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Application News

GC-MS GCMS-QP2020 NX

Quantitative Analysis of 57 Fragrance Allergens in Cosmetics Using Twin Line MS System

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User Benefits

- The twin line MS system enables efficient analysis of fragrance allergens in cosmetics.
- By using two types of columns, even a single quadrupole GCMS can effectively separate contaminants.
- A twin line MS System does not require column replacement, which significantly reduces downtime.

■ Introduction

Under the European Cosmetics Directive (EC 1223/2009)[1], 24 of the fragrances used in cosmetics are regulated as fragrance allergens. If a leave-on product contains more than 0.001 % or a rinse-off product contains more than 0.01 %, it must be labeled on the product. Recently, however, following an opinion by the Scientific Committee on Consumer Safety (SCCS), the number of regulated compounds has been scheduled to be expanded to more than 80. Therefore, manufacturers of cosmetics need to know exactly what fragrance compounds are contained in finished products or raw materials.

This Application News describes an example of analysis of 57 fragrance allergens in a commercial hair oil using the twin line MS system, based on the analysis method reported by IFRA[2].

Fig. 1 AOC™-30i + GCMS-QP2020 NX

■ Fragrance Allergens

Fragrances are used in perfumes as well as detergents, fabric softeners, and other household products, but can cause allergies when skin is exposed to the fragrances.

SCCS states in "Opinion on Fragrance allergens in cosmetic products (SCCS/1459/11)[3]" that contact allergy to fragrances is relatively common. Since allergic contact dermatitis can be severe and widespread and can significantly impair quality of life and affect work fitness, fragrance allergens must be used in appropriate quantities for public health risk management measures.

In the above document, SCCS states that a maximum exposure of 0.8 µg/cm^2 (0.01 % for cosmetics) at typical levels would be acceptable for most consumers, including those with contact allergies to fragrance allergens. Following the recommendations from SCCS, the EU Commission has issued the EU Cosmetics Directive's Draft Amendment (G/TBT/N/EU/924)[4] to the EU Cosmetics Directive in September 2022. This draft is expected to be adopted in the first half of 2023.

Regulations on fragrance allergens are not limited to Europe. In the United States, the Modernization and Regulation of Cosmetics Act (MoCRA)[5] was adopted in December 2022, which will require the labeling of fragrance allergens. Consumers are increasingly demanding safety and security in cosmetics, and quantitative analysis of fragrance allergens is becoming increasingly important.

Table 1 Analytical Conditions

System				
GCMS Model:	GCMS-QP2020 NX			
Autoinjector:	AOC-30i			
Column 1:	SH-I-17 (30 m × 0.25 mm I.D. 0.25 µm)			
Column 2:	SH-1 (30 m × 0.25 mm I.D. 0.25 µm)			
GC Conditions		**MS Conditions**		
Injection Mode:	Split		Ion Source Temp.:	200 °C
Injection Volume:	1 µL		Interface Temp.:	280 °C
Injector Temp.:	280 °C		Emission Current:	20 µA
Split Ratio:	10		Data Acquisition Mode:	SIM
Carrier Gas:	He		Event Time:	0.3 sec
Carrier Gas Control:	Linear velocity (40 cm/s)			
Column 1 (SH-I-17): Temp. Program:	80 °C (1 min)_10 °C/min_135 °C (2 min) _3 °C/min_170 °C (1 min) _10 °C/min_280 °C (2 min)			
Column 2 (SH-1): Temp. Program:	80 °C (4 min)_15 °C/min_105 °C (2 min) _4 °C/min_150 °C_10 °C/min_280 °C (2 min)			

■ System and Analytical Conditions

The twin line MS system of GCMS-QP2020 NX, a single quadrupole mass spectrometer, was used for the analysis, and AOC-30i was used for the autoinjector.

Standards were a 57-fragrance allergen mixture diluted in MtBE to concentrations 0.5 – 50 mg/kg. 1,4-dibromobenzene and 4,4'-dibromobiphenyl were used as internal standards, each adjusted to 50 mg/kg. Commercial hair oil was used for the unknown sample, 1 g of hair oil was diluted in a measuring cylinder to 10 mL with MtBE in order to arrange the matrix. In order to confirm the detection of each compound, a sample was analyzed with a standard added so that the concentration of the target compound was 1 mg/kg at this time. The analytical conditions are shown in Table 1.

