

**PROPERTIES OF PARTICLEBOARDS RESINATED  
WITH ESTER MODIFIED PF RESIN  
PART B. THE EFFECT OF THE TYPE OF ALCOHOL  
FORMING THE ESTER ON THE POTENTIAL  
SHORTENING OF PRESSING TIME**

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**Abstract.** The study investigated the effect of the modification of phenolic resin with organic acid esters, such as ethyl, butyl and pentyl acetates, on the possibility to shorten pressing time of particleboards produced with modified PF resin. Conducted investigations showed that all types of esters added to resin make it possible to produce particleboards with good properties at shortened pressing times. Butyl acetate turned out to be the most effective modifier, as it facilitated shortening of pressing time by 30%.

**Key words:** PF resin, particleboard, ester

**INTRODUCTION**

It results from the analysis of literature that much attention has been paid to the problem of PF resin reactivation using esters [Pizzi and Stephanou 1994, Tohmura and Higuchi 1995, Conner et al. 2002]. Studies conducted by the authors of this study [Łęcka et al. 2001, Mirski et al. 2002, Mirski et al. 2003] also confirm reports published so far on the potential improvement of properties of particleboards with increased water resistance, produced using PF resin modified with organic acid esters. These studies showed that organic acid esters with various alkyl substituents in the acid group, used as modifiers of PF resin, make it possible to produce particleboards with considerably better physical and mechanical properties under standard pressing conditions or to manufacture boards with properties comparable to the control board at pressing time shortened by 30% [Mirski et al. 2002], or at pressing temperature lowered by approx. 10% [Mirski et al. 2003].

Moreover, the effect was examined of the alkyl substituent in the alcohol group of organic acid esters on their effectiveness as modifiers of phenolic resin. The results of these investigations were presented in the first part of this series [Mirski et al. 2004].

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Relevant studies show that the modification of phenolic resin with esters containing various substituents in their alcohol groups results in a shortening of resin gel time and a lowering of its activation energy. It also considerably improves physical and mechanical properties of particleboards. This improvement of investigated properties of particleboards becomes more pronounced along with the increase both in the length of the carbon chain in the alkyl substituent and the amount of the ester introduced to phenolic resin.

For this reason the aim of this study is to investigate the effect of the type of alcohol forming the ester on the potential shortening of pressing time in case of particleboards resinated with modified PF resin.

## MATERIALS AND METHODS

For the study purposes, PF resin applied to the production of particleboards of increased water-resistance was used.

The following esters were used as modifiers of the phenolic resin: ethyl acetate, butyl acetate and amyl acetate in the amount of 0.05 mole/100 g of dry resin solids.

One-layer particleboards with the dimensions of 600 × 500 × 12 mm and density of 700 kg·m<sup>-3</sup> were produced from pine particles with use of the modified resin. The experimental particleboards were produced using the following pressing parameters:

- pressing time 3.5; 4.0; 4.5 and 5.0 min,
- temperature 180°C,
- pressure 2.5 MPa,
- degree of resination with PF 8%.

Properties of the produced boards were investigated in accordance with the relevant standards:

- internal bond after the boiling test according to EN 1087-1,
- swelling in thickness after 24h soaking according to EN 317,
- internal bond IB according to EN 319,
- modulus of rupture MOR and modulus of elasticity MOE according to EN 310.

## DISCUSSION OF RESULTS

Results of studies on the possibility to shorten pressing time for particleboards produced using PF resin modified with esters are presented on Figures 1-5. It results from the investigations conducted in this respect that both the type of the applied ester and pressing time generally do not have an effect on swelling of manufactured boards (Fig. 1). Although a slight decrease in their hydrophobicity is found along with the shortening of pressing time, it is not significant taking into consideration the values of standard deviations.

As may be concluded from the data presented in Figure 2, boards investigated in this study exhibited very high internal bond after the boiling test. The longer the carbon chain in the alkyl group of the alcohol forming the ester, the better strength properties of

