

1. What is MonoTrap™?

1-1. What is MonoTrap?

MonoTrap is an adsorptive material made of high-purity monolithic silica. The product features a through-pore due to the macropores of the silica base and a large surface area (at least 150 m²/g) due to the mesopores within the silica frame.

MonoTrap is available in two types, one for solvent extraction and the other one for thermal desorption.

1-2. Structure and Characteristics of MonoTrap™

Samples will be trapped by Polydimethylsiloxane (PDMS), C18 and carbon adsorptives that are coated on the surface of the silica skeleton. As MonoTrap has high air permeability, samples are easily spread to the silica skeleton and contact the PDMS, C18 and adsorptive. This skeleton structure also offers high liquid permeability, so that organic solvents or gases immediately spread to the silica skeleton for desorption. In addition, due to the large surface area of monolithic silica, large volume samples can be applied for highly sensitive measurements.



Fig.1 Enlarged view of MonoTrap

1-3. Principles of sample trapping using MonoTrap™

1-3-1. Trapping gaseous samples

With existing trapping materials coated with PDMS, compounds move depending on the distribution coefficient between the gas phase and PDMS. The distribution coefficient is a physical coefficient that shows how compounds exist in certain concentrations between different phases. Compounds in a gaseous sample move to the PDMS phase with a concentration based on the distribution coefficient and will be trapped. Existing PDMS trapping materials have small surface areas, so that long sampling times are required for satisfactory recovery rates.

With MonoTrap, adsorbents such as PDMS, C18, active carbon or graphite carbon coated on the silica skeleton are involved in the trapping process. In addition, the large surface area requires only short sampling times.

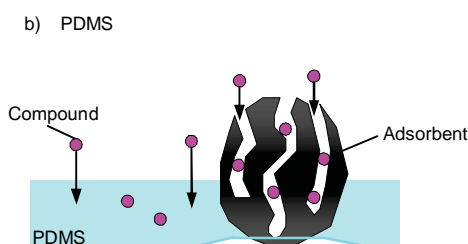
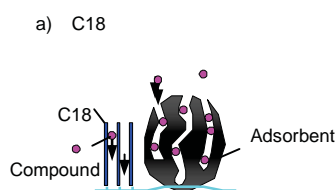


Fig.2 Trapping image of MonoTrap

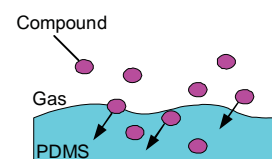


Fig.3 Existing PDMS

1-3-2. Trapping liquid samples

For headspace sampling in a sealed vial (container), compounds in a liquid sample move from the liquid phase to the gaseous phase with a concentration based on their distribution coefficient. Compounds in a gaseous sample will be trapped by adsorbents such as PDMS or C18 on the MonoTrap surface. Once the concentration of compounds in the gaseous sample decreases due to trapping, compounds in the liquid sample move to the atmosphere in order to maintain the equilibrium condition and more compounds move to, and will be trapped by, MonoTrap.

Compounds move between liquid phase and gaseous phase depending on their distribution coefficient. Therefore, it is possible to shorten the sampling time and improve the recovery rate by conducting desalting and adjusting the pH as for normal solvent extraction and solid phase extraction (See 5-2-3, 5-2-4).

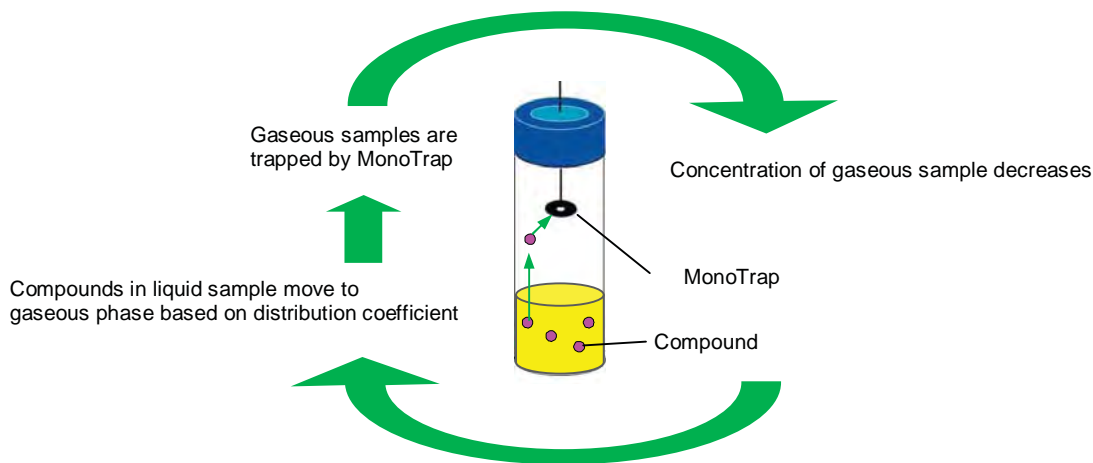


Fig.4 Headspace sampling

Due to the C18 functionality and endcapping treatment on the surface of monolithic silica, MonoTrap is highly hydrophobic and floats on the liquid. MonoTrap may be floated on the liquid or put into the liquid and shaken for sampling. In this case, as well as the transfer of compounds as shown above, compounds move directly in to the MonoTrap and can be retained. This enables effective trapping of hydrophilic compounds as well.

As MonoTrap is hydrophobic on its surface, water does not permeate into the inside of MonoTrap. Therefore, water can easily be removed from MonoTrap after sampling.

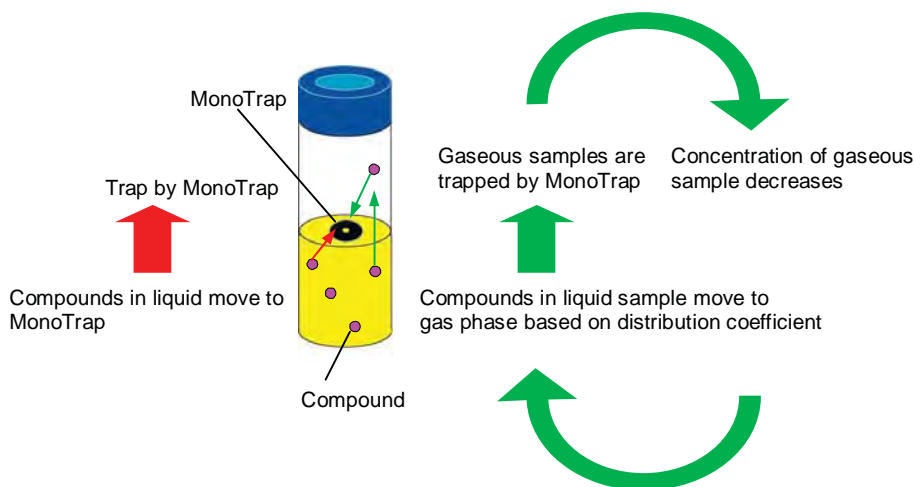


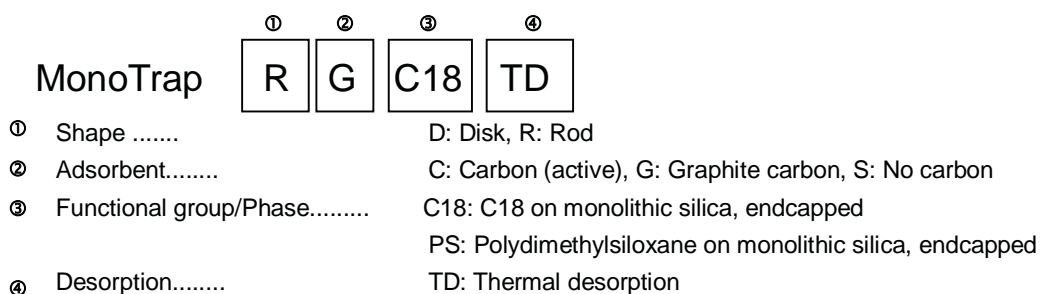
Fig.5 Sampling by floating or shaking of MonoTrap




Warning

When the sample solvent is hydrophobic or organic, putting MonoTrap directly into the sample is not suitable as these solvents permeate into MonoTrap and the MonoTrap sinks in the solvents.

2. MonoTrap™ Series

How to read and understand MonoTrap series (example)



	Desorption	Description	Picture	Shape	Size* ¹ (Diameter x Height)	Adsorbents/Functional Group/Coating			
						Active Carbon	Graphite Carbon	C18	PDMS
Solvent Extraction		MonoTrap DCC18		Disk	φ10 mmx1 mm	●		●	
		MonoTrap RCC18		Rod	φ2.9 mmx5 mm	●		●	
		MonoTrap DSC18		Disk	φ10 mmx1 mm			●	
		MonoTrap RSC18		Rod	φ2.9 mmx5 mm			●	
Thermal Desorption		MonoTrap RGC18 TD		Rod	φ2.9 mmx10 mm		●	●	
		MonoTrap RSC18 TD		Rod	φ2.9 mmx10 mm			●	
		MonoTrap RGPS TD		Rod	φ2.9 mmx10 mm		●		●

*1: There is a through bore of φ1mm on each MonoTrap

3. How to use MonoTrap™

There is no need for conditioning before use.

3-1. Open the package

Make sure to open the package just before sampling.

10 pieces of MonoTrap for solvent extraction (DCC18, RCC18, DSC18, and RSC18) are packed in a vial (Fig.6). Keep the vial cap closed.

Each piece of MonoTrap for thermal desorption (RGC18 TD, RSC18 TD, RGPS TD) is individually sealed in an ampoule (Fig.7) .



Fig.6 MonoTrap for Solvent Extraction



Fig.7 MonoTrap for Thermal Desorption

Warning

- Make sure to keep the vial cap closed to avoid unnecessary adsorption of compounds from the atmosphere.
- We recommend that MonoTrap be used immediately once the package is opened.
- Depending on the targeted sensitivity, blank may look outstanding. Make sure to conduct a blank test and compare it to the actual analysis.

3-2. Sampling

MonoTrap is small and light. Various sampling methods can be applied, such as headspace gas sampling (HS), passive sampling etc. MonoTrap can be floated on the liquid sample or agitated with the sample.



Fig.8 Headspace Gas Sampling



Fig.9 Passive Sampling

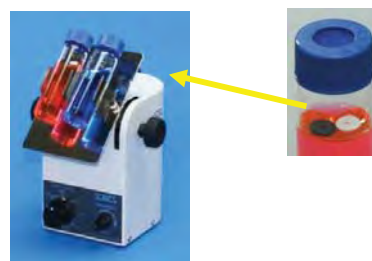


Fig.10 Agitation



Fig.11 Handless Shaker



Fig.12 Thermal Chamber & Bath (EYELA, NTS-4000B)

3-3. Desorption

3-3-1. Solvent Extraction

It is convenient to use a MT Extract Cup for extraction from Disk type MonoTrap. Put a MonoTrap and extracting solvent into a MT Extract Cup and apply ultrasonication.

For extraction from Rod type MonoTrap, put a MonoTrap into an autosampler vial with an inert extraction solvent, and then apply ultrasonication. In this way, there is no need to move the extracted solvent to another container prior to autosampler injection into a GC. When doing so, adjust the height of the autosampler syringe needle so it does not touch the MonoTrap in the vial.

For both Disk type and Rod type, make sure to use more than 200 μL of organic solvent for each piece of MonoTrap.



Inject organic solvent to MT Extract Cup



Put in the MonoTrap after sampling. Close the vial and ultrasonicate

Fig.13 Solvent Extraction (Disk type)



Fig.14 Solvent Extraction (Rod type)

For higher sensitivity measurements, enrich the solvent by spraying with inactive gas. The Silivap (Cat.No.1030-44020) has 6 outlets for gas and can enrich fast. Note, however, that compounds with low boiling point may also be volatilized. There is a possibility that solvent might be stuck on the vial wall after spraying with inactive gas. When diluting the enriched sample again, make sure to apply the solvent to the vial inner wall. As the bottom of Mini vials (Cat.No.1030-11112) has an inverted cone shape, small amounts of sample, after enrichment, can be used without waste.



Fig.15 Silivap



Fig.16 Mini Vials

Warning

Make sure to do solvent extraction immediately after the sampling and store the extracted solvent in a freezer or a refrigerator.

3-3-2. Thermal Desorption

Put a MonoTrap into a glass tube and install it into a thermal desorption device. Using a special glass tube for MonoTrap enables effective desorption.



Fig.17 MonoTrap special glass tube

Warning

When storing MonoTrap after sampling, put the MonoTrap in a small vial and keep it in a refrigerator. Note that the recovery rate from stored MonoTrap might be lower compared to the one desorbed immediately after sampling.

4. Different kinds of MonoTrap™ depending on samples

4-1. Sampling of polar compounds

For sampling of polar compounds, such as fatty acids and alcohols or nitrogenous compounds, MonoTrap with active carbon or graphite carbon is useful.

- Comparison data 1: DCC18 (active carbon) and DSC18 (w/o active carbon)

Compounds from white wine were trapped by a DCC18 (active carbon) and a DSC18 (w/o active carbon) MonoTrap. Polar compounds such as phenyl alcohols were trapped better by a DCC18 (active carbon).