■ Twin Line MS System

The twin line MS system performs analysis with two different columns simultaneously connected to the MS. Since two columns are connected to the MS at the same time, it is possible to switch between the two columns and perform analysis with different columns without stopping the MS.

When analyzing samples with complex matrices such as cosmetics, it is effective to use two columns with different polarities. If one column cannot separate contaminants, the use of the other column with a different polarity increases the possibility of effective separation of the target compound. In this Application News, analysis was performed using SH-I-17, a medium-polarity column, and SH-1, a non-polarity column.

■ Separations by Scan Analysis

Fig. 2 shows TIC chromatograms of the 57 fragrance allergens standard for each column. Since SH-I-17 is a medium-polar column and SH-1 is a non-polar column, Figure 2 shows that the separation patterns of the two columns are different. The SH-I-17 column was able to separate all targets, including isomers, while only two isomeric peaks of galaxolide were detected on SH-1, overlapping each other.

■ Calibration Curves

Following the scan measurement, a calibration curve at 0.5 to 50 mg/kg was generated by SIM measurement. The SIM ions are shown in Table 2.

The R^2 values of the calibration curves for each compound are shown in Table 2. 54 of the 57 compounds had R^2 values greater than 0.999, indicating very good linearity. The other three compounds also showed sufficient linearity for quantification at 0.997 or higher. In addition to these three compounds (farnesol, benzyl salicylate, and sclareol), calibration curves for α-pinene, DMBC acetate, and benzyl cinnamate are shown in Fig. 3 as common examples.

■ Repeatability

The area repeatability of six consecutive analyses at the minimum concentration (0.5 mg/kg) of the calibration curve was checked. The area % RSD for each compound is shown in Table 2.

The area RSD of 97 % of the compounds on the SH-I-17 column was better than 5 %, and the area RSD of 88 % of the peaks on the SH-1 column was also better than 5 %. Both columns gave good results with area %RSDs of less than 10 % for all compounds.

