# GC-TOFMS for Fast Targeted Allergen Screening and Non-Targeted Characterization for Personal Care Products

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## Introduction

Contact allergens can be a problem in perfumes and other personal care products as some people have sensitivities to some of the fragrance compounds. Various regulations require allergen compounds to be listed on packaging materials when present above certain levels (for example, 10 ppm for a leave-on product, according to the European Cosmetics Directive). Pairing GC with TOFMS is an excellent choice for measuring many of these analytes, and a rapid screening method using LECO's Pegasus® BT is demonstrated here. Calibration data for regulated analytes were determined and applied to eight different perfume samples. In addition to facilitating this targeted analysis, non-targeted characterization was also accomplished using the same full range m/z acquired data, with deconvolution providing key benefits.

## Methods

A set of calibration standards was prepared from a fragrance allergen standard (Restek, Bellefonte, PA) at concentrations of 100 ppb to 100 ppm. The standards were subsequently analyzed with a 100:1 split (resulting in an effective concentration range of 1 ppb to 1 ppm). Eight perfume samples were diluted 10x prior to analysis to fit within the calibration range. All standards and samples were analyzed with the instrument conditions listed in Table 1.

***Table 1. GC-TOFMS Instrument Conditions***

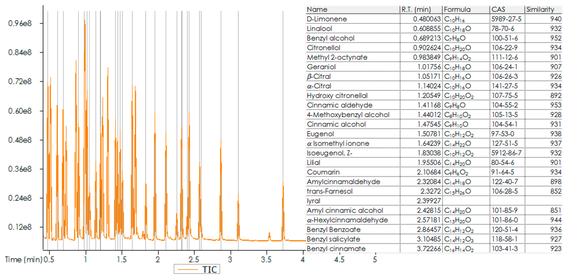
| Gas Chromatograph | Agilent 7890 with LECO L-PAL3 Autosampler |
|---|---|
| Injection | 1 $\mu$L split 100:1 with inlet @ 250°C |
| Carrier Gas | He @ 1.0 ml/min, Constant Flow |
| Column | Rxi-17Sil MS, 9.4 m x 0.18 mm i.d. x 0.18 $\mu$m coating (Restek) |
| Oven Program | 0.1 min at 100°C ramped 40°C/min to 300°C |
| Transfer Line | 300°C |
| Mass Spectrometer | LECO Pegasus BT |
| Ion Source Temperature | 250°C |
| Mass Range | 35-650 m/z |
| Acquisition Rate | 20 spectra/s |

## 5 Minute Separation of Standard

Many suggested methods for allergen screening are 20-50 minutes. Here, a rapid GC-TOFMS method was developed to separate and detect a target set of contact allergens in approximately 5 minutes. To achieve this separation in such a short time, this method utilized:

- A short and narrow column (9.4 m x 0.18 mm i.d.)
- A fast temperature program (40°C/min)
- ChromaTOF's automated deconvolution

Peak finding located and identified all of the target analytes, indicated with vertical line peak markers in Figure 1, with an average similarity of 920.




| Name | R.T. (min) | Formula | CAS | Similarity |
|---|---|---|---|---|
| D-Limonene | 0.480063 | $C_{10}H_{16}$ | 5989-27-5 | 940 |
| Linalool | 0.608855 | $C_{10}H_{18}O$ | 78-70-6 | 932 |
| Benzyl alcohol | 0.689215 | $C_7H_8O$ | 100-51-6 | 952 |
| Citronellol | 0.902624 | $C_{10}H_{20}O$ | 106-22-9 | 934 |
| Methyl 2-octynate | 0.983849 | $C_9H_{14}O_2$ | 111-12-6 | 901 |
| Geraniol | 1.01756 | $C_{10}H_{18}O$ | 106-24-1 | 907 |
| β-Citral | 1.05171 | $C_{10}H_{16}O$ | 106-26-3 | 926 |
| α-Citral | 1.14024 | $C_{10}H_{16}O$ | 141-27-5 | 934 |
| Hydroxy citronellal | 1.20549 | $C_{10}H_{20}O_2$ | 107-75-5 | 892 |
| Cinnamic aldehyde | 1.41148 | $C_9H_8O$ | 104-55-2 | 953 |
| 4-Methoxybenzyl alcohol | 1.44012 | $C_8H_{10}O_2$ | 105-13-5 | 928 |
| Cinnamic alcohol | 1.47545 | $C_9H_{10}O$ | 104-54-1 | 931 |
| Eugenol | 1.50781 | $C_{10}H_{12}O_2$ | 97-53-0 | 938 |
| α Isomethyl ionone | 1.64239 | $C_{14}H_{22}O$ | 127-51-5 | 937 |
| Isoeugenol, Z- | 1.83038 | $C_{10}H_{12}O_2$ | 5912-86-7 | 932 |
| Lilial | 1.95506 | $C_{14}H_{22}O$ | 80-54-6 | 901 |
| Coumarin | 2.10684 | $C_9H_6O_2$ | 91-64-5 | 934 |
| Amylcinnamaldehyde | 2.32084 | $C_{14}H_{18}O$ | 122-40-7 | 898 |
| trans-Farnesol | 2.3272 | $C_{15}H_{26}O$ | 106-28-5 | 852 |
| lyral | 2.39927 | | | |
| Amyl cinnamic alcohol | 2.42815 | $C_{14}H_{20}O$ | 101-85-9 | 851 |
| α-Hexylcinnamaldehyde | 2.57181 | $C_{15}H_{20}O$ | 101-86-0 | 944 |
| Benzyl Benzoate | 2.86457 | $C_{14}H_{12}O_2$ | 120-51-4 | 936 |
| Benzyl salicylate | 3.10485 | $C_{14}H_{12}O_3$ | 118-58-1 | 927 |
| Benzyl cinnamate | 3.72266 | $C_{16}H_{14}O_2$ | 103-41-3 | 923 |

