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Properties of High Density Fiberboard Mixed with Poplar Bark

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Abstract

Formaldehyde in the indoor air is one of the chemicals which can cause health risk; therefore, researchers have strived to reduce formaldehyde emissions from different wood products. There are many chemical compounds in bark, including tannins, which can react with formaldehyde. The aim of this study was to reduce the formaldehyde emissions from HDF by mixing poplar bark powder into the raw material. 2, 4, 6, and 8 % (based on dry weight) *Populus*×*euramericana* bark was mixed with fibers, and HDF panels were manufactured with urea-formaldehyde resin. Mechanical properties, color change, and formaldehyde release were measured. Contrary to expectations, the mixed bark did not reduce formaldehyde emissions, but the mechanical properties deteriorated due to the bark powder. Formaldehyde emissions were reduced only in the case of 2 % added bark; in cases of 4, 6, and 8 %, the emissions increased.

Keywords: Formaldehyde emissions, Poplar bark, HDF

Introduction

Formaldehyde has been found to be a source of indoor air pollution, and over 500 other VOC has been detected over the last decades [1,2]. The binding of formaldehyde has been attempted using many different methods, and bark absorbing ability has also been also tested [2-13]. Bark components are very similar to wood components, but several other types of materials can be observed in bark in different proportions, such as waxes, terpenes, flavonoids, alkaloids, suberin, condensed tannins, etc. [14-19]. It is believed that tannins and condensed tannins in bark can react with formaldehyde [20-22]. The (+)-catechin is usually used as a model compound to study the reaction of condensed tannins with formaldehyde [23-28]. It was found that, during the reaction of formaldehyde and (+)-cathecin, methylolation and condensation can occur and, after it, polymerization can also take place [10].

In the study of Boran *et al*. [29], the effects of the tannin content of urea formaldehyde (UF) resin on the panel properties of medium-density fiberboard was examined. It was found that the amount of formaldehyde emitted from the MDF panels decreased when the ratio of tannin content in the UF resin increased. The values of the mechanical properties were lower, compared to the control MDF panels.

The properties of wood panels are influenced by a number of factors: the species [30,31], the type of raw material, the size and geometry of the particles [32,33], their orientation, moisture content, glue [34-36], etc. The rate of dust in boards affects the mechanical properties of them. As the rate of sawdust or powder increases, the mechanical properties become less favorable [35].

The overall objective of this research was to study whether mixing bark powder into the HDF raw material can affect the mechanical properties, the color, and whether it would influence a reduction in formaldehyde emission during the manufacture of the HDF boards. Since powder has a negative effect on wood panel properties, relatively small quantities were mixed in the raw material: powder contents of 2, 4, 6, and 8 % were used in the dry raw material.

Materials and methods

14.5 % of the harvested trees in Hungary are hybrid poplars [37], and the importance of poplar plantations is expected to increase, thus increasing the amount of the harvested wood, as well as the available bark. The most widespread clone in Hungary is the *Populus*×*euramericana*; this study examined the bark of this clone. Bark was collected from the local sawmill in Sopron (Hungary), peeling it from timber to be cut in wet conditions, and was dried to around 15 %. The dried bark was ground in a hammer grinder, then dried further to a moisture content of 6 %.

The fibers for the experiment originated from HDF Company (Kronospan MOFA) and were made of beech (*Fagus sylvatica*) 50 % m/m, softwood (*Picea abies*) 20 % m/m, and poplar (*Populus* sp.) 30 % m/m.

300×300×4 mm^3 panels were produced with 4 % adhesive - urea formaldehyde - with the targeted density of 800 kg/m^3 using a laboratory hot press (Siempelkamp); 0, 2, 4, 6, and 8 % (on dry mass base) bark powder were added and mixed with the fibers. Three panels from each type were made.

The pressing time was 18 s per thickness millimeter, a total of 72 s; the press temperature was 180 °C; and the maximum pressure was 5.15 MPa, which was reduced after 24 s to 3.43 MPa and, after, an additional 24 s to 1.72 MPa, to release steam pressure inside the panel.

