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# MATERIALS USED FOR THE PRODUCTION OF UPHOLSTERED FURNITURE LIKE SOURCE OF ODORS IN INTERIOR

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## Abstract

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This paper investigates the problematic of VOC emissions and their assessment by olfactory methods. The main goal of this contribution is determine the odors emitted by upholstery fabrics used for upholstered furniture. This contribution researches the correlation between the results, which were obtained by the olfactory assessment and the results of the measurements of volatile organic compounds (VOCs) emitted by choose the kind of covering textiles. This research judged the influence of upholstery fabrics with different chemical composition (polyester, cotton and mixture of viscose and cotton) on olfactometric assessment. It was mainly focused on the determination of Hedonic tone and intensity of the odor. These olfactometric characteristics were determined using an equipment Sniffer 9000. Concurrently was also assessed the influence of climatic conditions in small space chamber on olfactometric assessment of tested materials. The climatic conditions differed mainly in terms of temperature and relative humidity in small space chamber. The results are compared with sensory perceptions and the qualitative and quantitative analysis of VOCs performed by using the gas chromatograph Agilent GC 6790 with mass spectrometer detector 5973. The experimental section shows that, the various types of criticized upholstery fabrics with different chemical composition emitted relatively low concentrations of VOC emissions. It was also demonstrated the influence of climatic conditions on VOC emissions and while on their olfactometric assessment. The tested materials of upholstery fabric showed very intensive olfactory sensation, which were described as very unpleasant (–4) in some cases.

Keywords: olfactometry, VOC emissions, gas chromatography, upholstery fabrics, percept, odor

## INTRODUCTION

Most frequent indoor complaints related to IAQ[1] are odor annoyance, irritation, headaches, and nausea (Reitzig *et al.*, 1998; Järnström *et al.*, 2006). Among these, the prevalent complaint is odor annoyance. Odor is perceived due to the chemical stimulation of chemoreceptor cells in the olfactory epithelium of the nose by the gas molecules (Dincer *et al.*, 2006; Duffee *et al.*, 2000). Odor property is important in indoor air quality for several reasons. Firstly, the sense of smell often serves as a warning signal, since reported odor detection thresholds of some volatile organic compounds (VOCs) are generally one to four orders of magnitude lower than estimated thresholds for irritation effects (Wolkoff *et al.*, 2006; Cometto-Muñiz *et al.*, 2004). Secondly, human sensitivity to odor is much greater than that of instrumental methods (Duffee *et al.*, 2000). Thirdly, odor character (the ability to distinguish among different odors) is a useful property for determining the possible source of an odor in complaint investigations.

1 IAQ – Indoor Air Quality

Therefore, recognition of odor character may be the first indication of possible sources. People are concerned with several issues regarding with odors, such as "Can odors cause health problems?", "What are the chemical characterizations of common indoor odors?", and "What is the relationship between chemical pollutants and perceived odors?" Odors are not necessarily associated with adverse health effects. Unpleasant odors have often been recognized as "warning" signs of potential risks to human health rather than direct triggers of health effects. Certain chemicals that produce odors are potentially harmful. On the other hand, an unpleasant odor does not mean it is harmful (Rosenkranz *et al.*, 2003). When the odor source is unidentified, negative emotion could increase and this would increase the arousal level (Wolkoff *et al.*, 2006). Therefore, it is important to find out the chemical characterization and sources of odors, and to understand the relationship between indoor chemical pollutants that produce significant adverse health effects and odors. The ultimate goals are to control the sources and solve the IAQ problem. Most odorants are organic compounds, especially compounds with sulfur, nitrogen, and oxygen, such as alcohols, aldehydes, ketones, esters, ethers, aromatics, terpenes, and amines (Duffee *et al.*, 2000; Filipy *et al.*, 2006).

Few similar studies are found for indoors. These studies focus on investigating the odor character from heating, ventilation and air conditioning (HVAC)[2] systems, such as filters and duct dust (Bitter *et al.*, 2002; Hyttinen *et al.*, 2007), and do not investigate the odor property for the whole indoor environment. Like industrial and urban facilities, each indoor odorous source has its characteristic odor and chemical composition. For example, furniture and wood paneling usually emit formaldehyde, which is characterized as sharp and irritating; new carpets release 4-phenylcyclohexene, which is considered as the odor of new carpets. Moreover, some chemicals frequently present indoors can exert specific and strong odors. These chemicals include aromatics (toluene, styrene, and xylene), aldehydes (formaldehyde, acetaldehyde) and terpenes (α-pinene and limonene). Therefore, there is a certain relationship between perceived odors and chemical composition indoors. Indoor odors are usually mild and intermittent, and the sources of indoor odor are varied and usually non-specific; therefore, it increases the difficulty to characterize indoor odors and to identify the odor sources. Still, characterization of odors (qualitative and quantitative) can help to identify pollution sources and play an important role in evaluating indoor air quality due to greater human sensitivity to odor (Duffee *et al.*, 2000; Knudsen *et al.*, 2007).

Bad odours of indoor air may be caused by equipment. In the study there has been investigated the upholstered furniture as the potential source of the bad odour. The objectives of this contribution are to characterize the influence of upholstery cover textile on the quality of indoor air from the point of chemical pollutants and their odor characteristics.

### The aim of this study

In this study there were compared and correlated the measured chemical concentrations and odor presence frequency of emitted volatile organic compounds by textile materials. Some kinds of upholstery fabrics belong to the important source of volatile organic compounds and so the sources of odours. We were investigating the VOC emissions emitted by some kinds of upholstery fabrics made from textile of various chemical compositions: We were monitored the influence of the climatic parameters in small space chamber (normal, high, low temperature and humidity) on the olfactometry activity of VOC emissions emitted by different samples of textiles.

1. To identify the main components of emissions emitted by upholstery fabrics,
2. to solve the odour impact of the individual chemical compound in the correlation with the concentration of measured emissions,
3. to identify the influence of the climatic conditions on the amount of VOC emissions and their odour activities,
4. to indentify the influence of the textile chemical composition on the amount of VOC emissions and their odour activities.

