

Studies upon wettability of solidified isocyanate adhesives layers formed on thermally modified ash wood (*Fraxinus excelsior* L.)

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Abstract: *Studies upon wettability of solidified isocyanate adhesives layers formed on thermally modified ash wood (*Fraxinus excelsior* L.).* The aim of this work was the determination of contact angle (Θ) of solidified layers from selected type of isocyanate adhesives formed on the ash wood thermally modified in industrial conditions at different parameters, and calculated free surface energy (γ_s), together with dispersion (γ_s^d) and polar (γ_s^p) shares. For realization of the experimental was chosen ash wood, which was thermally modified in technological conditions at two temperatures (192 and 200°C). of the conducted processes Obtained wooden products are offered with trade names suitably the ash in the „amber” and „cognac” version. As binding agents were chosen isocyanate adhesives (EPI, 1- and 2K), which were applied with the aid of the applicator at the thickness of layers 180 μm . Measurement of the angle Θ were carried out with the biological microscope with the goniometric equipment after the lapse appropriately 24, 72, 168 and 336 h of conditioning of samples in RT and RH. On the basis of the angle Θ values, was calculated γ_s , together with γ_s^d and polar γ_s^p shares. It was stated among others, that differential values of the angle Θ (35÷65°), first of all from the kind of the adhesives, and only in the decidedly smaller degree, with thermally modified wood. During conditioning of layers it did not note down significant changes of the γ_s .

Keywords: ash wood, thermally modified, isocyanate adhesive, contact angle, surface free energy

INTRODUCTION

Wood except advantages shows also defects, to which counts the hygroscopicity and related to it phenomena of the shrinkage, swelling, the low durability in variable weather conditions, the inflammability and anisotropic properties. Wood defects limits across modification processes. One of more interesting methods in this regard to the constitutes the thermal working both coniferous species (spruce), and first of all broadleaved species (oak, ash, birch, beech, locust), during which wood is processed the high temperature in the atmosphere of the steam water (Alen, Kotilainen and Zaman 2002, Bulian and Graystone 2009, Grześkiewicz 2009). Whereat it is proper to mention, that over the recent years the more and more greater use finds thermally modified ash wood. Increase of the temperature causes not only changes in the quantitative composition of individual wood components, but also reduction of the polymerization degree of the cellulose, the growth of the degree of the crystallinity and the reduction of amount hydroxyl groups (Tjeerdsma et al. 1998, Sivonen 2002, Nuopponen et al. 2003, Rowell 2005). Thanks to this, thermally modified wood is decidedly more resistant on the influence of external environment, what creates simultaneously extensive directions of its uses, in which usually necessary is the use of the joining by means of binding agents (Nuopponen et. al 2003, Reinprecht and Vidholdová 2008). The important meaning in various fields of woodworking industry, among other things in the building woodworking industry play isocyanate adhesives offered both in 1- and 2K versions, as and in EPI systems too. Having on the regard the occurrence in these adhesives of -NCO formations, reactive in the process of their hardening with -OH groups contained in wood, is interesting the recognition, in which degree the thermally modification will influences in this arrangement. On the basis of thermodynamic principles it can accept, that about the adhesion of adhesive to the substrate decides the relation of the free surface energy (γ_s) of both interaction materials, whereat adhesives about γ_s of smaller from γ_s of glued together material well wet him and create resistant bonding (Zenkter 1996).

In the above context basing on fundamental criterion of the adsorptive theory of the adhesion it can undertake the work, whose aim was the determination of contact angle (Θ) of solidified layers from selected type of isocyanate adhesives formed on the ash wood thermally modified in industrial conditions at different parameters, and γ_s together with dispersion (γ_s^d) and polar (γ_s^p) shares.

