Acta Sci. Pol.
Silv. Colendar. Rat. Ind. Lignar. 6(4) 2007, 101-106

PROPERTIES OF PARTICLEBOARDS RESINATED WITH PMDI MODIFIED WITH POLYETHYLENE GLYCOLS

Dorota Dziurka[1], Marek Jabłoński[2], Radosław Mirski[1]

[1]Agricultural University of Poznań
[2]Warsaw University of Life Science – SGGW

Abstract. The study investigated properties of particleboards resinated with PMDI modified with polyethylene glycols with varying molar masses (PEG 200 and 400). The conducted investigations showed that PMDI resin modification with both PEG 200 and PEG 400 causes an increase in mechanical properties of manufactured boards. In turn, modulus of elasticity decreases with an increase in plasticity of the modified resin. Then, water resistance of the tested boards, measured by their tear resistance after the boiling test, irrespective of the type and the amounts of applied modifiers, is very high and considerably exceeds the requirements specified in the respective standard. Particleboards exhibiting better mechanical properties and considerably improved water resistance may be obtained by the modification of PMDI resin with polyethylene glycol of a higher molar mass.

Key words: PMDI, polyethylene glycols, particleboard

INTRODUCTION

Isocyanates are highly reactive materials, capable of reacting with a wide variety of molecules. They especially easily attach compounds containing an active hydrogen atom, in the form of the hydroxyl group [Milota and Wilson 1985, Gallagher 1982, Sonnenschein and Wendt 2005]. In this group of compounds ethylene glycol and PEG 300 were the subject of our early research. The investigations conducted in this respect showed that both PMDI modifiers cause an increase in the mechanical properties and water resistance of manufactured boards. However, their spreading onto chips before gluing, above the specified amount, results in a deterioration of board properties [Dziurka 2005].

Thus the aim of this study was to investigate properties of particle boards resinated with PMDI modified with polyethylene glycols with varying molar masses.

Corresponding author – Adres do korespondencji: Dr Dorota Dziurka, Department of Wood Based Materials of Agricultural University of Poznań, Wojska Polskiego 38/42, 60-627 Poznań, Poland, e-mail: ddziurka@au.poznan.pl

MATERIAL AND METHODS

PMDI used in the experiments had the following characteristics: dry resin solids – 100%, dynamic viscosity 176 mPa·s, NCO-content – 33.3 g/100 g, and acidity as HCl – 97 mg/kg. Polyethylene glycols PEG 200 and PEG 400 in the amounts of 0.005, 0.01, 0.015, 0.02 and 0.025 mole per 100 g dry resin solids were used as PMDI modifiers. Single-layer particleboards with the density of 700 kg/m^3 and the thickness of 12 mm were manufactured under laboratory conditions from pine chips and modified resin, applying the following pressing parameters:

- pressing time 5 min
- unit pressure 2.5 N/mm^2
- temperature 200°C
- resination rate 6%.

Particleboards manufactured in this way were tested according to respective standards in terms of such properties as:

- modulus of rupture and modulus of elasticity according to PN-EN 310
- internal bond according to PN-EN 319
- internal bond after the boiling test according to PN-EN 1087-1
- swelling in thickness according to PN-EN 317.

RESULTS AND DISCUSSION

Testing results of the effect of the amounts and molar masses of polyethylene glycols used as modifiers of PMDI resin on the properties of produced boards are presented in Figures 1-3 and Table 1.

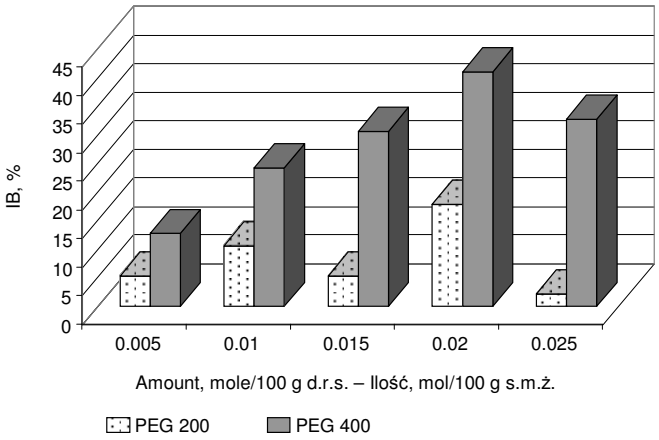

Fig. 1. Increase in internal bond of particleboards resinated with modified PMDI
Rys. 1. Wzrost wytrzymałości płyt wiórowych zaklejanych modyfikowanym PMDI

