PAL SYSTEM
Ingenious sample handling

PAL Smart SPME Arrow
The Better SPME

Bigger, Smarter, Better - PAL Smart SPME Arrow

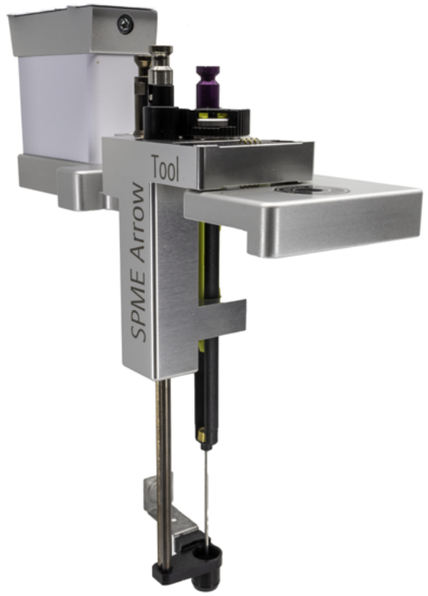
- Bigger surface, faster extraction
- More sorption phase, superior sensitivity
- Optimized geometry, greater robustness
- Full traceability
- Patented

- Each SPME Arrow is equipped with its unique Smart chip containing parameters, ranges and usage history.
- Automatic application of the correct parameters for the individual Smart Arrow.
- Color coded for easy optical identification of coating type and thickness.

PAL Smart SPME Arrows - The new dimension for Solid-Phase Micro Extraction

SPME has become one of the most widely used extraction technologies for environmental, food and clinical analyses. It is well suited for automated sample preparation resulting in reduced time per sample, less sample manipulation and solvent consumption. However, the technology remained almost unchanged with some significant drawbacks, such as the limited mechanical stability and small phase volumes of the fibers.

The PAL SPME Arrow is a new patented technology for micro-extraction, combining trace level sensitivity with high mechanical robustness. The PAL SPME Arrow has an outer diameter of 1.1 or 1.5mm, resulting in large sorption phase surfaces and volumes. The arrow-shaped tip allows smooth penetration of vial and injector septa. In contrast to traditional SPME Fibers, the Arrow design fully protects the sorptive material, minimizing adverse influences and loss of analytes during transfer processes.
With PAL RTC and PAL RSI the SPME Arrow sampling is fully automated leading to high productivity.



PAL Smart SPME Arrow installed in tool.

Find more information about SPME Arrow

What Better SPME means

Bigger surface, faster extraction → 2 x higher sample throughput.

More sorption phase, superior sensitivity → up to 10 x more sensitivity - wider linear range.

Optimized geometry, greater robustness → PAL SPME Arrows last at least 2 x longer. Lower running costs.

