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Emission of formaldehyde from cured UF resin with filler activated in electromagnetic fields

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Abstract: *Emission of formaldehyde from cured UF resin with filler activated in electromagnetic fields.* The paper presents the effect of treated clinoptilolite filler in the electromagnetic field of ultra-high frequency (EMF microwave) resp. weak pulsed magnetic field (PMF) used in urea-formaldehyde resins (UF) for lowering of formaldehyde. The reduction of the formaldehyde content in the cured UF resin was 15-17 % and the reduction of the emission of free formaldehyde from the cured adhesive composition in plywood was 15-19 %. The effect of microwave EMF is 1.5 times higher than the pre-activation of the filler in the PMF.

Keywords: urea-formaldehyde resin, modification, clinoptilolite filler, pulsed magnetic field.

INTRODUCTION

One of the key steps in the production of wood glued materials is providing of the binder based on UF (***Belchinskaya 2012a, Report. NTIS Accession 1999, Wolcott et al., Report, CARB Contract 1996***). These resins (***Dunky 2004, Mamiński et al. 2006, Freeman et al. 2000 , Troughton 1967***) are widely used due to their low cost and high reactivity, and also for the high quality of finished product. A significant disadvantage of UF is their toxicity, caused by releasing of free formaldehyde from resins and adhesives during the production process, and from the finished products. According to the World Health Organization result of exceeding the limit of formaldehyde in the air is the increase of diseases of the population, lowered of immunity, mutagenic and embryological action. Observance of state standards Formaldehyde Emissions provides improved quality of life.

One of the most effective ways to reduce the emission of free formaldehyde from the UF and products based on them is adsorption. Previously, (***Belchinskaya 2012a, Belchinskaya 2012b, Anisimov 2013, Anisimov et al. 2014***) we have established the ability to use natural nano porous aluminosilicate clinoptilolite as a sorbent of formaldehyde.

Clinoptilolite has a three-dimensional alumino siliceo oxygen framework forming system of cavities (polyhedra) and channels (the sizes from 0.395 to 1.1 nm), the exchangeable cations of alkali and alkaline earth metals, and water molecules are located inside. As previously stated during dehydration, the adsorptive properties of clinoptilolite are amplified (***Belchinskaya 2012a***).

As a binder, there was used urea resin KF-N66F and KRONORESS SB1100 (Russian and Slovak production). Both resins are low toxicity with formaldehyde content of 0.15 % and 0.20 %, respectively. However, while working with these resins allowable values of 0,124 mg/m^3 were not exceeded.

Filler of the adhesive composition is a natural mineral clinoptilolite of Slovak origin, (content of clinoptilolite is 95 % and a particle size is 20 microns), which partially replaced

traditional fillers (kaolin and wood flour).

The aim of this work is reduction of the emission of formaldehyde from of the UF adhesive bonded composites as plywood with active filler for lowering of gas pollution in industrial and residential premises.

METHODS

The sorption capacity of clinoptilolite in the native form is not sufficient for ensure the necessary level (***Belchinskaya 2012a***) to reduce the concentration of formaldehyde. To improve it, pre-adsorption activation of sorbent in the electromagnetic field of ultrahigh frequency (EMF microwave) and weak pulsed magnetic field (SIMP) were used. The ability of activation of aluminum silicate in PMF first established contact in 1986 (***Krasnoboyarova et al. 1986***), the optimal treatments of zeolite are regimens according to the literature (***Dunky 2004, Mamiński et al. 2006, Freeman et al. 2000 , Troughton 1967***).

Activation of natural clinoptilolite sample in PMF was carried out in the equipment, the main part of which is the solenoid, allowing to change the value of the magnetic induction. The sample of natural sorbent state mass needed for research was placed in an open glass container with volume of 10 ml and installed inside the solenoid, then determined activation mode. For the treatment of the zeolite in microwave EMF was applied plant using heating effect of water-based materials with using electromagnetic waves of ultrahigh frequency (2450 MHz), the maximum rated power of 1000 W. For activation used the same weight of sorbent, which is activated in the PMF.

Eight adhesive compositions were prepared according to the formulations presented in Table 1.

Tab. 1 Formulations of used adhesive compositions

№ of sample	**Resin**	**Hardener**	**Filler 1**	**Filler 2**
Sample 1	KRONORES CB 1100 (100)	Ammonium nitrate (4)	Wood flour (10)	-
Sample 2	KRONORES CB 1100 (100)	Ammonium nitrate (4)	Wood flour (7,8)	Natural clinoptilolite (2,2)
Sample 3	KRONORES CB 1100 (100)	Ammonium nitrate (4)	Wood flour (7,8)	clinoptilolite, activated in microwave EMF (2,2)
Sample 4	KRONORES CB 1100 (100)	Ammonium nitrate (4)	Wood flour (7,8)	clinoptilolite, activated in PMF (2,2)
Sample 5	Resin KF-N66F (100)	Ammonium nitrate (3)	Kaolin (10)	-
Sample 6	Resin KF-N66F (100)	Ammonium nitrate (3)	Kaolin (7,8)	Natural clinoptilolite (2,2)
Sample 7	Resin KF-N66F (100)	Ammonium nitrate (3)	Kaolin (7,8)	clinoptilolite, activated in microwave EMF (2,2)
Sample 8	Resin KF-N66F (100)	Ammonium nitrate (3)	Kaolin (7,8)	clinoptilolite, activated in PMF (2,2)

RESULTS

According to the presented methods the samples of adhesive compositions was tested on free formaldehyde content after addition of sorbents fillers, and the level of free formaldehyde emission from cured adhesives. Twenty-eight measurements were carried out to obtain a single value, results of which were processed by statistical methods. The error of the results does not exceed 3 %. Figure 1 shows the effect of sorbent-fillers on the amount of free formaldehyde (c, %) in the cured adhesive. Figure 2 shows the effect of sorbent-fillers on the amount of free formaldehyde emission (ŋ, mg/m^3) from the cured adhesive wood composite.

