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Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples Per EPA Method 1633

Agilent Bond Elut PFAS WAX SPE cartridges

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Abstract

United States (US) Environmental Protection Agency (EPA) Method 1633[1] is an analysis method for the detection and quantitation of per- and polyfluoroalkyl substances (PFAS) in many matrices including wastewater, soils, solids, and tissues. A previous application note[2] used existing solid phase extraction (SPE) technology and highlighted Agilent instrument performance. This application note addresses PFAS testing in aqueous wastewater samples per the EPA Method 1633 using Agilent Bond Elut PFAS WAX SPE cartridges. The instrumentation for analysis utilized the Agilent 1290 Infinity II liquid chromatograph (LC) system coupled to the Agilent 6470 triple quadrupole (TQ) mass spectrometer (LC/TQ). The study verified method performance in terms of analyte extraction recoveries, sensitivity (method detection limits), and reproducibility.

Introduction

Many methods perform the analyses of PFAS in drinking water, non-potable water, soil, sediments, landfill leachate, and other potentially complex matrices. EPA Method 1633 is an isotope dilution method that strives to standardize the methodology for the quantitation of 40 PFAS across nine compound classes. These classes include linear and branched isomers in nonpotable aqueous, solid, biosolid, and tissue samples. All analytes listed in EPA drinking water Methods 533 and 537.1 are included in the method. While samples are prepared and extracted according to their matrices, all the methods within EPA Method 1633 specify SPE using weak anion exchange (WAX) and carbon cleanup.

This application note focuses on EPA Method 1633 for aqueous matrices using a 150 mg, 6 mL Agilent Bond Elut PFAS WAX cartridge for SPE and Carbon S for cleanup. Bond Elut PFAS WAX SPE cartridges are specifically designed for PFAS analysis and comply with stringent regulatory requirements. The cartridges undergo PFAS-specific QC testing to ensure optimal cleanliness and recovery. The 500 mg, 6 mL Bond Elut PFAS WAX cartridge was previously investigated for EPA Method 533 and an extended panel, with excellent results.[3] Carbon S is an advanced hybrid carbon material with optimized carbon content and pore structure providing a better balance between analyte recovery and matrix removal efficiency than traditional GCB sorbent.[4]

Initial performance tests, including precision, recovery, and detection limits, used an Agilent 1290 Infinity II LC system coupled to an Agilent 6470 triple quadrupole LC/MS (LC/TQ). Method performance for the analysis of wastewater effluent was also evaluated. The method was followed closely; only permitted changes in supplies and instrumentation parameters were made. Sample size was 500 mL.

Experimental

Consumables and supplies

To assist laboratories in preparing to run the method, a list of Agilent consumables used in this application note is provided in the appendix.

Extraction procedure

The extraction procedure for aqueous samples described in EPA Method 1633 was followed (Figure 1) for reagent water and wastewater effluent grab samples. Briefly, unpreserved 500 mL aqueous samples were fortified with surrogates (extracted internal standards [EIS]). Bond Elut PFAS WAX SPE cartridges packed with silanized glass wool were conditioned with methanolic ammonium hydroxide followed by formic acid. Samples were loaded onto the SPE cartridges at a slow flow rate and rinsed with reagent water and 1:1 formic acid/methanol. The sample bottles were rinsed, and cartridges eluted with 1% methanolic ammonium hydroxide. The eluate was treated with acetic acid and cleaned up with loose Carbon S.

After centrifugation, the samples were filtered through a nylon syringe filter into a collection tube containing internal standard (nonextracted internal standard [NIS]).

