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INFLUENCE OF THE PACKING METHOD OF WOOD PRODUCTS ON THE EMISSION OF VOLATILE ORGANIC COMPOUNDS

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ABSTRACT

The work presents the influence of the way of packing the furniture on the level of emissions of volatile organic compounds (VOCs) emitted from the furniture after its unpacking. The study involved oak wood samples finished with selected varnish coating (polyurethane, waterborne and waterborne UV curable coating). After preparation the samples have been packed for 15 days into selected packaging materials: corrugated cardboard, polyurethane foam and stretch film. The VOC tests were carried out by means of the chamber test method. VOCs were analyzed by gas chromatography fitted with mass spectrometry and thermal desorption. The influence of the used type of packaging material on the level of VOCs emitted from furniture items after their immediate unpacking has been observed. The highest concentration of VOCs was found in items wrapped in stretch film while the lowest concentration was found in items packed in corrugated cardboard. That trend was irrespective of the type of coating material.

KEYWORDS: Volatile organic compounds (VOCs), TD-GC-MS, furniture, packaging materials, air pollution.

INTRODUCTION

Analytes from the group of volatile organic compounds have a significant impact on the quality of indoor air, i.e. the air present indoors. Volatile organic compounds represent 60% of all compounds polluting the atmosphere, and up to 73% among the compounds classified by the *Toxic Release Inventory* (*TRI*) as carcinogenic (Cohen 1996). As it can be seen from the conducted studies, the concentration of harmful air contaminants may be higher indoors than outdoors (Daisey et al. 2003, Kotzias et al. 2009, Geiss et al. 2011).

Long-term observations of the impact of volatile compounds on human's health suggest that those compounds may contribute to a variety of diseases, among others, respiratory diseases, allergic disorders, migraine, general irritation, attention disorders, and even cancer (Chin et al. 2014). Symptoms resulting from staying in contaminated indoors are called the "*Sick Building Syndrome*" – *SBS* (Brinke et al. 1998, Wargocki et al. 1999). According to the World Health Organization volatile organic compounds are said to cause the Sick Building Syndrome (Brinke et al. 1998).

Volatile organic compounds are emitted by both, construction materials and interior furnishing elements found indoors. Our daily activities, such as smoking or cleaning with the use of detergents contribute to the increase of the concentration of those compounds in the air as well.

Among many sources which emit volatile organic compounds, significant importance is attributed to furniture and other wood and wood-based products. The impact of wood products on the environment depends on the type of construction and finishing raw materials used during their production. Both, unfinished wood and wood-based materials which are an essential construction material of furniture are the source of emission of volatile organic compounds (Risholm-Sundman et al. 1998, Barry and Corneau 1999, Guo and Murray 2001, Gaca and Dziewanowska-Pudliszak 2005, Hennecke et al. 2006, Kilic and Altuntas 2006, Makowski and Ohlmeyer 2006, Roffael et al. 2007).

Finishing materials, including various types of varnish, furniture veneers or laminates are an additional source of emission (Uhde and Salthammer 2007, Salthammer 1997, Kagi et al. 2009, Stachowiak-Wencek et al. 2015).

An essential issue is to seek ways to reduce the emissions of volatile organic compounds from products to a level safe for the health of its users. As shown in the literature, in order to reduce the emissions of VOCs, materials which are characterised by high emission of those compounds should be replaced by more environmentally friendly materials, for example solvent based varnish should be replaced by waterborne varnish, UV varnish or high solids type varnish (Salthammer 1997, Dziewanowska-Pudliszak 2007, Stachowiak-Wencek and Prądzyński 2011, Stachowiak-Wencek et al. 2014). In addition, literature reports presented among others by Scheithauer and Aehlig (1995) show that emissions of organic compounds from products can be limited, among others, by improving packing methods. However, reports found in literature on how to pack furniture products have not been supported by research so far.

In order to verify the existing opinions, studies were carried out to assess the impact of different methods of packing of furniture products on the way the emission of volatile compounds is forming. For research purposes three types of packaging materials used in the furniture industry were selected: double layered corrugated cardboard, stretch film and polyethylene foam.

MATERIALS AND METHODS

Research material

Research material included samples of oak wood (*Quercus* L.) with dimensions 280 x 200 x 16 mm, prepared in industrial conditions. Wood has been dried in a chamber dryer (Hamech SK 55, Hajnówka) equipped with Automatex software. Samples were made of 100 mm wide strips which were glued with poly(vinyl acetate) glue. The surface of the wood was polished with a 180-grit and 220-grit sandpaper.

Moisture content of samples determined by oven-drying method according to PN-77/D-04100 was at the level of 7-8% and the density determined by the stoichiometric method according to PN-77/D-04101 was at the level of 687 $kg \cdot m^{-3}$.

For that study three types of varnishes were chosen: polyurethane product - PUR1, waterborne - WB1 and waterborne UV curable - WB/UV1 product specifications which are given in Tab. 1.

Tab. 1: Technical parameters of varnishes used in the research (based on manufacturer's data).

Parameters	Varnishs		
	PUR	WB	WB/UV
Binding agent	Alkyd resins, vinyl copolymers	Acrylic dispersion	Unsaturated acrylic oligomers and prepolymers
Photoinitiator	-	-	HCPK*
Solvents	esters, ketones	water	water
Curing agent (part by volume)	20	-	-
Content of solids (%)	35	32	35
Specific gravity ($g \cdot cm^{-3}$)	0.97	1.04	1.05
Commercial viscosity at temp. 22±1°C (s)**	40	30	40-50
Application viscosity at temp. 22±1°C (s)**	22	22	delivered

*HCPK (1-hydroxy-cyclohexyl-phenone),

**Value measured using a Ford's cup No. 4 (Viscosity of 22 s is recommended for spraying application, still being the most common surface refining method used in furniture industry).

The polyurethane and waterborne varnish were applied with a brush in the amount of 110 $g \cdot m^{-2}$ and dried in laboratory conditions for a period of 24 h. According to the information provided by the manufacturer, that allowed them to dry and cure to the required extent. On the other hand, the UV product was applied on wood surfaces by means of a pneumatic spray gun (nozzle diameter - 1.4 mm). The application amount of the lacquering product applied was 110 ± 5 $g \cdot m^{-2}$. The drying and curing process consisted of three parts. The first part was a flash-off-period - 10 min at a temperature of 23-25°C. The second part was the proper drying period - 15 min at a temperature of 60°C. The third part was the ultraviolet curing with a UV unit equipped with a mercury lamp and an elliptical (focused) reflector. The power of the UV lamp was characterised as 120 $W \cdot cm^{-1}$. The speed of the conveyor during the drying and curing process was 10 $m \cdot min^{-1}$.

