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Analysis of Volatile Organic Compound Emissions from Fragranced Consumer Products

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Submitted in total fulfilment of the degree of

Doctor of Philosophy

Department of Infrastructure Engineering

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The University of Melbourne

August 2019

Abstract

Fragranced consumer products—such as cleaning supplies, air fresheners, and personal care products—emit numerous volatile organic compounds (VOCs), some classified as potentially hazardous. In addition, emissions from fragranced products can be a primary contributor to indoor and outdoor air pollutants, and human exposure risks. Further, exposure to volatile emissions from fragranced products has been associated with adverse human health effects in approximately one-third of Australians. However, fragranced products are exempt from full ingredient disclosure, thus limiting information and awareness about emissions. Moreover, relatively little prior research has analysed emissions from these products. The overall aim of this thesis research is to investigate volatile emissions from a wide range of fragranced consumer products. As a three-part research study, it investigates VOCs emitted from 200 products in three groups: 42 baby products, 24 essential oils, and 134 consumer products. Products include both regular versions and those with claims of being green or related terms such as organic or natural. Volatile emissions from each individual product were analysed using headspace gas chromatography/mass spectrometry. Overall, the study found 2,817 VOCs, including 848 potentially hazardous VOCs, emitted from the 200 products. Specifically, for each group of products, the study found (1) 684 VOCs including 207 potentially hazardous VOCs in baby products; (2) 589 VOCs including 124 potentially hazardous VOCs in essential oils; and (3) 1,538 VOCs including 517 potentially hazardous VOCs in consumer products. Across the 200 products, fewer than 4% of VOCs and 9% of potentially hazardous VOCs were disclosed by being listed on product labels. For each of the three groups of products, emissions of potentially hazardous VOCs were not significantly different between regular and green fragranced products.

This dissertation research provides contributions to knowledge through the analysis and comparison of relatively large number and diversity of products, a broad suite of VOCs, compounds classified as potentially hazardous, and both regular and green products. Results from this research provide new knowledge on volatile emissions from consumer products, which can improve awareness of potential exposures and effects on air quality, health, and societal well-being.

Declaration

This is to certify that:

- i. The thesis comprises only my original work towards the PhD except where indicated in the Preface;
- ii. Due acknowledgement has been made in the text to all other material used;
- iii. The thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Neda Nematollahi

Preface

Chapter 3 of this thesis has previously been published as:

Nematollahi N, Doronila A, Mornane PJ, Duan A, Kolev SD, Steinemann A (2018a) Volatile Chemical Emissions from Fragranced Baby Products. *Air Quality, Atmosphere & Health* 11:785-90. doi: 10.1007/s11869-018-0593-1

Chapter 4 of this thesis has previously been published as:

Nematollahi N, Kolev SD, Steinemann A (2018b) Volatile chemical emissions from essential oils. *Air Quality, Atmosphere & Health* 11:949–954. doi: 10.1007/s11869-018-0606-0

Chapter 5 of this thesis has been submitted as:

Nematollahi N, Kolev SD, Steinemann A (2019) Volatile Chemical Emissions from 134 Common Consumer Products. *Air Quality, Atmosphere & Health*

Each of these three journal articles presents part of the full series of complementary studies making up this thesis. As lead author, I carried out at least 80% of the work for each of the publications. This includes the background research, experimental work, analysis of results, writing of the articles, and editing them in response to co-author and reviewer comments. The co-authors provided advice on experimental design and manuscript review.

Springer Nature Limited, the publisher of the articles in Chapters 3, 4, and 5 permits the author to republish these articles as part of a PhD thesis.

Acknowledgements

I wholeheartedly thank my principal supervisor Professor Anne Steinemann for her generosity, unlimited support, encouragement, kind understanding, and mentorship during my PhD study. I am especially grateful for her invaluable guidance through each stage of this research and her insightful discussions and leadership in academic writing and critical thinking. I also would like to greatly thank my co-supervisor Professor Spas Kolev for his valuable advice, continuous support, and mentorship throughout my research. I gratefully acknowledge him for providing me with accessibility to all the required experimental equipment and an excellent laboratory environment. I also thank my Chair, Professor Lu Aye, for his encouragement and helpful advice.

I gratefully acknowledge financial support from the Australian Government Research Training Program Scholarship (RTP), through the University of Melbourne; the Australian Department of Education and Training (Australian Postgraduate Award); and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

I thank Dr Augustine Doronila, Dr Patrick Mornane, Dr Alex Duan, and Dr Ines Almeida for their experimental advice and expertise; and Dr Nigel Goodman for his kind support. I also wish to thank my friends for their friendship and encouragement.

Finally, I would like to express my deepest gratitude to my family for their support and encouragement. I especially thank my husband, Amin, for his love, patience, encouragement and continuous support during my PhD study.

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1 Introduction and background

1.1 Problem statement

Contrary to popular belief, most of our exposure to potentially hazardous pollutants comes from sources that are relatively small, close to us, and seemingly benign: common fragranced consumer products. "Fragranced consumer products" (also referred to in this thesis as "fragranced products") are products with a fragrance or scent, such as air fresheners, deodorizers, cleaning products, laundry supplies, household items, perfumes, essential oils, baby products, and personal care products (Steinemann 2015).

Emissions from fragranced consumer products have been associated with adverse effects to humans, the economy, and the environment. For instance, more than one-third of Australians report health problems, such as asthma attacks and migraine headaches, from exposure to fragranced consumer products. Exposures to fragranced products in the workplace have been associated with lost work days or lost jobs for more than one million Australians in one year, with economic costs estimated at more than \$2.6 billion per year (Steinemann 2019). Fragranced consumer products are also a primary contributor to indoor air pollution (Goodman et al. 2017) as well as outdoor air pollution and the formation of urban smog (McDonald et al. 2018).

Fragranced consumer products emit numerous volatile organic compounds (VOCs). VOCs are a major category of pollutants, associated with adverse effects on human health (e.g., WHO 2018; NIH 2017; SWA 2018; Wallace 2001). A "fragrance" in a consumer product, despite the singular term, is a complex formulation of several dozen

to several hundred chemicals. Previous studies have found more than 150 different VOCs emitted from fragranced products, including terpenes such as limonene and alpha-pinene, and hazardous air pollutants such as formaldehyde (Steinemann 2015).

However, the chemicals in a "fragrance" do not need to be fully disclosed to the public on product labels, safety data sheets, websites, or elsewhere. Further, consumer products (other than personal care products) do not even need to disclose that they contain fragrance (Lunny et al. 2017). Even so-called unscented products may in fact contain fragrance chemicals, due to the addition of a masking fragrance to cover the scent (Steinemann 2009).

In addition, fragranced product claims of "green," or related terms such as "organic" or "natural," are largely unregulated and unsubstantiated (Steinemann 2015). For instance, a study of fragranced consumer products (Steinemann 2015) found similar potentially hazardous compounds in so-called green products as in regular products.

Fragranced product use and exposure is pervasive. Over 98.5% of the general population in Australia, as well as in the United States, United Kingdom, and Sweden, is exposed to fragranced products at least once a week through their own use, others' use, or both (Steinemann 2019).

Despite the prevalence of fragranced products in society, and the potential adverse effects from exposures and emissions, what remains largely unknown is what volatile chemicals these products actually emit. Little prior research has investigated this

question, as will be demonstrated by the literature review. Therefore, we lack understanding about volatile emissions from fragranced consumer products. We also lack understanding about differences between green and regular products, and between product ingredients emitted and ingredients disclosed.

An overarching aim of this thesis research is to provide a rigorous analysis of fragranced product emissions, together with an examination of product claims of green and ingredient disclosure. Results of this research contribute to scientific understanding of product emissions, as well as provide needed public knowledge that can reduce potential risks to human health, the environment, and society.

1.2 Review of the literature

An extensive review of the literature on VOC emissions from fragranced consumer products was conducted to understand the state of knowledge and identify knowledge gaps.

Relatively little prior work has been performed on analysing and evaluating a broader suite of VOC emissions from a range of fragranced consumer products. Steinemann (2015) analysed VOC emissions from 37 fragranced consumer products, including air fresheners, laundry products, cleaning supplies, and personal care products, both green and regular versions, as well as fragrance-free products. Uhde and Schulz (2015) analysed VOC emissions from 14 air fresheners such as diffusers and evaporators, spray odorizers, and scented candles. Zarogianni (2017) tested fragrance ingredients in 14

detergents including green and regular versions. Jo (2008) analysed VOCs in 26 air fresheners, and Kwon (2007) and Kwon and Jo (2007) analysed respectively 59 and 42 household products, such as cleaning supplies and air fresheners.

Previous research on VOC emissions from fragranced consumer products found the most common compounds were ethanol and limonene (Steinemann 2015), limonene (Dimitroulopoulou 2015), and limonene and linalool (ter Burg 2014). In addition, other terpenes such as alpha-pinene and beta-pinene, and other volatiles such as acetone, acetaldehyde, benzyl acetate, and methanol, were also common (Steinemann 2015). No prior research was identified that specifically analysed the VOCs emitted from fragranced baby products.

Previous studies have examined essential oils; however, most used their own extracted oils from plant leaves, roots or fruits (Isidorov and Jdanova 2002; Winters 2009; Helmig 2013; González-Rivera 2016), instead of commercially available essential oils. In addition, studies on essential oils typically focus on providing information about anti-bacterial and anti-oxidant benefits (Lee 2005, 2013) rather than emissions or possible risks.

A relatively small subset of studies examined VOC emissions from commercially available essential oils. For example, Chiang (2010) analysed VOC emissions from five essential oils and found the main carbonyl compounds were acetaldehyde, formaldehyde, acetone, and propionaldehyde. Chiu (2009) analysed VOC emissions from five essential oils and found the main VOCs were toluene, 1,2,3-

trimethylbenzene, 1,2,4-trimethylbenzene, n-undecane, p-diethylbenzene, and m-diethylbenzene. Cheng and Lai (2014) found alkane compounds such as propane and isobutane. Su (2007) found the main VOCs were linalool and other terpenes. Francis and Stusdal (2014) analysed three mint essential oils and found the main compounds were menthone, menthol, limonene, 1,8-cineole, menthofuran, and neomenthol, and carvone. Most studies, however, analysed five or fewer essential oils rather than a range of types and brands, which is the aim of this research.

Fragranced consumer products in Australia, as in all other countries, are not required to disclose all ingredients (Lunny et al. 2017), not even potentially hazardous compounds. For instance, an analysis of 37 fragranced consumer products (Steinemann 2015) found they collectively emitted 559 volatile ingredients, including 230 potentially hazardous pollutants such as formaldehyde. So-called "green," "natural," and "organic" consumer products contained similar types and concentrations of potentially hazardous compounds as regular products. However, fewer than 3% of all product ingredients, and fewer than 6% of all potentially hazardous ingredients, were disclosed to the public on any product label, safety data sheet, website, or other resource. Also, two-thirds of fragranced consumer products tested did not list on the label or elsewhere that the products contained a fragrance. Further, if any ingredients were disclosed, they were typically reported in general sounding terms (such as "cleaning agents") rather than as specific chemical ingredients.

Lack of knowledge of emissions may impair consumer choice. Consumers may be attracted to so-called green products, assuming they may contain fewer chemicals of concern (Klaschka 2016). However, previous studies have discovered that products called natural, green, and organic emitted hazardous air pollutants similar to their regular counterparts (Steinemann 2015). Currently, there is no objective basis for claims of green or natural consumer products. For organic products, Australian Certified Organic (ACO) provides specifications that products should consist of at least 95% organic ingredients to be called "organic." For products less than 95% organic, labels can make reference to the specific organic ingredients (ACO 2018).

Given the lack of information on product ingredients, consumers may turn to popular product evaluation guides (e.g., EWG 2018, GG 2018). However, the organisations that produce these guides do not actually chemically analyse the products. Instead, they base their ratings solely on publicly available information, which typically covers only a few percent of all actual ingredients. Thus, consumers have incomplete and often misguided information. As an example, Steinemann (2015) analysed the laundry detergents that received the highest rankings according to these guides, and found that all emit carcinogenic hazardous air pollutants, which have no safe exposure levels according to USA regulations.

Therefore, emissions from fragranced consumer products are largely unknown and undisclosed (Steinemann 2019). Relatively little prior research has examined a broad suite of VOC emissions from a range of consumer products. Further, no law in any country requires that consumer products (other than foods, drugs, and cosmetics)

disclose all specific ingredients (Steinemann 2009). Further, the fragrance formulation in any product is exempt from full ingredient disclosure (Steinemann 2015, Lunny et al. 2017). Product claims of green or related terms such as natural or organic are largely unregulated and unsubstantiated when they concern fragranced consumer products. Thus, the aim of this research, the analysis of volatile emissions from products, can provide important and new information on ingredients, and potential exposures and effects.

1.3 Knowledge gaps

This review of the literature identified three gaps: A lack of prior work and knowledge on (1) emissions from a range of baby products, both green and regular; (2) emissions from a range of commercial essential oils, both natural and regular; (3) emissions from a range of common consumer products, both green and regular.

Prior studies on VOC emissions on fragranced consumer products focused on: (a) targeted VOCs, rather than a broad suite of VOCs; (b) specific types of products (e.g., air fresheners), rather than a range of products; (c) a few products (<10), rather than a greater number of products; (d) composited samples, rather than individual products; and (e) regular products, rather than differentiating between regular and those with claims of green, organic, or all natural

This research differs from and extends prior work by analysing: (a) a broad suite of VOCs; (b) a range of products; (c) a greater number of products; (d) emissions from

individual products; and (e) both regular products and those with claims of green, organic, or all natural.

1.4 Research aims

The overall aim of this research is to increase understanding of volatile emissions from fragranced consumer products which can help to improve public awareness and reduce potential risks associated with exposures and emissions. This thesis research pursues three specific scientific aims:

The first aim is to investigate the VOC emissions from baby products, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and green baby products, and to compare VOCs identified with ingredients listed on labels.

The second aim is to investigate the VOC emissions from commercial essential oils, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and natural essential oils, and to compare VOCs identified with ingredients listed on labels.

The third aim is to investigate the VOC emissions from common consumer products, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and green consumer products, and to compare VOCs identified with ingredients listed on labels.

1.5 Thesis organisation

This thesis is arranged into seven chapters. The document is structured as follows.

Chapter 1 is introduction and background that provides the literature review along with the need for the research.

Chapter 2 states each research aim and describes the research methods to address the aims. The following three Chapters (3-5) are the three journal articles derived from this thesis.

Chapter 3 provides experimental methods, results, discussion, and conclusions from the analysis of VOC emissions from baby products.

Chapter 4 provides experimental methods, results, discussion, and conclusions from the analysis of VOC emissions from essential oils.

Chapter 5 provides experimental methodologies, results, discussion, and conclusions from the analysis of VOC emissions from consumer products.

Chapter 6 provides discussion and conclusions of this research. It also identifies areas for possible future research.

References and Appendices are provided at the end of the thesis.

2 Research methods

The purpose of this section is to specify the research aims and the research approach and methods to pursue the aims. Each of the aims has methods both specific to that aim (e.g., product selection) and general to all the aims (e.g., GC/MS analysis).

For this thesis research, "fragranced products" are identified as products that contain "fragrance," "parfum," "perfume," "essential oils," or an aromatic scent. "Fragrance-free products" are identified as products with the claim of "fragrance-free," "scent free," or "no fragrance."

"Green products" are identified as products with the claim of "green," "certified green," "organic," "certified organic," "natural," "no petrochemicals," "non-toxic," "plant-based," or "essential oils" for the entire product or specific ingredients. "Regular products" are the products not in the "green" category.

"Baby" products are defined in this study as products containing specific designations, such as wording (e.g., "baby shampoo") or illustrations (e.g., picture of a baby), that they are intended for use on infants and toddlers.

For each of the three aims, the study sought (1) to analyse VOC emissions from individual products and determine the most prevalent compounds among different product types and categories, (2) to ascertain the VOCs classified as potentially hazardous, (3) to compare emissions between green and regular versions, and (4) to

assess differences between the VOCs emitted and the ingredients listed on product labels.

For each of the three aims, the analytic approach used was gas chromatography/mass spectrometry (GC/MS), with details as follows.

Headspace GC/MS measurements of the baby products were performed using a Shimadzu GC/MS-QP2010 Plus instrument coupled to an automated Shimadzu AOC-5000 sample injection system. Approximately 2 g of each product were weighed into a 10 mL amber vial. Each vial was then tightly sealed with a magnetic screw cap with a PTFE/silicone septum. Samples were incubated at 40°C for 1 h immediately prior to injection of 2.5 mL of the headspace into the injection port heated at 240°C (split ratio 25). Separation was performed on a BPX-VOL capillary column (30 m × 0.25 mm, 1.4 µm film thickness) using helium as the carrier gas (flow rate 30 cm/s). The oven temperature was kept at 35°C for 3 min, then increased by 5°C/min to 220°C and held at this temperature for 5 min. The total run time was 45 min. The mass spectrometer ion source and interface temperatures were maintained at 200°C and 240°C, respectively. The mass spectrometer was operated in full scan mode between 25 – 400 m/z. Blanks were analysed periodically each day to account for any background impurities. The volatile sample components were identified based on the mass spectral library of the National Institute of Standards and Technology NIST Version 2.0 (Stein 2008).

2.1 Research aim 1

To investigate the VOC emissions from baby products, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and green baby products, and to compare VOCs identified with ingredients listed on labels.

To address Research aim 1, headspace GC/MS was used to identify chemicals emitted from 42 baby fragranced products in two categories: 21 regular and 21 green. The regular category included 9 shampoos (hair shampoos, conditioners and body washes), 9 lotions (lotions, creams, ointments, and oils), 2 hair sprays, and 1 fragrance spray. The green category included 12 shampoos (hair shampoos, conditioners and body washes), 8 lotions (lotions, creams and oils), and 1 anti-bug spray. All of these 42 products were purchased from stores in Australia, including groceries, pharmacies, and organic food stores.

2.2 Research aim 2

To investigate the VOC emissions from commercial essential oils, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and natural essential oils, and to compare VOCs identified with ingredients listed on labels.

To address Research aim 2, headspace GC/MS was used to analyse VOCs emitted from 24 essential oils. Essential oils were in two categories: 12 regular and 12 natural. The

regular category included 2 lavender oils, 2 jasmine oils, 1 orange oil, 1 English rose oil, 1 rose and grapefruit oil, 1 lemongrass oil, and 4 mixture of aromas oils. The natural category included 2 tea tree oils, 2 eucalyptus oils, 1 lavender oil, 1 orange oil, 1 peppermint oil, 1 lime and coconut oil, and 4 mixtures of aromas oils. Commercial essential oils in this study were purchased from supermarkets, aroma stores, organic stores, and pharmacies in Australia, and were from both domestic and international suppliers.

2.3 Research aim 3

To investigate the VOC emissions from common consumer products, to identify compounds classified as potentially hazardous, to evaluate VOC emissions between regular and green consumer products, and to compare VOCs identified with ingredients listed on labels.

To address Research aim 3, headspace GC/MS was used to analyse VOCs emitted from 134 consumer products (Table 1). The 134 products included 104 fragranced products, 15 sunscreens, and 15 fragrance-free products, in two categories: 68 regular and 66 green. The 104 fragranced products represented four types: personal care products (50), air fresheners (12), cleaning supplies (22), and laundry products (20). The 15 fragrance-free products represented three types: personal care products (10), cleaning supply (1), and laundry products (4). The 15 sunscreens were considered separately because they are regulated differently than the other consumer products (Lunny et al. 2017).

For each of the three research aims, two regulatory analyses were performed to identify whether chemicals emitted from the products could be classified as (i) potentially hazardous under Australian regulations or (ii) carcinogenic under the World Health Organization. For (i), Safe Work Australia (SWA) maintains a Hazardous Chemical Information System ("HCIS") that permits identification of chemicals with hazard classifications (SWA 2018). For (ii), the World Health Organization, International Agency for Research on Cancer (IARC) (WHO 2018), evaluates the carcinogenic risk of chemicals to humans. However, these analyses do not imply that the chemicals identified are the only ones with potential hazards. Furthermore, these analyses did not assess whether the products that contained these chemicals could pose any potential hazards as a whole. All products for this research were purchased from stores in Australia, including groceries, pharmacies, and organic or natural products stores.

3 Volatile chemical emissions from fragranced baby products

This chapter has been published as:

Nematollahi N, Doronila A, Mornane PJ, Duan A, Kolev SD, Steinemann A (2018a) Volatile Chemical Emissions from Fragranced Baby Products. *Air Quality, Atmosphere & Health* 11:785-90. doi: 10.1007/s11869-018-0593-1

To be consist with the thesis chapter numbering, the numbering of sections, figures, and tables in the original publication have been altered for this chapter. Also, the references have been also incorporated into the full list of references at the end of this thesis.

3.1 Abstract

Fragranced consumer products have been associated with adverse effects on human health. Babies are exposed to a variety of fragranced consumer products, which can emit numerous volatile organic compounds (VOCs), some considered potentially hazardous. However, fragranced baby products are exempt from disclosure of all ingredients. Consequently, parents and the public have little information on product emissions. This study investigates VOCs emitted from a range of fragranced baby products, including baby hair shampoos, body washes, lotions, creams, ointments, oils, hair sprays, and fragrance. The products were analysed using gas chromatography/mass spectrometry (GC/MS) headspace analysis. Of 42 baby products tested, 21 products made claims of being green, organic, or all-natural. Results of the analysis found 684 VOCs emitted collectively from the 42 products, representing 228 different VOCs. Of these 684 VOCs, 207 are classified as potentially hazardous under federal regulations, representing 43 different VOCs. The most common VOCs emitted were limonene, acetaldehyde, ethanol, alpha-pinene, linalool, beta-myrcene, acetone, and beta-pinene. A comparison between ingredients emitted and ingredients listed reveals that only 5% of the 684 VOCs, including 12% of 207 potentially hazardous VOCs, were listed on the product label, safety data sheet, or website. More than 95% of both green and regular products emitted one or more potentially hazardous VOCs. Further, emissions of the most prevalent VOCs from green, organic, or all-natural products were not significantly different from regular products. Results from this study can help improve public awareness about emissions from baby products, with the aim to reduce pollutant exposure and potential adverse effects on babies.

Keywords: baby products, fragrance, volatile organic compounds, emissions,
ingredients

3.2 Introduction

Volatile organic compounds (VOCs) are a major category of pollutants, associated with adverse effects on human health (e.g., WHO 2018; NIH 2017; SWA 2018; Wallace 2001). Fragranced consumer products, widely used in society, emit numerous VOCs. Previous studies have found more than 150 different VOCs emitted from fragranced products, including terpenes such as limonene and alpha-pinene, and hazardous air pollutants such as formaldehyde and acetaldehyde (Steinemann 2015). Fragranced consumer products (or, for brevity, fragranced products) are defined as products with an added fragrance or scent, such as air fresheners, deodorizers, cleaning products, laundry supplies, household items, perfume, and personal care products (Steinemann 2015), as well as items for babies.

Exposure to fragranced consumer products is widespread. For instance, an estimated 98.5% of Australians are exposed to fragrance products at least once a week from their own use, others' use, or both (Steinemann 2016, 2017). For babies, while comparable population studies are lacking in Australia, some international studies have found average use of baby shampoo, cleaning liquid or gel, and moisturising cream, respectively, as 2.9, 4.4, and 1.4 g/day (Gomez-Berrada et al. 2017) and 1.55, 2.91 and 2.99 g/day (Lee et al. 2017).

Exposure to fragranced consumer products has been associated with health problems such as asthma attacks, migraine headaches, respiratory difficulties, and allergic reactions among adults (Steinemann 2016, 2017; Weinberg et al. 2017). In young

children, exposure to VOCs from household products, such as air fresheners, has been associated with infant diarrhoea and earache (Farrow et al. 2003). Babies can be exposed to product VOCs through epidermal, inhalation, and ingestion routes (Ott et al. 2007) as well as in utero (Bagasra et al. 2013).

The precise and full ingredients of fragranced products are not required to be fully disclosed (Lunny et al. 2017). The disclosure requirements depend on the type of product. For consumer products such as cleaning supplies, laundry products, air fresheners, and household items, no law in Australia requires disclosure of all ingredients. For personal care products, ingredients need to be listed on product labels, but the general term "fragrance" or "parfum" can be listed instead of the specific fragrance ingredients. However, a single "fragrance" in a product is typically a mixture of several dozen chemicals (Steinemann et al. 2011). Baby products are treated the same as adult products for the purposes of ingredient disclosure. Thus, fragranced baby consumer products (other than personal care products) have no requirement to disclose all ingredients, and baby personal care products are required to disclose ingredients except those in fragrance mixtures (Lunny et al. 2017).

Lack of knowledge of full ingredients may impair consumer choice. Consumers may be attracted to "natural" (or green or organic) products, assuming they may contain fewer chemicals of concern (Klaschka 2016). However, previous studies have discovered that products called natural, green, and organic emitted hazardous air pollutants similar to their regular counterparts (Steinemann 2015). Currently, there is no objective basis for claims of green or natural baby products. For organic baby products, Australian

Certified Organic (ACO) provides a detailed standard (ACO 2018). Among the specifications, products should consist of at least 95% organic ingredients to be called "organic." For products less than 95% organic, labels can make reference to the specific organic ingredients.

Previous research on VOC emissions from fragranced consumer products found the most common compounds were ethanol and limonene (Steinemann 2015), limonene (Dimitroulopoulou et al. 2015), and limonene and linalool (ter Burg et al. 2014). In addition, other terpenes such as alpha-pinene and beta-pinene, and other volatiles such as acetone, acetaldehyde, benzyl acetate, and methanol, were also common (Steinemann 2015). However, no prior research was identified that specifically analysed the VOCs emitted from fragranced baby products.

This article reports on the first known study to investigate the VOCs emitted from fragranced baby products, including both regular products and green products. "Green" products are defined in this study as the products with the claim of "certified organic," "certified green," "green," "organic," "natural," "no petrochemicals," "non-toxic," "plant-based," and "essential oils" for the whole products or their ingredients on their product label, safety data sheet, or website. "Regular" products are the products not in the green category. In addition, this study compares the ingredients emitted from the products with the ingredients listed on the product label, safety data sheet, and website. Moreover, the emitted chemicals are compared with those classified as potentially hazardous under federal regulations. Finally, emissions between regular and green products are contrasted, and their links with hazard classifications and labelling.

3.3 Materials and methods

Headspace GC/MS was used to identify chemicals emitted from 42 baby fragranced products in two categories: 21 regular and 21 green. The regular category includes 9 shampoos (hair shampoos, conditioners and body washes), 9 lotions (lotions, creams, ointments, and oils), 2 hair sprays, and 1 fragrance spray. The green category includes 12 shampoos (hair shampoos, conditioners and body washes), 8 lotions (lotions, creams and oils), and 1 anti-bug spray. All of these 42 products were purchased from stores in Australia, including groceries, pharmacies, and organic food stores.

"Green" products are defined in this study as the products with the claim of "certified organic," "certified green," "green," "organic," "natural," "no petrochemicals," "non-toxic," "plant-based," and "essential oils" for the whole products or their ingredients on their product label, safety data sheet, or website. "Regular" products are the products not in the green category.

"Baby" products are defined in this study as products containing specific designations, such as wording (e.g., "baby shampoo") or illustrations (e.g., picture of a baby), that they are intended for use on infants and toddlers.

"Fragranced" products are identified in this study as products containing fragrance, parfum, aromatic extracts, or essential oils.

Headspace GC/MS of the baby products was performed using a Shimadzu GC/MS-QP2010 Plus instrument coupled to an automated Shimadzu AOC-5000 sample injection system. Approximately 2 g of each baby product was weighed into a 10 mL amber vial. Each vial was then tightly sealed with a magnetic screw cap with a PTFE/silicone septum. Samples were incubated at 40°C for 1 h immediately prior to injection of 2.5 mL of the headspace into the injection port heated at 240°C (split ratio 25). Separation was performed on a BPX-VOL capillary column (30 m × 0.25 mm, 1.4 µm film thickness) using helium as the carrier gas (flow rate 30 cm/s). The oven temperature was kept at 35°C for 3 min, then increased by 5°C/min to 220°C and held at this temperature for 5 min. The total run time was 45 min. The mass spectrometer ion source and interface temperatures were maintained at 200°C and 240°C, respectively. The mass spectrometer was operated in full scan mode between m/z 25 - 400. Blanks were analysed periodically each day to account for any background impurities. The volatile sample components were identified based on the mass spectral library of the National Institute of Standards and Technology NIST Version 2.0 (Stein 2008).

Two regulatory analyses were performed to identify whether chemicals emitted from baby products could be classified as (i) potentially hazardous under Australian regulations or (ii) carcinogenic under the World Health Organization. For (i), Safe Work Australia (SWA) maintains a Hazardous Chemical Information System ("HCIS") that permits identification of chemicals with hazard classifications (SWA 2018). For (ii), the World Health Organization, International Agency for Research on Cancer (IARC) (WHO 2018), evaluates the carcinogenic risk of chemicals to humans. However, these analyses do not imply that the chemicals identified are the only ones with potential

hazards. Furthermore, these analyses did not assess whether the products that contained these chemicals could pose any potential hazards as a whole.

3.4 Results and discussion

3.4.1 VOCs emitted

A summary of all VOCs emitted from "green" and "regular" baby products is provided in Table 1. The term "VOC occurrences" refers to the number of individual VOCs peaks detected by GC/MS, where each peak represents an ingredient in the product. The term "VOC identities" refers to the number of different VOCs, where each VOC is present in one or more of the products. Among the 42 products, a total of 684 VOC occurrences representing 228 VOC identities were detected. Each baby product emitted between 1 and 47 VOCs (see Supplementary Tables 1 and 2, Appendix A). Complete data on VOCs identified for all 42 products, green products, and regular products are provided as Supplementary Tables 3, 4, and 5 (Appendix A).

Table 1 VOCs emitted from 42 baby products compared with VOCs listed

Type	Number of products	Emitted		Listed	
		All VOCs	Potentially Hazardous VOCs	All VOCs	Potentially Hazardous VOCs
Regular	21	286 occurrences 137 identities	95 occurrences 30 identities	13 occurrences 5 identities	9 occurrences 2 identities
Green	21	398 occurrences 154 identities	112 occurrences 33 identities	21 occurrences 4 identities	16 occurrences 3 identities
Total	42	684 occurrences 228 identities	207 occurrences 43 identities	34 occurrences 7 identities	25 occurrences 3 identities

3.4.2 Most prevalent

Among the 42 products, the most prevalent VOCs (in at least 40% of the products) were limonene, acetaldehyde, ethanol, alpha-pinene, linalool, beta-myrcene, acetone, and beta-pinene. In regular products, the six most prevalent VOCs were ethanol, limonene, acetaldehyde, alpha-pinene, ethyl butyrate, and phenoxyethanol. In green products, the six most prevalent VOCs were limonene, linalool, acetaldehyde, beta-myrcene, alpha-pinene, and acetone. Among all the identified VOCs, limonene was the most common, found in 67% of the products. (See Table 2 for the most prevalent compounds.)

Table 2 Most prevalent compounds among baby products

Compound	CAS #	Prevalence (# of products)		
		Total	Regular	Green
<u>All products (n=42)</u>				
Limonene*	138-86-3	28	11	17
Acetaldehyde*	75-07-0	23	10	13
Ethanol*	64-17-5	23	14	9
alpha-Pinene	80-56-8	21	8	13
Linalool	78-70-6	20	4	16
beta-Myrcene	123-35-3	19	6	13
Acetone*	67-64-1	17	5	12
beta-Pinene	127-91-3	17	7	10
Eucalyptol	470-82-6	14	4	10
Ethyl butyrate	105-54-4	13	8	5
3-Carene	13466-78-9	12	3	9
Phenoxyethanol*	122-99-6	12	8	4
Benzyl alcohol*	100-51-6	11	4	7
Benzyl acetate	140-11-4	10	5	5
Camphene	79-92-5	10	3	7
Camphor	76-22-2	10	2	8
gamma-Terpinene	99-85-4	10	3	7

Regular products (n=21)

Ethanol*	64-17-5	14
Limonene*	138-86-3	11
Acetaldehyde*	75-07-0	10
alpha-Pinene	80-56-8	8
Ethyl butyrate	105-54-4	8
Phenoxyethanol*	122-99-6	8

Green products (n=21)

Limonene*	138-86-3	17
Linalool	78-70-6	16
Acetaldehyde*	75-07-0	13
beta-Myrcene	123-35-3	13
alpha-Pinene	80-56-8	13
Acetone*	67-64-1	12
Eucalyptol	470-82-6	10
beta-Pinene	127-91-3	10
Ethanol*	64-17-5	9
3-Carene	13466-78-9	9
Linalool acetate	115-95-7	8
Camphor	76-22-2	8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3.4.3 Regulatory classifications

Of the 684 VOC occurrences, 207 are classified as potentially hazardous under Australian regulations (Table 3), and 95% of products emitted at least one potentially hazardous VOC. Among the most prevalent VOCs (in at least 40% of the products), 50% are classified as potentially hazardous: limonene, acetaldehyde, ethanol, and acetone. Also, among these 684 VOC occurrences, 25 are classified as possibly carcinogenic to humans and 1 is classified as probably carcinogenic to humans (Table

4). However, none of these carcinogenic compounds were listed on any product label, safety data sheet, or website.

*Table 3 Compounds classified as potentially hazardous among baby products**

Compound	CAS #	Prevalence (# of products)		
		Total	Regular	Green
Limonene	138-86-3	28	11	17
Acetaldehyde	75-07-0	23	10	13
Ethanol	64-17-5	23	14	9
Acetone	67-64-1	17	5	12
Phenoxyethanol	122-99-6	12	8	4
Benzyl alcohol	100-51-6	11	4	7
Isopropyl alcohol	67-63-0	9	4	5
Ethyl Acetate	141-78-6	8	5	3
1-Octanol	111-87-5	7	1	6
Pentane	109-66-0	6	3	3
Isoamyl acetate	123-92-2	5	4	1
2,4-Dimethylhexane	589-43-5	4	0	4
Toluene	108-88-3	4	1	3
2-Methylbutyl acetate	624-41-9	3	2	1
Cyclohexane	110-82-7	3	1	2
Hexane	110-54-3	3	1	2
Methanol	67-56-1	3	2	1
Octamethylcyclotetrasiloxane	556-67-2	3	3	0
Propanal	123-38-6	3	3	0
2-Butenal	4170-30-3	2	1	1
2-Methyl-1-propene	115-11-7	2	0	2
2-Methylpentane	107-83-5	2	0	2
3-Methylhexane	589-34-4	2	1	1
Benzaldehyde	100-52-7	2	1	1
Butyl acetate	123-86-4	2	1	1
Isobutyl 2-methyl-2-propenoate	97-86-9	2	0	2
Tetrahydrofuran	109-99-9	2	2	0
(2Z)-3,7-dimethylocta-2,6-dienal	106-26-3	1	1	0
1-Hexanol	111-27-3	1	1	0
2,4-Dimethylpentane	108-08-7	1	0	1

2,4-Pentanedione	123-54-6	1	0	1
3-Methylpentane	96-14-0	1	0	1
Amyl acetate	628-63-7	1	0	1
Benzyl benzoate	120-51-4	1	1	0
Butane	106-97-8	1	1	0
Citral	5392-40-5	1	0	1
Dichloromethane	75-09-2	1	1	0
Ethyl lactate	97-64-3	1	0	1
Ethyl methyl ether	540-67-0	1	1	0
Ethyl propionate	105-37-3	1	1	0
Methylcyclohexane	108-87-2	1	0	1
Octane	111-65-9	1	0	1
Pentyl acetate	628-63-7	1	0	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Table 4 Compounds classified for carcinogenic risk

Compound	CAS #	Classification group*	Prevalence (# of products)		
			Total	Regular	Green
Acetaldehyde	75-07-0	2B	23	10	13
Isopropyl alcohol	67-63-0	3	9	4	5
Toluene	108-88-3	3	4	1	3
Tetrahydrofuran	109-99-9	2B	2	2	0
2-Butenal	4170-30-3	3	2	1	1
Dichloromethane	75-09-2	2A	1	1	0

*Group 2A: Probably carcinogenic to humans, Group 2B: Possibly carcinogenic to humans, Group 3: Not classifiable as to its carcinogenicity to humans (WHO 2018).

3.4.4 Green products

Among the green products, 20 emitted at least 1 VOCs classified as potentially hazardous (Supplementary Table 1, Appendix A). Among the regular products, 20 emitted at least 1 VOCs classified as potentially hazardous (Supplementary Table 2, Appendix A). Among the most prevalent VOCs also classified as potentially hazardous, 75% are similar among regular and green products. Comparing the 21 regular and 21

green products, no significant difference was found in the most prevalent VOCs ($p < 0.05$, t-test).

3.4.5 Listing of ingredients

Among all the 684 VOC occurrences, only 34 were listed on any baby product label, safety data sheet, or website. Thus, 5% of all volatile chemicals identified were listed. Further, among all the 207 VOCs classified as potentially hazardous, only 25 were listed on any baby product label, safety data sheet, or website. Thus, 88% of all potentially hazardous volatile chemicals identified were undisclosed.

3.4.6 Limitations

This analysis focused on the primary VOC emissions, even though secondary pollutants (such as formaldehyde) could also be generated. Further, the study focused on VOCs, even though other chemical classes (such as semi-volatile or non-volatile organic compounds) could also pose potential hazards. Finally, the relative safety or hazard of products depends on many factors (e.g., VOC concentrations, frequency and duration of exposure), and this study focused exclusively on identifying VOC emissions.

3.5 Conclusions

This study provides the results of VOCs emitted from 42 common fragranced baby products, finding a total of 684 VOCs emitted (representing 228 different VOCs), with 207 VOCs emitted (representing 43 different VOCs) classified as potentially hazardous. However, only 5% of all VOCs and 12% of potentially hazardous VOCs were listed on

any product label, safety data sheet, or website. Moreover, emissions of the most prevalent VOCs from green, organic, and natural fragranced baby products were not significantly different from regular baby products. The results of this study can contribute to improved awareness of product ingredients and to reduce the risk of exposure for babies.

3.6 Acknowledgments

The study received support from the Australian Government Research Training Program Scholarship (RTP), through the University of Melbourne; the Australian Department of Education and Training (Australian Postgraduate Award); and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This article is dedicated to the memory of Neda Yarmahmoudi.

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4 Volatile chemical emissions from essential oils

This chapter has been published as:

Nematollahi N, Kolev SD, Steinemann A (2018b) Volatile chemical emissions from essential oils. *Air Quality, Atmosphere & Health* 11:949–954. doi: 10.1007/s11869-018-0606-0

To be consist with the thesis chapter numbering, the numbering of sections, figures, and tables in the original publication have been altered for this chapter. Also, the references have been also incorporated into the full list of references at the end of this thesis.

