Critical information for robust PFAS analysis

Per- and polyfluoroalkyl substances (PFAS) are a large group of human-made substances that are highly persistent in the environment. It is estimated that there are now over 6000 types of PFAS compounds. PFAS compounds are prevalent because they are persistent and used in a wide variety of products.

Consumers may be exposed to PFASs in non-stick cookware, grease-resistant paper, fast food wrappers, microwave popcorn bags, stain-resistant carpets and fabrics, water-resistant clothing, cleaning products, and personal care products.

PFASs are also used in industrial processes such as firefighting foams used by the military, airport authorities, and local fire and rescue agencies. The United States Environmental Protection Agency (EPA) says that it is these foams that are most often implicated when PFAS compounds are found in groundwater or in the environment.

The most well-known PFAS compounds, PFOA and PFOS, have been the most extensively produced and studied for chemical properties and toxicological effects. Both chemicals are very persistent in the environment and accumulate in the human body over time.

PFAS methods for low level detection

Though analyzed for many years, recent developments have resulted in the need to quantify PFAS compounds for potential compliance monitoring in public water supplies. Examples of methods developed by the EPA for drinking water are 537, 537.1 and 533. EPA methods developed for additional waters are EPA 8327 and ASTM 7979. New methods are under development for sediment and soil extracts.

Typical considerations for the development of validated methods are water type, such as drinking, surface or waste waters, calibration range, detection limit, screening, quantitation and other factors. The minimum reporting level (MRL) of EPA method 537.1 for the 18 PFAS compounds is 0.53–6.3 ng/L. The interference from solvents, reagents, containers, and SPE instruments needs to be maintained below 1/3 of the MRL value. The EPA method emphasizes that care must be taken with solid phase extraction (SPE) systems to ensure that PTFE commonly used in these systems does not contribute to background levels.

Sample preparation requirements for PFAS analysis

Analysis of PFAS compounds can be performed using direct injection, offline and online SPE. Because of their hydrophobicity and acidity, extracts are prepared in methanol and acetic acid prior to direct injection, such as in EPA 8327 and ASTM D7979. Offline and online SPE use weak anion exchange columns to preconcentrate the PFAS compounds and remove matrix prior to injection. An example of an offline SPE method is EPA 537.1 and EPA 533. Offline SPE can be manual or automated.

The analytical challenges of PFAS analysis

There are many analytical challenges encountered during PFAS analysis. Losses due to interaction with matrix, leaching from system components, laboratory environment, quality assurance requirements [limits of detection/limits of quantitation (LOD/LOQ), reproducibility, recovery, identification and confirmation] combined can pose some serious analytical challenges.

For quantitation, tandem mass spectrometry (MS/MS) systems are typically used. Validated methods are typically performed using MS/MS system as these have a select, targeted compound list. Due to the large number of possible PFAS compounds and lack of standards, PFAS analysis very often involves screening of unknowns. In such cases high resolution accurate mass (HRAM) methods are the logical approach. It is well known that Orbitrap™ technology has significantly greater resolving power, greater stability, dynamic range and that Orbitrap is the state-of-the-art technique for PFAS analysis using HRAM. Additional aspects are:

- Robustness – high throughput, less downtime to without compromising data quality.
- Sensitivity – since requirements are often in the low ppt range.
- Precision and accuracy – crucial for characterization of unknowns to ensure greater confidence in identification.

Software for data processing

Software requirements include compliance tools, networking capabilities, instrument control, automation, data processing, and more. In addition, increased flexibility is needed in performing targeted screening and routine quantitation with either HRAM and/or triple stage quadrupole (TSQ) mass spectrometers. A powerful software is key in ensuring increased productivity for your analytical laboratory, enabling you to address analytical challenges today and tomorrow. HRAM software is a must for screening accurate spectral fragmentation libraries and compound databases to identify unknowns with speed and confidence.

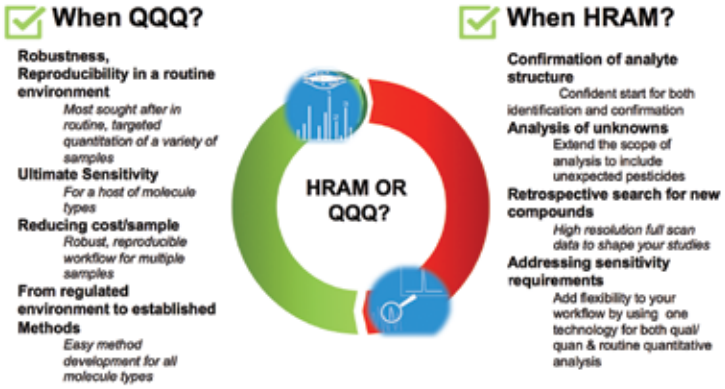
From known to unknown identification of PFAS compounds

Unknown identification is one of the toughest challenges in many small-molecule analyses. By integrating multiple tools for gathering identification information, the Thermo Scientific™ Compound Discoverer™ software enables you to identify more of your unknowns. Automatically identify more unknowns faster with spectral library searching against both the online Thermo Scientific™ mzCloud™ spectral library and the in-house Thermo Scientific™ mzVault™ spectral libraries. It is also possible to easily elucidate structures, rank putative results, generating matches for identification, and integrated batch searching of mzCloud can also produce similarity matches.

