PAL SYSTEM
Ingenious sample handling



PAL RSI and PAL RTC
Sample Prep and Injection



PAL Systems inject precisely and accurately and also perform dilutions, liquid/liquid extractions, derivatizations, µSPE.

Content

Introduction	4 - 7
PAL RTC - Robotic Tool Change	8 - 9
PAL RSI - Robotic Sample Injection	10 - 11
PAL DHR - Dual Head	12 - 13
Sample Preparation Tools & Modules	14 - 27
▪ Mixing and Extraction	16
▪ Centrifugation	16
▪ Capping and Decapping	16
▪ Incubation and Agitation	17
▪ Dilution	17
▪ Barcoding	17
▪ Online Sampling	17
▪ SPME and SPME Arrow Extraction	18 - 19
▪ ITEX DHS Headspace and Static Headspace	20
▪ Micro-SPE	21
▪ LC/MS Tools and Options	22
▪ Liquid Handling and Pipetting	23
▪ Transportation	23
▪ Solvent Storage	24
▪ Wash Modules	25
▪ Valve Drives	25
▪ Sample Storage temperature controlled and ambient	26 - 27
Chronos	28 - 29
PAL Method Composer	30 - 31
PAL Accessories & Consumables for PFAS Analysis	32 - 33
PAL Accessories & Consumables	34 - 45
Applications	46 - 53
Specifications	54 - 55



The PAL System is one of the most widely used and successful sample preparation and handling platforms.

Automated sample prep and injection just in time for every analytical laboratory worldwide

PAL System is your Tool Box for sample preparation, from a simple liquid injection to complete workflows. A PAL System can be adapted or extended to meet almost any requirement.

Numerous options allow to increase sample capacity or add further modules for sample preparation. Listed below are the method steps that a PAL System can perform:

- Liquid injection GC and LC
- Gas injection
- Headspace sampling
- Dynamic headspace sampling (ITEX DHS)
- SPME Fiber and SPME Arrow sampling
- Temperature controlled storage of samples
- Incubation 40 - 200 °C
- Robotic Tool Change (PAL RTC only)
- Transport of vials and other objects
- Thermal mixing and Vortex mixing
- Centrifugation up to 5000 g
- Dilution
- Standard addition
- Liquid / liquid extraction (LLE)
- Derivatizations
- Micro-SPE (µSPE)

More than 70’000 users in gas and liquid chromatography, mass spectrometry and optical spectroscopy can’t be wrong.

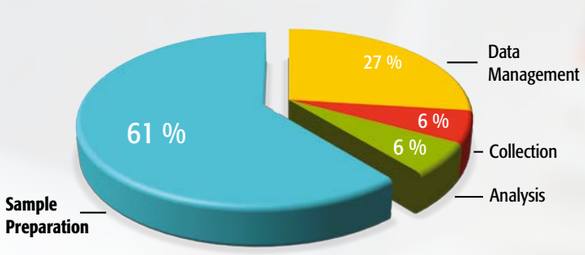
Visit our Newsroom and stay informed about industry trends, innovative solutions, and upcoming events that drive the future of automated sample prep.

Subscribe to our newsletter and receive up to three exclusive updates per year on our latest products and solutions.

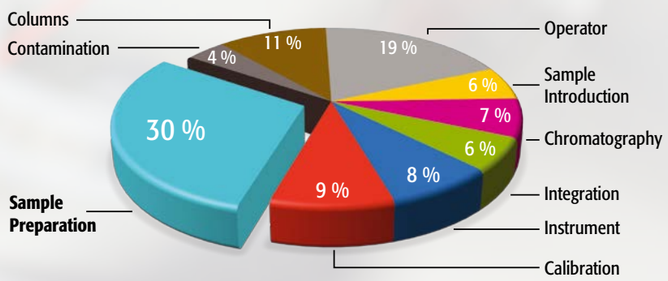
Sample preparation is the key to success in achieving precise and accurate results.

For a typical chromatographical analysis 61 % of time is spent on sample prep, 30 % of errors are linked to sample prep*.

Time Spent on Typical Chromatographic Analysis



Sources of Error Generated During Chromatographic Analysis



* data taken from the book “SAMPLE PREPARATION FUNDAMENTALS FOR CHROMATOGRAPHY” from Agilent Technologies.

PAL RTC - Highest Productivity & Flexibility

The PAL RTC with Robotic Tool Change is the logical (r)evolution of the successful PAL-***xt*** product line. It is a robotic platform for the efficient and safe automation of most sample preparation steps.

The robotic change of Tools enables unattended 24/7 operation, even for multistep workflows and thereby greatly increases the productivity of labs. At the same time process safety is optimized since all operations become traceable.

PAL RSI - The Workhorse

The RSI is the robust workhorse for analytical labs. It is the cost effective solution for labs in need of robustness and uncompromising performance.

The PAL RSI is a safe investment: if your requirements grow an upgrade to the full RTC functionality is possible and gives access to complete workflow automation.

Chronos -Software for Efficient Operation of PAL RTC & RSI

CHRONOS

The latest generation of PALs can all be controlled by the user friendly Chronos software. It interfaces seamlessly with many common CDS and MS-data systems (e.g. Agilent Chemstation, Masshunter, Sciex Analyst, or Thermo Scientific Xcalibur) or can be used for offline sample preparation. With a few clicks you can import or generate sample lists and start the data acquisition. Or you can quickly set up workflows to eliminate tedious manual operations. Chronos allows overlapping of time consuming steps. This increases sample throughput greatly and boosts productivity.

PAL Method Composer

PAL MC

For PAL Systems integrated in a GC/MS or LC/MS system, PAL Method Composer lets you easily create new methods.
The graphical user interface allows the creation of a method by drag & drop. The check for validity of the method is performed automatically on the fly.
More details on page 30/31 or on PAL Method Composer

PAL RTC is all about increasing productivity



PAL RTC with extended x-axis for LC/MS

Robotic Tool Change takes productivity to a new level



Park Station for
Robotic Tool Change



PAL RTC with standard x-axis for GC & GC/MS

Automation improves process safety

Automation is the way to increase productivity and (process) safety in the laboratory. Transferring repetitive or dangerous manual tasks to a robot improves safety. The possibility to run the instrument 24h/day increases throughput, especially for long sample preparations.

The PAL RTC was developed to maximize productivity in analytical and clinical labs. Robotic Tool Change (RTC) brings sample preparation to a higher level.

Every process requires a number of different Tools for best performance, e.g. a 10 µl syringe for the accurate addition of small volumes followed by the dilution with a 1 ml syringe. Robotic Tool Change allows to switch between different Tools automatically.

This additional versatility in combination with the large number of available Tools enable the design of tailored automation processes.

Ingeniously productive

- Automatic selection of the syringe with optimal accuracy for adding standards or preparing serial dilutions.
- On the fly switching between a syringe Tool for the addition of an internal standard and the LC/MS Tool for subsequent analysis.
- Possibility to permanently configure several workflows on one system for a walk-up prep station, e.g. Liquid/ Liquid Extraction and Solid Phase Extraction (SPE).
- Automated optimization of SPME and SPME Arrow methods e.g. by selecting the most suitable Smart SPME Fiber/Arrow phase from an array of up to 6 different ones.
- Derivatization reactions performed without manual intervention for productivity, protection against hazardous chemicals and process safety.
- Automation of labor intensive manual workflows like protein digestion.

For detailed examples of workflows see p. 46 - 53

PAL RSI is the reliable workhorse for analytical labs



PAL RSI with compact x-axis for LC/MS

Ingeniously reliable

Laboratories work under time pressure and often with a tremendous workload. The reliability of hardware and software should not be something the user has to worry about. Reliability is just expected from every Tool.

That is exactly what the PAL RSI was designed for. It is a Tool that you can rely on. 70.000 PAL Systems worldwide are proof of this.

PAL RSI defines the industry standard for intelligent sample preparation

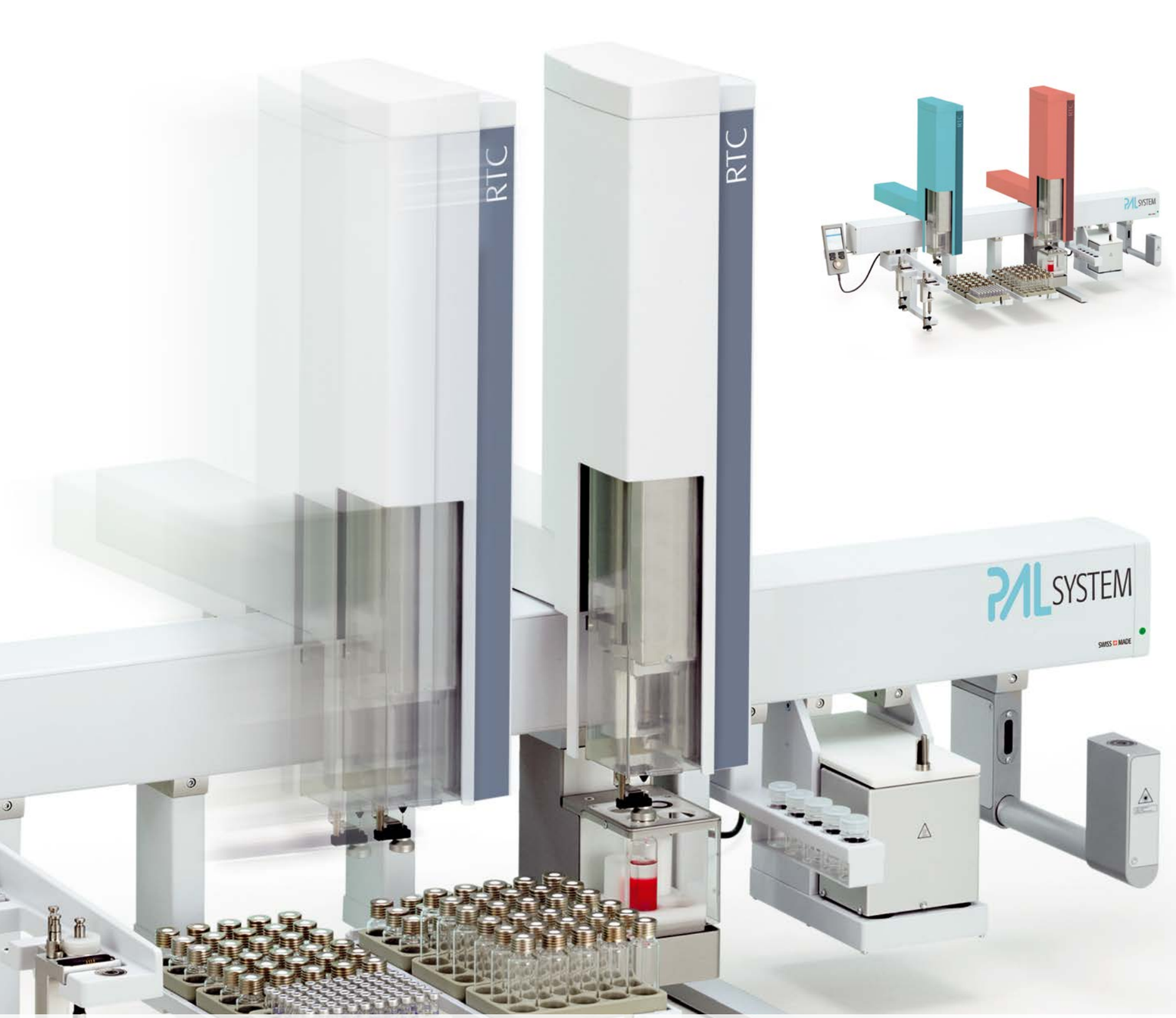


PAL RSI with standard x-axis for GC & GC/MS

The most flexible system on the market

RSI is a flexible Tool. Its open and modular architecture makes it the most versatile system on the market. Tools can be exchanged readily within minutes.