4.1 Abstract

Essential oils, widely used in society, emit numerous volatile organic compounds (VOCs). Some of these VOCs are considered as potentially hazardous under federal regulations. However, essential oils are exempt from disclosure of their ingredients on their label. Thus, the public may lack information on emissions and potential hazards from essential oils. This study examined VOCs emitted from a range of commercial essential oils, including tea tree oils, lavender oils, eucalyptus oils, and other individual oils and mixtures of oils. Using headspace gas chromatography/mass spectrometry (GC/MS), the study analysed 24 commercial essential oils, including 12 with claims of being "natural" or related terms, such as organic, 100% pure, or plant-based. Results identified 595 VOCs emitted from the 24 essential oils, representing 188 different VOCs. The most common VOCs emitted were alpha-pinene, limonene, acetone, linalool, alpha-phellandrene, beta-myrcene, and camphene. Among the 589 VOCs identified, 124 VOCs, representing 33 different VOCs, are classified as potentially hazardous. All natural and regular essential oils emitted one or more potentially hazardous VOCs, such as acetaldehyde, acetone, and ethanol. Toluene was also found in 50% of essential oils. Moreover, for the prevalent VOCs classified as potentially hazardous, no significant difference was found between regular and natural essential oils. This study provides insights and information about emissions of commercial essential oils that can be useful for public awareness and risk reduction.

Keywords: essential oils, fragrance, volatile organic compounds, emissions, ingredients

4.2 Introduction

Essential oils, such as lavender oil, orange oil, eucalyptus oil, and tea tree oil, are widely used in cosmetics, cleaning supplies, fragranced products, building systems, and aromatherapy. Essential oils are complex mixtures of various compounds such as terpenes (Huang et al. 2012). Exposure to compounds emitted from essential oils has been associated with adverse health effects such as skin irritation (Chiang et al. 2010; Sarkic and Stappen 2018), asthma exacerbation, decrease of pulmonary function, chest tightness, and wheezing (Su et al. 2007). Moreover, exposure to some of these compounds during pregnancy may potentially harm a developing fetus (Bagasra et al. 2013).

Numerous studies have examined essential oils, and most used their own extracted oils from plant leaves, roots or fruits (Isidorov and Jdanova 2002; Winters et al. 2009; Helmig et al. 2013; González-Rivera et al. 2016), instead of commercially available essential oils. In addition, studies on essential oils typically focus on providing information about anti-bacterial and anti-oxidant benefits (Lee et al. 2005, 2013) rather than emissions or possible risks.

Among the literature, a relatively small subset of studies examined VOC emissions from commercially available essential oils. For example, Chiang et al. (2010) analysed emitted compounds from five essential oils (i.e., lavender, lemon, rose, rosemary, and tea tree), and found the main carbonyl compounds were acetaldehyde, formaldehyde, acetone, and propionaldehyde. Chiu et al. (2009) analysed VOC emissions from five

essential oils (i.e., rose, lemon, rosemary, tea tree, and lavender), and found the predominant VOCs were toluene, 1,2,3- trimethylbenzene, 1,2,4-trimethylbenzene, n-undecane, p-diethylbenzene, and m-diethylbenzene. Cheng and Lai (2014) analyzed by-products of tea tree essential oils, and found alkane compounds such as propane and isobutane, as well as aromatic compounds such as ethylbenzene, m/p-xylene, 1,2,3-trimethylbenzene, 1,2,4 trimethylbenzene, 1,4-diethylbenzene, and acetone. Su et al. (2007) analyzed three essential oils (i.e., lavender, eucalyptus, and tea tree), and showed the main VOCs were linalool, linalyl arthranilate, eucalyptol, D-limonene, p-cymene, γ -terpinene, and terpinene-4-ol-, all from the family of terpenes. Francis and Stusdal (2014) analyzed three mint essential oils (i.e., peppermint oil, Japanese peppermint, and spearmint oil), and found the main compounds from peppermint and Japanese peppermint oil were menthone, menthol, limonene, 1,8-cineole, menthofuran, and neomenthol, and from spearmint oil were carvone, limonene, and 1,8-cineole. Collectively, these studies provide evidence that essential oils emit numerous VOCs, with some considered as potentially hazardous. However, most studies analyzed five or fewer essential oils rather than a range of types and brands, which is a contribution of this present study.

This study investigates the VOCs emitted from a variety of 24 commercial essential oils of different types and brands, including both regular and natural essential oils. In addition, this study compares the emitted VOCs from both regular and natural essential oils, and examines their classifications as potentially hazardous under federal regulations. "Essential oil" will be considered, for this paper, as an oil derived from or with the aroma of the essence of a plant substance. The term "Commercial essential

oils" in this study refers to essential oils that are publicly available for purchase. The classifier "natural" for essential oils refers to oils or diffusers with the claim of "natural" or a related term such as "certified organic," "100% pure," "organic," "no petrochemicals," "non-toxic," or "plant-based," for the whole essential oil or individual ingredients. However, this study did not seek to authenticate the product claims of "natural." The classifier "regular" for essential oils refers to those not in the natural category.

4.3 Materials and methods

Headspace GC/MS was used to analyze VOCs emitted from 24 essential oils. Essential oils were in two categories: 12 regular and 12 natural. The regular category included 2 lavender oils, 2 jasmine oils, 1 orange oil, 1 English rose oil, 1 rose and grapefruit oil, 1 lemongrass oil, and 4 mixture of aromas oils. The natural category included 2 tea tree oils, 2 eucalyptus oils, 1 lavender oil, 1 orange oil, 1 peppermint oil, 1 lime and coconut oil, and 4 mixtures of aromas oils. Commercial essential oils in this study were purchased from supermarkets, aroma stores, organic stores, and pharmacies in Australia, and were from both domestic and international suppliers.

Headspace GC/MS analysis of the essential oils was performed using a Shimadzu GC/MS equipped with a BPX-VOL capillary column. The volatile components of samples were identified based on the mass spectral library of the National Institute of Standards and Technology NIST Version 2.0 (Stein 2008). More details about the GC/MS methods are described in Nematollahi et al. (2018). Although the

chromatograms of most of the essential oils exhibited more than 100 peaks (see Supplementary Figure, available online), only the top 25 peaks for each of the samples were processed.

Emitted VOCs from essential oils were examined for classification as (i) potentially hazardous under Australian regulations or (ii) potentially carcinogenic under the World Health Organization. For (i), Safe Work Australia (SWA) provides a Hazardous Chemical Information System (HCIS) with a database of potentially hazardous compounds (SWA 2018). Although SWA uses the Globally Harmonised System of Classification and Labelling of Chemicals (GHS 2018) with concentration thresholds to determine a specific hazard class and category, overall risk depends on additional factors such as exposures. For (ii), the World Health Organization, International Agency for Research on Cancer (IARC) (World Health Organization (WHO) 2018), evaluates compounds for their potential carcinogenic risk to humans. However, these two analyses do not suggest that the VOCs discussed in the current study are the only potentially hazardous compounds emitted from essential oils. Moreover, this study focused on individual compounds, and did not examine potential hazards of one or more compounds together in one essential oil.

4.4 Results and discussion

4.4.1 VOCs emitted

Each essential oil emitted between 20 to 140 VOCs (see Supplementary Tables 1 and 2, Appendix B). Table 5 shows the summary of VOCs emitted from "natural" and

"regular" essential oils. In this paper, the term "VOC occurrences" represents the number of individual VOCs emitted from each essential oil corresponding to the top 25 chromatographic peaks. The term "VOC identities" represents the number of unique VOCs, which can be emitted from one or more of the essential oils. For all the 24 essential oils, the numbers of VOC occurrences and identities were 589 and 188, respectively. Supplementary Tables 3, 4, and 5 (Appendix B) provide details about the VOCs emitted from all 24 essential oils, and subsets of "natural" essential oils and "regular" essential oils.

Table 5 VOCs emitted from 24 essential oils

Type	Number of essential oils	All VOCs	Potentially hazardous VOCs
Regular	12	289 occurrences 132 identities	74 occurrences 27 identities
Natural	12	300 occurrences 95 identities	50 occurrences 16 identities
Total	24	589 occurrences 188 identities	124 occurrences 33 identities

4.4.2 Most prevalent VOCs

Among the 24 essential oils, the most prevalent VOCs (in at least 50% of all essential oils) were alpha-pinene, limonene, acetone, linalool, alpha-phellandrene, beta-myrcene, camphene, ethanol, beta-pinene, 3-carene, eucalyptol, acetaldehyde, beta-phellandrene, gamma-terpinene, m-cymene, beta-trans-ocimene, methanol, and terpinolene. In "regular" essential oils, the most prevalent VOCs (in at least 50% of regular essential oils) were acetaldehyde, linalool, 1-(2-methoxy-1-methylethoxy)propan-2-ol, alpha-pinene, limonene, acetone, ethanol, and 1-(2-methoxypropoxy)propan-2-ol. In "natural"

essential oils, the most prevalent VOCs (in at least 65% of natural essential oils) were alpha-pinene, alpha-phellandrene, beta-pinene, limonene, 3-carene, beta-myrcene, eucalyptol, gamma-terpinene, camphene, acetone, beta-phellandrene, and m-cymene.

Table 6 presents the most prevalent VOCs.

Table 6 Most prevalent VOCs emitted by the 24 essential oils

Compound	CAS #	Prevalence (# of essential oils)		
		Total	Regular	Natural
<u>All essential oils (n=24)</u>				
alpha-Pinene	80-56-8	20	8	12
Limonene*	138-86-3	19	8	11
Acetone*	67-64-1	17	8	9
Linalool	78-70-6	16	9	7
alpha-Phellandrene	99-83-2	16	4	12
beta-Myrcene	123-35-3	15	5	10
Camphene	79-92-5	15	5	10
Ethanol*	64-17-5	15	8	7
beta-Pinene	127-91-3	15	3	12
3-Carene	13466-78-9	14	3	11
Eucalyptol	470-82-6	14	4	10
Acetaldehyde*	75-07-0	13	10	3
beta-Phellandrene	555-10-2	13	4	9
gamma-Terpinene	99-85-4	13	3	10
m-Cymene	535-77-3	11	3	8
beta-trans-Ocimene	3779-61-1	10	3	7
Methanol*	67-56-1	10	3	7
Terpinolene	586-62-9	10	3	7
<u>Regular essential oils (n=12)</u>				
Acetaldehyde*	75-07-0	10		
Linalool	78-70-6	9		
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	8		

alpha-Pinene	80-56-8	8
Limonene*	138-86-3	8
Acetone*	67-64-1	8
Ethanol*	64-17-5	8
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	6

Natural essential oils (n=12)

alpha-Pinene	80-56-8	12
alpha-Phellandrene	99-83-2	12
beta-Pinene	127-91-3	12
Limonene*	138-86-3	11
3-Carene	13466-78-9	11
beta-Myrcene	123-35-3	10
Eucalyptol	470-82-6	10
gamma-Terpinene	99-85-4	10
Camphene	79-92-5	10
Acetone*	67-64-1	9
beta-Phellandrene	555-10-2	9
m-Cymene	535-77-3	8
Linalool	78-70-6	7
beta-trans-Ocimene	3779-61-1	7
4-Carene	29050-33-7	7
Methanol*	67-56-1	7
Ethanol*	64-17-5	7
Terpinolene	586-62-9	7
alpha-Thujene	2867-05-2	6
alpha-Terpineol	98-55-5	6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4.4.3 Regulatory classifications

All the essential oils emitted at least 1 VOC classified as potentially hazardous

(Supplementary Table 1 and 2, Appendix B). Among all the 589 VOC occurrences, 124

VOCs were classified as potentially hazardous under Australian regulations (Table 7).

The most prevalent potentially hazardous compounds (in at least 40% of essential oils) were limonene, acetone, ethanol, acetaldehyde, and methanol.

Table 7 Compounds classified as potentially hazardous among VOCs emitted from the essential oils*

Compound	CAS #	Prevalence (# of essential oils)		
		Total	Regular	Natural
Limonene	138-86-3	19	8	11
Acetone	67-64-1	17	8	9
Ethanol	64-17-5	15	8	7
Acetaldehyde	75-07-0	13	10	3
Methanol	67-56-1	10	3	7
Ethyl acetate	141-78-6	4	4	0
Ethyl formate	109-94-4	4	3	1
Methyl acetate	79-20-9	4	4	0
2-Methylpropene	115-11-7	3	3	0
Acetaldehyde diethyl acetal	105-57-7	3	3	0
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	3	3	0
Methyl formate	107-31-3	3	2	1
(S)-(-)-propylene oxide	16088-62-3	2	2	0
(Z)-citral	106-26-3	1	1	0
Butane	106-97-8	3	0	3
Citral	5392-40-5	2	1	1
Isoamyl acetate	123-92-2	1	0	1
(R)-(-)-2-butanol	14898-79-4	1	1	0
1-Hexanol	111-27-3	2	0	2
1-Octanol	111-87-5	1	0	1
2,4-Dimethylhexane	589-43-5	1	0	1
2-Butene	107-01-7	1	1	0
Benzaldehyde	100-52-7	1	1	0
Benzyl alcohol	100-51-6	1	1	0
Benzyl benzoate	120-51-4	1	1	0
Butyl butyrate	109-21-7	1	0	1
Carbon disulphide	75-15-0	1	1	0
Cyclohexane	110-82-7	1	1	0

Ethyl methyl ether	540-67-0	1	1	0
Ethylbenzene	100-41-4	1	0	1
Isopropyl alcohol	67-63-0	1	0	1
Propylene glycol butyl ether	5131-66-8	1	1	0
p-Xylene	106-42-3	1	1	0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Table 8 presents the most common potentially hazardous compounds, as classified under Safe Work Australia (SWA 2018), among all emitted compounds (not only those corresponding to the top 25 chromatographic peaks). These results indicate that acetaldehyde, acetone and ethanol were emitted from almost all (over 90%) of the essential oils studied. Toluene was also emitted from 50% of essential oils. Table 9 indicates the carcinogenic risks of compounds among all emitted compounds (not only those corresponding to the top 25 chromatographic peaks). Among these emitted compounds, 6 VOCs, representing 49 VOC occurrences, are classified as Group 1, 2, or 3 under the World Health Organisation (WHO 2018).

Table 8 Most common compounds classified as potentially hazardous among all VOCs emitted from the essential oils*

Compound	CAS #	Prevalence (# of essential oils)		
		Total	Regular	Natural
Acetaldehyde	75-07-0	24	12	12
Acetone	67-64-1	22	10	12
Ethanol	64-17-5	22	11	11
Methanol	67-56-1	18	6	12
Methyl acetate	79-20-9	14	8	6
Toluene	108-88-3	12	4	8
Ethyl acetate	141-78-6	12	7	5
Ethyl formate	109-94-4	8	4	4
Isopropyl alcohol	67-63-0	7	2	5

1-Hexanol	111-27-3	6	1	5
2-Butene	107-01-7	4	1	3
Hexane	110-54-3	4	2	2
Methyl isobutyl ketone	108-10-1	4	0	4
Ethylbenzene	100-41-4	1	0	1
Benzene	71-43-2	1	0	1
p-Xylene	106-42-3	1	1	0
Benzyl alcohol	100-51-6	1	1	0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Table 9 Compounds classified for carcinogenic risk among all VOCs emitted from the essential oils

Compound	CAS #	Classification group*	Prevalence (# of essential oils)		
			Total	Regular	Natural
Acetaldehyde	75-07-0	2B	24	12	12
Toluene	108-88-3	3	12	4	8
Isopropyl alcohol	67-63-0	3	7	2	5
Methyl isobutyl ketone	108-10-1	2B	4	0	4
Benzene	71-43-2	1	1	0	1
Ethylbenzene	100-41-4	2B	1	0	1

*Group 1: Carcinogenic to humans, Group 2A: Probably carcinogenic to humans, Group 2B: Possibly carcinogenic to humans, Group 3: Not classifiable as to its carcinogenicity to humans (WHO 2018).

4.4.4 Potentially hazardous emissions

All "natural" essential oils emitted at least 3 VOCs classified as potentially hazardous, i.e., acetaldehyde, acetone, and methanol (Table 8). All "regular" essential oils emitted at least 1 VOC classified as potentially hazardous, i.e., acetaldehyde (Table 8.). The most prevalent potentially hazardous VOCs emitted by at least 50% of all "natural" and "regular" essential oils were the same. Interestingly, the prevalences of 3 out of 7 of the most prevalent compounds were higher in "natural" essential oils than in "regular" essential oils. Moreover, for the prevalent VOCs classified as potentially hazardous

(Table 8), no significant difference was found between regular and natural essential oils ($p < 0.05$, t-test).

4.4.5 Limitations

The current study was focused on identifying primary VOC emissions from essential oils, but other relevant phenomena such as the formation of secondary pollutants (e.g., formaldehyde) and the effect of VOC concentrations and exposures on the overall risk could also be investigated. In addition, while the study identified what VOCs were present, it did not seek to determine why those VOCs were present, which could be associated with factors such as sources and extraction methods. Finally, the study did not seek to authenticate whether the essential oils that claimed to be "natural" were in some way truly natural.

4.5 Conclusions

This study analysed VOCs emissions from 24 commercial essential oils of different types and brands. The results indicated that 589 VOCs, representing 188 different VOCs, were emitted, with 124 VOCs, representing 33 different VOCs, classified as potentially hazardous. Furthermore, emissions of the most prevalent potentially hazardous VOCs from "regular" and "natural" essential oils were not significantly different. Essential oils are not required to disclose their ingredients on their labels. Thus, results from this study can improve public awareness about the emitted VOCs from essential oils.

4.6 Acknowledgments

The study received support from the Australian Government Research Training Program Scholarship (RTP), through the University of Melbourne; the Australian Department of Education and Training (Australian Postgraduate Award); and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This article is dedicated to the memory of Neda Yarmahmoudi.

4.7 References

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5 Volatile Chemical Emissions from 134 Common Consumer Products

This chapter has been submitted as:

Nematollahi N, Kolev SD, Steinemann A (2019) Volatile Chemical Emissions from 134 Common Consumer Products. *Air Quality, Atmosphere & Health*

To be consist with the thesis chapter numbering, the numbering of sections, figures, and tables in the original publication have been altered for this chapter. Also, the references have been also incorporated into the full list of references at the end of this thesis.

5.1 Abstract

Emissions from everyday consumer products have been associated with adverse effects on air quality and health. This study investigates volatile organic compounds (VOCs) emitted from 134 common consumer products, both fragranced and fragrance-free, including those with claims of green. Product types include personal care products, air fresheners, cleaning supplies, laundry products, and sunscreens. Using GC/MS headspace analysis, this study found 1,538 VOC occurrences (individual ingredients), representing 338 VOC identities (different compounds), emitted from the 134 consumer products. Among the 1,538 VOCs, 517 VOCs are classified as potentially hazardous. The most common VOC emitted from the 104 fragranced products was limonene, which was absent in fragrance-free versions. Comparing the green and regular fragranced products, no significant difference was found between the most prevalent potentially hazardous VOCs. Among all volatile ingredients emitted, fewer than 4% were listed on product labels. This study provides extensive findings on volatile emissions from consumer products, which can improve awareness of potential exposures and effects on air quality and health.

Keywords: consumer products, volatile organic compounds, fragrance, cleaning products, air fresheners, emissions, ingredients

5.2 Introduction

Volatile organic compounds (VOCs) are a main category of pollutant associated with adverse effects on air quality and human health. An important source of VOC pollutants within indoor environments is fragranced consumer products, such as air fresheners, cleaning supplies, laundry detergents, and personal care products (Steinemann 2015, 2019 a,b). In addition to concerns for indoor air quality, fragranced products also generate pollutants that impair outdoor air quality (McDonald et al. 2018). Further, fragranced product use and exposure is widespread. For instance, according to recent surveys, over 98.5% of the population in the United States, Australia, United Kingdom, and Sweden are exposed to a variety of fragranced products at least once a week from their own use, others' use, or both (Steinemann 2019).

However, ingredients in fragranced consumer products are largely undisclosed (Steinemann 2019). No law in any country requires that consumer products (other than foods, drugs, and cosmetics) disclose all specific ingredients (Steinemann 2009). Further, the fragrance formulation in any product is exempt from full ingredient disclosure (Steinemann 2015, Lunny et al. 2017). Thus, chemical analysis of products can provide important and new information on product emissions and potential exposures.

Relatively few prior studies have investigated the range of VOCs emitted from different types of fragranced consumer products. Steinemann (2015) analyzed VOC emissions from 37 fragranced consumer products, including air fresheners, laundry products,

cleaning supplies, and personal care products, both green and regular versions, as well as fragrance-free products. Uhde and Schulz (2015) analyzed VOC emissions from 14 air fresheners such as diffusers and evaporators, spray odorizers, and scented candles. Zarogianni et al. (2017) tested fragrance ingredients in 14 detergents including green and regular versions. Nematollahi et al. (2018a) analyzed VOC emissions from 42 baby products, such as baby hair shampoos, body washes, lotions, and creams, both green and regular versions. Nematollahi et al. (2018b) analyzed VOC emissions from 24 essential oils, both natural and regular versions. Jo et al. (2008) analyzed VOCs from 26 air fresheners, and Kwon et al. (2007) and Kwon and Jo (2007) analyzed respectively 59 and 42 household products, such as cleaning supplies and air fresheners.

This present study analyzes VOC emissions from 134 common consumer products of five different types: personal care products, air fresheners, cleaning supplies, laundry products, and sunscreens. Product categories include fragranced and fragrance-free, and regular and green versions. The study pursued four main objectives: (1) to analyze VOC emissions from individual products and determine the most prevalent compounds among different product types and categories, (2) to ascertain the VOCs classified as potentially hazardous, (3) to compare emissions between green and regular versions, and (4) to assess differences between the VOCs emitted and the ingredients listed on product labels. This study is unique in the large number of fragranced products analyzed (more than 100), including both green and regular versions. Results can contribute to improved awareness of product emissions and exposures, and potential effects on air quality and health.

5.3 Materials and methods

Headspace GC/MS was used to analyze VOCs emitted from 134 consumer products (Table 10). The 134 products included 104 fragranced products, 15 sunscreens, and 15 fragrance-free products, in two categories: 68 regular and 66 green. The 104 fragranced products represented four types: personal care products (50), air fresheners (12), cleaning supplies (22), and laundry products (20). The 15 fragrance-free products represented three types: personal care products (10), cleaning supply (1), and laundry products (4). The 15 sunscreens were considered separately because they are regulated differently than the other consumer products (Lunny et al. 2017). All products were purchased from stores in Australia, including groceries, pharmacies, and organic or natural products stores.

Table 10 Types of tested products

	Personal care products	Air fresheners	Cleaning supplies	Laundry products	Sunscreens	Fragrance-free products
Regular	25	6	11	10	11	5
Green	25	6	11	10	4	10
Total	50	12	22	20	15	15

"Fragranced products" are identified in this study as products that contain "fragrance," "parfum," "perfume," "essential oils," or an aromatic scent. "Fragrance-free products" are identified as products with the claim of "fragrance-free," "scent free," or "no fragrance." "Green products" are identified as products with the claim of "green," "certified green," "organic," "certified organic," "natural," "no petrochemicals," "non-

toxic," "plant-based," or "essential oils" for the entire product or specific ingredients.

"Regular products" are the products not in the "green" category.

Headspace GC/MS analysis of the products was performed using a Shimadzu GC/MS equipped with a BPX-VOL capillary column. The volatile compound emissions from products were identified based on the mass spectral library of the National Institute of Standards and Technology NIST Version 2.0 (Stein 2008). The top 20 peaks for each sample were reported, even though chromatograms of some products showed more than 70 peaks. Additional details about the analytical method are described in Nematollahi et al. (2018a).

A regulatory analysis identified VOCs classified as (i) potentially hazardous under Australian regulations or (ii) carcinogenic under the World Health Organization. For (i), Safe Work Australia (SWA) contains a Hazardous Chemical Information System ("HCIS") with a database of chemicals and hazard classifications (SWA 2019). For (ii), the World Health Organization, International Agency for Research on Cancer (IARC) (WHO 2019), provides classifications of chemicals according to potential carcinogenic risk. Note that this analysis does not determine whether products that contain these VOCs pose potential hazards when used. This analysis also does not imply that these compounds, either individually or in mixtures, are the only ones that may pose potential hazards.

5.4 Results and discussion

A summary of VOCs emitted according to product type and category is provided in Table 11. The term "VOC occurrences" refers to the number of individual VOCs peaks detected by GC/MS, where each peak represents an ingredient in the product. The term "VOC identities" refers to the number of different VOCs, where each VOC may be present in one or more of the products. Complete data on VOC occurrences, identities, and prevalences, according to product types and categories, are presented in Supplementary Tables 1-18, Appendix C.

Table 11 VOCs emitted from products compared with VOCs listed on product labels

Type	Number of products	Emitted		Listed	
		All VOCs	Potentially Hazardous VOCs	All VOCs	Potentially Hazardous VOCs
Regular personal care products	25	353 occurrences 118 identities	117 occurrences 25 identities	24 occurrences 8 identities	18 occurrences 5 identities
Green personal care products	25	263 occurrences 95 identities	82 occurrences 25 identities	20 occurrences 4 identities	14 occurrences 3 identities
Regular air fresheners	6	111 occurrences 69 identities	51 occurrences 23 identities	1 occurrences 1 identities	1 occurrences 1 identities
Green air fresheners	6	111 occurrences 60 identities	39 occurrences 13 identities	0 occurrences 0 identities	0 occurrences 0 identities
Regular cleaning supplies	11	143 occurrences 95 identities	43 occurrences 29 identities	0 occurrences 0 identities	0 occurrences 0 identities
Green cleaning supplies	11	142 occurrences 77 identities	38 occurrences 16 identities	1 occurrences 1 identities	1 occurrences 1 identities
Regular laundry products	10	167 occurrences 86 identities	47 occurrences 23 identities	0 occurrences 0 identities	0 occurrences 0 identities
Green laundry products	10	163 occurrences 73 identities	41 occurrences 21 identities	3 occurrences 2 identities	3 occurrences 2 identities

Sunscreens	15	53 occurrences 23 identities	38 occurrences 13 identities	8 occurrences 3 identities	8 occurrences 3 identities
Fragrance-free products	15	31 occurrences 20 identities	21 occurrences 10 identities	2 occurrences 1 identities	2 occurrences 1 identities

5.4.1 VOCs emitted and most prevalent compounds

Among the 104 fragranced products, the analysis found the following VOC occurrences and identities for each product type (Table 11): for 50 personal care products, 617 VOC occurrences representing 172 VOC identities; for 12 air fresheners, 222 VOC occurrences representing 105 VOC identities; for 22 cleaning supplies, 285 VOC occurrences representing 145 VOC identities; and for 20 laundry products, 330 VOC occurrences representing 130 VOC identities. Complete data on VOC identities and VOC occurrences for all fragranced products are provided, respectively, in Supplementary Tables 3-6 and 9-16, Appendix C.

Prevalent compounds were determined for different fragranced product types and categories (Table 12 and Supplementary Tables 3-6, Appendix C). Among the 50 personal care products, the most prevalent VOCs (in at least 60% of products) were limonene and linalool. Among the 12 air fresheners, the most prevalent were ethanol, limonene, and alpha-pinene. Among the 22 cleaning supplies, the most prevalent was limonene. Among the 20 laundry products, the most prevalent were limonene, beta-trans-ocimene, eucalyptol, alpha-pinene, beta-myrcene, and acetaldehyde. Across all fragranced product types and categories, and all identified VOCs, the most commonly identified compound was limonene.

Table 12 Prevalent compounds emitted from the products

Compound	CAS #	Prevalence (# of products)		
		Total	Regular	Green
<u>Personal care products (n=50)</u>				
Limonene*	138-86-3	37	17	20
Linalool	78-70-6	31	22	9
Ethanol*	64-17-5	20	14	6
Benzyl acetate	140-11-4	18	16	2
beta-Pinene	127-91-3	17	5	12
Eucalyptol	470-82-6	17	4	13
Acetaldehyde*	75-07-0	16	4	12
beta-trans-Ocimene	3779-61-1	16	5	11
gamma-Terpinene	99-85-4	15	4	11
<u>Air fresheners (n=12)</u>				
Ethanol*	64-17-5	10	5	5
Limonene*	138-86-3	10	5	5
alpha-Pinene	80-56-8	7	2	5
beta-Myrcene	123-35-3	6	1	5
Linalool	78-70-6	6	3	3
2-Methyl-2-propanol*	75-65-0	5	3	2
Acetaldehyde*	75-07-0	4	1	3
Acetone*	67-64-1	4	1	3
beta-Pinene	127-91-3	4	2	2
Camphene	79-92-5	4	0	4
beta-Phellandrene	555-10-2	4	1	3
Ethyl acetate*	141-78-6	4	1	3
gamma-Terpinene	99-85-4	4	2	2
Butane*	106-97-8	4	4	0
Isopentane*	78-78-4	4	4	0
Pentane*	109-66-0	4	4	0
Methanol*	67-56-1	4	0	4
(E)-citral*	141-27-5	4	0	4
beta-Citral*	106-26-3	4	0	4
Methylcyclopentane	96-37-7	4	3	1

Cleaning supplies (n=22)

Limonene*	138-86-3	15	7	8
beta-trans-Ocimene	3779-61-1	11	4	7
beta-Myrcene	123-35-3	10	3	7
Ethanol*	64-17-5	9	2	7
Eucalyptol	470-82-6	9	6	3
gamma-Terpinene	99-85-4	8	3	5
Sabinene	3387-41-5	7	1	6
Terpinolene	586-62-9	7	4	3
Camphene	79-92-5	7	4	3

Laundry products (n=20)

Limonene*	138-86-3	18	9	9
beta-trans-Ocimene	3779-61-1	16	1	15
Eucalyptol	470-82-6	14	7	7
alpha-Pinene	80-56-8	13	7	6
beta-Myrcene	123-35-3	12	4	8
Acetaldehyde*	75-07-0	12	7	5
Camphene	79-92-5	9	5	4
Dihydromyrcenol	18479-58-8	9	8	1
Terpinolene	586-62-9	8	3	5
gamma-Terpinene	99-85-4	8	2	6
Ethanol*	64-17-5	7	4	3
beta-Phellandrene	555-10-2	6	1	5
4-tert-Butylcyclohexyl acetate	32210-23-4	6	6	0

Sunscreens (n=15)

Acetaldehyde*	75-07-0	9
Phenoxyethanol*	122-99-6	6
Isopropyl alcohol*	67-63-0	5

Fragrance-free products (n=15)

Ethanol*	64-17-5	6
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*Classified as potentially hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2019)

Among the 15 sunscreens, the analysis detected a total of 53 VOC occurrences representing 23 VOC identities (Table 11). For the 15 sunscreens, the most prevalent compound (in at least 60% of products) was acetaldehyde (Table 12). Among the 15 fragrance-free products, the analysis detected a total of 31 VOC occurrences representing 20 VOC identities (Table 11). For the 15 fragrance-free products, the most prevalent compound (in 40% of products) was ethanol (Table 12).

5.4.2 Potentially hazardous compounds

A regulatory analysis identified potentially hazardous compounds according to classifications by Safe Work Australia (SWA 2019).

For the VOCs emitted from all 134 products, 69 VOC identities are classified as potentially hazardous (Supplementary Table 19, Appendix C). The most prevalent of these VOCs (in at least four products) are presented in Table 4. Nearly all products (98%) emitted at least one VOC classified as potentially hazardous (Supplementary Tables 9-18, Appendix C), with the most prevalent being limonene (Table 13).

Table 13 Most prevalent compounds classified as potentially hazardous among all 134 products*

Compound	CAS #	Prevalence (# of products)		
		Total	Regular (n=68)	Green (n=66)
Limonene	138-86-3	82	40	42
Ethanol	64-17-5	56	27	29
Acetaldehyde	75-07-0	50	23	27
Ethyl acetate	141-78-6	25	12	13
Butane	106-97-8	22	19	3

Acetone	67-64-1	21	6	15
Benzyl alcohol	100-51-6	19	7	12
Isopropyl alcohol	67-63-0	18	12	6
Pentane	109-66-0	17	12	5
Methanol	67-56-1	17	9	8
Phenoxyethanol	122-99-6	14	9	5
Isopentane	78-78-4	12	12	0
Octamethylcyclotetrasiloxane	556-67-2	10	8	2
Isoamyl acetate	123-92-2	10	7	3
3-Methylhexane	589-34-4	9	9	0
1-Octanol	111-87-5	9	1	8
Heptane	142-82-5	8	8	0
2-Methyl-2-propanol	75-65-0	8	5	3
2-Methylhexane	591-76-4	7	7	0
Toluene	108-88-3	7	4	3
Cyclohexane	110-82-7	6	6	0
beta-Citral	106-26-3	6	1	5
(E)-citral	141-27-5	5	1	4
Ethyl formate	109-94-4	5	0	5
2-Butene	107-01-7	4	4	0
Carbon monoxide	630-08-0	4	4	0

Collectively, among the 1,538 VOC occurrences emitted from the products, 517 VOC occurrences (34%) are classified as potentially hazardous (see Supplementary Tables 1 and 19, Appendix C). Among the 338 VOC identities emitted from the products, 69 VOC identities (20%) are classified as potentially hazardous (see Supplementary Tables 1 and 19, Appendix C).

For the VOCs emitted from the 104 fragranced products, 68 VOC identities are classified as potentially hazardous (Supplementary Tables 2 and 20, Appendix C). The most prevalent of these VOCs (in at least four products) are presented in Table 14. Nearly all fragranced products (98%) emitted at least one VOC classified as potentially

hazardous (Supplementary Tables 9-16, Appendix C), with the most prevalent being limonene (Table 14).

Table 14 Most prevalent compounds classified as potentially hazardous among 104 fragranced products*

Compound	CAS #	Prevalence (# of products)		
		Total	Regular (n=52)	Green (n=52)
Limonene	138-86-3	80	38	42
Ethanol	64-17-5	46	25	21
Acetaldehyde	75-07-0	38	14	24
Ethyl acetate	141-78-6	22	9	13
Butane	106-97-8	20	18	2
Acetone	67-64-1	18	5	13
Methanol	67-56-1	16	8	8
Benzyl alcohol	100-51-6	15	5	10
Pentane	109-66-0	13	12	1
Isopentane	78-78-4	12	12	0
Isopropyl alcohol	67-63-0	12	8	4
Octamethylcyclotetrasiloxane	556-67-2	10	8	2
Isoamyl acetate	123-92-2	10	7	3
3-Methylhexane	589-34-4	9	8	1
Heptane	142-82-5	8	8	0
Phenoxyethanol	122-99-6	8	4	4
1-Octanol	111-87-5	8	1	7
2-Methylhexane	591-76-4	7	7	0
2-Methyl-2-propanol	75-65-0	7	5	2
Toluene	108-88-3	6	4	2
beta-Citral	106-26-3	6	1	5
Cyclohexane	110-82-7	5	5	0
2-Butene	107-01-7	4	4	0
Carbon monoxide	630-08-0	4	4	0

*Classified as potentially hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2019)

Collectively, among the 1,454 VOC occurrences and 331 VOC identities emitted from the fragranced products, 458 VOC occurrences (32%) and 68 VOC identities (21%) are classified as potentially hazardous (see Supplementary Tables 2 and 20, Appendix C).

The regulatory analysis also investigated VOCs with classifications of potential carcinogenic risk according to the World Health Organization, IARC (WHO 2019).

Among all VOCs emitted from all 134 products, 65 VOC occurrences, representing 10 VOC identities, are classified as Group 2B and 3 under the World Health Organisation (Table 15).

Table 15 Compounds with classifications of carcinogenic risk among all 134 products*

Compound	CAS #	Classification group*	Prevalence (# of products)		
			Total	Regular	Green
Acetaldehyde	75-07-0	2B	50	23	27
Isopropyl alcohol	67-63-0	3	18	12	6
Toluene	108-88-3	3	7	4	3
1,4-Dioxane	123-91-1	2B	2	1	1
Methyl isobutyl ketone	108-10-1	2B	2	0	2
1,1-dichloroethylene	75-35-4	2B	1	1	0
Amitrole (ISO)	61-82-5	3	1	1	0
Carbon tetrachloride	56-23-5	2B	2	1	1
Chloroform	67-66-3	2B	1	1	0
Chloromethane	74-87-3	3	1	0	1

* Group 2B: Possibly carcinogenic to humans, Group 3: Not classifiable as to its carcinogenicity to humans (WHO 2019).

A primary difference between the fragranced and fragrance-free products is that terpenes (such as limonene, linalool, alpha-pinene, and beta-pinene) are present and prevalent in fragranced products but absent in fragrance-free products (Supplementary

Tables 2 and 8, Appendix C). While some terpenes may lack classification as potentially hazardous, they can nonetheless react with ozone to generate hazardous pollutants, such as formaldehyde and acetaldehyde.

5.4.3 Comparison of VOCs emitted from regular and green products

Among the prevalent VOCs in fragranced products (Table 12), no significant difference was found in VOC occurrences between regular and green products ($p=0.25$, t-test). In addition, among the most prevalent potentially hazardous VOCs in fragranced products (Table 14), no significant difference was found in VOC occurrences between regular and green products ($p=0.09$, t-test). Further, among the most prevalent VOCs classified as potentially hazardous in all products (Table 13), approximately 75% of VOC identities are the same among regular and green products.

5.4.4 Listing of ingredients

Among the 1,538 VOC occurrences, 59 were listed on any product label. Thus, fewer than 4% of all volatile chemicals identified were listed on product labels. Further, among the 517 VOC occurrences classified as potentially hazardous, 47 were listed on any product label. Thus, fewer than 10% of all potentially hazardous volatile chemicals identified were listed on product labels.

Key results from this study are consistent with previous studies. First, in prior work that examined a full suite of VOC emissions from fragranced consumer products (e.g., Steinemann 2015, Kwon et al. 2007, Kwon and Jo 2007, Nematollahi et al. 2018a; Uhde and Schulz 2015), limonene was also the most commonly identified compound. Second,

among VOCs emitted (occurrences) that are classified as potentially hazardous, this study found 34%, and previous studies (Steinemann 2015, Nematollahi 2018a, b) found 41%, 30%, and 21% respectively. Third, in comparisons of green and regular fragranced products, other studies (Steinemann 2015, Nematollahi 2018a, b) also found no significant difference between the most prevalent potentially hazardous VOCs. Fourth, in comparisons of ingredients emitted with ingredients listed, other studies (e.g., Steinemann 2015, Nematollahi 2018a, b, Uhde and Schulz 2015) also found that fewer than 10% of volatile ingredients in fragranced consumer products were disclosed.

