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Application of β-cyclodextrin and pickering emulsion to enhance the ozone stability of *Acorus tatarinowii* and *Atractylodes lancea* volatile oils

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This study aimed to evaluate the stability and quality enhancement of *Acorus tatarinowii* and *Atractylodes lancea* volatile oils (ATaAL-VO) and their β-cyclodextrin encapsulated and Pickering emulsion forms under ozone exposure. Under an ozone environment, ATaAL-VO were subjected to three treatments: raw oil, β-cyclodextrin encapsulated oil, and pickering emulsion. Peroxide values were quantified. GC-MS was employed to identify compositional variances, while t-tests were used to identify compounds with significant quantitative differences. PCA charts were generated using OmicShare, and line diagrams were created with Rmisc and reshape2. OmicShare was also utilized to construct Upset diagrams for filtering qualitative differential compounds, and charts illustrating newly formed and disappeared qualitative differential compounds were composed. Principal compounds' box diagrams were crafted through reshape2 and ggplot2. The β-cyclodextrin and pickering emulsion groups exhibited lower oxidation levels compared to the original oil group after ozone exposure. The pickering emulsion and β-cyclodextrin encapsulation groups both demonstrated a marked improvement in the stability of the majority of volatile components. The stability and quality of ATaAL-VO can be markedly enhanced through β-cyclodextrin encapsulation or Pickering emulsion preparation, with the latter offering distinct advantages.

Keywords *Acorus tatarinowii* and *Atractylodes lancea* volatiles oil, β-cyclodextrin encapsulation, Pickering emulsion, GC-MS, Stability, Ozone

The main components of Acorus calamus include α-asarone, γ-asarone, methyl eugenol, linalool, trans-methyl isoeugenol, δ-cadinene, caryophyllene, and α-humulene[1,2]. It is traditionally believed to possess analgesic, antibacterial, anti-inflammatory, and digestive regulatory effects according to traditional herbal medicine theory[3,4]. *Atractylodes lancea* primarily contains volatile components, such as Atractylodin, β-eudesmol, and Atractylone[5,6]. It is considered to possess biological activities including antibacterial, anti-inflammatory, antioxidant, anticancer, and antiallergic properties[7,8]. *Acorus tatarinowii* and *Atractylodes lancea* volatile oils (ATaAL-VO) can be extracted and utilized as herbal ingredients in the preparation of herbal products, traditional Chinese medicine prescriptions, flavorings, food additives, and skincare products[9,10]. However, the ATaAL-VO are prone to oxidation, and long-term exposure to an ozone environment may lead to degradation and evaporation of their components[11].

Pickering emulsion is a new type of emulsion prepared by using ultrafine solid particles or solid colloidal particles instead of traditional surfactants as emulsifiers[12,13]. As a cutting-edge emulsification technology that employs solid particles as stabilizers, Pickering emulsion has emerged as a focal point across multiple research domains, including chemical engineering, materials science, and food science[14]. Encapsulating volatile oils in Pickering emulsion is an effective way to improve the stability of volatile oils[15]. It is simple to prepare, highly biocompatible, and stable. Furthermore, it can be further dehydrated, dried, and solidified, achieving solid

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powderization[16–18]. This has important value and significance for the subsequent processing and application of traditional Chinese medicine volatile oils[19,20]. β-cyclodextrin is a natural starch derivative with a cyclic structure and excellent inclusion ability[21]. β-cyclodextrin can encapsulate volatile oils within its cavity, forming stable inclusion complexes, thereby reducing the evaporation and oxidation of volatile oils, extending their stability and shelf life[22]. When complexed with β-cyclodextrin, the release of volatile oils can be controlled to achieve a slow-release effect and prolong their activity. β-cyclodextrin can also enhance the solubility of volatile oils in water or other solvents, thereby improving their uniformity and dissolution in formulations[23,24]. In summary, utilizing β-cyclodextrin to encapsulate volatile oils can enhance their stability, controlled release properties, solubility, and odor-masking advantages. This makes β-cyclodextrin an important carrier and excipient widely used in the fields of pharmaceuticals, food, and cosmetics[23–25].

Our research team has previously completed the preparation and characterization of β-cyclodextrin encapsulation and Pickering emulsions, with a focus on optimizing their preparation processes[26]. Building on this foundation, as shown in Fig. 1 this study further compares the stability and compositional changes of these systems in an ozone environment, aiming to enhance the stability and quality of ATaAL-VO.

Materials and methods

Materials and equipment

Acorus tatarinowii, (*Acori tatarinowii* Rhizoma) is *acorus* grassleaf sweetflag rhizome; *Atractylodes lancea* (*Atractylodis lanceae* Rhizoma) is the rhizome of the *Atractylodes* plant in the Asteraceae family. The volatile oils used in this study was purchased from Shaanxi Momentum Qixuehe Pharmaceutical Co., Ltd. and authenticated by Professor Yonggang Yan from Shaanxi University of Chinese Medicine as complying with the required standards.

The LS-F8 multifunctional negative ion oxygen detox machine (Xiamen Laisen Electronics Co., Ltd.), JY-3002 one ten-thousandth analysis balance (Shanghai Puchun Instrument Co., Ltd.), IKA T18 digital high - speed disperser (Shanghai Tusen Vision Technology Co., Ltd.), DHG – 9140 A electrically heated forced - air drying oven (Shanghai Hengkai Scientific Instrument Co., Ltd.), and DZTW electronically temperature - adjustable heating mantle (Beijing Yongguangming Medical Equipment Co., Ltd.) were used in the experiments. The Agilent 7890B/5977B gas chromatography-mass spectrometer (Agilent, USA) was applied.

Sodium thiosulfate (batch no. 20180806), sodium carbonate anhydrous (batch no. 20210506), soluble starch (batch no. 20180808), sodium chloride (batch no. 20210302), and chloroform (batch no. 20210203), were all purchased from Tianjin Tengli Chemical Reagent Co., Ltd. Potassium iodide (Tianjin Kemio chemical reagent Co., Ltd., batch no.20220422), n-Hexane (Grace Chemical Technology Co. LTD, Lot: 2112091), and n-Docosane (Grace Chemical Technology Co. LTD, Lot: G171809, purity: 99.6%) were used in the study. The ATaAL-VO was obtained from Shaanxi Momentum Qixuehe Pharmaceutical Co., Ltd. (batch no. S-230204).

The preparation of β-cyclodextrin encapsulation of ATaAL-VO, and pickering emulsion

The encapsulation of ATaAL-VO with β-cyclodextrin, as well as the Pickering emulsion preparation, were previously conducted by our previous study. The optimal encapsulation process of ATaAL-VO was determined as follows: a grinding duration of 33 min, a ratio of β-cyclodextrin to volatile oil of 6.3:1, and a water to β-cyclodextrin ratio of 2.6:1. The most optimal method for the preparation of the Pickering emulsion included the usage of PEG4000, a PEG4000 to natural indigo ratio of 5:1, a melting temperature of 228 °C, a melting duration of 5 min, an oil to water ratio of 13:7, an addition of 0.5 g of modified natural indigo, a stirring speed of 10,000 rpm, and a stirring duration of 2 min[26].

Preparation of modified particles: PEG4000 and finely milled Indigo Naturalis were weighed separately, PEG4000 was placed in an electric heating jacket to melt it, and then indigo was immediately added to dry and crush for later use[27].

Preparation of Pickering emulsion: the modified indigo was weighed and it was combined with ATaAL-VO and water in the centrifuge tube. Then the mixture was put into a high-speed shear machine for operation, culminating in the formation of a modified Indigo Naturalis Pickering emulsion.

Preparation of β-cyclodextrin encapsulation of ATaAL-VO: β-cyclodextrin was weighed meticulously and introduced into a ball mil. Next volume of purified water, equating to 1.5 times its original volume (108 mL) was added in β-cyclodextrin, resulting in a β-cyclodextrin slush.

After slush formation, a diluted solution made by mixing equal volumes of volatile oil and ethanol (12 mL in total) was gradually added and carefully mixed into the ball mill. Then it filtered under vacuum, followed by three washing schemes. The resulting product was dried and finally roughly absorbed into a 40 mesh product for collection. Based on the above conditions, the process of β-cyclodextrin inclusion of ATaAL-VO and Pickering emulsion was optimized.

Collection of volatile oils under ozone exposure and determination of peroxide contents

Crude oil (a mixture of ATaAL-VO extractions) and Pickering emulsion were each placed in 25 mL open colorimetric tubes, while β-cyclodextrin encapsulated ATaAL-VO was placed in a 250 mL conical flask. Ozone at a concentration of 4.28 ppm was continuously introduced into the colorimetric tubes and the conical flask for 10, 15, and 20 min.The mixed extraction of ATaAL-VO from the crude oil group was then retrieved and set aside. The β-cyclodextrin encapsulation group and the Pickering emulsion group were subjected to steam distillation to extract the ATaAL-VO within, distilled for 5 h, the oil phase was separated and set aside for future use. These procedures were performed in triplicate.

Accurately pipette 500 µL of the volatile oil sample into a 10 mL conical flask containing 10 mL of a chloroform/acetic acid mixture (4:6, v/v). Then, 1mL of saturated potassium iodide solution was added, the flask was tightly sealed, shaken for 0.5 min, and left in a dark place for 3 min. The flask was then taken out and 3 mL of water was

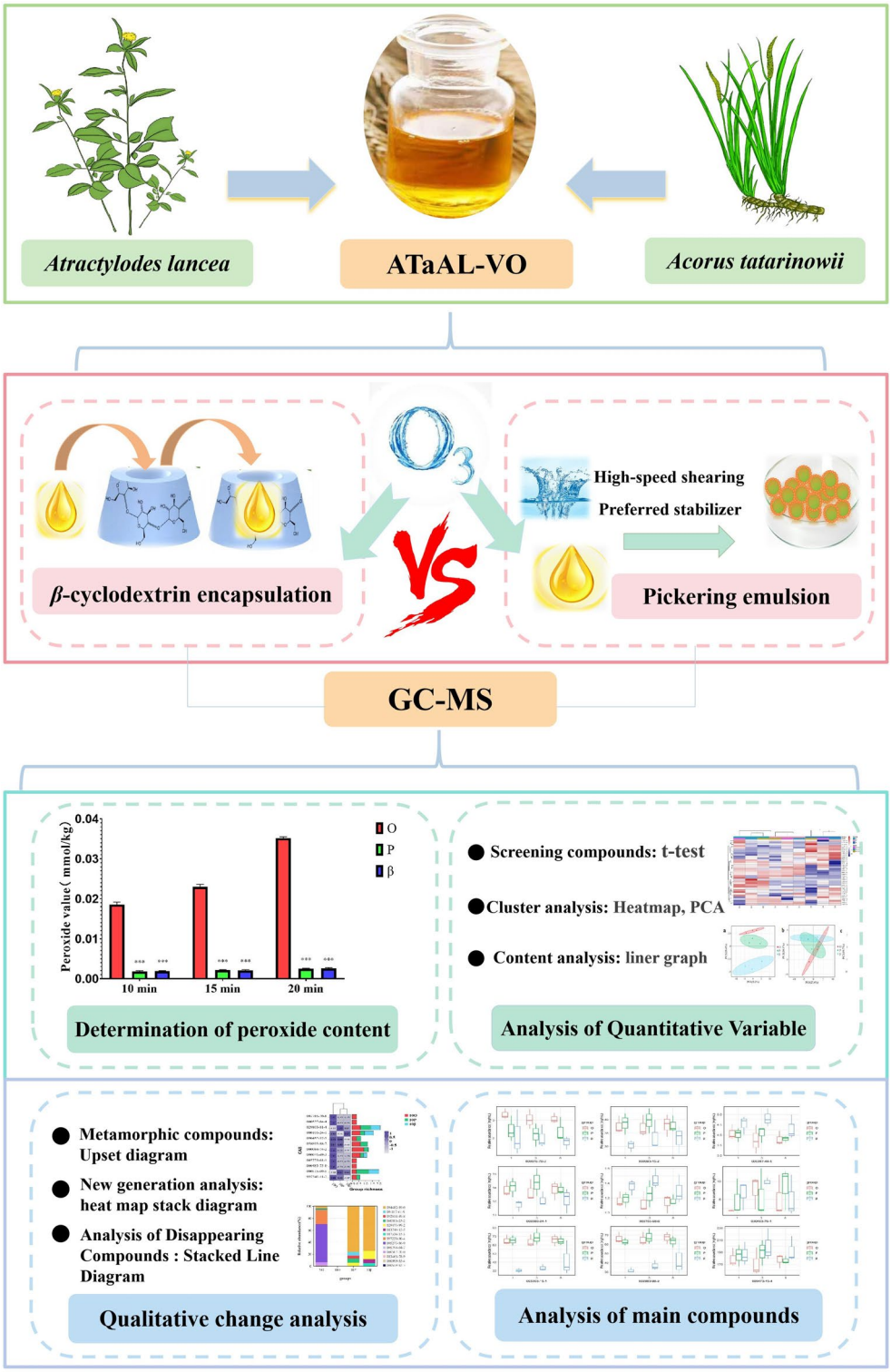

Fig. 1. Based on *β*-cyclodextrin inclusion and pickering emulsion technology, the research strategy diagram of improving the stability of volatile oil of *Acorus tatarinowii Schott* and *Atractylodes lancea* was proposed.

added, followed by the addition of 1.00 mL of 1% starch indicator. The solution was titrated with 0.00001 mol/L sodium thiosulfate standard solution until the blue color disappeared, and the volume of sodium thiosulfate standard solution consumed was recorded. The peroxide value was calculated based on these measurements[28].

Determination of volatile oil components in ozone environment by GC-MS

Preparation of internal standard solution

Precise weighing of 50.50 mg of the n-docosane standard substance was performed, and it was then placed into a 5 mL vial. n-Hexane was added to the calibration line, followed by thorough shaking to obtain a concentrated n-docosane internal standard solution with a concentration of 10 mg/mL.

Preparation of the test sample solution

Accurately transfer 100 µL of volatile oil samples from each group into 10 mL vials. Add 100 µL of n-docosane internal standard solution, then bring the volume to the calibration line with n-hexane. Add an appropriate amount of anhydrous sodium sulfate to remove moisture. The mixture was shaken thoroughly and filtered through a 0.22 µm organic filter membrane to obtain the test solution of volatile oils from different groups[26].

Analytical conditions for GC-MS

The test samples were prepared using liquid injection method, and the influence of different GC and MS conditions on the chromatographic information of the samples was investigated. Using chromatographic information abundance as the evaluation index, the optimal conditions for maximizing component information acquisition were determined as follows: Employ an HP-5 MS quartz capillary column (30 m × 0.25 mm × 0.25 µm), with helium gas (purity 99.999%) serving as the carrier gas at a flow rate of 1 mL/min. A 1 µL sample was injected with a split ratio of 10:1. The injector temperature was 230 ℃. The column temperature started at 50 ℃, rose at 15 ℃/min to 140 ℃, then at 0.4 ℃/min to 144 ℃ with a 5 min hold. It then increased at 10 ℃/min to 250 ℃ with a 2 - min hold, and finally at 4 ℃/min to 280 ℃ with a 2 - min hold. Electron ionization (EI) mode with 70 eV electron energy was used. The ion source temperature was maintained at 230 °C, and the quadrupole temperature was kept at 150 °C. The mass scan range was set from 35 to 500 m/z, with a solvent delay of 3 min. After the acquisition of GC-MS data, the Agilent database analysis software Data Analysis was used to access the NIST14.0 database and summarize the components using n-alkanes as references[27].

Volatile oil quantitative change difference compounds in ozone environment

Selection of volatile oil quantitative change difference compounds in ozone environment

A t-test was conducted to screen for differential components under this environment. We compared the crude oil group with the groups exposed to ozone for 10, 15, and 20 min. We performed a t-test on the concentration data of each component to check for significant differences between groups. The pheatmap package was used to generate heatmap plots of the 37 differential components[28]. The PCA plots of the 37 differential components in the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group were generated using the OmicShare online platform (https://www.omicshare.com/tools).

Analysis of volatile oil quantitative change difference compounds in ozone environment

Line plots of the 37 quantitative variable differential components were generated using the Rmisc and reshape2 packages[29,30].

Volatile oil qualitative change difference compounds in ozone environment

Selection of volatile oil qualitative change differential compounds in ozone environment

The Upset diagram of the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group under ozone exposure was generated using the OmicShare online platform. The horizontal bars on the left denote the compound count for each set. The individual points in the matrix below the graph indicate compounds unique to a specific set, while the connecting lines between points represent intersections among statistically associated sets. The vertical bars above represent the number of compounds that are unique or intersectional in the statistical analysis[15,31].

Analysis of newly generated qualitative change differential compounds in volatile oil under ozone environment

The heatmap stack plot of newly generated compounds under ozone exposure in the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group was generated using the OmicShare online platform. The horizontal axis of the heatmap represents the samples and groups, while the vertical axis represents the compounds. Each square in the heatmap represents the abundance of a compound in a sample, indicated by the color. In the stack plot, the horizontal axis denotes the abundance of compound groups, while the vertical axis indicates the compounds. Each bar's color distinguishes different groups, and its height reflects the compound's abundance within each group.

Analysis of disappear qualitative change differential compounds in volatile oil under ozone environment

The stack plot of disappearance compounds under ozone exposure in the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group was created using the OmicShare online platform.

Analysis of the main components of volatile oil in ozone environment

The main components of Acorus calamus include α-asarone (CAS number: 002883-98-9), γ-asarone (CAS number: 005353-15-1), methyl eugenol (CAS number: 000093-15-2), linalool (CAS number: 000078-70-6), trans-methyl isoeugenol (CAS number: 006380-24-1), δ-cadinene (CAS number: 000483-76-1), caryophyllene

(CAS number: 000087-44-5), α-humulene (CAS number: 006753-98-6), and others. The main component of Curcuma zedoaria is β-eudesmol (CAS number: 000473-15-4). The Rmisc, reshape2, and ggplot2 packages were used to plot the boxplots of the main component compounds in the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group in ozone environment[29,30,32].