LC/TQ instrument conditions

LC/TQ analysis was performed using a 1290 Infinity II LC system coupled to a 6470 triple quadrupole LC/TQ. The LC configuration and method parameters are shown in Table 1. The PFAS-specific delay column was placed between the pump and multisampler to separate background contaminants from compounds originating in the sample vial without significantly increasing backpressure. The system was controlled by Agilent MassHunter Acquisition software. The mobile phases were matched to the EPA Method 1633 for consistency; however, the gradient was simplified to increase throughput while maintaining the separation needed in the method. The MS method parameters (Table 2) were optimized using the Agilent Source Optimizer. Dynamic multiple reaction monitoring (dMRM) in negative electrospray ionization mode was used for data acquisition. dMRM methods for Agilent triple quadrupole instruments enable accurate quantification of exceedingly narrow peaks from fast 1290 Infinity UHPLC separations for multi-analyte assays. The number of MRM transitions is adjusted dynamically throughout the LC run, selecting only transitions with relevant retention time windows. The analyte transitions selected (provided in the appendix) were similar to those listed in the method. Data were processed using MassHunter Quantitative analysis for QQQ software version 10.1.
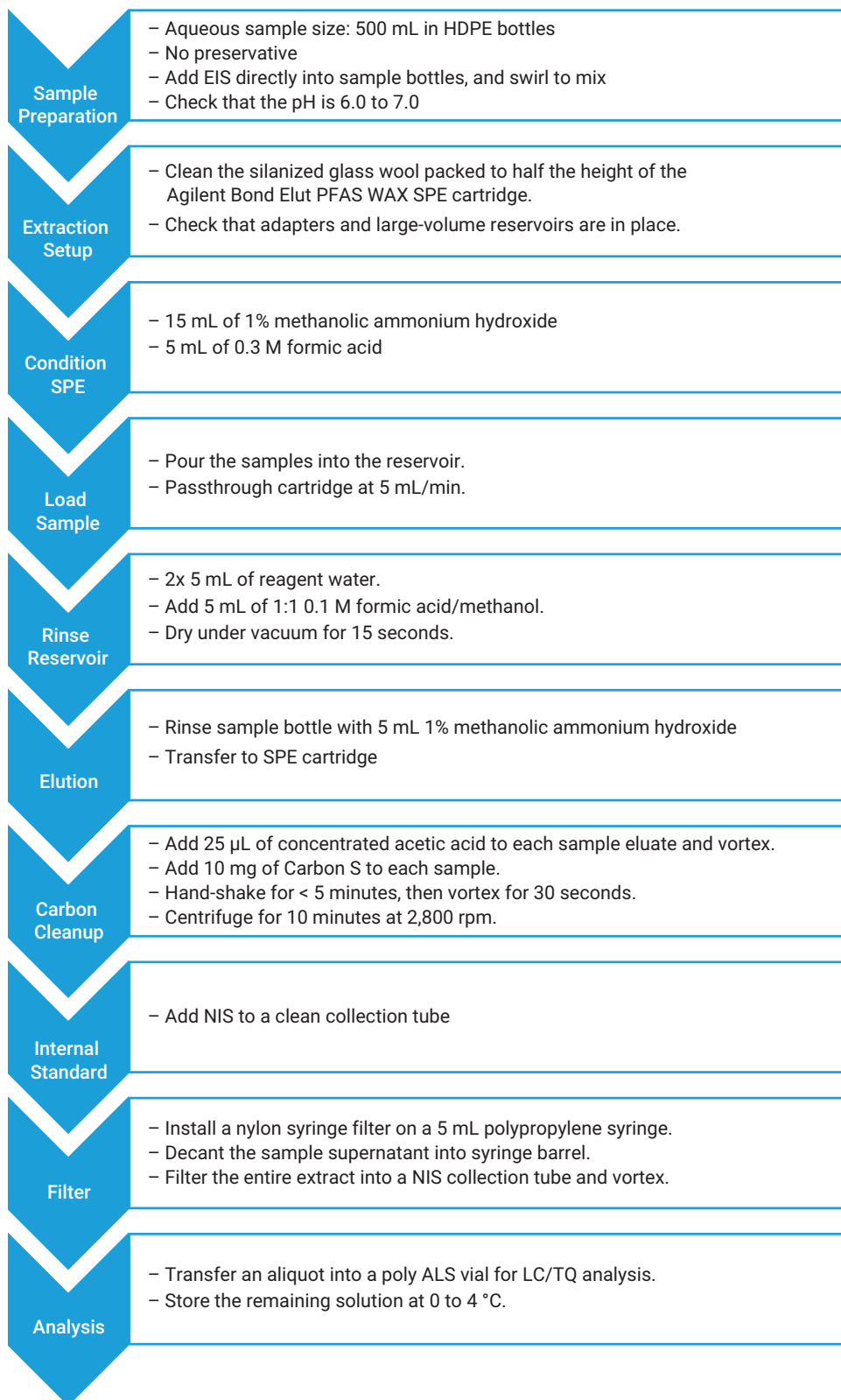
Sample Preparation
- Aqueous sample size: 500 mL in HDPE bottles
- No preservative
- Add EIS directly into sample bottles, and swirl to mix
- Check that the pH is 6.0 to 7.0

Extraction Setup
- Clean the silanized glass wool packed to half the height of the Agilent Bond Elut PFAS WAX SPE cartridge.
- Check that adapters and large-volume reservoirs are in place.