Physical and mechanical properties of the boards were investigated. The bulk density (ρ) of the boards had been calculated from ten samples of the panels. The bending strength and modulus of elasticity (MOR, MOE) (EN 310) were tested by using a universal testing machine, Instron 5506. The specimens were prepared from different areas of the board and cut according to EN 326-1 (1994) European standards.

Color of specimens was measured using a color analyzer (X-rite 500 series). Three color parameters, L*, a*, b*, were used to identify the colors of the specimens. L* represents lightness, a* represents redness-greenness (+ or –a*), and b* (+ or –b*) represents yellowness-blueness.

The formaldehyde emissions from the HDF samples were determined by the gas analysis method described by standard MSZ EN ISO 12460-3:2016. The samples were cut and the edges were sealed immediately with self-adhesive aluminum tape. The prepared samples with known surface area were placed in the test chamber where 60 °C cleaned and dry air with controlled airflow was introduced. The air from the chamber containing the released formaldehyde was continually (for 4 h) passed through wash bottles filled with distilled water, which absorbed the formaldehyde. The formaldehyde release was determined by the Hantzsch method, where acetyl acetone and ammonium acetate reacts with formaldehyde and forms diacetyldihydrolutidine. The concentration was determined photometrically and calculated based on a calibration curve prepared previously with formaldehyde solutions. The gas analysis value was expressed in mg CH_2O/m^2h. Formaldehyde (37 %), acetyl acetone, and ammonium acetate used for the formaldehyde release determination were supplied by Molar Chemicals Hungary Ltd.

Results and discussion

Figure 1 shows the surface texture of the produced HDF mixed with poplar bark of various content. The control is also presented for comparison. It was found that the bark had a slightly effect on the color of the finished board, especially at a relatively high bark content. More redness appeared in HDF with bark content of 6 and 8 %, as can be seen from a* value (**Figure 2**).

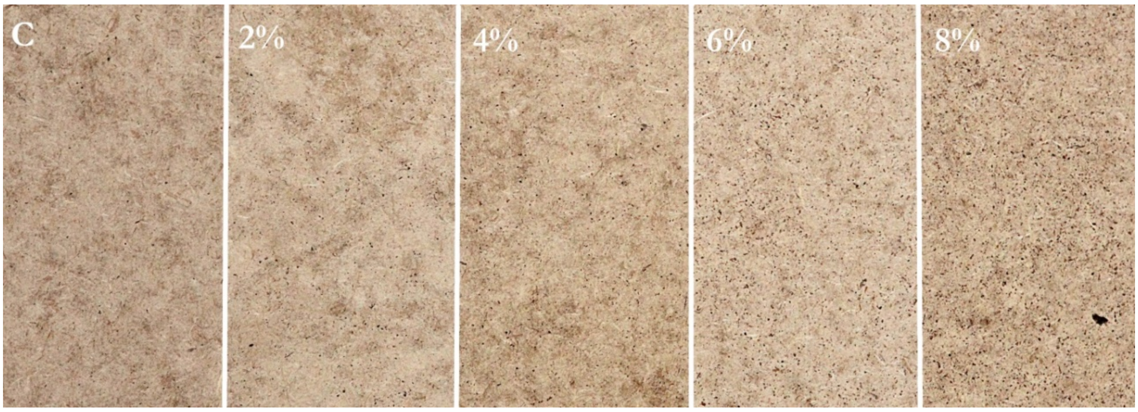


Figure 1 HDF samples with different amounts of poplar bark powder.