Results

Collection of volatile oils under ozone exposure and determination of peroxide contents

As shown in Fig. 2, following 10, 15, and 20 min of ozone exposure, both β-cyclodextrin encapsulated and Pickering emulsion groups exhibited significantly lower peroxide content compared to the crude oil group ($p < 0.001$). No statistically significant difference was observed in peroxide levels between the β-cyclodextrin encapsulated group and the Pickering emulsion group ($p > 0.05$). These findings indicate that both β-cyclodextrin and Pickering emulsion were capable of reducing the peroxide content in the ATaAL-VO to a certain extent under ozone exposure.

Determination of volatile oil components in ozone environment by GC-MS

The results of GC-MS volatile components of ATaAL-VO in each group under ozone environment are shown in Table 1, and the GC-MS chromatogram stack plot is shown in Fig. 3A. The chromatograms show that at 5 min, crude oil and Pickering emulsion groups exhibit compound loss, while the β-cyclodextrin encapsulation group has new compounds. At 15 min, the crude oil group's compound abundance is slightly lower than the other groups. By 20 min, the Pickering emulsion group's compound abundance is higher than the others. At 25 min, the crude oil group's compound abundance is lower. Overall, the overlaid chromatograms more intuitively highlight the protective effects of Pickering emulsion and β-cyclodextrin encapsulation group on crude oil, enhancing its stability.

Volatile oil quantitative change difference compounds in ozone environment

Selection of volatile oil quantitative change differential compounds in ozone environment

As shown in Fig. 3B, compared to the crude oil, there were 3 differential components ($p < 0.05$) after 10 min of ozone exposure. Similarly, there were 3 differential components ($p < 0.05$) after 15 min of ozone exposure. In comparison, there were 33 differential components ($p < 0.05$) after 20 min of ozone exposure, resulting in a total of 37 differential components after removing duplicates. As shown in Fig. 3C. in the heatmap (generated via the pheatmap package) of 37 differential components under various ozone conditions, the nine groups were divided into six clusters:①: Crude oil groups after 15 and 20 min ozone exposure.②: Crude oil group after 10 min ozone exposure.③: β-cyclodextrin encapsulation groups after 10 and 15 min ozone exposure.④: β-cyclodextrin encapsulation group after 20 min ozone exposure.⑤: Pickering emulsion groups after 10 and 15 min ozone exposure.⑥: Pickering emulsion group after 20 min ozone exposure. In clusters ① and ②, the 15 and 20 min crude oil groups had similar component concentrations, which differed from the 10 min group. This might be because oxidation wasn't stable after 10 min ozone exposure, causing significant concentration changes. In clusters ③

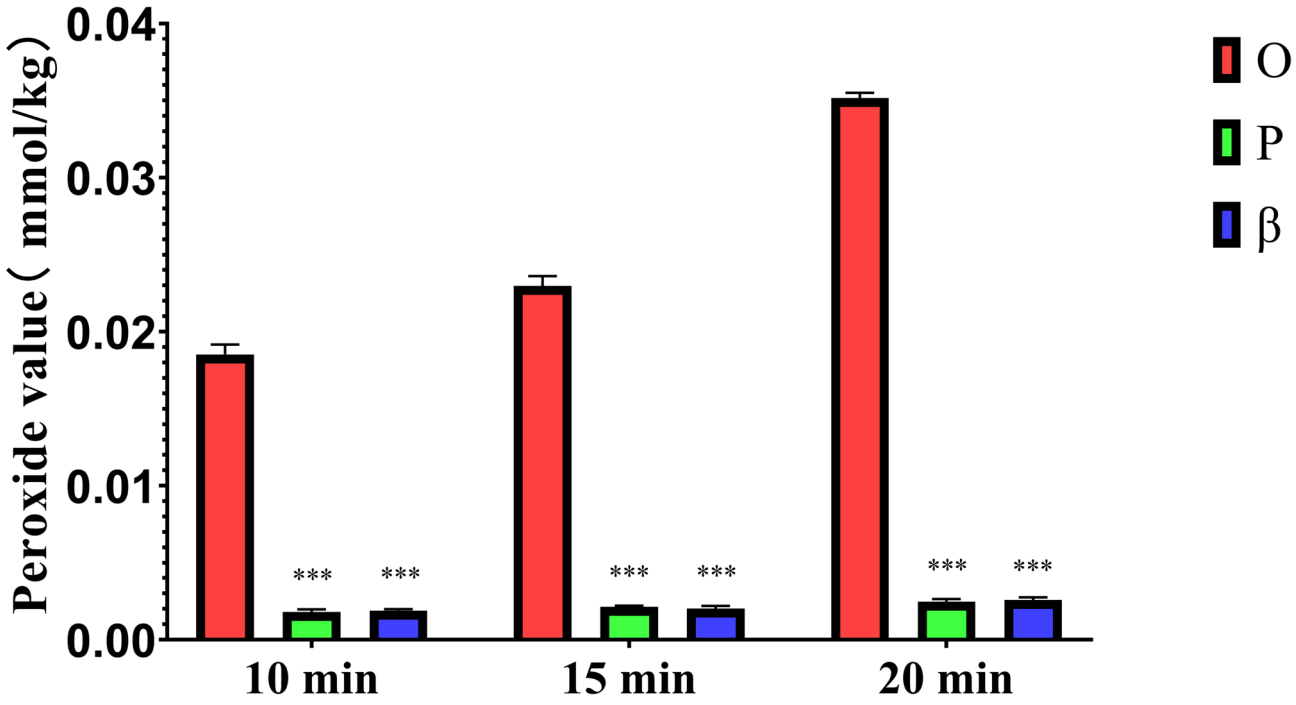

Fig. 2. Plots of volatile oil peroxide content changes in mixed extraction of *Acorus tatarinowii* and *Atractylodes lancea* by different groups under ozone environment. Compared to the crude oil group, ***$p < 0.001$.

serial number	Relative content (mg/mL)										
	CAS	10O	10P	10β	15O	15P	15β	20O	20P	20β	YO
1	007785-70-8	0.39 ± 0.68	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.36 ± 0.63	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	000079-92-5	0.22 ± 0.03	0.00 ± 0.00	0.07 ± 0.12	0.08 ± 0.15	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.12
3	000527-84-4	0.34 ± 0.57	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.23	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	013877-91-3	0.61 ± 0.53	0.14 ± 0.24	0.25 ± 0.44	0.59 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.62 ± 0.54	0.00 ± 0.00	0.00 ± 0.00	0.58 ± 0.51
5	000078-70-6	3.33 ± 0.29	2.47 ± 0.70	2.16 ± 1.28	3.05 ± 0.55	2.21 ± 0.64	2.02 ± 0.64	3.20 ± 0.21	2.04 ± 0.05	1.80 ± 0.37	2.95 ± 0.17
6	029803-81-4	0.37 ± 0.33	0.47 ± 0.09	0.42 ± 0.16	0.36 ± 0.31	0.44 ± 0.12	0.26 ± 0.22	0.37 ± 0.32	0.26 ± 0.22	0.15 ± 0.26	0.00 ± 0.00
7	000464-48-2	2.80 ± 0.28	1.80 ± 1.58	0.00 ± 0.00	1.57 ± 1.38	1.61 ± 1.39	2.46 ± 0.28	1.74 ± 1.51	2.04 ± 0.19	2.06 ± 0.31	2.33 ± 0.14
8	000464-45-9	2.72 ± 0.22	2.64 ± 0.36	2.43 ± 0.34	2.65 ± 0.27	2.62 ± 0.53	2.70 ± 0.11	2.83 ± 0.15	2.48 ± 0.13	2.55 ± 0.32	0.83 ± 1.43
9	000562-74-3	0.96 ± 0.09	0.89 ± 0.14	0.82 ± 0.22	0.89 ± 0.16	0.81 ± 0.13	0.57 ± 0.49	0.93 ± 0.06	0.77 ± 0.05	0.81 ± 0.13	0.88 ± 0.07
10	000140-67-0	2.23 ± 0.21	2.12 ± 0.31	1.80 ± 0.46	1.82 ± 0.73	1.63 ± 0.46	2.17 ± 0.28	1.88 ± 0.61	1.57 ± 0.58	1.12 ± 0.99	2.09 ± 0.16
11	000106-22-9	0.50 ± 0.05	0.32 ± 0.29	0.47 ± 0.07	0.33 ± 0.29	0.30 ± 0.27	0.54 ± 0.05	0.16 ± 0.28	0.30 ± 0.26	0.46 ± 0.06	0.30 ± 0.26
12	000106-24-1	0.42 ± 0.37	0.23 ± 0.39	0.46 ± 0.40	0.58 ± 0.09	0.64 ± 0.08	0.59 ± 0.53	0.41 ± 0.35	0.19 ± 0.33	0.19 ± 0.33	0.00 ± 0.00
13	004057-31-2	0.14 ± 0.24	0.00 ± 0.00	0.12 ± 0.20	0.12 ± 0.20	0.11 ± 0.19	0.14 ± 0.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.25 ± 0.22
14	138752-24-6	0.32 ± 0.03	0.28 ± 0.04	0.21 ± 0.19	0.21 ± 0.18	0.17 ± 0.15	0.19 ± 0.18	0.22 ± 0.19	0.18 ± 0.15	0.29 ± 0.05	0.31 ± 0.02
15	030021-74-0	0.39 ± 0.34	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.22	0.00 ± 0.00	0.00 ± 0.00	0.16 ± 0.27
16	005989-08-2	0.49 ± 0.05	0.42 ± 0.04	0.42 ± 0.10	0.32 ± 0.29	0.28 ± 0.25	0.30 ± 0.26	0.33 ± 0.29	0.28 ± 0.24	0.40 ± 0.05	0.46 ± 0.04
17	001137-12-8	1.20 ± 0.11	1.13 ± 0.11	1.24 ± 0.22	1.18 ± 0.13	1.21 ± 0.22	0.84 ± 0.74	1.25 ± 0.07	1.15 ± 0.09	1.32 ± 0.17	1.13 ± 0.09
18	068269-87-4	1.79 ± 1.56	2.48 ± 0.23	2.77 ± 0.41	2.55 ± 0.28	2.61 ± 0.43	3.40 ± 1.06	2.67 ± 0.10	1.72 ± 1.50	2.92 ± 0.36	2.51 ± 0.20
19	065372-78-3	3.67 ± 0.35	3.59 ± 0.33	4.04 ± 0.54	3.62 ± 0.40	3.86 ± 0.72	2.74 ± 2.39	3.85 ± 0.26	3.64 ± 0.32	2.73 ± 2.41	3.54 ± 0.28
20	000093-15-2	37.65 ± 3.33	38.60 ± 3.91	30.38 ± 2.24	37.12 ± 4.05	39.66 ± 4.60	33.55 ± 5.50	38.98 ± 2.64	38.18 ± 2.98	32.16 ± 4.09	34.91 ± 2.72
21	002387-78-2	0.40 ± 0.04	0.38 ± 0.03	0.43 ± 0.06	0.27 ± 0.24	0.25 ± 0.22	0.45 ± 0.04	0.27 ± 0.23	0.25 ± 0.21	0.46 ± 0.07	0.38 ± 0.04
22	071596-72-0	3.71 ± 0.35	3.62 ± 0.31	4.03 ± 0.48	3.62 ± 0.42	3.86 ± 0.65	4.19 ± 0.40	3.82 ± 0.20	3.64 ± 0.27	2.74 ± 2.42	3.54 ± 0.28
23	000087-44-5	4.09 ± 0.38	4.03 ± 0.34	4.53 ± 0.46	3.76 ± 0.70	4.07 ± 0.40	4.82 ± 0.44	3.93 ± 0.28	3.79 ± 0.13	4.32 ± 0.59	3.87 ± 0.34
24	003242-08-8	0.32 ± 0.28	0.18 ± 0.31	0.20 ± 0.34	0.17 ± 0.30	0.15 ± 0.27	0.20 ± 0.35	0.15 ± 0.27	0.16 ± 0.28	0.00 ± 0.00	0.17 ± 0.30
25	006380-24-1	13.75 ± 1.23	14.11 ± 1.40	11.46 ± 0.83	13.40 ± 1.59	14.80 ± 2.00	12.22 ± 1.04	14.17 ± 0.75	13.89 ± 0.78	11.51 ± 1.22	13.01 ± 1.01
26	006753-98-6	1.17 ± 0.10	1.19 ± 0.11	1.35 ± 0.11	1.13 ± 0.14	1.26 ± 0.18	1.45 ± 0.13	1.18 ± 0.05	1.17 ± 0.07	1.50 ± 0.26	1.10 ± 0.11
27	150320-52-8	0.63 ± 0.07	0.43 ± 0.37	0.41 ± 0.36	0.41 ± 0.36	0.41 ± 0.36	0.46 ± 0.40	0.20 ± 0.35	0.00 ± 0.00	0.18 ± 0.31	0.38 ± 0.33
28	090457-37-7	0.36 ± 0.62	0.35 ± 0.61	0.00 ± 0.00	0.00 ± 0.00	0.30 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
29	094535-52-1	3.00 ± 0.27	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.84 ± 1.60
30	020085-19-2	1.02 ± 0.09	1.03 ± 0.08	0.80 ± 0.69	1.00 ± 0.12	1.12 ± 0.17	0.46 ± 0.80	0.73 ± 0.63	0.74 ± 0.64	0.44 ± 0.76	0.96 ± 0.09
31	023986-74-5	1.16 ± 0.11	1.16 ± 0.09	1.02 ± 0.36	0.77 ± 0.68	0.78 ± 0.68	0.71 ± 0.76	0.77 ± 0.66	0.75 ± 0.65	0.22 ± 0.39	1.10 ± 0.11
32	000104-20-1	2.11 ± 3.65	1.75 ± 3.04	3.54 ± 3.09	2.12 ± 3.66	1.78 ± 3.08	4.07 ± 3.55	0.00 ± 0.00	2.00 ± 3.47	3.66 ± 3.21	1.83 ± 3.16
33	010208-80-7	2.03 ± 1.77	2.92 ± 0.21	2.57 ± 0.20	2.87 ± 0.37	3.17 ± 0.43	2.93 ± 0.35	3.00 ± 0.11	3.04 ± 0.23	1.78 ± 1.57	2.81 ± 0.25
34	000483-76-1	1.92 ± 0.17	4.91 ± 5.04	6.65 ± 4.07	7.61 ± 4.63	5.82 ± 6.73	9.91 ± 1.02	8.40 ± 5.54	8.80 ± 6.04	2.17 ± 0.88	1.86 ± 0.16
35	039029-41-9	2.83 ± 0.26	2.78 ± 0.23	2.47 ± 0.16	2.70 ± 0.42	2.95 ± 0.31	3.04 ± 0.32	2.85 ± 0.11	2.91 ± 0.23	2.52 ± 0.29	2.64 ± 0.22
36	058893-88-2	0.75 ± 0.65	0.68 ± 0.59	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.35 ± 0.61	0.34 ± 0.60	2.38 ± 4.12	0.00 ± 0.00
37	000639-99-6	23.22 ± 2.10	25.10 ± 2.61	27.32 ± 2.20	22.72 ± 2.54	26.65 ± 3.91	29.06 ± 3.47	24.04 ± 1.52	24.84 ± 1.78	26.41 ± 4.62	22.05 ± 1.62
38	015423-57-1	1.11 ± 0.58	1.09 ± 0.47	1.61 ± 0.13	1.37 ± 0.17	1.20 ± 0.60	1.38 ± 0.71	1.42 ± 0.09	1.39 ± 0.09	1.40 ± 0.40	1.31 ± 0.10
39	997221-34-6	1.66 ± 1.45	0.83 ± 1.44	2.75 ± 0.20	2.21 ± 0.44	0.74 ± 1.28	0.90 ± 1.56	1.48 ± 1.29	0.75 ± 1.30	2.39 ± 0.72	0.73 ± 1.27
40	005353-15-1	65.27 ± 5.78	65.52 ± 5.91	30.51 ± 2.35	64.04 ± 7.31	69.48 ± 9.52	33.45 ± 3.88	67.71 ± 4.45	65.52 ± 5.36	30.01 ± 3.73	62.27 ± 4.28