To note, this study focused on identifying the primary VOC emissions in the headspace analysis, even though reaction products and secondary pollutants could also be examined. In addition, this study focused on analyzing VOCs, even though other chemical classes such as semi-volatile or non-volatile organic compounds could also be emitted from the products. The approach of assessing and comparing VOC occurrences and prevalences is intended as a straightforward metric, rather than as an analysis of relative risk. Finally, this study focused on the identification of individual VOCs emitted from the products, and makes no claims about VOC exposures or product safety.

5.5 Conclusions

This study provides findings on the VOCs emitted by 134 common consumer products. The analysis found 1,538 VOC occurrences, with 517 VOC occurrences classified as potentially hazardous, emitted from the consumer products. Limonene was the most

commonly emitted compound, found in 77% of fragranced products. Emissions of the most prevalent potentially hazardous VOCs from regular and green fragranced products were not significantly different. Fewer than 4% of all VOCs and fewer than 10% of potentially hazardous VOCs were listed on any product label. Results of this study can improve public awareness about emissions and exposures from common products in society.

5.6 Acknowledgments

The study received support from the Australian Government Research Training Program Scholarship (RTP), through the University of Melbourne; the Australian Department of Education and Training (Australian Postgraduate Award); and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

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6 Discussion and conclusions

This thesis research investigated volatile organic compound emissions from 200 common consumer products: 42 baby products, 24 essential oils, and 134 consumer products. Products include both regular and green versions. Main findings from the three-part research study include the following:

(1) Across the 200 products, the study found 2,817 VOCs, including 848 potentially hazardous VOCs, emitted from the 200 products. Specifically, for each group of products, the study found (i) 595 VOCs including 124 potentially hazardous VOCs for baby products; (ii) 684 VOCs including 207 potentially hazardous VOCs for essential oils; and (ii) 1,538 VOCs including 517 potentially hazardous VOCs for consumer products.

(2) In addition, across the 200 products, fewer than 4% of VOCs and 9% of potentially hazardous VOCs were disclosed by being listed on product labels. Specifically, for each group of products, the study found (i) 34 VOCs including 25 potentially hazardous VOCs for baby products listed; (ii) no VOCs or potentially hazardous VOCs for essential oils listed; and (ii) 59 VOCs including 47 potentially hazardous VOCs for consumer products.

(3) For each of the three groups of products, emissions of potentially hazardous VOCs were not significantly different between regular and green fragranced products.

The implications of these findings are significant in light of that fragranced consumer products can be a primary source of human exposure to pollutants, and both indoor and outdoor air pollutants. Relatively little public information exists about product ingredients and emissions. Products that may be presumed to be in some way safe or healthy (e.g., green products, baby products, and essential oils) uniformly emitted potentially hazardous chemicals. Further, no significant difference was found between emissions of potentially hazardous chemicals from regular and green products. However, a primary difference between fragranced and fragrance-free versions of products was the presence of terpenes in fragranced products but not in fragrance-free products. Terpenes can be both primary pollutants and generate secondary hazardous pollutants such as formaldehyde.

Results from the research reported in this thesis are consistent with those obtained in previous studies. First, in prior work that examined a full suite of VOC emissions from fragranced consumer products (e.g., Steinemann 2015, Kwon 2007, Kwon and Jo 2007, Uhde and Schulz 2015), limonene was also the most commonly identified compound. Second, among VOCs emitted (occurrences) that are classified as potentially hazardous, this study found 30%, 21%, and 34% (for the three research aims, respectively) and previous research (Steinemann 2015) found 41%. Third, in comparisons to green and regular fragranced products, previous research (Steinemann 2015) also found no significant difference between the most prevalent potentially hazardous VOCs. Fourth, in comparisons of ingredients emitted with ingredients listed, other studies (e.g., Steinemann 2015, Uhde and Schulz 2015) also found that fewer than 10% of volatile ingredients in fragranced consumer products were disclosed.

This study focused on primary VOC emissions using headspace analysis of products, and future work could examine reaction products and the generation of secondary pollutants. In addition, this study focused on analysing VOCs emissions, while other chemical classes such as semi-volatile or non-volatile organic compounds could also be examined. Finally, this study focused on the identification of individual VOCs emitted from the products studied, which can support a more extensive analysis of effects of product emissions on ambient air quality and exposures.

This dissertation research provides contributions to knowledge through the investigation of a relatively large number of diverse consumer products, a broad suite of VOCs, compounds classified as potentially hazardous, and both regular and green products. Results from this research can improve awareness of potential exposures and effects on air quality, health, and societal well-being.

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Appendices

Appendix A

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Supplementary Table 1: VOC occurrences among green baby products (n=21)

1. Baby hair and body wash^{Cp}

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
Pentanal	110-62-3
2,4-Dimethylhexane*	589-43-5
Hexanal	66-25-1
beta-Pinene	127-91-3
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Camphene	79-92-5
Sabinene	3387-41-5
3-Carene	13466-78-9
beta-Myrcene	123-35-3
Ocimene	13877-91-3
beta-trans-Ocimene	3779-61-1
3-Octanol	589-98-0
Limonene*	138-86-3
beta-Phellandrene	555-10-2
Eucalyptol	470-82-6
Terpinolene	586-62-9
Linalool	78-70-6
Camphor	76-22-2
alpha-Terpineol	98-55-5
Linalool acetate	115-95-7
Carvone	99-49-0
Neryl acetate	141-12-8
Geraniol acetate	105-87-3
Piperonal	120-57-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Cp}Certified organic product

2. Baby shampoo and conditioner

Compounds	CAS#
Acetaldehyde*	75-07-0
Isopropyl alcohol*	67-63-0
2,4-Dimethylheptane	2213-23-2
alpha-Pinene	80-56-8
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
Eucalyptol	470-82-6
Tridecane	629-50-5
Linalool	78-70-6
1-Undecanol	112-42-5
Cyclododecane	294-62-2
Benzyl acetate	140-11-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. Baby body wash^{Ci}

Compounds	CAS#
Methanol*	67-56-1
Ethanol*	64-17-5
Acetone*	67-64-1
2,4-Dimethylhexane*	589-43-5
alpha-Thujene	2867-05-2
alpha-Pinene	80-56-8
Camphene	79-92-5
Undecane	1120-21-4
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
3-Octanone	106-68-3
3-Carene	13466-78-9
Hexyl acetate	142-92-7
Limonene*	138-86-3
beta-Phellandrene	555-10-2
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
2-Methylenehexanal	1070-66-2
Ocimene	13877-91-3
1-Octanol*	111-87-5
Linalool	78-70-6
Methyl octanoate	111-11-5
Dodecane	112-40-3
Camphor	76-22-2
alpha-Terpineol	98-55-5
Linalool acetate	115-95-7
Phenoxyethanol*	122-99-6
Neryl acetate	141-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

4. Baby shampoo and conditioner

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
Ethyl acetate*	141-78-6
Ethyl butyrate	105-54-4
Hexanal	66-25-1
Ethyl 2-methylbutyrate	7452-79-1
Isoamyl acetate*	123-92-2
2-Methylbutyl acetate*	624-41-9
cis-3-Hexenol	928-96-1
Amyl acetate*	628-63-7
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
Limonene*	138-86-3
1-Octanol*	111-87-5
Linalool	78-70-6
Benzyl acetate	140-11-4
Phenoxyethanol*	122-99-6
1-Dodecanol	112-53-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. Baby hair and body wash

Compounds	CAS#
2-Methyl-1-propene*	115-11-7
Acetaldehyde*	75-07-0
Acetone*	67-64-1
2-Methylpentane*	107-83-5
2,3,4-Trimethylhexane	921-47-1
Ethyl butyrate	105-54-4
Ethyl 2-methylbutyrate	7452-79-1
Ethyl 2-methylpentanoate	39255-32-8
beta-Pinene	127-91-3
Hexyl acetate	142-92-7
Dihydromyrcenol	18479-58-8
3,7-Dimethyl-3-octanol	78-69-3
Benzyl acetate	140-11-4
Linalool	78-70-6
Methyl phenylcarbinyl acetate	93-92-5
3,7-Dimethyloctan-3-yl acetate	20780-48-7
Phenoxyethanol*	122-99-6
2-tert-Butylcyclohexanol	13491-79-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. Baby hair and body wash

Compounds	CAS#
Isopropyl alcohol*	67-63-0
2-Butenal*	4170-30-3
Ethyl acetate*	141-78-6
Cyclohexane*	110-82-7
3-Methyl-1-octene	13151-08-1
3-Carene	13466-78-9
1-Decene	872-05-9
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
1-Octanol*	111-87-5
Linalool	78-70-6
Benzyl acetate	140-11-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. Baby shampoo and body wash

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
2-Methylfuran	534-22-5
1,1-Dimethylallyl alcohol	115-18-4
Toluene*	108-88-3
Ethyl butyrate	105-54-4
Ethyl 2-methylbutyrate	7452-79-1
alpha-Pinene	80-56-8
Prenyl acetate	1191-16-8
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
4-Hexen-1-ol, acetate	72237-36-6
Hexyl acetate	142-92-7
Limonene*	138-86-3
3-Carene	13466-78-9
Dihydromyrcenol	18479-58-8
1-Octanol*	111-87-5
Linalool	78-70-6
1-Methyl-3-cyclohexene-1-carbaldehyde	931-96-4
Allyl heptanoate	142-19-8
Benzyl acetate	140-11-4
Ethyl linalool	10339-55-6
4-tert-Butylcyclohexyl acetate	32210-23-4
2-tert-Butylcyclohexanol	13491-79-7
trans-beta-Ionone	79-77-6
2-Phenoxyethyl isobutyrate	103-60-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. Baby lotion

Compounds	CAS#
2-Methyl-1-propene*	115-11-7
Acetaldehyde*	75-07-0
Acetone*	67-64-1
Hexanal	66-25-1
Benzaldehyde*	100-52-7
Benzyl alcohol*	100-51-6
Phenylethyl alcohol	60-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. Baby lotion

Compounds	CAS#
Pentane*	109-66-0
Ethanol*	64-17-5
Isobutyl isobutyrate	97-85-8
alpha-Pinene	80-56-8
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
Eucalyptol	470-82-6
Benzyl alcohol*	100-51-6
Linalool	78-70-6
Camphor	76-22-2
Linalool acetate	115-95-7
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. Baby lotion^{Ci}

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
2-Methylpentane*	107-83-5
3-Methylpentane*	96-14-0
Hexane*	110-54-3
alpha-Pinene	80-56-8
Limonene*	138-86-3
Eucalyptol	470-82-6
Linalool	78-70-6
Camphor	76-22-2
Linalool acetate	115-95-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

11. Baby body wash

Compounds	CAS#
Acetaldehyde*	75-07-0
Hexane*	110-54-3
2-Methylfuran	534-22-5
Cyclohexane*	110-82-7
2,4-Dimethylhexane*	589-43-5
2,2-Dimethyldecane	17302-37-3
Benzyl alcohol*	100-51-6
Dodecane	112-40-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

12. Baby bath oil^{Ci}

Compounds	CAS#
Acetaldehyde*	75-07-0
2-Methyl-1-butene	563-46-2
Ethanol*	64-17-5
Acetone*	67-64-1
Methyl hexyl ether	4747-07-3
Isobutyl isobutyrate	97-85-8
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Isobutyl 2-methyl-2-propenoate*	97-86-9
Camphene	79-92-5
Sabinene	3387-41-5
3-Carene	13466-78-9
beta-Myrcene	123-35-3
3-Methyl-2-butenic acid, octyl ester	56500-47-1
3-Octanone	106-68-3
gamma-Terpinene	99-85-4
Hexyl acetate	142-92-7
Octanal	124-13-0
Limonene*	138-86-3
beta-Phellandrene	555-10-2
Eucalyptol	470-82-6
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1
Bromocyclohexane	108-85-0
Terpinolene	586-62-9
Benzyl alcohol*	100-51-6
1-Octen-3-yl-acetate	2442-10-6
Linalool	78-70-6
2,2,6,6-Tetramethylcyclohexanol	6948-41-0
Hexyl butyrate	2639-63-6
Octyl butyrate	110-39-4
Camphor	76-22-2
4-Terpineol	562-74-3
Borneol	10385-78-1
alpha-Terpineol	98-55-5
Dihydrocarveol	38049-26-2
Linalool acetate	115-95-7
1,1-Dimethyl-2-(2-methyl-1-propenyl)cyclopropane	33422-32-1
Neryl acetate	141-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

13. Baby shampoo and body wash

Compounds	CAS#
Acetone*	67-64-1
Isopropyl alcohol*	67-63-0
Methylcyclopentane	96-37-7
2,4-Dimethylpentane*	108-08-7
Octane*	111-65-9
Ethyl butyrate	105-54-4
2,4-Pentanedione*	123-54-6
alpha-Pinene	80-56-8
Camphene	79-92-5
Undecane	1120-21-4
3-Carene	13466-78-9
beta-Myrcene	123-35-3
alpha-Phellandrene	99-83-2
Ocimene	13877-91-3
Terpinolene	586-62-9
Limonene*	138-86-3
beta-Phellandrene	555-10-2
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Benzyl alcohol*	100-51-6
Linalool	78-70-6
Tridecane	629-50-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

14. Baby hair and body wash

Compounds	CAS#
Acetaldehyde*	75-07-0
Acetone*	67-64-1
Isopropyl alcohol*	67-63-0
Methylcyclohexane*	108-87-2
Hexanal	66-25-1
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
Limonene*	138-86-3
Ocimene	13877-91-3
1-Octanol*	111-87-5
Linalool	78-70-6
Phenylethyl alcohol	60-12-8
3,5,5-Trimethylhexyl acetate	58430-94-7
Ethyl linalool	10339-55-6
Linalyl anthranilate	7149-26-0
1-Undecanol	112-42-5
alpha-Terpineol	98-55-5
Linalool acetate	115-95-7
2-Carene	554-61-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

15. Baby hair and body wash

Compounds	CAS#
Acetaldehyde*	75-07-0
Pentane*	109-66-0
Acetone*	67-64-1
Isopropyl alcohol*	67-63-0
3-Methylhexane*	589-34-4
2,4-Dimethylhexane*	589-43-5
Isobutyl isobutyrate	97-85-8
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
beta-Phellandrene	555-10-2
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
3-Carene	13466-78-9
gamma-Terpinene	99-85-4
1-Octanol*	111-87-5
Benzyl alcohol*	100-51-6
Decamethylcyclopentasiloxane	541-02-6
Amyl senecioate	56922-72-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

16. Baby body wash^{Gi}

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
3-Methylfuran	930-27-8
Toluene*	108-88-3
Methyl hexyl ether	4747-07-3
Butyl acetate*	123-86-4
Isobutyl isobutyrate	97-85-8
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Isobutyl 2-methyl-2-propenoate*	97-86-9
Camphene	79-92-5
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Hexyl butyrate	2639-63-6
3-Octanone	106-68-3
beta-trans-Ocimene	3779-61-1
Hexyl acetate	142-92-7
Limonene*	138-86-3
3-Carene	13466-78-9
(Z)-beta-ocimene	3338-55-4
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1
gamma-Terpinene	99-85-4
2,6-Octadiene, 2,4-dimethyl-	63843-03-8
Terpinolene	586-62-9
Benzyl alcohol*	100-51-6
1-Octen-3-yl-acetate	2442-10-6
Linalool	78-70-6
3-Octyl acetate	4864-61-3
4,4,6,6-Tetramethylbicyclo[3.1.0]hex-2-ene	19487-09-3
2-Methyl pentyl isobutyrate	84254-82-0
Amyl senecioate	56922-72-6
Octyl butyrate	110-39-4
Camphor	76-22-2
4-Terpineol	562-74-3
Ocimenol	5986-38-9
Linalool acetate	115-95-7
Lavandulyl acetate	25905-14-0
Neryl acetate	141-12-8
Geraniol acetate	105-87-3
(Z)-beta-farnesene	28973-97-9
Bicyclo[5.2.0]nonane, 4-ethenyl-4,8,8-trimethyl-2-methylene-	242794-76-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

17. Baby cream

Compounds	CAS#
Ethyl acetate*	141-78-6
Ethyl butyrate	105-54-4
Ethyl lactate*	97-64-3
Ethyl isovalerate	108-64-5
Limonene*	138-86-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

18. Baby lotion

Compounds	CAS#
alpha-Pinene	80-56-8
Limonene*	138-86-3
Eucalyptol	470-82-6
Linalool	78-70-6
Ocimenol	5986-38-9
β -Citronellol	106-22-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

19. Baby moisturizer^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
alpha-Pinene	80-56-8
Camphene	79-92-5
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
m-Cymene	535-77-3
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Linalool	78-70-6
Camphor	76-22-2
Linalool acetate	115-95-7
D,l-isobornyl acetate	92618-89-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

20. *Baby anti-bug*^{Gi}

Compounds	CAS#
Acetaldehyde*	75-07-0
Pentane*	109-66-0
1,4-Pentadiene	591-93-5
2-Methyl-2-butene	513-35-9
Acetone*	67-64-1
Dimethyl sulfide	75-18-3
Isobutyraldehyde	78-84-2
3-Methyl-1-cyclopentene	1120-62-3
2-Methylfuran	534-22-5
Methylcyclopentane	96-37-7
1,1-Dimethylallyl alcohol	115-18-4
Isovaleraldehyde	590-86-3
2-Methylbutyraldehyde	96-17-3
2-Ethylfuran	3208-16-0
Toluene*	108-88-3
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Camphene	79-92-5
beta-Phellandrene	555-10-2
beta-Pinene	127-91-3
3,3-Dimethylallyl bromide	870-63-3
2,3-Dehydro-1,8-cineole	92760-25-3
6-Methyl-5-hepten-2-one	110-93-0
4-Carene	29050-33-7
Limonene*	138-86-3
m-Cymene	535-77-3
3-Carene	13466-78-9
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
4-Nonanone	4485-09-0
Linalool	78-70-6
Acetylmethylcyclohexene,4-acetyl-1-methyl-1-cyclohexene	70286-20-3
(R)-(+)-citronellal	2385-77-5
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6
(1R,4S)-p-menthan-3-one	14073-97-3
Camphor	76-22-2
L-menthol	2216-51-5
Methyl salicylate	119-36-8
β-Citronellol	106-22-9
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2
(2Z)-3,7-dimethylocta-2,6-dienal*	106-26-3
DI-menthyl acetate	16409-45-3

Citral*	5392-40-5
Neryl acetate	141-12-8
β -Caryophyllene	87-44-5
alpha-Himachalen	3853-83-6
alpha-Longipinene	5989-08-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

21. *Baby lotion*

Compounds	CAS#
3,7-Dimethyl-3-octanol	78-69-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 2: VOC occurrences among regular baby products (n=21)

1. Baby shampoo

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethyl butyrate	105-54-4
alpha-Pinene	80-56-8
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
2,6-Dimethyl-2-heptanol	13254-34-7
Limonene*	138-86-3
3-Carene	13466-78-9
1-Octanol*	111-87-5
1,3,4-Trimethyl-3-cyclohexen-1-carboxaldehyde	40702-26-9
Linalool acetate	115-95-7
Cyclododecane	294-62-2
1-Tridecene	2437-56-1
Benzyl acetate	140-11-4
alpha-Isomethyl ionone	127-51-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. Baby hair and body wash

Compounds	CAS#
2-Butene*	107-01-7
Pentane*	109-66-0
Isopropyl alcohol*	67-63-0
2-Methyl-1-pentene	763-29-1
Ethyl acetate*	141-78-6
Cyclohexane*	110-82-7
Hexamethylcyclotrisiloxane	541-05-9
cis-3-Hexenol	928-96-1
1-Hexanol*	111-27-3
2,7-Dimethyl-1,7-octadiene	59840-10-7
3,7-Dimethyl-1,6-octadiene	10281-56-8
Octamethylcyclotetrasiloxane*	556-67-2
Hexyl acetate	142-92-7
1,4-Hexadiene	592-45-0
cis-6-Nonenyl acetate	76238-22-7
Phenoxyethanol*	122-99-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Piperonal	120-57-0
4-tert-Pentylcyclohexanol	20698-30-0
Nopyl acetate	128-51-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. *Baby oil*

Compounds	CAS#
Isobutyl cyanate	1768-25-8
Acetaldehyde*	75-07-0
Pentane*	109-66-0
Hexane*	110-54-3
3-Methylhexane*	589-34-4
3,4-Dimethylheptane	922-28-1
Benzyl alcohol*	100-51-6
Phenylethyl alcohol	60-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. Detangling conditioning spray

Compounds	CAS#
Ethyl methyl ether*	540-67-0
Ethanol*	64-17-5
Propanal*	123-38-6
Isopropyl alcohol*	67-63-0
Dichloromethane*	75-09-2
Methacrolein	78-85-3
Trimethylsilanol	1066-40-6
Ethyl acetate*	141-78-6
Ethyl butyrate	105-54-4
Tris(trimethylsilyl) borate	4325-85-3
Ethyl 2-methylbutyrate	7452-79-1
cis-3-Hexenol	928-96-1
Octamethylcyclotetrasiloxane*	556-67-2
Limonene*	138-86-3
Benzyl alcohol*	100-51-6
Decamethylcyclopentasiloxane	541-02-6
alpha-Isomethyl ionone	127-51-5
trans-beta-Ionone	79-77-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. Baby cream

Compounds	CAS#
Butane*	106-97-8
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
Isopropyl alcohol*	67-63-0
Isobutyraldehyde	78-84-2
Ethyl acetate*	141-78-6
Tetrahydrofuran*	109-99-9
Isovaleraldehyde	590-86-3
2-Methylbutyraldehyde	96-17-3
2-Pentanone	107-87-9
Toluene*	108-88-3
cis-3-Hexenol	928-96-1
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
beta-Phellandrene	555-10-2
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
alpha-Thujene	2867-05-2
4-Carene	29050-33-7
Limonene*	138-86-3
o-Cymene	527-84-4
3-Carene	13466-78-9
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Terpinolene	586-62-9
Bicyclo[3.1.0]hexan-2-ol, 2-methyl-5-(1-methylethyl)-, (1.alpha.,2.beta.,5.alpha.)-	15537-55-0
(-)-Terpinen-4-ol	20126-76-5
alpha-Terpineol	98-55-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. Baby hair spray

Compounds	CAS#
Acetaldehyde*	75-07-0
Methyl isopropyl ether	598-53-8
Propanal*	123-38-6
Isopropyl alcohol*	67-63-0
2-Ethyl-4-methyl-1,3-dioxolane	4359-46-0
1,3-Dioxane	505-22-6
Tris(trimethylsilyl) borate	4325-85-3
Ethyl 2-methylbutyrate	7452-79-1
alpha-Pinene	80-56-8
Octamethylcyclotetrasiloxane*	556-67-2
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
cis-3-Hexenyl acetate	3681-71-8
Limonene*	138-86-3
gamma-Terpinene	99-85-4
Dihydromyrcenol	18479-58-8
Benzyl alcohol*	100-51-6
Decamethylcyclopentasiloxane	541-02-6
Tetrahydrolinalool	57706-88-4
Linalool	78-70-6
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
Allyl heptanoate	142-19-8
Benzyl acetate	140-11-4
(Z+E)-2-methyl-2-(4-methyl-3-pentenyl) cyclopropane carbaldehyde	97231-35-1
4-tert-Butylcyclohexyl acetate	32210-23-4
p-Anisaldehyde	123-11-5
2-tert-Butylcyclohexanol	13491-79-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. Baby body spray

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Ethyl acetate*	141-78-6
Ethyl butyrate	105-54-4
Ethyl 2-methylbutyrate	7452-79-1
Ethyl isovalerate	108-64-5
Isoamyl acetate*	123-92-2
2-Methylbutyl acetate*	624-41-9
2,2-Dimethyldecane	17302-37-3
Ethyl hexanoate	123-66-0
Limonene*	138-86-3
Isoamyl butylate	106-27-4
3,5,5-Trimethylhexyl acetate	58430-94-7
Benzyl acetate	140-11-4
Phenoxyethanol*	122-99-6
2,6-Dichlorobenzyl alcohol	15258-73-8
2,6-Di-tert-butyl-4-methylphenol	128-37-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. Baby body wash

Compounds	CAS#
Ethanol*	64-17-5
Ethyl butyrate	105-54-4
Isoamyl acetate*	123-92-2
2-Methylbutyl acetate*	624-41-9
Pentyl acetate*	628-63-7
alpha-Pinene	80-56-8
beta-Phellandrene	555-10-2
Undecane	1120-21-4
beta-Myrcene	123-35-3
Limonene*	138-86-3
Isoamyl butylate	106-27-4
Dipentyl ether	693-65-2
Amyl butyrate	540-18-1
2-Methylbutyl 2-methylbutyrate	2445-78-5
Isoamyl isovalerate	659-70-1
2-Methylbutyl isovalerate	2445-77-4
Linalool	78-70-6
Phenoxyethanol*	122-99-6
Benzyl benzoate*	120-51-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. Baby body wash

Compounds	CAS#
Ethanol*	64-17-5
Ethyl acetate*	141-78-6
Ethyl propionate*	105-37-3
Ethyl butyrate	105-54-4
Ethyl 2-methylbutyrate	7452-79-1
Ethyl 2-methylpentanoate	39255-32-8
beta-Myrcene	123-35-3
Ethyl hexanoate	123-66-0
Limonene*	138-86-3
(Z)-7-tetradecene	41446-60-0
Cyclododecane	294-62-2
Phenoxyethanol*	122-99-6
Ethyl nonanoate	123-29-5
4-tert-Butylcyclohexyl acetate	32210-23-4
2-tert-Butylcyclohexanol	13491-79-7
Nonadecane	629-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. Baby lotion

Compounds	CAS#
Ethanol*	64-17-5
Ethyl butyrate	105-54-4
cis-1,3,5-Trimethylcyclohexane	1795-27-3
Dodecane	112-40-3
Isoamyl acetate*	123-92-2
1-Ethyl-2-methylcyclohexane	3728-54-9
2,6-Dimethyl octane	2051-30-1
alpha-Pinene	80-56-8
2-Butyl-1-octanol	3913-02-8
1-Butyl-2-propylcyclopentane	62199-50-2
3-Methylnonane	5911-04-6
1-Ethyl-2-propylcyclohexane	62238-33-9
1,2-Diethylcyclohexane	824-43-1
1-Methyl-2-propylcyclohexan	4291-79-6
Undecane	1120-21-4
beta-Myrcene	123-35-3
2,5,5-Trimethylheptane	1189-99-7
Butylcyclohexane	1678-93-9
Limonene*	138-86-3
trans-Decahydronaphthalene	493-02-7
1,3,4-Trimethyl-3-cyclohexen-1-carboxaldehyde	40702-26-9
Linalool	78-70-6
Benzyl acetate	140-11-4
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

11. Baby shower gel

Compounds	CAS#
Ethanol*	64-17-5
Butyl acetate*	123-86-4
Ethyl 2-methylbutyrate	7452-79-1
cis-3-Hexenol	928-96-1
Isoamyl butylate	106-27-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

12. Baby body wash

Compounds	CAS#
Ethanol*	64-17-5
Ethyl butyrate	105-54-4
(Z)-7-tetradecene	41446-60-0
Cyclododecane	294-62-2
Phenoxyethanol*	122-99-6
Nonadecane	629-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

13. Baby body wash

Compounds	CAS#
Ethanol*	64-17-5
Ethyl 2-methylbutyrate	7452-79-1
Isoamyl acetate*	123-92-2
beta-Pinene	127-91-3
Benzaldehyde*	100-52-7
Limonene*	138-86-3
Amyl butyrate	540-18-1
1-Tridecene	2437-56-1
Ethyl benzoate	93-89-0
Phenoxyethanol*	122-99-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Nonadecane	629-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

14. Baby body wash

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Ethyl butyrate	105-54-4
Hexyl acetate	142-92-7
Tridecane	629-50-5
(Z)-7-tetradecene	41446-60-0
Nonadecane	629-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

15. Baby ointment

Compounds	CAS#
Acetaldehyde*	75-07-0
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Camphene	79-92-5
beta-Phellandrene	555-10-2
beta-Pinene	127-91-3
alpha-Thujene	2867-05-2
beta-trans-Ocimene	3779-61-1
Pentylidenecyclopentane	53366-55-5
4-Carene	29050-33-7
Limonene*	138-86-3
m-Cymene	535-77-3
3-Carene	13466-78-9
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Terpinolene	586-62-9
(E)-3,3-Dimethylcyclohexylideneacetaldehyde	26532-25-2
Camphor	76-22-2
Dl-menthol	15356-70-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

16. Baby ointment

Compounds	CAS#
Acetaldehyde*	75-07-0
Methanol*	67-56-1
Ethanol*	64-17-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

17. Baby cream

Compounds	CAS#
alpha-Pinene	80-56-8
(+)-Camphene	5794-03-6
Camphene	79-92-5
beta-Pinene	127-91-3
m-Cymene	535-77-3
Eucalyptol	470-82-6
Dihydromyrcenol	18479-58-8
Tetrahydrolinalool	57706-88-4
Camphor	76-22-2
Isoborneol	124-76-5
2,9-Dimethyl-5-decyne	19550-56-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

18. Baby cream

Compounds	CAS#
Acetone*	67-64-1
Benzyl alcohol*	100-51-6
Phenylethyl alcohol	60-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

19. Baby cream

Compounds	CAS#
Ethanol*	64-17-5
Acetone*	67-64-1
alpha-Pinene	80-56-8
Camphene	79-92-5
beta-Pinene	127-91-3
Limonene*	138-86-3
Eucalyptol	470-82-6
Linalool	78-70-6
Phenylethyl alcohol	60-12-8
Benzyl acetate	140-11-4
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

20. Baby ointment

Compounds	CAS#
Acetaldehyde*	75-07-0
Methanol*	67-56-1
Pentane*	109-66-0
Ethanol*	64-17-5
Propanal*	123-38-6
Acetone*	67-64-1
1,5-Hexadien-3-ol	924-41-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

21. Baby ointment

Compounds	CAS#
Acetaldehyde*	75-07-0
Ethanol*	64-17-5
Acetone*	67-64-1
Tetrahydrofuran*	109-99-9
1,1'-Oxydi-2-propanol	110-98-5
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
2,2'-Oxydipropanol	108-61-2
Phenylethyl alcohol	60-12-8
7-Hydroxycitronellal	107-75-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 3: VOC identities and prevalences among all regular and green baby products (n=42)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	28
Acetaldehyde*	75-07-0	23
Ethanol*	64-17-5	23
alpha-Pinene	80-56-8	21
Linalool	78-70-6	20
beta-Myrcene	123-35-3	19
Acetone*	67-64-1	17
beta-Pinene	127-91-3	17
Eucalyptol	470-82-6	14
Ethyl butyrate	105-54-4	13
3-Carene	13466-78-9	12
Phenoxyethanol*	122-99-6	12
Benzyl alcohol*	100-51-6	11
Benzyl acetate	140-11-4	10
Camphene	79-92-5	10
Camphor	76-22-2	10
gamma-Terpinene	99-85-4	10
beta-Phellandrene	555-10-2	9
Ethyl 2-methylbutyrate	7452-79-1	9
Isopropyl alcohol*	67-63-0	9
Linalool acetate	115-95-7	9
alpha-Phellandrene	99-83-2	8
Ethyl acetate*	141-78-6	8
1-Octanol*	111-87-5	7
Hexyl acetate	142-92-7	7
Terpinolene	586-62-9	6
beta-trans-Ocimene	3779-61-1	6
Pentane*	109-66-0	6
Phenylethyl alcohol	60-12-8	6
4-tert-Butylcyclohexyl acetate	32210-23-4	5
alpha-Terpineol	98-55-5	5
cis-3-Hexenol	928-96-1	5
Isoamyl acetate*	123-92-2	5

Neryl acetate	141-12-8	5
2,4-Dimethylhexane*	589-43-5	4
2-tert-Butylcyclohexanol	13491-79-7	4
Cyclododecane	294-62-2	4
Dihydromyrcenol	18479-58-8	4
Hexanal	66-25-1	4
Isobutyl isobutyrate	97-85-8	4
m-Cymene	535-77-3	4
Nonadecane	629-92-5	4
Ocimene	13877-91-3	4
Toluene*	108-88-3	4
Undecane	1120-21-4	4
4-Carene	29050-33-7	3
(Z)-7-tetradecene	41446-60-0	3
2-Methylbutyl acetate*	624-41-9	3
2-Methylfuran	534-22-5	3
3-Octanone	106-68-3	3
alpha-Thujene	2867-05-2	3
Cyclohexane*	110-82-7	3
Decamethylcyclopentasiloxane	541-02-6	3
Dodecane	112-40-3	3
Hexane*	110-54-3	3
Isoamyl butylate	106-27-4	3
Methanol*	67-56-1	3
Octamethylcyclotetrasiloxane*	556-67-2	3
Propanal*	123-38-6	3
Tridecane	629-50-5	3
1,1-Dimethylallyl alcohol	115-18-4	2
1,3,4-Trimethyl-3-cyclohexen-1-carboxaldehyde	40702-26-9	2
1-Octen-3-yl-acetate	2442-10-6	2
1-Tridecene	2437-56-1	2
1-Undecanol	112-42-5	2
2,2-Dimethyldecane	17302-37-3	2
2-Butenal*	4170-30-3	2
2-Methyl-1-propene*	115-11-7	2
2-Methylbutyraldehyde	96-17-3	2
2-Methylpentane*	107-83-5	2
2-Phenoxyethyl isobutyrate	103-60-6	2
3,5,5-Trimethylhexyl acetate	58430-94-7	2
3,7-Dimethyl-3-octanol	78-69-3	2

3-Methylhexane*	589-34-4	2
4-Terpineol	562-74-3	2
Allyl heptanoate	142-19-8	2
alpha-Isomethyl ionone	127-51-5	2
Amyl butyrate	540-18-1	2
Amyl senecioate	56922-72-6	2
Benzaldehyde*	100-52-7	2
Butyl acetate*	123-86-4	2
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1	2
Ethyl 2-methylpentanoate	39255-32-8	2
Ethyl hexanoate	123-66-0	2
Ethyl isovalerate	108-64-5	2
Ethyl linalool	10339-55-6	2
Geraniol acetate	105-87-3	2
Hexyl butyrate	2639-63-6	2
Isobutyl 2-methyl-2-propenoate*	97-86-9	2
Isobutyraldehyde	78-84-2	2
Isovaleraldehyde	590-86-3	2
Methyl hexyl ether	4747-07-3	2
Methylcyclopentane	96-37-7	2
Ocimenol	5986-38-9	2
Octyl butyrate	110-39-4	2
Piperonal	120-57-0	2
Sabinene	3387-41-5	2
Tetrahydrofuran*	109-99-9	2
Tetrahydrolinalool	57706-88-4	2
trans-beta-Ionone	79-77-6	2
Tris(trimethylsilyl) borate	4325-85-3	2
β-Citronellol	106-22-9	2
(+)-Camphene	5794-03-6	1
alpha-Longipinene	5989-08-2	1
(1R,4S)-p-menthan-3-one	14073-97-3	1
(2Z)-3,7-dimethylocta-2,6-dienal*	106-26-3	1
(E)-3,3-Dimethylcyclohexylideneacetaldehyde	26532-25-2	1
(R)-(+)-citronellal	2385-77-5	1
(Z)-beta-farnesene	28973-97-9	1
(Z)-beta-ocimene	3338-55-4	1
(Z)-sabinene hydrate	15537-55-0	1
(Z+E)-2-methyl-2-(4-methyl-3-pentenyl) cyclopropane carbaldehyde	97231-35-1	1

1,1-Dimethyl-2-(2-methyl-1-propenyl)cyclopropane	33422-32-1	1
1,1'-Oxydi-2-propanol	110-98-5	1
1,2-diethylcyclohexane	824-43-1	1
1,3-Dioxane	505-22-6	1
1,4-Hexadiene	592-45-0	1
1,4-Pentadiene	591-93-5	1
1,5-Hexadien-3-ol	924-41-4	1
1-Butyl-2-propylcyclopentane	62199-50-2	1
1-Decene	872-05-9	1
1-Dodecanol	112-53-8	1
1-Ethyl-2-methylcyclohexane	3728-54-9	1
1-Ethyl-2-propylcyclohexane	62238-33-9	1
1-Hexanol*	111-27-3	1
1-Methyl-2-propylcyclohexan	4291-79-6	1
1-Methyl-3-cyclohexene-1-carbaldehyde	931-96-4	1
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	1
2,2,6,6-Tetramethylcyclohexanol	6948-41-0	1
2,2'-Oxydipropanol	108-61-2	1
2,3,4-Trimethylhexane	921-47-1	1
2,3-dehydro-1,8-cineole	92760-25-3	1
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	1
2,4-Dimethylheptane	2213-23-2	1
2,4-Dimethylpentane*	108-08-7	1
2,4-Pentanedione*	123-54-6	1
2,5,5-Trimethylheptane	1189-99-7	1
2,6-Dichlorobenzyl alcohol	15258-73-8	1
2,6-Dimethyl octane	2051-30-1	1
2,6-Dimethyl-2-heptanol	13254-34-7	1
2,6-Di-tert-butyl-4-methylphenol	128-37-0	1
2,6-Octadiene, 2,4-dimethyl-	63843-03-8	1
2,7-Dimethyl-1,7-octadiene	59840-10-7	1
2,9-Dimethyl-5-decyne	19550-56-2	1
2-Butyl-1-octanol	3913-02-8	1
2-Carene	554-61-0	1
2-Ethyl-4-methyl-1,3-dioxolane	4359-46-0	1
2-Ethylfuran	3208-16-0	1
2-Methyl pentyl isobutyrate	84254-82-0	1
2-Methyl-1-butene	563-46-2	1
2-Methyl-1-pentene	763-29-1	1

