INTERACTION OF COPPER WOOD PRESERVATIVES AND ADHESIVES

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Introduction

Compared to other substrates, wood is generally easy to bond. However, adhesion is diminished when the wood surface is covered by chemicals, whether natural oils and resins or added chemicals. Among the chemicals added to wood are fire retardants and wood preservatives. Chromated copper arsenate (CCA) has been widely used to protect wood against rot and termites, but concern about the toxicity of arsenic is leading companies to turn to other treatment chemicals (1). The two most prominent chemicals for replacing CCA in treating wood are ammonical copper quat (ACQ) and copper azole (CAz).

Most treatment chemicals tend to reduce the strength of wood bonds (2). In fact, the bonds of CCA-treated wood have been found to be less durable than those of untreated wood (3). The lack of adhesion is usually revealed by an environmental resistance test, which is critical since preservative-treated wood is often exposed to water. Exposure to water and drying is a severe test for wood adhesion since the bond has to withstand the expansion and shrinking that occurs when the wood picks up and loses moisture content, as well as the thermal expansion and contraction of the wood (4).

The reduced adhesion of treated wood can be the result of a number of factors. For example, nodules of CCA on the wood surface can limit adhesion (5). However, treatment with CCA does not accelerate the cure of the adhesive (6). There is little in the literature on bonds of ACQ- and CAz-treated woods.

Experimental

For these experiments, we used the higher levels of treatment that are designed for wood in ground contact to emphasize bond strength differences. The phenol-resorcinol-formaldehyde (PRF) adhesive was a commercial formulation used for bonding of CCA-treated wood. The adhesion testing was done according to the wetting and drying cycles of ASTM D 2559-00 (7). This is a three cycle test involving vacuum de-aeration, water soaking, and oven drying, with steaming added in the second cycle. The amount of delamination is determined after the third cycle.

One way to test the effect of chemicals on the cure of the adhesive resin is to measure the peak temperature and the heat generated during the curing process, using differential scanning calorimetry (DSC). To ensure that water loss did not complicate the results, DSC was run in sealed pans using a Perkin Elmer DSC 7. The wood powder was mixed with the adhesive shortly before the measurement.

Results and Discussion

Treated laminated wood is generally used for exterior structural applications. Thus, the adhesive used in our study is one that would pass tests for creep. The question is how well the bonded assembly withstands the forces from the expansion and shrinking of wood during water gain and loss in exposure to the elements. The most severe test is usually considered to be ASTM D 2559. After the water soaking and drying cycles, significant cracking of the wood occurs, but what is of concern is delamination along the bondline. Therefore, the results of this test are a measure of the percentage of failure of the bond. Whether the failure takes place in the adhesive, the adhesive interphase, the interface between the wood and adhesive, or the wood interphase is not recorded in this test.

Since ACQ and CAz appear to be the most likely replacements for CCA, we tested wood treated with these chemicals against CCA-treated and untreated wood. Because adhesives are formulated for specific purposes, we used a commercial PRF that is used for exterior structural applications. One striking result was the good adhesion of the CCA-treated wood, as well as the untreated wood (Table 1). The delamination rate was higher with the CAz-treated wood and highest with the ACQ-treated wood. The higher rate of delamination may be due to a difference in the chemistry, topology, or morphology of the additive on the surface of the wood.

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Table 1. Bonding of Southern Yellow Pine with PRF Adhesive.	
Treatment	**Delamination (%)**
None	1.7-3.0
CCA	0.4-1.2
CAz	2.0-8.9
ACQ	6.5-44

One concern is that additive chemicals change the chemistry of the adhesive. Inhibiting the cure can lead to a weak interphase layer in the adhesive, while accelerating the cure can reduce penetration of the adhesive into the wood. One way to look at the cure is gel time, but adding wood powder greatly increases the measured gel time, making this method less reliable. On the other hand, the peak exothermic temperature in DSC can also indicate if the treated wood is affecting the cure of the adhesive (6). Wood treated with the selected additives was ground and mixed with the adhesive prior to running the DSC experiment. As previously reported with a phenol-formaldehyde adhesive, the CCA-treated wood did not cause a change in the curing temperature of the phenol-resorcinol-formaldehyde resin (Table 2). In ACQ- and CAz-treated wood, the cure rate was accelerated (lowering of exothermic temperature) as a result of the copper mixture (Cu), not the quat portion (BAC).

Table 2. DSC Data for PRF Adhesive With Different Treatment Chemicals		
Additive	**Peak Temperature (°C)**	**Delta H (J/g)**
None	82.1	43.2
CCA	81.8	46.8
Caz	77.8	42.7
ACQ	75.6	32.6
Cu	74.0	30.5
BAC	81.6	39.8

For difficult to bond woods, hydroxymethylated resorcinol (HMR) was found to be effective in improving bond strength as determined by delamination in ASTM D 2559 treatment cycles (3). The HMR primer was also effective in reducing delamination of CAz-treated wood from 5% (unprimed wood) to 1% (primed wood) and in reducing delamination of ACQ-treated wood from 17% to 5%.

Concluding Remarks

Wood generally becomes a more difficult substrate to bond when treated with chemicals such as preservatives and fire retardants, which can interfere with the rates of reaction of the adhesive or block the surface available for bonding. Treatment with chromated copper arsenate (CCA) has been found to block the surface for adhesion, but it does not affect the curing of the adhesive. We studied the bonding of wood treated with ammonical copper quat (ACQ) and copper azole (CAz), the most likely replacements for CCA. In using a phenol-resorcinol-formaldehyde adhesive formulated for bonding treated wood, we found that the resistance to delamination was in the order of CCA>CAz>ACQ. A similar order was observed for the treated wood in the acceleration of cure as measured by the peak exothermic temperature using differential scanning calorimetry.

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