= 2 x productivity

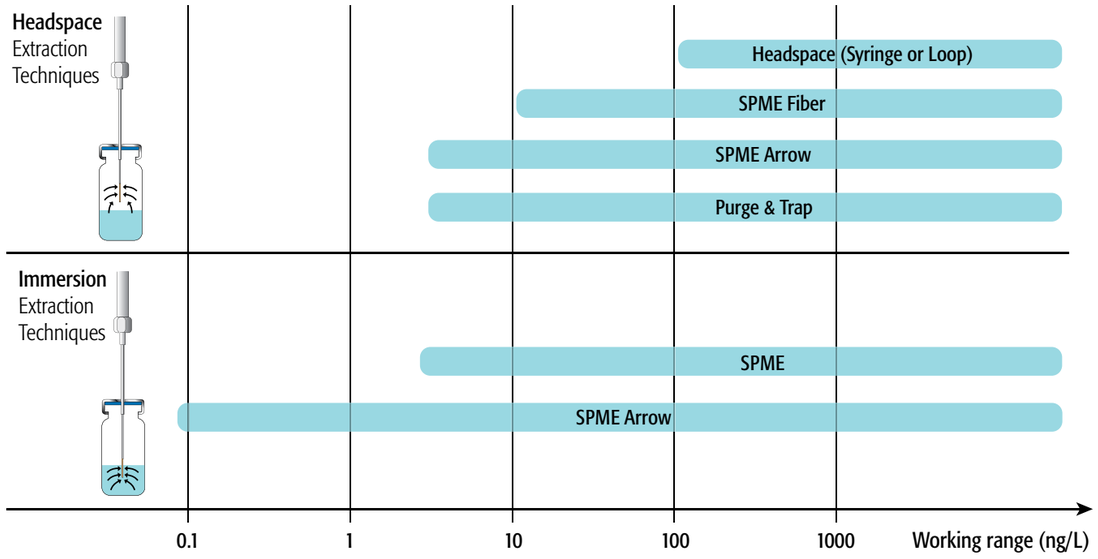


Fig. 1 Comparison of different extraction techniques

Better SPME

- Adaptation of existing SPME methods is straightforward
- PAL SPME Arrow works well for headspace and immersion extraction
- With the wide selection of sorption materials (cf. page 9) a wide variety of compounds are now amenable to SPME
- The PAL SPME Arrow is an ideal field sampling device
- PAL SPME Arrow covers a wide range of applications. However, for dynamic headspace applications, especially for volatiles we recommend ITEX Dynamic Headspace (DHS).
- This powerful technology achieves ng/L sensitivities without the pitfalls of purge & trap systems.

More Volume: Up to 10x more Sensitivity

The table below shows the dimension of the different SPME Types.

SPME Types		Sorption phase	
		Surface (mm²)	Volume (µL)
SPME Arrow 1.1mm		44.0	3.8
SPME Arrow 1.5mm - PDMS 250µm		62.8	11.8
SPME Arrow 1.5mm - Widesleeve*		44.0	3.8
SPME Fiber		9.4	0.6

Table 1: Comparison between Smart SPME Arrows and Smart SPME Fiber

*Widesleeve arrows with 1.5mm diameter have the same phase dimensions as the corresponding 1.1mm 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 1.1mm Arrows.

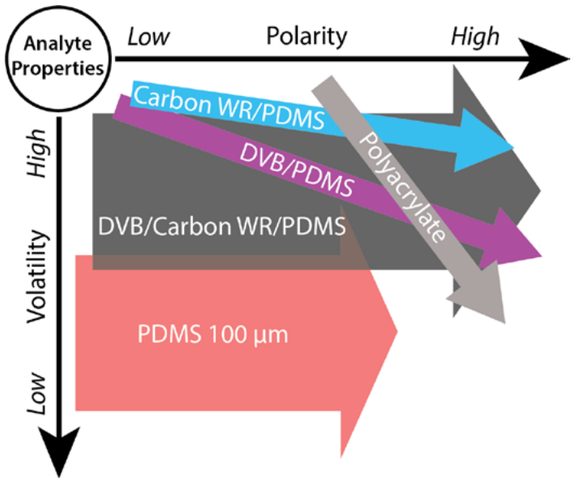
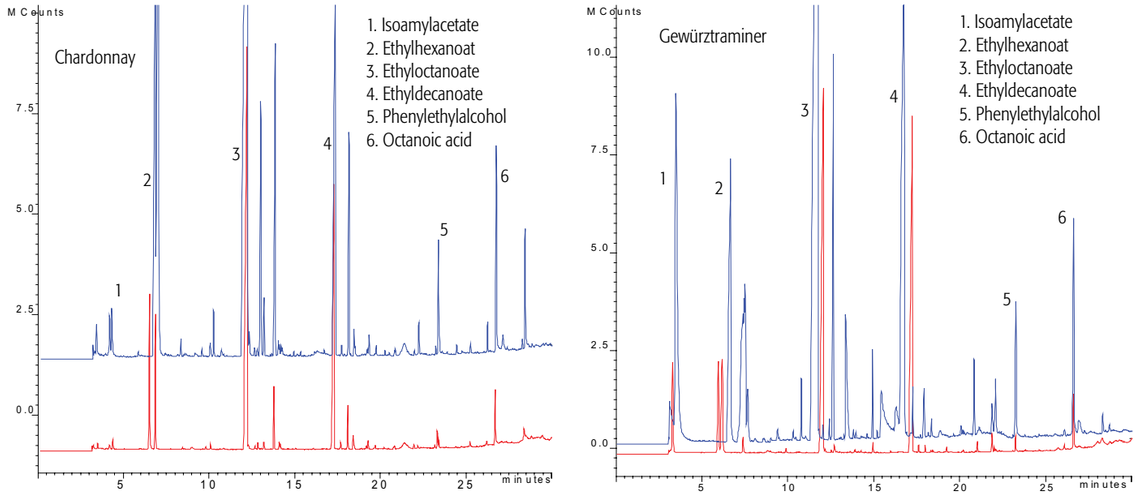