2-Methyl-2-butene	513-35-9	1
2-Methylbutyl 2-methylbutyrate	2445-78-5	1
2-Methylbutyl isovalerate	2445-77-4	1
2-methylenehexanal	1070-66-2	1
2-Pentanone	107-87-9	1
3,3-Dimethylallyl bromide	870-63-3	1
3,4-Dimethylheptane	922-28-1	1
3,7-Dimethyloctan-3-yl acetate	20780-48-7	1
3,7-Dimethyl-1,6-octadiene	10281-56-8	1
3-Methyl-1-cyclopentene	1120-62-3	1
3-Methyl-1-octene	13151-08-1	1
3-Methyl-2-butenic acid, octyl ester	56500-47-1	1
3-Methylfuran	930-27-8	1
3-Methylnonane	5911-04-6	1
3-Methylpentane*	96-14-0	1
3-Octanol	589-98-0	1
4,4,6,6-Tetramethylbicyclo[3.1.0]hex-2-ene	19487-09-3	1
3-Octyl acetate	4864-61-3	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
4-Hexen-1-ol, acetate	72237-36-6	1
4-Nonanone	4485-09-0	1
4-tert-Pentylcyclohexanol	20698-30-0	1
6-Methyl-5-hepten-2-one	110-93-0	1
7-Hydroxycitronellal	107-75-5	1
Acetylmethylcyclohexene,4-acetyl-1-methyl-1-cyclohexene	70286-20-3	1
alpha-himachalen	3853-83-6	1
Amyl acetate*	628-63-7	1
Benzyl benzoate*	120-51-4	1
Bicyclo[5.2.0]nonane, 4-ethenyl-4,8,8-trimethyl-2-methylene-	242794-76-9	1
Borneol	10385-78-1	1
Bromocyclohexane	108-85-0	1
Butane*	106-97-8	1
Butylcyclohexane	1678-93-9	1
Carvone	99-49-0	1
cis-1,3,5-Trimethylcyclohexane	1795-27-3	1
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	1
cis-3-Hexenyl acetate	3681-71-8	1
cis-6-Nonenyl acetate	76238-22-7	1

Citral*	5392-40-5	1
D,L-isobornyl acetate	92618-89-8	1
Dichloromethane*	75-09-2	1
Dihydrocarveol	38049-26-2	1
Dimethyl sulfide	75-18-3	1
Dipentyl ether	693-65-2	1
DL-menthol	15356-70-4	1
DL-menthyl acetate	16409-45-3	1
Ethyl benzoate	93-89-0	1
Ethyl lactate*	97-64-3	1
Ethyl methyl ether*	540-67-0	1
Ethyl nonanoate	123-29-5	1
Ethyl propionate*	105-37-3	1
Hexamethylcyclotrisiloxane	541-05-9	1
Isoamyl isovalerate	659-70-1	1
Isoborneol	124-76-5	1
Isobutyl cyanate	1768-25-8	1
Lavandulyl acetate	25905-14-0	1
Linalyl anthranilate	7149-26-0	1
L-menthol	2216-51-5	1
Methacrolein	78-85-3	1
Methyl isopropyl ether	598-53-8	1
Methyl octanoate	111-11-5	1
Methyl phenylcarbinyl acetate	93-92-5	1
Methyl salicylate	119-36-8	1
Methylcyclohexane*	108-87-2	1
Nopyl acetate	128-51-8	1
Octanal	124-13-0	1
Octane*	111-65-9	1
o-Cymene	527-84-4	1
p-Anisaldehyde	123-11-5	1
Pentanal	110-62-3	1
Pentyl acetate*	628-63-7	1
Pentylidenecyclopentane	53366-55-5	1
Prenyl acetate	1191-16-8	1
trans-Decahydronaphthalene	493-02-7	1
Trimethylsilanol	1066-40-6	1
β -Caryophyllene	87-44-5	1
(-)-Terpinen-4-ol	20126-76-5	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 4: VOC identities and prevalences among all green baby products (n=21)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	17
Linalool	78-70-6	16
Acetaldehyde*	75-07-0	13
beta-Myrcene	123-35-3	13
alpha-Pinene	80-56-8	13
Acetone*	67-64-1	12
Eucalyptol	470-82-6	10
beta-Pinene	127-91-3	10
Ethanol*	64-17-5	9
3-Carene	13466-78-9	9
Linalool acetate	115-95-7	8
Camphor	76-22-2	8
Benzyl alcohol*	100-51-6	7
Camphene	79-92-5	7
gamma-Terpinene	99-85-4	7
1-Octanol*	111-87-5	6
beta-Phellandrene	555-10-2	6
alpha-Phellandrene	99-83-2	6
Isopropyl alcohol*	67-63-0	5
Benzyl acetate	140-11-4	5
Ethyl butyrate	105-54-4	5
beta-trans-Ocimene	3779-61-1	5
Hexyl acetate	142-92-7	5
Neryl acetate	141-12-8	5
Phenoxyethanol*	122-99-6	4
Hexanal	66-25-1	4
alpha-Terpineol	98-55-5	4
2,4-Dimethylhexane*	589-43-5	4
Terpinolene	586-62-9	4
Isobutyl isobutyrate	97-85-8	4
Ocimene	13877-91-3	4
Ethyl acetate*	141-78-6	3
Ethyl 2-methylbutyrate	7452-79-1	3

Pentane*	109-66-0	3
3-Octanone	106-68-3	3
2-Methylfuran	534-22-5	3
Toluene*	108-88-3	3
Cyclohexane*	110-82-7	2
1-Undecanol	112-42-5	2
Undecane	1120-21-4	2
Phenylethyl alcohol	60-12-8	2
Dihydromyrcenol	18479-58-8	2
Hexane*	110-54-3	2
Sabinene	3387-41-5	2
Tridecane	629-50-5	2
Ethyl linalool	10339-55-6	2
Dodecane	112-40-3	2
2-Methylpentane*	107-83-5	2
2-Methyl-1-propene*	115-11-7	2
2-tert-Butylcyclohexanol	13491-79-7	2
Geraniol acetate	105-87-3	2
3,7-Dimethyl-3-octanol	78-69-3	2
1,1-Dimethylallyl alcohol	115-18-4	2
Methyl hexyl ether	4747-07-3	2
Isobutyl 2-methyl-2-propenoate*	97-86-9	2
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1	2
1-Octen-3-yl-acetate	2442-10-6	2
Hexyl butyrate	2639-63-6	2
Octyl butyrate	110-39-4	2
4-Terpineol	562-74-3	2
Methylcyclopentane	96-37-7	2
Amyl senecioate	56922-72-6	2
Ocimenol	5986-38-9	2
β -Citronellol	106-22-9	2
m-Cymene	535-77-3	2
cis-3-Hexenol	928-96-1	1
Carvone	99-49-0	1
Piperonal	120-57-0	1
Cyclododecane	294-62-2	1
trans-beta-Ionone	79-77-6	1
4-tert-Butylcyclohexyl acetate	32210-23-4	1
Pentanal	110-62-3	1
3-Octanol	589-98-0	1

2,4-Dimethylheptane	2213-23-2	1
Methanol*	67-56-1	1
alpha-Thujene	2867-05-2	1
Bromocyclohexane	108-85-0	1
Isoamyl acetate*	123-92-2	1
2-Butenal*	4170-30-3	1
2-Methylenehexanal	1070-66-2	1
Methyl octanoate	111-11-5	1
2-Methylbutyl acetate*	624-41-9	1
Amyl acetate*	628-63-7	1
1-Dodecanol	112-53-8	1
2,3,4-Trimethylhexane	921-47-1	1
Ethyl 2-methylpentanoate	39255-32-8	1
Methyl phenylcarbinyl acetate	93-92-5	1
3,7-Dimethyloctan-3-yl acetate	20780-48-7	1
3-Methyl-1-octene	13151-08-1	1
1-Decene	872-05-9	1
Prenyl acetate	1191-16-8	1
4-Hexen-1-ol, acetate	72237-36-6	1
1-Methyl-3-cyclohexene-1-carbaldehyde	931-96-4	1
Allyl heptanoate	142-19-8	1
2-Phenoxyethyl isobutyrate	103-60-6	1
Benzaldehyde*	100-52-7	1
3-Methylpentane*	96-14-0	1
2,2-Dimethyldecane	17302-37-3	1
2-Phenoxyethyl isobutyrate	103-60-6	1
2-Methyl-1-butene	563-46-2	1
3-Methyl-2-butenic acid, octyl ester	56500-47-1	1
Octanal	124-13-0	1
2,2,6,6-Tetramethylcyclohexanol	6948-41-0	1
Borneol	10385-78-1	1
Dihydrocarveol	38049-26-2	1
1,1-Dimethyl-2-(2-methyl-1-propenyl)cyclopropane	33422-32-1	1
2,4-Dimethylpentane*	108-08-7	1
Octane*	111-65-9	1
2,4-Pentanedione*	123-54-6	1
Methylcyclohexane*	108-87-2	1
3,5,5-Trimethylhexyl acetate	58430-94-7	1
Linalyl anthranilate	7149-26-0	1
2-Carene	554-61-0	1

3-Methylhexane*	589-34-4	1
Decamethylcyclopentasiloxane	541-02-6	1
3-Methylfuran	930-27-8	1
Butyl acetate*	123-86-4	1
(Z)-beta-ocimene	3338-55-4	1
2,6-Octadiene, 2,4-dimethyl-	63843-03-8	1
3-Octyl acetate	4864-61-3	1
4,4,6,6-Tetramethylbicyclo[3.1.0]hex-2-ene	19487-09-3	1
2-Methyl pentyl isobutyrate	84254-82-0	1
Lavandulyl acetate	25905-14-0	1
(Z)-beta-farnesene	28973-97-9	1
Bicyclo[5.2.0]nonane, 4-ethenyl-4,8,8-trimethyl-2-methylene-	242794-76-9	1
Ethyl lactate*	97-64-3	1
Ethyl isovalerate	108-64-5	1
D,l-isobornyl acetate	92618-89-8	1
1,4-Pentadiene	591-93-5	1
2-Methyl-2-butene	513-35-9	1
Dimethyl sulfide	75-18-3	1
Isobutyraldehyde	78-84-2	1
3-Methyl-1-cyclopentene	1120-62-3	1
Isovaleraldehyde	590-86-3	1
2-Methylbutyraldehyde	96-17-3	1
2-Ethylfuran	3208-16-0	1
3,3-Dimethylallyl bromide	870-63-3	1
2,3-Dehydro-1,8-cineole	92760-25-3	1
6-Methyl-5-hepten-2-one	110-93-0	1
4-Carene	29050-33-7	1
4-Nonanone	4485-09-0	1
Acetylmethylcyclohexene,4-acetyl-1-methyl-1-cyclohexene	70286-20-3	1
(R)-(+)-citronellal	2385-77-5	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
(1R,4S)-p-menthan-3-one	14073-97-3	1
L-menthol	2216-51-5	1
Methyl salicylate	119-36-8	1
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	1
(2Z)-3,7-dimethylocta-2,6-dienal*	106-26-3	1
DI-menthyl acetate	16409-45-3	1
Citral*	5392-40-5	1

β -Caryophyllene	87-44-5	1
alpha-Himachalen	3853-83-6	1
alpha-Longipinene	5989-08-2	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 5: VOC identities and prevalences among all regular baby products (n=21)

Compound	CAS #	Prevalence (# of products)
Ethanol*	64-17-5	14
Limonene*	138-86-3	11
Acetaldehyde*	75-07-0	10
alpha-Pinene	80-56-8	8
Ethyl butyrate	105-54-4	8
Phenoxyethanol*	122-99-6	8
beta-Pinene	127-91-3	7
beta-Myrcene	123-35-3	6
Ethyl 2-methylbutyrate	7452-79-1	6
Acetone*	67-64-1	5
Benzyl acetate	140-11-4	5
Ethyl acetate*	141-78-6	5
Linalool	78-70-6	4
Eucalyptol	470-82-6	4
Benzyl alcohol*	100-51-6	4
Isopropyl alcohol*	67-63-0	4
Phenylethyl alcohol	60-12-8	4
cis-3-Hexenol	928-96-1	4
4-tert-Butylcyclohexyl acetate	32210-23-4	4
Isoamyl acetate*	123-92-2	4
Nonadecane	629-92-5	4
3-Carene	13466-78-9	3
Camphene	79-92-5	3
beta-Phellandrene	555-10-2	3
gamma-Terpinene	99-85-4	3
Pentane*	109-66-0	3
Cyclododecane	294-62-2	3
Octamethylcyclotetrasiloxane*	556-67-2	3
Propanal*	123-38-6	3
(Z)-7-tetradecene	41446-60-0	3
Isoamyl butylate	106-27-4	3
Terpinolene	586-62-9	2
4-Carene	29050-33-7	2

Camphor	76-22-2	2
Hexyl acetate	142-92-7	2
alpha-Phellandrene	99-83-2	2
Undecane	1120-21-4	2
Dihydromyrcenol	18479-58-8	2
alpha-Isomethyl ionone	127-51-5	2
2-tert-Butylcyclohexanol	13491-79-7	2
Methanol*	67-56-1	2
alpha-Thujene	2867-05-2	2
1,3,4-Trimethyl-3-cyclohexen-1-carboxaldehyde	40702-26-9	2
1-Tridecene	2437-56-1	2
Tris(trimethylsilyl) borate	4325-85-3	2
Decamethylcyclopentasiloxane	541-02-6	2
Tetrahydrofuran*	109-99-9	2
m-Cymene	535-77-3	2
Tetrahydrolinalool	57706-88-4	2
Amyl butyrate	540-18-1	2
Ethyl hexanoate	123-66-0	2
2-Methylbutyl acetate*	624-41-9	2
Linalool acetate	115-95-7	1
1-Octanol*	111-87-5	1
beta-trans-Ocimene	3779-61-1	1
alpha-Terpineol	98-55-5	1
Cyclohexane*	110-82-7	1
Hexane*	110-54-3	1
Piperonal	120-57-0	1
Tridecane	629-50-5	1
Dodecane	112-40-3	1
1-Hexanol*	111-27-3	1
trans-beta-Ionone	79-77-6	1
Toluene*	108-88-3	1
Dichloromethane*	75-09-2	1
Hexamethylcyclotrisiloxane	541-05-9	1
2,6-Dimethyl-2-heptanol	13254-34-7	1
2-Butene*	107-01-7	1
2-Methyl-1-pentene	763-29-1	1
2,7-Dimethyl-1,7-octadiene	59840-10-7	1
3,7-Dimethyl-1,6-octadiene	10281-56-8	1
1,4-Hexadiene	592-45-0	1
cis-6-Nonenyl acetate	76238-22-7	1

4-tert-Pentylcyclohexanol	20698-30-0	1
Nopyl acetate	128-51-8	1
Isobutyl cyanate	1768-25-8	1
3-Methylhexane*	589-34-4	1
3,4-Dimethylheptane	922-28-1	1
Ethyl methyl ether*	540-67-0	1
Methacrolein	78-85-3	1
Trimethylsilanol	1066-40-6	1
1,1'-Oxydi-2-propanol	110-98-5	1
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	1
2,2'-Oxydipropanol	108-61-2	1
7-Hydroxycitronellal	107-75-5	1
1,5-Hexadien-3-ol	924-41-4	1
(+)-Camphene	5794-03-6	1
Isoborneol	124-76-5	1
2,9-Dimethyl-5-decyne	19550-56-2	1
Pentylidenecyclopentane	53366-55-5	1
(E)-3,3-Dimethylcyclohexylideneacetaldehyde	26532-25-2	1
Dl-menthol	15356-70-4	1
Benzaldehyde*	100-52-7	1
Ethyl benzoate	93-89-0	1
Butyl acetate*	123-86-4	1
cis-1,3,5-Trimethylcyclohexane	1795-27-3	1
1-Ethyl-2-methylcyclohexane	3728-54-9	1
2,6-Dimethyl octane	2051-30-1	1
2-Butyl-1-octanol	3913-02-8	1
1-Butyl-2-propylcyclopentane	62199-50-2	1
3-Methylnonane	5911-04-6	1
1-Ethyl-2-propylcyclohexane	62238-33-9	1
1,2-Diethylcyclohexane	824-43-1	1
1-Methyl-2-propylcyclohexan	4291-79-6	1
2,5,5-Trimethylheptane	1189-99-7	1
Butylcyclohexane	1678-93-9	1
trans-Decahydronaphthalene	493-02-7	1
Ethyl propionate*	105-37-3	1
Ethyl 2-methylpentanoate	39255-32-8	1
Ethyl nonanoate	123-29-5	1
Pentyl acetate*	628-63-7	1
Dipentyl ether	693-65-2	1
2-Methylbutyl 2-methylbutyrate	2445-78-5	1

Isoamyl isovalerate	659-70-1	1
2-Methylbutyl isovalerate	2445-77-4	1
Benzyl benzoate*	120-51-4	1
Ethyl isovalerate	108-64-5	1
2,2-Dimethyldecane	17302-37-3	1
3,5,5-Trimethylhexyl acetate	58430-94-7	1
2,6-Dichlorobenzyl alcohol	15258-73-8	1
2,6-Di-tert-butyl-4-methylphenol	128-37-0	1
Methyl isopropyl ether	598-53-8	1
2-Ethyl-4-methyl-1,3-dioxolane	4359-46-0	1
1,3-Dioxane	505-22-6	1
cis-3-Hexenyl acetate	3681-71-8	1
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	1
Allyl heptanoate	142-19-8	1
(Z+E)-2-methyl-2-(4-methyl-3-pentenyl) cyclopropane carbaldehyde	97231-35-1	1
p-Anisaldehyde	123-11-5	1
Butane*	106-97-8	1
Isobutyraldehyde	78-84-2	1
Isovaleraldehyde	590-86-3	1
2-Methylbutyraldehyde	96-17-3	1
2-Pentanone	107-87-9	1
o-Cymene	527-84-4	1
(Z)-sabinene hydrate	15537-55-0	1
(-)-Terpinen-4-ol	20126-76-5	1

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Appendix B

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Supplementary Table 1: VOC occurrences among green essential oils (n=12)

1. Tea tree oil

Compounds	CAS#
Acetone*	67-64-1
alpha-Pinene	80-56-8
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
Limonene*	138-86-3
beta-Phellandrene	555-10-2
4-Terpineol	562-74-3
gamma-Terpinene	99-85-4
4-Carene	29050-33-7
Ethanol*	64-17-5
m-Cymene	535-77-3
Terpinolene	586-62-9
Eucalyptol	470-82-6
alpha-Phellandrene	99-83-2
Ocimenol	5986-38-9
Isobutyraldehyde	78-84-2
3-Carene	13466-78-9
Alloaromadendrene	25246-27-9
(+)-Ledene	21747-46-6
delta-Cadinene	483-76-1
Butane*	106-97-8
2-Methylbutyraldehyde	96-17-3
alpha-Gurjunene	489-40-7
Ethyl acetate*	141-78-6
Acetaldehyde*	75-07-0

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2. *Eucalyptus* oil

Compounds	CAS#
Eucalyptol	470-82-6
alpha-Pinene	80-56-8
Limonene*	138-86-3
m-Cymene	535-77-3
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
3-Carene	13466-78-9
alpha-Thujene	2867-05-2
alpha-Terpineol	98-55-5
Ethanol*	64-17-5
beta-Myrcene	123-35-3
4-Carene	29050-33-7
alpha-Phellandrene	99-83-2
Camphene	79-92-5
4-Terpineol	562-74-3
Acetone*	67-64-1
beta-Phellandrene	555-10-2
Isovaleraldehyde	590-86-3
Linalyl isobutyrate	78-35-3
(+)-Camphene	5794-03-6
Isoamyl alcohol	123-51-3
2,4-Thujadiene	36262-09-6
Terpinolene	586-62-9
Methanol*	67-56-1
Isoamyl acetate*	123-92-2

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3. *Eucalyptus* oil

Compounds	CAS#
Eucalyptol	470-82-6
Limonene*	138-86-3
alpha-Pinene	80-56-8
gamma-Terpinene	99-85-4
m-Cymene	535-77-3
3-Carene	13466-78-9
beta-Pinene	127-91-3
alpha-Thujene	2867-05-2
beta-Myrcene	123-35-3
4-Carene	29050-33-7
alpha-Terpineol	98-55-5
Terpinolene	586-62-9
Isovaleraldehyde	590-86-3
Ethanol*	64-17-5
4-Terpineol	562-74-3
beta-trans-Ocimene	3779-61-1
Acetone*	67-64-1
Pentylidenecyclopentane	53366-55-5
alpha-Pinene oxide	1686-14-2
Linalool	78-70-6
Isoamyl alcohol	123-51-3
alpha-Phellandrene	99-83-2
Methanol*	67-56-1
Camphene	79-92-5
2-Isopropenyltoluene	7399-49-7

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4. Peppermint oil

Compounds	CAS#
Menthone	89-80-5
Menthol	1490-04-6
Eucalyptol	470-82-6
Limonene*	138-86-3
beta-Pinene	127-91-3
alpha-Pinene	80-56-8
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6
beta-Phellandrene	555-10-2
DI-Menthyl acetate	16409-45-3
D,l-Menthol	15356-70-4
m-Cymene	535-77-3
Acetone*	67-64-1
4-Carene	29050-33-7
gamma-Terpinene	99-85-4
Methanol*	67-56-1
2-Isopropylidene-5-methylcyclohexanone	15932-80-6
Caryophyllene	87-44-5
Isovaleraldehyde	590-86-3
2-Methylbutyraldehyde	96-17-3
alpha-Phellandrene	99-83-2
Camphene	79-92-5
2,5-Diethyl tetrahydrofuran	41239-48-9
alpha-Thujene	2867-05-2
Butane*	106-97-8
(R)-(+)-pulegone	89-82-7

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5. Lavender oil

Compounds	CAS#
Linalool	78-70-6
Linalyl butyrate	78-36-4
Eucalyptol	470-82-6
Ocimene	13877-91-3
3-Octanone	106-68-3
(-)-Terpinen-4-ol	20126-76-5
Hexyl methyl ether	4747-07-3
alpha-Pinene	80-56-8
Acetone*	67-64-1
beta-Myrcene	123-35-3
Hexyl acetate	142-92-7
Camphor	76-22-2
3-Carene	13466-78-9
alpha-Phellandrene	99-83-2
Camphene	79-92-5
cis-1,2-Dimethylcyclopropane	930-18-7
Neryl acetate	141-12-8
Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	242794-76-9
Methanol*	67-56-1
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
m-Cymene	535-77-3
1-Octen-3-yl-acetate	2442-10-6
Ocimenol	5986-38-9
Isovaleraldehyde	590-86-3

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6. Mixture of oils

Compounds	CAS#
Eucalyptol	470-82-6
Propylene glycol	57-55-6
alpha-Pinene	80-56-8
Limonene*	138-86-3
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
m-Cymene	535-77-3
Camphene	79-92-5
Menthol	1490-04-6
3-Carene	13466-78-9
alpha-Thujene	2867-05-2
beta-Myrcene	123-35-3
alpha-Terpineol	98-55-5
Camphor	76-22-2
4-Carene	29050-33-7
alpha-Phellandrene	99-83-2
Methyl salicylate	119-36-8
gamma-Terpineol	586-81-2
Terpinolene	586-62-9
beta-trans-Ocimene	3779-61-1
beta-Terpineol	138-87-4
Pentylidenecyclopentane	53366-55-5
Caryophyllene	87-44-5
Borneol	10385-78-1
Dihydrocarveol	619-01-2

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7. Mixture of oils

Compounds	CAS#
Ethanol*	64-17-5
Eucalyptol	470-82-6
Linalyl butyrate	78-36-4
Limonene*	138-86-3
Linalool	78-70-6
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
3-Octanone	106-68-3
Camphene	79-92-5
Caryophyllene	87-44-5
Hexyl methyl ether	4747-07-3
beta-Pinene	127-91-3
Hexyl acetate	142-92-7
m-Cymene	535-77-3
alpha-Phellandrene	99-83-2
beta-trans-Ocimene	3779-61-1
gamma-Terpinene	99-85-4
3-Carene	13466-78-9
Camphor	76-22-2
Terpinolene	586-62-9
Hexyl butyrate	2639-63-6
Butyl butyrate*	109-21-7
beta-Phellandrene	555-10-2
Neryl acetate	141-12-8
4-Terpineol	562-74-3

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8. Mixture of oils

Compounds	CAS#
Limonene*	138-86-3
Linalool	78-70-6
Linalyl butyrate	78-36-4
(Z)-beta-ocimene	3338-55-4
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
(-)-Terpinen-4-ol	20126-76-5
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1
3-Octanone	106-68-3
Acetone*	67-64-1
Neryl acetate	141-12-8
Hexyl acetate	142-92-7
Caryophyllene	87-44-5
3-Carene	13466-78-9
beta-Phellandrene	555-10-2
1-Octen-3-yl-acetate	2442-10-6
Methanol*	67-56-1
Iso-amyl-senecioate	56922-73-7
alpha-Phellandrene	99-83-2
alpha-Terpineol	98-55-5
Camphene	79-92-5
Hexyl methyl ether	4747-07-3
Isobutyl butyrate	539-90-2
beta-Pinene	127-91-3
beta-trans-Ocimene	3779-61-1

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9. Mixture of oils

Compounds	CAS#
Limonene*	138-86-3
alpha-Pinene	80-56-8
Linalool	78-70-6
Linalyl butyrate	78-36-4
Eucalyptol	470-82-6
beta-Pinene	127-91-3
Camphene	79-92-5
beta-Myrcene	123-35-3
Benzyl acetate	140-11-4
Acetone*	67-64-1
beta-Phellandrene	555-10-2
Caryophyllene	87-44-5
Methyl benzoate	93-58-3
Borneol	10385-78-1
3-Carene	13466-78-9
alpha-Phellandrene	99-83-2
Isomenthone	491-07-6
Citronellyl formate	105-85-1
3-Octanone	106-68-3
Hexyl acetate	142-92-7
beta-Citronellol	106-22-9
beta-trans-Ocimene	3779-61-1
Isopropyl alcohol*	67-63-0
Acetaldehyde*	75-07-0
Octanal	124-13-0

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10. Sweet orange oil^C

Compounds	CAS#
Limonene*	138-86-3
beta-Pinene	127-91-3
alpha-Pinene	80-56-8
beta-Phellandrene	555-10-2
3-Carene	13466-78-9
beta-trans-Ocimene	3779-61-1
Methanol*	67-56-1
Acetone*	67-64-1
Octanal	124-13-0
Linalool	78-70-6
Ocimene	13877-91-3
Ethanol*	64-17-5
alpha-Thujene	2867-05-2
1,1-Dimethylallyl alcohol	115-18-4
1-Octanol*	111-87-5
(+)-Limonene oxide	1195-92-2
Methyl formate*	107-31-3
Decanal	112-31-2
alpha-Terpineol	98-55-5
gamma-Terpinene	99-85-4
(+)-(E)-limonene oxide	6909-30-4
Nonanal	124-19-6
1-Hexanol*	111-27-3
alpha-Phellandrene	99-83-2
Camphene	79-92-5

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11. Tea tree oil

Compounds	CAS#
(-)-Terpinen-4-ol	20126-76-5
gamma-Terpinene	99-85-4
4-Carene	29050-33-7
m-Cymene	535-77-3
alpha-Pinene	80-56-8
Eucalyptol	470-82-6
Terpinolene	586-62-9
alpha-Phellandrene	99-83-2
Ethanol*	64-17-5
Limonene*	138-86-3
alpha-Terpineol	98-55-5
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
3-Carene	13466-78-9
Alloaromadendrene	25246-27-9
Isobutyraldehyde	78-84-2
alpha-Thujene	2867-05-2
(+)-Ledene	21747-46-6
delta-Cadinene	483-76-1
beta-Phellandrene	555-10-2
gamma-Muurolene	30021-74-0
Butane*	106-97-8
Acetone*	67-64-1
2-Methylbutyraldehyde	96-17-3
alpha-Gurjunene	489-40-7

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12. Lime and coconut oil

Compounds	CAS#
Acetaldehyde*	75-07-0
Methanol*	67-56-1
Ethanol*	64-17-5
Ethyl formate*	109-94-4
Ethyl 2-methylbutyrate	7452-79-1
Ethylbenzene*	100-41-4
alpha-Phellandrene	99-83-2
alpha-Pinene	80-56-8
Camphene	79-92-5
beta-Phellandrene	555-10-2
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
4-Carene	29050-33-7
Limonene*	138-86-3
3-Carene	13466-78-9
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Terpinolene	586-62-9
Linalool	78-70-6
Decanal	112-31-2
Citral*	5392-40-5
gamma-Octalactone	104-50-7
Heneicosane	629-94-7
gamma-Nonanolactone	104-61-0

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Supplementary Table 2: VOC occurrences among regular essential oils (n=12)

1. Lavender oil

Compounds	CAS#
Ethanol*	64-17-5
Eucalyptol	470-82-6
Limonene*	138-86-3
Linalyl formate	115-99-1
alpha-Pinene	80-56-8
Carbon disulphide*	75-15-0
Linalool	78-70-6
beta-Myrcene	123-35-3
Camphene	79-92-5
gamma-Terpinene	99-85-4
beta-Pinene	127-91-3
m-Cymene	535-77-3
Camphor	76-22-2
Benzyl benzoate*	120-51-4
N-butylbenzenesulfonamide	3622-84-2
alpha-Phellandrene	99-83-2
2-Methyl-1-butene	563-46-2
Terpinolene	586-62-9
beta-Phellandrene	555-10-2
Acetaldehyde*	75-07-0
3-Carene	13466-78-9
Ethyl acetate*	141-78-6
beta-trans-Ocimene	3779-61-1
3-Octanone	106-68-3
3,5,5-Trimethylhexyl acetate	58430-94-7

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2. Lavender oil

Compounds	CAS#
Ethanol*	64-17-5
Methanol*	67-56-1
Limonene*	138-86-3
alpha-Pinene	80-56-8
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Terpinolene	586-62-9
beta-Myrcene	123-35-3
Linalyl acetate	115-95-7
Camphor	76-22-2
D,l-isobornyl acetate	92618-89-8
Camphene	79-92-5
4-Carene	29050-33-7
Linalool	78-70-6
Iso-camphane	473-19-8
gamma-Terpinene	99-85-4
2-Methylpropene*	115-11-7
1-Ethoxy-1-methoxyethane	10471-14-4
Dihydromyrcenol	18479-58-8
3-Carene	13466-78-9
2-Carene	554-61-0
Acetaldehyde*	75-07-0
alpha-Phellandrene	99-83-2
Methyl formate*	107-31-3
Acetone*	67-64-1

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3. Orange oil

Compounds	CAS#
Limonene*	138-86-3
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
3-Carene	13466-78-9
beta-Phellandrene	555-10-2
1,1'-dimethyldiethyleneglycol	110-98-5
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
2,2'-Oxydipropanol	108-61-2
beta-trans-Ocimene	3779-61-1
Acetaldehyde*	75-07-0
2-Butanol,3,3'-oxybis	54305-61-2
alpha-Phellandrene	99-83-2
Octanal	124-13-0
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
(Z)-beta-ocimene	3338-55-4
Camphene	79-92-5
2-Butene*	107-01-7
Acetone*	67-64-1
alpha-Thujene	2867-05-2

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4. English rose oil

Compounds	CAS#
1,1'-dimethyldiethyleneglycol	110-98-5
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
2,2'-Oxydipropanol	108-61-2
2-Butanol,3,3'-oxybis	54305-61-2
(Z)-rose oxide	16409-43-1
Benzyl alcohol*	100-51-6
beta-Citronellol	106-22-9
Acetaldehyde*	75-07-0
cis-3,7-Dimethyl-2,6-octadien-1-ol*	106-25-2
Limonene*	138-86-3
Triacetin	102-76-1
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Phenylethyl alcohol	60-12-8
Diethyl phthalate	84-66-2
Acetone*	67-64-1
(+)-trans-Rose oxide	876-18-6
Eucalyptol	470-82-6
Diphenyl ether	101-84-8
(-)-Camphene	5794-04-7
Benzaldehyde*	100-52-7
D,l-isobornyl acetate	92618-89-8
alpha-Pinene	80-56-8
(R)-(-)-2-butanol*	14898-79-4
Geranyl bromide	35719-26-7
3,5,5-Trimethylhexyl acetate	58430-94-7

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5. *Jasmine oil*

Compounds	CAS#
Ethyl isovalerate	108-64-5
Benzyl acetate	140-11-4
1,1'-dimethyldiethyleneglycol	110-98-5
Di(propylene glycol) methyl ether	34590-94-8
Dl-2-methylbutyrate	7452-79-1
2,2'-Oxydipropanol	108-61-2
Diethyl malonate	105-53-3
2-Butanol,3,3'-oxybis	54305-61-2
Eucalyptol	470-82-6
Limonene*	138-86-3
Triacetin	102-76-1
Linalool	78-70-6
2-tert-Butylcyclohexanol	13491-79-7
alpha-Pinene	80-56-8
Citronellyl acetate	150-84-5
4-Phenyl-2-butanone	2550-26-7
Diethyl phthalate	84-66-2
Acetaldehyde*	75-07-0
Methyl acetate*	79-20-9
4-Carene	29050-33-7
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
Benzyl isobutyrate	103-28-6
2,2,3,3-Tetramethylpentane	7154-79-2
Ethanol*	64-17-5
Heptylhexyl ether	7289-40-9

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6. Rose and grapefruit oil

Compounds	CAS#
Ethanol*	64-17-5
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
Di(propylene glycol) methyl ether	34590-94-8
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Dihydromyrcenol	18479-58-8
Benzyl acetate	140-11-4
2-Cyclohexene-1-acetaldehyde, 3-methyl-	129993-40-4
Linalool	78-70-6
1-(4-Methyl-1-cyclohex-3-enyl)ethanone	70286-20-3
Octanal dimethyl acetal	10022-28-3
Ethyl acetate*	141-78-6
4-Hexen-1-ol, acetate	72237-36-6
Acetaldehyde*	75-07-0
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3
beta-Ionone	79-77-6
cis-3,7-Dimethyl-2,6-octadien-1-ol*	106-25-2
Decanal	112-31-2
alpha-Ionone	6901-97-9
2-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
Acetone*	67-64-1
Ethyl formate*	109-94-4
Methyl acetate*	79-20-9
Acetaldehyde diethyl acetal*	105-57-7
Ethyl methyl carbonate	623-53-0

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7. Freesia and jasmine oil

Compounds	CAS#
Propylene glycol butyl ether*	5131-66-8
3,5,5-Trimethylhexyl acetate	58430-94-7
Dihydromyrcenol	18479-58-8
Hexanal	66-25-1
trans-3-Hexenyl acetate	3681-82-1
4-tert-Butylcyclohexyl acetate	32210-23-4
DI-4-hydroxy-3-methoxymandelic acid	928-96-1
Benzyl acetate	140-11-4
Acetaldehyde dibutyl acetal	871-22-7
Phenylethyl alcohol	60-12-8
Methyl phenylcarbinyl acetate	93-92-5
2-tert-Butylcyclohexanol	13491-79-7
2-Cyclohexene-1-acetaldehyde, 3-methyl-	129993-40-4
Ethyl butyrate	105-54-4
2-Methyl-5-propylnonane	31081-17-1
Ethyl 2-methylpentanoate	39255-32-8
2,6-Dimethyl-5-heptenal	106-72-9
5-(2-Methylpropyl)nonane	62185-53-9
4-Methylanisole	104-93-8
(Z)-rose oxide	16409-43-1
3,7-Dimethyldecane	17312-54-8
5,6-Dimethylundecane	17615-91-7
2,6,11-Trimethyldodecane	31295-56-4
cis-3,7-Dimethyl-2,6-octadien-1-ol*	106-25-2
4-Methyldodecane	6117-97-1

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8. Mixture of oils

Compounds	CAS#
beta-Pinene	127-91-3
alpha-Pinene	80-56-8
Eucalyptol	470-82-6
Linalool	78-70-6
Linalyl butyrate	78-36-4
Camphor	76-22-2
Camphene	79-92-5
Acetone*	67-64-1
Limonene*	138-86-3
4-Terpineol	562-74-3
Borneol	10385-78-1
m-Cymene	535-77-3
Methanol*	67-56-1
cis-1,2-Dimethylcyclopropane	930-18-7
alpha-Phellandrene	99-83-2
beta-Phellandrene	555-10-2
(+)-Camphene	5794-03-6
Ethanol*	64-17-5
Neryl acetate	141-12-8
1-Octen-3-yl acetate	2442-10-6
Carane	554-59-6
3-Octanone	106-68-3
beta-trans-Ocimene	3779-61-1
1-Hexanol*	111-27-3
beta-Myrcene	123-35-3

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9. Lemongrass oil

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
gamma-Terpinene	99-85-4
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
Di(propylene glycol) methyl ether	34590-94-8
m-Cymene	535-77-3
Dihydromyrcenol	18479-58-8
(Z)-citral*	106-26-3
alpha-Pinene	80-56-8
Undecane	1120-21-4
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Linalool	78-70-6
alpha-Terpineol	98-55-5
Terpinolene	586-62-9
Acetaldehyde*	75-07-0
Acetone*	67-64-1
2-Methyl-2-hepten-6-one	110-93-0
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethyl formate*	109-94-4
beta-Pinene	127-91-3
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
Citral*	5392-40-5
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3
Camphene	79-92-5
Decanal	112-31-2

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10. Mixture of oils

Compounds	CAS#
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
Di(propylene glycol) methyl ether	34590-94-8
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Propyl 2-methyl butyrate	37064-20-3
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3
Tripropylene glycol monomethyl ether	20324-33-8
2-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3
2-(2-Methoxypropoxy)propan-1-ol	13588-28-8
Phenylethyl alcohol	60-12-8
Cyclohexane*	110-82-7
Acetaldehyde*	75-07-0
Glutaric acid dimethyl ester	1119-40-0
4-tert-Butylcyclohexanol	98-52-2
Hexyl acetate	142-92-7
4-Hexen-1-ol, acetate	72237-36-6
Linalool	78-70-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethyl methyl ether*	540-67-0
Methylcyclopentane	96-37-7
Methyl formate*	107-31-3
Methyl acetate*	79-20-9
4-Methoxybenzaldehyde	123-11-5
p-Xylene*	106-42-3
Dimethyl adipate	627-93-0
Ethanone, 1-(6,6-dimethylbicyclo[3.1.0]hex-2-en-2-yl)-	24555-40-6

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11. Mixture of oils

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Ethyl formate*	109-94-4
4-tert-Butylcyclohexanol	98-52-2
Linalool	78-70-6
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethyl acetate*	141-78-6
Benzyl acetate	140-11-4
Acetaldehyde*	75-07-0
Acetone*	67-64-1
2-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3
alpha-Pinene	80-56-8
alpha-Guaiene	3691-12-1
(S)-(-)-propylene oxide*	16088-62-3
Methyl acetate*	79-20-9
Acetaldehyde diethyl acetal*	105-57-7
beta-Phellandrene	555-10-2
beta-Myrcene	123-35-3
2-(2-Methoxypropoxy)propan-1-ol	13588-28-8
Linalyl acetate	115-95-7
(+)-Cycloisositivene	22469-52-9
2-Methylpropene*	115-11-7

