Comprehensive PFAS Screening in Textiles Using LC-MS/MS and GC-MS/MS

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1. Introduction

PFAS are widely used due to their unique physicochemical properties, but their high persistence leads to environmental accumulation and potential human exposure. To mitigate these risks, regulatory measures restricting the manufacture and use of PFAS in products have been introduced worldwide. Under the EU POPs Regulation, concentration limits of 0.025 mg/kg (25 ppb) have been established for selected PFAS such as PFOA, PFOS, and PFHxS.[1)] The European standard EN 17681 defines analytical methods for PFAS in textiles, comprising LC-MS/MS based analysis for ionic PFAS (Part 1) and GC-MS based analysis for neutral volatile and semi-volatile PFAS (Part 2).[2),3)] This study aims to demonstrate the practical applicability of LC-MS/MS and GC-MS/MS for PFAS screening in textiles based on EN 17681-1 and -2.

2. Methods

Analytical methods were developed based on EN 17681-1/-2 for PFAS analysis in textiles. A total of 39 PFAS were analyzed using LC-MS/MS and GC-MS/MS. The analytical conditions and sample preparation were mainly based on Application News No. 01-01108 (Fig.1). LC-MS/MS data were acquired using LCMS-8050RX (Fig.2).

GC-MS/MS data were acquired using the newly developed GCMS-TQ8040 RX (Fig.3) equipped with a Multi-Mode Injection unit (MMI). The MMI supports five injection modes, as shown in Figure 4. This expanded range of injection modes provides greater application flexibility and streamlines operation for even the most challenging samples.

Fig. 1 01-01108-EN
(Analytical Condition and Pretreatment)



Fig. 2 LCMS™-8050RX



Fig. 3 GCMS-TQ™8040 RX



Fig. 4 Available Injection Modes of the MMI

3. Optimization of MMI Conditions

As shown in Figure 5, increasing the injection volume from 2 to 6 µL using MMI-PTV improved sensitivity. Although the peak width of Me-PFOA broadened with increasing injection volume, co-injection of 2 µL ethyl acetate significantly improved peak shape. A total injection volume of 8 µL enabled trace-level analysis even with the standard performance model, GCMS-TQ8040 RX.

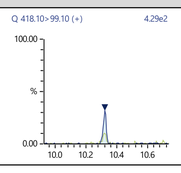
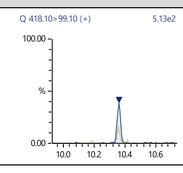
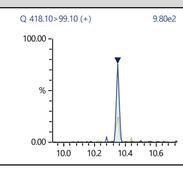
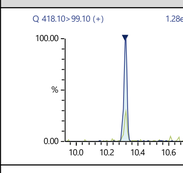
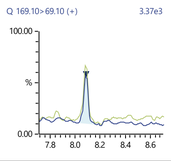
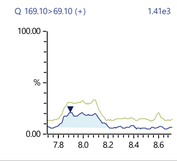
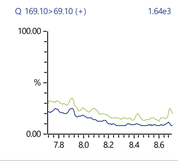
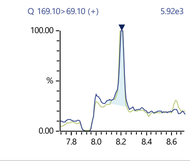
Injection volume	Sample 2 µL	Sample 4 µL	Sample 6 µL	Sample 6 µL + Ethyl Acetate 2 µL
6:2 FTA				
Me-PFOA				

Fig. 5 Chromatogram Comparison of Selected EN 17681-2 Targets at 1 µg/L with Different Injection Volumes

4. Analysis of Standards

For LC-MS/MS, calibration curves were prepared for 33 target compounds at 0.1–10 µg/L, while fluorotelomer alcohols (FTOHs) were calibrated at 10–1000 µg/L. For GC-MS/MS, calibration curves were prepared for eight target compounds (excluding Et-PFOA) with four additional FTOHs in the range of 1–10 µg/L. Excellent linearity (R > 0.998) and repeatability (%RSD < 20) were obtained for all target analytes. Good peak shape was also observed at the lowest calibration level for both GC-MS/MS (Fig. 6) and LC-MS/MS (Fig. 7).

