

Polyfluorinated telomer alcohols (FTOHs) in indoor dust

Mahiba Shoeib¹, Tom Harner¹, Bryony Wilford², Jiping Zhu³

¹Environment Canada

²Lancaster University

³Health Canada

Introduction

Polyfluorinated telomer alcohols (FTOHs) are a group of fluorinated organic compounds used in variety of consumer and industrial products as intermediates in ink synthesis, paint, coating for oil and water resistance, waxes and polishes¹. FTOHs are a class of linear long chain alcohols named based on the ratio of fluorinated carbon to the hydrogenated carbon (e.g. 6:2, 8: 2 and 10: 2). FTOHs and perfluoro alkylsulfonamides PFASs (methyl-perfluorooctane sulfonamidoethanol MeFOSE and ethyl-perfluorooctane sulfonamidoethanol EtFOSE) are believed to be precursors for perfluoroalkyl carboxylates (PFCAs) and perfluorooctane sulfonate (PFOS). PFOS and PFCAs have been detected in humans and in biological samples from around the world²⁻⁴ including remote regions⁵. Due to the widespread presence of perfluorinated organic compounds in environmental and biological samples, there is growing concern regarding their fate and potential health effects.

To better understand sources of these chemicals, more than 50 homes in Ottawa, Canada were surveyed to determine the emission strength and potential human exposure of FTOHs. Exposure to house dust represents a particular concern for children and infants, since they spend a lot of the time on floors and carpets where dust accumulates; they frequently put their hands and other object to their mouths, increasing their ingestion uptake. Overall, infants and toddlers ingest about twice as much dust as adults⁶.

Material and Methods

Sample Collection. Indoor dust was collected from 66 randomly selected homes in the city of Ottawa, Canada during the winter of 2002/03. Details on sample collection and handling are given elsewhere^{7,8}. Briefly, dusts were collected from vacuum cleaners; the bags were detached and sealed in polyethylene sample bags. Upon arrival in the laboratory, the bags were then cut open with clean scissors and the content of each bag was transferred to a vibratory sieve. After all dust was sieved, any visible hairs were removed using tweezers and/or a brush. Three grams of the resulting fine dust was then transferred to a 20mL clear wide mouth bottle with an aluminum liner screw cap. The dust samples were stored at -20°C until analysis. Sodium sulphate was placed in the same types of bottles and stored together with processed dust samples to serve as a combined storage and analytical method blank.

Extraction: Dust extractions were performed by weighing approximately 0.2g dust, mixing with an equal amount of anhydrous sodium sulfate (Na_2SO_4) and soxhlet extracting with dichloromethane (DCM) for 24 hours. Recovery tests were performed by spiking 17µg of 4:2, 6:2, 8:2 and 10:2 FTOH standards into approximately 0.5g sodium sulfate and treating as a dust sample.

Analysis: FTOHs were analyzed by gas-chromatography mass spectrometry (GC-MS) using a Hewlett-Packard 6890 GC-5973 mass selective detector MSD in positive chemical ionization mode (PCI) employing selective ion monitoring (SIM). Gas chromatographic separation was performed on a 30m DBwax column (0.25 mm id, 250 µm film thickness, J&W Scientific) using helium as carrier gas. The GC oven temperature was 60°C, 0.75min, 3°C min⁻¹ to 110°C, and then 20°C min⁻¹ to 240°C. Splitless injections were 1mL with split opened after 0.75min and the injector at 200°C. The ion source and quadrupole were kept at 250°C and 150°C respectively. Confirmation analysis was performed on a DB5 60m column using same conditions indicated above. The ions monitored and instrumental detection limits (calculated as 3 times the noise) are given in Table 1.

Results and Discussion

Quality assurance /Quality control

Recoveries were greater than 90% for 6:2, 8:2 and 10:2 FTOHs, while recoveries for 4:2 were ~20% Table 1. The low recovery for 4:2 FTOH is probably due to volatilization losses during the blowdown process. FTOHs were detected in sodium sulfate used as storage and analytical procedure blanks (n= 5) at mean concentrations of 1.1 (1.0), 1.2 (0.9) and 0.8 (0.6)ng g⁻¹ for 6:2, 8:2 and 10:2 FTOHs respectively. No recovery or blank correction was applied to the dust data.

Table 1. Analytical details for FTOH**Compounds Molecular Formula Ion IDL, ng % Recovery**

4:2 FTOH C₄F₉C₂H₄OH 265,227 - 17.3

6:2 FTOH C₆F₁₃C₂H₄OH 365,327 0.7 91.1

8:2 FTOH C₈F₁₇C₂H₄OH 465,427 0.4 95.8

10:2 FTOH C₁₀F₂₁C₂H₄OH 565,566,527 0.5 111

IDL instrumental detection limit, 3 times noise level.

