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

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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 sulfonyl (MeSO2) 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 MeSO2- 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-polychlorobiphenyls 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 HO-PCBs

The published reports on HO-PCBs and MeSO2-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 MeSO2-PCBs

Similarly, for MeSO2-PCB congeners, the PCB number is first determined according to the chlorine substitution of the biphenyl by omitting the MeSO2-functional group. The initial shorthand notation used for MeSO2-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; Weisstrand 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-MeSO2-2,2’,4,4’,5-tetrachlorobiphenyl (Table 1),
which is intended when the short notation 3-MeSO2-CB49 is used. Although this appears to be the only environmentally relevant possibility, two other metabolites would have exactly the same 3-MeSO2-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 MeSO2-PCBs and have suggested alternate approaches (Letcher et al. 2000a and references therein). In several recent reports, the number of the MeSO2-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-MeSO2-2,2',4’,5’,6-tetrachlorobiphenyl is abbreviated to 3’-MeSO2-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 MeSO2-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 MeSO2-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-MeSO2-2,2’,3’,4’,5’,6-hexachlorobiphenyl to 5-MeSO2-CB149 rather than to 3-MeSO2-CB149 (Table 1) because the MeSO2-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 MeSO2-PCB structures with the same chlorine substitution pattern. Because the MeSO2-group is not assigned the lowest possible number, the substitution position of the chlorine atoms is also maintained. Consequently, the identity of the MeSO2-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-MeSO2-CBs would have to be renamed as 5-MeSO2-CBs (Table 2).
Table 2. Current and proposed PCB metabolite nomenclature.

| Abbreviation | Proposed nomenclature |
|--------------|-----------------------|
| 3-MeSO2-2,4´,5´-trichlorobiphenyl | 3-MeSO2-2,4´,5´-trichlorobiphenyl |
| 4-MeSO2-2,4´,5´-trichlorobiphenyl | 4-MeSO2-2,4´,5´-trichlorobiphenyl |
| 3-MeSO2-2,4´,5´-pentachlorobiphenyl | 3-MeSO2-2,4´,5´-pentachlorobiphenyl |
| 4-MeSO2-2,4´,5´-pentachlorobiphenyl | 4-MeSO2-2,4´,5´-pentachlorobiphenyl |
| 3-MeSO2-2,4´,5´-pentachlorobiphenyl | 3-MeSO2-2,4´,5´-pentachlorobiphenyl |
| 3-MeSO2-2,4´,5´-pentachlorobiphenyl | 3-MeSO2-2,4´,5´-pentachlorobiphenyl |
| 3-MeSO2-2,4´,5´-pentachlorobiphenyl | 3-MeSO2-2,4´,5´-pentachlorobiphenyl |
| 4-MeSO2-2,3´,4´,6-tetrachlorobiphenyl | 4-MeSO2-2,3´,4´,6-tetrachlorobiphenyl |
| 3-MeSO2-2,3´,4´,6-tetrachlorobiphenyl | 3-MeSO2-2,3´,4´,6-tetrachlorobiphenyl |

**Abbreviations:**
- HO-PCBs (Bennett et al. 2002; Campbell et al. 2003; Hovander et al. 2002; Li et al. 2003)
- MeSO2-PCBs (Larsson et al. 2002; Weisstr and Norén 1997)
- HO-PCBs (Bergman et al. 1994; Hovander et al. 2003)
- MeSO2-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; Sanda et al. 2000a; Sjödin et al. 1998; HO-PCBs (Campbell et al. 2003; Sandala et al., in press; Sandau et al. 2000a; Sjödin et al. 1998).

*Original B2/revised PCB number.*
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