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Physical and Mechanical Properties of Chipboards using a Modified Binder

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ABSTRACT: The article deals with some issues of creating new modified polymer binders for wood-based panel materials. Local raw material resources are used as modifier. The optimum quantities of modifier introduced and its influence on physical and mechanical properties of plates have been revealed.In addition, the release of toxic free formaldehyde from the plates has been determined. As a result of the research, the optimum amount of modifier was determined, where high physical and mechanical properties of the product are achieved and the modifier-free formaldehyde dependence was identified. The obtained wood boards fully meet the requirements of the standard for plates.

KEYWORDS: urea-formaldehyde binder, a modifier, particle Board, water absorption, swelling, tensile strength at break perpendicular to the surface, the tensile strength in bending,wood chips.

I.INTRODUCTION

The following work was carried out to obtain the chipboards: Preparation of gossypol resin by dissolving it in white spirit in an I:I ratio. The wood was chopped to a length of 2-3 cm and a width of 0.2-0.4 cm. The accepted dimension of the chips was determined from previous works. The total amount of binder was 10 % of the absolutely dry chips. The binder modification was carried out at a temperature of

60 °C for 3 hours. Binder concentration was 64%. Pressing temperature - 160 °C, pressing time - 0.30 mm/min, thickness of board - 16 mm, pressure - 2.5 MPa.

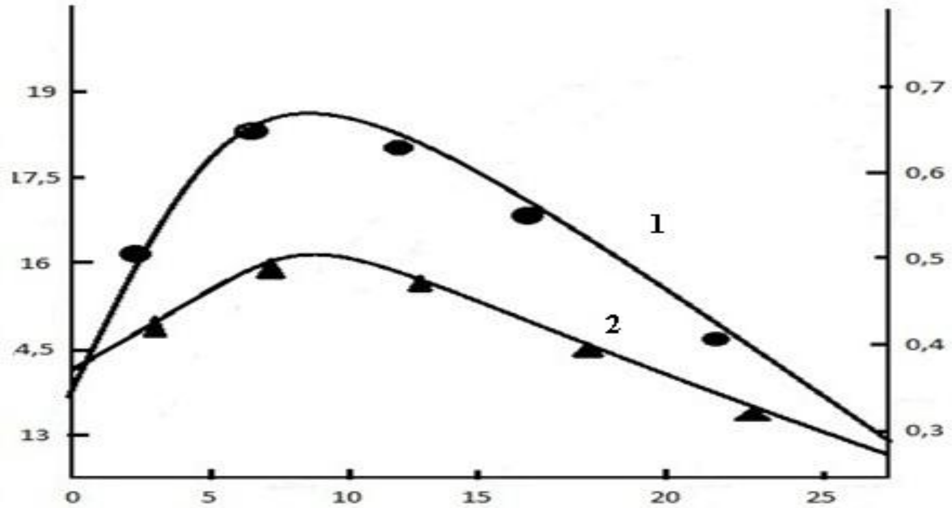

Figure 1. Dependence of static bending strength (1) and static bending strength (2) on gossypol resin content in the binder.

A study of the effect of gossypol resin on the physic-chemical properties of urea-formaldehyde binder showed that the modifier has a positive effect on the polymer properties, increasing hydrophobicity, thermal resistance, adhesion ability, etc. Now it was necessary to carry out tests on a specific product, where different data can be obtained,

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even if they do not coincide with the polymer's properties. The effect of the modifier content in the binder on the physical and mechanical properties of the boards was investigated, i.e. the results of experiments with the binder were transferred to the finished product - chipboard.

As the results of experiments have shown (Fig.1,2), the introduction of gossypol resin improves the physical and mechanical properties of the chipboard.

Gossypol resin was injected in an amount of 0.5; 10; 15; 20; 30 of the dry resin residue to determine the optimum resin content.

As can be seen from figure 1, a study of the effect of the amount of modifier in the binder on the static bending and perpendicular fracture strength showed that, compared to the unmodified composition, the bending strength of samples with gossypol resin increased from 13.3 MPa with 10 % modifier to

18,8 (±0,5) MPa. Further increase of gossypol resin content leads to decrease of the investigated index. It is known that flexural strength depends mainly on the bonding strength of chip particles, therefore, we can talk about the positive impact of modification on the properties of the resin, which leads to a more active interaction of functional groups of the binder and filler.

A similar pattern is observed when specimens are tested perpendicular to the strata. The boards based on the modified binder have a high performance. With 10-15 % polymer modification the fracture strength of the strata increased by 40-45 %. This is due to the increased adhesive capacity of the polymer.

The tensile strength of a board with a modified binder is significantly higher than that of an unmodified board, with the best result of 0.5 MPa, also corresponding to 10% gossypol resin content in the composition. A further increase in the amount of modifier leads to a reduction in tensile strength. The increase in tensile strength of samples based on a modified binder is explained by an increase in the degree of curing of the binder, its interaction with the filler particles and the bonding strength of compounds on the boundary of the adhesive-substrate. The introduction of gossypol resin, which contains 10-12 % nitrogen-containing substances also increases the adhesive capacity, and the carboxylic groups deepen the degree of curing of the resin.

Figure 2 shows the effect of gossypol resin content on water absorption and swelling of the boards.