## MATERIALS AND METHODS

### Used methods

The special combined techniques of the sensorial analysis E-nose Sniffer in conclusion with the GC-MS chromatography and the thermal desorption were used for the measurement.

In the first step the samples of the textile with the area 1m$^2$ were prepared for testing. The prepared sample of the textile was put into the chamber with different climatic conditions.

In the second step we started to collect VOC emission emitted by the tested sample of the different textile into the desorption tubes on the sorbent TENAX TA.

In the third step the emitted air collected into desorption tubes was evaluated and split of the effluent of chromatography column into two streams. One stream is analyzed by the detector of the gas chromatography and the second stream is passed into an effluent of spectro Sniffer. The results of gas chromatography is the chromatogram

2 HVAC – Heating, Ventilation and Air Conditioning

with quality and quality identification of chemicals and the olfactogram coming at in the same time from human olfactory response sniffer is the. The both reached results: the quality and quantity of determined volatile organic compounds to the sensory results were compared. The results of the chromatogram and the results of the olfactogram were evaluated.

### Tested samples

We were investigating the VOC emissions emitted by some kinds of upholstery fabrics made from textile of various chemical compositions:

1. first kind: **textile A** – Polyester (100%),
2. second kind: **textile B** – Cotton (100%),
3. third kind: **textile C** – mixture of Viscose (63%), Cotton (37%).

### Tested conditions in small space chamber

- Time of sampling of air from small space chamber was 3 hours (180 minutes) for all tested samples,
- volume of sampling of air was 36 litres (used air sampler GILIAN with flow 12l.h$^{-1}$) for all tested samples.

### Methods of VOC testing were set via standards

ISO 16000: 2007 Indoor air,

ISO 16000-1: 2007 General aspects of sampling strategy,

ISO 16000-5: 2007 Sampling strategy for volatile organic compounds (VOCs),

ISO 16000-11: 2007 Determination of the emission of volatile organic compounds sampling, storage of samples and preparation of test specimens.

### VOC samplings in small-space chambers were done according to

ISO 16000-6: 2007 Determination of volatile organic compounds indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and chromatography using MS/FID,

ISO 16000-9: 2007 Determination of the emission of volatile organic compound from building products and furnishing- Emission test chamber method.

The main impact for odour has the irritant thresholds of emitted chemicals that means at what level a chemical is an odorant for the first time and then becomes an irritant. We compared the thresholds of volatile organic compounds.

### Determination of hedonic tone for individual VOCs in the mixture

Hedonic tone for each substance is determined using by equipment Sniffer 9000. The Assessor submits the assessment of individual substances at specified time intervals. Assessor determines hedonic tone of odor substances under according the Hedonic scale. At the same time he writes data from the point of the character, odor and

I: *Parameters of tested samples*

| Upholstery fabric | Textile materials | Old materials from production | Sample preparation | Storage conditions | |
|---|---|---|---|---|---|
| | | | | Temperature [° C] | Rel. Humidity [%] |
| Textile (A) | Polyester (100%) | 6 months | cut of 1m$^2$ | 23 | 50 |
| Textile (B) | Cotton (100%) | 6 months | cut of 1m$^2$ | 23 | 50 |
| Textile (C) | Mixture of Viscose (63%) and Cotton (37%) | 5 months | cut of 1m$^2$ | 23 | 50 |

II: *Parameters of climatic conditions from small space chamber*

| Climatic conditions | Normal conditions | High conditions | Low conditions |
|---|---|---|---|
| Temperature [°C] | 23 | 40 | 15 |
| Relative Humidity [%] | 50 | 55 | 40 |
| Air changing rate [1m$^3$.h$^{-1}$] | 1 | 1 | 1 |
| Air speed over the tested samples [m.s$^{-1}$] | 0.3 | 0.3 | 0.3 |

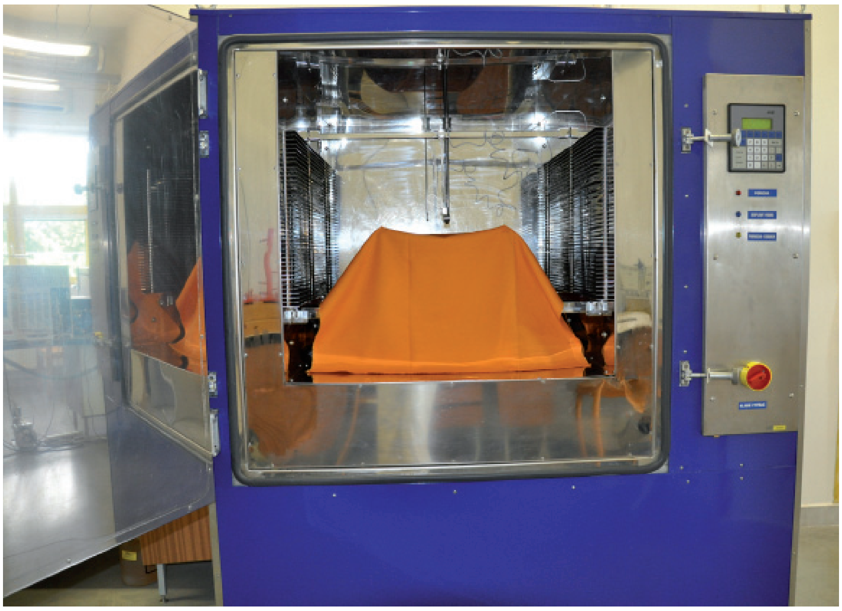
III: *Rating scale of odors*

| Hedonic tone and intensity of odour | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| very unpleasant | unpleasant | mind it | could mind it | rather don´t like it | Don´t mind it | rather like it | could like it | pleasant | very pleasant | very pleasant glow |
| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |

pleasantness. The data have been expressed Signed / + /, or annoyance expressed Signed / – /, made into tables. The output is a graph of sensations with retention times. Its overlap with the chromatogram assign to individual records identified substance.

