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MEASUREMENT OF VOC EMISSIONS FROM CURATIVE TREATED WOOD : A NEW EMISSION TEST CHAMBER METHOD

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Introduction

A poor indoor air quality (IAQ) is now recognized as a potential factor affecting occupants health. There are three basic strategies to improve IAQ: source control, improvement of the ventilation and use of air cleaners. Usually, the most efficient way to improve IAQ is to eliminate the different pollutant sources or to reduce their emissions.

In order to precisely measure emissions from building products and estimate the potential heath impact of emitted pollutants, standardised analytical methods are needed. The aim of this paper is to present the new standards prepared by the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO) for the measurement of indoor air pollutants and their application to the characterization of emissions from wood products.

The prestandard ENV 13419, subdivided in three parts, has been prepared by the CEN technical committee 264 :

- ✓ ENV 13419-1 : Building products – Determination of the emission of volatile organic compounds – Part 1 : Emission test chamber method,
- ✓ ENV 13419-2 : Building products – Determination of the emission of volatile organic compounds – Part 2 : Emission test cell method,

- ✓ ENV 13419-3 : Building products – Determination of the emission of volatile organic compounds – Part 3 : Procedure for sampling, storage of samples and preparation of test specimens.

The two first parts of the prestandard ENV 13419 specify a general laboratory test method for the determination of the area specific emission rate of volatile organic compounds (VOCs) from newly produced building products under defined climate conditions in a test chamber (Part 1) or cell (Part 2). The third part specifies for solid, liquid or combined products, the sampling procedure, transport and storage conditions and preparation of test specimens.

In France, those European prestandards have been translated by the French Normalisation Association (AFNOR) in three experimental standards : XP ENV 13419-1, XP ENV 13419-2 and XP ENV 13419-3 [1-3].

In parallel to the ongoing work at CEN, the technical committee 146 of International Organization for Standardization (ISO) has prepared the draft international standard ISO/DIS 16000 related to indoor air. Part 6 of this standard specifies a method for the determination of the emission of single volatile organic compounds (VOCs) and total volatile organic compounds (TVOC) from building materials using test chambers and cells [4]:

- ✓ ISO/DIS 16000-6 : Indoor air – Part 6 : Determination of volatile organic compounds in indoor and chamber air by active sampling on TENAX TA sorbent, thermal desorption and gas chromatography using MS/FID.

It is intended that, after the final voting stage, the CEN prestandards (Parts 1-3) will be taken over by ISO and that Part 6 of the ISO standard will be taken over by CEN as the fourth part of the ENV 13419 prestandard.

As an example, the volatile organic compounds emissions from preservative treated wood samples were characterised according to the CEN ENV 13419-1 prestandard describing the emission test chamber method and to the ISO/DIS 16000-6 prestandard for the analytical method. Two representative wood preservatives (hydrodispersable and petroleum solvent formulation) were tested for this purpose. The VOCs concentrations in the test chamber were monitored during 6 days following a simulated curative wood treatment.

Methods

Test specimen preparation

Test specimens were prepared with 4 spruce tree boards previously conditioned by CTBA at 23°C and 50 % relative humidity (RH). Their individual surface was 0.1 m^2 (0.5 x 0.2 m). The total surface of a test specimen is therefore 0.4 m^2.

Two wood preservative products representative of the actual market were selected for this study according to their respective solvent formulation : petroleum solvent (PS) or hydrodispersable (HD).

Wood treatment was simulated by applying 300 $ml.m^{-2}$ PS or HD products on spruce boards using a paintbrush. The 2 prepared specimens were placed in the test chamber just after wood treatment simulation. A reference specimen made of untreated wood was also studied in the same environmental conditions.

Test specimen conditioning

The selected test chamber environmental conditions are in accordance with the ENV 13419-1 prestandard. These conditions are presented in Table 1. The specific ventilation rate was chosen as representative of the surface of a frame in a roof trussing (1.5 $m^3.m^{-2}.h^{-1}$).

Sampling and analysis

Air sampling in the test chamber has been performed using TENAX TA sorbent after 2, 4, 6, 24, 48, 72 and 144 hours. The sampling air flow rate was 100 $ml.mn^{-1}$. Subsequent VOCs analysis was performed by thermal desorption and gas chromatography using MS/FID according to ISO/DIS 16000-6. The analytical conditions are detailed elsewhere [5].

According to the definition of the ISO/DIS 16000-6 draft standard, the TVOC concentration is calculated as the sum of concentrations of identified and unidentified VOCs eluting between and including hexane and hexadecane. The quantification of identified compounds is

done using individual response factor when available. For the quantification of other identified compounds or unidentified compounds the toluene response factor is used.

