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Application News

Analysis of PFAS in Textiles Based on EN 17681-1 and EN 17681-2

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User Benefits

- Combining LCMS and GCMS enables the determination of PFAS below threshold limits in textiles.
- Spike recovery test shows good percentage recoveries of all compounds (70–130 %) that are at or below the EU POPs threshold limit (25 ppb).
- LabSolutions™ software offers integrated control over GCMS and LCMS for more efficient testing and data analysis.

■ Introduction

Per- and polyfluoroalkyl substances (PFAS) are used in a wide range of applications because of their useful properties, such as heat resistance and water repellency. However, PFAS are also extremely stable substances that resist degradation and accumulate in the environment, which has led to concerns about their effects on humans. Since eliminating sources of PFAS is essential to prevent them from accumulating in the environment and in living organisms, many countries are passing laws that restrict the production, distribution, and use of PFAS in products. For example, the EU POPs Regulation sets a permitted threshold of up to 0.025 mg/kg (25 ppb) for certain PFAS (including PFOA, PFOS, and PFHxS) in substances, mixtures, and products[1].

EN 17681 is a European standard that describes methods for determining PFAS in textiles. The EN 17681 standard is divided into two parts according to the target compounds and methods. EN 17681-1 describes an LC/MS/MS method that targets ionic PFAS, and EN 17681-2 describes a GC/MS(/MS) method that targets certain semi-volatile and volatile neutral PFAS. A 2025 revision of EN 17681-1 changed the sample preparation method for more efficient PFAS extraction[2),3)].

This Application News describes the analysis of the target compounds shown in Table 1 based on the EN 17681-1 and EN 17681-2 standards, using both LC/MS/MS and GC/MS/MS.

Fig. 1 LCMS-8050RX (Left) and GCMS-TQ™8050 NX (Right)

■ EN 17681-1 and EN 17681-2

EN 17681 is a series of standards, developed by the European Committee for Standardization (CEN), that define methods for the determination of PFAS in textile products.

- In April of 2025, EN 17681-1:2025 replaced the previous pure methanol extraction with an extraction step that includes alkaline hydrolysis. This update enables the degradation of side-chain fluorinated polymers during extraction. As a result, more sensitive detection of specific PFAS, particularly fluorotelomer alcohols (FTOHs), is achieved compared with the previous method. The EN 17681-1:2025 method uses LC/MS/MS and can assess textile samples for levels of mostly ionic PFAS.
- EN 17681-2 prescribes a GC/MS(/MS) method for determining certain semi-volatile and volatile neutral PFAS. Since these compounds are not readily analyzed by LC/MS/MS, GC/MS/MS provides a more suitable and sensitive analytical approach. EN 17681-2 targets many compounds used in textile treatments that confer water repellency and stain resistance, including certain volatile PFAS and fluoroalkyl ether compounds.

Table 1 EN 17681-1 and EN 17681-2 Analytes

#	Compounds	Targeted by EN 17681-1 (LC/MS/MS)	Targeted by EN 17681-2 (GC/MS(/MS))
1	PFBA	✓	
2	PFPeA	✓	
3	PFHxA	✓	
4	PFHpA	✓	
5	PFOA	✓	
6	PFNA	✓	
7	PFDA	✓	
8	PFUnA	✓	
9	PFDoA	✓	
10	PFTrDA	✓	
11	PFTeDA	✓	
12	PFBS	✓	
13	PFHxS	✓	
14	PFHpS	✓	
15	PFOS	✓	
16	PFDS	✓	
17	4:2FTS	✓	
18	6:2FTSA	✓	
19	8:2FTSA	✓	
20	10:2 FTS	✓	
21	FOSA	✓	
22	NMeFOSA	✓	
23	NEtFOSA	✓	
24	NMeFOSE	✓	✓
25	NEtFOSE	✓	✓
26	HFPO-DA	✓	
27	PF-3,7-DMOA	✓	
28	4HPFUnA	✓	
29	7HPFHpA	✓	
30	4:2FTOH	✓	*1
31	6:2FTOH	✓	*1
32	8:2FTOH	✓	*1
33	10:2FTOH	✓	*1
34	Me-PFOA		✓
35	Et-PFOA		✓*2
36	6:2 FTA		✓
37	8:2 FTA		✓
38	10:2 FTA		✓
39	6:2 FTMA		✓
40	8:2 FTMA		✓
41	MPFOA	IS	
42	MPFOS	IS	
43	PFDodiAOMe*3		Surrogate

*1: Not targeted by EN 17681-2 but measured by GC/MS/MS

*2: Because Et-PFOA converts to Me-PFOA in methanol, an Et-PFOA calibration curve was not prepared, and Et-PFOA was not included in the spike recovery .