PAL customers working with GC love the possibility to use liquid, headspace or SPME sampling on the same system. LC customers use the PAL because of its huge sample capacity, the range of syringes and valves available.



Add sample 1 to vial 1 → Transport vial 1 to balance → Weigh sample 1 → Place vial 1 back

Get weighed vial 1 → Injection using Head 2 → Data acquisition

Add sample 2 to vial 2 → Transport vial 2 to balance → Weigh sample 2 → Place vial 2 back

Get weighed vial 2 → Injection using Head 2 → Data acquisition

Workflow 1 (Head 1)

Workflow 2 (Head 2)

PAL DHR Dual Head - Productivity x2

- Two heads can move independently
- The heads can execute two independent workflows
  - Headspace sampling with standard addition
  - Parallel injections into two GC- or LC-systems
- The software optimizes the time table to maximize productivity
- Collision control → process safety and easy programming
- 80 to 200 cm wide working area
- Combinations of RTC/RSI heads
- With an RTC head Robotic Tool Change expands the options further

Application Examples

- Automated weighing of samples, combined with the analysis of a weighed sample
- High throughput LC/MS injections with 2 completely independent LC streams (2 injection valves, 2 columns or staggered injections into mutltiple streams)
- Sample prep combined with parallel headspace GC analysis

Aspirate sample 1 → Inject into valve 1 → Clean tool and valve → Prep ahead → Next sample

Aspirate sample 2 → Inject into valve 2 → Clean tool and valve → Prep ahead → Next sample

Add int. standard sample 1 → Vortex sample 1 → Clean syringe → Next sample

Aspirate sample 1 → Inject into valve 1 → Clean tool and valve → Next sample

Workflow 1 (Head 1)

Workflow 2 (Head 2)

For precise sample preparation you need the right tools and modules.

Here is the complete PAL Toolbox.

The right tool for each application

Starting from 10 ml of a water sample, extracting pesticides by SPE and precisely injecting 1 µl of extract: the PAL Sytem performs this job flawlessly. This is only one example how PAL System improves productivity and process safety.

Liquid, gaseous or solid samples require different workflows and therefore different Tools. The following pages introduce you to the PAL Toolbox equipped with the best Tools and modules available for sample preparation.

Change the tool at any time with the Park Station (PAL RTC only)

The unique Park Station allows a Robotic Tool Change (syringes with different volumes or different Tool types) for advanced sample preparation, liquid handling (dilutions), derivatization steps or any other time consuming repetitive step. The additional versatility in combination with the increased volume range are significant benefits and allow the realization of tailor-made automation processes.

- Park Station for up to three PAL Tools
- Installation of up to 2 Park Stations on one PAL RTC
- Process safety through Tool recognition and position control
- Designed for automated screening of method conditions with multiple tools



Mixing and Extraction

PAL3-Vortex Mixer

- For efficient mixing (dilution / extraction)
- Standard vial sizes: 2 ml / 10 ml / 20 ml
- 1 additional slot for custom specific vials
- Provides efficient mixing with up to 2000 rpm



PAL3-Thermal Mixer

- For shaking and heating of well plates
- Temparature range 30 - 100°C
- Mixing 0 - 2000 rpm
- Only compatible with PAL table mounted
- Adapter needs to be orderd separately:
  PAL3-TM-Adap-ABGene / PAL3-TM-Adap-EPP



Centrifugation

PAL3-Centrifuge-Combi
PAL3-Centrifuge-2mL
PAL3-Centrifuge-10mL

- For the efficient centrifugation in automated workflows (e.g. protein precipiation, phase separation)
- Control through many Chromatographic Data Systems
- Relative centrifugal force:
  - 2000 x g with Centrifuge Combi
  - 5600 x g with Centrifuge 2 ml
  - 2600 x g with Centrifuge 10 ml
- Vial format:
  - Centrifuge Combi: 2 ml (4 vials,) 10 ml / 20 ml (2 vials)
  - Centrifuge 2 ml: 2 ml (8 vials)
  - Centrifuge 10 ml: 10 ml (6 vials, optional 2 ml and 4 ml)





Rotor 2 ml



Rotor 10 ml



Rotor Combi

Capping and Decapping

PAL3-Decapper

- Opens/closes 2, 10, 20 ml screw cap vials without any change of hardware (no adapters required)
- Defined torque guarantees the reproducible and leak-tight closing of headspace vials



Incubation and Agitation

PAL3-Agitator

- For the incubation and agitation of samples
- 6 positions for 20 ml vials
- Temperature range 40 - 200 °C
- Agitation speed 250 - 750 rpm
- Optional adapters for 2 ml or 10 ml vials



Dilution

PAL3-DilutorMulti
PAL3-DilutorSingle
PAL3-TH-Dilutor

- For the efficient and accurate addition of larger amounts of liquids
- 100 µl, 1 ml, 5 ml & 10 ml dispensing syringes available
- Consisting: Dilutor, Dilutor Tool, Syringe, Tubing, Solvent bottles, Solvent Inlet tubings
- Optional selector valves allow dispensing of up to 5 different liquids

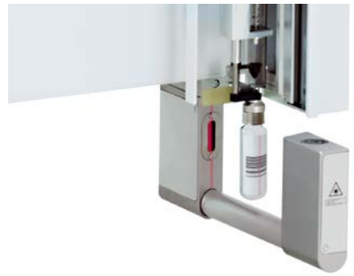


Barcode Reading

PAL3- Barcode Reader

This unique Barcode Reader allows PAL RSI and PAL RTC to read the barcode labels on 2 ml, 10 ml and 20 ml vials regardless of the orientation on the vials. Therefore it ensures highest process safety and traceability.

- Reads horizontal 1D barcodes
- Two scanners allow identification of vials irrespective of position of the barcode
- Works with 2 ml / 10 ml / 20 ml vials



Online Sampling

PAL3-Flow Cell

- Flow Cell for sampling from a flow-through stream
- Up to 6 Flow Cells on one holder



SPME and SPME Arrow Extraction

PAL3- SPME Arrow Conditioning Module

- For the conditioning of SPME Arrows and SPME Fibers prior to sample enrichment, max. 350 °C
- Position for automated conditioning
- Position for manual pre-conditioning
- Automated purge gas valve
- Manual gas valve for pre-conditioning



PAL3-Heatex Stirrer

- For powerful mixing and heating in sample prep and SPME Arrow
- Temperature range 40 ° - 150 °C
- Stirring speed up to 1600 rpm (i.e. 200 cycloidal loops)
- Optimized for 20 ml vials (for 10 ml vials special adapters are required)



PAL3-Agitator

- For the incubation and agitation of samples
- 6 positions for 20 ml vials
- Temperature range 40 - 200 °C
- Agitation speed 250 - 750 rpm
- Optional adapters for 2 ml or 10 ml vials



SPME and SPME Arrow Extraction

PAL3-SPME-SARR-Kit

Smart SPME Arrow Kit, consisting of:
1 pc SPME Arrow Tool
1 pc Smart SPME Arrow Assortment Kit (SARR1115-SEL5-S2)
1 pc SPME Performance Evaluation Mix
(Requires adaptation kit for GC specific Injector)

- For SPME Arrows with 1.1 and 1.5 mm diameter
- Easy fiber exchange by hand
- SPME Arrows are available with the following sorbents:
- PDMS, DVB, PA, Carbon WR, PDMS/Carbon WR, PDMS/Carbon WR/DVB

New: SPME Arrow Tools now are equipped with the SPME MultiGuide. This allows SPME extractions in the Heatex Stirrer or in the Agitator. When using the SPME MultiGuide, the extractions can be done in the agitator. For immersion extraction a Heatex Stirrer is required.



PAL3-SPME-SFib-Kit

Smart SPME Fiber Kit, consisting of:
1 pc SPME Tool
1 pc Smart SPME Fiber Assortment Kit (SFIB-SEL5-S2)
1 pc SPME Performance Evaluation Mix

- Easy fiber exchange by hand
- For 10 mm or 20 mm fiber length
- SPME Fibers are available with the following sorbents:
- PDMS, DVB, PA, Carbon WR, PDMS/Carbon WR, Carbon WR/DVB

New: SPME Fiber Tools can now be upgraded for using 1.1 mm SPME Arrows. This is now possible using the SPME MultiGuide (PAL3-SPME-MG).