Condition SPE
- 15 mL of 1% methanolic ammonium hydroxide
- 5 mL of 0.3 M formic acid

Load Sample
- Pour the samples into the reservoir.
- Passthrough cartridge at 5 mL/min.

Rinse Reservoir
- 2x 5 mL of reagent water.
- Add 5 mL of 1:1 0.1 M formic acid/methanol.
- Dry under vacuum for 15 seconds.

Elution
- Rinse sample bottle with 5 mL 1% methanolic ammonium hydroxide
- Transfer to SPE cartridge

Carbon Cleanup
- Add 25 µL of concentrated acetic acid to each sample eluate and vortex.
- Add 10 mg of Carbon S to each sample.
- Hand-shake for < 5 minutes, then vortex for 30 seconds.
- Centrifuge for 10 minutes at 2,800 rpm.

Internal Standard
- Add NIS to a clean collection tube

Filter
- Install a nylon syringe filter on a 5 mL polypropylene syringe.
- Decant the sample supernatant into syringe barrel.
- Filter the entire extract into a NIS collection tube and vortex.

Analysis
- Transfer an aliquot into a poly ALS vial for LC/TQ analysis.
- Store the remaining solution at 0 to 4 °C.

Figure 1. Extraction procedure.

Calibration standards

Analytical standard mixes were purchased from Wellington Laboratories. Subsequent combination and dilution of the standards were performed to prepare a high calibrator (level 10) with analyte concentrations closely mirroring those in the high calibration standard of the method. A series of dilutions was prepared to a final calibrator concentration below that of the low standard in the method.

Results and discussion

Calibration performance

Instrument linearity was established per the method guidelines and is described elsewhere.[2] However, briefly all analytes had stable retention times with RSDs less than 3%, and excellent R^2 values of greater than 0.998. The relative standard errors (RSE) of the analytes were less than 10%. EPA Method 1633 specifies that the chromatographic separation between the bile salts (TDCA) and PFOS must be at least 1 minute. The analytical conditions used met the criteria with TDCA and PFOS eluting at 5.7 and 7.1 minutes, respectively.

Surrogate recoveries

Extracted surrogate recovery in reagent water for n = 21 replicates (lab reagent blanks, precision and accuracy spikes, and low-level spikes for determining MDL) ranged from 63 to 121%. The recoveries also had RSDs of less than 20%. This is well within typically acceptable EPA surrogate recovery range of 50 to 150% and RSDs of < 20%.

Table 1. LC instrument conditions.

Parameter	Value
LC	Agilent 1290 Infinity II LC with G7120A High Speed Pump (G7120A), Multisampler (G7167B), Multicolumn Thermostat column compartment (G7116B)
UHPLC Guard Column	Agilent ZORBAX Eclipse Plus C18, 2.1 × 5 mm, 1.8 µm (part number 821725-901)
Analytical Column	Agilent ZORBAX Eclipse Plus C18, 2.1 × 100 mm, 1.8 µm (part number 959758-902)
Delay Column	Agilent InfinityLab PFC Delay Column, 4.6 × 30 mm (part number 5062-8100)
Column Temperature	40 °C
Injection Volume	5 µL
Mobile Phase	A) 2 mM Ammonium acetate in 95% water (LC grade), 5% acetonitrile B) Acetonitrile (LC grade)
Gradient Flow Rate	0.4 mL/min
Gradient	Time (min) % B 0.0 2 0.2 2 10 95
Stop Time	12.2 min
Post Time	2.0 min

Table 2. TQ instrument conditions.

Parameter	Value
MS	Agilent 6470B LC/TQ with Agilent Jet Stream ESI source
Source Parameters	
Gas Temperature	230 °C
Gas Flow	6 L/min
Nebulizer	20 psi
Sheath Gas Temperature	355 °C
Sheath Gas Flow	10 L/min
Capillary Voltage (Neg)	2,500 V
Nozzle Voltage (Neg)	0 V

Method detection limits

Method detection limits (MDLs) were determined according to the MDL procedure in 40 CFR Part 136, appendix B. Initial MDLs achieved following extraction of low-level spikes and lab reagent blanks (LRB) with the Bond Elut PFAS WAX SPE are equivalent or better than those documented in the method. See Table 3 for more details.

Precision and accuracy

Precision and accuracy extraction studies at the mid-level concentration produced excellent reproducibility. All RSDs were less than 9% and recoveries (expressed as accuracy and shown in Figure 2) fell between 70 and 116%.

Table 3. Initial method detection limits achieved with the Agilent Bond Elut PFAS WAX SPE extraction of low-level spikes and lab reagent blanks (LRB).

