PERFLUOROALKYL CONTAMINANTS IN INDOOR WINDOW FILM BEFORE AND AFTER A CARPET INSTALLATION

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Abstract
Although perfluoroalkyl contaminants (PFCs) have been detected throughout the world, confusion still exists regarding their routes of exposure to humans. The purpose of this study was first, to determine if window film could be used to monitor PFCs, and second to evaluate if carpet was a source of PFCs to the film. The window film in a room where carpet was installed was sampled on a window just before and a window two months after carpet installation. The film was sampled by washing the windows with precleaned laboratory kimwipes using methanol. Two windows in a nearby reference room where carpet was not installed were also sampled on the two sampling dates. Field blank samples were also taken. PFCs were detected in all of the film samples but in none of the field blanks. PFOA was the dominant PFC in all window film samples, followed by PFOS and PFDS. Total PFC concentrations in the carpeted room prior to carpet installation was 5.62 pg/cm^2 window and increased 2.4-fold to 13.4 pg/cm^2 two months after carpet installation. Total PFC concentrations in the reference room at both sampling dates were similar and low (3.85 and 3.32 pg/cm^2 window) compared to the carpeted room.

Introduction
Perfluoroalkyl contaminants (PFCs) have been detected in areas throughout the globe, ranging from the arctic to indoor air and human blood.[1-3] Indoor air concentrations were recently shown to have much higher concentrations of several PFCs compared to outdoor air.[2] Since humans spend much of their time indoors, we likely receive most of our PFC exposure in the indoor environment. However, confusion still exists on specific exposure routes to humans.

Fluorinated polymers and surfactants have been used since the 1950s as stain-resistant coatings for carpets. In 73 randomly selected homes in Ottawa, Canada, PFCs in house dust were significantly and positively correlated with the percentage of carpeting found in the house.[4] Shoeib et al.[2] found elevated concentrations of PFCs in a laboratory in which several floors were carpeted and new carpet was continually installed during renovations. Dinglasan-Panlilio and Mabury[5] quantified unbound fluorinated telomere alcohols (FTOHs) in two different brands of carpet protectors suggesting that outgassing of these chemicals after carpet treatment could be a source of PFCs to the environment. These studies strongly suggest that carpet is a source of PFCs to the environment and as such, the extent of environmental contamination due to carpet installation merits further study.

Window film has been previously identified as an effective sampler of air concentrations of a variety of contaminants such as polychlorinated biphenyls and polybrominated diphenyl ethers.[6,7] Window film has been shown to be easy to collect and analyze and can be used as a time-integrated sampler of contaminant concentrations in air.[6] However, prior to this study the use of window film to measure PFCs had not been assessed.

The first objective of this study was to determine if window film could be used to monitor PFCs. The second objective was to determine if a carpet installation was a source of PFCs to window film by evaluating the difference between PFC indoor window film concentrations before and after a carpet installation.

Materials and Methods
The window film in a room where carpet was installed was sampled on a window just before and a window two months after a carpet installation. Two windows in a nearby reference room where carpet was not installed were also sampled on the two sampling dates (i.e. a different window was sampled on each sampling date). The film was sampled by washing the windows with precleaned laboratory kimwipes using methanol as a solvent. Before and after window sampling, the kimwipes were stored in 15 mL plastic centrifuge tubes (polypropylene copolymer).

Each window sampled had an area of approximately 0.7 m^2. Field blank samples were taken by waving precleaned laboratory kimwipes in the air for 2 minutes at both sampling dates.

The samples were extracted with a modification of the Hansen et al. ion pairing method.[8] Briefly, extraction of the kimwipe samples or field blanks were performed in the 15 mL centrifuge tubes. The samples were spiked with a $^{14}C_4$-PFOA control standard. HPLC water, Na_2CO_3, TBAS (ion-paring agent), and MTBE were then added to the tubes. The tubes were then shaken vigorously for 5 minutes and centrifuged to separate the supernatant (MTBE). The extraction process was repeated 3 times. The solvents were then evaporated and rewetted with methanol. The samples were then analyzed by liquid chromatography tandem quadrupole mass spectrometry (HPLC-MS/MS).[9] The following PFCs were quantified: perfluorohexane sulfonate (PFHxS), perfluorooctane sulfonate (PFOS), perfluorodecane sulfonate (PFDS), perfluorooctane sulfonamide (PFOSA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid (PFDoA), perfluorotetradecanoic acid (PFTeA), 6:2-fluorotelomer unsaturated carboxylic acid (6:2-FTUCA), 8:2-fluorotelomer unsaturated carboxylic acid (8:2-FTUCA), and 10:2-fluorotelomer unsaturated carboxylic acid (10:2-FTUCA).

Results and Discussion

Figure 1 shows total PFC concentrations, i.e. the sum of all PFCs analyzed, in the window film samples and blanks. No PFCs were detected in any of the field or analytical method blank samples. In contrast, PFCs were found in all of the film samples. The percent recovery of $^{14}C_4$-PFOA ranged from 85 to 106%. These results suggest that window film can be used to monitor PFC compounds.