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12. Mixture of oils

Compounds	CAS#
Ethanol*	64-17-5
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
Di(propylene glycol) methyl ether	34590-94-8
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
Benzyl acetate	140-11-4
Ethyl acetate*	141-78-6
Linalool	78-70-6
Dl-lactic acid	50-21-5
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3
4-Hexen-1-ol, acetate	72237-36-6
(S)-(-)-propylene oxide*	16088-62-3
2-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3
Acetone*	67-64-1
Methyl phenylcarbinyl acetate	93-92-5
Acetaldehyde*	75-07-0
Methanol*	67-56-1
Acetaldehyde diethyl acetal*	105-57-7
2-(2-Methoxypropoxy)propan-1-ol	13588-28-8
Tripropylene glycol monomethyl ether	20324-33-8
2-Methylpropene*	115-11-7

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Supplementary Table 3: VOC identities and prevalences among all regular and green essential oils (n=24)

Compound	CAS #	Prevalence (# of essential oils)
alpha-Pinene	80-56-8	20
Limonene*	138-86-3	19
Acetone*	67-64-1	17
Linalool	78-70-6	16
alpha-Phellandrene	99-83-2	16
beta-Myrcene	123-35-3	15
Camphene	79-92-5	15
Ethanol*	64-17-5	15
beta-Pinene	127-91-3	15
3-Carene	13466-78-9	14
Eucalyptol	470-82-6	14
Acetaldehyde*	75-07-0	13
beta-Phellandrene	555-10-2	13
gamma-Terpinene	99-85-4	13
m-Cymene	535-77-3	11
beta-trans-Ocimene	3779-61-1	10
Methanol*	67-56-1	10
Terpinolene	586-62-9	10
4-Carene	29050-33-7	9
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	8
alpha-Terpineol	98-55-5	7
alpha-Thujene	2867-05-2	7
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	6
3-Octanone	106-68-3	6
Benzyl acetate	140-11-4	6
Camphor	76-22-2	6
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3	5
4-Terpineol	562-74-3	5
Caryophyllene	87-44-5	5
Hexyl acetate	142-92-7	5
Di(propylene glycol) methyl ether	34590-94-8	5
Linalyl butyrate	78-36-4	5

4-tert-Butylcyclohexyl acetate	32210-23-4	4
Decanal	112-31-2	4
Dihydromyrcenol	18479-58-8	4
Ethyl acetate*	141-78-6	4
Ethyl formate*	109-94-4	4
Isovaleraldehyde	590-86-3	4
Methyl acetate*	79-20-9	4
Neryl acetate	141-12-8	4
2-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3	4
(-)-Terpinen-4-ol	20126-76-5	3
Borneol	10385-78-1	3
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	3
1,1'-dimethyldiethyleneglycol	110-98-5	3
1-Octen-3-yl-acetate	2442-10-6	3
2-(2-Methoxypropoxy)propan-1-ol	13588-28-8	3
2,2'-Oxydipropanol	108-61-2	3
2-Butanol,3,3'-oxybis	54305-61-2	3
2-Methylpropene*	115-11-7	3
3,5,5-Trimethylhexyl acetate	58430-94-7	3
4-Hexen-1-ol, acetate	72237-36-6	3
Acetaldehyde diethyl acetal*	105-57-7	3
cis-3,7-Dimethyl-2,6-octadien-1-ol*	106-25-2	3
Hexyl methyl ether	4747-07-3	3
Methyl formate*	107-31-3	3
Octanal	124-13-0	3
Phenylethyl alcohol	60-12-8	3
2-Methylbutyraldehyde	96-17-3	3
Butane*	106-97-8	3
(S)-(-)-propylene oxide*	16088-62-3	2
(+)-Camphene	5794-03-6	2
(Z)-rose oxide	16409-43-1	2
Isobutyraldehyde	78-84-2	2
2-Cyclohexene-1-acetaldehyde, 3-methyl-	129993-40-4	2
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	2
2-tert-Butylcyclohexanol	13491-79-7	2
4-tert-Butylcyclohexanol	98-52-2	2
cis-1,2-Dimethylcyclopropane	930-18-7	2
Citral*	5392-40-5	2

D,l-isobornyl acetate	92618-89-8	2
Diethyl phthalate	84-66-2	2
Ocimenol	5986-38-9	2
beta-Citronellol	106-22-9	2
Isoamyl alcohol	123-51-3	2
Linalyl acetate	115-95-7	2
Menthol	1490-04-6	2
Methyl phenylcarbinyl acetate	93-92-5	2
alpha-Gurjunene	489-40-7	2
Alloaromadendrene	25246-27-9	2
delta-Cadinene	483-76-1	2
Ocimene	13877-91-3	2
Pentylidenecyclopentane	53366-55-5	2
Triacetin	102-76-1	2
Tripropylene glycol monomethyl ether	20324-33-8	2
1-Hexanol*	111-27-3	2
(+)-Ledene	21747-46-6	2
(+)-trans-Rose oxide	876-18-6	1
(R)-(-)-2-butanol*	14898-79-4	1
(R)-(+)-pulegone	89-82-7	1
(Z)-beta-ocimene	3338-55-4	1
(Z)-beta-ocimene	3338-55-4	1
1-(4-Methyl-1-cyclohex-3-enyl)ethanone	70286-20-3	1
1-Ethoxy-1-methoxyethane	10471-14-4	1
1-Octanol*	111-87-5	1
2-Methyl-2-hepten-6-one	110-93-0	1
2,2,3,3-Tetramethylpentane	7154-79-2	1
2,4-Dimethylhexane*	589-43-5	1
2,4-Thujadiene	36262-09-6	1
2,5-Diethyl tetrahydrofuran	41239-48-9	1
2,6,11-Trimethyldodecane	31295-56-4	1
2,6-Dimethyl-5-heptenal	106-72-9	1
2-Butene*	107-01-7	1
2-Carene	554-61-0	1
2-Isopropenyltoluene	7399-49-7	1
2-Isopropylidene-5-methylcyclohexanone	15932-80-6	1
2-Methyl-1-butene	563-46-2	1
2-Methyl-5-propylnonane	31081-17-1	1
3,7-Dimethyldecane	17312-54-8	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1

4-Methoxybenzaldehyde	123-11-5	1
4-Methylanisole	104-93-8	1
4-Methyldodecane	6117-97-1	1
4-Phenyl-2-butanone	2550-26-7	1
5-(2-Methylpropyl)nonane	62185-53-9	1
5,6-Dimethylundecane	17615-91-7	1
Acetaldehyde dibutyl acetal	871-22-7	1
alpha-Guaiene	3691-12-1	1
alpha-Ionone	6901-97-9	1
alpha-Pinene oxide	1686-14-2	1
Benzaldehyde*	100-52-7	1
Benzyl alcohol*	100-51-6	1
Benzyl benzoate*	120-51-4	1
Benzyl isobutyrate	103-28-6	1
beta-Ionone	79-77-6	1
beta-Terpineol	138-87-4	1
Bicyclo[5.2.0]nonane, 2-methylene- 4,8,8-trimethyl-4-vinyl-	242794-76-9	1
Butyl butyrate*	109-21-7	1
Carane	554-59-6	1
Carbon disulphide*	75-15-0	1
Citronellyl acetate	150-84-5	1
Citronellyl formate	105-85-1	1
Cyclohexane*	110-82-7	1
Diethyl malonate	105-53-3	1
Dihydrocarveol	619-01-2	1
Dimethyl adipate	627-93-0	1
Diphenyl ether	101-84-8	1
DI-2-methylbutyrate	7452-79-1	1
DI-4-hydroxy-3-methoxymandelic acid	928-96-1	1
DI-lactic acid	50-21-5	1
DI-Menthyl acetate	16409-45-3	1
Ethanone, 1-(6,6- dimethylbicyclo[3.1.0]hex-2-en-2-yl)-	24555-40-6	1
Ethyl 2-methylbutyrate	7452-79-1	1
Ethyl 2-methylpentanoate	39255-32-8	1
Ethyl butyrate	105-54-4	1
Ethyl isovalerate	108-64-5	1
Ethyl methyl carbonate	623-53-0	1
Ethyl methyl ether*	540-67-0	1
Ethylbenzene*	100-41-4	1

gamma-Muurolene	30021-74-0	1
gamma-Nonanolactone	104-61-0	1
gamma-Octalactone	104-50-7	1
gamma-Terpineol	586-81-2	1
Geranyl bromide	35719-26-7	1
Glutaric acid dimethyl ester	1119-40-0	1
Heneicosane	629-94-7	1
Heptylhexyl ether	7289-40-9	1
Hexanal	66-25-1	1
Hexyl butyrate	2639-63-6	1
Isobutyl butyrate	539-90-2	1
Iso-camphane	473-19-8	1
Isomenthone	491-07-6	1
Isopropyl alcohol*	67-63-0	1
Linalyl formate	115-99-1	1
Linalyl isobutyrate	78-35-3	1
Menthone	89-80-5	1
Methyl benzoate	93-58-3	1
Methyl salicylate	119-36-8	1
Octanal dimethyl acetal	10022-28-3	1
Propyl 2-methyl butyrate	37064-20-3	1
Propylene glycol	57-55-6	1
Propylene glycol butyl ether*	5131-66-8	1
p-Xylene*	106-42-3	1
trans-3-Hexenyl acetate	3681-82-1	1
Undecane	1120-21-4	1
(+)-Cycloisosativene	22469-52-9	1
(+)-(E)-limonene oxide	6909-30-4	1
D,l-Menthol	15356-70-4	1
(+)-Limonene oxide	1195-92-2	1
(Z)-citral*	106-26-3	1
1,1-Dimethylallyl alcohol	115-18-4	1
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1	1
Isoamyl acetate*	123-92-2	1
Methylcyclopentane	96-37-7	1
N-butylbenzenesulfonamide	3622-84-2	1
Nonanal	124-19-6	1
(-)-Camphene	5794-04-7	1
Iso-amyl-senecioate	56922-73-7	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 4: VOC identities and prevalences among all natural essential oils (n=12)

Compound	CAS #	Prevalence (# of essential oils)
alpha-Pinene	80-56-8	12
alpha-Phellandrene	99-83-2	12
beta-Pinene	127-91-3	12
Limonene*	138-86-3	11
3-Carene	13466-78-9	11
beta-Myrcene	123-35-3	10
Eucalyptol	470-82-6	10
gamma-Terpinene	99-85-4	10
Camphene	79-92-5	10
Acetone*	67-64-1	9
beta-Phellandrene	555-10-2	9
m-Cymene	535-77-3	8
Linalool	78-70-6	7
beta-trans-Ocimene	3779-61-1	7
4-Carene	29050-33-7	7
Methanol*	67-56-1	7
Ethanol*	64-17-5	7
Terpinolene	586-62-9	7
alpha-Thujene	2867-05-2	6
alpha-Terpineol	98-55-5	6
Caryophyllene	87-44-5	5
Hexyl acetate	142-92-7	4
3-Octanone	106-68-3	4
4-Terpineol	562-74-3	4
Isovaleraldehyde	590-86-3	4
Linalyl butyrate	78-36-4	4
Acetaldehyde*	75-07-0	3
Camphor	76-22-2	3
Neryl acetate	141-12-8	3
(-)-Terpinen-4-ol	20126-76-5	3
Hexyl methyl ether	4747-07-3	3
2-Methylbutyraldehyde	96-17-3	3
Butane*	106-97-8	3

Octanal	124-13-0	2
Borneol	10385-78-1	2
Isobutyraldehyde	78-84-2	2
(+)-Ledene	21747-46-6	2
delta-Cadinene	483-76-1	2
Alloaromadendrene	25246-27-9	2
Ocimenol	5986-38-9	2
Isoamyl alcohol	123-51-3	2
Pentylidenecyclopentane	53366-55-5	2
alpha-Gurjunene	489-40-7	2
Ocimene	13877-91-3	2
Menthol	1490-04-6	2
Decanal	112-31-2	2
1-Octen-3-yl-acetate	2442-10-6	2
1,1-Dimethylallyl alcohol	115-18-4	1
Ethyl 2-methylcyclopropanecarboxylate	20913-25-1	1
beta-Citronellol	106-22-9	1
Isoamyl acetate*	123-92-2	1
1-Octanol*	111-87-5	1
Isopropyl alcohol*	67-63-0	1
Benzyl acetate	140-11-4	1
Ethyl 2-methylbutyrate	7452-79-1	1
Hexyl butyrate	2639-63-6	1
(+)-Limonene oxide	1195-92-2	1
(Z)-beta-ocimene	3338-55-4	1
Linalyl isobutyrate	78-35-3	1
(+)-Camphene	5794-03-6	1
2,4-Thujadiene	36262-09-6	1
alpha-Pinene oxide	1686-14-2	1
2-Isopropenyltoluene	7399-49-7	1
Menthone	89-80-5	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
DI-Menthyl acetate	16409-45-3	1
2-Isopropylidene-5-methylcyclohexanone	15932-80-6	1
Citral*	5392-40-5	1
2,5-Diethyl tetrahydrofuran	41239-48-9	1
(R)-(+)-pulegone	89-82-7	1
cis-1,2-Dimethylcyclopropane	930-18-7	1
Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	242794-76-9	1

Propylene glycol	57-55-6	1
Methyl salicylate	119-36-8	1
gamma-Terpineol	586-81-2	1
beta-Terpineol	138-87-4	1
Dihydrocarveol	619-01-2	1
Butyl butyrate*	109-21-7	1
Isobutyl butyrate	539-90-2	1
Methyl benzoate	93-58-3	1
Isomenthone	491-07-6	1
Citronellyl formate	105-85-1	1
Methyl formate*	107-31-3	1
Nonanal	124-19-6	1
1-Hexanol*	111-27-3	1
gamma-Murolene	30021-74-0	1
Ethyl formate*	109-94-4	1
Ethylbenzene*	100-41-4	1
gamma-Octalactone	104-50-7	1
Heneicosane	629-94-7	1
gamma-Nonanolactone	104-61-0	1
(+)-(E)-limonene oxide	6909-30-4	1
D,l-Menthol	15356-70-4	1
Iso-amyl-senecioate	56922-73-7	1
Ethyl acetate*	141-78-6	1

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Supplementary Table 5: VOC identities and prevalences among all regular essential oils (n=12)

Compound	CAS #	Prevalence (# of essential oils)
Acetaldehyde*	75-07-0	10
Linalool	78-70-6	9
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	9
alpha-Pinene	80-56-8	8
Limonene*	138-86-3	8
Acetone*	67-64-1	8
Ethanol*	64-17-5	8
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	6
4-tert-Butylcyclohexyl acetate	32210-23-4	6
alpha-Phellandrene	99-83-2	5
beta-Myrcene	123-35-3	5
Camphene	79-92-5	5
Benzyl acetate	140-11-4	5
2-(1-Methoxypropan-2-yloxy)propan-1-ol	55956-21-3	5
3-Carene	13466-78-9	4
Eucalyptol	470-82-6	4
beta-Phellandrene	555-10-2	4
Dihydromyrcenol	18479-58-8	4
Ethyl acetate*	141-78-6	4
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	4
Methyl acetate*	79-20-9	4
gamma-Terpinene	99-85-4	3
beta-trans-Ocimene	3779-61-1	3
m-Cymene	535-77-3	3
Methanol*	67-56-1	3
Terpinolene	586-62-9	3
Camphor	76-22-2	3
Ethyl formate*	109-94-4	3
3,5,5-Trimethylhexyl acetate	58430-94-7	3
2-Methylpropene*	115-11-7	3
1,1'-dimethyldiethyleneglycol	110-98-5	3
2,2'-Oxydipropanol	108-61-2	3

2-Butanol,3,3'-oxybis	54305-61-2	3
cis-3,7-Dimethyl-2,6-octadien-1-ol*	106-25-2	3
Phenylethyl alcohol	60-12-8	3
Di(propylene glycol) methyl ether	34590-94-8	3
4-Hexen-1-ol, acetate	72237-36-6	3
Acetaldehyde diethyl acetal*	105-57-7	3
2-(2-Methoxypropoxy)propan-1-ol	13588-28-8	3
-(1-ethoxyethoxy)-3-methyl-1,4-butanediol	88481-54-3	3
beta-Pinene	127-91-3	2
4-Carene	29050-33-7	2
3-Octanone	106-68-3	2
Decanal	112-31-2	2
Methyl formate*	107-31-3	2
Linalyl acetate	115-95-7	2
D,l-isobornyl acetate	92618-89-8	2
Triacetin	102-76-1	2
Diethyl phthalate	84-66-2	2
2-tert-Butylcyclohexanol	13491-79-7	2
2-Cyclohexene-1-acetaldehyde, 3-methyl-	129993-40-4	2
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	2
Methyl phenylcarbinyl acetate	93-92-5	2
Tripropylene glycol monomethyl ether	20324-33-8	2
(S)-(-)-propylene oxide*	16088-62-3	2
(Z)-rose oxide	16409-43-1	2
Hexyl acetate	142-92-7	1
alpha-Terpineol	98-55-5	1
4-Terpineol	562-74-3	1
Borneol	10385-78-1	1
Linalyl butyrate	78-36-4	1
Neryl acetate	141-12-8	1
beta-Citronellol	106-22-9	1
Octanal	124-13-0	1
Methylcyclopentane	96-37-7	1
(Z)-beta-ocimene	3338-55-4	1
(Z)-citral*	106-26-3	1
2-Methyl-2-hepten-6-one	110-93-0	1
N-butylbenzenesulfonamide	3622-84-2	1
Citral*	5392-40-5	1

cis-1,2-Dimethylcyclopropane	930-18-7	1
Nonanal	124-19-6	1
Linalyl formate	115-99-1	1
Undecane	1120-21-4	1
Carbon disulphide*	75-15-0	1
Benzyl benzoate*	120-51-4	1
2-Methyl-1-butene	563-46-2	1
Iso-camphane	473-19-8	1
1-Ethoxy-1-methoxyethane	10471-14-4	1
2-Carene	554-61-0	1
2-Butene*	107-01-7	1
Benzyl alcohol*	100-51-6	1
(-)-Camphene	5794-04-7	1
Benzaldehyde*	100-52-7	1
(R)-(-)-2-butanol*	14898-79-4	1
Geranyl bromide	35719-26-7	1
Ethyl isovalerate	108-64-5	1
Dl-2-methylbutyrate	7452-79-1	1
Diethyl malonate	105-53-3	1
Citronellyl acetate	150-84-5	1
4-Phenyl-2-butanone	2550-26-7	1
Benzyl isobutyrate	103-28-6	1
2,2,3,3-Tetramethylpentane	7154-79-2	1
Heptylhexyl ether	7289-40-9	1
1-(4-Methyl-1-cyclohex-3-enyl)ethanone	70286-20-3	1
Octanal dimethyl acetal	10022-28-3	1
beta-Ionone	79-77-6	1
alpha-Ionone	6901-97-9	1
Ethyl methyl carbonate	623-53-0	1
Propylene glycol butyl ether*	5131-66-8	1
Hexanal	66-25-1	1
trans-3-Hexenyl acetate	3681-82-1	1
Dl-4-hydroxy-3-methoxymandelic acid	928-96-1	1
Acetaldehyde dibutyl acetal	871-22-7	1
Ethyl butyrate	105-54-4	1
2-Methyl-5-propylnonane	31081-17-1	1
Ethyl 2-methylpentanoate	39255-32-8	1
4-Methylanisole	104-93-8	1
5,6-Dimethylundecane	17615-91-7	1
(+)-Camphene	5794-03-6	1

1-Octen-3-yl acetate	2442-10-6	1
Carane	554-59-6	1
Propyl 2-methyl butyrate	37064-20-3	1
Cyclohexane*	110-82-7	1
Glutaric acid dimethyl ester	1119-40-0	1
Ethyl methyl ether*	540-67-0	1
4-Methoxybenzaldehyde	123-11-5	1
p-Xylene*	106-42-3	1
Dimethyl adipate	627-93-0	1
Ethanone, 1-(6,6-dimethylbicyclo[3.1.0]hex-2-en-2-yl)-	24555-40-6	1
2-(1-ethoxyethoxy)-3-methylbutane-1,4-diol	88481-54-3	1
alpha-Guaiene	3691-12-1	1
DL-lactic acid	50-21-5	1
(+)-trans-Rose oxide	876-18-6	1
Diphenyl ether	101-84-8	1
2,6,11-Trimethyldodecane	31295-56-4	1
5-(2-Methylpropyl)nonane	62185-53-9	1
3,7-Dimethyldecane	17312-54-8	1
4-Methyldodecane	6117-97-1	1
2,6-Dimethyl-5-heptenal	106-72-9	1

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Supplementary Table 1: VOC identities and prevalences among all products (n=134)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	82
Ethanol*	64-17-5	56
Acetaldehyde*	75-07-0	50
beta-trans-Ocimene	3779-61-1	49
Linalool	78-70-6	45
beta-Myrcene	123-35-3	42
Eucalyptol	470-82-6	42
gamma-Terpinene	99-85-4	35
beta-Pinene	127-91-3	32
alpha-Pinene	80-56-8	29
Dihydromyrcenol	18479-58-8	27
4-tert-Butylcyclohexyl acetate	32210-23-4	25
Ethyl acetate*	141-78-6	25
Benzyl acetate	140-11-4	22
Butane*	106-97-8	22
Terpinolene	586-62-9	22
Acetone*	67-64-1	21
Camphene	79-92-5	20
Benzyl alcohol*	100-51-6	19
beta-Phellandrene	555-10-2	18
Isopropyl alcohol*	67-63-0	18
Methanol*	67-56-1	17
Pentane*	109-66-0	17
alpha-Phellandrene	99-83-2	15
Hexyl acetate	142-92-7	15
Phenoxyethanol*	122-99-6	14
Sabinene	3387-41-5	14
Decamethylcyclopentasiloxane	541-02-6	12
Ethyl 2-methylbutyrate	7452-79-1	12
Isopentane*	78-78-4	12
2-tert-Butylcyclohexanol	13491-79-7	11
Linalyl anthranilate	7149-26-0	11
Octanal	124-13-0	11
6-Methyl-5-hepten-2-one	110-93-0	10

Isoamyl acetate*	123-92-2	10
Linalyl acetate	115-95-7	10
Octamethylcyclotetrasiloxane*	556-67-2	10
o-Cymene	527-84-4	10
Tetrahydrolinalool	57706-88-4	10
1-Octanol*	111-87-5	9
Ethyl 2-methylpentanoate	39255-32-8	9
Ethyl butyrate	105-54-4	9
2-Methyl-2-propanol*	75-65-0	8
2-Methylpentane*	107-83-5	8
Caryophyllene	87-44-5	8
Hexane*	110-54-3	8
Undecane	1120-21-4	8
(Z)-7-tetradecene	41446-60-0	7
1,4-Cineole	470-67-7	7
2-Carene	554-61-0	7
3-Methylpentane*	96-14-0	7
alpha-Terpineol	98-55-5	7
Methylcyclopentane	96-37-7	7
Toluene*	108-88-3	7
(-)-Camphor	464-48-2	6
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	6
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	6
beta-Citral*	106-26-3	6
Cyclohexane*	110-82-7	6
Terpinyl acetate	80-26-2	6
Tridecane	629-50-5	6
(E)-citral*	141-27-5	5
(Z)-beta-ocimene	3338-55-4	5
3-Carene	13466-78-9	5
3-Methylhexane*	589-34-4	5
4-Terpineol	562-74-3	5
6-Methyl-1,6-heptadiene	13643-06-6	5
Allyl heptanoate	142-19-8	5
Dodecane	112-40-3	5
Ethyl formate*	109-94-4	5
Hexamethyldisiloxane	107-46-0	5
Hexanal	66-25-1	5
m-Cymene	535-77-3	5

(+)-Camphor	464-49-3	4
(R)-(+)- β -Citronellol	1117-61-9	4
2-Butene*	107-01-7	4
4-Hexen-1-ol, acetate	72237-36-6	4
Carbon monoxide*	630-08-0	4
D,l-isobornyl acetate	92618-89-8	4
Decanal	112-31-2	4
Dl-menthyl acetate	16409-45-3	4
Menthone	10458-14-7	4
Methyl isopropyl ether	598-53-8	4
(1R)-(+)- α -Pinene	7785-70-8	3
1,1-Dimethylallyl alcohol	115-18-4	3
2,2-Dimethyloxetane	6245-99-4	3
2,4-Dimethylpentane*	108-08-7	3
2,6-Di-tert-butyl-4-methylphenol	128-37-0	3
2-Methylfuran	534-22-5	3
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6	3
4-tert-Butylcyclohexanol	98-52-2	3
α -Thujene	2867-05-2	3
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	3
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0	3
D,l-Menthol	15356-70-4	3
Diethyl phthalate	84-66-2	3
Heptane*	142-82-5	3
Hexamethylcyclotrisiloxane	541-05-9	3
Methyl phenylcarbinyl acetate	93-92-5	3
Neryl acetate	141-12-8	3
Nonadecane	629-92-5	3
Nonylcyclopropane	74663-85-7	3
p-Cymene	99-87-6	3
Phenylethyl alcohol	60-12-8	3
Tetracarbonylnickel*	13463-39-3	3
(-)-Isopulegol	89-79-2	2
(E)-2-dodecene	7206-13-5	2
(E)-3-Tetradecene	41446-68-8	2
1,4-Dioxane*	123-91-1	2
1-Hexanol*	111-27-3	2
1-Pentanol*	71-41-0	2
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2	2

2-(2-Hydroxypropoxy)-1-propanol	106-62-7	2
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6	2
2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4	2
2,2,4,4-Tetramethyloctane	62183-79-3	2
2,2,4,6,6-Pentamethylheptane	13475-82-6	2
2,2-Dimethylbutane*	75-83-2	2
2,3,4-Trimethylhexane	921-47-1	2
2-Methyl-1-butene	563-46-2	2
2-Methylhexane*	591-76-4	2
2-methylundecanal	110-41-8	2
2-Phenoxyethyl isobutyrate	103-60-6	2
3,5,5-Trimethylhexyl acetate	58430-94-7	2
3-Methoxy-3-methylbutanol	56539-66-3	2
3-Octanone	106-68-3	2
4-Carene	29050-33-7	2
4-Dodecene	2030-84-4	2
5-Methylheptan-3-one*	541-85-5	2
6-Ethyl-2-methyl-6-hepten-2-ol	18479-59-9	2
6-Methyltridecane	13287-21-3	2
Acetaldehyde diethyl acetal*	105-57-7	2
Allyl hexanoate	123-68-2	2
Benzaldehyde*	100-52-7	2
Carbon tetrachloride*	56-23-5	2
cis-6-Nonenyl acetate	76238-22-7	2
Cyclofenchene	488-97-1	2
Cyclopropane, 1-methyl-2-(1-methylethyl)-3-(1-methylethylidene)-, cis-	24524-52-5	2
D-carvone*	2244-16-8	2
Decyl trifluoroacetate	333-88-0	2
Dodecamethylcyclohexasiloxane	540-97-6	2
Ethinamate	126-52-3	2
Ethyl 2,3-dimethylbutanoate	54004-42-1	2
Ethyl linalool	10339-55-6	2
Ethyl methyl ether*	540-67-0	2
Isoamyl butylate	106-27-4	2
Methyl isobutyl ketone*	108-10-1	2
Methylcyclohexane*	108-87-2	2
Myrtanyl acetate	29021-36-1	2
n-Butyl ether*	142-96-1	2
p-Anisaldehyde	123-11-5	2

Piperonal	120-57-0	2
Prenyl acetate	1191-16-8	2
Propyl 2-methyl butyrate	37064-20-3	2
trans-2,2-Dimethyl-4-heptenal	91296-58-1	2
Trimethylsilanol	1066-40-6	2
Tris(trimethylsilyl) borate	4325-85-3	2
(-)-Camphene	5794-04-7	1
(+)-Camphene	5794-03-6	1
(±)-2-Methyl-1-butanol	137-32-6	1
(E)-2,5-Dimethyl-1,6-octadiene	68702-25-0	1
(E)-5-Tetradecene	41446-66-6	1
(E)-sabinene hydrate	17699-16-0	1
(Z)-linalool oxide (furanoid)	5989-33-3	1
(Z)-rose oxide	16409-43-1	1
(Z)-sabinene hydrate	15537-55-0	1
1-(1,2-Dimethyl-cyclopent-2-enyl)-ethanone	70987-82-5	1
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	1
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	1
1,1-dichloroethylene*	75-35-4	1
1,1'-Oxydi-2-propanol	110-98-5	1
1,3,6-Trioxocane	1779-19-7	1
1,3-Dimethyl-2-(1-methylethyl)cyclopentene	61142-32-3	1
1-[2-(Allyloxy)-1-methylethoxy]-2-propanol	55956-25-7	1
1-Acetyl-2-methyl-1-cyclopentene	3168-90-9	1
1-Chloro-2-methylpropane	513-36-0	1
1-Decanol	112-30-1	1
1-Decene	872-05-9	1
1-Dodecene	112-41-4	1
1-Heptene	592-76-7	1
1-Isopropyl-2,3-dimethyl-1-cyclopentene	7712-73-4	1
1-Isopropyl-2-methyl-3-(1-methylethylidene)cyclopropane	24524-51-4	1
1-Methyl-2-(3-methylpentyl)cyclopropane	62238-07-7	1
1-Methyl-3-isopropylcyclopentane	53771-88-3	1
1-Methylcyclopentene	693-89-0	1
1-Octene	111-66-0	1
1-Octyl trifluoroacetate	2561-21-9	1

1-Phenylethanol	98-85-1	1
1-Propanol*	71-23-8	1
1-Undecanol	112-42-5	1
2,2,4,4,6,8,8-Heptamethylnonane	4390-04-9	1
2,2,4-Trimethylhexane	16747-26-5	1
2,2,6-Trimethyl-6-vinyltetrahydropyran	7392-19-0	1
2,2,6-Trimethyloctane	62016-28-8	1
2,2'-Oxydipropanol	108-61-2	1
2,3,3-Trimethylhexane	16747-28-7	1
2,3,4-Trimethyldecane	62238-15-7	1
2,3,4-Trimethylpentane*	565-75-3	1
2,3-Dimethyloctane	7146-60-3	1
2,3-Dimethylpentane	565-59-3	1
2,4,4-Trimethyl-2-pentene	107-40-4	1
2,4,4-Trimethylpent-1-ene*	107-39-1	1
2,4-Dimethyldodecane	6117-99-3	1
2,4-Dimethylhexane*	589-43-5	1
2,4-Dimethylpentan-3-one*	565-80-0	1
2,5-Dimethyldodecane	56292-65-0	1
2,5-Dimethylundecane	17301-22-3	1
2,6,10-Trimethyldodecane	3891-98-3	1
2,6,11-Trimethyldodecane	31295-56-4	1
2,6-Dimethyl-2-heptanol	13254-34-7	1
2,6-Dimethyl-2-octanol	18479-57-7	1
2,7-Dimethyl-1,7-octadiene	59840-10-7	1
2,8-Dimethyl-5-nonanol	19780-96-2	1
2-chlorotoluene*	95-49-8	1
2-Hexyloxyethanol*	112-25-4	1
2-Isopropenyltoluene	7399-49-7	1
2-Methoxyethyl acetate	110-49-6	1
2-Methyl-1-butanol	34713-94-5	1
2-Methyl-1-phenyl-2-propanol	100-86-7	1
2-Methyl-4-penten-2-ol	624-97-5	1
2-Methylbutyraldehyde	96-17-3	1
2-methylenehexanal	1070-66-2	1
2-Methylpropan-1-ol*	78-83-1	1
2-Octanone	111-13-7	1
2-Pentyl butyrate	60415-61-4	1
2-Pentylfuran	3777-69-3	1
2-Propylheptanol	10042-59-8	1

3-(Neopentyloxy)-2-butanol	74793-66-1	1
3,5-Dimethyloctane	15869-93-9	1
3,6-Dimethylundecane	17301-28-9	1
3,7-Dimethyl-7-octenal	141-26-4	1
3-[2-(2-Methoxyethoxy)ethoxy]-1-propene	13752-97-1	1
3'-Methylacetophenone	585-74-0	1
3-Ethyl-3-methyl-1-pentene	6196-60-7	1
3-Isopropenyl-5-methyl-1-cyclohexene	56816-08-1	1
3-Methyl-1-cyclopentene	1120-62-3	1
3-Methyl-1-hexene	3404-61-3	1
3-Methyldecane	13151-34-3	1
3-Methylene-1,7-octadiene	68695-13-6	1
3-Octanol	589-98-0	1
3-Octyl acetate	4864-61-3	1
3-Phenyl-2-butanone	769-59-5	1
4,4'-Isopropylidenebis(2,6-dimethylphenol)	5613-46-7	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
4-Decyne	2384-86-3	1
5,5-Dimethylcyclopentadiene	4125-18-2	1
5-Butylnonane	17312-63-9	1
5-Isopropenyl-1-methyl-1-cyclohexene	13898-73-2	1
5-Methylundecane	1632-70-8	1
6-Methylundecane	17302-33-9	1
Acetic acid*	109-60-4	1
Acetylpentacarbonylmanganese	13963-91-2	1
Allyl alcohol*	107-18-6	1
alpha-Fenchene	471-84-1	1
alpha-Ionone	127-41-3	1
alpha-Isomethyl ionone	127-51-5	1
alpha-Terpinene	99-86-5	1
amitrole (ISO)*	61-82-5	1
Amyl butyrate	540-18-1	1
Artemesia triene	29548-02-5	1
Benzenepropanol	122-97-4	1
Benzyl propionate	122-63-4	1
beta-Ionone	79-77-6	1
Bornyl acetate	76-49-3	1
Butyl acetate*	123-86-4	1

Butyric acid, 2-tridecyl ester	55193-07-2	1
Carane	554-59-6	1
Chloroform*	67-66-3	1
Chloromethane*	74-87-3	1
cis-1,2-dimethylcyclopentane	1192-18-3	1
cis-3-Hexenyl acetate	3681-71-8	1
cis-4-tert-Butylcyclohexanol	937-05-3	1
Citronellyl acetate	150-84-5	1
Cyclododecane	294-62-2	1
Cyclopentane*	287-92-3	1
Decane	124-18-5	1
delta-Undecalactone	710-04-3	1
Dibutyl phthalate*	84-74-2	1
Dicyclopentenyl alcohol	37275-49-3	1
Dihydroterpineol	21129-27-1	1
Diisopropyl adipate	6938-94-9	1
Diisopropyl ether*	108-20-3	1
Dimethoxymethane	109-87-5	1
Diphenyl ether	101-84-8	1
Di-sec-butyl ether	6863-58-7	1
d-Verbenol	473-67-6	1
Ethyl isobutyrate	97-62-1	1
gamma-Nonanolactone	104-61-0	1
Hexyl methyl ether	4747-07-3	1
Hexyl propionate	2445-76-3	1
Hexyl salicylate	6259-76-3	1
Isoamyl alcohol	123-51-3	1
Isobutyl isobutyrate	97-85-8	1
Isobutyraldehyde	78-84-2	1
Isocitronellene	85006-04-8	1
Isomenthone	491-07-6	1
Isopulegol	7786-67-6	1
Isovaleraldehyde	590-86-3	1
Lavandulyl acetate	25905-14-0	1
l-Menthol	2216-51-5	1
Menthyl acetate	89-48-5	1
Methoxyacetic acid*	625-45-6	1
Methyl (S)-2-methylbutanoate	53955-81-0	1
Methyl 2-ethylhexanoate	816-19-3	1
Methyl acetate*	79-20-9	1

Methyl butyrate	623-42-7	1
Methyl hexanoate	106-70-7	1
Methyl laurate	111-82-0	1
Methyl propionate	554-12-1	1
Methyl valerate	624-24-8	1
n-Butylbenzenesulfonamide	3622-84-2	1
n-Chlorodimethylamine	1585-74-6	1
n-Octanal diethyl acetal	54889-48-4	1
Nonane	111-84-2	1
Nopyl acetate	128-51-8	1
Octanal dimethyl acetal	10022-28-3	1
Octane*	111-65-9	1
Octyl acetate	112-14-1	1
Octylcyclopropane	1472-09-9	1
p, α , α -Trimethylbenzyl alcohol	1197-01-9	1
Propanal*	123-38-6	1
Propylcyclopropane	2415-72-7	1
Propylene glycol	57-55-6	1
Propylene glycol butyl ether*	5131-66-8	1
p-tert-Butyl cyclohexyl-acetate cis	10411-92-4	1
Pulegone	89-82-7	1
trans-1-Methyl-1,2-cyclohexanediol	19534-08-8	1
trans-2-Pentene	646-04-8	1
trans-3-Hexenyl acetate	3681-82-1	1
trans-3-Isopropyl-6-methylcyclohexene	1124-26-1	1
trans-4-Tetradecene	41446-78-0	1
trans-7-Tetradecene	41446-63-3	1
trans-Rose oxide	876-18-6	1
Verdyl acetate	5413-60-5	1
Vinyl formate	692-45-5	1
α , α -Dimethylphenethyl acetate	151-05-3	1
α , α -Dimethylphenethyl butyrate	10094-34-5	1
γ -Decalactone	706-14-9	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 2: VOC identities and prevalences among all fragranced products (n=104)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	80
beta-trans-Ocimene	3779-61-1	49
Ethanol*	64-17-5	46
Linalool	78-70-6	45
beta-Myrcene	123-35-3	42
Eucalyptol	470-82-6	42
Acetaldehyde*	75-07-0	38
gamma-Terpinene	99-85-4	35
beta-Pinene	127-91-3	31
alpha-Pinene	80-56-8	29
Dihydromyrcenol	18479-58-8	27
4-tert-Butylcyclohexyl acetate	32210-23-4	25
Benzyl acetate	140-11-4	22
Ethyl acetate*	141-78-6	22
Terpinolene	586-62-9	22
Butane*	106-97-8	20
Camphene	79-92-5	20
Acetone*	67-64-1	18
beta-Phellandrene	555-10-2	18
Methanol*	67-56-1	16
alpha-Phellandrene	99-83-2	15
Benzyl alcohol*	100-51-6	15
Hexyl acetate	142-92-7	15
Sabinene	3387-41-5	14
Pentane*	109-66-0	13
Ethyl 2-methylbutyrate	7452-79-1	12
Isopentane*	78-78-4	12
Isopropyl alcohol*	67-63-0	12
2-tert-Butylcyclohexanol	13491-79-7	11
Linalyl anthranilate	7149-26-0	11
Octanal	124-13-0	11
6-Methyl-5-hepten-2-one	110-93-0	10
Decamethylcyclopentasiloxane	541-02-6	10
Isoamyl acetate*	123-92-2	10

