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THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2019

PFAS in indoor air

Methods for measuring concentrations in air and understanding emissions from materials

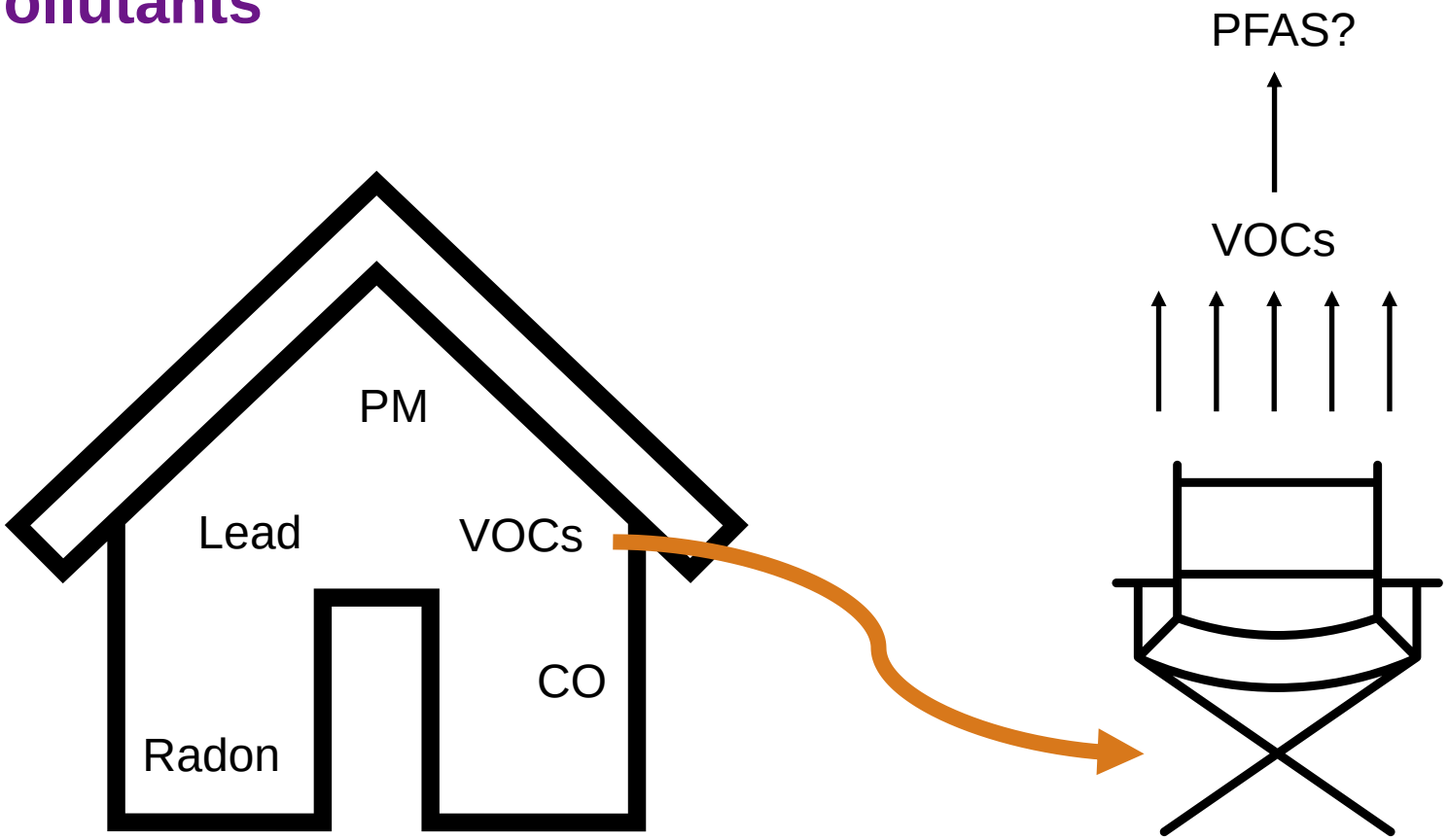
Contents

- Introduction to indoor air quality (IAQ) monitoring and material emission testing
- Monitoring methods
  - How TD-GC-MS is used
- TD-GC-MS/MS performance for PFAS monitoring
- Workplace air
- Materials testing

