

Effect of molar ratio of melamine-urea-formaldehyde adhesive resins condensed no-waste method's on the selected properties of the polycondensates during storage time

II. Gluing quality

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Abstract: In presented article were discussed properties of beech plywood produced with the use of melamine-urea-formaldehyde resins (MUF) in function of molar ratio and storage time. Shear strength (R_t) of adhesive glue line of plywood accordingly to the requirements of standards EN 314-1 after tests p.5.1.1, and p.5.1.3 were tested. On the base of carried out tests it was stated, that independent of storage time and molar ratio of MUF resin, produced 3-layers plywood fulfilling the requirements of EN 314-2 standard for 3 class of gluing quality.

Keywords: resin, waste, plywood, molar ratio

INTRODUCTION

For many years, they are conducted multifaceted research on the synthesis of melamine-urea-formaldehyde (MUF) adhesive resins. Studies were conducted on the synthesis of MUF resin [Luo and Zhang 2015], also without formaldehyde, which replaced of dimethoxyethanal [Despres et al. 2008], or the modification of industrial resins MUF of glutaraldehyde [Mamiński et al. 2007, Zhou et al. 2013], or soybean meal [Fan et al. 2011, Gao et al. 2013]. The increase of the water resistance of glue lines MUF resins were also obtained by use of a salt of melamine as curing agent [Weinstabl et al. 2001, Zanetti and Pizzi 2004] or natural alkilorezorcyn [Jozwiak et al. 2003] or ionic liquid [[Jozwiak et al. 2010]. Another direction of increasing the bonding process efficiency was the use of hybrid systems [Wieland et al. 2007], polyvinyl acetate [Kaborani and Riedl 2011] or nanofillers [Lei et al 2008, Zhou et al. 2012].

In the Wood Technology Institute recently conducted research has shown that in an uncomplicated process of condensation, MUF resins by no-waste method [JóŹwiak 2011]. Resins synthesized in this way, characterized in a relative lower dry matter content and a much lower viscosity compared to industrial resin. The reduced viscosity of the resin may present some difficulties in obtaining a waterproof glue

The aim of the research were examine of effect of molar ratio of MUF adhesive resins condensed no-waste way on the gluing quality of beech plywood in function of storage time.

MATERIALS AND METHODS

Resin. In our studies we applied MUF resins condensed on a lab scale for the molar ratio of formaldehyde (F) : melamine (M) : urea (U) as follows F= 4.6; 4.2; 3.8; 3.2; 2.8 and M:U = 1.0 : 1.0 mole. The condensation was a three-stage process performed at a temperature of $82 \pm 2^\circ\text{C}$ and 0.2 mole of urea was additionally condensed in the third stage. Condensation was carried out to water tolerance in the range of $100 \div 150\%$. Polycondensate was not distilled. The resins were stored at a temperature of $20 \pm 2^\circ\text{C}$. The basic physicochemical properties of the resin were presented earlier in the first part of the article.

Veneer. In the study beech veneer were used. For the preparation of 3-layer plywood, veneers with dimensions 300x300x1, 8 ± 0.1 mm, and $MC = 6 \pm 1\%$ were used.

Glue mixtures. To approximately one third of the MUF resin was added a certain amount of filler, (wheat flour type 650 and kaolin powder KOG-OS, and active silica Aerosil-120 part. by wt.), then the mass was stirred for 10 min with a mechanical stirrer, and then introduced the remainder part of the resin was carried out by stirring for a further 20 min. In the final stage of preparation of the adhesive, the hardener 1,6% NH_4NO_3 was added.

The parameters pressing process. Veneer was applied on one side with the adhesive roller in an amount of 180 g/m^2 . Then three layer sets was formed. After 30 min (glue) or 24 h (layer) assembly time sets pressing at 125°C for 5 min at a pressure of 1.8 MPa.