### Used equipment

- Small-space chamber for VOCs testing,
- thermal Desorption Tube 786090, inner diameter 4 mm, filled in with 100 mg of Tenax TA (Scientic Instrument Services Company) for collection of VOC emissions tested samples into the air in chamber,
- air sampler Gilian – LFS 113 SENSIDYNE with air flow $12\ l.h^{-1}$,
- gas chromatograph Agilent GC 6790 with MS (mass spectrometer) detector 5973, thermal desorption,
- olfactory detector outlet Sniffer 9000 based on sensor techniques, one the most sensitive and intelligent detector.



1: *Air conditioning of tested sample in small space chamber – VOC TEST 1000*


2: *Sniffer 9000 – equipment for detection of olfactometric record (in conjunction with gas chromatograph – Agilent 4890)*

## RESULTS

IV: *VOCs emissions emitted by textile – A (100% PES)*

| | VOCs | Climatic conditions | | | |
|---|---|---|---|---|---|
| | **Volatile organic compounds (VOCs)** | **Normal (23 °C, 50%)** | **Hight (40 °C, 55%)** | **Low (15 °C, 40%)** | **Decree No.6/2003** |
| **No.** | **Compounds** | **Average result ± expanded measurement uncertainty** | **Average result ± expanded measurement uncertainty** | **Average result ± expanded measurement uncertainty** | **Hygienic Limit **** |
| | **Unit** | **μg/m³** | **μg/m³** | **μg/m³** | **μg/m³** |
| 1 | Ethyl acetate | (0.6 ± 0.2) | (1.2 ± 0.4) | (0.5 ± 0.2) | NLC |
| 2 | Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | 7 |
| 3 | 1-Methoxy-2-Propanol | (0.4 ± 0.1) | (0.1 ± 0.03) | (0.2 ± 0.1) | NLC |
| 4 | Pentanal | (0.4 ± 0.1) | (0.2 ± 0.1) | (0.4 ± 0.1) | NLC |
| 5 | Trichlorethylene | < 0.1 | < 0.1 | < 0.1 | 150 |
| 6 | Toluene | (1.3 ± 0.4) | (2.1 ± 0.6) | (1.4 ± 0.4) | 300 |
| 7 | Hexanal | (0.8 ± 0.2) | (0.4 ± 0.1) | (0.6 ± 0.2) | NLC |
| 8 | Tetrachlorethylene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | 150 |
| 9 | n-Butyl acetate | (0.7 ± 0.2) | (0.4 ± 0.1) | (0.6 ± 0.2) | NLC |
| 10 | Ethylbenzene | (0.2 ± 0.1) | (0.2 ± 0.1) | (0.2 ± 0.1) | 200 |
| 11 | m,p-Xylene | (0.8 ± 0.2) | (0.8 ± 0.2) | (1 ± 0.3) | 200*** |
| 12 | Styrene | (0.2 ± 0.1) | (0.1 ± 0.03) | (0.1 ± 0.03) | 40 |
| 13 | o-Xylene | (0.2 ± 0.1) | (0.2 ± 0.1) | (0.2 ± 0.1) | 200*** |
| 14 | Butoxy-Ethanol | (0.2 ± 0.1) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 15 | α-Pinene | (0.1 ± 0.03) | (0.2 ± 0.1) | (0.3 ± 0.1) | NLC |
| 16 | Camphene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 17 | 3-Ethyl-Toluene | (0.5 ± 0.2) | (0.4 ± 0.1) | (0.5 ± 0.2) | NLC |
| 18 | 4-Ethyl-Toluene | (0.3 ± 0.1) | (0.2 ± 0.1) | (0.5 ± 0.2) | NLC |
| 19 | 1,3,5-Trimethyl-Benzene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 20 | β-Pinene | (0.1 ± 0.03) | (0.3 ± 0.1) | (0.2 ± 0.1) | NLC |
| 21 | 2-Ethyl Toluene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 22 | Myrcene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 23 | 1,2,4-Trimethyl-Benzene | (0.3 ± 0.1) | (0.3 ± 0.1) | (0.3 ± 0.1) | NLC |
| 24 | α-Phellandrene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 25 | 3-δ-Caren | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 26 | 1,2,3-Trimethyl-Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 27 | Limonene | (0.2 ± 0.1) | (0.1 ± 0.03) | (0.3 ± 0.1) | NLC |
| 28 | γ-Terpinene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 29 | Bornyl Acetate | < 0.1 | < 0.1 | < 0.1 | NLC |
| 30 | $TVOC^{3}_{MS}$[4] | (32± 10) | (39± 12) | (27 ± 8) | NLC[5] |