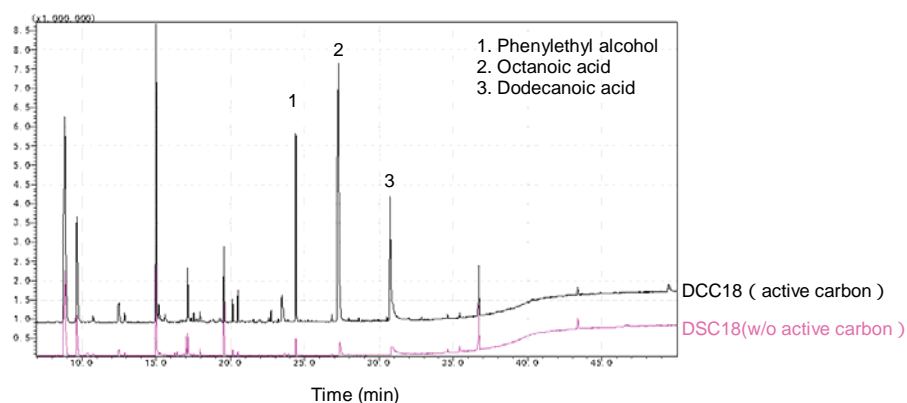
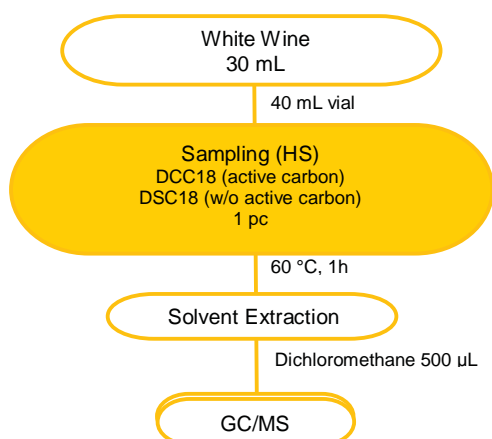


Fig.18 Aroma compounds from white wine

Comparison data 2: DCC18 (active carbon) and DSC18 (w/o active carbon)

Ten compounds (limonene, cineol, β -linalool, methylpyrazine, 2,6-dimethylpyrazine, indole, camphor, octanoic acid, coumarin, 2-acetonaphthone) were dissolved in methanol and adjusted to 200 $\mu\text{g}/\text{mL}$ each. This is called standard sample A hereafter.

Standard sample A (25 μL) was added to a 40 mL vial and the headspace gas collected using a DCC18 (active carbon) and DSC18 (w/o active carbon). The recovery rates^{*2} of linalool, a polar compound, and methylpyrazine, a nitrogenous compound, were much better with a DCC18 (active carbon).

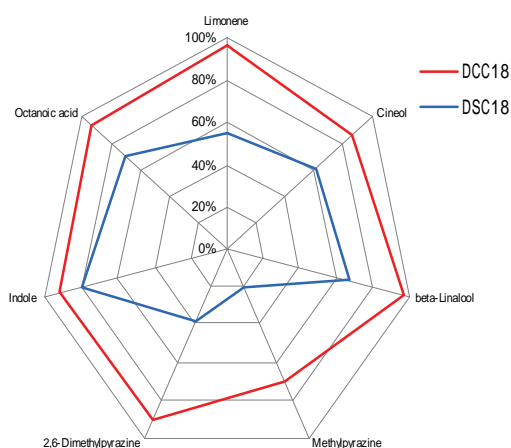
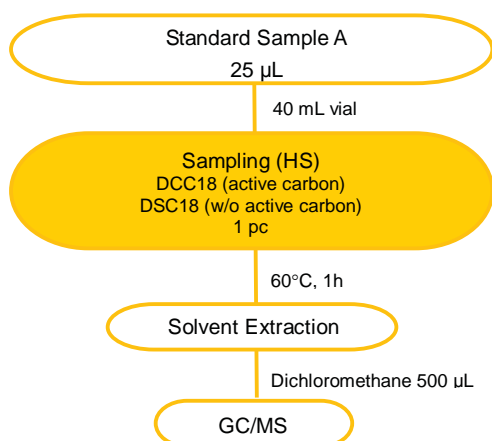


Fig.19 Recovery rate comparison of standard sample A

*2: Recovery rate was calculated as follows:

$$\text{Recovery rate (\%)} = A / B \times 100$$

A: Peak area measured by GC after trapping the sample by MonoTrap and carrying out solvent extraction.

B: Peak area obtained after the sample was measured by GC.

Comparison data :RGC18 TD (graphite carbon) and RSC18 TD (w/o graphite carbon)

Aroma compounds from coffee powder were trapped by an RGC18 TD (graphite carbon) and an RSC18 TD (w/o graphite carbon) MonoTrap. When comparing the peak areas of nitrogenous and other compounds using RGC18 TD (graphite carbon) and RSC18 TD (w/o graphite carbon), compounds trapped by RGC18 TD (graphite carbon) showed approx. 2- 4.8 times higher peak areas compared to those of RSC18 TD (w/o graphite carbon) (Table1).

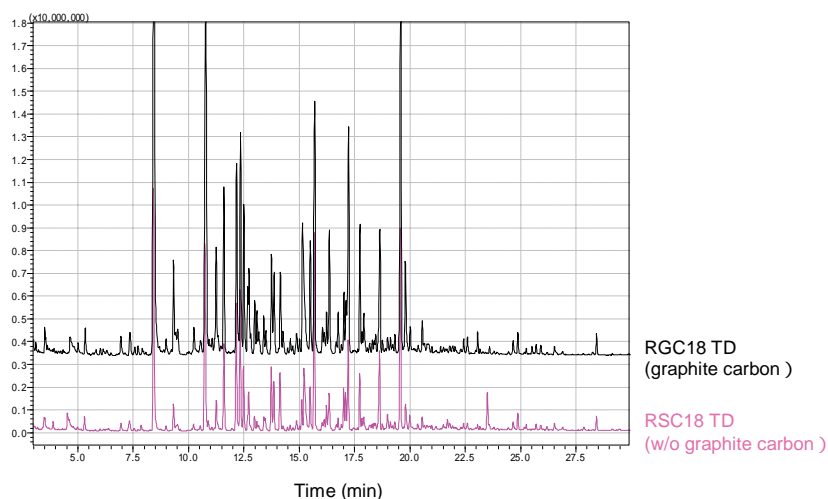
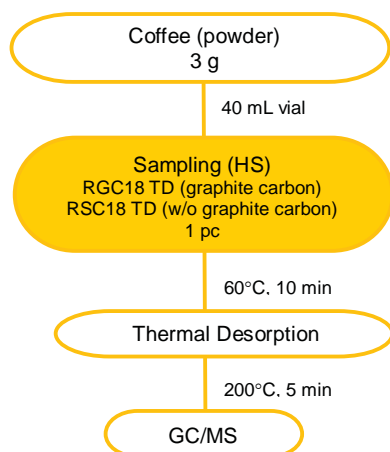


Fig.20 Aroma compounds from coffee

Table1 Peak areas				
RT (min)	Compounds	RGC18 TD (graphite carbon)	RSC18 TD (w/o graphite carbon)	Peak area ratio (RGC18 TD / RSC18 TD)
8.45	Pyridine	43483675	16327015	2.7
9.32	Pyrazine	8494875	2217897	3.8
10.77	Methylpyrazine	27379533	12124448	2.3
11.60	1-Hydroxy-2-propanone	18223342	9064394	2.0
16.35	Acetylfuran	5348316	1623925	3.3
17.20	Acetic acid furfurylester	6668769	2440513	2.7
23.05	o-Methoxyphenol	785224	163347	4.8

RGPS TD (PDMS, graphite carbon)

Aroma compounds from spoiled milk were trapped by an RGPS TD (PDMS, graphite carbon). Satisfactory sensitivity was obtained for polar compounds such as fatty acids and alcohols.

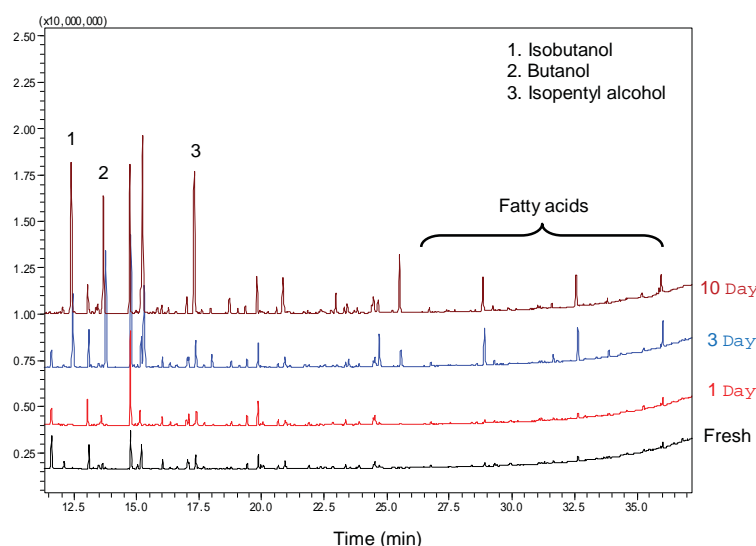
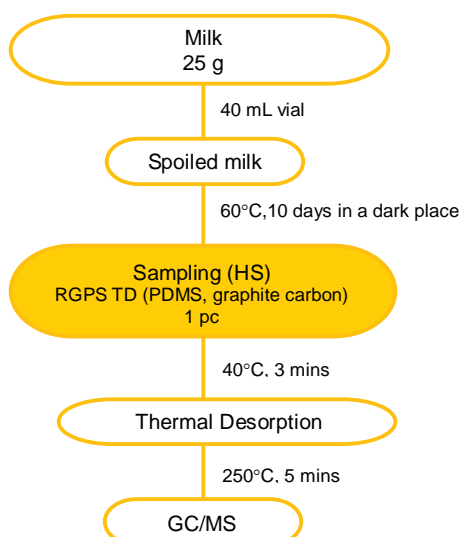


Fig.21 Aroma compounds from spoiled milk

4-2. Sampling of hydrophobic compounds

For compounds with low boiling points, it is effective to use MonoTrap with adsorbents for stronger trapping ability. For compounds with mid to high boiling points, it is more effective to use MonoTrap without adsorbents for better desorption.

Comparison data :DCC18 (active carbon) and DSC18 (w/o active carbon)

An amount corresponding to 2µg of samples (normal chain hydrocarbons: C7- C14, 1mg/mL each) were added to 40mL of 15% NaCl solution. The concentration of each compound in aqueous solution was 50ng/mL.

A DCC18 (active carbon) MonoTrap gave large peak areas for low boiling point compounds, but for compounds larger than C8, the peak area decreased. Due to the adsorption ability of active carbon, DCC18 (active carbon) is optimal for trapping low boiling point hydrophobic compounds.

As the carbon number increased, DSC18 (w/o active carbon) showed increasing peak area. While DSC18 (w/o active carbon) shows weak trapping ability for compounds with low boiling point, it is optimal for hydrophobic compounds with mid to high boiling point due to the high desorption ability.

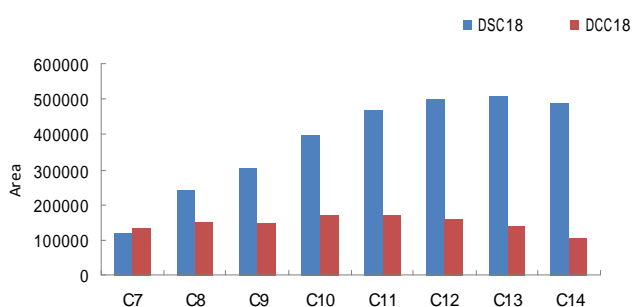
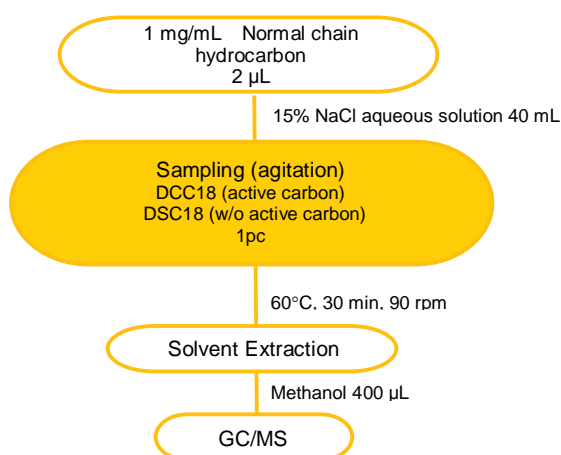


Fig.22 Peak area comparison

A strong extracting solvent such as dichloromethane shows a good recovery rate with DCC18 (active carbon).

After trapping normal chain hydrocarbons with a DCC18 (active carbon) as shown above, the sample was extracted with methanol and dichloromethane. Extraction with dichloromethane led to larger peak areas for all the compounds than when extracted with methanol. Also, the decrease of peak areas for high boiling point compounds was improved.

