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THE EFFECT OF MODIFICATION OF PHENOLIC RESIN WITH SODIUM OXALATE AND ETHYLENE GLYCOL ON PROPERTIES OF PARTICLEBOARDS

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SYNOPSIS. The study investigated the effect of the modification of phenolic resin with sodium oxalate and ethylene glycol on properties of particleboards. It results from the conducted tests that the simultaneous introduction of ethylene glycol and sodium oxalate to PF resin, irrespective of the amounts of modifiers, results in a slight increase in bending strength and modulus of elasticity of particleboards. However, a strong decrease was observed in internal bond after the boiling test. Observed changes in properties of particleboards, occurring under the influence of the applied modification, undermine the applicability of such a modification.

KEY WORDS: PF resin, particleboard, polyols

INTRODUCTION

As early as the mid-1990's Pizzi and Stephanou showed a significant effect of such esters as glycerol triacetate, propylene carbonate or ethyl formate on crosslinking of PF resin. In turn, particleboards resinated with such modified resin were characterised by a very high resistance to the action of changeable environmental conditions, even at the application of pressing times comparable to those of particleboards resinated with urea-formaldehyde resin (UF) (Pizzi and Stephanou 1994). Also studies conducted by Łęcka and Dukarska (1998) confirmed high efficacy of esters in the enhancement of reactivity in case of PF resin. This line of research has been developed at the Department of Wood-Based Materials, the Poznań University of Life Sciences, which has resulted in numerous papers on the effect of esters on the behaviour of such modified resin. In those studies analyses were conducted to evaluate the effect of both the type of the acid radical of the organic acid forming the ester and that of the alkyl coming from the alcohol. It results from the investigations on the subject that the effectiveness of the action of esters differing in the acid ligand was increasing with an increase

in the dissociation constant of the acid contained in the ester. In turn, for esters differing in the alcohol ligand it was shown that esters of diols were much more effective as modifiers than monohydric alcohols. However, in case of the latter no dependence was observed for the effect of their action depending on the length of the carbon chain of alcohol (Mirski et al. 2008 a). Such an enhancement of reactivity in case of PF resin modified with esters made it possible – at a shortened pressing time or reduced temperature – to manufacture particleboards with very good physico-chemical properties. Thus, e.g. the application of ethyl propionate or butyrate makes it possible to manufacture – at a temperature of 160°C – particleboards with physico-chemical properties comparable to those of control particleboards pressed at 180°C (Mirski et al. 2003). When evaluating the effect of the type of the ester-forming alcohol on the potential shortening of pressing time for particleboards it was shown that all types of esters added to resin (i.e. ethyl, butyl and pentyl acetates) facilitate the manufacture of particleboards exhibiting good properties at the application of a reduced pressing time, with butyl acetate being the most effective modifier, making it possible to reduce pressing time by as much as 30% (Mirski et al. 2006). Among all the tested esters it was esters of diols which turned out to be most effective, as at their application, even at an amount of 0.025 mole/100 g of dry resin solids, it is possible to manufacture particleboards and plywood with good properties at a shortened pressing time (Mirski et al. 2008 b, 2011). However, adhesive mixtures with an addition of this type of esters are characterised by a relatively short pot life, which may hinder their commercial scale applications. Esters of dicarboxyl acids turned out to be much more stable and capable of forming particleboards with good properties (Mirski et al. 2008 a, Mirski and Gotych 2008). Thus, in view of the results of previous studies conducted by the authors, presented above, it was decided in this study to investigate whether and to what extent simultaneous modification of phenolic resin with the radical of an organic acid and a difunctional alcohol affect properties of particleboards.

MATERIAL AND METHODS

The analyses were conducted using Fenokol-43 (Chemko Strazske), a resin used in the manufacture of particleboards with an enhanced resistance to the action of changeable environmental conditions, which basic properties are presented in Table 1.

A mixture of ethylene glycol and a difunctional organic acid was applied as a modifier of PF resin, with oxalic acid used in the form of a sodium salt in order to prevent a reduction in stability of liquid resin. The mixture of modifiers was mixed at a mol/mol ratio and added to the resin in amounts ranging from 0.01 to 0.15 mol per 100 g d.m. resin.