*3: Dimethylicosafluorododecane-1,10-dioate

■ EN 17681-1 and EN 17681-2 Sample Preparation

The EN 17681-1 sample preparation method is shown in Fig. 2, and the EN 17681-2 method is shown in Fig. 3. Figure 2 also compares the EN 17681-1 procedure before and after the 2025 update. EN 17681-1:2022 uses ultrasonic extraction in pure methanol, whereas the updated EN 17681-1:2025 adds NaOH to employ alkaline hydrolysis in the extraction step. For this analysis, samples were prepared using the updated EN 17681-1:2025 method. Specifically, a 1 g sample was cut into pieces no larger than 0.3–0.5 cm square, NaOH and methanol were added, and then ultrasonic extraction was performed at 60 °C for 1 hour. The resulting extracted solution was made up to 20 mL, the pH was adjusted, and it was filtered. Matrix effects were investigated by LC/MS/MS analysis after adding MPFOA and MPFOS as internal standards (IS). In accordance with the prescribed EN 17681-1 method, no surrogates were used.

The EN 17681-2 sample preparation method is similar to the EN 17681-1 method. Samples were prepared by cutting a 1 g sample into pieces no larger than 0.3–0.5 cm square, adding methanol and a surrogate (PFDodiAOMe), and then performing ultrasonic extraction at 60 °C for 2 hours. The resulting extracted solution was centrifuged, and the supernatant analyzed by GC/MS/MS. EN 17681-2 states that samples can be concentrated by nitrogen purging if necessary, but this step was omitted.

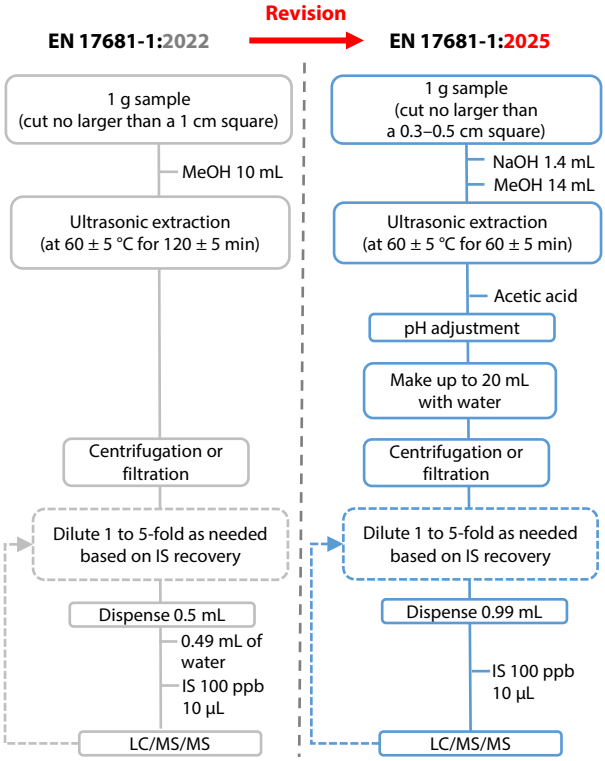

Fig. 2 EN 17681-1 Sample Preparation

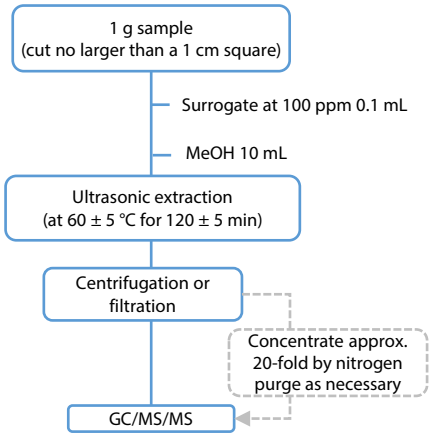

Fig. 3 EN 17681-2 Sample Preparation

■ EN 17681-1 (LC/MS/MS) Analysis Conditions

Analysis was performed using the LCMS-8050RX triple-quadrupole mass spectrometer (Fig. 1, left). The analysis conditions used are shown in Table 3. Analyzing PFAS necessitates caution because PFAS can leach from the analytical system, the mobile phase or other sources. PFAS contamination from the system was minimized by attaching a delay column between the mixer and autosampler. The mobile phase was also prepared using PFAS grade reagents.