Linalyl acetate	115-95-7	10
Octamethylcyclotetrasiloxane*	556-67-2	10
o-Cymene	527-84-4	10
Tetrahydrolinalool	57706-88-4	10
Ethyl 2-methylpentanoate	39255-32-8	9
1-Octanol*	111-87-5	8
2-Methylpentane*	107-83-5	8
Caryophyllene	87-44-5	8
Ethyl butyrate	105-54-4	8
Hexane*	110-54-3	8
Phenoxyethanol*	122-99-6	8
Undecane	1120-21-4	8
1,4-Cineole	470-67-7	7
2-Carene	554-61-0	7
2-Methyl-2-propanol*	75-65-0	7
3-Methylpentane*	96-14-0	7
alpha-Terpineol	98-55-5	7
Methylcyclopentane	96-37-7	7
(-)-Camphor	464-48-2	6
(Z)-7-tetradecene	41446-60-0	6
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	6
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	6
beta-Citral*	106-26-3	6
Terpinyl acetate	80-26-2	6
Toluene*	108-88-3	6
Tridecane	629-50-5	6
(E)-citral*	141-27-5	5
(Z)-beta-ocimene	3338-55-4	5
3-Carene	13466-78-9	5
4-Terpineol	562-74-3	5
6-Methyl-1,6-heptadiene	13643-06-6	5
Allyl heptanoate	142-19-8	5
Cyclohexane*	110-82-7	5
Dodecane	112-40-3	5
Ethyl formate*	109-94-4	5
m-Cymene	535-77-3	5
(+)-Camphor	464-49-3	4
(R)-(+)-β-Citronellol	1117-61-9	4
2-Butene*	107-01-7	4

3-Methylhexane*	589-34-4	4
4-Hexen-1-ol, acetate	72237-36-6	4
Carbon monoxide*	630-08-0	4
D,l-isobornyl acetate	92618-89-8	4
Decanal	112-31-2	4
Dl-menthyl acetate	16409-45-3	4
Menthone	10458-14-7	4
Methyl isopropyl ether	598-53-8	4
(1R)-(+)-alpha-Pinene	7785-70-8	3
1,1-Dimethylallyl alcohol	115-18-4	3
2,2-Dimethyloxetane	6245-99-4	3
2,4-Dimethylpentane*	108-08-7	3
2,6-Di-tert-butyl-4-methylphenol	128-37-0	3
2-Methylfuran	534-22-5	3
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6	3
4-tert-Butylcyclohexanol	98-52-2	3
alpha-Thujene	2867-05-2	3
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	3
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0	3
D,l-Menthol	15356-70-4	3
Diethyl phthalate	84-66-2	3
Heptane*	142-82-5	3
Methyl phenylcarbinyl acetate	93-92-5	3
Neryl acetate	141-12-8	3
Nonadecane	629-92-5	3
Nonylcyclopropane	74663-85-7	3
p-Cymene	99-87-6	3
Phenylethyl alcohol	60-12-8	3
Tetracarbonylnickel*	13463-39-3	3
(-)-Isopulegol	89-79-2	2
(E)-2-dodecene	7206-13-5	2
1,4-Dioxane*	123-91-1	2
1-Hexanol*	111-27-3	2
1-Pentanol*	71-41-0	2
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2	2
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	2
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6	2
2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4	2
2,2,4,4-Tetramethyloctane	62183-79-3	2

2,2,4,6,6-Pentamethylheptane	13475-82-6	2
2,2-Dimethylbutane*	75-83-2	2
2,3,4-Trimethylhexane	921-47-1	2
2-Methyl-1-butene	563-46-2	2
2-Methylhexane*	591-76-4	2
2-methylundecanal	110-41-8	2
2-Phenoxyethyl isobutyrate	103-60-6	2
3,5,5-Trimethylhexyl acetate	58430-94-7	2
3-Octanone	106-68-3	2
4-Carene	29050-33-7	2
4-Dodecene	2030-84-4	2
5-Methylheptan-3-one*	541-85-5	2
6-Ethyl-2-methyl-6-hepten-2-ol	18479-59-9	2
6-Methyltridecane	13287-21-3	2
Acetaldehyde diethyl acetal*	105-57-7	2
Allyl hexanoate	123-68-2	2
Benzaldehyde*	100-52-7	2
cis-6-Nonenyl acetate	76238-22-7	2
Cyclofenchene	488-97-1	2
Cyclopropane, 1-methyl-2-(1-methylethyl)-3-(1-methylethylidene)-, cis-	24524-52-5	2
D-carvone*	2244-16-8	2
Decyl trifluoroacetate	333-88-0	2
Ethinamate	126-52-3	2
Ethyl 2,3-dimethylbutanoate	54004-42-1	2
Ethyl linalool	10339-55-6	2
Ethyl methyl ether*	540-67-0	2
Hexamethylcyclotrisiloxane	541-05-9	2
Hexanal	66-25-1	2
Isoamyl butylate	106-27-4	2
Methyl isobutyl ketone*	108-10-1	2
Methylcyclohexane*	108-87-2	2
Myrtanyl acetate	29021-36-1	2
n-Butyl ether*	142-96-1	2
p-Anisaldehyde	123-11-5	2
Piperonal	120-57-0	2
Prenyl acetate	1191-16-8	2
Propyl 2-methyl butyrate	37064-20-3	2
trans-2,2-Dimethyl-4-heptenal	91296-58-1	2
(-)-Camphene	5794-04-7	1

(+)-Camphene	5794-03-6	1
(±)-2-Methyl-1-butanol	137-32-6	1
(E)-2,5-Dimethyl-1,6-octadiene	68702-25-0	1
(E)-3-Tetradecene	41446-68-8	1
(E)-5-Tetradecene	41446-66-6	1
(E)-sabinene hydrate	17699-16-0	1
(Z)-linalool oxide (furanoid)	5989-33-3	1
(Z)-rose oxide	16409-43-1	1
(Z)-sabinene hydrate	15537-55-0	1
1-(1,2-Dimethyl-cyclopent-2-enyl)-ethanone	70987-82-5	1
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	1
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	1
1,1-dichloroethylene*	75-35-4	1
1,1'-Oxydi-2-propanol	110-98-5	1
1,3,6-Trioxocane	1779-19-7	1
1,3-Dimethyl-2-(1-methylethyl)cyclopentene	61142-32-3	1
1-[2-(Allyloxy)-1-methylethoxy]-2-propanol	55956-25-7	1
1-Acetyl-2-methyl-1-cyclopentene	3168-90-9	1
1-Chloro-2-methylpropane	513-36-0	1
1-Decanol	112-30-1	1
1-Decene	872-05-9	1
1-Dodecene	112-41-4	1
1-Heptene	592-76-7	1
1-Isopropyl-2,3-dimethyl-1-cyclopentene	7712-73-4	1
1-Isopropyl-2-methyl-3-(1-methylethylidene)cyclopropane	24524-51-4	1
1-Methyl-2-(3-methylpentyl)cyclopropane	62238-07-7	1
1-Methyl-3-isopropylcyclopentane	53771-88-3	1
1-Methylcyclopentene	693-89-0	1
1-Octene	111-66-0	1
1-Octyl trifluoroacetate	2561-21-9	1
1-Phenylethanol	98-85-1	1
1-Propanol*	71-23-8	1
1-Undecanol	112-42-5	1
2,2,4,4,6,8,8-Heptamethylnonane	4390-04-9	1
2,2,4-Trimethylhexane	16747-26-5	1
2,2,6-Trimethyl-6-vinyltetrahydropyran	7392-19-0	1

2,2,6-Trimethyloctane	62016-28-8	1
2,2'-Oxydipropanol	108-61-2	1
2,3,3-Trimethylhexane	16747-28-7	1
2,3,4-Trimethyldecane	62238-15-7	1
2,3,4-Trimethylpentane*	565-75-3	1
2,3-Dimethyloctane	7146-60-3	1
2,3-Dimethylpentane	565-59-3	1
2,4,4-Trimethyl-2-pentene	107-40-4	1
2,4,4-Trimethylpent-1-ene*	107-39-1	1
2,4-Dimethyldodecane	6117-99-3	1
2,4-Dimethylhexane*	589-43-5	1
2,4-Dimethylpentan-3-one*	565-80-0	1
2,5-Dimethyldodecane	56292-65-0	1
2,5-Dimethylundecane	17301-22-3	1
2,6,10-Trimethyldodecane	3891-98-3	1
2,6,11-Trimethyldodecane	31295-56-4	1
2,6-Dimethyl-2-heptanol	13254-34-7	1
2,6-Dimethyl-2-octanol	18479-57-7	1
2,7-Dimethyl-1,7-octadiene	59840-10-7	1
2,8-Dimethyl-5-nonanol	19780-96-2	1
2-chlorotoluene*	95-49-8	1
2-Hexyloxyethanol*	112-25-4	1
2-Isopropenyltoluene	7399-49-7	1
2-Methoxyethyl acetate	110-49-6	1
2-Methyl-1-butanol	34713-94-5	1
2-Methyl-1-phenyl-2-propanol	100-86-7	1
2-Methyl-4-penten-2-ol	624-97-5	1
2-Methylbutyraldehyde	96-17-3	1
2-methylenehexanal	1070-66-2	1
2-Methylpropan-1-ol*	78-83-1	1
2-Octanone	111-13-7	1
2-Pentyl butyrate	60415-61-4	1
2-Pentylfuran	3777-69-3	1
3-(Neopentyloxy)-2-butanol	74793-66-1	1
3,5-Dimethyloctane	15869-93-9	1
3,6-Dimethylundecane	17301-28-9	1
3,7-Dimethyl-7-octenal	141-26-4	1
3-[2-(2-Methoxyethoxy)ethoxy]-1-propene	13752-97-1	1
3'-Methylacetophenone	585-74-0	1
3-Ethyl-3-methyl-1-pentene	6196-60-7	1

3-Isopropenyl-5-methyl-1-cyclohexene	56816-08-1	1
3-Methoxy-3-methylbutanol	56539-66-3	1
3-Methyl-1-cyclopentene	1120-62-3	1
3-Methyl-1-hexene	3404-61-3	1
3-Methyldecane	13151-34-3	1
3-Methylene-1,7-octadiene	68695-13-6	1
3-Octanol	589-98-0	1
3-Octyl acetate	4864-61-3	1
3-Phenyl-2-butanone	769-59-5	1
4,4'-Isopropylidenebis(2,6-dimethylphenol)	5613-46-7	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
4-Decyne	2384-86-3	1
5,5-Dimethylcyclopentadiene	4125-18-2	1
5-Butylnonane	17312-63-9	1
5-Isopropenyl-1-methyl-1-cyclohexene	13898-73-2	1
5-Methylundecane	1632-70-8	1
6-Methylundecane	17302-33-9	1
Acetic acid*	109-60-4	1
Acetylpentacarbonylmanganese	13963-91-2	1
Allyl alcohol*	107-18-6	1
alpha-Fenchene	471-84-1	1
alpha-Ionone	127-41-3	1
alpha-Isomethyl ionone	127-51-5	1
alpha-Terpinene	99-86-5	1
amitrole (ISO)*	61-82-5	1
Amyl butyrate	540-18-1	1
Artemesia triene	29548-02-5	1
Benzenepropanol	122-97-4	1
Benzyl propionate	122-63-4	1
beta-Ionone	79-77-6	1
Bornyl acetate	76-49-3	1
Butyl acetate*	123-86-4	1
Butyric acid, 2-tridecyl ester	55193-07-2	1
Carane	554-59-6	1
Carbon tetrachloride*	56-23-5	1
Chloroform*	67-66-3	1
Chloromethane*	74-87-3	1
cis-1,2-dimethylcyclopentane	1192-18-3	1
cis-3-Hexenyl acetate	3681-71-8	1

cis-4-tert-Butylcyclohexanol	937-05-3	1
Citronellyl acetate	150-84-5	1
Cyclododecane	294-62-2	1
Cyclopentane*	287-92-3	1
Decane	124-18-5	1
delta-Undecalactone	710-04-3	1
Dibutyl phthalate*	84-74-2	1
Dicyclopentenyl alcohol	37275-49-3	1
Dihydroterpineol	21129-27-1	1
Diisopropyl ether*	108-20-3	1
Diphenyl ether	101-84-8	1
Di-sec-butyl ether	6863-58-7	1
Dodecamethylcyclohexasiloxane	540-97-6	1
d-Verbenol	473-67-6	1
Ethyl isobutyrate	97-62-1	1
gamma-Nonanolactone	104-61-0	1
Hexamethyldisiloxane	107-46-0	1
Hexyl methyl ether	4747-07-3	1
Hexyl propionate	2445-76-3	1
Hexyl salicylate	6259-76-3	1
Isoamyl alcohol	123-51-3	1
Isobutyl isobutyrate	97-85-8	1
Isobutyraldehyde	78-84-2	1
Isocitronellene	85006-04-8	1
Isomenthone	491-07-6	1
Isopulegol	7786-67-6	1
Isovaleraldehyde	590-86-3	1
Lavandulyl acetate	25905-14-0	1
l-Menthol	2216-51-5	1
Menthyl acetate	89-48-5	1
Methoxyacetic acid*	625-45-6	1
Methyl (S)-2-methylbutanoate	53955-81-0	1
Methyl 2-ethylhexanoate	816-19-3	1
Methyl acetate*	79-20-9	1
Methyl butyrate	623-42-7	1
Methyl hexanoate	106-70-7	1
Methyl laurate	111-82-0	1
Methyl propionate	554-12-1	1
Methyl valerate	624-24-8	1
n-Butylbenzenesulfonamide	3622-84-2	1

n-Chlorodimethylamine	1585-74-6	1
n-Octanal diethyl acetal	54889-48-4	1
Nopyl acetate	128-51-8	1
Octanal dimethyl acetal	10022-28-3	1
Octane*	111-65-9	1
Octyl acetate	112-14-1	1
Octylcyclopropane	1472-09-9	1
p, α , α -Trimethylbenzyl alcohol	1197-01-9	1
Propanal*	123-38-6	1
Propylene glycol	57-55-6	1
Propylene glycol butyl ether*	5131-66-8	1
p-tert-Butyl cyclohexyl-acetate cis	10411-92-4	1
Pulegone	89-82-7	1
trans-1-Methyl-1,2-cyclohexanediol	19534-08-8	1
trans-2-Pentene	646-04-8	1
trans-3-Hexenyl acetate	3681-82-1	1
trans-3-Isopropyl-6-methylcyclohexene	1124-26-1	1
trans-Rose oxide	876-18-6	1
Trimethylsilanol	1066-40-6	1
Tris(trimethylsilyl) borate	4325-85-3	1
Verdyl acetate	5413-60-5	1
Vinyl formate	692-45-5	1
α , α -Dimethylphenethyl acetate	151-05-3	1
α , α -Dimethylphenethyl butyrate	10094-34-5	1
γ -Decalactone	706-14-9	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 3: VOC identities and prevalences among all regular and green personal care products (n=50)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	37
Linalool	78-70-6	31
Ethanol*	64-17-5	20
Benzyl acetate	140-11-4	18
beta-Pinene	127-91-3	17
Eucalyptol	470-82-6	17
Acetaldehyde*	75-07-0	16
beta-trans-Ocimene	3779-61-1	16
gamma-Terpinene	99-85-4	15
Ethyl acetate*	141-78-6	14
Butane*	106-97-8	14
beta-Myrcene	123-35-3	14
4-tert-Butylcyclohexyl acetate	32210-23-4	13
Benzyl alcohol*	100-51-6	12
Dihydromyrcenol	18479-58-8	10
Ethyl 2-methylbutyrate	7452-79-1	9
Hexyl acetate	142-92-7	9
Decamethylcyclopentasiloxane	541-02-6	8
Linalyl anthranilate	7149-26-0	8
Octamethylcyclotetrasiloxane*	556-67-2	8
alpha-Pinene	80-56-8	8
Phenoxyethanol*	122-99-6	8
alpha-Phellandrene	99-83-2	8
Isoamyl acetate*	123-92-2	7
Pentane*	109-66-0	7
Camphene	79-92-5	7
beta-Phellandrene	555-10-2	7
Ethyl 2-methylpentanoate	39255-32-8	6
Acetone*	67-64-1	6
Isopentane*	78-78-4	6
Isopropyl alcohol*	67-63-0	5
Sabinene	3387-41-5	5
2-tert-Butylcyclohexanol	13491-79-7	5
Methanol*	67-56-1	5

Tetrahydrolinalool	57706-88-4	5
Cyclohexane*	110-82-7	4
Allyl heptanoate	142-19-8	4
Linalyl acetate	115-95-7	4
Ethyl butyrate	105-54-4	4
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	4
Terpinolene	586-62-9	4
2,2-Dimethyloxetane	6245-99-4	3
Phenylethyl alcohol	60-12-8	3
2-Methylpentane*	107-83-5	3
Hexane*	110-54-3	3
(Z)-beta-ocimene	3338-55-4	3
Diethyl phthalate	84-66-2	3
4-Hexen-1-ol, acetate	72237-36-6	3
Undecane	1120-21-4	3
(Z)-7-tetradecene	41446-60-0	3
Toluene*	108-88-3	3
Nonadecane	629-92-5	3
4-Terpineol	562-74-3	3
2-Carene	554-61-0	3
o-Cymene	527-84-4	3
6-Ethyl-2-methyl-6-hepten-2-ol	18479-59-9	2
Tridecane	629-50-5	2
2-Methyl-2-propanol*	75-65-0	2
3-Methylpentane*	96-14-0	2
cis-6-Nonenyl acetate	76238-22-7	2
6-Methyl-1,6-heptadiene	13643-06-6	2
Nonylcyclopropane	74663-85-7	2
Ethyl linalool	10339-55-6	2
2-Phenoxyethyl isobutyrate	103-60-6	2
Methyl phenylcarbinyl acetate	93-92-5	2
Ethinamate	126-52-3	2
Prenyl acetate	1191-16-8	2
5-Methylheptan-3-one*	541-85-5	2
2,2,4,4-Tetramethyloctane	62183-79-3	2
Hexamethylcyclotrisiloxane	541-05-9	2
Dodecane	112-40-3	2
1,1-Dimethylallyl alcohol	115-18-4	2
Allyl hexanoate	123-68-2	2
Decyl trifluoroacetate	333-88-0	2

4-tert-Butylcyclohexanol	98-52-2	2
Benzaldehyde*	100-52-7	2
alpha-Terpineol	98-55-5	2
m-Cymene	535-77-3	2
Dl-menthyl acetate	16409-45-3	2
(R)-(+)- β -Citronellol	1117-61-9	2
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	2
1-Octanol*	111-87-5	2
Piperonal	120-57-0	2
Ethyl formate*	109-94-4	2
Caryophyllene	87-44-5	2
2,3,4-Trimethylhexane	921-47-1	2
(-)-Camphor	464-48-2	2
alpha-Thujene	2867-05-2	2
1-Decene	872-05-9	1
2,6-Dimethyl-2-heptanol	13254-34-7	1
Cyclopentane*	287-92-3	1
p-Anisaldehyde	123-11-5	1
(Z)-sabinene hydrate	15537-55-0	1
1-Dodecene	112-41-4	1
2-Methyl-1-phenyl-2-propanol	100-86-7	1
1,1'-Oxydi-2-propanol	110-98-5	1
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	1
2,2'-Oxydipropanol	108-61-2	1
Butyl acetate*	123-86-4	1
Isobutyl isobutyrate	97-85-8	1
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6	1
2-Butene*	107-01-7	1
1-Chloro-2-methylpropane	513-36-0	1
Butyric acid, 2-tridecyl ester	55193-07-2	1
trans-1-Methyl-1,2-cyclohexanediol	19534-08-8	1
trans-2,2-Dimethyl-4-heptenal	91296-58-1	1
Dicyclopentenyl alcohol	37275-49-3	1
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2	1
2,2,4,4,6,8,8-Heptamethylnonane	4390-04-9	1
2,6,10-Trimethyldodecane	3891-98-3	1
6-Methyltridecane	13287-21-3	1
2,2,4-Trimethylhexane	16747-26-5	1
2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4	1
2,5-Dimethylundecane	17301-22-3	1

3-(Neopentyloxy)-2-butanol	74793-66-1	1
Methyl 2-ethylhexanoate	816-19-3	1
α,α -Dimethylphenethyl acetate	151-05-3	1
α,α -Dimethylphenethyl butyrate	10094-34-5	1
Hexyl salicylate	6259-76-3	1
D,l-isobornyl acetate	92618-89-8	1
gamma-Nonanolactone	104-61-0	1
Propyl 2-methyl butyrate	37064-20-3	1
cis-3-Hexenyl acetate	3681-71-8	1
Cyclododecane	294-62-2	1
Methyl isopropyl ether	598-53-8	1
cis-4-tert-Butylcyclohexanol	937-05-3	1
2,2,6-Trimethyl-6-vinyltetrahydropyran	7392-19-0	1
D,l-Menthol	15356-70-4	1
Isoamyl butylate	106-27-4	1
Menthone	10458-14-7	1
2-Pentyl butyrate	60415-61-4	1
trans-3-Hexenyl acetate	3681-82-1	1
Nopyl acetate	128-51-8	1
Menthyl acetate	89-48-5	1
Carane	554-59-6	1
3-Isopropenyl-5-methyl-1-cyclohexene	56816-08-1	1
Neryl acetate	141-12-8	1
p-Cymene	99-87-6	1
(+)-Camphor	464-49-3	1
Hexamethyldisiloxane	107-46-0	1
2,2,4,6,6-Pentamethylheptane	13475-82-6	1
2,8-Dimethyl-5-nonanol	19780-96-2	1
Propanal*	123-38-6	1
Tris(trimethylsilyl) borate	4325-85-3	1
Trimethylsilanol	1066-40-6	1
Chloromethane*	74-87-3	1
(1R)-(+)-alpha-Pinene	7785-70-8	1
2,4-Dimethylpentan-3-one*	565-80-0	1
Isovaleraldehyde	590-86-3	1
Methyl isobutyl ketone*	108-10-1	1
Cyclofenchene	488-97-1	1
Isomenthone	491-07-6	1
6-Methyl-5-hepten-2-one	110-93-0	1
(-)-Isopulegol	89-79-2	1

2-Methylfuran	534-22-5	1
Isoamyl alcohol	123-51-3	1
trans-2-Pentene	646-04-8	1
3-Methylhexane*	589-34-4	1
1-Heptene	592-76-7	1
1-Octene	111-66-0	1
Benzenepropanol	122-97-4	1
Dodecamethylcyclohexasiloxane	540-97-6	1
Hexanal	66-25-1	1
D-carvone*	2244-16-8	1
3-Octanone	106-68-3	1
Artemesia triene	29548-02-5	1
2-Methyl-1-butene	563-46-2	1
Hexyl methyl ether	4747-07-3	1
2,3,3-Trimethylhexane	16747-28-7	1
Methylcyclopentane	96-37-7	1
Isobutyraldehyde	78-84-2	1
2-Methylbutyraldehyde	96-17-3	1

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Supplementary Table 4: VOC identities and prevalences among all regular and green air fresheners (n=12)

Compound	CAS #	Prevalence (# of products)
Ethanol*	64-17-5	10
Limonene*	138-86-3	10
alpha-Pinene	80-56-8	7
beta-Myrcene	123-35-3	6
Linalool	78-70-6	6
beta-Pinene	127-91-3	6
2-Methyl-2-propanol*	75-65-0	5
beta-trans-Ocimene	3779-61-1	5
Acetaldehyde*	75-07-0	4
Acetone*	67-64-1	4
Camphene	79-92-5	4
beta-Phellandrene	555-10-2	4
Ethyl acetate*	141-78-6	4
gamma-Terpinene	99-85-4	4
Butane*	106-97-8	4
Isopentane*	78-78-4	4
Pentane*	109-66-0	4
Methanol*	67-56-1	4
(E)-citral*	141-27-5	4
beta-Citral*	106-26-3	4
Methylcyclopentane	96-37-7	4
Linalyl acetate	115-95-7	3
Terpinolene	586-62-9	3
Octanal	124-13-0	3
Dihydromyrcenol	18479-58-8	3
2-Methylpentane*	107-83-5	3
Hexane*	110-54-3	3
3-Methylpentane*	96-14-0	3
Eucalyptol	470-82-6	2
Caryophyllene	87-44-5	2
Linalyl anthranilate	7149-26-0	2
alpha-Terpineol	98-55-5	2
Benzyl acetate	140-11-4	2
2-tert-Butylcyclohexanol	13491-79-7	2

Ethyl butyrate	105-54-4	2
Methylcyclohexane*	108-87-2	2
3-Methylhexane*	589-34-4	2
2-Butene*	107-01-7	2
Ethyl 2-methylpentanoate	39255-32-8	2
Acetaldehyde diethyl acetal*	105-57-7	2
Ethyl formate*	109-94-4	2
6-Methyl-5-hepten-2-one	110-93-0	2
m-Cymene	535-77-3	2
Decanal	112-31-2	2
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2	1
1,1-Dimethylallyl alcohol	115-18-4	1
Bornyl acetate	76-49-3	1
Citronellyl acetate	150-84-5	1
Undecane	1120-21-4	1
Methyl (S)-2-methylbutanoate	53955-81-0	1
Dodecane	112-40-3	1
2-chlorotoluene*	95-49-8	1
Terpinyl acetate	80-26-2	1
(E)-sabinene hydrate	17699-16-0	1
Hexyl acetate	142-92-7	1
trans-2,2-Dimethyl-4-heptenal	91296-58-1	1
Isoamyl acetate*	123-92-2	1
Menthone	10458-14-7	1
D,l-Menthol	15356-70-4	1
Neryl acetate	141-12-8	1
Propylene glycol	57-55-6	1
Ethyl isobutyrate	97-62-1	1
Cyclohexane*	110-82-7	1
2,2-Dimethylbutane*	75-83-2	1
Heptane*	142-82-5	1
2-Methylhexane*	591-76-4	1
cis-1,2-dimethylcyclopentane	1192-18-3	1
Acetic acid*	109-60-4	1
2,4-Dimethylpentane*	108-08-7	1
Propyl 2-methyl butyrate	37064-20-3	1
o-Cymene	527-84-4	1
2-Methyl-1-butene	563-46-2	1
Sabinene	3387-41-5	1
n-Octanal diethyl acetal	54889-48-4	1

3-Methyl-1-cyclopentene	1120-62-3	1
Isopulegol	7786-67-6	1
(-)-Isopulegol	89-79-2	1
1-Methyl-3-isopropylcyclopentane	53771-88-3	1
1-Methylcyclopentene	693-89-0	1
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6	1
Dl-menthyl acetate	16409-45-3	1
2,4,4-Trimethylpent-1-ene*	107-39-1	1
Ethyl 2-methylbutyrate	7452-79-1	1
6-Methyl-1,6-heptadiene	13643-06-6	1
alpha-Terpinene	99-86-5	1
2,4,4-Trimethyl-2-pentene	107-40-4	1
3-Carene	13466-78-9	1
alpha-Phellandrene	99-83-2	1
3,5,5-Trimethylhexyl acetate	58430-94-7	1
1-Phenylethanol	98-85-1	1
2,6-Di-tert-butyl-4-methylphenol	128-37-0	1
γ-Decalactone	706-14-9	1
D,l-isobornyl acetate	92618-89-8	1
2,6-Di-tert-butyl-4-methylphenol	128-37-0	1
Toluene*	108-88-3	1
4-Decyne	2384-86-3	1
3-[2-(2-Methoxyethoxy)ethoxy]-1-propene	13752-97-1	1
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	1
Octanal dimethyl acetal	10022-28-3	1
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7	1
4-Hexen-1-ol, acetate	72237-36-6	1
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7	1
beta-Ionone	79-77-6	1
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	1
alpha-Ionone	127-41-3	1

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Supplementary Table 5: VOC identities and prevalences among all regular and green cleaning supplies (n=22)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	15
beta-trans-Ocimene	3779-61-1	12
beta-Myrcene	123-35-3	10
Ethanol*	64-17-5	9
Eucalyptol	470-82-6	9
gamma-Terpinene	99-85-4	8
Sabinene	3387-41-5	7
Terpinolene	586-62-9	7
Camphene	79-92-5	7
4-tert-Butylcyclohexyl acetate	32210-23-4	6
Acetaldehyde*	75-07-0	6
Dihydromyrcenol	18479-58-8	5
beta-Pinene	127-91-3	4
Octanal	124-13-0	4
Carbon monoxide*	630-08-0	4
Methanol*	67-56-1	4
6-Methyl-5-hepten-2-one	110-93-0	4
1,4-Cineole	470-67-7	4
o-Cymene	527-84-4	4
Ethyl acetate*	141-78-6	4
Undecane	1120-21-4	3
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	3
Linalool	78-70-6	3
Tetracarbonylnickel*	13463-39-3	3
1-Octanol*	111-87-5	3
Tridecane	629-50-5	3
(-)-Camphor	464-48-2	3
Acetone*	67-64-1	3
6-Methyl-1,6-heptadiene	13643-06-6	2
Terpinyl acetate	80-26-2	2
Hexyl acetate	142-92-7	2
alpha-Phellandrene	99-83-2	2
1,4-Dioxane*	123-91-1	2

4-Dodecene	2030-84-4	2
(E)-2-dodecene	7206-13-5	2
Isopropyl alcohol*	67-63-0	2
Menthone	10458-14-7	2
4-Carene	29050-33-7	2
Cyclopropane, 1-methyl-2-(1-methylethyl)-3-(1-methylethylidene)-, cis-	24524-52-5	2
3-Carene	13466-78-9	2
1-Isopropyl-2-methyl-3-(1-methylethylidene)cyclopropane	24524-51-4	1
Ethyl butyrate	105-54-4	1
(Z)-beta-ocimene	3338-55-4	1
beta-Phellandrene	555-10-2	1
alpha-Pinene	80-56-8	1
D,l-Menthol	15356-70-4	1
Dl-menthyl acetate	16409-45-3	1
Dihydroterpineol	21129-27-1	1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6	1
Caryophyllene	87-44-5	1
Pulegone	89-82-7	1
3-Octanol	589-98-0	1
(E)-2,5-Dimethyl-1,6-octadiene	68702-25-0	1
1-(1,2-Dimethyl-cyclopent-2-enyl)-ethanone	70987-82-5	1
1-[2-(Allyloxy)-1-methylethoxy]-2-propanol	55956-25-7	1
2-(2-Hydroxypropoxy)-1-propanol	106-62-7	1
1,3-Dimethyl-2-(1-methylethyl)cyclopentene	61142-32-3	1
2,7-Dimethyl-1,7-octadiene	59840-10-7	1
1-Isopropyl-2,3-dimethyl-1-cyclopentene	7712-73-4	1
(E)-citral*	141-27-5	1
trans-3-Isopropyl-6-methylcyclohexene	1124-26-1	1
beta-Citral*	106-26-3	1
Isocitronellene	85006-04-8	1
(Z)-linalool oxide (furanoid)	5989-33-3	1
1-Methyl-2-(3-methylpentyl)cyclopropane	62238-07-7	1
Octylcyclopropane	1472-09-9	1
1-Undecanol	112-42-5	1

Octyl acetate	112-14-1	1
Benzyl alcohol*	100-51-6	1
3-Methylpentane*	96-14-0	1
Methylcyclopentane	96-37-7	1
Hexane*	110-54-3	1
Octane*	111-65-9	1
2-Methylpentane*	107-83-5	1
Methyl hexanoate	106-70-7	1
Methyl valerate	624-24-8	1
Methyl laurate	111-82-0	1
Methyl butyrate	623-42-7	1
Hexyl propionate	2445-76-3	1
Methyl propionate	554-12-1	1
Allyl heptanoate	142-19-8	1
Methyl acetate*	79-20-9	1
3-Methoxy-3-methylbutanol	56539-66-3	1
L-menthol	2216-51-5	1
alpha-Fenchene	471-84-1	1
1-Decanol	112-30-1	1
2-Isopropenyltoluene	7399-49-7	1
4-Terpineol	562-74-3	1
5,5-Dimethylcyclopentadiene	4125-18-2	1
3'-Methylacetophenone	585-74-0	1
1-Acetyl-2-methyl-1-cyclopentene	3168-90-9	1
p, α , α -Trimethylbenzyl alcohol	1197-01-9	1
Methyl isobutyl ketone*	108-10-1	1
(E)-5-Tetradecene	41446-66-6	1
(E)-3-Tetradecene	41446-68-8	1
(Z)-7-tetradecene	41446-60-0	1
2-Methyl-4-penten-2-ol	624-97-5	1
3-Methyl-1-hexene	3404-61-3	1
Butane*	106-97-8	1
Isopentane*	78-78-4	1
5-Butylnonane	17312-63-9	1
6-Methylundecane	17302-33-9	1
2,3-Dimethyloctane	7146-60-3	1
2,4-Dimethyldodecane	6117-99-3	1
2,3,4-Trimethyldecane	62238-15-7	1
6-Methyltridecane	13287-21-3	1
2,6,11-Trimethyldodecane	31295-56-4	1

2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4	1
5-Methylundecane	1632-70-8	1
2,5-Dimethyldodecane	56292-65-0	1
3,6-Dimethylundecane	17301-28-9	1
2,3,4-Trimethylpentane*	565-75-3	1
Pentane*	109-66-0	1
Dodecane	112-40-3	1
2,2,4,6,6-Pentamethylheptane	13475-82-6	1
2-Butene*	107-01-7	1
Propylene glycol butyl ether*	5131-66-8	1
D,l-isobornyl acetate	92618-89-8	1
Di-sec-butyl ether	6863-58-7	1
Decanal	112-31-2	1
2-methylundecanal	110-41-8	1
(R)-(+)- β -Citronellol	1117-61-9	1
3-Ethyl-3-methyl-1-pentene	6196-60-7	1
Acetylpentacarbonylmanganese	13963-91-2	1
2-Hexyloxyethanol*	112-25-4	1
3-Methylhexane*	589-34-4	1
2-Methylhexane*	591-76-4	1
2,3-Dimethylpentane	565-59-3	1
Heptane*	142-82-5	1
Isoamyl acetate*	123-92-2	1
3,5-Dimethyloctane	15869-93-9	1
p-Cymene	99-87-6	1
2-methylenehexanal	1070-66-2	1
2,2-Dimethylbutane*	75-83-2	1
2,2,6-Trimethyloctane	62016-28-8	1
2-Pentylfuran	3777-69-3	1
Hexanal	66-25-1	1
amitrole (ISO)*	61-82-5	1
Vinyl formate	692-45-5	1
Carbon tetrachloride*	56-23-5	1
Chloroform*	67-66-3	1
1,1-dichloroethylene*	75-35-4	1
Decane	124-18-5	1
N-Chlorodimethylamine	1585-74-6	1
Diphenyl ether	101-84-8	1

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Supplementary Table 6: VOC identities and prevalences among all regular and green laundry products (n=20)

Compound	CAS #	Prevalence (# of products)
Limonene*	138-86-3	18
beta-trans-Ocimene	3779-61-1	16
Eucalyptol	470-82-6	14
alpha-Pinene	80-56-8	13
beta-Myrcene	123-35-3	12
Acetaldehyde*	75-07-0	12
Camphene	79-92-5	9
Dihydromyrcenol	18479-58-8	9
Terpinolene	586-62-9	8
gamma-Terpinene	99-85-4	8
Ethanol*	64-17-5	7
beta-Phellandrene	555-10-2	6
4-tert-Butylcyclohexyl acetate	32210-23-4	6
Linalool	78-70-6	5
Acetone*	67-64-1	5
Isopropyl alcohol*	67-63-0	5
Tetrahydrolinalool	57706-88-4	5
alpha-Phellandrene	99-83-2	4
Octanal	124-13-0	4
2-Carene	554-61-0	4
2-tert-Butylcyclohexanol	13491-79-7	4
beta-Pinene	127-91-3	4
(+)-Camphor	464-49-3	3
Caryophyllene	87-44-5	3
alpha-Terpineol	98-55-5	3
1-Octanol*	111-87-5	3
Linalyl acetate	115-95-7	3
Hexyl acetate	142-92-7	3
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0	3
Terpinyl acetate	80-26-2	3
Methyl isopropyl ether	598-53-8	3
Methanol*	67-56-1	3
6-Methyl-5-hepten-2-one	110-93-0	3

1,4-Cineole	470-67-7	3
2-Methylfuran	534-22-5	2
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6	2
3-Carene	13466-78-9	2
Benzyl alcohol*	100-51-6	2
Ethyl methyl ether*	540-67-0	2
Ethyl 2,3-dimethylbutanoate	54004-42-1	2
Myrtanyl acetate	29021-36-1	2
1-Pentanol*	71-41-0	2
Ethyl 2-methylbutyrate	7452-79-1	2
2,4-Dimethylpentane*	108-08-7	2
Benzyl acetate	140-11-4	2
Toluene*	108-88-3	2
Octamethylcyclotetrasiloxane*	556-67-2	2
Decamethylcyclopentasiloxane	541-02-6	2
(1R)-(+)-alpha-Pinene	7785-70-8	2
o-Cymene	527-84-4	2
(Z)-7-tetradecene	41446-60-0	2
1-Hexanol*	111-27-3	2
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1	2
n-Butyl ether*	142-96-1	2
Heptane*	142-82-5	1
m-Cymene	535-77-3	1
Neryl acetate	141-12-8	1
Lavandulyl acetate	25905-14-0	1
4-Terpineol	562-74-3	1
Linalyl anthranilate	7149-26-0	1
Hexane*	110-54-3	1
Methylcyclopentane	96-37-7	1
3-Methylpentane*	96-14-0	1
2,4-Dimethylhexane*	589-43-5	1
2-Methylpentane*	107-83-5	1
Undecane	1120-21-4	1
Ethyl formate*	109-94-4	1
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2	1
2-Methyl-1-butanol	34713-94-5	1
Ethyl 2-methylpentanoate	39255-32-8	1
2,6-Dimethyl-2-octanol	18479-57-7	1
(Z)-rose oxide	16409-43-1	1