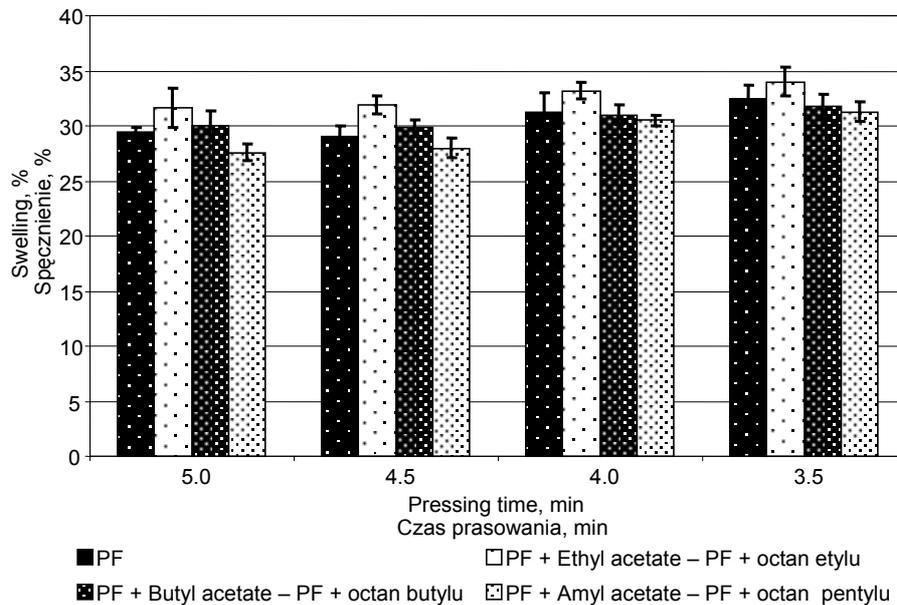


Fig. 1. The effect of the pressing time on the swelling of particleboards glued with PF resin modified with esters

Rys. 1. Wpływ czasu prasowania na spęcznienie płyt wiórowych zaklejanych żywicą PF modyfikowaną estrami

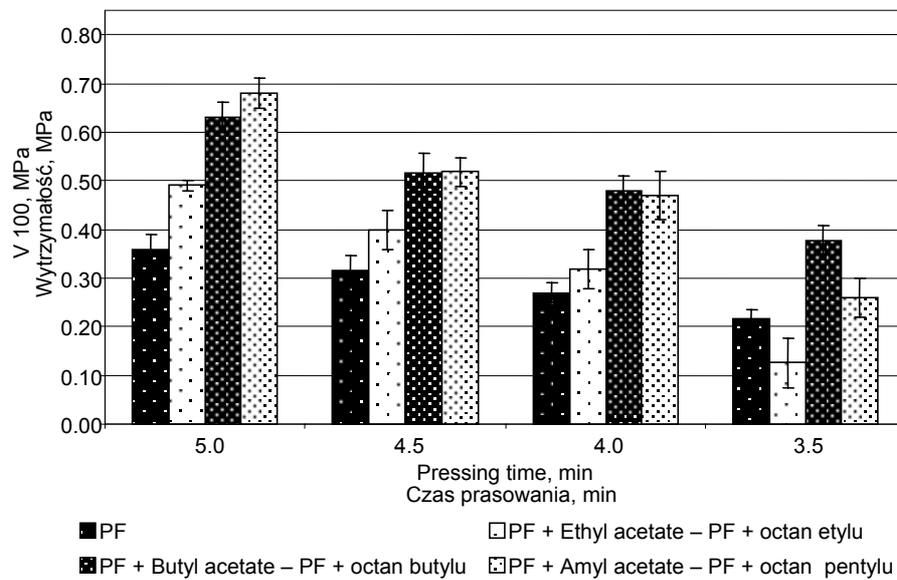


Fig. 2. The effect of the pressing time on the moisture resistance of particleboards glued with PF resin modified with esters

Rys. 2. Wpływ czasu prasowania na wytrzymałość na rozciąganie prostopadłe do płaszczyzn płyty po próbie gotowania płyt wiórowych zaklejanych żywicą PF modyfikowaną estrami

boards pressed for 5 min, and thus in case of boards resinated with resin modified with pentyl acetate the obtained water resistance values were almost twice as high as those of the control board. It was also observed that although shortening of pressing time by 1 min causes a considerable drop in strength properties, still water resistance of boards resinated with PF resin modified with pentyl acetate was higher by 60% and 30%, respectively, than that of the control board pressed under identical conditions and that pressed for 5 min.

It is different in case of the effect of applied modifiers on internal bond (Fig. 3). As can be seen from the data presented in that figure, only in case of boards resinated with PF resin modified with butyl and pentyl acetates, and only for pressing times of 5 and 4.5 min, considerably higher strength values were observed in comparison to corresponding control boards. Further shortening of pressing time (to 4 and 3.5 min) results in a significant decrease in internal bond of boards resinated with ester-modified resin at the simultaneous slight decrease in this property in boards resinated with non-modified resin. In consequence, the obtained strength values for boards resinated both with modified and non-modified resins are generally similar.