Analyte	Bond Elut PFAS WAX Initial MDL (ng/L)	EPA 1633 Aq. MDL (ng/L)*	Analyte	Bond Elut PFAS WAX Initial MDL (ng/L)	EPA 1633 Aq.MDL (ng/L)*
PFBA	0.38	0.79	6:2FTS	0.58	2.45
PFPeA	0.71	0.54	8:2FTS	0.84	2.50
PFHxA	0.09	0.46	PFOSA	0.20	0.32
PFHpA	0.19	0.37	NMeFOSA	0.09	0.43
PFOA	0.23	0.54	NEtFOSA	0.17	0.45
PFNA	0.15	0.45	NMeFOSAA	0.27	0.68
PFDA	0.15	0.52	NEtFOSAA	0.34	0.59
PFUnA	0.13	0.45	NMeFOSE	1.41	3.81
PFDoA	0.29	0.40	NEtFOSE	1.97	4.84
PFTrDA	0.33	0.46	HFPO-DA	0.60	0.51
PFTeDA	0.38	0.49	ADONA	0.26	0.50
PFBS	0.12	0.37	PFMPA	0.36	1.46
PFPeS	0.15	0.50	PFMBA	0.13	1.41
PFHxS	0.26	0.54	NFDHA	0.38	0.75
PFHpS	0.21	0.50	9Cl-PF3ONS	0.52	1.38
PFOS	0.39	0.63	11Cl-PF3OUdS	1.38	1.67
PFNS	0.15	0.47	PFEESA	0.26	1.17
PFDS	0.23	0.60	3:3 FTCA	0.82	2.47
PFDoS	0.44	0.60	5:3 FTCA	3.77	9.59
4:2FTS	0.43	1.69	7:3 FTCA	3.27	8.71

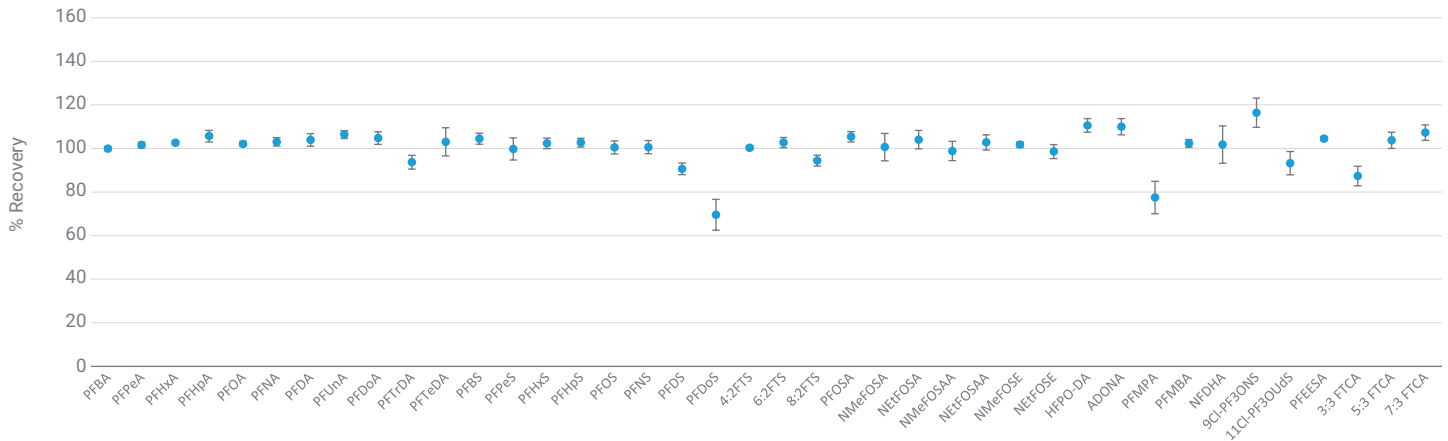* EPA Method 1633 — Table 9, multi-lab validation results.

Figure 2. Performance demonstrated by precision and accuracy in reagent water using Agilent Bond Elut PFAS WAX SPE cartridges.

Wastewater effluent samples

To demonstrate the real-world applicability of EPA Method 1633 and Bond Elut PFAS WAX SPE cartridges, three unique wastewater effluent samples were analyzed in replicate. Several PFAS were detected in each sample as shown in Figure 3. Perfluoroalkyl carboxylic acids were the most common group detected, with PFHxA consistently having the highest concentration among the acids. Also, 6:2 FTS (fluorotelomer sulfonate) was detected in all samples at concentrations up to 34 ng/L.

