Journal of International Scientific Publications: Materials, Methods and Technologies

Volume 8, ISSN 1314-7269 (Online), Published at: http://www.scientific-publications.net

AEROBIC DEGRADATION OF MEDIUM DENSITY FIBERBOARD (MDF) AS A WOODMANUFACTURING INDUSTRY WASTE WITH COMPOST ADDITION

George Ntalos[1], Charis Tsanaktsis[2]

[1]Department of Wood & Furniture Design & Technology, Technological Institute of Larisa,

V. Griva 11, 43100 Karditsa

[2]Department of Environmental Engineering, Democritus University of Thrace, 67100 Xanthi

Abstract

The fiberboard waste constitutes in our days an important part of urban waste stream, because they are used in increasing amounts, for the production of interior wood constructions. The management of such waste already troubles the modern societies. However, via biodegradation it is possible this waste material to constitute a valuable resource for the production of new wood based panels, thus helping on one part in the partial satisfaction of increased needs for wood and on the other part in the restriction of problems caused by these materials when they are disposed. The aim of this researchwas to study the influence of compost in degrading formaldehyde adhesives so that a large percentage could be reused as wood waste panels or further environmental disposal. Particularly we managed to determine whether the contact of these two materials favors the degradation of formaldehyde adhesives. It was used small chamber test in stable conditions (temperature, moisture, weight) for 21 days period, using wood waste from the same fiberboard in order to reduce heterogeneity problems. Further removal of formaldehyde, confirms that compost could be a favorable factor in wood waste degradation. Nevertheless, it is particularly important the way that compost participates in process.

Key words: *MDF, Waste Management, Formaldehyde reduction, Composting*

INTRODUCTION

For many years Medium Density Fiberboard (MDF), produced from small wood fragments and wood fibers bonded with urea-formaldehyde resin, has been increasingly used to make furniture and components of building materials due to its good strength and low cost (CanFibre, 2000). This use of MDF leads to large quantities of useless residues which become part of the municipal solid waste (MSW) stream. Instead of disposing the material, it could be converted and used as a raw material with great potential or used as biomass for energy production (Skarvelis et al 2005). However, as MDF contains formaldehyde at concentrations of 5 to 15 mg/100 g dry mass or even more (BS EN 120:1992), it should be found a natural and low cost process contributing in formaldehyde degradation. Formaldehyde, is a volatile organic compound that chemical industrieswidely useand constitutes a key ingredient in production of wood adhesives (Que et Furuno, 2007). Due to volatility of compound and water solubility of urea-formaldehyde resins, it is favorable to treat them in high temperature and moisture content. The organic fraction of MSW,which is subjected to aerobic degradation gives, as final product a microbial stable material, compost (Tchobanoglous et al., 1993). Composting process requires mesophilic or thermophilic zone temperatures and moisture content up to 60-65 % to avoid anaerobic conditions. Formaldehyde is degradable under aerobic and anaerobic conditions in aqueous and soil media (Azachi et al., 1995Omilet al., 1999) there is no significant research regarding formaldehyde degradation during composting. Keener et al. (1994) studied formaldehyde emission during composting of spent press-molded, wood fiber pallets bonded with urea-formaldehyde.In general formaldehyde gas is potentially harmful, causing eye and nose irritation. It is also considered to be carcinogen (Mazumber, 1997). The allowable levels of formaldehyde in Greece and many other European countriesare equal to or less than 8 mg/100 g dry mass in all the glued products (Y.A. Z3-7835/2011. FEK 2650/B'/9.11.2011). Formaldehyde is a toxic substance to humans, animals and plants, furthermore inhibits the growth of microorganisms such as bacteria and fungi (Eicker and Apostolides, 1986, Omilet al., 1999).No quantitative data on the biodegradability of industrial wood-based construction materials appear to have been published. This research reports the aerobic biodegradability of MDF under laboratory conditions and compost effect. The microbial growth during formaldehyde reduction was also determined.