ITEX DHS Headspace and Static Headspace

PAL3-Agitator



- For the incubation and agitation of samples
- 6 positions for 20 ml vials
- Temperature range 40 - 200 °C
- Agitation speed 250 - 750 rpm
- Optional adapters for 2 ml or 10 ml vials

PAL3-SITEX-Kit



PAL Smart ITEX DHS Kit, consisting of:
1 pc Smart ITEX syringe 1.3 ml (SITEX-1300-T)
2 pcs ITEX Trap TENAX TA 80/100 mesh (PAL3-ITEX-Trap-TXTA100)

- For powerful dynamic headspace extractions with Tenax TA trap, other materials available
- Active cooling to minimize idle times
- Temperature range: 40 - 350 °C for efficient desorption

PAL3-TH-HS1000 / PAL3-TH-HS2500/PAL3-TH-HS5000



- Dedicated Tools for different syringe types available:
  - 1 ml / 2.5 ml / 5 ml (with corresponding Tools)
- Syringe temperature 40 °C up to 150 °C in 1 °C steps
- Syringe flush with inert gas flow through X-Y-Z rail
- Magnetic vial transport for 2 ml, 10 ml and 20 ml vials

PAL3-MHE Module



- Multiple Headspace Extraction Module

Micro - SPE (µSPE)

PAL3-TH-D857-uSPE



- Liquid Tool for handling µSPE Cartridges
- Loads and elutes samples from100 - 1000 µl

PAL3-HW-uSPE54

µSPE Hardware Kit for PAL System cartridges and PAL RTC,
consisting of:

1 pc µSPE Liquid Tool D8/57 with Needle Guide for µSPE Cartridges
2 pcs Liquid Smart Syringe 1000 µl (SF1000-57-T-22-FL), gauge 22, flat tip
1 pc Tray Holder
2 pcs VT54 rack (PAL3-Rack-VT54)
1 pc µSPE Cartridge Tray, 54 position, aluminum
1 pc µSPE Elution Tray Cover, 54 position aluminum
1 pc Waste Receptacle with drain
4 pcs PAL System µSPE Cartridges for initial installation, 3-point teaching
USB stick with installation guide and scripts

requires 2 ml vials with split septa

PAL System µSPE Cartridges need to be purchased separate



PAL3-WashFast



- Recommended syringe size: 10 - 100 µl
- Cleans syringes of gauges 19 to 26
- Integrated pumps for active wash solvent delivery
- Supports two different wash solvents (aqueous and organic)
- Reduces wash solvent consumption by automatic flow adjustments
- Can be mounted underneath valve drives to minimize required space

LC/MS Tools and Options

PAL3-TH-SLCMS-AWC-100 / PAL3-TH-SLCMS-AWC-100DX

LC/MS setup consisting of:
1 pc LC/MS-P-100 Tool incl. 100 µl Smart Syringe, Needle and FEP Loop
1 pc 2-Channel Volumetric Pump incl. PAL Bus Connection Cable
1 pc Wash Cup PEEK
1 pc PFA Transfer Tube 1/16" (for up to 850 mm)
2 pcs Solvent Bottle 1000 ml
2 pcs Solvent Inlet Tubing Kit PFA

- The combination of LC/MS Tool with the Wash Cup minimizes carryover and enables very fast injection cycles.
- The Volumetric pump delivers solvents precisely and accurately.
- Service interval is > 280'000 samples leading to high up-time and low maintenance cost.
- Injection volume LCMS-100, 1 - 80 µl
- Injection volume LCMS-250, 1 - 230 µl
- Needle length 51 or 80 mm (DX)



PAL3-TH-SLCMS-AWC-100PF

LC/MS setup for PFAS Analysis consisting of:
1 pc LC/MS-P Tool incl. 100 µl Smart Syringe, Needle and PEEK Loop
1 pc 2-Channel Volumetric Pump incl. PAL Bus Connection Cable
1 pc PEEK Wash Cup PEEK
1 pc PEEK transfer tube 1/16" (for up to 1200 mm PAL)
2 pcs Solvent bottle 1000 ml
2 pcs PFAS-free Solvent Inlet Tubing Kit



PAL3-TH-SLCMS-AWC-250 / PAL3-TH-SLCMS-AWC-250DX

LC/MS setup, consisting of:
1 pc LC/MS-P-250 Tool incl. 250 µl Smart Syringe, needle and FEP loop
1 pc 2-Channel Volumetric Pump incl. PAL Bus Connection cable
1 pc Wash Cup PEEK
1 pc PFA transfer tube 1/16" (for up to 850 mm)
2 pcs Solvent Bottle 1000 ml
2 pcs Solvent Inlet Tubing Kit PFA

2-Channel Volumetric Pump:

- Delivers solvents accurately
- Guarantees consistent wash performance
- Minimizes carryover
- Low cost per sample
- Can be used as wash pump for LC/MS Tools, pump for online PE or syringe pump



PAL3-WashLCMS and PAL3-WashLCMS-DX

- Passive Wash module for use with LC/MS Tools or Dilutor Tools
- PAL3-WashLCMS-DX for LC/MS Tools with 80 mm Support



Liquid Handling & Pipetting

PAL3-T-D757
PAL3-TH-D785
PAL3-TH-D857
PAL3-TH-D885
PAL3-TH-D1857

- Dedicated Liquid Syringe tTools for 57 mm or 85 mm syringe needle lengths available
- Syringes available:
  - 1.2 µl / 10 µl / 25 µl / 100 µl with D7 Tool
  - 250 µl / 500 µl / 1'000 µl with D8 Tool
  - 5'000 µl / 10'000 µl with D18 Tool



85 mm
needle length



57 mm
needle length

PAL3-TH-Pip20
PAL3-TH-Pip200
PAL3-TH-Pip1000

- For automated pipetting with 20 µl, 200 µl or 1000 µl tips
- Single or multi-dispense mode
- A special adapter allows direct injection into LC Valves
- Also works with capped vials in combination with the Decapper







Solvent Storage

PAL3-Solvent Module

- For large solvent demands, e.g. for the addition of larger volumes of solvents or serial dilutions
- 3 x 100 ml solvent container (glass) with septum cap



PAL3-Large Wash Module

- Wash module for large volume injections
- 2 x 100 ml solvent container (glass) with septum cap
- Waste port with tubing olive to connect waste bottle



Transportation

PAL3-SlotStation-20ml

- Slot Station with clip 20 ml for the transportation of 10 ml or 20 ml vials with magnetic caps
- includes PAL3-Slot-20mL and PAL3-Clip-20mL



PAL3-SlotStation-DX

- Slot Station with Clip Dx for the transportation of primary tubes.
- Includes PAL3-Slot-Dx and PAL3-Clip-Dx.

PAL3-TH-Gripper

- For transporting non-magnetic items
- Different gripping adapters available
- 4-pin gripping adapter included for items 5 - 24 mm in diameter



Wash Modules

PAL3-WashStd

- Standard wash module for low volume injections
- 4 x 10 ml wash solvent vials
- 1 x 10 ml waste vial
- Optional waste port adapter to connect a tube to a waste bottle



PAL3-WashFast

- Recommended syringe size: 10 - 100 µl
- Cleans syringes of gauges 19 to 26
- Integrated pumps for active wash solvent delivery
- Supports two different wash solvents (aqueous and organic)
- Reduces wash solvent consumption by automatic flow adjustments
- Can be mounted underneath valve drives to minimize required space



PAL3-WashFast-HF

additional features:

- Recommended syringe size: 25 - 10000 µl
- Wash module for flow rates up to 40 ml/min

Valve Drives

PAL3-Valve Drive-V and PAL3-ValveDrive-R

Universal Valve Drive for applications like sample injection, column switching for online LC-LC/MS or online SPE-LC/MS, Multiplexing, column selection and many more.

- Valve Drive supports VICI/Valco and Rheodyne valve types
- Injection port bottom sensing minimizes carryover
- Constant Force Technology to reduce dead volume during injection process
- UHPLC/HPLC: up to 50 % faster switching times for optimum
- System performance and prolonged column life time
- Stackable design to reduce the space required
- Huge flexibility to arrange multiple valve solutions
- The Fast Wash Module is also stackable below Valve Drive



Two injection valves staggered configuration reduces space required.

Temparture Controlled Sample Storage

PAL3-TrayCooler

For the storage of 3 racks or plates under defined temperature conditions between 4 °C and 40 °C.

Capacity:

- 3 x MTP (multitier plate)
- or 3 x DW (deepwell plate)
- or 3 x VT15 (15 x 10 ml)
- or 3 x VT54 (54 x 2 ml)
- or 3 x VT70 (70 x 1 ml)
- or combinations
- depending on tray type inserts are required



PAL3-LiqCooler

- Tray Holder incl. sample tray
- For up to 32 vials of 20 ml
- External circulator bath for heating/cooling not included



PAL3-PeltierStack2DW
PAL3-PeltierStack6DW
PAL3-PeltierStack12MT

For the storage of two (2DW) or 6 (6DW) racks or plates or 12MT plates (12 MT) under defined temperature conditions between 4 °C and 40 °C. Allows to use transparent standard vials with light sensitive compounds.

Capacity 2DW:

- 2 x MTP (multititer plate)
- or 2 x DW (deepwell)
- or 2 x VT15 (15 x 10 ml)
- or 2 x VT 54 (54 x 2 ml)
- or 2 x VT70 (70 x 1 ml)
- or combinations

Capacity 6DW:

- 6 x MTP (multititer plate)
- or 6 x DW (deepwell plate)
- or 6 x VT15 (15 x 10 ml)
- or 6 x VT 54 (54 x 2 ml)
- or 6 x VT70 (70 x 1 ml)
- or combinations

Capacity 12MT:

- 12 x MTP (multititer plate, shallow well)



(Stack 6DW shown)

Sample Storage at Ambient Temperature

PAL3-Stack6DW
PAL3-Stack12MT

For the storage of racks or plates at room temperature. Allows to store samples with light sensitive compounds. A maximum of four stacks can be configured on a PAL with extended x-axis length.

Capacity 6 DW:

- 6 x MTP (multititer plate)
- or 6 x DW (deepwell plate)
- or 6 x VT15 (15 x 10 ml)
- or 6 x VT54 (54 x 2 ml)
- or 6 x VT70 (70 x 1 ml)
- or combinations

Capacity 12 MT:

12 x MTP (multititer plate, shallow well)



(Peltier Stack 6DW shown)

PAL3-Trayholder

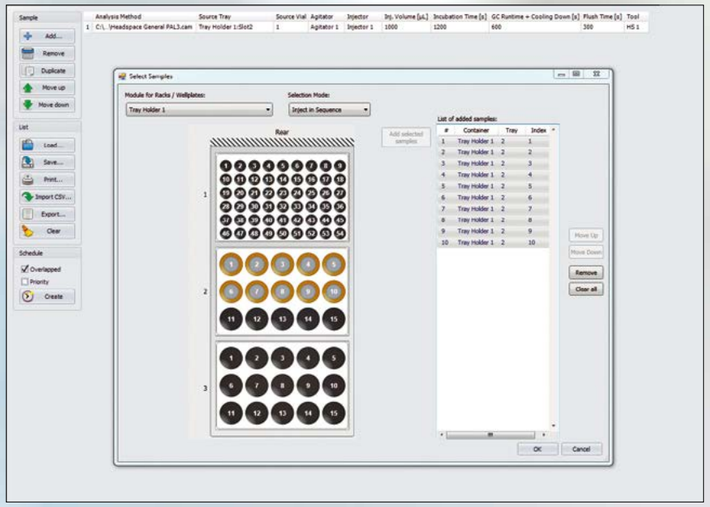
The Tray Holder offers sample storage at room temperature.
A PAL with extended x-axis length can hold up to 7 Tray Holders.