Continued

	Relative content (mg/mL)										
serial number	CAS	10O	10P	10β	15O	15P	15β	20O	20P	20β	YO
41	000489-86-1	0.49 ± 0.43	0.50 ± 0.44	0.22 ± 0.39	0.26 ± 0.44	0.25 ± 0.43	0.22 ± 0.38	0.47 ± 0.40	0.46 ± 0.40	0.30 ± 0.51	0.66 ± 0.06
42	002883-98-9	66.37 ± 6.17	62.72 ± 4.10	31.77 ± 2.78	64.95 ± 7.37	68.05 ± 8.43	36.94 ± 5.22	68.58 ± 4.47	63.37 ± 6.26	31.44 ± 4.32	40.99 ± 35.51
43	001209-71-8	30.46 ± 2.79	31.89 ± 3.20	35.86 ± 2.96	29.71 ± 3.44	34.01 ± 5.08	36.65 ± 4.31	31.63 ± 2.01	31.75 ± 2.13	44.82 ± 15.45	29.28 ± 2.17
44	004630-07-3	122.21 ± 10.93	126.53 ± 12.29	134.52 ± 9.88	119.51 ± 13.90	133.72 ± 19.30	140.80 ± 15.56	126.24 ± 8.48	125.45 ± 8.82	132.49 ± 18.06	80.12 ± 67.86
45	000473-15-4	179.24 ± 15.66	185.23 ± 17.65	186.31 ± 19.00	171.45 ± 23.24	190.61 ± 21.02	199.84 ± 26.37	180.75 ± 6.16	179.23 ± 6.82	186.51 ± 27.11	173.52 ± 11.71
46	021653-33-8	8.41 ± 0.76	5.76 ± 5.06	9.24 ± 0.65	8.19 ± 0.92	5.71 ± 4.98	3.36 ± 5.83	5.64 ± 4.89	2.89 ± 5.01	6.37 ± 5.60	8.06 ± 0.60
47	997153-98-9	21.11 ± 1.87	0.89 ± 0.13	0.21 ± 0.36	20.51 ± 2.30	1.08 ± 0.24	9.54 ± 7.85	14.12 ± 12.25	7.61 ± 12.54	3.64 ± 6.30	20.78 ± 1.50
48	000084-74-2	0.39 ± 0.05	0.15 ± 0.13	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.16	0.00 ± 0.00	0.30 ± 0.26	0.16 ± 0.14	0.00 ± 0.00	0.00 ± 0.00
49	007785-26-4	0.34 ± 0.59	0.00 ± 0.00	0.35 ± 0.61	0.69 ± 0.60	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.36 ± 0.62
50	000099-83-2	1.42 ± 1.23	0.29 ± 0.38	0.69 ± 1.19	2.04 ± 0.33	0.05 ± 0.09	0.21 ± 0.36	2.07 ± 0.11	0.00 ± 0.00	0.08 ± 0.14	2.27 ± 0.18
51	000099-87-6	0.34 ± 0.59	0.00 ± 0.00	0.34 ± 0.59	0.82 ± 0.42	0.00 ± 0.00	0.00 ± 0.00	0.70 ± 0.61	0.00 ± 0.00	0.00 ± 0.00	1.04 ± 0.08
52	000624-15-7	0.20 ± 0.34	0.24 ± 0.42	0.20 ± 0.34	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.19 ± 0.33	0.24 ± 0.42	0.17 ± 0.30
53	000076-49-3	0.22 ± 0.19	0.09 ± 0.16	0.09 ± 0.16	0.09 ± 0.16	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.23 ± 0.20	0.00 ± 0.00
54	729602-94-2	0.62 ± 0.54	0.00 ± 0.00	0.78 ± 0.68	0.96 ± 0.12	0.76 ± 0.67	0.78 ± 0.68	1.00 ± 0.04	0.99 ± 0.06	0.86 ± 0.74	0.93 ± 0.09
55	024406-05-1	0.32 ± 0.55	0.36 ± 0.62	0.00 ± 0.00	0.68 ± 0.60	0.00 ± 0.00	0.00 ± 0.00	0.36 ± 0.63	0.00 ± 0.00	0.00 ± 0.00	0.64 ± 0.55
56	112421-19-9	0.78 ± 1.36	1.48 ± 1.28	0.00 ± 0.00	0.00 ± 0.00	0.87 ± 1.50	1.11 ± 1.92	0.83 ± 1.43	0.81 ± 1.40	0.00 ± 0.00	1.60 ± 1.39
57	019912-67-5	0.43 ± 0.75	1.39 ± 0.15	1.36 ± 0.10	0.89 ± 0.79	1.48 ± 0.20	1.74 ± 0.40	1.38 ± 0.06	1.36 ± 0.07	1.57 ± 0.30	1.31 ± 0.10
58	000080-56-8	0.33 ± 0.57	0.05 ± 0.09	0.00 ± 0.00	0.33 ± 0.57	0.00 ± 0.00	0.00 ± 0.00	0.64 ± 0.56	0.00 ± 0.00	0.00 ± 0.00	0.78 ± 0.68
59	003779-61-1	0.28 ± 0.48	0.00 ± 0.00	0.00 ± 0.00	0.26 ± 0.46	0.00 ± 0.00	0.10 ± 0.17	0.28 ± 0.48	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
60	029803-82-5	0.17 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.16 ± 0.28	0.15 ± 0.25	0.16 ± 0.28	0.31 ± 0.27	0.23 ± 0.21	0.11 ± 0.19	0.46 ± 0.04
61	020307-84-0	0.11 ± 0.19	0.33 ± 0.04	0.42 ± 0.19	0.31 ± 0.27	0.21 ± 0.18	0.64 ± 0.32	0.12 ± 0.20	0.20 ± 0.17	0.36 ± 0.32	0.48 ± 0.07
62	000483-75-0	0.92 ± 1.59	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.82 ± 1.43	0.00 ± 0.00	0.00 ± 0.00	1.05 ± 1.05	0.00 ± 0.00
63	000515-69-5	2.29 ± 3.97	6.79 ± 0.55	5.69 ± 0.42	6.66 ± 1.36	6.74 ± 0.43	6.13 ± 0.72	4.52 ± 3.93	6.86 ± 0.56	3.93 ± 3.44	0.00 ± 0.00
64	997340-11-2	0.17 ± 0.29	0.13 ± 0.22	0.00 ± 0.00	0.19 ± 0.32	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.35	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
65	000095-93-2	0.00 ± 0.00	0.17 ± 0.30	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
66	005655-61-8	0.00 ± 0.00	0.12 ± 0.20	0.11 ± 0.19	0.00 ± 0.00	0.09 ± 0.15	0.22 ± 0.19	0.21 ± 0.18	0.20 ± 0.17	0.00 ± 0.00	0.00 ± 0.00
67	094482-89-0	0.00 ± 0.00	2.04 ± 1.76	2.01 ± 1.74	0.90 ± 1.56	3.19 ± 0.45	3.22 ± 0.31	1.05 ± 1.81	3.00 ± 0.23	0.00 ± 0.00	1.05 ± 1.82
68	001117-61-9	0.00 ± 0.00	0.17 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.30	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.24
69	092618-89-8	0.00 ± 0.00	0.13 ± 0.22	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.10 ± 0.17	0.10 ± 0.17
70	997220-41-0	0.00 ± 0.00	0.63 ± 0.55	0.34 ± 0.59	0.00 ± 0.00	0.00 ± 0.00	0.37 ± 0.63	0.00 ± 0.00	0.00 ± 0.00	0.34 ± 0.59	0.00 ± 0.00
Continued											

	Relative content (mg/mL)										
serial number	CAS	10O	10P	10β	15O	15P	15β	20O	20P	20β	YO
71	086000-71-7	0.00 ± 0.00	0.29 ± 0.51	0.00 ± 0.00	0.00 ± 0.00	0.27 ± 0.46	0.37 ± 0.64	0.00 ± 0.00	0.26 ± 0.45	0.00 ± 0.00	0.00 ± 0.00
72	005956-05-8	0.00 ± 0.00	2.97 ± 5.14	0.00 ± 0.00	0.00 ± 0.00	3.58 ± 6.21	5.37 ± 4.65	3.09 ± 5.35	5.81 ± 5.06	3.08 ± 5.33	0.00 ± 0.00
73	000076-22-2	0.00 ± 0.00	0.68 ± 1.18	2.22 ± 0.82	1.05 ± 1.81	0.57 ± 0.98	0.00 ± 0.00	0.96 ± 1.66	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
74	000106-25-2	0.00 ± 0.00	0.19 ± 0.33	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.24 ± 0.42	0.19 ± 0.33	0.20 ± 0.34	0.19 ± 0.34	0.35 ± 0.31
75	068705-63-5	0.00 ± 0.00	0.11 ± 0.20	0.12 ± 0.22	0.00 ± 0.00	0.14 ± 0.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
76	029873-99-2	0.00 ± 0.00	0.15 ± 0.27	0.38 ± 0.33	0.14 ± 0.25	0.00 ± 0.00	0.23 ± 0.40	0.16 ± 0.28	0.16 ± 0.28	0.61 ± 0.06	0.12 ± 0.21
77	018252-44-3	0.00 ± 0.00	0.19 ± 0.33	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.22 ± 0.38	0.20 ± 0.35	0.00 ± 0.00	0.00 ± 0.00
78	000451-55-8	0.00 ± 0.00	0.91 ± 1.58	0.00 ± 0.00	2.01 ± 1.76	0.00 ± 0.00	0.00 ± 0.00	1.99 ± 1.72	0.00 ± 0.00	1.94 ± 1.70	0.00 ± 0.00
79	000523-47-7	0.00 ± 0.00	0.59 ± 1.02	1.12 ± 1.05	0.61 ± 1.05	0.00 ± 0.00	2.51 ± 0.23	0.63 ± 1.09	0.63 ± 1.10	0.00 ± 0.00	0.00 ± 0.00
80	000105-87-3	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
81	046030-07-3	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.35	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
82	997153-49-7	0.00 ± 0.00	0.00 ± 0.00	7.98 ± 6.96	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.23 ± 0.40	0.00 ± 0.00	0.00 ± 0.00
83	013744-15-5	0.00 ± 0.00	0.00 ± 0.00	0.19 ± 0.32	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.35	0.22 ± 0.39	0.19 ± 0.33
84	997220-96-6	0.00 ± 0.00	0.00 ± 0.00	0.88 ± 1.53	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.17 ± 2.02	0.00 ± 0.00
85	023515-88-0	0.00 ± 0.00	0.00 ± 0.00	0.34 ± 0.59	0.00 ± 0.00	0.00 ± 0.00	0.38 ± 0.66	0.00 ± 0.00	0.34 ± 0.59	0.00 ± 0.00	0.00 ± 0.00
86	017334-55-3	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.23	0.00 ± 0.00	0.00 ± 0.00	0.47 ± 0.16	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.32 ± 0.28
87	000515-17-3	0.00 ± 0.00	0.00 ± 0.00	0.38 ± 0.66	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
88	997220-90-4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.31 ± 0.53	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.57 ± 0.65
89	029050-33-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.24	0.00 ± 0.00	0.00 ± 0.00	0.16 ± 0.27	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
90	000099-86-5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.15 ± 0.26	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
91	019912-62-0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.55 ± 6.15	4.74 ± 8.21	0.00 ± 0.00	4.25 ± 7.37	4.27 ± 7.40	0.00 ± 0.00	0.00 ± 0.00
92	005273-86-9	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.47 ± 0.81	0.61 ± 1.05	0.00 ± 0.00	0.53 ± 0.91	0.00 ± 0.00	0.00 ± 0.00	23.06 ± 39.94
93	005794-04-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.12	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.12	0.00 ± 0.00	0.00 ± 0.00	0.09 ± 0.15
94	007785-53-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.34	0.00 ± 0.00	0.18 ± 0.30	0.16 ± 0.28	0.78 ± 1.35	0.00 ± 0.00
95	000105-90-8	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.12 ± 0.21	0.00 ± 0.00	0.15 ± 0.26	0.13 ± 0.23	0.00 ± 0.00	0.00 ± 0.00
96	025905-14-0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
97	020126-76-5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.31 ± 0.54	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
98	000489-39-4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.35 ± 0.61	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
99	000489-40-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.92 ± 1.59	0.00 ± 0.00	0.68 ± 1.18	0.00 ± 0.00	0.00 ± 0.00
100	095910-36-4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.34 ± 0.58	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Continued											

	Relative content (mg/mL)										
serial number	CAS	10O	10P	10β	15O	15P	15β	20O	20P	20β	YO
101	997221-08-8	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.35 ± 0.60	0.00 ± 0.00	0.00 ± 0.00
102	022469-52-9	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.38 ± 0.65	0.00 ± 0.00	0.00 ± 0.00
103	000495-60-3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.22 ± 0.39	0.00 ± 0.00
104	000088-84-6	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.36 ± 0.63	0.00 ± 0.00
105	022567-17-5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.59 ± 1.02	0.00 ± 0.00
106	000586-62-9	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.09 ± 0.16	0.00 ± 0.00
107	997220-96-1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.75 ± 3.02	0.00 ± 0.00
108	005951-67-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.38 ± 0.65	0.00 ± 0.00
109	017066-67-0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	4.62 ± 7.99	0.00 ± 0.00
110	010219-75-7	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.83 ± 3.17	0.00 ± 0.00
111	997218-00-9	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.41 ± 5.91	0.00 ± 0.00
112	006813-21-4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.27 ± 0.46	0.00 ± 0.00
113	063891-61-2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.35 ± 0.61	0.00 ± 0.00
114	000514-51-2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 1.73	0.00 ± 0.00
115	022451-73-6	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.05 ± 3.56	0.00 ± 0.00
116	000507-70-0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.70 ± 1.49
117	013466-78-9	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.28 ± 0.49
118	000099-85-4	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.11
119	000619-62-5	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.18 ± 0.31

Table 1. Volatile component information of *Acorus tatarinowii* and *Atractylodes lancea* in ozone environment. (1) 10/15/20 min; (2) P: Pickering emulsion group; (3) *β*: *β*-cyclodextrin inclusion complex group; (4) YO: Crude oil.

and ④, the 10 and 15 min β-cyclodextrin encapsulation groups had similar concentrations but differed from the 20 min group. This could be due to the protective effect of β-cyclodextrin encapsulation in the early stage, reducing oxidation loss. However, as ozone exposure time increased, the stability of the inclusion complexes might have decreased, causing more components to be oxidized or released. In clusters ⑤ and ⑥, the 10 and 15 min pickering emulsion groups had similar concentrations but differed from the 20 min group. This might be because the stability of Pickering emulsion wasn't significantly affected in the short term, maintaining a relatively stable interface. However, after 20 min ozone exposure, the stability of the emulsion might have decreased due to changes in emulsifier properties and interfacial tension, possibly leading to breaking of the emulsion and different component concentrations compared to the 10 and 15 min groups (Tables 2, 3, 4).

Based on the clustering results of the volatile components, the characteristic components could be divided into 6 categories: (1) alpha-Bisabolol (CAS No. 000515-69-5), (+)-DELTA-CADINENE (CAS No. 000483-76-1), Germacrene B (CAS No. 015423-57-1), etc.; (2) Geraniol (CAS No. 000106-24-1), 1-Ethenyl-1-Methyl-4-Propan-2-Ylidene-2-Prop-1-En-2-Ylcyclohexane (CAS No. 003242-08-8), 4-Allylanisole (CAS No. 000140-67-0), etc.; (3) Methyl eugenol (CAS No. 000093-15-2), (-)-GUAIOL (CAS No. 000489-86-1), ISOEUGENYLMETHYLETHER (CAS No. 006380-24-1), etc.; (4) (+)-LONGICYCLENE (CAS No. 001137-12-8), Terpinen-4-ol (CAS No. 000562-74-3), (+)-Acorenone B (CAS No. 021653-33-8), etc.; (5) delta-elemene (CAS No. 020307-84-0), Elemol (CAS No. 000639-99-6), b-Eudesmol (CAS No. 000473-15-4); (6) Camphor (CAS No. 000464-48-2), Cyclopenta[c]pentalene (CAS No. 138752-24-6), Naphthalene (CAS No. 058893-88-2). As shown in Fig. 3D, in the PCA analysis, after 10 min of ozone exposure, the Pickering emulsion group and crude oil group were in the upper part of the plot, while the β-cyclodextrin encapsulation group was in the lower part. The three groups were clearly separated, indicating significant differences. After 15 min, the β-cyclodextrin encapsulation group moved to the top of the plot, and some overlap occurred between the three groups, suggesting some components had similar properties. After 20 min, the overlap between groups increased, especially between the crude oil and Pickering emulsion groups. As ozone exposure time increased, the differences between groups decreased, and component properties became more similar.

Analysis of volatile oil quantitative change difference compounds in ozone environment

As shown in Fig. 4, in the Pickering emulsion group, the declining trends of differential components 000084-74-2, 000464-48-2, 003242-08-8, and 020085-19-2 were alleviated. Meanwhile, the increasing trends of differential components 000483-76-1, 000515-69-5, 005353-15-1, 006380-24-1, 010208-80-7, 015423-57-1, and 068269-87-4 were mitigated. The decreasing trends of differential components 000489-86-1, 002387-78-2, 138752-24-6, and 150320-52-8 in the β-cyclodextrin encapsulation group were alleviated. The increasing trend of differential component 729602-94-2 in the β-cyclodextrin encapsulation group was mitigated. The decreasing trend of differential component 000106-22-9 in both the Pickering emulsion group and β-cyclodextrin encapsulation group was alleviated.

Volatile oil qualitative change difference compounds in ozone environment

Selection of volatile oil qualitative change differential compounds in ozone environment

As shown in Fig. 5A, compared to the crude oil, after 10 min of ozone exposure, the crude oil group generated 12 new compounds and lost 14; the Pickering emulsion group generated 18 new compounds and lost 17; and the β-cyclodextrin encapsulation group generated 15 new compounds and lost 17. The unique compounds in each group were 7 for crude oil, 4 for the crude oil group, 5 for the Pickering emulsion group, and 6 for the β-cyclodextrin encapsulation group. As shown in Fig. 5B, after 15 min of ozone exposure, the crude oil group generated 12 new compounds and lost 13; the Pickering emulsion group generated 13 new compounds and lost 21; and the β-cyclodextrin encapsulation group generated 15 new compounds and lost 19. A total of 43 compounds were common to all four groups, with 3 shared among the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group. The unique compounds were 10 for crude oil, 5 for the crude oil group, 5 for the Pickering emulsion group, and 7 for the β-cyclodextrin encapsulation group. As shown in Fig. 5C, after 20 min of ozone exposure, the crude oil group generated 20 new compounds and lost 14; the Pickering emulsion group generated 18 new compounds and lost 21; and the β-cyclodextrin encapsulation group generated 24 new compounds and lost 21. A total of 39 compounds were common to all four groups, with 6 shared among the crude oil group, β-cyclodextrin encapsulation group, and Pickering emulsion group. The unique compounds were 10 for crude oil, 7 for the crude oil group, 6 for the Pickering emulsion group, and 17 for the β-cyclodextrin encapsulation group. As shown in Fig. 5D, after 10, 15, and 20 min of ozone exposure, 34 compounds were common between the crude oil and all groups, while only 3 compounds were common among all groups. Crude oil had 4 unique compounds. After 10 min, the Pickering emulsion and β-cyclodextrin encapsulation group had 1 and 3 unique compounds, respectively. After 15 min, the crude oil and β-cyclodextrin encapsulation group had 1 and 3 unique compounds, respectively. After 20 min, the crude oil, Pickering emulsion, and β-cyclodextrin encapsulation group had 1, 2, and 13 unique compounds, respectively.