Table 3 Nexera and LCMS-8050RX Analysis Conditions

UHPLC (Nexera™-X3 System)	
Analytical Column:	Shim-pack Scepter™ C18-120 (100 mm × 3.0 mm I.D., 1.9 µm, P/N:227-31013-03)
Solvent Delay Column:	Delay column for PFAS (GL Science, P/N: 5020-90005)
Mobile Phase A:	5 mM Ammonium Acetate in reagent water
Mobile Phase B:	5 mM Ammonium Acetate in Acetonitrile
Gradient Program:	B 1 % – 45 % (2.0 - 5.0 min) – 99 % (18.0 - 21.0 min) – 1 % (21.1 - 25.0 min)
Flowrate:	0.30 mL/min (0.0 - 5.0 min) – 0.40 mL/min (18.0 - 21.0 min) – 0.30 mL/min (21.1-25.0 min)
Column Temp.:	40 °C
Injection Volume:	5 µL
Run Time:	25 min
MS (LCMS-8050RX)	
Ionization:	ESI (Negative mode)
Mode:	MRM
Nebulizing Gas:	3 L/min
Drying Gas Flow:	5 L/min
Heating Gas Flow:	10 L/min
DL Temp.:	150 °C
Block Heater Temp.:	250 °C
CID:	250 kPa
Interface Temp.:	200 °C
Interface Voltage:	-1 kV
Probe Position:	+2 mm
m/z:	See Table 5

■ EN 17681-2 (GC/MS(/MS)) Analysis Conditions

Analysis was performed using a GCMS-TQ8050 NX triple-quadrupole mass spectrometer (Fig. 1, right) that was equipped with a boosted efficiency ion source (BEIS). The BEIS optimizes the electron beam focus for maximum ionization efficiency, enabling reliable analysis of PFAS at very low levels. The analysis conditions used are shown in Table 4.

Table 4 GCMS-TQ8050 NX Analysis Conditions

GC (Nexis GC-2030)	
Autosampler:	AOC-30i
Injection Temp.:	250 °C
Injection Mode:	Splitless (high pressure injection at 240 kPa, 1 min)
Carrier Gas:	He
Carrier Gas Control:	Linear velocity (40 cm)
Column:	SH-I-624Sil MS (P/N: 221-75963-60) (60 m × 0.32 mm I.D., 1.8 µm)
Guard Column:	SH-I (P/N: 227-36305-01) (5 m × 0.32 mm)
Column Temp.:	40 °C (3 min) – 25 °C/min – 250 °C – 15 °C/min – 280 °C (5 min)
Injection Volume:	2 µL
MS (GCMS-TQ8050 NX)	
Ion Source:	BEIS
Ion Source Temp.:	200 °C
Interface Temp.:	250 °C
Acquisition Mode:	MRM
m/z:	See Table 5

■ Measurement of Calibration Standards

EN 17681-1 calibration standards were prepared at concentrations between 0.1 and 10 µg/L (10 to 1000 µg/L for FTOH) to construct external standard calibration curves. The left part of Table 5 shows calibration standard measurements obtained by LC/MS/MS, and Fig. 4 shows two example calibration curves (PFOA and PFOS). The coefficient of correlation (R) was greater than 0.998 for all calibration curves, showing good linearity. The repeatability (n = 5) of the lowest calibration curve concentration was also good for most compounds at %RSD below 20. Mean true values (n = 5) remained within 80 to 120 % for every calibration curve concentration. Fig. 5 shows MRM chromatograms for 33 target compounds at 0.1 µg/L (FTOH at 10 µg/L). These MRM chromatograms show good peak profiles even at the lowest calibration concentration.

EN 17681-2 calibration standards were prepared at concentrations between 1 and 100 µg/L to construct internal standard calibration curves. The right part of Table 5 shows EN 17681-2 calibration standard measurements. PFDodiAOMe was used as the internal standard. The four FTOH compounds in the right part of Table 5 are not targeted by the EN 1768-2 method. Typically, they are analyzed more often by GC/MS(/MS) than by LC/MS/MS. For this reason, these four FTOH compounds were also measured by the GC/MS/MS. The coefficient of correlation (R) was greater than 0.998 for all calibration curves, showing good linearity. The repeatability (n = 5) of the lowest calibration curve concentration was also good for all compounds at %RSD below 20. Fig. 5 shows MRM chromatograms for 12 target compounds at 0.1 µg/L. These MRM chromatograms show good peak profiles even at the lowest calibration concentration.

