

Analyzing Specific Health Hazards in Perfumes by Identifying Ingredients using Gas Chromatography-Mass Spectrometry

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BRIEF. The ingredients in perfumes were identified using Gas Chromatography-Mass Spectrometry then analyzed for health hazards based on data provided on publically available Safety Data Sheets as well as standards set by the United Nations Globally Harmonized System of Classification and Labelling of Chemicals.

ABSTRACT. Studies show there are hazardous chemical ingredients in perfumes known to lead to adverse conditions, such as asthma, rash, and irritation. However, the specific ingredients causing these adverse effects in particular perfumes are not identified. The purpose of this project was to identify organic chemicals in perfumes that have been linked with health hazards. Name-brand perfume samples were analyzed using Gas Chromatography-Mass Spectrometry. Organic chemical ingredients identified were referenced against Safety Data Sheets to determine associated health hazards. Results indicated that every perfume tested had multiple organic ingredients that fell under one or more of the health hazards noted in the United Nations Globally Harmonized System of Classification and Labelling of Chemicals: acute toxicity, skin corrosion/irritation, serious eye damage/irritation, respiration or skin sensitization, germ cell mutagenicity, carcinogenicity, reproductive toxicology, specific target organ toxicity - single exposure, specific target organ toxicity - repeated exposure, and aspiration toxicity. Trade secrets of the fragrances are protected and perfume companies are not required by the Food and Drug Administration to list the fragrance-composing chemicals on ingredient listings. This policy permits potential health dangers to the person wearing the perfume and also to others within proximity of the fragrance.

INTRODUCTION.

Previous studies have shown that the use of perfume can cause adverse health effects, such as asthma, rash, and irritation; however, the exact toxic ingredients in particular perfumes are not fully known [1][2]. Seventy-five percent of asthmatics have experienced asthma attacks triggered by a perfume or cologne [1]. Household products with a fragrance have also been known to affect those with asthma. A study by Vethanayagam et al demonstrated that when exposed to fragranced products, persons without asthma, with mild asthma, or with moderate asthma all showed nasal symptoms [3]. The greatest severity of nasal symptoms occurred in those with moderate asthma.

Fragrance sensitization in the general public is also very common [4]. In previous studies, allergic dermatitis patients in dermatology clinics identified “perfume” as the second most common trigger for an allergic reaction [5]. Persons with multiple chemical sensitivities often complain about respiratory symptoms from the exposure to perfume, as well as asthma or eczema symptoms [6].

Despite concerns about health effects on perfumes, current United States regulations do not require perfume manufacturers to publically list ingredients. Several compounds, however, have been noted by other studies to be present in common fragrances and linked to potential ill health effects. Diethyl phthalate, a chemical commonly used to prolong perfume fragrance, is listed as a toxic and priority pollutant under the United States Clean Water Act [7]. Exposure to phthalates is linked to obesity and insulin resistance [8].

A prior study completed by the Environmental Working Group, a non-profit research and advocacy association, found an average of fourteen unlisted chemicals in seventeen different name-brand perfumes. Of the unlisted chemicals, sixty-six percent had not been assessed by the Food and Drug Administration (FDA). Of the listed chemicals, nineteen percent had not been FDA assessed. There was an average of ten chemicals per perfume tested known to be sensitizers, or chemicals evoking an allergic reaction. On average there were four chemicals per perfume tested known to disrupt human hormones [2].

Despite the above findings, limited information is available about the identity of unlisted chemical ingredients in popular perfumes that may pose serious health risks. In addition, we are not aware of prior published studies in the United States investigating different perfumes of the same popular brand through Gas Chromatography-Mass Spectrometry (GC/MS). Our study utilized GC/MS to identify unlisted organic chemicals in popular perfumes of well-known brands then categorized the health hazards of these GC/MS identified chemicals according to the United Nations Globally Harmonized System of Classification and Labelling of Chemicals (GHS) [9].

MATERIALS AND METHODS.

Selection of Perfumes for Analysis.

Twelve perfumes were selected to represent multiple popular scents in a variety of common cosmetic brands.

Perfume Number	Brand	Scent
1	Bath and Body Works	Sweet Pea
2	Bath and Body Works	Twilight Woods
3	Bath and Body Works	White Citrus
4	Secret	Cocoa Butter Kiss
5	Secret	Ooh La La Lavender
6	Bodycology	Toasted Vanilla Sugar
7	Bodycology	Wild Poppy
8	Essence of Beauty	Citrus Coconut
9	Essence of Beauty	Sun Blossom
10	Elizabeth Taylor	White Diamonds
11	Elizabeth Taylor	Violet Eyes
12	Aqua Velva	Musk

Table 1. The brands, scents and assigned number to the perfumes selected for testing.

Gas Chromatography-Mass Spectrometry.

