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MODFIED PHENOL – PHORMALDEHYDE RESINS USED FOR PLAYWOOD GLUING

Miglena Valyova, Yordanka Ivanova

University of Forestry, Faculty of Ecology and Landscape Architecture, Sofia, Bulgaria,
e-mail:mvalyova@abv.bg; yordanka_b_ivanova@abv.bg

ABSTRACT

In this study the influence of tartaric acid, ferric chloride, phthalic anhydride and quebracho extract on the setting time of phenol-formaldehyde resin and the adhesive strength of adhesive-bonded joint was investigated. The test samples used for the experiments were in dry state and previously immersed in boiling water for one hour. The amounts of applied modifiers were 0.5 %; 1.0 %, 1.5 % and 2 % in relation to solid content of the resin. It was found that added compounds exert a positive influence on the setting time of the resin, in addition to improving the binding strength of the produced plywood.

Key words: phenol-formaldehyde resin, modifiers, curing time

1. INTRODUCTION

Production of plywood brought new requirements for synthetic resins: lowering the glue consumption, increasing the strength and water resistance of the adhesive-bonded joint, fast curing, as well as improving hygienic properties of the production (Sedliačik, Bekhta, Potapova, 2010; Conner, Lorenz, Kolby, 2002). Strength and sustainability of plywood to atmospheric influences depend largely on the type and quality of the binder used (Bekhta, Ortynska, Sedliacik, 2014). Phenol-formaldehyde resin is used for manufacture of plywood with high water resistance (Grenier-Loustalot et al, 1996). These resins also possess excellent temperature stability (Cetin, Ozmen, 2002). In order to reduce the pressing time and to provide a good adhesion quality of the resin, modifying compounds are added (Dziurka, Łęcka, Mirski, 2009; Czarnecki, Łęcka, 2003).

Thus the aim of this study was to select modifying substances for phenol-formaldehyde resin with a view to increasing the adhesion strength and water resistance of the plywood. This can be achieved by adding active compounds which may have positive impact on multilateral phenol - formaldehyde resins as an adhesive, as well as on the adhesion strength of the plywood.

2. MATERIAL AND METHODS

The influence of tartaric acid, ferric chloride, phthalic anhydride and quebracho extract on the phenol-formaldehyde resin hardening was investigated. The quantity of the used modifiers was 0.5 %, 1.0 %, 1.5 %, 2.0 %, and only for quebracho extract it was 2.5 % in relation to solid content of the resin. All experiments were carried out with 20% solutions. The adhesive strength of plywood depending on the quantity of different modifiers (from 0.5 to 2.5 %) also was studied in compliance with relevant standard test methods- БДС ISO 6238:2004 and EN 314.

Commercial phenol-formaldehyde resin with the following physicochemical properties: solid content – 47.8 %; complete solubility in water, viscosity- 93 s; pH – 11; curing time at 150º C – 68 s, was used in this research.Beech veneer sheets with thickness 2.2 mm were used for the experiments. Three-layer plywood with dimensions 500 × 500 mm was with the following technological parameters

of pressing: pressure of 1,8 MPa, temperature of 155 °C, press time of 4.5 min, glue spread of 130 $g.m^{-2}$.

During the experiment, all plywood samples were conditioned before testing for one year at 20±2 °C and 65±5 % relative humidity. The results of the experiments were processed statistically and the indicator of accuracy was lower than 5%.

3. RESULTS AND DISCUSSION

To reduce the duration of the gluing process of alkali synthesized resin, it was necessary to create rapid hardening adhesives. Acceleration of the curing process of resole phenol-formaldehyde resin can be achieved in acidic medium. Therefore mainly compounds with acidic effect were used as modifying agents. Investigations were carried out to establish the relationship between the amount of substances added to the resin and the curing time of the adhesives obtained. The relationship between the amount of added modifiers to the resin and the setting time of the adhesives obtained was observed.

Variations in phenol-formaldehyde resin curing time, depending on the type and quantity of modifiers, is shown in Fig. 1. The increase of amount modifying agents leads to an increase in the curing rate of the resin. The addition of 2 % tartaric acid into the composition of adhesive mixture shows reduction in the curing time by about three times at 150º C (from 68 to 20 s). Similar results were obtained when adding ferric chloride. The best effect by using phthalic anhydride at concentration of 0.75 % was observed.

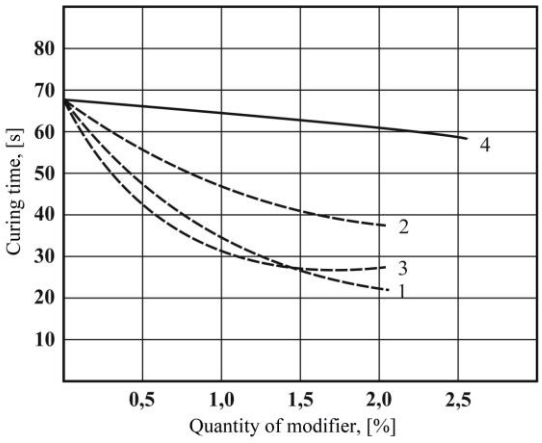

Figure. 1. *Curing time depending on the quantity of added modifier: 1- tartaric acid; 2- ferric chloride; 3- phthalic anhydride; 4- quebracho extract*