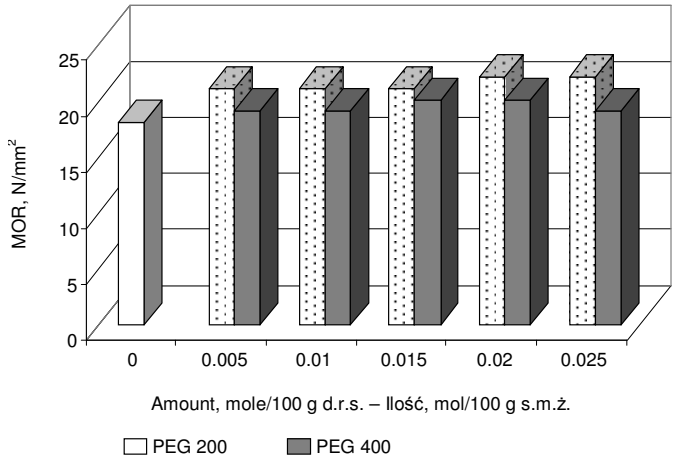

Fig. 2. Modulus of rupture of particleboards resinated with modified PMDI
Rys. 2. Wytrzymałość na zginanie płyt wiórowych zaklejanych modyfikowanym PMDI

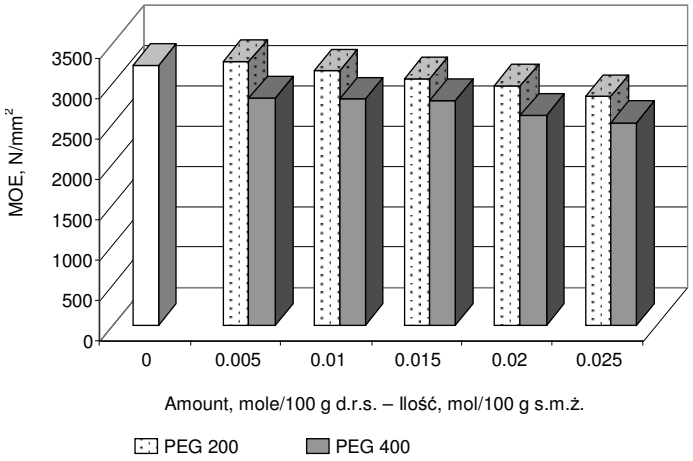

Fig. 3. Modulus of elasticity of particleboards resinated with modified PMDI
Rys. 3. Moduł elastyczności płyt wiórowych zaklejanych modyfikowanym PMDI

Table 1. Water resistance of particleboards resinated with modified PMDI
Tabela 1. Wodoodporność płyt wiórowych zaklejanych modyfikowanym PMDI

Type of modifier Rodzaj modyfikatora	Amount mole/100 g d.r.s. Ilość mol/100 g s.m.ż.	V-100 $N \cdot mm^{-2}$	Swelling Spęcznienie %	Absorbability Nasiąkliwość %
Control board Płyta kontrolna	0	0.37	23	73.4
		8.8[*]	*8.9*	*10.6*
PEG 200	0.005	0.60	24.5	70.3
		9.2	*11.2*	*9.9*
	0.01	0.52	21.4	69.2
		10.1	*10.9*	*11.3*
	0.015	0.48	22.6	67.7
		9.6	*6.9*	*8.9*
	0.02	0.47	22.0	65.7
		7.8	*9.1*	*9.2*
	0.025	0.43	21.8	63.8
		15.8	*8.2*	*5.1*
PEG 400	0.005	0.49	24.0	72.0
		9.1	*11.2*	*10.8*
	0.01	0.47	22.2	66.6
		9.9	*9.8*	*10.8*
	0.015	0.47	21.8	63.1
		7.8	*9.3*	*10.6*
	0.02	0.52	21.9	60.3
		8.6	*9.7*	*9.9*
	0.025	0.52	21.6	59.8
		14.5	*7.2*	*7.7*

[*]Coefficient of variation.
[*]Współczynnik zmienności.

It results from the conducted investigations that molar masses of applied PEG considerably affect strength properties of particle boards. Thus, if internal bond increases by a maximum of 24% in case of PEG 200, the addition of PEG 400 causes its increase by as much as 41% (Fig. 1). Such a considerable increase in internal bond might have been caused by the fact that the latter in relation to the former contains by a half less hydroxyl groups. It is known that they react with isocyanate groups of PMDI forming urethane-bonds causing higher cross-linking of such resin. At the same time, the fewer these groups in polyethylene glycol the more free isocyanate groups capable of entering into a further reaction with hydroxyl groups of wood. As a result greater numbers of polymer-wood bonds are formed, causing improvement in strength properties. In con-

trast, the observed decrease in IB for both modifiers introduced in the maximum amount of 0.025 moles might have been caused by the fact that as a result of excessive polyol concentration PMDI reacted primarily with hydroxyl groups coming from polyols, instead of hydroxyl groups of wood. A consequence of this fact is the formation of a lower number of polymer-wood bonds, which results in a deterioration of strength properties [Milota and Wilson 1985].