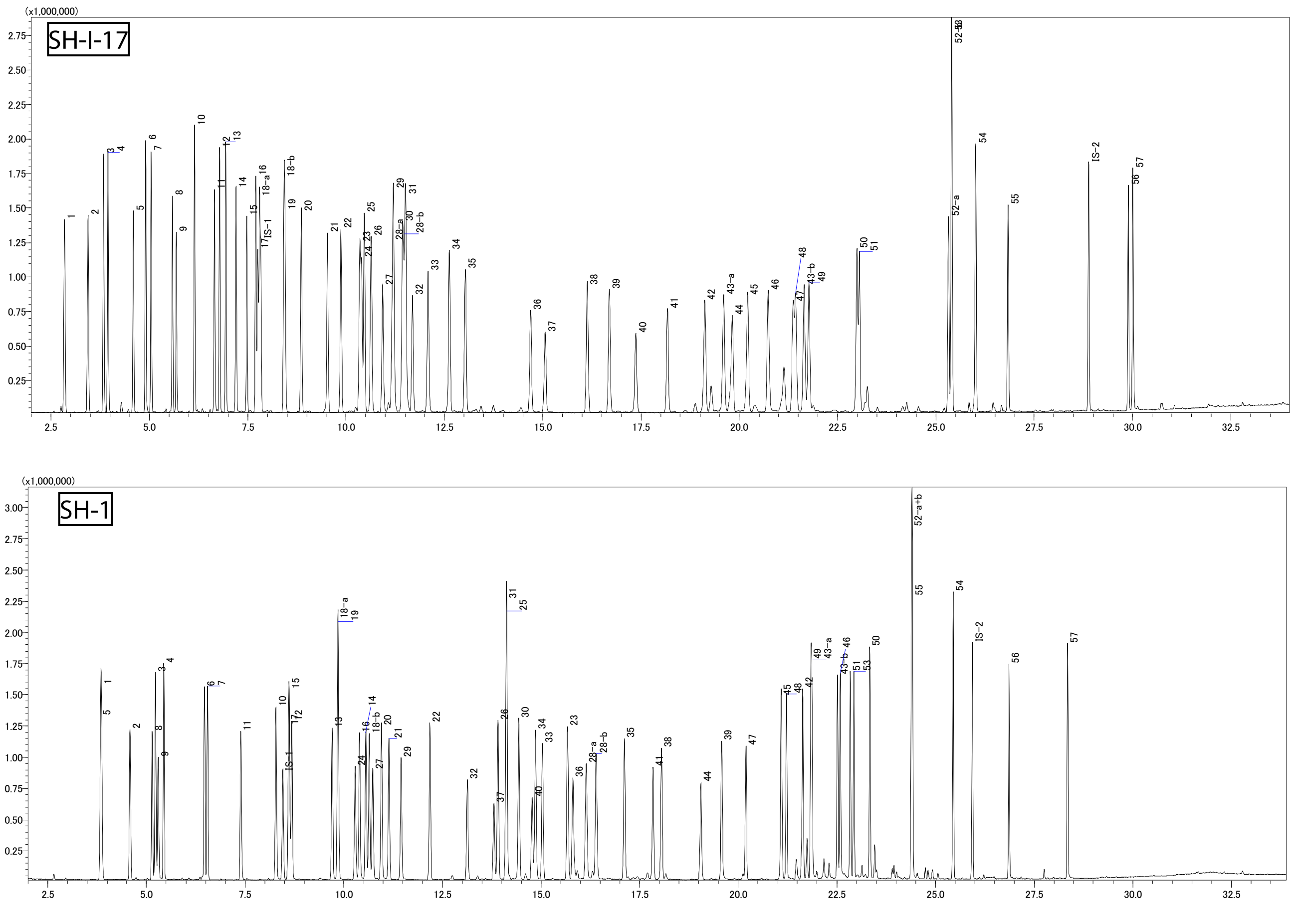

Fig. 2 TIC Chromatograms of 57 Fragrance Allergen Standards (50 mg/kg)

Table 2 List of Allergens with SIM Ions, R^2 and RSD%.

