Hexabromocyclododecanes in Dust from Public Facilities and Business Places in Japan

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Introduction

Brominated flame retardants (BFRs) are widely used in building materials, textiles, electric appliances and other materials to protect them from ignition and open fire. Since high concentrations of BFRs were found recently in indoor dust collected from several parts of the world (Stapleton et al., 2005; Suzuki et al., 2006; Abdallah et al., 2008), dust ingestion is considered as one of the main exposure routes of BFRs to humans, especially in case of infants. Among BFRs, polybrominated diphenyl ethers (PBDEs) in dust were intensively studied so far (e.g. Stapleton et al., 2005; Suzuki et al., 2006). On the other hand, only a few studies focused on other BFRs including hexabromocyclododecanes (HBCDs) used mainly as a flame retardant of building materials and textile goods such as curtains.

In Japan, flammable items including draperies and carpets used in the places regulated by Fire Prevention regulations (e.g. high-rise buildings, underground malls, and public facilities such as theaters, hospitals, and hotels) are obligated to use flame-retarded products. Therefore, the concentrations of flame retardants including HBCDs in the indoor environment of the above-mentioned places are expected to be much higher than those at homes. Based on such a background, the aim of this study is to understand the range of concentrations and patterns of HBCD diastereomers in dust from the public facilities and business places in Japan in addition to those collected from homes.

Materials and Methods

Samples: A total of 36 dust samples collected from offices (*n*=9), hotels (*n*=9), preschools (*n*=9), hospitals (*n*=2), restaurants (*n*=2), dry-cleaner's (n=2), aged care facilities (*n*=2), and electric store (*n*=1) in Japan in 2007 were used in this study. Dust samples were collected from cleaner bags of the vacuum cleaners routinely used there. In addition, dust from 4 homes and 4 offices in Japan collected

in 2005 were included in this study. Debris was removed from each sample before chemical analysis.

Chemical Analysis: Approximately 5 g of dust sample was extracted by using a Soxhlet apparatus with acetone for 6 h, and subsequently with toluene for 16 h. The both extracts were combined, spiked with $^{13}C_{12}$ α-, β-, and γ-HBCD as internal standards, and concentrated using a rotary evaporator. Then, solvent were exchanged into hexane, and the crude extract was passed through a sulfuric acid impregnated silica gel column with 10% dichloromethane/hexane. The eluate was concentrated using a gentle stream of nitrogen, and then, re-dissolved with methanol. After adding d_{18} α-, β-, and γ-HBCD as recovery standards, identification and quantification of HBCD diastereomers were carried out using an Alliance 2695 liquid chromatograph equipped with a Quattro Ultima triple quadrupole mass spectrometer (Waters, Tokyo).

Results and Discussion

HBCDs were detected in all the dust samples analyzed (Figure 1). The highest concentration was found in the sample from a hospital (5,700 ng/g). HBCDs detected in dust from preschools showed relatively high concentrations compared to other facilities. In general, HBCD concentrations in house dust in Japan were lower than those found in the public facilities and business places, indicating that HBCD treated goods were used more in those places and the products used there are contributing to HBCD levels in dust. However, one of the house dust samples was revealed to contain high HBCD concentration (3,400 ng/g) exceeding those in most of the public facilities and business places analyzed. This result might imply that there are homes using significant amount of flame-retarded articles as abundant as those in the places regulated by Fire Prevention regulations.

When diastereomer profiles were compared, α-HBCD was predominant in most of the dust samples investigated (Figure 1). Interestingly, the percentage of γ-HBCD in dust from preschools, hospitals, and aged care facilities were comparable with or larger than α-HBCD. As γ-HBCD is the most abundant diastereomer accounting up to 89% in the HBCD technical mixture (Covaci et al., 2006), this result suggests that at least some of the flame-retarded products used in these places are treated with HBCD.

