SHIMADZU
Excellence in Science

C146-E396

Multifunctional Autosampler System

AOC-6000 Plus

Multifunctional Autosampler System

AOC-6000 Plus

Multifunctional Autosampler Dramatically Improves GC/MS Analysis Productivity

Multiple GCMS Sample Injection Methods in One Device

Perform liquid sample injection, headspace injection, solid phase micro injection (SPME) and more, all in one device. In addition, by using the tool-switching feature, all the syringe tools for various injection methods installed on the park station can be swapped automatically.

Increased Data Reliability

Recording of syringe and fiber usage history on a chip improves the reliability of acquired data. Automated sample adjustment also reduces the burden on the operator and contributes to analysis accuracy.

High-Sensitivity Analysis Achieved by Latest Concentration Technology

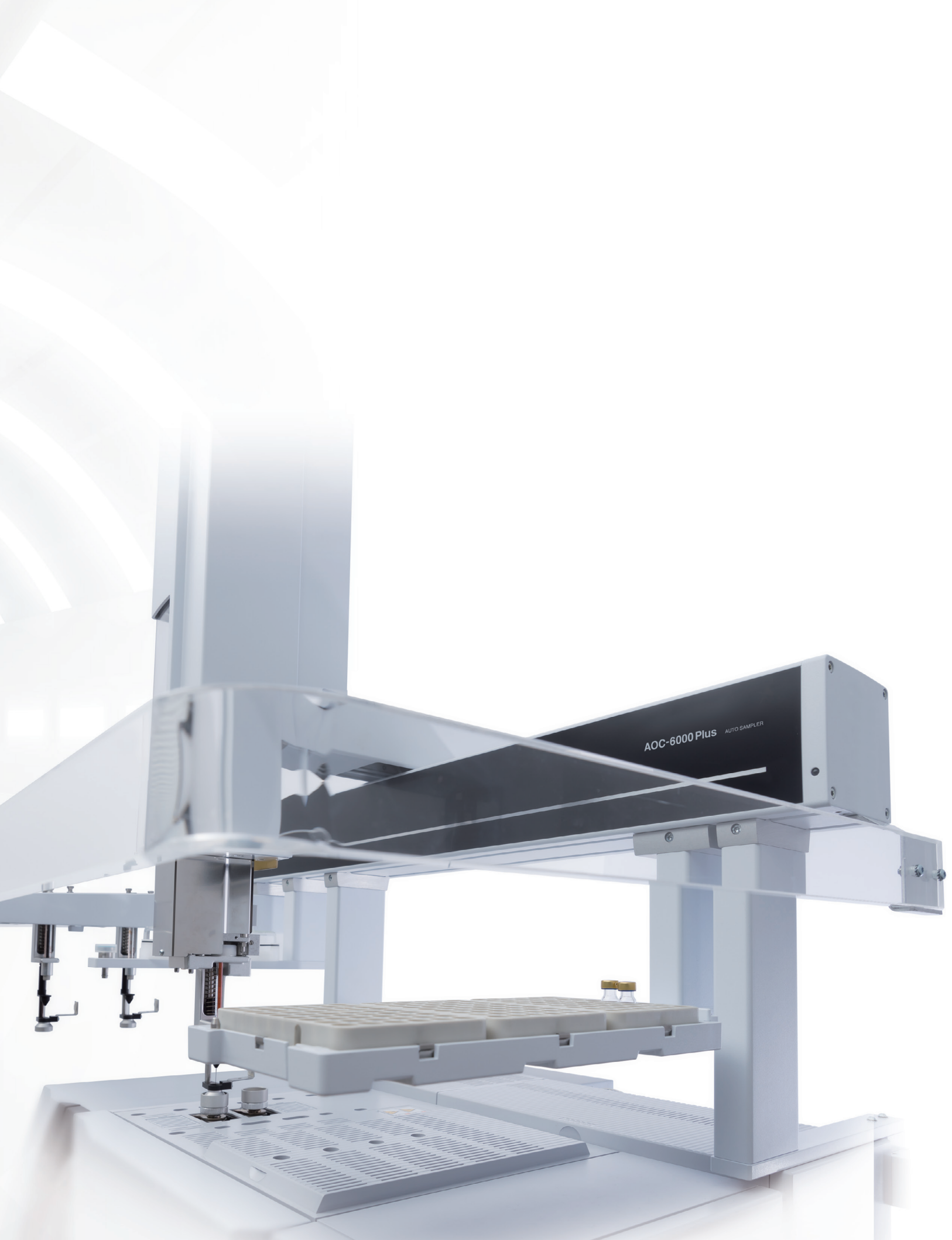
Compared to previous SPME methods, the SPME Arrow achieves enhanced sensitivity and durability, and the ITEX DHS (In-tube Extraction Dynamic Headspace) offers higher sensitivity compared with previous HS, which makes analyses that employ the latest concentration technology possible.

Accommodates a Wide Range of Sample Forms

By using the AOC-6000 Plus with the OPTIC-4 multimode inlet, with its wealth of injection modes, pyrolysis analysis of solid samples, thermal desorption analysis of gaseous components, and a wide variety of other samples and analyses can be handled.

Simple to Operate with GCMSsolution™

The AOC-6000 Plus is controlled by GCMSsolution GC/MS software.
Analysis accuracy control is easy since the AOC-6000 Plus and GC/MS analysis conditions are stored with the measured data.
An overlap function can also be used to heighten the efficiency of continuous analyses.


AOC-6000 Plus
AUTO SAMPLER

Multiple GCMS Sample Injection Methods in One Device

Accommodates Multiple GC/MS Sample Introduction Methods

Choose among liquid injection, headspace injection, and solid-phase microextraction (SPME) injection, etc. The sample injection method can be selected to suit the sample form and the components targeted for analysis.

