A Reassessment of the Nomenclature of Polychlorinated Biphenyl (PCB) Metabolites

Johan Maervoet,[1] Adrian Covaci,[1] Paul Schepens,[1] Courtney D. Sandau,[2] and Robert J. Letcher[3]

[1]Toxicological Center, University of Antwerp, Wilrijk, Belgium; [2]Division of Laboratory Sciences, Centers for Disease Control and Prevention, Atlanta, Georgia, USA; [3]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada

Polychlorinated biphenyls (PCBs) are a widespread class of persistent organic chemicals that accumulate in the environment and humans and are associated with a broad spectrum of health effects. PCB biotransformation has been shown to lead to two classes of PCB metabolites that are present as contaminant residues in the tissues of selected biota: hydroxylated (HO) and methyl sulfone ($MeSO_2$) PCBs. Although these two types of metabolites are related structures, different rules for abbreviation of both classes have emerged. It is important that a standardized nomenclature for the notation of PCB metabolites be universally agreed upon. We suggest that the full chemical name of the PCB metabolite and a shorthand notation should be adopted using the International Union of Pure and Applied Chemistry's chemical name/original Ballschmiter and Zell number of the parent congener, followed by the assignment of the phenyl ring position number of the $MeSO_2$- or HO-substituent. This nomenclature provides a clear, unequivocal set of rules in naming and abbreviating the PCB metabolite structure. Furthermore, this unified PCB metabolite nomenclature approach can be extended to the naming and abbreviation of potential metabolites of structurally analogous contaminants such as HO-polybrominated biphenyls and HO-polybrominated diphenyl ethers. *Key words:* hydroxylated metabolites, methyl sulfone metabolites, nomenclature, polychlorinated biphenyls. *Environ Health Perspect* 112:291–294 (2004). doi:10.1289/ehp.6409 available via *http://dx.doi.org/* [Online 3 December 2003]

Nomenclature of Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are a class of chemical compounds in which 1–10 chlorine atoms are attached to a biphenyl backbone. Theoretically, 209 discrete congeners are possible (Ballschmiter and Zell 1980). However, PCB technical mixtures are composed of a smaller suite of congeners (Frame et al. 1996), and only about 80–100 PCB congeners are of actual environmental relevance (de Voogt et al. 1990).

The full chemical notation for these 209 possible PCB congeners is inconvenient, and therefore various shorthand notations have been developed and adopted (Erickson 1997, 2001). Ballschmiter and Zell (1980) originally introduced a system (BZ) in which congeners were arranged in the ascending numerical order based on the number of chlorine atoms and their substitution pattern on the biphenyl base structure. Minor theoretical discrepancies in the BZ naming system were later corrected (Ballschmiter et al. 1992; Guitart et al. 1993; Schulte and Malisch 1983). The BZ system of PCB shorthand notation was subsequently recognized by the International Union of Pure and Applied Chemistry (IUPAC) (U.S. Environmental Protection Agency 2003) and is the generally accepted notation used by scientists who perform congener-specific PCB research.

Metabolism of PCBs

PCBs that accumulate in biota are subject to elimination processes that are facilitated by processes including enzyme-mediated degradation. The mechanism and kinetics of PCB biotransformation depend on a number of factors, including the metabolic capacity of the organism and the PCB congener structure. PCB biotransformation has been shown to lead to two classes of PCB metabolites that are present as contaminant residues in the tissues of biota that have been studied: hydroxylated (HO) and methyl sulfone (CH_3SO_2) PCBs (Letcher et al. 2000a). CH_3SO_2-PCBs are generally referred to as $MeSO_2$-PCBs. The numbers of animals and populations where tissue residues of these PCB metabolites have been characterized remains small, but HO-PCBs and $MeSO_2$-PCBs are emerging as common contaminant phenomena in wildlife and humans and are of increasing importance in risk assessments of exposure to PCBs (Bennett et al. 2002; Campbell et al. 2003; Chu et al. 2002, 2003; Guvenius et al. 2002; Hoekstra et al. 2003; Hovander et al. 2002; Letcher et al. 2000a, 2000b; Li et al. 2003; Sandala et al., in press; Sandau et al. 2000a, 2000b, 2002; Stapleton et al. 2001). In some species and tissues, HO-PCB and $MeSO_2$-PCB concentrations may be in a similar or higher range with respect to the concentrations of the parent PCBs. Furthermore, congeners of these two classes of PCB metabolites, which are present as contaminant residues, have demonstrated biologic and toxicologic activity—for example, endocrine-related activity (Brouwer et al. 1998; Letcher et al. 2000a, 2002).

