

Application News

Characterization and Temporal Monitoring of Volatile Organic Compounds (VOCs) Released in Response to Plant Stress

Hitomi Tsujihata

User Benefits

- ◆ MonoTrap is well suited for field sampling because it is easy to transfer and store, enabling collection of plant-derived VOCs.
- ◆ Plant-derived VOCs can be analyzed without the complicated pretreatment procedure such as solvent extraction.
- ◆ This analysis system is ideal for measuring time-dependent changes in VOCs associated with plant stress responses.

■ Introduction

Plants release volatile organic compounds (VOCs) in response to stressors such as changes in growing conditions and physical damage. These VOCs are known to have various physiological functions, including repelling herbivorous insects, enhancing resistance against pathogens, and facilitating plant-to-plant communication. For example, green leaf volatiles (GLVs) are a group of fatty acid-derived C6 VOCs released in response to stressors such as herbivore damage and pathogenic infection, and are reported to play an important role in plant defense response.¹⁾ However, VOCs sampling from living plants is labor-intensive because collection equipment must be carried in the field.

This Application News describes the collection of VOCs released from plant leaves in response to cutting and ultraviolet stress using MonoTrap, followed by analysis using a thermal desorption GC-MS system. VOC profiles generated under different stress conditions were compared, and time-dependent changes in VOCs emissions were evaluated.



Fig. 1 TD-30R and GCMS-QP2050

■ Advantages of MonoTrap

MonoTrap is an adsorbent consisting of a monolith silica substrate and characterized by its ability to efficiently collect VOCs. Its large surface area enables the adsorption of a wide range of compounds from small molecules to medium- and high-boiling point components. MonoTrap is compatible with various desorption techniques, including solvent extraction and thermal desorption. Because it is small in size, and easy to handle, MonoTrap is ideal for sampling in the field, offering excellent ease of use, transport, and storage, making it well suited for field sampling of VOCs and environmental gases.

In this study, a MonoTrap RGC18 TD (Cat.No.:1050-74201, GL Sciences) designed for thermal desorption-based analysis was used. After VOC collection, the MonoTrap was simply placed in a glass thermal desorption tube for analysis (Fig. 2). This approach simplifies the workflow from sampling to analysis, and helps reduce the variability between operators.

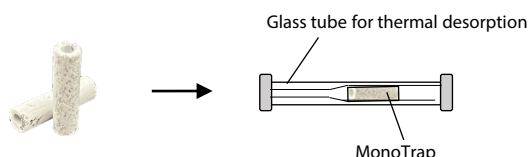


Fig. 2 MonoTrap and Preparing for Sample Analysis

■ Method: Collecting Plant-Released VOCs

Sample 1: No Stress

The Smart Bag PA AAK-0.5 (Cat.No.:3008-97995, GL Sciences) was used as the sampling bag. A single leaf was enclosed in the sampling bag, and a MonoTrap RGC18 TD was placed on the leaf. The opening around the stem was sealed with the tape. The sample was then left undisturbed for 1 hour to collect VOCs released by the leaf.

Sample 2: Cutting Stress

Approximately 2 cm was cut from two locations on the leaf using scissors. VOCs were then collected following the same process as described for sample 1.

Sample 3: UV Stress

A single leaf was enclosed in the sampling bag with MonoTrap. Using a spotlight source (LC8, Hamamatsu), ultraviolet light with an intensity of 0.61 mW/cm² and a wavelength range of 280 to 400 nm was irradiated onto a 2-cm-diameter area of the leaf through the outside of the sampling bag for 1 hour. To evaluate time-dependent changes in VOCs released during UV irradiation, 1 µL of a 100 µg/mL solution of p-bromofluorobenzene in methanol was spiked to the sample bag as an internal standard (IS).

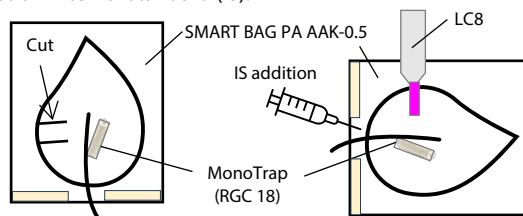


Fig. 3 Method of Collecting Plant-Released VOCs
(Left: Cutting, Right: UV Irradiation)

■ Analysis Conditions

The MonoTrap was placed in a glass tube for thermal desorption, which was set in a TD-30R thermal desorption system. The analysis conditions are shown in Table 1.

