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Fragranced consumer products and undisclosed ingredients

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ABSTRACT

Fragranced consumer products—such as air fresheners, laundry supplies, personal care products, and cleaners—are widely used in homes, businesses, institutions, and public places. While prevalent, these products can contain chemicals that are not disclosed to the public through product labels or material safety data sheets (MSDSs). What are some of these chemicals and what limits their disclosure? This article investigates these questions, and brings new pieces of evidence to the science, health, and policy puzzle. Results from a regulatory analysis, coupled with a chemical analysis of six best-selling products (three air fresheners and three laundry supplies), provide several findings. First, no law in the U.S. requires disclosure of all chemical ingredients in consumer products or in fragrances. Second, in these six products, nearly 100 volatile organic compounds (VOCs) were identified, but none of the VOCs were listed on any product label, and one was listed on one MSDS. Third, of these identified VOCs, ten are regulated as toxic or hazardous under federal laws, with three (acetaldehyde, chloromethane, and 1,4-dioxane) classified as Hazardous Air Pollutants (HAPs). Results point to a need for improved understanding of product constituents and mechanisms between exposures and effects.

1. Introduction

Scientific evidence grows about chemical exposures and potential health risks from everyday consumer products (e.g., CDC, 2001, 2003, 2005; Wallace, 1987, 1991, 1993, 2001). Essential to risk reduction is information, yet we have relatively little information on chemical constituents for many types of products. For instance, fragranced consumer products typically contain VOCs,[1] some of which may pose risks, but, as this article will show, may not be disclosed.

This article investigates the case of fragranced consumer products, and the challenges for understanding hazards. For one, chemicals are essentially invisible, making it difficult to discern to what, where, when, and how we are being exposed. Thus, we rely on product information (such as labels) and product regulations to reduce potential risks. For another, health effects from exposures are often difficult to detect. While some effects are immediate and noticeable, others are gradual, subtle, and sub-clinical. Of particular concern are chronic and often low-level exposures to mixtures of chemicals, which are the type of exposures that typify daily life. Finally—and the focus of this article—chemical constituents are often undisclosed. That is, chemicals in products may not be identified through information provided to the public or to regulatory agencies.

This article proceeds as follows. After this introduction, the second section reviews studies of human exposure and VOCs emitted from fragranced consumer products. The third section investigates the U.S. regulatory framework to see whether and how the laws require disclosure of ingredients in consumer products, and fragrances in those products. The fourth section presents results from a chemical analysis, using gas chromatography/mass spectrometry (GC/MS), that identifies VOCs in six fragranced consumer products, each widely used in the U.S. Chemicals identified in the GC/MS analysis are then compared to the chemicals on product labels and MSDSs, and to chemicals regulated under federal laws. The fifth section provides conclusions and recommendations for future work.

2. Human exposure and VOCs in fragranced consumer products

Human exposure studies, over the past two decades, have revealed widespread U.S. population exposure to VOCs (Wallace et al., 1991b; Wallace, 2001). Paradoxically, the largest contributors of VOCs to human exposure (nearly 90%) are not the sources traditionally recognized and regulated, but rather sources that are small, close to us, largely unregulated, yet often within our control (Wallace, 2001; Wallace et al., 1987), such as consumer products and other indoor sources. In particular, fragrance compounds, used in a wide variety of consumer products, can be primary sources of human exposure to VOCs (EPA, 1989; Sack et al., 1992; Wallace et al., 1991a; Cooper et al., 1992, 1995).

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[1] Although definitions and regulatory exclusions vary, VOCs can be considered as carbon-based compounds that exist in the gas phase at room temperature. VOCs typically have vapor pressures between 0.1 mm Hg and 380 mm Hg at 25 °C (Spicer et al., 2002:12-13).

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"Fragranced consumer products," as used in this article, refers to chemically formulated products with a fragrance, such as air fresheners, laundry detergents, dryer sheets, fabric softeners, dishwashing detergents, personal care products, cosmetics, after-shave, soaps and lotions, hand sanitizers, and cleaners. An individual "fragrance" in a product can contain up to several hundred chemicals (Bickers et al., 2003), and while the composition of an individual fragrance mixture is generally unknown to the public (Bridges, 2002), more than 2600 ingredients have been documented for use in fragrances (Ford et al., 2000).

