

# EMISSIONS AFTER PARQUET SURFACE TREATMENTS - COMPARISON BETWEEN TEST CHAMBERS AND INDOOR AIR EXAMINATIONS

Michael Köhler<sup>1</sup>, Norbert Weis<sup>1</sup> and Bernd Jastorff<sup>2</sup>

<sup>1</sup> Bremer Umweltinstitut GmbH

<sup>2</sup> Zentrum für Umweltforschung und Umwelttechnologie (UFT), Universität Bremen

## ABSTRACT

The emissions of surface treatments of parquets were studied by using small test chambers and comparing taking air samples taken in the rooms. On the one hand the aim was on the one hand to gather information about the VOC concentrations caused by treatment with oil-/ wax-combinations in practise and, on the other hand, to ensure that small test chambers are feasible to predict emission behaviour of those treatments. The emissions of four different oil-/ wax-combinations were examined in test chambers and by taking air samples. The TVOC of the combinations differed clearly with high emission rates caused by lemon-oil containing products, and lower emission rates caused by solvent-free products. In two of the four objects the test chamber and the room concentration could well be compared, in one object great differences due to special conditions occurred. Although test chambers are therefore feasible to predict VOC- pollution by parquet surface treatment, more efforts are needed to understand the consequences of problems in application.

KEYWORDS: Aldehydes, chamber study, test room, VOC, TVOC

## INTRODUCTION

In Germany wood parquet is very popular because it creates a pleasant living atmosphere. Therefore and to fit ideas of healthy indoor air there is an increasing request for parquets with low emissions. Especially in flats situated in old houses, where old parquets (often oak), still exist, there is a need to treat the surface with low emission products. Combinations of oils and waxes based on plant raw materials are often used for ecological reasons. Nevertheless surface treatment of parquets with these products can cause nuisance by odours and may cause health problems.

To gather information about emissions of parquets surface treatments test chambers can be used. Emission rates of several thousands  $\mu\text{g}/(\text{m}^2 \text{ h})$  for a wax and two solvent-diluted oils with a slow decrease of emission were reported [1], but no data for the common oil-/wax-combinations are available. Small chambers were used to create these data, so that the testing could be done with low expenditure. Skilful craftsman were choosen, to get a technical ideal treatment. To ensure the feasibility of the method a comparison to room concentrations was desirable.

## METHODS

At all four rooms and corresponding samples of treated parquets were examined. Two of these rooms are located in an office building in the center of Bremen (Object A and B) and could be investigated intensively. Objects N and O are rooms in an older house in a living area of Bremen. In object A and B new parquets were laid (sea pine parquets fixed with nails), while in object N and object O the old oak parquets were ground and surface-treated again. Loading factors of the parquets in objects A and B were roughly  $0,4 \text{ m}^2/\text{m}^3$  and  $0,3 \text{ m}^2/\text{m}^3$  in objects N and O (ceiling height 3,4 m).

The parquet of object A was treated with oil and wax both containing lemon-oil. The parquet of object B was treated with an solvent-free oil-/wax-combination (as declared by the manufacturer). At object O the lemon-oil containing oil and the solvent-free wax were combined. At object N an isoalkane-containing oil and the solvent-free wax were used. All treatments were done by craftsman, the oils were applied sparingly in a thin film. After a few days the wax was added.

In each object the examination started after the surface treatment was finished (day number 0), with exception of a first air sample, which was taken before surface treatment was started (to estimate influences of other VOC sources).

Air samples were taken and analyzed according to the German guideline VDI 3482 [2]: Adsorption on charcoal (Auergesellschaft, type NIOSH), desorption with  $\text{CS}_2$ , analyzed with GC/FID and GC/MS. (to ensure that more polar substances are simultaneously emitted and not analyzed, at least once adsorption with anasorb 747 (SKC) and desorption with dichlormethan/methanol (95:5) was carried out. No different substances could be found).

The  $\text{TVOC}_{\text{CCT}}$  was calculated by the total area of all substance peaks ranging from n-hexane to n-tetradecane evaluated as toluene („CCT“ is an abbreviation for explaining the method for creating the TVOC; C = charcoal adsorption, C = desorption with  $\text{CS}_2$  and T = calculating as toluene; for details see [3] and [4]). At least eight hours before air samples in the rooms were taken, all windows and doors were closed. Temperature was measured every time air samples were taken, it varied from 18 to 28 °C. Between the measurements the rooms were ventilated.