Table 1 Analysis Conditions

GC Model:	Nexis GC-2030
MS Model:	GCMS-QP2050
Autosampler:	TD-30R
[TD-30R]	
Tube Desorb Temp.:	200 °C (10 min)
Tube Desorb Flow:	60 mL/min (N ₂)
Trap Cooling Temp.:	-20 °C
Trap Desorb. Temp.:	200 °C
Joint Temp.:	200 °C
Valve Temp.:	200 °C
Transfer Line Temp.:	200 °C
[GC]	
Column:	SH-5Sil MS (30 m, 0.25 mm ID, 0.25 µm)
Injection Mode:	Split
Split Ratio:	5
Carrier Gas:	He
Carrier Gas Control:	Pressure (83.5 kPa)
Column Oven Temp.:	50 °C (5 min) → (10 °C/min) → 250 °C (5 min)
[MS]	
Ion source:	200 °C
Interface Temp.:	250 °C
Analysis Mode:	Scan (m/z 35 - 400)

■ Identification of Detected Compounds

Fig. 4 compares the total ion current chromatograms (TICCs) obtained from sample 1 (no stress), sample 2 (cutting stress), and sample 3 (UV stress). The compounds detected in each sample are shown in Table 2. Compared with sample 1, compounds showing little change are indicated by a horizontal arrow (→), while compounds showing increased abundance are indicated by a vertical arrow (↑).

GLVs, fatty acids, aromatics, hydrocarbons, and terpenes were detected.

1. Comparison of Stress-Response VOCs under Different Stress Conditions

The detected compounds were compared under different stress conditions. Comparison of sample 2 (cutting stress) and sample 3 (UV stress) revealed differences in the compounds detected between 1 and 10 minutes of retention time. GLVs such as 3-hexen-1-ol and 3-hexenyl acetate were detected in sample 2. Compared with sample 1, increased amounts of acetol, phenol, and other compounds were observed in sample 2 and sample 3. These results indicate that the composition and abundance of released compounds vary depending on the type of stress.

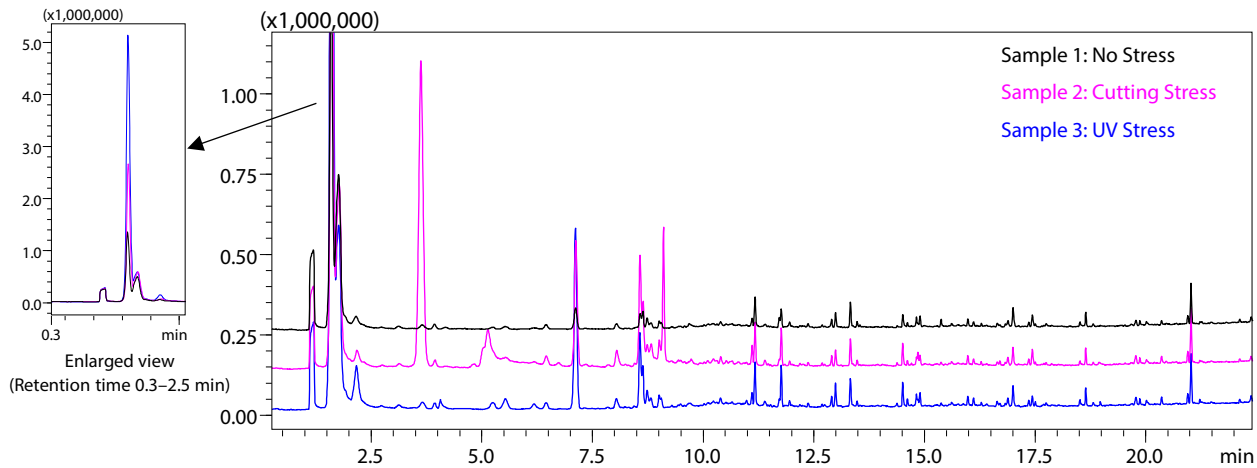


Fig. 4 Comparison of Total Ion Current Chromatograms of VOCs Released from Plant Leaves

2. Time-Dependent Change in Response Compounds during UV Irradiation

The effect of UV irradiation time on plant-released VOCs was investigated. Fig. 5 shows the relationship between UV irradiation time and the timing of VOC collection. Time-dependent changes in response compounds were monitored by replacing the MonoTrap at different time points during UV irradiation.

