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PVAc GLUE AS A BINDING AGENT IN PARTICLEBOARDS

The increasing demands concerning formaldehyde content in/emission from particleboards force search after alternative bonding agents. One of such bonding agents can be polivinylacetate (PVAc) glue. Unfortunately its high viscosity makes it difficult to apply the glue using methods for urea-formaldehyde glues. The viscosity change as dry mass decreases can be the reason for low strength of particleboards produced with such glue. The results show that bending strength and internal bond strength of particleboards produced with the use of PVAc glue is lower than for panels produced with the use of UF resin.

Keywords: particleboard, glue, pvac

Introduction

The most common adhesives used during wood-based panel production are amino resins based on urea-formaldehyde condensation. According to Warcok [2007] urea-formaldehyde (UF) and melamine-urea-formaldehyde (MUF) resins have the biggest share in the production of wood composites, even up to 90%. This situation is caused by low price and the most beneficial functional features of the above-mentioned resins. However, the main disadvantage of those resins is their principal component, i.e. formaldehyde that is considered carcinogenic. The second important adhesive for wood-based panel production is phenolic resin used mainly in products intended for exterior applications. Unfortunately, the price of phenol which is a petrochemical by-product is strongly connected with oil prices. Since early 1970s the interest in 4,4-methylenediphenyl isocyanate (MDI) binder, generally sold as PMDI (polymeric MDI) and EMDI (a water emulsion of PMDI), has been growing. Composite panels bonded with those resins are characterised by high strength, moisture resistance, and low swelling [Papadopoulos et al. 2002].

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Nowadays, so as to reduce the dependence of wood composite industry on petrochemical by-products and meet stricter requirements concerning formaldehyde emission, much research is focused on development of alternative binders.

Many investigations on modification UF or PF resins with the use of various natural derived materials like tannin, lignin, cellulose, crude pyrolysis oil of wood, and soy have been carried out. At the same time they were promoting nontoxic, environmentally friendly materials from renewable resources [Pizzi, Scharfetter 1982, Athanassiadou et al. 2002; Ballerini et al. 2005; Papadopoulou et al. 2008; Yang et al. 2006]. According to Markessini [2000] substitution of 50% phenol in PF resin with different natural products can lead to reduction of an adhesive cost up to 10%. To improve the efficiency of production lines, mechanical properties or water resistance of particleboard, another interesting modification of phenolic resin with alkylresorcinols or isocyanate resin was proposed by Dziurka et al. [2006 a,b].

Although there are many achievements in the field of wood adhesives, modified or new alternative products still cause some inconveniences. Either they have colour which limits the number of applications or they are toxic at some level [Despres et al. 2009]. A common issues also are low reactivity, difficulty in coating, high cost of some components (e.g. tannin, MDI) or more complicated production procedure. The great interest in that and related areas results from the importance of adhesives in the production of wood-based panels. The cost of adhesives is at the same level as wood, i.e. around 7% of the whole production cost.

In this study an attempt to investigate the possibilities of polivinylacetate (PVAc) glue use in particleboard production was made. The knowledge about the use of this type of glue is insufficient and so far there was not many experiments devoted to this topic. The main attribute of polivinylacetate glue is lack of harmful formaldehyde and relatively low cost compared to other formaldehyde free adhesives. In the research a typical commercially available polivinylacetate glue as well as industrial wooden chips for particleboard production were used.

Materials and methods

A typical commercial PVAc glue was used in tests. Dry mass content in the glue was 46 %. The glue viscosity, measured with the use of RheoTec RC 01/02 viscosimeter based on the Brookfield method, was strongly connected to temperature (fig. 1). In the temperature of 25°C the viscosity of the glue was about 14400 mPas, and decreased when the temperature increased; in the temperature of 90°C the viscosity was about 6600 mPas. Compared to industrial urea-formaldehyde resins the above – mentioned viscosity is very high. According to

Drouet [1992] the viscosity of U-70 resin is about 1000–2000 mPas and of Silekol-W1 resin 400–800 mPas. The optimal glue viscosity for particleboard production, suggested by Drouet, should be in the range of 50–200 mPas. To reduce viscosity, PVAc glue was diluted with water in the proportion of 2:1 (2 mass portion of glue:1 mass portion of water).

The research was carried out using three different variants (table 1) of particleboards. In all variants three-layer particleboards were 16 mm thick and their assumed density was 600 kg/m³. The particleboards were produced from industrial chips resinated with UF or PVAc glue. In fig. 2 the difference between the methods of bonding can be observed. Production parameters (pressing time factor, pressure, temperature, resination) were close to industrial conditions. Produced panels were tested for bending strength (EN 310) and internal bond strength perpendicular to the plane of the board (EN 319).