Results

Reference specimen

The emissions of the untreated spruce board were characterised after 72 h.

The emissions of the untreated spruce sample are dominated by alkanes (mainly decane: 475 $\mu g.m^{-3}$, nonane: 130 $\mu g.m^{-3}$ and undecane: 75 $\mu g.m^{-3}$), cycloalkanes (propylcyclohexane: 70 $\mu g.m^{-3}$ and butylcyclohexane: 55 $\mu g.m^{-3}$), aromatic compounds (ethylbenzene: 35 $\mu g.m^{-3}$, xylene: 70 $\mu g.m^{-3}$), different alkyled cycloalkanes and alkyled aromatic compounds.

The TVOC value of the untreated spruce sample is around 1 900 $\mu g.m^{-3}$ after 72 h.

PS treated test specimen

The emissions of the sample treated with the PS wood preservative product are characterised by alkanes (undecane, dodecane, tridecane, tetradecane), cycloalkanes (butylcyclohexane), alkyled cycloalkanes, aromatic compounds (decahydronaphtalene and 2-methyl-decahydronaphtalene), terpenes (limonene, camphene, 3-carene and eucalyptol) and 1-methoxy-2-propanol.

The emissions of cycloalkanes, aromatic compounds and terpenes are very high during the first 6 hours conditioning in the test chamber. Then, they show a sharp decrease after 48 or 72 hours. The respective examples of butylcyclohexane, decahydronaphtalene and camphene are illustrated on Figure 1.

The evolution of alkanes during 144 hours in the test chamber is less pronounced than for other compounds (see Figure 2). For instance, undecane, dodecane and tridecane show only a small decrease and are still present at high concentration levels after 6 days. For other compounds like tetradecane, even slightly increasing emissions are observed in the test chamber.

HD treated test specimen

The emissions of the HD wood preservative product are different and globally lower (as for instance indicated by the TVOC value) than that of the PS product. These emissions are dominated by glycol ethers (mainly 1-methoxy-2-propanol and 1-(2-methoxy-1-methylethoxy)-2-propanol), alkanes (dodecane, tridecane and tetradecane), aldehydes (hexanal, nonanal and decanal), acetic and butyric acids.

Numerous compounds such as acetophenone, cyclohexanone, butyrolactone, octane, nonane, most of identified glycol ethers, and methyl octanoate disappear from the chamber after the first 6 hours of the test. For instance, the glycol ethers concentrations have generally decreased from 90% of their initial values after 24 hours, as illustrated on Figure 3.

On the other hand, if the concentrations of compounds such as hexanal or some alkanes also decrease during the first hours of the test, they tend to increase again after 48 hours (Figure 4).

Discussion

In order to compare the emissions of the two specimen respectively treated with the petroleum solvent or hydrodispersable wood preservatives, the emissions in the test chamber after 72 hours are reported in Table 2. Emissions of the untreated reference sample are also shown. Three days (72 hours) is the minimal time generally recommended by the professional wood preservative applicators before re-entry in a local after its treatment.

After 72 hours, the global pollution load in the test chamber expressed by the TVOC value is respectively 1 900, 3 800 and 380 000 $\mu g.m^{-3}$ for the untreated, HD treated and PS treated test specimen. Therefore, less chemical compounds are emitted by the HD than by the PS wood preservative.

This comparison clearly show the difference in the solvent formulations of the tested wood preservative. The PS wood preservative treatment is characterised by important emissions of alkanes and some aromatic compounds. We also have to mention that an important part of the measured VOCs have not been identified (Table 2). Nevertheless, after 72 h, most

concentrations of the identified compounds in the test chamber are well below the guideline values for air quality recommended by WHO [6].

On the other hand, if these measurements show that global emissions of the HD curative treatment are lower than emissions of the PS treatment, they are dominated by glycol ethers. The most toxic glycol ethers (2-methoxyethanol, 2-butoxyethanol and their respective acetates) have not been identified in the test chamber. The HD treatment emissions are dominated mainly by 1-methoxy-2-propanol, and to a lesser extent, by dipropylene glycol methyl ether, 1-(2-methoxypropoxy)-2-propanol and 2-ethylhexanol. We have seen on Figure 3 that these compounds show a rapid decrease in the test chamber. Nevertheless, the 1-methoxy-2-propanol concentration measured after 2 hours in the test chamber (330 $mg.m^{-3}$) is just below the guideline value recommended in France for working conditions (360 $mg.m^{-3}$). After 24 hours, the 1-methoxy-2-propanol concentration has decreased down to 6.6 $mg.m^{-3}$, and to 1.7 $mg.m^{-3}$ after 72 hours. This indicates that precautions have to be taken during the application of HD preservative wood treatment, especially by professional applicators which are more exposed, and that an efficient ventilation of the treated space must be operated.