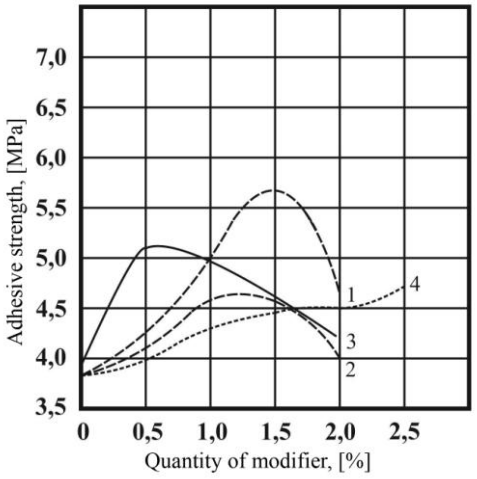

Figure 2. *Adhesive strength of plywood depending on the quantity and type of the modifier: 1- tartaric acid; 2- ferric chloride; 3- phthalic anhydride; 4- quebracho extract*

The impact of quebracho extract on spatial cross-linking of the resin was different. Change in the acidity of the medium was not noted, but the viscosity of the adhesive mixture changed noticeably. The probable explanation is that quebracho extract contains a large number of active functional groups which participate in the curing process.

The results showed that there are great possibilities for regulation of the setting time of phenol-formaldehyde resin by using different modifying agents.

Investigated modifiers significantly change the glue properties and adhesive-bonded joint. In addition, variations in the adhesive strength in dry state and after treating of samples in boiling water for one hour depend on the type and content of the modifier applied (Fig. 2, Fig. 3).

Tartaric acid, ferric chloride and phthalic anhydride as a phenol-formaldehyde resin modifying agents reduce pH of the adhesive mixture. As a result of this, hardening and spatial cross-linking of the resin occurred An addition of 1.5 % tartaric acid influenced the adhesive and cohesive bonds formation into adhesive-bonded joint. The adhesion strength in dry state is increased by approximately

48%, compared to the reference phenol-formaldehyde resin. For treating test samples in hot water, this influence is more significant (54 %).

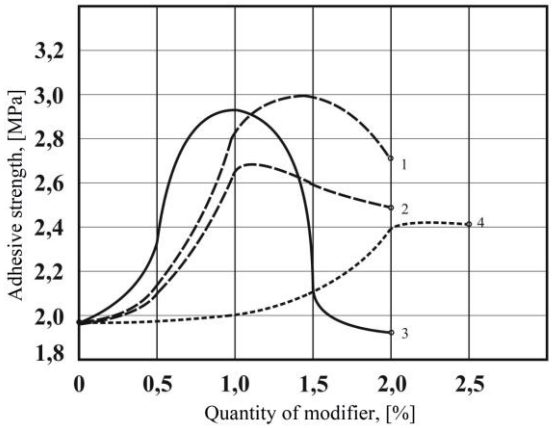

Figure 3. *Adhesive strength of plywood after treating in boiling water for one hour, depending on the type and quantity of the modifier: 1- tartaric acid; 2- ferric chloride; 3- phthalic anhydride; 4- quebracho extract*

The results from Fig. 2 and Fig. 3 showed that increasing of ferric chloride amount added to phenol-formaldehyde resin (from 0.5 % to 2.0 %) leads to increment of the adhesive joint strength. Hydro-thermal stability of adhesive-bonded joint was found to increase substantially. In both cases the optimal quantity of added ferric chloride was 1 %. Higher quantities cause Reduction in the strength of the generated bonds. A similar trend was also found for phthalic anhydride.

Raising the amount of modifying agents up to certain limits leads to an increase in the adhesive strength of the plywood produced.. Introduction of larger amounts had a negative effect on the hardening process of phenol-formaldehyde resin. This can be explained by forming of colloidal structure of the resin, which interferes with the curing process. At high temperatures the excess amount of modifier does not affect the reaction. As a result, curing of the resin can be impaired followed by reduction in the seam adhesive strength.

The influence of quebracho extract on the strength of adhesive-bonded joint was different when compared to other modifiers. The positive effect of the extract on the curing process is shown in Fig. 2 and Fig. 3. Excellent results at gluing plywood with phenol-formaldehyde resin containing about 2.0-2.5 % modifying agent, were obtained.

4. CONCLUSIONS

As a result of phenol-formaldehyde resin modification with tartaric acid, ferric chloride, phthalic anhydride and quebracho extract, deepening of the hardening process and increment in water resistance of resin was achieved. The plywood produced on the basis of modified glues is characterized with high adhesive strength in dry state as well as after hydro-thermal effect.

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Assist. Prof. Miglena Valyova, Ph.D.
Assist. Prof. Yordanka Ivanova, Ph.D.
Department of Plant Pathology and Chemistry
Faculty of Ecology and Landscape Architecture
University of Forestry
10 Kliment Ohridsky Blvd.
1756 Sofia, Bulgaria