Relatively little prior work has investigated the range of VOCs emitted from fragranced consumer products. In early, landmark studies, Wallace et al. (1991a) and Cooper et al. (1992) analyzed 31 fragranced products, such as perfumes, deodorants, soaps, fabric softeners, and air fresheners. The most common VOCs, with confirmed identification in more than one-third of the products, were ethanol, limonene, linalool, β-phenethyl alcohol, β-myrcene, benzyl acetate, benzyl alcohol, benzaldehyde, α-terpineol, β-citronellol, and α-pinene. Rastogi et al. (2001) analyzed 59 domestic and occupational products, such as soap, laundry products, dish wash, and cleaners, for 19 target fragrance compounds. Of these, the most common VOCs, in more than one-third of the products, were limonene, linalool, citronellol, eucalyptol, geraniol, and α-pinene.

In addition to primary VOC emissions from products, fragranced consumer product compounds can react with ambient compounds to generate secondary pollutants. For instance, terpenes (such as d-limonene, linalool, α-pinene, and β-pinene), emitted from the use of fragranced products (such as cleaning supplies and air fresheners), can react with indoor ozone to produce potentially substantial levels of secondary pollutants (Singer et al., 2006), which can include aldehyde compounds (such as formaldehyde), ultrafine particles, glycol ethers, secondary organic aerosols, and the hydroxyl radical (Nazaroff and Weschler, 2004; Liu et al., 2004; Sarwar et al., 2004; Wainman et al., 2000; Destaillats et al., 2006; Singer et al., 2006).

Exposure to fragranced products, as suggested by some studies, have potential associations with adverse health effects, including asthma and asthmatic exacerbations (Rumchev et al., 2004; Shim and Williams, 1986; Kumar et al., 1995), headaches (Kelman, 2004; Farrow et al., 2003), mucosal symptoms (Elberling et al., 2005; Millqvist et al., 1999), and, the emphasis of most prior work, epidermal exposure effects such as allergic contact dermatitis (e.g., de Groot and Frosch, 1997; Johansen, 2003).

On the other hand, studies conducted by the Research Institute for Fragrance Materials (RIFM) have evaluated the safety of fragrance ingredients (e.g., Bickers et al., 2003; Ford et al., 2000; Cadby et al., 2002; Smith, 2003, 2004; Smith et al., 2004), with considerable attention to acute toxicity and dermatological exposure effects,[2] and expanding research to other toxicological effects and exposure routes (Bickers et al., 2003). Additional studies report that no evidence indicates that fragranced product exposures elicit objective adverse effects in asthmatics (e.g., Opiekun et al., 2003), that inadequate or insufficient evidence exists to determine an association between fragrance exposure and asthma development (IOM, 2000), and that no evidence suggests that current UK indoor domestic exposures to VOCs, either individually or as a total, pose a health risk (IEH, 1996).

Prior work, as context for this particular study, examined two categories of fragranced consumer products (air fresheners and laundry supplies) and possible reactions, based on self-reported data. In two surveys of the U.S. population (n=1057, 1058; CL=95%; CI=3%), Caress and Steinemann (2004, 2005) found that 17.8% and 20.5% (first and second study) reported headaches, breathing difficulties, or other health problems when exposed to air fresheners or deodorizers; and 10.9% (second study only) reported irritation from the scent of laundry products, fabric softeners, or dryer sheets that are vented outside. The percentages were higher among susceptible populations. For instance, among asthmatics, 29.7% and 37.2% reported breathing difficulties, headaches, or other health problems when exposed to air fresheners; and 21.2% reported irritation from the scent of laundry products, fabric softeners, or dryer sheets that are vented outside.

Studies on exposures, emissions, and effects rely on and contribute to information on product constituents. The next section examines the U.S. laws that address the disclosure of ingredients in products.

3. Regulatory analyses

In the U.S., manufacturers of consumer products, and owners of chemical formulations (such as fragrances) in those products, are not required to disclose all ingredients to consumers. This section investigates the U.S. regulations that pertain to fragrances and consumer products, and the exemptions and exceptions in that coverage.