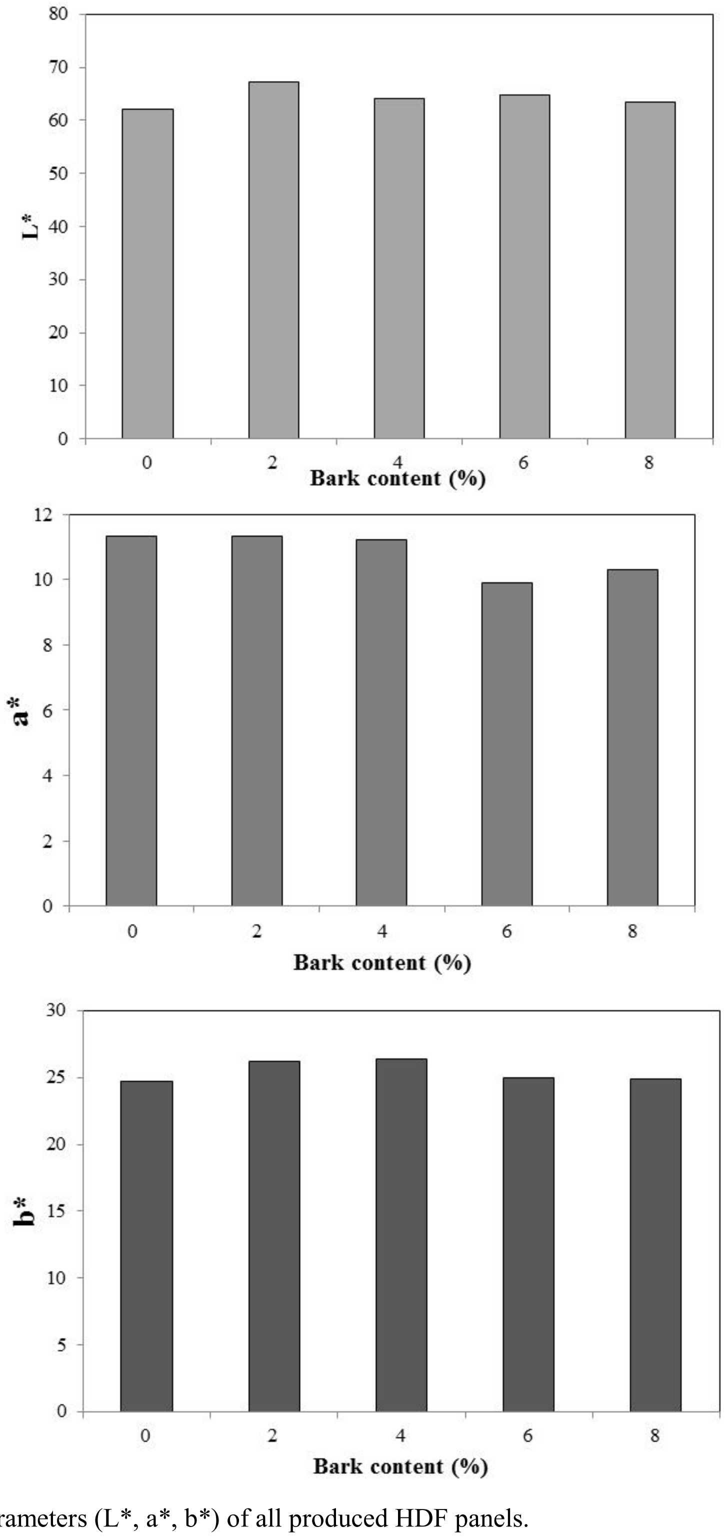
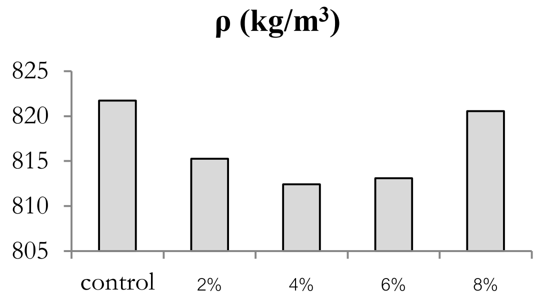


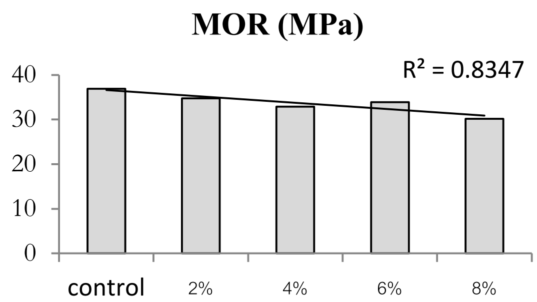
Figure 2 Color parameters (L*, a*, b*) of all produced HDF panels.