Volume 8, ISSN 1314-7269 (Online), Published at: http://www.scientific-publications.net

MATERIALS AND METHODS

We used MDF waste derived from PINDOS S.A. a fiberboard production industry placed in northern Greece. Specifically are MDF residues that arising during production process due to manufacturing problems, which were exposed for different intervals but from the same production line. The compost that was used produced in the mechanical recycling and composting plant in Chania and derived from the biological aerobic treatment of the organic matter of mixed solid waste. Its moisture content was 26,9 %, pH 8 and the C/N 15. In order to reduce heterogeneity problems, we used wood residues from the same fiberboard. We cut the sample in cubes (25x25 mm) to match the specification of the Perforator Method (EN-120:1992). The initial moisture content was measured 8,6 % and the density was 0,65 g/cm^2. We put them in sealed glass vessels, adding water to reach 50 % moisture, with the following proportions:

A. vessel with MDF waste (225 g)

B. vessel with MDF which is in contact with compost (225 g MDF, 75 g compost)

C. vessel with MDF which is not in contact with compost (225g MDF, 75 g compost)

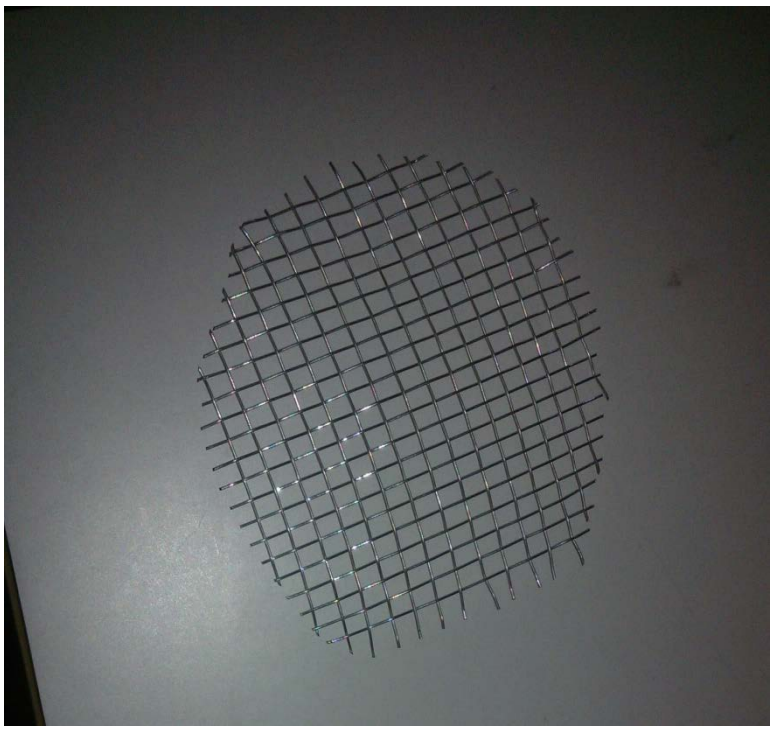
They were treated for 21 days period, in stable conditions at 35^{0}C in oven. Every 24 hours there was a manual ventilation and compost stirring. The B vessel which contains a mixture of these two materials, after the first week a crust of compost in MDFwas created after the stirring (Pic. 1). At the other vessel (C) the two materials are separated with a stainless grid (Pic. 2), which is removed in every stirring, and compost substrates of MDF.

The CO_2 production

The CO_2 gas was measured with respirometry tests every week. It was trapped in a 2N KOH solution which was present in all vessels. The solution was titrated weekly by using 0.1 N H_2SO_4 to determine CO_2 concentration. At the end of the test the moisture content of the substrate was measured, to correct the HCHO concentration rates.



Picture1. Compost crust in MDF residues surface



Picture2. Stainless grid used in the C vessel

Determination of moisture content

Moisture content was determined in accordance with EN 322:1993. The moisture content on sampleswas determined of at least 4 test pieces (25mm x 25mm). The samples were weight to an accuracy of 0.1 % into the watch glass and were dried in the oven at a temperature of 103 ± 2^0C to constant mass (about 12 hours). Constant mass is considered to have been reached when the results of two successive weightings, carried out at intervals of non-less than 6 hours, do not differ by more than 0.1% of the mass of the test pieces. After the removal from the drying oven, the test pieces shall be allowed to cool in a desiccator before weighting.