Parquet samples (sea pine for object A and B, oak for N O) were surface treated and put in test chambers (loading factor  $L = 1,5 \text{ m}^2/\text{m}^3$  for objects A and B ;  $L = 1,25 \text{ m}^2/\text{m}^3$  for object N and  $L = 1 \text{ m}^2/\text{m}^3$  for object O). Also an untreated sample of sea pine was used to examine the Pinene- and Carene-emission. Small chambers ( $0,02 \text{ m}^3$ ) made of glass were used and ventilated with an air exchange rate  $n = 1,5 \text{ h}^{-1}$  (objects A, B, N) and  $n = 1 \text{ h}^{-1}$  (object O). Temperature and humidity were kept mostly constant ( $23^\circ\text{C} \pm 2^\circ\text{C}$ ,  $50\% \pm 5\%$ ). Air mixing and surface velocity were confirmed with magnetic stirers according to [5]. Air samples were taken and analyzed as described above.

In object A a FLEC with an air exchange rate of  $686 \text{ h}^{-1}$  was also used twice, to examine the emission of the parquet.

The air ventilation rates in the rooms of object A and B were measured under not ventilated condition as described in [6].

## RESULTS

Two object (object A and B) had a new parquet made of sea pine. The air samples showed increased Pinene-concentrations even before surface treatment with oils and waxes was started (sum of  $\alpha$ -Pinene and  $\beta$ -Pinene; object A: roughly  $500 \mu\text{g}/\text{m}^3$ , object B: roughly  $300 \mu\text{g}/\text{m}^3$ ). To verify, if the sea pine parquet itself is the source for the Pinenes, it was examined in the test chamber. A concentration of approximately  $600 \mu\text{g}/\text{m}^3$  (sum of Pinenes, as above) was determined. The parquet has knot-holes (for esthetic reasons). This may partly explain the differences in the room concentrations.

## Object A

In figure 1 the emission data of Limonene of the parquet in the test chamber and of the test room are compared. Limonene is the dominating substance in room and in chamber air. It is emitted from the surface treatment, which could already be suspected from the manufacturer's information. At the first day after the surface treatment was completed, the Limonene-concentration was above  $10 \text{ mg}/\text{m}^3$  in the room and probably also in the test chamber ( $9000 \mu\text{g}/\text{m}^3$  measured at the second day). During the first few days the Limonene-concentration rapidly declined (in the room less than  $1000 \mu\text{g}/\text{m}^3$  is reached after 19 days, in the test chamber after 9 days). The examinations were continued until the 49th day, when the Limonene-concentration reached  $120 \mu\text{g}/\text{m}^3$  in the test chamber and  $265 \mu\text{g}/\text{m}^3$  in the test room. At this time the Limonene-concentration was less than the Pinene-concentration in the room.