Methyl phenylcarbiny acetate	93-92-5	1
Benzyl propionate	122-63-4	1
(Z)-beta-ocimene	3338-55-4	1
Diisopropyl ether*	108-20-3	1
alpha-Isomethyl ionone	127-51-5	1
(-)-Camphor	464-48-2	1
p-Anisaldehyde	123-11-5	1
2-Methoxyethyl acetate	110-49-6	1
Butane*	106-97-8	1
Isopentane*	78-78-4	1
Pentane*	109-66-0	1
(R)-(+)-β-Citronellol	1117-61-9	1
3,5,5-Trimethylhexyl acetate	58430-94-7	1
p-tert-Butyl cyclohexyl-acetate cis	10411-92-4	1
4-tert-Butylcyclohexanol	98-52-2	1
trans-Rose oxide	876-18-6	1
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6	1
alpha-Thujene	2867-05-2	1
Amyl butyrate	540-18-1	1
Ethyl butyrate	105-54-4	1
Isoamyl butylate	106-27-4	1
Isoamyl acetate*	123-92-2	1
2-Methylpropan-1-ol*	78-83-1	1
d-Verbenol	473-67-6	1
beta-Citral*	106-26-3	1
5-Isopropenyl-1-methyl-1-cyclohexene	13898-73-2	1
3-Octanone	106-68-3	1
3-Octyl acetate	4864-61-3	1
Dodecane	112-40-3	1
Nonylcyclopropane	74663-85-7	1
2,6-Di-tert-butyl-4-methylphenol	128-37-0	1
Methoxyacetic acid*	625-45-6	1
(±)-2-Methyl-1-butanol	137-32-6	1
Sabinene	3387-41-5	1
2-Octanone	111-13-7	1
1-Octyl trifluoroacetate	2561-21-9	1
1,3,6-Trioxocane	1779-19-7	1
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7	1
(+)-Camphene	5794-03-6	1
Decanal	112-31-2	1

Cyclofenchene	488-97-1	1
3,7-Dimethyl-7-octenal	141-26-4	1
p-Cymene	99-87-6	1
1-Propanol*	71-23-8	1
Dibutyl phthalate*	84-74-2	1
3-Phenyl-2-butanone	769-59-5	1
4,4'-Isopropylidenebis(2,6-dimethylphenol)	5613-46-7	1
Verdyl acetate	5413-60-5	1
N-butylbenzenesulfonamide	3622-84-2	1
Allyl alcohol*	107-18-6	1
D,l-isobornyl acetate	92618-89-8	1
Tridecane	629-50-5	1
(-)-Camphene	5794-04-7	1
3-Methylene-1,7-octadiene	68695-13-6	1
3-Methyldecane	13151-34-3	1
delta-Undecalactone	710-04-3	1
D-carvone*	2244-16-8	1
2-methylundecanal	110-41-8	1

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Supplementary Table 7: VOC identities and prevalences among all regular and green sunscreens (n=15)

Compound	CAS #	Prevalence (# of products)
Acetaldehyde*	75-07-0	9
Phenoxyethanol*	122-99-6	6
Isopropyl alcohol*	67-63-0	5
Ethanol*	64-17-5	4
Pentane*	109-66-0	4
Hexamethyldisiloxane	107-46-0	3
Hexanal	66-25-1	3
Decamethylcyclopentasiloxane	541-02-6	2
Butane*	106-97-8	2
Limonene*	138-86-3	2
Diisopropyl adipate	6938-94-9	1
Ethyl butyrate	105-54-4	1
beta-Pinene	127-91-3	1
Ethyl acetate*	141-78-6	1
Benzyl alcohol*	100-51-6	1
Tris(trimethylsilyl) borate	4325-85-3	1
3-Methylhexane*	589-34-4	1
Cyclohexane*	110-82-7	1
Dodecamethylcyclohexasiloxane	540-97-6	1
Hexamethylcyclotrisiloxane	541-05-9	1
Acetone*	67-64-1	1
Methanol*	67-56-1	1
Dimethoxymethane	109-87-5	1

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Supplementary Table 8: VOC identities and prevalences among all regular and green fragrance-free products (n=15)

Compound	CAS #	Prevalence (# of products)
Ethanol*	64-17-5	6
Acetaldehyde*	75-07-0	3
Benzyl alcohol*	100-51-6	3
Ethyl acetate*	141-78-6	2
Acetone*	67-64-1	2
1-Octanol*	111-87-5	1
3-Methoxy-3-methylbutanol	56539-66-3	1
2-Propylheptanol	10042-59-8	1
Nonane	111-84-2	1
Carbon tetrachloride*	56-23-5	1
(E)-3-Tetradecene	41446-68-8	1
trans-4-Tetradecene	41446-78-0	1
(Z)-7-tetradecene	41446-60-0	1
trans-7-Tetradecene	41446-63-3	1
Toluene*	108-88-3	1
Trimethylsilanol	1066-40-6	1
Hexamethyldisiloxane	107-46-0	1
Isopropyl alcohol*	67-63-0	1
Propylcyclopropane	2415-72-7	1
2-Methyl-2-propanol*	75-65-0	1

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Supplementary Table 9**VOC occurrences among regular personal care products (n=25):****1. PC#1 shampoo**

Compounds	CAS#
Limonene*	138-86-3
Benzyl alcohol*	100-51-6
Ethyl 2-methylbutyrate	7452-79-1
beta-Pinene	127-91-3
Linalool	78-70-6
Isopropyl alcohol*	67-63-0
4-tert-Butylcyclohexyl acetate	32210-23-4
Dihydromyrcenol	18479-58-8
beta-trans-Ocimene	3779-61-1
Ethyl acetate*	141-78-6
Hexyl acetate	142-92-7
Isoamyl acetate*	123-92-2
Benzyl acetate	140-11-4

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2. PC#2 antiperspirant

Compounds	CAS#
Isopentane*	78-78-4
Butane*	106-97-8
Pentane*	109-66-0
Decamethylcyclopentasiloxane	541-02-6
2,2-Dimethyloxetane	6245-99-4
Ethanol*	64-17-5
Phenylethyl alcohol	60-12-8
Linalool	78-70-6
2,6-Dimethyl-2-heptanol	13254-34-7
Cyclopentane*	287-92-3
Tetrahydrolinalool	57706-88-4
Linalyl anthranilate	7149-26-0
p-Anisaldehyde	123-11-5
Eucalyptol	470-82-6
6-Ethyl-2-methyl-6-hepten-2-ol	18479-59-9

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3. PC#3 shampoo

Compounds	CAS#
Limonene*	138-86-3
Ethyl 2-methylpentanoate	39255-32-8
Octamethylcyclotetrasiloxane*	556-67-2
Ethyl 2-methylbutyrate	7452-79-1
Hexyl acetate	142-92-7
Butane*	106-97-8
beta-Pinene	127-91-3
Isoamyl acetate*	123-92-2
4-tert-Butylcyclohexyl acetate	32210-23-4
beta-trans-Ocimene	3779-61-1
Ethyl acetate*	141-78-6
Linalool	78-70-6
gamma-Terpinene	99-85-4
Cyclohexane*	110-82-7
Tridecane	629-50-5
beta-Myrcene	123-35-3
(Z)-sabinene hydrate	15537-55-0
Allyl heptanoate	142-19-8
Linalyl anthranilate	7149-26-0
Acetaldehyde*	75-07-0

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4. PC#4 body spray

Compounds	CAS#
Ethanol*	64-17-5
Isopentane*	78-78-4
Pentane*	109-66-0
Butane*	106-97-8
2-Methyl-2-propanol*	75-65-0
2,2-Dimethyloxetane	6245-99-4
2-Methylpentane*	107-83-5
Hexane*	110-54-3
3-Methylpentane*	96-14-0

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5. PC#5 shower gel

Compounds	CAS#
Limonene*	138-86-3
beta-Pinene	127-91-3
alpha-Pinene	80-56-8
Linalool	78-70-6
cis-6-Nonenyl acetate	76238-22-7
Ethyl acetate*	141-78-6
Cyclohexane*	110-82-7
Linalyl acetate	115-95-7
6-Methyl-1,6-heptadiene	13643-06-6
gamma-Terpinene	99-85-4
Dihydromyrcenol	18479-58-8
Camphene	79-92-5
Nonylcyclopropane	74663-85-7
(Z)-beta-ocimene	3338-55-4
Ethyl 2-methylpentanoate	39255-32-8
Sabinene	3387-41-5
Ethyl linalool	10339-55-6
beta-trans-Ocimene	3779-61-1
1-Dodecene	112-41-4
Benzyl acetate	140-11-4

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6. PC#6 hand cream

Compounds	CAS#
Limonene*	138-86-3
Diethyl phthalate	84-66-2
Ethanol*	64-17-5
Butane*	106-97-8
Phenoxyethanol*	122-99-6
Eucalyptol	470-82-6
4-tert-Butylcyclohexyl acetate	32210-23-4
2-Methyl-1-phenyl-2-propanol	100-86-7

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7. PC#7 ointment

Compounds	CAS#
Butane*	106-97-8
Phenoxyethanol*	122-99-6
1,1'-Oxydi-2-propanol	110-98-5
Limonene*	138-86-3
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
2,2'-Oxydipropanol	108-61-2

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8. PC#8 conditioner

Compounds	CAS#
Limonene*	138-86-3
Dihydromyrcenol	18479-58-8
Ethyl 2-methylbutyrate	7452-79-1
4-tert-Butylcyclohexyl acetate	32210-23-4
Octamethylcyclotetrasiloxane*	556-67-2
Ethyl acetate*	141-78-6
Linalool	78-70-6
Benzyl acetate	140-11-4
Ethyl butyrate	105-54-4
Hexyl acetate	142-92-7
Pentane*	123-92-2
Butyl acetate*	123-86-4
2-tert-Butylcyclohexanol	13491-79-7
Isobutyl isobutyrate	97-85-8
Ethyl linalool	10339-55-6
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
4-Hexen-1-ol, acetate	72237-36-6
Linalyl anthranilate	7149-26-0
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6
2-Phenoxyethyl isobutyrate	103-60-6

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9. PC#9 antiperspirant

Compounds	CAS#
Isopentane*	78-78-4
Butane*	106-97-8
Decamethylcyclopentasiloxane	541-02-6
Pentane*	109-66-0
2-Butene*	107-01-7
Ethanol*	64-17-5
Dihydromyrcenol	18479-58-8
Limonene*	138-86-3
2-Methyl-2-propanol*	75-65-0
Linalool	78-70-6
2-Methylpentane*	107-83-5
Hexane*	110-54-3
beta-Pinene	127-91-3
Phenylethyl alcohol	60-12-8
3-Methylpentane*	96-14-0
gamma-Terpinene	99-85-4
Isopentane*	78-78-4

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10. PC#10 moist cream

Compounds	CAS#
Butane*	106-97-8
Isopentane*	78-78-4
Decamethylcyclopentasiloxane	541-02-6
Pentane*	109-66-0
1-Chloro-2-methylpropane	513-36-0
Phenylethyl alcohol	60-12-8
Tetrahydrolinalool	57706-88-4
Benzyl acetate	140-11-4

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11. PC#11 antiperspirant

Compounds	CAS#
Isopentane*	78-78-4
Butane*	106-97-8
Decamethylcyclopentasiloxane	541-02-6
Pentane*	109-66-0
Methanol*	67-56-1
2,2-Dimethyloxetane	6245-99-4
Tetrahydrolinalool	57706-88-4
Limonene*	138-86-3
Butyric acid, 2-tridecyl ester	55193-07-2
Hexyl acetate	142-92-7
Benzyl acetate	140-11-4
trans-1-Methyl-1,2-cyclohexanediol	19534-08-8
trans-2,2-Dimethyl-4-heptenal	91296-58-1

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12. PC#12 shampoo

Compounds	CAS#
Hexyl acetate	142-92-7
Limonene*	138-86-3
4-tert-Butylcyclohexyl acetate	32210-23-4
Linalool	78-70-6
Ethyl 2-methylbutyrate	7452-79-1
Butane*	106-97-8
Dihydromyrcenol	18479-58-8
Benzyl acetate	140-11-4
Dicyclopentenyl alcohol	37275-49-3
Octamethylcyclotetrasiloxane*	556-67-2
Methyl phenylcarbinyl acetate	93-92-5
Ethinamate	126-52-3
Prenyl acetate	1191-16-8
gamma-Terpinene	99-85-4
5-Methylheptan-3-one*	541-85-5
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2
Isoamyl acetate*	123-92-2

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13. PC#13 body lotion

Compounds	CAS#
2,2,4,4,6,8,8-Heptamethylnonane	4390-04-9
2,6,10-Trimethyldodecane	3891-98-3
Limonene*	138-86-3
Butane*	106-97-8
6-Methyltridecane	13287-21-3
2,2,4-Trimethylhexane	16747-26-5
2,2,4,4-Tetramethyloctane	62183-79-3
Acetaldehyde*	75-07-0
Linalool	78-70-6
2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4
2,5-Dimethylundecane	17301-22-3
Benzyl acetate	140-11-4
6-Ethyl-2-methyl-6-hepten-2-ol	18479-59-9

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14. PC#14 ointment

Compounds	CAS#
Butane*	106-97-8

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15. PC#26 conditioner

Compounds	CAS#
D,L-Menthol	15356-70-4
Benzyl alcohol*	100-51-6
2-tert-Butylcyclohexanol	13491-79-7
Dihydromyrcenol	18479-58-8
Ethyl 2-methylbutyrate	7452-79-1
Isoamyl butylate	106-27-4
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
Menthone	10458-14-7
1,1-Dimethylallyl alcohol	115-18-4
Prenyl acetate	1191-16-8
Allyl heptanoate	142-19-8
Ethyl 2-methylpentanoate	39255-32-8
Eucalyptol	470-82-6
Linalool	78-70-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Phenoxyethanol*	122-99-6
Hexyl acetate	142-92-7
5-Methylheptan-3-one*	541-85-5
2-Pentyl butyrate	60415-61-4
trans-3-Hexenyl acetate	3681-82-1

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16. PC#27 facial gel

Compounds	CAS#
Tetrahydrolinalool	57706-88-4
4-tert-Butylcyclohexanol	98-52-2
cis-6-Nonenyl acetate	76238-22-7
Acetaldehyde*	75-07-0
Nopyl acetate	128-51-8
4-tert-Butylcyclohexyl acetate	32210-23-4
Menthyl acetate	89-48-5
Dihydromyrcenol	18479-58-8
DI-menthyl acetate	16409-45-3
Carane	554-59-6
4-Hexen-1-ol, acetate	72237-36-6
Undecane	1120-21-4

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17. PC#17 hand cream

Compounds	CAS#
Butane*	106-97-8
Ethanol*	64-17-5
Benzyl acetate	140-11-4
Phenoxyethanol*	122-99-6

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18. PC#18 shampoo

Compounds	CAS#
Octamethylcyclotetrasiloxane*	556-67-2
Limonene*	138-86-3
Hexamethylcyclotrisiloxane	541-05-9
Isopropyl alcohol*	67-63-0
Dodecane	112-40-3
Decamethylcyclopentasiloxane	541-02-6
Linalool	78-70-6
Methanol*	67-56-1
Benzyl acetate	140-11-4
Acetaldehyde*	75-07-0
Tridecane	629-50-5
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethinamate	126-52-3

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19. PC#19 conditioner

Compounds	CAS#
Ethyl 2-methylbutyrate	7452-79-1
Benzyl alcohol*	100-51-6
Dihydromyrcenol	18479-58-8
Ethyl 2-methylpentanoate	39255-32-8
4-tert-Butylcyclohexyl acetate	32210-23-4
Allyl heptanoate	142-19-8
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
α,α -Dimethylphenethyl acetate	151-05-3
4-Hexen-1-ol, acetate	72237-36-6
Limonene*	138-86-3
Ethyl butyrate	105-54-4
Benzyl acetate	140-11-4
Isopropyl alcohol*	67-63-0
1,1-Dimethylallyl alcohol	115-18-4
Allyl hexanoate	123-68-2
Hexyl acetate	142-92-7
2-tert-Butylcyclohexanol	13491-79-7
α,α -Dimethylphenethyl butyrate	10094-34-5
Hexyl salicylate	6259-76-3
Isoamyl acetate*	123-92-2

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20. PC#20 body wash

Compounds	CAS#
Limonene*	138-86-3
Benzyl acetate	140-11-4
Ethanol*	64-17-5
Linalool	78-70-6
Benzyl alcohol*	100-51-6
Acetone*	67-64-1
D,l-isobornyl acetate	92618-89-8
gamma-Nonanolactone	104-61-0
beta-trans-Ocimene	3779-61-1
Decyl trifluoroacetate	333-88-0
beta-Myrcene	123-35-3
1-Decene	872-05-9

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21. PC#21 shampoo

Compounds	CAS#
Octamethylcyclotetrasiloxane*	556-67-2
Cyclohexane*	110-82-7
4-tert-Butylcyclohexyl acetate	32210-23-4
Limonene*	138-86-3
Propyl 2-methyl butyrate	37064-20-3
Ethyl 2-methylpentanoate	39255-32-8
Benzyl acetate	140-11-4
Ethyl acetate*	141-78-6
(Z)-7-tetradecene	41446-60-0
Isoamyl acetate*	123-92-2
Linalool	78-70-6
cis-3-Hexenyl acetate	3681-71-8
beta-Pinene	127-91-3
Cyclododecane	294-62-2
Ethyl 2-methylbutyrate	7452-79-1

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22. PC#22 conditioner

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Limonene*	138-86-3
Linalool	78-70-6
Dihydromyrcenol	18479-58-8
Benzyl alcohol*	100-51-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethyl 2-methylbutyrate	7452-79-1
Hexyl acetate	142-92-7
Ethyl butyrate	105-54-4
2-tert-Butylcyclohexanol	13491-79-7
4-tert-Butylcyclohexanol	98-52-2
Ethyl acetate*	141-78-6
Benzaldehyde*	100-52-7
alpha-Terpineol	98-55-5
Methyl isopropyl ether	598-53-8
Acetone*	67-64-1
Methyl phenylcarbinyl acetate	93-92-5
Benzyl acetate	140-11-4
cis-4-tert-Butylcyclohexanol	937-05-3
2,2,6-Trimethyl-6-vinyltetrahydropyran	7392-19-0

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23. PC#23 shampoo

Compounds	CAS#
Limonene*	138-86-3
Octamethylcyclotetrasiloxane*	556-67-2
Ethyl 2-methylbutyrate	7452-79-1
Hexyl acetate	142-92-7
Ethyl 2-methylpentanoate	39255-32-8
Linalool	78-70-6
Allyl heptanoate	142-19-8
Ethyl acetate*	141-78-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Decamethylcyclopentasiloxane	541-02-6
Cyclohexane*	110-82-7
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
Dihydromyrcenol	18479-58-8
2-Phenoxyethyl isobutyrate	103-60-6
Undecane	1120-21-4
Nonylcyclopropane	74663-85-7
Toluene*	108-88-3
Benzyl acetate	140-11-4
Allyl hexanoate	123-68-2
Nonadecane	629-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

24. PC#24 liquid soap

Compounds	CAS#
Diethyl phthalate	84-66-2
Benzyl acetate	140-11-4
Methanol*	67-56-1
(Z)-7-tetradecene	41446-60-0
2-tert-Butylcyclohexanol	13491-79-7
Ethyl butyrate	105-54-4
Linalool	78-70-6
Nonadecane	629-92-5
Dodecane	112-40-3
Decyl trifluoroacetate	333-88-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

25. PC#25 liquid soap

Compounds	CAS#
Limonene*	138-86-3
Eucalyptol	470-82-6
Benzyl acetate	140-11-4
Linalool	78-70-6
beta-trans-Ocimene	3779-61-1
Methanol*	67-56-1
beta-Myrcene	123-35-3
Toluene*	108-88-3
Nonadecane	629-92-5
(Z)-7-tetradecene	41446-60-0
m-Cymene	535-77-3
Linalyl anthranilate	7149-26-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 10
VOC occurrences among green personal care products (n=25):

1. PC#15 facial wash gel

Compounds	CAS#
Butane*	106-97-8
Undecane	1120-21-4
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. PC#28 makeup remover

Compounds	CAS#
Benzyl alcohol*	100-51-6
Limonene*	138-86-3
Ethanol*	64-17-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. PC#29 hand and body wash

Compounds	CAS#
Limonene*	138-86-3
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
gamma-Terpinene	99-85-4
Linalool	78-70-6
Ethanol*	64-17-5
(R)-(+)- β -Citronellol	1117-61-9
beta-trans-Ocimene	3779-61-1
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2
Acetaldehyde*	75-07-0
beta-Phellandrene	555-10-2
1-Octanol*	111-87-5
3-Isopropenyl-5-methyl-1-cyclohexene	56816-08-1
Neryl acetate	141-12-8
beta-trans-Ocimene	3779-61-1
alpha-Phellandrene	99-83-2
Piperonal	120-57-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. PC#30 shampoo ^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
alpha-Pinene	80-56-8
p-Cymene	99-87-6
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
beta-Pinene	127-91-3
Camphene	79-92-5
4-Terpineol	562-74-3
alpha-Phellandrene	99-83-2
Limonene*	138-86-3
6-Methyl-1,6-heptadiene	13643-06-6
(+)-Camphor	464-49-3
Linalool	78-70-6
2-Carene	554-61-0
Ethyl formate*	109-94-4
beta-Phellandrene	555-10-2
Linalyl anthranilate	7149-26-0
Ethyl acetate*	141-78-6
Terpinolene	586-62-9
Acetone*	67-64-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

5. PC#31 shampoo ^{Ci}

Compounds	CAS#
Limonene*	138-86-3
beta-Pinene	127-91-3
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
gamma-Terpinene	99-85-4
Benzyl alcohol*	100-51-6
Linalool	78-70-6
Eucalyptol	470-82-6
Phenoxyethanol*	122-99-6
Sabinene	3387-41-5
Linalyl acetate	115-95-7
Ethanol*	64-17-5
beta-Phellandrene	555-10-2
alpha-Phellandrene	99-83-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

6. PC#32 shampoo^{Ci}

Compounds	CAS#
Octamethylcyclotetrasiloxane*	556-67-2
Hexamethyldisiloxane	107-46-0
2,2,4,6,6-Pentamethylheptane	13475-82-6
2,8-Dimethyl-5-nonanol	19780-96-2
Propanal*	123-38-6
Tris(trimethylsilyl) borate	4325-85-3
Trimethylsilanol	1066-40-6
Decamethylcyclopentasiloxane	541-02-6
Hexamethylcyclotrisiloxane	541-05-9
Diethyl phthalate	84-66-2
2,2,4,4-Tetramethyloctane	62183-79-3
Chloromethane*	74-87-3
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

7. PC#33 body lotion ^{Ci}

Compounds	CAS#
(1R)-(+)-alpha-Pinene	7785-70-8
Benzyl alcohol*	100-51-6
Eucalyptol	470-82-6
m-Cymene	535-77-3
alpha-Phellandrene	99-83-2
beta-Pinene	127-91-3
Limonene*	138-86-3
Isoamyl acetate*	123-92-2
2,4-Dimethylpentan-3-one*	565-80-0
Acetone*	67-64-1
Isovaleraldehyde	590-86-3
gamma-Terpinene	99-85-4
Linalool	78-70-6
Methyl isobutyl ketone*	108-10-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

8. PC#34 conditioner^{Ci}

Compounds	CAS#
Linalool	78-70-6
Eucalyptol	470-82-6
beta-trans-Ocimene	3779-61-1
Limonene*	138-86-3
(R)-(+)- β -Citronellol	1117-61-9
alpha-Terpineol	98-55-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

9. PC#35 cleansing foam ^{Ci}

Compounds	CAS#
Limonene*	138-86-3
Camphene	79-92-5
Eucalyptol	470-82-6
Cyclofenchene	488-97-1
Benzyl alcohol*	100-51-6
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
Isomenthone	491-07-6
6-Methyl-5-hepten-2-one	110-93-0
(-)-Isopulegol	89-79-2
3-Carene	13466-78-9
Benzaldehyde*	100-52-7
Acetaldehyde*	75-07-0
Linalool	78-70-6
1-Octanol*	111-87-5
Caryophyllene	87-44-5
Sabinene	3387-41-5
DL-menthyl acetate	16409-45-3
2-Methylfuran	534-22-5
Isoamyl alcohol	123-51-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

10. PC#36 liquid soap ^{Cp}

Compounds	CAS#
Ethanol*	64-17-5
Pentane*	109-66-0
alpha-Pinene	80-56-8
Limonene*	138-86-3
beta-Pinene	127-91-3
Eucalyptol	470-82-6
Linalool	78-70-6
beta-Myrcene	123-35-3
Linalyl anthranilate	7149-26-0
Camphene	79-92-5
trans-2-Pentene	646-04-8
Butane*	106-97-8
3-Methylhexane*	589-34-4
Acetaldehyde*	75-07-0
1-Heptene	592-76-7
2,3,4-Trimethylhexane	921-47-1
1-Octene	111-66-0
Terpinolene	586-62-9
beta-trans-Ocimene	3779-61-1
Caryophyllene	87-44-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Cp}Certified organic product

11. PC#37 hand cream

Compounds	CAS#
Ethanol*	64-17-5
Linalool	78-70-6
Eucalyptol	470-82-6
Linalyl anthranilate	7149-26-0
Limonene*	138-86-3
Toluene*	108-88-3
Benzenepropanol	122-97-4
Acetaldehyde*	75-07-0
(-)-Camphor	464-48-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

12. PC#38 deodorant

Compounds	CAS#
Piperonal	120-57-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

13. PC#39 conditioner

Compounds	CAS#
Decamethylcyclopentasiloxane	541-02-6
Limonene*	138-86-3
Dodecamethylcyclohexasiloxane	540-97-6
Methanol*	67-56-1
Octamethylcyclotetrasiloxane*	556-67-2
Hexanal	66-25-1
Phenoxyethanol*	122-99-6
Acetone*	67-64-1
D-carvone*	2244-16-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

14. PC#40 hand cream

Compounds	CAS#
Ethanol*	64-17-5
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

15. PC#41 hand and body lotion ^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
Eucalyptol	470-82-6
Linalool	78-70-6
Ethyl acetate*	141-78-6
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
Linalyl acetate	115-95-7
(-)-Camphor	464-48-2
beta-Phellandrene	555-10-2
Acetone*	67-64-1
3-Octanone	106-68-3
Acetaldehyde*	75-07-0
Artemesia triene	29548-02-5
Sabinene	3387-41-5
2-Methyl-1-butene	563-46-2
Hexyl methyl ether	4747-07-3
Ethanol*	64-17-5
Limonene*	138-86-3
Eucalyptol	470-82-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

16. PC#42 daily control head lice spray

Compounds	CAS#
Ethanol*	64-17-5
Ethyl acetate*	141-78-6
Acetaldehyde*	75-07-0
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

17. PC#43 deodorant^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
alpha-Pinene	80-56-8
beta-Myrcene	123-35-3
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
2,3,3-Trimethylhexane	16747-28-7
alpha-Phellandrene	99-83-2
(Z)-beta-ocimene	3338-55-4
2-Methylpentane*	107-83-5
Ethyl acetate*	141-78-6
2,3,4-Trimethylhexane	921-47-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

18. PC#44 liquid soap^{Ci}

Compounds	CAS#
Eucalyptol	470-82-6
Limonene*	138-86-3
alpha-Pinene	80-56-8
o-Cymene	527-84-4
3-Carene	13466-78-9
beta-Pinene	127-91-3
alpha-Phellandrene	99-83-2
beta-Myrcene	123-35-3
beta-Phellandrene	555-10-2
gamma-Terpinene	99-85-4
Pentane*	109-66-0
Camphene	79-92-5
(Z)-beta-ocimene	3338-55-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

19. PC#45 body lotion ^{Ci}

Compounds	CAS#
Limonene*	138-86-3
Benzyl alcohol*	100-51-6
Ethanol*	64-17-5
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
Acetaldehyde*	75-07-0
Benzyl acetate	140-11-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

20. PC#46 facial moisturizer

Compounds	CAS#
Limonene*	138-86-3
Benzyl alcohol*	100-51-6
Phenoxyethanol*	122-99-6
gamma-Terpinene	99-85-4
Linalool	78-70-6
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
beta-Pinene	127-91-3
Eucalyptol	470-82-6
Linalyl anthranilate	7149-26-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

21. PC#47 hand cream ^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
beta-Pinene	127-91-3
Linalool	78-70-6
beta-trans-Ocimene	3779-61-1
Ethyl acetate*	141-78-6
Acetaldehyde*	75-07-0
o-Cymene	527-84-4
gamma-Terpinene	99-85-4
beta-Myrcene	123-35-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

22. PC#48 deodorant

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
alpha-Pinene	80-56-8
Eucalyptol	470-82-6
alpha-Phellandrene	99-83-2
beta-Phellandrene	555-10-2
Linalool	78-70-6
Linalyl acetate	115-95-7
Terpinolene	586-62-9
Camphene	79-92-5
2-Carene	554-61-0
Ethyl acetate*	141-78-6
Sabinene	3387-41-5
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2
alpha-Thujene	2867-05-2
4-Terpineol	562-74-3
3-Carene	13466-78-9
Decanal	

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

23. PC#49 body wash

Compounds	CAS#
Tetrahydrolinalool	57706-88-4
Limonene*	138-86-3
beta-Pinene	127-91-3
Isopropyl alcohol*	67-63-0
Benzyl acetate	140-11-4
Linalool	78-70-6
Hexane*	110-54-3
gamma-Terpinene	99-85-4
Methylcyclopentane	96-37-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

24. PC#50 shampoo

Compounds	CAS#
Ethanol*	64-17-5
gamma-Terpinene	99-85-4
beta-trans-Ocimene	3779-61-1
2-Carene	554-61-0
o-Cymene	527-84-4
Limonene*	138-86-3
Eucalyptol	470-82-6
4-Terpineol	562-74-3
alpha-Phellandrene	99-83-2
Terpinolene	586-62-9
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
beta-Phellandrene	555-10-2
Isobutyraldehyde	78-84-2
alpha-Thujene	2867-05-2
Ethyl formate*	109-94-4
Ethyl acetate*	141-78-6
Camphene	79-92-5
Linalool	78-70-6
2-Methylbutyraldehyde	96-17-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

25. PC#16 facial scrub

Compounds	CAS#
Limonene*	138-86-3
Benzyl alcohol*	100-51-6
3-(Neopentyloxy)-2-butanol	74793-66-1
Eucalyptol	470-82-6
Methyl 2-ethylhexanoate	816-19-3
beta-trans-Ocimene	3779-61-1
Acetaldehyde*	75-07-0
Linalool	78-70-6
beta-Pinene	127-91-3
4-tert-Butylcyclohexyl acetate	32210-23-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 11
VOC occurrences among regular air fresheners (n=6):

1. AF#7 citrus

Compounds	CAS#
Ethanol*	64-17-5
Butane*	106-97-8
Isopentane*	78-78-4
Pentane*	109-66-0
Limonene*	138-86-3
2-Methyl-2-propanol*	75-65-0
Propylene glycol	57-55-6
2-Methylpentane*	107-83-5
Hexane*	110-54-3
3-Methylpentane*	96-14-0
beta-trans-Ocimene	3779-61-1
beta-Pinene	127-91-3
Acetone*	67-64-1
Methylcyclopentane	96-37-7
Ethyl isobutyrate	97-62-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Cp}Certified organic product

2. AF#8 citrus grove

Compounds	CAS#
Ethanol*	64-17-5
Butane*	106-97-8
Isopentane*	78-78-4
Pentane*	109-66-0
Limonene*	138-86-3
2-Methyl-2-propanol*	75-65-0
2-Methylpentane*	107-83-5
Hexane*	110-54-3
3-Methylpentane*	96-14-0
Cyclohexane*	110-82-7
2,2-Dimethylbutane*	75-83-2
Methylcyclopentane	96-37-7
Heptane*	142-82-5
2-Methylhexane*	591-76-4
Methylcyclohexane*	108-87-2
3-Methylhexane*	589-34-4
cis-1,2-dimethylcyclopentane	1192-18-3
Acetic acid*	109-60-4
2,4-Dimethylpentane*	108-08-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. AF#9 sparkling citrus

Compounds	CAS#
Limonene*	138-86-3
Isopentane*	78-78-4
2-Butene*	107-01-7
Butane*	106-97-8
beta-Pinene	127-91-3
gamma-Terpinene	99-85-4
Propyl 2-methyl butyrate	37064-20-3
Ethyl 2-methylpentanoate	39255-32-8
o-Cymene	527-84-4
alpha-Pinene	80-56-8
2,4,4-Trimethylpent-1-ene*	107-39-1
Pentane*	109-66-0
Ethyl 2-methylbutyrate	7452-79-1
Linalool	78-70-6
Linalyl acetate	115-95-7
Terpinolene	586-62-9
6-Methyl-1,6-heptadiene	13643-06-6
Octanal	124-13-0
alpha-Terpinene	99-86-5
2,4,4-Trimethyl-2-pentene	107-40-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. AF#10 citrus sunburst

Compounds	CAS#
Limonene*	138-86-3
Ethanol*	64-17-5
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
beta-Phellandrene	555-10-2
m-Cymene	535-77-3
3-Carene	13466-78-9
Dihydromyrcenol	18479-58-8
Octanal	124-13-0
2-Methyl-2-propanol*	75-65-0
Linalool	78-70-6
Decanal	112-31-2
alpha-Phellandrene	99-83-2
2-tert-Butylcyclohexanol	13491-79-7
Ethyl 2-methylpentanoate	39255-32-8
beta-trans-Ocimene	3779-61-1
3,5,5-Trimethylhexyl acetate	58430-94-7
gamma-Terpinene	99-85-4
Terpinolene	586-62-9
1-Phenylethanol	98-85-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. AF#11 French vanilla

Compounds	CAS#
Ethanol*	64-17-5
Butane*	106-97-8
Isopentane*	78-78-4
2,6-Di-tert-butyl-4-methylphenol	128-37-0
Pentane*	109-66-0
Ethyl butyrate	105-54-4
Limonene*	138-86-3
2-Butene*	107-01-7
Hexane*	110-54-3
2-Methylpentane*	107-83-5
γ -Decalactone	706-14-9
3-Methylpentane*	96-14-0
Methylcyclohexane*	108-87-2
D,l-isobornyl acetate	92618-89-8
Methylcyclopentane	96-37-7
3-Methylhexane*	589-34-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. AF#12 rose & grapefruit

Compounds	CAS#
Ethanol*	64-17-5
Dihydromyrcenol	18479-58-8
Toluene*	108-88-3
4-Decyne	2384-86-3
Ethyl acetate*	141-78-6
Linalool	78-70-6
Benzyl acetate	140-11-4
3-[2-(2-Methoxyethoxy)ethoxy]-1-propene	13752-97-1
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
Octanal dimethyl acetal	10022-28-3
cis-3,7-Dimethyl-2,6-octadien-1-ol	106-25-2
1-(2-Methoxy-1-methylethoxy)propan-2-ol	20324-32-7
4-Hexen-1-ol, acetate	72237-36-6
1-(2-Methoxypropoxy)propan-2-ol	13429-07-7
beta-Ionone	79-77-6
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
alpha-Ionone	127-41-3
Decanal	112-31-2
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 12

VOC occurrences among green air fresheners (n=6):

1. AF#1 orange

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
2-Methyl-2-propanol*	75-65-0
Sabinene	3387-41-5
Acetaldehyde diethyl acetal*	105-57-7
beta-Phellandrene	555-10-2
Ethyl formate*	109-94-4
beta-trans-Ocimene	3779-61-1
Acetone*	67-64-1
Acetaldehyde*	75-07-0
(E)-citral*	141-27-5
beta-Citral*	106-26-3
Methanol*	67-56-1
2-Methyl-1-butene	563-46-2
n-Octanal diethyl acetal	54889-48-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Cp}Certified organic product

2. AF#2 lemon tea tree and eucalyptus

Compounds	CAS#
alpha-Pinene	80-56-8
(±)-Citronellal	106-23-0
Limonene*	138-86-3
Methylcyclopentane	96-37-7
beta-Pinene	127-91-3
3-Methyl-1-cyclopentene	1120-62-3
Isopulegol	7786-67-6
1-Methyl-3-isopropylcyclopentane	53771-88-3
Eucalyptol	470-82-6
(-)-Isopulegol	89-79-2
(E)-citral*	141-27-5
1-Methylcyclopentene	693-89-0
beta-Citral*	106-26-3
6-Methyl-5-hepten-2-one	110-93-0
Bornyl acetate	76-49-3
Acetaldehyde*	75-07-0
Camphene	79-92-5
Acetone*	67-64-1
6-Octen-1-ol, 3,7-dimethyl-	150-84-5
Caryophyllene	87-44-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. AF#3 lemon myrtle

Compounds	CAS#
Ethanol*	64-17-5
Methanol*	67-56-1
(E)-citral*	141-27-5
beta-Citral*	106-26-3
6-Methyl-5-hepten-2-one	110-93-0
beta-Myrcene	123-35-3
Acetone*	67-64-1
Acetaldehyde*	75-07-0
Ethyl formate*	109-94-4
Acetaldehyde diethyl acetal*	105-57-7
Undecane	1120-21-4
Methyl (S)-2-methylbutanoate	53955-81-0
Dodecane	112-40-3
3-Buten-2-ol, 2-methyl-	115-18-4
2-chlorotoluene*	95-49-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. AF#4 lemon grass & cedarwood^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
Linalool	78-70-6
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
beta-Pinene	127-91-3
Methanol*	67-56-1
Terpinyl acetate	80-26-2
(E)-sabinene hydrate	17699-16-0
Ethyl acetate*	141-78-6
Camphene	79-92-5
gamma-Terpinene	99-85-4
alpha-Terpineol	98-55-5
Octanal	124-13-0
(E)-citral*	141-27-5
beta-trans-Ocimene	3779-61-1
Linalyl anthranilate	7149-26-0
Linalyl acetate	115-95-7
beta-Citral*	106-26-3
beta-Phellandrene	555-10-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

5. AF#5 grapefruit & pomegranate ^{Ci}

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
Methanol*	67-56-1
Linalool	78-70-6
Hexyl acetate	142-92-7
beta-Pinene	127-91-3
alpha-Pinene	80-56-8
trans-2,2-Dimethyl-4-heptenal	91296-58-1
Benzyl acetate	140-11-4
beta-Myrcene	123-35-3
2-tert-Butylcyclohexanol	13491-79-7
gamma-Terpinene	99-85-4
Dihydromyrcenol	18479-58-8
beta-trans-Ocimene	3779-61-1
Ethyl butyrate	105-54-4
Isoamyl acetate*	123-92-2
2-Methyl-2-propanol*	75-65-0
Ethyl acetate*	141-78-6
Camphene	79-92-5
Terpinolene	586-62-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

6. AF#6 mix

Compounds	CAS#
Ethanol*	64-17-5
Linalool	78-70-6
Limonene*	138-86-3
Ethyl acetate*	141-78-6
Linalyl acetate	115-95-7
Menthone	10458-14-7
Eucalyptol	470-82-6
D,l-Menthol	15356-70-4
alpha-Pinene	80-56-8
beta-Myrcene	123-35-3
Camphene	79-92-5
alpha-Terpineol	98-55-5
Caryophyllene	87-44-5
Linalyl anthranilate	7149-26-0
beta-Pinene	127-91-3
m-Cymene	535-77-3
beta-Phellandrene	555-10-2
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6
Dl-menthyl acetate	16409-45-3
Neryl acetate	141-12-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 13
VOC occurrences among regular cleaning supplies (n=10):