Indoor air monitoring

- Unregulated
- Average person spends 80 – 90% of their time indoors
- Sources of indoor pollutants are regulated
  - Emissions testing

Pollutants



Methods for monitoring VOCs

1 Particulate sampling

A Direct desorption of filters

2 Gas phase sampling

A Pumped sampling onto sorbent tubes

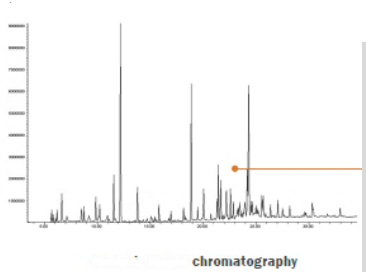
B Passive sampling onto sorbent tubes

C Canisters and bags

D On-line monitoring

3 Material sampling

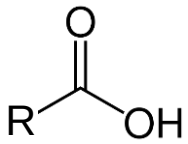
A Chamber emission testing



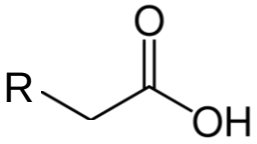
chromatography

The main sampling approaches used to monitoring VOCs and SVOCs in air from the environment are all compatible with TD

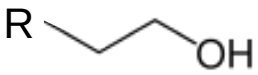
Target compounds



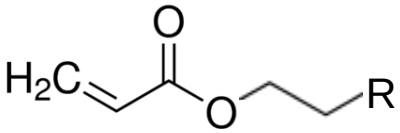
PFCAs
bpt: 65-270 ºC



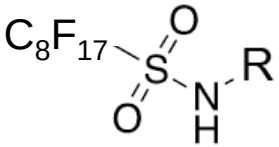
FTCAs
bpt: 78-300 ºC



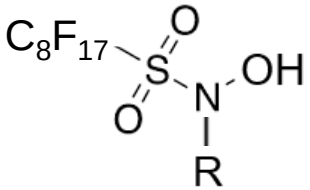
FTOHs
bpt: 140-187 ºC



FTAcs
bpt: 78-300 ºC



FOSAs
bpt: 150-270 ºC



FOSEs
bpt: 150 ºC

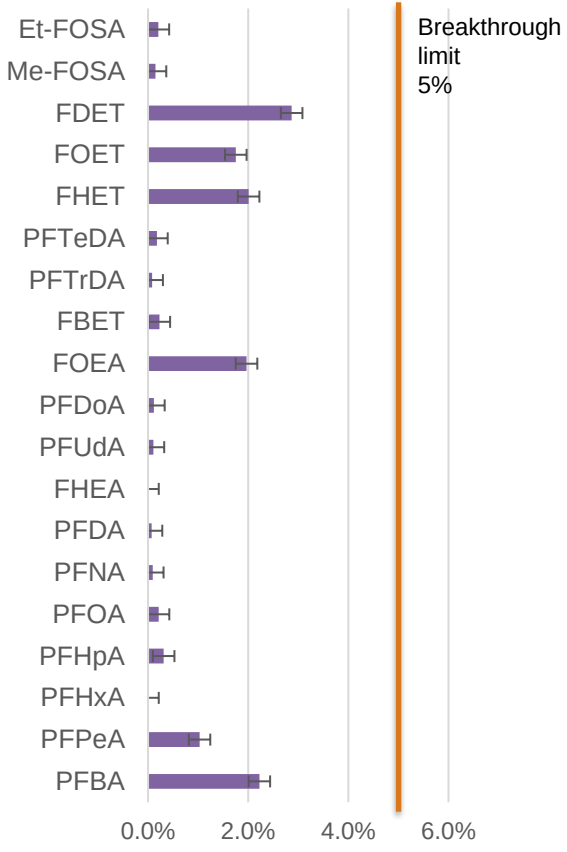
PFAS Class	Analyte
Perfluoroalkylcarboxylic acids (PFCA)	PFBA
	PFPeA
	PFHxA
	PFHpA
	PFOA
	PFNA
	PFDA
	PFUdA
	PFDoA
	PFTrDA
	PFTeDA
Fluorotelomer acids (FTCA)	6:2 FTCA (FHEA)
	8:2 FTCA (FOEA)
Fluorotelomer alcohols (FTOH)	4:2 FTOH (FBET)
	6:2 FTOH (FHET)
	8:2 FTOH (FOET)
	10:2 FTOH (FDET)
Fluorotelomer acrylates (FTAc)	8:2 FTAcr
Perfluorooctanesulfonamides (FOSA)	Me-FOSA
	Et-FOSA
Perfluorooctanesulfonamidoethanols (FOSE)	Me-FOSE

