Application Note

Food Testing

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Fully Automated Workflow for Volatile PFAS Analysis in Food Contact Materials Using GC-Triple Quadrupole MS

Authors

Gwen Lim
CTC Analytics AG,
Switzerland

Auni Wong, Zhang Yufeng,
and Aimei Zou
Agilent Technologies, Inc.

Abstract

To address the growing concerns about per- and polyfluoroalkyl substances (PFAS) from food contact materials (FCMs), this study presents a robust and fully automated method that uses the PAL3 Series 2 RTC autosampler coupled with an Agilent 7010D triple quadrupole GC/MS (GC/TQ) system to quantify over 30 volatile PFAS in FCMs. For the analysis of paper coffee cup FCMs, the automated analytical workflow demonstrated excellent calibration precision and accuracy, sample extraction efficiency, and targeted quantitation. Method detection limits (MDLs) of ≤ 1 µg/kg (ppb) were achieved for 25 targets and ≤ 2 µg/kg for six targets. Additionally, all targets achieved a relative standard deviation (RSD) of recoveries ≤ 17% across three QC levels for intrabatch analyses. The automated workflow offers a reliable, high-throughput solution for routine laboratory monitoring of trace volatile PFAS in FCMs to provide food safety guidance to regulatory bodies.

Introduction

"Forever Chemicals" is a term used to describe PFAS due to their slow chemical breakdown and persistence in the environment. Because of their excellent waterproof, nonstick, and stain-resistant properties, PFAS are widely used in various industries and consumer applications. Materials containing PFAS have been used in food packaging and FCMs since the mid-20th century.[1,2] Scientific studies have shown that PFAS are prone to migrating into food through various pathways, potentially leading to public health issues.[2,3] Consequently, new guidelines and regulations have been established to ensure the quality and safety of the materials used in the food industry.

In the United States, the Food and Drug Administration (FDA) has phased out the use of certain PFAS as grease-proofing agents in paper and paperboard packaging, including perfluorooctanoate (PFOA), perfluorooctane sulfonate (PFOS), and 6:2 fluorotelomer alcohol (6:2 FTOH).[4] In addition, the European Union (EU) is working on a comprehensive restriction of PFAS under the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), which aims to limit the use of PFAS in various applications including food packaging and FCMs.[5] Germany, Denmark, the Netherlands, Norway, and Sweden have also jointly proposed that the European Chemicals Agency (ECHA) enact a broad ban on PFAS in the EU market (REACH Appendix XV).[6] It is expected that more regulations and voluntary initiatives will be implemented to address and control PFAS contamination in food packaging and contact materials.

Therefore, establishing a sensitive and accurate quantitative analytical approach for PFAS analysis is crucial to ensure the safety of materials used in food industry. Technologies such as liquid chromatography (LC) and gas chromatography (GC) paired with triple quadrupole mass spectrometry (TQ) are often used to analyze different PFAS groups based on their properties.[3] Volatile compounds such as FTOHs and fluorotelomer acrylates (FTAs) are particularly suitable for GC/TQ analysis due to their high vapor pressure. Manual sample preparation for PFAS in food packaging or FCMs involves processes such as leaching, cleanup and evaporation that are labor-intensive, costly, and reduce lab productivity.[7] This application note presents a robust and fully automated method that uses the PAL3 Series 2 RTC autosampler coupled with an Agilent 7010D GC/TQ to quantify more than 30 volatile PFAS analytes in paper coffee cups, an FCM. The performance of the automated workflow was evaluated in terms of calibration linearity, MDLs, QC recovery, and method precision.

Experimental

A total of 38 PFAS, including 34 native and 4 labeled compounds (serving as internal standards), were analyzed using an automated procedure that included heating-assisted solvent extraction, centrifugation, filtration, and injection.

Chemicals and consumables

The ethyl acetate (EA, HPLC grade) used for this study was purchased from Sigma and tested for suitability in PFAS analysis. Native and isotopically labeled PFAS standards were sourced from Wellington Laboratories Inc. (Guelph, ON, Canada), AccuStandard, Apollo Scientific, Santa Cruz Biotechnology, and Cambridge Isotope as stock solutions and in powdered form.

All consumables used were from Agilent and verified to deliver ultra-trace levels of PFAS background.

Instrumentation

Figure 1 shows the integrated PAL3 Series 2 RTC autosampler coupled with an Agilent 7010D GC/TQ in the setup used to apply the fully automated PFAS quantitation workflow to paper coffee cup matrix.

A 120 cm PAL3 Series 2 RTC autosampler was used as an automated liquid handling platform for calibration standards preparation, sample extraction, and injections onto the GC/TQ system. Equipped with various tools and modules, the PAL3 Series 2 RTC autosampler provided the necessary capabilities for its designated functions.

All solvent tubing used on the PAL3 Series 2 RTC autosampler was PFAS-free. The following tools and modules were used:

- Vortex Mixer
- Agitator
- Centrifuge
- Tray Cooler (2/10/20 mL vials)
- Tray Holders with rack (2/10/20 mL vials)
- Micro-SPE Tray (2 mL vials and micro-SPE cartridges)
- Fast Wash Module

For the analysis of PFAS, a 7010D GC/TQ with a HES 2.0 ion source was coupled to an Agilent 8890 GC system equipped with an MMI inlet and splitless liner (part number 5190-2293). SWARM autotune was performed to obtain the optimal instrument settings. The entire system was managed by Agilent MassHunter Acquisition 13.0 software, which provides an integrated single-software-system experience. The instrument operating conditions and parameters are listed in Table 1.