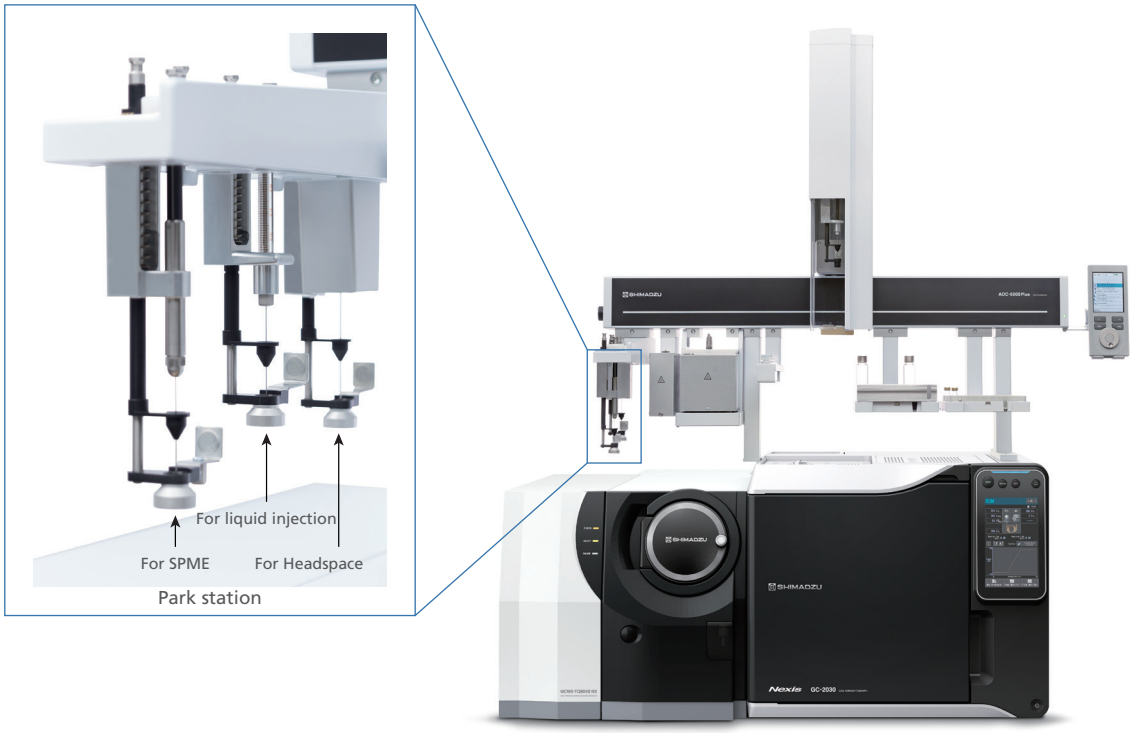
Liquid injection method

Headspace method
(Syringe method)

SPME method

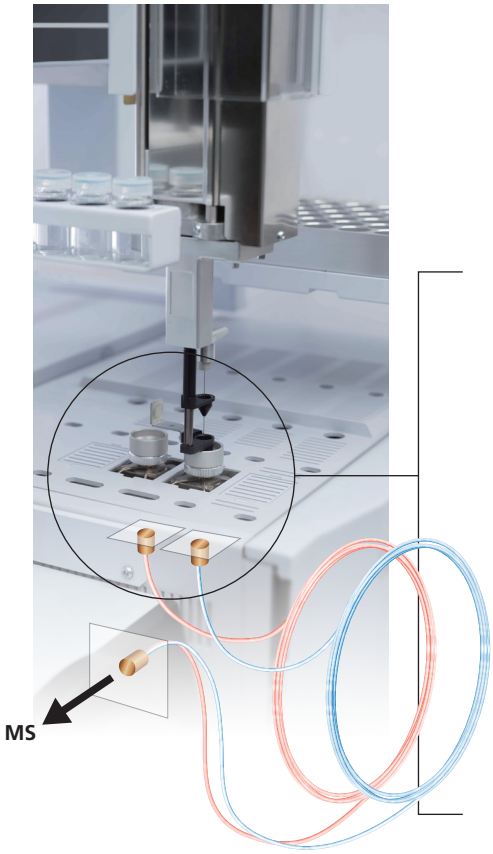
Automatic Switching of Sample Injection Methods

The AOC-6000 Plus automatically exchanges the syringe tools installed in the park station for each sample injection method (automatic tool exchange function).



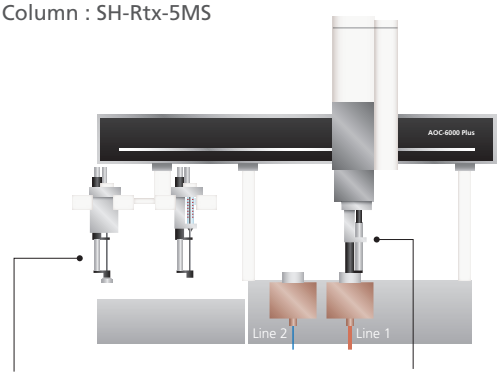
Automatic Switching of Sample Introduction Methods and Columns During Continuous Analyses —Twin Line MS System

By using the AOC-6000 Plus in combination with the Twin Line MS System*[1], continuous analyses are possible while sample introduction methods are switched automatically.



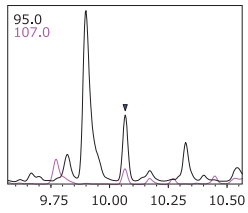
Line 1 : Analysis of components of mold odor

Sample injection method : SPME
Column : SH-Rtx-5MS



Syringe tool for HS analysis

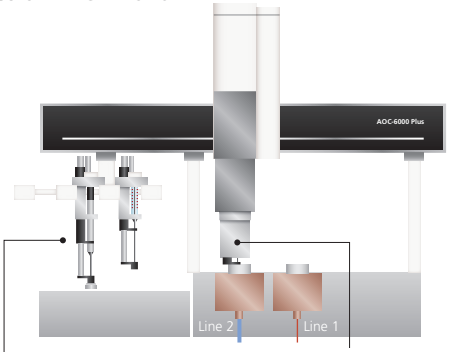
Syringe tool for SPME analysis



2-Methylisoborneol (Conc.: 1 ng/L)

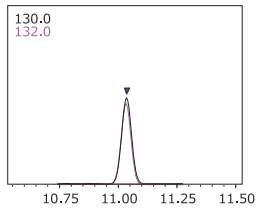
Line 2 : Analysis of VOCs

Sample injection method : Headspace
Column : SH-Rtx-624



Syringe tool for SPME analysis

Syringe tool for HS analysis

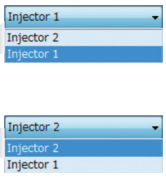


Trichloroethylene (Conc.: 0.1 µg/L)

Since the two injection ports on the Twin Line MS System each have their own separate column connected to them, even analyses that require the use of different columns, such as analyses of mold odors and components of VOCs, can be carried out continuously without the need for releasing the MS vacuum. The only requirement is specifying the injection port to be used within the method file. This also significantly reduces downtime, since there is no need for the time-consuming column changing task.

	Tray	Vial#	Method File
1	Rack 4	1	SPME.qgm
2	Rack 4	2	SPME.qgm
3	Rack 4	3	SPME.qgm
4	Rack 4	4	Headspace.qgm
5	Rack 4	5	Headspace.qgm
6	Rack 4	6	Headspace.qgm

Schedule for SPME and HS analyses



In the method file, select the injection port to be used.

Previous model

Analysis of mold odor components (SPME method) → Vacuum release, column exchange, evacuation (wait for stabilization), syringe exchange → VOCs analysis (HS method)

AOC-AOC-6000 Plus (With Twin Line MS)

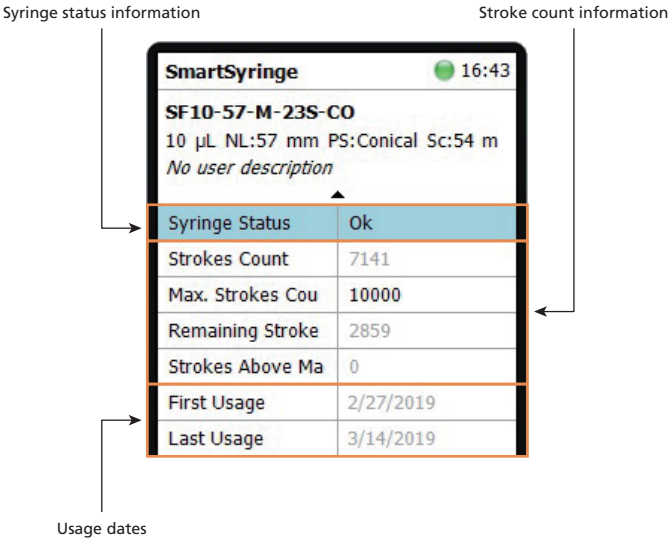
Analysis of mold odor components (SPME method) → VOCs analysis (HS method) → **Time reduction (6 hours)**