Fragrance ingredients are exempt from disclosure, in any product. Depending on the product, the word "fragrance" may or may not need to be listed, and this section looks at the two main cases. First, for fragranced products regulated under the Federal Food, Drug, and Cosmetic Act (FFDCA),[3] the product label needs to list the word "fragrance," but not the ingredients in the fragrance.[4] The label can also list a similar term, such as "perfume," "parfum," "natural fragrance," "pure fragrance," "organic fragrance," etc., even though these terms are not legally defined.[5] Also, an "unscented" or "fragrance-free" product may be a fragranced product, with the addition of a "masking fragrance." Second, for fragranced consumer products not regulated under the FFDCA, the product label does not need to list the word "fragrance" (or a similar word), or the ingredients in the fragrance. If the product does list the word "fragrance," the specific ingredients in the fragrance are still protected from disclosure.

Consumer product ingredients, more generally, are exempt from disclosure in several ways. Regulation of consumer products (other than food, drugs, cosmetics, tobacco, and pesticides) largely falls under the Consumer Product Safety Act (CPSA).[6] The CPSA relies on and gives preference to voluntary consumer product safety standards,[7] and may require labeling only if a warning is "reasonably necessary to prevent or reduce an unreasonable risk of injury associated with such product," [8] or if voluntary standards would not "eliminate or adequately reduce the risk," or are not likely to be followed.[9] Labeling requirements are limited to the date and place of manufacture, the identification of the manufacturer, and a certification that the product meets all applicable consumer product safety standards—if such a standard exists for that product.[10]

Notably, the CPSA does not require disclosure of all ingredients in products. Instead of listing ingredients, a manufacturer can provide other information on a product, such as a warning label. Similarly, the Federal Hazardous Substances Act (FHSA)[11] requires warning labels for hazardous substances,[12] but does not require that all ingredients be disclosed on the product's label.

[2] This emphasis is consistent with skin application considered the major route of exposure for intentional use of fragranced cosmetic products (e.g., Cadby et al., 2002).

[3] Pub. L. No. 75-717, 52 Stat. 1040, codified at 21 U.S.C. Section 321–397 (2000).

[4] 21 C.F.R. Section 701.3.

[5] Rastogi et al. (1996) found that 82% of perfumes based on "natural ingredients" contained synthetic fragrances.

[6] Pub. L. No. 92-573, 86 Stat. 1207 (1972), codified at 15 U.S.C. Section 2051–2084 (2002).

[7] 15 U.S.C. Section 2056(b) (1) (2002).

[8] 15 U.S.C. Section 2056(a) (2002); see also 58 Fed. Reg. 8013, 8015 (1993).

[9] 15 U.S.C. Section 2056(b) (2002); see also 58 Fed. Reg. 8013, 8015 (1993).

[10] 15 U.S.C. Section 2063(c).

[11] Federal Hazardous Substances Act, Pub. L. No. 86-613, 74 Stat. 372 (1960) (codified as amended at 15 U.S.C. Section 1261–1273 (2000)).

[12] A substance may be classified as a banned hazardous substance if the cautionary labeling required under the FHSA is found to be inadequate to protect public health and safety. id. Section 1261(q) (1).

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Ingredients can also be exempt from disclosure through "trade secrets" protection. Although definitions vary by jurisdiction, a trade secret is generally considered to be information that is not generally known to the public, provides independent economic value to its owner by maintaining its secrecy, and is the subject of reasonable efforts by its owner to maintain its secrecy.[13] Trade secrets protection differs from other legal protections, such as patents, in several ways. First, trade secrets are protected without requiring the disclosure of the secret, as is required for a patent. Thus, manufacturers of consumer products (and owners of information on chemical formulations in those products) can keep as secret the full composition of their products. Second, trade secrets can be protected indefinitely, whereas patents have an expiration date. Third, trade secrets do not need to be novel or original for protection, unlike patents and other forms of intellectual property. Fourth, trade secrets protection can take less time and expense to obtain than a patent.