Figure 1. PAL3 Series 2 RTC autosampler with Agilent 7010D triple quadrupole GC/MS.

Table 1. Agilent 8890 GC and 7010D GC/TQ instrument parameters.

GC Conditions	
Injection Volume	3 µL
Column	Agilent J&W DB-624, 30 m × 0.25 mm, 1.40 µm (p/n 122-1334UI)
Inlet Temperature	70 °C for 0.01 min; 300 °C/min to 250 °C
Injection Mode	Pulsed splitless
Carrier Gas	Helium, constant flow, 1 mL/min
Transfer Line Temperature	240 °C
Oven Program	– 45 °C hold for 2 min – 5 °C/min to 75 °C, hold for 1 min – 5 °C/min to 110 °C, hold for 1 min – 10 °C/min to 190 °C – 5 °C/min to 210 °C – 2 °C/min to 216 °C – 10 °C/min to 236 °C, hold 1 min
MS Parameters	
Acquisition Mode	dMRM
Ion Source Temperature	280 °C
Quadrupole Temperature	150 °C
Ionization	EI mode
Gain	10
Solvent Delay	5 minutes

Automated calibration preparation using the PAL3 Series 2 RTC autosampler

A total of nine calibration levels were prepared automatically by the PAL3 Series 2 RTC autosampler. The placement of GC vials is shown in Figure 2. A stock mix standard solution (index 1) and internal mix standard (ISTD, index 2) were manually prepared at a concentration of 1.0 µg/mL (ppm) and 0.5 µg/mL (ppm) in EA, respectively. As shown in Figure 2, the PAL3 Series 2 RTC autosampler prepared two intermediate standard solutions (A and B) from the stock mix standard solution. The autosampler then used the intermediate solutions to prepare nine levels of calibration standards from 1 to 500 ng/mL (ppb) with a constant amount of ISTD spiked into each calibration vial. A calibration blank used to monitor for contamination during calibration preparation was prepared by spiking the ISTD mix into solvent. The stocks, intermediates, and calibration vials were placed, then prepared on a Tray Cooler at 10 °C to maintain stability and minimize evaporation of volatile PFAS.

Sample preparation using the PAL3 Series 2 RTC autosampler

A paper coffee cup was used as a sample matrix to test the workflow's extraction efficiency. The entire automated analytical workflow is shown in Figure 3.

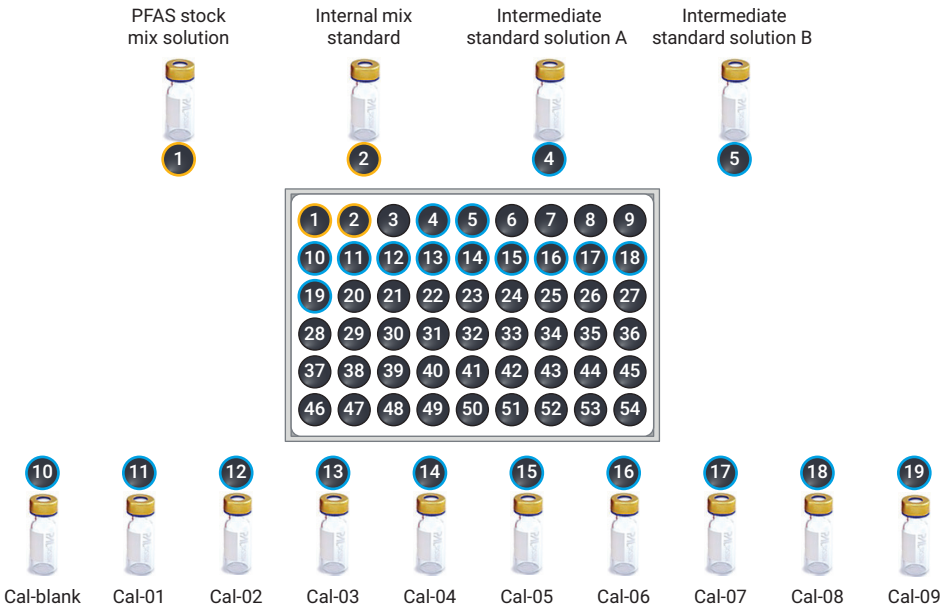

Figure 2. Automated preparation of calibration standards using a PAL3 Series 2 RTC autosampler.

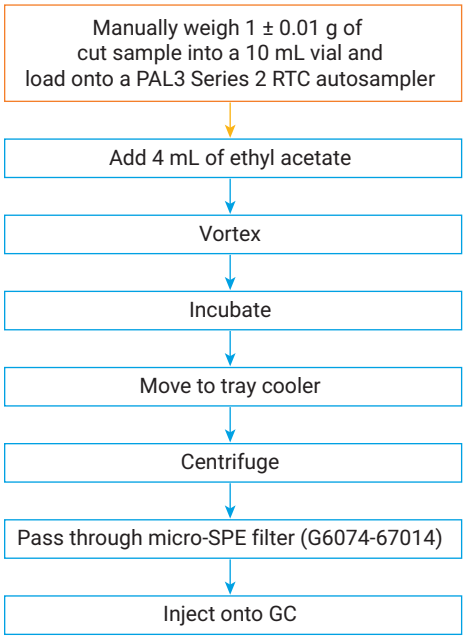

Figure 3. Automated sample preparation using a PAL3 Series 2 RTC autosampler.