3 TVOC – Total Volatile Organic Compounds
4 MS – Mass Spectrometer
5 NLC – Not specified Limit Concentration

V: *VOCs emissions emitted by textile – B (100% COTTON)*

| | VOCs | Climatic conditions | | | |
|---|---|---|---|---|---|
| | Volatile organic compounds (VOCs) | Normal (23 °C, 50%) | Hight (40 °C, 55%) | Low (15 °C, 40%) | Decree No.6/2003 |
| No. | Compounds | Average result ± expanded measurement uncertainty | Average result ± expanded measurement uncertainty | Average result ± expanded measurement uncertainty | Hygienic Limit ** |
| | Unit | μg/m³ | μg/m³ | μg/m³ | μg/m³ |
| 1 | Ethyl acetate | (0.4 ± 0.1) | (0.8 ± 0.2) | (0.5 ± 0.2) | NLC |
| 2 | Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | < 0.1 | 7 |
| 3 | 1-Methoxy-2-Propanol | (0.3 ± 0.1) | (0.2 ± 0.1) | (0.2 ± 0.1) | NLC |
| 4 | Pentanal | (0.3 ± 0.1) | (0.4 ± 0.1) | (0.4 ± 0.1) | NLC |
| 5 | Trichlorethylene | < 0.1 | < 0.1 | < 0.1 | 150 |
| 6 | Toluene | (1.7 ± 0.5) | (3.9 ± 1.2) | (3.3 ± 1) | 300 |
| 7 | Hexanal | (0.5 ± 0.2) | (0.7 ± 0.2) | (0.6 ± 0.2) | NLC |
| 8 | Tetrachlorethylene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | 150 |
| 9 | n-Butyl acetate | (0.7 ± 0.2) | (0.7 ± 0.2) | (0.9 ± 0.3) | NLC |
| 10 | Ethylbenzene | (0.1 ± 0.03) | (0.5 ± 0.2) | (0.3 ± 0.1) | 200 |
| 11 | m,p-Xylene | (1 ± 0.3) | (1.9 ± 0.6) | (1.1 ± 0.3) | 200*** |
| 12 | Styrene | (0.1 ± 0.03) | < 0.1 | (0.1 ± 0.03) | 40 |
| 13 | o-Xylene | (0.3 ± 0.1) | (0.4 ± 0.1) | (0.3 ± 0.1) | 200*** |
| 14 | Butoxy-Ethanol | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 15 | α-Pinene | (0.2 ± 0.1) | (0.3 ± 0.1) | (0.2 ± 0.1) | NLC |
| 16 | Camphene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 17 | 3-Ethyl-Toluene | (0.5 ± 0.2) | (0.1 ± 0.03) | (0.4 ± 0.1) | NLC |
| 18 | 4-Ethyl-Toluene | (0.5 ± 0.2) | (0.1 ± 0.03) | (0.3 ± 0.1) | NLC |
| 19 | 1,3,5-Trimethyl-Benzene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 20 | β-Pinene | (0.2 ± 0.1) | (0.2 ± 0.1) | (0.2 ± 0.1) | NLC |
| 21 | 2-Ethyl Toluene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 22 | Myrcene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 23 | 1,2,4-Trimethyl-Benzene | (0.4 ± 0.1) | (0.5 ± 0.2) | (0.3 ± 0.1) | NLC |
| 24 | α-Phellandrene | < 0.1 | (0.1 ± 0.03) | < 0.1 | NLC |
| 25 | 3-δ-Caren | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 26 | 1,2,3-Trimethyl-Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 27 | Limonene | (0.2 ± 0.1) | < 0.1 | (0.1 ± 0.03) | NLC |
| 28 | γ-Terpinene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 29 | Bornyl Acetate | < 0.1 | < 0.1 | < 0.1 | NLC |
| 30 | $TVOC_{MS}$ | (36 ± 11) | (43 ± 13) | (20 ± 6) | NLC |

VI: *VOCs emissions emitted by textile REAL (63% VISCOSE, 37% COTTON)*

| | **VOCs** | **Climatic conditions** | | | |
|---|---|---|---|---|---|
| | **Volatile organic compounds (VOCs)** | **Normal (23 °C, 50%)** | **Hight (40 °C, 55%)** | **Low (15 °C, 40%)** | **Decree No.6/2003** |
| **No.** | **Compounds** | **Average result ± expanded measurement uncertainty** | **Average result ± expanded measurement uncertainty** | **Average result ± expanded measurement uncertainty** | **Hygienic Limit **** |
| | **Unit** | **μg/m³** | **μg/m³** | **μg/m³** | **μg/m³** |
| 1 | Ethyl acetate | (0.8 ± 0.2) | (0.1 ± 0.03) | (0.6 ± 0.2) | NLC |
| 2 | Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | 7 |
| 3 | 1-Methoxy-2-Propanol | (0.2 ± 0.1) | < 0.1 | (0.2 ± 0.1) | NLC |
| 4 | Pentanal | (0.3 ± 0.1) | (0.5 ± 0.2) | (0.3 ± 0.1) | NLC |
| 5 | Trichlorethylene | < 0.1 | < 0.1 | < 0.1 | 150 |
| 6 | Toluene | (1.3 ± 0.4) | (2 ± 0.6) | (2.5 ± 0.8) | 300 |
| 7 | Hexanal | (0.4 ± 0.1) | (0.9 ± 0.3) | (0.6 ± 0.2) | NLC |
| 8 | Tetrachlorethylene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | 150 |
| 9 | n-Butyl acetate | (0.4 ± 0.1) | (1.1 ± 0.3) | (1.1 ± 0.3) | NLC |
| 10 | Ethylbenzene | (0.3 ± 0.1) | (0.7 ± 0.2) | (0.7 ± 0.2) | 200 |
| 11 | m,p-Xylene | (1.7 ± 0.5) | (2.3 ± 0.7) | (2.2 ± 0.7) | 200*** |
| 12 | Styrene | < 0.1 | < 0.1 | < 0.1 | 40 |
| 13 | o-Xylene | (0.3 ± 0.1) | (0.6 ± 0.2) | (0.5 ± 0.2) | 200*** |
| 14 | Butoxy-Ethanol | (0.1 ± 0.03) | (0.3 ± 0.1) | (0.1 ± 0.03) | NLC |
| 15 | α-Pinene | (0.1 ± 0.03) | (0.5 ± 0.2) | (0.3 ± 0.1) | NLC |
| 16 | Camphene | < 0.1 | (0.1 ± 0.03) | < 0.1 | NLC |
| 17 | 3-Ethyl-Toluene | (0.4 ± 0.1) | (0.7 ± 0.2) | (0.5 ± 0.2) | NLC |
| 18 | 4-Ethyl-Toluene | (0.2 ± 0.1) | (0.4 ± 0.1) | (0.3 ± 0.1) | NLC |
| 19 | 1,3,5-Trimethyl-Benzene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 20 | β-Pinene | (0.1 ± 0.03) | (0.4 ± 0.1) | (0.3 ± 0.1) | NLC |
| 21 | 2-Ethyl Toluene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 22 | Myrcene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 23 | 1,2,4-Trimethyl-Benzene | (0.3 ± 0.1) | (0.5 ± 0.2) | (0.4 ± 0.1) | NLC |
| 24 | α-Phellandrene | < 0.1 | < 0.1 | < 0.1 | NLC |
| 25 | 3-δ-Caren | (0.1 ± 0.03) | (0.3 ± 0.1) | (0.2 ± 0.1) | NLC |
| 26 | 1,2,3-Trimethyl-Benzene | (0.1 ± 0.03) | (0.1 ± 0.03) | (0.1 ± 0.03) | NLC |
| 27 | Limonene | (0.1 ± 0.03) | (0.3 ± 0.1) | (0.6 ± 0.2) | NLC |
| **28** | γ-Terpinene | < 0.1 | < 0.1 | < 0.1 | NLC |
| **29** | Bornyl Acetate | < 0.1 | < 0.1 | < 0.1 | NLC |
| **30** | $TVOC_{MS}$ | (32 ± 10) | (43 ± 13) | (24 ± 7) | NLC |