EXPERIMENTS

For the realization of the experimental part was chosen ash wood, which was modified thermally in technological conditions of the „Sawmill - Stefan” Comp. in Włoszakowice at two temperatures (192 and 200°C). Obtained products are offered with trade names suitably the ash in the „amber” and „cognac” version. Values of moisture content of modified wood was in the range 5±1%, however the density shaped for „amber” - 660 kg/m³, however „cognac” - 630 kg/m³. From the group of binding agents were chosen 3 adhesives from the offer of the KLEBCHEMIE M. G. Becker GmbH & Co. Comp. in Weingarten/Baden. In this 2 of the group on the basis of PUR (Kleiberit 510.0 in the version 1K and Kleibit 303 applied with 303.5 hardener) and EPI (PVAC - Kleibit 304.5 catalyzed with the isocyanate in the form of commercial product Kleibit 808.2.). Adhesives were applied in RT conditions (20±1°C and RH 65±5%) on samples both from ash wood in versions non- and modified at dimensions 100x100x5 mm, and also glass plates with the aid of the applicator at the thickness of layers 180 µm (150 g/m²). In measurement of the angle Θ of the surface of solidified adhesive layers were 10 drops of redistilled water at the volume 3.5 µl, with the aid of the chromatographic syringe. Measurement of the contact angle were carried out with the biological microscope with the goniometric equipment after the lapse appropriately 24, 72, 168 and 336 h of conditioning of samples in RT and RH conditions. On the basis of the angle Θ values and dependences published in the literature γ_s together with (γ_s^d) and (γ_s^p) shares were calculated (Kloubek 1974, Liptáková and Paprzycki 1983).

RESULTS

On the basis of the results of angle Θ measurement of hardened adhesive layers, solidified on different substrates in function of conditioning time, appropriately after the lapse 24, 72, 168 and 336 h one prepared Fig. 1÷3. It is proper to mention, that for performed angle Θ measurement, values of the coefficient of the correlation placed in the range 0.53÷13.14%, what testifies about the good repeatability and simultaneously reliabilities of carried out measurements. From the data analysis it was stated, that the average values of angle Θ appropriately for 303, 304.5 and 510.0 adhesives contained within the range from 35° (glass and the 303 adhesive) to 65° (ash not modified and the 304.5 adhesive). Decidedly higher values of the angle Θ was noted down for layers from the EPI adhesives (61÷65°). On the basis of these data it can be stated, that the differentiated wettability of the surfaces of individual adhesives on determined kinds of the substrate. Whereat registered dependences within the range the influence of the kind of the substrate, on the formation of the angle Θ value, do not show unambiguous tendencies. During conditioning of layers it did not note down significant changes of this parameter, therefore, that of the consolidation processes of adhesive layers connected with the evaporation of volatile components and with hardening processes in the polyaddition in time 24 h. In turn average values γ_s for solidified adhesives carried out 47÷62 mJ/m² and together with the extension of the conditioning time placed themselves like the dependence for angle Θ , on the stabilized level. In the course of γ_s the decidedly greater participation, for 510.0 and 304.5 adhesives, had constituent γ_s^d . The exception from this rule constituted the 303 adhesive, whose components oscillated on the close level.

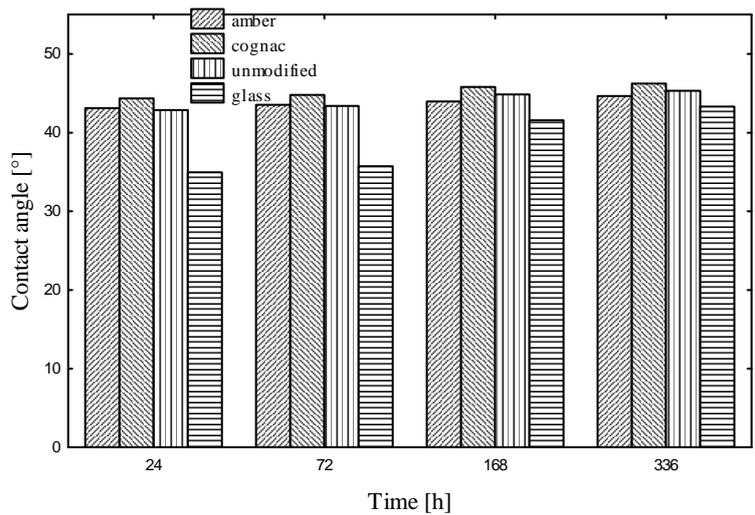


Fig. 1. The course of the angle Θ values of solidified layers on different substrates from the Klebit 303 adhesive vs. conditioning time

