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A Modified Glue for Producing Particle Boards and Boards Based on Waste of Annual Plants

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Abstract—This paper proposes a water-soluble phenol–formaldehyde resin modified by an alkyd oligomer for reducing the surface tension of an adhesive composition and improving its distribution over wood particles or particles of annual plants during the production of compressed board materials for construction purposes. It was found that the physical and mechanical characteristics of boards increase when produced with the use of the modified glue obtained with a small change in its production technology.

Keywords: phenol–formaldehyde resin, modification, alkyd oligomer, bonding, physical and mechanical properties

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Currently, the production of wood board materials is developing at a high rate, which is associated with annually increasing needs for high-quality structural boards in the construction, furniture industry, automotive industry, carriage engineering, and in other areas both in Russia and abroad [1]. Particle boards produced in accordance with *GOST* (State Standard) meet the requirements of consumers in terms of their basic physical and mechanical characteristics, but the problems of increasing the strength and water resistance of wood board products remain relevant.

There are various ways to increase the strength and water resistance of wood-based panels, which consist in regulating the properties of wood raw materials and adhesives used for gluing, where properties of the used binder have the greatest effect on the performance characteristics [2–4].

Traditionally, particle boards and boards based on discrete waste of annual plants are produced using urea-formaldehyde resins and are widely used in most applications. For boards operated under conditions of increased loads, as well as with variable temperature and humidity, the use of phenol–formaldehyde resins is effective. Glue based on SFZh-3014 resol phenol–formaldehyde resin is the most suitable for technological conditions of board production [5]. However, the water-soluble phenol–formaldehyde resin has a large surface tension (60–70 mN/m), therefore, it is unevenly distributed over the surface of wood particles and over the surface of particles of annual plants, for example, flax hurds that have a smaller surface tension (40–50 mN/m depending on the tree species and the plant filler type). The physical and mechanical properties of particle boards and boards based on the waste of annual plants, made using phenol–formaldehyde resins, are insufficient due to the limited flowability of the binder and its uneven distribution over the surface of filler particles [6].

Board production can effectively employ alcohol-soluble phenol–formaldehyde resins (phenol–alcohols) with the distillation of the water-alcohol fraction [7], which have a lower surface tension and are more evenly distributed over the surface of wood particles during the resinification and allow producing particle boards with higher physical and mechanical characteristics. However, these resins are characterized by increased toxicity of both the production itself and the finished boards made with their use, since the emission of volatile toxic substances from the adhesive composition is very significant. In addition, the pressing of wood boards using these adhesives is associated with technological difficulties, for example, with the need to predry the resinous materials to increase the viscosity and the adhesive ability. Phenol alcohols are more expensive than water-soluble phenol–formaldehyde resins, and their dissolution requires an appropriate solvent, alcohol.

There is a known adhesive composition for the production of boards based on discrete waste of annual plants using a phenol–formaldehyde resin with a modifying additive based on butanol-1, which has a reduced surface tension [8]. However, its use is associated with both toxicity and fire hazard of the technological process, since butanol-1 is highly flammable.

By introducing into adhesive compositions based on synthetic resins various modifiers [9, 10], including

Table 1. Characteristics of adhesive compositions based on SFZh-3014 phenol–formaldehyde resin modified with Resydrol VAL5547W alkyd oligomer

Amount of Resydrol VAL5547W alkyd oligomer, wt pts	Surface tension, mN/m	Surface wetting angle	
		birch wood particles	flax hurds
0	66.0	61°36′	72°12′
0.5	52.2	37°24′	48°24′
1.0	48.1	15°12′	21°36′
1.5	45.3	8°0′	11°24′
2.0	42.1	0°	8°12′
2.5	40.4	0°	0°
3.0	39.1	0°	0°

modifiers in the form of high-molecular compounds used in the paint industry as plasticizers and film-forming agents [11], adhesion properties of glues can be improved. As part of this work, in the composition of the glue based on the water-soluble resol phenol–formaldehyde resin SFZh-3014, as a modifying additive we used Resydrol VAL5547W alkyd oligomer, which is a maleinization product of linseed and dehydrated castor oil copolymer modified with rosin.

It was experimentally found that the interaction of phenol–formaldehyde resin with the Resydrol alkyd oligomer is manifested in a decrease in the surface tension of the adhesive composition and makes it possible to improve technological properties of the adhesive composition in terms of increasing the adhesiveness and the formation of adhesive joints with increased strength [12].

The relationship of thermodynamic characteristics of the phenol–formaldehyde resin SFZh-3014, depending on the proportion of the modifier, Resydrol VAL5547W alkyd oligomer, is presented in Table 1. With the introduction of Resydrol VAL5547W alkyd oligomer into the adhesive composition based on the phenol–formaldehyde resin, the wetting angle is significantly reduced. Full uniform wetting of the surface of wood particles is provided by introducing 2 wt pts and more of Resydrol VAL5547W alkyd oligomer into the composition of the glue based on the phenol–formaldehyde resin. Full uniform wetting of the surface of the particles based on the waste of annual plants (in this work, based on the flax hurds) occurs with the introduction of 2.5 wt pts or more of Resydrol VAL5547W alkyd oligomer into the composition of the glue based on the phenol–formaldehyde resin.

To assess the influence of the properties of the adhesive composition based on the phenol–formaldehyde resin with the addition of Resydrol VAL5547W alkyd oligomer on the physical and mechanical properties of wood board materials, a series of test pressings was carried out.