One gram (1 ± 0.01 g) of the sample was cut into small pieces, excluding the adhesive portion, and weighed into a 10 mL sample vial. The vial was securely capped and placed on the sample rack (PAL VT15 Rack for 10/20 mL vial). As illustrated in Figure 3, the remaining steps were carried out by the PAL3 Series 2 RTC autosampler. The ISTD mix (used as extracted internal standards) was spiked into the 10 mL sample vial, followed by spiking of PFAS targets if matrix-spiked QCs were needed. In this study, QC samples with low, middle, and high analyte concentrations of 20 µg/kg (LSQ), 100 µg/kg (MSQ), and 200 µg/kg (HSQ) were prepared in multiple technical preparations (n = 4) by the PAL3 Series 2 RTC autosampler, using the automated workflow. A matrix blank (MB) was prepared without spiking target analytes. After filtration, the extract was directly injected onto the GC/TQ by the PAL3 Liquid Tool without further evaporation and reconstitution, resulting in a 4-fold dilution factor. Automating procedural steps eliminates tedious manual labor, providing a simple and fast solution for routine laboratories.

Online analysis sequence

An online analysis sequence batch included working calibration standards, reagent blank (RB), matrix blank (MB), and matrix-prespiked QC samples. Initially, the PAL3 Series 2 RTC autosampler prepared the nine working calibration standards, which were then analyzed by the 7010D GC/TQ. Upon the completion of the calibration analysis, the autosampler prepared the RB and immediately injected it into the GC/TQ for quantitative analysis. While the GC/TQ was acquiring data for the RB, the autosampler proceeded to prepare the next sample in the series, allowing concurrent sample preparation and analysis. Consequently, overall productivity increased, and time-to-results decreased by reducing the wait time between runs.

Results and discussion

Method optimization

Initial compound identification used the Agilent GC/Q-TOF PFAS personal compound database and library (PCDL), which was converted into a library file using the Agilent Library Editor.[8] The converted library facilitated initial identification of each target compound using the Agilent MassHunter Unknowns Analysis software (version 12.1). MassHunter Optimizer (integrated into MassHunter Acquisition software version 13.0) was then used to identify target compound precursor and product ions, as well as collision energies for each transition (precursor → product ion). Figure 4 shows the MassHunter Optimizer results for 8:2 FTOH. Figure 4A shows the chromatogram of identified transition 127 → 76.9 with different abundances at retention time 18.38 minutes. Figure 4B presents the ion breakdown profile at different collision energies for the selected product ion (76.9). The optimal collision energy of 15 eV was determined for the MRM transition 127 → 76.9. MassHunter Optimizer automatically generates a results summary that provides a comprehensive overview of the optimization process. This feature allows users to quickly determine the optimal parameters for their method, significantly reducing the time required to develop methods compared to manual optimization. Additionally, the optimization results are stored in a compound database and can be imported seamlessly into the acquisition method, facilitating efficient data management and analysis.

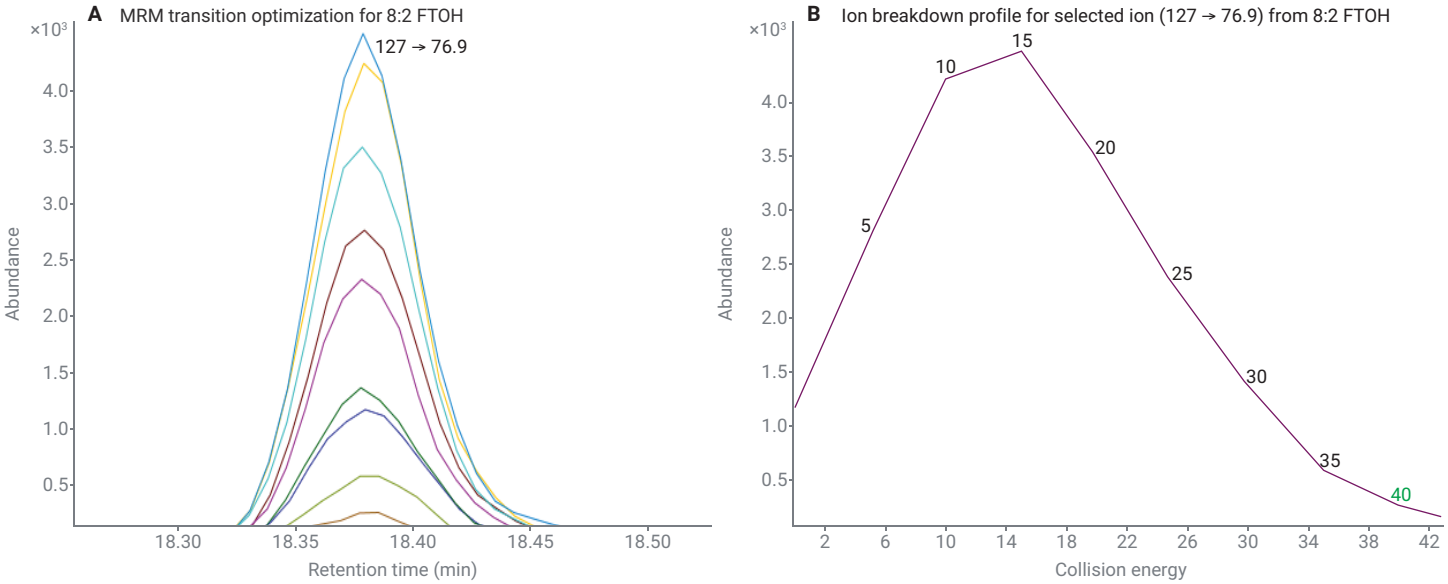

Figure 4. Agilent MassHunter Optimizer optimization results for 8:2 FTOH.