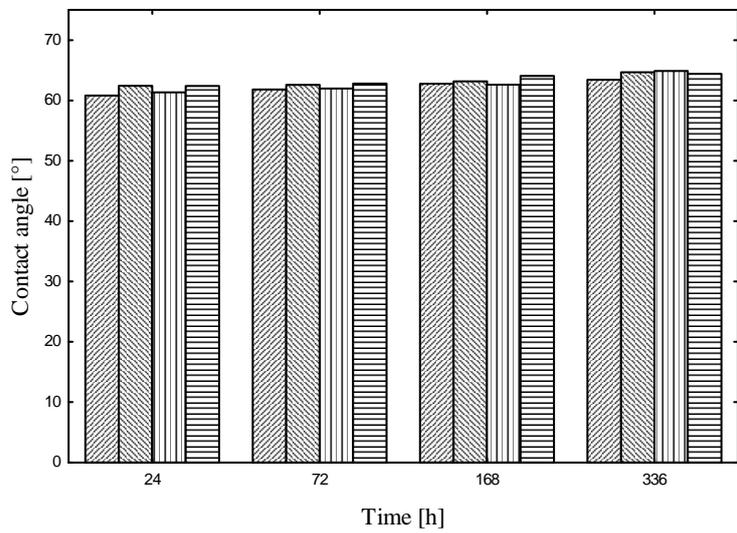


Fig. 2. The course of the angle Θ values of solidified layers on different substrates from the Klebit 304.5 adhesive vs. conditioning time

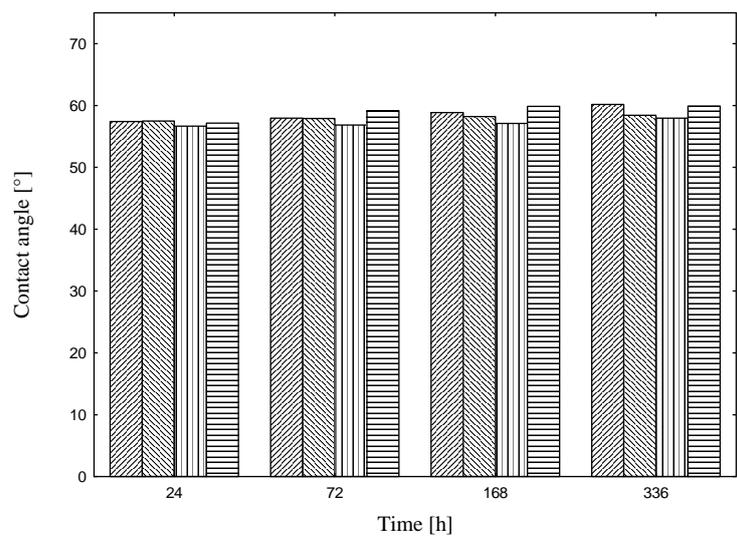


Fig. 3. The course of the angle Θ values of solidified layers on different substrates from the Klebit 510.0 adhesive vs. conditioning time

CONCLUSIONS

1. Contact angle values for the surface of solidified layers from various isocyanate adhesives formed on different substrates contained within the range $35\div 65^\circ$ values.
2. Differential values of the angle Θ resulted, first of all from the kind of the adhesives, and only in the decidedly smaller degree, with modified substrate.
3. During conditioning of layers it did not note down significant changes of the γ_S parameter, therefore, that the consolidation of adhesive layers processes, related to the evaporation of volatile components and with hardening processes in time 24 h.

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Streszczenie: *Badania zwilżalności warstw zestalonych klejów izocyjanianowych na termicznie modyfikowanym drewnie jesionu (*Fraxinus excelsior* L.). Dla zestalonych warstw z wybranych grup klejów izocyjanianowych, uformowanych na powierzchni drewna jesionu modyfikowanego w warunkach przemysłowych przy różnych parametrach określano kąt zwilżania (Θ) oraz wyznaczono swobodną energię powierzchniową wraz ze składowymi dyspersyjną i polarną. Pomiary kąta zwilżania przeprowadzono mikroskopem biologicznym z przystawką goniometryczną, odpowiednio po upływie czasu 24, 72, 168 i 336 h klimatyzowania próbek w warunkach RT i RH. Na podstawie rezultatów badań, m.in. stwierdzono, że wartości kąta Θ dla powierzchni zestalonych warstw z klejów izocyjanianowych uformowanych na różnych podłożach zawierały się w zakresie wartości 35÷65°. Zróżnicowanie wartości kąta Θ wynikało, przede wszystkim z rodzaju kleju, a jedynie w zdecydowanie mniejszym stopniu, związane było z modyfikowanym przy różnych parametrach drewnem. W czasie klimatyzowania warstw nie odnotowano znaczących zmian wartości swobodnej energii powierzchniowej.*

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