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Small-scale passive emission chamber for screening studies on monoterpene emission flux from the surface of wood-based indoor elements

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HIGHLIGHTS

• The passive emission chamber as a useful tool for fast screening terpene emission flux
• Emission flux of *α-Pinene*, *3-Carene*, and *D-Limonene* from wood-based material was studied.
• The effect of furnishing on indoor air quality of newly build apartment was studied.

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ABSTRACT

Analysis of literature data published in the last few years leads to the conclusion that in the process of assessment of emission flux of organic compounds emitted from different types of equipment and finishing materials, new types of devices, among which small-scale passive emission chambers for the performance of in-situ research are designed and applied on a larger scale. These devices can be successfully used for the assessment of emission flux of organic compounds in any location of an apartment, with no interference with its normal exploitation.
In the following article the possibility of application of a designed and constructed small-scale passive emission chamber for the evaluation of emission flux of organic compounds (mainly monoterpenes) emitted from the surface of wood-based material made of laminated chipboard has been presented. The emission chamber made from polished stainless steel of the inner volume of 3.65 dm^3 allows for the examination/assessment of emission flux from the surface of 452 cm^2. A diffusive passive sampler was installed inside of the small-scale chamber, which enables collecting samples of the analytes emitted from the examined surface of indoor material. The working time of the passive emission chamber equaled 300 min.
The results of preliminary studies show that, the constructed device can be successfully used for screening studies, related with the determination of emission flux of monoterpenes from any type of wood-based flat surface located indoors.

1. Introduction

Over the last few decades one can notice a clear turn in architectural engineering towards better calking of residential and office buildings by the use of energy saving thermal insulation (i.e. tight PVC windows) in order to save energy (Ng et al., 2012; Righi et al., 2002). Moreover, it can be noticed that the lack of optimal ventilation indoors (limited air exchange inside of a building) causes particular contamination which is present in indoor air on a relatively high level, being the reason for many respiratory, cardiovascular and nervous system diseases (Shinohara et al., 2009). Additionally, in recently built apartments, a new type of synthetic material is used as the elements of indoor equipment, the presence of which in an indoor environment may influence the kind, type and concentration of chemical compounds in indoor air (Shinohara et al., 2007; Wensing et al., 2005).

The results of studies performed in many research centers clearly indicate that the presence of organic compounds that can threaten human health in indoor air, results from the fact, that they are emitted from the surface of building materials and indoor finishing elements such as: furniture and wood-based plates, paints, glues and flat surface covers (wall papers, PVC floors, carpets etc.). One of the main groups of organic

Abbreviations: BTEX, benzene, toluene, ethylbenzene, o- m- and p-xylene; BVOCs, biogenic volatile organic compounds; EU, European Union; FLEC, field and laboratory emission cell; GC, gas chromatography; HDF, high-density fiberboard; MS, mass spectrometer; PFS, passive flux sampler; PVC, poly(vinyl chloride); SSPEC, small-scale passive emission chamber; TD, thermal desorption; TWA, time weight average; UV, ultraviolet; VOCs, volatile organic compounds.

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compounds having adverse health effect on humans is volatile organic compounds (He et al., 2012; Guo et al., 2003; Shin and Jo, 2012).

Monoterpenes are the main groups of VOCs, the presence of which has been stated in indoor air. These compounds can be emitted to indoor air from wood-based products or cosmetics, personal hygiene products and air fresheners (Forester and Wells, 2011; Singer et al., 2006; Schripp et al., 2012). Moreover, green plants grown in closed rooms can be an additional source of emission of terpenes to indoor air (BVOCs) (Ortega et al., 2008; Joo et al., 2010).

Monoterpenes are characterized by high reactivity. Reacting with nitrogen oxides and tropospheric ozone they form indirect (secondary) contamination of indoor air, to which belong i.e.: pinene oxide, pinonaldehyde (when *α-Pinene* is the reaction substrate) and limonene oxide, carvone, formaldehyde (when *D-Limonene* is the reaction substrate) (Uhde and Salthammer, 2007). Nitrogen oxides and tropospheric ozone are mainly transported indoors directly from the atmospheric air surrounding the closed room. Additionally, nitrogen oxides and tropospheric ozone can be emitted to the indoor air from devices being the equipment of living or office quarter that is photocopiers, laser printers, gas stoves, and UV light sources (Uhde and Salthammer, 2007; Hubbard et al., 2005). A detailed description of the mechanisms of reactions taking place in indoor air leading to the formation of secondary contamination of indoor air can be found in many reports in literature (Atkinson and Arey, 2003; Aschmann et al., 2002).

Their concentrations in indoor air are much higher, than other organic contaminants such as benzene, toluene or xylenes (Hollender et al., 2002; Saarela et al., 2003). Due to the fact, that adults spend from 80 up to 90% of their life indoors (Righi et al., 2002; Yrieix et al., 2010; Salthammer, 2011), the time of human exposure to the harmful effect of xenobiotics present in indoor air is very long, which increases the risk of endangering human body to the negative influence of chemical compounds.