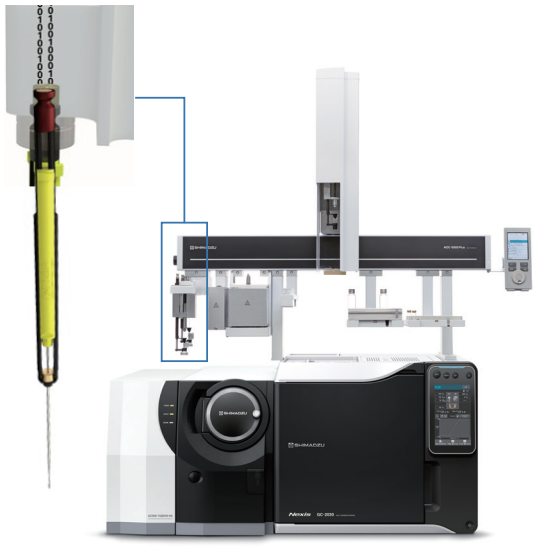
*1 Twin Line MS System: Outlets of two different columns are attached to the MS at the same time to obtain application data from different columns without releasing the MS vacuum.

Increased Data Reliability

Increased Data Reliability with Syringe and Fiber Usage History

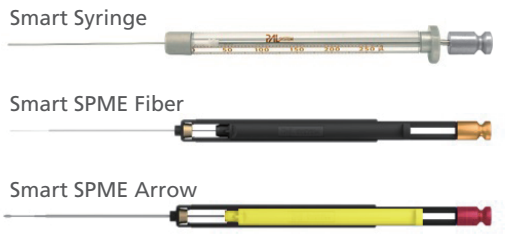
The AOC-6000 Plus includes a feature for managing the use of syringes and fibers. It reads the Smart Chips built into the specially-designed Smart Syringe, Smart SPME Fiber, and Smart SPME Arrow and displays information for the device, such as temperature resistance, usage history, usage dates and stroke count*[2]. The ability to automate complicated consumables management and monitor the conditions of syringes and fibers leads to more reliable data.





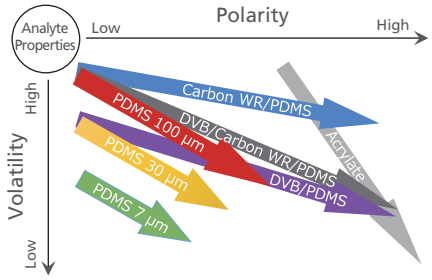
A broad lineup of Smart Syringes, Smart SPME Fibers and Smart SPME Arrows compatible with the AOC-6000 Plus are available to cover any analysis.

CoreFocus
The Smart Choice In Consumables SHIMADZU



The Smart Syringes have color-coded plungers so that the volume can be distinguished at a glance.

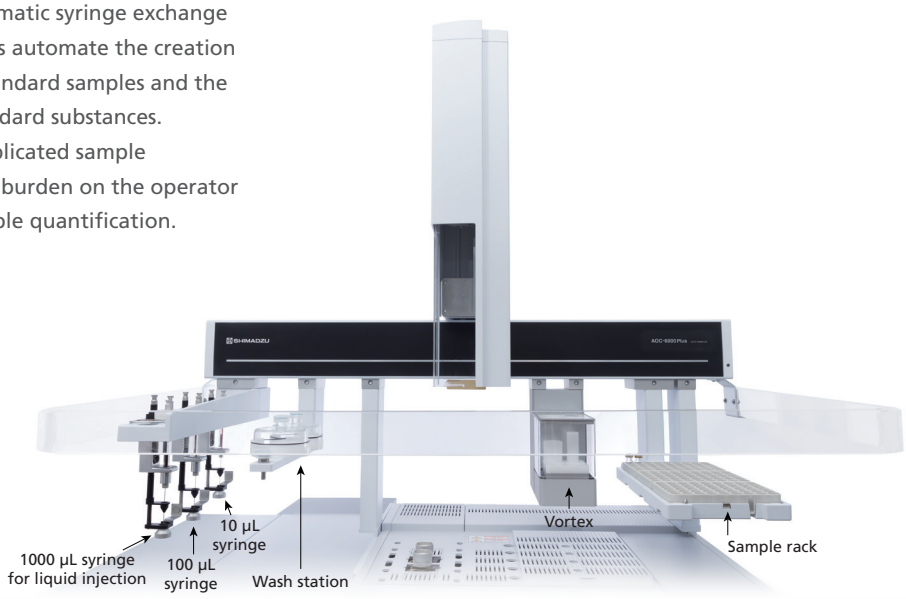
Choose the best consumables for your application with a lineup of Smart SPME Fibres and Smart SPME Arrows covering all types of mobile phase. Plungers are color-coded according to the mobile phase type so that consumables can be distinguished easily.



*2 The AOC-6000 Plus is only compatible with the Smart Syringe, Smart SPME Fiber and Smart SPME Arrow. Syringes and fibers without a Smart Chip cannot be used.

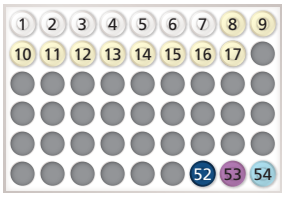
Automated Pretreatment Enhances Reliability of Data

The AOC-6000 Plus automatic syringe exchange and vial mixing functions automate the creation of a dilution series of standard samples and the addition of internal standard substances.
The automation of complicated sample preparation reduces the burden on the operator and enables highly reliable quantification.



Simply set up the empty vials, standard samples, internal standard substances, protectants, and samples to be inspected on the sample rack, then start the batch table. The quantitation of residual pesticides will be performed automatically.

Set up the empty vials, samples to be inspected, standard samples, internal standard substances, and protectants.



- Empty vials
- Samples to be inspected
- Standard samples
- Internal standard substances
- Protectants

Create a batch table.

Vial#	Sample Name	Sample Type	Level#	Method File	
1		0:Unknown	1	Dilution of STD.qgm	A
1		0:Unknown	1	Addition of ISTD.qgm	B
1	STD 1ppb(ISTD and Protectant added)	1:Standard(I)	1	Liquid Injection.qgm	C
2	STD 5ppb(ISTD and Protectant added)	1:Standard	2	Liquid Injection.qgm	
3	STD 10ppb(ISTD and Protectant added)	1:Standard	3	Liquid Injection.qgm	
4	STD 20ppb(ISTD and Protectant added)	1:Standard	4	Liquid Injection.qgm	
5	STD 50ppb(ISTD and Protectant added)	1:Standard	5	Liquid Injection.qgm	
6	STD 100ppb(ISTD and Protectant added)	1:Standard	6	Liquid Injection.qgm	
7	STD 500ppb(ISTD and Protectant added)	1:Standard	7	Liquid Injection.qgm	
8	Sample_001	0:Unknown	1	Liquid Injection.qgm	D
9	Sample_002	0:Unknown	1	Liquid Injection.qgm	
10	Sample_003	0:Unknown	1	Liquid Injection.qgm	
11	Sample_004	0:Unknown	1	Liquid Injection.qgm	
12	Sample_005	0:Unknown	1	Liquid Injection.qgm	
13	Sample_006	0:Unknown	1	Liquid Injection.qgm	
14	Sample_007	0:Unknown	1	Liquid Injection.qgm	
15	Sample_008	0:Unknown	1	Liquid Injection.qgm	
16	Sample_009	0:Unknown	1	Liquid Injection.qgm	
17	Sample_010	0:Unknown	1	Liquid Injection.qgm	

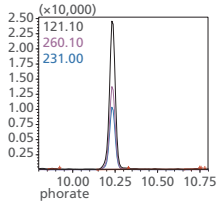
Ⓐ In empty vials 1-7, the internal standard substance and protectant are added to create a diluted standard sample series (1 ppb, 5 ppb, 10 ppb, 20 ppb, 50 ppb, 100 ppb, and 500 ppb).

