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INVESTIGATION OF INTERACTION OF BASIC COMPONENTS OF THE WOOD WITH UREA FORMALDEHYDE RESIN

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ABSTRACT

The quantity of the wood components (cellulose, lignin, holocellulose) before and after interaction with urea formaldehyde resin (UFR), their nitrogen content and IR spectra were investigated. Increasing of the quantity of these components and of their nitrogen content was established. New bands, belonging to UFR were registered in IR spectra.

Key words: wood, UFR, cellulose, holocellulose, lignin, WPB

INTRODUCTION

Urea formaldehyde resins comprise about 80 % of the amino resins produced worldwide. These resins are the most prominent examples of the class of thermosetting resins usually referred to as amino resins (Updegraff 1990; Wiliams 1991).

The use of urea-formaldehyde resins as a major adhesive by the forest products industry is due to a number of advantages, including low cost, ease of use under a wide variety of curing conditions, low cure temperatures, water solubility, resistance to microorganisms and to abrasion, hardness, excellent thermal properties, and lack of colour, especially of the cured resin.

It is known that wood contains about 0,2 % nitrogen, mainly in the soluble components (Draganova 1976). Their quantity and composition depend not only on tree species, but also by geographic region. For example, in oak, raised in our latitudes tannin is contained in quantities below 1 %, while in Sudan there is trees over 25 % tannin (Hristova et al. 1999), due to very intense solar radiation in this country.

One of the most famous authors in the field of wood composites with synthetic resins A. Pizzi has investigated the effect of crystallinity of wood cellulose on its adhesion with urea-formaldehyde resin (UFR), (Pizzi 1990). Pizzi found an inverse relationship that the increasing of crystallinity led to decreasing of adhesion. Other researchers have found that some components of wood at temperatures up to 40 ^{o}C interact with the resulting free formaldehyde, i.e. form new compounds, which lead to the reduction of formaldehyde emission. (Schäfer and Roffael 2000). However, this mainly refers to the soluble constituents of the wood. It was established the melt penetration of UFR into the wood (Sernek et al. 1999). Fr. A. Kamke и Jong N. Lee have determined the penetration as a major method for investigation of tree composites with resins (Kamke and Lee 2007). Rials and coauthors discussed using of infrared spectroscopy to predict the mechanical properties of wood composites (Rials et al., 2002). This article, however, does not explain the interaction between the components of wood with resins. Using NMR spectroscopy and dynamic mechanical analysis was confirmed that UFR penetrates into the wood, thus led to increasing and improving the characteristics of the resulting composites (Marcinco et al. 1998). This article also does not give an answer weather there is an interaction be-

tween tested composites by forming new compounds and chemical bonds.

This theoretical formulation virtually loses its meaning, because the improvement of characteristics is achieved for all products of wood composites with UFR. On the other hand the resin penetrates into the wood and the separation of the components is impossible due to cross-linking of the resin. The aim of the present research is attempting to explain this theoretical question by determining the changes in nitrogen content of wood components (cellulose, lignin, holocellulose) and by infrared spectroscopy, before and after formation of composite – particleboard with UFR.

MATERIALS AND METHODS

Isolation of components - cellulose, lignin, holocellulose from the starting wood material and particleboard samples was carried out by standard methods. Quantitative analysis of these compounds was performed using standard methods for accuracy 0,0001 g, after drying at 105 ºC to constant mass. The nitrogen content of the samples was determined by the Kjeldahl method. Infrared spectra of the various samples in potassium bromide pellets were obtained using Specord 71 IR, Karl Zeiss, (Germany) spectrophotometer.

RESULTS AND DISCUSSION

During the laboratory analysis, the soluble components were not separated from the wood samples, although existing methodologies to ensure the identity with wood samples in particleboard received from the factory materials with UFR. After separation of cellulose, lignin, holocellulose in both materials their quantities were determined. The obtained results are presented in Table 1.

Table 1: Quantities and differences (Δ) of the components

№	Sample	Lignin [%]	Δ [%]	Cellulose [%]	Δ [%]	Holocellulose [%]	Δ [%]
1	Starting wood material	24,77	-	39,72	-	51,94	-
2	Particleboard	28,72	15,95	44,91	13,07	54,38	4,7

The increase (Δ) in the values of the analyzed components quantities decreases in the order:

Lignin > Cellulose > Holocellulose (1)

It is known, that the amount of the UFR in particleboard manufacturing is about 8 %.

The increase in amount of lignin with approximately 16 % is an indication that UFR reacts mainly with it. This can be explained by the structure of lignin. It is known that it contains carboxyl, hydroxyl and other polar groups that can react with UFR methylol groups. It is more difficult to explain the great difference in values of Δ at cellulose and holocellulose. The probable explanation is that holocellulose, which is distributed mainly in the walls of the wood cells and cross-linked with tannin, has no possibility of impregnation with UFR as observed in cellulose. Data on the nitrogen content of the studied samples are given in Table 2.

Table 2: Nitrogen content, %

Sample	Nitrogen [%]	Lignin [%]	Cellulose [%]	Holocellulose [%]
Wood	0,36	0,09	0,08	0,04
Particleboard	1,44	1,58	0,14	0,06

The components of studied materials by nitrogen content are listed in order, identical to the one shown above (1):

Lignin > Cellulose > Holocellulose (2)

The same order of the components in (1) and (2) showed that analysis is accomplished correctly.

There are no significant differences in the IR spectra of cellulose and holocellulose isolated from wood and particleboard, probably due to the low values of the UFR quantities in these materials and the accuracy of the analytical method. It is known that with Specord 71 IR, Karl Zeiss, can be found compounds and groups of atoms with concentrations up to 5 %. This fact can not be explained in any other way, because in both materials there is cross-linked UFR. This explanation is confirmed by the spectrum of lignin isolated from particleboard. This spectrum data indicated a band at 1680 cm^{-1} characteristic for carbonyl group of urea in UFR. The band at 1635 – 1645 cm^{-1} corresponds to the overlay of bending vibrations for NH groups with vibrations of different C – O bonds, while the band at 1550 cm^{-1} is assigned to peptide group and the band at 1245 cm^{-1} for C – N bond. All these bands obtained by IR spectral analyses are characteristic for UFR.

CONCLUSION

From the performed investigations of cellulose, lignin and holocellulose quantities, their nitrogen content and IR spectra before and after interaction of particleboards with UFR was established increasing in the quantities of these components, as well as in their nitrogen content. It was registered new bands in IR spectra characteristic for UFR.

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