Replicates (three or four) of each of the three wastewater effluent samples were spiked with target analytes and extracted following the method procedure. The average background levels of the unspiked wastewater samples were subtracted from the measured concentration in the spiked samples and the recovery (accuracy) calculated. Table 4 shows the spiked concentration, the average recovery (accuracy), and the range of recoveries of the batches.

Surrogate recoveries in wastewater effluent (n = 24) were generally between 50 and 150% with good reproducibility. However, the FTS class of PFAS extracted surrogates had consistently high recoveries in matrix, demonstrating the importance of matched and labeled internal standards to accurately correct for matrix effects.
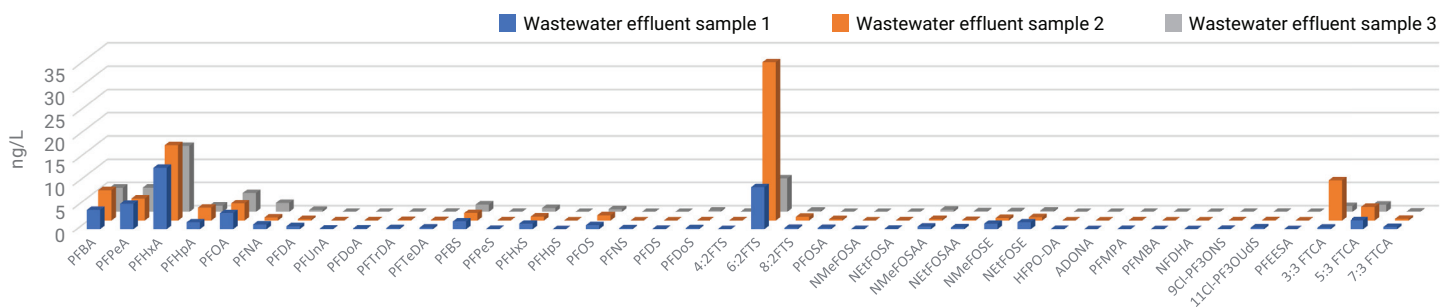

Figure 3. PFAS detected in wastewater effluent.

Table 4. Spiked concentration, average recovery (accuracy), and range of recoveries of PFAS in wastewater samples.

Analyte	Spiked Concentration (ng/L)	Average Accuracy (Recovery)	Low Average Recovery Range	High Average Recovery Range
PFBA	50	91%	86%	99%
PFPeA	25	88%	84%	95%
PFHxA	12.5	93%	85%	103%
PFHpA	12.5	97%	91%	104%
PFOA	12.5	96%	87%	107%
PFNA	12.5	94%	85%	101%
PFDA	12.5	96%	90%	103%
PFUnA	12.5	95%	90%	101%
PFDoA	12.5	92%	87%	95%
PFTrDA	12.5	90%	85%	96%
PFTeDA	12.5	96%	88%	103%
PFBS	12.5	104%	92%	114%
PFPeS	12.5	92%	86%	98%
PFHxS	12.5	91%	88%	94%
PFHpS	12.5	99%	90%	105%
PFOS	12.5	97%	84%	105%
PFNS	12.5	82%	76%	87%
PFDS	12.5	70%	65%	76%
PFDoS	12.5	48%	45%	50%
4:2FTS	50	95%	90%	104%
6:2FTS	50	95%	92%	99%
8:2FTS	50	89%	77%	105%
PFOSA	12.5	96%	88%	103%
NMeFOSA	12.5	89%	83%	93%
NEtFOSA	12.5	92%	81%	99%
NMeFOSAA	12.5	105%	100%	115%
NEtFOSAA	12.5	96%	92%	103%
NMeFOSE	125	92%	86%	101%
NEtFOSE	125	93%	89%	98%
HFPO-DA	50	109%	90%	120%
ADONA	50	111%	91%	122%
PFMPA	25	103%	95%	111%
PFMBA	25	102%	93%	106%
NFDHA	25	48%	39%	54%
9Cl-PF3ONS	50	100%	82%	109%
11Cl-PF3OUdS	50	74%	61%	84%
PFEESA	25	96%	93%	101%
3:3 FTCA	50	114%	97%	127%
5:3 FTCA	250	153%	136%	169%
7:3 FTCA	250	141%	117%	156%

Conclusion

This application note presented an example of the experimental performance that can be obtained following EPA Method 1633. The performance was for the analysis of 25 extracted internal standards (surrogates) and 40 target PFAS in aqueous samples using the Agilent Bond Elut PFAS WAX SPE cartridges. The method was verified using optimized solid phase sample extraction and analysis using the Agilent 1290 Infinity II LC coupled to the 6470 LC/TQ. The midconcentration level precision and accuracy demonstrated strong performance with RSDs less than 9% and recoveries between 70 and 130%. Initial method detection limits (MDL) were comparable to those in the method. Examples of PFAS detected in wastewater effluent were described and the recoveries of both surrogate and target analytes in wastewater effluent spiked with all analytes were demonstrated.