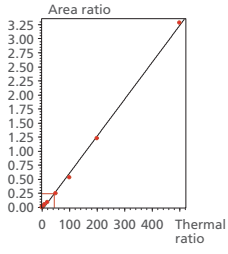
Ⓑ The internal standard substance is added to the samples to be inspected (vials 8-17).

Ⓒ The diluted standard sample series (vials 1-7) is analyzed. The automatic analysis function automatically detects the peaks of the standard substance, and automatically creates a calibration curve.

Ⓓ The samples to be inspected (vials 8-17) are analyzed. The automatic analysis function automatically searches for quantified substances, and automatically performs quantitation using the calibration curve.

Once the analyses is complete, the quantitation results are confirmed.





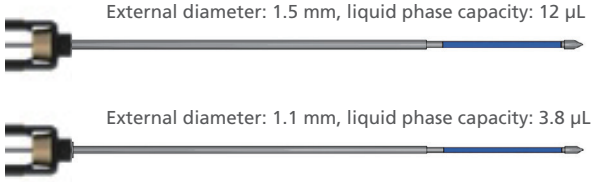
High-Sensitivity Analysis Achieved by Latest Concentration Technology

SPME Arrow

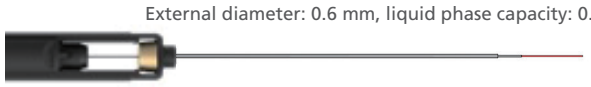
Compared to previous SPME methods, the next-generation SPME Arrow offers higher sensitivity, superior durability, and high-speed extraction*3.

- Unlike conventional SPME, the SPME Arrow can hold a larger volume of adsorbent, and has a thicker, sturdier design. It also provides higher sensitivity and durability.

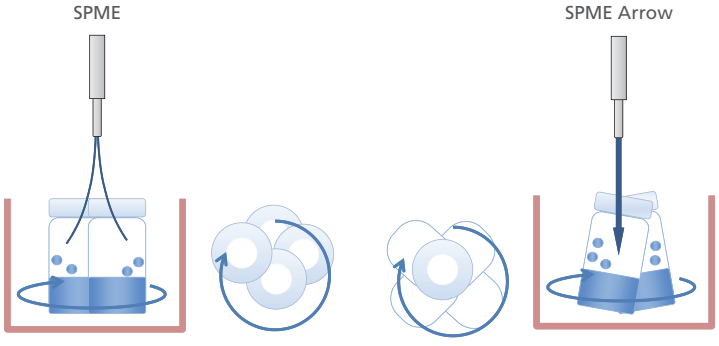
SPME Arrow



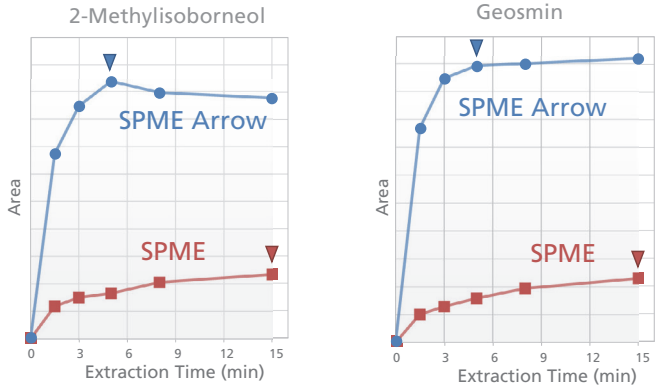
Previous SPME



- By employing the dedicated Heatex Stirrer, which is highly efficient at stirring, the SPME Arrow enables acceleration of the pretreatment process.



In the analysis of moldy odor substances in water, the SPME Arrow achieved a five-time increase in sensitivity compared with previous SPME. Moreover, the time required for the extraction to reach equilibrium was reduced to five minutes, which is 1/3 that of previous SPME.

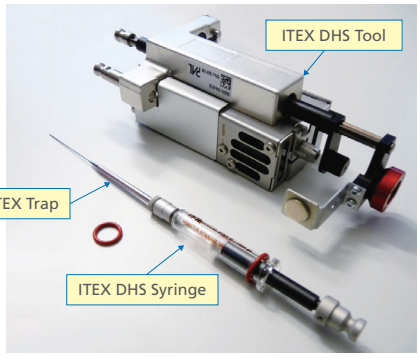


Comparison of Extraction Times and Peak Area Values for SPME and SPME Arrow

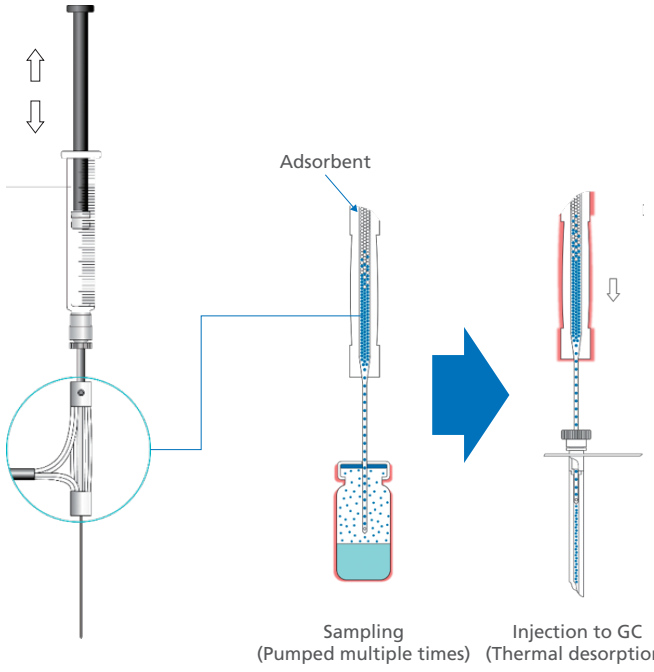
*3 Due to its large external diameter, the SPME Arrow cannot be used with an ordinary GC injection port. Use only GC injection ports that have a wide diameter hole and are designed for the SPME Arrow.

ITEX DHS (In-tube Extraction Dynamic Headspace)

With the ITEX DHS, it is possible to concentrate the vial's headspace components in the adsorbent of the syringe. Since the volatile components are concentrated, high-sensitivity analysis can be performed.

