ASSESSING URBAN INDOOR EXPOSURES TO PHTHALATE PLASTICIZERS, PAHS, NEW BFRS AND PFCS

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Introduction

The contents of homes, including the products we buy, furnishings, the way we heat and use rooms, as well as the building and finishing materials of homes can all influence the exposure we receive to organic pollutants and persistent organic pollutants (POPs), e.g. phthalates, PAHs, BFRs, PCBs and PFCs [1 2 3 4]. POPs are often brought into the home via commercially available consumer goods, and over time leach from the original products (which act as a source) into the surrounding indoor environment. The human exposure to POPs has been identified to be a potential risk at even low doses, and can cause detrimental health effects at low invivo concentrations.

The relevance of dust and particulate sampling locations and matrix type to human exposure is variable, but related to characteristic behaviour of the compounds. Due to spatial variability of dust across indoor rooms and environments [3 5] correlating the dust which represents that received by human exposure has not yet be defined, and a number of different sampling procedures are currently practised. For POPs which remain predominantly in the particulate phase at ambient room temperatures, they can partition into settled surface and floor dust[6] as well as onto surface films, such as those located on windows [7].

Exposure to new emerging BFRs due to a ban in the use of penta and octa-BFR mixtures, and the immentent restriction of deca-BDE in Canada, 2012, is leading to companies turning towards the new BFRs. These compounds are expected to follow the same pathway of exposure as previously used BFRs[8], and thus are emerging in the indoor matrices were HBCDs and PBDEs are found[2 9]. Though current measurements of new BFRs (NBFRs) in homes indicate that some compounds such as BTBPE and DBDPE, have a more homogeneous distribution throughout the home, in comparison to HBCDs and TBB and TB[10]. This suggests that the appropriate sampling technique for estimatng indoor human exposure may need to be independently selected for NBFRs, and will be investigated within this study.

The complete intensive study aims to characterize temporal and spatial variations in house dust and health-relevant constituents such as phthalate plasticizers, PAHs, new BFRs and PFCs. The study conducts an assessment of the most appropriate sampling methods and matrices for estimating indoor exposure to POPs and other indoor pollutants, which are known to cause adverse health effects. This paper concentrates on various sampling techniques for dust, and compares them to the use of window wipes, along with air concentrations as a means for estimating human indoor exposure to indoor common POPs and organic pollutants.

Materials and Method

Sampling Strategy - Five downtown Toronto homes were used for the collection of dust and window wipes over a 4-day period in late September 2010. Measurements were conducted in two to four rooms per home for a total of 14 sites. Dust was collected from a centrally located area within the room. Air samples were collected using sorbent impregnated PUF (SIP) disks and were deployed for a period of ca. 1 month. Continuous measurements were also recorded of temperature, air exchange rate (AER), $PM_{2.5}$ concentration, and relative humidity.

Window wipes were collected using baked quartz filters, (QF), soaked with iso-propanol, and an area of 40 cm^2 was wiped.

Analytical Procedures - Extraction of samples was conducted on the ASE using an acetone: hexane ratio (3:7), followed by reduction, solvent exchange and microfiltration. Samples were then injected onto a GC-MS for the analysis of phthalates, non-polar PFCs, and NBFRs.

Results and Discussion

Surface loadings of dust was significantly higher in carpeted bedrooms than non-carpeted bedrooms ($p = 0.001$). Similarly, the dust loading in carpeted family rooms was higher than non-carpeted family rooms ($p = 0.001$). In contrast, there was no difference in phthalate surface loadings between the two flooring types. One possible interpretation of this observation is that at the concentrations observed in this study, the partitioning of phthalates to dust particles is at equilibrium, resulting in uniform loading of phthalates in all dust throughout the rooms' various surfaces.

While all the phthalates followed a log-normal distribution, distribution testing revealed that heavier molecular weight (HMW) phthalates (BBP, DEHP and DiNP) generally had a higher goodness-of-fit compared to lower molecular weight (LMW) phthalates (DEP, DiBP and DnBP). These observations suggest that HMW phthalates are less variant in home environments while LMW phthalates vary widely across individual homes. Consequently, when considering chronic human exposure to phthalates via settled dust (e.g. by ingestion), HMW phthalates may have a greater long-term contribution via dust than LMW phthalates which are found predominantly in air.

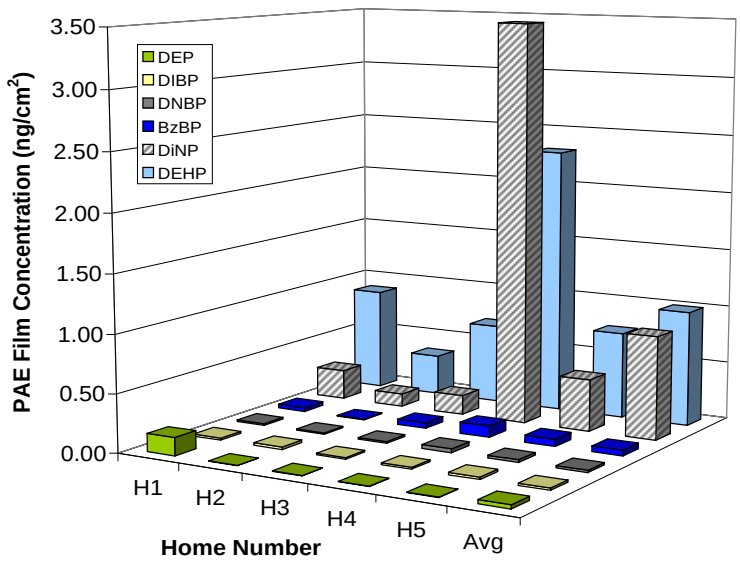

Figure 2: Phthalate concentrations in window films from homes (ng/cm^2) and the arithmetic average of all homes.

