

Wood Protection without Biocides: a Perspective

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Introduction

It is a reality that wood preservation is viewed by many as an entrenched industry where change occurs slowly, or not at all. The latter is personified by the first industrial wood preservative, creosote, which was developed in the 1830s for the treatment of crossties and remains the dominant, perhaps almost sole, treatment for this application even today, some 180 years after its commercialization. However, change does occur, and in some sectors the pace of change has increased rapidly over the last 30 years. Most developments in wood protection chemicals over the last century have been driven by sought-after environmental benefits. These can be toxicological, eco-toxicological or a combination of these. A more recent reality is that the available biocides for use in wood protection are becoming limited and unlikely to expand rapidly in the future as the wood protection industry is dependent on developments in other fields such as agriculture for new biocides. Most such developments are focused on herbicides and insecticides, but the primary need in wood protection is for fungicides, and developments in this area are significantly lower. Also, the fungicide developments are increasingly targeted towards control of specific organisms. This can be contrasted with wood protection needs, where products are subjected to a plethora of microorganisms and where biodegradation of the biocide is not a sought after characteristic, at least during the service period.

This reality of future biocide availability is a driver in the emergence of interest in wood protection without biocides. This is manifesting in two ways, thermal modification of wood, and modification of wood with non-biocidal chemicals. Neither of these approaches is new, indeed most date back to the 1930s, or beyond. But the changes in the marketplace for treated wood products, plus competition from manufactured materials such as wood plastic composites (WPC) and plastic composites, is spurring interest in providing competitive treated products that provide the natural appearance of wood, and provide wood stability in service beyond that achieved with current commodity preservatives.

Initial long term uses of wood relied on utilization of the heartwood of naturally durable species. Over time increasing human population overtook availability of old growth forests. In some species (e.g. redwood, cedar) excellent natural biodeterioration protection was accompanied by stable wood properties in use. Today, the availability of such old-growth material is greatly diminished, and unlikely to be seen again in the foreseeable future.

As I was once told by a prominent wood preservative treater who is also WPC manufacturer, “my challenge is to make WPC look like wood, your challenge is to make treated wood behave like WPC during weathering in service”.

Options to achieve this include the use of naturally durable and stable wood species, but as mentioned earlier this is a diminishing resource, and the second growth and plantation grown wood from such species can have markedly different properties compared with their old growth predecessors. The use of conventional water borne wood preservatives on their own generally has little positive impact on wood appearance in service, while water repellent treatments can provide major improvements but are preservative dependent and do not provide true dimensional stabilization. Thermal treatments appear to provide some positive help but their ability to protect wood from decay and insects requires additional treatments to be viable in exposed situations. On the other hand wood modification can lead to true dimensional stabilization, but such technologies need to be robust commercially in order to achieve more than niche player status.

History

In North America, the most significant developments on a range of wood modification technologies were led by Alfred Stamm at the Forest Products Laboratory starting in the late 1930s. Later work over the last 40 years by Roger Rowell, also at the FPL, furthered these developments, with a major focus on acetylation. During this time European interest in wood modification grew and is today a significant focus of European wood product protection research. These European developments have been vibrant for the last 20 years, and have moved forward with commercialization of several technologies. Japan has had an active development program for 40 years with commercialization focused initially on specialty products, although some developments are now spreading into structural lumber applications.

Economic Realities of Wood Modification

Unlike conventional wood protection with biocides, wood modification requires the use of much higher retentions in order to provide the protection necessary against biological and weathering vectors. In addition, some wood modification technologies have significantly different processing costs than is the norm in wood preservation with water-based biocide formulations.

Challenges

Because of the substantially different cost of modified wood, a significant investment in marketing to the end user will be necessary to overcome the cost premium over commodity treated wood as we know it today. Initially the targeted competition will likely be WPC and naturally durable wood species, as well as alternate materials such as stone patios. Eventual opportunities for larger scale acceptance will likely depend on regulatory, cost and market drivers in regards to metallic preservatives and organic biocides.