Appendix

Agilent consumables and supplies used in this application note for EPA Method 1633

Please reference the PFAS consumables ordering guide (5994-2357EN) for more consumables recommendations.

Description	Specifics	Part Number
PFC Delay Column	Agilent InfinityLab PFC Delay Column 4.6 × 30 mm	5062-8100
UHPLC Guard Column	Agilent ZORBAX Eclipse Plus C18, 2.1 × 5 mm, 1.8 μm	821725-901
Analytical Column	Agilent ZORBAX Eclipse Plus C18, 2.1 × 100 mm, 1.8 μm	959758-902
Autosampler Vials	Vial, screw, 2 mL, polypropylene, certified for PFAS, 100/pk	5191-8121
Autosampler Caps	Cap, 9 mm, screw, clear, thin membrane polypropylene/silicone septa, certified for PFAS, 100/pk	5191-8151
SPE Cartridges	Bond Elut PFAS WAX SPE cartridges, 150 mg, 6 mL, 30/pk	5610-2150
Glass Wool	Glass wool, silane treated, 50 g	8500-1572
Centrifuge Tubes	Centrifuge tubes and caps, 15 mL, 50/pk	5610-2039
Carbon	Carbon S bulk, 25 g bottle	5610-2093
Syringes	5 mL disposable syringe, 100/pk	9301-6476
Nylon Filters	Agilent Captiva Premium Syringe Filter, nylon, 25 mm, 0.2 μm, 100/pk	5190-5092

dMRM transitions monitored

Compound Group	Compound Name	Precursor Ion	Product Ion	RT (min)	Fragmentor	Collision Energy	Cell Accelerator Voltage
Acid	PFBA	213	168.9	3.5	60	8	2
Acid	PFPeA	263	219	4.5	72	4	2
Acid	PFHxA	313	268.9	5.2	70	8	2
Acid	PFHxA	313	119	5.2	70	18	2
Acid	PFHpA	362.9	319	5.7	72	4	2
Acid	PFHpA	362.9	169	5.7	72	14	2
Acid	PFOA	413	369	6.2	69	4	2
Acid	PFOA	413	169	6.2	69	12	2
Acid	PFNA	463	419	6.6	66	4	2
Acid	PFNA	463	219	6.6	66	17	2
Acid	PFDA	513	469	7.0	72	12	2
Acid	PFDA	513	219	7.0	72	20	2
Acid	PFUnA	563	519	7.5	100	12	2
Acid	PFUnA	563	269	7.5	100	20	2
Acid	PFDoA	613	569	7.9	100	8	2
Acid	PFDoA	613	319	7.9	100	20	2
Acid	PFTrDA	663	619	8.2	100	12	2
Acid	PFTrDA	663	169	8.2	100	32	2
Acid	PFTeDA	712.9	669	8.6	100	12	2
Acid	PFTeDA	712.9	169	8.6	100	32	2
Ether Sulfonic Acids	PFEESA	314.9	134.9	5.6	110	24	2
Ether Sulfonic Acids	PFEESA	314.9	83	5.6	124	20	5
Ether Sulfonic Acids	PFEESA	314.9	69	5.6	110	60	2
Ether Sulfonic Acids	9Cl-PF3ONS	530.9	350.9	7.6	145	28	2
Ether Sulfonic Acids	9Cl-PF3ONS	530.9	83	7.6	145	32	2
Ether Sulfonic Acids	11Cl-PF3OUdS	630.9	83	8.4	160	32	2
Ether Sulfonic Acids	11Cl-PF3OUdS	630.9	450.9	8.4	165	32	2
Flurotelomer Carboxylic Acid	3-3 FTCA	241	177	4.2	74	4	3
Flurotelomer Carboxylic Acid	3-3 FTCA	241	117	4.2	74	44	3
Flurotelomer Carboxylic Acid	5-3 FTCA	341	237	5.6	84	12	3

