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An Overview on New Generation of Preservation Treatments for Wood-Based Panels and Other Engineered Wood Products

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October, 2003

SEVENTH EUROPEAN PANEL PRODUCTS SYMPOSIUM

North Wales Conference Centre

Llandudno · UK

AN OVERVIEW ON NEW GENERATION OF PRESERVATION TREATMENTS FOR WOOD-BASED PANELS AND OTHER ENGINEERED WOOD PRODUCTS

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SUMMARY

A host of new treatments are being developed for protecting wood-based panels and other engineered wood building products against biological elements. The major impetus for this need for better protection is the expansion of the use of these materials to applications exposing them to greater biological hazards. This document summarises protection needs, treatment methods, and treatment chemistries for wood-based panel and engineered wood products including plywood, OSB, LVL, MDF, and particleboard. Also discussed are test methods, both conventional and novel, which are being used to determine efficacy and durability of treatments applied to these products for mould, termite and decay resistance.

INTRODUCTION

Wood-based panel products and other types of engineered wood are widely used as building materials. In some applications, however, use is limited by concerns over the long-term durability of these materials where agents of deterioration such as mould, decay, insects (primarily termites) and moisture may be present. For solid lumber building materials durability concerns have historically been addressed through the use of chemical treatments employing a variety of application methods including pressure impregnation, immersion, diffusion, and vacuum-assisted treatments. With the exception of pressure-treated plywood, chemical treatments have not been widely used to enhance the durability of wood-based panel products. In many cases traditional treatment methods have not proven to be practical or effective enough for materials such as OSB, LVL, MDF, or particleboard. Currently however, a new generation of treatments and treating methods are being developed to meet the challenge of enhancing the durability of these building materials.

PROTECTION NEEDS

While it is desirable to enhance the durability of wood-based panel products, the addition of preservative, insecticide and water repellent treatments inevitably increases their cost. Offsetting these product cost considerations are a number of factors that are driving the need for more protection.

Mould

In the United States, concerns over indoor air quality have been prevalent for a number of years. In the past, those concerns have revolved around purported hazards from materials such as asbestos, radon, and formaldehyde and from second-hand tobacco smoke. Since 1999, widespread media coverage has given rise to homeowner concerns over potential toxins emitted from mould. While it remains to be scientifically determined whether mould-related health concerns constitute true hazards or are manifestations of homeowner hysteria, it is clear that plaintiffs' attorneys, insurers, builders, product manufacturers and government agencies are taking them seriously. According to the Insurance Information Institute, there are currently 10,000 mould-related lawsuits pending in the USA. In 2002 a Texas jury ruled that Farmers Insurance Group had to pay a family $32 million for damages related to a mould-infested home. The award was reduced to $4 million by an appeals court, but the attention drawn by the case has led to the filing of similar lawsuits nationwide.

Decay

Degradation of wood-based panel products due to fungal attack is a problem which is not limited to mould issues inside the home. Some manufacturers of hardboard siding have had to deal with decay issues in areas of the USA which are well suited to fungal growth. While decay is generally not considered a human health hazard in the same category as mould, it can result in significant property damage. Decay claims in hardboard siding have been costly to manufacturers and have caused several producers to abandon this market.

Termites

Widespread infestations of the Formosan termite (*Coptotermes formosanus*) in southern Louisiana have caused damage estimated in the hundreds of millions of dollars. Formosan termites pose a major threat to wood-based panel products and all cellulosic building materials because they consume wood much faster than native subterranean termites, and they grow colonies that can be ten times larger than those of native termites. Due to the spread of Formosan termites in infested recycled railroad crossties (sleepers), there is a serious concern that this voracious pest will soon threaten other parts of the South and Gulf Coast of the USA. Wood composites are particularly vulnerable to termite attack if unprotected. The good news is that these materials can be successfully protected by treatment with insecticides, as has been standard practice in Japan and Hawaii for a number of years.

Moisture

Most wood-based panel products such as OSB, MDF and hardboard are susceptible to damage from excessive amounts of moisture. This can cause swelling, delamination and loss of strength properties. Common moisture sources include rain and snow during storage and the construction process, humidity and condensation inside wall cavities, plumbing leaks, flooding and rainwater intrusion due to faulty construction or design. Excessive or repeated moisture contact can be especially devastating since it can lead to mould growth and decay and can be an attractant to insects.