On the other hand, trade secrecy does not protect the owner from "reverse engineering"; that is, discovery and disclosure of the secret, such as through chemical analysis of a product. Also, trade secrets do not have general protection under federal law, but only exemptions from public disclosure requirements in specific statutes. Under the Freedom of Information Act (FOIA), trade secrets are exempt from disclosure requirements.[14] Under the FFDCA, fragrance ingredients that qualify as trade secrets may be listed as "and other ingredients," without disclosing the ingredients.[15] Under the CPSA, "nothing contained in this Act shall be construed to require the release of any information" [16] for trade secrets and other confidential information.[17]

Other federal laws address consumer products, but do not require full disclosure of ingredients. Under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard,[18] chemical manufacturers and importers are required to obtain or develop an MSDS for each hazardous chemical they produce or import, and employers are required to have an MSDS in the workplace for each hazardous chemical that they use.[19] The MSDS requirement is designed for employers and employees, even though it also provides information for consumers. A consumer product is exempt from this regulation, however, if it is "used in the workplace for the purpose intended by the chemical manufacturer or importer of the product, and the use results in a duration and frequency of exposure which is not greater than the range of exposures that could reasonably be experienced by consumers when used for the purpose intended."[20] That is, the MSDS regulation for consumer products applies only if workplace use could result in a greater exposure than general public use, even though general public use is not covered by the MSDS requirement.

Further, a consumer product ingredient does not need to be reported on an MSDS if the manufacturer or importer deems that the ingredient is not hazardous. Because OSHA relies on the manufacturer's or importer's evaluation of chemical hazards, the "accuracy and completeness of MSDSs is vulnerable," and surveys of MSDSs found that most were incomplete, inaccurate, or both (GAO, 1991), especially concerning information on chronic toxicity. OSHA lacks an effective process for detecting inaccuracy and enforcing compliance, and "cannot identify the manufacturers or importers who consistently prepare and distribute erroneous MSDSs" (GAO, 1991).

The Clean Air Act (CAA)[21] is the nation's comprehensive law to address pollutants in ambient air, but the CAA does not define "ambient air,"[22] and the U.S. Environmental Protection Agency (EPA) has limited its interpretation of ambient air to the regulation of outdoor air, or "air external to buildings."[23] Thus, the CAA does not specifically regulate pollutants in indoor air, even though human exposure to all but a few pollutants is higher indoors than outdoors (Wallace, 1991). For example, the 1990 Clean Air Act Amendments contained a list of 189 Hazardous Air Pollutants (HAPs), defined as substances "which present, or may present, through inhalation or other routes of exposure, a threat of adverse human health effects."[24] Many HAPs are VOCs. In contrast to the criteria air pollutants[25] regulated in ambient air, the HAPs have no ambient standards or exposure thresholds, and carcinogenic HAPs are assumed to have no known safe levels of exposure. While existing regulations focus on HAPs outdoors, HAPs have been found at higher levels indoors than outdoors, because of sources such as consumer products (Sack et al., 1992). More recently, under the CAA, consumer products are regulated under VOC emission standards if they account for at least 80% of the VOC emissions outdoors in areas that violate the standards for ozone.[26] However, the VOC standards exempt some fragranced consumer products such as air fresheners.[27]

The Toxic Substances Control Act (TSCA) of 1976 authorizes the EPA to secure information on all new and existing chemicals (or mixtures) sold in interstate commerce. EPA has reviewed the risks of less than 2% of the 62,000 existing chemicals in TSCA's 1979 inventory, and performs a detailed review of only 2%–3% of premanufacture notices (PMNs) of new chemicals (GAO, 1994). About 95% of PMNs for new chemicals contain some information that is claimed as confidential (GAO, 2005). TSCA does not require companies to conduct tests on toxicity and exposure prior to EPA review of new chemicals, and there is "little assurance that health and environmental risks are identified before the chemicals enter commerce" (GAO, 2005). Once a chemical is in production and use, in order to take action, the EPA must demonstrate that the chemical presents an unreasonable risk of injury to health or the environment,[28] which is a standard that has been difficult to meet (GAO, 2005), and that usually depends on additional data from industry. Even if met, the EPA may impose limitations only "to the extent necessary to protect adequately against such risk using the least burdensome requirements."[29] For instance, if unreasonable risk could be managed with a warning label, then the EPA could not ban or otherwise restrict use of that chemical (GAO, 2005). Since the enactment of TSCA, and with more than 75,000 chemicals on TSCA's current inventory, the EPA has promulgated rules under TSCA to place restrictions on only five existing chemicals/chemical classes and four new chemicals (GAO, 2005).