Analysis of newly generated qualitative change differential compounds in volatile oil under ozone environment

As shown in Fig. 5E-a, after 10 min of ozone exposure, compound 000106-24-1 exhibited higher relative abundance in the crude oil and β-cyclodextrin encapsulation group than in the Pickering emulsion group. Additionally, compounds 000076-49-3, 058893-88-2, 000084-74-2, and 997340-11-2 showed greater relative abundance in the crude oil group and lower in the Pickering emulsion group, with the latter two being undetected in the β-cyclodextrin encapsulation group. Figure 5E-b highlights that after 15 min of ozone exposure, compound 003779-61-1 had the highest relative abundance in the crude oil group, lower in the β-cyclodextrin encapsulation group, and was undetected in the Pickering emulsion group. Compound 000076-22-2 showed higher relative abundance in the crude oil group and lower in the Pickering emulsion group, while

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
	10 O	–	–	–	–	–
000076-22-2	10 P	6.1753	0.3291	Camphor	67,090	97
	10 β	6.1754	0.3097	Camphor	67,090	97
	10 O	7.8647	0.0464	Bornyl acetate	179,280	99
000076-49-3	10 P	7.8645	0.0436	Bornyl acetate	179,280	99
	10 β	7.8646	0.0478	Bornyl acetate	179,278	98
	10 O	5.6157	0.4864	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
000078-70-6	10 P	5.6157	0.3032	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	10 β	5.6159	0.2614	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	10 O	4.1545	0.0319	Bicyclo [2.2.1] heptane, 2,2-dimethyl-3-methylene-	40,249	97
000079-92-5	10 P	–	–	–	–	–
	10 β	4.1545	0.0358	Bicyclo [2.2.1] heptane, 2,2-dimethyl-3-methylene-	40,249	97
	10 O	3.999	0.1553	2-Pinene	40,319	95
000080-56-8	10 P	3.9991	0.0209	2-Pinene	40,320	97
	10 β	–	–	–	–	–
	10 O	28.3939	0.0568	Dibutyl phthalate	460,421	91
000084-74-2	10 P	28.394	0.0328	Dibutyl phthalate	460,421	94
	10 β	–	–	–	–	–
	10 O	10.59	0.5973	Isocaryophyllene	204,346	99
000087-44-5	10 P	10.59	0.592	Caryophyllene	204,349	99
	10 β	10.5902	0.7168	Isocaryophyllene	204,346	99
	10 O	9.9786	5.5464	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,483	96
000093-15-2	10 P	9.9786	5.5736	Methyleugenol	127,480	96
	10 β	9.9684	4.917	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,483	96
	10 O	–	–	–	–	–
000095-93-2	10 P	4.8903	0.0694	Benzene, 1,2,4,5-tetramethyl-	37,527	94
	10 β	–	–	–	–	–
	10 O	4.6832	0.3308	.alpha.-phellandrene (only name in Wiley6)	40,523	91
000099-83-2	10 P	4.683	0.0966	.alpha.-phellandrene (only name in Wiley6)	40,523	95
	10 β	4.683	0.3412	.alpha.-phellandrene (only name in Wiley6)	40,523	95
	10 O	4.8904	0.1563	Benzene, 1-methyl-4-(1-methylethyl)-	37,380	94
000099-87-6	10 P	–	–	–	–	–
	10 β	4.8903	0.1685	Benzene, 1-methyl-4-(1-methylethyl)-	37,380	94
	10 O	12.5488	0.8476	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
000104-20-1	10 P	12.5487	0.8505	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
	10 β	12.5487	0.9399	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
	10 O	9.4294	0.064	Geranyl acetate	179,150	87
000105-87-3	10 P	–	–	–	–	–
	10 β	9.4295	0.0653	Geranyl acetate	179,154	90
	10 O	9.4295	0.0631	2,6-Octadien-1-ol, 3,7-dimethyl-, propanoate, (E)-	223,867	87
000105-90-8	10 P	9.4293	0.0568	Geranyl propionate	223,873	87
	10 β	9.4293	0.0766	Geranyl propionate	223,873	83
	10 O	6.9733	0.0717	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
000106-22-9	10 P	6.9733	0.0692	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
	10 β	6.9734	0.0739	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
	10 O	7.3154	0.0914	Geraniol	71,982	94
000106-24-1	10 P	7.3152	0.0986	Geraniol	71,982	94
	10 β	7.3154	0.1054	Geraniol	71,982	93
	10 O	–	–	–	–	–
000106-25-2	10 P	7.3152	0.0922	2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)-	71,992	94
	10 β	–	–	–	–	–
	10 O	–	–	–	–	–
000451-55-8	10 P	12.0616	0.4411	1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene	204,326	97
	10 β	–	–	–	–	–

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000140-67-0	10 O	6.6936	0.3308	Anisole, p-allyl-	59,576	96
	10 P	6.6935	0.3125	Anisole, p-allyl-	59,576	97
	10 β	6.6935	0.2418	Anisole, p-allyl-	59,576	97
000464-45-9	10 O	6.393	0.3982	Bicyclo [2.2.1] heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	10 P	6.393	0.396	Bicyclo [2.2.1] heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	10 β	6.3931	0.3778	Bicyclo [2.2.1] heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
000464-48-2	10 O	6.1754	0.4192	Bicyclo [2.2.1] heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,089	97
	10 P	6.1753	0.3954	Bicyclo [2.2.1] heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,089	97
	10 β	–	–	–	–	–
000473-15-4	10 O	20.1035	26.4175	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,358	99
	10 P	20.0931	27.0858	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,358	99
	10 β	20.0932	31.6255	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,358	99
000473-16-5	10 O	–	–	–	–	–
	10 P	20.8288	1.3179	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,8a-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,477	74
	10 β	20.8186	1.4678	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,8a-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,477	74
000483-75-0	10 O	12.8077	0.4322	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-	204,483	97
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
000483-76-1	10 O	13.616	1.719	.delta.-Cadinene	204,022	99
	10 P	13.6161	1.7347	.delta.-Cadinene	204,022	98
	10 β	13.6162	1.359	.delta.-Cadinene	204,022	98
000489-40-7	10 O	17.72	0.2028	.alpha.-Gurjunene	204,569	74
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
000489-86-1	10 O	16.8288	0.1047	Guaiol	265,977	99
	10 P	16.8287	0.1037	Guaiol	265,977	99
	10 β	16.8183	0.1107	Guaiol	265,977	99
000515-17-3	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	14.1446	0.1901	.gamma.-Selinene	204,521	94
000515-69-5	10 O	21.8133	1.0772	.alpha.-Bisabolol	265,906	90
	10 P	21.8134	0.9806	.alpha.-Bisabolol	265,906	90
	10 β	21.803	0.9229	.alpha.-Bisabolol	265,906	91
000523-47-7	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	13.0668	0.2109	Naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,616	95
000523-47-7	10 O	–	–	–	–	–
	10 P	13.0668	0.2843	Naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,616	95
	10 β	–	–	–	–	–
000527-84-4	10 O	4.8904	0.0039	o-Cymene	37,575	94
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
000562-74-3	10 O	6.4967	0.1416	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	10 P	6.4966	0.137	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	10 β	6.4967	0.1209	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
000624-15-7	10 O	7.3154	0.0908	2,6-Octadien-1-ol, 3,7-dimethyl-	71,985	96
	10 P	7.3153	0.097	2,6-Octadien-1-ol, 3,7-dimethyl-	71,989	91
	10 β	7.3153	0.1044	2,6-Octadien-1-ol, 3,7-dimethyl-	71,989	91
000629-97-0	10 O	31.1299	1.3395	Docosane	571,714	99
	10 P	31.1299	1.3417	Docosane	571,714	99
	10 β	31.13	1.5268	Docosane	571,714	99
000639-99-6	10 O	14.6629	3.4321	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
	10 P	14.6628	3.6867	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
	10 β	14.6629	4.554	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
	10 O	–	–	–	–	–
001117-61-9	10 P	6.9733	0.0732	6-Octen-1-ol, 3,7-dimethyl-, (R)-	76,885	97
	10 β	–	–	–	–	–
	10 O	9.5331	0.177	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
001137-12-8	10 P	9.533	0.1645	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
	10 β	9.5331	0.1914	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
	10 O	18.694	4.4616	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
001209-71-8	10 P	18.6941	4.6764	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	10 β	18.6838	5.7192	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	10 O	10.1547	0.0581	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
002387-78-2	10 P	10.1548	0.0545	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	10 β	10.1549	0.0655	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	10 O	18.1551	9.7246	Asarone	216,637	97
002883-98-9	10 P	18.1448	9.0114	Asarone	216,632	97
	10 β	18.0827	5.3395	Asarone	216,632	97
	10 O	–	–	–	–	–
003218-36-8	10 P	24.829	3.0173	[1,1'-Biphenyl]-4-carboxaldehyde	139,647	81
	10 β	24.8186	2.0187	[1,1'-Biphenyl]-4-carboxaldehyde	139,647	81
	10 O	10.818	0.069	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,873	96
003242-08-8	10 P	10.818	0.0769	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,876	94
	10 β	10.818	0.0988	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,880	96
	10 O	8.9837	0.1806	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1 S-(1.alpha.,4.alpha.,7.alpha.)]-	203,860	86
003691-12-1	10 P	8.9838	0.169	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1 S-(1.alpha.,4.alpha.,7.alpha.)]-	203,860	83
	10 β	–	–	–	–	–
	10 O	5.0768	0.1308	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	40,369	96
003779-61-1	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
	10 O	7.8646	0.0562	1,3,3-Trimethylbicyclo[2.2.1]hept-2-yl acetate	179,262	99
004057-31-2	10 P	–	–	–	–	–
	10 β	7.8645	0.0585	1,3,3-Trimethylbicyclo[2.2.1]hept-2-yl acetate	179,262	99
	10 O	19.2951	17.9677	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
004630-07-3	10 P	19.3055	18.5356	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	10 β	19.3056	22.1898	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	10 O	15.6577	9.6305	.gamma.-Asarone	216,177	97
005353-15-1	10 P	15.6473	9.626	.gamma.-Asarone	216,177	97
	10 β	15.5852	5.0179	.gamma.-Asarone	216,177	96
	10 O	–	–	–	–	–
005655-61-8	10 P	7.8646	0.0475	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
	10 β	7.8647	0.0507	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
	10 O	–	–	–	–	–
005956-05-8	10 P	21.4195	1.2901	Acorenone	257,619	99
	10 β	–	–	–	–	–
	10 O	9.0771	0.0729	.alpha.-Longipinene	204,069	99
005989-08-2	10 P	9.077	0.0585	.alpha.-Longipinene	204,069	99
	10 β	9.0771	0.0645	.alpha.-Longipinene	204,069	99
	10 O	11.3052	2.0311	(Z)-Methyl isoeugenol	127,050	97
006380-24-1	10 P	11.3051	2.0661	(Z)-Methyl isoeugenol	127,050	97
	10 β	11.2949	1.8416	(Z)-Methyl isoeugenol	127,050	97
	10 O	11.4917	0.1722	.alpha.-Humulene	203,988	98
006753-98-6	10 P	11.4917	0.1713	.alpha.-Humulene	203,988	98
	10 β	11.4814	0.2123	.alpha.-Humulene	203,988	98
	10 O	–	–	–	–	–
006831-16-9	10 P	–	–	–	–	–
	10 β	8.9837	0.2469	Aristolene	204,005	83

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
006813-21-4	10 O	15.8443	0.3523	Selina-3,7(11)-diene	204,725	84
	10 P	15.8338	0.3449	Eudesma-3,7(11)-diene	204,727	52
	10 β	–	–	–	–	–
006831-16-9	10 O	–	–	–	–	–
	10 P	8.9837	0.1622	(-)-Aristolene	204,003	89
	10 β					
007785-26-4	10 O	3.9992	0.1574	(1 S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene	40,321	96
	10 P					
	10 β	3.999	0.1754	(1 S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene	40,321	96
007785-70-8	10 O	3.9992	0.1583	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene	40,325	96
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
010208-80-7	10 O	12.8079	0.436	.alpha.-Muurolene	204,479	98
	10 P	12.8078	0.4164	.alpha.-Muurolene	204,479	98
	10 β	12.8077	0.4534	.alpha.-Muurolene	204,479	99
013744-15-5	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	11.7197	0.0978	1 H-Cyclopenta[1,3]cyclopropa[1,2]benzene, 2,3,3a.alpha.,3b.alpha.,4,5,6,7-octahydro-4.alpha.-isopropyl-7.beta.-methyl-3-methylene-	204,010	95
013877-91-3	10 O	5.0769	0.1315	.beta.-Ocimene	40,365	97
	10 P	5.0769	0.0566	.beta.-Ocimene	40,365	97
	10 β	5.0768	0.1255	.beta.-Ocimene	40,365	97
015423-57-1	10 O	15.0462	0.207	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
	10 P	15.0462	0.2068	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
	10 β	15.0462	0.2763	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
017334-55-3	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	10.9216	0.0646	1 H-Cyclopropa[a]naphthalene, 1a,2,3,5,6,7,7a,7b-octahydro-1,1,7,7a-tetramethyl-, [1aR-(1a.alpha.,7.alpha.,7a.alpha.,7b.alpha.)]-	204,283	98
017408-66-1	10 O	17.2537	0.1239	7-Isopropyl-4a,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-2(1 H)-naphthalenone	258,338	46
	10 P	17.2536	0.1286	7-Isopropyl-4a,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-2(1 H)-naphthalenone	258,338	53
	10 β	–	–	–	–	–
018252-44-3	10 O	–	–	–	–	–
	10 P	11.7196	0.0931	(1R,2 S,6 S,7 S,8 S)-8-Isopropyl-1-methyl-3-methylenetricyclo[4.4.0.02,7]decane-rel-	204,603	95
	10 β	–	–	–	–	–
019912-67-5	10 O	17.72	0.1987	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	10 P	17.7199	0.1981	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	10 β	17.7095	0.2286	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
020085-19-2	10 O	12.1757	0.1503	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	97
	10 P	12.1756	0.147	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	96
	10 β	12.1757	0.1783	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	97
020307-84-0	10 O	8.7246	0.0526	.delta.-Elemene	204,748	93
	10 P	8.7247	0.0487	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	97
	10 β	8.7247	0.0497	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	97
021653-33-8	10 O	21.4197	1.2431	Acorenone B	257,617	99
	10 P	21.4092	1.2593	Acorenone B	257,617	99
	10 β	21.4195	1.5161	Acorenone B	257,617	99
021698-46-4	10 O	17.2535	0.1222	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	86
	10 P	17.2535	0.1218	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	78
	10 β	17.2433	0.1472	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	50
022567-17-5	10 O	20.829	1.3168	Azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1R-(1.alpha.,3a.beta.,4.alpha.,7.beta.)]-	203,954	70
	10 P	–	–	–	–	–
	10 β	15.8236	0.2985	1.beta.,4.beta.H,10.beta.H-Guaia-5,11-diene	203,958	83
023515-88-0	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	12.1756	0.1796	(1 S,4aR,8aS)-1-isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,471	97

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
023986-74-5	10 O	12.2793	0.1723	(-)-Germacrene D	204,036	97
	10 P	12.2792	0.1664	(-)-Germacrene D	204,036	97
	10 β	12.2792	0.2171	(-)-Germacrene D	204,036	97
024406-05-1	10 O	14.1551	0.1469	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,482	94
	10 P	14.155	0.1435	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,482	95
	10 β	–	–	–	–	–
025905-14-0	10 O	–	–	–	–	–
	10 P	9.4294	0.0553	4-Hexen-1-ol, 5-methyl-2-(1-methylethenyl)-, acetate	179,195	86
	10 β	–	–	–	–	–
029803-81-4	10 O	5.8956	0.0803	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	10 P	5.8955	0.075	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	10 β	5.8955	0.098	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
029873-99-2	10 O	–	–	–	–	–
	10 P	10.818	0.0744	.gamma.-Elemene	203,875	95
	10 β	10.818	0.0939	.gamma.-Elemene	203,875	96
029803-82-5	10 O	5.8955	0.0795	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
030021-74-0	10 O	8.7248	0.0842	.gamma.-Muurolene	204,738	93
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
035010-17-4	10 O	24.1037	0.08	1-(2'-Nitrophenyl)-2-phenylacetylene	268,234	72
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
035727-45-8	10 O	22.1658	0.6186	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-	266,054	70
	10 P	22.1553	0.4582	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-	266,054	86
	10 β	–	–	–	–	–
039029-41-9	10 O	13.3261	0.4156	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	98
	10 P	13.3259	0.4002	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	98
	10 β	13.3157	0.3828	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	97
046030-07-3	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	12.3623	0.0916	(3R,4aS,5R)-3-isopropenyl-4a,5-dimethyl-2,3,4,5,6,7-hexahydro-1 H-naphthalene	204,458	92
058893-88-2	10 O	14.1549	0.1609	(4aR,8aS)-4a-Methyl-1-methylene-7-(propan-2-ylidene)decahydronaphthalene	204,518	97
	10 P	14.1549	0.1655	(4aR,8aS)-4a-Methyl-1-methylene-7-(propan-2-ylidene)decahydronaphthalene	204,518	98
	10 β	–	–	–	–	–
065372-78-3	10 O	9.8544	0.5444	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	10 P	9.8543	0.5198	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	10 β	9.8542	0.7475	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
068269-87-4	10 O	9.7093	0.381	Modephene	203,866	97
	10 P	9.7092	0.3602	Modephene	203,866	97
	10 β	9.7093	0.4298	Modephene	203,866	97
068705-63-5	10 O	–	–	–	–	–
	10 P	9.4293	0.0554	Butanoic acid, 2-methyl-, 3,7-dimethyl-2,6-octadienyl ester, (E)-	320,915	90
	10 β	9.4294	0.0654	Butanoic acid, 2-methyl-, 3,7-dimethyl-2,6-octadienyl ester, (E)-	320,915	90
071596-72-0	10 O	10.3518	0.5505	.beta.-isocomene	204,223	99
	10 P	10.3517	0.5218	.beta.-isocomene	204,223	99
	10 β	10.3518	0.6308	.beta.-isocomene	204,223	99
074744-54-0	10 O	–	–	–	–	–
	10 P	–	–	–	–	–
	10 β	17.2432	0.1585	4-Hexadecen-6-yne, (Z)-	258,522	62
078781-34-7	10 O	–	–	–	–	–
	10 P	20.8392	1.3382	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	78
	10 β	20.8288	1.4911	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	78