ID	Compounds	SIM ions			R^2		%RSD	
		1	2	3	SH-I-17	SH-1	SH-I-17	SH-1
1	α-Pinene	93.1	121.1	136.1	0.99995	0.99998	0.9	3.1
2	β-Pinene	121.1	93.1	91.1	0.99997	0.99997	2.2	3.5
3	α-Terpinene	121.1	136.1	93.1	0.99995	0.99993	1.3	3.9
4	Limonene	68.0	67.0	94.1	0.99999	0.99998	1.2	3.1
5	Benzaldehyde	106.0	77.0	105.1	0.99996	0.99998	1.1	3.5
6	Terpinolene	93.1	136.1	121.1	0.99999	0.99998	1.3	3.4
7	Linalool	93.1	71.1	121.1	1.00000	0.99990	1.3	3.7
8	Benzyl alcohol	108.1	79.1	107.1	0.99996	0.99972	1.0	4.6
9	Salicylaldehyde	122.0	121.0	93.0	0.99957	0.99955	1.0	3.7
10	Menthol	95.1	123.1	138.1	0.99999	0.99996	2.4	3.4
11	Camphor	108.1	95.1	152.1	1.00000	0.99995	1.3	3.2
12	α-Terpineol	136.1	121.1	59.0	1.00000	0.99995	0.9	3.8
13	Citronellol	82.1	81.1	95.1	0.99990	0.99907	1.8	3.6
14	Linalyl acetate	121.1	93.1	80.1	0.99996	0.99993	1.0	3.4
15	Methyl 2-octynoate	123.1	95.1	67.0	0.99992	0.99987	1.6	4.9
16	Geraniol	69.1	123.1	41.0	0.99972	0.99909	1.4	5.0
17	Methyl salicylate	120.0	152.0	65.0	0.99990	0.99983	1.3	4.1
18-a	Neral	69.0	109.1	94.1	0.99997	0.99983	1.5	4.3
18-b	Geranial	69.1	84.1	137.1	0.99991	0.99978	1.8	3.1
19	Carvone	108.1	82.1	93.1	0.99998	0.99994	2.1	4.6
20	Hydroxycitronellal	96.1	81.1	95.1	0.99998	0.99992	3.0	7.2
21	trans-Anethole	148.1	121.1	133.1	0.99999	0.99999	1.3	3.2
22	Dimethylbenzylcarbinyl acetate	132.1	117.1	91.1	0.99995	0.99998	1.0	3.2
23	β-Caryophyllene	189.2	161.1	147.1	0.99999	0.99995	2.5	4.0
24	Cinnamaldehyde	131.1	132.1	103.1	0.99997	0.99968	1.4	3.6
25	Geranyl acetate	80.1	84.1	136.1	0.99999	0.99958	2.8	4.2
26	δ-Damascone	69.0	123.1	192.1	0.99996	0.99969	1.6	3.6
27	Anise alcohol	138.1	137.1	109.1	0.99995	0.99957	1.2	5.0
28-a	Ebanol 1	149.1	164.2	83.1	0.99996	0.99971	2.6	5.0
28-b	Ebanol 2	149.1	164.2	83.1	0.99998	0.99982	2.5	5.4
29	Cinnamyl alcohol	92.1	134.1	115.1	0.99972	0.99962	6.4	4.6
30	α-Damascone	192.1	123.1	177.1	0.99999	0.99988	2.1	4.1
31	β-Damascenone	190.1	175.1	105.1	0.99997	0.99985	2.5	5.3
32	Eugenol	164.1	149.0	131.1	0.99997	0.99949	1.6	4.0
33	β-Damascone (E)	177.1	192.1	135.1	0.99999	0.99990	1.6	3.8
34	Trimethyl-benzenepropanol	106.1	91.0	105.1	0.99999	0.99975	1.3	4.1
35	α-Isomethylionone	150.1	135.1	107.1	0.99999	0.99981	1.0	3.8
36	Isoeugenol	164.1	149.1	133.1	0.99987	0.99965	1.2	3.6
37	Vanillin	151.0	152.0	109.0	0.99930	0.99917	1.0	3.5
38	Butylphenyl methylpropional	204.1	189.1	147.1	0.99970	0.99982	1.5	2.9
39	Amyl salicylate	120.0	138.0	208.1	0.99934	0.99944	0.9	4.0
40	Coumarin	146.0	118.0	90.0	0.99994	0.99997	1.2	3.3
41	Eugenyl acetate	164.1	149.0	206.1	0.99961	0.99975	0.9	3.4
42	β-Tetramethylacetyloctahydronaphthalene	191.1	121.0	109.1	0.99982	0.99998	1.3	2.4
43-a	α-Santalol	94.1	93.1	122.1	0.99911	0.99973	1.6	5.0
43-b	β-Santalol	94.1	93.1	122.1	0.99980	0.99906	1.7	3.6
44	3-Propylidene phthalide	159.1	174.1	104.0	0.99990	0.99980	1.4	2.9
45	α-Amyl cinnamaldehyde	202.1	201.1	173.1	0.99939	0.99925	2.3	3.6
46	trans,trans-Farnesol	109.1	81.1	69.1	0.99621	0.99719	8.1	4.4
47	Isoeugenyl acetate	164.1	149.1	131.1	0.99989	0.99981	1.1	3.1
48	Hydroxyisohexyl 3-cyclohexene carboxaldehyde (major)	136.1	108.1	192.0	0.99972	0.99959	2.2	4.9
49	α-Amylcinnamyl alcohol	148.1	133.1	115.0	0.99957	0.99905	1.8	4.6
50	α-Acetyl cedrene	246.2	161.1	231.2	0.99975	0.99991	0.9	3.6
51	α-Hexylcinnamaldehyde	216.1	129.1	145.1	0.99952	0.99965	2.0	4.5
52-a	Galaxolide 1	213.2	258.2	244.2	0.99976	0.99995	1.3	2.8
52-b	Galaxolide 2	213.2	258.2	244.2	0.99995		1.0	
53	Benzyl benzoate	212.1	105.0	194.0	0.99995	0.99997	1.6	3.5
54	Hexadecanolactone	83.1	97.1	111.1	0.99992	0.99992	0.4	2.7
55	Benzyl salicylate	228.1	92.0	65.0	0.99899	0.99959	1.1	3.0
56	Benzyl cinnamate	192.1	193.1	238.1	0.99933	0.99916	1.1	2.9
57	Sclareol	109.1	177.1	257.2	0.99736	0.99669	1.9	5.2