Subsequently, the samples were packed in three kinds of packaging materials:

- double layered corrugated cardboard with a weight of 200 $g \cdot m^{-2}$ which consisted of a layer of fluting and two liners,
- polyethylene foam – white, 2 mm thick,
- stretch film – colourless, 23 μm,

and left packed for a period of 15 days.

After 15 days the samples were unpacked and placed in a test chamber. Tests were carried out in a 0.225 m3 glass chamber. The following climatic conditions in the chamber were maintained in terms of temperature 23°C ± 1°C, relative moisture content 45% ± 1%, air exchange rate 1 h^{-1} and material load 1 m^2/1 m^3. The measurements were made after 5 h, 24 h, 48 h, 72 h, 120 h and 240 h. Tenax TA (35/60 mesh) was used as the main sorbent. In each case three parallel air samples were collected in the amount of 1000 ml at a sampling flow rate of 100 $ml \cdot min^{-1}$ as well as the background air was collected by means of a FLEC air pump (Chematec APS).

TD-GC-MS analysis

The analytes adsorbed on the sorbent bed were released in thermal desorber in conditions compiled in Tab. 2.

Tab. 2: Thermal desorber operating conditions.

Elements of the system	Parameters
Injector	Thermal desorber connected to sorption microtrap; Purging gas: argon at 20 m^3min^{-1}; Desorption temperature: 250°C during 5 min.
Microtrap	Sorbent: 80 mg Tenax TA/30 mg Carbosieve III; Desorption temperature: 250°C during 90 s.

The chromatographic analysis of the desorbed analytes was performed using a gas chromatograph fitted with a mass spectrometer in conditions shown in Tab. 3.

Compounds were identified by comparing the obtained mass spectra with the spectra mentioned in the NIST MS library - program version 1.7 and have been confirmed by comparing the mass spectra with the retention times of identified compounds with spectra and retention times of relevant standards.

The quantitative analysis of volatile organic compounds emitted from the test surfaces was performed by a standard addition method using 1-bromo-4-fluorobenzene.

Tab. 3: Parameters of GC/MS analytical system.

Elements of the system	Parameters
Gas chromatograph	TRACE GC, Thermo Quest
Column	RTX – 624 Restek Corporation, 60m x 0,32mm ID; D_f – 1,8 μm: 6% cyanopropylophenyl, 94% dimethylopolysiloxane
Detector	Mass spectrometer (SCAN: 10 – 350)
Carrier gas	Helium: 100 kPa, ~2 cm^3min^{-1}.
Temperature settings	40°C during 2 min, 7°C min^{-1} to 200°C, 10°C min^{-1} to 230°C, 230°C during 20 min

Statistical analysis

For the identified compounds, a one-way analysis of variance (ANOVA) was conducted to study the effect of the packaging methods on VOC emissions at the 0.05 significance level. Duncan's tests were conducted for multiple comparisons of the means of the concentrations of compounds released by test varnish products.

RESULTS

The obtained results are shown in Tabs. 4 - 12.

Tab. 4: VOCs emission from samples finished with polyurethane product, packed in corrugated cardboard ($\mu g \cdot m^{-3}$).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
Ethyl acetate	32.0 ± 2.4	29.2-35.4	27.6 ± 6.9	20.1-37.1	19.2 ± 0.9	18.3-20.1	17.8 ± 0.8	17.0-19.1	15.0 ± 1.2	14.2-17.1	15.1 ± 1.3	13.5-17.1
toluene	146.1 ± 4.3	142.4-153.3	106.3 ± 18.2	88.3-129.0	73.2 ± 3.8	69.1-77.9	67.2 ± 4.2	60.2-70.5	47.8 ± 2.1	45.5-49.6	33.1 ± 3.2	29.4-38.1
2-methylpropyl acetate	123.6 ± 3.9	120.4-129.6	95.1 ± 4.4	90.1-102.2	68.0 ± 4.1	61.0-71.2	58.2 ± 4.8	52.8-62.5	51.2 ± 2.8	48.3-55.1	39.6 ± 28	36.5-44.2
n-butyl acetate	1478.9 ± 33.0	1420.9-1499.6	1114.4 ± 80.4	996.3-1223	834.2 ± 34.8	800.0-869.9	761.2 ± 38.0	718.6-799.4	612.3 ± 41.7	569.8-654.2	528.2 ± 35.2	489.4-576.5
etylobenzene	121.2 ± 4.1	116.5-126.0	87.0 ± 4.4	80.3-91.7	62.2 ± 3.8	59.0-68.4	55.8 ± 4.2	51.3-59.6	46.9 ± 9.3	32.8-55.3	25.9 ± 1.3	24.3-27.2
m-xylene	530.8 ± 27.9	498.1-556.3	393.6 ± 44.2	354.8-461.8	275.2 ± 27.4	238.9-299.9	182.3 ± 20.8	162.2-215.2	143.2 ± 12.2	129.6-158.7	124.7 ± 3.7	122.0-131.1
1-methoxy-2-propyl acetate	347.9 ± 43.1	304.0-392.4	288.8 ± 17.6	269.9-312.3	226.8 ± 18.6	203.3-255.2	200.1 ± 10.6	185.2-215.2	161.0 ± 13.3	145.9-184.5	144.4 ± 7.5	135.5-152.4
o-xylene	417.6 ± 45.0	368.4-468.9	337.3 ± 30.3	307.1-374.8	287.3 ± 27.5	239.8-305.6	198.2 ± 23.2	182.2-238.1	187.3 ± 18.0	160.2-205.4	161.2 ± 8.2	154.2-174.4
1-methyletyhyl-benzene	10.0 ± 1.2	8.1-11.1	8.5 ± 0.9	7.0-9.1	6.1 ± 0.6	5.4-6.6	5.2 ± 0.4	4.9-5.8	5.0 ± 0.4	4.5-5.3	3.7 ± 0.2	3.5-3.9
3-methoxy-2-butyl acetate	550.7 ± 57.2	497.6-632.2	486.1 ± 30.4	439.9-519.8	391.5 ± 29.3	359.4-422.2	346.5 ± 26.2	303.3-366.6	258.2 ± 35.0	200.3-286.3	233.3 ± 25.6	200.5-268.8
n-propylobenzene	3.2 ± 0.2	3.1-4.0	2.8 ± 0.3	2.4-3.0	2.1 ± 0.1	2.0-2.3	2.5 ± 0.1	2.4-2.7	1.8 ± 0.2	1.6-2.2	2.1 ± 0.1	2.0-2.1
unidentified	52.0 ± 16.0	40-79	40.3 ± 5.8	35.2-47.4	27.8 ± 4.3	24.0-32.5	27.4 ± 2.7	25.0-32.2	28.2 ± 2.8	25.4-31.5	21.2 ± 3.1	19.5-26.7
Total VOCs:	**3814**		**2988**		**2274**		**1922**		**1558**		**1332**	