Analyzing literature data published in the last few years (presented in the scientific reviews by Marć et al. (2012, 2013) and Salthammer and Bahadir (2009) and in original publications cited in them) one can distinguish two basic methodological approaches in the scope of determining or estimating the organic compound emission flux emitted from the surface of finishing materials and indoor equipment elements:

- Ex-situ methods — mostly based on the use of stationary (small or large) testing emission chambers, in which environmental parameter optimization such as: temperature, pressure, humidity, air exchange rate, and loading factor is possible,
- In-situ methods — measurements are performed directly in closed rooms with no interference with everyday functioning of their users. Devices characterized by small size are commonly used, to which belong: field and laboratory emission cell (FLEC) and passive flux sampler (PFS).

The use of stationary testing emission chambers is very time consuming, costly and is related with the transportation of indoor material to the research laboratory and, in case of the use of small size emission chambers, it is necessary to comminute the indoor material into elements of appropriate length and width, in order to adjust the surface of the studied elements to the requirements of the chamber research, reflecting conditions and obtaining indoors (Wensing et al., 2005; Marć et al., 2012; Yamashita et al., 2010). Due to this fact devices enabling screening test performance in a fast and non-invasive manner in order to obtain analytical information on the type and quantity of VOCs, which are emitted from the surface of the tested indoor material, are becoming more and more popular.

In the in-situ studies emission flux of VOCs, devices using passive sampling technique at the stage of samples collection emitted from the surface of indoor materials have been used. Passive devices for screening in-situ studies on the emission flux combine the features of classical emission chambers in a small-scale form (small-scale passive emission chambers — SSPEC), with the advantages of passive sampling technique (lack of carrier gas supply lines, low cost of particular construction elements, measurement easiness, possibility of handling by unqualified staff). Moreover, small-scale passive emission chambers (SSPEC), because of their small size and simplicity of handling, can be used in many indoor locations without an inconvenient influence on functioning of the users (Yamashita et al., 2010; Blondel and Plaisance, 2011; Kang et al., 2010).

The applicability of the SSPEC in emission flux in-situ screening studies has been presented in this work. The *Radiello®* diffusive passive sampler was used, as an element for collecting organic compounds, emitted from the surface of indoor material. The use of the SSPEC described in the article allows for estimating the average emission flux of monoterpenes emitted from the indoor material in a non-invasive/non-destructive way. Moreover, the results of preliminary screening studies performed in in-situ conditions aimed at receiving of analytical information about the quantity of monoterpenes emitted from a wood-based material being the equipment of an apartment, have been presented in the article. Additionally, an attempt of the assessment of the influence of emission of monoterpenes emitted from the surface of the studied wood-based material on the quality of indoor air in the studied closed room was made.

2. Materials and methods

2.1. Sampling device characteristic

In order to obtain analytical information about the quantity and type of VOC compounds (including monoterpenes), which can be emitted from the surface of finishing or indoor material, the small-scale passive

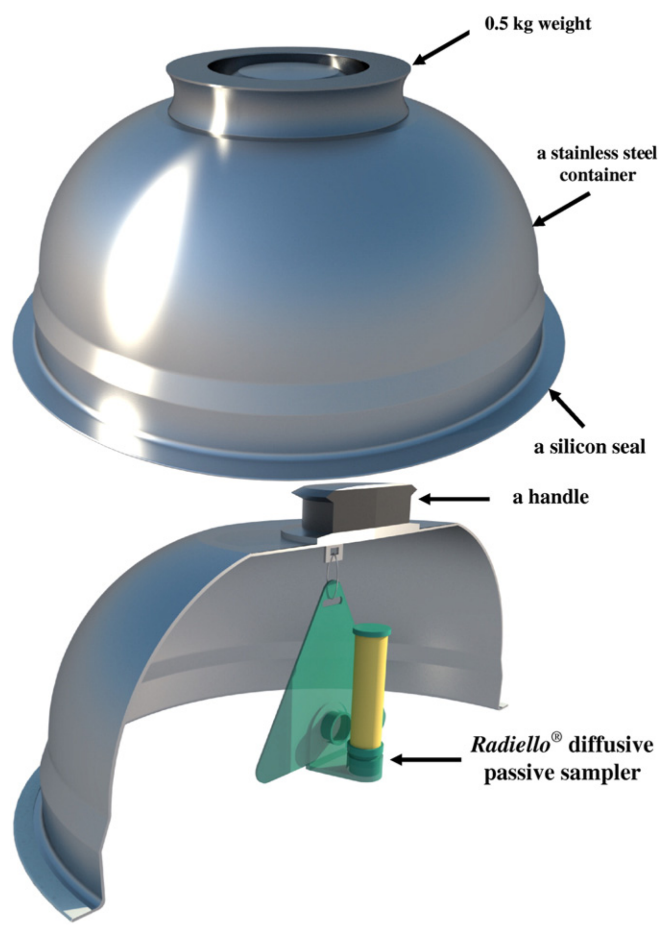

Fig. 1. General schematic view of the small-scale passive emission chamber.