TEXTE
07/2012

Emission behaviour of wood and materials produced from wood

Summary

Umwelt Bundes Amt
Für Mensch und Umwelt

| TEXTE | 07/2012

ENVIRONMENTAL RESEARCH OF THE
FEDERAL MINISTRY OF THE ENVIRONMENT,
NATURE CONSERVATION AND NUCLEAR SAFETY

Project No. (FKZ) 3707 62 301
Report No. (UBA-FB) 001580/KURZ, E

Emission behaviour of wood and materials produced from wood

Summary

by

Dr. Olaf Wilke, Dr. Katharina Wiegner, Dr. Oliver Jann, Doris Brödner, Harald Scheffer
BAM Bundesanstalt für Materialforschung und -prüfung

On behalf of the Federal Environment Agency (Germany)

UMWELTBUNDESAMT

This publication is only available online. It can be downloaded from
http://www.uba.de/uba-info-medien-e/4262.html along with a
German version and a German summary.

ISSN 1862-4804

Study performed by: BAM – Bundesanstalt für Materialforschung und -prüfung
Unter den Eichen 87
12205 Berlin

Study completed in: February 2010

Publisher: Federal Environment Agency (Umweltbundesamt)
Wörlitzer Platz 1
06844 Dessau-Roßlau
Germany
Phone: +49-340-2103-0
Fax: +49-340-2103 2285
Email: info@umweltbundesamt.de
Internet: http://www.umweltbundesamt.de
http://fuer-mensch-und-umwelt.de/

Edited by: Section III 1.4 Substance-related Product Issues
Dr. Frank Brozowski, Dr. Frank Brauer (III 2.5)

Dessau-Roßlau, March 2012

Summary

This research project investigated the emission behaviour of natural pine wood and materials produced from pine wood, such as Oriented Strand Board (OSB) and plywood.

To do this the wood of a freshly felled pine tree was tested and OSBs from 5 manufacturers were bought at different DIY stores. Also, 5 pine and 2 spruce plywood boards were purchased at the same markets. The age of the boards could not be determined.

A number of OSBs were made from the wood of the felled pine in IHD's pilot plant in Dresden under different conditions. The drying temperature of the strands and the press temperature were varied during production. In addition, strands from different trunk sections of the pine were used for producing the boards.

The prime objective of the investigation was to find various solutions for reducing VOC emissions from timber, in particular from OSB.

For this purpose antioxidants were also added in the production process of additional OSB batches in the IHD plant.

A pre-selection of antioxidants took place in tests carried out in a so-called µ-chamber (chamber volume 45 ml, 6 single chambers). Emissions were measured from fresh, dried strands and from those spiked with different antioxidants 24 hours after placing them in the chambers. This initial screening enabled multiple tests to be undertaken on a large number of samples treated using a variety of methods.

The most problematic substances in terms of a health-related evaluation of building products according to the AgBB scheme are usually substances with a low LCI value. For OSB this means unsaturated aldehydes. These compounds are generated in the production process by the oxidation of fatty acids, of which pine wood contains more compared with other types of wood. Since saturated aldehydes, especially hexanal, are also produced during fat oxidation, but in higher concentrations, hexanal is a good guide component for investigating the reduction of aldehyde emissions.

Out of the OSBs acquired in stores, boards from 3 manufacturers would not meet the AgBB scheme's requirements. The emissions of unsaturated aldehydes play a crucial role here.