Nomenclature of HO-PCBs

The published reports on HO-PCBs and $MeSO_2$-PCBs have generally used IUPAC guidelines to describe the full chemical name of these metabolites. However, the presently used abbreviations for HO-PCB congeners deviate from the general IUPAC naming rules. The HO-functional group is not given numbering priority on the biphenyl backbone; rather, the chlorine pattern on the biphenyl ring determines the congener number according to the BZ or IUPAC PCB numbering rules (Ballschmiter and Zell 1980; Ballschmiter et al. 1992; Guitart et al. 1993; Schulte and Malisch 1983), and the HO-group(s) are numbered thereafter. As a result, an HO-functionality in the *meta*-position relative to the central carbon–carbon bond of the biphenyl attachment is in either position 3 or position 5. When the HO-substituent is located on the ring with the lowest chlorine numbering priority, its number is primed in the same manner as is done for the chlorine atoms on the same phenyl ring. The HO-metabolite 5′-HO-2,3′,4,4′-tetrachlorobiphenyl (three unsubstituted *meta*-positions in the 3, 5, and 5′ positions of the corresponding PCB congener), for example, is therefore uniquely abbreviated to 5′-HO-CB66 using this notation approach (Table 1).

Nomenclature of $MeSO_2$-PCBs

Similarly, for $MeSO_2$-PCB congeners, the PCB number is first determined according to the chlorine substitution of the biphenyl by omitting the $MeSO_2$-functional group. The initial shorthand notation used for $MeSO_2$-PCBs assigned the methyl sulfonyl group based on a higher numbering priority on the biphenyl system than for chlorine atoms, and thus the position of methyl sulfonyl substitution was not primed (Letcher et al. 1995; Weistrand and Norén 1997). For example, using this initial numbering approach, a methyl sulfonyl group in a *meta*-position would always be assigned to position 3. This nomenclature approach can be problematical, as illustrated by the example of 3-$MeSO_2$-2,2′,4′,5-tetrachlorobiphenyl (Table 1),

Address correspondence to J. Maervoet, Toxicological Center, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium. Telephone: 0032-3-820-2704. Fax: 0032-3-820-2722. E-mail: Johan.Maervoet@ua.ac.be

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which is intended when the short notation 3-$MeSO_2$-CB49 is used. Although this appears to be the only environmentally relevant possibility, two other metabolites would have exactly the same 3-$MeSO_2$-CB49 abbreviation if the methyl sulfonyl group were positioned on either of the two free *meta*-positions of the other, 2,4-chloro–substituted, phenyl ring.

Different authors have acknowledged the inconsistencies in the naming of $MeSO_2$-PCBs and have suggested alternate approaches (Letcher et al. 2000a and references therein). In several recent reports, the number of the $MeSO_2$-group has been primed or unprimed depending on which phenyl ring this substituent was positioned (Guvenius et al. 2002; Hoekstra et al. 2003; Letcher et al. 2000a, 2000b). Following this revised nomenclature system, 3-$MeSO_2$-2,2′,4′,5-tetrachlorobiphenyl is abbreviated to 3′-$MeSO_2$-CB49. Because the number of the methyl sulfonyl group is primed, and the other meta-carbon position on the primed phenyl ring is substituted with a chlorine atom, the abbreviation indicates only one structural possibility. Because methyl sulfonyl groups on the most commonly encountered congener residues in biota usually occur on a 2,5- or 2,3,6- chlorine–substituted phenyl ring, one *meta*-position will normally be occupied by a chlorine atom on the $MeSO_2$-substituted phenyl ring. It is clear that this might not be the case for some other, at least theoretical, metabolites.