Tab. 5: VOCs emission from samples finished with polyurethane product, packed in polyethylene foam ($\mu g \cdot m^{-3}$).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
ethyl acetate	36.6 ± 3.4	31.7-39.9	25.8 ± 3.8	22.1-31.5	18.2 ± 2.0	15.8-19.8	18.3 ± 1.2	17.3-20.3	15.2 ± 2.7	11.5-18.3	15.7 ± 1.3	14.3-17.8
toluene	169.5 ± 11.5	153.3-182.4	119.4 ± 18.7	89.9-138.8	81.2 ± 7.9	71.3-91.2	39.2 ± 4.8	33.3-45.6	40.2 ± 7.6	33.2-48.8	38.2 ± 9.2	28.6-48.2
2-methylpropyl acetate	151.7 ± 4.9	145.5-156.4	106.8 ± 5.6	100.3-115.5	75.4 ± 4.4	68.3-80.2	48.7 ± 2.1	44.6-49.5	60.8 ± 5.8	55.3-68.7	41.2 ± 4.7	36.6-46.8
n-butyl acetate	1587.2 ± 63.5	1482.5-1652.4	1252.1 ± 64.8	1195.2-1355.4	925.2 ± 19.9	889.9-936.6	725.8 ± 31.8	691.5-760.2	608.5 ± 43.3	545.3-640.3	549.6 ± 51.5	495.5-601.5
etylobenzene	138.7 ± 12.9	127.5-155.5	97.7 ± 10.8	85.2-110.5	69.0 ± 6.4	60.8-75.9	32.0 ± 2.7	28.2-34.5	55.6 ± 6.2	45.2-60.8	26.9 ± 5.1	21.0-32.5
m-xylene	589.5 ± 38.6	525.4-621.4	442.3 ± 29.2	400.2-476.2	305.2 ± 18.5	289.3-336.5	233.4 ± 5.6	200.5-260.3	188.2 ± 20.9	167.6-215.6	160.4 ± 14.5	1465-182.1
1-methoxy-2-propyl acetate	398.2 ± 15.9	372.4-415.2	324.5 ± 24.9	300.5-356.6	251.6 ± 25.2	211.3-275.5	224.4 ± 20.7	189.5-244.6	162.6 ± 16.7	144.3-180.1	168.2 ± 18.3	143.3-182.2
o-xylene	482.2 ± 17.5	452.2-495.8	379.0 ± 49.5	297.6-416.8	223.3 ± 23.4	200.7-257.6	206.6 ± 20.2	175.2-230.0	189.2 ± 11.5	175.2-206.8	168.5 ± 10.5	152.2-179.8
1-methyletyhyl-benzene	11.5 ± 1.5	10.0-13.8	9.6 ± 0.7	8.5-10.6	6.8 ± 0.9	6.1-8.3	4.1 ± 0.3	3.8-4.4	5.1 ± 0.4	206.8-455.5	3.8 ± 0.4	3.3-.4.4
3-methoxy-2-butyl acetate	625.7 ± 29.3	589.2-665.3	546.2 ± 27.6	503.3-576.6	392.4 ± 31.9	366.2-444.3	424 ± 22.8	389.5-452.5	300.8 ± 26.2	279.9-342.2	234.1 ± 35.8	200.5-278.9
n-propylobenzene	3.7 ± 0.3	3.2-3.9	3.2 ± 0.2	3.0-3.3	2.3 ± 0.3	2.0-2.6	2.6 ± 0.1	2.5-2.6	1.8 ± 0.1	1.6-1.9	2.2 ± 0.1	2.0-2.3
unidentified	62.1 ± 9.1	55.2-78.1	45.3 ± 5.2	40.3-53.2	30.8 ± 4.4	26.0-36.8	28.2 ± 3.3	24.3-32.3	25.1 ± 2.7	22.5-28.3	18.0 ± 1.7	16.0-20.5
Total VOCs:	**4257**		**3352**		**2381**		**1987**		**1653**		**1332**	

Tab. 6: VOCs emission from samples finished with polyurethane product, wrapped in stretch film ($\mu g \cdot m^{-3}$).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
Ethyl acetate	37.5 ± 5.0	30.1-43.6	28.6 ± 1.4	26.6-29.8	22.3 ± 1.5	20.5-24.3	19.2 ± 0.6	18.5-19.9	14.6 ± 1.3	13.2-16.2	13.2 ± 1.7	11.5-15.6
toluene	168.2 ± 16.9	143.2-186.6	132.5 ± 14.5	110.5-149.5	80.1 ± 5.8	70.6-85.2	71.6 ± 3.7	65.5-74.8	46.4 ± 4.4	40.3-52.6	34.4 ± 3.8	30.5-40.6
2-methylpropyl acetate	163.1 ± 11.0	150.1-179.3	118.5 ± 12.0	103.5-136.4	76.3 ± 4.7	70.6-82.1	51.1 ± 4.5	44.7-56.6	49.7 ± 5.6	44.1-56.6	41.2 ± 4.7	36.1-48.6
n-butyl acetate	1952.2 ± 22.7	1798.8-2133.7	1452.2 ± 86.9	1336.5-1552.7	967.6 ± 37.5	905.7-1003.6	762.1 ± 36.2	700.3-789.9	593.9 ± 24.9	560.4-624.3	535.2 ± 29.1	500.3-568.6
etylobenzene	159.9 ± 10.6	144.0-169.8	121.4 ± 9.7	105.6-130.7	72.2 ± 5.6	65.3-79.4	48.7 ± 6.3	44.3-59.6	35.2 ± 3.0	30.5-38.4	26.9 ± 3.4	22.1-31.5

