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THE INFLUENCE OF DECORATIVE SURFACE OF COMMERCIAL PARTICLEBOARDS ON THE FORMALDEHYDE RELEASE MEASURED BY FLASK METHOD

dr Mladan Popović, associate professor, University of Belgrade – Faculty of Forestry
(mladjan.popovic@sfb.bg.ac.rs)

msc Tijana Todorović, University of Belgrade – Faculty of Forestry

dr Milanka Điporovic-Momčilović, full professor, University of Belgrade – Faculty of Forestry

dr Ivana Gavrilović-Grmuša, associate professor, University of Belgrade – Faculty of Forestry

dr Jasmina Popović, assistant professor, University of Belgrade – Faculty of Forestry

Abstract: The formaldehyde release and the formaldehyde content from the commercial particleboards were determined using the flask and perforator methods. Since the melamine faced boards were used in this research, the flask method was applied to evaluate how much the decorative surface (melamine impregnated paper) affects the test results in terms of reducing the formaldehyde emission from the samples. Hence, the flask method tests were performed simultaneously with one test series presenting the melamine faced samples, and the other one presenting the samples with sanded surface. Also, the decorative surface was sanded off from all of the test samples intended for formaldehyde content measurements using perforator method. During this research, it was found that by removing the decorative surface, the formaldehyde emission increased in the range from 12.6% to 16.6%, suggesting that the decorative surface acts as a barrier to formaldehyde emission even for the samples of such a small size used in the flask method. In addition, very high correlation, of 0,989 and 0,959, was found between the formaldehyde content values (perforator method) and the values of formaldehyde release from sanded and melamine faced samples, respectively.

Key words: formaldehyde, particleboard, perforator method, flask method

INTRODUCTION

Wood based composite panels bonded with urea-formaldehyde (UF) resins present one of the major sources of formaldehyde emission into the indoor air. These products, such as the particleboards and medium density fiberboards (MDF), have become increasingly popular during the second half of the twentieth century, especially in the furniture production and for the use in other interior applications and constructions. This trend con-

tinues today together with the increased health concerns, but also with a number of more stringent regulations and emission standards (Ruffing *et al.*, 2011). Throughout this period the various testing methods have been developed. Today, various chamber methods has been established as a reference methods for testing the formaldehyde emission from wood based panels. In North America, the large chamber method - ASTM E1333 is

selected as a primary method by the CARB regulation intended to reduce the formaldehyde emission from composite wood products (CARB, 2008); while in the Europe, the large and small chamber methods are described in the EN 717-1 standard and are used as initial type testing methods for wood based panels (EN 13986, 2004). However, the chamber methods need a steady state of formaldehyde emission at the ambient temperature. The time required to reach this constant concentration of formaldehyde inside the chamber may last from 10 to 28 days. From the perspective of regular factory control, the methods that can produce results accurately, but faster are more suitable. Hence, there are number of alternative methods for testing the formaldehyde emission from wood based panels.

In this paper, two of such alternative methods were used to test the formaldehyde emission from commercial particleboards. One is the extraction method, the so called perforator method (EN 120, 1991), which is used for determination of formaldehyde content inside the board, or formaldehyde potential. The correlation between perforator values and the formaldehyde emission depends on the type of board material, its density, porosity and moisture. Since the extraction is performed in the boiling toluene, this method often rises some occupational health concerns (Risholm-Sundman *et al.*, 2007). Apart from this, it is relatively simple and quick method, and its application cost is roughly 200 times lower than for the large chamber method (Salem *et al.*, 2012). The other method used in this research is the flask method. It is also very simple and inexpensive method for testing the formaldehyde emission of the samples suspended above the surface of distilled water inside the plastic bottle, heated at 40°C during 3h. It is derived from the WKI method published by Wilhelm-Klauditz-Institute and developed by Roffael (EN 717-3, 1996, Meyer and Hermanns, 1986).

The comparison between the perforator and the flask methods have been studied earlier. Sundin and Roffael (1992) have found high correlation coefficient of 0.92 between these two methods when testing large number of particleboard and MDF samples. They have also made remarks on the certain advantages of the flask method

over the perforator method, such as: flask method is less susceptible to the moisture content of the board; does not use harmful chemicals; it is easier to perform and the larger number of samples can be tested (Sundin and Roffael, 1992). The studies were also made on comparing the perforator method with the original WKI method (similar to the flask method, but with the longer testing time of 24h or 48h), and the high correlation coefficients were also found (Roffael, 1988, Crnogorac, 1992).

Another aspect of this research was to study the influence of the decorative surface of the commercial particleboards (coated with melamine impregnated decorative paper) on the results of formaldehyde emission determined by the flask method. The case here was not to determine the potential of decorative surface to minimize the formaldehyde release from the panel, like it was done in some earlier studies. For instance, Barry and Corneau (2006) have found that the 80 g melamin paper have reduced the formaldehyde emission from particleboard for 93%. They have used the small chamber method and the edge-sealed test samples of 10.5x10.5 cm in size. However, the test pieces for the flask method are much smaller (2.5x2.5 cm) and the dominant route for the formaldehyde release is through their edges. Since the flask method allows the testing of both melamine faced and sanded particleboard samples, it was interesting to find how much the decorative surface affects the test results.