Fig. 6 compares the TICCs obtained after 1, 3, and 5 hours of UV irradiation, and Table 2 shows the IS-corrected peak area ratios of detected compounds. The results show that acetol was released after 1 hour of UV irradiation and tended to reach saturation after 5 hours. By contrast, phenol was detected at its highest level after 1 hour of UV irradiation, and octanal reached its highest after 5 hours. These results indicate that the stress response to UV irradiation varies depending on the duration of UV exposure.

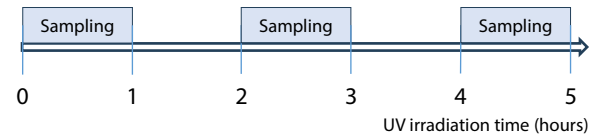


Fig. 5 The Relationship between UV Irradiation Time and the Timing of VOC Collection

Table 2 Compounds Detected in Each Sample and IS-Corrected Peak Area Ratios for Sample 3 at Different UV Irradiation Times
(—: undetected, →: similar, ↑: increased compared with sample 1)

No.	Retention Time (min)	Compound	m/z	Detection			IS-Corrected Peak Areas after Various UV Irradiation Times		
				Sample 1	Sample 2	Sample 3	1 hour	3 hours	5 hours
1	1.60	Acetol	74	✓	↑	↑	6.65	10.6	10.9
2	1.72	Acetic acid	60	✓	↑	↑	0.630	0.642	0.625
3	3.66	3-Hexenal	69	—	↑	—	—	—	—
4	5.02	2-Hexenal	83	—	↑	—	—	—	—
5	5.15	Hexen-1-ol	67	—	↑	—	—	—	—
6	8.57	Phenol	94	✓	↑	↑	0.672	0.067	0.041
7	9.01	Decane	85	✓	↑	→	0.017	0.018	0.059
8	9.06	Octanal	57	✓	↑	↑	0.057	0.062	0.217
9	9.11	3-Hexenyl acetate	67	—	↑	—	—	—	—
10	12.69	Naphthalene	128	✓	→	→	0.015	0.010	0.011
11	14.62	Undecanal	82	✓	↑	↑	0.005	0.004	0.003
12	16.29	Longifolene	161	✓	→	→	0.003	0.003	0.004
13	16.65	Geranylacetone	69	✓	→	→	0.005	0.002	0.003
14	17.70	Cadinene	161	✓	→	→	0.001	0.002	0.002
15	17.75	Calamenene	159	✓	→	→	0.010	0.013	0.013
16	18.81	Tetradecanal	57	✓	→	→	0.034	0.034	0.029
17	19.87	Heptadecane	57	✓	→	→	0.011	0.012	0.009

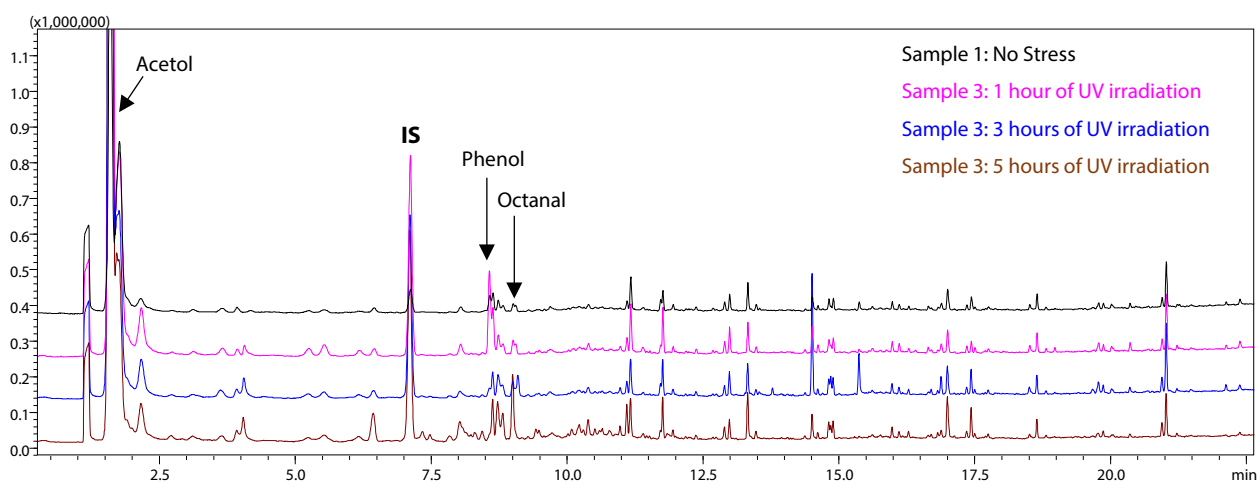


Fig. 6 Comparison of Total Ion Current Chromatograms of VOCs Released under UV Stress