Table 1. Properties of PF resin

Property	Unit	Value
Dry mass	%	45.2
Density	g/cm^3	1.112
Free phenol content	%	0.02
Free formaldehyde content	%	0.026
Viscosity by Ford no. 4/20°C	s	106
Gel time in 130°C	s	146
pH	–	12.52

RESULTS AND DISCUSSION

Testing results concerning properties of particleboards depending on the amount of sodium oxalate and ethylene glycol introduced to PF resin are given in Tables 2 and 3.

Table 2. Properties of particleboards depending on the amount of sodium oxalate and ethylene glycol introduced to PF resin

Kind of addition	Amount [mole/100 g d.m.r.]	Bending strength		Modulus of elasticity at bending [N/mm^2]		Internal bond	
0*	0	18.7	0.4	2 640	270	0.60	0.10
sodium oxalate + ethylene glycol	0.01	20.5	0.7	2 760	240	0.62	0.12
	0.025	20.1	0.9	2 700	210	0.67	0.08
	0.05	20.0	0.8	2 690	190	0.74	0.19
	0.01	20.4	0.9	2 730	250	0.70	0.10
	0.15	20.2	0.9	2 760	230	0.67	0.05

0* – control particleboard.

As it results from the presented data, manufactured particleboards are characterised by a higher bending strength in comparison to the control particleboard pressed under identical conditions (Table 2). However, the increase in strength in relation to the control particleboard did not exceed 10% and it was much lower than at the application of alcohols (Łęcka et al. 2001). Moreover, no significant effect was found for the amount of the added modifier mixture on bending strength, since differences for individual amounts did not exceed 0.5 MPa and were generally statistically non-significant. The trend for the effect of applied modifiers on the modulus of elasticity at bending was similar (Table 2). Moreover, conducted tests concerning mechanical properties showed that internal bond was significantly improved under the influence of the applied modification (Table 2). In this case the introduction of a mixture of modifiers already at 0.025 mol/100 g d.m. resin resulted in a 10% increase in strength, while a two-fold increase in its amount

Table 3. Moisture resistance of particleboards depending on the amount of sodium oxalate and ethylene glycol introduced to PF resin

Kind of addition	Amount [mole/100 g d.m.r.]	Swelling		Absorbability		Moisture resistance after V-100 [MPa]	
0*	0	24.6	2.1	82.4	3.2	0.32	0.05
sodium oxalate + ethylene glycol	0.01	22.1	3.2	80.7	3.4	0.28	0.02
	0.025	23.7	2.8	84.9	4.5	0.26	0.03
	0.05	23.2	1.4	83.4	2.0	0.31	0.04
	0.01	23.9	3.0	81.2	2.5	0.25	0.03
	0.15	23.7	1.4	79.1	3.4	0.25	0.04

0* – control particleboard.

resulted in an improvement of this property by almost 25% in particleboards. A further increase in the amounts of introduced modifiers did not cause any further improvement in case of this property.

Results of tests on the effect of modification of phenolic resin using sodium oxalate and ethylene glycol on hydrophobic properties of manufactured particleboards are presented in Table 3. As it results from these data, the introduction of the modifying mixture to PF resin causes only a slight decrease in swelling in thickness of particleboards after 24 h soaking in water. It is biggest (approx. 10%) for the smallest amount of introduced modifiers. In contrast, no effect of the applied modification was found on absorbability of tested particleboards. In turn, results of testing for water resistance of particleboards (Table 3), measured by internal bond after the boiling test (V-100), showed that particleboards resinated with modified PF resin exhibit lower strength than the control particleboard, decreasing with an increase in the amount of modifiers introduced to the resin. Such a behaviour of particleboards after the boiling test was probably caused by the action of the Na^+ cation.

CONCLUDING REMARKS

It results from the conducted tests that the simultaneous introduction of ethylene glycol and sodium oxalate to PF resin, irrespective of the amounts of modifiers, results in a slight increase in bending strength and modulus of elasticity of particleboards. In contrast, internal bond increases significantly. However, a strong decrease was observed in internal bond after the boiling test, most probably as a result of an excessive amount of Na^+ ions introduced together with the applied modifiers. In contrast, no negative effect of the applied modification on water resistance was found for the particleboards, as measured by their swelling in thickness and absorbability. Observed changes in properties of particleboards, occurring un-

der the influence of the applied modification, undermine the applicability of such a modification and do not explain causes of such good results recorded when esters were applied.

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