VII: *Hedonic tone and intensity of odor emitted by textile – A (100% Polyester)*

| Normal conditions (23 °C, 50%) | | | High conditions (40 °C, 55%) | | | Low conditions (15 °C, 40%) | | |
|---|---|---|---|---|---|---|---|---|
| **R.T.**[6] | **HED. TONE INTENSITY** | **NAME OF VOCs** | **R.T.** | **HED. TONE INTENSITY** | **NAME OF VOCs** | **R.T.** | **HED. TONE INTENSITY** | **NAME OF VOCs** |
| 0.9 | –1 | Ethyl acetate | 0.9 | –1 | Ethyl acetate | 0.9 | –1 | Ethyl acetate |
| 1.6 | –1 | Butanol | 1.6 | –2 | Butanol | 1.6 | +1 | Butanol |
| 2.2 | –1 | Benzene | 2.2 | –2 | Benzene | 2.2 | +2 | Benzene |
| 2.7 | +1 | 1-methoxy-2-propanol | 2.7 | –2 | 1-methoxy-2-propanol | 2.7 | –1 | 1-methoxy-2-propanol |
| 3.4 | +1 | Pentanal | 3.4 | –1 | Pentanal | 3.4 | –2 | Pentanal |
| 5.6 | +2 | Toluene | 5.6 | –2 | Toluene | 5.6 | +1 | Toluene |
| 6.7 | –1 | Hexanal | 6.7 | –2 | Hexanal | 6.7 | –2 | Hexanal |
| 7.2 | +2 | Butyl acetate | 7.2 | –2 | Butyl acetate | 7.2 | –1 | Butyl acetate |
| 8.5 | –1 | Ethylbenzene | 8.5 | –2 | Ethylbenzene | 8.5 | –1 | Ethylbenzene |
| 8.9 | +1 | m,p-Xylene | 8.9 | –2 | m,p-Xylene | 8.9 | +1 | m,p-Xylene |
| 9.4 | –1 | Styrene | 9.4 | –2 | Styrene | 9.4 | –1 | Styrene |
| 9.6 | +1 | o-Xylene | 9.6 | –1 | o-Xylene | 9.6 | –2 | o-Xylene |
| 9.9 | –2 | Butoxyethanol | 9.9 | –1 | Butoxyethanol | 9.9 | –1 | Butoxyethanol |
| 10.6 | –2 | α-Pinene | 10.6 | –3 | α-Pinene | 10.6 | +1 | α-Pinene |
| 11.2 | –2 | Camphene | 11.2 | –2 | Camphene | 11.2 | +1 | Camphene |
| 11.7 | +2 | β-Pinene | 11.7 | –1 | β-Pinene | 11.7 | –1 | β-Pinene |
| 11.9 | –4 | 2-Ethyl-toluene | 11.9 | –4 | 2-Ethyl-toluene | 11.9 | –2 | 2-Ethyl-toluene |
| 12.7 | +1 | α-Phellandrene | 12.7 | +1 | α-Phellandrene | 12.7 | –1 | α-Phellandrene |
| 12.9 | +1 | 3-δ-Carene | 12.9 | +1 | 3-δ-Carene | 12.9 | –1 | 3-δ-Carene |
| 13.3 | +1 | Limonene | 13.3 | +1 | Limonene | 13.3 | +1 | Limonene |
| 13.9 | +1 | γ-terpinene | 13.9 | –2 | γ-terpinene | 13.9 | –2 | γ-terpinene |
| 14.7 | –1 | Nonanal | 14.7 | –3 | Nonanal | 14.7 | –1 | Nonanal |
| 19.0 | –2 | Bornyl acetate | 19.0 | –3 | Bornyl acetate | 19.0 | +1 | Bornyl acetate |
| TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | |
| –2 | | | –3 | | | –1 | | |