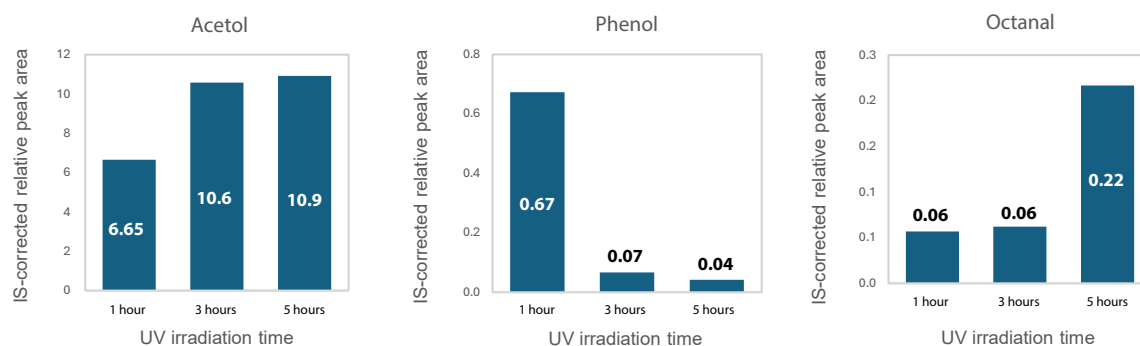


Fig. 7 Time-Dependent Changes in Stress Response Compounds at Different UV Irradiation Times

Conclusion

VOCs released from plant leaves in response to cutting and ultraviolet stress were collected using MonoTrap and analyzed by thermal desorption GC-MS system. The results showed that both the stress response compounds and the amounts of VOCs released varied depending on the stress conditions. GLVs such as 3-hexenal and 3-hexen-1-ol were detected under cutting stress. In addition, time-dependent changes in response compounds during UV irradiation were successfully monitored.

MonoTrap for thermal desorption does not require complicated sample processing such as solvent extraction, and can be combined with a thermal desorption GC-MS system to streamline procedures from sampling to qualitative analysis.

Acknowledgments

We are sincerely grateful to Dr. Ko Mochizuki of The University of Tokyo and to Dr. Yumiko Higuchi of Kyoto University for providing the samples used in this Application News. Their assistance is much appreciated.

References

- 1) A. Scala et al. "Green Leaf Volatiles: A Plant's Multifunctional Weapon against Herbivores and Pathogens" *Int. J. Mol. Sci.* 2013, 14(9), 17781-17811

Nexis is a trademark of Shimadzu Corporation or its affiliated companies in Japan and/or other countries.

01-01240-EN

First Edition: Oct. 2026



Shimadzu Corporation

www.shimadzu.com/an/

For Research Use Only. Not for use in diagnostic procedures.

This publication may contain references to products that are not available in your country. Please contact us to check the availability of these products in your country.

The content of this publication shall not be reproduced, altered or sold for any commercial purpose without the written approval of Shimadzu. See <https://www.shimadzu.com/about/trademarks/index.html> for details.

Third party trademarks and trade names may be used in this publication to refer to either the entities or their products/services, whether or not they are used with trademark symbol "TM" or "®".

Shimadzu disclaims any proprietary interest in trademarks and trade names other than its own.

The information contained herein is provided to you "as is" without warranty of any kind including without limitation warranties as to its accuracy or completeness. Shimadzu does not assume any responsibility or liability for any damage, whether direct or indirect, relating to the use of this publication. This publication is based upon the information available to Shimadzu on or before the date of publication, and subject to change without notice.

© Shimadzu Corporation, 2026

› Please fill out the survey

Related Products

Some products may be updated to newer models.



› Nexis GC-2030
Gas Chromatograph



› Brevis GC-2050
Gas Chromatograph



› GCMS-QP2050
Gas Chromatograph Mass Spectrometer



› TD-30 Series
Thermal Desorption Systems

Related Solutions

› Life Science

› Metabolomics

› Price Inquiry

› Product Inquiry

› Technical Service /
Support Inquiry

› Other Inquiry