Sorbent selection

Ideal detection limit 1 – 50pg

- PFAS tubes connected in series
- Spiked with the target analytes
- Challenged with a volume of 500L N2

- Across 5 replicates breakthrough was not seen at 500L
- Sorbent tubes are the optimum sampling method



Analytical method

Sample introduction: TD100-xr

- Sorbent tubes: PFAS extended volume tubes
- Focusing trap: PFAS focusing trap
- Internal standard: Toluene D8

Analysis: TSQ™ 9610

- GC: Trace™1610
- Column: TG-200ms 30m x 0.25mm x 1.0 mm
- Detector: XRXL™
- Ion Source: NeverVent™AEI

Samples

Varied use workplace

- Office
- Laboratory
- Corridor
- Storage area




20 L sample

Materials

- Childs waterproof coat

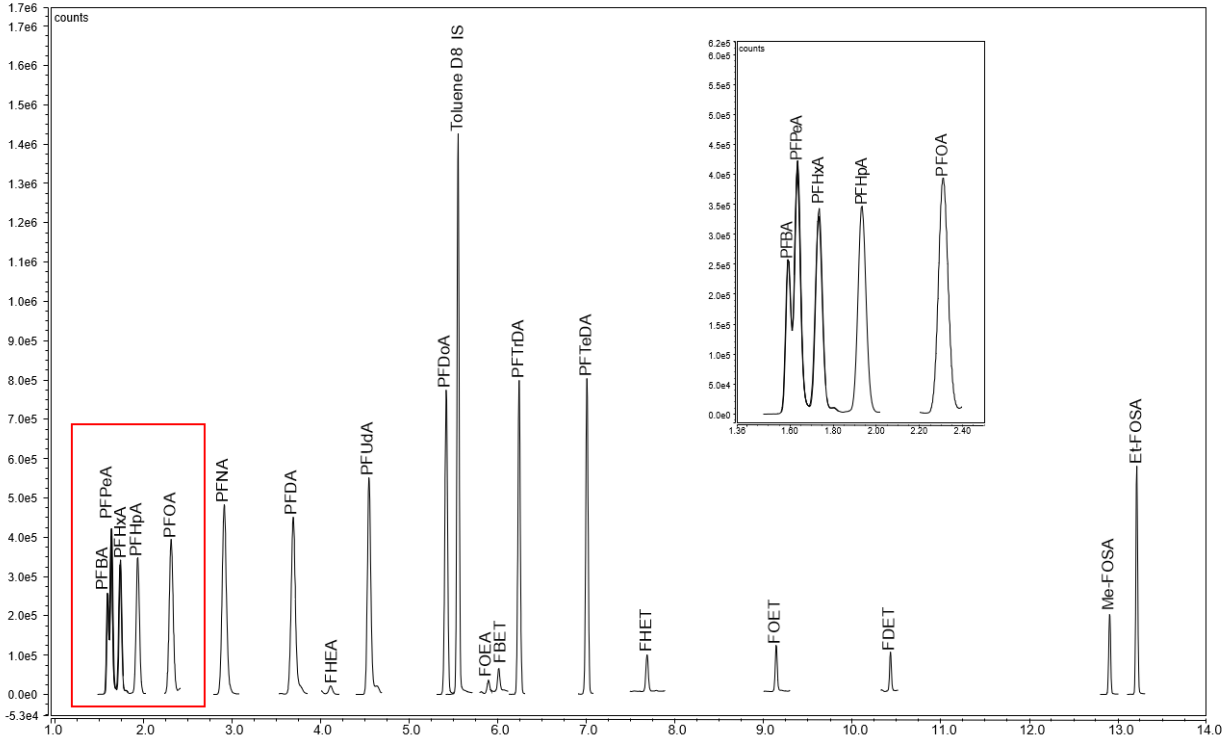
3 L sample

Weight 0.7 g

Chromatography

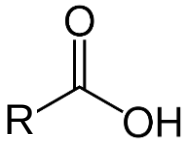
PFAS standard, 500 pg on tube. 200MS column, 35 °C starting oven.