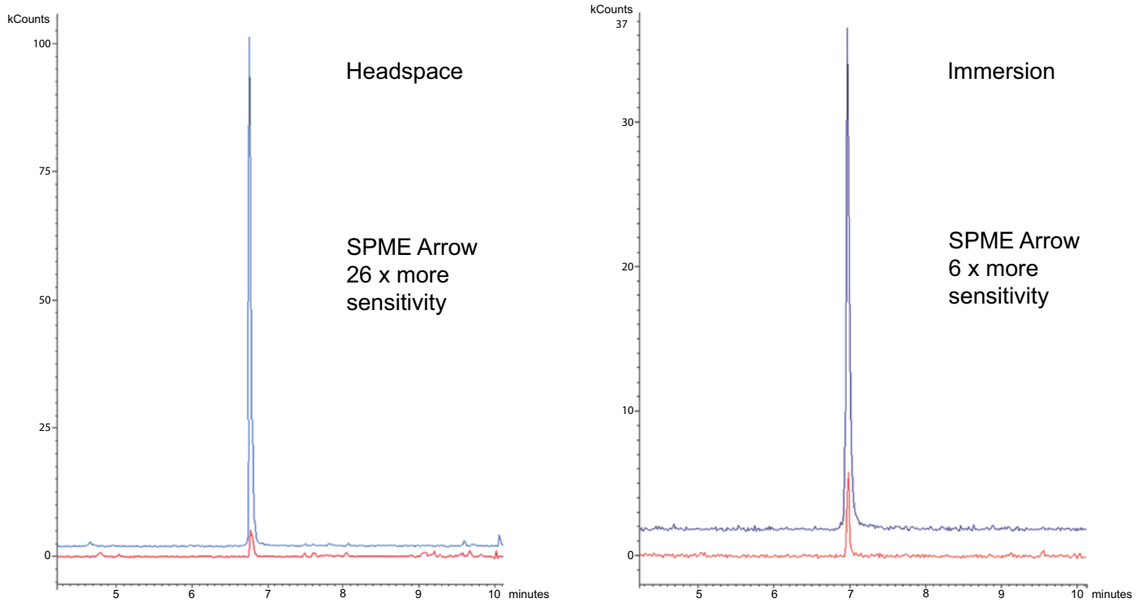
Fig. 2: Color Code for easy optical identification of coating type and thickness

Headspace Extraction: Aroma Analysis in White Wines



Chromatograms showing the headspace extraction of aroma components from different white wines with PDMS fibers (PAL SPME Arrow 100 µm, 20 x 1.1 mm compared to SPME Fiber 100 µm, 10 x 0.3 mm)

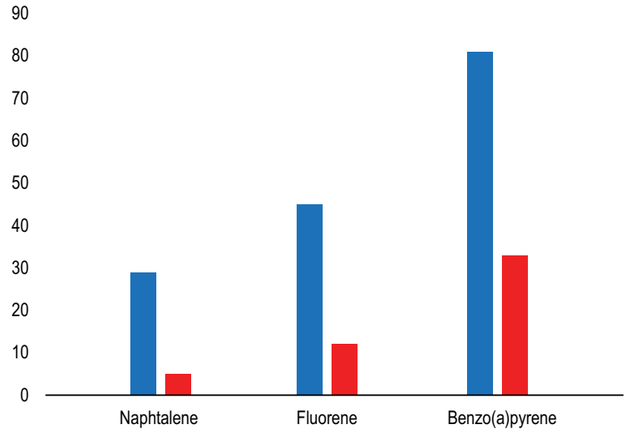
Iodoform in Water



Extraction of 1 µg/L iodoform from tap water with DVB fibers (headspace and immersion extraction), PAL SPME Arrow 100 µm, 20 x 1.1 mm compared to SPME Fiber 100 µm, 10 x 0.3 mm.