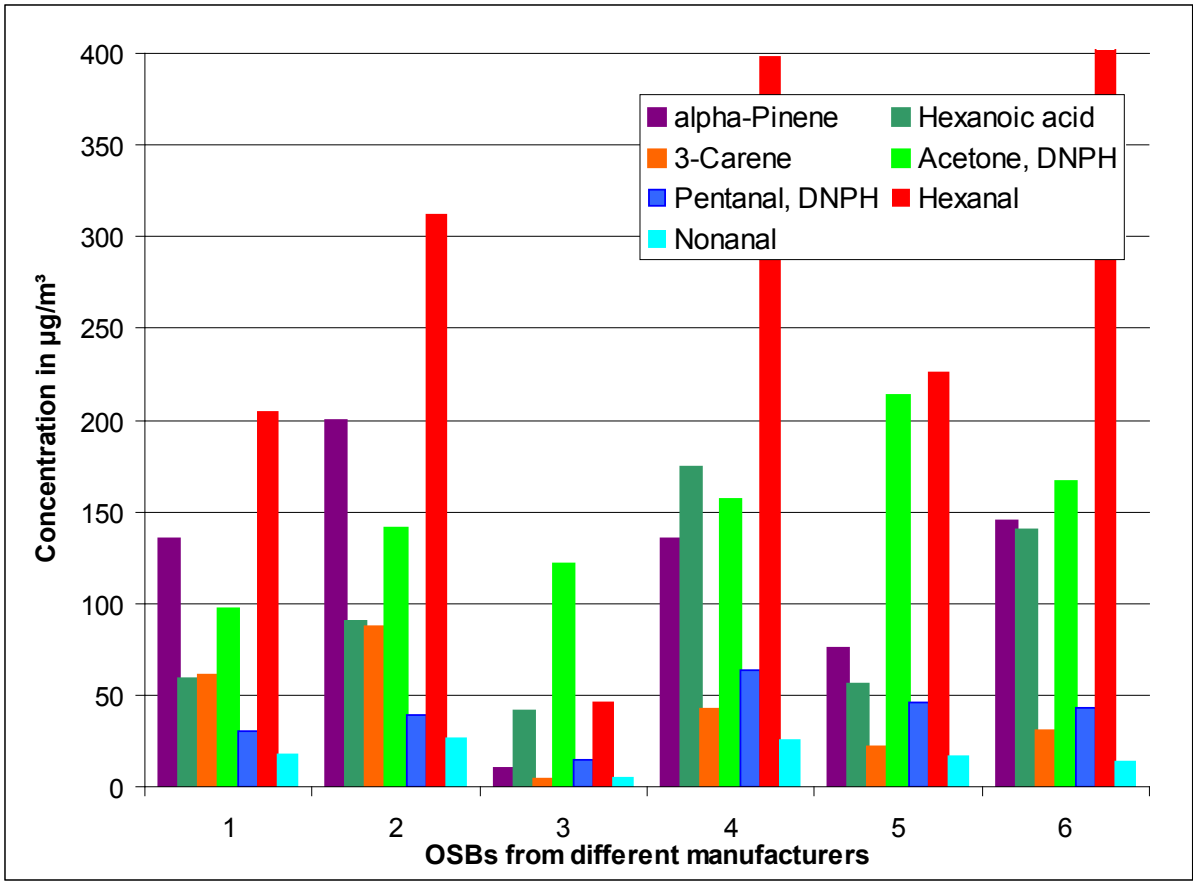

Figure 1: Emissions from OSBs of 5 manufacturers (bought in DIY stores), 28th day of chamber testing

Table 1: AgBB evaluation of OSBs

Criteria/ Material Requirements	$TVOC_3$ mg m^{-3} ≤ 10	$TVOC_{28}$ mg m^{-3} ≤ 1	$TSVOC_{28}$ mg m^{-3} ≤ 0,1	R ≤ 1	non-assesable VOC mg m^{-3} ≤ 0,1	Evaluation AgBB	q m^3 m^{-2} h^{-1}
OSB 1	**1,1**	**0,54**	**0**	**1,56**	**0,04**	**failed**	**1,0**
OSB 2	**3,03**	**0,93**	**0**	**1,81**	**0,06**	**failed**	**1,0**
OSB 3	**0,16**	**0,14**	**0**	**0,17**	**0,01**	**passed**	**1,0**
OSB 4	**2,82**	**0,98**	**0**	**1,90**	**0,02**	**failed**	**1,0**
OSB 5	**1,75**	**0,56**	**0**	**0,56**	**0,03**	**passed**	**1,0**
OSB 6	**1,64**	**0,99**	**0**	**4,32**	**0,00**	**failed**	**1,0**

Emission measurements were performed in test chambers (as per ISO 16000-9). The temperature was 23°C, the relative humidity 50% and the area-specific air flow rate q was 1,0 m³/m²h.

Figure 2: 23-litre emission test chamber

The determination of the test chamber air concentration and assessment according to the AgBB scheme took place on the 3rd, 7th/10th and 28th day.

Sampling for volatile organic compounds took place using Tenax tubes and the samples were analysed by means of thermodesorption and GC-MS (ISO 16000-6). In addition, sampling for aldehydes and ketones was carried out with DNPH cartridges and the analysis was performed using HPLC-DAD (ISO 16000-3).

In order to be able to reduce aldehyde emissions, the influence of the raw materials and process parameters were investigated first. Furthermore, OSBs spiked with antioxidants and preservatives were tested and their emissions measured. For these experiments, the wood of an 80-year-old pine tree was divided into heart- and sapwood at different heights (1-2 m, 6-8 m and 12-14 m) and the emissions from the different samples were determined in 23-litre chambers. In addition, OSBs were produced from the sections already tested using different production parameters in the pilot plant. Simultaneously, preliminary tests were performed for the selection of the most effective antioxidants and preservatives. Afterwards OSBs supplemented with antioxidants and preservatives from the said trunk sections were produced in the pilot plant under specified process conditions and compared with untreated OSBs.

The tests on pine heart- and sapwood showed differences in the spectrum of substances emitted as well as in the concentration levels. Fresh trunk sections from

sapwood emit more aldehydes, for example hexanal and octanal, and less terpenes, particularly α-pinene and 3-carene, than heartwood trunk sections which emit more terpenes but no aldehydes.