m-xylene	658.9 ± 40.6	589.9-692.2	491.0 ± 24.9	452.5-521.1	319.2 ±16.6	300.5-354.3	245.1 ± 23.8	223.3-279.6	128.7 ± 10.2	113.5-140.3	118.3 ± 10.5	103.1-128.7
1-methoxy-2-propyl acetate	398.7 ± 16.4	375.2-415.2	306.5 ± 11.2	287.6-315.7	263.1 ± 13.5	245.3-276.8	228.7 ± 19.2	200.3-254.0	156.1 ± 12.0	135.6-165.8	130.2 ± 12.5	89.6-123.4
o-xylene	551.2 ± 30.5	505.3-586.2	441.6 ± 12.6	425.5-460.9	333.3 ± 21.2	303.5-354.3	268.2 ± 16.5	245.3-287.1	192.1 ± 23.2	170.2-228.8	168.2 ± 28.3	
1-methyletyhyl-benzene	13.3 ± 0.7	12.5-14.3	10.7 ± 04	10.3-11.2	7.1 ± 0.3	6.6-7.4	4.3 ± 0.3	4.1-4.7	4.9 ± 0.1	4.7-5.0	3.8 ± 0.1	3.7-3.9
3-methoxy-2-butyl acetate	597.4 ± 17.2	572.6-618.6	501.2 ± 26.4	463.6-530.6	415.2 ± 18.6	387.6-433.0	385.1 ± 25.0	351.2-415.4	253.1 ± 16.7	231.7-275.8	212.6 ± 16.6	200.3-241.3
n-propylobenzene	4.3 ± 0.2	4.1-4.6	4.1 ± 0.1	4.0-4.2	2.4 ± 0.1	2.2-2.5	2.7 ± 0.3	2.3-2.9	1.7 ± 0.2	1.5-1.9	2.2 ± 0.1	2.1-2.3
unidentified	100.3 ± 11.2	89.5-119.1	62.1 ± 2.6	58.7-64.5	39.2 ± 3.6	34.5-43.6	29.6 ± 5.3	24.5-36.8	22.5 ± 3.3	20.1-26.8	22.0 ± 2.9	19.0-26.8
Total VOCs:	**4805**		**3670**		**2598**		**2116**		**1499**		**1308**	

Tab. 7: VOCs emission from samples finished with waterborne product, packed in corrugated cardboard ($\mu g \cdot m^{-3}$).

Compounds	**5h**		**24h**		**48h**		**72h**		**120h**		**240h**	
	Mean ± s.d.	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**
acetic acid	60.2 ± 4.9	54.0-67.8	46.5 ± 4.9	40.3-52.6	38.5 ± 5.7	32.5-45.2	34.2 ± 3.4	29.2-37.2	28.1 ± 2.6	25.2-31.5	15.2 ± 1.2	13.3-16.5
toluene	8.9 ± 0.6	8.1-9.6	7.2 ± 0.4	6.8-7.8	6.1 ± 0.4	5.5-6.6	5.1 ± 0.3	4.6-5.5	3.9 ± 0.3	3.4-4.3	3.3 ± 0.2	3.0-3.6
n-nonane	12.5 ± 1.7	10.5-14.6	8.2 ± 0.6	7.6-9.2	7.2 ± 0.5	6.5-7.8	7.6 ± 0.5	7.0-8.2	7.5 ± 0.3	7.0-7.8	5.2 ± .4	4.6-5.6
propylcyclo-hexane	12.9 ± 2.1	9.8-14.5	7.3 ± 0.5	6.5-7.8	7.2 ± 0.2	6.9-7.4	6.2 ± 0.3	5.7-6.5	5.9 ± 0.7	5.2-6.7	3.6 ± 0.5	3.1-4.5
2-butoxy-ethanol	1899.6 ± 103.9	1775.3-1787.3	1432.5 ± 64.3	1352.3-1521.2	987.3 ± 16.3	969.5-1009.1	732.4 ± 20.9	700.1-752.0	632.4 ± 20.4	598.7-646.7	489.2 ± 9.7	448.9-521.6
n-decane	92.4 ± 6.6	85.3-102.1	57.3 ± 5.4	50.1-63.6	48.2 ± 6.0	40.3-55.5	36.7 ± 10.7	34.1-61.4	18.5 ± 0.7	18.0-19.6	6.6 ± 0.4	6.0-7.2
n-undecane	40.5 ± 5.2	35.4-46.5	20.2 ± 2.0	19.0-23.6	16.9 ± 2.9	13.8-20.4	13.1 ± 0.4	12.6-13.6	8.8 ± 0.2	8.6-9.0	<1	<1
unidentified	179.2 ± 14.1	160.5-192.5	131.2 ± 10.4	121.3-148.9	97.4 ± 15.4	80.5-121.5	75.1 ± 4.6	68.5-79.8	62.5 ± 5.3	55.2-69.9	36.1 ± 6.7	30.3-46.6
Total VOCs:	**2306**		**1710**		**1209**		**910**		**768**		**559**	

Tab. 8: VOCs emission from samples finished with waterborne product, packed in polyethylene foam ($\mu g \cdot m^{-3}$).