***Figure 1. GC-TOFMS data were collected for an allergen standard, containing 25 regulated analytes. The entire separation occurs in less than 5 minutes. Allergens are indicated in the standard with vertical line peak markers. Peak metric information is provided in the associated table.***

## Deconvolution

Most of the target allergens are chromatographically separated, but some coelutions can still occur. In Figure 2, one of the target analytes (geraniol) coelutes with an internal standard. Deconvolution determined accurate information for each analyte. Coelutions with matrix compounds are also common, further highlighting the need for deconvolution.

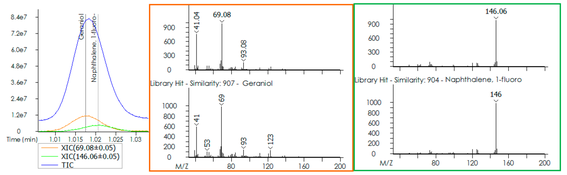



***Figure 2. Deconvolution, automated as part of the data processing, effectively separates one of the target analytes from an added internal standard. XICs show chromatographic profiles for each and MS data are used for identification via library similarity.***

## Calibration

A set of calibration standards from 100 ppb to 100 ppm were prepared and subsequently analyzed (with a 100:1 split) by GC-TOFMS. Calibration equations were calculated for each allergen standard with an average r value above 0.999 across all targets. Calibration information for a collection of representative analytes is shown in Figure 3.

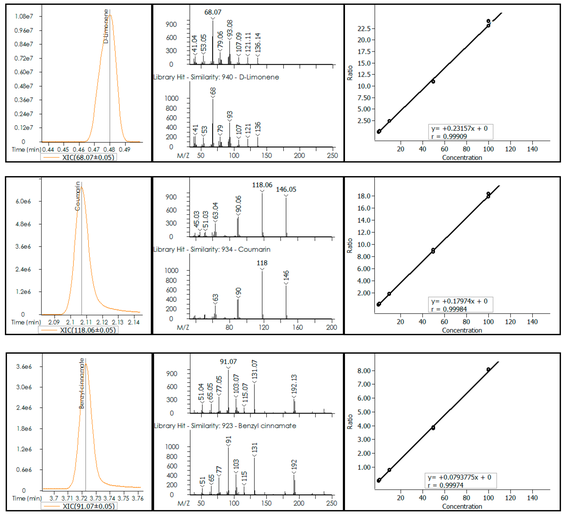
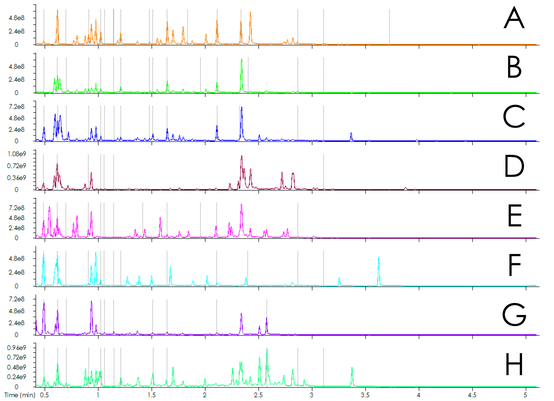



***Figure 3. The peak profile, mass spectral information, and calibration data for three targets are compiled as representative examples. The calibration range extends below the required reporting threshold (10 ppm) accommodating dilutions, if needed. Calibration equations for all analytes were determined with automated data processing with an average r value of 0.9991±0.00098.***

## Results

The calibrations were applied to eight commercially-available perfume and cologne samples, and quantitative information for the targeted allergens was determined. Figure 4 shows TIC chromatograms for each sample with vertical line peak markers indicating allergens observed above the reporting threshold (10 ppm).




| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| D-Limonene | 362 | 37 | 1591 | 1156 | 3529 | 3938 | 5066 | 2047 |
| Linalool | 4170 | 2094 | 2818 | 7206 | 5273 | 4407 | 4593 | 6689 |
| Benzyl alcohol | 40 | 153 | 257 | | 14 | 71 | 27 | 918 |
| Citronellol | 1088 | 476 | 348 | 160 | 2020 | 363 | | 2229 |
| Methyl 2-octynate | | | | | | | | |
| Geraniol | 1664 | 576 | 677 | 84 | 328 | 987 | 171 | 4272 |
| β-Citral | 79 | | 52 | 56 | 227 | 254 | 997 | 45 |
| α-Citral | 40 | 14 | 30 | 55 | 163 | 192 | 905 | 50 |
| Hydroxycitronellal | 1567 | 910 | 591 | | | 32 | | 2805 |
| Cinnamic aldehyde | | | | | 15 | | | |
| 4-Methoxybenzyl alcohol | | | | | | | | |
| Cinnamic alcohol | 313 | 255 | 384 | | | | | |
| Eugenol | 116 | 104 | 1555 | | | | 556 | 5355 |
| à Isomethyl ionone | 2103 | 1157 | 1314 | | 487 | 69 | 340 | 190 |
| Isoeugenol | 19 | | | | | | | |
| Lilial | | 75 | | | 262 | | | |
| Coumarin | 3338 | 1413 | 2146 | | 231 | 470 | 399 | |
| Amylcinnamaldehyde | | | 231 | | | | | |
| trans-Farnesol | 1045 | | | | | | | |
| lyral | | 28 | | | | 64 | | |
| Amyl cinnamic alcohol | | | | | | | | |
| à-Hexylcinnamaldehyde | | | | | | | 4299 | 21621 |
| Benzyl Benzoate | 335 | 255 | 49 | | 40 | 93 | | 146 |
| Benzyl salicylate | 121 | 54 | 221 | 16 | | 28 | | 65 |
| Benzyl cinnamate | 37 | | | | | | | |

***Figure 4. The calibration equations were applied to eight perfume samples using automated data processing. Vertical line peak markers are displayed and the concentrations are tabulated for any target allergen present above the 10 ppm reporting threshold (reported concentration values are in ppm and corrected for dilution). This method provides rapid screening for the regulated target allergens to quickly determine what analytes would need to be reported. When packaging labels were available, there was good agreement between the reported analytes and those observed here.***

## Non-target Characterization

In addition to the target allergens, these data also provide excellent unknown characterization information for non-targeted analytes from the same injection. These can be observed in Figure 4 as there are many peaks without peak markers. Several examples of non-targeted analytes present in the perfume samples are shown in Figure 5. In each of these cases, deconvolution was able to separate a non-target analyte that coelutes with one of the target analytes, and provide tentative identification for the non-target analyte. In Perfume A, the target analyte eugenol with spicy odor properties was mathematically separated from citronellyl butyrate with floral odor properties. In Perfume E, the target analyte coumarin with tonka odor properties was mathematically separated from cedrol with woody odor properties. And, in Perfume F, the target analyte citronellol with floral odor properties was mathematically separated from α-terpineol with piney odor properties. There are hundreds of additional analytes observed within these data that can provide a better understanding of the aroma properties of the perfumes.

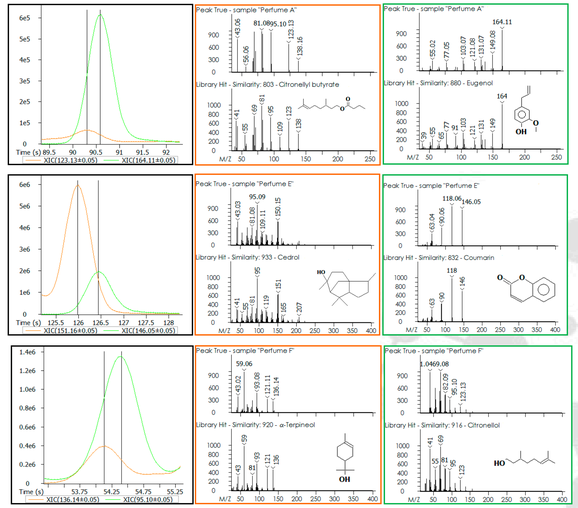
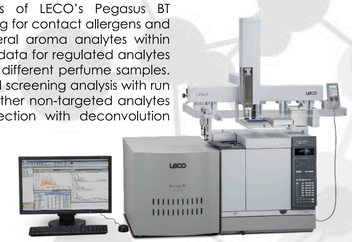



***Figure 5. Three examples of non-targeted characterization that were provided through automated data processing and deconvolution. In each case a non-target analyte from the matrix coelutes with one of the target allergen standards. Deconvolution provides information on the target analyte free from the interference, and also provides information on the non-target analyte that aids in general characterization and better understanding of the samples.***

## Conclusion

This study demonstrates the benefits of LECO's Pegasus BT GC-TOFMS to provide targeted screening for contact allergens and non-targeted characterization of general aroma analytes within complex perfume samples. Calibration data for regulated analytes were determined and applied to eight different perfume samples. The GC-TOFMS method provides a rapid screening analysis with run times of roughly 5 minutes. Numerous other non-targeted analytes were also observed in the same injection with deconvolution providing key benefits.



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