TITAN WOOD

Prepared by TRADA TECHNOLOGY

November 2009

Titan Wood Ltd
66 Hammersmith Road
London W14 8UD
United Kingdom

Email: info@titanwood.com
www.accoya.com

Tel: +44 (0)333 888 4141
Fax: +44 (0)333 888 4141

A modified wood product

Figure 1: Accoya® wood cladding

Modified wood is a term used to describe wood whose molecular composition has been altered, normally by chemical or thermal processes. This differs from a conventional preservative treatment where wood is impregnated with a biocide. An increasing range of modified wood products are available in the UK and it is essential, when specifying, that they are considered individually because their properties vary considerably.

Accoya® is the brand name of wood that has been modified by acetylation. This modification process replaces the water binding sites in the wood cell wall with acetyl groups that do not bind with water. These acetyl groups occur naturally in wood, albeit at much lower levels than in Accoya® wood.

Although Accoya® wood has only been on the EU market since April 2007, research on acetylated wood began as early as 1928. For this reason there is a wealth of knowledge on the performance of acetylated wood.

Acetylation significantly improves several wood properties. It increases durability of both sapwood and heartwood, and makes timber more dimensionally stable. For these reasons, Accoya® wood offers many advantages over unmodified wood. Some properties, such as ease of processing, strength, adhesion and ease of fixing, are relatively unaffected.

Radiata pine is the wood species presently used to manufacture Accoya®, although the process has proven effective on a range of other softwoods and hardwoods.The radiata pine is sourced sustainably and, since acetylated wood may be re-used, recycled and disposed of without the risks of environmental damage, Accoya® offers an alternative to using preservative treated wood (or increasingly scarce naturally durable timbers) for applications where there is a risk from decay.

This sheet outlines the principles of the Accoya® wood modification process, properties of Accoya® wood and its increasing number of applications.

The materials and process

Accoya® is currently manufactured from radiata pine that is supplied from sustainable sources in the southern hemisphere including sources certified by the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC). Certified timber is harvested from well-managed forests and full 'chain of custody' ensures that all wood used to manufacture Accoya® is sustainably sourced to the highest standards.

More information on the process of timber certification as a tool for ensuring supply of sustainable timber products is covered in TRADA WIS 2/3-58. Both FSC and PEFC certified woods meet requirements of the UK Government timber procurement policy via The Central Point of Expertise on Timber Procurement (CPET). Therefore, Accoya® is suitable for use in UK government buildings, both national and regional.

Radiata pine (also known as Monterey pine) is a native of North America, but is widely grown around the world. The largest areas of plantation are in New Zealand, Chile and Australia. Radiata pine was selected for the manufacture of Accoya® because pruning of the trees results in large volumes of clear grade wood. Modification takes place throughout its section. This allows for conversion of Accoya® post modification without risk of exposing untreated wood, which is a real benefit over preservative treated wood. As part of the Accoya® quality control processes, sample cores are taken from the centres of boards to confirm modification has taken place throughout the section. *Figure 2* shows a sample being taken from the centre of a section of Accoya® wood.

Figure 2: Taking a sample core

The modification process involves impregnating wood with acetic anhydride, a colourless liquid used for the manufacture of photographic films and in the production of aspirin and other medicinal drugs. Accoya® is produced by placing dried timber in large autoclaves and then introducing and removing acetic anhydride from these vessels.

The finished Accoya® wood has a very low residual acetic acid (vinegar) level and slight associated odour. This odour dissipates naturally or can be immediately blocked by wood coatings. Acetylation causes no significant change to wood colour. Although there is darkening of the outer surface, this is insignificant compared to wood treated by thermal modification processes which considerably darken wood. *Figure 3* shows radiata pine with little colour change after treatment and planing.

Figure 3: Colour of radiata pine following the acetylation

Accoya® wood is presently manufactured by Titan Wood in the Netherlands where the production plant can produce 40,000 m³ per year (*see Figure 4*).

Figure 4: Titan Wood's Accoya® wood production plant

Properties of Accoya® wood

The properties of wood acetylated by Titan Wood's process have been investigated using both standard and non-standard test methods conducted by many independent test laboratories. Extensive long-term field testing allows performance of Accoya® wood in service to be predicted with confidence. In many cases reference timbers, whose properties are well understood, were

included in tests for comparison. In addition, there is a body of information available regarding performance of acetylated wood exposed in exterior trials for up to 18 years.