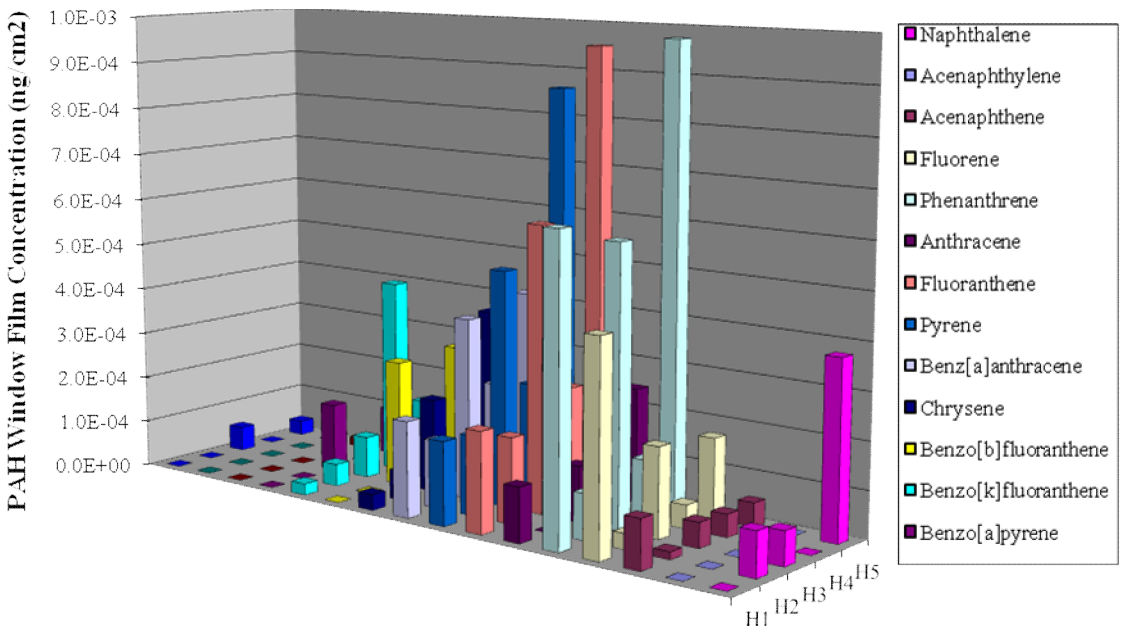

Figure 1: PAH Window Film Concentration (ng/cm2) per Home Number (H1…Hn)

The source distribution for urban indoor PAHs in window films (*Figure 1*) is highly correlated to the source distribution determined for outdoor urban surface films by Diamond *et al.*[11], whilst displaying a different signature compared to indoor air concentrations[12]. The presence of the heavier molecular weight compounds in the films and not air suggest that as an estimate of exposure, measuring the air concentrations alone is not sufficient in capturing the profile of these HMW compounds, and could result in an underestimate of indoor exposure. This behaviour and distribution of compounds is also seen for PFCs[4], PBDEs[13] but not TBBPA[2] thus the behaviour of the NBFRs within this study will need to be independently assessed in both the air and dust matrices from homes, and within different rooms.

The variability of NBFRs between homes, offices and classrooms has already been noted by Ali *et al.*[8], which indicated that sources and/or applications are more prevalent in classrooms and office. The data within this study will allow the spatial variability within homes to be assessed.

The variability of concentrations from films within the homes is displayed in Error! Reference source not found. which indicates that concentrations are higher in kitchens> bedrooms> living rooms. Thus the sampling of a single room may not provide an accurate estimate of the received exposure from the entire home. The reason for this relationship is unclear, the kitchen is likely to be higher due to cooking and heating sources[14] however the difference between living rooms and bedrooms is not known. These

Conclusions

Capturing dust as an estimate of human indoor exposure to a variety of POP and organic pollutants becomes dependent upon the volatility of the desired compound. Results indicate the use of window films for lighter

molecular weight compounds including PAHs, PFCs and phthalates can be used as an accurate representation of the dose received from indoor environments. Results also indicate that lower molecular weight compounds tend to reach equilibrium quickly within individual rooms, suggesting that the collection of a one-room dust sample can accurately represent concentrations across the whole home. This is not likely to be true for the heavier molecular weight compounds, such as PBDEs which have been found to be heterogeneous throughout homes[5]. The indoor human exposure to higher molecular weight compounds are therefore expected to be best represented by dust sampling.

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