Wood Industry and Engineering

http://dergipark.org.tr/wie

Volume: 01 Number: 01 Pages: 14-19

Paper Type: Research Article Received: 29.11.2019

FORMALDEHYDE EMISSIONS AND EFFECTS ON HEALTH DURING ARRIVAL OF FURNITURE TO ULTIMATE CONSUMER

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Abstract

People spend most of their time in closed areas such as home, office, school. For this reason, indoor environment pollution has great importance for human health. In this environment, the formaldehyde gas in the indoor furniture produced by the synthetic resin made from the panels is gradually released into the living spaces. The indoor concentration of formaldehyde gas in ppm is higher than the international standard, that is, the comfort limit value accepted by the western countries, which causes considerable damage to human health, especially to children.

In this study; formaldehyde emission values of five different companies' wood-based panel products determined by three different methods in Turkey and in 50 furniture manufacturing facilities, 50 furniture stores, 50 new apartments; formaldehyde gas analysis have been performed. As a result; on average, furniture manufacturing 0.45 ppm, in furniture store 0.37 ppm, in new apartments 0.11 ppm formaldehyde gas release has been measured.

Keywords: Formaldehyde, Furniture, Particleboard, MDF, Human health

1. Introduction

The simplest member of the aldehyde group, formaldehyde (H2C = O), is technically produced by the oxidation of methane and methanol. Formaldehyde can be generally described as a colorless, unscented substance. In forest products industry, urea is widely used as an adhesive in the production of wood-based composite materials such as chipboard, plywood and fiberboard by being condensed with melamine and phenol resins (Şahin, 2005).

Formaldehyde is classified by the International Agency for Research on Cancer as Group 2A as a carcinogenic substance (Soysal and Demiral , 2007). Studies have shown that formaldehyde contributes to the development of nasal and upper respiratory cancers and skin cancer (Muzi et al., 2004). The amount of formaldehyde in indoor environments is important because of the health effects and the common occurrence of indoor living areas as pollutants. Formaldehyde gas can enter the respiration of living things, the mouth and the skin through contact. In general, when the formaldehyde concentration exceeds a certain level and those suffering from formaldehyde may have complaints such as fatigue, headache (Emri et al., 2004).

Formaldehyde can be formic acid in the human body and is excreted in the urine. However, if formaldehyde is present in excess of a certain amount (> 1 ppm) in the human body, significant problems may occur in the central nervous system and respiratory tract (Emri et al., 2004).

Formaldehyde-based glues are preferred in the forest products industry due to their low price and ease of use. In the production of composite panel board (chipboard, fiberboard, plywood), it is used as cross-linking material. The high reactivity of formaldehyde allows it to pass easily to the atmosphere when it is in free state. Therefore, during the use of furniture and composite panel products manufactured using formaldehyde-based glue indoors, depending on atmospheric conditions, it may become formaldehyde emission in time (Şahin et al., 2011).

In a survey of urban and rural areas in Ankara, for the reason that formaldehyde levels in the living room and kitchen are higher than allowed and health problems such as eyebrows, runny nose, dry throat in home residents, formaldehyde level has been determined statistically significant high (Aksakal et al.,

2005). The permissible exposure limit (PEL) for formaldehyde as determined by the OSHA (Agency for Safety and Health at Work) is 0.75 ppm for the 8 hours time average (TWA) (Vaizoğlu, 1998).

57 workers working in 100 furniture manufacturing factories in the Siteler Industrial Zone in Ankara stated that they were exposed to formaldehyde levels above 0.75 ppm and 1% of 229 workers were exposed to formaldehyde levels above 0.75 ppm for more than 8 hours (Evci et al. 2002).

A statistically significant relationship has been found between the levels of kitchen formaldehyde and the frequency of the occurrence of eyebrows, dry throat and runny nose in people living in these houses; complaints of eyebrows, dry throat and runny nose in households that kitchen formaldehyde level higher than 0.10 ppm is more frequent than those living in houses with lower formaldehyde levels than 0.10 ppm (Evci et al., 2002).

Formaldehyde has an unpleasant odor. Formaldehyde gas has an irritant effect on the skin, eyes and lungs. Some irritant effects can now occur even below 0.75 ppm PEL, which is reported by OSHA as the legal boundary (Rosenstock and Cullen, 2005). The formaldehyde level should normally be below 0.03 ppm in closed environments (CPSC, 1997).

