First International Conference on Bio-based Building Materials

June 22nd - 24th 2015
Clermont-Ferrand, France

INDOOR AIR EMISSION TESTS OF NATURAL MATERIALS

M. Richter[1*], W. Horn[1], O. Jann[1], E. Juritsch[1], A. Klinge[2], E. Roswag[2], P. Fontana[3], L. Miccoli[3]

[1] BAM Federal Institute for Materials Research and Testing, Division 4.2 Materials and Air Pollutants, Berlin, Germany

[2] Roswag Architekten GvA mbH Berlin, Germany

[3] BAM Federal Institute for Materials Research and Testing, Division 7.1 Building Materials, Berlin, Germany

*Corresponding author; e-mail: matthias.richter@bam.de

Abstract

Emissions of building materials might have negative impact on human health and well-being. In the EU-funded research project H-House more than 30 natural materials (earthen dry boards and plasters, bio-based insulation materials made of wood, flax, reed, straw, etc.) used for renovation and refurbishment were tested regarding emissions of VOC, formaldehyde and radon. Different to ordinary emission tests on single materials this study focuses on the emissions from complete wall assemblies. Therefore, specially designed test chambers were used allowing the compounds to release only from the surface of the material facing indoors. The testing parameters were chosen in order to simulate model room conditions. The emission results were finally evaluated using the AgBB evaluation scheme, a procedure currently applied for the approval of flooring materials in Germany.

Keywords:

Emission testing, natural materials, VOC, formaldehyde, radon

1 INTRODUCTION

Indoor environment has a significant influence on our health and perception of well-being. Knowledge of indoor air quality, its health significance and the factors that cause poor quality are crucial to enable actions by relevant stakeholders – including building owners, developers, users and occupants – to maintain clean indoor air. Many of these actions are beyond the power of the individual building user and must be taken by public authorities through the relevant regulatory measures concerning building design, construction and materials, and through adequate housing and occupancy policies.

Investigations have shown that building materials and furniture can emit substances that have the capability to cause negative health issues. These health effects are often referred to as “sick building syndrome” and are a symptom of the fact that in western countries most of the time is spent indoors [Brasche 2005]. The substances emitted to air are classified as very volatile, volatile and semi-volatile organic compounds (VVOC, VOC, SVOC). The basic requirement No. 3 “Hygiene, health and the environment” of the European Regulation 305/2011 (CPR - Construction Products Regulation) [CPR 2011] demands a healthy indoor environment. This can be achieved by controlling the sources and by eliminating or limiting the release of pollutants into the air.

The EU-funded project H-House (Healthier Life with Eco-Innovative Components for Housing Constructions) aims to develop new eco-innovative building components for external and internal walls for new buildings and for renovation.

In the present study, chemical features in terms of emissions into indoor air from natural building materials were investigated by means of newly designed and adapted emission test chambers. The tests were focused on the emissions of formaldehyde, VOCs, SVOCs and radon.

2 METHODS

More than 30 natural materials (earthen dry boards and plasters, bio-based insulation materials made of wood, flax, reed, straw ; etc.) have undergone emission testing. The test series were designed such that complete wall assemblies in 18 different combinations were tested in order to obtain results that are as close to reality as possible.

2.1 Emissions testing

Emission tests are performed according to ISO 16000-9:2006 and CEN/TS 16516:2013 using a special emission test chamber construction (Fig. 1). The advantage of this design is the possibility to use the complete bottom of the chamber to expose the surface of the material for emission. The test chambers are completely made of stainless steel with an electropolished surface providing inertness and minimizing adsorption of emitted molecules. The standardised test conditions are (23 ± 1) °C and (50 ± 5) % RH.

The test chambers are operated dynamically. That means that an air change rate *n* is applied, defined as the ratio of air volume fed into the test chamber to the free volume of the test chamber. In order to simulate realistic indoor air conditions, *n* will be set to 0.5 1/h. The test chambers are equipped with an agitator enabling the homogenisation of the air inside.

The test standards require representativeness with regard to the intended use of the test samples. This is assured by applying a product loading factor *L* of 1.0 m²/m³ for wall materials. *L* is defined as the ratio of the exposed area of the test specimen and the volume of the test facility.