In summary, although numerous laws govern chemicals and product safety, none require either consumer product or fragrance chemicals to be disclosed fully, even though some may represent primary sources of VOC exposures.

4. Chemical analyses and results

Given non-disclosure, chemical constituents in products can be identified through advances in technology and analytical methods. For this study, gas chromatography and mass spectrometry (GC/MS)

[13] See, e.g., The Uniform Trade Secrets Act, a model law used by many states, 1985 amendments; American Bar Association, February 11, 1986.
[14] 5 U.S.C. Section 552(b) (4).
[15] 21 C.F.R. Section 701.3(a).
[16] 15 U.S.C. Section 2055(a) (1).
[17] 5 U.S.C. Section 552(b) (4).
[18] 5 CFR 1910.1200.
[19] 29 CFR 1910.1200 (g) (1).
[20] 1910.1200(b) (6)(ix).
[21] 42 U.S.C. Section 7401–7671q (2002).
[22] 42 U.S.C. Section 7409 (2000).
[23] 40 C.F.R. Section 50.1 (e) (2002).
[24] 42 U.S.C. Section 7412 (b) (2) (2002).
[25] Criteria air pollutants: carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM2.5 and PM10), and lead (Pb).
[26] Clean Air Act Section 183(e), 42 U.S.C. Section 7511b (e): National Volatile Organic Compound Emission Standards for Consumer Products, Fed. Reg. 48819–48847 (1998), 40 C.F.R. Section 59.201–59.214 (2003).
[27] 40 C.F.R. Section 59.201 (c) (1)–(7) (2003).
[28] 15 U.S.C. Section 2605(a) (2002).
[29] 15 U.S.C. Section 2605(a) (2002).

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Table 1
Air freshener 1

Compound	CAS #
d-limonene	138-86-3
4-*tert*-butylcyclohexyl acetate	32210-23-4
Acetaldehyde	75-07-0
Benzyl acetate	140-11-4
2,7-dimethyl-2,7-octanediol	19781-07-8
Acetone	67-64-1
Ethanol	64-17-5
Carene isomer	e.g. 13466-78-9
Citronellyl acetate	150-84-5
Hexanal	66-25-1
2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal 1)	68039-49-6
Allyl heptanoate	142-19-8
1-methyl-4-(1-methylethyl)-cyclohexane	6069-98-3
Ethyl butanoate	105-54-4
3-hexen-1-ol	928-96-1
o, *m*, or *p*-cymene	527-84-4, 535-77-3, or 99-87-6
α-pinene	80-56-8
Carene isomer	e.g. 13466-78-9

headspace analysis[30] was performed on fragranced consumer products that are widely used in the U.S. (and in other countries) to identify VOCs emitted from those products.

This section examines, in depth, the ingredients and labeling of six products: three air fresheners (solid deodorizer disk, liquid spray, plug-in oil), and three laundry supplies (dryer sheet, fabric softener, detergent). These six products were selected because of their market popularity (each one is a best-seller in its category[31]), their potential for public and perhaps involuntary exposures, and their associations with possible adverse effects as suggested by prior studies.

Results for each product are presented as follows. First, VOCs identified from the GC/MS headspace analyses are listed in rank order of their relative concentrations (Tables 1–6). While more VOCs were detected, only those with a headspace concentration of greater than 300 μg/m^3 are reported herein.[32] Second, among these reported compounds, VOCs that are regulated as toxic or hazardous under one or more federal laws are identified and summarized (Table 7). Third, ingredients from the product label and product MSDS are presented, verbatim. Finally, VOCs identified in the GC/MS analysis are compared to those listed on the product labels and MSDSs.