In this study, at least two MRM transitions per compound were identified, resulting in an acquisition method containing 112 MRMs to cover the 34 analytes and four ISTDs. Figure 5 shows a representative MRM chromatogram of the 34 analytes at 0.25 µg/mL and four ISTDs at 0.50 µg/mL in EA (Cal 8). Typical volatile PFAS, such as 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, and 10:2 FTOH are labeled in Figure 5, with their zoomed-in chromatograms shown in the inset. The symmetrical, sharp peaks confirm efficient chromatographic separation of the PFAS and excellent optimization performance of the MassHunter Optimizer, both of which are crucial for accurate and reliable compound analysis.

Chromatographic performance, in terms of compound identification and elution profile, can adversely be affected by matrix effects and interferences in real sample matrices. To further assess the reliability of the newly developed 7010D GC/TQ acquisition method, MRM chromatograms of all PFAS prespiked at a concentration of 200 µg/kg in the sample matrix were acquired. The MRM transitions for each compound were identified without significant MRM interference. This result demonstrated that the comprehensive 7010D GC/TQ method for the analysis of volatile PFAS was reliable and interference-free for complex sample matrices. The precision of the chromatographic elution was evaluated based on the %RSD of retention times (RT) from four technical preparations of matrix-spiked samples (at 200 µg/kg). Figure 6 shows that the %RSD of RT was less than 0.05 for all compounds in the matrix, confirming the excellent robustness of chromatographic separation using an Agilent 8890 GC system.

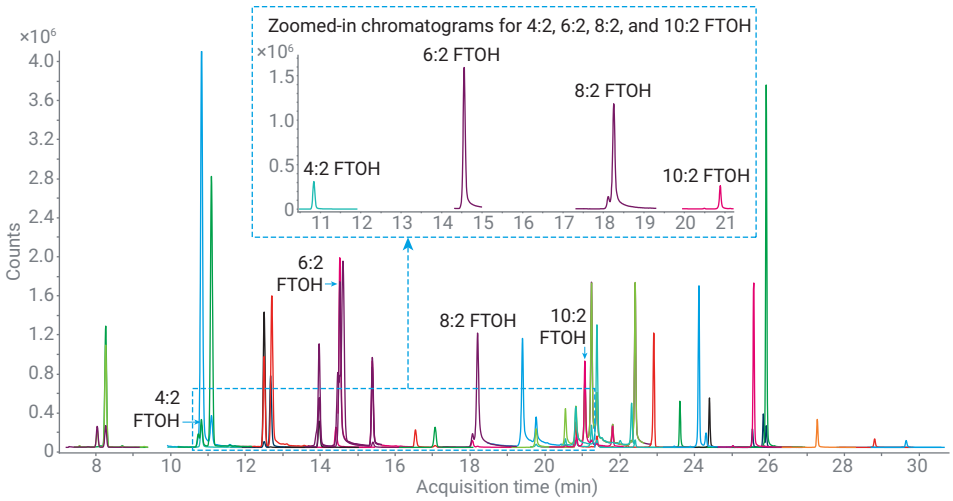

Figure 5. Representative MRM chromatogram of the 34 analytes at 0.25 µg/mL and four ISTDs at 0.50 µg/mL in EA.

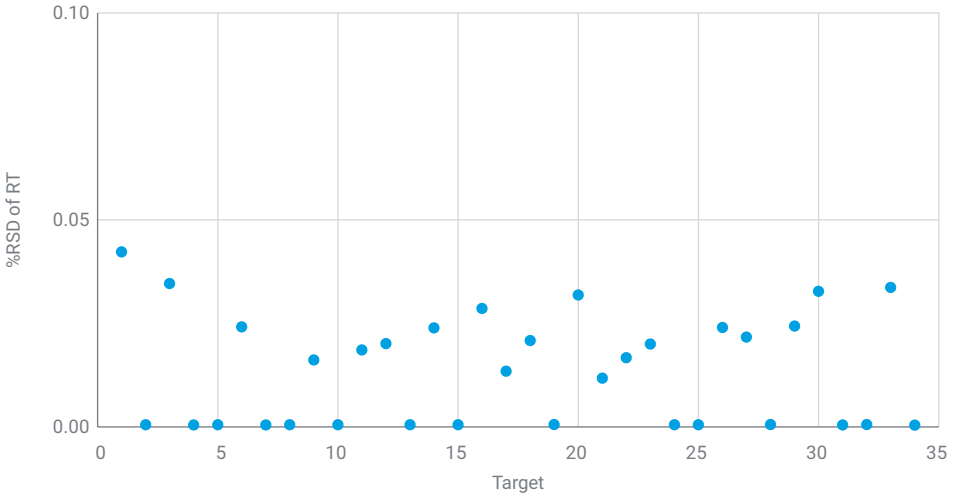

Figure 6. %RSD of RT for all compounds from four technical preparations of matrix-spiked samples.