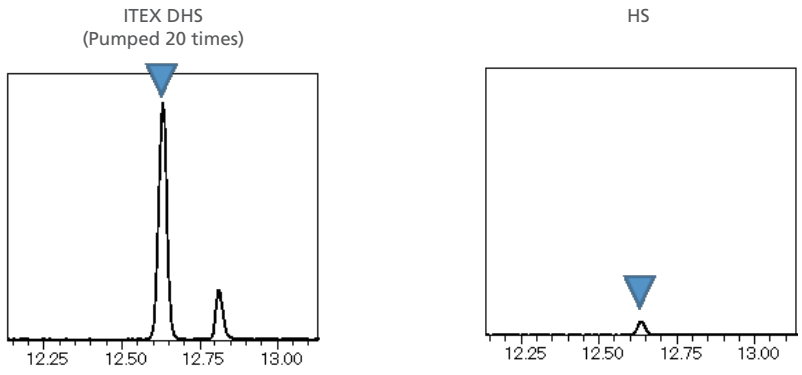


- The ITEX DHS concentrates the volatile components on the adsorbent by pumping the syringe multiple times in the headspace portion of the heated vial. Then, after applying thermal desorption at the injection port of the GC, the volatile components are analyzed.



- Since the concentration method uses a syringe, concerns about contamination are eliminated and maintenance is easy.

In the analysis of volatile organic compounds in wine, ethyl octanoate was detected with a ten-time increase in sensitivity compared to HS. Moreover, the sensitivity could be increased further by pumping more.



TIC Comparison of Ethyl Octanoate in Wine

Accommodates a Wide Range of Sample Forms

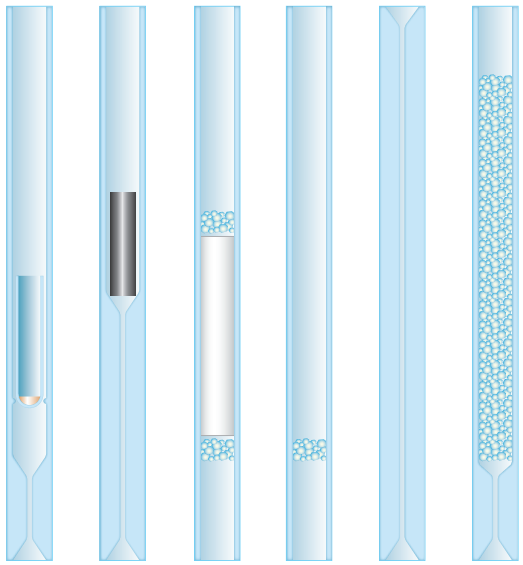
The wide range of injection modes offered by the OPTIC-4 multimode inlet makes it possible to accommodate many different sample forms. So, in addition to split/splitless injections, many other analyses, such as the pyrolysis analysis of solid samples and the thermal desorption analysis of odor components, can be performed.

Simplifying Pretreatment—DMI (Difficult Matrix Introduction)

With DMI, a microvial containing the sample is inserted in the liner, and the liner is then heated at the injection port before analyzing the sample. By adjusting the temperature of the injection port, non-volatile impurity components are left remaining in the microvial, enabling GC/MS measurements to be performed with a minimal amount of pretreatment.

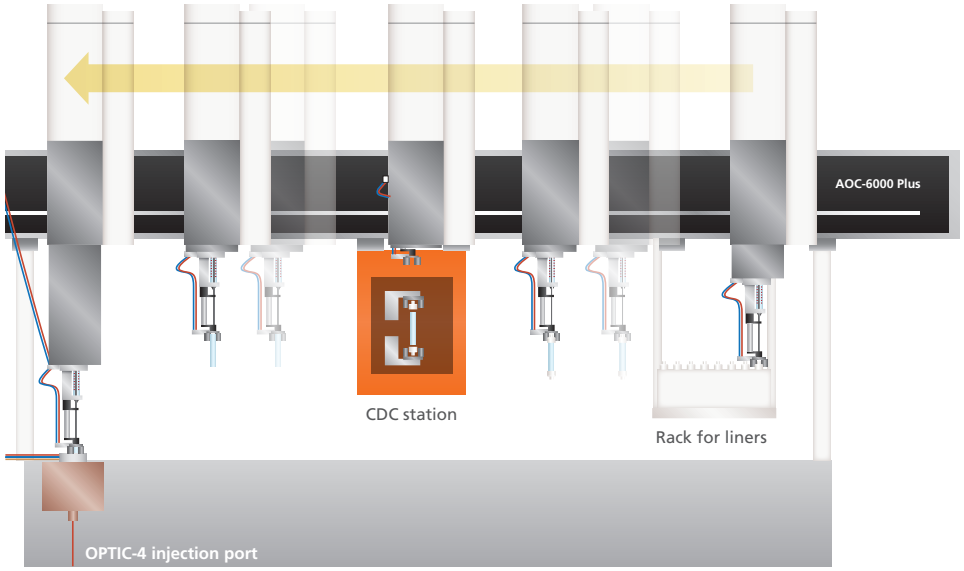
After Trapping/Concentration Using MonoTrap®, Thermal Desorption Provides High-Sensitivity Analysis

By using the MonoTrap*4, which has a silica monolith structure and a high trapping efficiency, to trap volatile components in the sample, then using the OPTIC-4 for thermal desorption, analyses requiring higher sensitivity can be performed. Moreover, the high-speed heating function provides for rapid desorption of the trapped components, which results in acquisition of sharper peaks.



Various liners

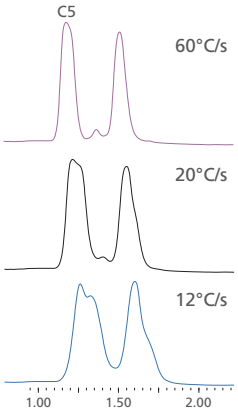
The liner placed in the rack, after removing its caps at the CDC station, is installed in the OPTIC-4 injection port.



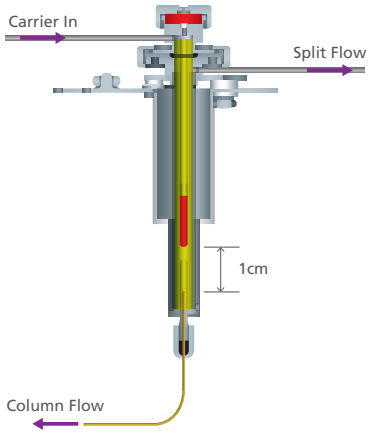
*4 For further information on the MonoTrap, refer to the website of GL Sciences, Inc.

Sharper Peaks, Enhanced Separation

Due to a sample introduction path of only 1 cm, and the adoption of a high-speed heating system capable of 60 °C /s, sharper peaks are realized.

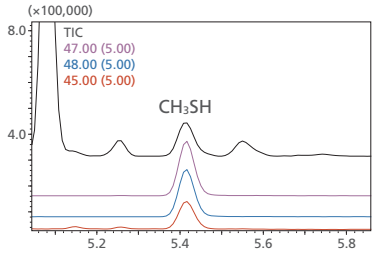


TD mode



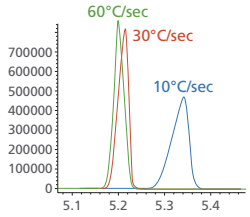
OPTIC-4 injection port

There is only 1 cm between the sample and the tip of the analysis column.
For this reason, the system is ideal for analysis of compounds with high adsorptivity or degradability.