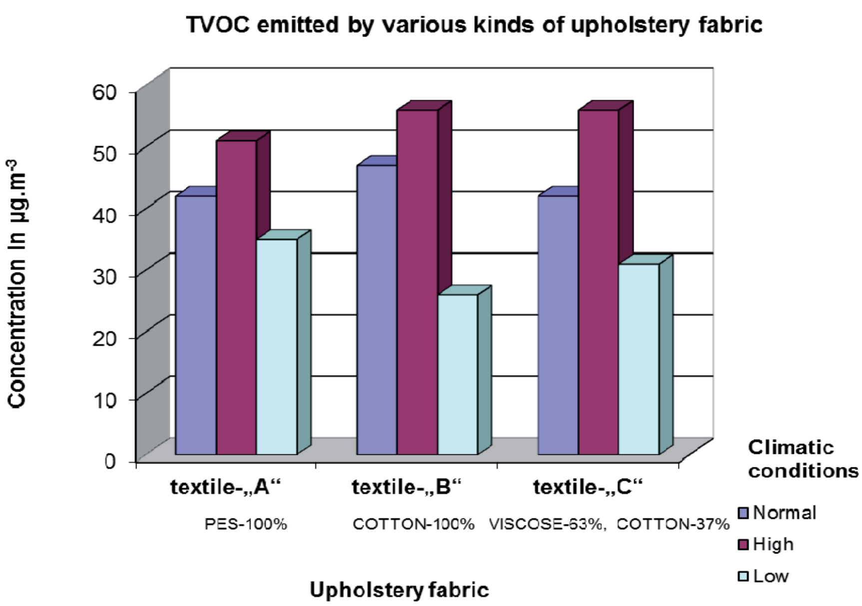
6 R.T. – Retention time of said VOC

VIII: *Hedonic tone and intensity of odor emitted by textile – B (100% COTTON)*

| Normal conditions (23 °C, 50%) | | | High conditions (40 °C, 55%) | | | Low conditions (15 °C, 40%) | | |
|---|---|---|---|---|---|---|---|---|
| **R.T.** | **HED. TONE INTENSITY** | **NAME OF VOCs** | **R.T.** | **HED. TONE INTENSITY** | **NAME OF VOCs** | **R.T.** | **HED. TONE INTENSITY** | **NAME OF VOCs** |
| 0.9 | –1 | Ethyl acetate | 0.9 | –2 | Ethyl acetate | 0.9 | –1 | Ethyl acetate |
| 1.6 | +1 | Butanol | 1.5 | –1 | Butanol | 1.6 | –1 | Butanol |
| 2.2 | –2 | Benzene | 2.2 | –1 | Benzene | 2.2 | –1 | Benzene |
| 2.8 | –1 | 1-methoxy-2-propanol | 2.7 | +1 | 1-methoxy-2-propanol | 2.7 | +1 | 1-methoxy-2-propanol |
| 3.4 | –2 | Pentanal | 3.4 | –1 | Pentanal | 3.3 | –2 | Pentanal |
| 5.7 | –2 | Toluene | 5.8 | –3 | Toluene | 5.7 | –1 | Toluene |
| 6.7 | –1 | Hexanal | 6.7 | –1 | Hexanal | 6.7 | –1 | Hexanal |
| 7.2 | –1 | Butyl acetate | 7.2 | –2 | Butyl acetate | 7.2 | –2 | Butyl acetate |
| 8.5 | –2 | Ethylbenzene | 8.6 | –2 | Ethylbenzene | 8.5 | +1 | Ethylbenzene |
| 8.9 | +2 | m,p-Xylene | 8.9 | –1 | m,p-Xylene | 8.9 | –2 | m,p-Xylene |
| 9.4 | –2 | Styrene | 9.4 | –3 | Styrene | 9.4 | +1 | Styrene |
| 9.6 | +2 | o-Xylene | 9.6 | –1 | o-Xylene | 9.6 | +1 | o-Xylene |
| 9.7 | +1 | Butoxyethanol | 9.7 | +1 | Butoxyethanol | 9.8 | –2 | Butoxyethanol |
| 10.6 | –1 | α-Pinene | 10.6 | –2 | α-Pinene | 10.6 | –1 | α-Pinene |
| 11.2 | +2 | Camphene | 11.2 | –1 | Camphene | 11.2 | –1 | Camphene |
| 11.8 | –2 | β-Pinene | 11.8 | +2 | β-Pinene | 11.7 | +1 | β-Pinene |
| 11.9 | +1 | 2-Ethyl-toluene | 11.9 | –3 | 2-Ethyl-toluene | 11.8 | –3 | 2-Ethyl-toluene |
| 12.6 | –2 | α-Phellandrene | 12.6 | –1 | α-Phellandrene | 12.5 | +2 | α-Phellandrene |
| 12.8 | +1 | 3-δ-Carene | 12.8 | +1 | 3-δ-Carene | 12.9 | +2 | 3-δ-Carene |
| 13.4 | +3 | Limonene | 13.4 | +2 | Limonene | 13.4 | +2 | Limonene |
| 13.7 | –2 | γ-terpinene | 13.8 | +2 | γ-terpinene | 13.8 | –1 | γ-terpinene |
| 14.7 | –1 | Nonanal | 14.7 | +2 | Nonanal | 14.7 | –1 | Nonanal |
| 19.0 | +1 | Bornyl acetate | 19.0 | +1 | Bornyl acetate | 19.0 | –3 | Bornyl acetate |
| TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | |
| –2 | | | –3 | | | –2 | | |

IX: *Hedonic tone and intensity of odor emitted by textile REAL (63% VISCOSE, 37% COTTON)*