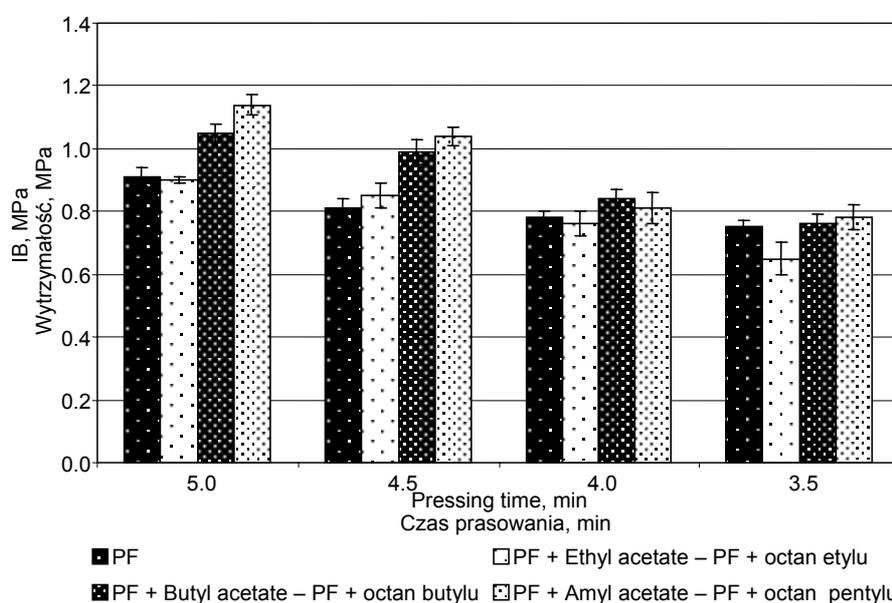


Fig. 3. The effect of the pressing time on the internal bond of particleboards glued with PF resin modified with esters

Rys. 3. Wpływ czasu prasowania na wytrzymałość na rozciąganie prostopadłe do płaszczyzn płyty płyt wiórowych zaklejanych żywicą PF modyfikowaną estrami

The effect of pressing time on bending strength of boards resinated with PF resin – both non-modified and modified with esters – is presented in Figure 4. It results from the presented data that boards resinated with PF resin modified with esters pressed for the period shortened to 3.5 min not only exhibit considerably higher strength than control boards produced under identical conditions, but also show a comparable, or even higher bending strength than the control board pressed for 5 min. Thus, despite the shortening

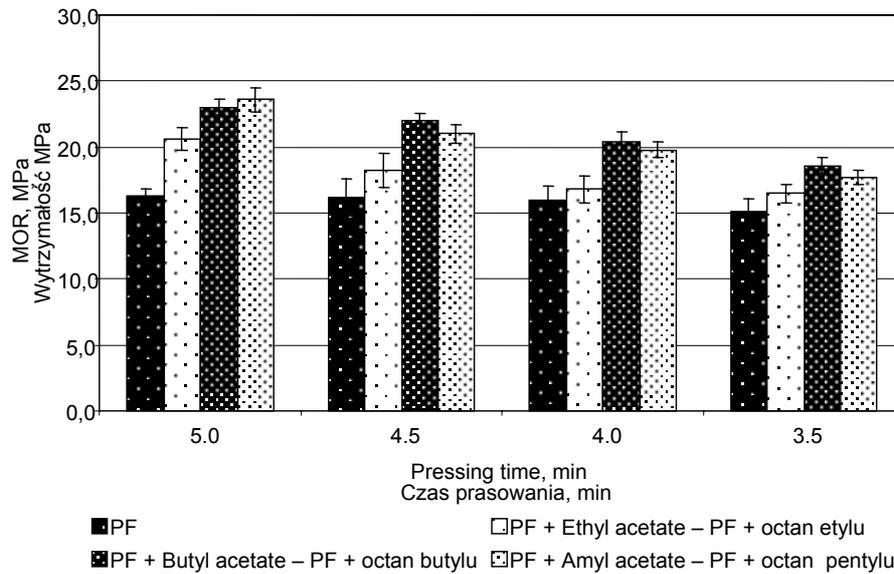


Fig. 4. The effect of the pressing time on the modulus of rupture of particleboards glued with PF resin modified with esters

Rys. 4. Wpływ czasu prasowania na wytrzymałość na zginanie statyczne płyt wiórowych zaklejanych żywicą PF modyfikowaną estrami