Table 1 Physical and mechanical properties of the measured HDFs.

	ρ (kg/m^3)	MOR (Mpa)	MOE (Mpa)	Formaldehyde emission (mg/m^2h)
Control	821.74	36.91	8396.86	0.3618
2 %	815.25	34.76	7754.66	0.3048
4 %	812.43	32.86	7122.33	0.3780
6 %	813.10	33.90	7368.21	0.3874
8 %	820.56	30.17	6842.55	0.4008

All of the pressed fiber boards reached the target density. The mechanical properties of the HDF boards deteriorated due to the bark particles. As the amount of the bark increased, the bending strength (MOR) and modulus of elasticity (MOE) decreased further, which can be explained by the lower bark mechanical properties (**Figure 3**, **Table 1**). Their correlation was linear with R^2 values of approximately 0.83. Opposed to this, Ružiak *et al*. [39] found that the mechanical properties of plywood with bark particle content in the adhesive had greater MOE and MOR values, although these values decreased with increasing bark content.





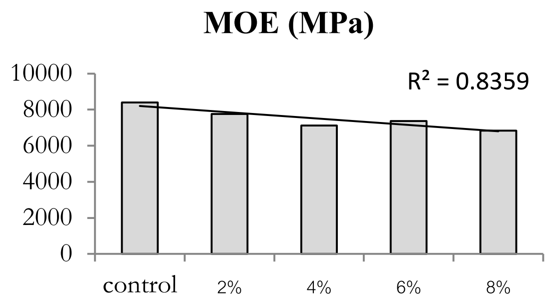


Figure 3 Density, MOR, MOE, and IB of HDF boards with different quantities of bark powder.

Contrary to expectations, the bark particles mixed with the raw material did not reduce formaldehyde emissions from the boards. For the 2 % bark fiber board, a slightly lower emission value was found, compared to the control, but all of the other boards showed similar or slightly higher formaldehyde emissions than the control boards (**Figure 4**, **Table 1**).

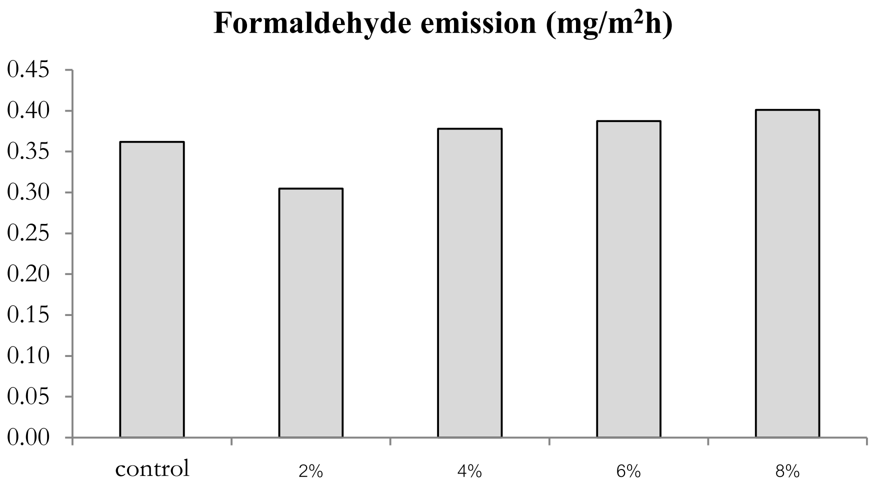


Figure 4 Formaldehyde emissions of HDF boards with different quantities of bark dust.

The results of formaldehyde emission did not show any clear relationship to the amount of mixed bark. Ružiak *et al*. [38] also could not find a clear correlation between beech bark amount mixed with the adhesive of plywood and formaldehyde emission.

Conclusions

(1) It is possible to manufacture HDF panels with poplar bark content.
(2) The mechanical properties, namely MOR and MOE, of the HDF panels linearly decrease with increasing bark particle content.
(3) The rate of decrease can be negligible at the amount of 2 % bark powder, so the HDF boards correspond to the levels recorded in the standard.
(4) Poplar bark powder mixed with the raw material did not reduce formaldehyde emissions from the boards.

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