Testing. Samples were cut to determine shear strength (R_t) of adhesive glue line of plywood in accordance to EN 314-1 standard. Before determining the shear strength of bonds, the 15 samples were subjected to hydrothermal treatments in accordance with point 5.1.1 (24 h soaking in water in temperature $20 \pm 3^\circ\text{C}$; test IF-20) and 5.1.3 (4 h boiling in water as well as 16 h drying in air at the temperature of $60 \pm 3^\circ\text{C}$ and 4 h boiling in water and cooling in water to the temperature of $20 \pm 3^\circ\text{C}$; test AW-100) of the EN314-01 standard All the samples were tested in wet state in the Schopper testing machine at loads ranging to 500 daN. Rupture of the samples were occurred within (30 ± 10 s). After shear tests, the samples were dried and the percentage share of the bond surface covered with wood fibers – wood failure (WF) was determined comparing the pictures of bond damage with those shown in EN 314-02 standard.

RESULTS

The results of studies on the effect of molar ratio in versus storage time of MUF adhesive resins condensed no-waste way on the gluing quality of beech plywood presented on Fig 1 and 2. Shear strength (R_t) and wood failure (WF) of tree-layer beech plywoods obtained after 30 min (glue) or 24 h (layer) assembly time after tests IF-20 and AW-100 (p.5.1.1. and 5.1.3. acc. to EN 314-1:2007). Graphs with thick line are presented shearing strength, and for presentations of their variability, standard deviation was put in form of perpendicular sections up and down from signs, and scale of reference was placed on the left side of the graph The quality of gluing (% of WF) was marked as line and scale of reference was placed on the right side of the graph. Plywood were characterized by very high quality waterproof glue lines, independently of the storage time. Higher values WF were obtained for 24 h assembly time. The gluing effect obtained with resin stored even longer than one year (molar ratio/ months = 4.6/15.3; 4.2/12 ; 3.8/14) represented a fully satisfactory, waterproof plywood. Plywood fulfilled the requirements for EN-314-02 standard in terms of strength and water resistance of glue lines.

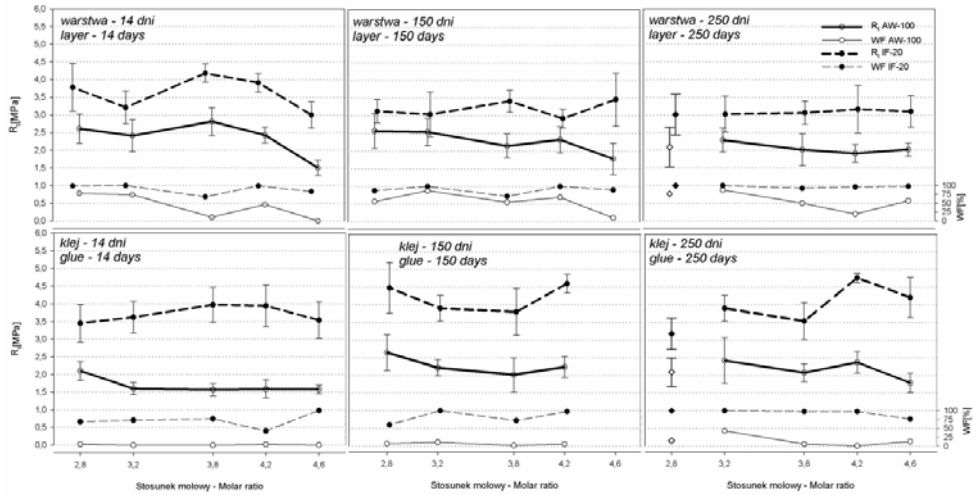


Fig.1 Shear strength (R_t) and wood failure (WF) of tree-layer beech plywoods obtained with two methods (after 30 min (glue) or 24 h (layer) assembly time) from MUF resin with different molar ratio and storage time after tests IF-20 and AW-100 (p.5.1.1. and 5.1.3. acc. to EN 314-1:2007)