A further challenge with some wood modification technologies relates to the current industry structure and how this differs from some of the modification systems being commercialized. The current structure in wood treatment generally is Chemical manufacturer to wood protection chemical company to wood treater to retailer to user. By contrast for some wood modification systems the most likely supply chain structure will be Chemical manufacturer/wood modifier to retailer to user. Given that such a supply chain would disenfranchise two of the current core constituencies in the supply chain, this scenario may face competitive push back.

Quality control and completeness of treatment will be an absolute necessity in the use of wood modification. With wood modification, be it chemical modification or thermal treatment, providing incomplete processing will be disastrous for various aspects of product integrity in service. While this applies to biocidal treatments also, where untreated sapwood zones and non-durable heartwood is increasingly susceptible as lower mobility treatments are used, in general some, but not all, biocides have a modicum of mobility that can provide a modest degree of protection even in poorly processed treatment. This is not the case with modified wood products.

Perhaps the greatest challenge to widespread usage of chemically modified wood relates to the availability of a suitable and economically competitive wood resource. When one considers that chemical modification of wood is defined by treatment add-on on a wt/wt basis, and with very high (by conventional preservative standards) percent product usage, wood species density has a major impact on the cost of the finished material. As an example, radiata pine has a density of 400-450 kg/m³, compared with southern pines & Scots pine densities being around 500-520 kg/m³. This factor alone means that approximately 20% more modification chemical is needed for southern pine and Scots pine than for radiata pine for any given volume of lumber.

Beyond the chemical usage aspect, the wood modification industry, in order to provide attractive products at the least cost possible given the level of treatment required, are building the industry on the use of clear radiata pine from pruned forests in the Southern Hemisphere. This not only provides superior appearance to the product, but there is some evidence that the relatively low density differentiation between earlywood and latewood in radiata pine lumber actually contributes to lower propensity to crack and split, and this appears to be the case when compared to many current southern pine lumber sources.

A further factor may be that while *Pinus radiata* is known to be an extremely treatable species, its treatment pathways are almost entirely radial. Tangential penetration is unusually low. Whether this differentiation has an impact on weathering performance during exposure in service is currently being investigated.

It seems timely that those using or considering the use of wood modification address the wood resource issue, as the amount of pruned radiata pine available is unlikely to satisfy the potential demand should wood modification become a mainstream lumber treatment. It is apparent that

for high end appearance products, consumers prefer that their substrate have no knots. This can be achieved from clear wood or from finger-jointed product. As stated above, for now radiata pine clear wood from high-pruned trees is the preferred substrate. However, other options must be developed.

Perhaps the most obvious among the softwoods is the use of plantation loblolly pine (*Pinus taeda*). There are already active plantations of loblolly in North and South America although high pruning is not a common practice it appears. Some reports suggest that in warmer climates high pruning can lead to insect ingress into the tree, with negative consequences. However, the potential for exploiting this option are good, and the density of some plantation loblolly pine is close to that of radiata pine, which would be a positive economic driver for further development.

Another resource that should be considered, but which probably requires much further work to determine performance criteria, is the use of plantation hardwoods. Potential species include *Populus* sp., *Paulownia*, *Acacia* sp., *Hevea* (rubberwood), as well as some *Eucalyptus* species. However, in general, low lignin hardwoods are more susceptible to decay than softwoods and require higher levels of protectants. Whether this is also the case with wood subjected to chemical modification is not clear, but if so would have a negative impact on the use of plantation hardwood lumber, all other things being equal.

Ideal criteria to bring chemical wood modification into widespread use

The most appropriate technologies will be water-based, the technologies should be compatible with current treatment plants for large scale commercial success, and the cost of modified treated wood should be competitive with WPC and naturally durable wood such as redwood of a suitable durability and stability.

Conclusions

Change is inevitable, even in the world of wood protection. Over the last decade the number of biocides available for use in wood protection has been in steady decline. At present, thermal treatments appear insufficient for even moderate exposure decay or termite hazards without augmentation with water repellents and/or biocides, which is somewhat counter-intuitive to the use of a modification technology. Chemical wood modification technologies are well developed but commercialization remains immature.

We believe that wood substrate sources and supply require thought and development, if wood modification is to achieve widespread acceptance and use. However, we believe that such future widespread commercialization is very likely at some point in the not too distant future.