These emissions results obtained from a small test chamber will be compared to other results from a larger test chamber (1 m^3) and to real life conditions in full scale experiments. This work is in current progress at CTBA and CSTB.

Conclusions

The chamber test method which is commonly used for the characterisation of building products VOC emissions is being actually standardised. This new European prestandard has been applied to the study of two wood preservative products emissions.

The emissions of a petroleum solvent wood preservative are dominated by alkanes and aromatic compounds. An important part of the measured VOCs remained unidentified. The hydrodispersable wood preservative product show globally lower emissions dominated by glycol ethers.

Important VOCs concentrations can be measured in the test chamber a few hours after introduction of the test specimen. For most identified compounds, these concentrations decrease with time reflecting the wood preservative solvent phase evaporation. This indicates

that the 3 days delay recommended by the wood preservative applicators before entering in the treated space appears to be sufficient. Nevertheless, during the application stage of the wood preservative, important indoor concentrations can be reached (e.g. 1-methoxy-2-propanol with HD product). Therefore precautions have to be taken by the applicators and a proper ventilation of the treated space has to be operated.

Acknowledgements

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References

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5 Kirchner S., Ramalho O., Vasselin F. and Yrieix C., Quantification des émissions de composés organiques volatils à partir de bois collés et traités, CTBA / CSTB internal report, February 2000.

6 Guidelines for Air Quality, published by the World Health Organization (WHO), Geneva, 2000.

Table 1 : Test chamber conditions

Parameters	Testing conditions
Chamber volume	0.051 m^{-3}
Temperature	23 ± 2 °C
Relative humidity	50 ± 5 %
Air velocity above specimen	0.1 $m.s^{-1}$
Air flow rate	0.6 $m^3.h^{-1}$
Test specimen surface	0.4 m^2
Air exchange rate	12 h^{-1}
Loading factor	8 $m^2.m^{-3}$
Specific ventilation rate	1.5 $m^3.m^{-2}.h^{-1}$
Test duration	144 hours (6 days)

Table 2 : Concentrations in the test chamber after 72 hours of sample conditioning (units: $\mu g.m^{-3}$)

Compounds	Untreated wood	PS treated wood	HD treated wood
Carboxylic acids			50
Alkanes	1 000	102 000	700
Alcools, glycols and glycol ethers		35	2 300
Aldehydes and ketones	10		40
Aromatic compounds	300	7 800	200
Cycloalkanes	350	220	40
Terpenes		200	
Unidentified VOCs	200	270 000	450
TVOC	1 900	380 000	3 800

Figure 1 : PS treated specimen : butylcyclohexane, decahydronaphtalene and camphene concentrations in the test chamber during 144 hours (units: µg.m^{-3})

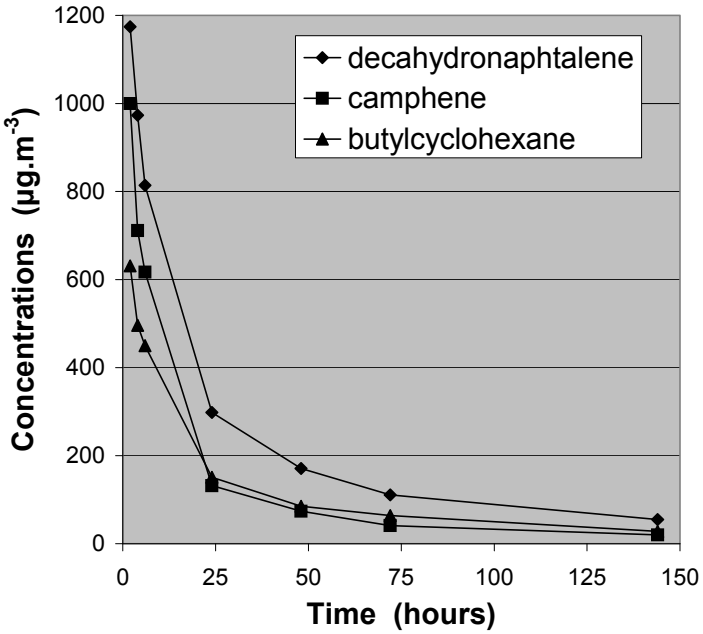

Figure 2 : PS treated specimen : alkanes concentrations in the test chamber during 144 hours (units: µg.m^{-3})