Applied polyols had a less pronounced effect on modulus of rupture (Fig. 2). In this case the maximum increase in strength, which was found for boards with the addition of both PEG 200 and PEG 400 at 0.025 moles, was 22% and 6%, respectively. Besides, irrespective of the amounts of polyethylene glycols measured values were similar.

In contrast, the modulus of elasticity decreased, generally along with the increase in the amount of added modifier (Fig. 3). The highest drop in the modulus, by as much as 710 MPa, was observed for PEG 400 introduced in the maximum amount of 0.025 moles. Results of these investigations confirm previous reports that polyols increase the plasticity of PMDI resin as a result of methylene bridges ($-CH_2-$) embedded in its structure [Milota and Wilson 1985]. With a higher molar mass, more methylene groups are in the alkyl chain of the polyol, responsible for the plasticity of resin.

Moreover, the investigations concerning water resistance, measured by internal bond after the boiling test showed that for particle boards glued with polyethylene glycol-modified PMDI it is very high and considerably exceeds the value defined by the respective standard (0.15 MPa according to PN EN 312-5; Table 1). In turn, in the dependence of the molar mass of PEG introduced to the resin a different trend is observed. Thus, if for PEG 200 internal bond decreases along with the increase in its amounts, in case of PEG 400 it increases. The results of these investigations are in good agreement with IB discussed earlier (Fig. 1).

Moreover, it may be concluded from the results of tests on absorbability and swelling presented in the table that the applied modifiers do not have a significant effect on these properties of the manufactured boards. Although an improvement in hydrophobic properties is observed, the measured values exhibit only a slight downward trend.

CONCLUSIONS

1. Modification of PMDI resin with PEG 200 or PEG 400 causes an increase in the mechanical properties of the manufactured boards, such as internal bond and modulus of rupture. In turn, the modulus of elasticity decreases in connection with an increase in plasticity of the modified resin.

2. Water resistance of the tested boards, measured by their tear resistance after the boiling test, irrespective of the type and the amounts of the applied modifiers, is very high and considerably exceeds the requirements specified in the respective standard.

3. Particleboards exhibiting better mechanical properties and considerably improved water resistance may be obtained by the modification of PMDI resin with polyethylene glycol of a higher molar mass.

REFERENCES

Dziurka D., 2005. Properties of particleboards resinated with PMDI resin modified with ethylene glycol and PEG 300. Folia For. Pol. Ser. B, 36, 59-65.

Milota M., Wilson J.B., 1985. Isoyanate-polyol resin as a binder for particleboard. Forest Prod. J. 35(7/8), 44-48.

Sonnenschein M.F., Wendt B.L., 2005. Efficacy of polymeric MDI/Polyol mixtures for binding wood boards. Wood Sci. Technol. 39, 27-36.

Gallagher J.A., 1982. Urethane bonded particleboard. Forest Prod. J. 32(4), 26-33.

WŁAŚCIWOŚCI PŁYT WIÓROWYCH ZAKLEJANYCH PMDI MODYFIKOWANYM POLIETYLENOGLIKOLAMI

Streszczenie. W pracy zbadano właściwości płyt wiórowych zaklejanych żywicą izocyjanianową modyfikowaną polietylenoglikolami o różnych masach molowych (PEG 200 i PEG 400) w ilościach 0,005-0,025 mola na 100 g suchej masy żywicy. Z przeprowadzonych badań wynika, iż modyfikacja PMDI wybranymi polietylenoglikolami wpływa na wzrost właściwości wytrzymałościowych wytworzonych płyt. Natomiast moduł sprężystości ulega zmniejszeniu ze względu na wzrost plastyczności modyfikowanej żywicy. Z kolei wodoodporność badanych płyt, mierzona ich wytrzymałością na rozrywanie po próbie gotowania, niezależnie od rodzaju i ilości polietylenoglikolu jest bardzo duża i znacznie przekracza wymagania określone odpowiednią normą.

Słowa kluczowe: PMDI, polietylenoglikole, płyta wiórowa

Accepted for print – Zaakceptowano do druku: 13.10.2007

For citation – Do cytowania: Dziurka D., Jabłoński M., Mirski R., 2007. Properties of particleboards resinated with PMDI modified with polyethylene glycols. Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lignar. 6(4) 2007, 101-106.