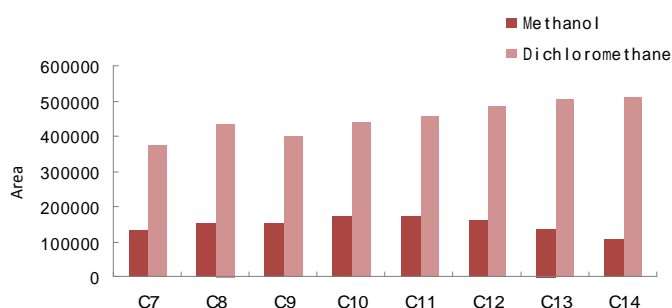
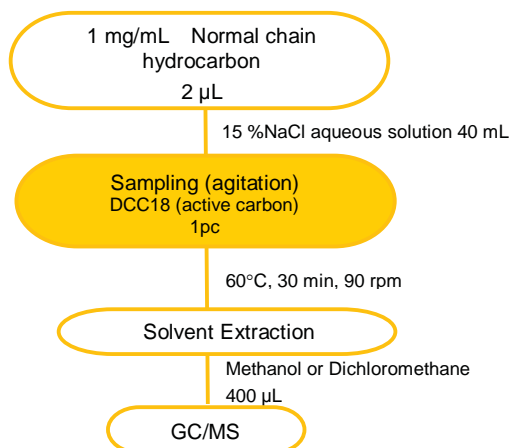


Fig.23 Peak area comparison

4-3. Sampling of hydrophilic compounds from aqueous samples

DCC18 (active carbon) traps well and shows satisfactory recovery for hydrophilic compounds from aqueous samples.

Hydrophilic compounds sampling by DCC18(active carbon)

A 25 μ L aliquot of standard sample A (see 4-1) was added to 15 % NaCl aqueous solution such that the concentration of each compound in aqueous solution was 250ng/mL. A DCC18 (active carbon) MonoTrap was added. LogP (octanol/water distribution coefficient) shows the ratio of equilibrium concentrations for compounds that are dissolved in the 2 phases, octanol and water. This parameter shows whether the compounds are hydrophobic or hydrophilic. For example, LogP=2 means that the concentration within the octanol layer is 100 times greater than within the water. The smaller this number, the greater the hydrophobicity and hence the harder it is to recover from water.

As shown below, greater than 19% recovery was obtained for methylpyrazine, which is a highly hydrophobic compound.

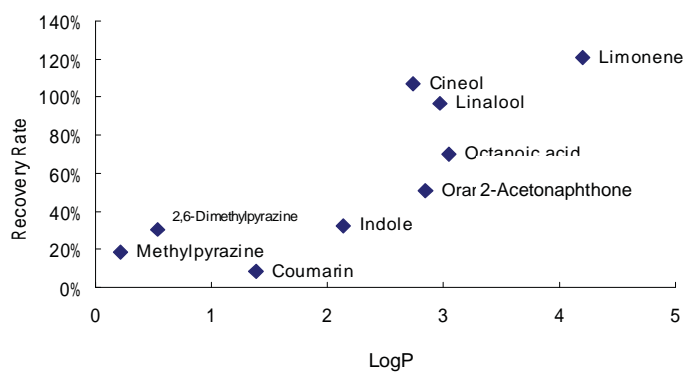
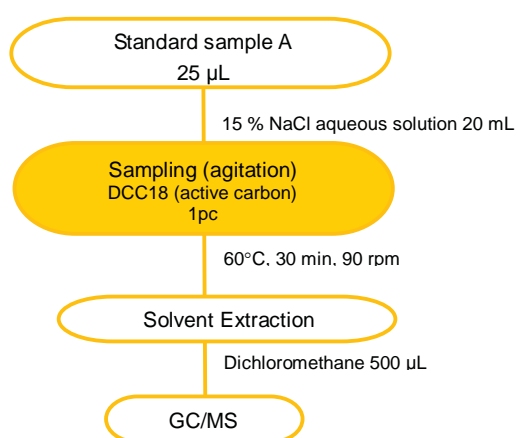


Fig.24 LogP and recovery rate

4-4. Sampling of high boiling point compounds

MonoTrap containing adsorbents lowers the sensitivity after trapping compounds with high boiling point as there is not enough desorption aftermath. In order to trap compounds with high boiling point, it is effective to use MonoTrap without adsorbents for better desorption ability.

Although PDMS type contains graphite carbon, it shows satisfactory sensitivity for compounds with high boiling point as the temperature can be raised up to 300°C.

Comparison data: RGC18 TD (graphite carbon) and RSC18 TD (w/o graphite carbon)

A 25 ng/mL aqueous solution of polycyclic aromatic hydrocarbons (PAHs) was trapped by an RGC18 TD (graphite carbon) and an RSC18 TD (w/o graphite carbon). Benzo [g,h,i] perylene, a compound with a high boiling point (545°C) was detected with higher sensitivity by RSC18 TD (w/o graphite carbon), which has superior desorption capability.

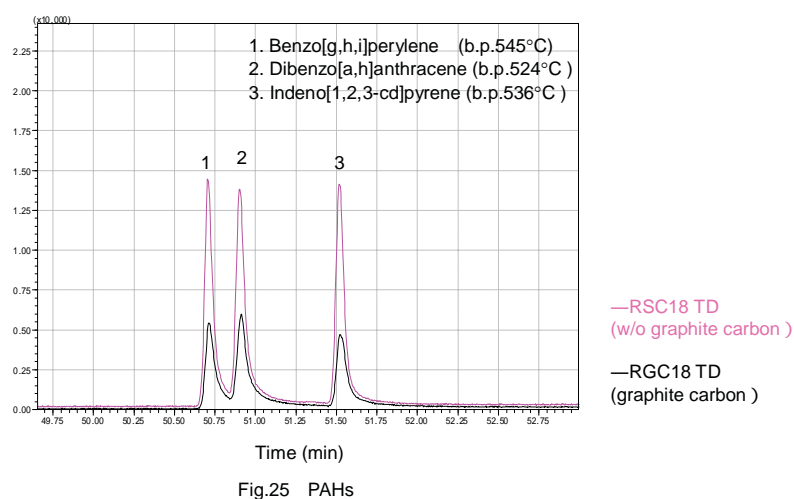
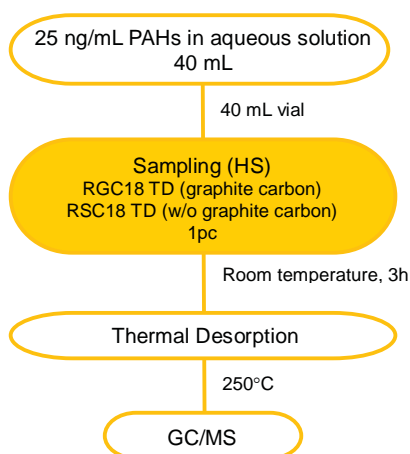


Table2 Recovery rate for each compound trapped by RSC18 TD (w/o graphite carbon)

Compounds	Recovery rate
Benzo[b]fluoranthene	88 %
Benzo[k]fluoranthene	86 %
Benzo[a]pyrene	82 %
Benzo[g,h,i]perylene	85 %
Dibenzo[a,h]anthracene	87 %

Recovery rate (%) = A / B × 100

A: Peak area obtained by thermal desorption – GC after trapping the sample by MonoTrap.

B: Peak area obtained by thermal desorption – GC after injecting the sample directly to MonoTrap.

4-5. Summary of different types of MonoTrap™

MonoTrap without adsorbent type (Solvent extraction:DSC18, RSC18 Thermal desorption:RSC18 TD)

There are 2 functionalities for trapping: silica and C18. Although the trapping ability is low for polar compounds, it shows superb desorption. For the solvent extraction type, even with less strongly extracting solvents such as methanol, effective desorption is shown. The thermal desorption type shows good desorption for high boiling point compounds such as PAHs at 250°C.

MonoTrap with graphite carbon (Thermal desorption: RGC18 TD)

Silica, C18 and graphite carbon function as trapping adsorbents. It is more effective at trapping polar compounds than MonoTrap without adsorbents (RSC18 TD).

MonoTrap with active carbon (Solvent extraction: DCC18, RCC18)

Silica, C18, and adsorptive carbon function as trapping adsorbents and this MonoTrap has the highest trapping ability among MonoTrap series. Therefore solvents with strong extractive character such as dichloromethane or acetone are recommended. As there is a temperature limit, it is not suitable for thermal desorption.

MonoTrap PDMS (Thermal desorption: RGPS TD)

PDMS and graphite carbon function as trapping adsorbents. With a superb desorption character, compounds with high boiling point can be measured at high sensitivity.

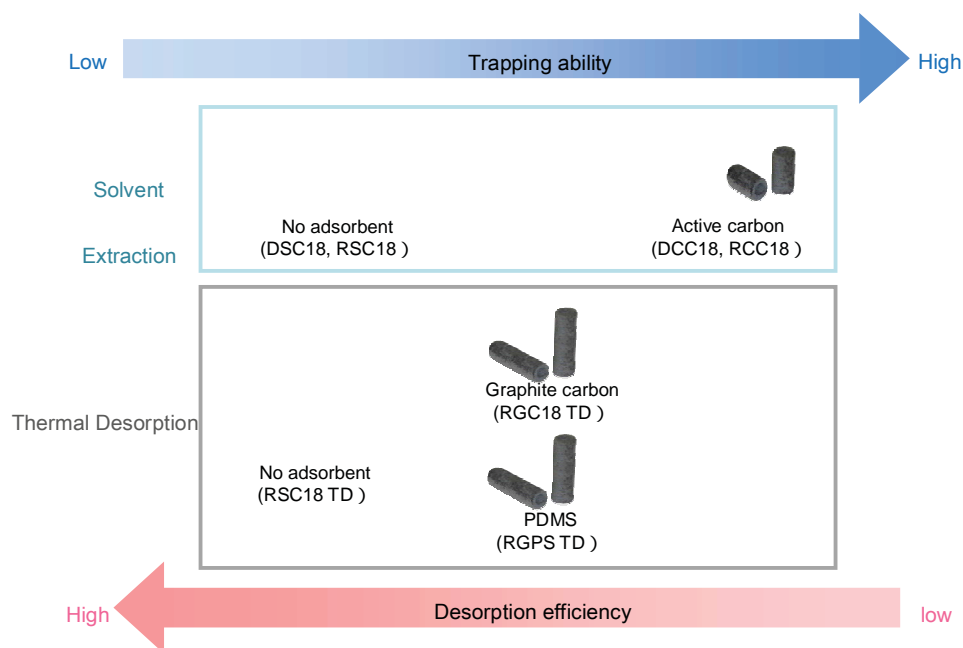


Fig.26 MonoTrap Characters

*3: If desorption is possible below 200°C, then RCC18 (active carbon) can also be used for thermal desorption.

5. For better trapping efficiency

5-1. Trapping gaseous samples

5-1-1. Trapping temperature of gaseous samples

As the diffusion coefficient of the atmosphere depends on the temperature, trapping efficiency improves by heating. In particular, less polar compounds are less influenced by moisture and can be trapped in a short time by increasing the temperature.

Comparison of sampling temperature

A 25 μ l aliquot of standard sample A (see 4-1) was added to 15 % NaCl aqueous solution in a 40 mL vial to trap compounds using MonoTrap DCC18 (active carbon) at 30°C and 60°C.

Linalool (b.p. 198°C) and 2-acetonaphthone (b.p. 302°C) showed improved recovery rates by increasing the trapping temperature.

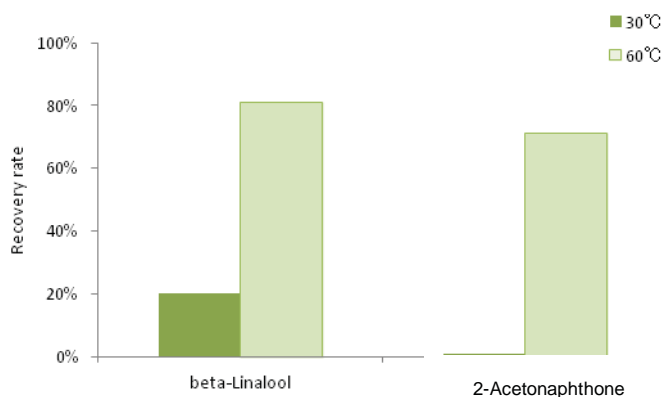
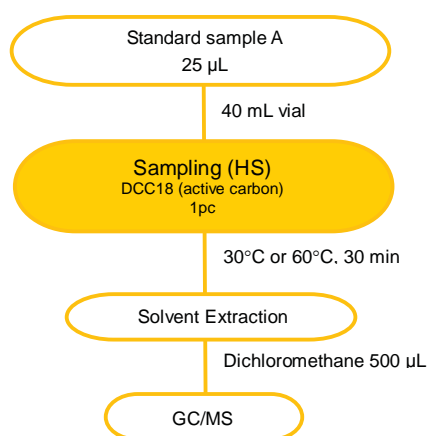


Fig.27 Trapping temperature and recovery rate of gaseous samples

5-1-2. Trapping time of gaseous samples

For low polarity compounds, the recovery rate at 60°C is sufficient after 30 minutes of sampling. For polar compounds (acidic and basic), 60 minutes of sampling is recommended, considering the influence from moisture or adsorption to vial.

Comparison of sampling time

A 25 μ l aliquot of standard sample A (see 4-1) was added to a 40 mL vial to trap compounds using MonoTrap DCC18 (active carbon).