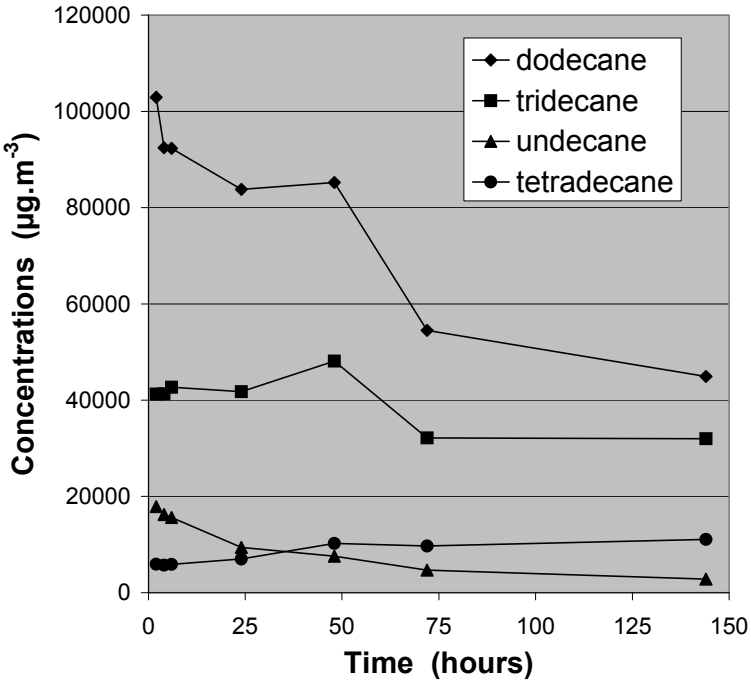

Figure 3 : HD treated specimen : glycol ether concentrations (log scale) in the test chamber during 144 hours (units: µg.m^{-3})

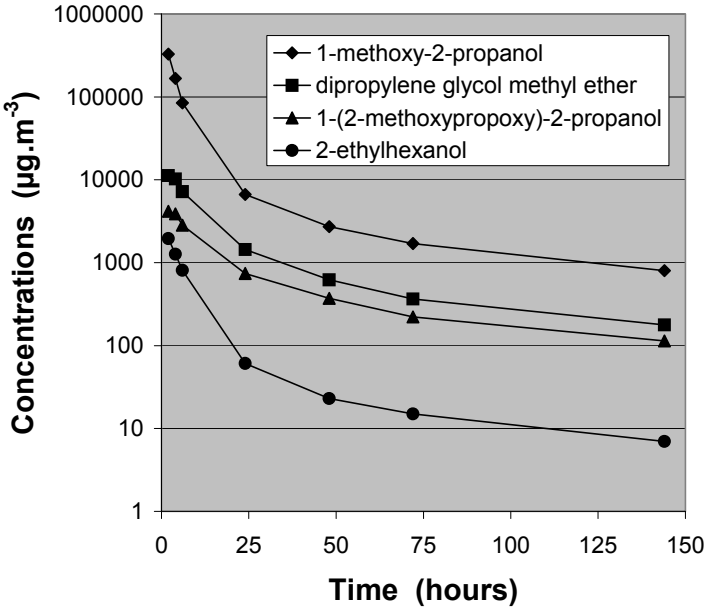
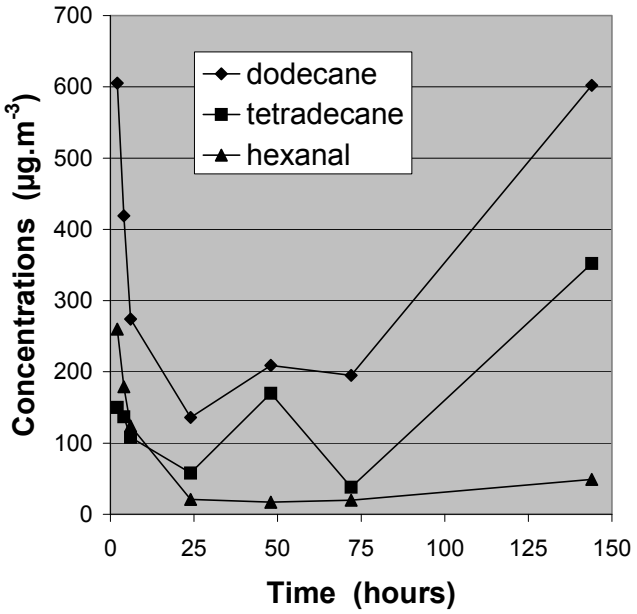
Figure 4 : HD treated specimen : hexanal and alkanes concentrations in the test chamber during 144 hours (units: µg.m^{-3})