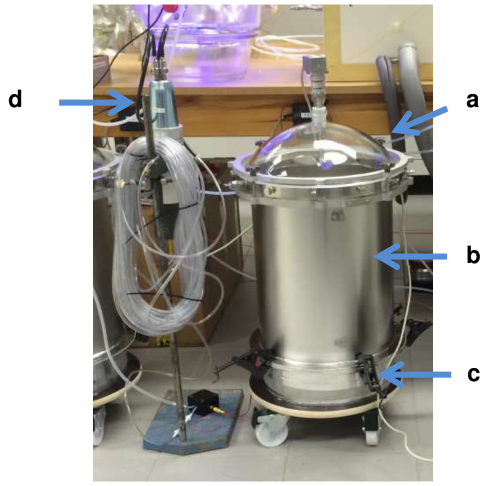

*Fig. 1: Emission test chamber with Lucas scintillation cell for radon measurement: **a.** glass lid with agitator, **b.** hollow cylinder, **c.** sample intake, **d.** Lucas cell*

2.2 Sample preparation

All materials that would make a wall assembly were installed in the sample intakes (Fig. 2, also cf. Fig. 1c). This way, the impact of all combined materials on the indoor air quality would be accounted for.

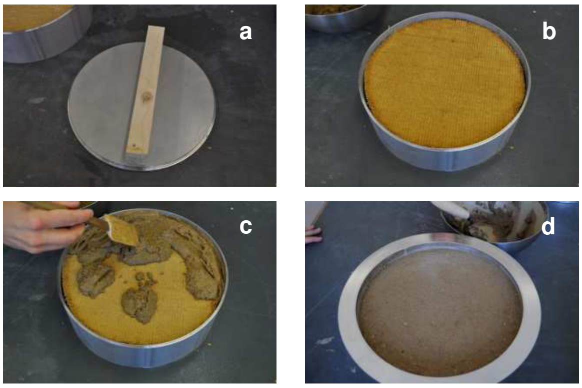

*Fig. 2: Sample installation into sample intake: **a.** wood stud, **b.** mounted earth dry board (wood insulation below), **c.** earth plaster final coat, **d.** sample ready for installation in test chamber*

The sample material should be measured immediately after production. However, after sample preparation a conditioning of the samples was necessary when the water content e.g. due to fresh plasters is high and the relative humidity in the test chambers thereby enhanced. As a rule of thumb earthen plasters have reached the state of "intended use" after a drying time of about 14 days. Hence, this was chosen as the maximum possible conditioning time.

2.3 Sampling and analysis

The emission tests lasted 28 days as maximum. Test chamber air samples were taken after 3, 7, 10 and 28 days. Air sampling is carried out according to ISO 16000-3:2011 and ISO 16000-6:2011. Air samples were taken on DNPH cartridges (determination of carbonyl and ketone compounds).and Tenax TA® (determination of other VOCs). DNPH cartridges were eluted with solvent and measurements carried out using HPLC-DAD. Tenax tubes were desorbed thermally and analyzed using GC-MS. At day 28 after installation of the product, either steady-state emissions have been reached, or the decay of emissions has at least slowed down significantly. If such a situation may be reached much earlier than 28 days, the test was terminated.

Radon (Rn-222) measurements were carried out with a calibrated Lucas scintillation chamber (Fig. 1d). As this measuring procedure is not selective for radon and its short-lived isotope thoron (Rn-220), the device was equipped with a PE hose located before the detector. This tube was dimensioned such that thoron has a retention time of three half-lives (about 3 minutes) on the way to the measuring cell. This ensures the certain measurement of radon without the influence of thoron.

2.4 Evaluation

Currently there is no harmonized regulation for the evaluation of emissions from building products in the EU, although a promising approach is under discussion [ECA Report 29 2014]. This approach is derived from an evaluation scheme developed by the German Committee for health-related evaluation of building materials (AgBB) (Fig. 3).

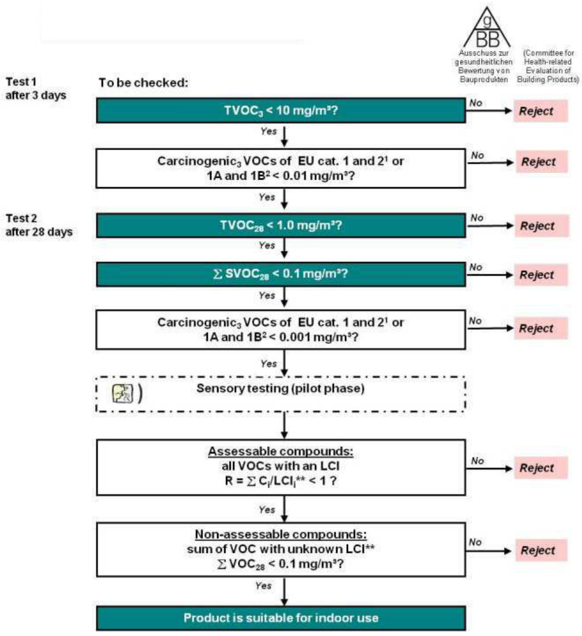

Fig. 3: AgBB scheme

This pass/fail scheme is currently mandatory for the approval of flooring materials to be used in buildings with public access in Germany.

