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Quality of the particleboards on serbian market in regard to the formaldehyde emission

ABSTRACT

The formaldehyde potential of particleboards imported on Serbian market was evaluated in this research. The sampling and testing of particleboards were conducted in two discrete periods: first was during 2011 and the second was in the period of 2015-2016. For both periods, the samples of raw particleboards originated from three different producers. The perforator method (EN 120) was used to test the formaldehyde content in the particleboard samples. In general, the results have showed that the majority of the samples belong to the E1 class of particleboards. In addition, 19 % of the particleboards sampled in 2011 and 31 % of the boards sampled in 2015-2016 were found to have formaldehyde content below 50 % of E1 class requirements.

Keywords: particleboards, formaldehyde, emission class, perforator.

1. INTRODUCTION

The exposure to formaldehyde can cause various symptoms and harmful effects on the human health. The increased concentration of formaldehyde in the surrounding air can cause the irritation of eyes, nose, throat and skin, which in more severe cases can lead to asthma and allergic reactions [1]. The World Health Organization (WHO) have classified the formaldehyde as the probable carcinogen to human (Group 2A), and in the 2004 the International Agency for Research on Cancer (IARC) has recommend the reclassification of formaldehyde as carcinogen to humans (Group 1) [2]. The wood-based panel products produced with adhesives that contain the formaldehyde are identified as the sources of formaldehyde in interior atmosphere. As a cross-linking agent for organic materials, the formaldehyde readily reacts with phenol, urea and melamine monomers, thus creating the family of formaldehyde based adhesives used in the industry of wood based panels such as the particleboards, MDF, hardboards and plywood [3].

The urea-formaldehyde (UF) resin is the most common adhesive system still used today for the production of interior class of wood-based composite panels. In 2001 the UF adhesive alone has amounted for 80% of the 6 million tons of total adhesive consumption by the European producers of wood-based panels [4]. Except for its low price, the advantages of UF adhesive can be found in its relatively quick curing time in the hot press, transparent or white glue-line, good adhesive strength, while at the same time it incorporates the significant production experience [5]. Although it belongs to the group of thermo-reactive adhesives, the cured UF adhesive (in wood-based panels) is susceptible to the hydrolysis of its weakly bound formaldehyde from N-methylol groups, acetals and hemiacetals, but also from methylene-ether linkages at high relative humidity, which altogether increase the content of emitable formaldehyde and create the permanent pool for the subsequent formaldehyde emission [6]. The mechanism of formaldehyde emission depends on the rate of its formation in the material, transport through the material and its transfer from the material into the atmosphere [7]. Besides the various processing parameters, the formaldehyde to urea ratio (F/U) is one of the initial factors that influence the formaldehyde emission from wood-based panels. Hence, lowering the F/U ratio enables the production of boards with lower formaldehyde emission [8]. The rate of the subsequent formaldehyde emission from wood-based panels

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also depends on the ambient conditions, i.e. the temperature and relative humidity. It was found that the increased temperature and/or humidity of surrounding air significantly increase the formaldehyde emission rate from the boards [9-12].

In 2010, the Republic of Serbia has accepted the European standards (EN) regarding the formaldehyde emission limits for the wood based panels, developed by the European Committee for Standardization (CEN). Standards such as, EN

312, EN 622-1 and EN 300 define the requirements for the particleboards, fiberboards and OSB panels, respectively; while the EN 13986 presents the harmonized standard that defines the emission limits for the wood based panels used in constructions (Table 1). Although many European countries still allow the production and distribution of E2 class of wood-based panels, the regulations in countries like Germany, Austria, Denmark and Sweden requires the compliance with E1 class [2].

Table 1. Formaldehyde classes for wood based panels according to the EN standards

Tabela 1. Klase formaldehida za ploče na bazi drveta prema EN standardima

Formaldehyde class	Panel type / standard	Formaldehyde Release (mg/m ³ air)	Formaldehyde content ^e (mg/100g o.d. board)
E1 class	EN 13968 ^a	≤ 0,124	≤ 8
	EN 622-1 ^b		
	EN 312 ^c		
	EN 300 ^d		
E2 class	EN 13968	> 0,124	> 8 ≤ 30
	EN 622-1	> 0,124 ≤ 0,3	> 8 ≤ 20
	EN 312		
	EN 300		

^a Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking, ^bFibreboards - Specifications - Part 1: General requirements, ^cParticleboards – Specifications, ^dOriented Strand Boards (OSB) - Definitions, classification and specifications, ^eRelates to the unfaced wood based panels

This paper presents the results of the survey on the formaldehyde class of the particleboards distributed in the Serbian market. The survey was made during 2011 and again during 2015-2016, and included imported particleboards used for furniture production.