Table 5 Results for Calibration Standards (Left: EN 17681-1 (LC/MS/MS), Right: EX17681-2 (GC/MS/MS))

EN 17681-1					
#	Compound	Quantifier Ion	Calibration Curve Range (µg/L)	Correlation Coefficient (R)	Area %RSD (n = 5) at 0.1 µg/L*4
1	PFBA	213.00>169.00	0.1-10	0.9985	4.0 %
2	PFPeA	263.00>219.00	0.1-10	0.9984	1.9 %
3	PFHxA	312.95>269.00	0.1-10	0.9982	6.6 %
4	PFHpA	362.95>319.00	0.1-10	0.9987	6.3 %
5	PFOA	412.95>369.00	0.1-10	0.9987	2.4 %
6	PFNA	462.95>418.95	0.1-10	0.9988	6.5 %
7	PFDA	512.95>468.95	0.1-10	0.9984	2.8 %
8	PFUnA	562.95>518.95	0.1-10	0.9986	2.2 %
9	PFDoA	612.95>568.95	0.1-10	0.9986	6.1 %
10	PFTrDA	662.95>618.95	0.1-10	0.9986	7.7 %
11	PFTeDA	712.95>668.95	0.1-10	0.9984	4.6 %
12	PFBS	298.95>79.95	0.1-10	0.9985	3.6 %
13	PFHxS	398.95>79.95	0.1-10	0.9987	3.8 %
14	PFHpS	448.95>79.95	0.1-10	0.9986	3.9 %
15	PFOS	498.95>79.95	0.1-10	0.9988	4.6 %
16	PFDS	598.90>79.95	0.1-10	0.9987	5.1 %
17	4:2FTS	326.95>306.95	0.1-10	0.9982	6.9 %
18	6:2FTSA	426.95>406.95	0.1-10	0.9983	5.8 %
19	8:2FTSA	526.95>506.95	0.1-10	0.9983	17.5 %
20	10:2 FTS	627.00>606.90	0.1-10	0.9984	15.0 %
21	FOSA	497.95>77.95	0.1-10	0.9983	3.2 %
22	NMeFOSA	511.95>169.00	0.1-10	0.9995	10.5 %
23	NEtFOSA	526.00>169.00	0.1-10	0.9991	8.6 %
24	NMeFOSE	616.00>59.00	0.1-10	0.9988	9.2 %
25	NEtFOSE	630.00>59.00	0.1-10	0.9991	10.2 %
26	HFPO-DA	329.00>169.00	0.1-10	0.9988	5.5 %
27	PF-3,7-DMOA	513.00>469.10	0.1-10	0.9989	6.1 %
28	4HPFUnA	491.05>367.00	0.1-10	0.9986	16.6 %
29	7HPFHpA	345.05>281.00	0.1-10	0.9985	4.7 %
30	4:2FTOH	323.05>59.10	10-1000	0.9996	11.6 %
31	6:2FTOH	423.15>59.15	10-1000	0.9982	17.1 %
32	8:2FTOH	523.10>59.00	10-1000	0.9991	11.5 %
33	10:2FTOH	623.10>59.20	10-1000	0.9990	22.6 %
41	MPFOA	417.05>372.05	1000	-	-
42	MPFOS	503.00>80.10	1000	-	-

EN 17681-2					
#	Compound	Quantifier Ion	Calibration Curve Range (µg/L)	Correlation Coefficient (R)	Area %RSD (n = 5) at 1 µg/L
24	N-MeFOSE	526.10>461.70	1-100	0.9992	6.3 %
25	N-EtFOSE	540.10>56.10	1-100	0.9993	2.1 %
30	4:2FTOH	196.10>127.10	1-100	0.9983	5.5 %
31	6:2FTOH	95.00>69.00	1-100	0.9994	3.0 %
32	8:2FTOH	95.00>69.00	1-100	0.9994	3.1 %
33	10:2FTOH	95.00>69.00	1-100	0.9988	4.8 %
34	Me-PFOA	169.10>69.10	1-100	0.9984	3.2 %
35	Et-PFOA	169.10>69.10	-	-	-
36	6:2 FTA	418.10>99.10	1-100	0.9986	9.5 %
37	8:2 FTA	518.10>99.00	1-100	0.9985	8.1 %
38	10:2 FTA	618.10>99.10	1-100	0.9992	9.8 %
39	6:2 FTMA	432.10>113.20	1-100	0.9989	5.1 %
40	8:2 FTMA	532.10>113.10	1-100	0.9984	7.6 %
43	PFDodiAOMe	574.10>374.10	1000	-	-