Standard methods for the determination of formaldehyde emissions;

If the formaldehyde emission is expressed as the mixing of the wood-based material in contact with the air after the production process by dissolving the formaldehyde in the ambient relative humidity, it has been mentioned in the scientific publications as the important and remarkable chemical. Formaldehyde emission caused by especially wood-based materials is important due to environmental and health effects (Mentese, 2009).

According to formaldehyde emission rates in forest products industry the classification of the panel board products is shown in table 1.

Table 1: Formaldehyde emission limits of wood-based panels

Emission Class	Board Type	Formaldehyde Measurement Limit Values	Test Metod
E1	MDF, YL, OSB	≤0.124 mg/m^3 (0.09 ppm)	EN 717-1- Chamber Method
		≤8.0 mg/100g	EN 120 – Perforator Metod
		≤3.5 mg/m^2 h	EN 717-2- Gas Analysis Method
E2	MDF, YL, OSB	>0.124 mg/m^3 (0.09 ppm)	EN 717-1- Chamber Method
		>8.0 mg/100g ≤ 30 mg/100g	EN 120 – Perforator Metod
		>3.5 mg/m^{2}h ≤ 8 mg/m^{2}h	EN 717-2- Gas Analysis Method

Various standard methods are used for the determination of formaldehyde emissions. The relevant European Union, Japan and ISO standards are briefly summarized below (Salthammer and Mentese, 2008).

European Union Standards;

EN 717-1 (2004): Determination of release of formaldehyde from wood-based panels-Part 1: Emission of formaldehyde by Chamber method (Chamber method)

EN 717-2 (1994): Determination of formaldehyde release in wood-based panels-Part 2: Release of formaldehyde by gas analysis method (gas analysis method)

EN 717-1 (1996): Wood-based panels-Determination of formaldehyde release-Part 3: Formaldehyde release by bottle method (Bottle method)

EN 120 (1993): Wood-based panels-Determination of formaldehyde content- (Perforator method)

Japanese standards;

Japanese standard methods are very similar to the European Union standard methods, but there are some differences in the volume of the rooms used and the areas of the test materials.

JIS A 1460 (2001) and JAS MAFF 233 (2003): Building panels: Determination of formaldehyde emissions-desiccator method (Desiccator methods).

JIS A 1901 (2003): Determination of volatile organic compounds and aldehyde emissions from building materials-small chamber method (Small Chamber Method).

ISO standard;

ISO.7CD 12460 (2005): Chamber method

The purpose of this study is to convey the current effects of manufactured products on human health determining the formaldehyde emissions at each stage until the final consumption of the products produced using wood based plates and to remark and contribute for the preparation of legal regulations and limits on formaldehyde emissions for finished furniture in Turkey.

2. Materials and Methods

2.1. Material

Particleboards used for formaldehyde emission tests have been obtained from five different factories that makes production in Turkey. During sampling; 18 mm has been preferred which constitutes a significant part of the production of plants in Turkey. A plate with an average density of 620-650 kg/m3 in white color and a melamine coated upper and lower side has been used at an average of 2100 mm x 2800 mm from each factory and it is stated as A, B, C, D, E before giving company names.

2.2. Method

Kastamonu Entegre whose formaldehyde emission from particle boards is Türkak 's accredited. (TS EN 717-1 (chamber method), TS EN 717-2 (gas analysis method) and TS EN 120 (perforator method).

In Ankara and Bursa İnegol as the most common furniture production in Turkey as well as in Kastamonu Center selected as the pilot region, emission measurement points are determined. Totally, in 50 furniture manufacturing plants and 50 furniture stores measurements have been made. In Ankara,20 furniture manufacturing facilities, 20 furniture stores, 20 furniture manufacturing facilities, 20 furniture stores in Bursa İnegöl Region, 10 furniture manufacturing facilities and 10 furniture stores in the central region of Kastamonu.

In the center of Kastamonu, which was chosen as the pilot region and mostly provide furniture from Ankara Siteler and Bursa İnegöl, measurements were made in kitchen and hall of 50 new offices ready to sit in October 2017. The kitchens of the apartments are 10 square meters, the living room is 20 square meters, the kitchen furniture is made of 18 mm white double face coated chipboard and the flooring is made as 8 mm laminate parquet.