Capacity:

- 3 x MTP (multitier plate)
- or 3 x DW (deepwell plate)
- or 3 x VT15 (15 x 10/20 ml
- or 3 x VT54 (54 x 2 ml)
- or 3 x VT70 (70 x 1 ml)
- or combinations
- or 60 x 10/20 ml (with one R60 tray)



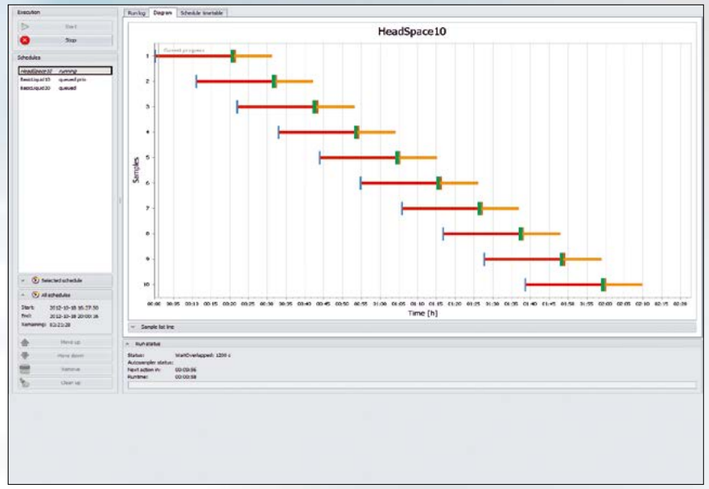
For more information about PAL Tools and Modules please visit our website: www.palsystem.com



Easy to use

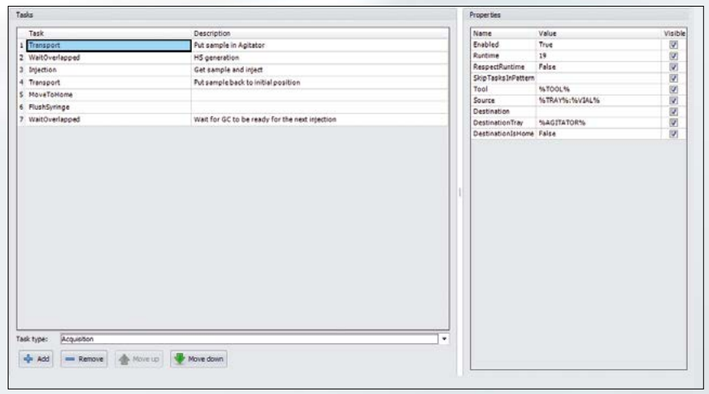
Creation or import of sample lists is done with a few clicks.

With one more click sample preparation and data acquisition are started.



Productivity

Chronos optimizes productivity by overlapping individual steps. In many cases runtimes of sequences can be cut to 1/3 or less compared to a sequential procedure.



Powerful Method Editor

A powerful yet easy to use Tool to generate custom methods is included.

Chronos

CHRONOS

Easy to use routine software

Chronos software is the user-friendly tool for the daily routine jobs. With a few clicks sample lists are generated or imported. Now Chronos starts the operation and the data acquisition. Since Chronos interfaces seamlessly with most of the major chromatographic or MS data systems only one sample list has to be handled. Different user levels ensure process safety.

Productivity

Chronos allows overlapping of time consuming steps. It optimizes automatically the timing of various steps in a sample preparation process and generates a schedule that minimizes the runtimes of sequences. This increases sample throughput greatly and boosts productivity.

Powerful Method Editor

While Chronos is straightforward to use in the daily operations it is also a powerful tool for the generation of tailored methods. A set of tested methods that comes with every system (e.g. headspace injection, partial loop liquid injection) can be used as templates and optimized or tailored for specific workflows. Furthermore a large number of building blocks (tasks) for method development are part of the software. These building blocks make it easy to generate new methods, even for complex workflows. Chronos is required for operating the PAL DHR.

Supported CDS and MS-Data Systems

- Agilent GC+ LC MassHunter, Agilent ChemStatio, Agilent EZChrom
- Agilent OopenLab CDS
- Bruker MS Workstation, HyStar und Compass
- DataApex Clarity
- GL Sciences Evolution Workstation
- Justice Chromperfect
- Sciex Analyst + SciexOS
- Shimadzu LabSolutions, GCMSSolution
- Thermo Omnic, Xcalibur
- Waters MassLynx

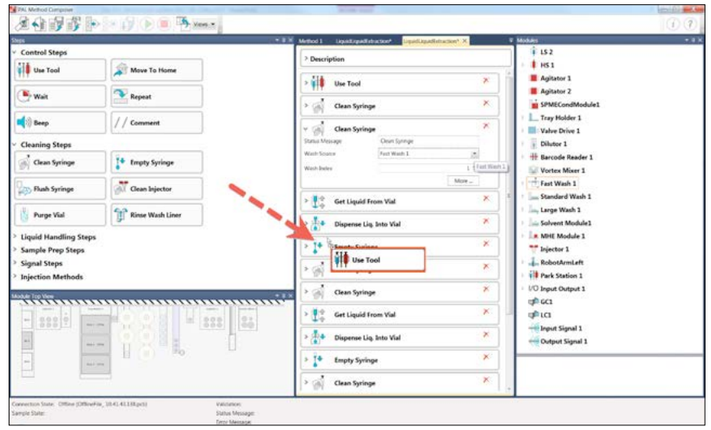
For details of the supported versions, please check the Chronos product homepage

PAL Method Composer lets you easily create new methods.

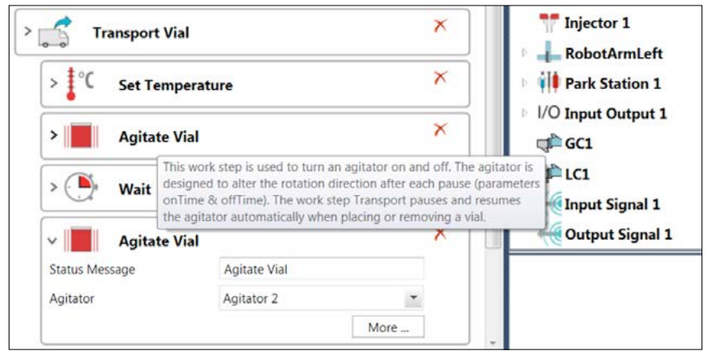
The check for validity of the method is performed automatically on the fly.

PAL Method Composer, methods in minutes

PAL Method Composer is a tool to intuitively generate methods for the integration in Chromatographic Data Systems (CDS). By simply dragging and dropping of the individual prep steps you can build a method in minutes. Each step's functions and parameters are explained.
The instrument configuration is visualized to easily optimize the sequence.
PAL Method Composer gives users easy access to tailored methods.



The parameters of the steps are default values that were experimentally determined. However, each step can be adjusted for specific methods.



PAL Method Composer works with the following CDS:

- Agilent: ChemStation / MassHunter / OpenLAB
- Bruker: Compass HyStar
- Sciex: Analyst AAO and ADD
- Shimadzu: GCMSsolution Software / LabSolutions
- Thermo: Xcalibur / Chromeleon / TraceFinder
- Waters: Empower 3

Minimize PFAS background and equip your PAL Systems with upgrade kits and consumables for PFAS analysis

Transition to tubings and kits for PFAS analysis to reduce background contamination

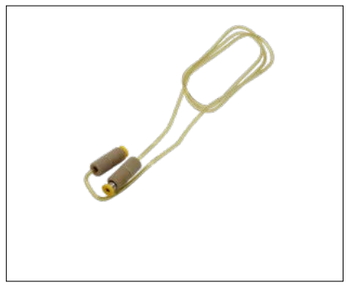
PAL upgrade kits and consumables for PFAS analysis ensure:

- Uncompromised Accuracy: Minimize background interference and maximize analytical precision for your PFAS analysis.
- Reliable Performance: Trust in the quality and reliability of our upgrade kits, engineered for optimal performance in PFAS analysis.
- Seamless Integration: Easily integrate our components into your existing instrument setup for hassle-free upgrades.













Find more information about Minimize PFAS Background

PAL Smart Consumables for full traceability.

A fast, safe and reliable sample preparation is the key factor for high productivity and reduces costs per sample.

PAL3 Series II with Smart Technology in combination with Smart Consumables provides the required process safety and efficiency:

- Full traceability
- Lower cost of ownership
- Higher sample throughput
- Highest result confidence



Smart Consumables status on a PAL Terminal



Smart Chip on a Tool





Find more information about Smart Consumables

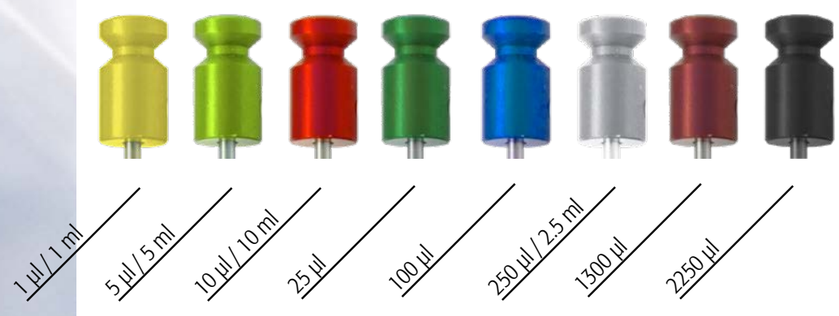
PAL Smart Syringe

Each PAL Smart Syringe is equipped with its own read/write chip with preset parameters, ranges, usage tracking and an unique ID.

- Error free usage (plug and play)
- Full traceability
- Optimized instrument up-time
- Status view
- Lower cost per sample
- Higher result confidence



Color code for easy identification of the syringe volume:



Find more information about Smart Syringes

PAL SMART SPME Arrow

The PAL SPME Arrow is the new patented technology for Micro Extraction, combining trace level sensitivity with high mechanical robustness.



- Integrated holder design facilitates installation
- Automatic identification of Arrow Fiber type
- Higher sample throughput
- Higher sensitivity
- Wider linear range
- Longer lifetime
- Full traceability


1.5 mm ∅ 120 µm phase thickness, Carbon WR/PDMS SPME Arrow


1.5 mm ∅ 120 µm phase thickness, DVB/Carbon WR/PDMS SPME Arrow


1.5 mm ∅ 120 µm phase thickness, DVB/PDMS SPME Arrow


1.5 mm ∅ 100 µm phase thickness, PDMS SPME Arrow


1.1 mm ∅ 120 µm phase thickness, DVB/Carbon WR/PDMS SPME Arrow


1.1 mm ∅ 120 µm phase thickness, Carbon WR/PDMS SPME Arrow


1.1 mm ∅ 120 µm phase thickness, DVB/PDMS SPME Arrow


1.1 mm ∅ 100 µm phase thickness, Polyacrylate SPME Arrow


1.1 mm ∅ 100 µm phase thickness, PDMS SPME Arrow

Find more information about SPME Arrows

PAL Smart SPME Fibers

PAL Smart Fibers have been developed and optimized for the most successful SPME sampler, the PAL System Autosampler.