HCHO concentration

HCHO concentration was measured in accordance with EN-120:1992 Perforator Method. About 110 g of test pieces are weighted to an accuracy of 0.1g and put into a round bottom flask. 600 ml of toluene were added. Subsequently, the round bottom flask is connected to the perforator. About 1000 ml of distilled water is poured into the perforator attachment, leaving a space of 20 mm to 30 mm between the surface of the water and the siphon outlet. The condenser and the gas absorption equipment are then connected. The absorption bulb of the gas absorption equipment is filled with about 100 ml of distilled water and connected to the apparatus. When the apparatus (Fig.1) has been assembled the cooling water and the heating are turned on. The extraction is carried on about 2 hours starting at the moment that the first bubbled pass through the filter insert. The HCHO is extracted from test pieces by means of boiling toluene and then transferred into distilled water. The formaldehyde content of this aqueous solution is determined photo-metrically after Handtzsch reaction. Aqueous HCHO reacts with ammonium ions acetylacetone to yield diacetyldihydrolutidine (DDL). DDL has an absorbance maximum in 412 nm. The reaction is highly specific to formaldehyde. We have to measure the final moisture of each mixture in order to correct the concentration rates if required.

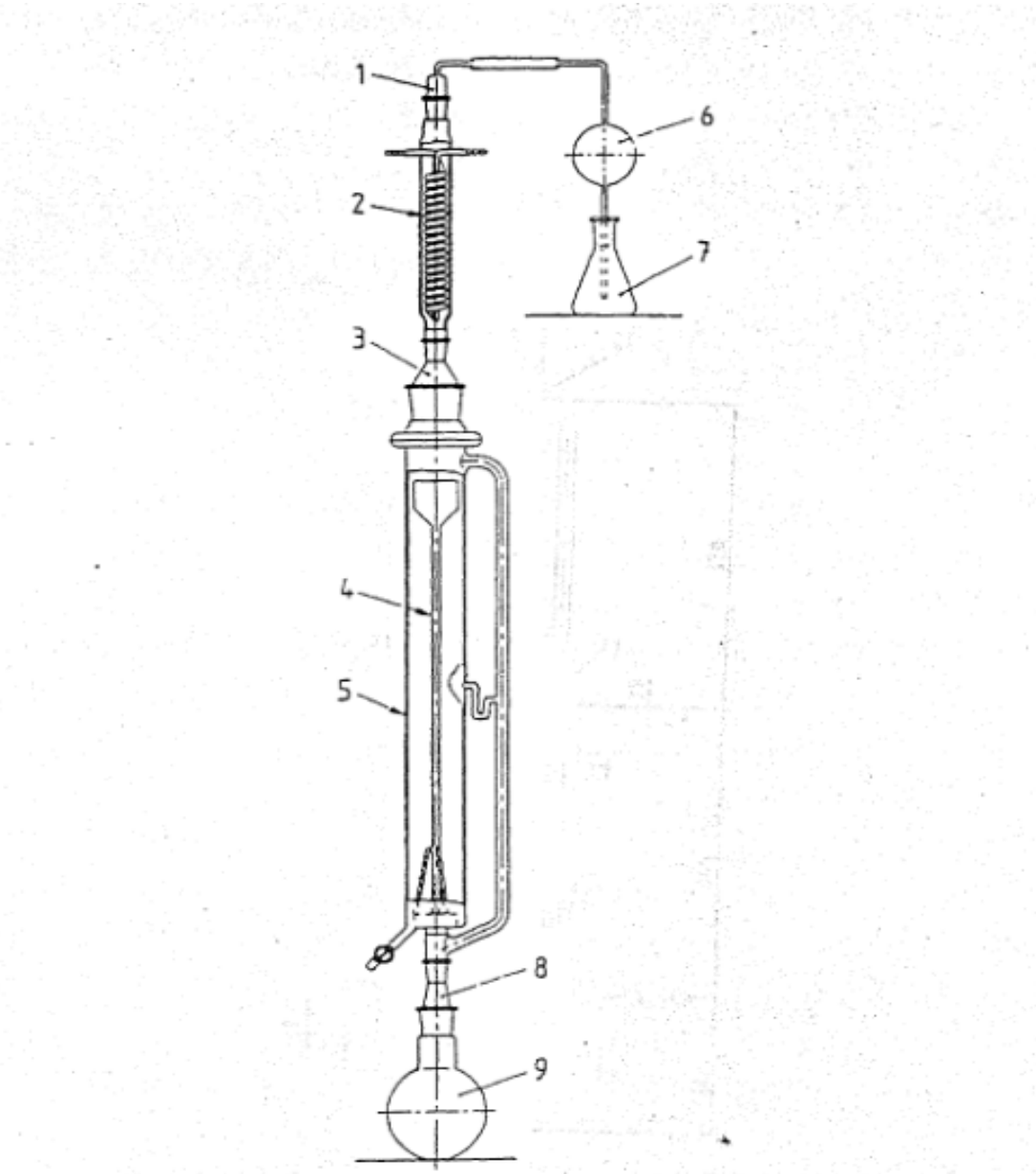


Figure 1. Extraction apparatus

RESULTS

The CO_2 cumulative production is shown in the following diagrams 1 and 2 in correlation with days.

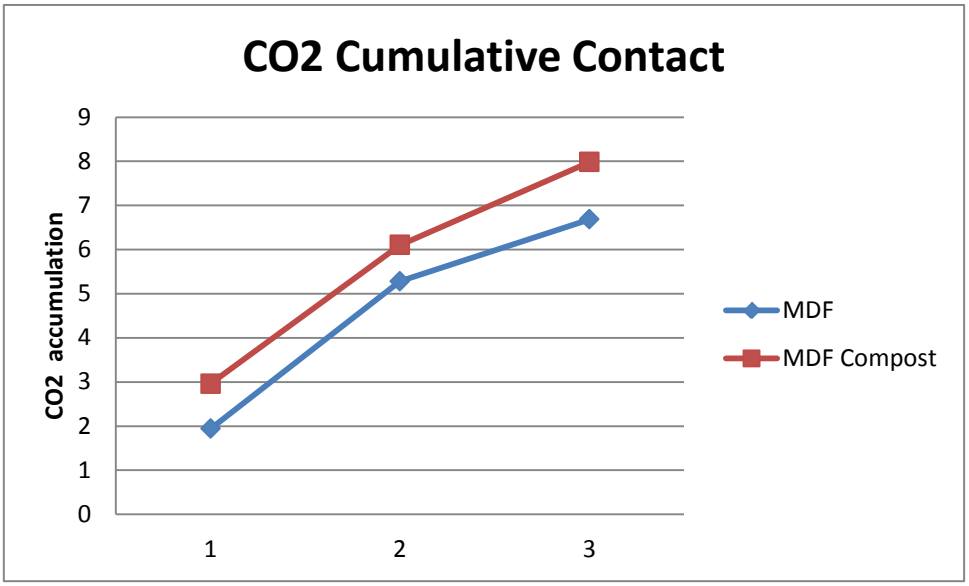


Diagram 1. CO2 Cumulative production when MDF is in contact with compost

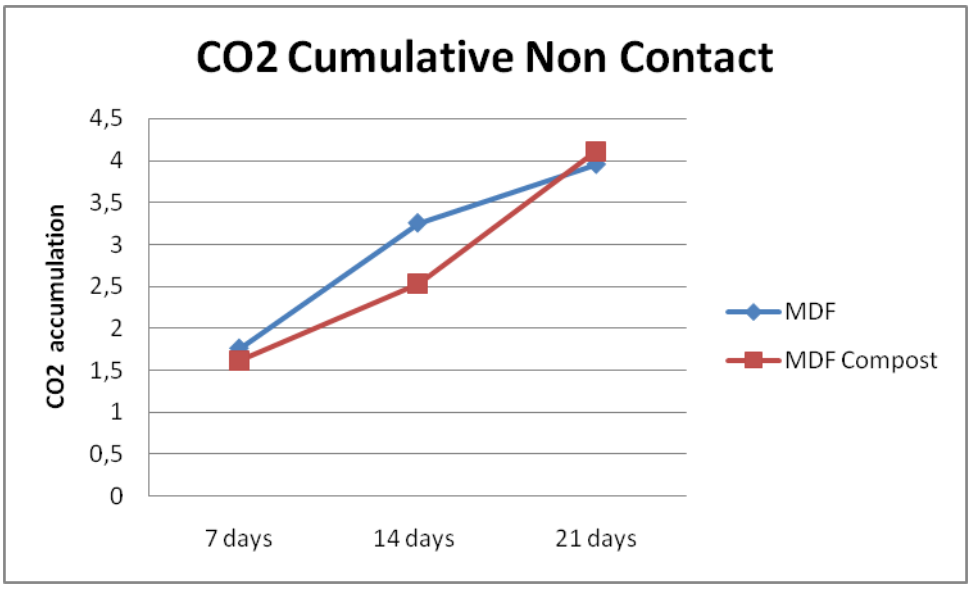


Diagram 2. CO2 Cumulative when MDF is not in contact with compost

The HCHO reduction during 21 days period, is shown in following diagram (3) for both of our treatments.