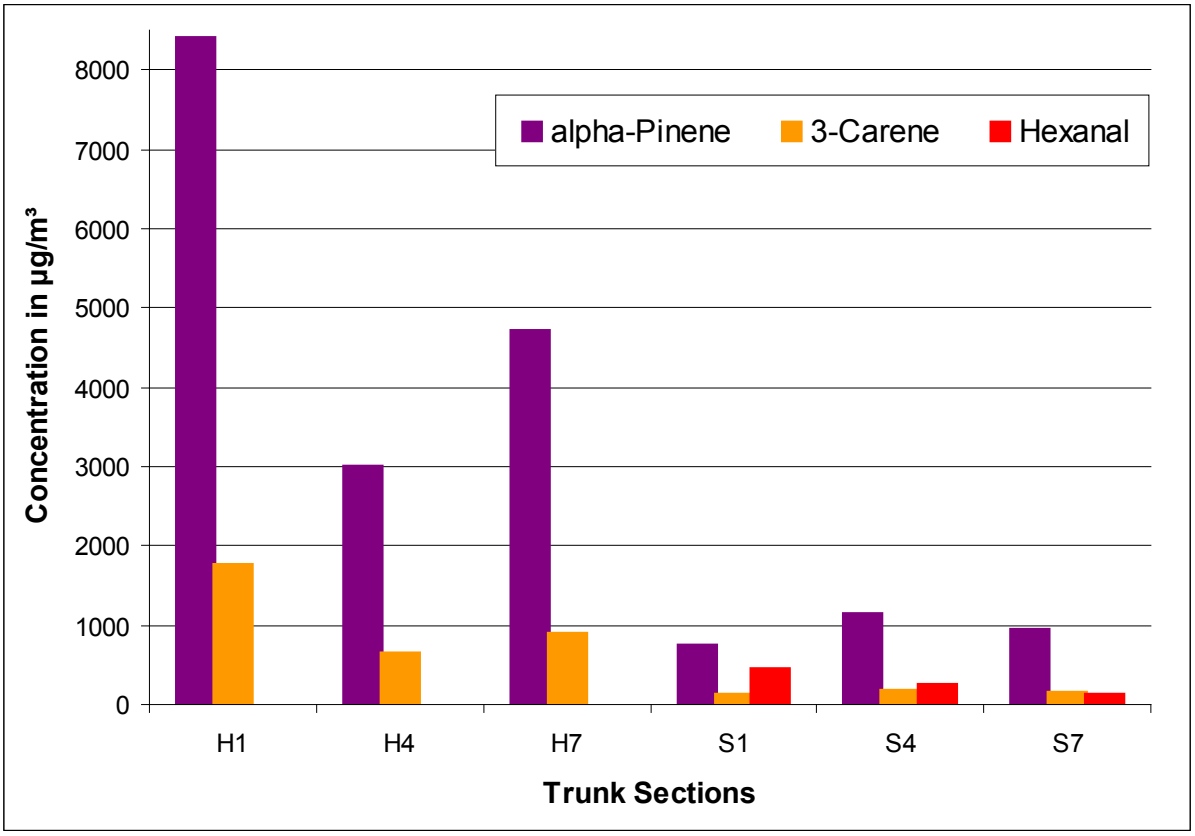

Figure 3: Emissions from pine heart(H)- and sapwood (S) on the 28th day of chamber testing, trunk sections 1, 4 and 7

The heart- and sapwood trunk sections were tested again after being stored in an emission chamber for about a year. Terpene emissions decrease both in heart- and sapwood during storage. Hexanal and hexanoic acid emissions from sapwood decreased within that one year. Contrary to these results, hexanal and hexanoic acid emissions from heartwood increased. In contrast to stored heartwood, stored sapwood emits about 250 µg/m^3 of hexanal and about 110 µg/m^3 of hexanoic acid.

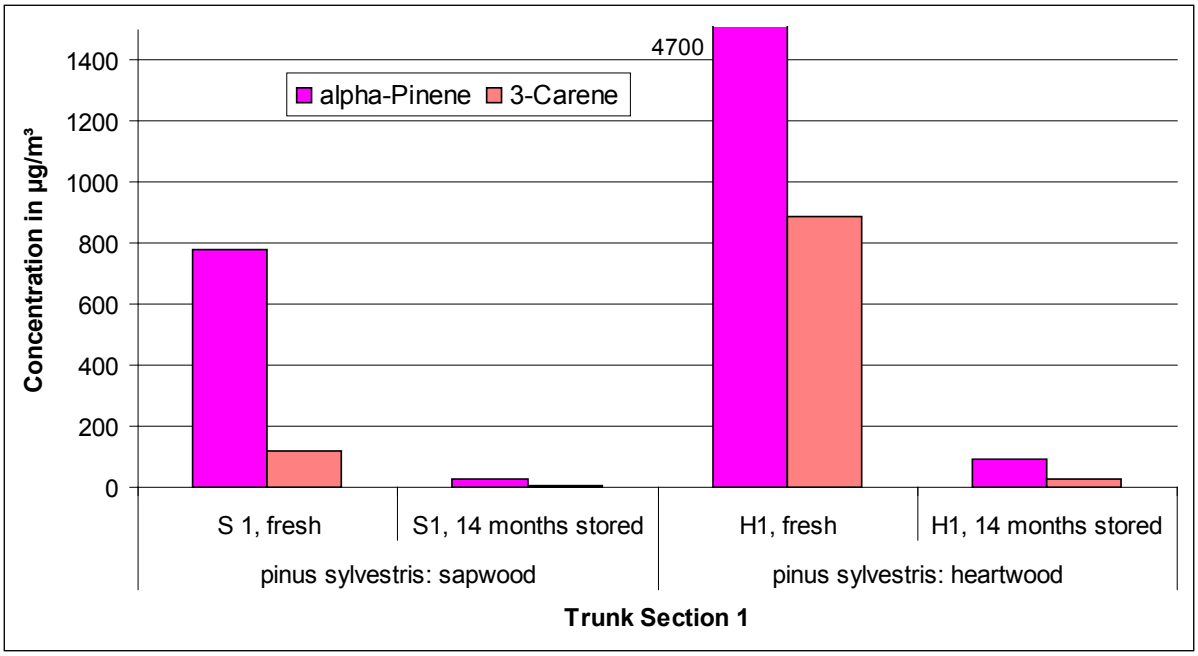

Figure 4:
Terpene emissions from fresh and stored heart- and sapwood on the 28th day of chamber testing