In addition to the cost of claims and litigation, a more significant threat to producers is the erosion of market share to non-wood based building materials. In Hawaii, for example, steel framing has taken over the market from wood framing due mainly to concerns over wood's vulnerability to attack from termites. Real or perceived weaknesses of wood and wood-based composites relating to vulnerabilities to mould, decay, insects or water damage pose a meaningful threat to the future markets for these products as building materials.

In response to these factors, wood composite manufacturers have begun to treat their products to help protect against mould, decay, termites and water damage. Globally, products are now being treated in Japan, Australia, New Zealand, and in North, Central and South America. In the USA, hardboard, MDF, OSB, and LSL are some of the products currently being treated. European producers have recently begun to see the advantages of treatment, as well.

TREATMENT METHODS

Solid wood products have been historically treated by a variety of methods. These include immersion (fence posts, millwork in the USA), Vac-Vac (joinery in the UK and other European countries), diffusion (poles, ties, lumber and logs), and pressure impregnation (poles, ties and decking lumber).

For engineered wood and wood composites the situation is a bit different. Commonly used methods include surface, glue line, pressure and integral treatments. A brief discussion of each method follows.

Surface treatments are applied to wood-based panel products either through immersion or spray applications. These afford an envelope of protection to the substrate and are mainly designed to provide short-term resistance to mold, decay and water intrusion. They are often utilised to protect building materials through transportation, storage and the construction process. Their major advantage is that they are relatively easy to apply and are very cost effective.

A recent innovation is the combination of surface treatments with diffusibles such as borates to form what we have termed a "penetrating barrier" of protection. In these systems, the face components remain at the surface where they are most needed to form a protective barrier against mold, insects and surface moisture. The diffusibles penetrate to provide deeper protection against decay and insects. Penetrating barrier treatments are also relatively easy to apply to most wood composites and they are very cost-effective compared to other methods of treatment. They can be used to protect plywood, particleboard, LVL, MDF, OSB, and I-joists.

Glue line treatments are mainly used for insect protection. They are applicable in products made from glue veneers such as plywood and LVL. Active ingredients are incorporated into the glue or resin system. In order to be effective, they must be able to withstand processing temperatures and be able to migrate into the veneers. Obviously, they must also be compatible with the glue systems so that they do not interfere with the curing process.

Pressure treatment of plywood has been in commercial use for many years to afford protection against decay and termites. Fire retardants are also applied in pressure processes. Plywood is one of the few engineered wood products that can be successfully pressure treated with water-based carriers. Other types of engineered wood and wood composites such as OSB, MDF, and LVL can only be pressure treated with LOSP systems such as mineral spirits. This type of treatment has been protecting engineered wood building materials in Hawaii from decay and termites for more than 20 years.

We use the term "integral treatment" to refer to the process whereby the active preservative ingredients are combined with the wood furnish (i.e., chips, flakes, strands, etc.) before processing. Active ingredients can include fungicides, insecticides and water repellents, either singly or in combination. They are often applied to the furnish in tumblers to assure good distribution throughout the treated component. Water, waxes or resins are used as the carriers for liquid systems. Powders can also be used. Ingredients must be capable of withstanding the processing temperatures associated with production, and they must be compatible with the resins used. Since they are distributed throughout the thickness of the substrate, integral treatments can offer long term protection against decay, mould, insect attack and water intrusion. Currently, integral treatments are used commercially to protect LSL, OSB, hardboard and MDF.

TREATMENT CHEMISTRIES

Active ingredients for the treatment of wood-based composites and panel products can be comprised of inorganic or organic materials.

Inorganic borates are used for both surface and integral treatments. As noted previously, their ability to diffuse into engineered wood products makes them useful as components of penetrating barrier surface treatments. Disodium octaborate tetrahydrate (DOT), often marketed as Timbor, is one such borate salt. For integral treatments, zinc borate is used to provide decay and insect resistance. It is combined with the wood strands or fibres as either a powder or liquid dispersion prior to processing of the panel product. Calcium borate can also be used in this application, although it is not at this time registered as a wood preserve with the U. S. EPA.

Organic ingredients must be capable of withstanding processing temperatures of up to 220° C if they are utilised as integral treatments. Materials that have been successfully employed as integral treatments include fungicides based on iodocarbamates, triazoles, and isothiazalones, and insecticides based on synthetic pyrethriods and nicotinimides. Surface treatments utilise many of the same chemistries.

Water repellents can be comprised of waxes, or other polymers and resins. These components are used in both surface and integral treatments.