*4: Area %RSD (n = 5) of four FTOH compounds was calculated at 10 µg/L

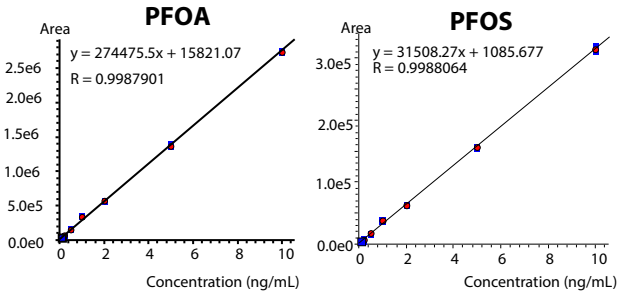

Fig. 4 EN 17681-1: PFOA and PFOS Calibration Curves Using LCMS-TQ8050RX

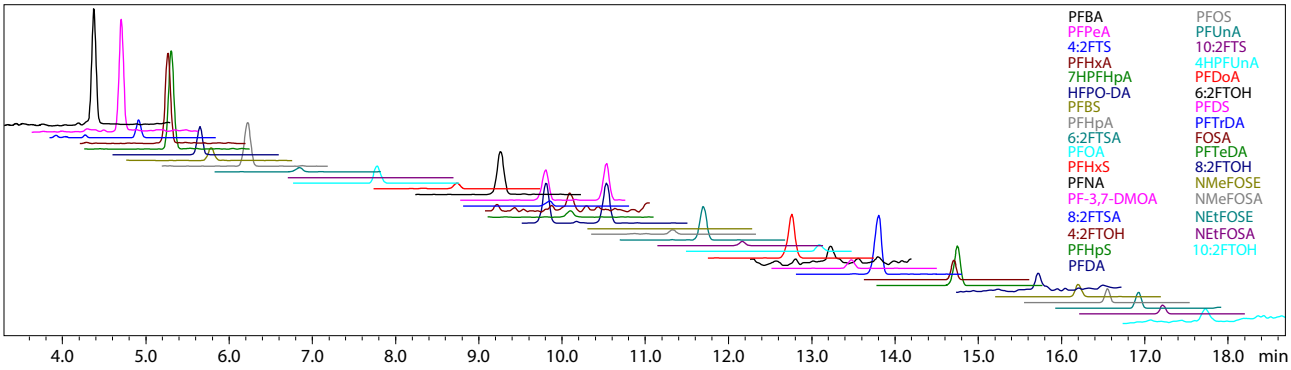

Fig. 5 EN 17681-1: MRM Chromatograms at 0.1 µg/L Using LCMS-TQ8050RX (Scale Changed for FTOH at 10 µg/L)

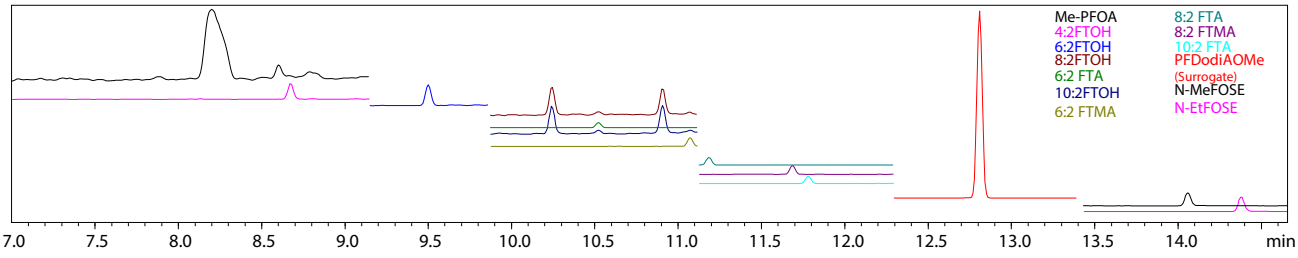

Fig. 6 EN 17681-2: MRM Chromatograms at 1 µg/L Using GCMS-TQ8050 NX (Scale changed for PFDodiAOMe at 1 mg/L)