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
	10 O	–	–	–	–	–
086000-71-7	10 P	17.2535	0.1276	Naphthalene, 1,2,3,4,5,8-hexahydro-6-methoxy-7-methyl-1-(1-methylethyl)-, (.+-.)-	257,398	90
	10 β	–	–	–	–	–
	10 O	11.8234	0.1449	Spiro[4.5]dec-7-ene, 1,8-dimethyl-4-(1-methylethenyl)-, [1 S-(1.alpha.,4.beta.,5.alpha.)]-	203,964	95
090457-37-7	10 P	11.8233	0.1414	Spiro[4.5]dec-7-ene, 1,8-dimethyl-4-(1-methylethenyl)-, [1 S-(1.alpha.,4.beta.,5.alpha.)]-	203,964	96
	10 β	–	–	–	–	–
	10 O	–	–	–	–	–
092618-89-8	10 P	7.8645	0.055	Acetic acid, 1,7,7-trimethyl-bicyclo[2.2.1]hept-2-yl ester	179,277	99
	10 β	–	–	–	–	–
	10 O	–	–	–	–	–
094482-89-0	10 P	12.0616	0.4195	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	10 β	12.0617	0.4569	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	10 O	–	–	–	–	–
118173-08-3	10 P	–	–	–	–	–
	10 β	15.8234	0.3053	Selin-6-en-4.alpha.-ol	265,839	83
	10 O	12.0617	0.4435	(1R,3aS,4aS,8aS)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,886	97
094535-52-1	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
	10 O	15.2432	0.3596	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	92
112421-19-9	10 P	15.2431	0.3629	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	92
	10 β	–	–	–	–	–
	10 O	8.5795	0.0459	Silphiperfol-5-ene	204,398	98
138752-24-6	10 P	8.5796	0.0415	Silphiperfol-5-ene	204,398	98
	10 β	8.5797	0.0402	Silphiperfol-5-ene	204,398	98
	10 O	11.7197	0.094	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	96
150320-52-8	10 P	11.7196	0.0915	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
	10 β	11.7197	0.0896	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	96
	10 O	11.8232	0.1448	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
729602-94-2	10 P	–	–	–	–	–
	10 β	11.8232	0.1985	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
	10 O	–	–	–	–	–
765307-45-7	10 P	–	–	–	–	–
	10 β	12.9632	0.1674	(3R,5aR,9 S,9aS)-2,2,5a,9-Tetramethyloctahydro-2 H-3,9a-methanobenzo[b]oxepine	265,610	78
	10 O	–	–	–	–	–
997153-49-7	10 P	–	–	–	–	–
	10 β	24.8188	1.9524	1-Methyl-5 H-pyrido[4,3-b]indole	139,185	90
	10 O	24.8291	3.113	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	96
997153-98-9	10 P	24.829	3.0486	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	97
	10 β	22.6113	0.1026	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	95
	10 O	–	–	–	–	–
997220-41-0	10 P	11.8232	0.1453	Italicene	203,893	96
	10 β	11.8233	0.1798	Italicene	203,893	95
	10 O	–	–	–	–	–
997220-96-6	10 P	–	–	–	–	–
	10 β	12.0616	0.4651	.gamma.-Curcumene	204,325	96
	10 O	9.7091	0.3796	4-(2', 4', 4'-trimethyl-yciclo[4.1.0]hept-2'-en-3'-yl)-3-buten-2-one	203,517	89
997220-02-6	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
	10 O	20.8288	1.316	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
997220-06-9	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
	10 O	8.9839	0.183	(+)-.alpha.-Selinene	204,401	70
997221-08-8	10 P	8.9837	0.1673	(+)-.alpha.-Selinene	204,401	78
	10 β	8.9839	0.1826	(+)-.alpha.-Selinene	204,401	78

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
997221-34-6	10 O	15.2432	0.3614	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	95
	10 P	15.2431	0.3619	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	92
	10 β	15.2431	0.4624	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	92
997288-22-8	10 O	24.1038	0.0793	1-naphthalenyl dihydrogen phosphate	269,687	86
	10 P	–	–	–	–	–
	10 β	–	–	–	–	–
997340-11-2	10 O	24.1036	0.0791	Isocalamendiol	320,570	90
	10 P	24.1036	0.0614	Isocalamendiol	320,570	90
	10 β	–	–	–	–	–

Table 2. Compound identification information in the environment of ozone for 10 min. – indicates that the corresponding group does not contain the parameter of this component.

being undetected in the β-cyclodextrin encapsulation group. Compounds 019912-62-0 were highly abundant in the crude oil and Pickering emulsion groups but absent in the β-cyclodextrin encapsulation group. Compounds 029803-81-4 and 000515-69-5 demonstrated greater relative abundance in the crude oil and Pickering emulsion groups compared to the β-cyclodextrin encapsulation group. As depicted in Fig. 5E-c, after 20 min of ozone exposure, compounds 000084-74-2, 005655-61-8, 018252-44-3, and 000105-90-8 had higher relative abundance in the crude oil group and lower in the Pickering emulsion group, with the latter two being undetected in the β-cyclodextrin encapsulation group. Compounds 000523-47-7 and 019912-62-0 showed higher relative abundance in the crude oil and Pickering emulsion groups but were absent in the β-cyclodextrin encapsulation group. Compounds 029803-81-4 and 000106-24-1 exhibited greater relative abundance in the crude oil group and lower in the other groups. Compound 000515-69-5 had higher relative abundance in the crude oil and Pickering emulsion groups than in the β-cyclodextrin encapsulation group.

Analysis of disappear qualitative change differential compounds in volatile oil under ozone environment
As shown in Fig. 5F-a, after 10 min of ozone exposure, the compounds 094482-89-0 and 029873-99-2, which were disappearing, were effectively preserved in both the Pickering emulsion and β-cyclodextrin encapsulation groups. Additionally, the Pickering emulsion group effectively preserved the disappearing compounds 001117-61-9, 092618-89-8, and 000106-25-2. The disappearing compounds 013744-15-5 and 017334-55-3 could be effectively preserved in the β-cyclodextrin encapsulation group. According to Fig. 5F-b, after 15 min of ozone exposure, the disappearing compound 112421-19-9 could be effectively preserved in the Pickering emulsion group and β-cyclodextrin encapsulation group. The disappearing compounds 000106-25-2 and 017334-55-3 could be effectively preserved in the β-cyclodextrin encapsulation group. According to Fig. 5F-c, after 20 min of ozone exposure, the disappearing compounds 000104-20-1, 000624-15-7, and 013744-15-5 could be effectively preserved in the Pickering emulsion group and β-cyclodextrin encapsulation group. The disappearing compound 092618-89-8 could be effectively preserved in the β-cyclodextrin encapsulation group.

Analysis of the main components of volatile oil in ozone environment
According to Fig. 6, compared to the crude oil group, the overall trends of the main components 000078-70-6, 000093-15-2, 000087-44-5, 006380-24-1, 006753-98-6, 005353-15-1, 002883-98-9, and 000473-15-4 in the Pickering emulsion group are more stable. The relative content of the main components 000087-44-5, 006753-98-6, and 000473-15-4 in the β-cyclodextrin encapsulation group is higher than that in the crude oil group.

Discussion

The pharmacological activity of volatile oils in traditional Chinese medicine is significant; however, their volatility and susceptibility to oxidation lead to poor formulation stability[33]. Ozone, as a strong oxidizing agent, has a high oxidation potential (2.07 V) and can attack unsaturated bonds (such as double and triple bonds) in volatile oils, triggering radical reactions[34]. Ozone's strong oxidizing ability enables it to react quickly with unsaturated components in volatile oils, thereby inducing oxidation reactions or altering the structure and composition of compounds in the oils[35,36].

This could result in structural alterations of certain compounds in the volatile oils, leading to their decomposition or degradation into other compounds and thus altering the composition of the volatile oil. The oxidative action of ozone may further reduce the stability of volatile oils and shorten their shelf life[37].

The application of Pickering emulsions and β-cyclodextrin encapsulation has shown significant effectiveness in reducing the peroxide values of ATaAL-VO. Compared to the crude oil group, these technologies led to a marked reduction in peroxide values ($p < 0.01$). GC-MS analysis revealed that these technologies could partially mitigate the increasing or decreasing trends of most differential components in the crude oil group when exposed to ozone. Additionally, they help reduce the loss of certain components in the crude oil group under ozone exposure, stabilize the variations of major components, and decrease the oxidative loss of key constituents.

These findings indicate that Pickering emulsions and β-cyclodextrin encapsulation, through physical barrier and chemical inclusion effects, reduce the direct contact between volatile oils and ozone, thereby inhibiting peroxide formation. They can also partially prevent the formation of new differential components and delay

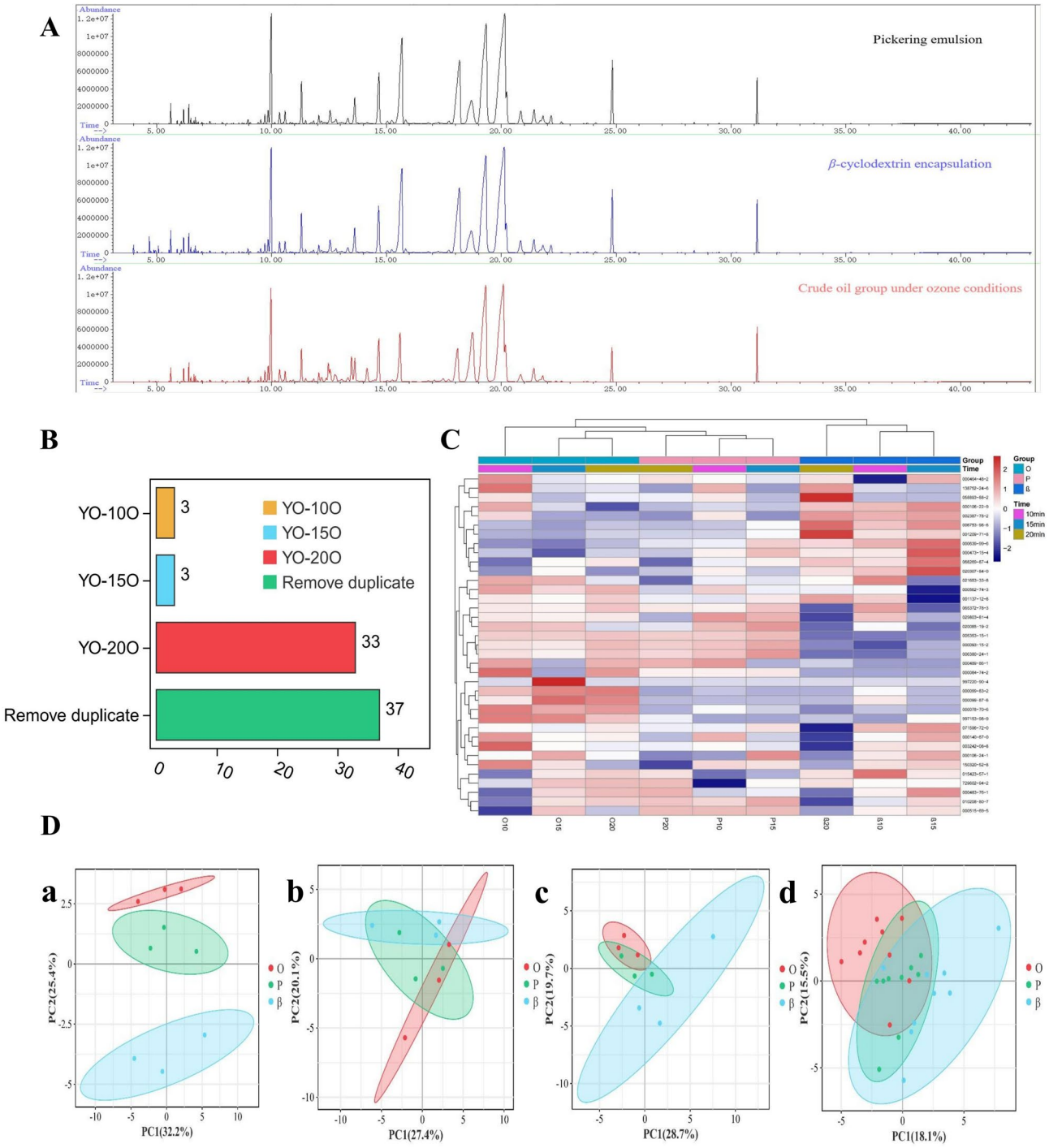

Fig. 3. Selection of differential components in ozone environment. **(A)** GC-MS chromatogram stack plot of Pickering emulsion, *β*-cyclodextrin encapsulation, and crude oil group under ozone conditions. **(B)** Bar chart of different time intervals under ozone exposure. **(C)** Heatmap of the 37 differential components. **(D)** PCA diagram of differential components in ozone environment. **(a)** PCA plot of differential components in different groups after 10 min of ozone exposure. **(b)** PCA plot of differential components in different groups after 15 min of ozone exposure. **(c)** PCA plot of differential components in different groups after 20 min of ozone exposure. **(d)** Overall PCA plot of differential components in different groups under ozone exposure.

the compositional changes of volatile oils caused by ozone exposure. By reducing the oxidative loss of major components, these technologies help maintain the bioactivity and chemical stability of volatile oils, demonstrating consistent antioxidant capabilities[14,38–41].

This study compares and analyzes the variations of peroxide value, differential components, quantitative components, qualitative components, and major components of ATaAL-VO in the presence of ozone, as well

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000076-22-2	15 O	6.1753	0.4184	Camphor	67,090	97
	15 P	6.1753	0.2719	Camphor	67,090	97
	15 β	–	–	–	–	–
000076-49-3	15 O	7.8647	0.0466	Bornyl acetate	179,280	98
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000078-70-6	15 O	5.6157	0.4821	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	15 P	5.6156	0.3471	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	15 β	5.6157	0.235	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
000079-92-5	15 O	4.1545	0.0335	Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene-	40,249	97
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000080-56-8	15 O	3.9992	0.1597	.alpha.-Pinene	40,324	95
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000087-44-5	15 O	10.5901	0.5979	Isocaryophyllene	204,346	99
	15 P	10.59	0.5289	Isocaryophyllene	204,346	99
	15 β	10.59	0.7183	Caryophyllene	204,349	99
000093-15-2	15 O	9.9786	5.5567	Methyleugenol	127,477	96
	15 P	9.9889	5.4275	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,483	96
	15 β	9.9682	5.4158	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,482	96
000099-83-2	15 O	4.683	0.3188	.alpha.-phellandrene (only name in Wiley6)	40,523	95
	15 P	4.683	0.0219	.alpha.-phellandrene (only name in Wiley6)	40,523	95
	15 β	4.6831	0.102	.alpha.-phellandrene (only name in Wiley6)	40,523	95
000099-86-5	15 O	6.6315	0.073	1,3-Cyclohexadiene, 1-methyl-4-(1-methylethyl)-	40,781	91
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000099-87-6	15 O	4.8903	0.1548	Benzene, 1-methyl-4-(1-methylethyl)-	37,380	94
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000104-20-1	15 O	12.5487	0.8448	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
	15 P	12.5486	0.8535	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
	15 β	12.5487	0.8931	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
000105-90-8	15 O	9.4295	0.0632	Geranyl propionate	223,873	87
	15 P	9.4293	0.058	Geranyl propionate	223,873	91
	15 β	9.4294	0.0765	Geranyl propionate	223,873	87
000106-22-9	15 O	6.9734	0.073	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
	15 P	6.9732	0.0652	6-Octen-1-ol, 3,7-dimethyl-	76,893	97
	15 β	6.9733	0.0795	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
000106-24-1	15 O	7.3153	0.0899	Geraniol	71,982	93
	15 P	7.3152	0.0861	Geraniol	71,983	93
	15 β	7.3153	0.1402	Geraniol	71,983	93
000140-67-0	15 O	6.6935	0.3228	Anisole, p-allyl-	59,576	96
	15 P	6.6934	0.1425	Anisole, p-allyl-	59,576	97
	15 β	6.6935	0.2959	Anisole, p-allyl-	59,576	97
000451-55-8	15 O	12.0618	0.442	1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene	204,326	97
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000464-45-9	15 O	6.393	0.3948	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	15 P	6.3929	0.3882	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	15 β	6.3929	0.3811	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
000464-48-2	15 O	6.1755	0.4185	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,089	97
	15 P	6.1753	0.3221	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,094	97
	15 β	6.1753	0.3143	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,094	97