TEST METHODS

Historically, established testing methods for new wood treatments often require 5 to 15 years of testing before market entry. There is a great need, however to reduce this time significantly. This can only be done if proper testing methods providing quality and appropriate data can be developed on the long-term efficacy of treated wood-based products. The need for shorter testing times is due to changing criteria for wood-based products in service and the desire for availability of new environmentally sensitive and safe preservatives. In addition, increasing health concerns by the general public on mould growth in structures are driving the need for development of new mould treatments. New treatments will also have to consider the increased use of engineered wood products such as oriented strandboard that are not suitable for waterborne impregnation.

In order to determine the suitability of a new treatment for commercial use in the United States, the treatment must be: 1) registered with the Environmental Protection Agency, 2) tested for efficacy with respect to the degrading organism(s), 3) tested to determine effects on product properties and product performance during service, and 4) a product that is economically viable in the market. Most commonly, items 2 and 3 are done by third party research organisations such as universities or independent testing laboratories to provide recognised unbiased information.

The testing standards for wood products used in the United States are developed and approved by standards organisations such as the American Standards and Testing of Materials (ASTM 2002) as well as others specialising in a specific area such as the American Wood-Preservers' Association for wood preservation treatments (AWPA 2002). In addition, numerous testing methodologies and protocols have been developed by universities and other research organisations and have been incorporated through common sharing of knowledge. Efficacy tests for new treatments normally begin with laboratory screening tests that are followed by long-term field tests to simulate severe service conditions. Decay and insect testing standards have been developed whereas mould standards are still being developed. Advances in testing methodologies for resistance to termites and mould are most noteworthy and will be discussed here.

Laboratory tests or screening tests for resistance to insect infestation is a relatively rapid process normally lasting approximately 4 weeks, depending on the insect being examined. In the United States, testing for resistance to termites is the most common test used primarily due to their greater and more devastating short-term damage to wood structures. The most common protocol used is

AWPA Standard E1-97, Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites. In essence, this test submits a test specimen to 400 termites for 4 weeks under controlled conditions. Analysis consists of determining termite mortality, specimen weight loss, and a subjective rating of degradation. Other insect screening tests follow much the same procedures; however containers, number of insects and specific timeframe can differ. These laboratory tests appear to work well when the standards are followed. Pitfalls can occur when termites are not kept healthy in the laboratory and may be weak when used. This can be indicated by the control samples; therefore it is important to always use a common control species for each trial so this comparison can be made, for example, southern yellow pine sapwood. Other pitfalls that can occur include strength of termite colonies, methods of termite collection, laboratory conditions for maintaining termites, sample preparation, mould growth, oxygen levels in testing jars, and termite handling during set-up.

Field testing of termite efficacy requires much longer testing times. This is an area where shorter times would be beneficial. Most commonly an area is identified that is infested with termites. Samples are placed in the field with controls and examined periodically to determine efficacy. Testing may take 5 years or longer and depends on the time it takes for the controls to be “hit” or attacked. It is also very difficult to have uniform attacks on all specimens. Two methodologies varying from this are a short-term bait crate test and a modified field test. The short term bait crate test follows much the same procedures as a bait crate termite collection technique (Smith, et al. 2002). In essence, an approximate one cubic foot milk crate is filled with controls and treated samples in a matrix configuration which allows easy termite access. The crate is then buried near a termite colony or tree identified as having active termites. It is left for approximately 2 months then retrieved and analyzed. This technique provides good data on treatment efficacy if the controls are attacked heavily. One must be careful, however, if testing repellents as these may keep the termites away and the crate will not provide sufficient data to confirm efficacy. In addition, this test can be affected by season, very wet or very dry weather and strength of the termite colony.

The modified field test is expected to shorten time substantially by enhancing a field site with termite colonies and enhancing the direction of foraging. Such a site will allow highly controlled and repeatable testing. This is done through establishing multiple seeded colonies in close proximity and facilitating their movements through feeder timbers placed beneath the soil. Test specimens can then be placed such that termite pressure on all samples can be more consistent. This will allow early initiation of attack and therefore may reduce the time required to achieve meaningful results. Once established, it is expected that a 2-year testing period may be sufficient to provide good efficacy data. The strength of the seeded colonies, however, must be strong and well established to assure intense and uniform attack on all samples. With multiple seeded colonies on one site, the effects of testing methodologies and procedures can also be evaluated using both within- and between-colony replications.