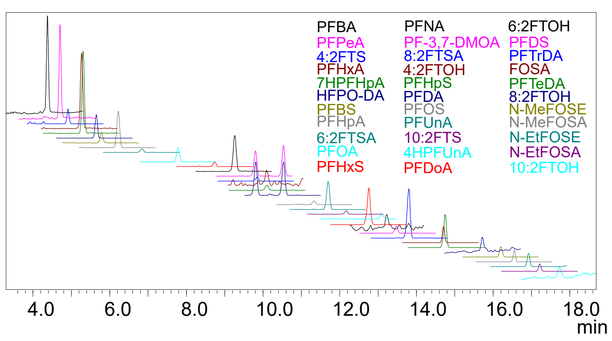


Fig. 6 EN 17681-1: MRM Chromatograms at 0.1 µg/L Using LCMS-TQ8050RX (Scale Changed for FTOH at 10 µg/L)

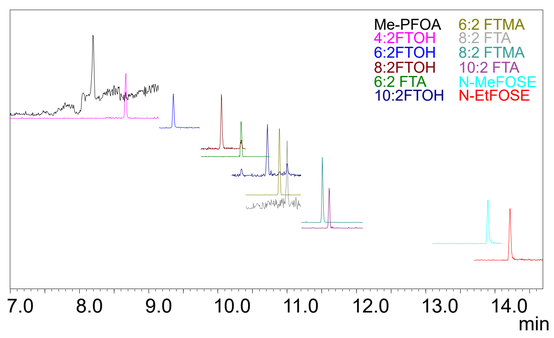


Fig. 7 EN 17681-2: MRM Chromatograms at 1 µg/L Using GCMS-TQ8040 RX (Scale Adjusted)

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5. Spike Recovery Test

Recovery tests for most target compounds were performed at spiking levels below 0.025 mg/kg in textile samples. The results showed satisfactory performance for both LC-MS/MS (Fig 8) and GC-MS/MS (Fig 9). Recoveries were ranged from 70 to 130 %, and % RSD (n = 3) was below 11 %, indicating good analytical accuracy and reproducibility.

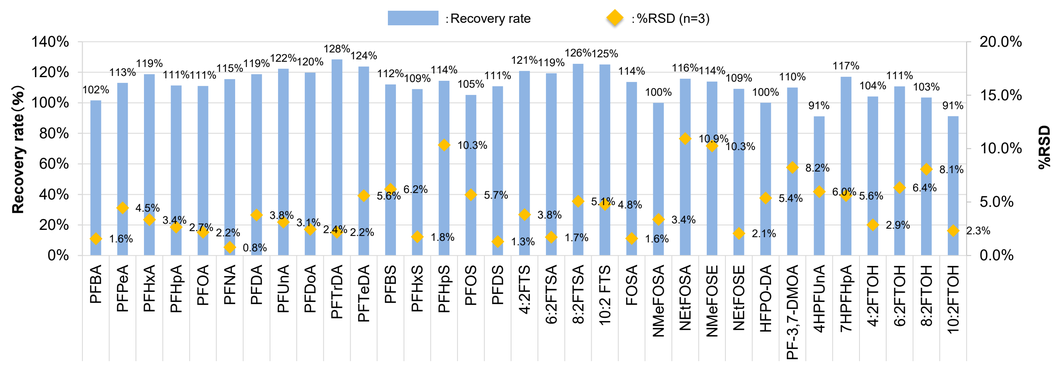


Fig. 8 Percentage Recoveries and Repeatability Data for EN 17681-1 (LC-MS/MS) Method

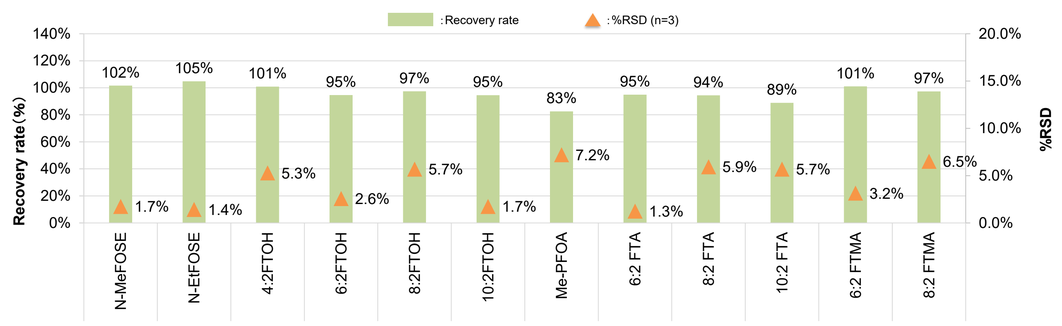


Fig. 9 Percentage Recoveries and Repeatability Data for EN 17681-2 (GC-MS/MS) Method