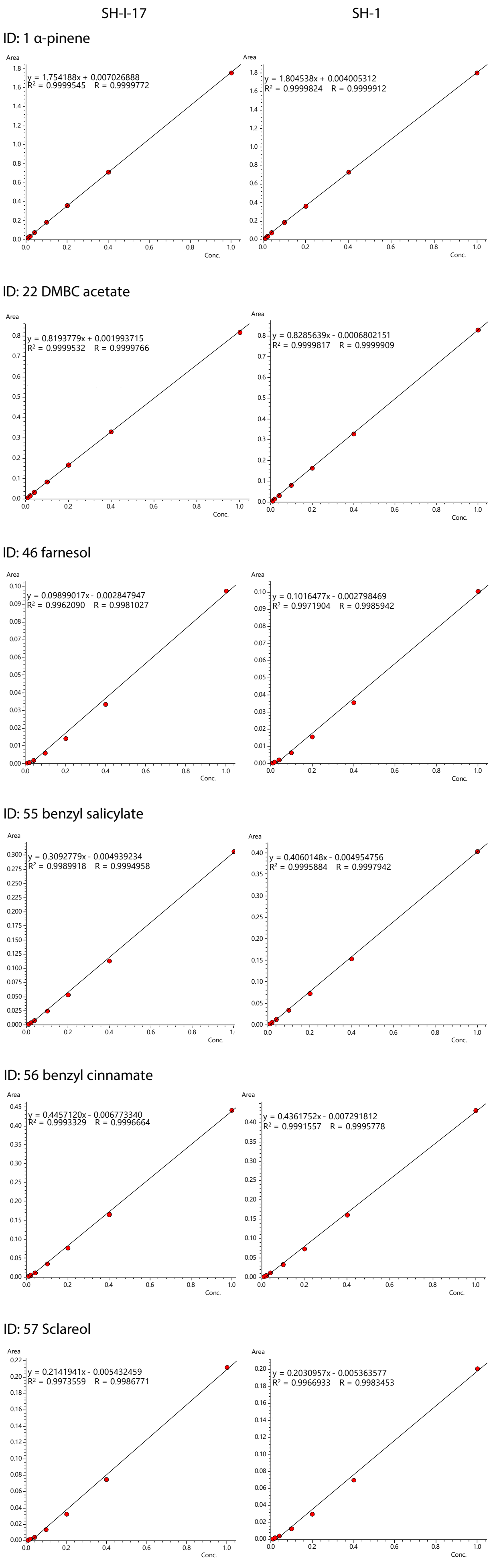

Fig. 3 Calibration curves for 0.5 to 50 mg/kg

■ Quantification of Hair Oil

This is an example of analyzing hair oil as an unknown sample. For a sample with a complex matrix such as hair oil, it is sometimes difficult to quantitate accurately with high selectivity using a single column. In such cases, quantitative analysis can be performed more accurately by using two columns with different polarities.

Fig. 4 shows an example of mass chromatograms of hair oil and standards in each column. Fig. 4 shows that the separation of the target and contaminants in the unknown sample is different when two columns with different polarities are used. In the examples of amyl salicylate and methyl 2-octynoate, it was difficult to accurately detect the peaks of the target on one column due to the large amount of contaminants, while on the other column, the peaks of the target were accurately detected. On the other hand, although neral and citronellol peaks were detected accurately on both columns at first glance, a comparison of the quantification results shows that the concentrations were calculated differently on both columns. This may be due to the fact that the peak of a contaminant overlaps the peak of the target in the column with the larger quantitation value, and in such cases, the result of the column with the smaller quantitation value can be considered the more accurate quantitation result.

Thus, by using the twin line MS system, it is possible to efficiently analyze fragrance allergens in cosmetics with sufficient sensitivity.

■ Conclusion

This Application News shows an example of quantitative analysis of 57 fragrance allergens by GCMS-QP2020NX. Analysis was performed by the twin line MS system with two types of columns, SH-I-17 and SH-1, connected simultaneously. As a result, it was confirmed that more than 90 % of the compounds showed high linearity with R^2 values of 0.999 or higher over a wide range of 0.5 to 50 mg/kg. In addition, repeatability was good with an RSD of less than 10 % for all compounds.

As a result of analyzing hair oil as an unknown sample, it was confirmed that analysis using two columns with different polarities effectively separates contaminants and enables more accurate quantification.