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000473-15-4	15 O	20.0931	26.3759	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,360	99
	15 P	20.1551	25.8367	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,360	99
	15 β	20.1345	31.1691	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,360	99
000483-76-1	15 O	13.6162	1.7323	.delta.-Cadinene	204,022	98
	15 P	13.6264	1.6711	.delta.-Cadinene	204,022	98
	15 β	13.6161	1.5052	.delta.-Cadinene	204,022	98
000489-40-7	15 O	17.7201	0.1983	.alpha.-Gurjunene	204,569	68
	15 P	–	–	–	–	–
	15 β	15.2432	0.4526	.alpha.-Gurjunene	204,563	90
000489-86-1	15 O	16.8287	0.1022	Guaiol	265,977	99
	15 P	16.8287	0.1046	Guaiol	265,977	99
	15 β	16.8184	0.1092	Guaiol	265,977	99
000508-32-7	15 O	4.963	0.1047	Tricyclo[2.2.1.02,6]heptane, 1,7,7-trimethyl-	40,590	86
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
000515-17-3	15 O	8.9839	0.1565	Naphthalene, decahydro-4a-methyl-1-methylene-7-(1-methylethylidene)-, (4aR-trans)-	204,517	70
	15 P	–	–	–	–	–
	15 β	8.9838	0.1741	.gamma.-Selinene	204,516	70
000515-69-5	15 O	21.8134	1.0737	.alpha.-Bisabolol	265,906	90
	15 P	21.8236	0.8136	.alpha.-Bisabolol	265,906	90
	15 β	21.8134	0.9436	.alpha.-Bisabolol	265,906	90
000523-47-7	15 O	13.067	0.2982	.beta.-Cadinene	204,611	95
	15 P	–	–	–	–	–
	15 β	13.0668	0.3769	Naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,616	95
000562-74-3	15 O	6.4966	0.1404	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	15 P	6.4965	0.1113	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	15 β	6.4966	0.1204	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
000629-97-0	15 O	31.1299	1.3311	Docosane	571,714	99
	15 P	31.1298	1.2304	Docosane	571,714	99
	15 β	31.1298	1.3573	Docosane	571,714	99
000639-99-6	15 O	14.6628	3.4102	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,534	91
	15 P	14.673	3.7683	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
	15 β	14.6731	4.4877	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
001137-12-8	15 O	9.533	0.1767	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
	15 P	9.5329	0.1758	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,686	99
	15 β	9.533	0.1862	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
001209-71-8	15 O	18.6941	4.4775	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	15 P	18.694	4.6486	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	15 β	18.6837	5.6495	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	98
002387-78-2	15 O	10.1549	0.0596	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	15 P	10.1547	0.0533	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	15 β	10.1548	0.066	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
002883-98-9	15 O	18.1552	9.7643	Asarone	216,637	97
	15 P	18.1551	9.706	Asarone	216,632	97
	15 β	18.1033	5.8167	Asarone	216,637	97
003242-08-8	15 O	10.818	0.0693	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,876	93
	15 P	10.818	0.0737	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,880	96
	15 β	10.8181	0.1	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,880	95
003779-61-1	15 O	5.077	0.1299	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	40,369	96
	15 P	–	–	–	–	–
	15 β	5.0769	0.0499	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	40,369	96
004057-31-2	15 O	7.8645	0.0471	1,3,3-Trimethylbicyclo[2.2.1]hept-2-yl acetate	179,262	99
	15 P	7.8645	0.0454	1,3,3-Trimethylbicyclo[2.2.1]hept-2-yl acetate	179,262	99
	15 β	7.8645	0.0583	1,3,3-Trimethylbicyclo[2.2.1]hept-2-yl acetate	179,262	99

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
004630-07-3	15 O	19.2951	18.0185	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	15 P	19.3054	18.3938	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	15 β	19.3262	21.5497	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
005273-86-9	15 O	21.6995	0.227	.beta.-Asarone	216,643	95
	15 P	21.7096	0.2238	.beta.-Asarone	216,643	95
	15 β	–	–	–	–	–
005353-15-1	15 O	15.6577	9.6362	.gamma.-Asarone	216,177	97
	15 P	15.6577	9.5374	.gamma.-Asarone	216,177	97
	15 β	15.5955	5.1431	.gamma.-Asarone	216,177	96
005794-04-7	15 O	4.1547	0.0339	Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene-, (1 S)-	40,247	97
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
005989-08-2	15 O	9.0771	0.0714	Tricyclo[5.4.0.0(2,8)]undec-9-ene, 2,6,6,9-tetramethyl-, (1R,2 S,7R,8R)-	204,074	99
	15 P	9.077	0.0597	Tricyclo[5.4.0.0(2,8)]undec-9-ene, 2,6,6,9-tetramethyl-, (1R,2 S,7R,8R)-	204,074	99
	15 β	9.0771	0.0816	.alpha.-Longipinene	204,069	99
006380-24-1	15 O	11.3051	2.0286	(Z)-Methyl isoeugenol	127,050	97
	15 P	11.3154	2.0692	(Z)-Methyl isoeugenol	127,050	97
	15 β	11.3051	1.8214	(Z)-Methyl isoeugenol	127,050	97
006753-98-6	15 O	11.4917	0.1712	.alpha.-Humulene	203,988	98
	15 P	11.4916	0.1769	.alpha.-Humulene	203,988	98
	15 β	11.4813	0.2173	.alpha.-Humulene	203,988	98
006813-21-4	15 O	15.834	0.3274	Eudesma-3,7(11)-diene	204,727	52
	15 P	15.8442	0.3427	Eudesma-3,7(11)-diene	204,727	55
	15 β	–	–	–	–	–
006831-16-9	15 O	8.9838	0.1835	Aristolene	204,005	89
	15 P	8.9838	0.1698	Aristolene	204,005	89
	15 β	–	–	–	–	–
007785-26-4	15 O	3.9992	0.1519	(1 S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene	40,321	96
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
010208-80-7	15 O	12.8078	0.4391	.alpha.-Muurolene	204,478	97
	15 P	12.8077	0.4403	.alpha.-Muurolene	204,479	98
	15 β	12.8078	0.4546	.alpha.-Muurolene	204,479	98
013877-91-3	15 O	5.077	0.1327	.beta.-Ocimene	40,365	97
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
015423-57-1	15 O	15.0462	0.2076	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
	15 P	15.0461	0.2155	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,056	99
	15 β	15.0462	0.2648	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
019912-62-0	15 O	20.1865	1.7196	4-Isopropyl-1,6-dimethyl-1,2,3,4,4a,7,8,8a-octahydro-1-naphthalenol	265,715	97
	15 P	20.2277	1.7488	4-Isopropyl-1,6-dimethyl-1,2,3,4,4a,7,8,8a-octahydro-1-naphthalenol	265,715	99
	15 β	–	–	–	–	–
019912-67-5	15 O	17.7096	0.1966	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	15 P	17.7198	0.2077	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	15 β	17.7096	0.2302	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
020085-19-2	15 O	12.1756	0.1519	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	96
	15 P	12.1756	0.1569	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	96
	15 β	12.1756	0.1873	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	96
020307-84-0	15 O	8.7247	0.0548	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	95
	15 P	8.7246	0.0443	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	95
	15 β	8.7247	0.1307	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	97
021653-33-8	15 O	21.4092	1.2291	Acorenone B	257,617	99
	15 P	21.4195	1.2681	Acorenone B	257,617	99
	15 β	21.4196	1.3698	Acorenone B	257,617	99

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
021698-46-4	15 O	17.2537	0.1181	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	78
	15 P	17.2536	0.1261	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	78
	15 *β*	–	–	–	–	–
023986-74-5	15 O	12.2792	0.1693	(-)-Germacrene D	204,036	97
	15 P	12.2792	0.1712	Germacrene D	204,033	97
	15 *β*	12.2792	0.2071	Germacrene D	204,032	97
024406-05-1	15 O	14.155	0.1499	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,482	97
	15 P	–	–	–	–	–
	15 *β*	–	–	–	–	–
029050-33-7	15 O	5.5433	0.0659	(+)-4-Carene	40,434	96
	15 P	–	–	–	–	–
	15 *β*	–	–	–	–	–
029803-81-4	15 O	5.8955	0.0782	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	15 P	5.8954	0.0684	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	15 *β*	5.8955	0.0545	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
029803-82-5	15 O	5.8957	0.0772	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
	15 P	6.0716	0.0536	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,122	97
	15 *β*	5.8956	0.0786	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
029873-99-2	15 O	10.8182	0.0699	.gamma.-Elemene	203,875	95
	15 P	–	–	–	–	–
	15 *β*	–	–	–	–	–
035010-17-4	15 O	24.1038	0.0802	1-(2'-Nitrophenyl)-2-phenylacetylene	268,234	59
	15 P	–	–	–	–	–
	15 *β*	–	–	–	–	–
035727-45-8	15 O	22.1555	0.6041	Cyclohexanol, 3-ethenyl-3-methyl-2-(1-methylethenyl)-6-(1-methylethyl)-, [1R-(1.alpha.,2.alpha.,3.beta.,6.alpha.)]-	266,054	70
	15 P	–	–	–	–	–
	15 *β*	–	–	–	–	–
039029-41-9	15 O	13.3259	0.4224	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	99
	15 P	13.3258	0.3953	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	98
	15 *β*	13.3156	0.4628	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	95
065372-78-3	15 O	9.8543	0.5421	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	15 P	9.8542	0.564	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	15 *β*	9.8543	0.7217	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
068269-87-4	15 O	9.7092	0.3819	Modephene	203,866	97
	15 P	9.7091	0.3446	Modephene	203,866	97
	15 *β*	9.7092	0.6226	Modephene	203,866	97
071596-72-0	15 O	10.3517	0.5466	.beta.-isocomene	204,223	99
	15 P	10.3516	0.5145	.beta.-isocomene	204,223	95
	15 *β*	10.3517	0.6217	.beta.-isocomene	204,223	99
078781-34-7	15 O	20.829	1.3357	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	78
	15 P	20.8392	1.3364	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	83
	15 *β*	–	–	–	–	–
094482-89-0	15 O	12.0618	0.4353	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	15 P	12.0615	0.4376	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	15 *β*	12.0616	0.4867	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
138752-24-6	15 O	8.5797	0.0467	Silphiperfol-5-ene	204,398	97
	15 P	8.5795	0.0366	Silphiperfol-5-ene	204,398	98
	15 *β*	8.5797	0.0578	Silphiperfol-5-ene	204,398	98
150320-52-8	15 O	11.7196	0.0909	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
	15 P	11.7196	0.0914	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
	15 *β*	11.7197	0.1059	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
729602-94-2	15 O	11.8234	0.1463	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
	15 P	11.8232	0.1502	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
	15 *β*	11.8233	0.1721	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
997153-98-9	15 O	24.829	3.081	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	96
	15 P	24.829	3.0477	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	97
	15 β	22.6114	0.0964	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	97
997220-06-9	15 O	20.829	1.3064	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
	15 P	20.8288	1.3247	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
	15 β	20.8289	1.4745	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
997220-90-4	15 O	17.2536	0.1232	1-Cycloheptene, 1,4-dimethyl-3-(2-methyl-1-propene-1-yl)-4-vinyl-	204,268	90
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
997220-91-2	15 O	15.8338	0.3489	.beta.-Panasinsene	204,276	80
	15 P	–	–	–	–	–
	15 β	–	–	–	–	–
997221-34-6	15 O	15.2431	0.3574	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	92
	15 P	15.243	0.3542	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	91
	15 β	15.2431	0.44	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	91
997340-11-2	15 O	24.1036	0.0743	Isocalamendiol	320,570	90
	15 P	24.1036	0.0577	Isocalamendiol	320,570	78
	15 β	–	–	–	–	–
000084-74-2	15 O	–	–	–	–	–
	15 P	28.3939	0.035	Dibutyl phthalate	460,421	94
	15 β	–	–	–	–	–
003691-12-1	15 O	–	–	–	–	–
	15 P	8.9837	0.1517	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1 S-(1.alpha.,4.alpha.,7.alpha.)]-	203,859	60
	15 β	–	–	–	–	–
007785-53-7	15 O	–	–	–	–	–
	15 P	6.6312	0.072	3-Cyclohexene-1-methanol, .alpha.,.alpha.,4-trimethyl-, (R)-	72,768	91
	15 β	–	–	–	–	–
068705-63-5	15 O	–	–	–	–	–
	15 P	9.4294	0.0596	Butanoic acid, 2-methyl-, 3,7-dimethyl-2,6-octadienyl ester, (E)-	320,915	90
	15 β	–	–	–	–	–
090457-37-7	15 O	–	–	–	–	–
	15 P	11.8232	0.1434	Spiro[4.5]dec-7-ene, 1,8-dimethyl-4-(1-methylethenyl)-, [1 S-(1.alpha.,4.beta.,5.alpha.)]-	203,964	96
	15 β	–	–	–	–	–
997288-22-8	15 O	–	–	–	–	–
	15 P	24.1035	0.067	1-naphthalenyl dihydrogen phosphate	269,687	78
	15 β	–	–	–	–	–
000106-25-2	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	7.3153	0.1173	2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)-	71,992	94
000109-20-6	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	9.4294	0.0677	Geranyl isovalerate	320,997	87
000483-75-0	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	12.1757	0.4073	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-	204,484	97
000489-39-4	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	14.1447	0.175	1,1,7-Trimethyl-4-methylenedecahydro-1 H-cyclopropa[e]azulene	204,136	92
017334-55-3	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	10.9217	0.0588	1 H-Cyclopropa[a]naphthalene, 1a,2,3,5,6,7,7a,7b-octahydro-1,1,7,7a-tetramethyl-, [1aR-(1a.alpha.,7.alpha.,7a.alpha.,7b.alpha.)]-	204,285	98
020126-76-5	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	6.4966	0.1549	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-, (R)-	72,749	97

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
022567-17-5	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	15.8235	0.3167	1.beta.,4.beta.H,10.beta.H-Guaia-5,11-diene	203,958	89
023515-88-0	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	12.1756	0.1865	(1 S,4aR,8aS)-1-isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,473	97
025905-14-0	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	9.4294	0.0709	2-Isopropenyl-5-methyl-4-hexenyl acetate	179,199	90
074806-55-6	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	17.2432	0.2638	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methylethenyl)-, (1.alpha.,2.beta.,3.alpha.,	167,382	55
118173-08-3	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	15.8235	0.3257	Selin-6-en-4.alpha.-ol	265,838	78
997220-41-0	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	11.8233	0.1806	Italicene	203,893	96
997221-08-8	15 O	–	–	–	–	–
	15 P	–	–	–	–	–
	15 β	8.9838	0.2502	(+)-.alpha.-Selinene	204,401	78
005655-61-8	15 O	–	–	–	–	–
	15 P	7.8644	0.0418	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
	15 β	7.8646	0.0505	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
005956-05-8	15 O	–	–	–	–	–
	15 P	21.4298	1.3226	Acorenone	257,619	99
	15 β	21.4196	1.3317	Acorenone	257,619	99
086000-71-7	15 O	–	–	–	–	–
	15 P	17.2535	0.1273	Naphthalene, 1,2,3,4,5,8-hexahydro-6-methoxy-7-methyl-1-(1-methylethyl)-, (.+-.)-	257,398	90
	15 β	17.2536	0.1814	Naphthalene, 1,2,3,4,5,8-hexahydro-6-methoxy-7-methyl-1-(1-methylethyl)-, (.+-.)-	257,398	90
112421-19-9	15 O	–	–	–	–	–
	15 P	15.2431	0.3623	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	92
	15 β	15.2431	0.4507	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	92

Table 3. Compound identification information in the environment of ozone for 15 min. – indicates that the corresponding group does not contain the parameter of this component.

as the stabilizing effects of Pickering emulsion and β-cyclodextrin. The advantages of Pickering emulsion and β-cyclodextrin in stabilizing the different groups of ATaAL-VO are elucidated. This research provides valuable insights for enhancing the quality of ATaAL-VO.

Conclusion

In this study, based on the concept of drug-assisted combination, Pickering emulsion was successfully prepared using PEG 4000 and finely ground indigo Naturalis via the melting method. It was applied to the stability of ATaAL-VO and rhizome in ozone environment. At the same time, we compared the change trend of volatile components of β-cyclodextrin and Pickering emulsion in ozone environment. In the ozone environment, the variation of volatile components of essential oils with time was analyzed from three aspects: quantity change, quality change and principal component change. In the above research process, we found that compared with

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000076-22-2	20 O	6.1753	0.4104	Camphor	67,090	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
000078-70-6	20 O	5.6157	0.408	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	20 P	5.6158	0.277	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
	20 β	5.6158	0.2725	1,6-Octadien-3-ol, 3,7-dimethyl-	71,792	97
000080-56-8	20 O	3.9991	0.1411	.alpha.-Pinene	40,324	95
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
000084-74-2	20 O	28.394	0.0677	Dibutyl phthalate	460,421	94
	20 P	28.394	0.034	Dibutyl phthalate	460,421	94
	20 β	–	–	–	–	–
000087-44-5	20 O	10.5901	0.597	Caryophyllene	204,349	99
	20 P	10.5901	0.5087	Caryophyllene	204,349	99
	20 β	10.5901	0.7229	Caryophyllene	204,349	99
000093-15-2	20 O	9.9786	5.5388	Methyleugenol	127,477	96
	20 P	9.9787	5.7937	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,483	96
	20 β	9.9683	4.9153	Benzene, 1,2-dimethoxy-4-(2-propenyl)-	127,483	96
000099-83-2	20 O	4.683	0.2698	.alpha.-phellandrene (only name in Wiley6)	40,523	95
	20 P	–	–	–	–	–
	20 β	4.6933	0.0408	.alpha.-phellandrene (only name in Wiley6)	40,523	91
000099-87-6	20 O	4.8903	0.1561	p-Cymene	37,379	94
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
000105-90-8	20 O	9.4293	0.0637	Geranyl propionate	223,873	91
	20 P	9.4294	0.0596	Geranyl propionate	223,873	91
	20 β	9.4295	0.0683	Geranyl propionate	223,873	87
000106-22-9	20 O	6.9733	0.0726	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
	20 P	6.9734	0.066	6-Octen-1-ol, 3,7-dimethyl-	76,893	96
	20 β	6.9734	0.0752	6-Octen-1-ol, 3,7-dimethyl-	76,893	97
000106-24-1	20 O	7.3153	0.0894	Geraniol	71,983	93
	20 P	7.3153	0.0795	Geraniol	71,983	93
	20 β	7.3155	0.1003	Geraniol	71,983	93
000106-25-2	20 O	7.3153	0.0786	2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)-	71,992	94
	20 P	7.3153	0.0881	2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)-	71,992	94
	20 β	7.3256	0.0947	NEROL	71,995	95
000140-67-0	20 O	6.6935	0.1618	Anisole, p-allyl-	59,576	96
	20 P	6.6936	0.1253	Anisole, p-allyl-	59,576	97
	20 β	6.6937	0.2606	Anisole, p-allyl-	59,576	97
000451-55-8	20 O	12.0616	0.4365	1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene	204,326	97
	20 P	–	–	–	–	–
	20 β	12.0617	0.4641	1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene	204,326	97
000464-45-9	20 O	6.393	0.406	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	20 P	6.393	0.3659	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
	20 β	6.393	0.3989	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1 S-endo)-	71,884	94
000464-48-2	20 O	6.1753	0.4069	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,089	97
	20 P	6.1754	0.2544	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,094	97
	20 β	6.1754	0.3279	Bicyclo[2.2.1]heptan-2-one, 1,7,7-trimethyl-, (1 S)-	67,089	97
000473-15-4	20 O	20.0931	25.3058	.beta.-Eudesmol	265,353	99
	20 P	20.0931	25.7313	.beta.-Eudesmol	265,353	99
	20 β	20.1139	31.3303	2-Naphthalenemethanol, decahydro-.alpha.,.alpha.,4a-trimethyl-8-methylene-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,360	99
000483-76-1	20 O	13.6161	1.6059	.delta.-Cadinene	204,022	98
	20 P	13.6161	1.7862	.delta.-Cadinene	204,022	98
	20 β	13.6264	1.8225	.delta.-Cadinene	204,022	98