- Integrated holder design facilitates installation
- Automatic identification of SPME Fiber type
- Excellent extraction properties
- Full traceability



Polyacrylate Fiber, 85 µm



PDMS Fiber, 100 µm



PDMS Fiber, 30 µm



DVB / PDMS Fiber, 65 µm



PDMS Fiber, 7 µm



DVB / PDMS / Carbon WR - Triple phase Fiber, 80 µm (50 µm / 30 µm)



Carbon WR / PDMS Fiber, 95 µm

Find more information about SPME Fibers

PAL SMART SPME Arrow

Color Code for easy optical identification of coating type and thickness

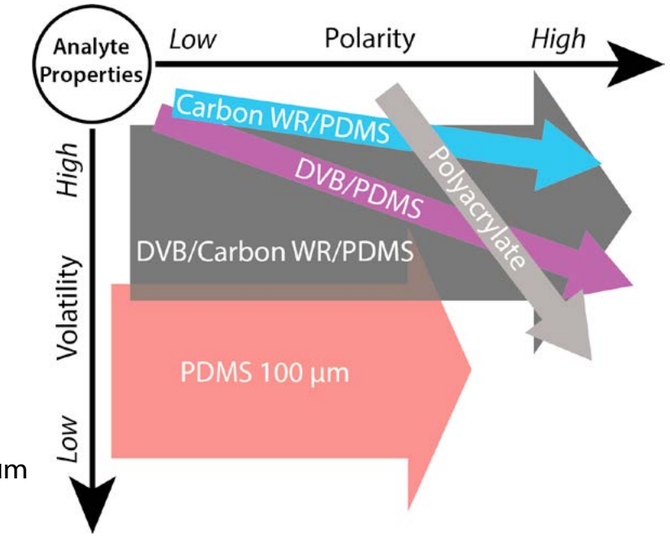
PDMS - 100 µm

Polyacrylate - 100 µm

Carbon WR / PDMS - 120 µm

DVB / PDMS - 120 µm

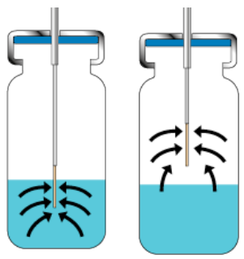
DVB / Carbon WR / PDMS - 120 µm

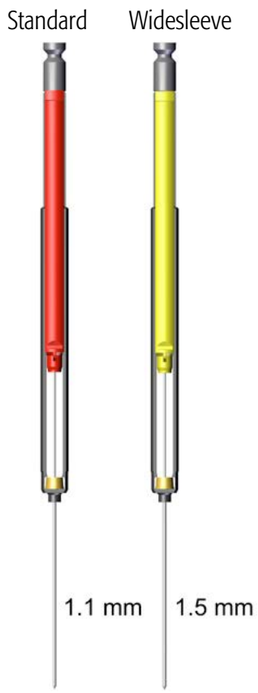




Optimized geometry:

- Up to 15 x more sorption phase
- Up to 6 x bigger surface
- Excellent extraction properties
- Designed for headspace and immersion sampling





Widesleeve Arrows with 1.5 mm diameter have the same phase dimensions as the corresponding 1.1 mm Arrows. The space to the outer needle allows phase swelling for special applications i.e. with high amounts of organic solvents. For all standard applications with aqueous samples we recommend to use 1.1 mm Arrows.

PAL SMART SPME Fiber

Color Code for easy optical identification of coating type and thickness

PDMS - 7 µm

PDMS - 30 µm

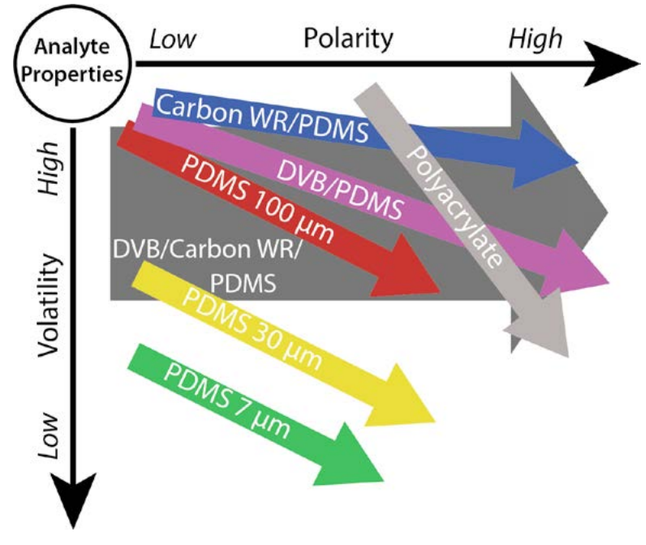
PDMS - 100 µm

Polyacrylate - 85 µm

Carbon WR - 95 µm

DVB / PDMS - 65 µm

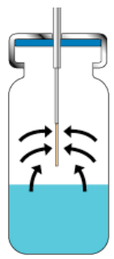
DVB /PDMS/ Carbon WR - 80 µm (50 µm / 30 µm)





Integrated holder design facilitates installation:

- Automatic identification of SPME Fiber type
- Excellent extraction properties
- Full traceability





Accessories and Consumables
It's all about your samples.

PAL Accessories and Consumables - For safe and reliable processing.

The complete portfolio of PAL tested and certified consumables ensuring highest performance of every PAL System. PAL System accessories are an integral part of the superior quality of every PAL System guaranteeing a safe and reliable operation.

- **µSPE Cartridges** for SPE of small volumes without the need for evaporation.
- **PAL Vials and Caps** - for centrifugation, de- and recapping.
- **PAL Pipette Tips** for consistent pipetting with the PAL pipette Tool.
- **PAL Needle Seals** for optimized LC injection with long lifetime, easy handling and no carryover.











Detailed information and specifications are listed in our Accessories and Consumables brochure.

High-Sensitivity PFAS Determination in Seafood

FOOD SAFETY

An Automated Triple Quadrupole LC/MS Workflow that Meets Regulatory Requirements

Gwen Lim[1], Hagen M. Gegner[1] and Aimei Zou[2] - [1] CTC Analytics AG, Switzerland, [2] Agilent Technologies, Inc.

Conclusion

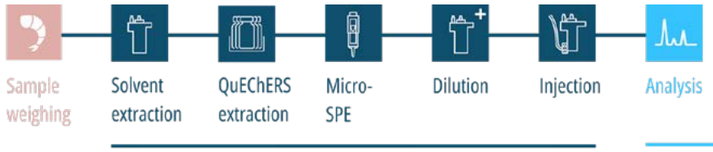
A Robust, Automated Solution for PFAS Analysis in Seafood

This application note presented a fully automated analytical method for the accurate and reliable quantification of per- and polyfluoroalkyl substances (PFAS) in seafood.

The method integrates a PAL RTC autosampler with an Agilent 6495D triple quadrupole LC/MS system, effectively transferring labor-intensive tasks – including calibration standard preparation, sample extraction, and analyte analysis – to a robotic system. The PAL RTC autosampler successfully automated the QuEChERS salting-out-assisted solvent extraction and Micro Solid Phase Extraction (µSPE) clean-up, eliminating tedious manual steps in the sample preparation process. The method demonstrated excellent performance across key analytical metrics: linearity, sensitivity (low detection and quantitation limits), accuracy (demonstrated through matrix-spiked recoveries), repeatability, and reproducibility. It consistently met or exceeded the stringent regulatory requirements and recommendations for PFAS analysis in seafood matrices set forth by the U.S. Food and Drug Administration (FDA), the European Union (EU), the EU Reference Laboratory for Halogenated Persistent Organic Pollutants (EURL POPs), and the Association of Official Analytical Chemists (AOAC) International. Notably, the method's performance also meets the specific requirements for PFAS analysis in other challenging matrices, such as eggs, coffee, fish oil, and feed.

Key Take aways

- Method detection limits (MDL) ≤ 10 ng/kg for 28 U.S. FDA-regulated PFAS.
- Validated limits of quantitation (LOQ) ≤ 0.3 µg/kg for 30 regulated PFAS.
- Method performance meets or exceeds U.S. FDA, EU, EURL POPs, and AOAC International standards.





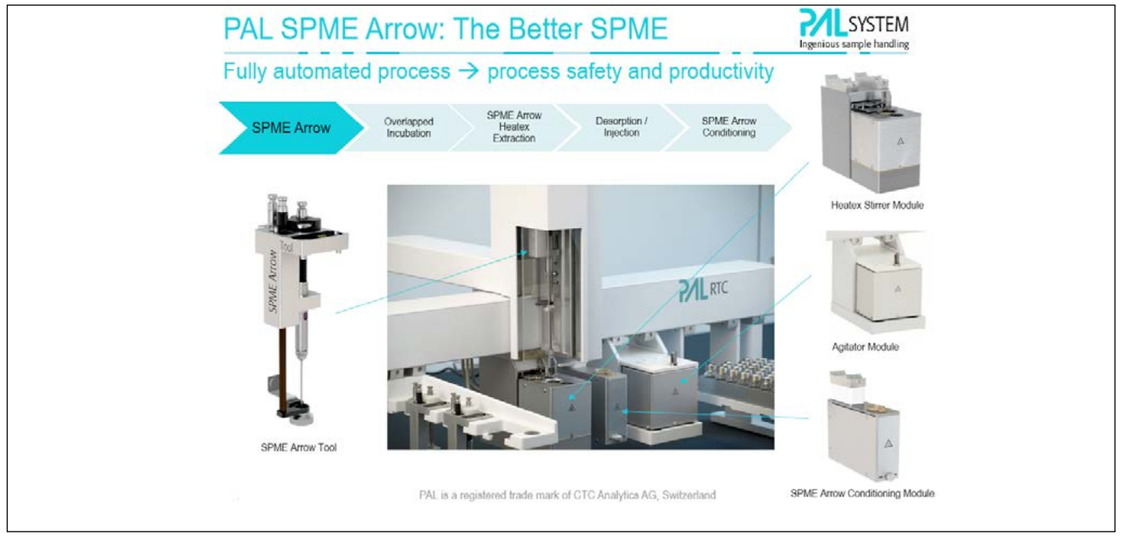
Profiling of Gin Botanicals by Headspace-SPME-ARROW-GCxGC-MSD/FID