A field site for Formosan subterranean termites has been established at the LSU Agricultural Center Citrus Research Experiment Station, Port Sulphur, Louisiana (Smith, et al. 2003). Similar testing methods have been established in known termite locations in Australia (Peters and Fitzgerald, 1997). Due to the large number of colonies, seeding in Australia is not necessary. Testing at the LSU site in cooperation with other universities will include evaluation of the effects of testing methodologies and procedures using both within- and between-colony replications, in-ground tests to evaluate preservatives (stake tests) or termite baits, test structures, above-ground preservative comparative tests and/or building component durability tests, and basic termite biology/behaviour/movement studies.

Mould testing methodologies and protocols are being developed. Currently there are several methods being used and there has been a draft for a standard developed for the American Wood Preservers' Association titled "Standard Method of Evaluating the Resistance of Wood Product Surfaces to Mold Growth". This standard is based on ASTM Standard Test Method D 3273-00 "Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber" (ASTM 2002). In the new AWPA mould standard, samples of wood-based products are placed in a chamber where temperature and relative humidity are controlled to provide ideal conditions for mould growth. The chamber and samples are inoculated with specified moulds, and circulating air within the chamber continually subjects samples to spores for the duration of the test. Additional mould spores may also be introduced from the air or soil and may compete with the inoculated moulds for colonisation on surfaces of test products. Samples are evaluated for growth of moulds on the sample surfaces every two weeks for eight weeks. Each sample is assigned a rating for extent and intensity of mould growth. Most common pitfalls that can be encountered include mould intensity, mould species used, subjective rating system, and difficulty to obtain true "in-service" conditions.

A simpler and less severe method has also been developed by Michigan Technological University. This test consists of taking treated and control samples and placing them in a plastic covered tub. The samples are placed horizontally on a screen suspended above water. The container is closed and placed in a warm room to assure high humidity conditions. Samples are periodically examined to determine amount of mould growth. Inoculation of the samples is done through natural means, i.e. existing airborne spores.

Field testing for mould efficacy has not been standardised. Current mould efficacy for a product is therefore based on laboratory tests. Field testing protocols, however, are being set up by individual researchers and/or treatment companies. Two in-service approaches are being developed. The first approach is protecting wood-based products from mould after product manufacturing, through handling and through the construction process. For example, structural lumber and panel treatments should protect these products from mould from the manufacturing plant through closing interior and exterior walls and roof structural components. The second area is determining if a treatment is effective within the closed structure for a number of years after construction. Most work is directed toward the first area which is easier to control. Once the material is placed in service a large number of variables have to be considered and can occur with no control by the treatment manufacturer such as liquid water remaining within the walls for long periods of time. In the case of a leaky pipe leaching may also occur. In addition, the greatest concern for mould growth is that it will occur on non-treated substrates other than wood and the wood-based product may still be blamed.

Some field testing procedures which are underway comprise a number of methodologies with the most common being a stack test. This is done by placing treated and untreated wood-based products in stacks that may or may not be covered in plastic to simulate shipping and storage conditions. To test long-term effectiveness, testing structures will need to be developed to simulate above ground in-wall conditions that are exposed to higher moisture and humidity. It is expected that these methodologies and protocols will begin to appear in the scientific literature since there is much emphasis in the United States on mould resistance. Pitfalls to be aware of include the large number of mould species that may or may not be included in the test, test specimen history, longevity of treatment chemical, product attributes that may affect treatment chemistry, testing environment, and researcher safety in handling specific moulds.

REFERENCES

ASTM 2002: Annual Book of ASTM Standards. West Conshohocken, PA

AWPA 2002: American Wood-Preservers' Association Book of Standards. AWPA, Selma, AL

PETERS B C and FITZGERALD C J (1997): Field Evaluation of the Effectiveness of a Barrier of Zeolite for the Protection of Timber from Damage by *Coptotermes acinaciformis* (Isoptera: Rhinotermidae) Sociobiology Vol. 30, No. 3.

SMITH W R, HENDERSON G and VOITIER M (2002): New and Faster Method for Formosan Subterranean Termite Collection – Bait Crates. Abstract in Biographies & Abstracts, Forest Products Society 56th Annual Meeting, Madison, Wis.

SMITH W R, AMBURGEY T L, HENDERSON G and RING D R (2003): Field Tests Facility on *Coptotermes formosanus* at LSU Agricultural Center: IRG-WG Proceedings, Annual Meeting, Brisbane, Australia. May 2003.