Choosing the right MS system

The choice of the most optimal MS system is dependent on the goals of the analysis. For routine, targeted analysis of a predefined list of pesticides, a triple quadrupole MS would be the most suitable option. However, if in addition to targeted analysis, there is an interest in screening for unknown compounds, an HRAM instrument like the Thermo Scientific™ Q Exactive™ Focus Hybrid Quadrupole-Orbitrap™ MS system is a more appropriate option. The considerations to be made in choosing the right platform are summarized in Figure 1.

Figure 1: Selecting the appropriate MS platform.



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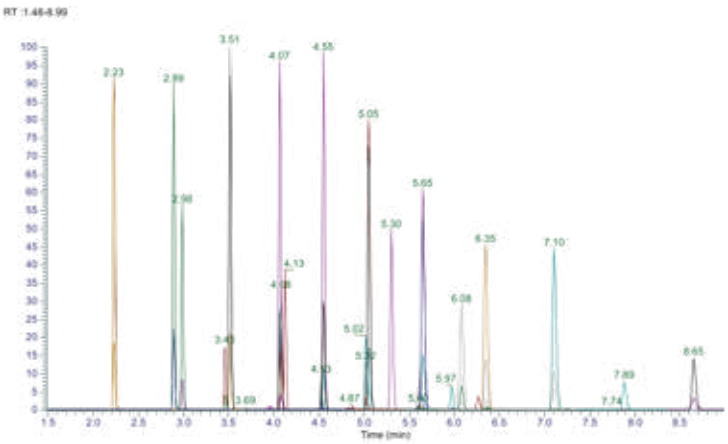
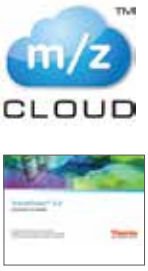
Fast run times

Thermo Scientific ultra-high performance liquid chromatography (UHPLC) systems deliver the robustness and speed required for reproducible and accurate analysis (Figure 2).

Figure 2: Example of a fast run time from PFAS compounds in EPA 537.1.



Complete workflow requirements for PFAS analysis

Sample Collection, Processing	Sample Extraction and Clean up	Analysis	Data Processing
	Offline SPE:  Online SPE: 	LC Teflon Free trap columns and tubing kits MS/MS systems:  HRAM systems: 	Thermo Scientific™ Chromeleon™ Chromatography Data System software:  Thermo Scientific™ TraceFinder™ software:  

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Workflow step	Product	Description
Offline SPE	Thermo Scientific™ Dionex™ AutoTrace™ 280 Solid-Phase SPE instrument	This instrument automates all four steps of SPE (conditioning, loading, rinsing, and eluting), reducing solvent consumption and improving recovery and reproducibility
Online SPE	Thermo Scientific™ EQuan MAX Plus™ LC-MS system	This system provides a turn-key solution for screening, identification, and quantitation of trace contaminants in environmental water, drinking water and beverage samples.
LC system	Thermo Scientific™ Vanquish™ Flex Quaternary system	This system shares all Vanquish-inherent values, such as a design focus on uptime, robustness and reliability. Multiple detection options give you the performance you need. Thermo Scientific™ Viper™ Fingertight Fitting connections throughout the system make set up easy.
	Vanquish PFAS installation kit	The peek based kit eliminates PFAS background from Teflon tubing and traps PFAS compounds from pump components for accurate determination and low background.
MS/MS	Thermo Scientific™ TSQ Altis™ triple quadrupole mass spectrometer Thermo Scientific™ TSQ Quantis™ triple quadrupole mass spectrometer Thermo Scientific™ TSQ Fortis™ triple quadrupole mass spectrometer	Our complete portfolio of instruments has the capability to analyze a broad range to detect high and low-level concentrations in complex matrices, proven robustness demonstrated in validation studies and easy-to-use software for accurate identification and quantitation.
HRAM	Q Exactive Q Exactive Focus	Orbitrap technology is the state of the art HRAM instrument. Based on the combination of hyperbolic quadrupole technology combined with Orbitrap analyzer technique. Implementation of a quadrupole mass filter in front of the curved ion trap (C-Trap) allows for precursor ion selection and hence for MS/MS and selected ion monitoring (SIM) scan modes besides the ability of full MS mode. In addition, the high sensitivity S-lens ion source, with the implementation of enhanced Fourier Transform (FT) transient processing, further increase of scan speed and resolving power can be achieved. Together with the new and unique scan type of spectra multiplexing, further reduction of cycle time can be accomplished. The Q Exactive system is very sensitive, perfectly combining precise quantification and high performance qualitative analysis by providing high resolution, high mass accuracy and high sensitivity without compromises.

Find out more at **www.thermofisher.com/PFAS**

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