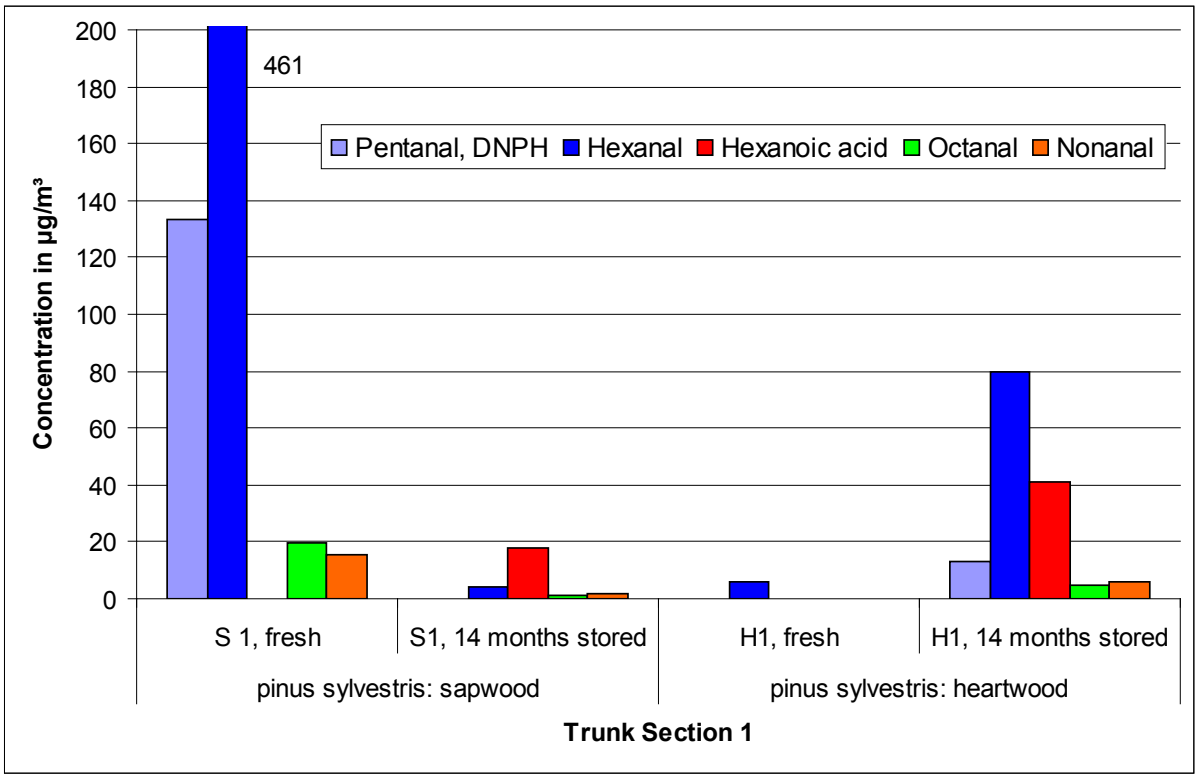

Figure 5:
Aldehyde emissions from fresh and stored heart- and sapwood on the 28th day of chamber testing

OSBs were produced from the characterized pine wood under specified production conditions and tested in emission test chambers. Production parameters comprised two different trunk heights (2 = 0-2 m and 6 = 6-8 m), two drying temperatures (250 °C and 400 °C) and three press temperatures (190 °C, 220 °C and 250 °C).