Total PFC concentration in the carpeted room prior to carpet installation was 5.62 pg/cm^2 window and increased 2.4-fold to 13.4 pg/cm^2 two months after carpet installation (Figure 1). Total PFC concentrations in the reference room at both sampling dates were similar and low (3.85 and 3.32 pg/cm^2 window), compared to the carpeted room.

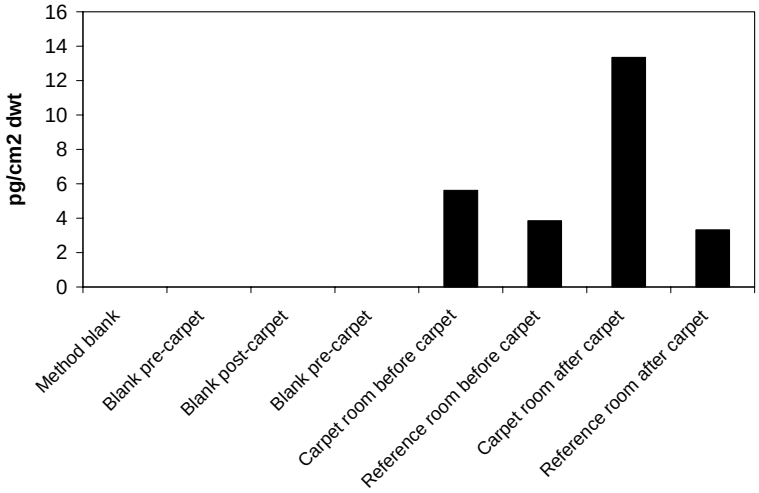

Figure 1: Total PFC concentrations (pg/cm^2) in window film.

PFOA was the dominant PFC in all window film samples, followed by PFOS, PFDS, and PFTeA (Figure 2). All PFC compounds analyzed except for PFHxS, 6:2-FTUCA, 8:2-FTUCA, and 10:2-FTUCA were detected in the film (Figure 2).

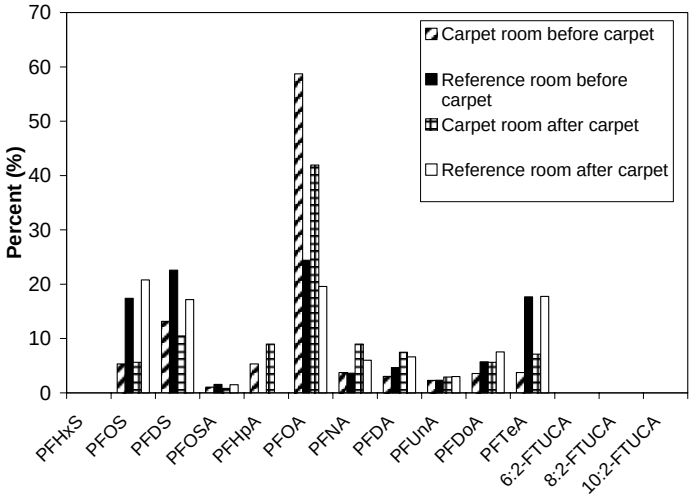

Figure 2: Percent contribution of each PFC analyzed to the sum of all of the PFCs analyzed.

Carpet installation caused little difference in the congener pattern in the reference room (Figure 2) and the ratio of PFC concentrations after to before carpet installation ranged 0.7 to 1.4 in this room (Figure 3). In contrast, in the carpeted room, the extent of increase after carpet installation varied widely between the PFC compounds, with concentrations increasing up to 6-fold for PFNA and PFDA (Figure 3). Whether this variation in the extent of increase among PFC compounds was due to the PFC pattern in the carpet or differences in their partitioning behavior is currently being determined.

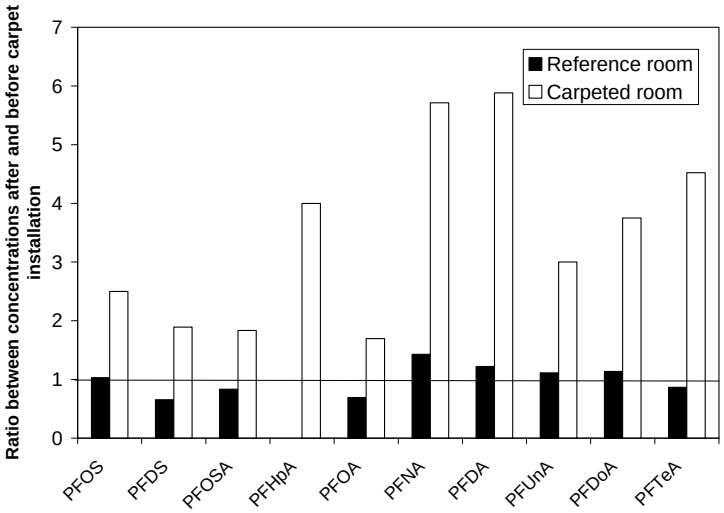

Figure 3: Ratio of PFC concentrations after to before carpet installation in the reference and carpeted rooms

Further studies are underway to evaluate if carpet installation results in a similar increase in window film concentrations at other sites using different carpet brands.

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