| Normal conditions (23 °C, 50%) | | | High conditions (40 °C, 55%) | | | Low conditions (15 °C, 40%) | | |
|---|---|---|---|---|---|---|---|---|
| R.T. | HED. TONE INTENSITY | NAME OF VOCs | R.T. | HED. TONE INTENSITY | NAME OF VOCs | R.T. | HED. TONE INTENSITY | NAME OF VOCs |
| 1.0 | −1 | Ethyl acetate | 0.9 | −2 | Ethyl acetate | | | |
| 1.6 | −2 | Butanol | 1.7 | −2 | Butanol | 1.6 | −1 | Butanol |
| 2.2 | −1 | Benzene | 2.2 | −2 | Benzene | 2.2 | −1 | Benzene |
| 2.7 | −1 | 1-methoxy-2-propanol | 2.7 | −2 | 1-methoxy-2-propanol | 2.7 | −1 | 1-methoxy-2-propanol |
| 3.4 | −1 | Pentanal | 3.4 | −2 | Pentanal | 3.4 | −2 | Pentanal |
| 5.6 | −2 | Toluene | 5.6 | −2 | Toluene | 5.6 | −1 | Toluene |
| 6.7 | −2 | Hexanal | 6.7 | −2 | Hexanal | 6.7 | −1 | Hexanal |
| 7.2 | −2 | Butyl acetate | 7.3 | −2 | Butyl acetate | 7.3 | −2 | Butyl acetate |
| 8.5 | −1 | Ethylbenzene | 8.5 | −2 | Ethylbenzene | 8.5 | −2 | Ethylbenzene |
| 8.9 | −2 | m,p-Xylene | 8.9 | −3 | m,p-Xylene | 8.9 | −2 | m,p-Xylene |
| 9.4 | −2 | Styrene | 9.4 | −2 | Styrene | 9.4 | −3 | Styrene |
| 9.6 | −1 | o-Xylene | 9.6 | −2 | o-Xylene | 9.6 | −1 | o-Xylene |
| 9.9 | −2 | Butoxyethanol | 9.9 | +1 | Butoxyethanol | 9.9 | −1 | Butoxyethanol |
| 10.6 | −2 | α-Pinene | 10.6 | −2 | α-Pinene | 10.6 | −2 | α-Pinene |
| 11.2 | −1 | Camphene | 11.2 | −2 | Camphene | 11.2 | −1 | Camphene |
| 11.8 | −2 | β-Pinene | 11.8 | −2 | β-Pinene | 11.8 | −1 | β-Pinene |
| 11.9 | −3 | 2-Ethyl-toluene | 11.9 | −4 | 2-Ethyl-toluene | 11.9 | −2 | 2-Ethyl-toluene |
| 12.7 | −2 | α-Phellandrene | 12.7 | +1 | α-Phellandrene | 12.7 | +1 | α-Phellandrene |
| 12.9 | −1 | 3-δ-Carene | 12.9 | −1 | 3-δ-Carene | 12.9 | −2 | 3-δ-Carene |
| 13.3 | +1 | Limonene | 13.3 | −1 | Limonene | 13.3 | −2 | Limonene |
| 13.9 | +1 | γ-terpinene | 13.9 | +2 | γ-terpinene | 13.9 | −2 | γ-terpinene |
| 14.7 | +3 | Nonanal | 14.7 | +2 | Nonanal | 14.7 | −1 | Nonanal |
| 19.0 | +1 | Bornyl acetate | 19.0 | −1 | Bornyl acetate | 19.0 | −1 | Bornyl acetate |
| TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | | TOTAL OLFACTIC PERCEPTION | | |
| −2 | | | −3 | | | −2 | | |




3: *TVOC emitted by various kinds of upholstery fabrics*

## DISCUSSION

The experimental part of this research was oriented on olfactometric assessment of volatile organic compounds emitted by upholstery fabric used for upholstered furniture.

The measured values of emission VOCs, emitted by individual upholstery fabrics, proved, that the composition of the material has no affect on the amount of emissions of VOCs that are released from these materials tested (1 Im.).

The tested samples of upholstery fabric were measured in depending on:

- different chemical composition,
- different climatic condition of tested samples in small space chamber.

The measured values concentrations of VOCs emitted by selected representatives of VOCs are very low and their concentrations, which does not exceed 3 μg.m$^{-3}$, which corresponds to the level of background. However some follow representatives of VOCs (2-Ethyl-toluene and Nonanal) showed very strong smell (unpleasant) even at low concentrations. This effect you can see especially at tested samples, which were conditioned in small space chamber at so called high conditions (temperature 40 °C, relative humidity 55%). Parameter of TVOC is not to exceed value 60 μg.m$^{-3}$ at any monitored of upholstery fabrics (Fig. 3).

### The influence of odorous effect of VOCs

Many VOCs, present in the indoor air and emitted from building products, have odour thresholds sufficiently low to cause an impact on the perceived air quality, in some cases even malodorous events. One aspect of building product emission testing and the evaluation thereof is the link between VOC emissions (concentrations) and perceived air quality and airway irritation. An understanding of this interrelation is essential to predict the possible impact of emitted VOCs. Such information is useful for the development of building products with a low emission and/or a low impact on the perceived air quality and a minimum of airway irritation, and ultimately a low risk of any health effect.

Among indoor air researchers, it is generally assumed that a low (chemical) emission building product is 'better' than a high emission product for the indoor environment. If sensory perception is a valid criterion of comparison, the assumption should be considered with some caution, because a building product with low VOC emission rates may only be satisfactory if the sensory impact is low too. For example, a building product that emits VOCs in low concentrations in a given scenario but with high odour indices (VOCx concentration/ odour threshold of VOCx) may continue to have a sensory impact on the perceived air quality. Observations in the literature indicate that VOCs with high odour indices also result in unacceptable ratings in panel evaluations. Therefore low emission building products may not necessarily be 'better', because emitted VOCs with odour indices > 0.1 (or even 0.01) may result in an adverse perception. In addition, those VOCs including building product surfaces that are oxidised by ozone may result in low molecular weight aldehydes and acids of which many are characterised by low odour thresholds or low airway irritation estimates (Wolkoff *et al.*, 1997).

The sum of intensities of a mixture of odorous VOCs above their respective odour thresholds is believed to be hypoadditive [i.e. the combined odour intensity of the mixture is less than the sum of the single odour intensities (Lawless, 1987; Cometto-Muñiz and Cain, 1991; Berglund and Lindvall, 1992; Berglund and Olsson, 1993; Laing *et al.*, 1994; Cometto-Muñiz *et al.*, 1997). However, below odour threshold mixtures may behave by normal or hyper addition. The latter, in particular, if the VOCs have a common chemical functionality (Guadagni *et al.*, 1963; Patterson *et al.*, 1993; Cometto-Muñiz *et al.*, 1997; Hau and Connell, 1998).

It is fair to say that odour indices can be used as a pragmatic guide that may identify which VOCs are likely to contribute most to the perceived odour intensity, at least above the odour threshold levels. However, odour indices do not consider psychophysical functionality or additive phenomena.

