Calibration Standard with 209 Congeners



Example Data – PCB15



Polychlorinated Biphenyls – Congeners

- Can do fingerprinting of PCB sources based on ratios and relative amounts of the individual congeners
- Comparison of Aroclor based PCB congeners versus presence of non-Aroclor based PCB congeners
- Homolog results determined by summing of individual congeners that make up each chlorination level.
- Total PCB concentration as well as special case congeners quantified.

Special Case Congeners

Dioxin-like PCBs (12)

- PCB77
- PCB81
- PCB105
- PCB114
- PCB118
- PCB123
- PCB126
- PCB156
- PCB157
- PCB167
- PCB169
- PCB189

Indicator PCBs (6)

- PCB28
- PCB52
- PCB101
- PCB138
- PCB153
- PCB180

Questions