Organic chemical ingredients in perfumes can be identified using GC/MS. In GC/MS, a substance is heated and separated into groups of molecules based on individual vaporization point. Generally, smaller molecules pass through the GC column at a faster rate than do the larger molecules, allowing separation of the chemicals.

Two milliliters of each selected perfume were measured using a micropipette and dispensed into the GC/MS vial. The vial was sealed with the screw top and placed in an Agilent 7683 Autosampler Tray and Tower (Agilent Technologies, Santa Clara, CA). This experiment utilized Agilent 6890N gas chromatography (Agilent Technologies, Santa Clara, CA) with a column that was 30 mL x 0.25 mm inner diameter x 0.25 um film thickness 5% phenyl-methyl silicone stationary phase and a carrier gas of helium. The GC/MS Parameters were then set in order to maximize the findings as described in Figure 1.

Analytical Conditions	
Injection	1.0 uL
Inlet	S/SI, 300 °C, split ratio= 1:100
Column 1	30.0 m x 250.00 um x 0.25 um Agilent Restek Rxi-5HT
(Carrier gas= He)	Flow = 1.3 mL/min; constant flow
	Inlet = Front Inlet, outlet = MSD
Column 2	15.0 m x 250.00 um x 0.25 um Agilent J&W 122-0112 DB-1ms
(Carrier gas= He)	1.3 mL/min constant flow mode
GC oven temperature	35 °C (5 min) -> 245 °C (35 min) at 6 °C/min
	Total run time = 40 min
MS data acquisition	35-700, samples = 4
MS solvent delay	0.00 min
MS temperatures	Source = 230 °C, quad = 150 °C

Figure 1. The GC/MS Analytical Conditions.

Once passing through the GC column, groups of molecules were analyzed through the Agilent 5975 mass spectrometer (Agilent Technologies, Santa Clara, CA). In the MS, molecules were ionized and filtered based on mass. Number of ions are then counted and plotted on a graph called the mass spectrum.

Identifying the Chemical Composition of Perfumes.

In order to identify each of our unknown compounds, we auto-integrated all chromatograms produced by the GC/MS in order select out the peaks that represented actual perfume ingredients using a minimum area of 7,500. The mass spectra for each peak represented the unknown perfume compounds. The mass spectra were then matched to the chemical fingerprints of known compounds filed in the National Institute of Standards and Technology 2008 Mass Spectral and Retention Index Library (NIST08).

Analyzing Chemicals for Toxicity and Health Hazards.

We used toxicology data found on the publically available chemical- specific Safety Data Sheets (SDS) for the identified compounds. The potential health effects of these compounds were categorized based on the criteria set by the GHS [9]. GHS notes ten health hazard classes of concern: acute toxicity, skin corrosion/irritation, eye effects, sensitization, germ cell mutagenicity, carcinogenicity, reproductive toxicology, target organ systemic toxicity (TOST) single exposure, TOST repeated exposure, and aspiration toxicity. All of these health hazard classes have up to five categories indicating the degree of potential adverse health effects with Category 1 being the most severely toxic.

This study used GC/MS to identify organic compounds in twelve popular perfumes across six common brands. The resultant list of ingredients, some of which were previously unidentified, was further analyzed for toxicity and adverse health effects utilizing their SDS sheets and GHS health hazard. We gave special attention to the Category 1 chemicals, the most severely toxic ingredients.

RESULTS.

Number of Chemicals Identified in Every Perfume.

A total of 130 unique chemicals were identified across the twelve perfumes tested, with the number of organic ingredients ranging from 14–33 per perfume. Of these, a total of 109 unique chemicals across the 12 perfumes are linked to GHS Health Hazard classes, with a range of 12–31 per perfume. Figure 2 illustrates the total number of organic ingredients identified per perfume, as well as the number of these ingredients that are considered toxic according to GHS Health Hazards classes.

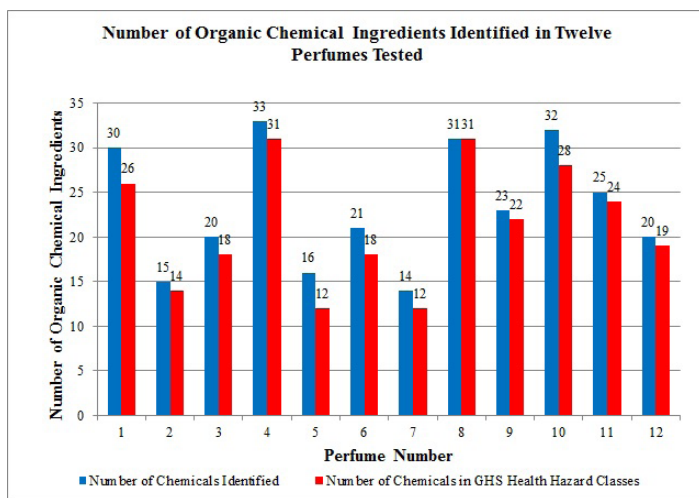


Figure 2. The number of organic compounds found in the perfumes tested.

