Thermally modified timber: durability under study

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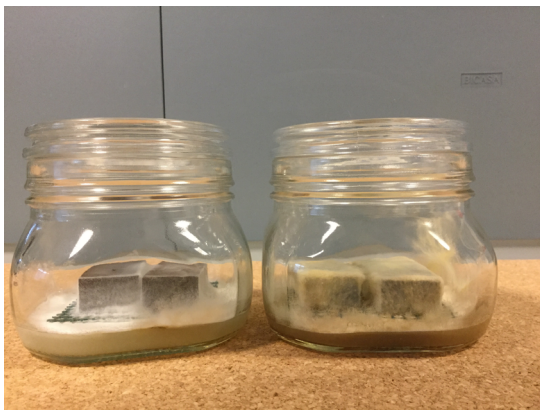

Each wood species is characterized by a certain degree of **resistance to attack by biological degradation agents**, mainly fungi and insects. This feature is the natural durability of the species. **The durability of wood can be improved** by some processes, in order to make a wood species more resistant to biological degradation. A laboratory method allows to test wood-based materials subjected to protective treatments and to assign them a durability class in order to allow comparison with the starting material and with other wood species of known durability. This is the case with thermally modified timber (TMT). To learn more go on reading .....

Wood originates from renewable sources, and as such it meets the increasing need to ensure environmental sustainability in the supply of raw materials. Being an organic material, however, it is subject to degradation caused by wood decay agents such as fungi, insects, bacteria and marine borers. Over the centuries, **various strategies have been employed to increase the resistance of wood** to biological degradation, and hence its service life, **mostly** based on the **use of chemicals** with biocidal action. To meet the needs of a market increasingly oriented towards alternative solutions to chemically treated wood, **new types of protective treatments** have been developed in the last decades which, by exploiting the irreversible chemical modification of wood, make it less susceptible to attack by decay organisms. Among these, **heat treatments** currently represent the most commercially advanced wood modification technologies, supplying the market with a range of different products known as TMT, Thermally Modified Timber. In addition to the first products made on an industrial scale, including the Finnish ThermoWood, the Dutch Plato Wood, the German OHT, the French Bois Perdure and NOW, other products have been developed in recent years, such as VacWood, made with the contribution of the Italian CNR IVALSA research institute (now CNR-IBE).

Heat treatments, carried out at temperatures between 150°C and 260 °C in the absence of oxygen, cause chemical transformations of the wood through a controlled degradation of the polymers that make up the wood cell wall. In fact, **wood that has undergone a thermal process is a new material**, with characteristics different from the original: color, density, hygroscopicity, dimensional stability, mechanical resistance and biological durability are altered.

In the next page, Figure 1 shows the main transformations of the various wood components due to heating to high temperature.

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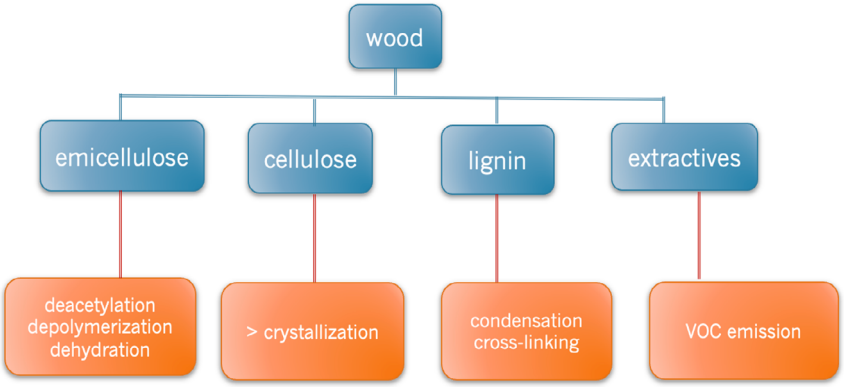

Figure 1. Chemical modifications of wood components

Several process parameters contribute to the final product, but the treatment temperature is the most relevant as regards the increase in biological durability, that is, the resistance to biological degradation. In practice, it is necessary to treat the wood at temperatures **above 200 ° C** to obtain a significant increase in biological durability. Only above this temperature the chemical transformation of the wood is such as to make it **"indigestible" for decay fungi**.

Wood durability: definition and classification through laboratory test

The term durability is intuitively associated with the service life of a wood product. And in fact, under the same conditions of use and risk of biological attack, a more durable wood will last longer. However, durability is not the only determining factor, as maintenance, exposure to weathering agents and design measures aimed at preventing the entry of water and the formation of condensation, contribute to the performance of wood in service.
The **durability classification of wood** gives a measure of the susceptibility of the various wood species to attack by decay organisms (fungi, insects, bacteria, marine organisms) **when this is favored by environmental conditions.** As for fungi, the condition that triggers decay is a moisture content of wood higher than 20%.