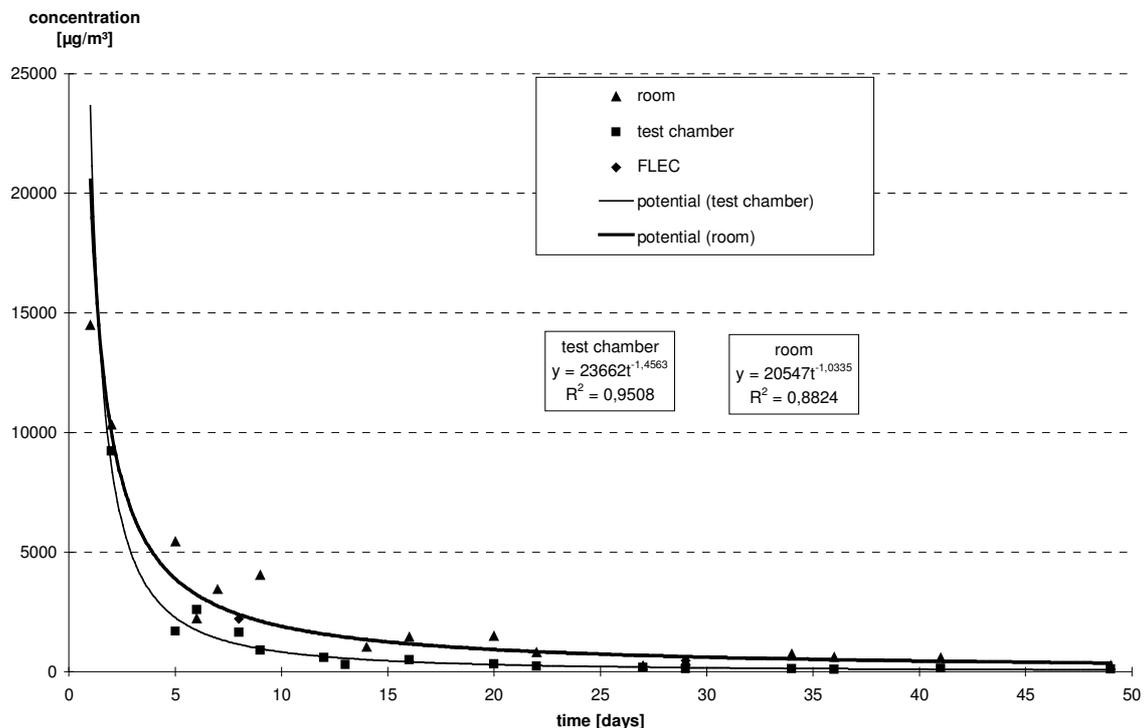


Figure 1. Object A; Comparison of the Limonene-concentration in object A in the room air and in the test chamber and two FLEC measurements;  $n/L$  (test chamber) =  $1/1 \text{ m}^3/(\text{m}^2 \text{ h})$ ;  $n/L$  (FLEC) =  $1,35 \text{ m}^3/(\text{m}^2 \text{ h})$

## Object B

Using the solvent-free oil/wax-combination lead to lower VOC-concentrations in the test room and in the test chamber than determined in object A. On the first day after completing the surface treatment a TVOC<sub>CCT</sub> of 2500 µg/m<sup>3</sup> was measured. Most of the TVOC<sub>CCT</sub> was caused either by Pinenes, emitted by the sea pine parquet and Limonene, which was mostly a contamination of the room of object A. Because of this the TVOC<sub>CCT</sub> was modified by omitting the Pinene and Limonene- concentrations. This lead to a TVOC<sub>CCT,mod.</sub> of around 500 µg/m<sup>3</sup> at the first day (in test chamber and test room). The most prominent substance, that can be identified, was n-hexanal. Moreover n-heptanal, n-octanal, n-nonanal and n-decanal could be found. Figure 2 shows a comparison of the emission-development of n-hexanal and n-nonanal in room and test chamber (the other aldehydes show a similar emission-behavior as n-nonanal).