At 60°C and 30 minutes sampling time, 2-acetonaphthone (b.p.302°C) showed an excellent recovery rate. However, a polar compound, octanoic acid (b.p. 237°C), took longer to stabilize the recovery rate. By sampling for 60 minutes, more than 60 % recovery was obtained.

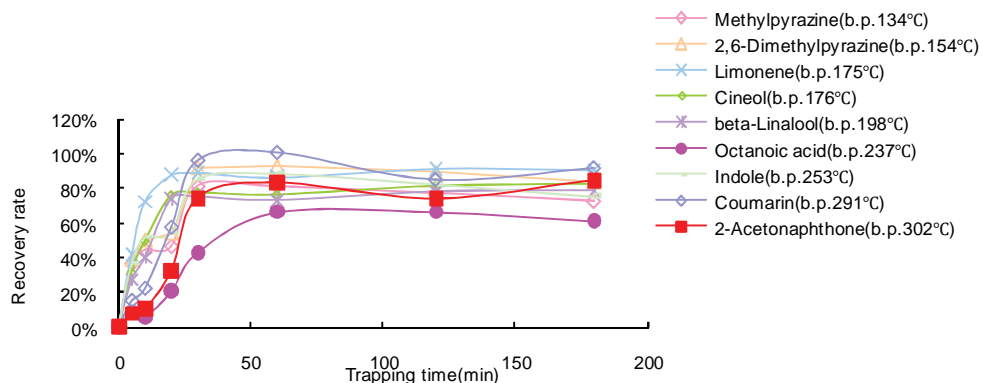
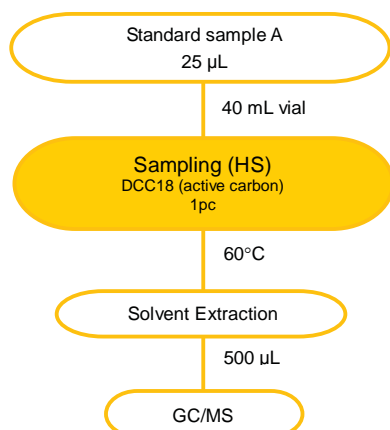


Fig.28 Sampling time and recovery rate for gaseous samples

5-2. Trapping aqueous samples

When trapping aqueous samples, sampling and desorption efficiency heavily depend on the characteristics or matrices of compounds. To improve recovery rate of target compounds, desalt and/or adjust pH.

5-2-1. How to trap aqueous samples

There are various ways of sampling with MonoTrap for aqueous samples (headspace: HS, agitation, floating etc) With agitation, solute of sample (phase), gaseous phase and MonoTrap are agitated to encourage compounds to move into these 3 phases. Agitation is the most effective way of sampling.

Comparison of sampling methods

A 25 μ L aliquot of standard sample A (see 4-1) was added to a 40 mL vial to trap compounds with MonoTrap DCC18 (active carbon) by HS, agitation and floating. The concentration of each compound in the aqueous solution was 125ng/mL.

All compounds showed the best recovery rate when HS was conducted for sampling.

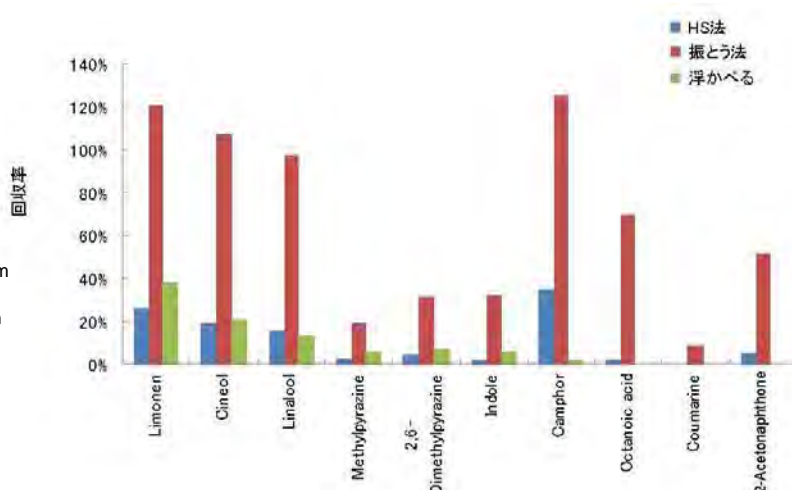
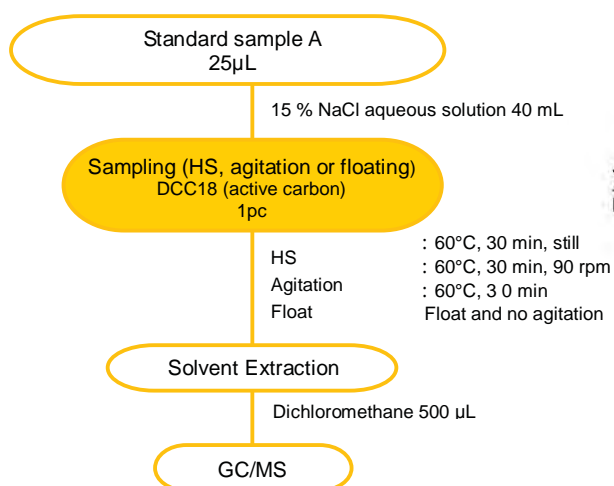
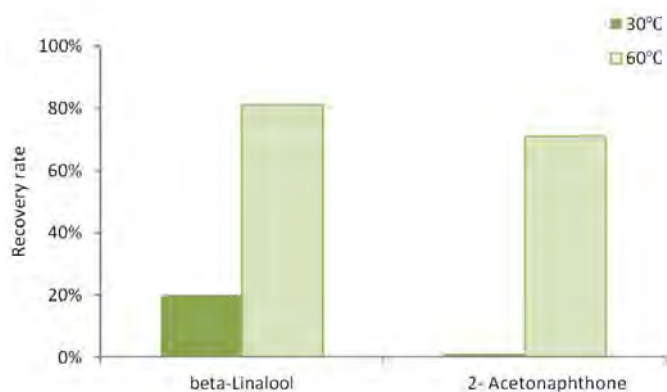


Fig.29 Sampling method and recovery rate for aqueous samples

5-2-2. Trapping time for aqueous samples

With headspace sampling, compounds become vaporized depending on the distribution coefficient between solute of compounds (liquid phase) and headspace (gaseous phase). MonoTrap traps compounds in the gaseous phase. As sampling goes on, the concentration of compounds decreases and once the concentration of compounds in gaseous phase becomes unbalanced, the compounds move from liquid phase to gaseous phase. As it takes time for compounds to become balanced again, a long sampling time is required to obtain high recovery rate.

With agitation, 30 minutes of sampling is enough to obtain a high recovery rate, as compounds move from liquid phase directly to MonoTrap besides from gaseous phase. Note that acidic or basic compounds need 60 minutes for sampling.



Comparison of sampling times

A 25 μ L aliquot of standard sample A (see 4-1) was added to 20mL of 15% NaCl aqueous solution to trap with a MonoTrap DCC18 (active carbon). HS and agitation sampling were conducted for different time periods. The concentration of each compound in the aqueous solution was 250ng/mL.

By HS, almost all the compounds seem to show increased recovery rate even after 180 minutes of sampling.

By agitation, many of the compounds showed the maximum recovery rate after 30 minutes of sampling. Octanoic acid, an acidic compound, showed low recovery rate after 30 minutes of sampling but a good recovery rate after 60 minutes of sampling.

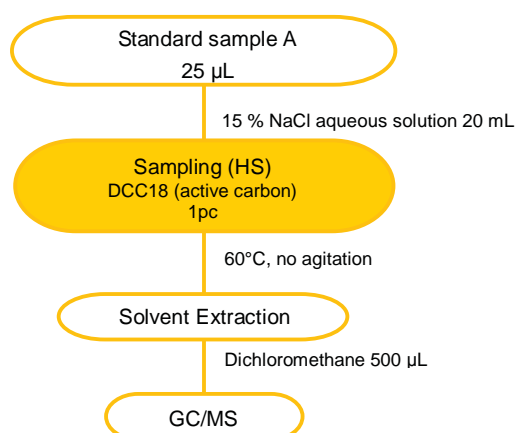


Fig.30 Sampling time and recovery rate by HS

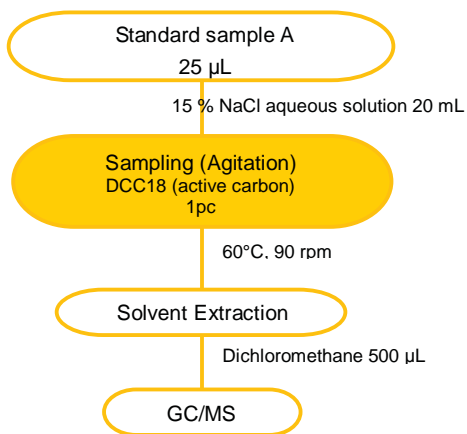


Fig.31 Sampling time and recovery rate by agitation

5-2-3. Effect of desalting

Desalting improves recovery rate. Also by adjusting pH of the sample, even better recovery rate can be expected (see 5-2-4).

Desalting and recovery rate

A 25μL aliquot of standard sample A (see 4-1) was added to 20mL of 15% NaCl aqueous solution to trap with a MonoTrap DCC18 (active carbon). The concentration of each compound in aqueous solution was 250ng/mL. Each compound showed better recovery rate using the desalting procedure.

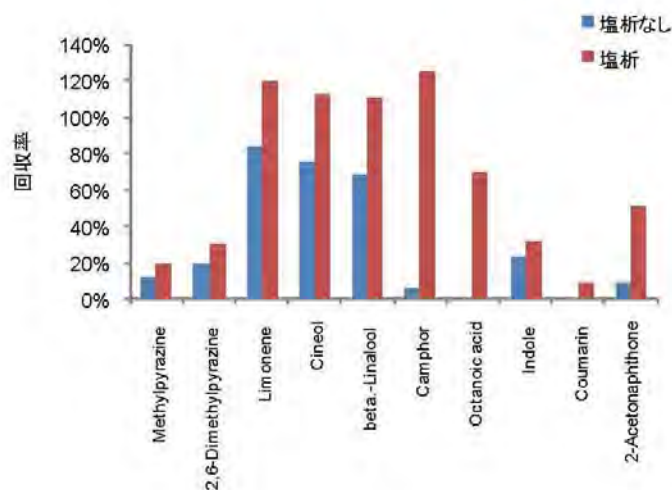
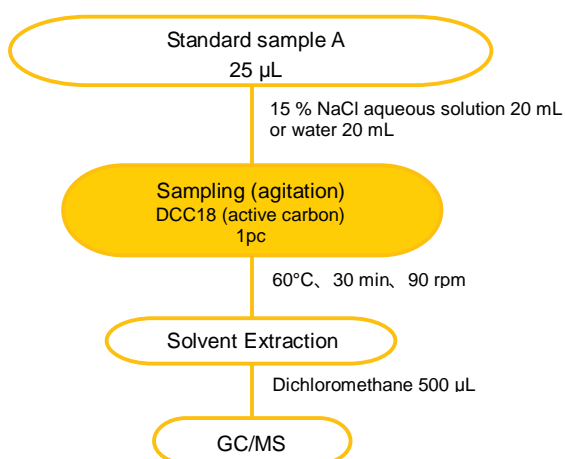


Fig.32 Recovery rate with and without desalting

5-2-4. Effect of pH adjustment

Desalting is effective for the sampling of aqueous samples (see 5-2-3). For even better recovery rates, adjusting the pH is effective in addition to desalting.

pH Adjustment and recovery rate

A 25 μ L aliquot of standard sample (see 4-1) was added to 15% NaCl aqueous solution adjusted to pH2 with phosphoric acid and also to 15% NaCl aqueous solution without pH adjustment, to trap compounds with a MonoTrap DCC18 (active carbon) by HS and agitation. The concentration of each compound in aqueous solution was 250ng/mL.

The recovery rate of octanoic acid, an acidic compound, improved close to 100% by conducting desalting and adjusting pH. Agitation shows more positive impacts of pH adjustment than HS.

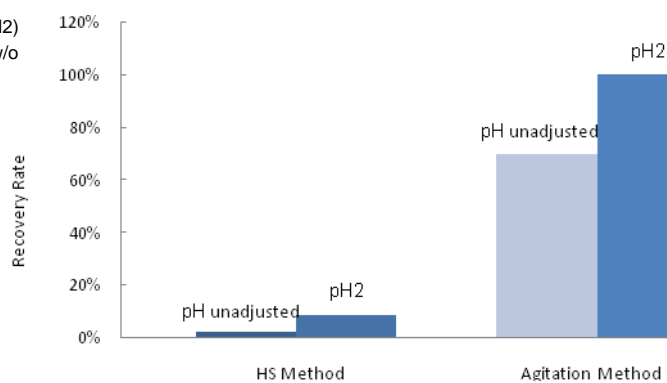
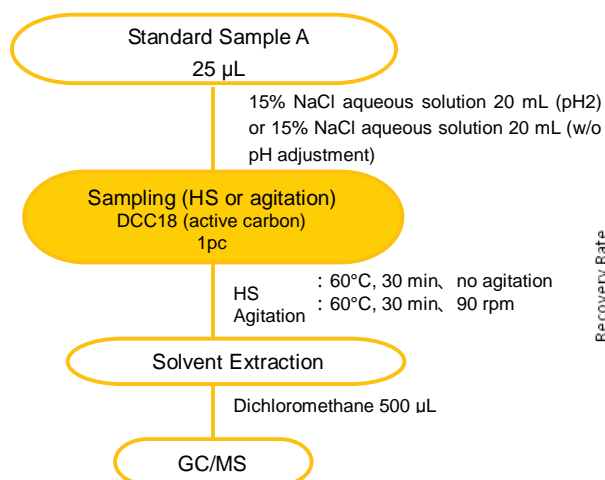


Fig.33 Recovery rate of octanoic acid

6. For better desorption efficiency

6-1. Solvent Extraction

Samples trapped by MonoTrap can be extracted in a short period of time with a small amount of solvent (200 μ L minimum).