1. CS#12 dust, shine and protects

Compounds	CAS#
Butane*	106-97-8
Isopentane*	78-78-4
5-Butylnonane	17312-63-9
Tridecane	629-50-5
6-Methylundecane	17302-33-9
2,3-Dimethyloctane	7146-60-3
2,4-Dimethyldodecane	6117-99-3
2,3,4-Trimethyldecane	62238-15-7
6-Methyltridecane	13287-21-3
2,6,11-Trimethyldodecane	31295-56-4
2,2,3,3,5,6,6-Heptamethylheptane	7225-67-4
5-Methylundecane	1632-70-8
Limonene*	138-86-3
2,5-Dimethyldodecane	56292-65-0
3,6-Dimethylundecane	17301-28-9
2,3,4-Trimethylpentane*	565-75-3
Pentane*	109-66-0
Dodecane	112-40-3
2,2,4,6,6-Pentamethylheptane	13475-82-6
2-Butene*	107-01-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. CS#13 glass spray

Compounds	CAS#
Propylene glycol butyl ether*	5131-66-8
Ethanol*	64-17-5
D,l-isobornyl acetate	92618-89-8
Dihydromyrcenol	18479-58-8
Di-sec-butyl ether	6863-58-7
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
Methanol*	67-56-1
Eucalyptol	470-82-6
Ethyl acetate*	141-78-6
Decanal	112-31-2
Cyclopropane, 1-methyl-2-(1-methylethyl)-3-(1-methylethylidene)-, cis-	24524-52-5
4-tert-Butylcyclohexyl acetate	32210-23-4
2-methylundecanal	110-41-8
(R)-(+)- β -Citronellol	1117-61-9
(-)-Camphor	464-48-2
o-Cymene	527-84-4
Hexyl acetate	142-92-7
3-Ethyl-3-methyl-1-pentene	6196-60-7
Octanal	124-13-0
Acetylpentacarbonylmanganese	13963-91-2

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. CS#14 glass Spray

Compounds	CAS#
2-Hexyloxyethanol*	112-25-4
Limonene*	138-86-3
Linalool	78-70-6
1-Octanol*	111-87-5
4-tert-Butylcyclohexyl acetate	32210-23-4
Tridecane	629-50-5
Tetracarbonylnickel*	13463-39-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. CS#15 hand dishwashing liquid

Compounds	CAS#
Limonene*	138-86-3
beta-trans-Ocimene	3779-61-1
beta-Pinene	127-91-3
Eucalyptol	470-82-6
1,4-Cineole	470-67-7
Terpinolene	586-62-9
3-Methylhexane*	589-34-4
Dihydromyrcenol	18479-58-8
2-Methylhexane*	591-76-4
gamma-Terpinene	99-85-4
Camphene	79-92-5
6-Methyl-1,6-heptadiene	13643-06-6
2,3-Dimethylpentane	565-59-3
Heptane*	142-82-5
(-)-Camphor	464-48-2
Isoamyl acetate*	123-92-2
3,5-Dimethyloctane	15869-93-9
o-Cymene	527-84-4
Carbon monoxide*	630-08-0
Tridecane	629-50-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. CS#16 oven and bbq cleaner

Compounds	CAS#
Limonene*	138-86-3
1,4-Cineole	470-67-7
Eucalyptol	470-82-6
p-Cymene	99-87-6
Acetone*	67-64-1
beta-trans-Ocimene	3779-61-1
Dihydromyrcenol	18479-58-8
Terpinolene	586-62-9
Camphene	79-92-5
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
beta-Myrcene	123-35-3
Carbon monoxide*	630-08-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. CS#18 wooden furniture cleaner

Compounds	CAS#
Methanol*	67-56-1
4-Dodecene	2030-84-4
1,4-Dioxane*	123-91-1
(E)-2-dodecene	7206-13-5
2-methylenehexanal	1070-66-2
Undecane	1120-21-4
Carbon monoxide*	630-08-0
2,2-Dimethylbutane*	75-83-2
2,2,6-Trimethyloctane	62016-28-8
2-Pentylfuran	3777-69-3
Hexanal	66-25-1
amitrole (ISO)*	61-82-5
Vinyl formate	692-45-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. CS#19 bathroom power gel

Compounds	CAS#
Carbon tetrachloride*	56-23-5
Chloroform*	67-66-3
1,1-dichloroethylene*	75-35-4
Tetracarbonylnickel*	13463-39-3
Decane	124-18-5
N-Chlorodimethylamine	1585-74-6
4-tert-Butylcyclohexyl acetate	32210-23-4
6-Methyl-5-hepten-2-one	110-93-0
Diphenyl ether	101-84-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. CS#20 dishwashing liquid

Compounds	CAS#
Limonene*	138-86-3
beta-trans-Ocimene	3779-61-1
Terpinolene	586-62-9
Eucalyptol	470-82-6
1,4-Cineole	470-67-7
Octanal	124-13-0
1-Methyl-2-(3-methylpentyl)cyclopropane	62238-07-7
beta-Myrcene	123-35-3
Camphene	79-92-5
1-Isopropyl-2-methyl-3-(1-methylethylidene)cyclopropane	24524-51-4
gamma-Terpinene	99-85-4
Carbon monoxide*	630-08-0
Acetaldehyde*	75-07-0
Octylcyclopropane	1472-09-9
o-Cymene	527-84-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. CS#21 multi-purpose kitchen spray

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
(E)-2,5-Dimethyl-1,6-octadiene	68702-25-0
Eucalyptol	470-82-6
4-tert-Butylcyclohexyl acetate	32210-23-4
1-(1,2-Dimethyl-cyclopent-2-enyl)-ethanone	70987-82-5
2-(2-Hydroxypropoxy)-1-propanol	106-62-7
1,3-Dimethyl-2-(1-methylethyl)cyclopentene	61142-32-3
1-[2-(Allyloxy)-1-methylethoxy]-2-propanol	55956-25-7
2,7-Dimethyl-1,7-octadiene	59840-10-7
1-Isopropyl-2,3-dimethyl-1-cyclopentene	7712-73-4
Cyclopropane, 1-methyl-2-(1-methylethyl)-3-(1-methylethylidene)-, cis-	24524-52-5
(E)-citral*	141-27-5
6-Methyl-5-hepten-2-one	110-93-0
Terpinyl acetate	80-26-2
trans-3-Isopropyl-6-methylcyclohexene	1124-26-1
Acetaldehyde*	75-07-0
Dihydromyrcenol	18479-58-8
beta-Citral*	106-26-3
Isocitronellene	85006-04-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. CS#22 dishwasher liquid

Compounds	CAS#
Limonene*	138-86-3
Eucalyptol	470-82-6
1,4-Cineole	470-67-7
beta-Myrcene	123-35-3
Terpinolene	586-62-9
(Z)-linalool oxide (furanoid)	5989-33-3
beta-trans-Ocimene	3779-61-1
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
Dihydromyrcenol	18479-58-8
4-tert-Butylcyclohexyl acetate	32210-23-4
6-Methyl-5-hepten-2-one	110-93-0
gamma-Terpinene	99-85-4
Sabinene	3387-41-5
beta-Pinene	127-91-3
Linalool	78-70-6
Camphene	79-92-5
Tetracarbonylnickel*	13463-39-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 14
VOC occurrences among green cleaning supplies (n=10):

1. CS#1 dishwash liquid

Compounds	CAS#
Limonene*	138-86-3
gamma-Terpinene	99-85-4
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
(Z)-beta-ocimene	3338-55-4
Sabinene	3387-41-5
alpha-Phellandrene	99-83-2
1,4-Dioxane*	123-91-1
beta-Phellandrene	555-10-2
Undecane	1120-21-4
Terpinolene	586-62-9
4-Dodecene	2030-84-4
(E)-2-dodecene	7206-13-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. CS#2 glass cleaner

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Limonene*	138-86-3
Menthone	10458-14-7
alpha-Pinene	80-56-8
D,L-Menthol	15356-70-4
beta-Pinene	127-91-3
Sabinene	3387-41-5
Eucalyptol	470-82-6
DL-menthyl acetate	16409-45-3
6-Methyl-1,6-heptadiene	13643-06-6
Dihydroterpineol	21129-27-1
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	494-90-6
Camphene	79-92-5
gamma-Terpinene	99-85-4
Caryophyllene	87-44-5
4-Carene	29050-33-7
alpha-Phellandrene	99-83-2
Pulegone	89-82-7
3-Octanol	589-98-0
Terpinolene	586-62-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. CS#3 rinse aid

Compounds	CAS#
Ethanol*	64-17-5
Ethyl acetate*	141-78-6
Isopropyl alcohol*	67-63-0
1-Octanol*	111-87-5
Ethyl butyrate	105-54-4
1-Undecanol	112-42-5
Octyl acetate	112-14-1
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. CS#4 dish liquid

Compounds	CAS#
Limonene*	138-86-3
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
Benzyl alcohol*	100-51-6
3-Methylpentane*	96-14-0
Methylcyclopentane	96-37-7
Hexane*	110-54-3
Octane*	111-65-9
Undecane	1120-21-4
3-Carene	13466-78-9
Sabinene	3387-41-5
beta-trans-Ocimene	3779-61-1
2-Methylpentane*	107-83-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. CS#5 multipurpose

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
Methanol*	67-56-1
Ethyl acetate*	141-78-6
4-tert-Butylcyclohexyl acetate	32210-23-4
Methyl hexanoate	106-70-7
Hexyl acetate	142-92-7
Methyl valerate	624-24-8
Methyl laurate	111-82-0
Methyl butyrate	623-42-7
Hexyl propionate	2445-76-3
beta-Myrcene	123-35-3
Methyl propionate	554-12-1
Allyl heptanoate	142-19-8
Methyl acetate*	79-20-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. CS#6 multipurpose cleaning

Compounds	CAS#
Limonene*	138-86-3
Ethanol*	64-17-5
beta-Myrcene	123-35-3
3-Methoxy-3-methylbutanol	56539-66-3
beta-Pinene	127-91-3
beta-trans-Ocimene	3779-61-1
Linalool	78-70-6
Methanol*	67-56-1
gamma-Terpinene	99-85-4
L-menthol	2216-51-5
Sabinene	3387-41-5
1-Octanol*	111-87-5
alpha-Fenchene	471-84-1
Camphene	79-92-5
3-Carene	13466-78-9
Octanal	124-13-0
Menthone	10458-14-7
Terpinyl acetate	80-26-2
beta-trans-Ocimene	3779-61-1
1-Decanol	112-30-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. CS#7 Bathroom cleaner

Compounds	CAS#
Limonene*	138-86-3
Eucalyptol	470-82-6
Ethanol*	64-17-5
o-Cymene	527-84-4
Acetaldehyde*	75-07-0
gamma-Terpinene	99-85-4
4-Carene	29050-33-7
Camphene	79-92-5
beta-trans-Ocimene	3779-61-1
2-Isopropenyltoluene	7399-49-7
4-Terpineol	562-74-3
5,5-Dimethylcyclopentadiene	4125-18-2
(-)-Camphor	464-48-2
Terpinolene	586-62-9
3'-Methylacetophenone	585-74-0
beta-Myrcene	123-35-3
1-Acetyl-2-methyl-1-cyclopentene	3168-90-9
p,α,α-Trimethylbenzyl alcohol	1197-01-9
Ethyl acetate*	141-78-6
Acetone*	67-64-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. CS#8 everyday cleaner

Compounds	CAS#
Limonene*	138-86-3
Ethanol*	64-17-5
beta-trans-Ocimene	3779-61-1
beta-Myrcene	123-35-3
Sabinene	3387-41-5
Octanal	124-13-0
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. CS#9 bathroom & shower cleaner

Compounds	CAS#
Ethanol*	64-17-5
Methyl isobutyl ketone*	108-10-1
(E)-5-Tetradecene	41446-66-6
Acetone*	67-64-1
Acetaldehyde*	75-07-0
(E)-3-Tetradecene	41446-68-8
(Z)-7-tetradecene	41446-60-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. CS#10 dishwashing liquid

Compounds	CAS#
(S)-p-mentha-1,8-diene*	5989-54-8
beta-Myrcene	123-35-3
beta-trans-Ocimene	3779-61-1
6-Methyl-5-hepten-2-one	110-93-0
Acetaldehyde*	75-07-0
2-Methyl-4-penten-2-ol	624-97-5
Ethanol*	64-17-5
3-Methyl-1-hexene	3404-61-3
Sabinene	3387-41-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 15
VOC occurrences among regular laundry products (n=10):

1. LL#11 lemon fresh

Compounds	CAS#
Limonene*	138-86-3
1,4-Cineole	470-67-7
Terpinolene	586-62-9
Camphene	79-92-5
Eucalyptol	470-82-6
gamma-Terpinene	99-85-4
Octanal	124-13-0
alpha-Pinene	80-56-8
2,4,6-Trimethyl-3-cyclohexene-1-carboxaldehyde	1423-46-7
Dihydromyrcenol	18479-58-8
(+)-Camphene	5794-03-6
beta-Myrcene	123-35-3
Decanal	112-31-2
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
Cyclofenchene	488-97-1
3,7-Dimethyl-7-octenal	141-26-4
p-Cymene	99-87-6
beta-trans-Ocimene	3779-61-1
alpha-Phellandrene	99-83-2
n-Butyl ether*	142-96-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. LL#12 almond milk

Compounds	CAS#
Tetrahydrolinalool	57706-88-4
Dihydromyrcenol	18479-58-8
4-tert-Butylcyclohexyl acetate	32210-23-4
2,4-Dimethylpentane*	108-08-7
1-Propanol*	71-23-8
Dibutyl phthalate*	84-74-2
2-tert-Butylcyclohexanol	13491-79-7
3-Phenyl-2-butanone	769-59-5
4,4'-Isopropylidenebis(2,6-dimethylphenol)	5613-46-7
Verdyl acetate	5413-60-5
n-Butyl ether*	142-96-1
N-butylbenzenesulfonamide	3622-84-2
1-Hexanol*	111-27-3
Allyl alcohol*	107-18-6
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. LL#13 mix

Compounds	CAS#
D,l-isobornyl acetate	92618-89-8
4-tert-Butylcyclohexyl acetate	32210-23-4
Tridecane	629-50-5
alpha-Pinene	80-56-8
Benzyl acetate	140-11-4
1,4-Cineole	470-67-7
(-)-Camphene	5794-04-7
Acetaldehyde*	75-07-0
3-Methylene-1,7-octadiene	68695-13-6
3-Methyldecane	13151-34-3
Eucalyptol	470-82-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. LL#14 mix

Compounds	CAS#
Limonene*	138-86-3
4-tert-Butylcyclohexyl acetate	32210-23-4
Eucalyptol	470-82-6
Tetrahydrolinalool	57706-88-4
1,4-Cineole	470-67-7
delta-Undecalactone	710-04-3
Dihydromyrcenol	18479-58-8
alpha-Pinene	80-56-8
Ethanol*	64-17-5
2-tert-Butylcyclohexanol	13491-79-7
Terpinolene	586-62-9
Acetaldehyde*	75-07-0
D-carvone*	2244-16-8
Camphene	79-92-5
6-Methyl-5-hepten-2-one	110-93-0
2-methyl-2-(4-methylpent-3-enyl)cyclopropane-1-carbaldehyde	97231-35-1
2-methylundecanal	110-41-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. LL#15 fabric softener, oriental blossom

Compounds	CAS#
Ethanol*	64-17-5
Ethyl methyl ether*	540-67-0
Octamethylcyclotetrasiloxane*	556-67-2
Isopropyl alcohol*	67-63-0
Limonene*	138-86-3
Tetrahydrolinalool	57706-88-4
3,5,5-Trimethylhexyl acetate	58430-94-7
2-tert-Butylcyclohexanol	13491-79-7
Decamethylcyclopentasiloxane	541-02-6
p-tert-Butyl cyclohexyl-acetate cis	10411-92-4
4-tert-Butylcyclohexanol	98-52-2
trans-Rose oxide	876-18-6
Acetaldehyde*	75-07-0
4-tert-Butylcyclohexyl acetate	32210-23-4
2-(4-tert-Butylbenzyl)propionaldehyde*	80-54-6
Hexyl acetate	142-92-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. LL#16 ironing spray, citrus fresh

Compounds	CAS#
Butane*	106-97-8
Isopentane*	78-78-4
Limonene*	138-86-3
Octamethylcyclotetrasiloxane*	556-67-2
Pentane*	109-66-0
Decamethylcyclopentasiloxane	541-02-6
Tetrahydrolinalool	57706-88-4
beta-Myrcene	123-35-3
Linalool	78-70-6
Dihydromyrcenol	18479-58-8
(R)-(+)- β -Citronellol	1117-61-9
2-Carene	554-61-0
Terpinolene	586-62-9
Linalyl acetate	115-95-7
beta-Phellandrene	555-10-2
Eucalyptol	470-82-6
alpha-Pinene	80-56-8
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0
6-Methyl-5-hepten-2-one	110-93-0
gamma-Terpinene	99-85-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. LL#17 fabric conditioner, mix

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Methanol*	67-56-1
Methyl isopropyl ether	598-53-8
Tetrahydrolinalool	57706-88-4
Dihydromyrcenol	18479-58-8
Eucalyptol	470-82-6
Terpinyl acetate	80-26-2
Linalool	78-70-6
Diisopropyl ether*	108-20-3
Limonene*	138-86-3
Limonene*	138-86-3
alpha-Isomethyl ionone	127-51-5
(-)-Camphor	464-48-2
beta-Pinene	127-91-3
p-Anisaldehyde	123-11-5
2-Methoxyethyl acetate	110-49-6
Toluene*	108-88-3
Camphene	79-92-5
Acetaldehyde*	75-07-0
beta-Myrcene	123-35-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. LL#18 fabric softener, mix

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Limonene*	138-86-3
Ethyl 2-methylbutyrate	7452-79-1
Myrtanyl acetate	29021-36-1
Ethyl 2-methylpentanoate	39255-32-8
Methyl isopropyl ether	598-53-8
Methanol*	67-56-1
Dihydromyrcenol	18479-58-8
2,6-Dimethyl-2-octanol	18479-57-7
alpha-Pinene	80-56-8
(Z)-rose oxide	16409-43-1
Eucalyptol	470-82-6
Methyl phenylcarbinyl acetate	93-92-5
Terpinyl acetate	80-26-2
Benzyl acetate	140-11-4
Camphene	79-92-5
4-tert-Butylcyclohexyl acetate	32210-23-4
2-tert-Butylcyclohexanol	13491-79-7
Benzyl propionate	122-63-4
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. LL#19 mix

Compounds	CAS#
Limonene*	138-86-3
Myrtanyl acetate	29021-36-1
alpha-Pinene	80-56-8
Ethyl 2,3-dimethylbutanoate	54004-42-1
Isopropyl alcohol*	67-63-0
Eucalyptol	470-82-6
beta-Pinene	127-91-3
Dihydromyrcenol	18479-58-8
Camphene	79-92-5
1-Pentanol*	71-41-0
2-Methyl-1-butanol	34713-94-5
Ethyl 2-methylbutyrate	7452-79-1
2,4-Dimethylpentane*	108-08-7
Ethanol*	64-17-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. LL#20 mix

Compounds	CAS#
Limonene*	138-86-3
Dihydromyrcenol	18479-58-8
beta-Myrcene	123-35-3
alpha-Pinene	80-56-8
4-tert-Butylcyclohexyl acetate	32210-23-4
Ethanol*	64-17-5
Hexyl acetate	142-92-7
Ethyl 2,3-dimethylbutanoate	54004-42-1
2-(1,1-Dimethyl-2-propenyl)-1,1-dimethylcyclopropane	81051-15-2
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0
Terpinyl acetate	80-26-2
Acetone*	67-64-1
Acetaldehyde*	75-07-0
Heptane*	142-82-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 16
VOC occurrences among green laundry products (n=10):

1. LL#1 lavender

Compounds	CAS#
Linalool	78-70-6
Limonene*	138-86-3
Eucalyptol	470-82-6
beta-Myrcene	123-35-3
Acetaldehyde*	75-07-0
(+)-Camphor	464-49-3
Caryophyllene	87-44-5
alpha-Pinene	80-56-8
alpha-Terpineol	98-55-5
m-Cymene	535-77-3
2-Methylfuran	534-22-5
Terpinolene	586-62-9
Neryl acetate	141-12-8
Lavandulyl acetate	25905-14-0
4-Terpineol	562-74-3
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6
1-Octanol*	111-87-5
Camphene	79-92-5
Linalyl anthranilate	7149-26-0
3-Carene	13466-78-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. LL#2 fabric conditioner, citrus

Compounds	CAS#
Limonene*	138-86-3
Ethanol*	64-17-5
Eucalyptol	470-82-6
alpha-Pinene	80-56-8
beta-Myrcene	123-35-3
Hexane*	110-54-3
Benzyl alcohol*	100-51-6
beta-Phellandrene	555-10-2
Methylcyclopentane	96-37-7
3-Methylpentane*	96-14-0
gamma-Terpinene	99-85-4
2,4-Dimethylhexane*	589-43-5
beta-trans-Ocimene	3779-61-1
Ethyl methyl ether*	540-67-0
2-Methylpentane*	107-83-5
alpha-Phellandrene	99-83-2
Octanal	124-13-0
Undecane	1120-21-4
Ethyl formate*	109-94-4
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. LL#3 sweet orange & lavender scent

Compounds	CAS#
Limonene*	138-86-3
alpha-Pinene	80-56-8
beta-Myrcene	123-35-3
Benzyl alcohol*	100-51-6
Linalool	78-70-6
Eucalyptol	470-82-6
beta-trans-Ocimene	3779-61-1
Linalyl acetate	115-95-7
beta-Phellandrene	555-10-2
gamma-Terpinene	99-85-4
(+)-Camphor	464-49-3
3-Carene	13466-78-9
Camphene	79-92-5
2-Carene	554-61-0
Caryophyllene	87-44-5
Terpinolene	586-62-9
Octanal	124-13-0
alpha-Terpineol	98-55-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. LL#4 eucalyptus and cherry

Compounds	CAS#
Eucalyptol	470-82-6
Limonene*	138-86-3
(1R)-(+)-alpha-Pinene	7785-70-8
gamma-Terpinene	99-85-4
o-Cymene	527-84-4
alpha-Thujene	2867-05-2
beta-Myrcene	123-35-3
beta-Pinene	127-91-3
beta-Phellandrene	555-10-2
2-Carene	554-61-0
Terpinolene	586-62-9
Toluene*	108-88-3
Amyl butyrate	540-18-1
Ethanol*	64-17-5
Ethyl butyrate	105-54-4
Isoamyl butylate	106-27-4
Isoamyl acetate*	123-92-2
2-Methylpropan-1-ol*	78-83-1
alpha-Phellandrene	99-83-2
Camphene	79-92-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

5. LL#5 lemon myrtle

Compounds	CAS#
6-Methyl-5-hepten-2-one	110-93-0
Acetaldehyde*	75-07-0
Limonene*	138-86-3
d-Verbenol	473-67-6
beta-Citral*	106-26-3
1-Octanol*	111-87-5
Acetone*	67-64-1
beta-Myrcene	123-35-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. LL#6 lavender and ylang ylang

Compounds	CAS#
Linalyl acetate	115-95-7
5-Isopropenyl-1-methyl-1-cyclohexene	13898-73-2
Linalool	78-70-6
Eucalyptol	470-82-6
3-Octanone	106-68-3
Hexyl acetate	142-92-7
beta-Myrcene	123-35-3
(+)-Camphor	464-49-3
3-Octyl acetate	4864-61-3
alpha-Pinene	80-56-8
Caryophyllene	87-44-5
Dodecane	112-40-3
alpha-Terpineol	98-55-5
Camphene	79-92-5
(Z)-7-tetradecene	41446-60-0
Terpinolene	586-62-9
Nonylcyclopropane	74663-85-7
Cyclopropane, 1,1-dimethyl-2-(3-methyl-1,3-butadienyl)-	68998-21-0
3-Ethyl-2-methyl-1,3-heptadiene	61142-35-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. LL#7 fabric conditioner, mix

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Limonene*	138-86-3
Acetone*	67-64-1
Methyl isopropyl ether	598-53-8
Eucalyptol	470-82-6
2,6-Di-tert-butyl-4-methylphenol	128-37-0
Methoxyacetic acid*	625-45-6
Methanol*	67-56-1
Dihydromyrcenol	18479-58-8
gamma-Terpinene	99-85-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. LL#8 wool & delicates, eucalyptus

Compounds	CAS#
Eucalyptol	470-82-6
Limonene*	138-86-3
o-Cymene	527-84-4
(1R)-(+)-alpha-Pinene	7785-70-8
gamma-Terpinene	99-85-4
alpha-Phellandrene	99-83-2
beta-Pinene	127-91-3
beta-Myrcene	123-35-3
beta-Phellandrene	555-10-2
2-Carene	554-61-0
Acetone*	67-64-1
beta-trans-Ocimene	3779-61-1
Ethanol*	64-17-5
Terpinolene	586-62-9

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. LL#9 mix

Compounds	CAS#
Limonene*	138-86-3
1-Pentanol*	71-41-0
Acetone*	67-64-1
(Z)-7-tetradecene	41446-60-0
alpha-Pinene	80-56-8
(±)-2-Methyl-1-butanol	137-32-6
Sabinene	3387-41-5
2-Octanone	111-13-7
1-Octyl trifluoroacetate	2561-21-9
Acetaldehyde*	75-07-0
1-Hexanol*	111-27-3
1,3,6-Trioxocane	1779-19-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. LL#10 citrus fusion

Compounds	CAS#
Limonene*	138-86-3
alpha-Pinene	80-56-8
beta-Myrcene	123-35-3
Acetaldehyde*	75-07-0
beta-Phellandrene	555-10-2
(Z)-beta-ocimene	3338-55-4
gamma-Terpinene	99-85-4
2-Methylfuran	534-22-5
Octanal	124-13-0
1-Octanol*	111-87-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 17
VOC occurrences among sunscreens (n=15):
G: green products, R: regular products

1. SS#1 baby (R)

Compounds	CAS#
Decamethylcyclopentasiloxane	541-02-6
Diisopropyl adipate	6938-94-9
Isopropyl alcohol*	67-63-0
Phenoxyethanol*	122-99-6
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. SS#2 baby (R)

Compounds	CAS#
Ethyl butyrate	105-54-4
Ethanol*	64-17-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. SS#3 baby (R)

Compounds	CAS#
Acetaldehyde*	75-07-0
Hexamethyldisiloxane	107-46-0
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. SS#4 baby (G) ^{Ci}

Compounds	CAS#
Pentane*	109-66-0
Butane*	106-97-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

5. SS#5 baby (R)

Compounds	CAS#
Ethanol*	64-17-5
Limonene*	138-86-3
beta-Pinene	127-91-3
Ethyl acetate*	141-78-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. SS#6 baby (R)

Compounds	CAS#
Benzyl alcohol*	100-51-6
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. SS#7 baby (G)

Compounds	CAS#
Ethanol*	64-17-5
Hexanal	66-25-1
Pentane*	109-66-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. SS#8 baby (R)

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Hexamethyldisiloxane	107-46-0
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. SS#9 baby (R)

Compounds	CAS#
Acetaldehyde*	75-07-0
Hexamethyldisiloxane	107-46-0
Tris(trimethylsilyl) borate	4325-85-3
3-Methylhexane*	589-34-4

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. SS#10 adult (R)

Compounds	CAS#
Phenoxyethanol*	122-99-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

11. SS#11 adult (R)

Compounds	CAS#
Acetaldehyde*	75-07-0
Phenoxyethanol*	122-99-6
Butane*	106-97-8

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

12. SS#12 adult (R)

Compounds	CAS#
Isopropyl alcohol*	67-63-0
Acetaldehyde*	75-07-0
Phenoxyethanol*	122-99-6
Cyclohexane*	110-82-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

13. SS#13 adult (G)

Compounds	CAS#
Decamethylcyclopentasiloxane	541-02-6
Isopropyl alcohol*	67-63-0
Ethanol*	64-17-5
Dodecamethylcyclohexasiloxane	540-97-6
Phenoxyethanol*	122-99-6
Hexanal	66-25-1
Hexamethylcyclotrisiloxane	541-05-9
Pentane*	109-66-0
Acetone*	67-64-1
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

14. SS#14 adult (G)

Compounds	CAS#
Pentane*	109-66-0
Hexanal	66-25-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

15. SS#15 adult (R)

Compounds	CAS#
Methanol*	67-56-1
Isopropyl alcohol*	67-63-0
Dimethoxymethane	109-87-5
Limonene*	138-86-3
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 18**VOC occurrences among fragrance-free products (n=15):****G: green products, R: regular products****1. FF#1 laundry liquid (G)**

Compounds	CAS#
Ethanol*	64-17-5
1-Octanol*	111-87-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

2. FF#2 laundry liquid (G)

Compounds	CAS#
3-Methoxy-3-methylbutanol	56539-66-3
2-Propylheptanol	10042-59-8
Nonane	111-84-2
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

3. FF#3 dish liquid (G)

Compounds	CAS#
Ethanol*	64-17-5
Carbon tetrachloride*	56-23-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

4. FF#4 body hand and face cream (G) ^{Ci}

Compounds	CAS#
Benzyl alcohol*	100-51-6
Ethanol*	64-17-5
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

^{Ci}Certified organic ingredients

5. FF#5 shampoo (G)

Compounds	CAS#
Ethanol*	64-17-5
(E)-3-Tetradecene	41446-68-8
(4E)-4-Tetradecene	41446-78-0
(Z)-7-tetradecene	41446-60-0
trans-7-Tetradecene	41446-63-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

6. FF#6 shampoo (G)

Compounds	CAS#
Toluene*	108-88-3

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

7. FF#7 moisturising lotion (R)

Compounds	CAS#
Trimethylsilanol	1066-40-6
Benzyl alcohol*	100-51-6
Hexamethyldisiloxane	107-46-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

8. FF#8 moisturising lotion (G)

Compounds	CAS#
Benzyl alcohol*	100-51-6
Isopropyl alcohol*	67-63-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

9. FF#9 Baby lotion (R)

Compounds	CAS#
Ethyl acetate*	141-78-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

10. FF#10 deodorant (G)

Compounds	CAS#
Ethanol*	64-17-5

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

11. FF#11 hand cream (R)

Compounds	CAS#
Propylcyclopropane	2415-72-7

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

12. FF#12 shampoo (G)

Compounds	CAS#
Acetone*	67-64-1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

13. FF#13 lotion (R)

Compounds	CAS#
Ethyl acetate*	141-78-6

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

14. FF#14 laundry liquid (R)

Compounds	CAS#
Acetone*	67-64-1
Acetaldehyde*	75-07-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

15. FF#15 laundry liquid (G)

Compounds	CAS#
Ethanol*	64-17-5
2-Methyl-2-propanol*	75-65-0

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 19

Potentially hazardous* compounds among all products (n=134):

Compound	CAS #	Prevalence (# of products)	Regular (n=68)	Green (n=66)
Limonene	138-86-3	82	40	42
Ethanol	64-17-5	56	27	29
Acetaldehyde	75-07-0	50	23	27
Ethyl acetate	141-78-6	25	12	13
Butane	106-97-8	22	19	3
Acetone	67-64-1	21	6	15
Benzyl alcohol	100-51-6	19	7	12
Isopropyl alcohol	67-63-0	18	12	6
Pentane	109-66-0	17	12	5
Methanol	67-56-1	17	9	8
Phenoxyethanol	122-99-6	14	9	5
Isopentane	78-78-4	12	12	0
Octamethylcyclotetrasiloxane	556-67-2	10	8	2
Isoamyl acetate	123-92-2	10	7	3
3-Methylhexane	589-34-4	9	9	0
1-Octanol	111-87-5	9	1	8
Heptane	142-82-5	8	8	0
2-Methyl-2-propanol	75-65-0	8	5	3
2-Methylhexane	591-76-4	7	7	0
Toluene	108-88-3	7	4	3
Cyclohexane	110-82-7	6	6	0
beta-Citral	106-26-3	6	1	5
(E)-citral	141-27-5	5	1	4
Ethyl formate	109-94-4	5	0	5
2-Butene	107-01-7	4	4	0
Carbon monoxide	630-08-0	4	4	0
2,4-Dimethylpentane	108-08-7	3	3	0
Tetracarbonylnickel	13463-39-3	3	3	0
2-Methylpentane	107-83-5	3	0	3
Hexane	110-54-3	3	0	3
2,2-Dimethylbutane	75-83-2	2	2	0
5-Methylheptan-3-one	541-85-5	2	2	0
Methylcyclohexane	108-87-2	2	2	0

n-Butyl ether	142-96-1	2	2	0
1,4-Dioxane	123-91-1	2	1	1
1-Hexanol	111-27-3	2	1	1
1-Pentanol	71-41-0	2	1	1
Benzaldehyde	100-52-7	2	1	1
Carbon tetrachloride	56-23-5	2	1	1
D-carvone	2244-16-8	2	1	1
Ethyl methyl ether	540-67-0	2	1	1
3-Methylpentane	96-14-0	2	0	2
Acetaldehyde diethyl acetal	105-57-7	2	0	2
Methyl isobutyl ketone	108-10-1	2	0	2
1,1-dichloroethylene	75-35-4	1	1	0
1-Propanol	71-23-8	1	1	0
2-(4-tert- Butylbenzyl)propionaldehyde	80-54-6	1	1	0
2,3,4-Trimethylpentane	565-75-3	1	1	0
2,4,4-Trimethylpent-1-ene	107-39-1	1	1	0
2-Hexyloxyethanol	112-25-4	1	1	0
Acetic acid	109-60-4	1	1	0
Allyl alcohol	107-18-6	1	1	0
amitrole (ISO)	61-82-5	1	1	0
Butyl acetate	123-86-4	1	1	0
Chloroform	67-66-3	1	1	0
Cyclopentane	287-92-3	1	1	0
Dibutyl phthalate	84-74-2	1	1	0
Diisopropyl ether	108-20-3	1	1	0
Propylene glycol butyl ether	5131-66-8	1	1	0
Undecane	1120-21-4	1	1	0
2,4-Dimethylhexane	589-43-5	1	0	1
2,4-Dimethylpentan-3-one	565-80-0	1	0	1
2-chlorotoluene	95-49-8	1	0	1
2-Methylpropan-1-ol	78-83-1	1	0	1
Chloromethane	74-87-3	1	0	1
Methoxyacetic acid	625-45-6	1	0	1
Methyl acetate	79-20-9	1	0	1
Octane	111-65-9	1	0	1
Propanal	123-38-6	1	0	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

Supplementary Table 20

Potentially hazardous compounds among all fragranced products (n=104):

Compound	CAS #	Prevalence (# of products)	Regular (n=52)	Green (n=52)
Limonene	138-86-3	80	38	42
Ethanol	64-17-5	46	25	21
Acetaldehyde	75-07-0	38	14	24
Ethyl acetate	141-78-6	22	9	13
Butane	106-97-8	20	18	2
Acetone	67-64-1	18	5	13
Methanol	67-56-1	16	8	8
Benzyl alcohol	100-51-6	15	5	10
Pentane	109-66-0	13	12	1
Isopentane	78-78-4	12	12	0
Isopropyl alcohol	67-63-0	12	8	4
Octamethylcyclotetrasiloxane	556-67-2	10	8	2
Isoamyl acetate	123-92-2	10	7	3
3-Methylhexane	589-34-4	9	8	1
Heptane	142-82-5	8	8	0
Phenoxyethanol	122-99-6	8	4	4
1-Octanol	111-87-5	8	1	7
2-Methylhexane	591-76-4	7	7	0
2-Methyl-2-propanol	75-65-0	7	5	2
Toluene	108-88-3	6	4	2
beta-Citral	106-26-3	6	1	5
Cyclohexane	110-82-7	5	5	0
2-Butene	107-01-7	4	4	0
Carbon monoxide	630-08-0	4	4	0
2-Methylpentane	107-83-5	3	0	3
Hexane	110-54-3	3	0	3
2,4-Dimethylpentane	108-08-7	3	3	0
Tetracarbonylnickel	13463-39-3	3	3	0
2,2-Dimethylbutane	75-83-2	2	2	0
5-Methylheptan-3-one	541-85-5	2	2	0
Methylcyclohexane	108-87-2	2	2	0
n-Butyl ether	142-96-1	2	2	0
1,4-Dioxane	123-91-1	2	1	1

1-Hexanol	111-27-3	2	1	1
1-Pentanol	71-41-0	2	1	1
Benzaldehyde	100-52-7	2	1	1
D-carvone	2244-16-8	2	1	1
Ethyl methyl ether	540-67-0	2	1	1
3-Methylpentane	96-14-0	2	0	2
Acetaldehyde diethyl acetal	105-57-7	2	0	2
Methyl isobutyl ketone	108-10-1	2	0	2
(E)-citral	141-27-5	1	1	0
1,1-dichloroethylene	75-35-4	1	1	0
1-Propanol	71-23-8	1	1	0
2-(4-tert- Butylbenzyl)propionaldehyde	80-54-6	1	1	0
2,3,4-Trimethylpentane	565-75-3	1	1	0
2,4,4-Trimethylpent-1-ene	107-39-1	1	1	0
2-Hexyloxyethanol	112-25-4	1	1	0
Acetic acid	109-60-4	1	1	0
Allyl alcohol	107-18-6	1	1	0
amitrole (ISO)	61-82-5	1	1	0
Butyl acetate	123-86-4	1	1	0
Carbon tetrachloride	56-23-5	1	1	0
Chloroform	67-66-3	1	1	0
Cyclopentane	287-92-3	1	1	0
Dibutyl phthalate	84-74-2	1	1	0
Diisopropyl ether	108-20-3	1	1	0
Propylene glycol butyl ether	5131-66-8	1	1	0
Undecane	1120-21-4	1	1	0
2,4-Dimethylhexane	589-43-5	1	0	1
2,4-Dimethylpentan-3-one	565-80-0	1	0	1
2-chlorotoluene	95-49-8	1	0	1
2-Methylpropan-1-ol	78-83-1	1	0	1
Chloromethane	74-87-3	1	0	1
Methoxyacetic acid	625-45-6	1	0	1
Methyl acetate	79-20-9	1	0	1
Octane	111-65-9	1	0	1
Propanal	123-38-6	1	0	1

*Classified as hazardous under Safe Work Australia, Hazardous Chemical Information System (SWA 2018)