4.1. Air freshener 1

This product is a solid deodorant disk that is used in the lavatories of a major commercial airline with both domestic and international routes. The company provides similar deodorizer disks for more than 20 domestic and international airlines.

VOCs identified in the GC/MS analysis are listed in Table 1. Of these chemicals, four (acetaldehyde, acetone, ethanol, α-pinene) are regulated as toxic or hazardous under federal laws.

The product package does not contain ingredient information.[33] The MSDS provides the following list of ingredients: "Fragrance, Essential Oils." The MSDS also states the following: "The specific chemical identities of the ingredients of this mixture are considered by [name of company] to be trade secrets and are withheld." None of the chemicals identified in the GC/MS analysis are listed on the product label or MSDS.

4.2. Air freshener 2

This product is a wall-mounted unit that emits a fragranced spray and that is used primarily in lavatories in industrial and institutional environments, including schools and health care facilities.

VOCs identified are listed in Table 2. Of these chemicals, one (ethanol) is regulated as toxic or hazardous under federal laws.

The product package does not contain ingredient information. The MSDS provides the following list of ingredients: "Essential Oils, Organic Perfume, Food Grade Gelling Agent (Proprietary trade secret)." None of the chemicals identified in the GC/MS analysis are listed on the product label or MSDS.

4.3. Air freshener 3

This product is a plug-in air freshener, used in residential, industrial, and institutional environments.

VOCs identified are listed in Table 3. Of these chemicals, seven (α-pinene, ethanol, ethyl acetate, acetaldehyde, benzaldehyde, isopropyl alcohol, acetone) are regulated as toxic or hazardous under federal laws.

The product label lists no ingredients. The MSDS provides the following list of ingredients: "Mixture of perfume oils." None of the chemicals identified in the GC/MS analysis are listed on the product label or MSDS.

4.4. Laundry supply 1

This product is a scented cloth dryer sheet that is added to laundry in the drying machine.

VOCs identified are listed in Table 4. Of these chemicals, two (ethanol, α-pinene) are regulated as toxic or hazardous under federal laws.

The product label contains the following list of ingredients: "biodegradable cationic softeners and perfume." The MSDS provides the following list of ingredients: "Non-ionic and cationic fabric conditioning agents, a perfume carrier, perfume, and non-woven cloth." None of the chemicals identified in the GC/MS analysis are listed on the product label or MSDS.

4.5. Laundry supply 2

This product is a scented liquid fabric softener that is typically added to laundry in the washing machine.

VOCs identified are listed in Table 5. Of these chemicals, four (ethanol, α-pinene, chloromethane, acetaldehyde) are regulated as toxic or hazardous by federal laws.

The product label contains the following list of ingredients: "biodegradable fabric softening agents (cationic)." The MSDS provides the following list of ingredients: "Non-ionic and cationic fabric softening agents, perfume, colorant, quality control agents." None of the chemicals identified in the GC/MS analysis are listed on the product label or MSDS.

[30] Compound identification was based, in part, on GC retention times and mass spectral library matches. Equilibrium headspace concentrations were estimated using relative response factors from chemically representative surrogate compounds. Instrument and media blanks demonstrated that background contamination was negligible. Mean concentrations of all compounds identified were at least three times greater than the corresponding concentrations in the method blank. Additional details of the analytical technique are in Steinemann et al. (in review).

[31] Market information was obtained from MarketResearch (2005, 2007) and from direct communication with company representatives. Each product was ranked as the highest selling brand in the U.S. in its category (or second-highest, depending on category definition), according to the most recent data available to the public or from the company. Product manufacturers are U.S. companies with both domestic and international sales. Annual U.S. sales for each product (excluding one air freshener, whose company did not provide data) ranged from $100 million to over $1 billion.

[32] The reporting threshold of 300 μg/m^3 is arbitrarily selected and not intended to connote significance. Average headspace concentrations of VOCs for the six products ranged from 1000 μg/m^3 to 74,000 μg/m^3.

[33] A company representative stated that the MSDS would cover all ingredients for the product package.

