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VOC emissions from melamine films and finish foils

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Abstract: *VOC emissions from melamine films and finish foils.* The paper presents results of investigations on VOC emissions from melamine films and finish foils, i.e. materials used to refine surface of wood-based materials. Compound adsorption was carried out on the Tenax TA solid sorbent. Volatile organic compounds were analysed with the assistance of gas chromatography coupled with mass spectrometry and thermal desorption (GC/MS/TD). It was concluded, on the basis of the obtained research results, that the tested finishing materials were characterised by relatively low levels of noxious emissions.

Keywords: Volatile organic compounds (VOC), Emission, Melamine films, Finish foils , Wood-based materials, Chamber studies, GC/MS/TD

INTRODUCTION

The quality of air inside buildings as well as the health of their users are influenced by all kinds of finishing materials found there, including articles manufactured from wood and wood-based materials. Sometimes, their quantities are very considerable and, when combined with insufficient air exchange, can contribute to air contamination. Apart from solid wood, materials in common use include: particleboards, MDF and HDF finished with laminates or artificial veneers. These materials are used to manufacture, among others, furniture, wall and floor panels, skirting boards and doors.

Considerable amounts of attention was devoted to investigations of VOC emissions from wood-based materials (Baumann *et al.* 1999, 2000; Stachowiak-Wencek and Prądzyński 2005; Kim *et al.* 2006, 2007; Ohlmeyer *et al.* 2008; Toftum *et al.* 2008) but little information can be found in the literature on the subject about VOCs released from materials used to finish wood surfaces, i.e. laminates and finish foils (Wiglusz *et al.* 2002; Gaca and Dziewanowska-Pudliszak 2005).

The objective of the investigations was to determine quality and quantity of VOCs liberated by melamine films and finish foils. The investigations made it possible to determine the impact of decorative products on VOC emissions from finished wood-based materials.

MATERIALS AND METODS

Investigations were conducted on melamine films and finish foils which were manufactured on the base of 70 g/m^2 grammage papers imitating the structure of different wood species. The investigated melamine films were from 0.113 to 0.125 mm thick, whereas the thickness of the applied finish foils ranged from 0.100 to 0.115 mm. The examined materials were obtained from a Polish manufacturer. A detailed list of the main raw materials used for the production of the tested materials is presented in Table 1.

Table 1. List of main raw materials used to manufacture the examined melamine films and finish foils in kg/m^2 (on the basis of the manufacturer's information)

Melamine films		**Finish foils**	
Decor paper	$1m^2$	Decor paper	$1m^2$
Urea-formaldehyde resin	0.12 kg	Urea-formaldehyde resin	0.0354 kg
Melamine resin	0.083 kg	Melamine resin	0.0150 kg
Triethanolamine	0.0005 kg	Acrylic resin	0.0192 kg
Butanol	0.0036 kg	Diethylene glycol	0.0005 kg
Polyglycol 2000	0.0004 kg	Waterborne lacquer	0.0185 kg
Diethylene glycol	0.0002 kg		

Investigations of VOC emissions were carried out in a glass chamber of 0.225 m^3 volume in which the following conditions were maintained: temperature 23 +/- 1°C; relative humidity - 45 +/- 2%; chamber load - $1m^2/1m^3$; air exchange - 1/h. After 24 hours, air from the chamber was collected into tubes packed with one layer Tenax TA (120 mg). Analytes adsorbed on the bed were released with the aid of a thermal desorber. Released analytes were transferred as a narrow band to the front of a chromatographic column, and then to a mass spectrometer. Parameters of the TD/GC/MS analytical system are presented in Table 2.

Table 2. Conditions for analytes determinations with the use of a TD/GC/MS technique

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)
Injector	Thermal desorber connected with sorption microtrap; Rinsing gas: argon 20 m^3min^{-1};
Microtrap	Sorbent: 80 mg Tenax TA/30 mg Carbosieve III; Desorption temperature: 250°C during 90 s.
Carrier gas	Helium: 100 kPa, ~2 cm^3min^{-1}.
Temperature setting	40°C during 2 min, 7°C min^{-1} to 200°C, 10°C min^{-1} to 230°C, 230°C during 20 min

Compound identification: Compounds were identified by comparing the obtained mass spectra with the spectra stored at the NIST 98 library and then confirmed by collating mass spectra and retention times of the identified compounds with the spectra and retention times of appropriate standards.

Quantitative analysis: The quantitative analysis of volatile organic compounds emitted from the examined surfaces was carried out using the method of addition of 4-bromofluorobenzene standard which was applied in the amount of 50 ng onto the tube with the sorbent.