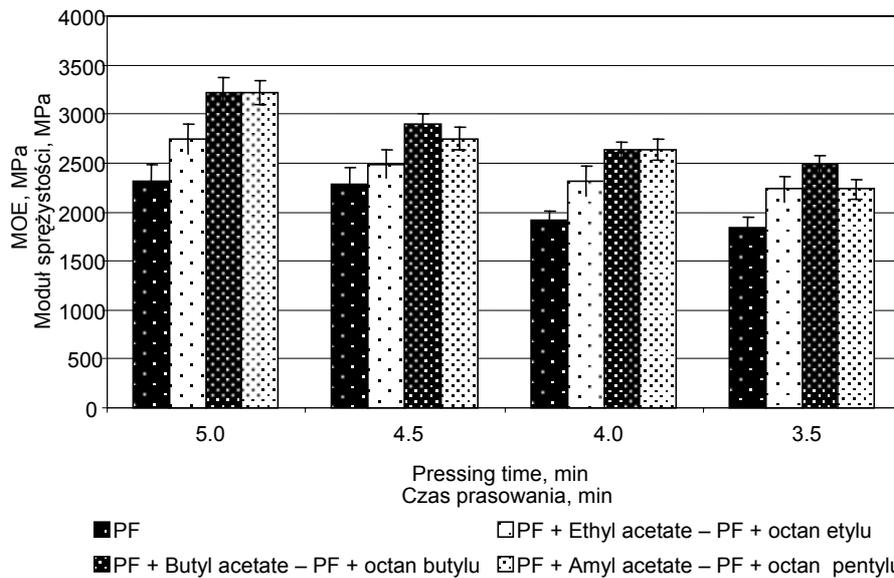


Fig. 5. The effect of the pressing time on the modulus of elasticity of particleboards glued with PF resin modified with esters

Rys. 5. Wpływ czasu prasowania na moduł sprężystości przy zginaniu statycznym płyt wiórowych zaklejanych żywicą PF modyfikowaną estrami

of pressing time by 1.5 min the strength of boards resinated with resin modified with butyl acetate is still by approx. 15% higher than that of control boards pressed for 5 min. It was also observed that the applied modifiers of PF resin considerably increase the modulus of elasticity of boards manufactured with their use, irrespective of their pressing times (Fig. 5). Even at pressing time of 3.5 min it is generally at the level of modulus of elasticity for boards produced at pressing time of 5 min with the use of non-modified resin. Such a considerable increase in modulus of elasticity for boards produced with the use of ester modifiers indicates that they significantly accelerate resin cross-linking processes. It pertains particularly to surface layers of boards, which are responsible for the obtained high values both in case of bending strength and modulus of elasticity.

## CONCLUSIONS

The conducted investigations on the possibility to shorten pressing time for particleboards resinated with PF resin depending on the type of ester alcohol group showed that the modification of PF resin with butyl or pentyl acetate makes it possible to produce particleboards at shortened pressing times with considerably improved properties than control boards, pressed under identical conditions. It also needs to be emphasized that the application of butyl acetate as a modifier of PF resin makes it possible, at pressing time shortened by 30%, to obtain boards with properties comparable to control board pressed for 5 min. In that case a slight deterioration of internal bond is not significant, as the measured values considerably exceed admissible values according to the PN-EN 312-5 standard.

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**WŁAŚCIWOŚCI PŁYT WIÓROWYCH ZAKLEJANYCH ŻYWICĄ  
FENOLOWO-FORMALDEHYDOWĄ MODYFIKOWANĄ ESTRAMI  
CZEŚĆ B. WPLYW RODZAJU ALKOHOLU TWORZĄCEGO ESTER  
NA MOŻLIWOŚĆ SKRÓCENIA CZASU PRASOWANIA PŁYT**

**Streszczenie.** W pracy zbadano wpływ modyfikacji żywicy fenolowej estrami kwasów organicznych takimi, jak octan etylu, butylu oraz pentylu, na możliwość skrócenia czasu prasowania płyt wiórowych, wytwarzanych z użyciem zmodyfikowanej żywicy PF. Przeprowadzone badania wykazały, iż wszystkie rodzaje dodawanych do żywicy estrów pozwalają na wytworzenie płyt wiórowych o dobrych właściwościach w skróconym czasie prasowania. Najbardziej efektywnym modyfikatorem okazał się octan butylu, który umożliwił skrócenie czasu prasowania o 30%.

**Słowa kluczowe:** żywica PF, płyta wiórowa, estry

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