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On organic emissions testing from indoor consumer products' use

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HIGHLIGHTS

- Three widely used consumer products were tested for their organic compound emissions.
- Three test chambers from different laboratories (0.26, 0.92, 20.24 m^3) were used.
- Emissions of the measured concentration were calculated by fit-for-purpose models.
- Terpenes' emission levels per product are given based on the three chamber testing.
- Emphasis is given on the variability of the results among the different chambers.

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ABSTRACT

A wide range of consumer and personal care products may, during their use, release significant amounts of volatile organic compounds (VOC) into the air. The identification and quantification of the emissions from such sources is typically performed in emission test chambers. A major question is to what degree the obtained emissions are reproducible and directly applicable to real situations. The present work attempts partly to address this question by comparison of selected VOC emissions in specific consumer products tested in chambers of various dimensions. The measurements were performed in three test chambers of different volumes (0.26–20 m^3). The analytic performance of the laboratories was rigorously assessed prior to chamber testing. The results show emission variation for major VOC (terpenes); however, it remains in general, within the same order of magnitude for all tests. This variability does not seem to correlate with the chamber volume. It rather depends on the overall testing conditions. The present work is undertaken in the frame of EPHECT European Project.

1. Introduction

A wide range of consumer products can release significant amounts of volatile organic compounds (VOCs) into the air, during their use. Based on respiratory health risk assessment studies in indoor environments, organic emissions from indoor sources such as the building materials and the consumer and personal care products may contribute considerably to the total exposure of VOC [1]. The identification and quantification of the emissions from these sources is typically performed in (small) emission test chambers, where environmental conditions are either controlled or well-characterized.

Until recently, the major part of the research activities on emission testing was focused on building material emissions. For building products, well-established emission test procedures, as well as sampling techniques, are also available, e.g. [2,3].

However, for consumer and personal care products, standards for emission testing and evaluation are currently unavailable. Based on literature, test protocols, as well as outcomes may vary between laboratories and may be difficult to compare, mainly due to different test conditions and objectives [4,5].

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In building material emission testing, the products are typically installed as a static object in the test chamber, with respect to the relevant ISO standard [3], test chamber dimensions, and reported loading factors. The compound emission is considered continuous. Several inter-laboratory studies have been performed in order to check the chamber test procedure in the light of repeatability and reproducibility of emission results [6–8]. The past studies showed significant variation of individual VOC emissions, among different laboratories (50–240%) while in the recent studies this variability reduced to about 20% [9]. This reduction is attributed to the use of more homogeneous emission sources and to the increscent of the standardization of test procedure. In addition, reference materials have been produced with an independently known emission rate in order to evaluate the performance of a laboratory emission chamber for furniture/building material VOC emission test [10].

In the case of the consumer products, the situation can be substantially different. Emissions will usually occur when a product is used; a realistic user scenario should, thus, be simulated in the test chamber. Some products can be considered as continuous emitting sources e.g., passive and plug-in (electric) air fresheners, while cleaning products and perfumes generally are sources with temporary (short-term) emission patterns. Emissions of such products were investigated in the past including volatile organic compounds [11–18] as well as the formation of secondary pollutants by the reaction of the emitted compounds with ozone [19–21]. The emission characterization was performed with various techniques such as head-space gas chromatography [15–18], solid phase microextraction [22], chamber test of various dimensions [11,14,19–21], and experimental houses [12,13]. Additionally, the products under study and the corresponding used scenarios differed from study to study.

However, an important aspect of an emission test protocol for consumer products is its comparability in emission test chambers of various dimensions together with the associated preparation of the products. To our knowledge, laboratory inter-comparisons of consumer product emissions have not been reported. Thus, for this reason, an inter-laboratory study on VOC emissions of consumer products was conducted, using a wide range of chamber test volumes. This study presents and compares the results of selected VOC emissions from three consumer products (plug-in air freshener, kitchen cleaning agent, and perfume) performed by three different laboratories with three different chamber tests.

2. The selected products

In the frame of the EPHECT Project, a series of consumer products characterized by exposures related to the household uses and user scenarios have been tested for organic and particle emissions [23,24]. The brand and product type selection for EPHECT product testing experiments was based on the IPSOS market survey study on EU users and their use patterns [25]. This market study took place in four (4) EU regions and led to the identification of the most used product brand and type in those regions and in the EU.

The list includes product classes such as cleaning agents, air fresheners, and personal care products that are known to emit VOCs. From these three product classes, three particular product types and brands have been selected for the inter-laboratory comparison by testing the same three consumer products in three different test chambers. The products were as follows:

a.) plug-in air freshener,
b.) kitchen cleaning agent, and
c.) perfume.

Based on the above mentioned IPSOS study, the selected products were the most popular in their class with 30% frequency use across the 10 countries for the kitchen cleaning agent, 55% for the plug-in air freshener, and 12% for the perfume.

According to anticipated best practice and feasibility, the products were applied and tested according to the EPHECT consumer product test protocol [23] that was developed on the basis of ISO 16000 standards.

3. The test chamber experiments

3.1. The experimental set up and test conditions

The climate chamber characteristics and the test conditions are summarised in Table 1, with chamber volumes that cover a wide range from 0.26 m^3 to a walk-in chamber of 20.24 m^3. The smallest chamber is a 0.26 m^3 emission test chamber made of stainless

Table 1
The climate chamber conditions.

Product category	Exp phase	Chamber volume V [m^3]	Air exchange rate λ [1/h]	Air velocity [cm/s]	T [°C]/RH [%]	Loading factor [m^2/m^3]	Product amount used m [g]	Sampling time [min]	Test duration [min]
Plug-in air freshener	1st phase	0.26	0.87	16	23/55	–	0.64 (0.10 g/h)	35–60	384
		0.92	0.5	30	23/50	–	0.27 (0.04 g/h)	30	390
		20.24	0.5	0.05	23/18	–	0.40 (0.08 g/h)	10–60	305
	2nd phase	0.26	0.87	–	22/50	–	1.25	10	490
		0.92	0.55	30	23/50	–	1.44	10	490
		20.24	0.5	0.05	23/18	–	0.52	10–60	427
Kitchen cleaning agent (cream)	1st phase	0.26	0.86	11.5	22/49	0.46	0.81	22–60	420
		0.92	0.5	30	23/50	0.4	0.43	30	390
		20.24	0.5	0.05	23/20	0.05	104.6	10–60	308
	2nd phase	0.26 (1)	0.88	6	23/55	0.47	0.86	10	430
		0.26 (2)	0.88	6	23/44	0.25	0.91	10	430
		0.26 (3)	0.88	6	23/52	0.47	1.45	10	430
		0.92 (1)	0.5	30	23/50	0.3	1.33	10	430
		0.92 (2)	0.5	30	23/50	0.4	1.73	10	430
		0.92 (3)	0.5	30	23/50	0.3	1.94	10	430
		20.24 (1)	0.6	0.05	26/40	0.074	17.5	10	379
		20.24 (2)	0.6	0.05	26/40	0.049	39.8	10	367
		20.24 (3)	0.6	0.05	25/40	0.099	42.04	10	491
		20.24 (4)	0.6	0.05	26/35	0.049	20.3	10	490
Perfume (liquid spray)	–	0.26	0.84	13	22/51	–	0.1	25–70	424
		0.92	0.5	30	23/50	–	0.06	30–60	420
		20.24	0.5	0.05	23/22	–	0.2	10	306