Method linearity

The calibration linearity and method sensitivity results are summarized in Table 2. The method linearity was evaluated across nine calibration levels, with analyte concentrations ranging from 1 to 500 ng/mL (1, 2.5, 5, 10, 25, 50, 100, 250, and 500 ng/mL). Linearity was determined using an isotopically labeled internal calibration with a 1/x weighting factor. The coefficient of determination (R^2) values for all analytes exceeded 0.99 with a minimum of five calibration points. Figure 7A shows the linearity of 8:2 FTOH over the entire calibration range (levels 1 to 9). Figure 7B displays the MRM overlay of $^{13}C_2$-6:2 FTOH (ISTD of 8:2 FTOH) across the same range. These figures demonstrate that automated calibration standard preparation using the PAL3 Series 2 RTC autosampler was reliable, precise, and accurate.

Method sensitivity

MDL and limit of quantitation (LOQ) were determined to evaluate the sensitivity of the automated workflow. The MDL was calculated using MassHunter Quantitative Analysis software version 12.1 based on nine continuous injections derived from four technical replicates of the LSQ samples.[9,10] The MDL values (based on sample weight) for each target are summarized in Table 2. Overall, 25 and 6 targets achieved MDLs of less than 1 and 2 µg/kg, respectively, demonstrating the high sensitivity of the workflow for PFAS analysis in FCMs. MDLs were not determined for three targets, namely perfluoro-3,6,9-trioxatridecanoic acid, PFHxDA, and PFODA, due to significant matrix effects.

The workflow LOQs were established based on the method-validated LOQ (LOQ_{vali}), which was a matrix-spiked QC level. In this work, the QC level was claimed as LOQ_{vali} if the target performance met the guideline criteria from AOAC SMPR 2023.003 for PFAS in food applications.[11] The method LOQ_{vali} for all PFAS analytes is listed in Table 2. Notably, 24 out of 34 analytes, including 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, and PFOSA, achieved an LOQ of 20 µg/kg. Figure 8 shows MRM overlays of four technical preparations at the LOQ level for 4:2 FTOH (A), 6:2 FTOH (B), and 8:2 FTOH (C), which confirmed the high sensitivity and excellent reproducibility of the automated workflow for routine PFAS analysis in FCM samples.

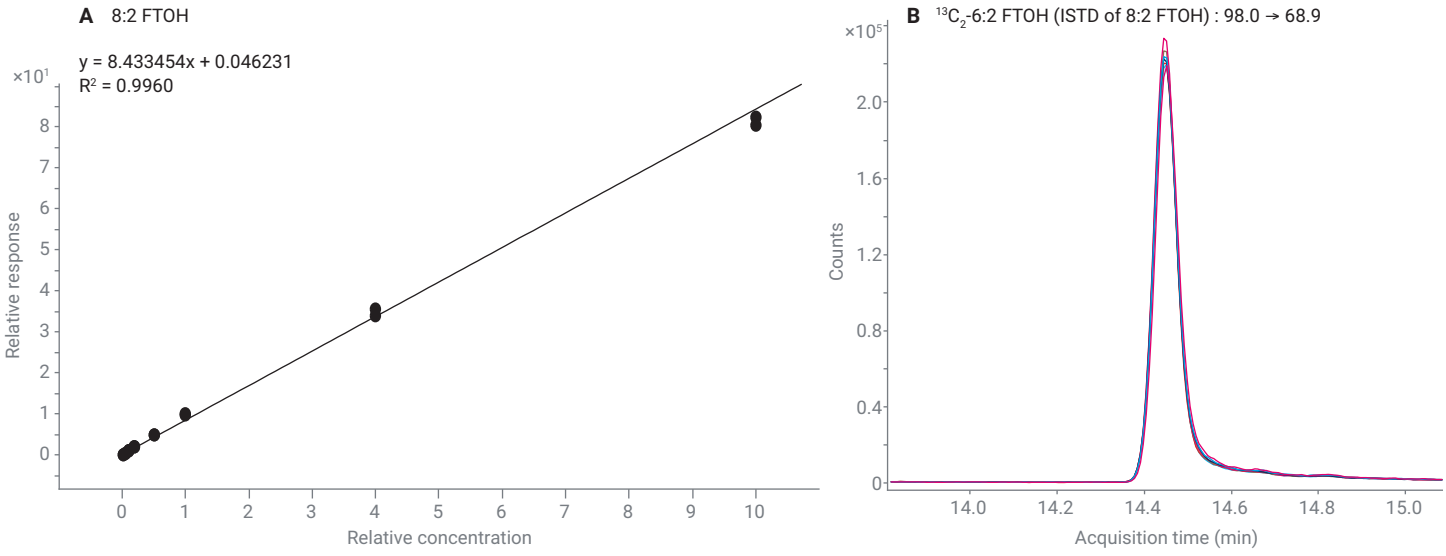

Figure 7. (A) Linearity of 8:2 FTOH over calibration levels 1 to 9 and (B) MRM overlay for $^{13}C_2$-6:2 FTOH from calibration levels 1 to 9.