Recently, Larsson et al. (2002) applied the same nomenclature rules for abbreviation of $MeSO_2$-metabolites as is normally done for HO-PCBs. That is, the methyl sulfonyl groups are numbered according to their substitution position, after the positions of the chlorine atoms are taken into account based on the revised BZ naming system. For example, Larsson et al. (2002) abbreviated 3-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl to 5-$MeSO_2$-CB149 rather than to 3-$MeSO_2$-CB149 (Table 1) because the $MeSO_2$-functional group is present in position 5 rather than in position 3. This abbreviation indicates only one distinct congener regardless of its chlorine substitution pattern, which eliminates the possibility of misidentifying $MeSO_2$-PCB structures with the same chlorine substitution pattern. Because the $MeSO_2$-group is not assigned the lowest possible number, the substitution position of the chlorine atoms is also maintained. Consequently, the identity of the $MeSO_2$-PCB congener is easily related to the parent PCB structure (Table 1). However, the implementation of this nomenclature approach for methyl sulfonyl-PCB metabolites poses a problem with respect to congener-specific comparisons in earlier publications where alternate nomenclature has been used. For example, some environmentally relevant 3-$MeSO_2$-CBs would have to be renamed as 5-$MeSO_2$-CBs (Table 2).

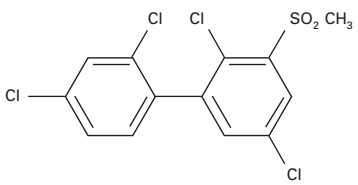
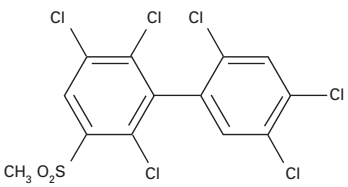
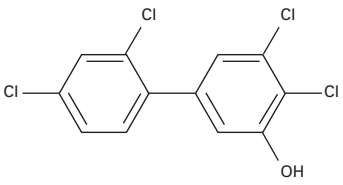
Proposed Nomenclature

On closer examination of the full chemical name of, for example, 3-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl, it is striking that the $MeSO_2$-group receives the same number (3) as a chlorine substituent present on the same ring. Therefore, it is evident from the full chemical name of PCB metabolites that it is not possible to combine both the fundamental IUPAC approach for naming aromatic compounds (i.e., giving the substituent numbering priority and numbering the chlorine atoms thereafter) and the IUPAC-accepted BZ rules for the naming of PCBs (i.e., a PCB-BZ number is clearly associated with the chlorine substitution pattern). Because the BZ system is so widely adopted, it would be logical to base the PCB metabolite nomenclature on the BZ system. Even though this approach requires exceptions to the IUPAC guidelines of nomenclature, we would suggest that the full chemical name/shorthand notation of the metabolite should be made by using the IUPAC full name/original BZ number of the parent congener and then assigning the $MeSO_2$- or HO-substituent a ring position number thereafter. For example, 5-$MeSO_2$-CB149 is the abbreviation for 5-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl (Table 1), where the 5-position of the substituent remains the same as in the abbreviation, and the chlorine pattern clearly indicates PCB number 149 (BZ). Table 2 shows how the proposed standardized nomenclature applies to the current list of identified and environmentally relevant HO- and $MeSO_2$-PCB congeners. It may be observed that, for $MeSO_2$-PCB metabolites, a 2,5-ring substitution of the PCB congener leads to a 3- or a 3′-substitution for the $MeSO_2$-group, whereas a 2,3,6-ring substitution leads to a 5- or a 5′-substitution (Table 2).

Table 2 can be used as a reference to unambiguously label the names of PCB metabolites. This nomenclature for both the abbreviation and full chemical name of a given PCB metabolite provides a clear, unequivocal structure and delivers a unified technique that can be used for both classes of PCB metabolites.

Although HO-PCBs and $MeSO_2$-PCBs are related structures, different rules for abbreviations of both classes have emerged. A standardized nomenclature that is presently suggested for the naming of a PCB metabolite should be universally adopted and sanctioned by IUPAC to facilitate unambiguous comparison of congener-specific data among published studies. Additionally, this nomenclature may be applicable to similar metabolites of other persistent aromatic organics, such as polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs). Studies on the formation of metabolites from the PBB and PBDE classes of pollutants are becoming more numerous in the literature (Burreau et al. 2000; Haglund et al. 1997; Hakk and Letcher 2003; Meerts et al. 2001; Valters et al. 2003). Therefore, it is important to adopt a general, unified nomenclature system for the full chemical name and shorthand notation of possible metabolites.