Compounds	**5h**		**24h**		**48h**		**72h**		**120h**		**240h**	
	Mean ± s.d.	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**	**Mean ± s.d.**	**Range**
acetic acid	61.2 ± 4.9	55.3-66.8	39.5 ± 6.4	30.5-46.8	38.3 ± 4.1	35.1-45.3	36.2 ± 3.9	30.5-41.3	27.6 ± 2.3	25.3-29.9	17.5 ± 1.8	15.5-20.3
toluene	12.4 ± 1.6	10.9-14.6	8.2 ± 0.1	8.1-8.3	6.3 ± 0.2	6.0-6.5	4.1 ± 0.1	4.0-4.3	3.9 ± 0.1	3.7-4.0	3.6 ± 0.2	3.3-3.8
n-nonane	8.7 ± 0.3	8.3-9.1	8.8 ± 0.4	8.1-9.2	7.2 ± 0.2	7.1-7.5	7.0 ± 0.1	6.8-7.0	7.0 ± 0.2	6.8-7.4	6.6 ± 0.3	6.1-6.8
Propylcyclo-hexane	13.5 ± 1.1	11.5-14.2	8.2 ± 0.4	7.6-8.6	6.3 ± 0.3	6.0-6.8	6.2 ± 0.2	6.0-6.4	5.4 ± 0.3	5.1-5.8	4.2 ± 0.2	4.0-4.5
2-butoxy-ethanol	1959.9 ± 104.2	1896.3-2141.3	1533.1 ± 58.0	1455.3-1588.1	1025.7 ± 28.9	998.2-1072.3	779.2 ± 28.0	731.9-805.3	712.4 ± 17.8	689.7-733.6	509.4 ± 26.4	465.3-532.3
n-decane	99.5 ± 6.7	88.6-106.5	64.7 ± 4.9	60.4-71.2	52.4 ± 4.2	45.3-56.3	39.9 ± 4.1	34.5-44.5	28.5 ± 3.2	25.8-33.6	6.6 ± 0.2	6.4-6.8
n-undecane	42.6 ± 3.1	40.1-46.0	26.5 ± 3.5	20.6-29.7	23.3 ± 3.3	20.1-28.3	18.6 ± 1.5	16.3-20.5	13.8 ± 2.2	11.1-16.8	<1	<1
unidentified	189.4 ± 9.8	175.9-200.4	137.4 ± 8.3	122.6-142.3	116.4 ± 3.0	100.1-130.4	94.3 ± 4.1	87.6-98.5	68.5 ± 5.3	60.5-75.2	42.1 ± 3.3	37.2-45.7
Total VOCs:	**2387**		**1826**		**1276**		**1826**		**867**		**590**	

Tab. 9: VOCs emission from samples finished with waterborne product, wrapped in stretch film (μg·m⁻³).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
acetic acid	58.2 ± 6.0	50.1-65.2	41.5 ± 4.1	36.6-47.3	39.2 ± 4.6	35.4-46.8	38.2 ± 3.3	32.5-41.3	20.5 ± 1.3	18.9-22.3	12.5 ± 0.9	10.9-12.9
toluene	10.5 ± 0.8	9.3-11.4	7.2 ± 0.2	7.0-7.3	6.9 ± 0.4	6.5-7.3	5.2 ± 0.2	5.0-5.4	4.0 ± 0.0	4.0-4.1	4.0 ± 0.1	1.0-4.2
n-nonane	9.8 ± 1.2	8.7-11.7	8.3 ± 0.6	7.6-9.2	6.9 ± 0.1	6.7-7.0	5.9 ± 0.2	5.7-6.1	5.8 ± 0.3	5.4-6.1	6.0 ± 0.2	5.8-6.3
propylcyclo-hexane	15.2 ± 1.9	14.2-18.6	10.5 ± 1.0	9.3-12.0	7.2 ± 0.2	7.0-7.6	5.2 ± 0.3	5.0-5.6	4.2 ± 0.1	4.0-4.2	4.1 ± 0.1	4.0-4.3
2-butoxy-ethanol	2045.6 ± 38.7	1993.3-2098.6	1601.4 ± 58.0	1520.3-1669.8	1102.5 ± 90.2	1000.3-1221.4	801.5 ± 29.8	754.1-836.2	761.2 ± 28.1	720.3-798.4	491.8 ± 25.7	453.3-519.0
n-decane	132.4 ± 12.0	120.3-148.9	73.2 ± 4.0	67.3-78.5	58.2 ± 5.7	48.3-62.7	44.2 ± 3.6	40.3-49.7	33.5 ± 1.3	32.0-35.4	21.2 ± 1.4	20.3-23.3
n-undecane	48.5 ± 8.1	40.1-59.6	32.5 ± 2.8	29.3-36.4	23.5 ± 3.0	20.3-26.7	17.3 ± 2.0	15.2-20.3	10.5 ± 0.7	9.8-11.3	3.3 ± 0.2	3.2-3.6
unidentified	236.5 ± 23.9	200.3-267.1	159.2 ± 8.7	145.3-167.9	105.2 ± 11.3	94.5-118.6	74.2 ± 5.5	65.8-79.4	52.1 ± 4.7	45.3-57.8	33.1 ± 3.6	30.5-39.4
Total VOCs:	**2557**		**1934**		**1350**		**992**		**892**		**576**	

Tab. 10: VOCs emission from samples finished with waterborne UV product, packed in corrugated cardboard (μg·m⁻³).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
acetone	36.2 ± 3.8	31.1-39.5	23.2 ± 2.4	20.1-26.5	15.4 ± 1.4	13.2-16.8	12.5 ± 1.4	10.5-14.3	6.5 ± 0.3	6.0-6.7	<1	<1
1-butanol	81.5 ± 4.2	75.9-85.7	51.2 ± 4.9	44.3-57.1	31.2 ± 2.6	28.7-34.7	19.2 ± 1.3	17.6-21.3	11.2 ± 0.5	10.8-12.0	7.5 ± 0.2	7.2-7.6
1.4-dioxane	39.5 ± 2.4	35.9-42.5	24.4 ± 2.7	20.7-27.8	22.5 ± 1.7	20.1-24.8	14.5 ± 0.8	13.3-15.4	6.6 ± 0.5	5.8-7.1	4.3 ± 0.1	4.2-4.3
hexanal	27.2 ± 3.2	21.8-29.9	27.5 ± 4.3	20.8-32.5	29.6 ± 1.9	27.3-32.6	33.1 ± 2.8	30.1-36.6	22.5 ± 1.8	19.7-24.8	10.5 ± 0.4	9.8-10.9
cyclohexanone	132.4 ± 7.4	120.1-138.7	86.5 ± 5.2	77.3-90.1	55.8 ± 3.9	50.2-58.9	48.2 ± 4.8	40.5-53.7	38.9 ± 2.8	34.4-42.1	33.2 ± 2.4	29.7-35.5
benzaldehyde	163.2 ± 12.0	153.7-184.1	116.8 ± 5.2	110.3-124.1	78.2 ± 5.0	72.1-84.5	62.8 ± 3.1	60.5-67.8	54.3 ± 3.6	50.4-58.7	52.1 ± 2.2	48.3-54.1
unidentified	39.6 ± 5.0	31.7-44.9	25.7 ± 2.7	21.6-27.4	9.3 ± 0.3	9.0-9.6	6.7 ± 0.5	5.8-6.9	3.3 ± 0.2	3.0-3.4	-	-
Total VOCs:	**520**		**355**		**242**		**197**		**143**		**108**	