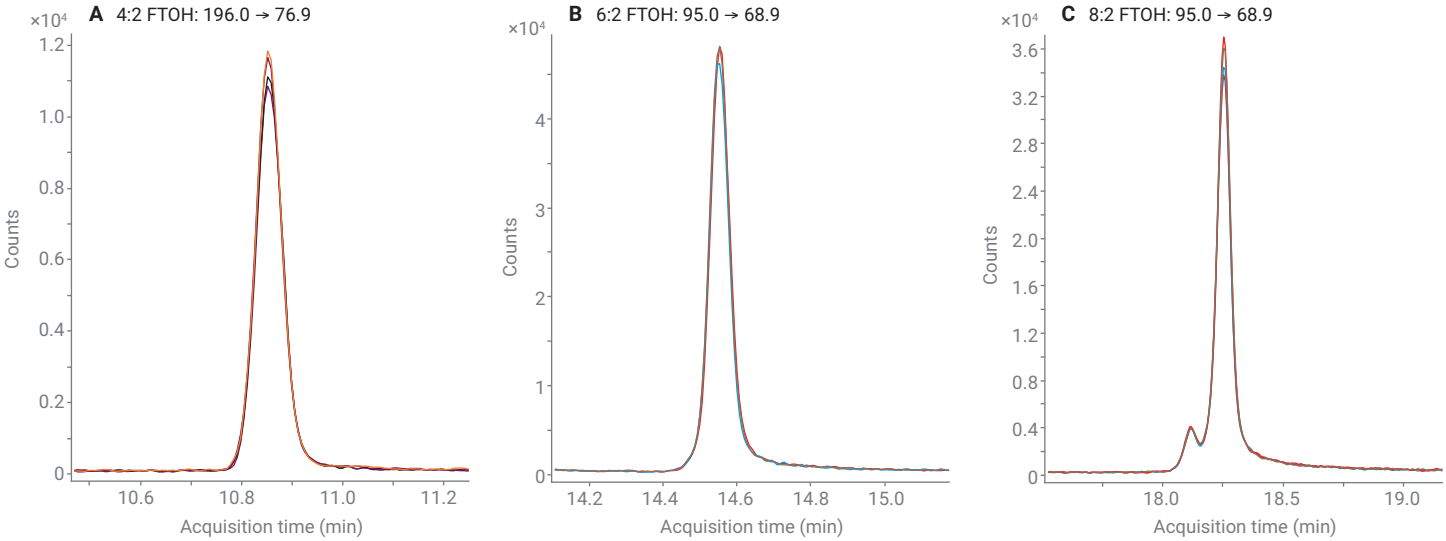

Figure 8. MRM overlays of four technical preparations at the LOQ for (A) 4:2 FTOH, (B) 6:2 FTOH, and (C) 8:2 FTOH.

Table 2. Analytical performance summary (continued on next page).

No.	Compound Name	CAS	ISTD	CF R^2	MDL (µg/kg)	LOQ_{vali} (µg/kg)	Recovery at LOQ Level (%)
1	((2,2,3,3-Tetrafluoropropoxy)methyl)oxirane	19932-26-4	$^{13}C_2$-6:2 FTOH	0.995	0.20	100	66
2	10:1 FTOH	307-46-0	$^{13}C_2$-6:2 FTOH	0.999	0.85	20	71
3	10:2 FTOH	865-86-1	$^{13}C_2$-6:2 FTOH	0.999	1.23	20	103
4	11:1 FTOH	423-65-4	$^{13}C_2$-6:2 FTOH	0.999	1.27	20	127
5	1H,1H,8H,8H-Perfluoro-3,6-dioxaoctane-1,8-diol	129301-42-4	$^{2}H_3$-N-MeFOSA	0.997	0.74	20	81
6	1H,1H,9H-Perfluorononyl acrylate	4180-26-1	$^{13}C_2$-6:2 FTOH	0.999	0.69	20	65
7	1H,1H-Perfluoro-3,6,9-trioxadecan-1-ol	147492-57-7	$^{13}C_2$-6:2 FTOH	0.996	0.17	20	83
8	1H,1H-Perfluorooctyl acrylate	307-98-2	$^{13}C_2$-6:2 FTOH	0.995	0.75	100	66
9	3-(Perfluorohexyl)-1,2-epoxypropane	38565-52-5	$^{13}C_2$-6:2 FTOH	0.991	0.31	20	67
10	3:3 FTOH	679-02-7	$^{13}C_2$-6:2 FTOH	0.995	0.94	20	93
11	4:2 FTOH	2043-47-2	$^{13}C_2$-6:2 FTOH	0.996	0.24	20	96
12	5H 4:1 FTOH7	355-80-6	$^{13}C_2$-6:2 FTOH	0.994	0.97	100	68
13	6:1 FTOH	375-82-6	$^{13}C_2$-6:2 FTOH	0.996	0.62	20	79
14	6:2 FTOH	647-42-7	$^{13}C_2$-6:2 FTOH	0.993	0.27	20	67
15	7:3 FTOH	25600-66-2	$^{13}C_2$-6:2 FTOH	0.997	0.63	20	84
16	7H 6:1 FTOH	335-99-9	$^{13}C_2$-6:2 FTOH	0.998	1.54	20	69
17	8:2 FTAC	27905-45-9	$^{13}C_2$-6:2 FTOH	0.992	1.12	20	90
18	8:2 FTOH	678-39-7	$^{13}C_2$-6:2 FTOH	0.996	0.51	20	68
19	FBSA	30334-69-1	$^{2}H_3$-N-MeFOSA	0.998	0.58	20	88
20	FHxSA	41997-13-1	$^{2}H_3$-N-MeFOSA	0.999	0.69	20	100
21	MeFBSA	68298-12-4	$^{2}H_3$-N-MeFOSA	0.998	0.47	20	72
22	MeFHxSA	68259-15-4	$^{2}H_3$-N-MeFOSA	0.998	0.27	20	74
23	MeFOSE	24448-09-7	d_7-N-MeFOSE-M	0.994	0.23	20	67
24	N-EtFOSA	4151-50-2	$^{2}H_3$-N-MeFOSA	0.997	0.46	20	88
25	N-EtFOSE	1691-99-2	$^{2}H_9$-EtFOSE	0.992	0.07	100	72
26	N-MeFOSA	31506-32-8	$^{2}H_3$-N-MeFOSA	0.996	0.33	20	79

