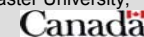


Polyfluorinated Compounds in the Home: Levels in Air and Dust and Human Exposure

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Introduction

Polyfluorinated compounds such as perfluorinated alkyl sulfonamides (PFASs) and polyfluorinated telomer alcohols (FTOHs) are used in a variety of consumer products for surface protection. PFASs and FTOHs are believed to be precursors for perfluorooctane sulfonate (PFOS) and perfluoroalkyl carboxylates (PFCAs) which have been detected in human and other biological samples from around the world¹⁻⁴. As a result of their use, FTOHs and PFASs exhibit elevated concentrations in indoor air and dust. Exposure to house dust represents a particular concern for children and infants who ingest about twice as much dust as adults⁵. In this study air and dust samples were analyzed for several PFASs including N-methylperfluorooctane sulfonamidoethanol (MeFOSE), N-ethylperfluorooctane sulfonamidoethanol (EtFOSE), N-ethylperfluorooctane sulfonamide (EtFOSA), N-methyl perfluorooctane sulfonamidethylacrylate (MeFOSEA) and fluorinated telomers - 6:2, 8:2 and 10:2.

Methodology

Sample collection: Indoor air (PUF disk, passive samples) and house dust samples (n=59) were collected from randomly selected homes in the city of Ottawa, Canada during the winter of 2002/03. Outdoor air samples were also collected (n=7).

Extraction: PUF samples were Soxhlet extracted for 21 hours in petroleum ether, concentrated to 0.5mL and transferred to isoctane by rotary evaporation and nitrogen blow-down. Dust extractions were performed by weighing approximately ~0.25g dust and Soxhlet extracting with dichloromethane (DCM) for 24 hours. No cleanup of extracts was performed for PUF or dust samples.

Analysis: PFASs were analyzed by gas-chromatography electron impact mass spectrometry (GC-EIMS) using a Hewlett-Packard 6890 GC-5973 mass selective detector (MSD) in selective ion monitoring (SIM) mode. Analytes were separated on a 60 m DB5 column. FTOH were analysed with positive chemical ionisation mode (PCI) using same instrument as above. Splitless injections were 1µL for both modes of analysis. The ion source and quadrupole were kept at 230°C and 150°C for EI and 250°C and 150°C, respectively, for PCI analysis. Standards were included every eight samples to monitor changes in sensitivity.

Results and Discussion

Indoor and Outdoor Air Concentrations

• Passive air samplers consisting of polyurethane foam (PUF) disks were calibrated and used to conduct the indoor (n=59, 21 day exposure) and outdoor (n=7, 70 day exposure) survey.

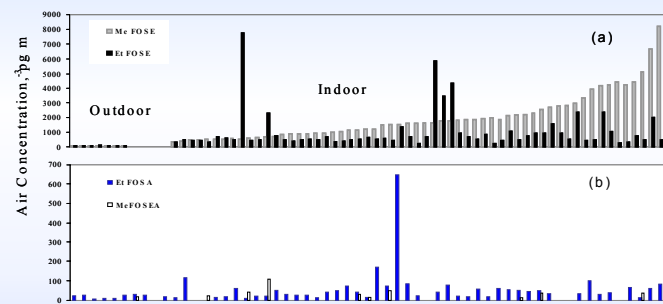


Figure 1. Indoor and outdoor air concentrations for (a) MeFOSE and EtFOSE and (b) EtFOSA and MeFOSEA.

• PFASs indoor air concentration distributions are shown in Figure 1; average concentrations for MeFOSE and EtFOSE were 1490 pg m⁻³ and 740 pg m⁻³, respectively. (see Table 1)

• Indoor air concentration for MeFOSE and EtFOSE were about 10 to 20 times greater than outdoor concentrations, establishing indoor air as an important source to the outside environment (Figure 1a).

• EtFOSA and MeFOSEA concentrations were lower in indoor air (40 pg m⁻³ and 29 pg m⁻³ respectively) and below detection in outdoor air samples (Figure 1b).

• Levels of MeFOSE and EtFOSE in indoor air and corresponding house dust samples were well correlated ($p < 0.0001$).

• FTOH were not analysed in passive samples due to methodology issues which are now being addressed.

House Dust Concentrations

• Dusts were collected from home vacuum cleaners. Sampling details are given elsewhere⁶⁻⁷.

• MeFOSE, EtFOSE and fluorotelomer 6:2, 8:2 and 10:2 were detected in all dust samples, MeFOSEA was detected in ~30% of the samples and EtFOSA was not detected in indoor dust.