Tab. 11: VOCs emission from samples finished with waterborne UV product, packed in polyethylene foam (μg·m⁻³).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
acetone	35.2 ± 4.1	30.1-41.3	27.5 ± 1.5	25.4-28.7	17.6 ± 1.3	15.4-18.9	11.9 ± 1.8	10.5-15.2	6.1 ± 0.2	5.8-6.3	3.0 ± 0.1	3.0-3.2
1-butanol	85.1 ± 4.8	77.1-89.4	48.6 ± 3.8	43.3-53.7	31.5 ± 1.0	30.5-33.2	19.9 ± 2.1	17.6-23.3	11.7 ± 1.2	9.8-12.9	5.6 ± 0.1	5.5-5.7
1.4-dioxane	32.6 ± 2.1	29.7-34.9	32.8 ± 3.3	27.6-36.4	15.9 ± 1.3	14.2-17.6	12.2 ± 1.0	11.0-13.6	8.3 ± 0.3	7.8-8.5	5.0 ± 0.3	4.8-5.5
hexanal	27.5 ± 2.0	24.3-29.4	28.1 ± 1.9	25.0-29.8	26.7 ± 3.2	21.5-30.4	26.3 ± 1.7	25.0-28.9	17.9 ± 1.3	16.1-19.5	17.6 ± 1.2	15.7-18.6
cyclohexanone	144.4 ± 12.2	130.1-162.7	92.2 ± 3.7	88.3-96.3	63.4 ± 4.5	57.6-68.9	49.5 ± 5.4	40.5-53.9	44.3 ± 4.9	36.8-48.5	27.3 ± 2.3	23.2-28.9
benzaldehyde	159.7 ± 7.6	148.7-167.6	114.8 ± 7.6	105.6-126.5	80.9 ± 5.2	72.2-85.5	63.2 ± 4.5	56.7-69.4	49.1 ± 5.1	40.5-53.3	41.6 ± 4.2	35.5-46.5
unidentified	44.2 ± 3.3	40.3-48.5	29.5 ± 2.9	25.6-33.5	12.7 ± 0.8	11.5-13.6	10.5 ± 0.7	10.0-11.4	6.7 ± 0.1	6.5-6.7	2.1 ± 0.1	2.0-2.1
Total VOCs:	**529**		**374**		**249**		**194**		**144**		**102**	

Tab. 12: VOCs emission from samples finished with waterborne UV product, wrapped in stretch film ($\mu g \cdot m^{-3}$).

Compounds	5h		24h		48h		72h		120h		240h	
	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range	Mean ± s.d.	Range
acetone	34.9 ± 2,5	30,5-36,8	28.1 ± 2,4	25,5-31,5	17.6 ± 1,6	15,2-19,3	8.9 ± 0,3	8,6-9,3	5.2 ± 0,1	5,0-5,4	2.2 ± 0,1	2,0-2,3
1-butanol	84.2 ± 4,4	77,1-88,5	53.8 ± 4,3	46,3-56,6	31.5 ± 2,1	30,1-34,8	22.8 ± 2,6	18,5-25,3	18.6 ± 1,4	16,3-19,7	10.9 ± 1,2	8,9-11,8
1.4-dioxane	40.6 ± 2,3	38,5-44,3	31,0 ± 2,5	28,1-33,8	15.9 ± 1,8	13,5-18,4	12.8 ± 1,7	11,3-14,8	8.5 ± 0,3	8,0-8,7	3.2 ± 0,0	3,2-3,3
hexanal	27.2 ± 3,0	22,1-29,7	25.4 ± 2,3	22,5-28,4	26.7 ± 3,2	21,1-28,7	30.1 ± 2,7	26,1-33,7	22.5 ± 1,8	19,7-24,3	22.5 ± 2,0	19,1-24,2
cyclohexanone	140.8 ± 5,6	133,3-148,9	81.1 ± 2,8	787,4-85,2	73.4 ± 4,5	68,1-80,5	39.2 ± 5,3	30,4-44,7	36.2 ± 3,0	31,1-38,7	25.2 ± 3,4	20,2-28,7
benzaldehyde	163.4 ± 5,7	155,3-170,1	132.1 ± 7,1	120,1-138,7	88.9 ± 5,3	80,4-93,7	75.9 ± 4,5	68,2-79,7	55.2 ± 3,4	49,7-58,1	40.9 ± 2,1	37,6-43,1
unidentified	40.6 ± 1,7	39,0-43,3	30.5 ± 1,8	28,7-33,2	15.3 ± 0,3	14,8-15,7	12,0 ± 1,4	10,6-14,3	3.2 ± 0,1	3,0-3,2	-	-
Total VOCs:	**532**		**382**		**269**		**202**		**149**		**105**	

The statistical analysis results are presented in Tab. 13-15. The same letters in each column indicate that there is no statistical difference between the samples according to the Duncan's multiply range test at $P < 0.05$.

Tab. 13: Duncan's results showing statistical differences between the packaging methods for polyurethane varnish.