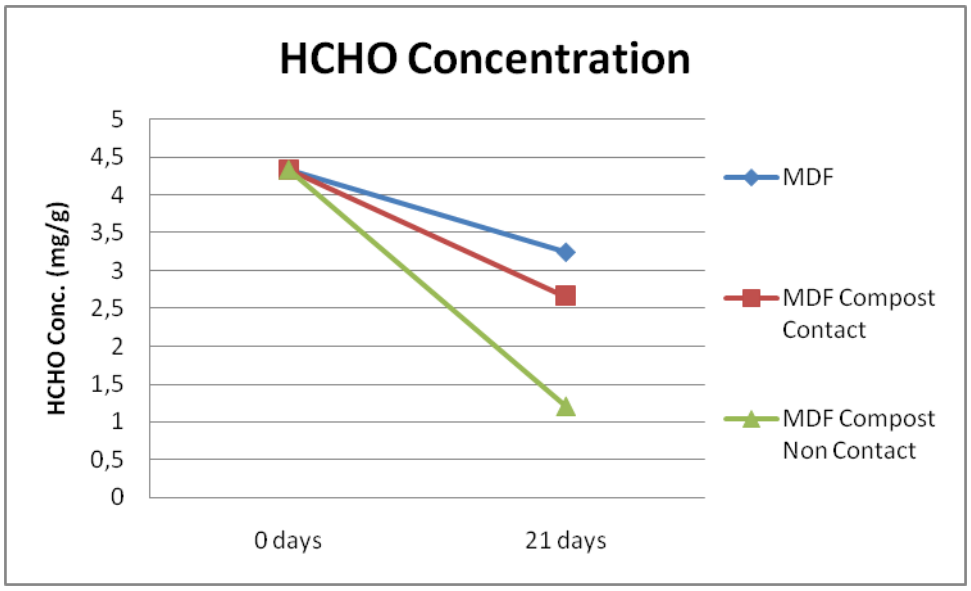


Diagram 3. HCHO Concentration during 21 days period

The % reduction of formaldehyde is shown in the following table (1) for both treatments.

Table 1.The reduction of formaldehyde after 20 days composting

	Initial Concentration	**Final Concentration**	**% Reduction**
MDF Contact	4,33	2,66	38,5
MDF Non contact	4,33	1,21	72

CONCLUSION

MDF residues have significant amount of formaldehyde adhesives, and this make them useless and environmental harmful. Formaldehyde concentration in MDF waste was determined according to EN-120:1992 Perforator Method. The results demonstrated that in the original MDF samples formaldehyde concentration varied 4, 12 to 4, 54 mg/100 g of dry MDF. These high concentrations may inhibit the microbial growth at the beginning of the process because formaldehyde can inhibit the growth of aerobic and anaerobic bacteria. The experiments were performed under fixed temperature of 35 ^{0}C (mesophilic temperature) giving optimal conditions to composting aerobic bacteria in order to use wood as carbon source, thus make easier the formaldehyde escape owing to its volatility. There is no significant difference between mesophilic and thermophilic zone temperatures in formaldehyde degradation so we choose the mesophilic zone due to lower cost. The microbial growth was determined by respirometry tests, which we measured with manometric method the CO_2 that was produced. It is shown in both diagrams (Diag. 1 andDiag. 2) for both treatments that the cumulative CO_2 has a continuous rising tendency beyond the 21 days of our test. This continuous rising is correct because composting is a long term process and could presenta logarithmic phase duration of 21 days owing to microbial activity. In vessels which MDF was in contact with compost, it was shown a faster production of CO_2 compared with the other treatment and the CO_2 values reach higher levels. This contact of two materials favors the faster microbial growth due to higher reaction between carbon source (which is in bigger quantities) and the microorganisms. In contrast to the C treatment, in which MDF was not in touch with compost, microorganisms present slow growthand they need more time to activate. We can also observe all that we mention above in Diagram 2 where microorganisms are less effective in C vesselfrom those who developed in A treatment.