■ Spike Recovery Test

The spike recovery of the EN 17681-1 used the updated EN 17681-1:2025 sample preparation method shown in Fig. 2. A 1 g fragment of a 100 % cotton glove was used as a sample, and PFAS were added to achieve a concentration of 20 ppb (2000 ppb for FTOH). As the EN 17681-1 method does not use a surrogate, the matrix effects on recovery were determined by adding internal standards (MPFOA and MPFOS) at the end of sample preparation and checking the percentage recovery of these internal standards (Table 6). Before LC/MS/MS analysis, the final extracted solution is diluted 2 to 5-fold as needed to ensure recovery of the internal standard is at least 60 % of the reference criterion. In this analysis, the internal standard recovery was verified as within the reference criterion with a 2-fold dilution of the final extracted solution after sample preparation (Table 6). The results of the EN 17681-1 spike recovery are shown in Figs. 7 and 8. Overall, the method demonstrated good recovery for all spiked compounds, with mean percentage recovery (n = 3) within 70 to 130 % for all compounds and the percentage recovery %RSD (n = 3) within 11 %.

The spike recovery of the EN 17681-2 used the sample preparation method shown in Fig. 3. A 1 g fragment of a 100 % cotton glove was used as a sample, and PFAS were added to achieve a concentration of 25 ppb in the sample. The results of the EN 17681-2 spike recovery that used the internal standard method are shown in Figs. 9 and 10. Overall, the method demonstrated good recovery for all spiked compounds, with mean percentage recovery (n = 3) within 70 to 130 % for all compounds and the percentage recovery %RSD (n = 3) within 10 %.