Time	Packaging material**	Compound											
		1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*
5h	CC	A	B	A	A	A	A	A	A	A	A	A	A
	PP	AB	A	B	A	B	B	B	B	A	B	B	A
	S	B	A	C	B	C	C	B	C	B	AB	C	B
24h	CC	A	A	A	A	A	A	A	A	A	A	A	A
	PP	A	AB	B	B	A	B	B	A	B	B	B	A
	S	A	B	C	C	B	C	AB	B	C	A	C	B
48h	CC	A	A	A	B	A	B	A	B	A	A	A	A
	PP	A	A	A	A	AB	A	AB	A	AB	A	A	A
	S	B	A	A	A	B	A	B	C	B	A	A	B
72h	CC	A	A	B	A	A	B	B	A	B	A	A	A
	PP	AB	B	A	A	B	A	A	A	A	C	A	A
	S	B	A	AB	A	A	A	A	B	A	B	A	A
120h	CC	A	A	A	A	A	A	A	A	A	A	A	B
	PP	A	A	A	A	A	B	A	A	A	B	A	AB
	S	A	A	A	A	B	A	A	A	A	A	A	A
240	CC	AB	A	A	A	A	A	B	A	A	A	B	AB
	PP	B	A	A	A	A	B	C	A	A	A	A	A
	S	A	A	A	A	A	A	A	A	A	A	A	B

*1(ethyl acetate), 2(toluene), 3(2-methylpropyl acetate), 4(n-butyl acetate), 5(etylobenzene), 6(m-xylene), 7(1-methoxy-2-propyl acetate), 8(o-xylene), 9(1-methylethylbenzene), 10(3-methoxy-2-butyl acetate), 11(n-propylobenzene), 12(unidentified);

**CC (corrugated cardboard), PP (polyethylene foam), S (stretch film).

Tab. 14: Duncan's results showing statistical differences between the packaging methods for waterborne varnish.

Time	Packaging material**	Compound							
		1*	2*	3*	4*	5*	6*	7*	8*
5h	CC	A	A	B	A	A	A	A	A
	PP	A	C	A	A	AB	A	A	A
	S	A	B	A	A	B	B	A	B
24h	CC	A	A	A	A	B	A	A	A
	PP	A	B	A	A	A	B	B	A
	S	A	A	A	B	A	C	C	B
48h	CC	A	A	A	A	A	A	B	A
	PP	A	A	A	B	A	AB	A	A
	S	A	B	A	A	B	B	A	A
72h	CC	A	A	C	A	B	A	A	A
	PP	A	B	B	A	A	A	A	B
	S	A	A	A	B	A	A	A	A
120h	CC	B	A	C	A	A	A	A	A
	PP	A	A	B	A	B	B	B	A
	S	A	A	A	B	C	C	A	B
240h	CC	B	A	A	A	A	A	A	AB
	PP	C	B	C	B	A	A	A	B
	S	A	C	B	AB	A	B	A	A

* 1(acetic acid), 2(toluene), 3(n-nonane), 4(propylcyclohexane), 5(2-butoxyethanol), 6(n-decane), 7(n-undecane), 8(unidentified);

**CC (corrugated cardboard), PP (polyethylene foam), S (stretch film).

Tab. 15: Duncan´s results showing statistical differences between the packaging methods for waterborne UV varnish.

Time	Packaging material**	Compound						
		1*	2*	3*	4*	5*	6*	7*
5h	CC	A	A	B	A	A	A	A
	PP	A	A	A	A	A	A	A
	S	A	A	A	A	A	A	A
24h	CC	B	A	B	A	A	A	B
	PP	A	A	A	A	B	A	A
	S	A	A	A	B	A	B	A
48h	CC	B	A	B	A	A	A	A
	PP	A	A	A	A	A	A	B
	S	A	A	A	A	A	B	C
72h	CC	A	A	B	C	A	A	A
	PP	A	A	A	A	A	A	B
	S	B	B	AB	B	B	B	C
120h	CC	A	A	B	A	A	AB	A
	PP	B	A	A	A	B	A	B
	S	C	B	A	A	A	B	A

240h	CC	A	B	C	A	B	B	A
	PP	C	A	B	B	A	A	B
	S	B	C	A	C	A	A	A

* 1(acetone), 2(1-butanol), 3(1,4-dioxane), 4(hexanal), 5(cyclohexanone), 6(benzaldehyde), 7(unidentified);
**CC (corrugated cardboard), PP (polyethylene foam), S (stretch film).

DISCUSSION

Changes the total concentration of VOCs emitted by the all tested coatings are shown in the graphs in Fig. 1.

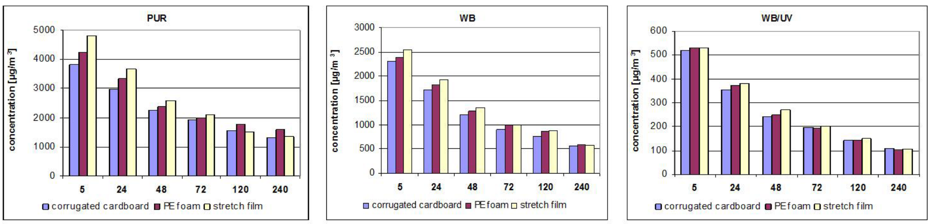

Fig. 1: The total concentration of volatile organic compounds emitted by tested materials after 5 h, 24 h, 48 h, 72 h, 120 h and 240 h of exposure in the test chamber.

On the basis of the research results it can be stated that the method of packing of the elements had an impact on the level of emission of volatile substances after their unpacking.

The emission of all compounds emitted from the samples coated with polyurethane varnish ranged from 3814 to 4805 mg·m^{-3} after 5h of sample exposure in the chamber. The highest amount of volatile substances was emitted by the samples wrapped in stretch film and the lowest amount was emitted by the samples packed in corrugated cardboard. The concentration of the volatile compounds released from the elements wrapped in stretch film was over 20% higher than the concentration of those compounds released from the items packed in corrugated cardboard and 10% higher than of those packed in polyethylene foam. The differences in amount of emitted compounds recorded after 24 hours were similar. After 24 h oak wood samples wrapped in stretch film have still emitted an 18% bigger amount of volatile compounds than the samples packed in corrugated cardboard and the samples packed in polyethylene foam have emitted approximately 9% more VOCs than samples packed in corrugated cardboard. After 48 h the differences decreased to approximately 12% and 8% and after 72 h to 6% and 9%.

After 120 hours of sample exposure in the test chamber not only did the quantity of the emitted compounds decrease but also the earlier observed trends changed. After 120 h the smallest amount of VOCs was emitted by samples wrapped in stretch film. The concentration of VOCs emitted by samples wrapped in stretch film was approximately 4% smaller than those packed in corrugated cardboard and more than 10% smaller than those packaged in polyethylene foam. After 240 h the amount of volatile compounds emitted from the tested samples the underwent further reduction to the level ranging from 1332 to 1427 mg·m^{-3}. After 240 h, same as after 120 h the smallest amount of VOCs was emitted by the samples wrapped in stretch film. The samples protected by corrugated cardboard and polyurethane foam emitted by 2.5% and 9% more compounds than the samples wrapped in stretch film.