The following sections consider specific properties of Accoya® wood and their significance.

Durability

Durability is the inherent resistance of wood to attack by wood destroying organisms. Use classes provide levels of risk for wood products used for different applications in the UK. These use classes and types of wood commodity included within each class are given in BS EN 335-2.

Fungi are the most important pests in the UK and, since they require a wood moisture content in excess of 20% to decay wood, wood that is exposed to wetting is at risk.

Insect pests are less important in the UK, the most common being death-watch beetle, house longhorn, powder post beetle and common furniture beetle.

Further information on common types of insects and fungi which can affect timber is covered in TRADA WIS 2/3-32.

Durability of the heartwood of a species is assessed using BS EN 350-1. This involves laboratory standard testing to BS EN 113 and field testing to DS DS/EN 252. *Table 1* shows the five durability classes from BS EN 350-1 with examples of species in each class from BS EN 350-2.

Table 1: Durability classes and example species

Class 1 very durable (jarrah)
Class 2 durable (European oak)
Class 3 moderately durable (Douglas fir)
Class 4 slightly durable (European larch)
Class 5 not durable (radiata pine).

Tests to BS EN 350-1 with radiata pine have shown that acetylation increases its durability against fungi from the least durable (Class 5) to the most durable (Class 1). Class 1 species can be used in ground contact conditions such as fence posts, railway sleepers, structural timber in fresh water (eg bridge foundations) and sole plates below damp-proof courses. They achieve a 60 year service life in above ground applications such as windows, doors, cladding and decking.

Independently conducted tests to BS EN 330 compared the durability of window joinery manufactured from radiata pine that was untreated, treated with alkenyl succinic anhydride (ASA) and acetylated radiata pine, and showed the acetylated L-joints (*see Figure 5*) performed significantly better than the others. After nine years of exposure, the acetylated timber showed slight discolouration but no significant softening or decay, while untreated and ASA-treated timber were both severely decayed. This trial indicates that Accoya® wood meets requirements for long-life exterior joinery applications in the UK. It also demonstrates that the product continues to perform following coatings failure (which is induced at the start of this test).

Figure 5: L-joints

Dimensional stability

Timber is a hygroscopic material. This means that its moisture content changes in response to the temperature and humidity of its surroundings and causes dimensional changes (shrinkage or swelling), known as 'movement'. The degree of movement exhibited by timbers varies with species.

Accoya® offers much better dimensional stability (resistance to movement) in both radial and tangential directions than unmodified radiata pine. Tests have shown that dimensional changes can be reduced by up to 80% (*see Figure 6*).

Since the movement of Accoya® is low, it is ideal for exterior applications where dimensional stability is important, such as doors, window frames, garden decking, cladding, boat decks and garden furniture that are exposed to wetting and drying. Other specialist applications such as guitars, bridges and large dimension mouldings also benefit from its improved dimensional stability.

The benefits of using the more dimensionally stable Accoya® wood can be seen in decking and cladding applications. The maximum nominal widths of decking or cladding boards should not exceed 150mm to reduce effects of moisture movement and risk of 'cupping'. Cupping occurs in flat sawn boards because of the differences in the amount of tangential and radial shrinkage across upper and lower faces. Since Accoya® is more dimensionally stable, flat sawn boards up to 325mm wide may be used without risk of cupping. This simplifies fixing and improves performance in service.

