CONGENER SPECIFIC ASSESSMENT OF HUMAN EXPOSURE TO POLYCHLORINATED BIPHENYLS

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ABSTRACT

Polychlorinated biphenyl (PCB) congeners and isomers were identified and analyzed in serum and adipose tissue specimens from humans after different exposures using high resolution gas chromatography - high resolution mass spectrometry (HRGC/HRMS) and high resolution gas chromatography electron capture detection (HRGC/EC). The exposures were classified as environmental, accidental or occupational using SIMCA pattern recognition and based on amounts of specific congeners.

INTRODUCTION

Commercial PCB products are mixtures of many PCB congeners and isomers and up to 100 isomers can be detected with capillary gas chromatography (HRGC/EC). Usually the profiles of the commercial PCB products cannot be discerned in biological specimens. The goal of this study was to characterize and determine the pattern of the dominating PCB isomers in human serum and adipose tissue at different exposure situations (environmental, accidental and occupational).

MATERIALS AND METHODS

The human specimens analyzed in this study came from following sources: the "control" specimens are from persons exposed solely from the environment (mainly dietary exposure). The "occupational" specimens were from workers exposed to PCB in capacitor manufacture; the exposure had ended 7 years before the sample collection. The "accident" specimens were from persons exposed to PCB in capacitor accidents (leakages, fires). The exposure thus was short, and varied in intensity from very low to high; the specimens were collected immediately after the exposure, and thus changes in the PCB pattern caused by metabolism and disposition were expected not to be extensive. Adipose tissue specimens were obtained at autopsy from persons not known to be exposed to PCBs. The serum and adipose tissue specimens were analysed both with high resolution gas chromatography - high resolution mass spectrometry (HRGC/HRMS) to verify the identity of the isomers and with HRGC/EC (Luotamo *et al*, 1985). Sample preparation was performed as described earlier (Luotamo *et al*, 1985). The identification and quantitation of the PCBs in serum or adipose tissue was based on 55 different tri-, tetra-, penta-, hexa- and heptachlorobiphenyls as standards. For the routine biological monitoring (HRGC/EC), the characterization and determination of PCB residues that we use (Luotamo *et al*, 1985) has been based on using two different standard patterns of PCB isomers: L-PCB pattern (lower chlorinated isomers consisting of di-, tri-, tetra- and pentachlorinated isomers) and H-PCB pattern (higher chlorinated isomers of penta-, hexa- and heptachlorinated isomers). To all standards and samples, the asymmetric 2,4,6-triCB (IUPAC no 30) and 2,3,4,5,6-pentaCB (IUPAC no 116) were added as internal standards.

RESULTS AND DISCUSSION

Nine different trichlorinated isomers were identified in different exposure groups: five in the controls (IUPAC 18, 16, 28, 33 and 22: the sum concentration was <0.27 μg/L), nine in accidental (IUPAC 18, 17, 27, 16, 26, 25, 28, 33 and 22: <3.4 μg/L) and occupational specimens (IUPAC 18, 17, 27, 16, 26, 25, 28, 33 and 22: <3.6 μg/L) and six trichlorobiphenyls (IUPAC 18, 17, 16, 28, 33 and 22) were detected in the adipose tissue (sum concentration, <1.6 μg/L). Three terachlorinated isomers (IUPAC 52, 74 and 66) were identified in controls (<0.32 μg/L), fourteen (IUPAC 53, 51, 45, 46, 52, 49, 47, 44, 42, 71, 74, 70, 66 and 60) in the accidental sera (<6.9 μg/L), nine (IUPAC 52, 49, 47, 44, 71, 74, 70, 66 and 60) in the

occupational sera (<35 μg/L) and eight (IUPAC 52, 49, 47, 44, 71, 74, 66 and 60) in the adipose tissue (<30 μg/g). Two pentachlorinated isomers (IUPAC 99 and 118) were identified in controls (<0.55 μg/L), seven (IUPAC 121, 89, 101, 99, 110, 118 and 105) in the accidental serum (<3.6 μg/L), eight (IUPAC 121, 89, 101, 99, 110, 118, 114 and 105) in the occupational exposure (<12 μg/L) and nine (IUPAC 121, 89, 101, 99, 110, 123, 118, 114 and 105) in the adipose tissue (<94 μg/g). Two hexachlorinated isomers (IUPAC 153 and 138) were identified in control serum (<2.3 μg/L), nine (IUPAC 151, 144, 149, 146, 153, 141, 137, 138 and 156) in accidental (<10 μg/L), ten (IUPAC 151, 144, 149, 146, 153, 141, 137, 138, 128 and 156) in the occupational (<16 μg/L) and thirteen hexaCBs (IUPAC 151, 144, 149, 131, 146, 153, 141, 130, 137, 138, 159, 128 and 156) in the adipose tissue (430 μg/g). In control serum no heptachlorobiphenyls were found, in the accidental sera three (IUPAC 187, 180 and 170: <2.6 μg/L), in the occupational five (IUPAC 187, 183, 177, 180 and 170: <7.1 μg/L) and in the adipose tissue ten heptaCBs (IUPAC 178, 187, 183, 177, 171, 172, 180, 193, 170 and 189: <310 μg/g) were identified in HRGC/HRMS.

In adipose tissue the hexachlorinated isomers 2,2',4,4',5,5'- (IUPAC 153) and 2,2',3,4,4',5'-hexaCB (IUPAC 138) represented 89% of all the isomers quantitated.

The correlations between the isomer concentrations of different PCB isomers in adipose tissue (n=59), improved with 2,4-substitution and increasing level of chlorination. Those isomers which showed best correlations were IUPAC codes 153/138 (correlation coefficient was 0.98), 153/183 (0.95), 138/183 (0.94), 153/156 (0.69) and 138/156 (0.66): the isomers 2,2',4,4',5,5'-hexaCB (153), 2,2',3,4,4',5'-hexaCB (138), 2,3,3',4,4',5-hexaCB (156) and 2,2',3,4,4',5',6-heptaCB (183) are reported to be bioaccumulating, and are slowly or not at all metabolized. These correlations between the different PCB isomers in adipose tissue also show that these isomers come from the same source of the exposure, i.e. environment.

The typical Clophen A30 tri- and tetrachlorobiphenyl profile was found only in the serum from accidentally exposed persons using either SIMCA pattern recognition method (Soft Independent Modelling of Class Analogies) (Luotamo *et al*, 1988) or high resolution gas chromatography high resolution mass spectrometry (HRGC/HRMS); The same isomers were detected also in sera from occupationally exposed persons, but the typical pattern was distorted.

In accidental exposure (capacitor leakes and fires), the pattern in biological samples depended mostly on the PCB product in question. When the level of chlorination is 42% (e.g. Clophen

A30, Aroclor 1242), the most pronounced isomers are tri- and tetrachlorobiphenyls. In accidental exposure the level of trichlorinated biphenyls increased 22-fold compared to controls, and trichlorinated isomers represented 35% of the total PCB concentration: the dominating isomer was 2,2',5-triCB. The level of tetrachlorinated isomers increased in accidental exposure 13-fold and tetrachlorobiphenyls represented 20% of all PCBs: the dominating isomer was 2,3',4,4'-tetraCB. In accidental exposure both tri- and tetraCBs were more homogeneously increased compared to controls, in occupational exposure the individual isomers 2,4,4'-triCB and 2,4,4',5-tetraCB were more pronounced compared to controls and accidental exposure.

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