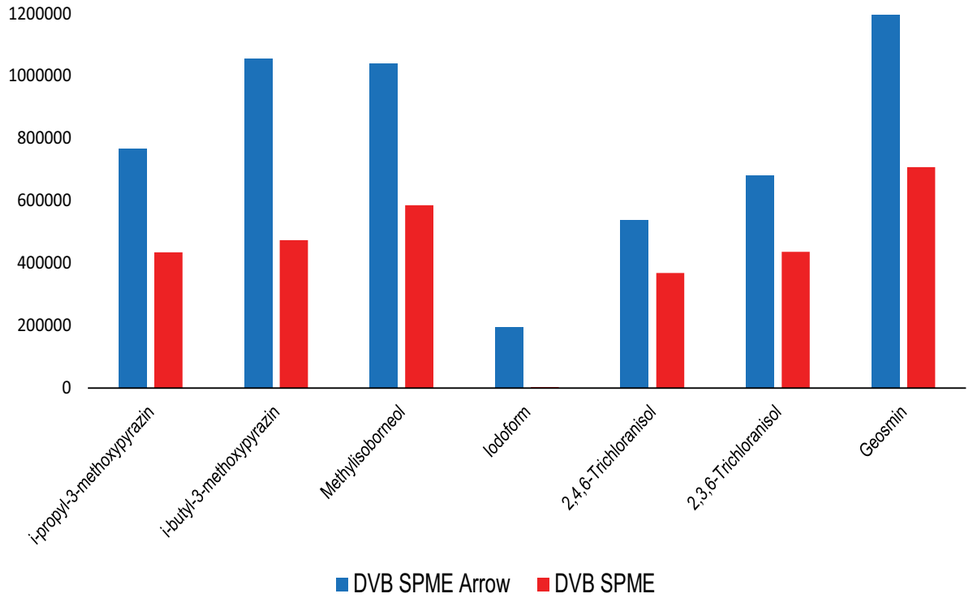
Bigger Surface: 2x Throughput

Immersion Extraction: Polyaromatic Hydrocarbons (PAHs) in Water



Relative immersion extraction yield (measured as % extracted after a 70 min) for PAHs at 50 ng/L with PDMS fibers (PAL SPME Arrow 100 µm, 20 x 1.1 mm compared to SPME Fiber 100 µm, 10 x 0.3 mm)

Headspace Extraction: Off Flavor Compounds in Water



Relative headspace extraction yield (measured as amount extracted after 30 min) for off-flavor compounds in water at 100 ng/L with DVB fibers. (PAL SPME Arrow 100 µm, 20 x 1.1 mm compared to SPME Fiber 100 µm, 10 x 0.3 mm)

References

[1] Belardi R., Pawliszyn J., Water Pollut. Res.J.Can. 1989, 24, 179

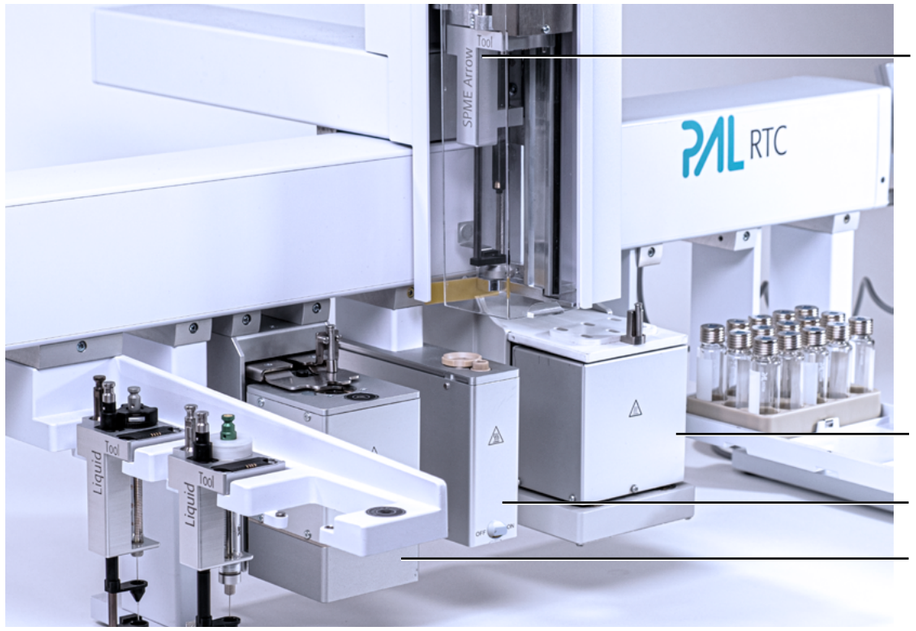
[2] SPME Arrow - Evaluation of a Novel Solid-Phase Microextraction Device for Freely Dissolved PAHs in Water; Kremser A. et al., Anal. Bioanal. Chem. 2016, 408, 943-952

[3] Solid phase microextraction Arrow for the sampling of volatile amines in wastewater and atmosphere; Helin A. Et al., J. Chrom. A 2015, in press

[4] PAL System Application Notes: Determination of iodoform in drinking water by SPME and GC/MS and Determination of C2-C12 aldehydes by SPME on-fiber derivatization and GCMS

With the PAL RTC and PAL RSI the entire SPME process is fully automated guaranteeing process safety and high reproducibility.