Table 1. Variants of particleboard production

Tabela 1. Warianty produkcji płyt wiórowych

Variant <i>Wariant</i>	1	2	3
Glue for bonding of chips <i>Klej do zaklejania wiórow</i>	UF	PVAc	PVAc
Bonding method <i>Metoda łączenia</i>	3-layer particleboard produced in one phase <i>trzywarstwowa płyta wiórowa wyprodukowana w jednym etapie</i>	3-layer particleboard with two face layers pressed in hot press and core layer pre-pressed in cold press. Separately created layers were joined with PVAc glue and left in cold press for about 12 h. <i>Trzywarstwowa płyta wiórowa o dwóch warstwach zewnętrznych prasowanych na gorąco oraz warstwie środkowej wstępnie prasowanej na zimno. Oddzielnie wytworzone warstwy zostały połączone przy użyciu kleju PVAc i pozostawione w prasie zimnej na około 12 h.</i>	3-layers particleboard with two face layers separately pressed in hot press and bonded with core layer formed without pre-pressing. Produced particleboard was left in cold press for about 12h. <i>Trzywarstwowa płyta wiórowa o dwóch warstwach zewnętrznych oddzielnie prasowanych na gorąco i połączonych z warstwą środkową uformowaną bez prasowania wstępnego. Wytworzoną płytę wiórową pozostawiono w prasie zimnej na około 12 h.</i>

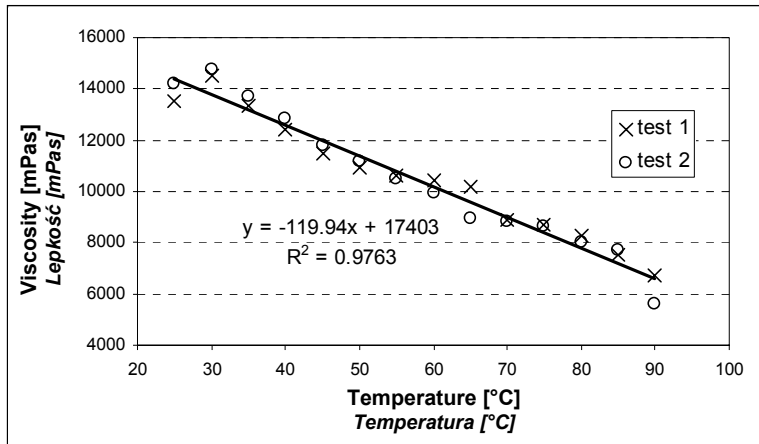


Fig. 1. The dependence of PVAc glue viscosity on temperature
Rys. 1. Zależność lepkości kleju PVAc od temperatury

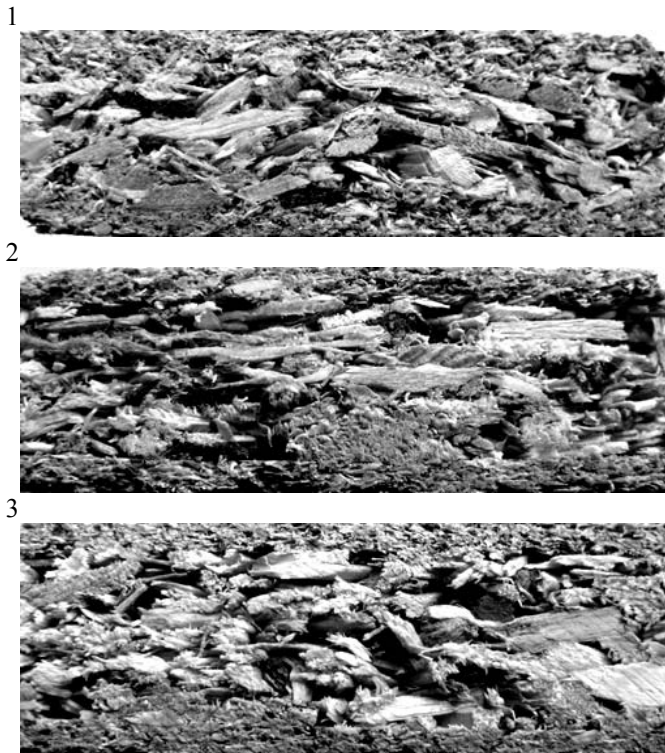


Fig. 2. Cross-sections of tested particleboards
Rys. 2. Przekroje badanych płyt wiórowych

Results and discussion

The results of measurement of tested particleboards' density profile are presented in fig 3. The density profile of panel no. 1 have a typical "M" shape. There is no clear border between the face and core layer. The other panels no. 2 and 3 were characterised by a clear border between the face and core layers (see also fig 2). In the case of panels no. 2 and 3 the face layers' density was about 900 kg/m^3 , which means that the assumed density was achieved.

