Drewno. Pr. Nauk. Donies. Komunik. 2010, vol. 53, nr 184

Mariusz KOT, Grzegorz KOWALUK

WOOD HYDROPHOBIZATION BY AMMONIUM IONIC LIQUIDS

Strongly hydrophobic ammonium ionic liquids penetrating the wood structure and protecting solid wood from water absorption were developed. By covering the surface of wood with ammonium ionic liquid the wood is hydrophobically and antiseptically protected for a long time. As it was mentioned above, swelling and water absorption of protected wood is several times less compared to unprotected wood. The dimensional stability is also improved.

Keywords: wood, ionic liquid, hydrophobization, swelling, water absorption

Introduction

Ionic liquids (IL's) are a class of chemical compounds composed of organic cations and organic or inorganic anions with melting points below 100°C [Welton 1999; Wasserscheid, Keim 2000; Wasserscheid, Welton 2008; Deetlefs, Seddon 2010; Dupont et al. 2002; Kichner 2009]. Typically IL's have broad liquid ranges, low vapour pressures, are thermally stable, and may be non-coordinating as well. They have attracted significant attention due to their potential application in wood preservation [Pernak et al. 2008; Stasiewicz et al. 2008; Pernak et al. 2004, 2005; Zabielska-Matejuk et al. 2004, 2008].

In this study the properties of one of the ammonium ionic liquids, i.e. didecyldimethylammonium dodecylbenzenesulfonate [DDA][ABS], are presented. The above-mentioned ionic liquid has been successfully synthesised in high yields by exchange reaction. The halide anion was replaced by new dodecylbenzenesulfonate anion. The new ionic liquid is solid in the room temperature, but in 55 degree Celsius it melts and becomes a highly hydrophobic oil. In this form it can be applied on wood surface.

Mariusz KOT, Poznan University of Technology, Wood Technology Institute, Poznan, Poland
e-mail: m_kot@itd.poznan.pl
Grzegorz KOWALUK, Wood Technology Institute, Poznan, Poland
e-mail: g_kowaluk@itd.poznan.pl

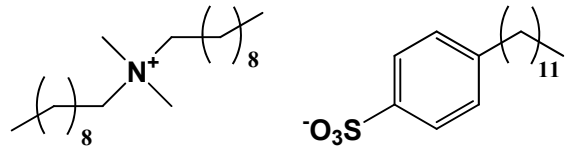

Fig. 1. Didecyldimethylammonium dodecylbenzenesulfonate [DDA][ABS]
Rys. 1. Dodecylobenzenosulfonian didecylodimetyloamoniowy [DDA][ABS]

The aim of the investigation was to verify the possibilities of wood hydrophobization using the ammonium ionic liquid. The investigation included measurement of water absorption by and swelling of solid wood impregnated with the above-mentioned liquid.

Materials and methods

Didecyldimethylammonium dodecylbenzenesulfonate used in the investigation is a solid substance when stored in the room temperature and changes to the liquid state when warmed up to a temperature of 70–90 deg. C in water bath.

Beech wood was used in the tests. 20 samples of the dimensions as in fig. 2 were prepared. The above-mentioned ionic liquid was applied on half of the samples by immersion. The excess of the liquid was mechanically removed. The average surface covering was about 80 g/m^2. On covering the samples with the ionic liquid all of them were conditioned at normal conditions (20 deg. C, 65% R.H.) for 18 hours.