- Sharp peaks
- Good resolution
- Compounds still stable on column after 500+ injections

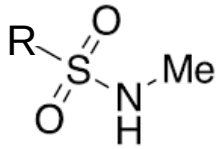


Method performance

Great linearity and repeatability, excellent Method Detection Limits (MDLs)



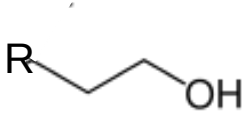
PFCAs
Average MDL = 4pg



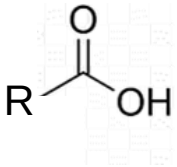
FOSAs
Average MDL = 1pg

Average MDL for a 20L sample:

~780 pg/m^3



FTOHs
Average MDL = 8 pg



FTCAs
Average MDL = 48 pg

- All compounds spiked at below the lowest calibration point to “challenge” the system

PFAS background

SIM: 131 m/z (shared PFAS ion)

TIC: 35-650 m/z blank

Taking the indoor air samples

Active (pumped) sampling

- Flow rate: 100mL/min
- Sampling time: 200 minutes (3hrs 20)
- Total volume: 20L

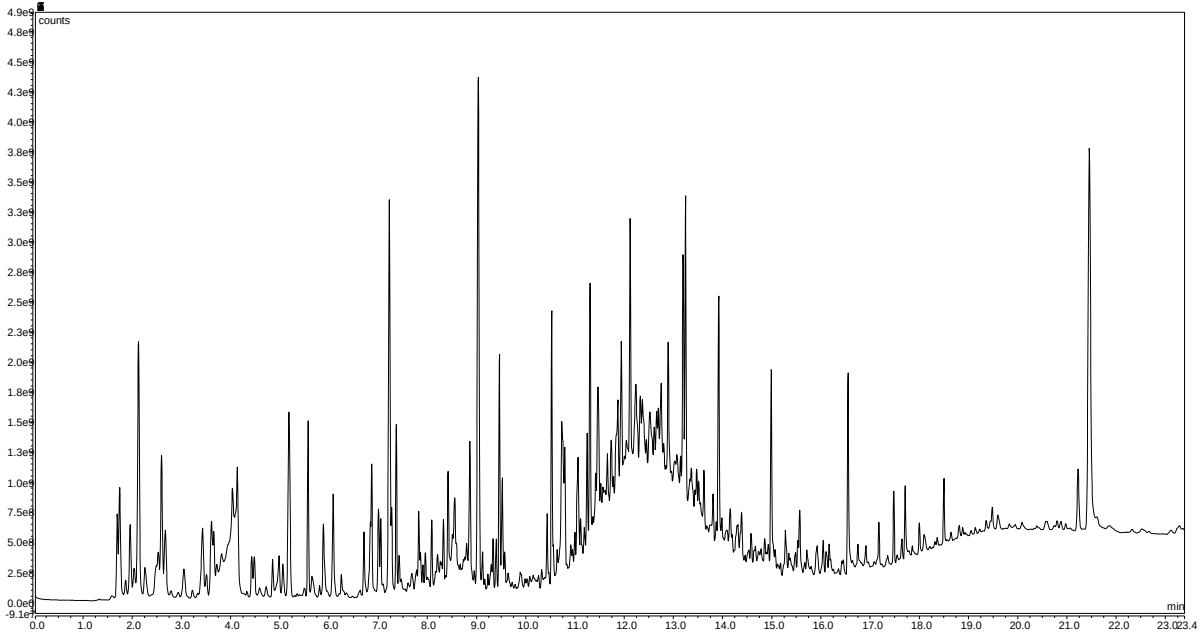
- Sampling pump: ActiVOC Plus
- Mode: Constant flow