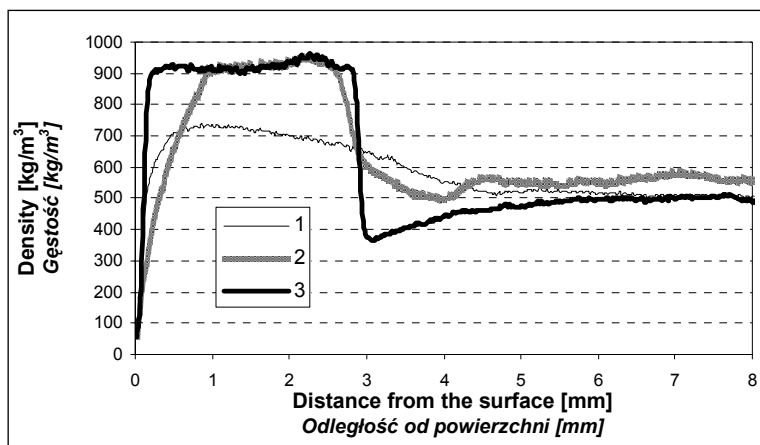


Fig. 3. Density profiles of tested panels

Rys. 3. Profile gęstości badanych płyt

Bending strength of tested panels is shown in fig. 4. According to fig. 4, the highest bending strength was observed for panel no. 1 and the lowest for panel no. 2. The bending strength of panel no. 2 constitutes 59 % of the strength of panel no. 1, and the bending strength of panel no. 3 is 70 % of the strongest panel's strength.

Internal bond strength of tested panels is presented in fig. 5. The internal bond of panels no. 2 and 3 is the same and amounts to 0.27 N/mm^2 , which means that it is 53% of the internal bond strength of panel no. 1.

The aim of bonding separately prepared layers to achieve a 3-layer panel was to increase bending strength by increasing density of face layers. It is well known that face layers are responsible for bending strength of bent materials. The research shows that even with such technology modification bending strength of panels bonded with PVAc glue is much lower than the strength of panels produced with the use of UF resin. The reason for this can be lower content of dry mass in PVAc glue, which is about 31 %, when typical dry mass

content in UF resin is about 65 %. In conducted tests the same mass amounts of glues (UF and PVAc) were used to avoid introducing additional water into panels.