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000489-86-1	20 O	16.8287	0.102	Guaiol	265,977	99
	20 P	16.8287	0.1082	Guaiol	265,977	99
	20 β	16.8286	0.1448	Guaiol	265,977	99
000515-17-3	20 O	8.9838	0.1585	Naphthalene, decahydro-4a-methyl-1-methylene-7-(1-methylethylidene)-, (4aR-trans)-	204,517	70
	20 P	8.9838	0.1758	.gamma.-Selinene	204,516	70
	20 β	8.9839	0.193	.gamma.-Selinene	204,516	78
000515-69-5	20 O	21.8134	0.8773	.alpha.-Bisabolol	265,906	90
	20 P	21.8134	1.0264	.alpha.-Bisabolol	265,906	91
	20 β	21.8135	0.9303	.alpha.-Bisabolol	265,906	90
000523-47-7	20 O	13.0669	0.286	Naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,616	95
	20 P	13.0669	0.2804	.beta.-Cadinene	204,611	95
	20 β	–	–	–	–	–
000527-84-4	20 O	4.8903	0.0552	o-Cymene	37,575	94
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
000562-74-3	20 O	6.4966	0.119	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	20 P	6.4967	0.0992	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
	20 β	6.4967	0.1269	3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-	72,748	97
000629-97-0	20 O	31.1299	1.3655	Docosane	571,714	99
	20 P	31.1299	1.3968	Docosane	571,714	99
	20 β	31.1299	1.4474	Docosane	571,714	99
000639-99-6	20 O	14.6628	3.4195	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
	20 P	14.6628	3.7321	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
	20 β	14.6732	4.5444	Cyclohexanemethanol, 4-ethenyl-.alpha.,.alpha.,4-trimethyl-3-(1-methylethenyl)-, [1R-(1.alpha.,3.alpha.,4.beta.)]-	265,535	91
001117-61-9	20 O	6.9733	0.0731	6-Octen-1-ol, 3,7-dimethyl-, (R)-	76,885	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
001137-12-8	20 O	9.533	0.1778	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
	20 P	9.5331	0.1747	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
	20 β	9.5331	0.2018	1,2,4-Methenoazulene, decahydro-1,5,5,8a-tetramethyl-	204,687	99
001209-71-8	20 O	18.6941	4.4896	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	20 P	18.6941	4.7386	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
	20 β	18.7458	10.0944	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, (2R-cis)-	266,051	99
002387-78-2	20 O	10.1548	0.0587	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	20 P	10.1548	0.0585	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
	20 β	10.1547	0.0848	3 H-3a,7-Methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-, [3aR-(3a.alpha.,4.beta.,7.alpha.)]-	204,530	98
002883-98-9	20 O	18.1655	9.7319	Asarone	216,632	97
	20 P	18.1552	9.589	Asarone	216,637	97
	20 β	18.0929	4.7067	Asarone	216,632	97
003218-36-8	20 O	24.8394	3.1217	[1,1'-Biphenyl]-4-carboxaldehyde	139,647	87
	20 P	24.8291	3.085	[1,1'-Biphenyl]-4-carboxaldehyde	139,647	81
	20 β	24.8189	1.9198	[1,1'-Biphenyl]-4-carboxaldehyde	139,647	87
003242-08-8	20 O	10.818	0.0701	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,876	96
	20 P	10.8181	0.0771	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)-	203,876	96
	20 β	–	–	–	–	–
003779-61-1	20 O	5.0768	0.1262	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	40,369	96
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
004630-07-3	20 O	19.3055	17.912	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	20 P	19.3055	18.8096	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
	20 β	19.3158	19.3547	4.beta.H,5.alpha.-Eremophila-1(10),11-diene	204,466	91
005273-86-9	20 O	21.689	0.2164	.beta.-Asarone	216,643	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–

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CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
005353-15-1	20 O	15.6576	9.6164	.gamma.-Asarone	216,177	96
	20 P	15.6577	9.671	.gamma.-Asarone	216,177	97
	20 β	15.5954	4.6044	.gamma.-Asarone	216,177	96
005655-61-8	20 O	7.8645	0.0464	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
	20 P	7.8646	0.0461	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, acetate, (1 S-endo)-	179,283	98
	20 β	–	–	–	–	–
005794-04-7	20 O	4.1545	0.0291	Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene-, (1 S)-	40,247	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
005956-05-8	20 O	21.4092	1.2658	Acorenone	257,619	99
	20 P	21.4093	1.2968	Acorenone	257,619	99
	20 β	21.4195	1.5013	Acorenone	257,619	99
005989-08-2	20 O	9.077	0.0727	.alpha.-Longipinene	204,069	99
	20 P	9.0771	0.0673	.alpha.-Longipinene	204,069	99
	20 β	9.077	0.0605	.alpha.-Longipinene	204,069	99
006380-24-1	20 O	11.3051	2.0352	(Z)-Methyl isoeugenol	127,050	97
	20 P	11.3052	2.0562	(Z)-Methyl isoeugenol	127,050	97
	20 β	11.3051	1.8758	(Z)-Methyl isoeugenol	127,050	97
006753-98-6	20 O	11.4813	0.1701	.alpha.-Humulene	203,988	98
	20 P	11.4917	0.1686	.alpha.-Humulene	203,988	98
	20 β	11.4916	0.2841	.alpha.-Humulene	203,988	98
006813-21-4	20 O	15.8338	0.3378	Eudesma-3,7(11)-diene	204,727	84
	20 P	–	–	–	–	–
	20 β	14.414	0.1294	Eudesma-3,7(11)-diene	204,726	97
007785-53-7	20 O	6.6313	0.0719	3-Cyclohexene-1-methanol, .alpha.,.alpha.,4-trimethyl-, (R)-	72,768	91
	20 P	6.6314	0.0685	3-Cyclohexene-1-methanol, .alpha.,.alpha.,4-trimethyl-, (R)-	72,768	91
	20 β	6.6312	0.3813	3-Cyclohexene-1-methanol, .alpha.,.alpha.,4-trimethyl-, (R)-	72,768	91
007785-70-8	20 O	3.9991	0.1481	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene	40,325	96
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
010208-80-7	20 O	12.8077	0.4362	.alpha.-Muurolene	204,479	99
	20 P	12.8078	0.4325	.alpha.-Muurolene	204,479	98
	20 β	12.8079	0.4152	.alpha.-Muurolene	204,479	99
013877-91-3	20 O	5.0768	0.1291	.beta.-Ocimene	40,365	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
015423-57-1	20 O	15.0462	0.2019	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
	20 P	15.0463	0.205	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
	20 β	15.0462	0.1594	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-, (E, E)-	204,054	99
017408-66-1	20 O	17.2536	0.117	7-Isopropyl-4a,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-2(1 H)-naphthalenone	258,338	64
	20 P	–	–	–	–	–
	20 β	17.2433	0.2223	7-Isopropyl-4a,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-2(1 H)-naphthalenone	258,338	60
018252-44-3	20 O	11.7196	0.0933	(1R,2 S,6 S,7 S,8 S)-8-Isopropyl-1-methyl-3-methylenetricyclo[4.4.0.02,7]decane-rel-	204,603	95
	20 P	11.7197	0.0899	(1R,2 S,6 S,7 S,8 S)-8-Isopropyl-1-methyl-3-methylenetricyclo[4.4.0.02,7]decane-rel-	204,603	97
	20 β	–	–	–	–	–
019912-62-0	20 O	20.176	1.7425	4-Isopropyl-1,6-dimethyl-1,2,3,4,4a,7,8,8a-octahydro-1-naphthalenol	265,715	98
	20 P	20.1864	1.7912	4-Isopropyl-1,6-dimethyl-1,2,3,4,4a,7,8,8a-octahydro-1-naphthalenol	265,715	97
	20 β	–	–	–	–	–
019912-67-5	20 O	17.7199	0.1955	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	20 P	17.72	0.1992	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
	20 β	17.7095	0.2602	4a(2 H)-Naphthalenol, 1,3,4,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1 S,4R,4aS,8aR)-	265,394	99
020085-19-2	20 O	12.1756	0.1538	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	97
	20 P	12.1757	0.1652	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	96
	20 β	12.1757	0.1912	(1R,4aS,8aR)-1-Isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,476	97

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CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
020307-84-0	20 O	8.7247	0.0533	.delta.-Elemene	204,748	93
	20 P	8.7247	0.0483	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	97
	20 β	8.7248	0.0874	Cyclohexene, 4-ethenyl-4-methyl-3-(1-methylethenyl)-1-(1-methylethyl)-, (3R-trans)-	204,311	97
021653-33-8	20 O	21.4196	1.239	Acorenone B	257,617	99
	20 P	21.4196	1.281	Acorenone B	257,617	99
	20 β	21.4094	1.5187	Acorenone B	257,617	99
021698-46-4	20 O	17.2535	0.1244	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	86
	20 P	17.2536	0.1276	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	60
	20 β	17.2434	0.1367	(3 S,6 S)-6-Isopropyl-3-methyl-2-(propan-2-ylidene)-3-vinylcyclohexanone	258,321	64
023986-74-5	20 O	12.2792	0.1683	(-)-Germacrene D	204,039	97
	20 P	12.2793	0.1768	(-)-Germacrene D	204,036	97
	20 β	12.2793	0.0972	Germacrene D	204,033	97
024406-05-1	20 O	14.155	0.1655	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1 S-(1.alpha.,4a.beta.,8a.alpha.)]-	204,482	94
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
025905-14-0	20 O	9.4294	0.0636	2-Isopropenyl-5-methyl-4-hexenyl acetate	179,199	86
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
029050-33-7	20 O	5.5432	0.0641	(+)-4-Carene	40,434	97
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
029803-81-4	20 O	5.8955	0.0797	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	20 P	5.8956	0.0513	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
	20 β	5.8956	0.0645	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, trans-	72,121	98
029803-82-5	20 O	5.8955	0.0779	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
	20 P	5.8956	0.0605	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
	20 β	5.8957	0.0595	2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethyl)-, cis-	72,118	98
029873-99-2	20 O	10.818	0.0706	.gamma.-Elemene	203,879	96
	20 P	10.8181	0.0726	.gamma.-Elemene	203,879	95
	20 β	10.818	0.1015	.gamma.-Elemene	203,875	97
030021-74-0	20 O	8.7247	0.0543	.gamma.-Cadinene	204,737	92
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
039029-41-9	20 O	13.3259	0.3828	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	98
	20 P	13.326	0.4426	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	98
	20 β	13.3157	0.4124	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1.alpha.,4a.beta.,8a.alpha.)-	204,744	96
058893-88-2	20 O	14.1549	0.1505	(4aR,8aS)-4a-Methyl-1-methylene-7-(propan-2-ylidene)decahydronaphthalene	204,518	97
	20 P	14.155	0.1632	(4aR,8aS)-4a-Methyl-1-methylene-7-(propan-2-ylidene)decahydronaphthalene	204,518	97
	20 β	14.1549	1.1611	(4aR,8aS)-4a-Methyl-1-methylene-7-(propan-2-ylidene)decahydronaphthalene	204,518	95
065372-78-3	20 O	9.8543	0.5608	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	20 P	9.8543	0.5608	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
	20 β	9.8544	0.6476	(1R,3aS,5aS,8aR)-1,3a,4,5a-Tetramethyl-1,2,3,3a,5a,6,7,8-octahydrocyclopenta[c]pentalene	204,543	97
068269-87-4	20 O	9.7092	0.3748	Modephene	203,866	97
	20 P	9.7092	0.382	Modephene	203,866	97
	20 β	9.7091	0.5134	Modephene	203,866	97
071596-72-0	20 O	10.3517	0.5465	.beta.-isocomene	204,223	99
	20 P	10.3517	0.5516	.beta.-isocomene	204,223	99
	20 β	10.3519	0.6499	.beta.-isocomene	204,223	99
093860-74-3	20 O	20.8288	1.3123	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.alpha.-decahydrocyclopropa[d]naphthalene	265,461	70
	20 P	20.8393	1.3377	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.alpha.-decahydrocyclopropa[d]naphthalene	265,461	70
	20 β	–	–	–	–	–
094482-89-0	20 O	12.0616	0.4287	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	20 P	12.0617	0.4565	(1R,3aR,4aR,8aR)-1,4,4,6-Tetramethyl-1,2,3,3a,4,4a,7,8-octahydrocyclopenta[1,4]cyclobuta[1,2]benzene	203,885	97
	20 β	–	–	–	–	–

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CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
095910-36-4	20 O	12.1756	0.1529	isoledene	204,374	92
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
112421-19-9	20 O	15.2431	0.3547	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	93
	20 P	15.2432	0.3569	(1aR,4R,4aR,7bS)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydro-1 H-cyclopropa[e]azulene	204,570	92
	20 β	–	–	–	–	–
138752-24-6	20 O	8.5796	0.0471	Silphiperfol-5-ene	204,398	98
	20 P	8.5797	0.0389	Silphiperfol-5-ene	204,398	98
	20 β	8.5899	0.0557	Silphiperfol-5-ene	204,398	98
150320-52-8	20 O	11.7196	0.0921	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
	20 P	–	–	–	–	–
	20 β	11.7198	0.0962	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	204,013	97
729602-94-2	20 O	11.8233	0.1416	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
	20 P	11.8233	0.1485	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
	20 β	11.8336	0.2127	(1R,4R,5 S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	203,959	98
997153-98-9	20 O	24.829	3.1091	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	96
	20 P	24.8291	3.0848	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	97
	20 β	24.8186	1.7736	2-[(1E,7E)-Nona-1,7-dien-3,5-diynyl]furan	139,645	97
997220-06-9	20 O	20.8392	1.3226	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
	20 P	20.8186	1.3315	5-methyl-2-(1-methylcyclohexyl)phenol	203,560	68
	20 β	–	–	–	–	–
997221-05-1	20 O	8.9837	0.1868	African-2(6)-ene	204,378	78
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
997221-34-6	20 O	15.2431	0.3543	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	95
	20 P	15.2432	0.3561	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	91
	20 β	15.2433	0.4392	(6 S,7R)-2,2,6-Trimethyl-10-methylene-bicyclo[5.4.0]undec-1(11)-ene	204,601	95
997268-24-9	20 O	23.7409	0.0608	(-)-1.beta.H,7.alpha.H,10.alpha.H-Guaia-4,11-dien-3-one	250,301	86
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
997340-11-2	20 O	24.1036	0.0917	Isocalamendiol	320,570	90
	20 P	–	–	–	–	–
	20 β	–	–	–	–	–
000076-49-3	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	7.8646	0.0518	Bornyl acetate	179,280	99
000088-84-6	20 O	–	–	–	–	–
	20 P	15.8339	0.2915	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethylidene)-, (1 S-cis)-	204,043	80
	20 β	12.3623	0.1922	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethylidene)-, (1 S-cis)-	204,044	90
000104-20-1	20 O	–	–	–	–	–
	20 P	12.5488	0.839	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
	20 β	12.5488	0.8725	2-Butanone, 4-(4-methoxyphenyl)-	127,104	94
000105-87-3	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	9.4295	0.0697	Geranyl acetate	179,150	87
000473-16-5	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	20.8187	1.4641	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,8a-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, [2R-(2.alpha.,4a.alpha.,8a.beta.)]-	265,477	74
000483-75-0	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.1859	0.3398	Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-	204,484	97
000495-60-3	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.3622	0.0971	1,3-Cyclohexadiene, 5-(1,5-dimethyl-4-hexenyl)-2-methyl-, [S-(R*,S*)]-	204,219	92