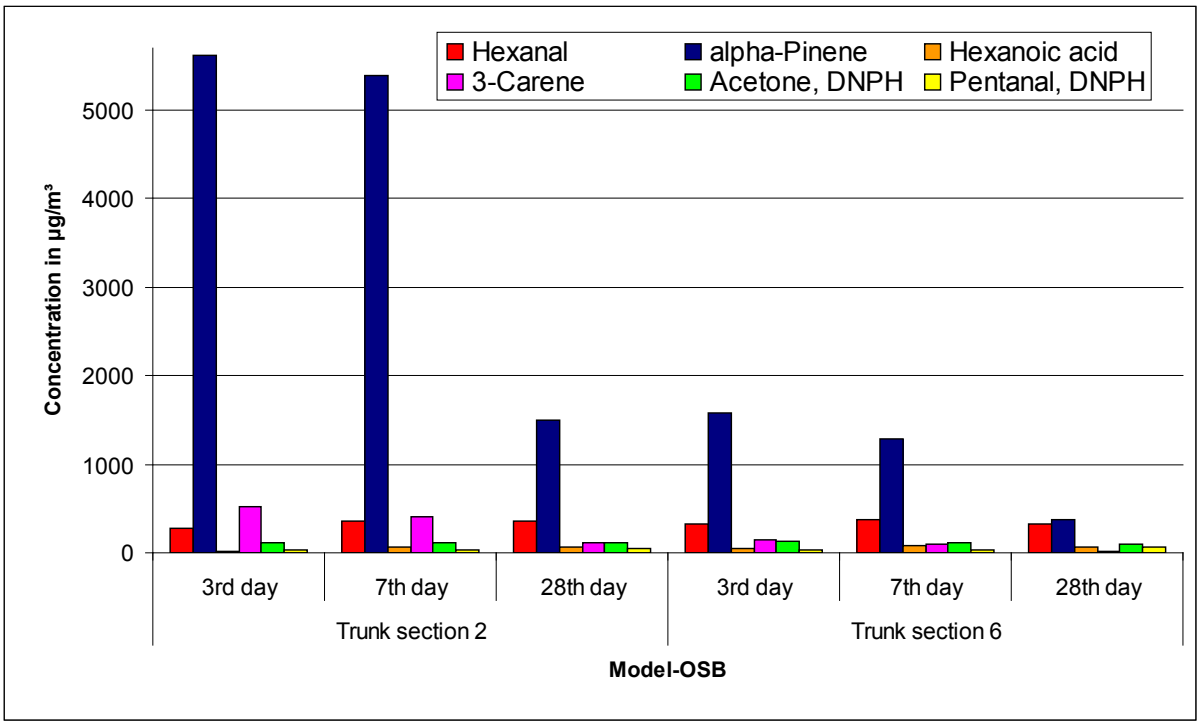

Figure 6: Emissions from model-OSBs which were made from trunk section 2 and 6

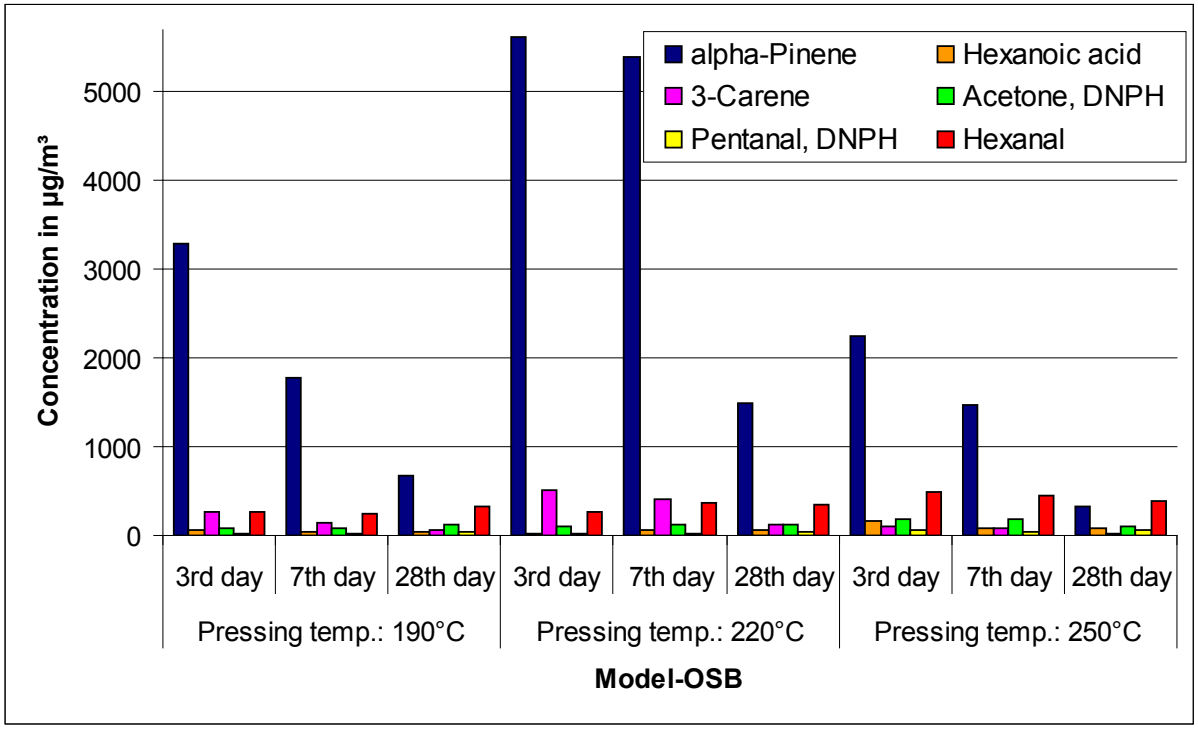

Figure 7:
Emissions from OSBs made from strands which were dried at 400 °C and pressed at different temperatures

Investigations into the effect of production parameters indicate that the trunk section is an influencing factor. OSBs made from trunk section 2 emit substantially more terpenes than OSBs made from trunk section 6. An OSB made from trunk section 2 shows an α-pinene concentration of 1500 µg/m³ on day 28, while an OSB from section 6 shows only 400 µg/m^3. It should be noted that the emission measurements started 5 days after the production of the OSBs. Hexanal concentration is similar for both trunk sections and, in contrast to α-pinene, does not fade over 28 days.

Hexanal concentration of OSBs is similar at different press temperatures as well, indicating that press temperature is not an influencing factor. In contrast, drying the strands at 250°C produced higher hexanal emissions on day 28 than drying them at 400°C.

A relatively constant acetone emission (concentration approx. 100 µg/m³) was measured from all OSBs, independent of drying and press temperature.

220°C press temperature yielded the highest terpene emissions and 250°C press temperature the highest hexanoic acid emissions.

All in all, emission behaviour (‘decay curve’) for terpenes, aldehydes, hexanoic acids and acetone from OSBs manufactured in the pilot plant was very different. The different decay behaviours of the substances was confirmed by a large number of measurements (altogether 16 OSBs were produced).

Since controlled reduction of aldehyde emissions was not possible with the parameters mentioned above, and because aldehydes are products of fat oxidation, the use of antioxidants and preservatives from food technology and food chemistry was tested and their effects on emissions investigated.

In preliminary tests, strands were submerged in solutions of antioxidants or preservatives one by one and afterwards dried in a muffle furnace at 250 °C and 400 °C, respectively. For comparison, untreated strands were also dried in the muffle furnace at 250 °C and 400 °C, respectively. After the drying process the strands were placed into an emission test chamber (µ chamber) and VOC emissions were determined.

The µ chamber was used to prove the efficacy of test solutions B to I on reducing aldehyde emissions from strands which were dried at different temperatures. These

preliminary tests were performed several times simultaneously because of the natural fluctuations and properties of the raw materials.

Out of all solutions A to I, solution B showed the best potential for reducing aldehyde emissions at a strand drying temperature of 400 °C. Further tests on strands dried at 250 °C and 400 °C respectively confirmed the previous results regarding the efficacy of solution B.