RESULTS AND DISCUSSION

The obtained results are collated in Tables 3 and 4.

Table 3. Concentration of VOCs from melamine films

Compounds	CAS[a] number	Chamber air concentration [µg/m^3]		
		L1	L2	L3
Acetone	67-64-1	5.8	3.9	ND[b]
1-butanol	71-36-3	31.4	58.8	105.0
Toluene	108-88-3	13.4	10.8	8.6
Ethylene glycol	107-21-1	10.3	15.8	28.8
Hexanal	66-25-1	7.6	4.6	ND[b]
α-pinene	80-86-8	8.6	58.8	ND[b]
3-carene	13466-78-9	5.3	ND[b]	ND[b]
Others		32.2	30.0	29.3
TVOC		**115**	**183**	**172**

[a] - Chemical Abstract Service; na[b]- not detectable; TVOC – sum of all VOCs

Table 4. Concentration of VOCs from finish foils

Compounds	CAS[a] number	Chamber air concentration [µg/m^3]		
		F1	F2	F3
Toluene	108-88-3	10.3	8.2	10.1
Ethylene glycol	107-21-1	72.2	27.2	59.3
α-pinene	80-86-8	11.0	10.8	10.2
3-carene	13466-78-9	7.7	7.1	5.5
others		14.6	6.8	12.9
TVOC		**116**	**60**	**98**

[a] - Chemical Abstract Service; TVOC – sum of all VOCs

The performed quantitative analysis revealed that the total emission of VOCs from the tested melamine films was determined at a higher level than from finish foils. Melamine films were found to release into the air from 115 to 183 µg/m^3 of organic compounds, while finish foils – from 60 to 116 µg/m^3.

On the basis of qualitative analyses, it was found that the examined melamine films released into the ambient air compounds belonging to ketones, alcohols, glycols, aromatic hydrocarbons and terpenes, whereas emissions from finish foils were made up of a smaller spectrum of compounds. Finish foils released mainly compounds belonging to glycols, aromatic hydrocarbons and terpenes. 1-butanol was the compound that was released in the highest quantities by melamine films. Its concentrations ranged from 31.4 to 105.0 µg/m^3. Moreover, the examined films also liberated significant quantities of ethylene glycol whose quantities fluctuated from 10.3 to 28.8 µg/m^3. Ethylene glycol was also a characteristic constituent of emissions released by finish foils. They were found to liberate higher than the examined melamine films quantities of this compound fluctuating between 27.2 and 72.2 µg/m^3.

The examined materials emitted terpenes, mainly α-pinene and 3-carene. Terpene emissions are characteristic for materials manufactured on the basis of different wood species (Sundin *et al.* 1992; Risholm-Sundman *et al.* 1998; Baumann *et al.* 1999). Similar compounds from finish foil were identified by Gaca and Dziewanowska-Pudliszak (2005).

CONCLUSION

1. Investigations of VOC emissions from decorative materials, i.e. melamine films and finish foils demonstrated differences both with respect to the quality and quantity of compounds released by them.
2. The examined finishing materials were characterised by a relatively low level of VOC emissions. Melamine films released slightly more volatile compounds (115 to 183 µg/m^3) than the tested foils (60 to 116 µg/m^3).
3. Melamine films released into the ambient air a wider spectrum of organic compounds in comparison with finish foils.
4. The performed qualitative analysis revealed that the dominant constituent of emissions released by melamine films was 1-butanol, while in the case of finish foils – ethylene glycol. The concentration of 1-butanol in the air collected from the chamber fluctuated at the level of 31.4 to 105.0 µg/m^3 and constituted from 31 to 61% of all emissions. The concentration of ethylene glycol released from the finish foils in largest quantities and constituted 27.2 to 72.2 µg/m^3 making up 45 to 62% of all compounds.

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Streszczenie: *Emisja VOC z filmów melaminowych oraz folii finish***.** W pracy przedstawiono wyniki badań emisji VOC z filmów melaminowych oraz folii finish, materiałów stosowanych do uszlachetniania powierzchni tworzyw drzewnych. Adsorpcję związków przeprowadzono na sorbencie stałym Tenax TA. Lotne związki organiczne analizowano za pomocą chromatografii gazowej sprzężonej z spektrometrią masową oraz termiczną desorpcją GC/MS/TD. W oparciu o uzyskane rezultaty stwierdzono, że badane materiały uszlachetniające charakteryzowały się stosunkowo niskim poziomem szkodliwych emisji.

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