Wood modified at a mix of low and high temperatures.

Thermal modification to improve wood performance

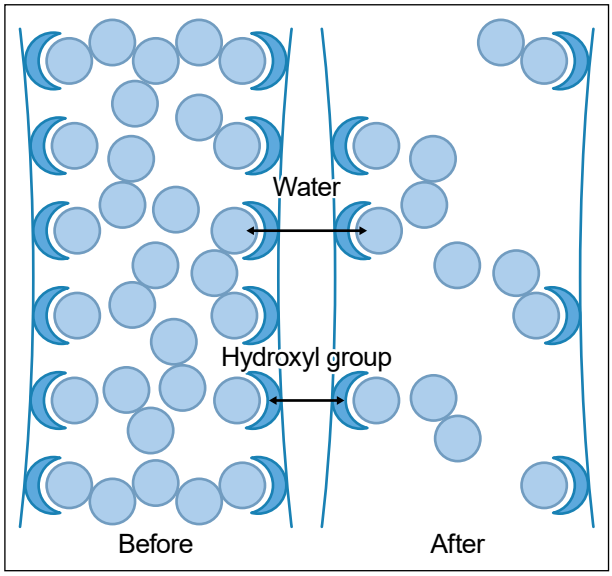
The durability, appearance and stability of many wood species can be improved using thermal modification. Scion's research modifying a range of species highlights the potential for wood without added chemicals for outdoor use. Scion continues to test timber durability and performance.

Senior technologist Rosie Sargent.

About the process

During thermal modification, timber is heated to high temperatures (170°C-230°C) in the absence of oxygen. This causes permanent changes in the chemical composition of wood preventing the wood cell walls from absorbing water. It leads to a darker appearance and altered mechanical and durability properties including enhanced wood dimensional stability – meaning it shrinks and swells less with humidity changes – and enhanced performance, all without the need for added chemicals.

Durability changes are generally seen in both durable and non-durable timber, including sapwood (the outermost wood) and heartwood (inner wood) of naturally durable species, when treated at high temperatures.



The process removes hydroxyl groups which attract water, so the wood absorbs less moisture.

Scion has two kilns capable of thermal modification of up to 230°C, one 0.1m3 wood drying kiln to enable treatment of 600mm lengths of wood and one 2m3 kiln able to modify 2.4m lengths of wood. Within the kilns, steam is used to create an oxygen-free atmosphere to prevent the wood igniting during thermal modification.

Research to date

We know radiata pine is not naturally durable, but it has been successfully thermally modified and commercialised for exterior cladding use. It is usually modified at 230°C.

Scion has researched several other species using funding from Forest Growers Research, the Specialty Wood Partnership and internal funding.

Douglas-fir (*Pseudotsuga menziesii*), lusitanica (*Cupressus lusitanica*) and tōtara (*Podocarpus totara*) have been modified to give sapwood some durability and increase the existing durability of heartwood. This allows the vulnerable sapwood to be used in exterior applications such as cladding and potentially decking. Nitens (*Eucalyptus nitens*) and silver beech (*Nothofagus menziesii*) didn't show improved durability but still had increased dimensional stability and a darker colour.

To avoid overcooking the wood, lusitanica and Douglas-fir have been modified around 220°C and tōtara around 210°C.

All of Scion's testing has been on New Zealand-grown species. Many had some natural durability with potential for improvement.

Unmodified wood samples alongside samples treated at 220°C and 230°C.

Testing

When developing a new product for outdoor use, it's important to understand how it performs in service. Scion conducts a range of tests and trials to predict in-service performance without having to wait 15+ years for real-time results. The tests range from accelerated lab tests giving broad indications of wood durability to longer field trials which better mimic in-service conditions.

The results from each stage of testing suggest whether it is worth continuing.

Fungus cellar stakelet testing involves putting sticks into warm, moist soil to accelerate degradation.

Testing includes:

- Lab tests (<1 year).
- Fungus cellar stakelets (3+ years).
- Outdoor durability testing (7+ years).

Thermally modified flat panel tests after installation.

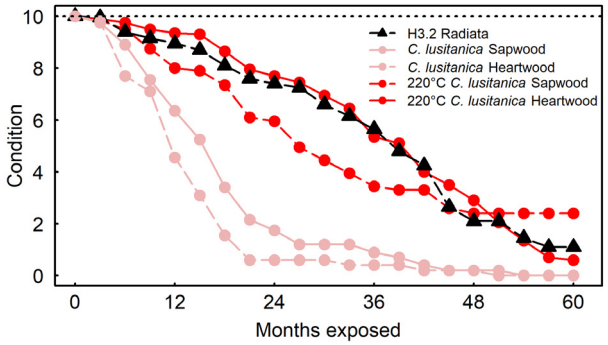
Results

Durability

Under harsh testing conditions, the quality of the wood samples degrades over time.

The condition of fungus cellar stakelets are assessed on a three-monthly basis and rated on a scale from 0 to 10 with 10 being an intact, perfect sample, and 0 being fully degraded. Evaluation of wood decay is largely subjective.

Samples are expected to fail in five years due to the severe test with in-ground contact. Thermally modified Douglas-fir, tōtara and lusitanica have all been in fungus cellar trials since 2019. Results show unmodified Douglas-fir failed much sooner than thermally modified Douglas-fir. Modified tōtara sapwood is performing much better than both unmodified sapwood and heartwood. The thermally modified heartwood is performing better again and is performing similarly to H3.2 treated radiata pine.



Trial results for lusitanica.

The above graph shows results for untreated and treated lusitanica and compares sapwood and heartwood and the H3.2 Radiata CCA treated control. In this instance thermally modified lusitanica is performing similarly to CCA treated radiata.

Dimensional stability

For every species Scion has looked at, thermal modification significantly improves dimensional stability. Severe modifications can improve both durability and dimensional stability, and milder modifications can improve dimensional stability to an extent, even without improved durability.

The Specialty Wood Species cabin combines a range of timbers treated without added chemicals.

Case studies:

Specialty Wood Partnership

The Specialty Wood Species Cabin showcases what can be done with alternative timbers and without using chemicals. It came about following the seven-year Specialty Wood Products Research Partnership (SWP) and was built by Vaughan Kearns of Ruapehu Sawmill to showcase thermally modified cypress created during the project and challenge its real-world use.

Three species of thermally modified cypress and one poplar were used in the cabin which was roughly half funded by Ruapehu Sawmill with contributions from SWP partners and the Industry Transformation Plan.

The timbers used in construction are either naturally durable or thermally modified and were supplied from trees grown in New Zealand. The only treated timber used was the skids in contact with the ground.

Thermally modified tōtara

Scion's research into thermally modified tōtara began around 2017 using relatively young trees from Northland – about 80-years-old.

Tōtara was chosen because it has natural durability. Modified stakelets have been in the fungus cellar for about seven years and in field testing for about two years. Early results are positive.

Tōtara and lusitanica have similar dimensional stability to radiata pine when unmodified, after severe modification the amount they shrink and swell with changes in air humidity halves, and is even significantly less than western red cedar, which is known to be very stable. Milder modification (e.g. 160°C) improves dimensional stability, though not significantly.

Scion's Rosie Sargent and Toby Stovold with Marco Lausberg from Forest Grower's Research (left).

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About Scion

Scion is the Crown research institute that specialises in research, science and technology development for forestry, wood and wood-derived materials, and other biomaterial sectors.

Scion's purpose is to create economic value across the entire forestry value chain, and contribute to beneficial environmental and social outcomes for New Zealand.

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