Table 6 EN 17681-1 Internal Standard (MFOA and MPFOS) Percentage Recovery

#	Compound	Mean Percentage Recovery (n = 3)
41	MPFOA	102.1 %
42	MPFOS	102.3 %

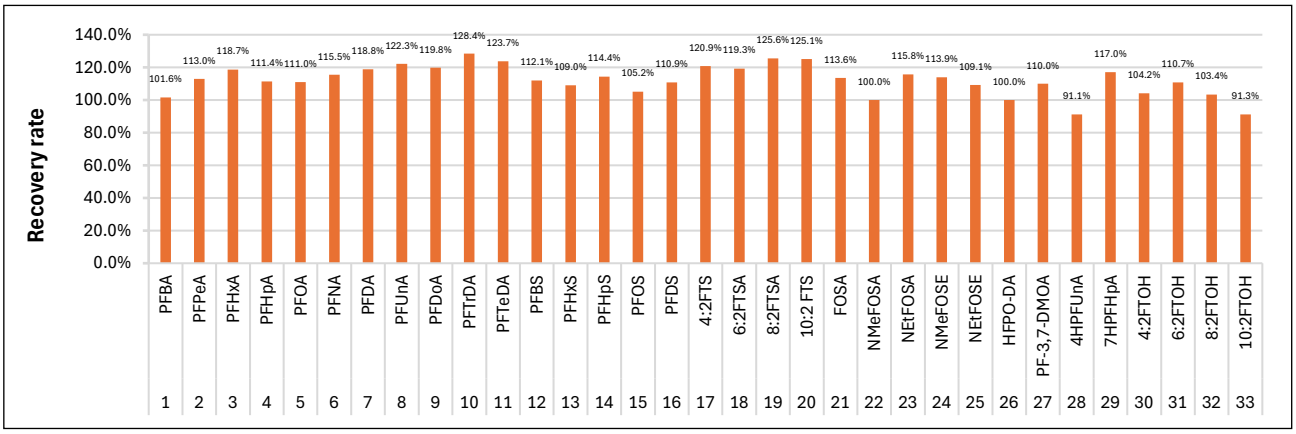

Fig. 7 Percentage Recoveries for EN 17681-1 (LC/MS/MS) Method

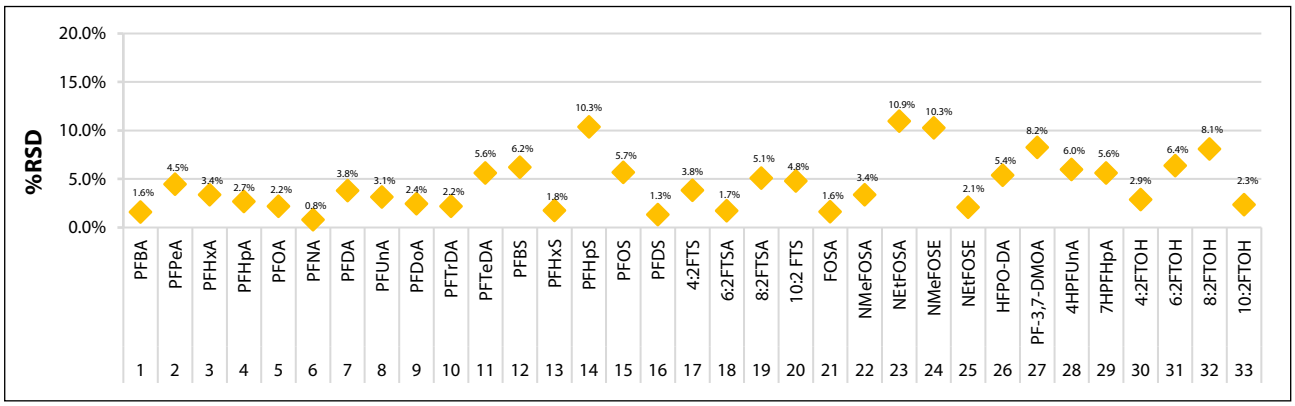

Fig. 8 Repeatability Data for EN 17681-1 (LC/MS/MS) Method

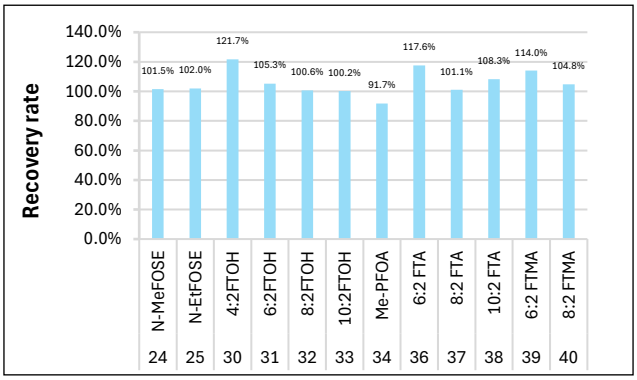

Fig. 9 Percentage Recoveries for EN 17681-2 (GC/MS/MS) Method

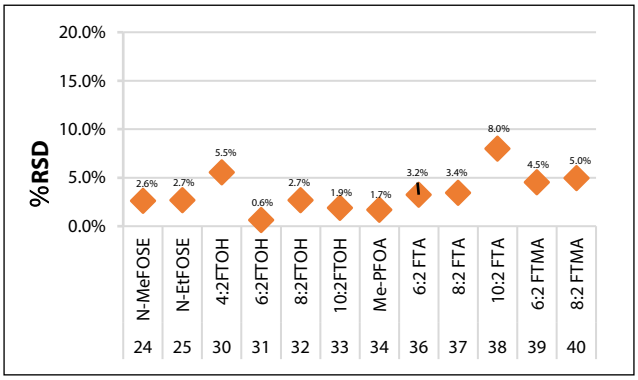

Fig. 10 Repeatability Data for EN 17681-2 (GC/MS/MS) Method

■ Results from Analysis of Ski Wear

Old ski clothing was used as a sample. The results obtained from analyzing this sample by the EN 17681-1 (LC/MS/MS) method are shown in Fig. 11. To investigate the effect of the EN 17681-1:2025 update, analysis was performed using both the pre-update (EN 17681-1:2022) and post-update (EN 17681-1:2025) sample preparation methods. The alkaline hydrolysis treatment used by the EN 17681-1:2025 method dramatically increased the amounts of NMeFOSE, 6:2 FTOH, 8:2 FTOH, and 10:2 FTOH that were detected, and these compounds were detected at levels above the upper limit of their respective calibration curve ranges. This shows that PFAS extraction is improved by using the updated EN 17681-1:2025 sample preparation method. Of the 33 compounds targeted by the LC/MS/MS method, 20 were detected in the sample.

Analyzing the sample by GC/MS/MS using the EN 17681-2 method detected 8 out of the 12 compounds targeted by the EN 17681-2 method. Of these, 8:2 FTOH and 10:2 FTOH were detected at levels above the upper limit of their respective calibration curve ranges (Fig. 12).

■ Conclusion

The analysis of PFAS in textiles was performed according to EN 17681-1 and EN 17681-2 standards, utilizing the LCMS-8050RX and GCMS-TQ8050 NX systems. By combining LC/MS/MS analysis and GC/MS analysis, all target compounds were successfully measured at levels of 25 ppb or less. Spike recovery test at the EU POPs threshold limit (25 ppb) also demonstrated good percentage recovery (70–130 %) for all compounds. Results also showed that PFAS extraction was improved by using the EN 17681-1:2025 sample preparation method, which was updated in 2025.