2. MATERIALS AND METHODS

The commercial particleboards were sampled from the distributors in Republic of Serbia. The samples originate from three different producers, and the sample series were designated accordingly as: "A", "B" and "C". Each sample series comprised of 5 to 7 particleboard samples selected randomly. All of the samples of particleboards belonged to the P2 class according to the EN 312, which relates to the boards for interior fitments (including furniture) for use in dry conditions. Thickness of the selected particleboard samples ranged from 16 to 25 mm. The moisture content of the samples was determined after drying the test pieces to the constant mass at 103±2°C in the laboratory oven, as described in the EN 322.

The formaldehyde content of the particleboards was determined by the extraction method, the so called perforator method, according to the EN 120 standard [13] (replaced with EN ISO 12460-5 from 2015). During the extraction phase, the particleboard test samples (approx. 110 g) were submerged into the boiling toluene for 2 h, to allow

the extraction of formaldehyde and its transfer into the distilled water. The blank test was also performed without the test samples. The acetylacetone method was used to prepare formaldehyde aqueous extracts for determination of formaldehyde. The absorbance of the solution was determined by the UV spectrophotometer (Evolution 300), at the wavelength of 412 nm. Then, the perforator value was calculated according to the following equation:

$$P_v = \frac{(A_s - A_b) \cdot f \cdot (100 + H) \cdot V}{m} \quad (1)$$

[mg/100g of oven-dry board]

where: A_s is the absorbance value of extracted formaldehyde solution; A_b is the absorbance of blank test solution (blank 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 volumetric flask (2000 ml) and m is the total mass of the test pieces used in extraction (g).

Since the perforator value applies for the particleboards with the moisture content of 6.5 %, the results were multiplied with the correction factor for moisture content (F) which is calculated by the following equation (EN 312):

$$F = - 0.133 H + 1.86 \quad (2)$$

The standard formaldehyde solution was used to obtain the calibration curve, for each sample series. The concentration of standard solution was determined by iodometric titration. The calibration solutions were then prepared for the determination of absorbance using UV spectrophotometer.

The statistical analysis of the results between two sample series was performed by the ANOVA (single factor) method, with the level of confidence of 95%.

3. RESULTS AND DISCUSSION

In the 2011 survey the formaldehyde values were significantly higher for the particleboards

originating from the producer B (Table 2 and 3). The formaldehyde content values for other two particleboard series (producer A and C) did not differ significantly. In the later survey of the 2015-2016 period, the formaldehyde values for all three producers were not statistically different at the confidence level of 95%.

When comparing the two survey periods, only the particleboards series from the producer B have showed the change in the formaldehyde content values, with the boards sampled in 2015-2016 period showed statistically significant lower results.

Table 2. Mean perforator values of the particleboards from different producers determined during the surveys in 2011 and 2015-2016

Tabela 2. Srednje vrednosti sadržaja formaldehida po perforator metodi za ploče iverice različitih proizvođača, određenih tokom perioda ispitivanja u 2011. godini i 2015-2016. godini.

Producer	2011		2015-2016	
	P (mg/100g o.d. board)*	st. dev.	P (mg/100g o.d. board)*	st. dev.
A	5.28	0.79	5.63	0.70
B	7.55	1.50	5.26	1.57
C	3.80	1.42	4.28	1.53

*the individual results are calculated to the moisture content of 6.5 %.

The lowest values of formaldehyde content for individual particleboard samples were found for the producer C. These values were 2.3 and 3.2

mg/100g of oven dried board, in the 2011 and 2015-2016 surveys, respectively.

Table 3. Statistical comparison of the formaldehyde content values (ANOVA)

Tabela 3. Statističko upoređenje vrednosti sadržaja formaldehida (ANOVA)

Between groups	2011		2015-16		Between groups	2011/2015-16	
	P-value	F/Fcrit	P-value	F/Fcrit		P-value	F/Fcrit
A/B	0.008348	2.161508*	0.638823	0.046088	$A_{2011}/A_{2015-16}$	0,505425	0,096114
B/C	0.004216	2.939176*	0.347209	0.187545	$B_{2011}/B_{2015-16}$	0,035805	1,188330*
A/C	0.063650	0.870296	0.106107	0.630131	$C_{2011}/C_{2015-16}$	0,643895	0,041709

*denotes a statistically significant difference at the confidence level of 95 %.