Table 1. Structure, abbreviations, and full chemical names of three PCB metabolites.

Structure			
IUPAC full chemical name[a]	3-$MeSO_2$-2,2′,4′,5-tetrachlorobiphenyl	3-$MeSO_2$-2,2′,4′,5,5′,6-hexachlorobiphenyl	3-HO-2′,4,4′,5-tetrachlorobiphenyl
Abbreviation 1[b]	3-$MeSO_2$-CB49	3-$MeSO_2$-CB149	
Abbreviation 2[c]	3′-$MeSO_2$-CB49	3-$MeSO_2$-CB149	
Abbreviation 3[d]	3′-$MeSO_2$-CB49	5-$MeSO_2$-CB149	5′-HO-CB66
Proposed full chemical name[e]	3′-$MeSO_2$-2,2′,4,5′-tetrachlorobiphenyl	5-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl	5′-HO-2,3′,4,4′-tetrachlorobiphenyl

[a]$MeSO_2$-PCBs (Larsson et al. 2002; Weistrand and Norén 1997); HO-PCBs (Bergman et al. 1994; Hovander et al. 2002). [b]$MeSO_2$-PCBs (Letcher et al. 1995; Weistrand and Norén 1997). [c]$MeSO_2$-PCBs (Guvenius et al. 2002; Hoekstra et al. 2003; Letcher et al. 2000a, 2000b). [d]$MeSO_2$-PCBs (Larsson et al. 2002); HO-PCBs (Bennett et al. 2002; Campbell et al. 2003; Hovander et al. 2002; Li et al. 2003; Sandala et al., in press; Sandau et al. 2000a; Sjödin et al. 1998). [e]HO-PCBs not previously used for $MeSO_2$-PCBs (Campbell et al. 2003; Sandala et al., in press; Sandau et al. 2000a; Sjödin et al. 1998).

Table 2. Current and proposed PCB metabolite nomenclature.