Why we used a Triple quad

Workplace air

- Full scan analysis shows high sample complexity
- High indoor exposure from reduced air circulation and outgassing from surroundings
- Compounds in the background are also present at high concentrations (x10^9)

Full scan analysis of indoor air sample, 20L



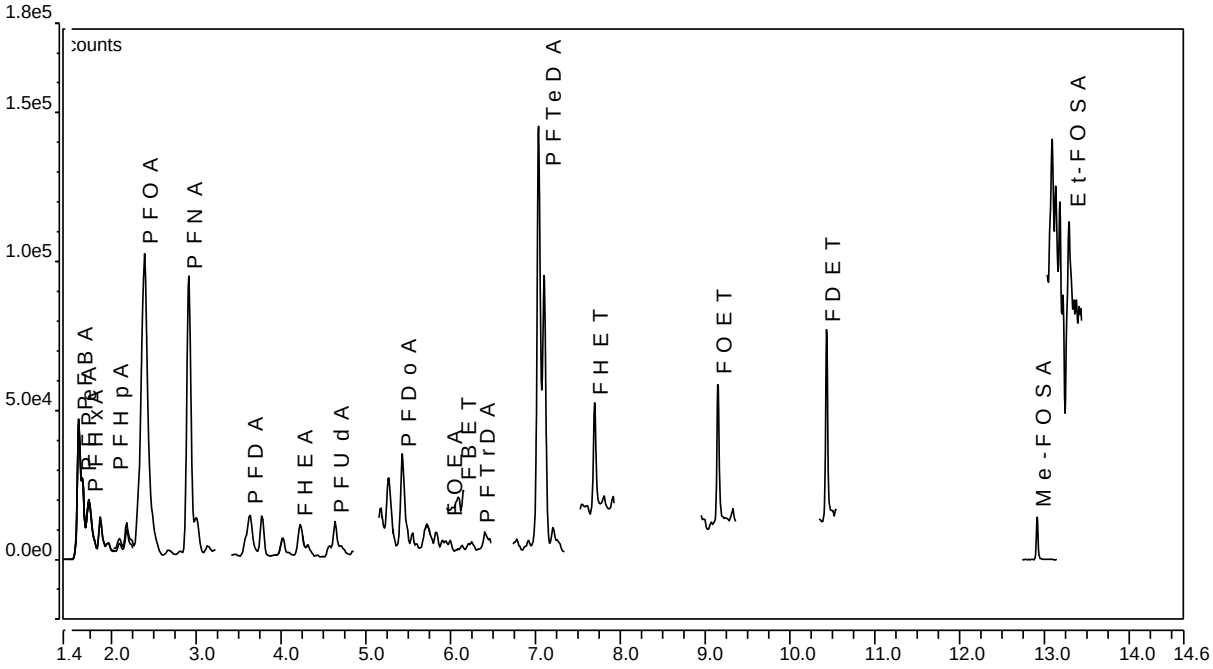
Why we used a Triple quad

Workplace air

- Using SRM for detection means the background is removed and targets can easily be quantified