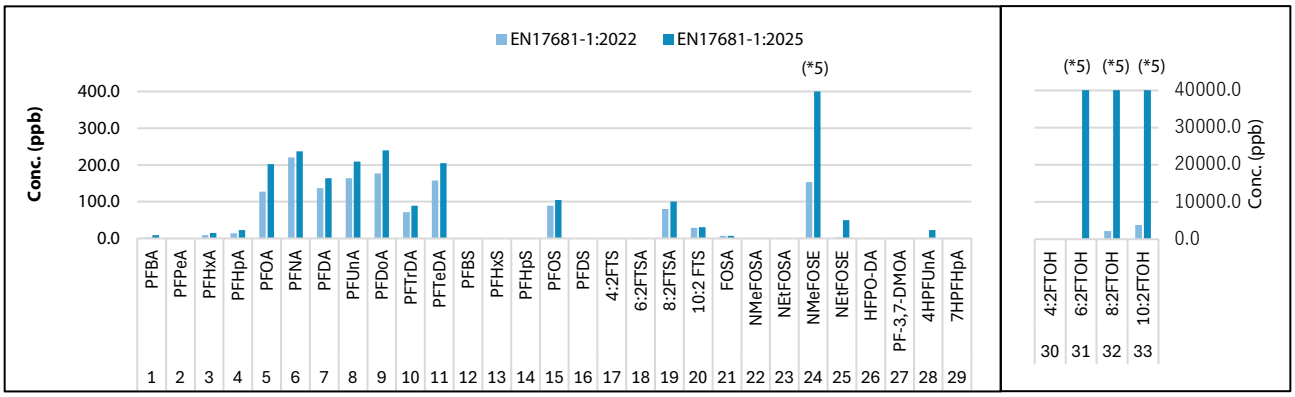

Fig. 11 Sample Measurements Comparing EN 17681-1:2022 and EN 17681-1:2025 Methods (LC/MS/MS)

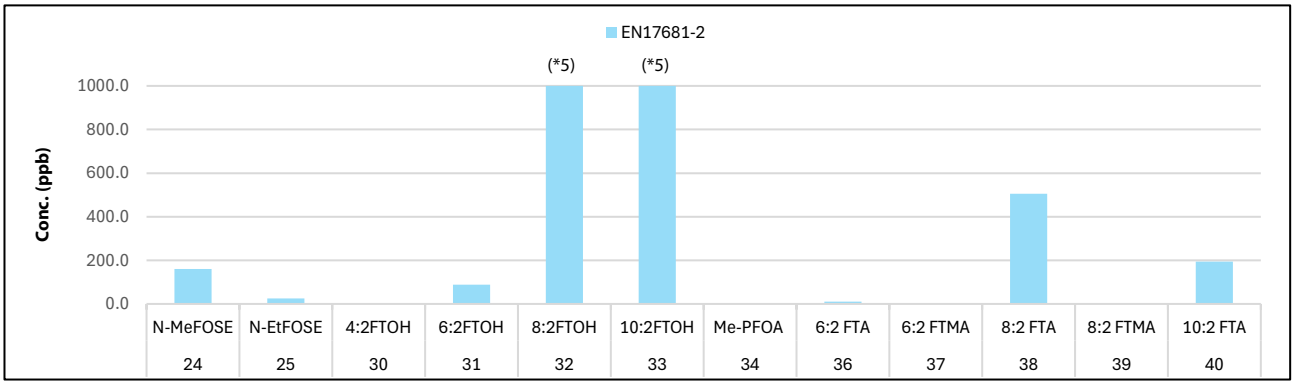

Fig. 12 Sample Measurements Using EN 17681-2 Method (GC/MS/MS)

*5: These compounds were detected at levels above the calibration curve concentration range. For ease of comparison, Figs. 11 and 12 only show data up to the maximum concentration on the calibration curve.

References

1) EUR-Lex - 02019R1021-20251203 - EN - EUR-Lex
2) EN 17681-1:2025 Textiles and textile products - Per- and polyfluoroalkyl substances (PFAS) - Part 1: Analysis of an alkaline extract using liquid chromatography and tandem mass spectrometry
3) EN 17681-2:2022 Textiles and textile products - Organic fluorine - Part 2: Determination of volatile compounds by extraction method using gas chromatography

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