Available online at www.sciencedirect.com
ScienceDirect
Building and Environment 42 (2007) 4059–4067
BUILDING AND ENVIRONMENT
www.elsevier.com/locate/buildenv

Sensory and chemical evaluation of odorous emissions from building products with and without linseed oil

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Received 18 January 2006; received in revised form 5 May 2006; accepted 18 May 2006

Abstract

Natural materials of biological origin degrade over time and may emit odorous chemical compounds that can influence the perceived indoor air quality. The objective of this study was to investigate how the perceived air quality is influenced by emissions from building products with linseed oil compared with similar conventional synthetic products without linseed oil. Two types of linoleum, two types of wall paint and two types of floor oil were selected as examples of natural products containing linseed oil. The selected synthetic products were PVC floor covering, a water-based paint, and a synthetic floor oil. The emissions from the products were monitored over a one-year period in small ventilated test chambers. The odorous emissions were evaluated by sensory panel assessments of odour intensity and acceptability and by chemical analysis of the odour-active volatile organic compounds (VOCs) and carbonyl compounds. Odour-active VOCs in the emissions from one floor oil with linseed oil and two pure linseed oils were detected by gas chromatography combined with olfactometry (GC-O) and attempted identified with mass spectrometry (MS). The products with linseed oil influenced the perceived air quality more negatively than the similar synthetic products and the odour was persistent over time. It was found that the products with linseed oil did not qualify for the Danish Indoor Climate Label, because of the persistency of the odour. The results of the GC-O/MS investigations and VOC measurements indicated that an almost constant emission of odour-active VOCs with low odour thresholds resulted in the persistency of the odour. The VOCs probably originated from oxidation products from the linseed oil used as raw material. The study indicates that the acceptability of the emissions from the floor oil was influenced by the linseed oil used as raw material. It is therefore suggested that systematic use of less odorous linseed oils may improve the acceptability of the emission from products with linseed oils. The applied combination of sensory assessment of perceived air quality and GC-O/MS seems to be a useful approach in the effort to eliminate unwanted odours from building products.

Keywords: Building products; Emission; Indoor chemistry; Linseed oil; Odour; Perceived air quality

1. Introduction

There is increasing environmental awareness and consequently a growing interest in using natural, including ecological, building products. Natural products possess a number of properties that building professionals and end-users consider attractive. The products may contain organic substances that originate directly from nature and thereby differ from conventional products that are often synthetic.

In addition to the interest in using natural building products there is an increasing consciousness about comfortable and healthy indoor environments. It is generally considered that building products emit pollutants that may influence the perceived indoor air quality. Therefore, when selecting environmentally friendly building products, it should not be at the expense of the indoor air quality.

Natural materials of biological origin are often more susceptible to degradation than synthetically produced materials. This may be due to e.g. reactions with ozone [1–3]. During this process unwanted odour-active chemical compounds can be formed that may influence the perceived

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doi:10.1016/j.buildenv.2006.05.009

air quality negatively. As early as the 1600s this was described for artists' use of linseed oil [4].

Linseed oil paints [5,6], linoleum [7–9] and conventional water-based paints [10] may emit odorous volatile organic compounds (VOCs). The process of degradation may continue during the entire life of the product, i.e. for several years [1]. This is opposed to the typically faster decay of the emission rate of synthetic products. These emissions often originate from compounds that have been added to the products during their production, e.g. solvents. This typically occurs in the course of a few weeks like in water-based paints [11,12]. Water-based paints may, however, contain additives that take over a year to emit [11,13].

The established Danish Indoor Climate Labelling Scheme for building products assesses the emission from products by means of chemical measurements and sensory assessments of the odour [14,15]. For a product to be awarded a label, the concentration of relevant VOCs and the perceived air quality must comply with established levels for approval. The time, when these requirements are satisfied, is called the indoor-climate-relevant time-value of the product [15]. The Labelling Scheme stipulates how high this value is allowed to be for different types of products. Experience shows that some building products with natural ingredients have difficulty in obtaining the Indoor Climate Label, because the indoor-climate-relevant time-value is unacceptably long. This is the case for example for some wood-based products and linoleum. Another experience is that the perceived air quality is influenced by emitted VOCs in low concentrations, and these are difficult to link to the odour, because our understanding of odorous mixtures is limited.

During product development of indoor climate friendly products there is a need to measure how the emissions are perceived by humans and there is a need to identify the emitted VOCs to help the manufacturer to reduce the odorous emission that influence the perceived air quality negatively. Traditionally, sensory measurements of perceived air quality are used without knowing the chemical composition of the emissions and chemical measurements are used to identify and quantify VOCs without knowing if they are important for the odour perception. However, the most relevant odour-active VOCs for the perceived air quality may be detected by a technique that combines gas chromatography with the use of olfactometry, the so-called GC-O technique [16]. In combination with mass spectrometry (GC-O/MS) some of the odour-active VOCs may be identified.

In this study, building products with linseed oil were selected as representative of natural products. The objective of the study was to investigate, whether emissions from building products with linseed oil influence the perceived air quality to a greater extent than similar conventional synthetic products without linseed oil. In addition, the objective was to try to identify the odour-active VOCs responsible for the perceived air quality by applying the GC-O/MS technique mentioned above.

2. Methods

The study was divided into three parts. (1) Odorous emissions from six selected wall and floor products with linseed oil and three similar conventional synthetic products without linseed oil were studied. Measurements were performed 2, 12, 25 and 51 weeks after the products were placed in ventilated test chambers. The emissions were evaluated in two ways, by a sensory panel assessing odour intensity and acceptability and by chemical measurements of VOCs and carbonyl compounds. (2) Odorous emissions from six pure linseed oils were evaluated by the same sensory panel in order to assess the difference of the linseed oils used as raw materials. (3) The GC-O/MS technique was used to detect and identify the odour-active VOCs in one floor oil with linseed oil and two pure linseed oils used as raw materials.

2.1. Investigated products

Linseed oil is a natural oil extracted from flax seeds. It is used as an ingredient in e.g. linoleums, paints, varnishes and stains and as preservative oil for wood and concrete.

The selected products shown in Table 1 represent floor covering, wall paint and floor oil. Emissions from these products may be important, since they cover large areas indoors and they are in direct contact with the indoor air. The products with linseed oil were selected and bought from shops specialising in natural products. The synthetic products were selected from leading brands that have been established on the Danish market for a long time and recognised for good quality and durability. An empty test chamber and the substrates used, i.e. plasterboard for wall paint and raw beechwood for floor oil, were all evaluated for the establishment of background levels.

Table 1
Products with and without linseed oil

Products with linseed oil	Products without linseed oil
Two types of linoleum	PVC
Linoleum 1 (low content of sawdust)	PVC
Linoleum 2 (high content of sawdust)	
Two types of wall paint, water-based with linseed oil, on plasterboard	Wall paint, water-based, on plasterboard
Paint 1	Synthetic paint
Paint 2	
Two types of floor oil, based on linseed oil, on raw beechwood	Synthetic floor oil with white spirit (isoparafine) as solvent, on raw beechwood
Floor oil 1	Synthetic floor oil
Floor oil 2	