To produce OSBs, fresh strands were sprayed with comparison solution A or with aqueous solution B in a gluing drum. The strands were then dried at 250 °C and 400 °C respectively, in a drum dryer in the pilot plant. After gluing the dried strands the OSBs were pressed at a temperature of 220 °C (press time factor 15 s/mm).

Altogether five OSBs were produced (four with solution B and one with the comparison solution A) and tested. After production, the boards were placed in emission test chambers and the VOC emission was measured over a period of up to 49 days. The hexanal emission reduction results are shown in Figure 8.

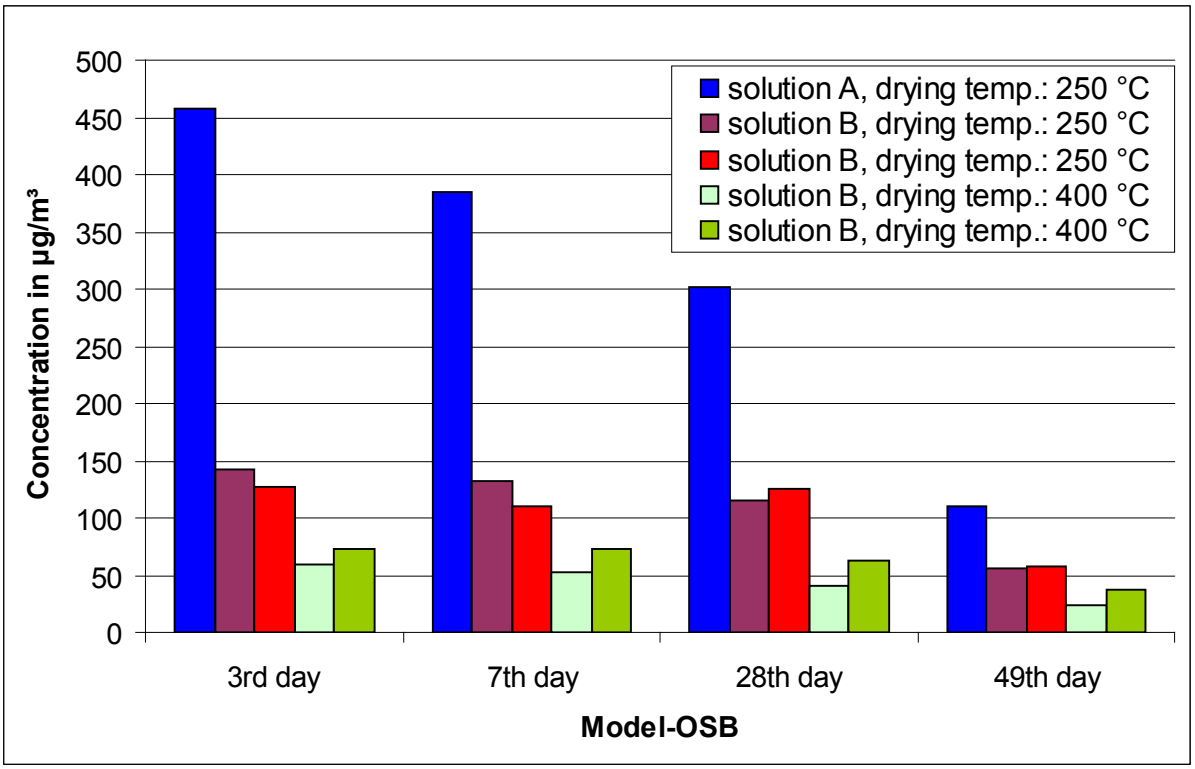

Figure 8: Hexanal emissions from OSB, which were made without additive (solution A) and with additive (solution B)

Antioxidants in solution B reduced aldehyde emissions at drying temperatures of 250 °C and 400 °C. Aldehyde emissions from the boards treated with solution B were

lower than those from the untreated board (solution A) (a decrease by ⅔ to ⅓ of the comparison sample). Hexanal emissions from OSBs treated with solution B are lower than those from the comparison board (solution A, 250 °C) from the third day on. Nor did aldehyde concentration from the treated boards increase later on. Figure 9 shows the emission measurement results from the OSBs after about 10 months of storage. They indicate that the treatment by solution B in effect reduced aldehyde content in the OSBs and did not just cause a time delay in aldehyde emissions.