In the experimental studies, the glue was prepared in the following sequence. Glue components (phenol–formaldehyde resin solution and Resydrol VAL5547W alkyd oligomer) were successively loaded into a mixer to form a uniform adhesive composition in the form of an emulsion. From the mixer, the prepared binder was fed into the mixer to tar the corresponding filler.

Tables 2 and 3 show the comparative physical and mechanical characteristics of particle boards and boards based on the waste of annual plants (based on flax hurds) made using the modified glue. Sixteen-millimeter-thick boards made from birch chips and flax hurds (fractional size 10/2, density 750 kg/m^3) were pressed, and the binder consumption was 12% relative to the mass of absolutely dry filler. During the pressing operation, the temperature of the press plates was 180°C, the specific pressing pressure was 2 MPa, and the holding time under pressure was 8 min.

Analysis of the experimental data showed that with the introduction of 1–3 wt pts of the modifying additive in the form of Resydrol VAL5547W alkyd oligomer into the adhesive composition based on the SFZh-3014 phenol–formaldehyde resin, the physical and mechanical characteristics of particle boards, as well as boards based on the waste of annual plants, for example, based on flax hurds, significantly increase.

Table 2. Properties of particle boards based on modified phenol–formaldehyde resin

Proportion of modifying additive*, wt pts	Bending strength, MPa	Perpendicular tensile strength, MPa	Thickness swelling, %	Water absorption, %
0	18.1	0.62	29.3	59.3
0.5	21.5	0.66	24.1	49.1
1.0	24.3	0.69	20.2	46.0
1.5	24.8	0.71	16.5	44.5
2.0	22.2	0.68	19.7	49.1
2.5	21.0	0.63	20.1	52.3
3.0	19.3	0.60	22.2	55.4

* The modifier is Resydrol VAL5547W alkyd oligomer.

Table 3. The properties of hurd boards based on modified phenol–formaldehyde resin

Proportion of modifying additives*, wt pts	Bending strength, MPa	Perpendicular tensile strength, MPa	Thickness swelling, %	Water absorption, %
0	13.2	0.26	32.1	69.1
0.5	16.5	0.38	28.2	54.6
1.0	18.3	0.43	24.5	52.3
1.5	19.4	0.48	22.1	50.1
2.0	20.4	0.49	19.3	48.1
2.5	21.2	0.49	20.1	45.3
3.0	18.1	0.38	24.6	51.2

* The modifier is Resydrol VAL5547W alkyd oligomer.

The considered method for modifying the phenol–formaldehyde resin reduces the surface tension of the adhesive composition and improves the uniformity of the glue distribution over wood particles in the manufacture of particle boards or over particles of the waste from annual plants, such as chopped straw of cereal plants, hemp hurds, sunflower husks, and rice husks, and to improve the performance characteristics of these boards with a slight change in the technology of production of the adhesive composition.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

1. A. P. Shalashov, "The state and prospects of development of the market of wood-based panels in Russia," in *The State and Prospects of Development of the Production of Wood-Based Panels: Proc. 21st International Scientific and Practical Conference* (VNIIDREV, Balabanovo, 2018) [in Russian].
2. A. A. Leonovich, *The Technology of Wood-Based Panels. Progressive Solutions* (KhIMIZDAT, St. Petersburg, 2005) [in Russian].
3. A. P. Petrova and G. V. Malysheva, *Glues, Adhesive Binders, and Adhesive Prepregs* (Vseross. Inst. Aviats. Mater., Moscow, 2017) [in Russian].
4. V. A. Zorin, N. I. Baurova, and A. M. Shakurova, "Investigation of the structure of an encapsulated anaerobic adhesive," Polym. Sci., Ser. D **4** (7), 303–305 (2014).
5. V. P. Kondrat'ev and V. I. Kondrashchenko, *Synthetic Adhesives for Wood Materials* (Nauchnyi Mir, Moscow, 2004) [in Russian].
6. N. I. Baurova, V. A. Zorin, and V. M. Prikhodko, "Description of the process of degradation of material properties using the apparatus of catastrophe theory," Polym. Sci., Ser. D **8** (2), 92–95 (2015).
7. A. A. Vandshteit and A. A. Vasil'ev, USSR Inventor's Certificate No. 65474 (1945).
8. S. A. Ugryumov and V. E. Tsvetkov, RF Patent No. 2377271 (2009).
9. A. M. Ivanov, D. S. Rusakov, G. S. Barankina, and A. N. Chubinskii, "Modification of phenol-formaldehyde resins by aluminosilicates for gluing plywood," Klei, Germetiki, Tekhnol., No. 3, 13–17 (2017).
10. G. S. Varankina, A. N. Chubinskii, and K. G. Brutyan, "Modified carbamide-formaldehyde and phenol-formaldehyde glues for chipboard and plywood," Klei, Germetiki, Tekhnol., No. 6, 12–14 (2017).
11. V. N. Volynskii, *The Technology of Wood-Based Panels and Composite Materials* (Lan', St. Petersburg, 2010) [in Russian].
12. S. A. Ugryumov, A. V. Sviridov, and A. A. Fedotov, "Technological and thermodynamic properties of the modified phenol-formaldehyde oligomer used in the production of plywood," Klei, Germetiki, Tekhnol., No. 11, 30–33 (2017).

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