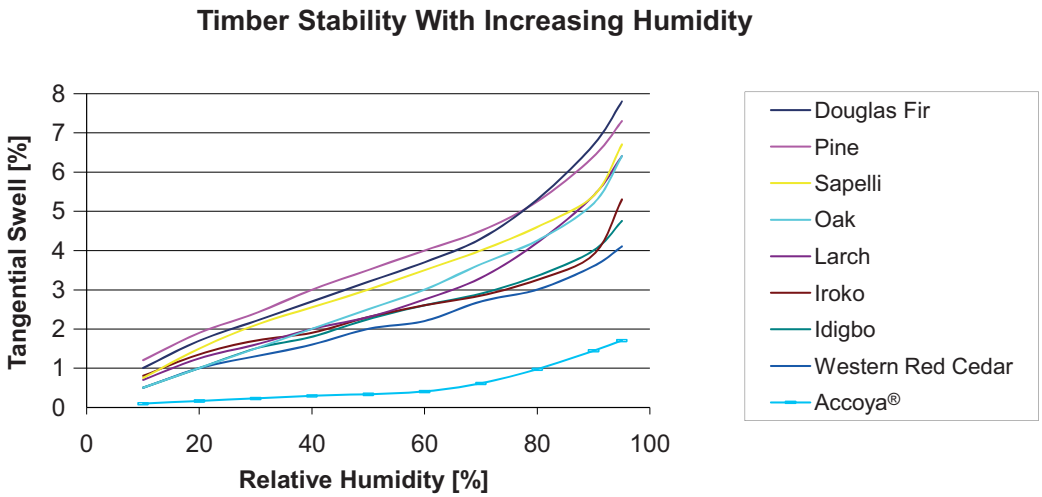

Figure 6: Tangential swelling of Accoya® and a range of unmodified wood species exposed to differing relative humidities at 20°C

Coatings

For many applications the frequency and cost of maintenance is a critical factor in determining the choice of material that is used.

Accoya® wood can be coated in the same way as other wood. Its better dimensional and UV stability means coatings last longer and require less frequent maintenance. For designers, architects, builders and property owners, the extended coating performance and guarantees reinforce the excellent natural performance attributes of Accoya®.

Independent tests (conducted as shown in *Figure 7*) have shown that coatings perform significantly better on acetylated wood than on untreated wood. After 9½ years' outdoor exposure, coatings on untreated samples were failing with cracking, flaking and complete erosion in some cases. In contrast, the same coating on Accoya® remained serviceable.

Figure 7: Exposure test rig

Based on these results, it is predicted that the maintenance frequency would be as low as once every ten years. Independent modelling studies into whole-life costing of window joinery manufactured from Accoya®, sapele, laminated European oak and European redwood showed that the Accoya® performed best over a simulated sixty-year period. Better performance was a direct result of the increased time intervals between coating maintenance cycles for Accoya® joinery.

Close collaboration with Teknos, Sikkens and GORI (three of Europe's leading wood coatings companies) has resulted in a package of coatings guarantees for windows and doors:

A 10-year guarantee for a translucent (wood stain), fully factory-applied maintenance coating system, to first brush applied maintenance.

A 12-year guarantee for opaque fully factory applied maintenance coating system, to first brush applied maintenance.

It is important to highlight that guarantees for these coatings on Accoya® are affected by the level of exposure of the site. Site exposure will also influence performance of coatings on unmodified wood.

Weathering performance

In outdoor weathering tests, Accoya® exposed to the sun changes colour in the same way as unmodified softwood, although rate of colour change is slower. The improved photostability of Accoya® allows for a broader range of translucent and lighter coloured coatings to be used, without the risk of the underlying wood darkening in service on exposure to sunlight.

Density and machining properties

Density has an important influence on the ease of wood machining. The rate at which a higher density timber can be cut or planed is reduced as density increases and the blunting effect is more severe.

The slight increase in the density of radiata pine as a result of modification using the Accoya® process has been shown to have little influence on ease of machining. Accoya® can be machined in the same way as unmodified wood. Cross cutting, ripping, planing and profiling result in a smooth surface comparable to other commonly used species in the joinery industry. In addition, the timber is relatively light and therefore easy to handle. These properties make Accoya® very suitable for joinery.

Strength

The strength of timber refers to its ability to resist applied forces that could lead to its failure. While some modification processes (eg thermal modification) weaken wood, acetylation does not reduce its strength.

The bending strength of both unmodified, non stress-graded radiata pine and Accoya® is 80N/mm^2. This is towards the middle of the range for cladding and joinery timbers, with Western red cedar being 55N/mm^2 and meranti 90N/mm^2. These values are obtained from standard tests on straight-grained timbers free from defects.