Regarding to the Table 1, where it is shown a significant reduction of formaldehyde concentration when MDF it is not in contact with compost, we have to clarify that the two materials coexist in vessels but there is no contact because of the stainless grid that separates them. This further reduction of formaldehyde leads us to conclude

that compost is an ideal "ally" for removing this undesirable substance. This conclusion is rewarded from the fact that composting is an aerobic process, it is favored by thermophilic and wet conditions and thus is created an intense microbial activity, activating the composting aerobic bacteria. These bacteria which are aerobic, they use external carbon source, which in our case could find only in MDF. In this way they penetrate into the MDF by opening holes (not visible with bare eye), creating accesses to formaldehyde in order to escape in the air. Formaldehyde as volatile and hydrophilic compound tends to escape, when there are such conditions. In the case of vessels that MDF was in contact with compost a crust of compost was created due to stirring and during the 21 days period. So even though the composting aerobic bacteria have the ideal conditions to effect, this crust was an inhibitor because overlaps the edges of the specimens. As it is well known edges of a board are the most exposed area in any kind of wood, to be affected by substance. This explains the further reduction of formaldehyde in vessels which MDF was not in contact with compost. However leaving the aerobic bacteria to effect,we have also to consider that the compost effect gives better results when it is not in touch with the material during the process.

REFERENCES

Gerike, P., Gode, P., 1990, the biodegradability and inhibitory threshold concentration of some disinfecants, Chemosphere. 21(6): 799-812

Keener, H.M., Dick, W.A., Marugg, C. and Hansen, R.C., 1994. Composting spent press-molded, wood fiber pallets bonded with urea-formaldehyde: a pilot scale evaluation Compost Sci. & Util.

Keener, H.M., Marugg, C., Hanse, R.C., and Hoitink, H.A.J. In: Science and Engineering of Composting: Design, Environmental, Microbiological and Utilization: Hoitink, H.A.J. and Keener H.M. Renaissance Publications, Worthington, Ohio 1993, pp. 59-94.

Mohn, W.M. 1997. Biodegradation of hydrocarbons on a commercial solvent. pp. 15-19

Qu, M. and Bhattacharya, S.K., 1997. Toxicity and biodegradation of formaldehyde in anaerobic methanogenic culture. BiotechnolBioeng. 55(5): 727-736

Omil, F., Mendez, D., Vidal., Mendez, R., and Lema, J.M., 1997. Biodegradation of formaldehyde under anaerobic conditions. Enzyme Microb.Tecnhnol.,24: 255-262

Hong, J.H., Keener, H.M. and Elwell, D.L. 1998. Preliminary study of the effect of continuous and intermittent aeration on composting hot manure amended with sawdust. Compost Sei. & Util., 6(3): 74-88

Conner, A. 1996. Urea – formaldehyde adhesive resins. In Encyclopedia of polymeric materials Vol.11. (Salamone, J.C.) 8497-8501

EN 120: 1992. Wood-based panels. Determination of formaldehyde content. Extraction method called the perforator method

CanFibre Home Page. http://www.canfibre.com

Tchobanoglous, G., Theisen, H., Virgil, S., Intergrated solid waste management engineering principles and management issues, 1993

Lykidis, C., Grigoriou, A., 2004. The influence of steam-recovering conditions on the quality of recycled particle boards. In Proceedings of "Management of Recovered Wood Recycling, Bio Energy and other Options". Thessaloniki, 22-24 April 2004, pp. 317-326

EN 322: 1993 Wood-based panels – Determination of moisture content

Skarvelis, M., Vasilopoulos, G., Lamb, A., Eleftheriadis, I., Samios, G., Lyrintzis, G., 2005.The supply of forest biomass for energy production. Records of 3rd PanhellenicConeference for Renewable energy sources. Athens 23-25/2 2005 pp. 219-223.

Y.A. Z3-7835/2011. FEK 2650/B'/9.11.2011

Petinarakis, I., Kavouras, P., 2005. The problem of formaldehyde emission from wood composite products developments and solution

Meyer, B., Boehme, C., 1997. Formaldehyde emission from solid wood. Forest Products Journal Vol. 47, No : 45-48