SPME Arrow → Extraction → Desorption / Injection → Conditioning



PAL Heatex Stirrer - New Mixing and Heating Technology for Sample Preparation and SPME.

The powerful PAL Heatex Stirrer mixes samples rapidly applying cycloid shaped mixing patterns without the need for stir bars. For SPME headspace and immersion sampling the special design (pat. pending) ensures optimal performance.

The PAL Heatex Stirrer offers:

- Rapid equilibration through effective stirring for headspace and immersion SPME sampling while ensuring the integrity of the fiber
- Efficient dissolution of solids, temperature controlled
- Thorough liquid/liquid extraction
- Stirring/heating for derivatization reactions
- No stir bar required, constant stirring also with samples containing solids
- No cross contamination
- Precise control of the equilibration temperature 40-150 °C
- Software controlled, temperature and stirring speed are logged

PAL Smart SPME Arrow Ordering Information

The PAL Smart SPME Arrows are available in order quantities of one, three or five Smart SPME Arrows per box.
For method development, a set of each SPME Arrow type (set of five) is available.

No.	Outer Diameter	Phase Thickness	Color Code	Set of 1 Smart SPME Arrow PNo.	Set of 3 Smart SPME Arrow PNo.	Set of 5 Smart SPME Arrow PNo.
	PDMS Smart SPME Arrow (Polydimethylsiloxane)					
1	1.1 mm	100 µm	Red	SARR11-P-100/20-P1	SARR11-P-100/20-P3	SARR11-P-100/20-P5
2	1.5 mm	100 µm	Red	SARR15-P-100/20-P1	SARR15-P-100/20-P3	SARR15-P-100/20-P5
	Polyacrylate Smart SPME Arrow					
3	1.1 mm	100 µm	Gray	SARR11-A-100/20-P1	SARR11-A-100/20-P3	SARR11-A-100/20-P5
	Carbon WR / PDMS Smart SPME Arrow (Carbon Wide Range / Polydimethylsiloxane)					
4*	1.1 mm	120 µm	Light Blue	SARR11-C-WR-120/20-P1	SARR11-C-WR-120/20-P3	SARR11-C-WR-120/20-P5
5*	1.5 mm	120 µm	Light Blue	SARR15-C-WR-120/20-P1	SARR15-C-WR-120/20-P3	SARR15-C-WR-120/20-P5
	DVB / PDMS Smart SPME Arrow (Divinylbenzene / Polydimethylsiloxane)					
6	1.1 mm	120 µm	Violet	SARR11-DVB-120/20-P1	SARR11-DVB-120/20-P3	SARR11-DVB-120/20-P5
7	1.5 mm	120 µm	Violet	SARR15-DVB-120/20-P1	SARR15-DVB-120/20-P3	SARR15-DVB-120/20-P5
	DVB / Carbon WR / PDMS Smart SPME Arrow (Divinylbenzene / Polydimethylsiloxane / Carbon Wide Range)					
8*	1.1 mm	120 µm	Dark Gray	SARR11-DVB/CWR120/20-P1	SARR11-DVB/CWR120/20-P3	SARR11-DVB/CWR120/20-P5
9*	1.5 mm	120 µm	Dark Gray	SARR15-DVB/CWR120/20-P1	SARR15-DVB/CWR120/20-P3	SARR15-DVB/CWR120/20-P5
	PDMS Smart SPME Arrow (Polydimethylsiloxane)					
10	1.5 mm	250 µm	Black	SARR15-P-250/20-P1	SARR15-P-250/20-P3	SARR15-P-250/20-P5
	Smart SPME Arrow Selection for method development (set of 5 different Smart SPME Arrow types)					
	Smart SPME Arrow Selection of 5 Smart SPME Arrow standard types No. 1, 3, 4, 6 and 8					SARR1115-SEL5-S2

* Smart SPME Arrow wide types - for use with solvents or reagents, that may lead to moderate swelling of PDMS phases.