The influence of the type of packaging on the emissions of volatile components in items coated with waterborne WB1 product was similar to that recorded for items finished with polyurethane varnish, wherein noted differences were smaller. After 5 hours the amount of the compounds emitted by the samples coated with a waterborne product ranged from 2306 to 2387 mg·m^{-3}. After 5 h the samples wrapped in stretch film emitted a more than 3% bigger amount of VOCs and those packed in polyethylene foam approximately more than 11% of VOCs than the samples packed in corrugated cardboard. After 24 h and 48 h, those differences increased. The elements packed in polyethylene foam emitted approximately 7-5% more VOCs and the items wrapped in stretch film approximately 13-11% more VOCs than the amount identified for the items packed in corrugated cardboard. After 72 h still the smallest amount of compounds was released to air by the samples packed in corrugated cardboard and that trend was maintained even after 120 h and 240 h. After 72 h the samples packed in corrugated cardboard emitted approximately 9% less volatile compounds than the samples wrapped in stretch film and 8% less than the samples packed in polyurethane foam. After 240 h the differences in emission level decreased to approximately 3% and 6%.

The smallest differences in the amount of emitted compounds was observed for elements finished with UV varnish. Those coatings also emitted the smallest amount of volatile compounds among all studied coatings. In the first test period, that is after 5 hours, the amount of released compounds varied and ranged from 523 to 532 mg·m^{-3}. After 5 h, 24 h and 48 h of sample exposure in the test chamber, similar trends were observed as for a polyurethane product and a waterborne product. The samples packed in polyethylene foam and stretch film emitted to the air a higher amount of volatiles than the samples packed in corrugated cardboard. However, those differences were not big. After 5 h the difference in the amount of emission was approximately 2%, after 24 h it rose to approximately 5-8% and after 48 h to 3-11%. After 72 h of sample exposure in the test chamber the concentration of compounds emitted by the samples remained at similar levels ranging from 201 to 207 mg·m^{-3}. After 240 h total VOCs decreased and ranged from 102 to 108 mg·m^{-3}.

Analyzing the type of compounds emitted by the samples it can be concluded that the type of packaging material used has no effect on the composition of compounds emitted from the tested samples. The only factor determining the type of released compounds was the kind of a finishing product which had been used. The type of identified volatile organic compounds was consistent with previous studies on varnish coatings, reported in literature.

The polyurethane varnish coating emitted mostly ester compounds. The share of esters in the total amount of emitted compounds during the entire study period, i.e. between 5 h and 240 h varied within the range from 66% to 72%. N-butyl acetate is the ester which was emitted in the biggest amount. Furthermore, the polyurethane varnish coating was the source of emissions of aromatic hydrocarbons. The share of compounds from the aromatic hydrocarbons group in the total amount of emissions, ranged from 26% to 33%. The results obtained in terms of the type of identified compounds are confirmed in the literature (Stachowiak-Wencek 2012). The polyurethane surfaces investigated by Stachowiak-Wencek (2012) emitted compounds from an ester group which ranged from 64.7% to 91.6% of total emission and aromatic hydrocarbons whose concentration was lower and ranged from 0.9% to 31.7%. Dziewanowska-Pudliszak (2007) concluded that the compound group emitted by polyurethane lacquered surfaces in the most considerate volume was aromatic and aliphatic hydrocarbons.

On the other hand, the oak wood samples coated with a waterborne product emitted predominantly compounds belonging to the glycols, and aliphatic hydrocarbons. The main component emitted by all of the tested materials was 2-butoxyethanol. The concentration of that compound after 24 hours was at the level of 1899.6 to 2045.6 mg.m-3and represented 80%-87% of the total emission. Literature reports that 2-butoxyethanol is a characteristic component released by waterborne varnish coating. The presence of that compound was also noted by Salthammer (1997), Stachowiak-Wencek and Prądzyński (2011). According to the literature, the emission of that compound ranged from 231.7 to 1531 $\mu g \cdot m^{-3}$ (Stachowiak-Wencek and Prądzyński 2011). Salthammer (1997) also reported that glycol emission prevailed in waterborne lacquer layers and 2-butoxyethanol was the main compound. Dziewanowska-Pudliszak (2007) investigating the emission from acrylic lacquer layers placed on a glass plate, determined the highest emission of alcohols. For layers on various wood species, VOC emission varied more and was more dependent on a surface type.

The dominant component emitted by all of the tested WB/UV coatings was benzaldehyde and cyclohexanone. The share of those compounds in the total emission has changed throughout the whole study period from 55% to 67%. Literature data (Salthammer et al. 1999, Salthammer 2004, Uhde and Salthammer 2007, Kagi et al. 2009, Stachowiak-Wencek et al. 2014) indicate that cyklohexanon and benzaldehyde are the products of decomposition of the photoinitiator type HCPK (1-hydroxy-cyclohexyl-phenone). According to information provided by the manufacturer, 1-hydroxy-cyclohexyl-phenone (HCPK) has been used as a photoinitiator which initiates the curing reaction. Stachowiak-Wencek et al. (2014) proved that UV-cured lacquer layers are characterised by relatively low VOC emission. The VOC volume amounted to 397-557 $\mu g \cdot m^{-3}$.

CONCLUSIONS

1. In the first stages of the study the impact of the type of packaging material on the quantity of emitted volatile organic compounds from furniture elements after unpacking was found.
2. After 5 h of sample exposure in the test chamber the highest concentration of the volatile compounds was observed in samples wrapped in stretch film while the lowest concentration in those packed in corrugated cardboard. That trend was found true for all the tested types of varnish coatings and has been maintained for 72 h and even 240 h, depending on the type of varnish which was used.
3. In the last stage of the study (after 240 h) the observed differences in the amount of emitted compounds by each of the tested coatings were not big and it can be stated that they did not depend on the type of the packaging material. In the case of polyurethane and waterborne coatings the smallest amount of volatile compounds was emitted by a sample packed in a corrugated cardboard, whereas in the case of coatings based on UV curable products it was the sample packed in polyurethane foam that emitted the least compounds.
4. No influence of the kind of used packaging material on the type of compounds emitted by the tested sample was found.
5. Research has shown that packing furniture in a rational way can reduce the amount of volatile compounds that are released when the furniture is unpacked.

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