There are only a few attempts to correlate the sensory and chemical emission of building products. We do not have simple additive models to predict how odorous VOCs combine into a perception and their addition still remains a puzzle, even from the point of odour intensity (Olsson, 1998). Some empirical observations, however, are useful. Panel evaluations on the intensity scale appeared to be governed by VOCs with high odour indices (Wolkoff *et al.*, 1991; Knudsen *et al.*, 1999). This is in agreement with the (laboratory) observation that the intensity of the strongest odorous VOC alone is approximately equal to the perceived total intensity (Berglund and Lindvall, 1992; Laing *et al.*, 1994; Cain *et al.*, 1995). However, the present experience is that building products may continue to influence the perceived air quality, despite the fact that VOC emissions have reached below their respective odour threshold levels or even lower. There are several explanations for these observations about measured VOC concentrations and odour intensity. Some are: (1) not all VOCs that may affect the odour intensity are measured; (2) available odour thresholds are too high, due to inadequate olfactometric techniques for their determination (Punter, 1983), uncertainties about exposure due to e.g. sniffing technique and insufficient air supply including problems with upscaling; (3) odour thresholds are based on 50% recognition of odour by a standardised panel of judges and they do not consider inter-personal variations, i.e. some individuals may be orders of magnitude more sensitive to odours than others may be; and (4) if a building product emits a mixture of similar odorous VOCs (e.g. aldehydes), below odour threshold, normal or hyperaddition may occur (see above). This means that mixtures of VOCs may affect the perceived air quality, despite the individual VOCs are all below their respective odour thresholds.

## CONCLUSIONS

### Olfactometric assessment of emission VOCs

The obtained values of hedonic tone and odor intensity, you can draw the following conclusions:

- **The influence of material composition of textiles on the hedonic tone and odor intensity**

The effects of the material composition of these fabrics on the quantity and quality of emitted emissions of VOC and also on their hedonic tone and their odor intensity has been demonstrated.

- **Influence of climatic conditions in the testing chamber**

The climatic conditions (normal, high, low) influence the values of hedonic tone and intensity of odor emitted by tested upholstery fabrics. The climatic condition in the chamber especially the increased temperature and relative humidity significantly influenced the values of olfactometric assessment of VOC. Minimal effect on the values of olfactometric assessment was lower temperature and relative humidity compared to normal laboratory conditions (23 °C and 50%). The results show the climatic conditions in chamber have great impact on the amount of emitted VOC emissions, their hedonic tone and their odor intensity.

- **The results reached in the work are the pilot significant olfactometric assessment by VOC emitted by the tested upholstery fabric. These results can be utilized by use upholstery furniture producers.**
- **Recommendation**

Pursuant of the results of experimental part of this work can propose the following measures, which would reduce the impact olfaktometric assessment of upholstery fabrics used for production of upholstered furniture:

- use only those textiles, that are at least one year from the date of manufacture,
- have optimal of climatic conditions in interior, especially temperature and relative humidity (23 °C and 50%),
- in the use of upholstered products we must interior frequently and thoroughly ventilate.


## SUMMARY

This paper investigates the problematic of VOC emissions and their assessment by olfactory methods. The main goal of this contribution is determine the odors emitted by upholstery fabrics used for upholstered furniture. Three kinds of upholstery fabrics of various chemical compositions were tested: textile A – Polyester (100%), textile B – Cotton (100%), textile C – mixture of Viscose (63%) and Cotton (37%). This contribution researches the correlation between the results, which were obtained by the olfactory assessment and the results of the measurements of volatile organic compounds emitted by choose the kind of covering textiles. The amount of emission of VOC emitted by choice kind of upholstery fabric is monitored in dependence on climatic conditions of tested samples (normal, high and low).

The special combined techniques of the sensorial analysis E-nose Sniffer in conclusion with the GC-MS chromatography and the thermal desorption were used for the measurement.

In the first step the samples of the textile with the area $1m^2$ were prepared for testing. The prepared sample of the textile was put into the chamber with different climatic conditions.

In the third step the emitted air collected into desorption tubes was evaluated and split of the effluent of chromatography column into two streams. One stream is analyzed by the detector of the gas chromatography and the second stream is passed into an effluent of spectro Sniffer.

The both reached results: the quality and quantity of determined volatile organic compounds to the sensory results were compared. The results of the chromatogram and the results of the olfactogram were evaluated.

The measured values of emission VOCs, emitted by individual upholstery fabrics, proved, that the composition of the material has no affect on the amount of emissions of VOCs that are released from these materials tested (1 Im.). The measured values concentrations of VOCs emitted by selected representatives of VOCs are very low and their concentrations, which does not exceed 3 $\mu g.m^{-3}$, which corresponds to the level of background. Parameter of TVOC is not to exceed value 60 $\mu g.m^{-3}$ at any monitored of upholstery fabrics.

The results of various kinds of upholstery fabric with different chemical composition were compared. The effects of the material composition of these fabrics on the quantity and quality of emitted emissions of VOC and also on their hedonic tone and their odor intensity has been demonstrated.

The climatic conditions (normal, high, low) influence the values of hedonic tone and intensity of odor emitted by tested upholstery fabrics. The climatic condition in the chamber especially the increased temperature and relative humidity significantly influenced the values of olfactometric assessment of VOC. Minimal effect on the values of olfactometric assessment was lower temperature and relative humidity compared to normal laboratory conditions (23 °C and 50%). The results show the climatic

conditions in chamber have great impact on the amount of emitted VOC emissions, their hedonic tone and their odor intensity.

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Standards

ISO 16000-1: 2007 General aspects of sampling strategy.

ISO 16000-5: 2007 Sampling strategy for volatile organic compounds (VOCs).

ISO 16000-6: 2007 Determination of volatile organic compounds indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and chromatography using MS/FID.

ISO 16000-9: 2007 Determination of the emission of volatile organic compound from building products and furnishing- Emission test chamber method.

ISO 16000-11: 2007 Determination of the emission of volatile organic compounds sampling, storage of samples and preparation of test specimens.

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