It is based on the analysis of test chamber air sampled at least after the 3rd and 28th day after loading. The following parameters are checked:

- TVOC (total VOC): sum of the concentration of all individual substances with concentrations equal to or greater than 5 µg/m³ within the retention range C_6 - C_{16}

- ΣSVOC: sum of the concentration of all individual substances with concentrations equal to or greater than 5 µg/m³ within the retention range > C_{16} - C_{22}
- carcinogenic substances belonging to EU categories 1 and 2 or EU categories 1A and 1B
- assessable compounds: all VOCs with an LCI value (LCI – **L**owest **C**oncentration of **I**nterest). Those compounds are listed in the appendix of the scheme
- non-assessable compounds: sum of VOC with unknown LCI

A detailed description of the AgBB evaluation scheme is published elsewhere [AgBB 2012].

3 RESULTS

During the investigations it turned out that from all tested materials very low indoor formaldehyde, (S)VOC and radon concentrations can be expected. Although in most cases clay render was used, no significant radon exhalation was detected. One reason is the low ratio of the installed total mass (clay thickness between 3 and 10 mm) to the chamber volume corresponding to the European model room (V = 30 m³ with L = 1.0 m²/m³, [CEN/TS 16516 2013]). Radon concentrations were in the range of 0 to 9 Bq/m³.

All tested single materials as well as sandwich elements passed the AgBB criteria, and some measurements could be terminated before the28th sampling day, when steady-state emissions have been reached much earlier. At day 28 formaldehyde concentrations were not higher than 15 µg/m³, the TVOC (total VOC concentrations) and TSVOC (total SVOC concentrations) ranged from 16 to 900 µg/m³ and from 0 to 12 µg/m³, respectively. Figure 4 summarises the results for all tested samples. The volatility of the TVOC at the 10th (when testing was terminated earlier) and the 28th sampling day is shown.

4 SUMMARY

This study as part of the H-House project pursued two aims, the evaluation of natural materials in terms of their potential impact on indoor air quality as well as the development of a test procedure for the reliable measurement of sandwich materials under standardized conditions. It revealed a good applicability of this new chamber design in accordance with the established emission test chamber standard (ISO 16000-9). Furthermore, all tested natural building materials were uncritical with respect to their emission properties and could be installed in buildings in arbitrary combination.

5 ACKNOWLEDGEMENTS

This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 608893.

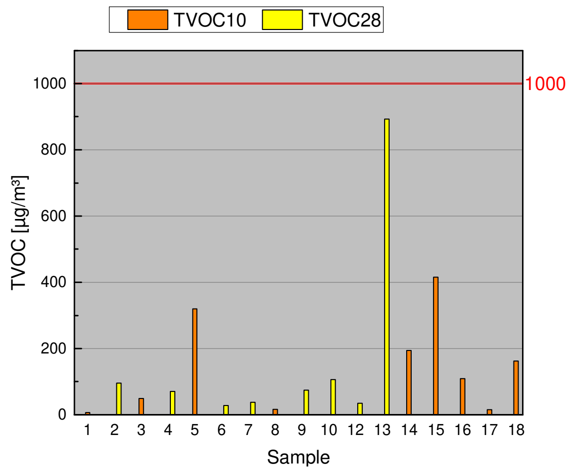

Fig. 4: TVOC at 10th and 28th sampling days. 1000 µg/m³ marks the limit that may not be exceeded at the 28th sampling day

6 REFERENCES

[AgBB 2012] Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VOC and SVOC) from Building Products. http://www.umweltbundesamt.de/sites/default/files/medien/355/dokumente/agbb_evaluation_scheme_2012_0.pdf, last retrieved on 25/03/2015

[Brasche 2005] Brasche, S., Bischof, W.; Daily time spent indoors in German homes – Baseline data for the assessment of indoor exposure of German occupant, International Journal of Hygiene and Environmental Health, 208, 4, 247-253.

[CEN/TS 16516 2013] Construction products – Assessment of release of dangerous substances – Determination of emissions into indoor air, Brussels, European Committee for Standardization, (CEN technical specification 16516)

[CPR 2011] Regulation (EU) No 305/2011, document L 88/5 from 04/04/2011.

[ECA Report 29 2014] Kephalopoulos, S., Geiss, O, Annys, E, Carrer, P. et al.; European Collaborative Action – Report No 29 : Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept, European Commission, Joint Research Center, ISBN 978-92-79-33194-7, ISSN 1831-9424

[ISO 16000-3 2011] Indoor air – Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air – active sampling method, Geneva, International Organization for Standardization

[ISO 16000-6 2011] Indoor air – Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and gas chromatography using MS or FID, Geneva, International Organization for Standardization

[ISO 16000-9 2006] Indoor air – Part 9: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method, Geneva, International Organization for Standardization