Table 2. PAL Smart SPME Arrow Order Information.

All Smart SPME Arrows have a phase length of 20 mm. Smart SPME Arrow cannot be used with standard SSL injectors of most GC manufactures. The use of the specific Smart SPME Arrow Adaptation Kit is mandatory. Liners in the injector must be selected to fit Smart SPME Arrows with 1.1 mm or 1.5 mm diameter. Please see the list of available kits at the end of this document. The Smart SPME Arrow assortment and the range of applications will be constantly expanded and developed.

Smart SPME Arrows are fully backward compatible with non smart SPME Arrows (any generation of PAL3 Systems).

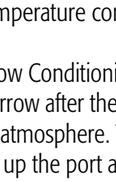
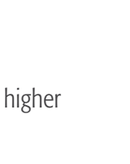
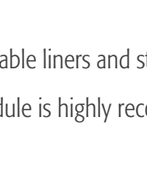
PAL Smart SPME Arrow Accessories

To use the SPME Arrow technique with a PAL System a dedicated kit is required, for more information see following table.

An Agitator is highly recommended for temperature controlled extractions. Furthermore the agitation speeds up the equilibration process.
A second optional module is the SPME Arrow Conditioning module. The conditioning station has two functions. The first function is the cleaning (bake-out) of the inserted Arrow after the analytical process to prepare for the next analysis. The second function is to condition a new Arrow in an inert gas atmosphere. This module is strongly recommended since it will help to protect the GC injection port from contamination and free up the port after thermal desorption.

System requirements

- PAL RTC or RSI with firmware 2.3 or higher
- PAL SPME Arrow Tool
- PAL Agitator & Heatex Stirrer module
- Adaptation of GC-injector (List of suitable liners and starter kits see page 11)
- A PAL SPME Arrow Conditioning module is highly recommended.

Smart SPME Arrow Kit PAL3-SPME-SArr-Kit		Smart SPME Arrow kit without GC adaption 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
SPME Arrow Conditioning Module PAL3-SPME-ArrowCond		• 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 requires firmware version 2.3 or higher
Agitator and Heatex Stirrer Kit PAL3-AgiHeatex-Kit	 	Agitator and Heatex Stirrer kit consisting of: 1 pc Agitator for the incubation and agitation of up to 6 x 20 mL vials 1 pc Heatex Stirrer for intensive heating and stirring of 1 x 20 mL vial without stir bar specific Heatex Stirrer insert for 10 mL vials available (not included) specific Agitator insert for 10 mL vials available (not included) requires firmware version 2.3 or higher and adapters for 10 mL vials