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Table 2
Air freshener 2

Compound	CAS #
d-limonene	138-86-3
3-methoxy-3-methylbutanol	56539-66-3
Linalool	78-70-6
Carene isomer	e.g. 13466-78-9
Nonanal	124-19-6
2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal 1)	68039-49-6
2-methyl-2,4-dimethoxybutane	39836-89-0
α-phenylethyl acetate	93-92-5
β-pinene	127-91-3
3-hexen-1-ol	928-96-1
Octanal	124-13-0
Ethanol	64-17-5

4.6. Laundry supply 3

This product is a scented liquid detergent that is typically added to laundry in the washing machine.

VOCs identified are listed in Table 6. Of these chemicals, five (ethanol, 1–4 dioxane, ethyl acetate, α-pinene, 2-butanone) are regulated as toxic or hazardous under federal laws.[34]

The product label contains the following: "Ingredients include biodegradable surfactants (anionic and non-ionic) and enzymes." The MSDS provides the following list of ingredients: "Ethanol, Borax, Ethanolamine." None of the chemicals identified in the GC/MS analysis are listed on the product label, and one (ethanol) is on the MSDS.

4.7. Summary of results

To summarize, among these six products, 98 VOCs were identified and reported in the tables, [35] representing 58 unique VOCs. The most commonly identified VOCs were the following: ethanol, d-limonene (in all six products); α-pinene, β-pinene (in five); carene isomer, 2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal 1) (in four); and acetaldehyde, benzyl acetate, 3-hexen-1-ol, and linalool (in three). Five of the six products emitted one or more Hazardous Air Pollutants (acetaldehyde, chloromethane, and 1,4-dioxane).

While this study offers insights on ingredients and their disclosure, it had several limitations, which offer areas for future research. First, the GC/MS analysis focused on compound identification and relative concentrations, rather than actual exposures, which would be important for understanding links between compounds and possible effects. Second, the analysis examined only primary VOC emissions from each product, rather than the possible generation of secondary pollutants, which could be encountered in actual exposure situations. Third, the analysis did not determine whether the VOCs were derived from the fragrance mix, the basic consumer product formulation, or both. Fourth, this study did not investigate whether the chemicals identified in the products would be at levels that would trigger one or more of the laws, or would be associated with possible health effects. Finally, compound identification focused on VOCs, and other classes of chemicals could be examined.[36]

5. Conclusions

This article reveals a difference between the chemicals identified and the chemicals disclosed in fragranced consumer products. None of the VOCs from the products were listed on their product labels, and one VOC was listed on one MSDS. Some of these VOCs are regulated as toxic or hazardous under federal laws, yet are exempt from disclosure in fragrances, consumer products, and fragranced consumer products.

Results suggest a need for more thorough identification and disclosure of ingredients that may be of concern, such as those already regulated. Otherwise, the public may have inadequate information about potential exposure risks, or perhaps a false sense of assurance that they do have such information. On the other hand, listing all chemical ingredients (potentially hundreds) on a product label could create false alarm, and may not necessarily promote risk reduction. As one approach, the European Union has identified 26 fragrance substances, above certain concentrations, for listing on cosmetic products and detergents (EU, 2003, 2006).[37]

The identification of individual ingredients is an important albeit incomplete perspective on risk. Additional needs are improved understanding of actual exposures and effects, and consideration of factors such as mixtures of compounds, multiple exposure routes, chronic and low-level exposures, secondary pollutants, and individual susceptibilities. Given that individuals have reported effects, further research can help to elucidate exposure mechanisms, the sources of risk and uncertainty, and the role of ingredient information.

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[37] The presence of any of the 26 fragrance substances must be indicated in the list of ingredients when its concentration exceeds 0.001% in leave-on products or 0.01% in rinse-off products.