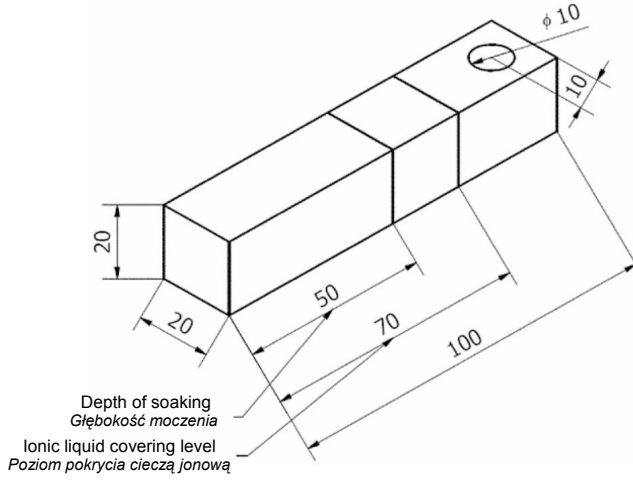

Fig. 2. The sample used for swelling and water absorption tests
Rys. 2. Próbka do badań spęcznienia i nasiąkliwości

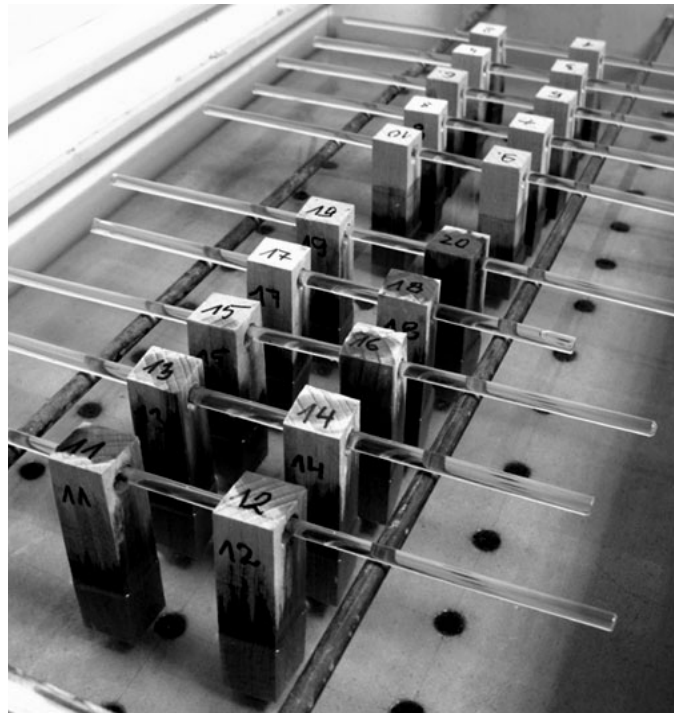

Fig. 3. The samples during soaking in water (unprotected samples at the front)
Rys. 3. Próbki podczas moczenia w wodzie (z przodu próbki niezabezpieczone)

The samples were soaked in water at the temperature of 20 deg. C for total time of 168 hours. During that time successive measurements of the dimensions and weight were made. The measurement of the dimensions was taken at the 25. mm of the sample length from the immersed end. The measurements were taken after 10 min, 30 min, 2 h, 6 h, 24 h, 72 h and 168 h since the immersion was started. The samples were immersed in water to the depth of 50 mm (fig. 3).

Results and discussion

The visual differences between the water absorption of the uncovered (unprotected) samples and the samples covered (protected) with the ammonium ionic liquid are shown in fig. 4. As it can be seen the most dynamic water uptake can be observed after the first 10–30 min from the beginning of the test. After 6 h from the test start the unprotected samples absorbed about 18% mass of water with the reference to the initial sample weight. At the same time the samples covered with the ionic liquid took less than 5% mass of water. After about 70–72

hours of soaking of the uncovered samples the intensity of the water absorption process got weaker. In the case of samples covered with the ionic liquid the dynamics of the water uptake was more regular and no changes similar to those which occurred in the case of unprotected samples were observed. After 7 days of soaking the total water uptake was over 60% in the case of unprotected samples and about 30% in the case of samples protected with the ionic liquid.

