Wood modification

the alternative to heavy metal impregnation

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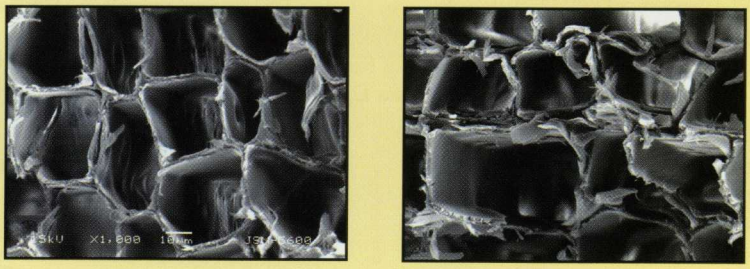
Professor Colin Birkinshaw and Seamus Dolan of the University of Limerick explain about the environmentally friendly options.

Wood continues to be the material of choice for numerous structural applications, but it is often necessary to provide some form of protection against wood destroying fungi. Historically, this has been done by impregnation with either a heavy metal system, such as copper-chromium-arsenic (CCA) or creosote. Although there is no question that these technologies are effective, they are certainly at odds with modern concerns about environmental impact, and waste wood impregnated with these materials is now defined as hazardous. Such concerns have driven the search for alternatives and although totally organic preservatives are available, a more novel approach is to modify the chemical structure of the wood in such a way that it becomes less attractive to the fungus as a food source. Two approaches, chemical modification and thermal modification, have now been evaluated for their effectiveness with fast grown Irish timber.

Chemical modification, of which acetylation is the most developed, works through esterification of the hydroxyl groups on all of the three main wood polymers, cellulose, hemicellulose and lignin. Typically, the wood will be brought to an almost dry condition and then reacted with acetic anhydride to give a weight gain of between 16% and 20%. A double benefit is conferred; first the wood is less hygroscopic and therefore more dimensionally stable, and, secondly; the resistance to fungal decay is greatly improved. The reasons for the decay resistance are not fully understood, as a simple explanation such as prevention of fungal enzymes recognizing the modified substrate can be contradicted by published evidence of cellulose acetate decay. It is, however possible, that some form of steric protection, by the larger acetate group, is occurring.

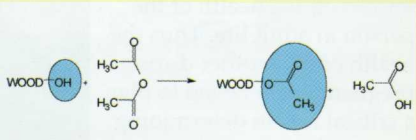


Fracture surfaces of Sitka spruce, a) control and b) heat treated, showing cell wall delamination, probably caused by degradation of hemicellulose binding agent.

Importantly, acetylated wood looks and feels like untreated wood and shows no significant mechanical property loss.

Thermal modification, in which the wood is held at temperatures around 200^{0}C, under vacuum or steam, seems to work through degradation of the hemicellulose removing available carbohydrate, and also through alteration of the substrate by modification of the lignin structure. Again, equilibrium moisture content is reduced and there are appreciable improvements in fungal resistance, but this process is not as effective as chemical modification in these respects and a significant drawback is that the wood is embrittled.

Two evaluation exercises with fast grown native timbers have been supported by COFORD and carried out by the University of Limerick. Sitka spruce, lodgepole pine and Japanese larch, among the most abundant timbers in Ireland, were subject to acetylation or to heat treatment and then tested against controls. Acetylation proved its effectiveness in giving a highly stable and durable product, fully resistant to aggressive brown rot organisms such as *Coniophera puteana*. Heat treatment gave materials with enhanced stability and durability, but clearly not good enough for ground contact applications. Embrittlement was substantial, with a loss of up to 40% in the modulus of rupture, and electron microscopy demonstrated that this could be ascribed to delamination in the middle lamella and the cell wall. Problems encountered with both processes were distortion and cracking caused by the severe drying required. This puts intolerable stresses on timber that does not have a perfectly true and even grain.



The reaction of wood polymers with acetic anhydride. Reaction occurs within the cell wall, causing significant bulking. The acetic acid formed must be removed to prevent corrosion of fixings.

There are also cost issues as modified wood, particularly acetylated wood, is much more expensive than treatment with CCA or creosote, and timber for the process will have to be specially selected. There are markets where modified wood materials are beginning to gain a share, but these are mainly in high value end-uses (such as exterior cladding), and to treat them as simple replacements for impregnated timber is probably inappropriate. It is clear, however, that they present no environmental hazard and no waste disposal problems arise, but it is still difficult to predict the future of wood modification in Ireland. Environmental pressures have to be balanced against process cost and effectiveness, and the final decision equation is also likely to have to take account of public perception of the timber industries.