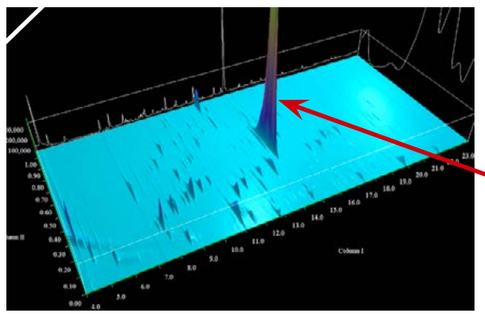
FOOD SAFETY

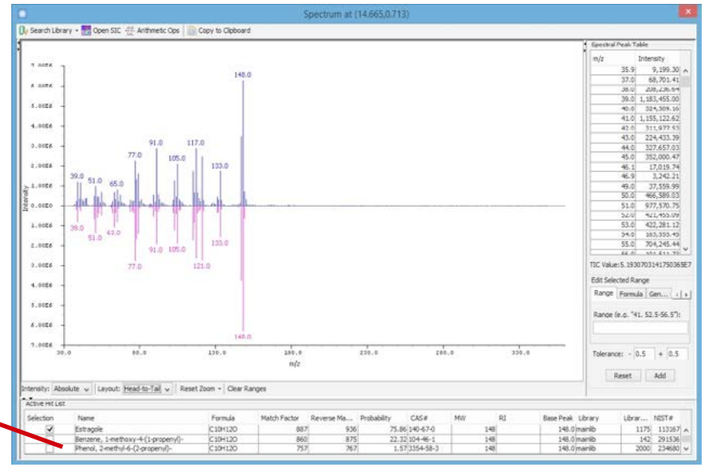
Andrew Ward, JSB UK & Ireland ltd. Horsham, UK

Conclusions

- HS-SPME Arrow-GCxGC-MSD/FID is a powerful tool in the chemical profiling of flavours and fragrances
- Reversed flow modulation delivers excellent resolution allowing easier, faster, detailed analysis of samples with complex matrices
- The high sensitivity provided by the Agilent 5977B with HES makes it the ideal tool to compensate for any decrease in sensitivity in GC-MS analysis observed as a consequence of switching from Helium to Hydrogen as carrier gas
- The SPME Arrow technique offers highly sensitive, fully automated, targeted extraction of compounds from complex sample matrices







Automated Determination of Fatty Acid Methyl Esters using a Method developed by PAL Method Composer

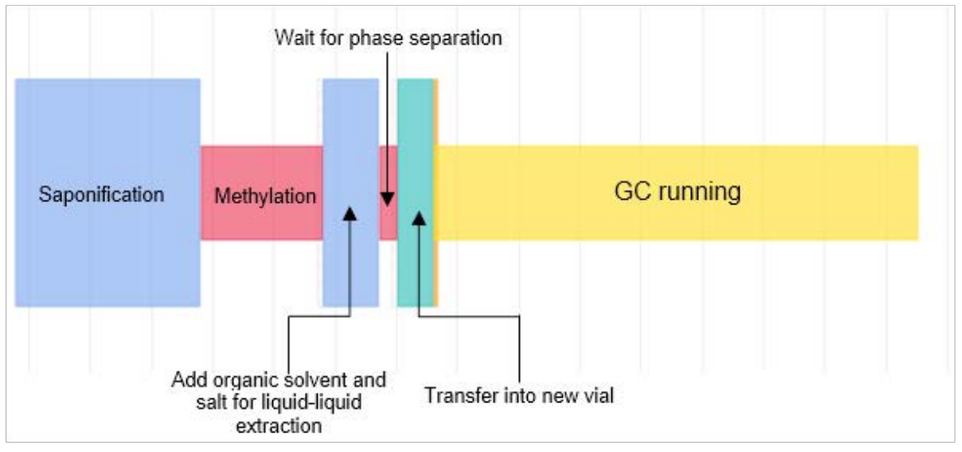
FOOD SAFETY

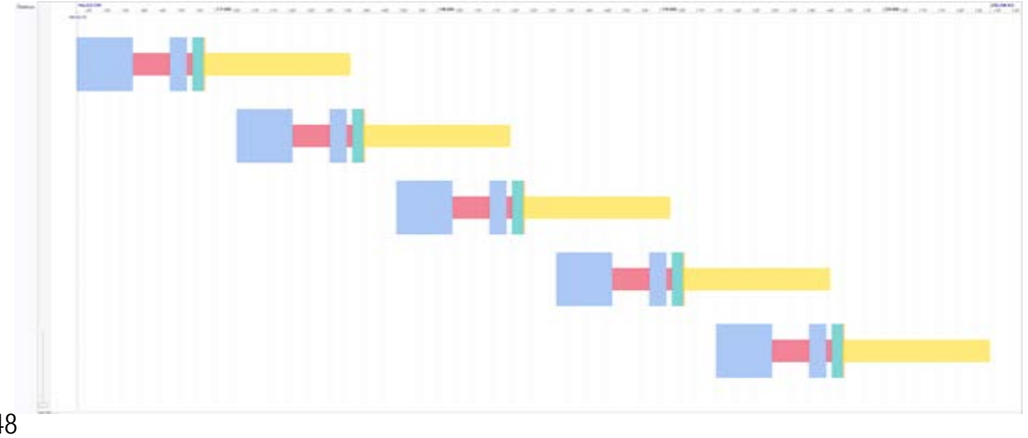
Chiew Mei Chong, CTC Analytics Pte. Ltd., Singapore

Conclusions

- An efficient method for the generation and GC-analysis of FAME was generated using PAL Method Composer ver. 1.4. PAL Method Composer allows to rapidly generate methods by simple drag & drop operations.
- The software supports up to two overlapped steps. A free trial version of PAL Method Composer can be downloaded here. With the new overlapping feature in PAL Method Composer the sample preparation time can be reduced by 40%.
- The automated method yielded fatty acid methyl esters from edible oils with good precision. Each sample required 75 minutes to complete the sample preparation and GC running. By using the overlapped PAL Method Composer, 5 samples can be completed in about 4 hours.
- The automated method minimizes the consumption of solvents and reagents and allwoed llowed to shorten the time for sample preparation by 40%

The color bar in the overlapping diagram has different meaning as follow:





Add 0.5M NaOH in Methanol

Incubate at 65°C

Add BF_3 in Methanol

Incubate at 65°C

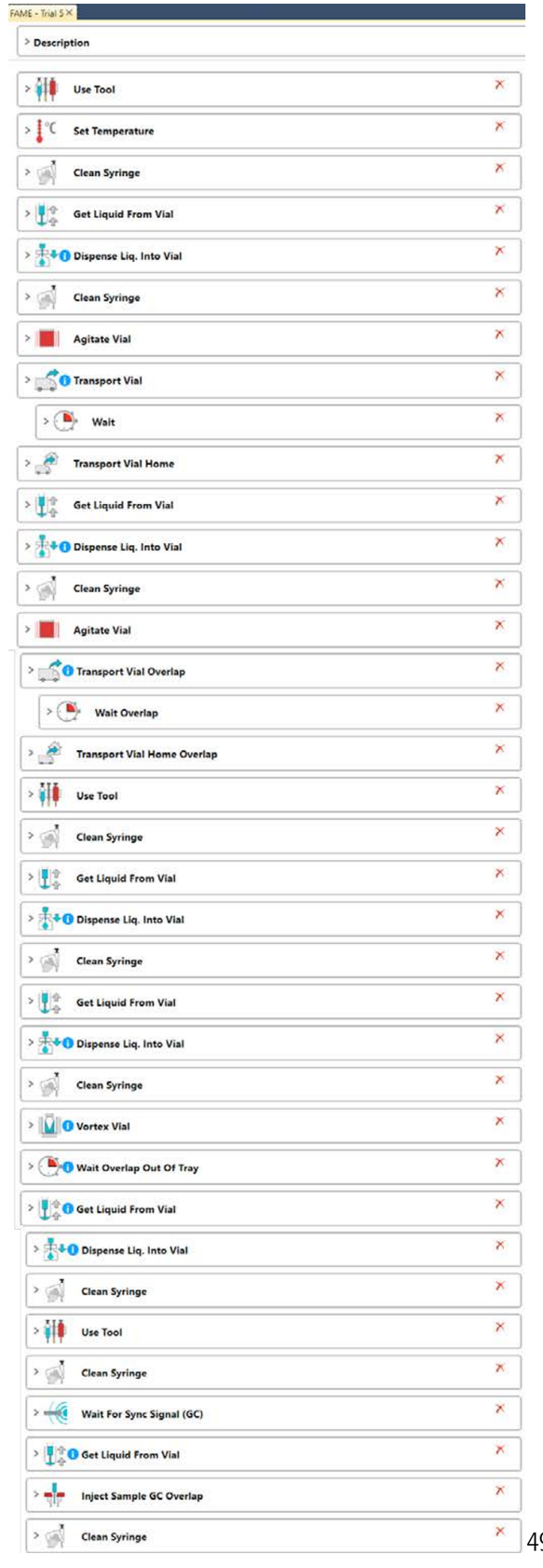
Add Hexane

Add NaCl

Wait for phase separation

Transfer the organic layer into a new vial

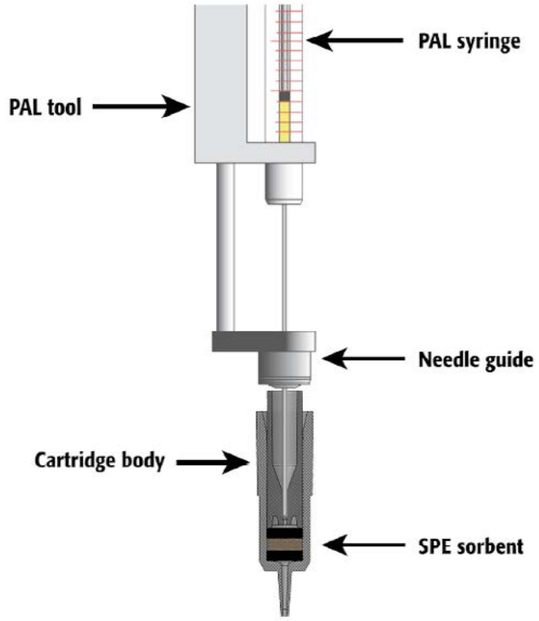
Inject into GC



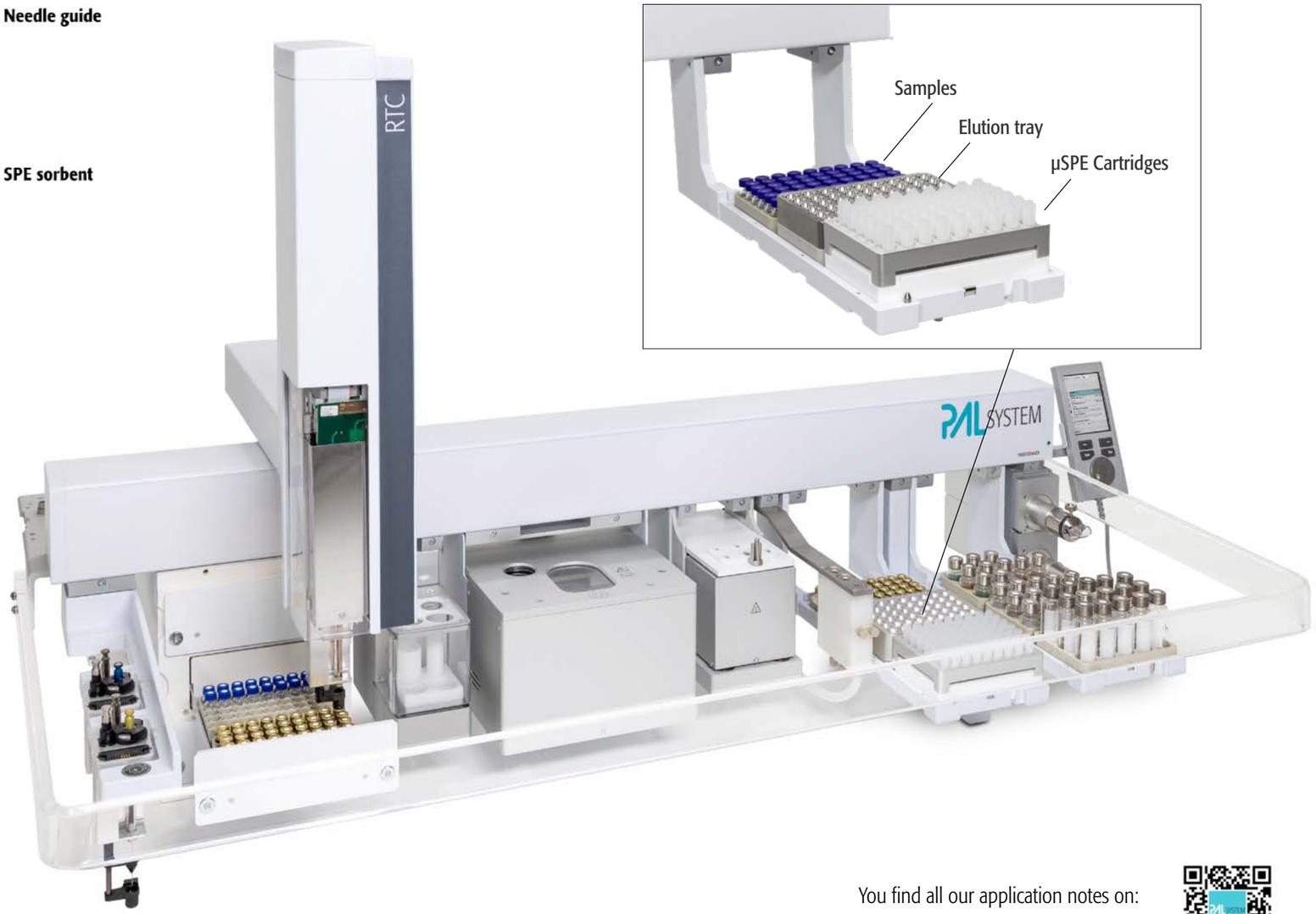
µSPE clean-up of QuEChERS extracts for GC and LC

FOOD SAFETY

- Get 1 mL syringe
- Load 300 µL raw extract from sample vial into 1 mL syringe
- Place µSPE cartridge above collection vial
- Elute extract through µSPE cartridge
- Discard µSPE cartridge
- Get 100 µL syringe
- Add 25 µL MeCN
- Add 25 µL analyte protectant and QC solution
- Inject Sample → Start analytical run
- Start next sample



- The µSPE cleanup achieves high quality results for diverse type of analytes and foods (apple, kiwi, carrot, kale, orange, black olive, pork loin, salmon, and avocado; Lehotay et al., 2016).
- The approach enables reliable, high-throughput operations without much labor or instrument maintenance.
- µSPE provides better cleanup than dispersive-SPE (d-SPE) while minimizing solvent use.
- Instrument up-time increases significantly because of cleaner extracts.
- The automated µSPE step takes 8 min per sample.



- The PAL syringe works as LC pump. Precisely controlled flow rates in the load and elution steps result in sharp analyte/matrix separation.
- µSPE employs miniaturized SPE cartridges (33 mm height x 8 mm diameter).
- The miniaturization of the clean-up step to a microliter scale solid phase extraction (µSPE) prevents the typical dilution by SPE elution thus avoids an additional evaporation step and minimizes solvent use.

Lehotay et. al. Chromatographia 79, 17, pp 1113–30, 2016 http://link.springer.com/article/10.1007/s10337-016-3116-y/fulltext.html
Morris, Schriner. J Agric Food Chem, 63, 5107-19, 2015 https://www.ncbi.nlm.nih.gov/pubmed/25702899

You find all our application notes on:

Application Notes

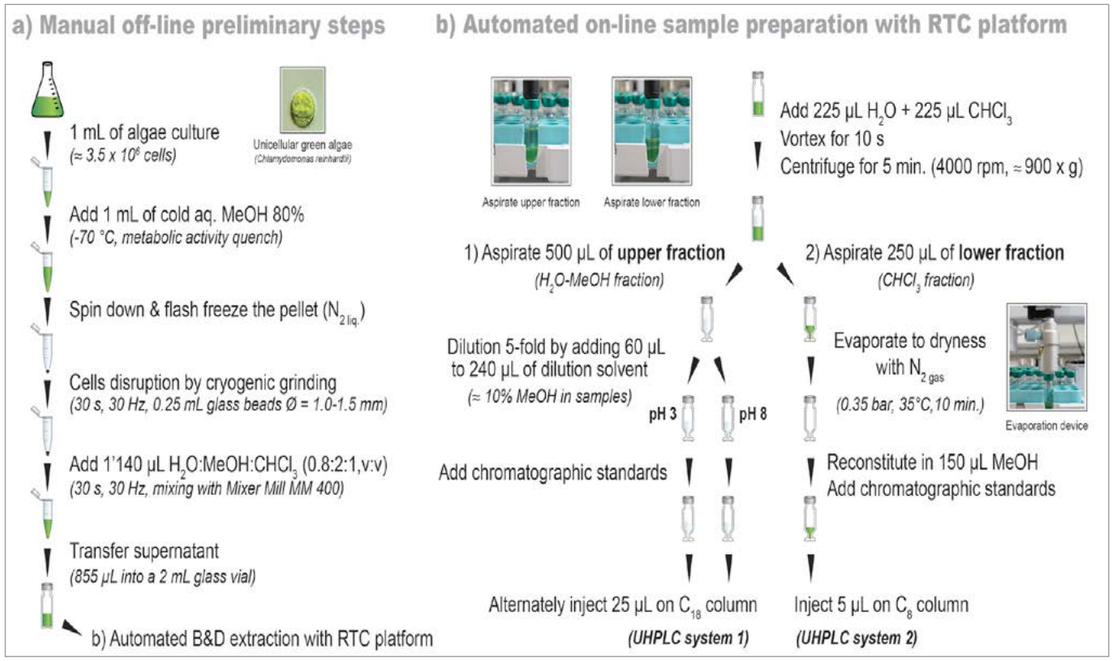
Fully integrated automated Bligh and Dyer extraction and dual-column analysis for metabolomics analyses of tissues and cells.

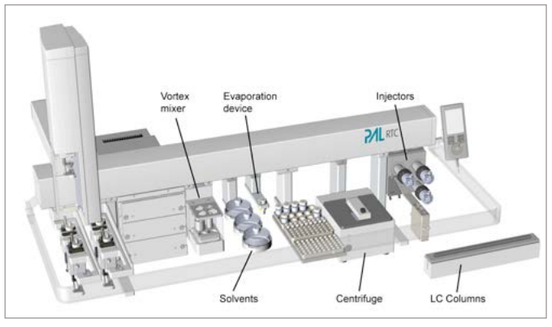
LIFE SCIENCE

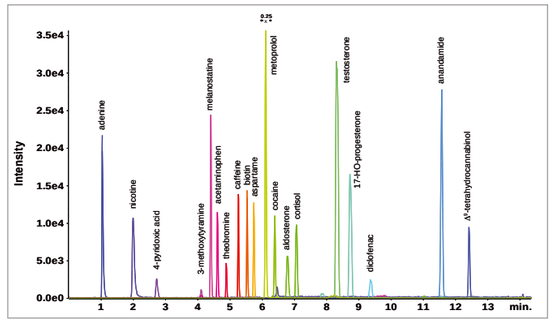
Emmanuel Varesio, Sandra Jahn, Sandrine Cudré, Gérard Hopfgartner, Life Sciences Mass Spectrometry, School of Pharmaceutical Sciences, University of Geneva, University of Lausanne, Switzerland; Renzo Picenoni, Guenter Boehm, Director Applications and Customer Communications, CTC Analytics AG, Zwingen, Switzerland

Conclusions

As laboratories are striving to uncover more «unknowns» and increase our understanding of biological processes there is a drive for procedures to become more efficient and repeatable. This is also true for extraction procedures which when performed manually can be time intensive and cumbersome, taking the valuable time of scientists. The automated Bligh and Dyer extraction described here was found to not only be more time efficient, but also to improve repeatability and quality of extraction and separation when compared to the standard manual approach.







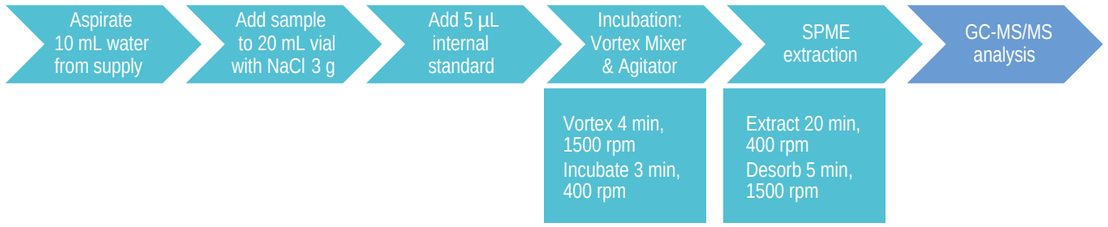
Real time monitoring for off-flavour compounds using a functionalized autosampler with SPME-GC-MS/MS.