N.D. = Not determined due to significant matrix effects.

No.	Compound Name	CAS	ISTD	CF R^2	MDL (µg/kg)	LOQ_{vali} (µg/kg)	Recovery at LOQ Level (%)
27	Nonafluoropentanamide	13485-61-5	$^{13}C_2$-6:2 FTOH	0.998	1.79	20	76
28	Perfluoro-3,6,9-trioxatridecanoic acid	330562-41-9	$^{13}C_2$-6:2 FTOH	0.996	N.D.	N.D.	N.D.
29	Perfluorooctanamide	423-54-1	$^{13}C_2$-6:2 FTOH	0.991	0.55	200	75
30	Perfluoropentanamide	355-81-7	$^{13}C_2$-6:2 FTOH	0.991	0.24	200	70
31	PFHxDA	67905-19-5	$^{13}C_2$-6:2 FTOH	0.994	N.D.	N.D.	N.D.
32	PFODA	16517-11-6	$^{13}C_2$-6:2 FTOH	0.995	N.D.	N.D.	N.D.
33	PFOSA	754-91-6	$^{2}H_3$-N-MeFOSA	0.997	1.26	20	111
34	Triethoxy((perfluorohexyl)ethyl)silane	51851-37-7	$^{2}H_3$-N-MeFOSA	0.996	0.64	100	68

N.D. = Not determined due to significant matrix effects.

Analysis of RB and MBs

A reagent blank (RB, equivalent to procedural blank) was processed through all stages of sample preparation and analyzed for the target compounds to evaluate contamination arising from the consumables and reagents used in the workflow. The concentration of all targets in the RB was less than 25% of the concentration in matrix blank (MB), indicating minimal PFAS background contribution from the sample preparation process.[11] Duplicate preparations of MB with ISTD addition were performed by the PAL3 Series 2 RTC autosampler. Certain PFAS, including PFOSA and MeFOSE, were detected at concentrations above the MDL level in the MB. This result confirms that the heat-assisted solvent extraction effectively leached PFAS from the paper coffee cup samples. The presence of PFAS in the samples also provides insights that authorities can use to establish regulatory limits for PFAS in FCMs.

Prespiked recovery

Prespiked QC recovery was used to evaluate the extraction efficiency and accuracy of the automated workflow. Both target analytes and ISTDs were automatically spiked into vials after sample weighing, and prepared using the procedure illustrated in Figure 3. The PAL3 Series 2 RTC autosampler prepared three levels of prespiked QC samples, with four separate technical replicates of the LSQ, MSQ, and HSQ samples. Each prespiked QC sample was analyzed in duplicate using the 7010D GC/TQ. Target recovery for each QC level was calculated from the average of eight analyses (two injections per technical preparation). Overall, 71% of analytes at the LSQ, 85% at the MSQ, and 85% at the HSQ had a recovery range of 65 to 135%, meeting the general performance criteria set by the AOAC for PFAS in food. The results demonstrate the excellent sample extraction efficiency and accuracy of the automated workflow for the analysis of PFAS in FCMs using a PAL3 Series 2 RTC autosampler with an Agilent 7010D GC/TQ. Consistently poor recovery (< 50%) was observed for three analytes — perfluoro-3,6,9-trioxatridecanoic acid, PFHxDA, and PFODA — across all QC samples, due to significant matrix effects (ion suppression).

Method precision was assessed based on the %RSD of QC recoveries (n = 8). Overall, a %RSD of less than 20 was achieved for all target analytes across three QC levels. Figure 9 shows the %RSD of recoveries at the MSQ for all targets, demonstrating the good precision of the automated analytical workflow for quantifying volatile PFAS in FCMs in a batch preparation (intrabatch). To further evaluate the reproducibility of the workflow, interbatch analyses were conducted on different days using different lots of coffee cup samples, liners, and columns. An interbatch recovery reproducibility ($\%RSD_R$) of ≤ 20 was achieved for all target analytes at the MSQ, except for perfluoro-3,6,9-trioxatridecanoic acid, PFHxDA, and PFODA, due to poor response. These results confirmed the excellent reproducibility of the automated PAL3 Series 2 RTC autosampler with Agilent 7010D GC/TQ-based workflow for volatile PFAS analysis in FCMs.