IUPAC full chemical name[a]	Proposed nomenclature	
	Abbreviation[b]	Proposed full chemical name[c]
3-$MeSO_2$-2,4′,5-trichlorobiphenyl	3-$MeSO_2$-CB31	3-$MeSO_2$-2,4′,5-trichlorobiphenyl
4-$MeSO_2$-2,4′,5-trichlorobiphenyl	4-$MeSO_2$-CB31	4-$MeSO_2$-2,4′,5-trichlorobiphenyl
3-$MeSO_2$-2,2′,4′,5-tetrachlorobiphenyl	3′-$MeSO_2$-CB49	3′-$MeSO_2$-2,2′,4,5′-tetrachlorobiphenyl
4-$MeSO_2$-2,2′,4′,5-tetrachlorobiphenyl	4′-$MeSO_2$-CB49	4′-$MeSO_2$-2,2′,4,5′-tetrachlorobiphenyl
3-$MeSO_2$-2,2′,5,5′-tetrachlorobiphenyl	3-$MeSO_2$-CB52	3-$MeSO_2$-2,2′,5,5′-tetrachlorobiphenyl
4-$MeSO_2$-2,2′,5,5′-tetrachlorobiphenyl	4-$MeSO_2$-CB52	4-$MeSO_2$-2,2′,5,5′-tetrachlorobiphenyl
3-$MeSO_2$-2,4′,5,6-tetrachlorobiphenyl	5-$MeSO_2$-CB64	5-$MeSO_2$-2,3,4′,6-tetrachlorobiphenyl
4-$MeSO_2$-2,3,4′,6-tetrachlorobiphenyl	4-$MeSO_2$-CB64	4-$MeSO_2$-2,3,4′,6-tetrachlorobiphenyl
3-$MeSO_2$-2,3′,4′,5-tetrachlorobiphenyl	3-$MeSO_2$-CB70	3-$MeSO_2$-2,3′,4′,5-tetrachlorobiphenyl
4-$MeSO_2$-2,3′,4′,5-tetrachlorobiphenyl	4-$MeSO_2$-CB70	4-$MeSO_2$-2,3′,4′,5-tetrachlorobiphenyl
3-$MeSO_2$-2,2′,3′,4′,5-pentachlorobiphenyl	3′-$MeSO_2$-CB87	3′-$MeSO_2$-2,2′,3,4,5′-pentachlorobiphenyl
4-$MeSO_2$-2,2′,3′,4′,5-pentachlorobiphenyl	4′-$MeSO_2$-CB87	4′-$MeSO_2$-2,2′,3,4,5′-pentachlorobiphenyl
3-$MeSO_2$-2,2′,4′,5,6-pentachlorobiphenyl	5-$MeSO_2$-CB91	5-$MeSO_2$-2,2′,3,4′,6-pentachlorobiphenyl
4-$MeSO_2$-2,2′,3,4′,6-pentachlorobiphenyl	4-$MeSO_2$-CB91	4-$MeSO_2$-2,2′,3,4′,6-pentachlorobiphenyl
3-$MeSO_2$-2,2′,3′,5,6′-pentachlorobiphenyl	3′-$MeSO_2$-CB95	3′-$MeSO_2$-2,2′,3,5′,6-pentachlorobiphenyl
4-$MeSO_2$-2,2′,3′,5,6′-pentachlorobiphenyl	4′-$MeSO_2$-CB95	4′-$MeSO_2$-2,2′,3,5′,6-pentachlorobiphenyl
3-$MeSO_2$-2,2′,4′,5,5′-pentachlorobiphenyl	3′-$MeSO_2$-CB101	3′-$MeSO_2$-2,2′,4,5,5′-pentachlorobiphenyl
4-$MeSO_2$-2,2′,4′,5,5′-pentachlorobiphenyl	4′-$MeSO_2$-CB101	4′-$MeSO_2$-2,2′,4,5,5′-pentachlorobiphenyl
3-$MeSO_2$-2,3′,4′,5,6-pentachlorobiphenyl	5-$MeSO_2$-CB110	5-$MeSO_2$-2,3,3′,4′,6-pentachlorobiphenyl
4-$MeSO_2$-2,3,3′,4′,6-pentachlorobiphenyl	4-$MeSO_2$-CB110	4-$MeSO_2$-2,3,3′,4′,6-pentachlorobiphenyl
3-$MeSO_2$-2,2′,3′,4′,5,6-hexachlorobiphenyl	5′-$MeSO_2$-CB132	5′-$MeSO_2$-2,2′,3,3′,4,6′-hexachlorobiphenyl
4-$MeSO_2$-2,2′,3,3′,4′,6-hexachlorobiphenyl	4′-$MeSO_2$-CB132	4′-$MeSO_2$-2,2′,3,3′,4,6′-hexachlorobiphenyl
3-$MeSO_2$-2,2′,3′,4′,5,5′-hexachlorobiphenyl	3′-$MeSO_2$-CB141	3′-$MeSO_2$-2,2′,3,4,5,5′-hexachlorobiphenyl
4-$MeSO_2$-2,2′,3′,4′,5,5′-hexachlorobiphenyl	4′-$MeSO_2$-CB141	4′-$MeSO_2$-2,2′,3,4,5,5′-hexachlorobiphenyl
3-$MeSO_2$-2,2′,4′,5,5′,6-hexachlorobiphenyl	5-$MeSO_2$-CB149	5-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl
4-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl	4-$MeSO_2$-CB149	4-$MeSO_2$-2,2′,3,4′,5′,6-hexachlorobiphenyl
3-$MeSO_2$-2,2′,3′,4′,5,5′,6-heptachlorobiphenyl	5′-$MeSO_2$-CB174	5′-$MeSO_2$-2,2′,3,3′,4,5,6′-heptachlorobiphenyl
4-$MeSO_2$-2,2′,3,3′,4′,5′,6-heptachlorobiphenyl	4′-$MeSO_2$-CB174	4′-$MeSO_2$-2,2′,3,3′,4,5,6′-heptachlorobiphenyl
4-HO-2,2′,4′,6′-tetrachlorobiphenyl	4′-HO-CB50	4′-HO-2,2′,4,6-tetrachlorobiphenyl
3-HO-2′,4,4′,5-tetrachlorobiphenyl	5′-HO-CB66	5′-HO-2,3′,4,4′-tetrachlorobiphenyl
4-HO-3,3′,4′,5-tetrachlorobiphenyl	4′-HO-CB79	4′-HO-3,3′,4,5′-tetrachlorobiphenyl
3-HO-2,2′,3′,4,4′-pentachlorobiphenyl	3′-HO-CB85	3′-HO-2,2′,3,4,4′-pentachlorobiphenyl
3,4′-diHO-2,2′,3′,4,5′-pentachlorobiphenyl	3′,4-diHO-CB90	3′,4-diHO-2,2′,3,4′,5-pentachlorobiphenyl
4-HO-2,2′,3,5,6-pentachlorobiphenyl	4-HO-CB93	4-HO-2,2′,3,5,6-pentachlorobiphenyl
4-HO-2,2′,3,4′,5′-pentachlorobiphenyl	4-HO-CB97	4-HO-2,2′,3,4,′5′-pentachlorobiphenyl
4-HO-2,2′,4′,5,5′-pentachlorobiphenyl	4′-HO-CB101	4′-HO-2,2′,4,5,5′-pentachlorobiphenyl
4-HO-2,2′,4′,6,6′-pentachlorobiphenyl	4′-HO-CB104	4′-HO-2,2′,4,6,6′-pentachlorobiphenyl
4-HO-2,3,3′,4′,5-pentachlorobiphenyl	4-HO-CB107	4-HO-2,3,3′,4′,5-pentachlorobiphenyl
2,4′-diHO-2′,3,3′,4,5′-pentachlorobiphenyl	2′,4-diHO-CB107	2′,4-diHO-2,3,3′,4′,5-pentachlorobiphenyl
4-HO-2′,3,3′,4′,5-pentachlorobiphenyl	4′-HO-CB108	4′-HO-2,3,3′,4,5′-pentachlorobiphenyl
4-HO-2,3,3′,5,6-pentachlorobiphenyl	4-HO-CB112	4-HO-2,3,3′,5,6-pentachlorobiphenyl
3-HO-2,3′,4,4′,5-pentachlorobiphenyl	3-HO-CB118	3-HO-2,3′,4,4′,5-pentachlorobiphenyl
4-HO-2′,3,4′,5,5′-pentachlorobiphenyl	4′-HO-CB120	4′-HO-2,3′,4,5,5′-pentachlorobiphenyl
4-HO-2′,3,4′,5,6′-pentachlorobiphenyl	4′-HO-CB121	4′-HO-2,3′,4,5′,6-pentachlorobiphenyl
4-HO-3,3′,4′,5,5′-pentachlorobiphenyl	4′-HO-CB127	4′-HO-3,3′,4,5,5′-pentachlorobiphenyl
4-HO-2,2′,3,3′,4′,5-hexachlorobiphenyl	4′-HO-CB130	4′-HO-2,2′,3,3′,4,5′-hexachlorobiphenyl
4-HO-2,2′,3,3′,5,6-hexachlorobiphenyl	4-HO-CB134	4-HO-2,2′,3,3′,5,6-hexachlorobiphenyl
3-HO-2,2′,3′,4,4′,5-hexachlorobiphenyl	3′-HO-CB138	3′-HO-2,2′,3,4,4′,5′-hexachlorobiphenyl
4-HO-2,2′,3,4′,5,5′-hexachlorobiphenyl	4-HO-CB146	4-HO-2,2′,3,4′,5,5′-hexachlorobiphenyl
3-HO-2,2′,4,4′,5,5′-hexachlorobiphenyl	3-HO-CB153	3-HO-2,2′,4,4′,5,5′-hexachlorobiphenyl
4-HO-2′,3,3′,4′,5,5′-hexachlorobiphenyl	4′-HO-CB159	4′-HO-2,3,3′,4,5,5′-hexachlorobiphenyl
4-HO-2,3,3′,4′,5,5′-hexachlorobiphenyl	4-HO-CB162	4-HO-2,3,3′,4′,5,5′-hexachlorobiphenyl
4-HO-2,3,3′,4′,5,6-hexachlorobiphenyl	4-HO-CB163	4-HO-2,3,3′,4′,5,6-hexachlorobiphenyl
