SHIMADZU

TP 125

High-Throughput Ultra-Short-Chain PFAS Analysis in Drinking Water using LC-MS/MS with Automated Sample Preparation

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1.Overview

A high-throughput LC–MS/MS workflow was evaluated for targeted analysis of ultra-short- and short-chain PFAS in drinking water. Seven drinking-water matrices were used to assess native background, matrix spike recovery, precision, continuing calibration verification, LOQ accuracy, and calibration performance.

2. Introduction

Ultra-short- and short-chain PFAS are highly mobile and persistent contaminants that are challenging to measure in drinking water due to high polarity, low molecular weight, poor chromatographic retention, and susceptibility to laboratory background contamination. This study evaluates a high-throughput LC–MS/MS workflow with automated sample preparation for targeted quantification of ultra-short and short-chain PFAS in drinking water. Method performance was assessed using native background, matrix spike recovery, precision, LOQ accuracy, calibration performance, and continuing calibration verification.

Figure 1. Automated sample preparation and LCMS workflow

3. Method

Nine target PFAS were evaluated: TFA, TFMS, PFPrA, PFMOAA, PFEtS, PFBA, PFPrS, TFSI, and PFBS. Samples and calibrants were prepared in acidified 50:50 PFAS-grade water/methanol using PFAS-grade water provided by MilliporeSigma and an automated ePrep sample preparation system equipped with PFAS-free accessories.

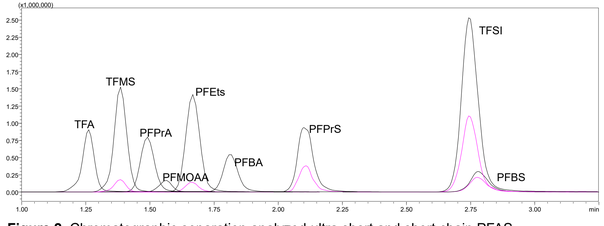

Figure 2. Chromatographic separation analyzed ultra short and short chain PFAS

Chromatographic separation was performed on a polar-embedded IBD column with a delay column to improve retention and minimize background interference. Analysis was performed on a Shimadzu LCMS-8065XE triple quadrupole system within an 8-minute total cycle time with a 10 µL injection volume (figure 2). Drinking-water samples were collected from seven local household sources and spiked at multiple concentration levels. Samples were ran in replicates to evaluate recovery, precision, and method robustness.

4. Results and Discussion

A nine-point calibration curve ranging from 10 to 2500 ng/L was prepared using the ePrep automated sample preparation system. All analytes, except PFMOAA, were evaluated at a 10 ng/L LOQ; PFMOAA was evaluated at a 50 ng/L LOQ. All analytes showed acceptable linearity, with R^2 values >0.99, and accuracy within 70–130% (Figure 3).

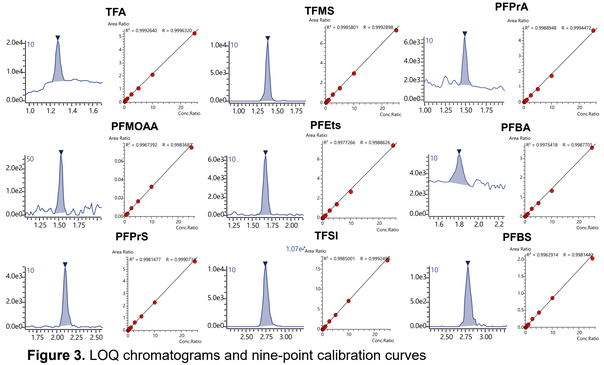

Figure 3. LOQ chromatograms and nine-point calibration curves

Representative chromatograms showed measurable TFA background in the solvent blank (Figure 4A), while PFPrA showed little to no background response (Figure 4B). TFSI showed no integratable blank peak (Figure 4C). These results highlight the importance of solvent screening and blank evaluation for all analyzed short-chain PFAS, particularly for compounds such as TFA that are more susceptible to background contamination

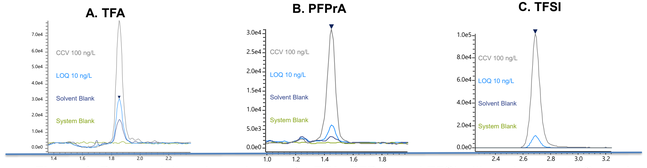

Figure 4. Representative chromatogram for TFA, PFPrA, and TFSI with system blank, Solvent Blank, LOQ and CCV

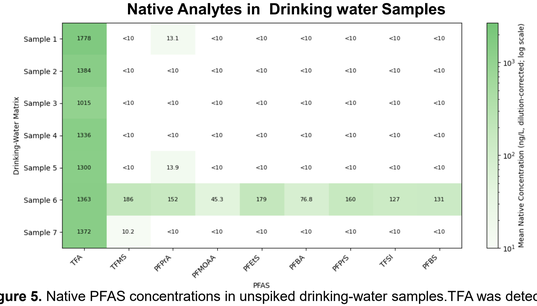

Figure 5. Native PFAS concentrations in unspiked drinking-water samples.TFA was detected in all samples.