MATERIALS AND METHODS

The commercial melamine faced particleboards (decorative surface with melamine impregnated paper) bonded with UF adhesive were used in this research. All the samples had a thickness of 18 mm. However, the samples intended for the perforator test method were prepared by removing (sanding) this decorative surface from both sides. The samples intended for flask method were used as both melamine faced boards and sanded boards, with the latter ones prepared in the same way as in the case with perforator method. The moisture content of the samples was determined

after drying the test pieces to the constant mass at $103\pm 2^\circ\text{C}$ in the laboratory oven, as described in the EN 322 standard method.

The particleboards from two different producers were used, and accordingly the samples were designated by its origin as "A" and "B" series. The samples from each of the these two series were further divided into subseries according to the test method: 1) perforator; 2) flask - surfaced boards and 3) flask - sanded boards. The analysis of the results between two sample series was performed using the t-test method, and at the level of confidence of 95%.

Determination of the formaldehyde content by perforator method

The formaldehyde content by perforator method was determined according to the EN 120 standard. The extraction phase lasted 2 h, during which time the formaldehyde has been extracted from the test pieces (approx. 110 g) into the boiling toluene and transferred to the distilled water. After the extraction phase, the water solution of formaldehyde was separated from toluene, cooled and further diluted with the addition of distilled water up to 2000 ml (EN 120, 1991). Blind test was performed under the same procedure but without the samples. The acetylacetone and ammonium acetate solutions were then added to the solution of extracted formaldehyde, and the absorbance of the resulted solution was determined with UV spectrophotometer (Evolution 300). The perforator value of the particleboard sample was calculated according to the following equation:

$$P_v = \frac{A \cdot f \cdot (100 + H) \cdot V}{m} \quad [\text{mg}/100\text{g of oven-dry board}]$$

where: **A** is absorbance value as a difference between the absorbance of extracted formaldehyde solution and the absorbance of distilled water from the blind test; **f** is the slope of the calibration curve (mg/ml); **H** is the moisture content of particleboard sample (%); **V** is the volume of the flask (2000 ml) and **m** is the total mass of the test pieces used in extraction (g).

Determination of the formaldehyde release by flask method

The flask method was used to compare the formaldehyde emissions from sanded particleboards and the melamine faced particleboards. The test pieces of particleboard samples were closed inside the flask (500 ml plastic bottle) together with 50 ml of distilled water, while being suspended above the water surface. Simultaneously, blind tests were performed without the particleboard samples. The flasks were then placed inside the laboratory oven at $40\pm 1^\circ\text{C}$ during 3 h, allowing the formaldehyde from the test pieces to be absorbed into the water. Then, the formaldehyde solution was further prepared for the UV spectrophotometry measurements as described in the EN 717-3 standard (EN 717-3, 1996). The flask value was calculated according to the following equation:

$$F_v = \frac{A \cdot f \cdot 50 \cdot 10 \cdot (100 + H)}{m} \quad [\text{mg}/\text{kg of oven-dry board}]$$

where: **A** is absorbance value as a difference between the absorbance of extracted formaldehyde solution and the absorbance of distilled water from the blind test; **f** is the slope of the calibration curve (mg/ml); **H** is the moisture content of particleboard sample (%) and **m** is the total mass of the test pieces (g).

Determination of calibration curve

Both standard methods used in this research describe the same procedure for determination of calibration curve. Firstly, the concentration of standard formaldehyde solution was determined by iodometric titration as described in both EN 120 and EN 717-3 standards. Then the calibration solution was prepared having the formaldehyde concentration of $15 \mu\text{g}/\text{ml}$, which was later added in the amounts of 0, 5, 10, 20, 50 and 100 ml into the 100 ml volumetric flasks, with each flask being filled with distilled water up to the 100 ml mark. The absorbance of each solution was determined by UV spectrophotometer and its values were plotted against the known formaldehyde concentrations. The resulting calibration curve are shown in the Figure 1.

RESULTS AND DISCUSSION

The Table 1 summarizes the results from the formaldehyde tests for A and B sample series, with the application of perforator and flask methods. The results of the formaldehyde content, obtained by perforator method, show that the A series fall into the E1 class of particleboard, according to the EN 312 standard. The formaldehyde content for the B sample series was 68.0% higher in regard to the A series, surpassing the limit value for E1 class of 8 mg/100g of oven dry board.

In addition, the formaldehyde release from the particleboard samples was determined by the flask method, on both melamine faced and sanded samples. Again, the results from the B series show significantly higher values than for the A series, i.e. 66.0% and 60.1% higher, respectively. However, the EN 312 standard does not support the particleboard classification based on the flask method measurements.