Hardness

Hardness is the resistance of timber to abrasion or indentation. Hardness provides useful information on how timber is likely to wear. Timber hardness is normally measured using the Janka test.

The higher density and lower moisture content of radiata pine modified according to the Accoya® process results in higher hardness values when tested to ASTM D143. Results show that acetylation increases hardness of radiata pine by 47% in the radial and 52% in tangential orientation.

Hardness values for Accoya® are similar to those of mahogany, black cherry or African walnut, wood species often used for flooring.

Thermal properties

Thermal conductivity of construction materials is increasingly important when considering performance of the building envelope, in particular windows and doors. Where wood is used for joinery (doors and windows) reduced thermal conductivity is beneficial.

Tests with Accoya® show this material has a lower thermal conductivity (0.108W/m^2/K) than that normally presented for softwoods and hardwoods (0.150 and 0.160) respectively. For this reason Accoya® joinery will give improved thermal performance.

Interaction with metal fixings

Since low concentrations of acetic acid may remain in the wood after acetylation, risk of corrosion of metal components is increased to a level comparable with many durable hardwoods. For this reason, and the fact that Accoya® wood may be exposed in applications that promote corrosion, only A2/A4 grade stainless steel and specifically tested alternatives should be used when wood contact or its interaction with the component is likely.

Adhesion

Accoya® wood can be glued using many commonly used wood adhesive systems. However, it is imperative that the product's modified properties are taken into account. TRADA recommends that Titan Wood be contacted in order to confirm compatibility of specific adhesives with this modified wood.

Disposal

At the end of its serviceable life, Accoya® may be recycled, disposed of responsibly and with ease (unlike many building products) because it contains only naturally occurring wood components. It can be composted or incinerated without release of toxic materials into the environment. It could also be used as a raw material for particleboard, MDF or other reconstituted wood.

Current and future UK consumption

Accoya® wood is currently being used for the following applications:

- decking
- doors and windows
- ground and waterworks
- cladding, siding and facades
- garden furniture
- conservatories
- civil engineering including glulam beams
- velodromes.

Accoya® can be used in other applications where strength, durability and environmental protection are important.

Figure 8a: Accoya® decking

Figure 8b: Accoya® cladding

Wood modification opens a new and broad range of innovative applications for timber, for which architects and designers have hitherto only considered using steel, synthetic materials or concrete. For example, a heavy load-bearing traffic bridge in the Netherlands, measuring twenty metres high by forty metres long, was completed in 2008 (*see Figure 9*). The structure comprises three-dimensional double bent glue-laminated beams, with exceptional dimensions of 1400 x 1080mm. The minimal required life expectancy of the bridge is 80 years, with minimal maintenance and high safety level. Accoya® is the first ever modified wood used for heavy traffic bridges, finding its place in civil engineering projects.

Figure 9: Clockwise from left: Accoya® wood window, balustrades and heavy traffic road bridge.

References

BS EN 113:1997 Wood preservatives. Test method for determining the protective effectiveness against wood destroying basidiomycetes. Determination of the toxic values.

BS EN 330:1993 Wood preservatives. Field test method for determining the relative protective effectiveness of a wood preservative for use under a coating and exposed out-of-ground contact. L-joint method.

BS EN 335-2:2006 Durability of wood and wood-based products. Definition of use classes. Application to solid wood.

BS EN 350-1:1994 Durability of wood and wood-based products. Natural durability of solid wood. Guide to the principles of testing and classification of the natural durability of wood.

DS DS/EN 252 Field test method for determining the relative protective effectiveness of wood preservative in ground contact.

Fuchs, W 1928 Genuine lignin. I. Acetylation of pine wood. Ber. 61B 948-51.

The central point of expertise for timber procurement (CPET) at www.proforest.net/cpet.

WIS 2/3-32 Timber: fungi and insect pests, TRADA.

WIS 2/3-58 Sustainable timber sourcing, TRADA.

Prepared by TRADA Technology for Titan Wood.

TRADA Technology Ltd
Stocking Lane, Hughenden Valley, High Wycombe, Buckinghamshire HP14 4ND, UK
Tel: +44 (0)1494 569600 Fax: +44 (0)1494 565487 email: information@trada.co.uk

www.trada.co.uk