MonoTrap used to analyze methanethiol in parmesan cheese

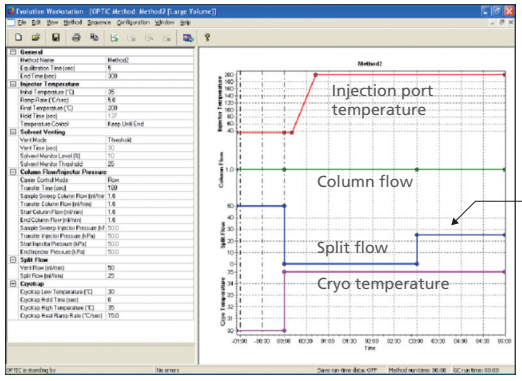
Peaks are made sharper by attaching a cryo-trap (option) to the GC oven. Samples trapped by the cryo-trap are heated rapidly, up to 60 °C/s, so the development of bands is kept to a minimum.



Intuitive Operation Using Dedicated Evolution Workstation Software

The dedicated Evolution Workstation software for the OPTIC-4 displays analysis conditions in a time chart for intuitive grasping and modification, enabling easy formulation of conditions. Optimization is easy, since methods accommodating various injection modes have been included.

Detailed parameters can be set/modified at will.



Settings and modifications can be accomplished by dragging points inside a graph.

Large volume injection method

Wide Variety of Injection Modes

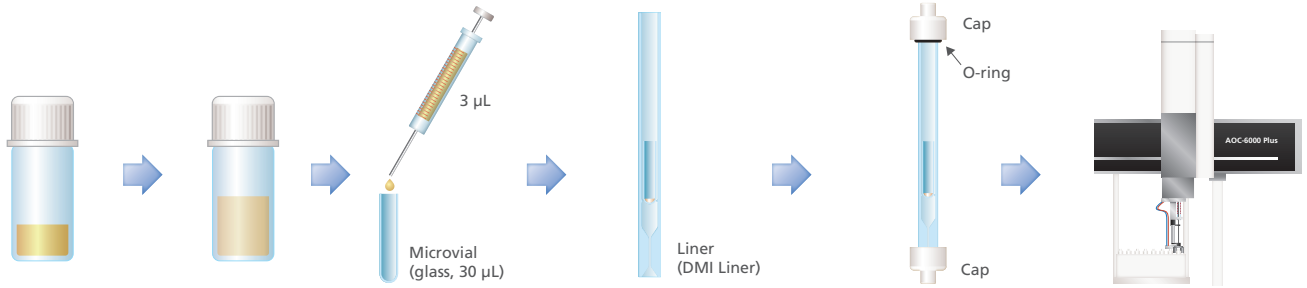
The various injection modes allow analysis of many different sample forms.

Liner	Sample Introduction Method	Application Examples	Page
DMI	Thermal extraction	Content of 1,4-dioxane in shampoo	12
MonoTrap TD	Thermal desorption	Odor from product	12
DMI	Pyrolysis	Pyrolysis of resin	13
Solid adsorption agent (TD)	Thermal desorption	Atmospheric gas in automobile	13

DMI Thermal extraction

Content of 1,4-Dioxane in Shampoo

Suspected of being carcinogenic, 1,4-dioxane is sometimes found as an impurity in cosmetic products. The use of the DMI mode for the quantitation of 1,4-dioxane in shampoo was investigated. A cryo-trap was used in order to make the peaks sharper.
By optimizing the temperature of the injection port, none of the high-boiling-point impurities in the shampoo, which can cause contamination of the column, were introduced to the column, and 1,4-dioxane was quantitated with a simple pretreatment. This mode makes use of thermal extraction and is useful in reducing the amount of required pretreatment.



Measure out 1 g of shampoo.

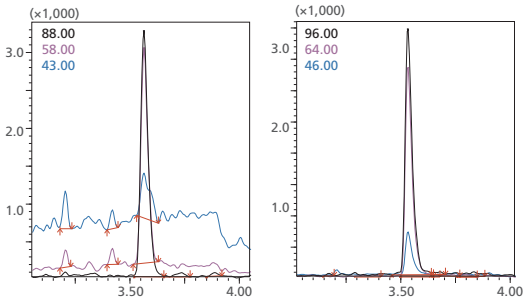
Add 1,4-dioxane-d8 to 1 g of ultrapure water and then agitate.

Place 3 µL in the microvial.

Insert the microvial in the liner.

Attach an O-ring to the upper part of the liner, then cap both top and bottom.

Place it in the AOC-6000 Plus rack, then start the analysis.



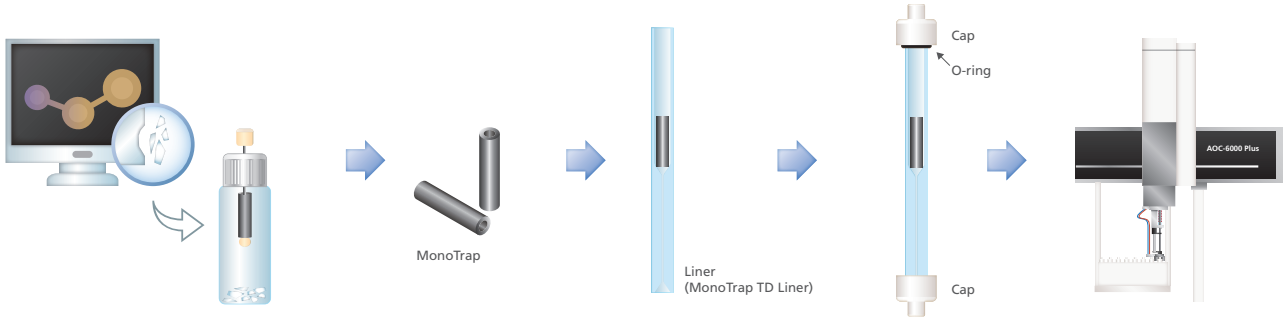
SIM Chromatograms

A SIM chromatogram resulting from shampoo to which 1,4-dioxane was added so as to produce a concentration of 3.6 ppm is shown in the figure at the far left. In the other figure, the SIM chromatogram of 4-dioxane-d8 used for quantitation is shown. The result of quantitation was 3.6 ppm.

MonoTrap Thermal desorption

Odor from Product

In order to solve problems related to odors, it is necessary to identify substance(s) causing the odors. Using the MonoTrap thermal desorption mode, the substance at the source of the disinfectant smell emanating from resin-based parts in an electrical device was identified. Some material was scraped from the chassis emitting the odor and placed inside a vial together with MonoTrap, and the odorous component was extracted and concentrated. The substance at the source of the odor, 2,6-dibromophenol (2,6-DBP), which has a low odor threshold, was detected. By using this mode, even components having a low odor threshold can easily be concentrated and detected.



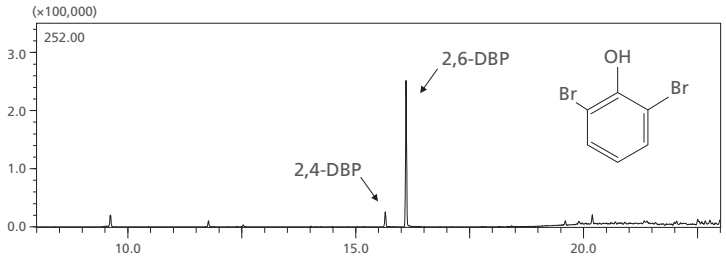
Scrape off some of the material emitting the odor, place it with MonoTrap inside a vial, and keep them at 180 °C for 30 minutes.