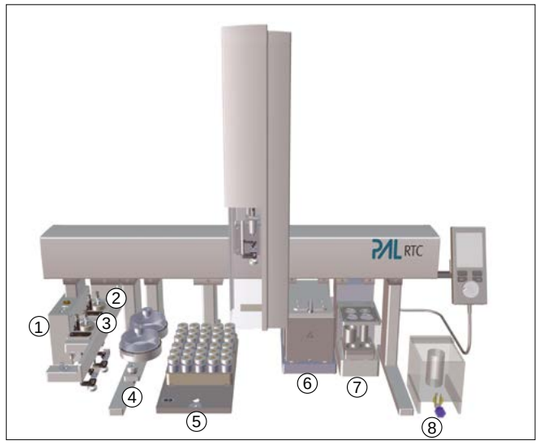
ENVIRONMENTAL

Jaewon Choi, Sung-Yun Ahn, Yuns Kim, Ilhwan Choi, Water Analysis & Research Center, K-water
Wonkyoung Lee*, Moondon Choi* , Jongsu Park*, * Euro Science, Seoul, South Korea

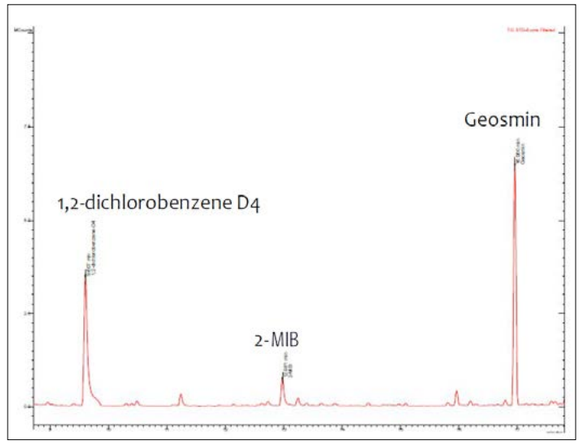
Conclusions

- This real time monitoring system has been operating continously for several months. A temporary trend was observed for geosmin during 2 months.
- This system uses standard instrumentation, and is harmonized with the accredited method for drinking water of Korean Ministry of Environment (MOE) including adding internal standard and salt.





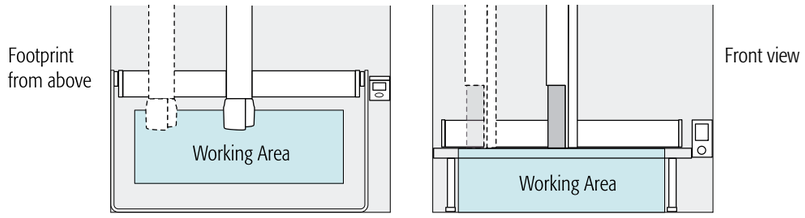
1 SPME Conditioning Station
2 10 µl Syringe Tool
3 10 ml Syringe Tool
4 Large Wash Module
5 Vial Tray Plate
6 Agitator Module
7 Vortex Mixer Module
8 Real Time Water Tank



Compound	Geosmin	2-MIB
R^2	0.998	0.995
Spiking conc. (ng/l)	1	2
LOD (ng/l)	0.16	0.17
LOQ (ng/l)	0.51	0.56
Precision (RSD %)	4.5	2.7
Recovery (%)	115	106

Dimensions

	Compact x-axis length PALbase 534 X/Y unit	Standard x-axis length PALbase 850 X/Y unit	Xtended x-axis length PALbase 1200 X/Y unit	Xpanded x-axis length PALbase 1600 X/Y unit	XXpanded-axis length PALbase 2000 X/Y unit
Working Space	Width: 420 mm (16.8 inches) Depth: 255 mm (10.0 inches) Height: 420 mm (16.8 inches)	Width: 735 mm (28.9 inches) Depth: 255 mm (10.0 inches) Height: 420 mm (16.8 inches)	Width: 1090 mm (43.0 inches) Depth: 255 mm (10.0 inches) Height: 420 mm (16.8 inches)	Width: 1511 mm (60.4 inches) Depth: 255 mm (10.0 inches) Height: 420 mm (16.8 inches)	Width: 1915 mm (73.4inches) Depth: 255 mm (10.0 inches) Height: 420 mm (16.8 inches)
Footprint Instrument dimensions with standard legs	Width: 600 mm (24.0 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 915 mm (36.6 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 1270 mm (50.8 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 1768 mm (70.7 inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)	Width: 2172 mm (85.5inches) Depth: 795 mm (31.8 inches) Height: 770 mm (30.8 inches)
Sample Capacity	2 Tray Holders Up to 420 1 ml vials 324 2 ml vials 90 10/20 ml vials 6 MT/DW plates	4 Tray Holders Up to 840 1 ml vials 648 2 ml vials 180 10/20 ml vials 12 MT/DW plates	6 Tray Holders Up to 1260 1 ml vials 972 2 ml vials 270 10/20 ml vials 18 MT/DW plates	9 Tray Holders Up to 1890 1 ml vials 1458 2 ml vials 405 10/20 ml vials 27 MT/DW plates	13 Tray Holders Up to 2730 1 ml vials 2106 2 ml vials 58510/20 ml vials 39 MT/DW plates
Sample Capacity Temperature Controlled (4-40°C)	1 Peltier Stack Up to 420 1 ml vials 324 2 ml vials 90 10 ml vials 6 MT/DW plates	Max. 3 Peltier Stacks Up to 1260 1 ml vials 972 2 ml vials 270 10 ml vials 18 MT/DW plates	Max. 4 Peltier Stacks Up to 1680 1 ml vials 1296 2 ml vials 360 10 ml vials 24 MT/DW plates 9216 samples (with 54 x 384 well MTPs)	Max. 6 Peltier Stacks Up to 2520 1 ml vials 1944 2 ml vials 540 10 ml vials 36 MT/DW plates 13824 samples (with 54 x 384 well MTPs) Max. 27648 samples with 6 x Peltier Stack 12MT and 384 MTPs.	Max.9 Peltier Stacks Up to 3780 1 ml vials 2916 2 ml vials 810 10 ml vials 54 MT/DW plates 20796 samples (with 54 x 384 well MTPs) Max. 27648 samples with 6 x Peltier Stack 12MT and 384 MTPs.



Supported injection techniques

Tool	Ranges/Tools
Liquid Injection Tools	0.5 - 100 µl syringes, 57 and 85 mm needle lengths, with corresponding Tools 250 - 1000 µl syringes, 57 and 85 mm needle lengths, with corresponding Tools 5 & 10 ml syringes, with corresponding Tools
µSPE Injection Tool	Liquid Tool for handling µSPE cartridges, holds syringes from 100-1000 µl
LC/MS Tools	Injection volume LC/MS-100, 1-80 µl, with corresponding Tools Injection volume LC/MS-250, 1-230 µl, with corresponding Tools
Headspace Extraction	1000 µl / 2500 µl / 5000 µl, with corresponding Tools
Solid Phase Micro Extraction (SPME Fiber & SPME Arrow)	SPME Fiber Tool (holds commercially available Fibers), SPME Arrow Tool
Multiple Headspace Extraction (MHE)	MHE Tool for 10 and 20 ml vials
ITEX Dynamic Headspace Extraction	ITEX DHS Tool with Tenax TA adsorbent (other materials upon request)
Pipette Tool Injection	Direct injection from Pipette Tip into LC-valve

Available Modules

Agitator	Temperature controlled agitation, 40 - 200 °C, 250-750 rpm
Barcode Reader	Reads 1D barcodes on 2, 10, 20 ml vials
Centrifuge	Essential for sample prep, Combi, 2 ml and 10 ml modules
Decapper	Opens & closes 2, 10 & 20 ml screw cap vials
Dilutor Single / Dilutor Multi	Fast and accurate dispensing of larger volumes of up to 5 different liquids
Fast Wash Module	Efficient cleaning of syringes / needles (gauge 19-26) with 2 different solvents
High Flow Fast Wash Module	Wash Module for flow rates up to 40 ml/min
Flow Cell	Up to 6 Flow Cells for online sampling
Heatex Stirrer	For mixing and heating in sample prep and SPME Arrow
Large Wash Module	2 x 100 ml solvent container and waste port for cleaning of syringes / needles
Liquid Cooler	Trayholder & tray for 32 10/20 ml vials (external cooler not included)
Peltier Stack (2DW, 6DW, 12MT)	Temperature controlled storage 4 - 40 °C for a range of vials and DW/MT plates
Tray Cooler	Temperature controlled storage 4 - 40 °C for a range of vials and DW/MT plates
Thermal Mixer	For shaking and heating of well plates, 30-100°C, 0-2000 rpm
Solvent Module	3 x 100 ml solvent container for the addition of larger volumes of liquids
SPME Arrow Conditioning Module	Conditioning of SPME Arrows and SPME Fibers, up to 350 °C, optional purge gas connection
Stack (6DW, 12 MT)	Storage at room temperature for a range of vials and DW/MT plates
Standard Wash Module	4 x 10 ml solvent vial, 1 x 10 ml waste vial
Valve Drive	For Rheodyne or Valco injection & switching valves
Vortex Mixer	Efficient mixing for 2, 10, 20 ml vials

LC Application Specifications

Type	Specifications	Comment
Injection volume	0.1-10000 µl	Depending on syringe
Liquid injection, repeatability (gravimetrical)	Full loop < 0.1 % RSD Partial loop < 0.15 % RSD	20 µl loop, 4 x overfill 10 µl in 20 µl loop
Liquid injection, linearity (gravimetrical)	R^2 > 0.9999	20, 40, 60, 80, 100 µl, n=3 each level
Liquid injection from small sample volume	3 injections 1 µl out of 5 µl	With bottom sense option and conical 150 µl vial
Carryover	< 30 ppm	With LC/MS Tool, blank measured after injection of Cl-Hexidine 0.6 mg/ml

GC Application Specifications

Type	Specifications	Comment
Injection volume	0.1-10000 µl	Depending on syringe
GC liquid injection, repeatability	< 0.60 % RSD	Alkanes C14, C15, C16, 1 µl, split mode
GC liquid injection, linearity (gravimetrical)	R^2 > 0.9999	20, 40, 60, 80, 100 µl, n=3 each level
GC head space injection, repeatability	< 1.00 % RSD	Iso-octan, 10 µl in 20 ml vial, 500 µl injection
GC needle discrimination	C40/C20 > 0.98	Restek Florida Mix 1 µl, 100 ms fast split/splitless injection

Detailed specifications on request.

PAL SYSTEM
Ingenious sample handling



Contact the experts for sample preparation:

Or find your nearest value added reseller.

For more information on the PAL RTC and RSI, including the latest application notes visit:

www.palsystem.com

PAL is a registered trademark of CTC Analytics AG, Switzerland

PAL Broch-RTC - RSI
Rev 7 | May 2025