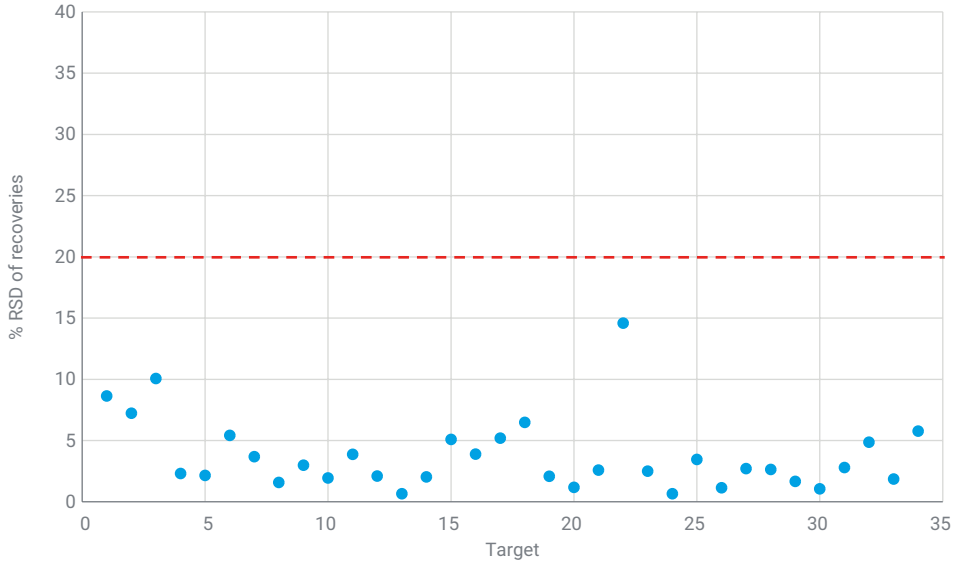

Figure 9. %RSD of recoveries at the MSQ for all targets from intrabatch analyses.

Conclusion

This study demonstrates a robust and fully automated method for the analysis of volatile PFAS in FCMs using a PAL3 Series 2 RTC autosampler coupled with an Agilent 7010D GC/TQ system. The Agilent MassHunter Optimizer proved invaluable by simplifying and accelerating the development of the acquisition method for the volatile PFAS, making the process user-friendly and efficient. The 7010D GC/TQ system with the next-generation HES 2.0 ion source provided exceptional sensitivity, achieving sub-ppb MDLs for the majority of PFAS analytes. This high level of sensitivity ensures accurate quantitation of trace levels of volatile PFAS, which is essential for reliable analysis. Notably, for all FTOHs, an LOQ of 20 µg/kg with recoveries ranging from 65 to 135% and %RSD < 10 were achieved, highlighting the high extraction efficiency, accuracy, and reliability of the automated PAL3 Series 2 RTC autosampler with Agilent 7010D GC/TQ workflow for PFAS analysis in FCMs.

Automation of the workflow offers significant advantages for routine laboratory operations. Automation reduces human errors, eliminates the need for manual intervention, decreases chemical usage, and enhances overall laboratory productivity. This high-throughput solution is not only reliable but can be used to provide valuable food safety guidance to regulatory bodies by ensuring that trace-level volatile PFAS monitoring in FCMs is efficient and accurate.

References

1. Consumer Reports. Dangerous PFAS Chemicals Are in Your Food Packaging. https://www.consumerreports.org/health/food-contaminants/dangerous-pfas-chemicals-are-in-your-food-packaging-a3786252074/ (accessed Oct 10, 2024).
2. OECD. PFASs and Alternatives in Food Packaging (Paper and Paperboard) Report on the Commercial Availability and Current Uses; OECD Series on Risk Management, No. 58; Environment, Health and Safety, Environment Directorate, OECD: Paris, **2020**.
3. Li, D.; *et al.* The Determination of Trace Per- and Polyfluoroalkyl Substances and Their Precursors Migrated into Food Simulants from Food Contact Materials by LC-MS/MS and GC-MS/MS. *LCGC North America* 07-01-**2019**, *37(7)*.
4. U.S. Food and Drug Administration. Market Phase-Out of Grease-Proofing Substances Containing PFAS, FDA. https://www.fda.gov/food/process-contaminants-food/market-phase-out-grease-proofing-substances-containing-pfas. (accessed Oct 10, 2024).
5. European Union. Commission Regulation (EU) No 10/2011.
6. European Chemicals Agency. ANNEX XV Restriction Report Proposal for a Restriction; ECHA: Helsinki, March **2023**.
7. Larson, N. Method Development and Screening of Extractable Organofluorine (EOF) and Targeted PFAS Analysis in Food Packaging Materials. Bachelor thesis, Chemistry. School of Science and Technology, Örebro University. *DiVA*. Spring, **2022**.
8. Wong, L.; *et al.* Accurate Mass Library for PFAS Analysis in Environmental Samples and Workflow for Identification of Pollutants in Drinking Water Using GC/Q-TOF. *Agilent Technologies application note*, publication number 5994-2291EN, **2024**.
9. Wells, G.; Prest, H.; Russ, C. W. Agilent Technologies. Signal, Noise, and Detection Limits in Mass Spectrometry. *Agilent Technologies application note*, publication number 5990-7651EN, **2023**.
10. U.S. Environmental Protection Agency. Definition and Procedure for the Determination of the Method Detection Limit, Revision 2; EPA 821-R-16-006; U.S. EPA: Washington, DC, December, **2016**.
11. AOAC International. Standard Method Performance Requirements (SMPRs) for Per- and Polyfluoroalkyl Substances (PFAS) in Produce, Beverages, Dairy Products, Eggs, Seafood, Meat Products, and Feed; AOAC SMPR2023.003. **2023**.

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