Remove the MonoTrap.

Inset the MonoTrap in the liner.

Attach an O-ring to the upper part of the liner, then cap both top and bottom.

Place it in the AOC-6000 Plus rack and start analysis

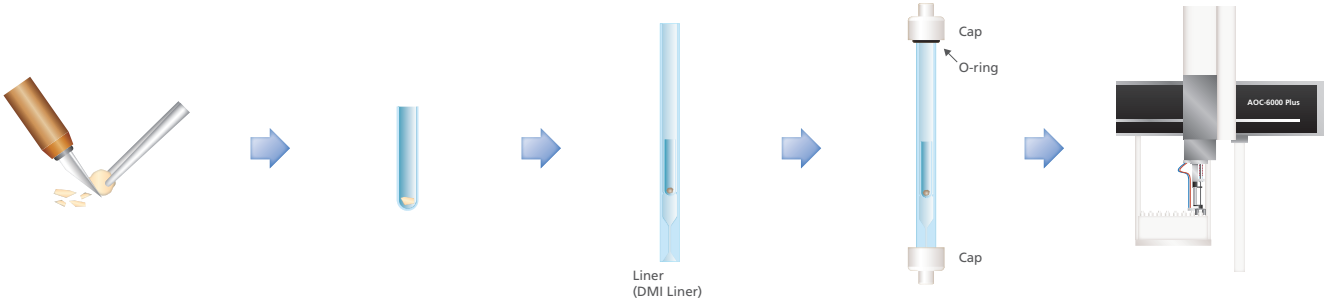


Mass chromatogram

DMI Pyrolysis

Pyrolysis of Resin

Pyrolysis gas chromatography is effective for the structural analysis of resins. In pyrolysis gas chromatography, it is necessary to rapidly heat the sample so that the pyrolysis products do not take part in a second-order reaction. Since this system is capable of rapid heating to temperatures of up to 600 °C, at a speed of 60 °C/s, it can provide data equivalent to that produced by instantaneous-heating pyrolyzers. Using this mode, polycarbonate resins were analyzed. Numerous phenolic compounds, including bisphenol A, were detected. The results were virtually identical to those yielded by instantaneous-heating pyrolyzers.



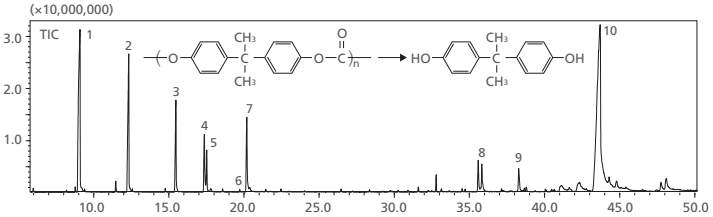
Cut out a small piece of sample using a cutter or file.

Place a small piece (several tens of µg or less) of the sample in the microvial.

Insert the microvial in the liner.

Attach an O-ring to the upper part of the liner, then cap both top and bottom.

Place it in the AOC-6000 Plus rack and start analysis



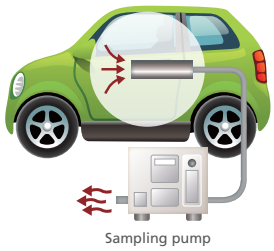
Pyrolysis total ion chromatogram of polycarbonate resin

1=phenol
2=p-cresol
3=p-ethylphenol
4=p-vinylphenol
5=p-isopropylphenol
6=p-tert-butylphenol
7=p-isopropenylphenol
8=p-hydroxy-2,2-diphenylpropane
9=p-hydroxy-3-methyl-2,2-diphenylpropane
10=bisphenol A

Solid adsorption Thermal desorption

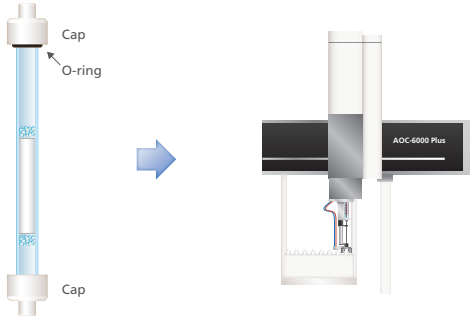
Atmospheric Gas in an Automobile

Efforts to reduce the volatile organic compounds (VOCs) inside an automobile are ongoing. VOCs inside an automobile were analyzed using solid adsorption-thermal desorption. A liner filled with a trapping agent was exposed to the air inside an automobile. Afterwards, this system was used to heat the liner and analyze the desorbed components. A cryo-trap was used in order to also target low-boiling-point components. Detected substances included toluene, ethyl benzene, and xylene. Also detected were dibutyl phthalates, which were vaporized as a result of direct sunlight heating resins.
This mode can be effectively used to analyze trace components in gases.



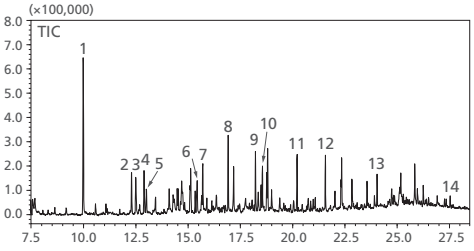
Sampling pump

Attach a liner specialized for TD that is filled with a trapping agent (Tenax TA 60/80 mesh 150 mg) to an atmospheric sampling pump and sample the air at 100 mL/min for 30 minutes.



Attach an O-ring to the upper part of the liner, then cap both top and bottom.

Place it in the AOC-6000 Plus rack and start analysis



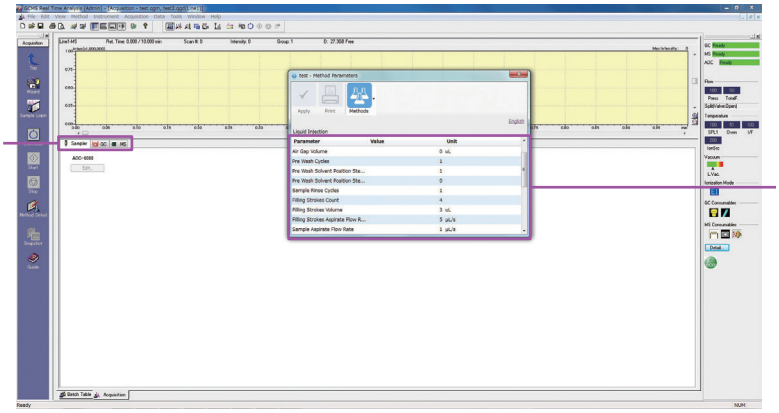
Total ion chromatogram of atmospheric air in an automobile

1=Toluene
2=Ethylbenzene
3=m-,p-Xylene
4=Styrene
5=o-Xylene
6=p-Dichlorobenzene
7=2-Ethyl-1-hexanol
8=Nonanal
9=Menthol
10=Decanal
11=Tridecane (C13)
12=Tetradecane (C14)
13=Hexadecane (C16)
14=Di-n-butyl phthalate (DBP)