The twin line MS system allows two columns to be connected to the MS simultaneously, and by using this system, users can switch between columns for analysis without stopping the MS. The twin line MS system supports efficient and accurate analysis of fragrance allergens in cosmetics.

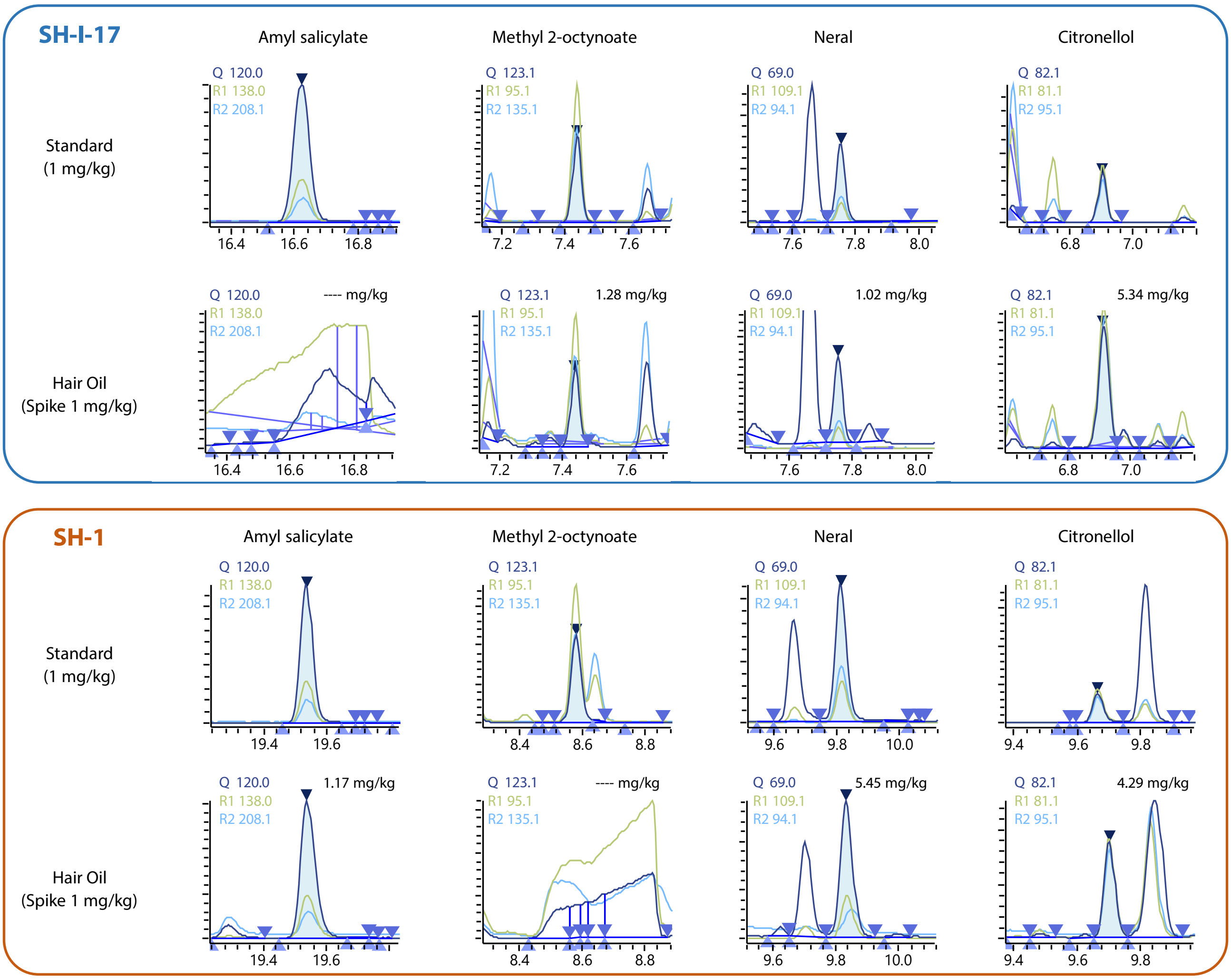

Fig. 4 Mass Chromatograms of Fragrance Allergens in Hair Oil

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01-00526-EN First Edition: Apr. 2023

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