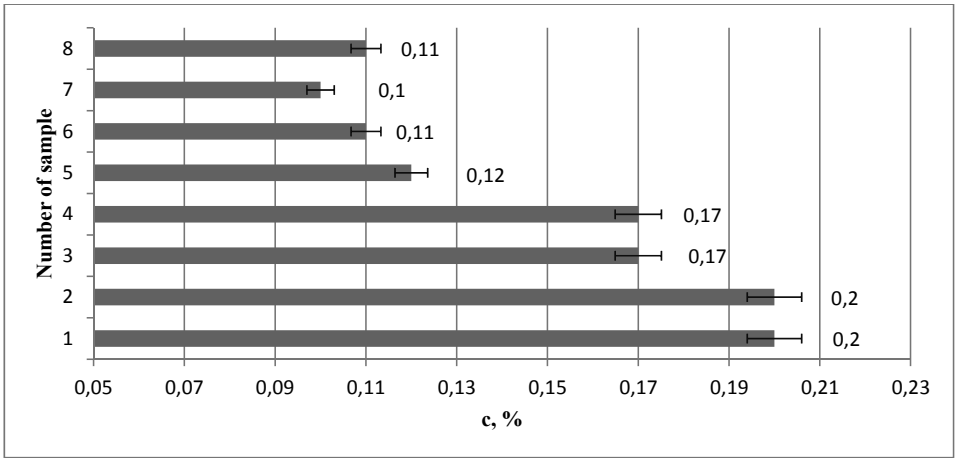

Fig. 1 Effect of sorbents on amount of formaldehyde (c, %) in the cured adhesive

Effect of activation of clinoptilolite in microwave EMFs and PMF is practically identical for the resin KRONORESS, reduction of formaldehyde is 15 % in the cured adhesive. In processing of fillers by studied kinds of electromagnetic fields the concentration in the adhesive, resin KF-N66F decreases to the same extent (15-17 %).

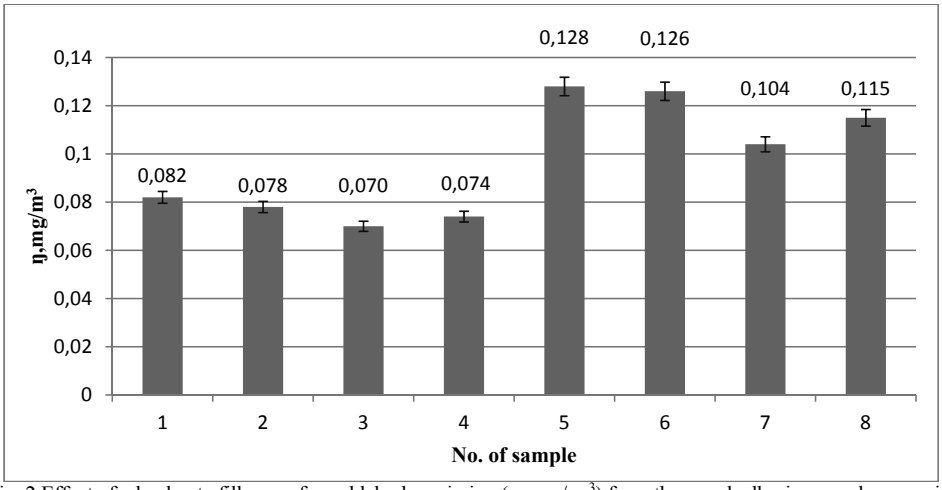

Fig. 2 Effect of adsorbents-fillers on formaldehyde emission (ŋ, mg / m^3) from the cured adhesive wood composite

According to obtained data, addition of clinoptilolite activated in microwave EMF, provides decrease of the emission of free formaldehyde from the cured adhesive composite with Slovak resin to 15 %. For resins KF-N66F processing of clinoptilolite in microwave EMF reduces free formaldehyde emissions by 19 %.

Processing of the zeolite in PMF reduces emission of free formaldehyde from the cured adhesive resin composition KRONORESS CB 1100 10 %, and using resin KF-N66F 11%.

CONCLUSIONS

1. Activation of fillers of the adhesive compositions in microwave EMF and PMF allows about 15 % reduction of formaldehyde content in the resin KRONORES SB1100 and 17 % in the resin KF-N66F.
2. The emission of formaldehyde from the glued wood composite with activated filler in electromagnetic fields is reduced to a greater degree by treatment in a microwave EMF (19 %). PMF processing is less efficient and estimated reduction in formaldehyde emissions by 10-15 %.
3. The effect of electromagnetic treatment is more significant on the amount of formaldehyde in the cured glue and emission from the cured adhesive composite for the binder resin KF-N66F.

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Streszczenie: *Emisja formaldehydu z utwardzonej żywicy mocznikowo-formaldehydowej aktywowanej w polu elektromagnetycznym.* W pracy przedstawiono efekt wpływu pola elektromagnetycznego o wysokiej częstotliwości na emisję formaldehydu z żywicy mocznikowo-formaldehydowej (UF). Metoda utwardzania żywicy w polu elektromagnetycznym o wysokich częstotliwościach jest alternatywą dla utwardzania w słabym, pulsacyjnym polu. Uzyskano redukcję emisji formaldehydu z utwardzonej żywicy UF o 15-17% oraz redukcję emisji ze sklejki o 15-19%.

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