Ordering information for starter kits and suitable liners

Starter Kits	PAL3-SARR-Start-GC2010	Starter Kit SPME Arrow for Shimadzu GC-2010 Plus consisting of: 1 Adaption Kit for the split/splitless injector of Shimadzu GC-2010 Plus (ARR-SSL-Inj-GC2010), 1 Liner Nut, 1 Screw Cap, 2 SPME Arrow Liner,1 SPME Arrow Tool Kit (PAL3-SPME-Arrow-Kit)
	PAL3-SARR-Start-GC2030	Starter Kit Smart SPME Arrow for Shimadzu GC-2030 consisting of: 1x Adaptation for the split/splitless injector of SHIMADZU GC-2030, 1 pc Liner Nut, 1 pc Screw Cap, 2 pc SPME Arrow Liner ID 1.3mm (ARRLIN13-GC2010), 2 pc SPME Arrow Liner ID 1.7mm (ARRLIN17-GC2010), 1x PAL Smart SPME Arrow Kit (PAL3-SPME-SArr-Kit)
	PAL3-SARR-Start-6890-LCh	Starter Kit Smart SPME Arrow for Agilent GC 6890 with large charcoal filter consisting of: 1 Adaptation for the split/splitless injector with large charcoal filter of AGILENT GC 6890 (ARR-SSL-Inj-GC6890-LCh), 2 SPME Arrow Liner for SSL Injector of Agilent GC 6890, 1 PAL Smart SPME Arrow Kit (PAL3-SPME-SArr-Kit)
	PAL3-SARR-Start-6890-Std	Starter Kit Smart SPME Arrow for Agilent GC 6890 with standard Assy consisting of: 1 Adaptation for the split/splitless injector with standard Assy of AGILENT GC 6890 (ARR-SSL-Inj-GC6890-STD), 2 SPME Arrow Liner for SSL Injector of Agilent GC 6890, 1x PAL Smart SPME Arrow Kit (PAL3-SPME-SArr-Kit)
	PAL3-SARR-Start-GC7890	Starter Kit SPME Arrow for Agilent GC 7890 consisting of: 1 Adaption Kit for the split/splitless injector of Agilent GC 7890 (ARR-SSL-Inj-GC7890), 2 SPME Arrow Liners for SSL Injector of the Agilent GC 7890, 1 SPME Arrow Tool Kit (PAL3-SPME-Arrow-Kit)
	PAL3-SARR-Start-GC8890	Starter Kit Smart SPME Arrow for Agilent GC 8890 / 8860 consisting of: 1 Adaptation for the split/splitless injector of AGILENT GC (ARR-SSL-Inj-GC8890), 2 SPME Arrow Liner for SSL Injector of Agilent GC , 1x PAL Smart SPME Arrow kit (PAL3-SPME-SArr-Kit)
	PAL3-SARR-Start-Intuvo	Starter Kit Smart SPME Arrow for Agilent GC Intuvo consisting of: 1 Adaptation for the split/splitless injector of AGILENT GC Intuvo (ARR-SSL-Inj-GCIntuvo), 2 SPME Arrow Liner for SSL Injector of Agilent GC , 1x PAL Smart SPME Arrow kit (PAL3-SPME-SArr-Kit)
	PAL3-SARR-Start-Tr1300	Starter Kit SPME Arrow for Thermo GC Trace 1300/1310 consisting of: 1 Adaptation Kit for the split/splitless injector of Thermo GC Trace1300/1310 (ARR-SSL-Inj-Trace1300), 2 SPME Arrow Liners for SSL Injector of Thermo GC Trace1300/1310, 1 SPME Arrow Tool Kit (PAL3-SPME-Arrow-Kit)
	PAL3-SARR-Start-TrUltra	Starter Kit SPME Arrow for Thermo GC Trace Ultra consisting of: 1 Adaptation Kit for the split/splitless injector of Thermo GC TraceUltra (ARR-SSL-Inj-TraceUltra), 2 SPME Arrow Liners for SSL Injector of Thermo GC TraceUltra, 1 SPME Arrow Tool Kit (PAL3-SPME-Arrow-Kit)
Suitable Liners	ARR-Liner-CondModule	Liner for SPME Arrow Conditioning Module, package containing 3 pcs
	ARRLIN13-GC2010-*	SPME Arrow liner ID 1.3mm, for SSL Injector of SHIMADZU GC 2010, only for SMPE Arrow OD 1.1mm
	ARRLIN13-GC6890-*	SPME Arrow liner ID 1.3mm, for SSL Injector of AGILENT GC 6890, only for SPME Arrow with OD 1.1mm
	ARRLIN13-GC7890-*	SPME Arrow liner ID 1.3mm, for SSL Injector of AGILENT GC 6890, only for SPME Arrow with OD 1.1mm
	ARRLIN13-Trace1300-*	SPME Arrow liner ID 1.3mm, for SSL Injector of Thermo GC Trace1300, only for SPME Arrow with OD 1.1mm
	ARRLIN17-GC2010-*	SPME Arrow liner ID 1.7mm, for SSL Injector of SHIMADZU GC 2010, for any SPME Arrow
	ARRLIN17-GC6890-*	SPME Arrow liner ID 1.7mm, for SSL Injector of AGILENT GC 6890, for any SPME Arrow
	ARRLIN17-GC7890-*	SPME Arrow liner ID 1.7mm, for SSL Injector of AGILENT GC 7890, for any SPME Arrow
	ARRLIN17-Trace1300-*	SPME Arrow liner ID 1.7mm, for SSL Injector of Thermo GC Trace1300, for any SPME Arrow
	ARRLIN20-TraceUltra-*	SPME Arrow liner ID 2.0mm, for SSL Injector of Thermo GC TraceUltra, for any SPME Arrow

*All PAL SPME Arrow liners are available as single liner (1) and as pack of 3 liners (3).

PAL SYSTEM

Ingenious sample handling

Contact the experts for sample preparation:

Or find your nearest value added reseller.

For more information on PAL System visit:

www.palsystem.com

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PAL Broch-Smart Arrow
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