FTOHs (6:2, 8:2 and 10:2) were detected in all dust samples, with mean concentrations (geometric mean) of 33ng g⁻¹, 55ng g⁻¹ and 35ng g⁻¹ respectively. Results of 4:2 FTOH were not included due to poor recoveries. The highest concentrations for 6:2, 8:2 and 10:2 FTOH were observed in the same samples which were about 18 times greater than average concentrations. Correlation tests resolved that 6:2, 8:2 and 10:2 FTOH were well correlated (p<0.0001). The distribution histogram of FTOH compounds in dust samples is shown in Figure 1. Other fluorinated compounds were also detected in this dust survey^{7,8}. Concentrations for MeFOSE and EtFOSE (geometric mean) were 113ng g⁻¹ and 138ng g⁻¹ respectively. This analysis was performed on DB5 60m column using electron impact ionization mode⁷. PFAS were re-analysed in the current study along with FTOH according to the method described, confirming the previous data. No significant correlations were obtained for FTOH compounds against MeFOSE or EtFOSE (p>0.7). PFOA, PFOS and perfluorohexane sulfonate PFHxS were also determined in these dust samples with geometric mean of 18ng g⁻¹, 59ng g⁻¹ and 46ng g⁻¹ respectively⁸. The concentrations range, arithmetic and geometric mean values of different fluorinated compounds are presented in Table2. Figure 2 shows the percentage distribution of median concentrations for fluorinated compounds in house dust. To our knowledge, these are the first measurements for FTOH and PFAS in house dust. PFOS and PFOA in dust collected from Japanese homes ranged from 11-2500 ng g⁻¹ and 69- 3700 ng g⁻¹ respectively⁹.

Table 2: Concentrations of Fluorinated compounds in house dust samples

Conc. ng g ⁻¹	6:2	8:2	10:2	MeFOSE ¹	EtFOSE ¹	PFOS ²	PFOA ²	PFHxS ²
Minimum	2	3	2	3	1	BDL	BDL	BDL
Maximum	2500	16315	8176	8860	75440	5063	1234	4305
Arithmetic Mean	156	410	233	412	2200	443	106	391
Geometric Mean	33	55	35	113	138	59	18	46

¹ ref. 7

² ref. 8

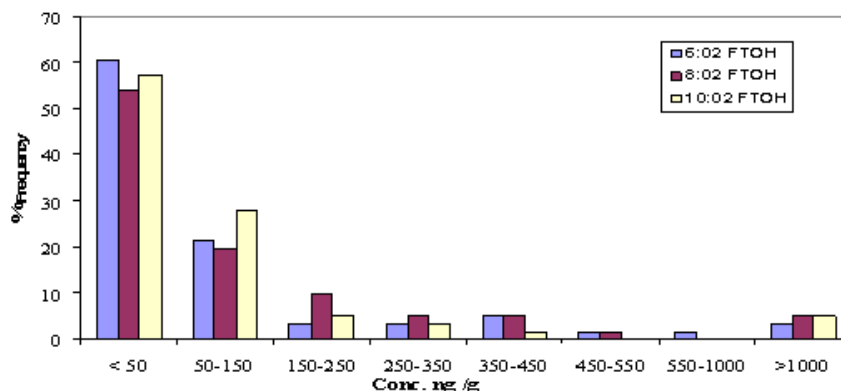


Figure 1. Distribution histogram of 6:2, 8:2 and 10:2 FTOH in dust samples.

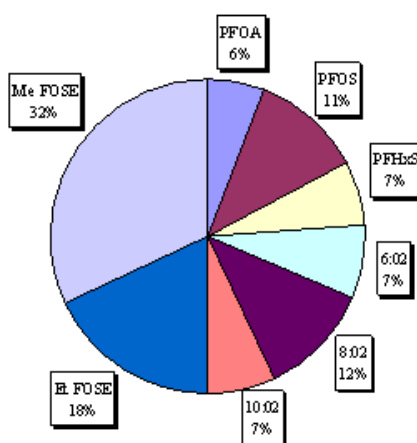


Figure 2. Percentage distribution of fluorinated compounds in dust samples.

Human exposure

PFOS and PFOA have been detected in human sera from around the world. It is not known whether this uptake takes place directly (i.e. PFOS and PFOA) or through the uptake and the biotransformation of other fluorinated compounds as FTOH and PFAS. Based on median dust concentration and infant ingestion rate of 200mg day^{-1} ⁶, exposure values were estimated to be 4.9, 8.0 and 4.6 ng day^{-1} for 6:2, 8:2 and 10:2 FTOH respectively.

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