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CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
000514-51-2	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	17.4711	0.4871	4,7-Methanoazulene, 1,2,3,4,5,6,7,8-octahydro-1,4,9,9-tetramethyl-	203,915	95
000586-62-9	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	8.7246	0.0445	Cyclohexene, 1-methyl-4-(1-methylethylidene)-	40,473	90
000624-15-7	20 O	–	–	–	–	–
	20 P	7.3153	0.0914	NEROL	71,996	93
	20 β	7.3154	0.1042	2,6-Octadien-1-ol, 3,7-dimethyl-	71,985	93
003691-12-1	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	8.9837	0.2308	Azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1 S-(1.alpha.,4.alpha.,7.alpha.)]-	203,860	70
005951-67-7	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	10.9527	0.1839	Cyclohexene, 6-ethenyl-6-methyl-1-(1-methylethyl)-3-(1-methylethylidene)-, (S)-	204,453	90
010219-75-7	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.7662	0.8935	Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1 S-(1.alpha.,7.alpha.,8a.alpha.)]-	204,469	94
013744-15-5	20 O	–	–	–	–	–
	20 P	11.7197	0.0956	1 H-Cyclopenta[1,3]cyclopropa[1,2]benzene, 2,3,3a.alpha.,3b.alpha.,4,5,6,7-octahydro-4.alpha.-isopropyl-7.beta.-methyl-3-methylene-	204,010	95
	20 β	11.7197	0.097	1 H-Cyclopenta[1,3]cyclopropa[1,2]benzene, octahydro-7-methyl-3-methylene-4-(1-methylethyl)-, [3aS-(3a.alpha.,3b.beta.,4.beta.,7.alpha.,7aS*)]-	204,008	96
017066-67-0	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.4761	2.2507	Naphthalene, decahydro-4a-methyl-1-methylene-7-(1-methylethenyl)-, [4aR-(4a.alpha.,7.alpha.,8a.beta.)]-	204,892	99
022451-73-6	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	20.8495	1.0011	5-Azulenemethanol, 1,2,3,3a,4,5,6,7-octahydro-.alpha.,.alpha.,3,8-tetramethyl-, [3 S-(3.alpha.,3a.beta.,5.alpha.)]-	265,711	91
022567-17-5	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	15.8236	0.3118	Azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1R-(1.alpha.,3a.beta.,4.alpha.,7.beta.)]-	203,954	91
063891-61-2	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	17.0773	0.1714	2-Naphthalenemethanol, 2,3,4,4a,5,6,7,8-octahydro-.alpha.,.alpha.,4a,8-tetramethyl-, [2R-(2.alpha.,4a.beta.,8.beta.)]-	265,948	95
078781-34-7	20 O	–	–	–	–	–
	20 P	20.8289	1.3274	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	78
	20 β	20.8289	1.4623	7.alpha.-(1-hydroxy-1-methylethyl)-4a.beta.-methyl-1a.beta.-decahydrocyclopropa[d]naphthalene	265,463	83
092618-89-8	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	7.8647	0.0511	Acetic acid, 1,7,7-trimethyl-bicyclo[2.2.1]hept-2-yl ester	179,287	98
765307-45-7	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.9634	0.1421	(3R,5aR,9 S,9aS)-2,2,5a,9-Tetramethyloctahydro-2 H-3,9a-methanobenzo[b]oxepine	265,610	45
997218-00-9	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	13.4813	1.6634	3-Acetyl-4-hydroxycoumarin	201,551	90
997220-41-0	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	11.8234	0.1818	Italicene	203,893	96
997220-96-1	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	10.362	0.8517	(-)-Selina-5,11-diene	204,320	93
997220-96-6	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	12.0616	0.5693	.gamma.-Curcumene	204,325	96

Continued

CAS	Type	RT	Area Pct	Library/ID	Ref	Qual
997221-08-8	20 O	–	–	–	–	–
	20 P	–	–	–	–	–
	20 β	8.9839	0.1948	(+)-.alpha.-Selinene	204,401	70
000489-40-7	20 O	–	–	–	–	–
	20 P	15.2432	0.286	1 H-Cycloprop[e]azulene, 1a,2,3,4,4a,5,6,7b-octahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.alpha.,4a.beta.,7b.alpha.)]-	204,566	93
	20 β	–	–	–	–	–
022469-52-9	20 O	–	–	–	–	–
	20 P	14.155	0.1669	(+)-Cyclosativene	204,775	91
	20 β	–	–	–	–	–
023515-88-0	20 O	–	–	–	–	–
	20 P	12.1756	0.1606	(1 S,4aR,8aS)-1-isopropyl-4,7-dimethyl-1,2,4a,5,6,8a-hexahydronaphthalene	204,473	95
	20 β	–	–	–	–	–
086000-71-7	20 O	–	–	–	–	–
	20 P	17.2536	0.1239	Naphthalene, 1,2,3,4,5,8-hexahydro-6-methoxy-7-methyl-1-(1-methylethyl)-, (.+-.)-	257,398	90
	20 β	–	–	–	–	–
118173-08-3	20 O	–	–	–	–	–
	20 P	15.8339	0.3306	Selin-6-en-4.alpha.-ol	265,838	83
	20 β	–	–	–	–	–
997153-49-7	20 O	–	–	–	–	–
	20 P	22.6217	0.1022	1-Methyl-5 H-pyrido[4,3-b]indole	139,185	90
	20 β	–	–	–	–	–
997221-24-1	20 O	–	–	–	–	–
	20 P	9.7092	0.3517	9-Methyltetracyclo[7.3.1.0(2.7)0.1(7.11)]tetradecane	204,505	72
	20 β	–	–	–	–	–
997288-22-8	20 O	–	–	–	–	–
	20 P	24.1037	0.0628	1-naphthalenyl dihydrogen phosphate	269,687	86
	20 β	–	–	–	–	–

Table 4. Compound identification information in the environment of ozone for 20 min. – indicates that the corresponding group does not contain the parameter of this component.

the original oil group, the β-cyclodextrin encapsulation group and the Pickering emulsion group exposed to ozone for 10, 15 and 20 min showed a lower degree of oxidation. In addition, GC-MS analysis showed that compared with the crude oil group, the stability of volatile components in the Pickering emulsion group and the β-cyclodextrin encapsulation group was significantly improved. In summary, both the complexation of β-cyclodextrin with ATaAL-VO and the formation of Pickering emulsions can significantly enhance the stability and quality of ATaAL-VO. Numerous studies have demonstrated that Pickering emulsions offer substantial advantages for the stabilization of volatile oils across different environments. Given these benefits, Pickering emulsions represent a promising approach for improving the stability and quality of volatile oils and are expected to have good development prospects in the future.

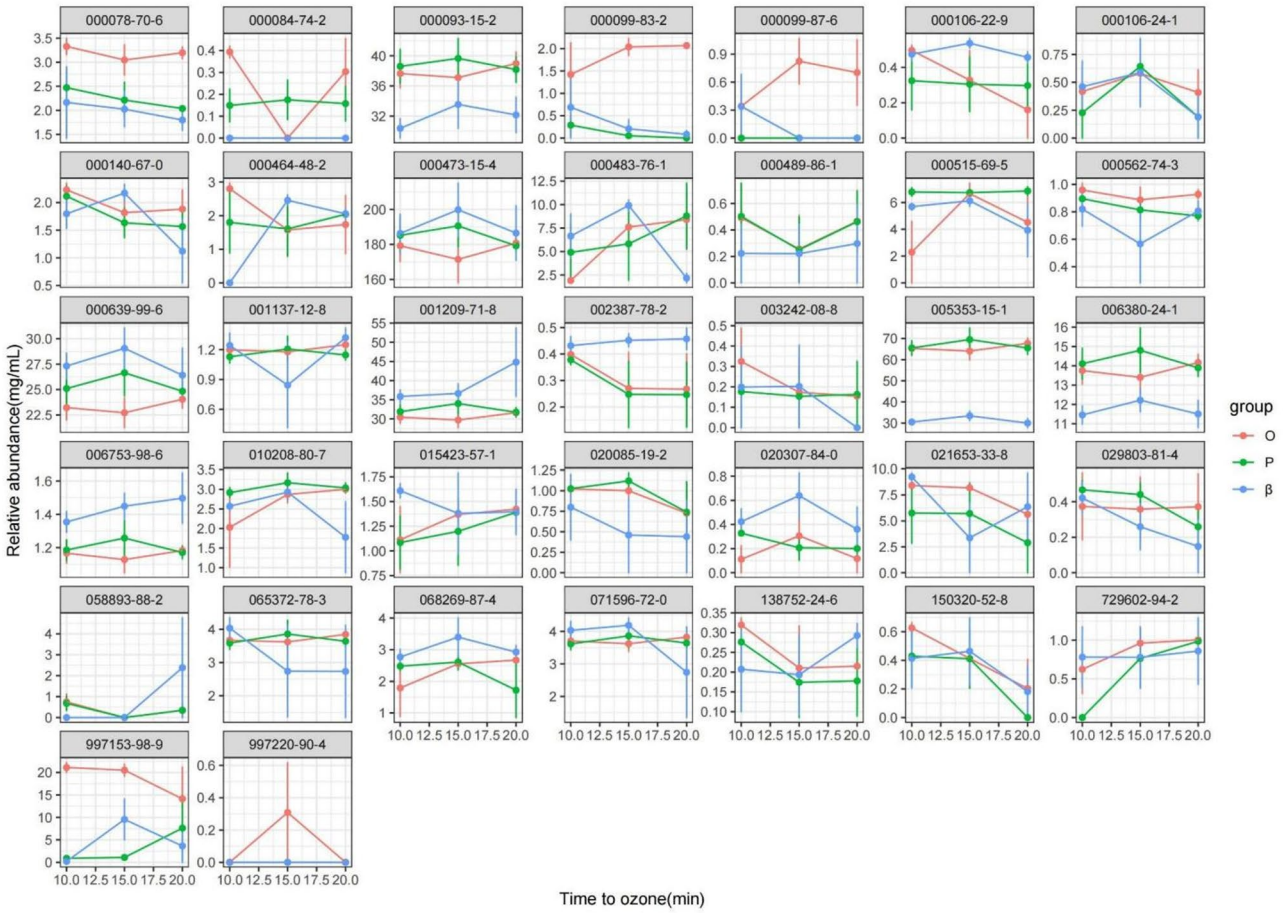
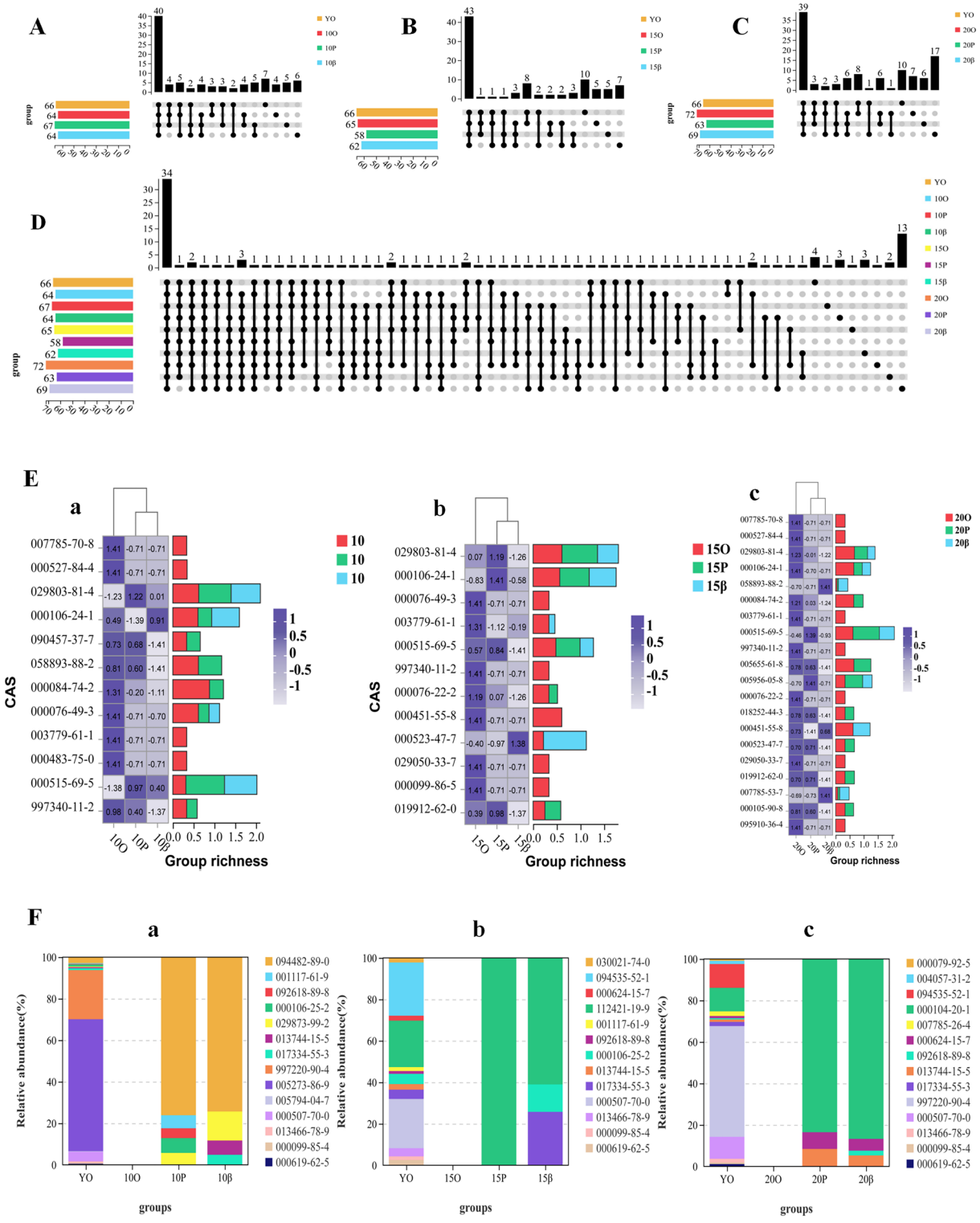


Fig. 4. Linear diagram of different components in each group under ozone environment.


A
B
C
D
E
a
b
c
F
YO
10O
10P
10β
15O
15P
15β
20O
20P
20β
group
CAS
Group richness
Relative abundance(%)
groups

◀**Fig. 5**. Selection and analysis of Volatile oil qualitative change difference compounds in ozone environment. **(A)** Upset diagram of different groups after 10 min of ozone exposure. **(B)** Upset diagram of different groups after 15 min of ozone exposure. **(C)** Upset diagram of different groups after 20 min of ozone exposure. **(D)** Overall Upset diagram of different groups under ozone exposure. **(E)** The heat map stacking diagram of newly generated compounds in each group under ozone environment **(a)** Heatmap stack plots of newly generated compounds in ATaAL-VO after 10 min of ozone exposure in different groups. **(b)** Heatmap stack plots of newly generated compounds in ATaAL-VO after 15 min of ozone exposure in different groups. **(c)** Heatmap stack plots of newly generated compounds in ATaAL-VO after 20 min of ozone exposure in different groups. **(F)** The stacking connection diagram of disappeared compounds in each group under ozone environment. **(a)** Stacked line plots of disappearing compounds in ATaAL-VO after 10 min of ozone exposure. **(b)** Stacked line plots of disappearing compounds in ATaAL-VO after 15 min of ozone exposure. **(c)** Stacked line plots of disappearing compounds in ATaAL-VO after 20 min of ozone exposure.

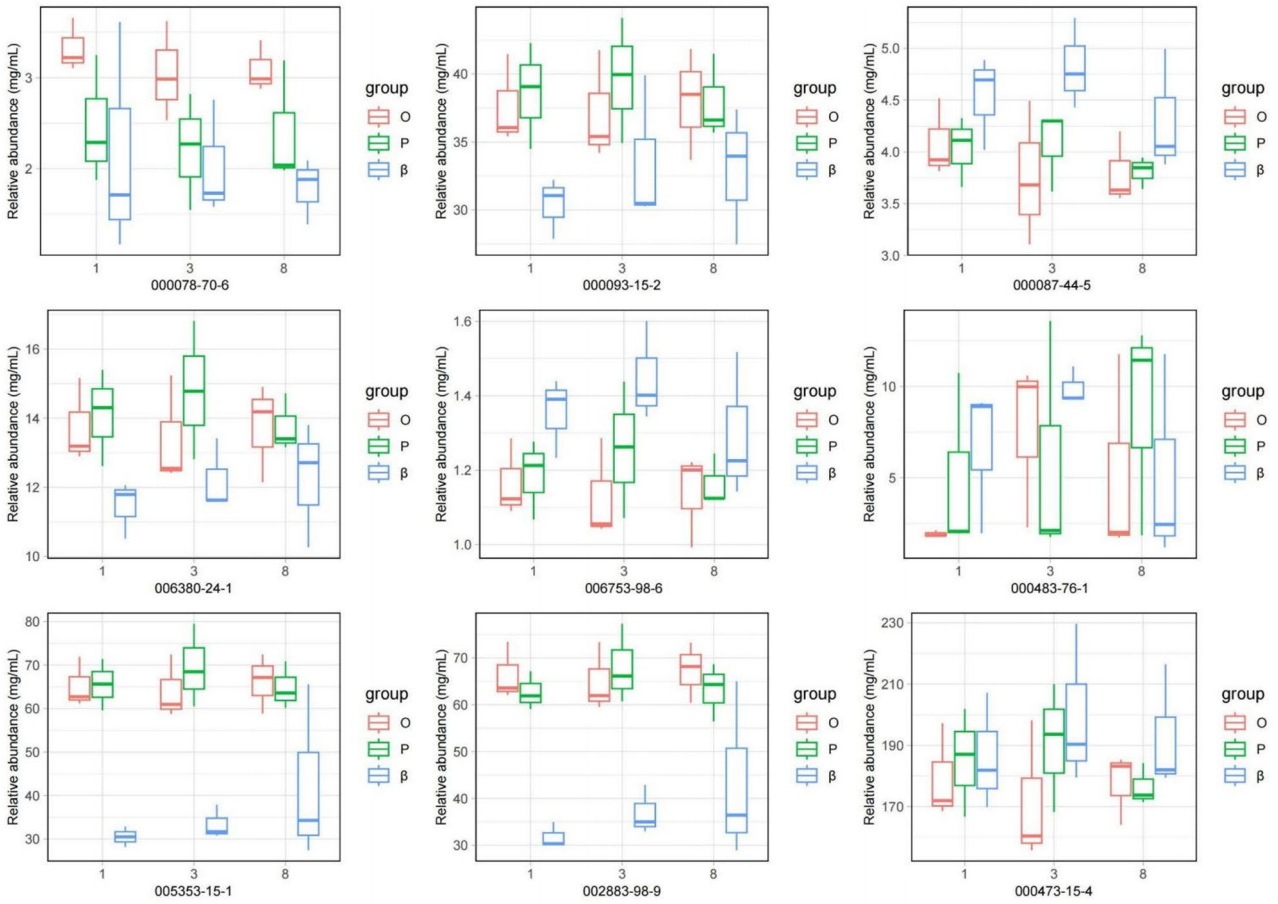


Fig. 6. Boxplots of major component compounds in different groups under ozone conditions.

Data availability

Data is provided within the manuscript information files.

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Author contributions

Fei Luan and Junbo Zou designed this study and amended the final manuscript. Junping Li and Zhongying Chen performed the experiment and wrote the manuscript. Yajun Shi, Jing Sun, and Xiaofei Zhang provided technical help and did data analysis for this experiment. Dongyan Guo, Bingtao Zhai and Fei Luan polished and revised the manuscript. All of the authors have read and approved the final manuscript. All authors contributed substantially to this study and approved the final manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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