It was also interesting to find how boards comply with the formaldehyde classification according to European standards, as stated in the Table 1. Hence, the Figure 1 shows the proportion between the E1 and E2 classes of particleboards sampled from the Serbian market, and also the contribution of particleboards that comply with half of the E1 class limits, which is important for Eco labeling and Blue Angel classes of boards [14, 15].

In the 2011 survey, close to 1/5 of the sampled particleboards belonged to the E2 class, i.e. having the formaldehyde content higher than the E1 limit value (8 mg/100g of oven dried board); while during the later survey (2015-2016) there were no particleboards of E2 class found in the scope of this research (tested particleboards originate from only three producers with highest ratio of imported quantities). It was also interesting to notice that the proportion of samples with half the E1 limit has slightly increased.

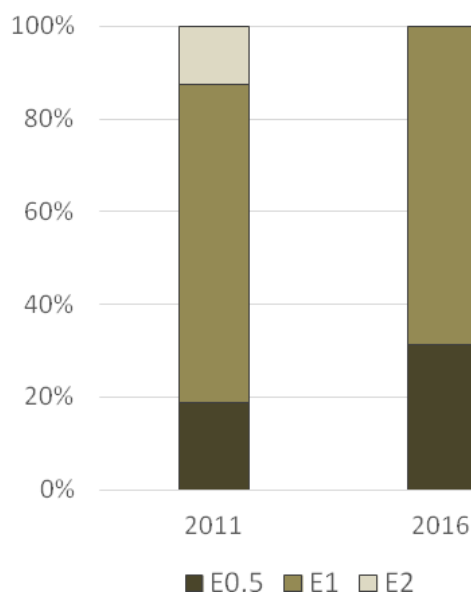


Figure 1. Proportion of the different formaldehyde classes of particleboards according to the survey made in 2011 and during 2015-2016 period in Serbia

Slika 1. Učešće ploča iverica različitih klasa formaldehida na osnovu preglednih ispitivanja tokom 2011. godine i 2015-2016. godine u Srbiji

Having in mind that, for the two survey periods, there were no significant differences in formaldehyde values for the particleboard samples originating from producers A and C, and that there were only three different producers in the scope of this research, it is not certain if these indicators show the improvements of particleboard quality in terms of formaldehyde content. However, these data allow us to reasonably assume that the particleboards of E1 class are dominant on our domestic market, which is of the great importance, not only for the consumers of particleboards in Serbia, but also for the export on European market.

4. CONCLUSIONS

The the samples of commercial particleboards marketed in Serbia tested in this research were mainly E1 class of board. However, the survey made in 2011 found that 87 % of the boards belong to the E1 class, while the rest was the E2 class. Yet, in the later survey, during 2015 and 2016, all the boards were found to belong to E1 class.

In addition, the proportion of the boards that have 50 % of E1 class has also increased from 19 % in 2011 to 31 % in the later survey. This relatively low formaldehyde content in the boards is

one of the conditions for these products to achieve EU Ecolabel mark.

There were significant differences in the results of formaldehyde tests in 2011 between the selected producers, however in 2015-2016 survey there were no such statistically significant differences at the confidence level of 95%.

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IZVOD

KVALITET PLOČA IVERICA NA TRŽIŠTU SRBIJE U POGLEDU EMISIJE FORMALDEHIDA

U ovom radu istražen je trend kretanja emisije formaldehida iz ploča iverica uvezenih na tržište Srbije. Uzorkovanje i ispitivanje ploča iverica obavljeno je u dva vremenski odvojena perioda. Prvi period ispitivanja odvijao se tokom 2011. godine, a drugi tokom 2015-2016. godine. U oba ova perioda, uzorkovane su sirove ploče iverice, poreklom od tri različita proizvođača. Perforator metoda (EN 120) korišćena je za ispitivanje sadržaja formaldehida u uzorcima ploča. Rezultati pomenutih ispitivanja pokazali su da velika većina uzoraka pripada E1 klasi ploča iverica. Pored toga, oko 19 % ploča iverica uzorkovanih u 2011. godini i oko 31 % ploča uzorkovanih tokom perioda 2015-2016. godine imali su sadržaj formaldehida ispod 50 % od zahteva za E1 klasom.

Ključne reči: ploča iverica, formaldehid, emisiona klasa, perforator.

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