Measurement of PFAS Released from Thermally Stressed Carpet and Upholstery Textiles

Dr. Brittany Stinger, Dr. Rick Davis
National Institute of Standards and Technology, Gaithersburg, MD

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Introduction

Purpose: Measurement of per- and polyfluoroalkyl substances (PFAS) gaseous emissions and soot from carpet and upholstery furniture textiles exposed to elevated temperatures.

Motivation: PFAS are widely used in household products to impart water repellency and stain resistance. While previous studies have quantified PFAS in indoor air using thermal desorption (TD) tubes and other methods, and analyzed PFAS accumulation in carpet dust, little is known about the release of PFAS when subjected to high temperatures, such as during a fire. We **hypothesize** thermal degradation at elevated temperatures could lead to the increased breakdown and volatilization of PFAS, thereby increasing airborne PFAS.

Study: Textiles were heated between 25 °C and 600 °C in a controlled tube furnace environment. Emissions collected on TD tubes and soot were analyzed for 55 targeted PFAS (volatile, semivolatile, and nonvolatile) using liquid chromatography/mass spectroscopy/mass spectroscopy (LC-MS/MS) and gas chromatography/mass spectroscopy (GC-MS). Preliminary findings on PFAS release profiles under varying thermal conditions will be presented.

Methodology

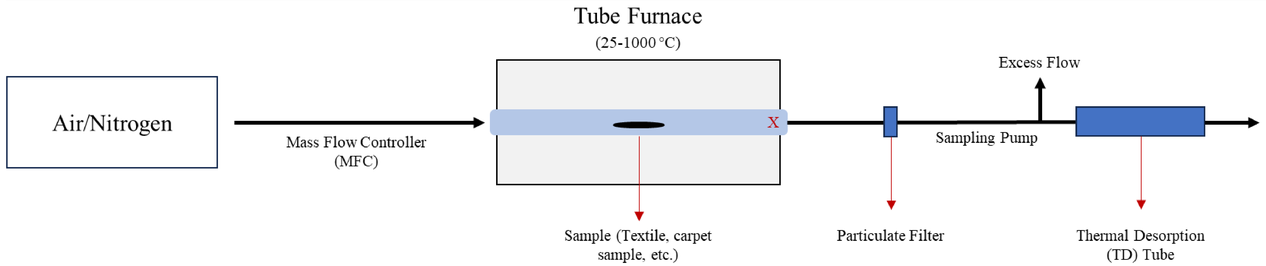

Figure 1. Diagram of tube furnace setup. The sample is placed in the center of the tube furnace in a quartz tube and heated to fixed temperatures. Black arrows indicate the direction of air flow. PFAS emissions are collected in the form of wipes at the end of the quartz tube (at the red X), soot on the particulate filter, and on the TD tube.

Preliminary Fabrics for Method Development

- Two fabrics were selected for method development based on the PFAS concentration previously found in firefighter gear textiles.[1,2,3]
- Outer shell textile with the fluoropolymer "Scoured" off (OS-FSC) was selected for the low concentration of targeted PFAS measured by both LC-MS/MS and GC-MS.[1]
- Outer shell textile (OS-C) was selected for the high concentrations of targeted PFAS measured by both LC-MS/MS and GC-MS.

Novel Methods

- Develop liquid extraction method for soot and methanol wipes collected from quartz tube.
- Method development for PFAS thermal desorption tube collection and analysis with TD-GCMS.

Analysis

- Targeted Analysis of liquid extracts on LC-MS/MS and GC-MS comprising a total of 55 PFAS Targeted Analytes with parameters previously reported in NIST TN 2313.[3]
- Non-targeted analysis of extracts on LC-Orbitrap-MS

References

(1) Maizel, A.; Thompson, A.; Tighe, M.; Escobar Veras, S.; Rodowa, A.; Falkenstein-Smith, R.; Benner Jr, B. A.; Hoffman, K.; Donnelly, M. K.; Hernandez, O.; Wetzler, N.; Ngu, T.; Reiner, J.; Place, B.; Kucklick, J.; Rimmer, K.; Davis, R. D. *Per- and Polyfluoroalkyl Substances in New Firefighter Turnout Gear Textiles*; National Institute of Standards and Technology: Gaithersburg, MD, 2023. https://doi.org/10.6028/nist.tn.2248.

(2) Maizel, A.; Thompson, A.; Tighe, M.; Escobar Veras, S.; Rodowa, A. E.; Falkenstein-Smith, R.; Benner, B.; Hoffman, K.; Donnelly, M.; Hernandez, O.; Wetzler, N.; Ngu, T.; Reiner, J.; Place, B.; Kucklick, J.; Rimmer, C.; Davis, R. D. *Per- and Polyfluoroalkyl Substances in Firefighter Turnout Gear Textiles Exposed to Abrasion, Elevated Temperature, Laundering, or Weathering*; National Institute of Standards and Technology: Gaithersburg, MD, 2024. https://doi.org/10.6028/nist.tn.2260.