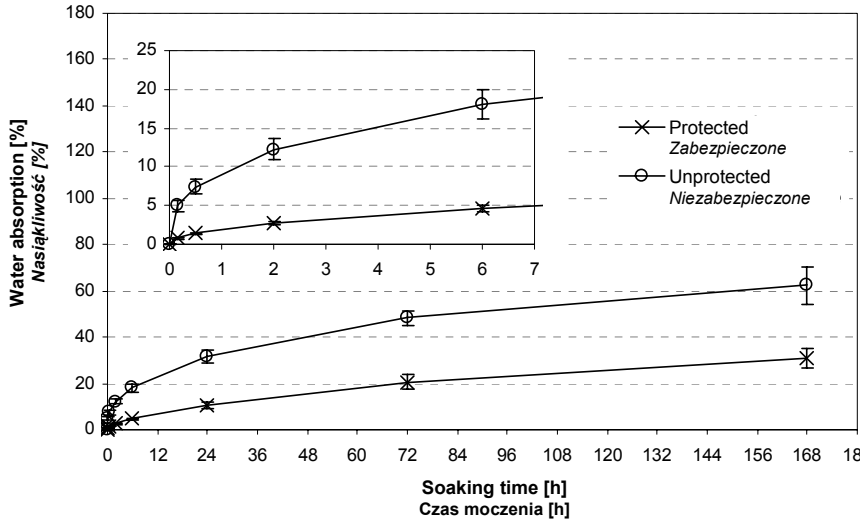

Fig. 4. The water absorption of the unprotected samples and the samples protected with the ionic liquid
Rys. 4. Nasiąkliwość próbek zabezpieczonych i niezabezpieczonych cieczą jonową

The swelling of the uncovered samples and the samples covered with the ammonium ionic liquid when soaked in water is presented in fig. 5. In comparison with the water absorption dynamics the biggest intensity of the swelling process could be observed during 2 initial hours of the test. The biggest differences between the intensity of swelling of both types of the samples were observed after 2 h of the test elapsed. Interestingly, in the case of unprotected samples the intensity of swelling decreased asymptotically after about 70–72 hours of the test, thus at the same time when water absorption decreased as well. After 7 days of soaking the swelling of all the samples (uncovered and covered with the ionic liquid) was almost the same. It can be pointed out, that the ammonium ionic liquid reduces water absorption by wood and, what was proved above, minimises the intensity of swelling of wood.

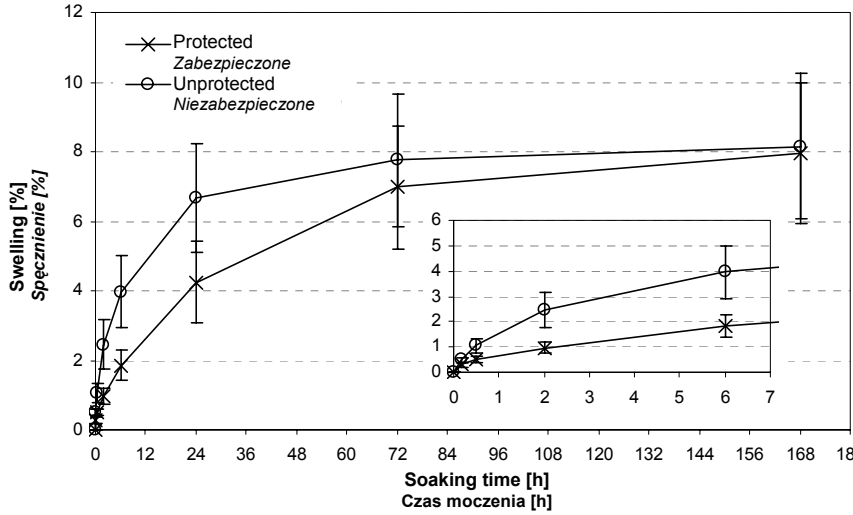

Fig. 5. The swelling of the unprotected samples and the samples protected with the ionic liquid
Rys. 5. Spęcznienie próbek zabezpieczonych i niezabezpieczonych cieczą jonową

