

HIGH RESOLUTION MASS SPECTROMETRY

Toxic Equivalency Factors

The Maxxam Advantage

Analytical Methods

Analyzing PCB's and Dioxin-like PCB Congeners

Polychlorinated biphenyls (PCBs) are a family of synthetic organic chemicals introduced in the 1940's for a variety of purposes. Normally a liquid, PCB's have properties of non-flammability, chemical stability, high boiling points, and electrical insulation. As a result, PCBs were used in hundreds of industrial and commercial applications including electrical insulation and heat transfer liquids, hydraulic equipment and plasticizers. More than 1.5 billion pounds of PCBs were manufactured in the United States prior to cessation of production in 1977.

PCB's are biphenyls with varying degrees of chlorine substitution on the biphenyl ring. The amount of chlorine substitution and the location of the chlorine(s) on the biphenyl ring are used to describe these molecules. Each possible configuration is referred to as a congener. 209 PCB congeners are possible. All are toxic chemicals, banned for commercial use, and subject to considerable environmental and health regulation throughout the world.

In addition, the World Health Organization (WHO) has designated a series of twelve (12) individual congeners as being "dioxin-like" in their potential health effects. Dioxins and furans are among the most toxic chemicals known. The dioxin-like PCBs exhibit increased toxicity compared to other PCB congeners.

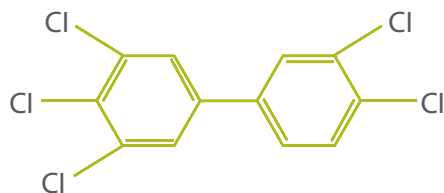
Toxic Equivalency Factors

The dioxin-like PCB congeners have been shown to produce health effects similar to those of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic dioxin. These include neuro-developmental effects, immunotoxicity, reproductive effects or teratogenicity, endocrine disruption and some forms of cancer. Under WHO, the dioxin-like PCB congeners have been assigned 2,3,7,8-TCDD Toxicity Equivalency Factors (TEFs), indicating their toxicity relative to 2,3,7,8-TCDD, which itself has been assigned a TEF of 1.0. For example, a PCB congener with a TEF of 0.01 is considered to be one hundred times less toxic than 2,3,7,8-TCDD.

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Maxxam is recognized internationally for its HRMS Services and commitment to quality. As a member of the Bureau Veritas Group of companies – a world leader in testing, inspection and certification services – we provide scientific solutions for our clients through innovation and expertise. Our ISO 17025 certified HRMS laboratories provides accredited ultra-trace analytical testing service globally for compounds such as polychlorinated dibenzo(p)dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs), and polychlorinated biphenyl (PCB) congeners.

Figure 1. - 3,3',4,4',5
Pentachlorobiphenyl (PCB-126)



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Analytical Methods

The methods used at Maxxam's HRMS facility are designed to identify and quantify ultra-trace levels of dioxin-like PCB congeners in liquid, solid, air, and biota. The analytical procedures are based on USEPA Method 1668A.

The typical analytical process includes: fortification of the sample with isotopically labeled surrogate standards, solvent extraction, application of a multi-component clean-up of the extract, and analysis by selected ion monitoring High Resolution Gas Chromatography / High Resolution Mass Spectrometry (HRGC/HRMS).

Table 1 - "Dioxin-like" PCB Congeners

BZ and IUPAC Name	IUPAC Number	CAS No.
PCB-77	3,3',4,4'-Tetrachlorobiphenyl	32598-13-3
PCB-81	3,4,4',5-Tetrachlorobiphenyl	70362-50-4
PCB-105	2,3,3',4,4'-Pentachlorobiphenyl	32598-14-4
PCB-114	2,3,4,4',5-Pentachlorobiphenyl	74472-37-0
PCB-118	2,3',4,4',5-Pentachlorobiphenyl	31508-00-6
PCB-123	2,3',4,4',5'-Pentachlorobiphenyl	65510-44-3
PCB-126	3,3',4,4',5-Pentachlorobiphenyl	57465-28-8
PCB-156	2,3,3',4,4',5-Hexachlorobiphenyl	38380-08-4
PCB-157	2,3,3',4,4',5'-Hexachlorobiphenyl	69782-90-7
PCB-167	2,3',4,4',5,5'-Hexachlorobiphenyl	52663-72-6
PCB-169	3,3',4,4',5,5'-Hexachlorobiphenyl	32774-16-6
PCB-189	2,3,3',4,4',5,5'-Heptachlorobiphenyl	39635-31-9

Ballschmitter, K. and Zell, M.: Analysis of polychlorinated biphenyls (PCB) by glass capillary gas chromatography. Fresenius Z. Anal. Chem. 302:20-31. 1980.

Table 2 - WHO 2005 Toxicity Equivalence Factors (TEFs)

BZ/IUPAC #	IUPAC Prefix	2005 WHO TEFs ¹		
		Humans/Mammals	Fish	Birds
PCB-77	3,3',4,4'-Tetra	0.0001	0.0001	0.05
PCB-81	3,4,4',5-Tetra	0.0003	0.0005	0.1
PCB-105	2,3,3',4,4'-Penta	0.00003	<0.000005	0.0001
PCB-114	2,3,4,4',5-Penta	0.00003	<0.000005	0.0001
PCB-118	2,3',4,4',5-Penta	0.00003	<0.000005	0.00001
PCB-123	2,3',4,4',5-Penta	0.00003	<0.000005	0.00001
PCB-126	3,3',4,4',5-Penta	0.1	0.005	0.1
PCB-156	2,3,3',4,4',5-Hexa	0.00003	<0.000005	0.0001
PCB-157	2,3,3',4,4',5-Hexa	0.00003	<0.000005	0.0001
PCB-167	2,3',4,4',5,5'-Hexa	0.00003	<0.000005	0.00001
PCB-169	3,3',4,4',5,5'-Hexa	0.03	0.00005	0.001
PCB-170	2,2',3,3',4,4',5-Hepta	--	--	--
PCB-180	2,2',3,4,4',5,5'-Hepta	--	--	--
PCB-189	2,3,3',4,4',5,5'-Hepta	0.00003	<0.000005	0.00001

The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxin and Dioxin-like Compounds

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