Category 1 Ingredients.

Each of the ten GHS health hazard classes has criteria for a chemical to be determined as a Category 1 chemical, considered to be of greatest toxicity [9].

Acute Toxicity—the class of Acute Toxicity has five subclasses: Oral, Dermal, Gases, Vapors, and Dust & Mists. Chemicals can be Category 1 for any number of these subclasses based on LD₅₀ and LC₅₀ values for four hour tests. To be in Category 1 for Acute Oral toxicity, the LD₅₀ had to be less than or equal to 5 mg/kg [9]. We found eight of the perfumes had chemicals in the Acute Oral toxicity subclass. Perfume 1 had nine chemicals; perfumes 4, 9, and 12 had two; and perfumes 5, 8, 10, and 11 had one chemical. To be in Category 1 for Acute Dermal toxicity, the LD₅₀ had to be less than or equal to 50 mg/kg [9]. Nine of the perfumes had chemicals in Acute Dermal toxicity. Perfume 1 had seven; perfume 10 had three; perfumes 8 and 9 had two; and perfumes 4, 5, 6, 11, and 12 had one. To be in Category 1 for Acute Gases toxicity, the LC₅₀ had to be less than or equal to 100 ppm [9]. We found that perfumes 3, 4, 7, 9, 10, 11, and 12 all had one chemical in Category 1 for Acute Gases Toxicity. To be in Category 1 for Acute Vapors toxicity, the LC₅₀ had to be less than or equal to 0.5 mg/l [9]. We found perfumes 1 and 10 both had one chemical in Category 1 of Acute Vapors Toxicity. To be in Category 1 for Acute Dusts & Mists toxicity, the LC₅₀ had to be less than or equal to 0.05 mg/l [9]. Only perfume 1 had one chemical that was category one for Acute Dust & Mists Toxicity.

Skin Corrosion—Category 1 chemicals show a destruction of skin tissue in tests not exceeding four hours [9]. We found six perfumes with chemicals meeting these criteria. Perfume 1 had four chemicals; perfumes 4 and 8 had two; and perfumes 5, 6, and 9 all had one.

Eye Effects—Category 1 chemicals show a destruction of eye tissue irreversible within twenty-one days of application [9]. We found seven perfumes with chemicals in this category - perfume 1 had three and perfumes 2, 4, 5, 6, 8 and 12 all had one.

Sensitization—could either be respiratory, affecting the airways, or skin, inducing an allergic response upon contact with the skin. If the chemical causes either of these, GHS defines it as a Category 1 sensitizer [9]. All of the perfumes were found to have at least one chemical ingredient falling into this category. Perfume 4 had six such chemicals; perfume 11 had five; perfumes 1, 3 and 12 had three; perfumes 2, 7, 8, 9, and 10 all had two; and perfumes 5 and 6 both had one.

Germ Cell Mutagenicity—chemicals known to cause heritable mutations in germs cells are Category 1 in the Germ Cell Mutagenicity class [9]. All of the perfumes had at least one ingredient in this category. Perfume 8 had five chemical ingredients in this category; perfumes 4, 6, and 11 had four; perfumes 1 and 9 had three; perfumes 2, 10, and 12 had two; and perfumes 3, 5, and 7 all had one.

Carcinogenicity—a known or presumed human carcinogen falls within the parameters of Category 1 in the Carcinogenicity class, with “known” being based on human evidence and “presumed” based on other animal evidence [9]. All of the perfumes had at least one chemical ingredient falling within these parameters. Perfumes 1, 6, 8, 9, and 11 all had three such chemical ingredients; perfumes 4, 7, 10 and 12 had two; and perfumes 2, 3, and 5 all had one.

Reproductive Toxicity—chemicals known or presumed to cause adverse effects on the human reproductive organs, human reproductive process or human development are Category 1 under the Reproductive Toxicity class [9]. Eleven of the twelve perfumes had chemical ingredients in Category 1. Perfumes 6, 8, and 11 had four chemicals; perfumes 9 and 10 both had three; perfumes 2, 3, 4, and 12 had two; and perfumes 1 and 5 had two.

TOST Single and Repeated Exposure—any chemicals known or presumed to cause significant toxicity based on reliable human studies or toxically severe animal studies are either in Category 1 of the classes TOST Single Exposure or TOST Repeated Exposure with the distinguishing factor being if the subject was exposed once or multiple times, respectively [9]. None of the perfumes we tested had any chemicals falling within the parameters of Category 1 for either TOST Single Exposure nor TOST Repeated Exposure.