Conclusions

The research has shown that the investigated ammonium ionic liquid ([DDA][ABS]) significantly minimises water absorption by wood. During the initial phase of soaking (i.e. after 10 minutes) the absorption by wood impregnated with the above-mentioned ionic liquid was over 6 times less in comparison with the untreated wood. That difference was getting smaller as the soaking time lengthened and after 7 days was about 2 times higher to the advantage of wood protected with the ionic liquid. The biggest difference (over 2.5 times bigger) between swelling of protected and unprotected wood was observed after about 2 hours of soaking. With time that difference was decreasing asymptotically. After the whole test (7 days) the swelling of protected and unprotected samples was almost equal.

Acknowledgements

This study was carried out with the financial support of the European Regional Development Fund within the framework of the Innovative Economy Operational Programme in Poland in the years 2007–2013, project number POIG.01.03.01-30-074/08 “Ionic liquids in innovative technologies connected with processing of lignocellulosic raw materials”.

References

Deetlefs M., Seddon K. [2010]: Assessing the greenness of some typical laboratory ionic liquid preparations. Green Chem. 12: 17–30

Dupont J., de Souza R.F., Suarez P. A. Z. [2002]: Ionic liquid (molten salt) phase organometallic catalysis. Chem. Rev. 102: 3667–3691

Kichner B. (vol. ed) [2009]: Ionic Liquids, Springer-Verlag Berlin, Heidelberg

Pernak J., Goc I., Fojutowski A. [2005]: Protic ionic liquids with organic anion as wood preservative. Holzforschung 59: 473–475

Pernak J., Jankowska N., Walkiewicz F., Jankowska A. [2008]: The use of ionic liquids in strategies for saving and preserving cultural artifacts. Polish J. Chem. 82: 2227–2230

Pernak J., Zabielska-Matejuk J., Kropacz A., Foksowicz-Flaczyk J. [2004]: Ionic liquids in wood preservation. Holzforschung 58: 286–291

Stasiewicz M., Fojutowski A., Kropacz A., Pernak J. [2008]: 1-Alkoxymethyl-X-dimethylaminopyridinium-base ionic liquids in wood preservation. Holzforschung 62: 309–317

Wasserscheid P., Keim W. [2000]: Selective trimerization of α-olefins with triazacyclohexane complexes of chromium as catalysts. Angew. Chem. Int. Ed. 39: 3772–3789

Wasserscheid P., Welton T. [2008]: Ionic Liquids in Synthesis, Wiley-VCH

Welton T. [1999]: Room-Temperature Ionic Liquids. Chem. Rev. 99: 2071–2084

Zabielska-Matejuk J., Stangierska A., Skrzypczak A. [2008]: Badania aktywności hydrofilowych i hydrofobowych cieczy jonowych w stosunku do grzybów rozkładu szarego oraz procesów ich sorpcji na glebie. DREWNO-WOOD 2008 [51]179: 5–28

Zabielska-Matejuk J., Urbanik E., Pernak J. [2004]: New bis-quaternary ammonium and bis-imidazolium chloride wood preservatives. Holzforschung 58: 292–299

HYDROFOBIZACJA DREWNA ZA POMOCĄ AMONIOWYCH CIECZY JONOWYCH

Streszczenie

Opracowano ciecze jonowe, o charakterze bardzo silnie hydrofobowym, które przenikając do struktury drewna zabezpieczają ją przed wnikaniem wody. Poprzez powierzchniowe naniesienie cieczy jonowej uzyskuje się drewno odporne przez długi czas na działanie wody oraz posiadające powierzchnię antyseptyczną. Drewno zabezpieczone w opisany sposób charakteryzuje się kilkakrotnie mniejszą nasiąkliwością i spęcznieniem, jak również mniejszymi odkształceniami, w porównaniu z drewnem niezabezpieczonym.

Słowa kluczowe: drewno, ciecz jonowa, hydrofobizacja, pęcznienie, nasiąkliwość