(3) Thompson, A. L.; Maizel, A.; Tighe, M.; Escobar Veras, S.; Rodowa, A.; Benner, B.; Tombaugh, A.; Reiner, J.; Donnelly, M.; Falkenstein-Smith, R.; Kucklick, J.; Rimmer, C.; Davis, R. *Per- and Polyfluoroalkyl Substances in Textiles Present in Firefighter Gloves, Hoods, and Wildland Gear*; National Institute of Standards and Technology: Gaithersburg, MD, 2024. https://doi.org/10.6028/nist.tn.2313.

Preliminary Results and Development

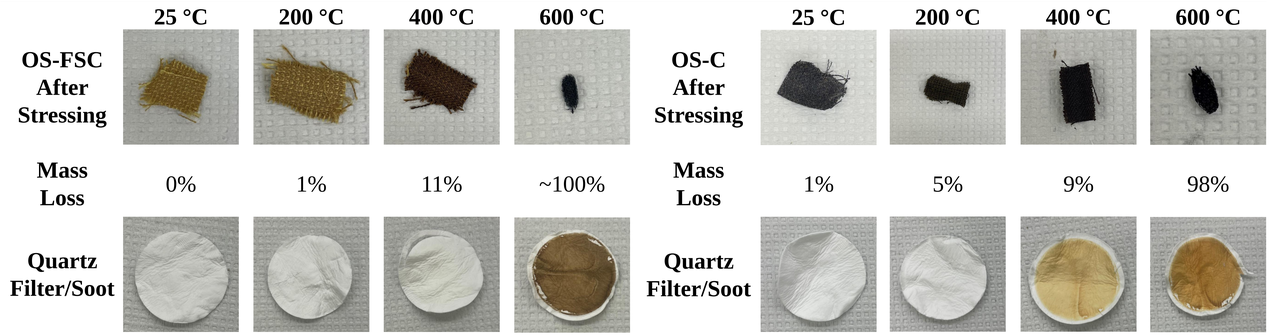

Figure 2. OS-FSC and soot on quartz filters after thermal stressing in the tube furnace. Mass loss of OS-FSC after stressing is shown.

Figure 3. OS-C and soot on quartz filters after thermal stressing in the tube furnace. Mass loss of OS-C after stressing is shown.

General Observations From Thermal Stressing

- OS-FSC and OS-C stressed at 600 °C result in the complete combustion and of the fabric (see pictures above).

Development Outcomes

- Liquid extraction method for soot is currently underway with a focus on measuring the PFAS recovery in different solvents.
- Modification of TD tube sample collection is necessary to prevent overloading the TD tubes with 6:2 FTOH and 6:2 FTMAC.

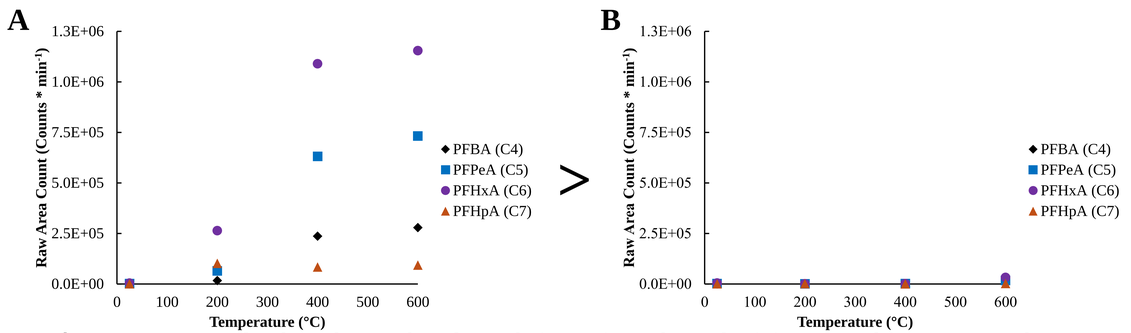

Figure 4. Raw area counts for short chain carboxylic acids (C4-C7) are shown for (A) OS-C and (B) OS-FSC. The area counts are notably higher from OS-C compared to OS-FSC. Note, these area counts are from a sample size of N=1.

Preliminary Results

- PFAS concentration: OS-C quartz filters/soot > OS-FSC quartz filters/soot (see figure 4 above).
- In general, increasing thermal stressing temperature yields higher shorter chain PFAS concentrations in quartz filters/soot (see figure 4 above)
- 6:2 FTOH and 6:2 FTMAC observed in quartz filters/soot.

Disclaimer: Results presented in this poster are preliminary and subject to change.

Next Steps

Methodology

- Continue updating sampling methodology specifically for volatile PFAS analysis on GC-MS.
- Repeat experiments in triplicate and confirm extraction methods including matrix spike recoveries.

Analysis

- Expand analytical PFAS targets to include less commonly quantified analytes.