By purging the sample with nitrogen gas, the extracted solvent can be enriched for even higher sensitivity detection. Note, however, compounds with low boiling point might become volatilized.

6-1-1. Selecting solvent for extraction

MonoTrap can be used with dichloromethane, acetone, methanol, ethanol and hexane etc. to extract compounds. DSC18 and RSC18 (w/o active carbon) do not show significant differences with type of solvents used.

However, DCC18 and RCC18 (active carbon) show significant differences in recovery rate depending on solvents used. Make sure to select a suitable solvent for target compounds. For better recovery rate, dichloromethane or acetone is recommended for extraction.

Solvents and recovery rate

A 25µL aliquot of standard sample A (See 4-1) was added to a 40 mL vial. After sampling with a DCC18 (active carbon), acetone, diethylether, hexane, methanol, dichloromethane and acetonitrile were used for extraction. Dichloromethane showed high recovery rates for all the compounds.

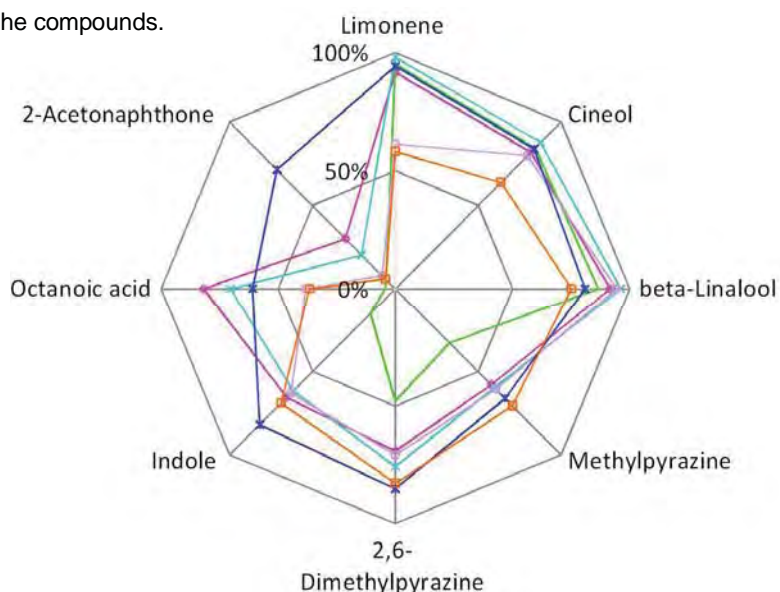
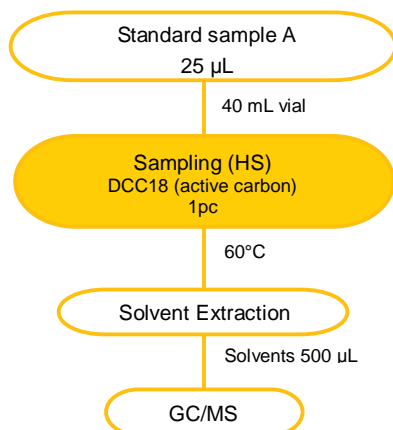


Fig.34 Solvents and recovery rate

6-1-2. Extraction time and recovery rate

Ultrasonication is recommended for extraction. 1-5 minutes of ultrasonication is sufficient for a good recovery rate. Note that too much ultrasonication heats the vial MonoTrap is in and the solvent may become volatized. Also, ultrasonication for longer than 5 minutes may lower the recovery rate.

Ultrasonication time and recovery rate

A 25µL aliquot of standard sample A (See 4-1) was added to a 40 mL vial. After sampling with DCC18 (active carbon), 500ul dichloromethane was used for extraction with various ultrasonication times. 5 minutes of ultrasonication gave a high recovery rate.

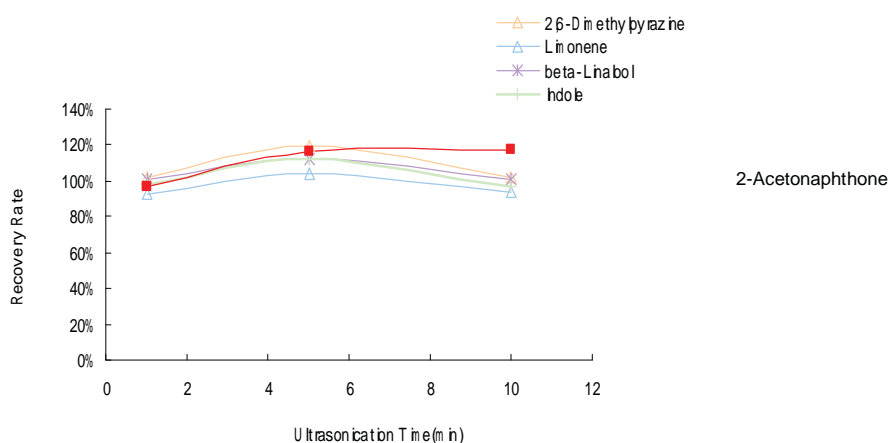
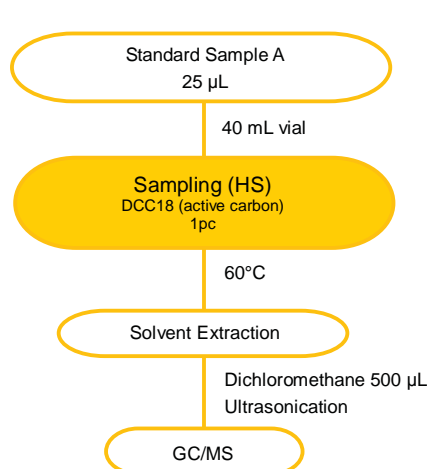


Fig.35 Period for ultrasonication and recovery rate

Warning

Make sure not to open the vial cap until the vial becomes cool enough after ultrasonication. The internal pressure of a vial heated by ultrasonication is increased due to solvent volatilization and it is dangerous to open the vial cap without caution.

6-2. Thermal desorption

6-2-1. Desorption temperature

The recommended desorption temperature for RGC18 TD (graphite carbon) and RSC18 TD (w/o graphite carbon) is 200°C and the maximum temperature is 250°C.

The recommended desorption temperature for RGPS TD (PDMS, graphite carbon) is 250°C and the maximum temperature is 300°C. Compared to MonoTrap with C18 and without PDMS (RGC18 TD and RSC18 TD), PDMS TD type is superior at enduring higher temperatures and shows lower blanks at high desorption temperatures. In order to detect compounds with high boiling points with high sensitivity, temperatures higher than 250°C are recommended for desorption.

MonoTrap has an excellent air permeability for gases or heat for thermal desorption, therefore there is no need for desorption at a high temperature. Heating above the maximum temperature creates more peaks in the blanks. Make sure to check the blank before use.

Comparison of desorption temperature with RGC18 TD (graphite carbon)

A 1 µL aliquot of 100 µg/mL normal hydrocarbon (C13 - C26) was applied directly using a micro syringe to an RGC18 TD (graphite carbon) and desorbed at 100°C - 300°C then injected into a GC/MS. Desorption at 200°C showed good sensitivity even for C26 with a boiling point 412°C.

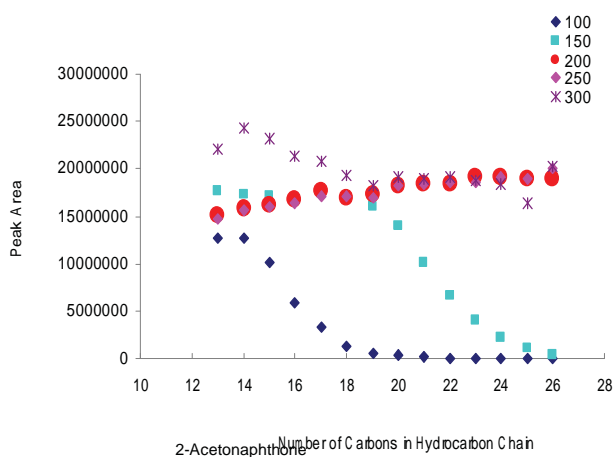
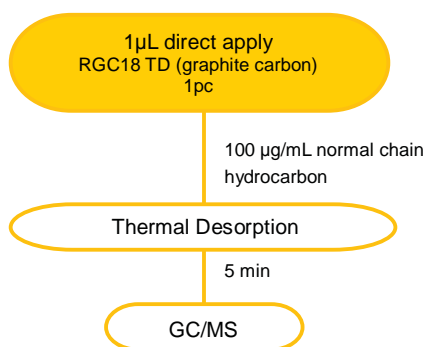


Fig.36 Desorption temperature and peak area

Comparison of desorption temperature with RGPS TD (PDMS, graphite carbon)

A 1 µL aliquot of 100 µg/mL normal chain hydrocarbon (C13~C26) solution was added directly to an RGPS TD (PDMS, graphite carbon) using a micro syringe and desorbed at 100°C ~ 300°C and then injected into a GC/MS. Compounds with high boiling points were detected at greater sensitivity when desorbed at higher than 300°C.

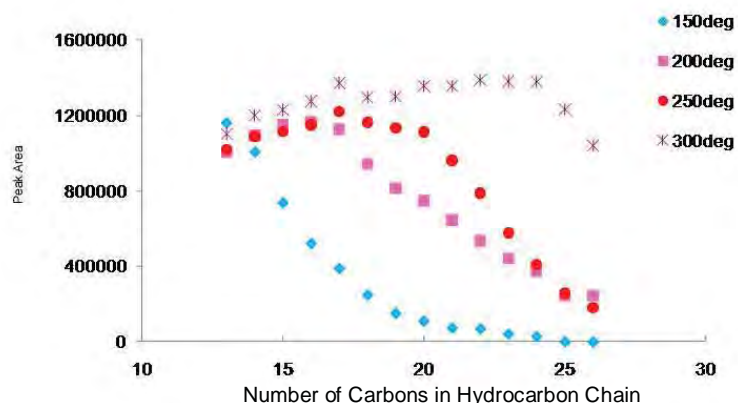
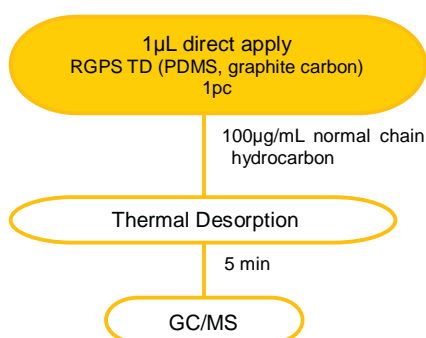


Fig.37 Desorption temperature and peak area

Desorption temperature of RGC18 TD (graphite carbon) and blank

A plain RGC18 TD (graphite carbon) was desorbed at 200°C - 350°C and injected to determine the blank. As the desorption temperature increased, the value of the blank became higher. In order to use MonoTrap with a low blank response, make sure to program the desorption temperature below 200°C. Temperatures higher than 200°C can be used when a blank is not an important factor of an analysis.

