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Impact of room fragrance products on indoor air quality

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HIGHLIGHTS

- Various room fragrance products were tested in emission test chambers.
- Many products were strong sources of odorless solvents.
- More than 100 different fragrance substances were identified and quantified.
- The long term emission behavior of some products was tested.
- Accidental spilling of fragrance liquids may cause extreme solvent concentrations.

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ABSTRACT

Everyday life can no longer be imagined without fragrances and scented products. For the consumer, countless products exists which are solely or partly intended to give off a certain scent in sufficient concentrations to odorize a complete room. Sprays, diffusers and evaporators, scented candles and automatic devices for the distribution of fragrance liquids are typical examples of such products. If the consumer uses such products, his consent to the release of certain chemicals in his home can be implied, however, he may not know what kind of fragrance substances and solvents will be present in which concentrations.

In this study, we determined the volatile emissions of a number of fragrance products in detail. Measurements were carried out under controlled conditions in test chambers. The products were tested in a passive (unused) and an active state, wherever applicable. Following a defined test protocol, the release of volatile organic compounds, ultrafine particles and NO_x was monitored for each product. The potential for forming secondary organic aerosols under the influence of ozone was studied, and for a selection of products the long-term emission behavior was assessed. A remarkable variety of fragrance substances was found and more than 100 relevant compounds were identified and quantified. While it is the intended function of such products to release fragrance substances, also considerable amounts of non-odorous solvents and by-products were found to be released from several air fresheners. Emissions rates exceeding 2 mg/(unit*h) were measured for the five most common solvents.

1. Introduction

Scenting of household products like cleaning agents or detergents with volatile organic substances, specifically terpenes and terpenoids, has been common for many decades. Nowadays, a variety of products is available for the consumer to also perfume the air in rooms and offices. As these products become more and more popular, questions in regard to a possible impairment of indoor air quality arise (Nazaroff and Weschler, 2004; Steinemann, 2009). The topic is of specific interest because of the substantial time per day dwellers are exposed to the scent substances (and additives/solvents) in case of home application, and when the source strength of such products is considered. It also has to be taken into account that fragrance substances of other sources may already be present in indoor air due to use of household products (Coleman et al., 2008; Kang et al., 2012; Rossignol et al., 2013; Singer et al., 2006), and room scenting products may increase both the number and the concentrations of such compounds in the indoor environment.

Terpenoid substances, aldehydes and lactones are common substances in scenting products, and a majority of the compounds

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used are reactive enough to be susceptible to indoor chemistry (Nazaroff and Weschler, 2004; Singer et al., 2006; Uhde and Salthammer, 2007). Certain conditions in the distribution devices (e.g., elevated temperature, or the storage of concentrated liquids under oxygen contact for long periods of time) will also increase the possibility of not only the fragrance substances, but also degradation products being present in the air.

The impact of terpene release in indoor air has been studied for a long time. The mono-terpenes as well as their ozone-initiated degradation products have been a research topic for several decades. Early work (Weschler and Shields, 1997, 1999) indicated that ozone-terpene reactions can actually be observed in the indoor environment. Extensive studies were carried out on the physiological effects of terpenes and their decomposition products/intermediates (Clausen et al., 2001; Nørgaard et al., 2006; Wilkins et al., 2003; Wolkoff et al., 2012, 1999, 2013).

Allergic properties of numerous fragrance substances are recognized today, but the knowledge about long-term inhalative exposure is still fragmentary. For cosmetics usage of these substances the dermal exposure pathway is considered most important, and data on the sensitizing potential exists, see e.g. Bhatia et al. (2008), Lalko et al. (2007) and Lapczynski et al. (2008). In some countries, such substances are regulated, or the declaration is legally enforced like in e.g. EU (2003). The effectiveness of such risk management efforts is discussed controversially (Klaschka, 2010). Air fresheners and room fragrances, however, are no cosmetic products and the market is therefore mostly unregulated.

Unlike fragranced detergents, cleaning products or cosmetics (Huang et al., 2011; Jo et al., 2008; Nazaroff and Weschler, 2004), the air fresheners have no other (primary) function; their sole purpose is to odorize air in a building. Their use therefore represents an intended release of a – mostly unknown – substance mix in an indoor environment (VITO, 2008).

In this study a variety of room fragrance products was tested under defined conditions. The released scent substances and solvents were identified, long term emission behavior was measured and possible room concentrations were calculated. The intention of this article is to provide a more detailed overview on substances currently on the market, and on the release characteristics of different types of air fresheners.

2. Methods

2.1. Studied products

All tested products were bought in local stores or supplied by manufacturers. The products were commercial items sold in complete packaging including consumer information. Due to the huge variety of products and the countless number of product types, a representative testing is hardly possible. Therefore, products were chosen to give a broad overview over existing technologies and fragrance substances. For the selection of products the following points were considered:

1) Availability
   (Major brands were preferred to niche products)
2) Different scents
   (For example, lemon or vanilla scented products are available from most brands, therefore other scents were selected when possible)
3) Different techniques
   (A selection of passively evaporating products, spray products, electrically driven items and scented candles was considered)

Whenever a product had several intensity settings, a mean setting was selected for the test. A short description of the tested products is given in Table 1.

2.1.1. Diffusers and evaporators

'Diffuser type' odorizers usually consist of a fragrance liquid/gel, a storage container and some means to control evaporation or diffusion to an evaporation surface. Typical examples are stick diffusers, where several (typically 6–12) wood sticks are placed in a bottle and slowly evaporate the rising fragrance liquid over a time frame of days to weeks. Other constructions with similar function, e.g. with a wooden lid, a membrane or perforated plastic part can be found as well. For small rooms or cars gel-/liquid-filled evaporators are available. Items of each group were tested.

Some products require the consumer to fill the diffuser with the fragrance liquid, while others come pre-assembled, with the liquid reservoir already in place. Therefore, the possible impact of spilling was assessed separately.

Table 1
Overview of tested fragrance products.

Product	Type	Scent type	Package size	Remarks
S1	Passive diffuser	'Spring'	5.5 ml	Fragrance liquid cartridge activated by inserting, adjustable strength
S2	Electric evaporator	'Exotic mango-orange'	8 ml	Removable fragrance liquid cartridge
S3	Wood-stick	'Green tea'	100 ml	10 sticks need to be inserted into the pre-filled bottle.
S4	Car diffuser	'White'	18 g	Activation by removing a plastic strip
S5	Automatic spray	'Cherry magnolia'	250 ml	Pressurized container, timer setting adjustable in 3 steps
S6	Spray	'Natural'	50 ml	Pressurized container
S7	Potpourri bag	'Lavender'	100 g	Potpourri stays in fabric bag
S8	Potpourri	'Vanilla'	100 g	Loose potpourri
S9	Wood-stick	'Cherry blossom'	50 ml	Fragrance liquid needs to be poured in glass container, 12 sticks are placed in separate drill holes of a wood lid.
S10	Wood top	'Vanilla'	50 ml	Fragrance liquid needs to be poured in glass container, wood lid with a wooden plug immersed in the liquid.
S11	Wood stick	'Vanilla'	50 ml	10 sticks need to be inserted into the pre-filled bottle.
S12	Jar + wood balls	'Vanilla'	100 ml	Pump spray needs to be applied to wooden balls in a glass dish
S14	Candle	'Ice cream'	450 g	

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