Compound Group	Compound Name	Precursor Ion	Product Ion	RT (min)	Fragmentor	Collision Energy	Cell Accelerator Voltage
Flurotelomer Carboxylic Acid	5-3 FTCA	341	217	5.6	84	24	3
Flurotelomer Carboxylic Acid	7-3 FTCA	441	337	6.6	76	12	3
Flurotelomer Carboxylic Acid	7-3 FTCA	441	317	6.6	76	24	3
FTS	4:2FTS	327	306.9	5.0	125	20	2
FTS	4:2FTS	327	80.9	5.0	125	36	2
FTS	6:2FTS	427	406.8	6.0	125	24	2
FTS	6:2FTS	427	80.9	6.0	125	40	2
FTS	8:2FTS	527	507	6.8	200	30	4
FTS	8:2FTS	527	80.9	6.8	170	40	2
ISTD	13C3-PFBA	216	171.9	3.5	65	8	2
ISTD	13C2-PFHxA	315	270	5.2	70	8	2
ISTD	13C4-PFOA	417	172	6.2	69	12	2
ISTD	18O2-PFHxS	403	83.9	6.4	100	49	2
ISTD	13C5-PFNA	468	423	6.6	66	4	2
ISTD	13C2-PFDA	515	470	7.0	81	4	2
ISTD	13C4-PFOS	503	80	7.3	148	54	2
ISTD	13C4-PFOS	502.9	98.9	7.3	180	48	2
Perfluorooctane Sulfonamide Ethanols	NMeFOSE	616	59	9.8	82	15	4
Perfluorooctane Sulfonamide Ethanols	NEtFOSE	630	59	10.1	124	45	4
Perfluorooctane Sulfonamides	PFOSA	497.9	478	8.6	150	36	3
Perfluorooctane Sulfonamides	PFOSA	497.9	78	8.6	150	36	3
Perfluorooctane Sulfonamides	PFOSA	497.9	48	8.6	150	110	3
Perfluorooctane Sulfonamides	NMeFOSA	512	219	9.9	156	28	5
Perfluorooctane Sulfonamides	NMeFOSA	512	169	9.9	156	32	5
Perfluorooctane Sulfonamides	NEtFOSA	526	269	10.3	160	28	5
Perfluorooctane Sulfonamides	NEtFOSA	526	219	10.3	160	28	5
Perfluorooctane Sulfonamides	NEtFOSA	526	169	10.3	160	28	5
Perfluorooctane Sulfonamidoacetic Acids	NMeFOSAA	570	482.9	7.1	150	16	2
Perfluorooctane Sulfonamidoacetic Acids	NMeFOSAA	570	419	7.1	150	20	2
Perfluorooctane Sulfonamidoacetic Acids	NEtFOSAA	584	526	7.3	100	20	2
Perfluorooctane Sulfonamidoacetic Acids	NEtFOSAA	584	419	7.3	100	20	2
Polyfluoroether Carboxylic Acids	PFMPA	229	84.9	4.0	60	12	2
Polyfluoroether Carboxylic Acids	PFMBA	279	235	4.8	80	1	5
Polyfluoroether Carboxylic Acids	PFMBA	279	84.9	4.8	70	12	2
Polyfluoroether Carboxylic Acids	NFDHA	295	201	5.1	75	5	2
Polyfluoroether Carboxylic Acids	NFDHA	295	85	5.1	120	32	5
Polyfluoroether Carboxylic Acids	NFDHA	201	85	5.1	70	15	5
Polyfluoroether Carboxylic Acids	HFPO-DA	285	185	5.4	50	20	5
Polyfluoroether Carboxylic Acids	HFPO-DA	285	169	5.4	50	4	5
Polyfluoroether Carboxylic Acids	ADONA	377	250.9	5.9	80	12	2
Polyfluoroether Carboxylic Acids	ADONA	377	85	5.9	80	36	2
Sulfonate	PFBS	298.9	98.9	5.3	100	29	2
Sulfonate	PFBS	298.9	80	5.3	100	45	2
Sulfonate	PFPeS	348.9	98.9	5.9	135	40	2
Sulfonate	PFPeS	348.9	79.9	5.9	135	40	2
Sulfonate	PFHxS	398.9	99	6.4	100	45	2