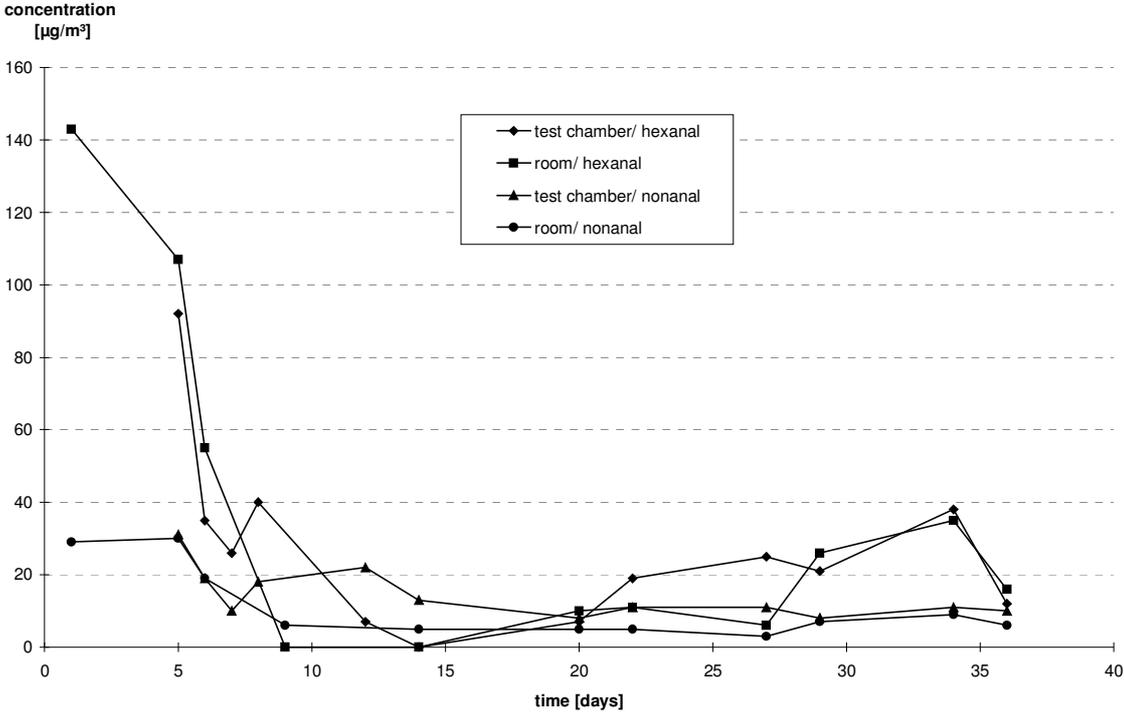


Figure 2. Object B; Comparison of the n-hexanal- and n-nonanal-emissions in the test room and in the test chamber; n/L (test chamber) = 1 m<sup>3</sup>/(m<sup>2</sup> h)

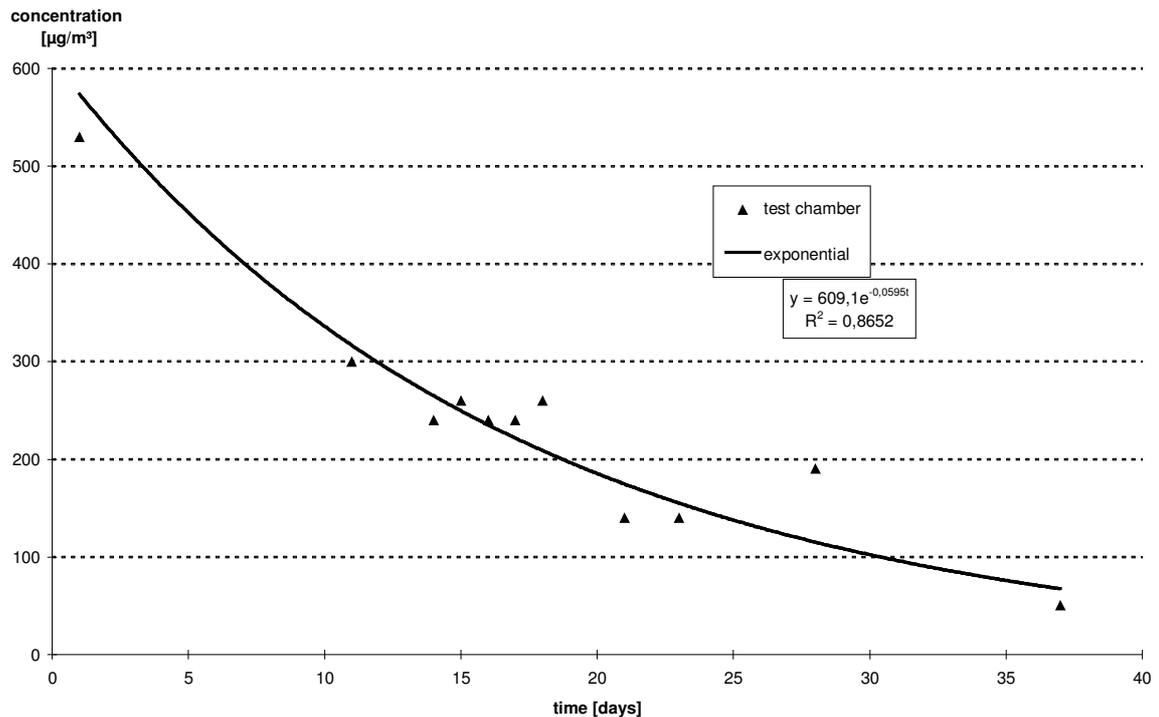


Figure 3: Object N, TVOC<sub>CCT</sub> in the test chamber;  $n/L$  (test chamber) = 1,2 m<sup>3</sup>/(m<sup>2</sup> h)

#### Object N

Figure 3 shows the emission rate of the parquet in the test chamber expressed as TVOC<sub>CCT</sub>, which is suitable according to [7] to represent the isoalkane concentration. Although the emission of the parquet was decreasing quite rapidly, the TVOC<sub>CCT</sub> measured in the room was still roughly 5000 µg/m<sup>3</sup> 4 months after finishing the treatment.