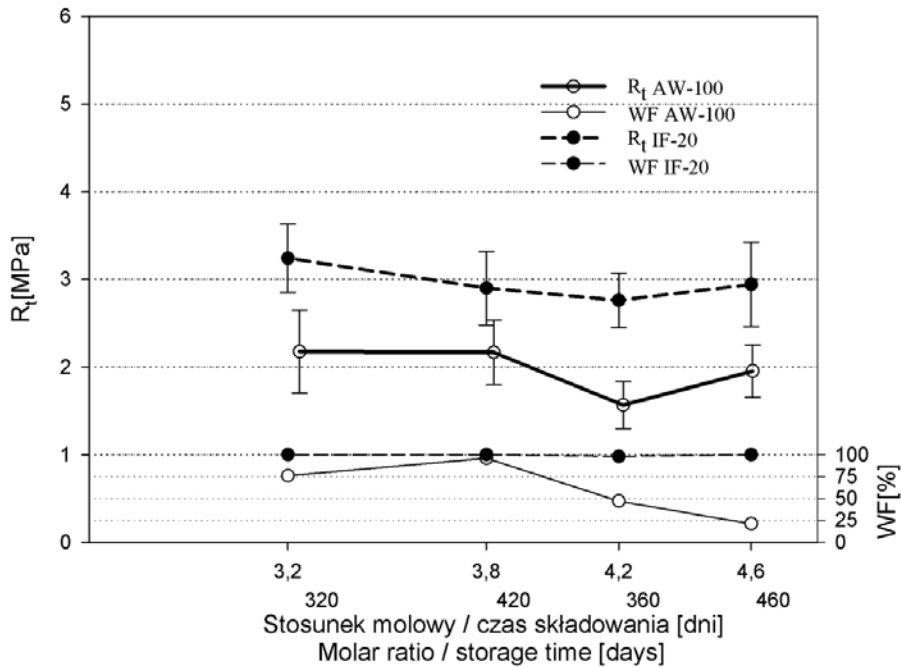


Fig.2 Shear strength (R_t) and wood failure (WF) of tree-layer beech plywoods obtained from MUF resin with different molar ratio (30 min assembly time) and extremal long storage time after tests IF-20 and AW-100 (p.5.1.1. and 5.1.3. acc. to EN 314-1:2007)

CONCLUSIONS

Plywood fulfilled the requirements of EN-314-02 in terms of strength and water resistance of adhesive glue lines, regardless of resin storage time, the molar ratio. The gluing effect obtained

with resin stored even longer than 12 months represented a fully satisfactory, waterproof plywood.

Based on the performed study it was found that independently of the storage time of the resin were characterized very high water resistance and quality of adhesives bonding. Plywood meet the requirements of EN-314-02 for class 3 of gluing quality.

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Streszczenie: *Wpływ stosunku molowego żywic melaminowo-mocznikowo-formaldehydowych (MUF) kondensowanych sposobem bezodpadowym na wybrane właściwości polikondensatów w czasie ich składowania II. Jakość sklejenia*

W pracy przedstawiono badania nad wpływem stosunku molowego żywic melaminowo-mocznikowo-formaldehydowych (MUF) na jakość sklejenia laboratoryjnej trójwarstwowej sklejki bukowej w funkcji czasu składowania. W badaniach zastosowano żywice MUF o stosunkach molowych M:U:F w zakresie 4,6; 4,2; 3,8; 3,2; 2,8 :1,0:1,0 kondensowane sposobem bezodpadowym. Wytworzone w skali laboratoryjnej 3-warstwowe sklejki bukowe przy zastosowaniu żywicy MUF, niezależnie od roboczego czasu klejenia (30 min i 24 h) oraz czasu składowania od 14 do 460 dni spełniały wymagania EN 314-2 dla 3- klasy jakości sklejenia wodoodpornego ($R_t = 1,0$ MPa, przy $WF=0\%$)

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