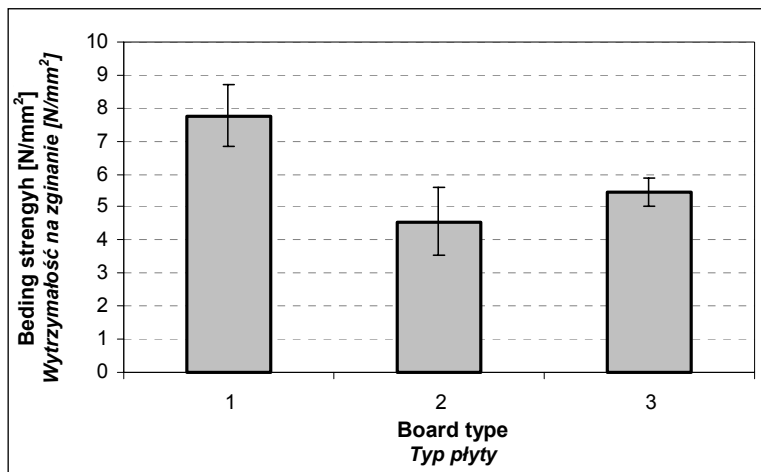


Fig. 4. Bending strength of tested panels

Rys. 4. Wytrzymałość na zginanie badanych płyt

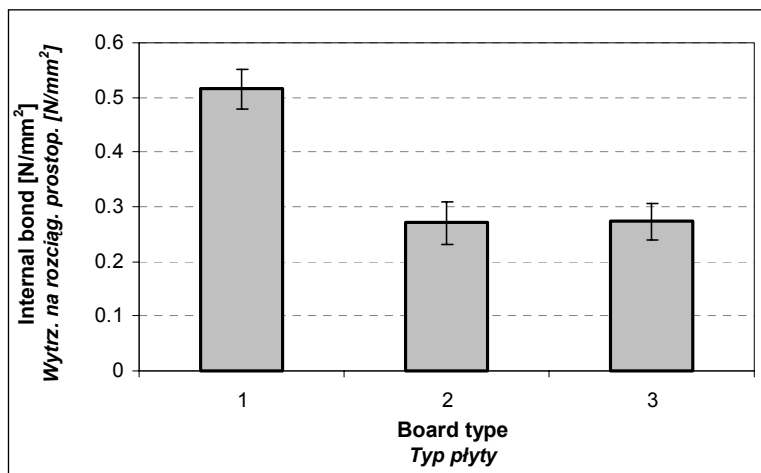


Fig. 5. Internal bond strength of tested panels

Rys. 5. Wytrzymałość na rozciąganie prostopadłe badanych płyt

Conclusions

The use of PVAc glue in particleboard production is uncommon. However, taking into account the increasing demands concerning formaldehyde content in/emission from panels, research on new binders for particleboard production is substantiated. The important issue connected with the use of such glue is its high viscosity which, as a matter of fact, decreases as temperature increases but still is too high to apply the glue using the method typical for UF resin. An addition of water results in lower viscosity but, on the other hand, dry mass content in glue decreases. The results show that bending strength and internal bond strength of particleboards produced with the use of PVAc glue are lower than in the case of panels produced with the use of UF resin.

References

- Athanassiadou E., Tsiantzi S., Panagiotis N.** [2002]: Wood adhesives made with pyrolysis oils. www.chimarhellas.com
- Ballerini A., Despres A., Pizzi A.** [2005]: Non-toxic, zero emission tannin-glyoxal adhesives for wood panels. *Holz als Roh- und Werkstoff* [63]: 477–478
- Despres A., Pizzi A., Vu C., Delmotte L.**, [2009]: Colourless formaldehyde-free urea resin adhesives for wood panels. *European Journal of Wood Products*. DOI 10.1007/s00107-009-0344-y
- Drouet T.** [1992]: *Technologia płyt wiórowych*. SGGW, Warszawa
- Dziurka D., Łęcka J., Dukarska D.** [2006 b]: The effect of modification of phenolic resin with akrylresorcinolis in the synthesis process on properties of particleboards. *Annals of Warsaw Agricultural University. Forestry and Technology* [58]: 277–281
- Dziurka D., Mirski R., Łęcka J.** [2006 a]: The effect of modification of phenolic resin with isocyanate resin on properties of boards manufactured from rape straw particles. *Annals of Warsaw Agricultural University. Forestry and Technology* [58]: 257–260
- Markessini A.C.** [2000]: Resins of the future. The continuing evaluation of resins for wood based panels. The European Panel Federation Annual General Meeting, Paris. www.chimarhellas.com
- Papadopoulos A., N., Hill C.A.S., Traboulay E., Hague J.R.B.** [2002]: Isocyanate resins for particleboard: PMDI vs EMDI. *Holz als Roh- und Werkstoff* [60]: 81-83
- Papadopolou E., Panagiotis N., Tsiantzi S., Athanassiadou E.** [2008]: The challenge of bio-adhesives for the wood composite industries. www.chimarhellas.com
- Pizzi A., Scharfetter H.** [1981]: Adhesives and Techniques open new possibilities for the wood processing industry. Part 1: Experience with Tannin Based Adhesives. *Holz als Roh- und Werkstoff* [39]: 85–89
- Warcok F.** [2007]: Nowe trendy w produkcji środków wiążących w świetle wymagań Unii Europejskiej dotyczących emisji formaldehydu. *Biuletyn Informacyjny OBR w Czarnej Wodzie* [1–2]: 35–42
- Yang I., Kuo M., Myers D.** [2006]: Bond quality of soy-based phenolic adhesives in Southern Pine plywood. *JAOCS* 83 [3]: 231–237

KLEJ PVAc JAKO SPOIWO W PŁYTACH WIÓROWYCH

Streszczenie

Rosnące wymagania dotyczące zawartości oraz emisji formaldehydu z płyt wiórowych zmuszają do poszukiwań alternatywnych środków wiążących. Jednym z takich klejów może być klej polioctanowinyłowy. Niestety jego wysoka lepkość utrudnia nanoszenie metodami stosowanymi dla klejów mocznikowo-formaldehydowych. Zmiana lepkości poprzez obniżenie zawartości suchej masy kleju może być powodem niskiej wytrzymałości płyt wiórowych wytworzonych z udziałem takiego kleju. Wyniki badań wykazały, iż wytrzymałość na zginanie, jak również wytrzymałość na rozciąganie prostopadłe płyt wytworzonych z użyciem kleju PVAc jest niższa niż dla płyt wytworzonych z użyciem żywicy UF.

Słowa kluczowe: płyta wiórowa, klej, pvac