Polychlorinated biphenyls (PCB) and polychlorinated dibenzofurans and dibenzo(p)dioxins (PCDF/D) in indoor air due to elastic sealants and coated particle boards

Balfanz, E., Fuchs, J., Kieper, H.
GfA - Gesellschaft für Arbeitsplatz- und Umweltanalytik mbH,
Otto-Hahn-Straße 22, D-4400 Münster, Germany

Introduction

The exposed use of polychlorinated biphenyls (PCB) as a softener in permanently elastic sealant material (thiocol rubber) has been known for some time to be a potential source of hygienically relevant PCB-related contaminations of indoor air[1,2,3]. In West Germany these materials found wide-spread use mainly in buildings constructed from prefabricated concrete elements until the mid seventies. As many school buildings and thus especially children are affected, the German Federal Health Office (BGA) has proposed guideline levels for PCB concentrations in indoor air[4].

In the course of the last three years, the GfA have carried out investigations on PCB contaminations in more than 150 buildings. In previously published papers we have described the method used in these examinations and some important factors in PCB air contamination due to permanently elastic sealants[3,5]. During further investigations, particle boards have been detected as an additional source of PCB indoor air contaminations. These boards are used for panelling ceilings and are sometimes equipped with a PCB containing coating. In addition to increased PCB indoor air concentrations the sealant materials as well as the coated particle boards cause PCB contaminations of other surfaces in the room. Because it is generally known that technical PCB mixtures are contaminated by polychlorinated dibenzofurans and dibenzo(p)dioxins (PCDF/D) some complementary measurements have been conducted to obtain information about the PCDF/D concentrations due to the exposed use of PCB.

Methods

The sampling method and analytical procedure used in examining the PCB-related indoor air contamination has been described earlier[5]. In accordance with the German DIN 51527 six indicator congeners were quantified. According to DIN/LAGA the total PCB content was calculated by multiplying the sum-total of the six DIN-congeners with the factor 5.

The sampling of the airborne PCDF/D was carried out by using the same equipment as described for the PCB. The sampling train consists of a glass fibre filter and three polyurethane foams (PU foams) of which the first was spiked with $^{13}C_{12}$-1234-TetraCDD standard prior to sampling. The sampling time was at least 24 hours.

For PCDF/D analysis all samples were soxhlet-extracted with toluene. Prior to extraction ten $^{13}C_{12}$-labelled PCDF/D standards were added to the toluene (one compound for each homolog group). The extract was purified several times by column chromatography. Recovery rates of $^{13}C_{12}$-labelled compounds were determined by adding further standards ($^{13}C_6$-1234-TetraCDD, $^{13}C_{12}$-12378-PentaCDF, $^{13}C_{12}$-123789-HexaCDF and $^{13}C_{12}$-1234789-HeptaCDF) prior to GC/MS analysis.

After separation by capillary gas chromatography on a polar stationary phase (SP 2331) the PCDF/D were detected by high resolution mass spectrometry. The totals for the Tetra- to OctaCDF homolog groups and the concentrations of congeners with 2378-chlorine substitution pattern were quantified. Based on these data Toxicity Equivalents (TE values) were calculated according to the recommendations of the BGA (1984)[6] and the NATO/CCMS (1988)[7].

Results and discussion

In our investigations on PCB-related indoor air contaminations due to permanently elastic sealant materials, PCB concentrations up to approx. 7,500 ng/m^3 have been measured so far. Important factors in the intensity of PCB indoor air concentrations are, inter alia, the PCB content of the source of emission, the type of PCB used therein and the indoor and outdoor air temperature at the time of sampling. Furthermore the increased PCB air concentrations lead to contaminations of surfaces in the room, such as walls, furniture, carpets etc., caused by adsorption effects. Generally PCB surface concentrations in such secondary contaminated materials are less than 1 g PCB/kg. Whereas originally PCB containing materials show a pattern of peaks nearly identical to that of technical PCB products, secondary contaminated materials show a profile which is quite similar to that of indoor air samples. Compared to the PCB product employed in the emission sources, the corresponding indoor air samples as well as the secondary contaminated materials show a significant shift to higher proportions of less chlorinated PCB. Those secondary contaminated materials must be regarded as a further potential emission source influencing the PCB indoor air concentration, because even after professional replacing of the sealants and exhausted cleaning of the room air concentrations higher than 1,000 ng PCB/m^3 can remain.

In our investigations on PCB containing sealant materials the GfA have measured indoor air concentrations in over 120 different buildings. In 39 % of the objects, PCB concentrations were found to be higher than 300 ng/m^3, a value which was proposed by the German BGA as a precautionary guideline level[4]. 6 % of the objects show concentrations higher than 3,000 ng/m^3, a value which was

proposed as a level of concern for starting remedial actions[4]. Remarkably such concentrations were only observed when Clophen A 40 containing sealants - with an average concentration of approx. 10 % PCB - were used. Where technical Clophens A 50 and A 60 were used as a softener, PCB indoor concentrations did not yet exceed 3,000 ng/m^3 although these PCB products were applied in higher concentrations, partly more than 30 %. All objects affected by PCB containing sealants so far were constructed in a close period of time, namely between 1960 and 1975.

Particle boards with a special surface treatment have been established as a further important source for PCB in indoor air. The coating of such particle boards, which were used for panelling ceilings, can contain 5 to 10 % Clophen A 60. Whereas Clophen A 60 containing sealants, even with more than 30 % PCB, still cause indoor air concentrations less than 1,000 ng PCB/m^3, Clophen A 60 containing particle boards can lead to indoor air concentrations up to 7,500 ng PCB/m^3 (see Table 1). Similar to the already discussed PCB-containing sealants, temperature conditions have a dominant influence on the level of the PCB concentrations in indoor air.

Table 1: Typical range of PCB contents in sealant materials and particle boards compared with the corresponding range of PCB indoor air concentrations

PCB source	Type of Clophen	Typical PCB concentrations in the source [%]	Typical PCB indoor air concentrations [ng/m^3]
sealant material	A 40	1 - 20	100 - 7,500
	A 50	1 - 35	100 - 2,500
	A 60	1 - 45	< 1,000
coated particle board	A 60	1 - 10	100 - 7,500

In our complementary PCDF/D analyses of selected sealant materials and particle boards, PCDF/D levels were determined which can distinctively exceed limits of the German Regulations for Hazardous Materials (GefStoffV)[8]. The results of our additional PCDF/D indoor air measurements in PCB contaminated buildings are summarized in Table 2. ITE-values for PCDF/D were found to be lower or equal than 0.1 pg ITE/m^3 in rooms with PCB containing sealant materials. In contrast to this, PCDF/D indoor air concentrations due to PCB containing particle boards

were observed to be 1.67 and 2.62 pg ITE/m^3 respectively. The latter value is higher than PCDF/D maximum values found in buildings with extensive use of wood preserving formulations containing pentachlorophenol (PCP)[9].

Table 2: Individual PCB and PCDF/D indoor air concentrations due to PCB containing sealant materials and coated particle boards

PCB source	Type of Clophen	PCB indoor air concentration [ng/m^3]	PCDF/D indoor air concentration [pg ITE/m^3]
sealant material	A 40	4,600 4,400 6,500	0.04 0.08 0.08
	A 50	1,400	0.10
coated particle board	A 60	4,000 5,700	1.67 2.62

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