4-HO-2,3,3′,5,5′,6-hexachlorobiphenyl	4-HO-CB165	4-HO-2,3,3′,5,5′,6-hexachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,5′-heptachlorobiphenyl	4′-HO-CB172	4′-HO-2,2′,3,3′,4,5,5′-heptachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,6-heptachlorobiphenyl	4′-HO-CB175	4′-HO-2,2′,3,3′,4,5′,6-heptachlorobiphenyl
4-HO-2,2′,3,3′,5,5′,6-heptachlorobiphenyl	4-HO-CB178	4-HO-2,2′,3,3′,5,5′,6-heptachlorobiphenyl
4-HO-2,2′,3,3′,5,5′,6′-heptachlorobiphenyl	4′-HO-CB178	4′-HO-2,2′,3,3′,5,5′,6-heptachlorobiphenyl
4,4′-diHO-2,2′,3,3′,5,5′,6-heptachlorobiphenyl	4,4′-diHO-CB178	4,4′-diHO-2,2′,3,3′,5,5′,6-heptachlorobiphenyl
3-HO-2,2′,3′,4,4′,5,5′-heptachlorobiphenyl	3′-HO-CB180	3′-HO-2,2′,3,4,4′,5,5′-heptachlorobiphenyl
3-HO-2,2′,3′,4,4′,5′,6-heptachlorobiphenyl	3′-HO-CB182	3′-HO-2,2′,3,4,4′,5,6′-heptachlorobiphenyl
3-HO-2,2′,3′,4,4′,5,6′-heptachlorobiphenyl	3′-HO-CB183	3′-HO-2,2′,3,4,4′,5′,6-heptachlorobiphenyl
3-HO-2,2′,3′,4,4′,6,6′-heptachlorobiphenyl	3′-HO-CB184	3′-HO-2,2′,3,4,4′,6,6′-heptachlorobiphenyl
3-HO-2,2′,3′,4,5,5′,6′-heptachlorobiphenyl	3′-HO-CB187	3′-HO-2,2′,3,4′,5,5′,6-heptachlorobiphenyl
4-HO-2,2′,3,4′,5,5′,6-heptachlorobiphenyl	4-HO-CB187	4-HO-2,2′,3,4′,5,5′,6-heptachlorobiphenyl
3,4′-diHO-2,2′,3′,4,5,5′,6′-heptachlorobiphenyl	3′,4-diHO-CB187	3′,4-diHO-2,2′,3,4′,5,5′,6-heptachlorobiphenyl
4-HO-2,3,3′,4′,5,5′,6-heptachlorobiphenyl	4-HO-CB193	4-HO-2,3,3′,4′,5,5′,6-heptachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,5′,6′-octachlorobiphenyl	4′-HO-CB198	4′-HO-2,2′,3,3′,4,5,5′,6-octachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,5′,6-octachlorobiphenyl	4′-HO-CB201/199[d]	4′-HO-2,2′,3,3′,4,5,5′,6′-octachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,6,6′-octachlorobiphenyl	4′-HO-CB200/201[d]	4′-HO-2,2′,3,3′,4,5′,6,6′-octachlorobiphenyl
4-HO-2,2′,3,3′,5,5′,6,6′-octachlorobiphenyl	4-HO-CB202	4-HO-2,2′,3,3′,5,5′,6,6′-octachlorobiphenyl
4,4′-diHO-2,2′,3,3′,5,5′,6,6′-octachlorobiphenyl	4,4′-diHO-CB202	4,4′-diHO-2,2′,3,3′,5,5′,6,6′-octachlorobiphenyl
3-HO-2,2′,3′,4,4′,5,5′,6′-octachlorobiphenyl	3′-HO-CB203	3′-HO-2,2′,3,4,4′,5,5′,6-octachlorobiphenyl
4-HO-2,2′,3,3′,4′,5,5′,6,6′-nonachlorobiphenyl	4′-HO-CB208	4′-HO-2,2′,3,3′,4,5,5′,6,6′-nonachlorobiphenyl

[a]$MeSO_2$-PCBs (Larsson et al. 2002; Weistrand and Norén 1997); HO-PCBs (Bergman et al. 1994; Hovander et al. 2002). [b]$MeSO_2$-PCBs (Larsson et al. 2002); HO-PCBs (Bennett et al. 2002; Campbell et al. 2003; Hovander et al. 2002; Li et al. 2003; Sandala et al., in press; Sandau et al. 2000a; Sjödin et al. 1998). [c]HO-PCBs (Campbell et al. 2003; Sandala et al., in press; Sandau et al. 2000a; Sjödin et al. 1998). [d]Original BZ/revised PCB number.

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