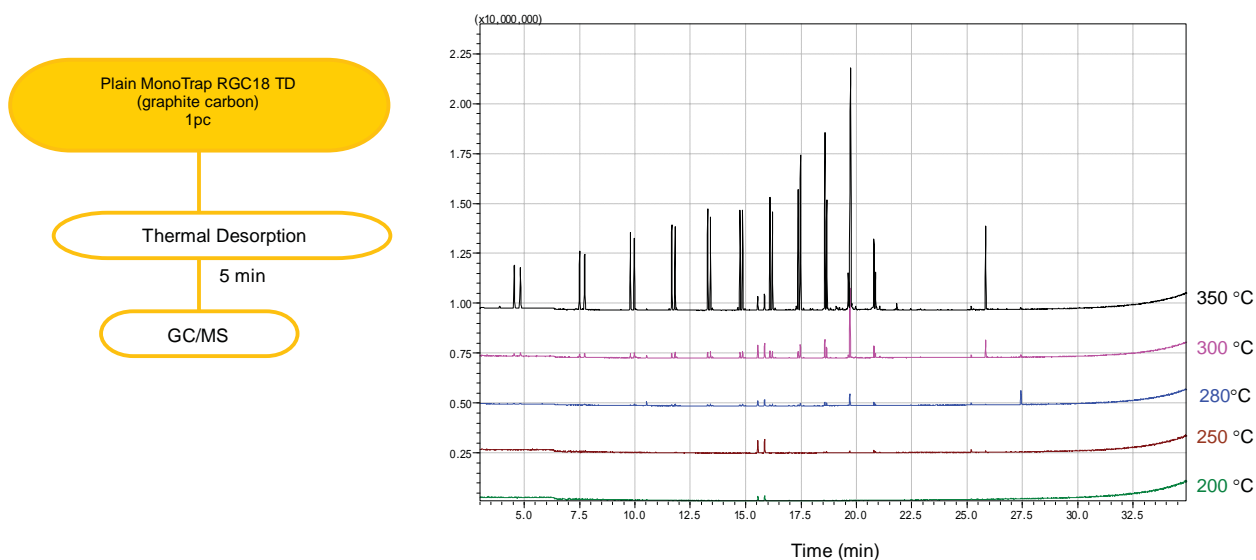


Fig.38 Desorption temperature and blank

7. Basic functions of MonoTrap™

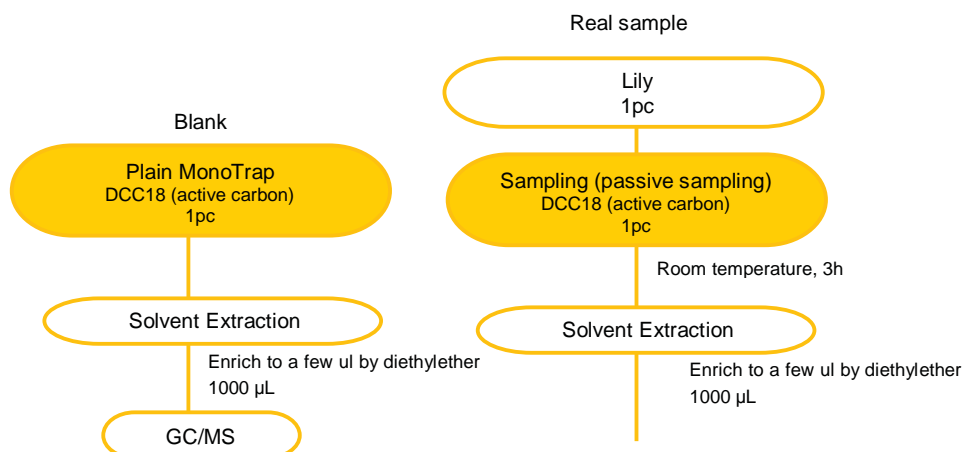
7-1. Blank level

MonoTrap is conditioned before shipment and therefore shows an extremely low blank. However, sometimes blank is observed depending on the conditions of use. Make sure to check blank before use (See 6-2-1).

Blank with DCC18 (active carbon)

A DCC18 (active carbon) was extracted with diethylether without sampling to check blank. As a comparison, the aroma compounds from lily were trapped by a DCC18 (active carbon) and were extracted by diethylether. The extracted solvents of both blank and lily were enriched to a few ul.

Compared to the chromatogram of lily, the chromatogram of a plain MonoTrap showed extremely lower blank. However a few peaks of blank were confirmed from a plain MonoTrap.



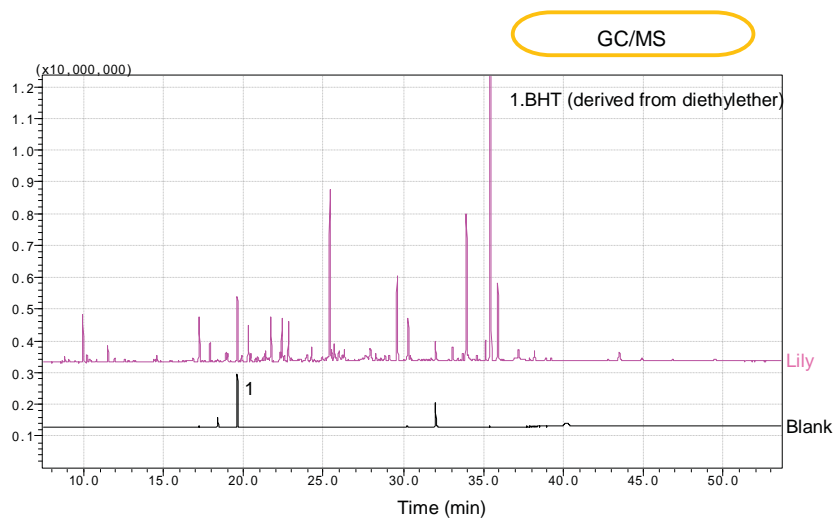


Fig.40 Chromatogram of blank and lily with a DCC18 (active carbon)

- Blank with RGC18 TD (graphite carbon)

Thermal desorption was conducted on an RGC18 TD (graphite carbon) without sampling. As a comparison, a worn sock was put into a Tedlar bag and an RGC18 TD (graphite carbon) was used for passive sampling and thermal desorption.

Compared to the chromatogram of a sock, the chromatogram of a plain MonoTrap RGC18 TD (graphite carbon) showed extremely lower blank.

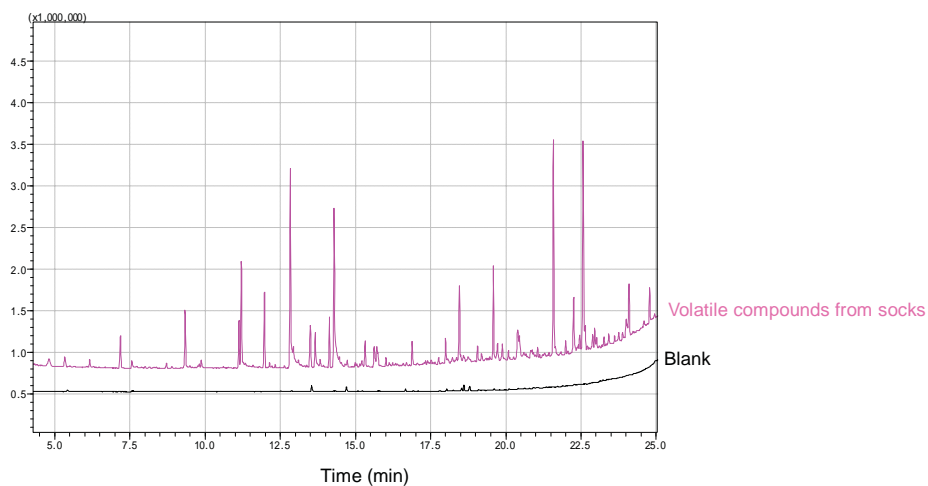
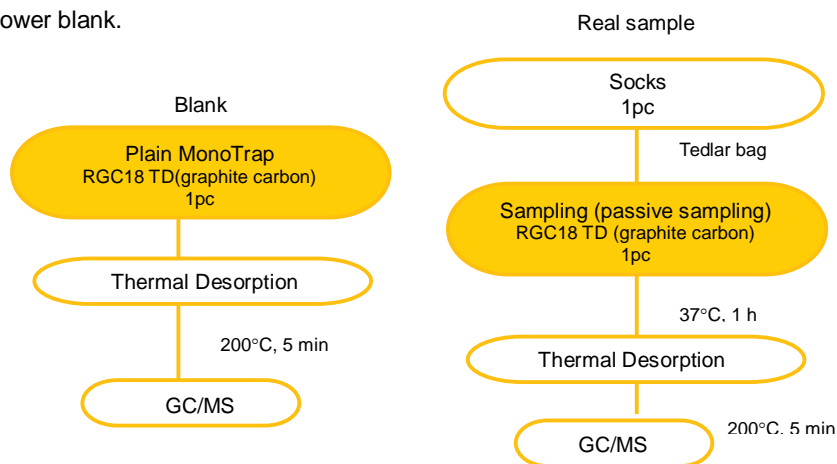


Fig.41 Chromatogram of blank and socks with a plain MonoTrap RGC18 TD (graphite carbon)

- Blank with RGPS TD (PDMS, graphite carbon)

Thermal desorption was conducted on an RGPS TD (PDMS, graphite carbon) without sampling. As a comparison, thermal desorption was conducted on an RGC18 TD (graphite carbon) without sampling for blank purpose and the compounds from maple syrup trapped by HS method with an RGPS TD (PDMS, graphite carbon). Splitless injection was used for blank and split injection for the real sample.

Compared to the chromatogram of the maple syrup, the chromatograms of RGPS TD (PDMS, graphite carbon) and RGC18 TD (graphite carbon) showed lower blank. Also RGPS TD (PDMS, graphite carbon) showed extremely low blank even at 250C for thermal desorption.

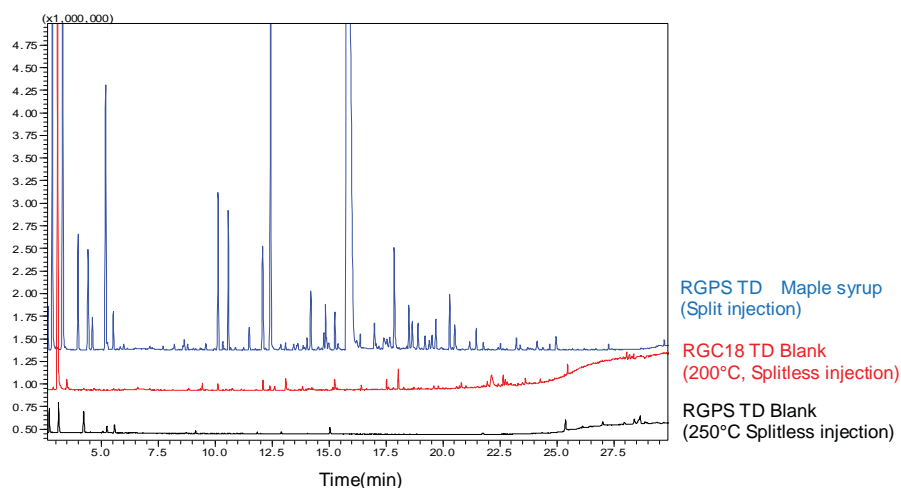
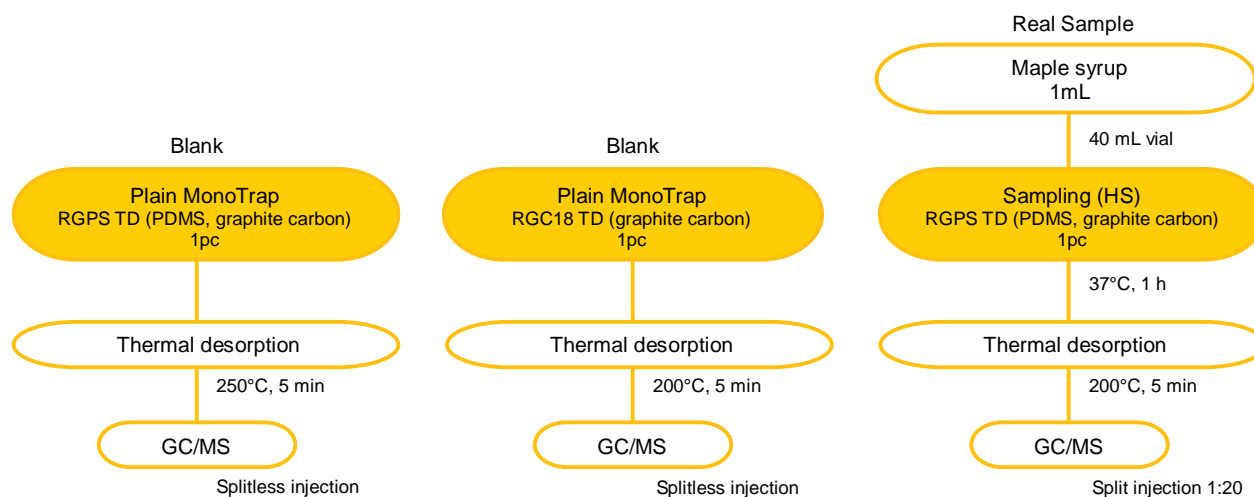


Fig.42 Chromatograms of blank and maple syrup with a plain MonoTrap RGPS TD (PDMS, graphite carbon)

7-2. Reproducibility

Reproducibility of DCC18 (active carbon)

A 25µL aliquot of standard sample (See 4-1) was added to a 40 mL vial to trap compounds with DCC18 (active carbon). 5pcs of DCC18 (active carbon) were used from the same lot to confirm reproducibility.

The reproducibility of each peak area detected was 6 – 13%.