Number of Category 1 Chemicals for Different Classes Set by United Nations Globally Harmonized System of Classification and Labelling of Chemicals														
Perfume Number	Acute Toxicity													
	Oral	Dermal	Gases	Vapors	Dusts & Mists	Skin Corrosion	Eye Effects	Sensitization	Germ Cell Mutagenicity	Carcinogenicity	Reproductive Toxicity	TOST: Single Exposure	TOST: Repeated Exposure	Aspiration Hazard
1	9	7	0	1	1	4	3	3	3	3	1	0	0	0
2	0	0	0	0	0	0	0	1	2	2	1	0	0	0
3	0	0	1	0	0	0	0	3	1	1	2	0	0	0
4	2	1	1	0	0	2	1	6	4	2	2	0	0	0
5	1	1	0	0	0	1	1	1	1	1	1	0	0	0
6	0	1	0	0	0	1	1	1	4	3	4	0	0	0
7	0	0	1	0	0	0	0	2	1	2	0	0	0	0
8	1	2	0	0	0	2	1	2	5	3	4	0	0	0
9	2	2	1	0	0	1	0	2	3	3	3	0	0	0
10	1	3	1	1	0	0	0	2	2	2	3	0	0	0
11	1	1	1	0	0	0	0	5	4	3	4	0	0	0
12	2	1	1	0	0	0	1	3	2	2	2	0	0	0

Figure 3. Number of Organic Chemical Ingredients Determined as Category 1 Based on Health Hazard Classes Set by GHS

Aspiration Hazard- based on human evidence, chemicals that are known human aspiration hazards are in Category 1 of the Aspiration Hazard class [9]. We did not find any perfumes in Category 1 for the Aspiration Hazard class.

Listed are the twelve perfumes tested in descending order of number of Category 1 ingredients: Bath & Body Works Sweet Pea (Perfume 1) with thirty-five Category 1 classifications; Secret Cocoa Butter Kiss (Perfume 4) with twenty-one; Essence of Beauty Citrus Coconut (Perfume 8) with twenty; Elizabeth Taylor Violet Eyes (Perfume 4) with nineteen; Essence of Beauty Sun Blossom (Perfume 9) with seventeen; Bodycology Toasted Vanilla Sugar (Perfume 6) and Elizabeth Taylor White Diamonds (Perfume 10) both with fifteen; Aqua Velva (Perfume 12) with fourteen; Bath & Body Work Twilight Woods (Perfume 2), Bath & Body Works White Citrus (Perfume 3), and Secret Ooh La La Lavander (Perfume 5) all with eight; and lastly, Bodycology Wild Poppy (Perfume 7) with six.

DISCUSSION.

The use of perfumes typically involves direct skin application or spraying that may aerosolize the perfume. These methods lead to direct exposure of the skin, eyes, nose, mouth, and respiratory system to the ingredients of the perfume. Our results suggest that some of these ingredients, many of which are not publicly identified by the perfume companies, are considered health hazards by international standards. Furthermore, some of these ingredients are known to be specifically hazardous to the typically exposed areas of skin, eyes, nose, mouth, and respiratory system [5][3][6].

Our identification of ingredients that are Category 1 health hazards suggests the need for significant concern about perfume ingredients. GHS health hazards are internationally standardized and broadly accepted when identifying the adverse health effects of specific chemicals. Category 1 designation is particularly concerning. The risk associated with Category 1 chemicals strengthens the argument for consumer knowledge of perfume ingredients.

A major limitation of this study was that we did not identify the amount of each toxic ingredient in the tested perfume, and if this amount stays constant from spray to spray. Additionally, there may be variance in how much of a perfume a consumer will use with a single use. Also, perhaps not all of the aerosolized perfume amount will be absorbed by the user. These variable factors present a challenge in assuming that the adverse health effects of the toxic ingredients will actually occur. Further research is needed to overcome these limitations and more definitively describe the toxic impact of the perfume use.

Additional limitations of this study include the potential for error in detecting all organic chemical ingredients in the tested perfumes – for example, if the parameters (such as temperature, rate, and run time) we utilized were not ideal for capturing certain potential ingredients. We attempted to minimize the influence of this limitation by testing different parameters and organic solvents in order to determine those that seemed to identify the most perfume ingredients.

This study may have implications on policy regarding listing of perfume ingredients. Though perfumes currently fall under FDA regulations, these current regulations allow fragrance ingredients to not be revealed on the product label [10]. This compromises the ability of the consumer to know what adverse health effects the perfume may have. Our study, which revealed the widespread

presence of toxic ingredients in common perfumes, prompts the need to reexamine current perfume labeling regulations.

Changes to labeling regulations may occur as more consumers are knowledgeable about adverse health effects of popular perfume ingredients. Greater consumer awareness requires increased health education efforts. Our study may help fuel these efforts and drive further research on this important topic.

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