Compound Group	Compound Name	Precursor Ion	Product Ion	RT (min)	Fragmentor	Collision Energy	Cell Accelerator Voltage
Sulfonate	PFHxS	398.9	80	6.4	100	49	2
Sulfonate	PFHpS	448.9	98.7	6.9	100	44	2
Sulfonate	PFHpS	448.9	80	6.9	148	50	2
Sulfonate	PFOS	498.9	99	7.3	100	50	2
Sulfonate	PFOS	498.9	80	7.3	100	50	2
Sulfonate	PFNS	548.9	99	7.7	148	52	2
Sulfonate	PFNS	548.9	80	7.7	148	56	2
Sulfonate	PFDS	598.9	99	8.1	148	56	2
Sulfonate	PFDS	598.9	80	8.1	148	60	2
Sulfonate	PFDoS	698.9	99	8.8	156	62	2
Sulfonate	PFDoS	698.9	80	8.8	156	67	2
Surrogate	13C4-PFBA	217	172	3.5	60	8	2
Surrogate	13C5-PFPeA	268	223	4.5	60	8	2
Surrogate	13C2-4:2FTS	329	309	5.0	125	20	2
Surrogate	13C2-4:2FTS	329	81	5.0	150	32	2
Surrogate	13C5-PFHxA	318	273	5.2	70	8	2
Surrogate	13C5-PFHxA	318	120	5.2	72	24	2
Surrogate	13C3-PFBS	302	99	5.3	130	32	2
Surrogate	13C3-PFBS	302	80	5.3	130	44	2
Surrogate	13C3-HFPO-DA	287	185	5.4	64	20	5
Surrogate	13C3-HFPO-DA	287	169	5.4	64	4	5
Surrogate	13C4-PFHpA	367	322	5.7	72	4	2
Surrogate	13C4-PFHpA	367	169	5.7	72	16	2
Surrogate	13C2-6:2FTS	429	409	6.0	125	24	2
Surrogate	13C2-6:2FTS	429	81	6.0	150	40	2
Surrogate	13C8-PFOA	421	376	6.2	69	4	2
Surrogate	13C8-PFOA	421	172	6.2	72	20	2
Surrogate	13C3-PFHxS	402	99	6.4	156	44	2
Surrogate	13C3-PFHxS	402	80	6.4	100	45	2
Surrogate	13C9-PFNA	472	427	6.6	66	4	2
Surrogate	13C9-PFNA	472	223	6.6	72	16	2
Surrogate	13C2-8:2FTS	529	509	6.8	170	28	2
Surrogate	13C2-8:2FTS	529	81	6.8	200	52	4
Surrogate	13C6-PFDA	519	474	7.0	72	8	2
Surrogate	D3-NMeFOSAA	573.2	419	7.1	150	20	2
Surrogate	D5-NEtFOSAA	589.2	419	7.2	100	20	2
Surrogate	13C8-PFOS	507	99	7.3	148	52	2
Surrogate	13C8-PFOS	507	80	7.3	100	50	2
Surrogate	13C7-PFUnA	570	525	7.5	100	8	2
Surrogate	13C2-PFDoA	615	570	7.9	90	12	2
Surrogate	13C2-PFTeDA	715	670	8.6	90	12	2
Surrogate	13C8-PFOSA	506	78	8.6	150	36	3
Surrogate	D7-NMeFOSE	623.2	59	9.8	82	15	4
Surrogate	D3-NMeFOSA	515	219	9.9	156	28	5
Surrogate	D9-NEtFOSE	639.2	59	10.1	124	45	4
Surrogate	D5-NEtFOSA	531	219	10.2	160	28	5
TDCA	TDCA	498.3	79.9	6.0	165	32	2

References

1. United States Environmental Protection Agency, Office of Water. Method 1633 Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC/MS/MS, **2024**. https://www.epa.gov/system/files/documents/2024-01/method-1633-final-for-web-posting.pdf (accessed April 29, 2024).

2. Hunt, K. *et al.* Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples Per EPA Method 1633 Using the Agilent 6470 Triple Quadrupole Mass Spectrometer, *Agilent Technologies application note*, publication number 5994-4926EN, **2022**.

3. Giardina, M. Determination of Per and Polyfluoroalkyl Substances in Drinking Water Using Agilent Bond Elut PFAS WAX SPE and LC/MS/MS, *Agilent Technologies application note*, publication number 5994-4960EN, **2022**.

4. Giardina, M. Determination of Per and Polyfluoroalkyl Substances in Soils Using Carbon S SPE by LC/MS/MS, *Agilent Technologies application note*, publication number 5994-4770EN, **2022**.

Additional resources

Bond Elut PFAS WAX cartridges:
www.agilent.com/chem/bond-elut-pfas-wax

PFAS Testing in Water:
www.agilent.com/chem/pfas-testing-in-water

PFAS Testing in Soil:
www.agilent.com/chem/pfas-testing-in-soil

PFAS Consumables Ordering Guide:
https://www.agilent.com/cs/library/brochures/brochure-PFAS-consumables-5994-2357EN-agilent-HR.pdf

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