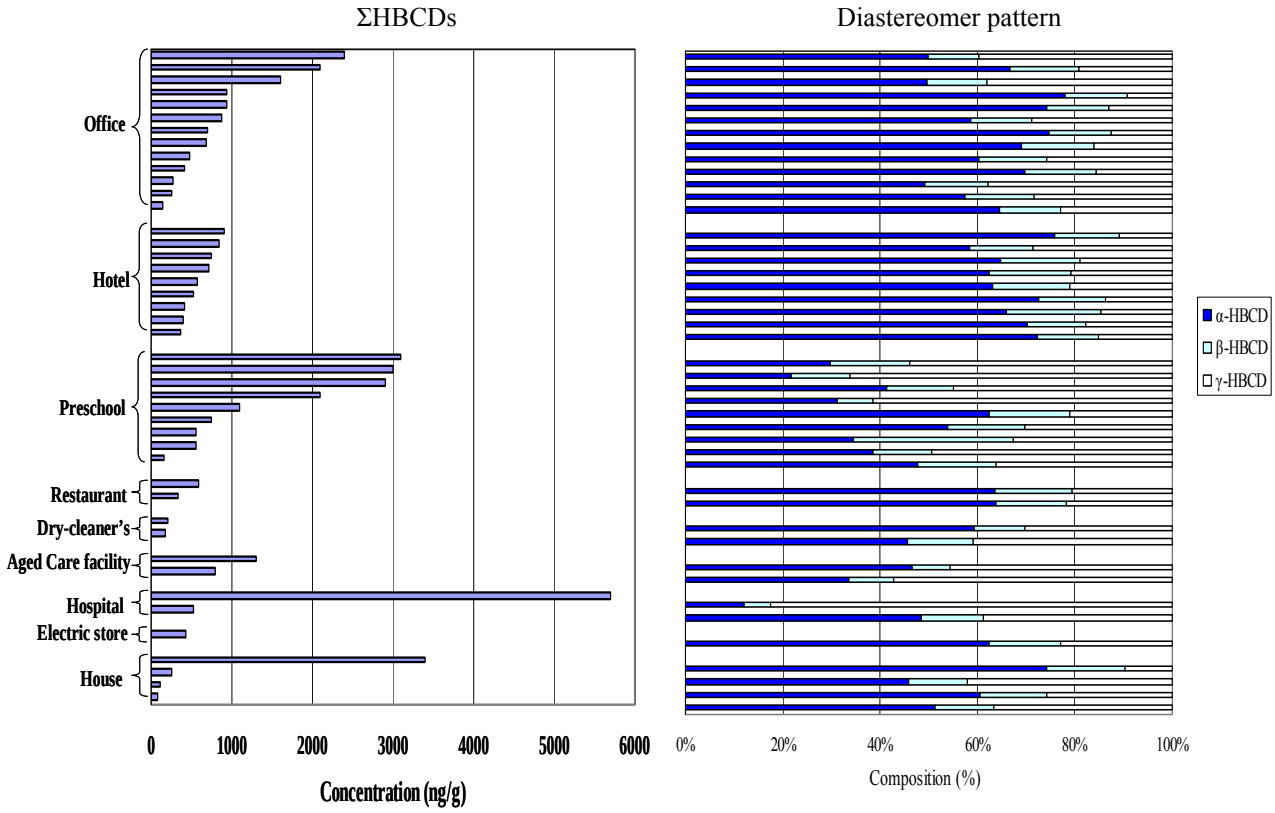

Figure 1. The concentration of ΣHBCDs (left) and HBCD diastereomer profiles (right) in dust from various places in Japan

For dust samples collected in 2005, concentrations of PBDEs and polybrominated dibenzo-*p*-dioxins and furans (PBDD/Fs) were reported previously by Suzuki et al (2006). HBCD concentrations reported in this study were generally lower than PBDE levels detected in the same samples (Table 1), suggesting that contamination by PBDEs is more remarkable in the indoor environment of Japan.

Table 1. Concentrations (ng/g) of HBCDs, PBDEs, and PBDD/Fs in house and office dust.

Sample name	α-HBCD	β-HBCD	γ-HBCD	ΣHBCD	ΣPBDE	ΣPBDD/Fs
HouseDust1	66	15	28	110	3,000	4.8
HouseDust2	2,500	540	330	3,400	200	0.6
HouseDust3	42	10	30	82	2,500	2.3
HouseDust4	120	32	110	260	2,000	3.8
OfficeDust1	810	200	620	1,600	1,500	1.3
OfficeDust2	510	110	250	870	1,500	4.8
OfficeDust3	93	18	33	140	4,400	1.6
OfficeDust4	280	65	120	470	2,900	1.9

As shown in Figure 2, mean and range of ΣHBCD concentration found in indoor dust from public facilities and business places analyzed in the present study were comparable with those of UK offices and US homes reported by Abdallah et al (2008).

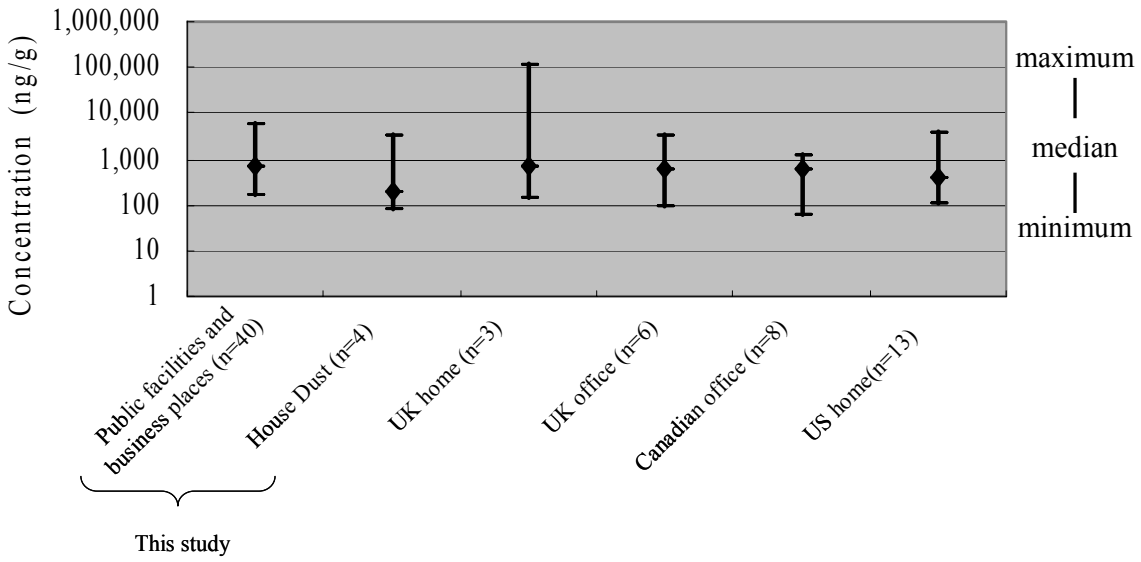

Figure 2. Comparison of the HBCD levels in the indoor dust collected in Japan (this study) with those found in other countries (Abdallah et al.,2008)

References

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