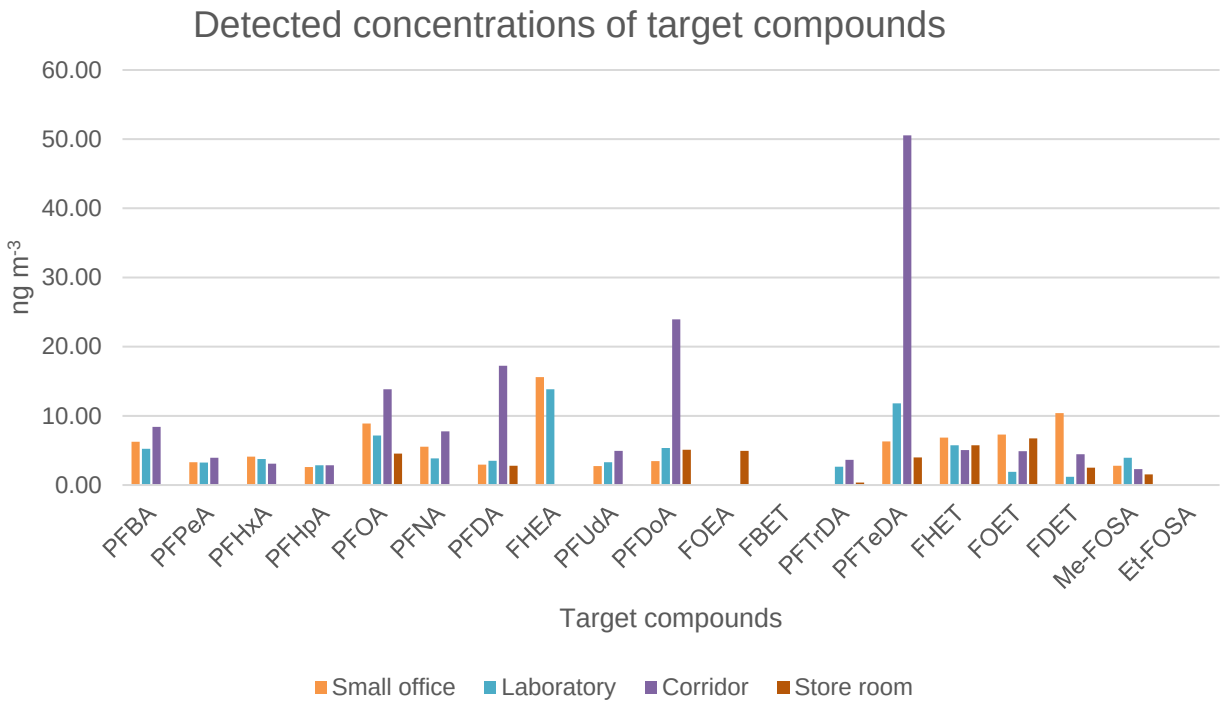
- Target PFAS species were at significantly lower levels in the sample
  - 10^5 for the PFAS species vs 10^9 for the background

SRM analysis of indoor air sample, 20L



Workplace air

Comparison of environments



Total PFAS

Office
89 ng m^{-3}

Lab
79 ng m^{-3}

Corridor
157 ng m^{-3}

Store
38 ng m^{-3}

Testing materials

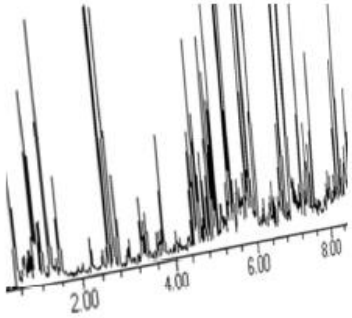
Micro-chamber/Thermal Extractor workflow