#### Object O

Figure 4 shows the development of the Limonene concentration in the test chamber. The initial concentration was much smaller compared to object A, partly because of the use of a different wax, maybe also because of the oak parquet, which may not be as infiltrated by the oil. Three times air samples were taken in the room of object O: at the 3rd day 5125 µg/m<sup>3</sup> Limonene, at the 11th day 110 µg/m<sup>3</sup> and at the 67th day 6 µg/m<sup>3</sup> were measured.

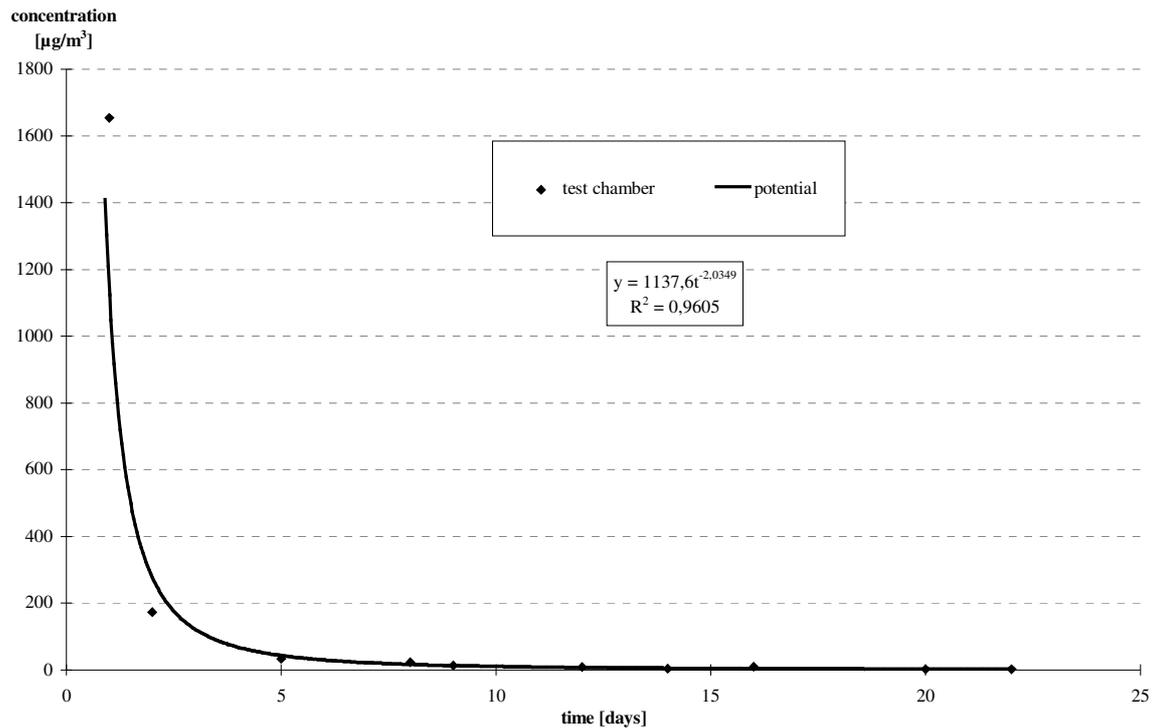


Figure 4: Object O, Limonene-concentration in the test chamber;  $n/L$  (test chamber) =  $1 \text{ m}^3/(\text{m}^2 \text{ h})$

## DISCUSSION

The four combinations of waxes and oils showed different emission-profiles. While the system containing lemon-oil causes high Limonene-concentrations in the first few weeks, other surface treatments - especially the one used in object B - only led to low emissions. Nevertheless odour annoyance can occur using any of these systems. One major reason for odour occurrence in object B seems to be the formation of aldehydes, which are substances with low odour thresholds.