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Table 3
Air freshener 3

Compound	CAS #
d-limonene	138-86-3
α-pinene	80-56-8
β-pinene	127-91-3
Ethanol	64-17-5
Ethyl butanoate	105-54-4
Ethyl acetate	141-78-6
3-hexen-1-ol	928-96-1
1-butanol, 3-methyl-, acetate	123-92-2
β-phellandrene	555-10-2
Acetaldehyde	75-07-0
Benzaldehyde	100-52-7
Carene isomer	e.g. 13466-78-9
1-methyl-3-(1-methylethyl)-cyclohexene	13828-31-4
Isopropyl alcohol	67-63-0
1-butanol, 2-methyl-, acetate	624-41-9
Camphene	79-92-5
Acetone	67-64-1
Methyl butanoate	623-42-7
Dimethyl ethyl cyclohexene	2228-98-0
α-phellandrene	99-83-2

Table 5
Laundry supply 2

Compound	CAS #
Ethanol	64-17-5
d-limonene	138-86-3
Methoxy ethane	540-67-0
α-pinene	80-56-8
Benzyl acetate	140-11-4
Isocineole	470-67-7
β-pinene	127-91-3
2-Methoxy propane	598-53-8
Linalool	78-70-6
(Z)-3,4-dimethyl-3-hexen-2-one	20685-45-4
Chloromethane	74-87-3
γ-terpinene coeluted with 2,7-dimethyl-2,7-octanediol	99-85-4 and 19781-07-8
Acetaldehyde	75-07-0
2,4-dimethyl-1,3-cyclopentanedione	34598-80-6
3-methyl-2-buten-1-ol acetate	1191-16-8
α-terpinolene	586-62-9
Diethoxy methane	462-95-3
1,5-dimethyl-1,4-cyclohexadiene	4190-06-1
1-methyltricyclo[2.2.1.0(2,6)]-heptane	4601-85-8
α-terpinene	99-86-5

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Table 4
Laundry supply 1

Compound	CAS #
Linalool	78-70-6
Ethanol	64-17-5
Benzyl acetate	140-11-4
cis-rose oxide	16409-43-1
Carene isomer	e.g. 13466-78-9
2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal 1)	68039-49-6
d-limonene	138-86-3
3-methyl-2-buten-1-ol acetate	1191-16-8
2,7-dimethyl-2,7-octanediol	19781-07-8
α-pinene	80-56-8
trans-rose oxide	876-18-6
Eucalyptol	470-82-6
α-phenylethyl acetate	93-92-5
β-pinene	127-91-3
2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal extra)	67801-65-4

Table 6
Laundry supply 3

Compound	CAS #
Ethanol	64-17-5
d-limonene	138-86-3
2-methyl-2-propanol	75-65-0
1,4-dioxane	123-91-1
3,7-dimethyl-1,6-octadiene	10281-56-8
Ethyl acetate	141-78-6
α-pinene	80-56-8
β-pinene	127-91-3
2-butanone	78-93-3
1-methyl-3-(1-methylethyl)-cyclohexene	13828-31-4
2,4-dimethyl-3-cyclohexene-1-carboxaldehyde (Triplal 1)	68039-49-6
Undecane	1120-21-4
β-terpinene	99-84-3

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Table 7
VOCs identified that are regulated as toxic or hazardous under federal laws

Compound	CAS #	CAA-HAP	CAA-RTEFS	CERCLA	CWA	EPCRA	FIFRA	OSH Act	RCRA
Acetaldehyde	75-07-0	√	√	√		√		√	
Acetone	67-64-1			√			√	√	
Benzaldehyde	100-52-7						√		
tert-butyl alcohol	75-65-0					√	√	√	
2-butanone	78-93-3			√		√		√	√
Chloromethane	74-87-3	√	√	√	√	√		√	√
1,4-dioxane	123-91-1	√		√		√		√	√
Ethanol	64-17-5						√	√	
Ethyl acetate	141-78-6			√			√	√	
Isopropyl alcohol	67-63-0					√	√	√	
α-pinene	80-56-8						√		

CAA-HAP: Clean Air Act–Hazardous Air Pollutant.
CAA-RTEFS: Clean Air Act–Regulated Toxic, Explosive, or Flammable Substances.
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act–Hazardous Substance.
CWA: Clean Water Act–Priority Pollutant.
EPCRA: The Emergency Planning & Community Right to Know Act–Toxic Release Inventory Chemical.
FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act–Registered Pesticide.
OSH Act: Occupational Safety and Health Act–Air Contaminants RCR.
RCRA: Resource Conservation and Recovery Act–Hazardous Constituents.

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