Brominated flame retardants (BFRs) in indoor in a community in a megacity of southern China: comparison with outdoor air

Nan Ding [1,2], Tao Wang [1,2], She-Jun Chen [1], Bi-Xian Mai [1*]

[1] *State Key Laboratory of Organic Geochemistry and Guangdong Key Laboratory of Environmental Protection and Resources Utilization, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China*; [2] *University of Chinese Academy of Sciences, Beijing 100049, China*

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1. Introduction

Brominated flame retardants (BFRs) are extensively used in a variety of products in homes and offices such as electronic equipment, furniture, fabrics, car interiors, and construction materials to slow the spread of fire (Batterman et al., 2009). Most of BFRs are physically mixed into products and are readily released into the environment. Thus, indoor environments contribute a significant portion of total human exposure to these chemicals. High levels of BFRs have been found in indoor dust in many regions (Besis and Samara, 2012). The Pearl River Delta (PRD) is one of the most prosperous regions of China. However, little is known about the BFR contamination in the indoor air in this region, which is possibly different from those in the developed countries.

In the present study, indoor and outdoor air samples were collected by passive air sampler (PAS) for more than one year. We aim to investigate and compare the BFR concentrations and composition profiles in the air, to know the seasonal pattern of BFRs, and to explore the potential link between indoor and outdoor compartments.

2. Material and methods

The sampling was conducted using PASs equipped with polyurethane foam disks. The PASs were deployed in three buildings (A, B, and C) from December 2012 to March 2014. Specifically, the samples were taken from one home in Building A, three homes in Building B, and two offices in Building C. The PASs were suspended in living room and open balcony, respectively. They were deployed for approximately 60 days in each sampling session and in total 72 samples. PUF samples were Soxhlet extracted with a mixture of hexane and acetone (1:1) for 48 h. Sample analysis was carried out using a GC-ECNI-MS. The recoveries of the surrogate standard (mean ± standard deviation) were 98.2 ± 19.4% for BDE77, and 73.2 ± 18.6% for BDE181, and 74.6 ± 17.6% for BDE205.

3. Results and discussion

The PentaBDE concentrations from the three buildings ranged from 1.43 to 30.8 pg/m^3 in the indoor air and from 1.07 to 15.3 pg/m^3 in the outdoor air. There was no statistically significant difference between the indoor and outdoor air. The concentrations of intermediate congeners (OctaBDEs), main components of the technical octa-BDE

mixture, were lower than the levels of PentaBDEs. The outdoor levels (median 2.44 pg/m^3) were a little higher than indoors (1.46 pg/m^3).

The concentrations DecaBDEs were significantly higher outdoors than indoors. DBDPE is a novel alternative BFR with high molecular weight also showed apparently higher outdoor concentrations (median = 127 pg/m^3) than indoors (74.9 pg/m^3). This is because technical DecaBDEs and DBDPE are being used in large quantities in China (Chen et al., 2013) and consequently are present at higher levels in the environment.

We observed higher concentrations of PentaBDEs in the home of Building A than homes in Buildings B and C; while the concentrations of other BFRs in the three buildings were comparable. This result indicated a stronger indoor source of PentaBDEs in homes of Building A probably due to the elder household products. In 2007, PBDEs that are largely from technical penta- and octa-BDE mixtures were banned in China leading to significant reduction in their use in relevant products and consequently the emissions from household products.

The congener profiles of lower brominated BDEs in the indoor and outdoor air were generally similar suggesting a common source for them (Fig. 1). The profiles of highly brominated BDEs were significantly similar in respective indoor and outdoor air than between them. It was found that the indoor profiles were closer to those in the technical products. The indoor-outdoor difference was likely due to different behaviors in the process of migration of these congeners from outdoors to indoors.

We found that the concentrations of PentaBDEs showed similar temporal variations to the ambient temperature in all the indoor and outdoor environments. This clearly indicated that these PBDEs, with higher vapor pressures, were strongly controlled by temperature-driven evaporation from indoor products and/or construction materials. The concentrations of OctaBDEs showed significantly or moderately temperature-dependence, suggesting a similar emission mechanism to the PentaBDEs. The temperature-dependence of air concentrations of DecaBDEs and DBDPE was much less significant given their low vapor pressures. The finding confirmed the primary industrial sources of these two BFRs in the air in the study region.

Correlations analysis was conducted between the indoor and outdoor BFR levels (Fig. 3). The correlations were most significant for penta-BDEs, followed by those for deca-BDEs, octa-BDEs, and DBDPE. These correlations were likely a reflection of the interactions between the indoor and outdoor compartments for the BFRs.

Acknowledgments

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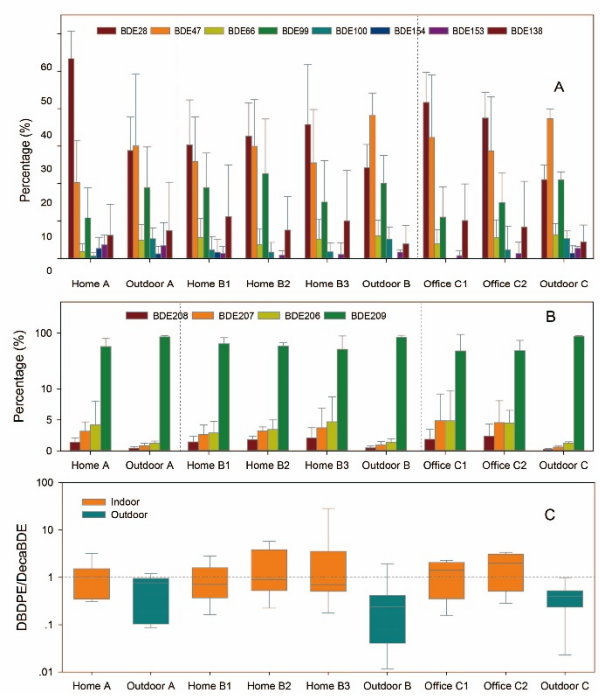

Fig. 1 BFR compositions in the indoor and outdoor air: congener profiles of the lower brominated BDEs (A), congener profiles of the highly brominated BDEs (B), and ratios of DBDPE to DecaBDE (C).

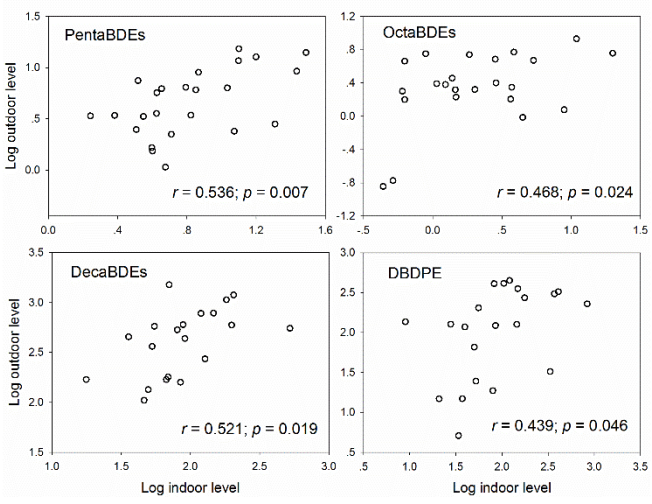

Fig. 3 Pearson correlations between the indoor and outdoor air BFR concentrations from the three buildings.