When comparing emissions in test chambers and in rooms, it is necessary to observe the area specific air flow rate  $q$ , which is the ratio of the air exchange rate and the product loading factor. While  $q$  is constant in the test chamber,  $n$  and therefore also  $q$  are fluctuating in the room. Under not ventilated conditions the air exchange rate was measured in the room of object A and B and  $0,11 \text{ h}^{-1}$  and  $0,09 \text{ h}^{-1}$  were confirmed. So at least a small air exchange rate could be suspected. An air exchange rate of  $0,3 \text{ h}^{-1}$  was postulated and the area specific airflow rate in the test chamber was fixed on  $1 \text{ m}^3/(\text{m}^2 \text{ h})$ . Concerning the objects N and O a higher air exchange rate was expected, because of the windows, that do not fit tightly.

Using these parameters, it could be shown, that for object B the test chambers can be used to predict the concentrations in the room. In Object A the reduction of the limonene-concentrations took longer than predicted by the results of the test chamber examination. This is probably due to sinks in the room (for instance wallpaper or the parquet itself). It can be estimated, that in Object A it took five to six times longer to reach  $50 \text{ µg/m}^3$  Limonene in the room than in the test chamber ( $50 \text{ µg/m}^3$  is said to be an usual concentration in german

households [8]). The FLEC was only used two times to determine the emission of the parquet in object A. The measured concentration corresponded very well.

In object O the comparison of the concentration in the room measured on the third day with the emission profile generated in the test chamber indicates, that the sample which was used in the test chamber was treated with less oil than the parquet in the room. Nevertheless from the emission profile and the informations of object A it can be estimated, that it will take approximately one to two months for the limonene-concentration to reach  $50 \mu\text{g}/\text{m}^3$ . This is confirmed by an examination of the air concentration at the 67th day, which showed a concentration of  $6 \mu\text{g}/\text{m}^3$ .

In Object N measurements were not corresponding. The concentration in the air was clearly higher than supposed by the test chamber examination. The inspection of the room leads one to suppose that strings of hemp, that are situated between the floor boards for esthetic reasons, have been infiltrated by the oil and caused an elevation of emission.

It must be concluded, that it is possible, to predict the emission behaviour of parquet surface treatments in general, but that many different factors as for example problems with application can alter the emission. More efforts are needed, to come to low-emission applications.

#### REFERENCES:

1. Tähtinen, M, Saarela K, Tirkkonen T et.al. 1996. Time Dependence of TVOC Emission for selected materials. Proceedings of the 7th international conference on indoor air quality and climate - Indoor Air '96, Vol. 3, pp. 591-596
2. Verein Deutscher Ingenieure (VDI). 1984. Measurement of Gaseous Emissions - Gaschromatographic Determination of organic Compounds using capillary columns No. 3482
3. Köhler, M, Weis, N, Stolz, P. 1997. Messung des TVOC-Wertes zur Beschreibung von Gesamtbelastungen in Innenräumen mit volatile organic compounds (VOC). In Ökologisch Bauen und Sanieren. F Diel, W Feist, H-U Krieg, W Linden, eds. Heidelberg: C.F.Müller Verlag.
4. Weis, N, Köhler, M, Stolz, P. 1997. Gesamtbewertung von Innenraumbelastungen flüchtiger organischer Verbindungen mittels des TVOC-Konzeptes. In Ökologisch Bauen und Sanieren. F Diel, W Feist, H-U Krieg, W Linden, eds. Heidelberg: C.F.Müller Verlag
5. Salthammer, T, Meininghaus R, Jacoby A, Bahadir M. 1995. Distribution of air velocities in a small voc test chamber. Fresenius Envir. Bull. 4, pp 695-700.
6. Krooß, J, Siemers, U, Stolz, P et.al. 1997. Luftwechselraten in Wohn- und Arbeitsräumen. Gefahrstoffe - Reinhaltung der Luft 57, pp 352-362
7. Scholz H. 1998. Vorkommen ausgewählter VOC in Innenräumen und deren Bewertung. In Gebäudestandard 2000: Energie & Raumluftqualität. AGÖF, ed. Sprunge-Eldagsen.
8. Krause, C, Chutsch, M, Henke M et.al. 1991: Umweltsurvey Band IIC: Wohn-Innenraum: Raumluft.Berlin