1 Load the material

2 Set the conditions

3 Collect the volatiles

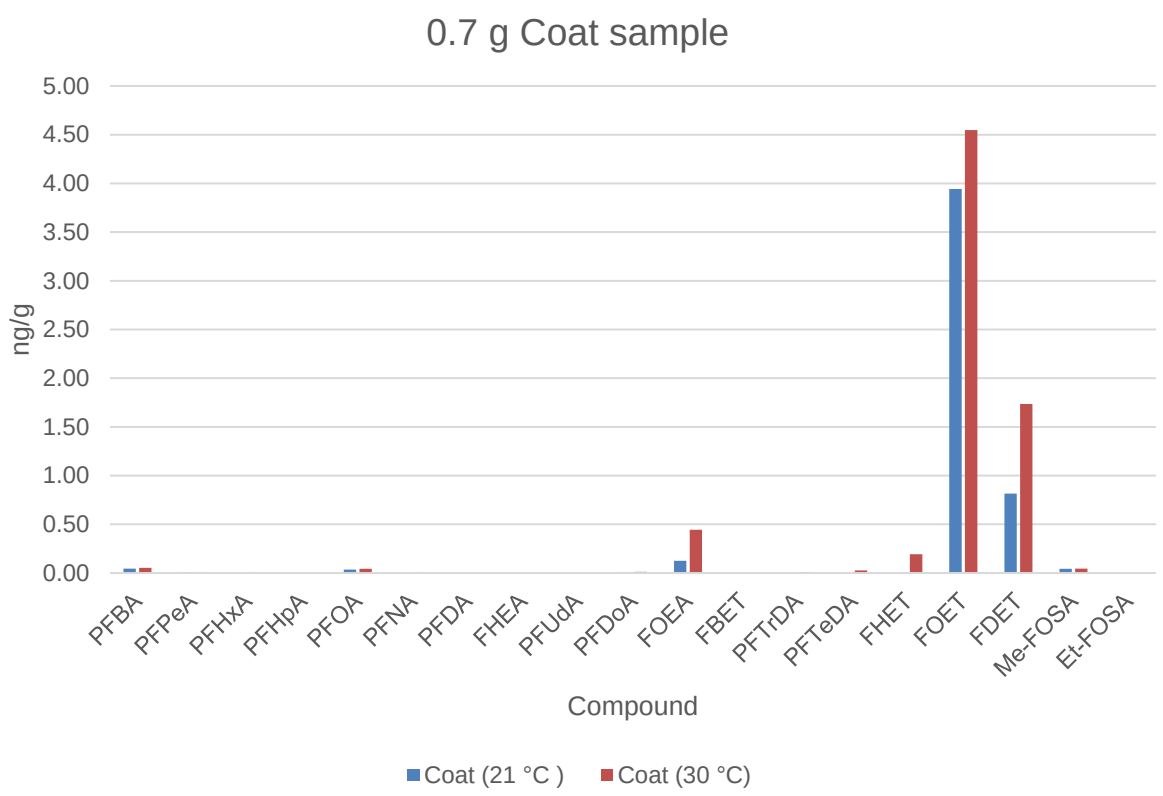
4 Analyse the sample



- Flow rate: 50 mL/min
- Sampling time: 60 minutes
- Total volume: 3L

- Temperatures: ambient (21 °C)
  30 °C

New coat smell



Total PFAS
(ng g^{-1})

21 ° C
5 ng g^{-1}

30 ° C
7 ng g^{-1}

Emission rates
(ng g^{-1} min^{-1})

21 ° C
0.084 ng g^{-1} min^{-1}

30 ° C
0.119 ng g^{-1} min^{-1}

Summary

- Techniques already used for monitoring VOCs in indoor air and their emissions from materials can also be applied to target PFAS

- Unclear what testing will look like for materials but indoor air standard methods for assessing vapour intrusion are in development.

- There is a significant amount of PFAS present in indoor environments and materials

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