The laboratory method used to determine the durability class of wood-based products against fungi is described in **EN 113-2**: **2020 Durability of wood and wood-based products - Test method against wood destroying basidiomycetes - Part 2**: **Assessment of inherent or enhanced durability**.
As the title suggests, the method is suitable for determining the natural durability of wood species but also that obtained with protective treatments, thus allowing to **evaluate** whether and to what extent a protective treatment enhances the durability of a wood species, and also to **classify** a product obtained through an industrial process and compare it with a natural product. For example, ash *(Fraxinus excelsior)* is classified as "slightly durable" (durability class 4, reference EN 350: 2016), but after heat treatment it can reach durability class 1, "very durable" like the durable tropical wood doussiè *(Afzelia spp.)*.
It should be emphasized that heat treatment, in addition to biological durability, **alters other properties of the wood**, determining in particular a decrease in mechanical strength. Therefore **it is important to take into account every aspect to decide on the most suitable final use of the TMT**.
In general, TMT is not suitable for structural use in buildings, while it can be used where good dimensional stability and durability are required, such as in flooring, cladding, windows, etc.

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The laboratory test consists in exposing wood specimens obtained from heat-treated sawn wood to the action of laboratory-grown fungi, in conditions of humidity and temperature favorable to their growth. Exposure to fungi lasts 4 months, at the end of which the mass loss of the wood specimens due to decay is measured. The **EN 350**: **2016 standard Durability of wood and wood-based products - Testing and classification of the durability to biological agents of wood and wood-based materials** defines 5 resistance classes to fungal degradation (DC, durability class) based on the mass loss of the specimens (Table 1).

Durability class	Description	Percentage mass loss (ML)
DC1	Very durable	ML ≤ 5
DC2	Durable	5 < ML ≤ 10
DC3	Moderately durable	10 < ML ≤ 15
DC4	Slightly durable	15 < ML ≤ 30
DC5	Not durable	ML > 30

Table 1. Durability classes according to EN 350:2016

Table 2 summarizes the results of durability tests carried out at CATAS over the years on various TMT products. These are mostly wood **species from temperate climates** growing in European and North American forests, which after heat treatment **can acquire a durability comparable to that of tropical species**, whose trade is often subject to restrictions due to the threat of extinction of some of the naturally most durable species. The column DC (natural) shows the durability class of each wood species as obtained from Annex B of the EN 350: 2016 standard, where most of the wood species of commercial importance are classified. The results of the durability tests carried out in our laboratory on different wood species subjected to heat treatment at different temperatures are presented in column DC (enhanced). These tests have been carried out over the years for different customers, who have employed different technologies and different process parameters; here we only take into account the treatment temperature as the most significant parameter affecting durability.

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Timber species	Scientific name	DC (natural)	DC (enhanced)	Treatment temperature (°C)
		Durabilità naturale	Durabilità indotta	
Scots pine/pino	Pinus sylvestris	3-4	2	215
Austrian pine/pino laricio	Pinus nigra	4v	3	190
Austrian pine/pino laricio			1	215
Radiata pine/pino radiata	Pinus radiata	4-5	3	215
Radiata pine/pino radiata			2	220
Norway spruce/abete rosso	Picea abies	4-5	3	190
Norway spruce/abete rosso			2	215
Ash/frassino	Fraxinus excelsior	4	4	190
Ash/frassino			1	210
Ash/frassino			1	215-220
American ash	Fraxinus americana	n.a.	1	210
American red oak/rovere rosso	Quercus rubra	3-4	1	210
American red oak/rovere rosso			1	215-220
European oak/rovere	Quercus robur	2-4	1	203
Maple/acero	Acer pseudoplatanus	5	1	210
Maple/acero			4	190
Beech/faggio	Fagus sylvatica	4-5	1	210
Tulipwood/tulipifera	Liriodendron tulipifera	4	1	210

Table 2. Enhanced durability by heat treatment: results of laboratory tests

As can be seen, **heat treatment generally improves the biological durability of wood**, but it is important to assess the effectiveness of the process by means of **a laboratory test in order to optimize the process parameters**. In particular, the treatment temperature drastically affects the biological durability.

The topic of this article was heat treatment, but the test method **EN 113-2:2020**, for which **CATAS is the only accredited laboratory in Italy**, is also suitable for the assessment of the biological durability of natural wood species or those **subjected to any another treatment**, chemical or otherwise, that alter their natural properties.

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