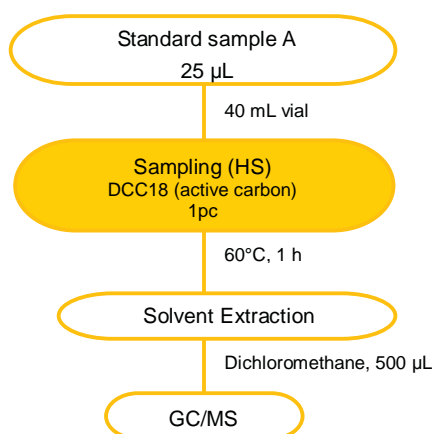


Table3 Reproducibility of each peak area with DCC18 (active carbon) (n=5)

	Compounds	1	2	3	4	5	CV
Alcohol/Terpene	Limonene	494006	485681	496876	536678	445839	7%
	Cineol	466202	462056	467971	503924	414963	7%
	beta-Linalool	374763	376581	379221	409548	344641	6%
Nitrogen Component	Methylpyrazine	475084	495867	400198	444554	478906	8%
	2,6-Dimethylpyrazine	600413	615705	515633	551620	587695	7%
	Indole	933392	943024	799651	865060	902124	7%
Ketone/Carbonyl	Camphor	392101	416782	352397	401182	382398	6%
	Octanoic acid	222252	249125	189229	208219	181751	13%
	Coumarin	406345	433194	346172	405409	383219	8%
	2-Acetonaphthone	435164	456385	339972	436287	433021	11%

Reproducibility of RGC18 TD (graphite carbon)

The standard sample containing the 9 compounds shown in Table 4 below was added to a 40 mL vial so that the concentration of gaseous phase was 2.5 ppb. 5pcs of RGC18 TD (graphite carbon) were used from the same lot to confirm reproducibility. The reproducibility of each peak area detected was 2 - 16 %.

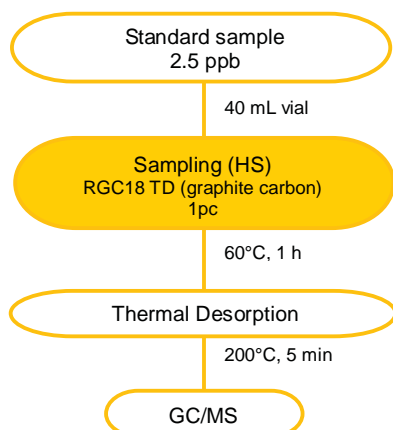


Table4 Reproducibility of each peak area with RGC18 TD (graphite carbon) (n=5)

Concentration	Compounds	CV (%)
2.5 ppb	Acetaldehyde	4 %
	Propanal	13 %
	Butanal	8 %
	Ethyl Acetate	3 %
	Isovaleraldehyde	16 %
	Pentanal	5 %
	Methyl Isobutyl Ketone	10 %
	Toluene	2 %
	Isobutyl alcohol	12 %

7-3. Minimum limit of detection

With MonoTrap it is possible to trap highly hydrophilic compounds down to an order of concentration of ppt. It can be diluted by addition of solvent. With thermal desorption, even higher sensitivity analyses are possible. Also the sensitivity can be improved by increasing the sample amount.

Minimum limit of detection for methylpyrazine

Prepare 20mL of each 10 and 100 ng/mL of methylpyrazine aqueous solution (15% NaCl) to trap compounds with a DCC18 (active carbon).

The peak of methylpyrazine was confirmed with both 10 and 100 ng/mL. A highly hydrophilic compound such as methylpyrazine was detected with low concentration.

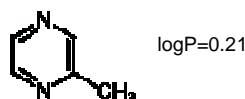


Fig.43 Methylpyrazine

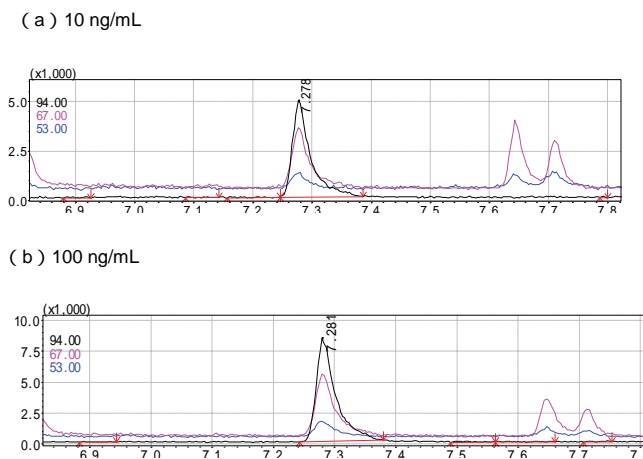
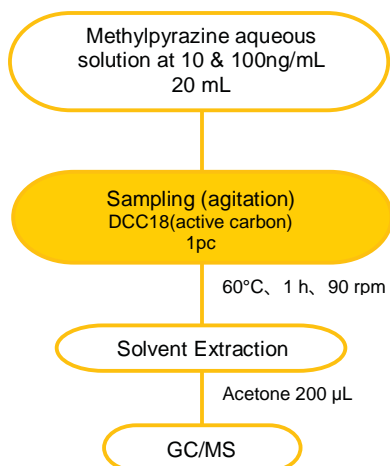


Fig.44 Methylpyrazine (SIM)

8. Comparison with other commercially available products

8-1. MonoTrap™ for solvent extraction and other products

It is easy to set up an analysis with MonoTrap for solvent extraction as the compounds are collected in the solvent. Sensitivity with MonoTrap for solvent extraction is compatible with other commercially available “thermal desorption” products.

MonoTrap™ DCC18 (active carbon) and fiber type product

Gardenia was covered with a tedlar bag and a DCC18 (active carbon) and a fiber type trapping tool A added to trap the compounds. After sampling for 3 hours, the compounds trapped by a DCC18 (active carbon) were extracted by solvent 1000 µL and enriched to 100 µL then 1µL of it was injected into a GC/MS. Thermal desorption was conducted with the fiber type product A and then GC/MS.

Compared to a fiber type product A, with the whole volume injected, MonoTrap DCC18 (active carbon) showed a compatible sensitivity even after being diluted 100 times for solvent extraction. Indole was detected better by MonoTrap DCC18 (active carbon).

(Note that the compounds shown in the chromatogram are the results based on the MS library and not identification results using standard samples).

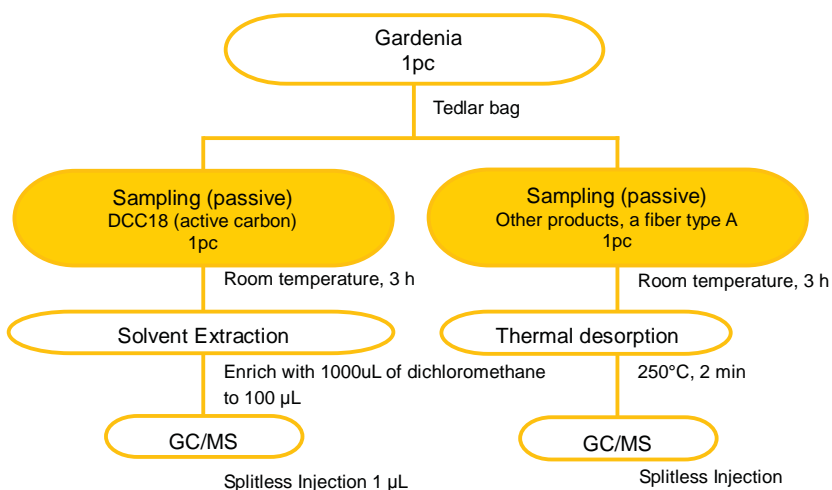


Fig.45 Sampling gardenia

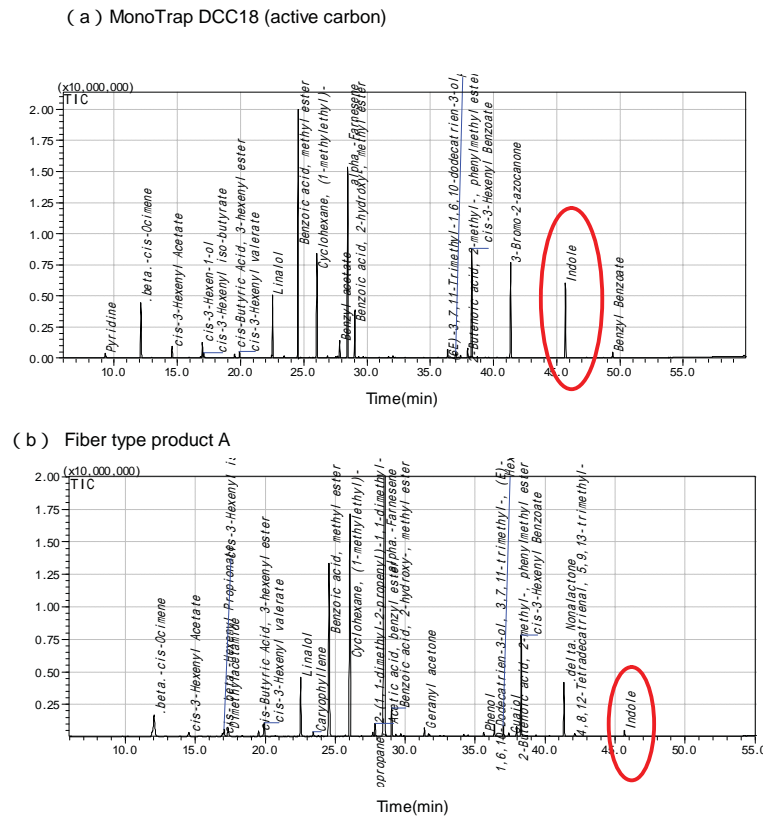


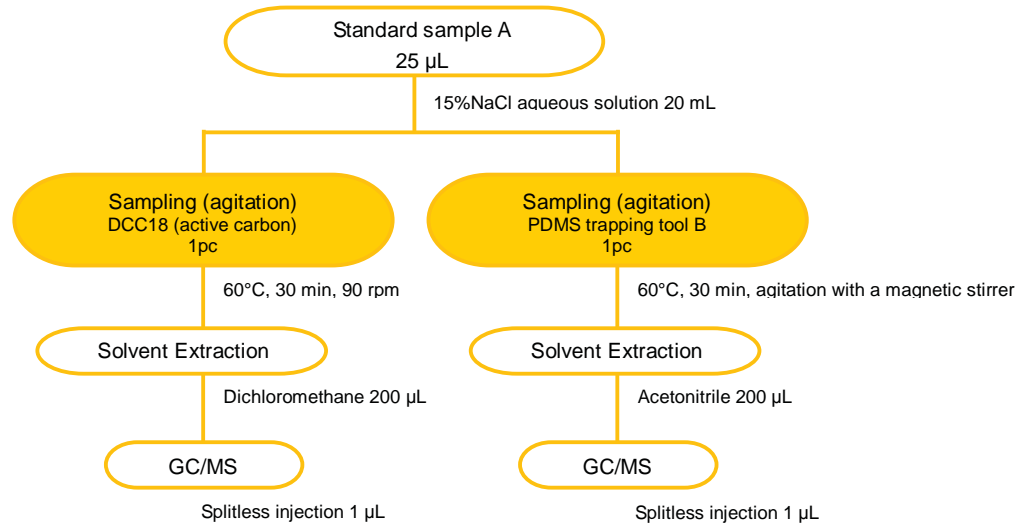
Fig.46 Compounds from gardenia

MonoTrap™ DCC18 (active carbon) and a PDMS trapping tool B

A 25uL aliquot of standard sample (See 4-1) was added to 20mL of 15 %NaCl aqueous solution and the compounds trapped by a DCC18 (active carbon) and a PDMS trapping tool B (the concentration of each compound in the aqueous solution was 250 ng/mL). The compounds trapped with a DCC18 (active carbon) were then extracted with 200uL of dichloromethane and a PDMS trapping tool B with 200uL of acetonitrile.

Compared to the PDMS trapping tool B, compounds from low LogP to high LogP, which are from high hydrophobicity to high hydrophilicity, appeared with a better recovery rate with DCC18 (active carbon). As there is a possibility that the PDMS phase of the PDMS trapping tool B might become destroyed, only limited solvents such as acetonitrile or methanol can be used.

However, as the base material of MonoTrap is silica, strongly extracting solvents such as dichloromethane can be used.



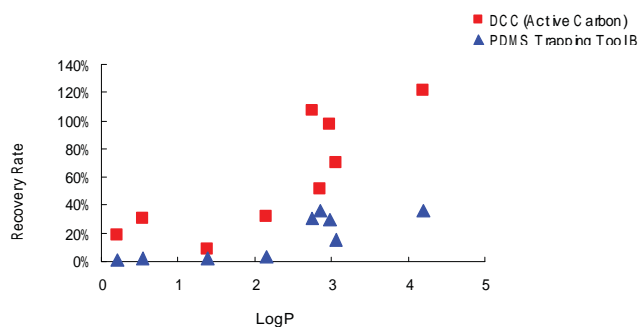


Fig.47 Recovery rate on DCC18 (active carbon) and a PDMS trapping tool B

Table 5 Recovery rate on DCC18 (active carbon) and a PDMS trapping tool B

Compounds	LogP	DCC (active carbon)	PDMS trapping tool B
Methylpyrazine	0.21	18.8 %	0.6 %
2,6-Dimethylpyrazine	0.54	30.7 %	1.8 %
Indole	2.14	32.0 %	3.5 %
Cineol	2.74	107.0 %	30.5 %
Linalool	2.97	97.0 %	29.8 %

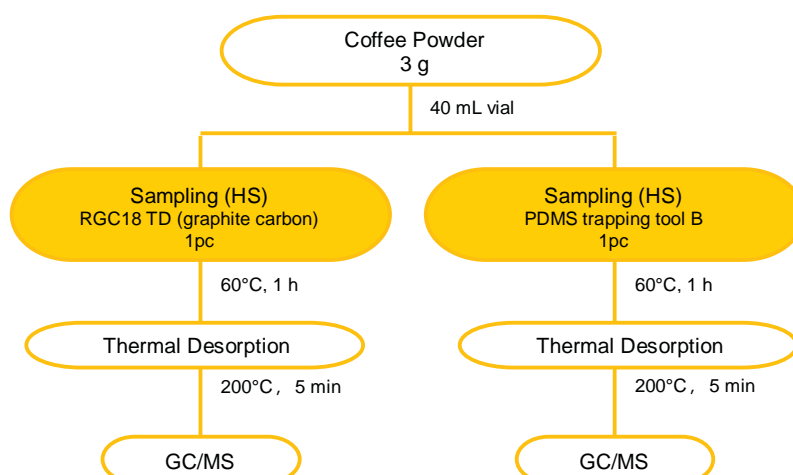
8-2. MonoTrap™ for thermal desorption and other products

MonoTrap for thermal desorption detects compounds with higher sensitivity than other commercially available PDMS trapping tools. In particular, compounds that are difficult to trap by PDMS trapping tools can be captured well by MonoTrap.