TFA was detected at >1000 ng/L in all unspiked samples from seven household drinking-water sources. PFPrA was detected at lower concentrations, and one matrix showed elevated native PFAS levels, emphasizing the importance of matrix-specific background assessment before spike-recovery evaluation (Figure 5). CCV recoveries remained within the acceptable 70–130% range with %RSD less than 20% (Table 1) for most compound, demonstrating system robustness during analysis.

LC–MS/MS Performance Summary for Target Ultra-Short- and Short-Chain PFAS

Analyte	MRM Transition	RT (min)	Calibration Range (ng/L)	CCV %RSD (n=79)
TFA	113.00 > 69.00	1.227	10–2500	16
TFMS	148.90 > 79.95	1.327	10–2500	13
PFPrA	162.98 > 119.00	1.43	10–2500	11
PFMOAA	178.98 > 84.90	1.535	50–2500	28
PFEtS	198.95 > 79.90	1.583	10–2500	13
PFBA	212.98 > 169.20	1.721	10–2500	12
PFPrS	248.95 > 79.95	1.979	10–2500	11
TFSI	279.90 > 147.10	2.578	10–2500	10
PFBS	298.94 > 80.00	2.596	10–2500	9

Table 1. Most analytes were quantified from 10–2500 ng/L, while PFMOAA was quantified from 50–2500 ng/L. CCV precision was evaluated across 79 injections.

Matrix spike recovery was generally acceptable for most analytes from 100–1000 ng/L across seven drinking-water matrices, demonstrating robustness of the automated sample preparation and LC–MS/MS workflow. Greater variability was observed at 10 ng/L, where native/background contribution had a stronger influence on calculated recovery. PFMOAA showed lower recovery and higher variability, indicating that additional optimization may be needed.

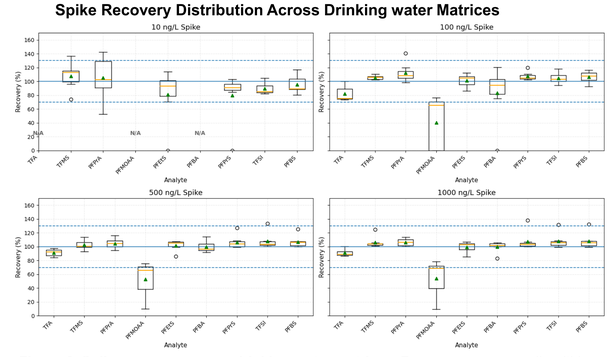

Figure 6. Spike recovery across drinking-water matrices. Recovery was generally within the 70–130% acceptance range for most analytes from 100–1000 ng/L.

Box plots in Figure 6 summarize recovery distributions for target ultra-short- and short-chain PFAS across seven drinking-water matrices at 10, 100, 500, and 1000 ng/L spike levels. The 10 ng/L results for TFA, PFBA, and PFMOAA were excluded where low-level recovery was not representative.

6. Conclusion

This 8-minute LC–MS/MS method enabled high-throughput analysis of ultra-short- and short-chain PFAS in drinking water. TFA background observed in blanks and unspiked samples emphasized the need for contamination control and matrix-specific background assessment. Practical LOQs were supported at 10 ng/L for most analytes and 50 ng/L for PFMOAA. Recovery and precision were generally acceptable from 100–1000 ng/L, with higher variability at 10 ng/L and for PFMOAA, indicating areas for further optimization. Calibration and CCV performance supported reliable quantification across the reportable range.

7. Reference

1.U.S. Environmental Protection Agency. *Method 533: Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry*; EPA 815-B-19-020; U.S. EPA: Washington, DC, 2019. (US EPA)

2. ASTM International. *ASTM D8421-22: Standard Test Method for Determination of Per- and Polyfluoroalkyl Substances in Aqueous Matrices by Co-solvation Followed by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)*; ASTM International: West Conshohocken, PA, 2022. (ASTM International | ASTM

3. U.S. Environmental Protection Agency. *Sampling for PFAS under the National Primary Drinking Water Regulation*; U.S. EPA: Washington, DC, 2025. (US EPA)