Simple to Operate with GCMSsolution

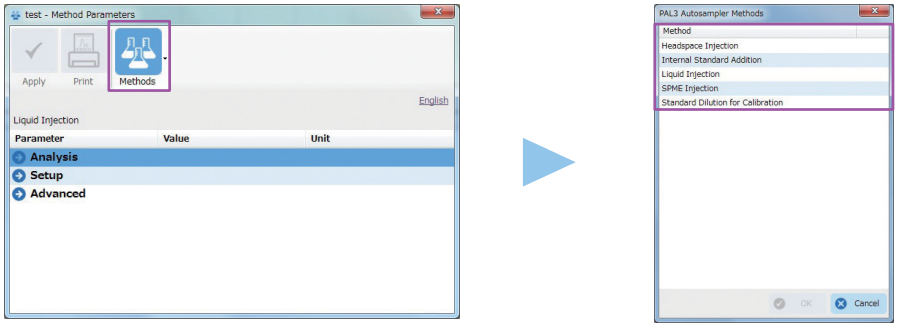
AOC-6000 Plus parameter settings and control are managed in GCMSsolution*5 software. Analysis accuracy control is easy since the AOC-6000 Plus and GC/MS analysis conditions are stored with the measured data.

GC/MS and the AOC-6000 Plus are controlled from the same software, simplifying method selection and the setting of analysis conditions.



AOC-6000 Plus analysis conditions are stored in the measurement data file.

AOC-6000 Plus method files are preconfigured with typical analysis conditions.
Injection volume and other parameters that need to be changed for each analysis can be easily edited.



Typical analysis conditions are preconfigured, so analysis can start immediately.

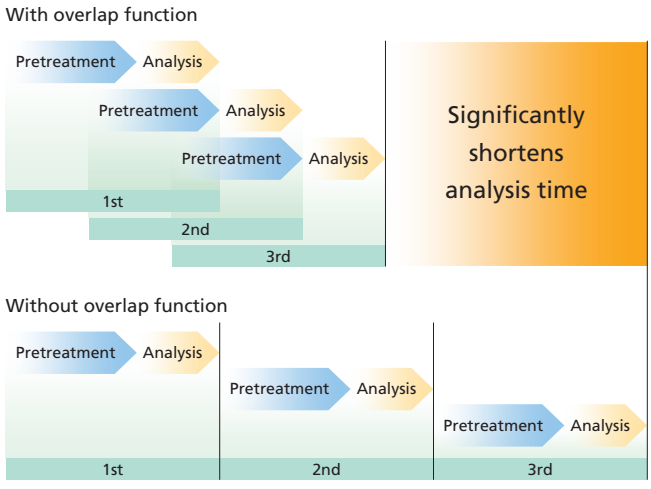
Overlap Function Improves Analysis Efficiency

The AOC-6000 Plus performs sample pretreatment and analysis in parallel. As a result, no time is lost in the continuous analysis of samples requiring HS sampling or other time-consuming pretreatments.

Continuous Analysis with HS Injections Using the Overlap Function

Conditions to perform pretreatment and analysis in parallel are preconfigured in AOC-6000 Plus method files. As a result, the time required to analyze multiple samples is significantly reduced.

■ Continuous Analysis Flow



*5 The AOC-6000 Plus is supported by GCMSsolution Ver. 4.30 or later.

Lineup

Four AOC-6000 Plus models are available. Select the model to suit your analysis.

Model	Main Function				Optional Function			
	Liquid Injection	HS Injection	SPME Injection	Automatic Tool Exchange	Reagent Mixing	SPME Arrow Injection	ITEX DHS Injection	OPTIC-4 Liner Exchange
Entry model	✓	✓	✓					
Standard model	✓	✓	✓	✓			✓	
Standard model (long rail type)	✓	✓	✓	✓		✓	✓	✓
High-end model	✓	✓	✓	✓	✓	✓	✓	✓

Specifications

Size of the main unit	Entry model Standard model	850(L)× 503(D)× 547(H) mm
	Standard model (long rail type) High-end model	1206(L)× 503(D)× 547(H) mm
Liquid injection	Number of vials	162 2 mL vials (54 x 3) per tray 45 10/20 mL vials (54 x 3) per tray (Up to two trays can be mounted)
	Liquid injection volume	1 µL to 10 µL (using a standard 10 µL syringe)
	Type of syringe	1, 5, 10, 25, 50, 100, 250, 500, 1000 µL
	Repeated injection	1 cycle to 99 cycles/vial
	Compatible syringe	Smart Syringe for liquid injection with Smart Chips
HS injection	Number of samples	45 10/20 mL vials (54 x 3) per tray
	Headspace injection volume	250 µL to 2,500 µL (using a standard 2.5 mL syringe)
	Syringe heating	Heating range up to 150 °C
	Agitator	Six heated vials Heating range up to 200 °C
	Compatible syringe	Smart Syringe for HS injection with Smart Chips
SPME injection	Number of samples	45 10/20 mL vials (54 x 3) per tray
	Fine bar conditioning temperature	Up to 350 °C
	Agitator	Six heated vials Heating range up to 200 °C
	Compatible SPME Fiber	Smart SPME Fiber with Smart Chips
Automatic tool exchange	Number of tools mounted	Default: 3, Maximum: 6
Reagent mixing	Maximum speed	2,000 rotations/minute max.
	Compatible vials	2 mL, 10mL, 20mL
SPME Arrow injection	Number of samples	45 10/20 mL vials (54 x 3) per tray
	SPME Arrow conditioning temperature	Up to 350 °C
	Agitator	Six heated vials Heating range up to 200 °C
	Heatex stirrer	One heated vial 1,600 times rotations/minute max.
	Compatible SPME Arrow	Smart SPME Arrow with Smart Chips
	GC injection port	GC injection port designed for the SPME Arrow
ITEX DHS injection	Number of samples	45 10/20 mL vials (54 x 3) per tray
	Syringe heating	Heating range up to 150 °C
	Trap heating	Up to 350 °C
	Agitator	Six heated vials Heating range up to 200 °C
	Compatible syringe	ITEX syringe with Smart Chips
Automatic tool exchange	Numbers	Default 3, up to 6
Reagent agitation	Maximum number of rotations	2,000 times rotations/minute max.
	Compatible vials	2mL, 10mL, 20mL
OPTIC-4 liner exchange	Number of liners (no caps)	160 (54 x 3) vials per tray
	Number of liners (with caps)	120 (40 x 3) vials per tray
	Syringe for liquid injection	Syringes with a capacity of a max. of 100 µL can be mounted

Compatible models

GC-MS

Model	Software
GCMS-TQ8040 NX/8050 NX GCMS-QP2020 NX series	GCMSsolution Ver.4.50 or later + AOC-6000 control software for GCMSsolution
GCMS-TQ8030/8040/8050 GCMS-QP2020 GCMS-QP2010 series	GCMSsolution Ver.4.30 or later + AOC-6000 control software for GCMSsolution

GC*

Model	Software
Nexis™ GC-2030 GC-2010 Plus GC-2010	LabSolutions™ LC/GC Ver.5.87 or later LabSolutions LC/GC Ver.6.71 or later + AOC-6000 Support Kit for LabSolutions

*The GC does not support SPME Arrow injection function, ITEX DHS injection function and the liner exchange function of the OPTIC-4.

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