• FTOHs dust concentration distributions are shown in Fig. 2 and compared to sulfonamides. Individual FTOH geometric mean dust concentrations (ng g⁻¹ dust) were 35, 55 and 35 for 6:2, 8:2 and 10:2 respectively. (see Table 1)

• Of all fluorinated compounds that were analysed in house dust, MeFOSE and EtFOSE showed the highest concentrations. (Table 1 and Figure 2).

• FTOH 6:2, 8:2 and 10:2 were well correlated ($p < 0.0001$) to each other. However, no correlation existed between MeFOSE and EtFOSE ($p > 0.5$) and between FTOHs and either MeFOSE or EtFOSE ($p > 0.7$).

• PFOS, PFAS and PFHxS were also analysed in the same dust samples⁷. Figure 3 summarizes the percent distribution of median house dust concentrations for all perfluorinated compounds analysed.

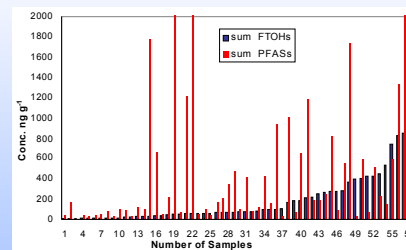


Figure 2. Concentrations of total fluorotelomer (6:2, 8:2 and 10:2) and total MeFOSE + EtFOSE in house dust samples.

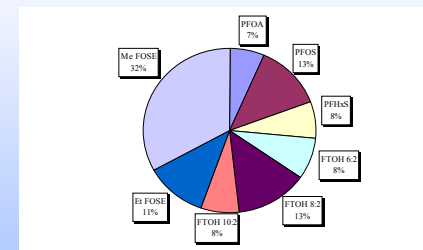


Figure 3. Percent distribution of fluorinated compounds in house dusts.

Human Exposure

It is not known whether the presence of PFOS and PFCAs in biota and humans occurs by direct uptake or by biotransformation of some precursors such as PFASs and FTOH. Because of elevated concentrations in indoor environments (associated with use indoors), it is possible that inhalation of contaminated air and ingestion of contaminated dust may be important pathways for human exposure. These have been assessed using the results of this study. Due to a lack of absorption data for both inhalation and ingestion of fluorinated compounds, 100 % absorption efficiency was assumed. Hence, these estimates represent maximum intakes for each scenario. Table 2 presents different exposure scenarios based on an inhalation rate of 20L min⁻¹ for adults and 13L min⁻¹ for toddlers, assuming 16hrs spent on light activity at home. Dust exposures were calculated assuming ingestion of 100mg day⁻¹ for adults and 200mg day⁻¹ for toddlers⁸.

Table 2: PFAS and FTOHs inhalation and dust ingestion exposure estimates for adults and toddlers (ng day⁻¹).

Intake (ng d ⁻¹):	Adult				Child (6 mths -2 yrs)			
	5th %-ile	median	95th %-ile	max	5th %-ile	median	95th %-ile	max
Air: PFASs	17	46	148	168	11	30	96	109
Dust: FTOHs	1.4	8.5	122	2546	2.8	17	243	5093
Dust: PFASs	3.4	19	244	1756	6.9	37.6	489	3512

Table 1. Concentrations of Fluorinated compounds in indoor and outdoor air samples and indoor house dusts

	MeFOSE	EtFOSE	EtFOSA	MeFOSEA	FTOH 6:2	FTOH 8:2	FTOH 10:2	PFOS ¹	PFOA ¹	PHHxS ¹
Outdoor Air, pg m⁻³										
Minimum	76	80	BDL	BDL						
Maximum	99	106	BDL	BDL						
Arithmetic mean	83	88	BDL	BDL						
Geometric mean	82	88	BDL	BDL						
Indoor Air, pg m⁻³										
Minimum	366	227	6	12						
Maximum	8190	7740	646	109						
Arithmetic mean	1970	1100	59	35						
Geometric mean	1490	744	40	29						
Indoor House Dust, ng g⁻¹										
Minimum	3	1	BDL	0.7	2	3	2	BDL	BDL	BDL
Maximum	8860	75440	BDL	44	2500	16315	8176	5063	234	4305
Arithmetic mean	412	2200	BDL	14	156	410	233	443	106	391
Geometric mean	113	138	BDL	7.9	33	55	35	59	18	46

¹ Ref 7

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