Comparison data 1: MonoTrap™ RGC18 TD (graphite carbon) and a PDMS trapping tool B

Coffee was put into a 40 mL vial and the compounds trapped with an RGC18 TD (graphite carbon) and a PDMS trapping tool B.

The chromatograms show that the compounds trapped with an RGC18 TD (graphite carbon) were detected with a higher sensitivity than a PDMS trapping tool B. Due to the adsorption ability of graphite carbon modified RGC18 TD, nitrogenous components were efficiently trapped.



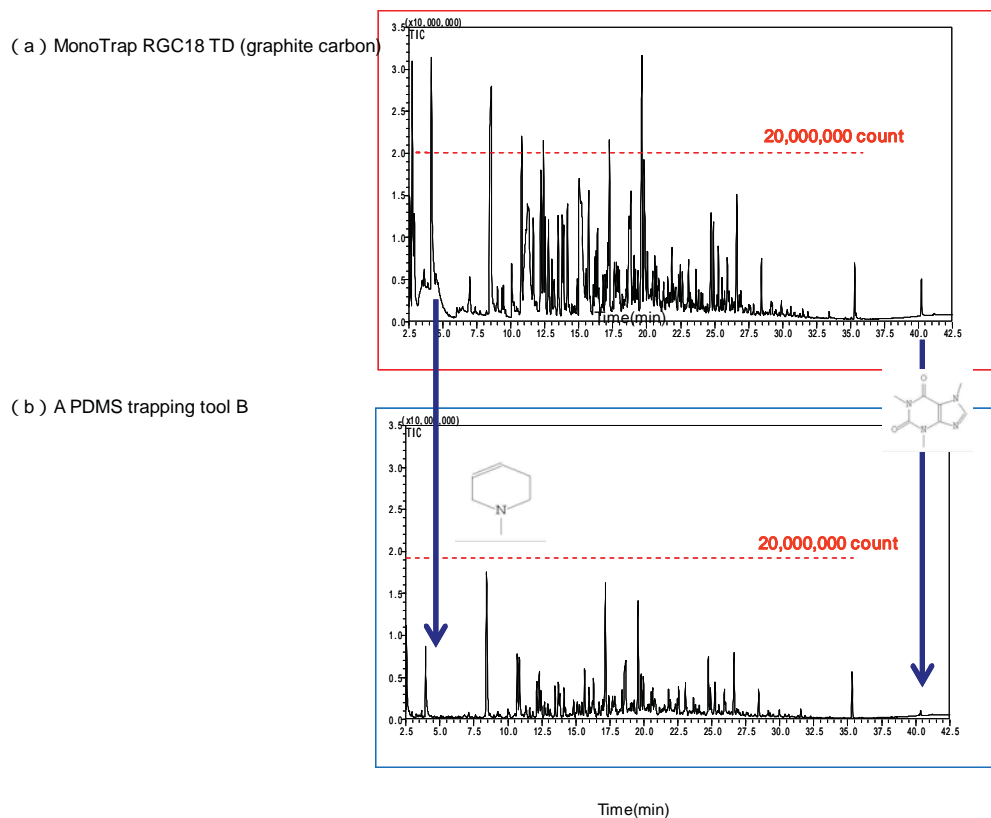


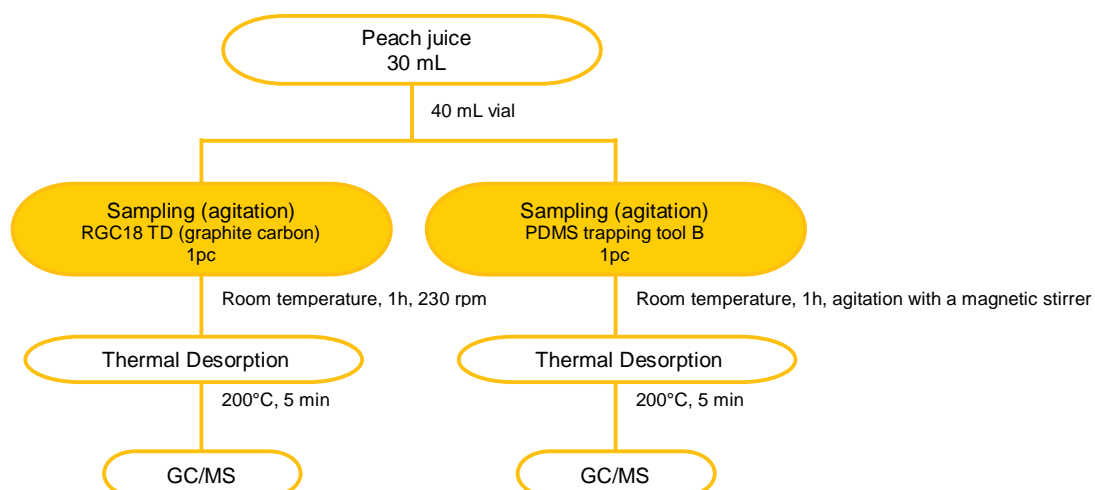
Fig.48 Compounds from coffee

Compounds	Area ratio (RGC18 TD/PDMS trapping tool B)
1-Methyl-1,2,5,6-tetrahydropyridine	4.8
(Dimethylamino)acetone	9.5
1-Hydroxy-2-propanone	9.6
Acetic acid	26.7
Caffeine	7.2

Table6 Area ratio of an RGC18 TD (graphite carbon) and a PDMS trapping tool B

Comparison data 2: MonoTrap™ RGC18 TD (graphite carbon) and a PDMS trapping tool B

Peach juice (30mL) was poured into a 40 mL vial and the compounds trapped with an RGC18 TD (graphite carbon) and a PDMS trapping tool B. An RGC18 TD was agitated with the sample with a shaker. The PDMS trapping tool B was agitated with a magnetic stirrer. MonoTrap RGC18TD showed better sensitivity than the PDMS trapping tool B (especially for peaks between 25 – 30 minutes, marked red in the following chromatogram).



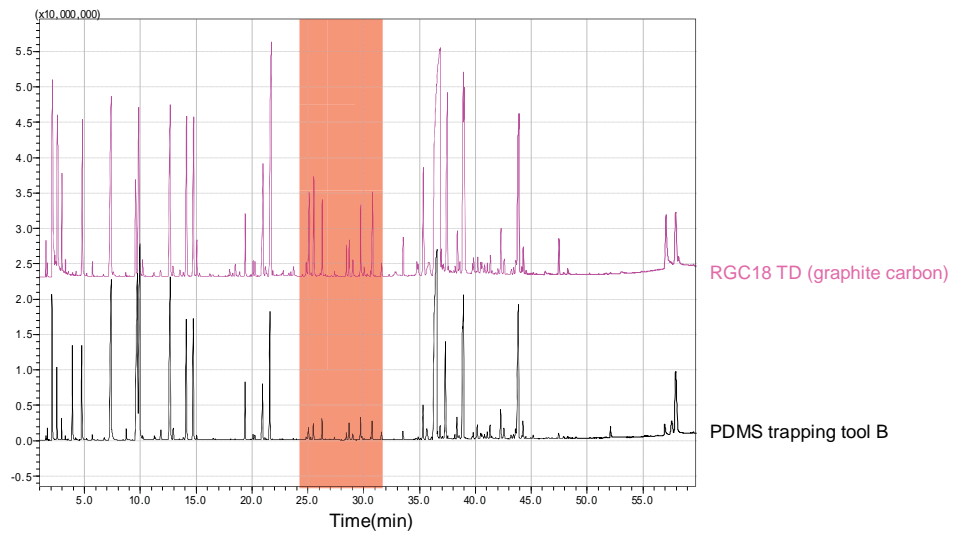
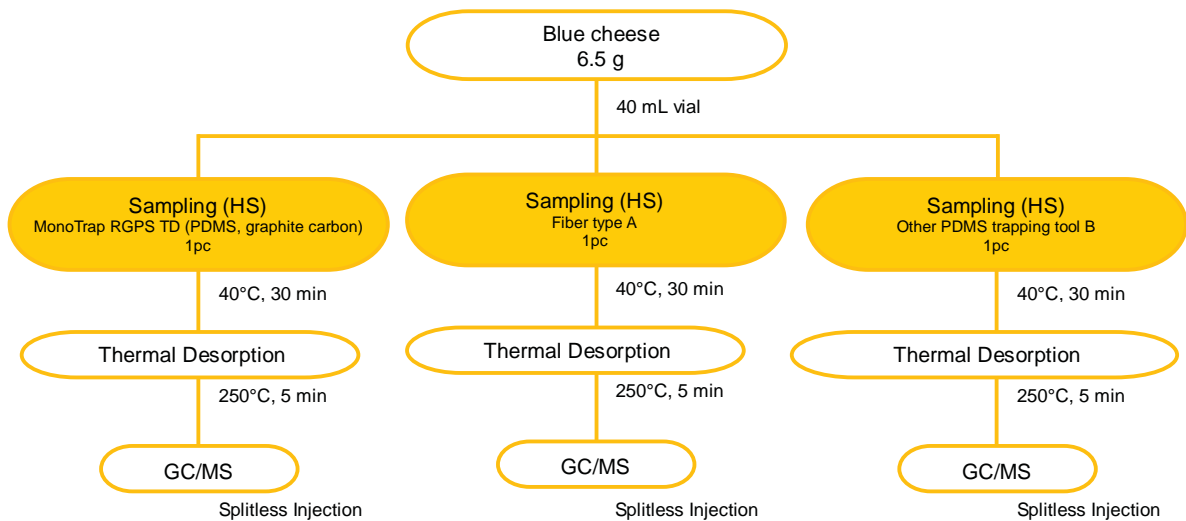


Fig.49 Compounds from peach juice

Comparison data: MonoTrap™ RGPS TD (PDMS, graphite carbon) and other trapping tools A and B

Blue cheese (6.5g) was put into a 40 mL vial and the compounds trapped with MonoTrap RGPS TD (PDMS and graphite carbon) and a fiber type trapping tool A and a PDMS trapping tool B by HS.

The chromatogram showed an extremely high sensitivity with MonoTrap RGPS TD (PDMS, graphite carbon) compared with these other trapping tools.



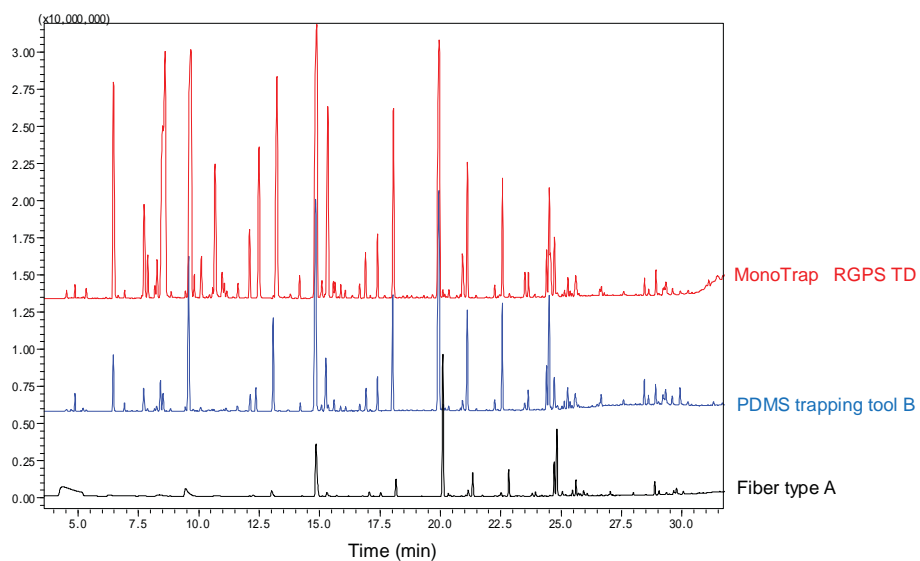


Fig.50 Compounds of blue cheese

This product is based on the monolith technology held by Merck KGaA, Darmstadt, Germany.

9. Product Information

GL Sciences Inc website: <http://www.glsciences.com/products.html>

MonoTrap: <http://www.glsciences.com/products/monotrap/index.html>

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