In this research, GANK-4 Formaldemeter device was used to determine furniture production facilities, furniture store measurements and formaldehyde emission measurements in salons and kitchens in new houses (Figure 1). Furniture production facilities, furniture store measurements and formaldehyde emission measurements in the salons and kitchens of new homes were made from the exact midpoint and 1 meter above the ground. Before each measurement of formaldehyde emissions, the humidity and temperature of the environment to be measured were measured with the Loyia H100 digital temperature and humidity meter. All measurements were made at 23 °C and 45% humidity.

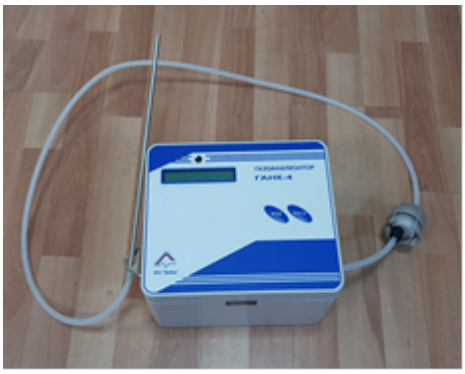

Figure 1: GANK-4 Formaldemeter device

3. Findings

3.1. Findings of Formaldehyde Emissions from Particle Boards

Formaldehyde emission value belongs to five different companies which makes production in Turkey were determined by perforator method, chamber method and gas analysis method and the results are given in Table 2.

Table 2: Formaldehyde emission values of chip board samples

Chipboard Producers	TS EN 120 Perforator Method (mg/100gr)	TS EN 717-1 Chamber Method (ppm)	TS EN 717-2 Gas Analysis Method (mg/m²h)
A	15	0.12	3.8
B	16	0.11	3.6
C	19	0.14	3.9
D	13	0.11	3.5
E	10	0.09	3.1

According to the results in Table 2, value of 10-19 mg/100gr were obtained as a result of the perforator method measurements. While the samples according to the chamber method gave a minimum of 0.09 ppm and a maximum of 0.14 ppm, the value obtained according to the gas analysis method were determined as 3.1-3.9 mg/m2h. The results obtained from E company are the lowest result in the three measurement methods according to the other firms, while the samples taken from C company gave the highest value.

3.2. Findings of Formaldehyde Emissions in Furniture Production Sites

In furniture manufacturing sites, 20 in the Siteler region in Ankara, 20 in the Bursa İnegöl region and also 10 in Kastamonu, were measured. The values of the measurements made in Table 3 are given.

Table 3: Measured formaldehyde emission values in furniture manufacturing plants

	≤ 0.3 ppm		0.4-0.5 ppm		≥ 0.6 ppm	
	Number	%	Number	%	Number	%
Ankara	1	5	18	90	1	5
Bursa	3	15	15	75	2	10
Kastamonu	-	-	8	80	2	20
Total	4	8	41	82	5	10

According to the results in Table 3, the results of measurements made at randomly selected furniture production facilities located in the Ankara site area resulted in value of 0.4-0.5 ppm at 90% and value of 0.6 ppm and 5% at 5%. 75% of firms measured in Bursa İnegöl and 80% in Kastamonu region are between 0.4-0.5 ppm. According to all the results made in the furniture production facilities, 8% is measured as ≤ 0.3 ppm, 82% is measured as 0.4-0.5 ppm, 10% is measured as 0.6 ppm. The lowest value of 0.3 ppm and the lowest value of 15% were determined in Bursa İnegöl region.

3.3. Findings of Formaldehyde Emissions in Furniture Production Sites

In furniture stores, 20 in the Siteler region in Ankara, 20 in the Bursa İnegöl region and also 10 in Kastamonu, were measured. The mean value of the measurements made are given in Table 4.

Table 4: Measured formaldehyde emission value in furniture manufacturing plants

	≤ 0.3 ppm		0.4-0.5 ppm		≥ 0.6 ppm	
	Number	%	Number	%	Number	%
Ankara	10	50	9	45	1	5
Bursa	3	15	15	75	2	10
Kastamonu	4	40	5	50	1	10
Total	17	34	29	58	4	18

In Table 4, as a result of the measurements made at the randomly selected furniture production facilities located in the Ankara site area, 50% ≤ 0.3 ppm, 45% 0.4-0.5 ppm value are obtained, 5% Value of 6 ppm and above were obtained. 75% of the stores measured in Bursa İnegöl and 50% in the Kastamonu region are between 0.4-0.5 ppm. According to all the results in the furniture stores, 34% ≤ 0.3 ppm, 58% 0.4-0.5 ppm and 18% was measured as ≥ 0.6 ppm. In the most of furniture stores, It is stated that the customers entering the store say there is a smell in the store.