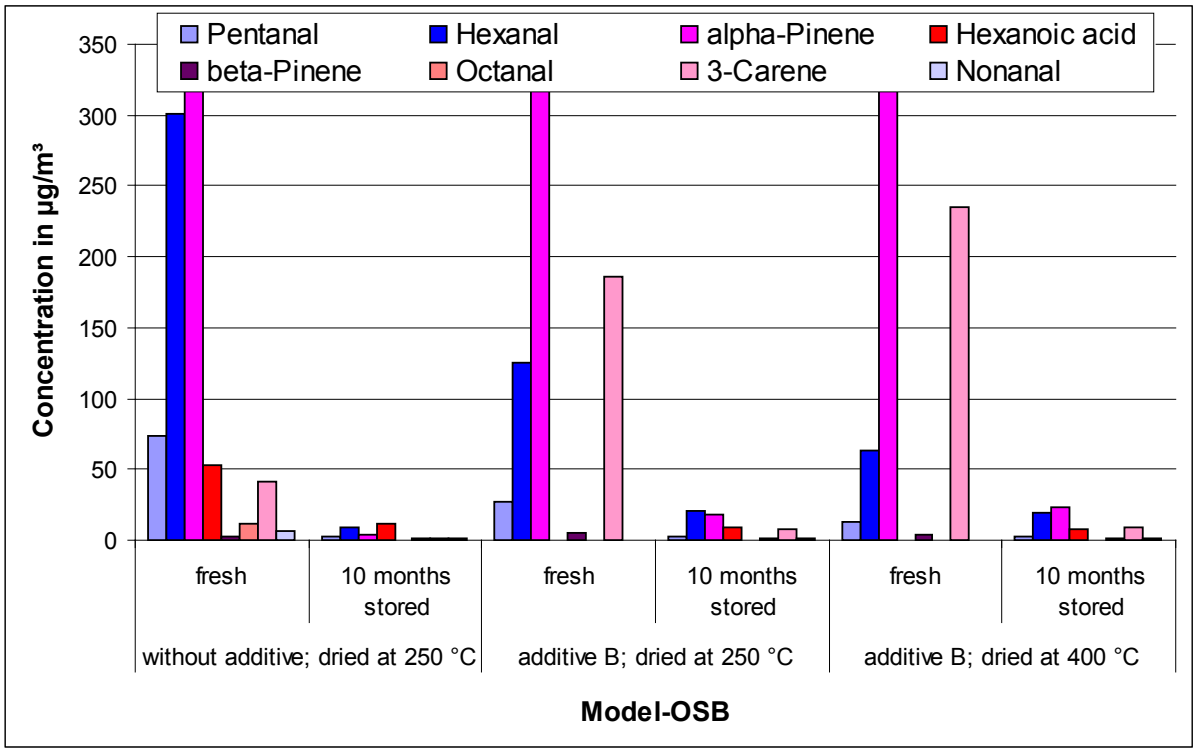

Figure 9: VOC-emissions from treated and untreated OSB on the 28th day of chamber testing (fresh and after 10 months of storing)

In addition to OSBs, five pine plywood boards and two spruce plywood boards were bought in different DIY stores and tested. No information was available about their production date and manufacturing conditions. With the exception of one board, the plywood boards were individually wrapped in plastic foil.

Figure 10 shows the terpene emissions from the five pine plywood boards bought in stores. The total terpene emission (α-pinene, β-pinene and 3-carene) from board D was 1600 µg/m³ on day 28 of the chamber test. This board would thus exceed the maximum TVOC value of 1000 µg/m³ specified by the AgBB scheme. The terpene concentration from board D noticeably increased from day 3 to 28. Board E also showed a moderate increase of terpene emissions over 28 days, however at a lower concentration level.

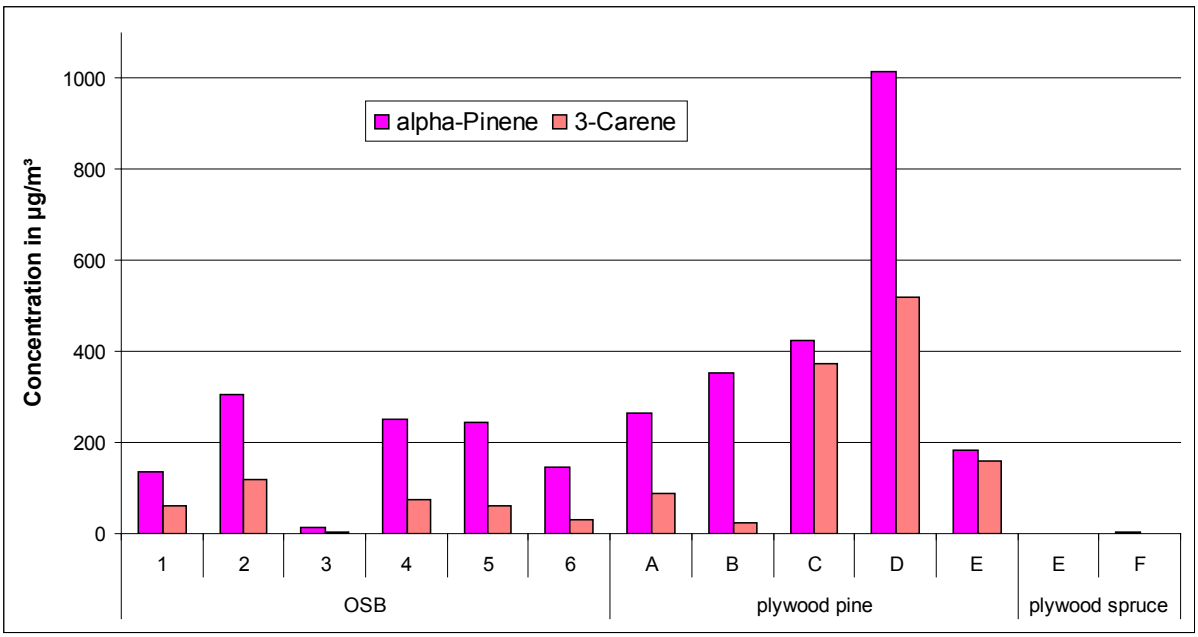

Figure 10: Terpene-emissions from OSB and plywood boards, 28th day of testing

The aldehyde emissions of all pine plywood boards tested decreased from day 3 to 28 (Figure 11). The greatest hexanal concentration on day 28 was 37 µg/m³, otherwise maximum pentanal, hexanal and octanal concentrations were around 20 µg/m³. Unsaturated aldehydes were not detected.

