PBDE EXPOSURE: WHICH IS MORE IMPORTANT, HOMES OR OFFICES?

Watkins D.[1], Stapleton H.M.[2], Chan S.[1], McClean M.D.[1], Webster T.F.[1]

[1]Department of Environmental Health, Boston University School of Public Health, Boston, MA, USA; [2]Nicholas School of the Environment, Duke University, Durham, NC, USA

Abstract
Previous studies of indoor environments in the USA have focused on homes rather than offices, yet fire standards for furniture are often more stringent for the latter. We actively sampled air from offices in Boston, Massachusetts and compared it with indoor air from homes in the same area. Our results suggest increased air concentrations of PentaBDE in offices compared to homes, while DecaBDE concentrations were less distinguishable.

Introduction
Polybrominated diphenyl ethers (PBDEs) occur as three commercial products: PentaBDE, OctaBDE and DecaBDE. PentaBDE was a major product manufactured and used primarily in the USA as a fire retardant in polyurethane foam for furniture until its manufacture was phased out in 2004. Nevertheless, large amounts of PentaBDE remain in use in the USA where the indoor environment is estimated to be a major source of exposure.[1,2] Zota et al.[3] recently hypothesized that concentrations of PentaBDE in serum of Californians were elevated compared to the rest of the USA because of the stricter fire standards in that state. Because of differences in dust sampling methods[4] and analysis, comparison of PBDEs in dust samples from around the country can be difficult. We recently reported relatively low prevalence of brominated flame retardants (BFRs) in foam furniture from many homes in the Boston, Massachusetts area, using X-ray fluorescence (XRF) as a screening tool.[5] However, there are few US data on PBDEs in offices, where many people spend substantial portions of their time. Furthermore, stricter fire standards for upholstered furniture often apply in offices and public buildings compared with homes. For example, in Boston, classrooms and offices in universities and elsewhere may be classified as public spaces and therefore subject to furniture fire codes comparable with those in California. The overall goal of our project is to compare exposure to PBDEs from various sources. We report here on air samples in offices compared with homes in the Boston area.

Materials and Methods
We recruited 31 people who work in offices in Boston, Massachusetts. We sampled serum as well as air, dust, and wipes from various indoor environments during January-March 2009; this time period minimizes the effects of ventilation via windows. We assessed the bromine content of products using XRF and administered a questionnaire, including questions regarding diet, office and home characteristics. Methods were based on those used previously.[4-6] Air, the focus of this paper, was actively sampled for approximately 48 hours during the work week at 4 L/minute for a total volume of about 11 m^3. Because of the logistics involved in active air sampling, the present study only collected air from offices. However, similarity of methods allow comparison with our earlier air sampling from Boston-area homes during January-March 2006.[6] We employed a glass-fiber filter (GFF) followed by a pre-cleaned polyurethane (PUF) plug. The method for chemical analysis of PBDEs was reported previously.[6] Data were analyzed for correlation between congeners and distribution and log-transformed where appropriate. Comparisons between air concentrations in offices and homes were made by two-tailed t-tests or non-parametric tests, as appropriate.

Results and Discussion
Congeners 17, 28/33, 47, 66, 85/155, 99, 100, 153, and 154 were summed (referred to here as Σ-non209) for comparison with our earlier data from Boston area homes.[6] Statistical analysis indicated that these congeners tended to be highly correlated with each other but not with BDE209, consistent with origins from PentaBDE and DecaBDE, respectively. Σ-non209 concentrations were lognormally distributed with a geometric mean concentration of 478 pg/m^3. BDE209 was not lognormally distributed; the geometric mean concentration was 81 pg/m^3 and the

median was 57 pg/m^3. Interestingly, four samples of office air had detectable levels of BDE183, whereas none of our earlier air samples from homes did; [6] these results may suggest OctaBDE in office equipment as a possible source.

In comparison with room air from 20 Boston area homes,[6] the geometric mean Σ-non209 concentration in office air was 47% higher than bedrooms (p=0.17) and 66% higher than main living areas (p=0.07). The latter result was marginally significant; larger, more powerful studies may show a clearer difference. In contrast, BDE209 in office air was lower than in the bedrooms and main living areas of homes, 14% lower comparing geometric means and about 40% lower comparing medians, although the difference was not even close to significant.

Our results suggest that air concentrations of PentaBDEs may be higher in offices than in homes in the Boston area. In contrast, air concentrations of DecaBDE appear more similar (or possibly lower) in offices. While we did not examine personal air in this study, our earlier work suggests that personal air concentrations were primarily elevated for DecaBDE due to a personal dust cloud effect.[6]

Our results are consistent with greater presence of PentaBDE in offices compared with homes, but more research is needed on this topic. Future work will compare PBDEs in dust between offices and homes, as well as XRF results for furniture.

References

1. Wu N., Herrmann T., Paepke O., Tickner J., Hale R., Harvey E., La Guardia M., McClean M.D. and Webster T.F. *Environ Sci Technol* 2007; 41: 1584-89.
2. Lorber M. *J. Exp. Sci. Environ. Epidemiol.* 2008; 18: 2–19.
3. Zota A.R., Rudel R.A., Morello-Frosch R.A. and J.G. Brody. *Environ Sci Technol* 2008; 42: 8158-64.
4. Allen J.G., McClean M.D., Stapleton H.M. and Webster T.F. *Environ Intern* 2008; 34: 1085-91.
5. Allen J.G., McClean M.D., Stapleton H.M., Webster T.F. *Environ Sci Technol* 2008; 42: 4222–28.
6. Allen J.G., McClean M.D., Stapleton H.M., Nelson J.W. and Webster T.F. *Environ Sci Technol* 2007; 41: 4574-79.