3.4. Findings of Formaldehyde Emissions in Newly Built Apartments

The value of the emission measurements made with the GANK-4 Formaldemeter are given in Table 5.

Table 5: Measured formaldehyde emission value in newly built apartments

Kastamonu	≤ 0.03 ppm		0.04-0.09 ppm		0.1-0.2 ppm		≥ 0.2 ppm	
	Number	%	Number	%	Number	%	Number	%
Kitchen	5	10	17	34	23	46	5	10
Living Room	3	6	18	36	22	44	7	14

According to the measurement results in the new apartments 10% of kitchens in apartments ≤ 0.03 ppm, 34% in 0.4-0.9 ppm, 46% in 0.1-0.2 ppm, 6% of halls ≤ 0.03 ppm, 0.4-0.9 ppm, 44% 0.1-0.2 ppm.

4. Results

In Turkey, in particle boards provided by five different manufacturers and mostly preferred in furniture production, as a result of the perforator method measurements, according to TS EN 13986 standard, the formaldehyde emission class is E2 (> 8 mg/100gr). According to the chamber method, the samples of A, B, C, D with regard to TS EN 13986 formaldehyde emission class E2 (> 0.09 ppm) and the sample E is E1 (≤ 0,09 ppm). According to the results of the gas analysis method, company samples A, B, C are of formaldehyde emission class E2 (> 3.5 mg / m2h) with regard to TS EN 13986 standard and sample E1 (≤3.5 mg/m2h) of D and E firms. According to these results, D and E companies' samples with E2 with regard to perforator method and E1 with chamber and gas analysis method.

The values determined as 8% for ≤ 0.3 ppm, 82% for 0.4-0.5 ppm and 10% for ≤ 0.6 ppm in the measurements made at the furniture manufacturing plants in Ankara Siteler, Bursa İnegöl and Kastamonu Center. In the furniture stores, in area where board panel furniture is exhibited 34% ≤ 0.3 ppm, 58% 0.4-0.5 ppm, and 10% ≥ 0.6 ppm determined. In the center of Kastamonu, measurements made in kitchens and halls of a newly built 50-apartment house, 10% of kitchens ≤ 0.03 ppm, 34% of 0.04-0.09 ppm, 46% of 0.1-0.2 ppm, 10% of ≥ 0.2 ppm, 6% of the halls are ≤ 0.03 ppm, 36% are 0.04-0.09 ppm, 44% are 0.1-0.2 ppm, 14% is ≥ 0.2 ppm are measured.

The Consumer Product Safety Commission (CPSC) has publicly declared that formaldehyde levels should normally be below 0.03 ppm in closed environments. As a result of the studies, all the measurements in furniture production facilities and furniture stores exceeded 0.03 ppm. In the results of measurements made in 50 newly built dwellings, only 6% was below 0.03 ppm.

5. Recommendations

Formaldehyde-based glues are widely used in the forest industry. Formaldehyde is a well-known indoor pollutant and affects everybody, from customer to consumer, in the indoor environment. In Europe, products are certified with Blue Angel, Ecolabel and E1 certificates and only products with formaldehyde emission class E1 are allowed to be produced and imported. In the US, products with CARB certification are certified and only products with a formaldehyde emission of 0.09 ppm are allowed.

The Turkish Standards Institute has been issuing E1 certificates since 2013.This document is not compulsory but is provided at the request of the firm. As a result of the study; the chipboards supplied from the 5 major producers in our country are above the E1 level. In addition, formaldehyde gas emission value of the furniture production area and composite panel plates, from the production process to the consumer, are considerably high.

Formaldehyde emission value determined for wood composite sheet products in our country should be more strictly controlled by the state and companies should be supervised in this regard. A standard that sets out the emission value of finished furniture products should be studied, the emission values of the products reaching the last consumer should be controlled by the government in terms of human health. In addition, the constructions on the furniture which reach the final consumer such as paint, coating reduce formaldehyde release. However; if these structures are worn out over time, the release will increase rapidly, so the supervisor to be brought must oblige E1 in the bare plate. It is important for these regulations to go into effect without losing time, in order to protect human health in the living spaces, especially for children who are our future guarantees.

6. Acknowledgments

This study was presented in ORENKO 2018 – International Forest Products Congress held by Karadeniz Technical University, Trabzon.

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