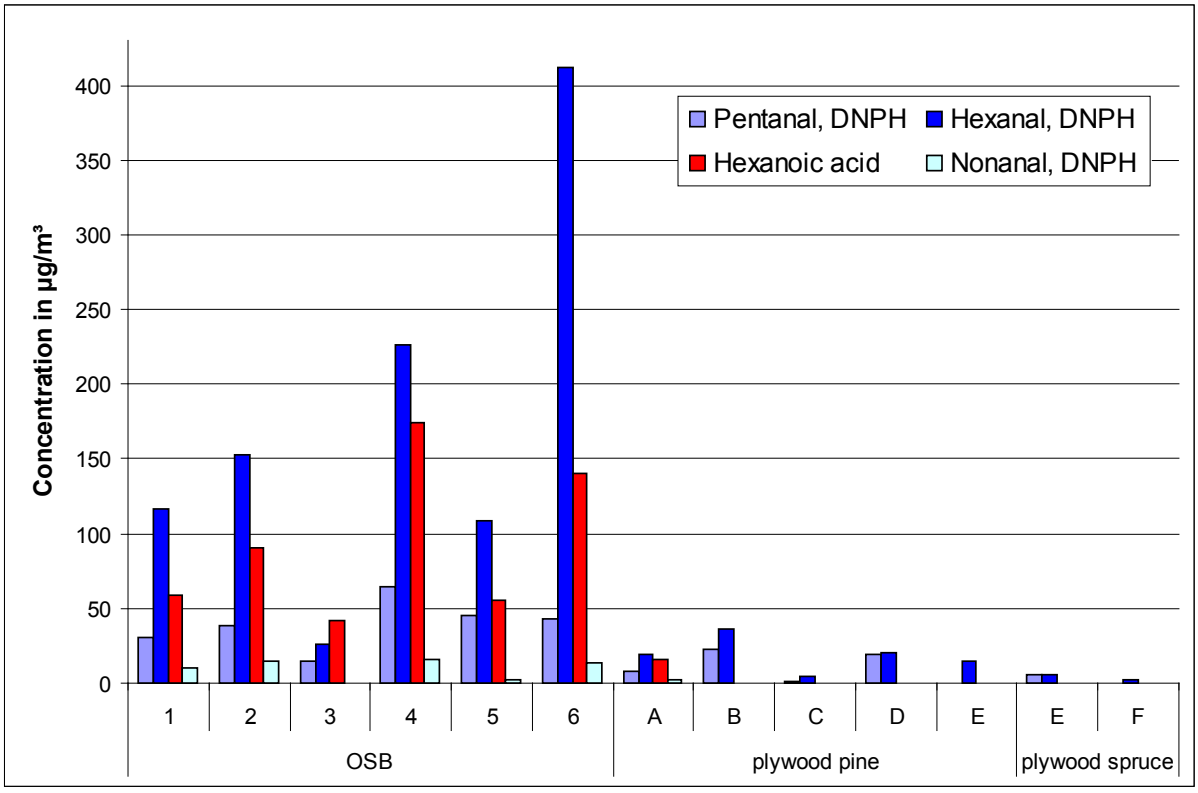

Figure 11: Aldehyde-emissions from OSB and plywood boards, 28th day of testing

Terpene and aldehyde emissions from the two spruce plywood boards purchased were very low, i.e. less than 10 µg/m^3 as early as on day 3. Hexanoic acid and octanal were not detected, unlike from pine plywood.

Comparing the emissions from OSBs and plywood boards bought in DIY stores it became apparent that the terpene emissions from pine plywood (boards A to E) on day 28 of the chamber test were greater on average than those from OSB (Figure 10). In contrast, aldehyde emissions from OSB were much greater than from plywood boards (Figure 11).

The results of the sensory testing for the investigated wood products are shown in figure 12. On the 28th day of chamber testing the values for hedonics were in a range between +1 and -1. The perceived intensity of the odour was in a range between 5 and 11 pi.

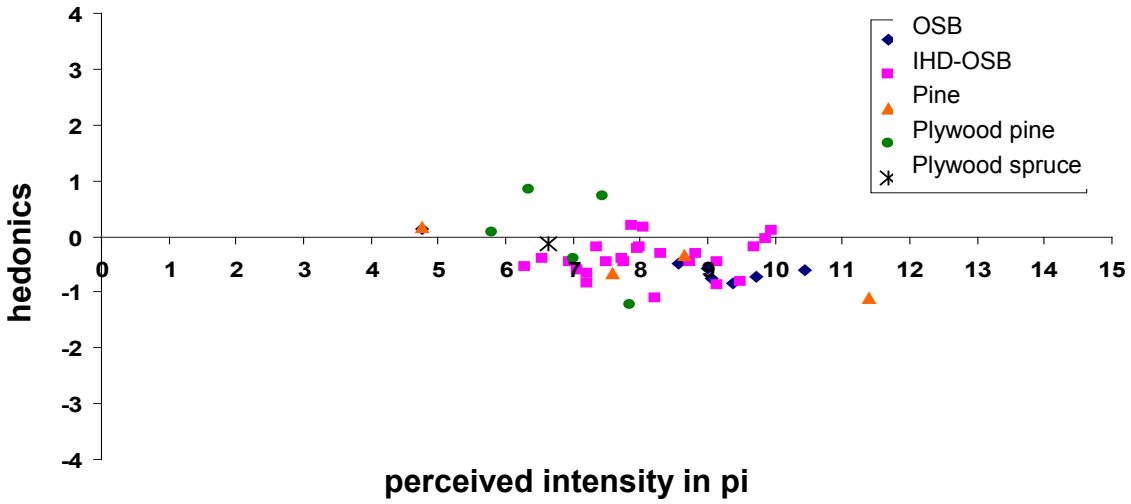

Figure 12: Results of sensory testing of wood products on day 28 (perceived intensity over hedonics)