6. Results from Analysis of Ski Wear

For sample analysis, old ski-wear textiles were pretreated according to EN 17681-1:2022 (methanol extraction) and EN 17681-1:2025 (alkaline hydrolysis), and the results were compared (Fig.10). The revised method resulted in higher detected levels of NMeFOSE and 6:2, 8:2, and 10:2 FTOHs due to an alkaline hydrolysis. Using LC-MS/MS, 20 out of 33 target compounds were detected in the ski-wear sample. Similarly, GC-MS/MS analysis following EN 17681-2-based pretreatment detected 8 out of 12 target compounds, with 8:2 and 10:2 FTOHs exceeding the calibration range (Fig 11).

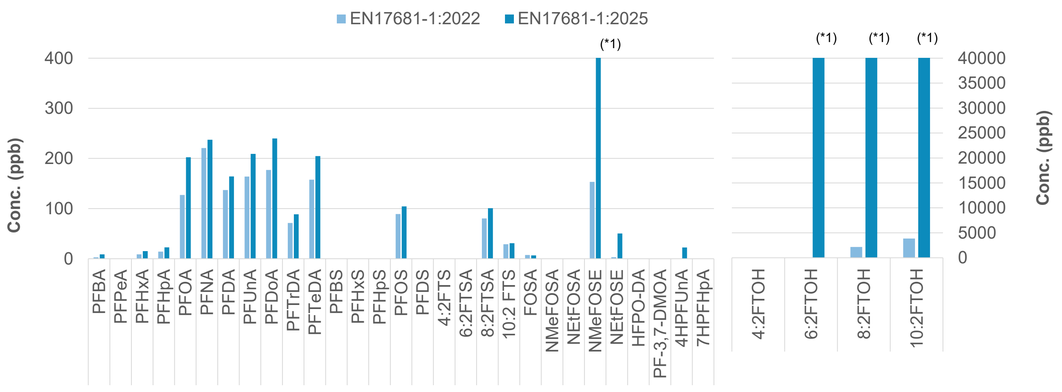


Fig. 10 Sample Measurements Comparing EN 17681-1:2022 and EN 17681-1:2025 Methods (LC-MS/MS)

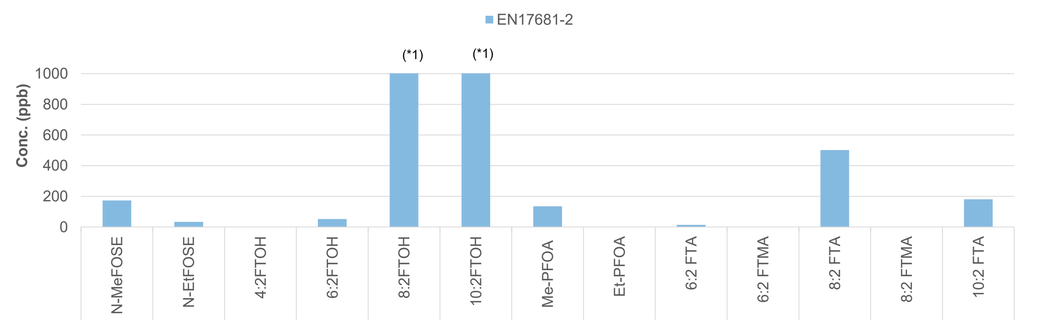


Fig. 11 Sample Measurements Using EN 17681-2 Method (GC-MS/MS)

*1: These compounds were detected at levels above the calibration range. For ease of comparison, Fig. 10 and 11 only show data up to the maximum concentration on the calibration curve.

7. Conclusion

The combined use of LC-MS/MS and GC-MS/MS enabled comprehensive PFAS screening in textiles at concentrations below regulatory limits. Notably, stable trace-level detection was achieved without applying the optional preconcentration step described in EN 17681, demonstrating the practicality of the proposed approach for routine regulatory screening. These results indicate that optimized instrumental sensitivity and appropriate application of EN 17681 procedures are essential for reliable PFAS analysis in textile materials.

Acknowledgements

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Reference

1) EUR-Lex - 02019R1021-20251203 - EN - EUR-Lex
2) EN 17681-1:2025 Textiles and textile products -PFAS - Part 1
3) EN 17681-2:2022 Textiles and textile products -Organic fluorine- Part 2