The influence of the decorative surface on the formaldehyde release was analyzed using the flask method. The simple approach was to sand off the decorative surface on one set of samples. The test results from both A and B sample series have shown higher formaldehyde release values with decorative surface sanded off. These samples had 12.5% and 16.6% higher values when compared to melamine faced samples, for A and B series, respectively. Hence, one can assume that the decorative surface acts as the barrier that slows the formaldehyde release, even for the samples of the relatively small sizes used by the flask method. In addition, the strong correlation of the formaldehyde release values exists between the coated and uncoated samples (Figure 2).

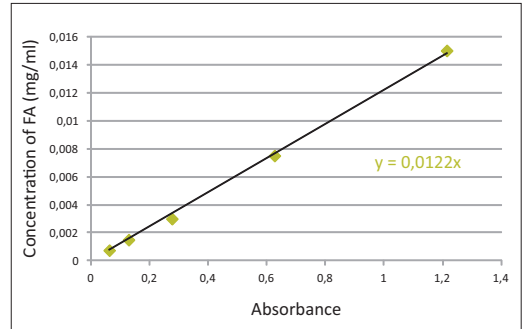


Figure 1. Calibration curve of the solutions with the absorbance values plotted against the formaldehyde concentrations between 0 and 0.015 mg/ml

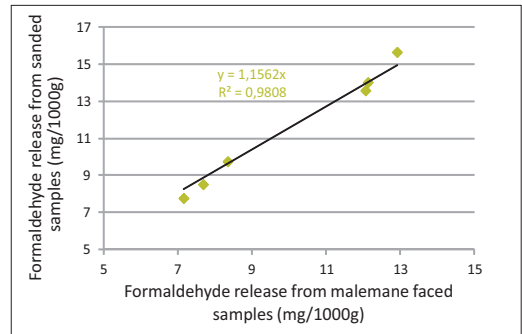


Figure 2. The correlation between the formaldehyde release values for sanded and melamine faced particleboard samples determined using the flask method

The perforator values for formaldehyde content were also found to be strongly related with the values of formaldehyde release measured by flask method for both sanded and melamine faced samples (Figures 3 and 4).

Table 1. The results of the formaldehyde content and formaldehyde release from the particleboard samples

Sample series by origin		Test method (test series)		
		Perforator - EN 120 (mg/100g)	Flask method - EN 717-3 (mg/1000g)	
			sanded surface	sanded surface
A series	Mean	6.42	8.69	7.73
	st. dev.	0.495	1.001	0.598
B series	Mean	10.79	14.43	12.37
	st. dev.	1.013	1.090	0.474

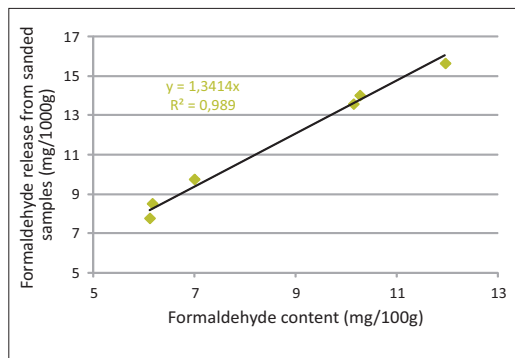


Figure 3. The correlation between the formaldehyde content determined using the perforator method (sanded samples) and the formaldehyde release determined by flask method (sanded samples)

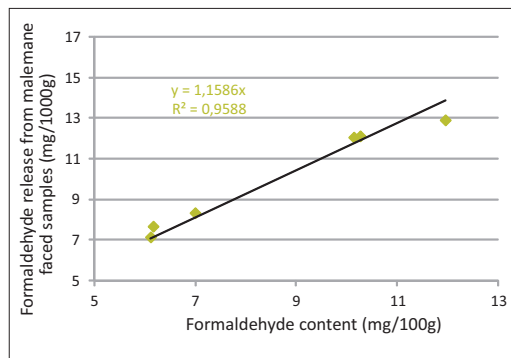


Figure 4. The correlation between the formaldehyde content determined using the perforator method (sanded samples) and the formaldehyde release determined by flask method (melamine faced samples)

CONCLUSIONS

The application of the flask method on both melamine faced and sanded particleboard samples have showed high correlation of the formaldehyde emission values between these two test series. The effect of decorative surface on the melamine faced samples was also evident. Hence, the unfaced samples (with the decorative surface sanded off) had 12.5 % to 16.6 % higher values of the formaldehyde emission than the melamine faced particleboard samples.

The comparison of the perforator values for the sanded particleboard samples with the values of formaldehyde emission obtained by flask method on both unfaced and melamine faced samples have showed high correlation coefficient of 0.989 and 0.959, respectively. The results of this research also suggest that the perforator method could be used to test the melamine faced particleboards after sanding the decorative surface. And in this way the applicability of the perforator method could be broaden.

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