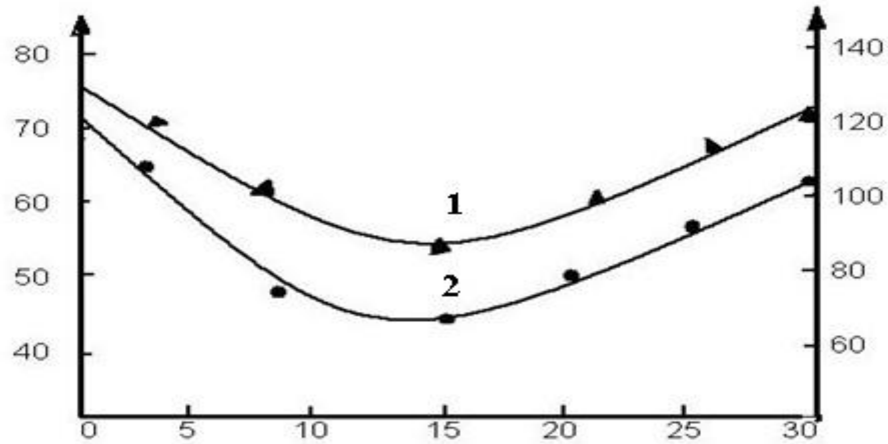

Fig. 2. Swelling (2) and water absorption (1) of chipboards as a function of gossypol resin content in the binder

As can be seen from Fig. 2, water absorption of chipboard based on a binder without a modifier was 135 %, and with the addition of gossypol resin to the binder, it decreased significantly, with the lowest value of water absorption observed at the content of the modifier 10-15 %. At its further increase the water absorption increases, reaching 78 % at 20 % content, at 30 % - 110 %, which is apparently explained by deterioration of the binder properties due to the introduction of a large quantity of solvent - white spirit. However, it should be noted that even the introduction of the maximum amount of gossypol resin (30 %) improved the water absorption of the boards by about 20 % compared with the unmodified composition.

A similar picture can be seen in the swelling of the boards. While the swelling of the control boards was 72% in 24 hours, with the modified binders it was 44%.

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Table 1
Physical and mechanical properties of chipboards.

Binder composition	Density,kg/m3	Flexural strength, MPa	Perpendicular tensile strength of the formation, MPa	Water absorption, %	Swelling, %
Urea-formaldehyde resin - gossypol resin 90:10 85:15	713 705	18,8 15,2	0,50 0,48	78 89	43 44
Urea-formal dehyderesin	697	13,3	0,34	135	72

As can be seen from Table 1, the positive effect of the introduction of gossypol resin is tangible. Particularly noteworthy is the increase in water resistance of the boards, which clearly lagged behind in the quality characteristics of the boards.

Thus, the experimental work done to determine the optimum content of gossypol resin in the composition showed that the introduction of this substance improves all major indicators of the physical and mechanical properties of the chipboard, due to improved properties of the resin, i.e. an increase in its curing, adhesion and hydrophobicity, which was confirmed by experiments with the resin.

The optimum modifier content is 10-15 % of the dry residue of the resin. The water absorption of the boards is reduced to 50 %, swelling to 37 %, the bending strength is increased to 40 % and the tensile strength by 68 % compared to the control or unmodified board.

The highest values are obtained with 10 % gossypol resin from the absolutely dry urea-formaldehyde resin residue grade - KF MT.

At present, sanitary and hygienic requirements impose restrictions on the emission of free formaldehyde from particle boards during operation. The study of the properties of the developed binder has shown that the introduction of gossypol resin into the carbamiformaldehyde binder leads to an increase in formaldehyde binding rate during curing of the binder containing 10% gossypol resin due to the interaction of reactive groups of gossypol resin and free formaldehyde during curing and modification.

Tests of single-layer chipboards made on the basis of a modified urea-formaldehyde binder obtained under different temperature conditions and with different contents of the modifier showed that the modification significantly affects the reduction of pharmaldehyde emissions from this composition, as compared to the control samples (Table 2).

The determination was made using the photocollometric method. Experimental results have shown that formaldehyde release decreases when the modifier is introduced, reaching a minimum at 10% formaldehyde content. The optimum pressing temperature is 170 (±5) °C, where the formaldehyde release reaches a minimum.

Table 2
Influence of the modifier content on the release of free formaldehyde from the chipboard.

Binder composition	Density, kg/m3	Chip moisture, %	Pressing temperature, °C	24 hours 40 °C
Urea-formaldehydegossypolresin				
95:5	717 709 710 690	7,7 7,3 7,5 8,1	150 160 170 20	39,1 32,4 31,1 35,4
90:10	697 730 707 714	7,8 8,4 7,6 7,5	150 160 170 20	31,5 24,5 22,3 23,1
85:15	710 725 72 714	7,1 8,8 8,9 8,0	150 160 170 20	40,7 36,0 34,7 39,1
Check	720	8,4	160	41,1

Further increases in the modifier resulted in a slight decrease in formaldehyde release. This is probably due to the increase in low molecular weight substances, which leads to a more difficult binding of free formaldehyde.

On the basis of the researches it has been established, that replacement of 10 % of urea-formaldehyde resin by gossypol resin leads to reduction of formaldehyde emission by 50-55 %, i.e. possibility of formaldehyde binding at exposure of oligomer and modifier during modification and pressing of cotton stalks cinder boards is confirmed.

Thus, the use of urea-formaldehyde binder modified with gossypol resin makes it possible to produce particleboards with high physical and mechanical properties. The single-layer particleboards using the binder offer good resistance to water and thermal stability. In addition, the boards are fully compliant with hygiene requirements and can be used in furniture production and construction.

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