Modified wood in composites

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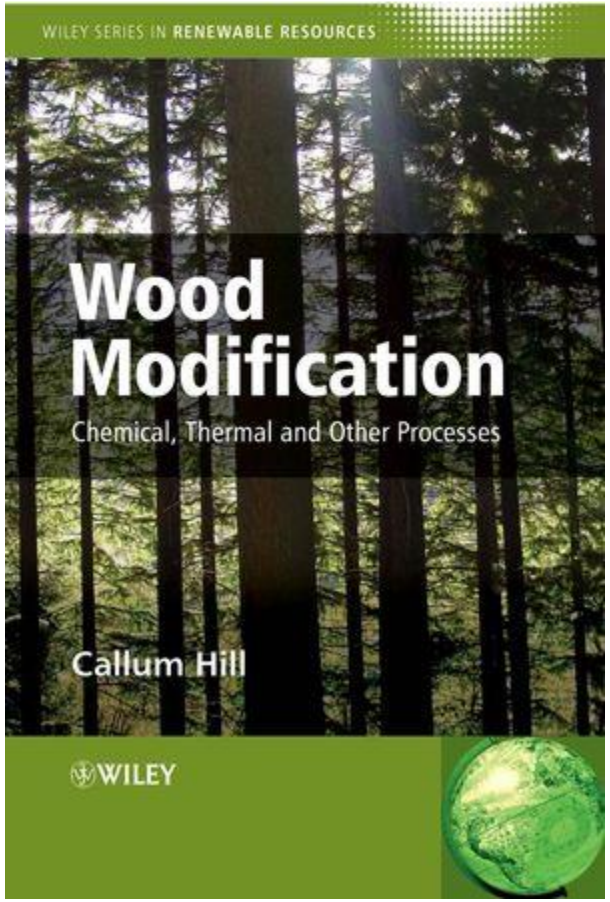
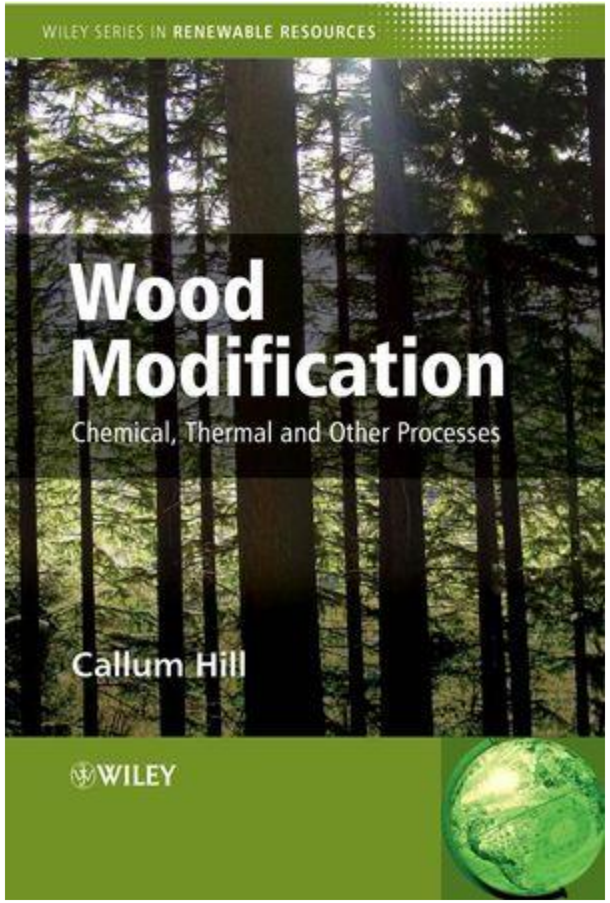
What is wood modification?

- Improving the performance of wood by modifying its molecular structure
- Potential property improvements
  - Durability
  - Moisture resistance
  - Dimensional stability
  - Paint adhesion
  - Colour
  - End of life!!
- Create new markets for local timber
  - Compete against imported hardwoods
  - Promote sustainable timber sources



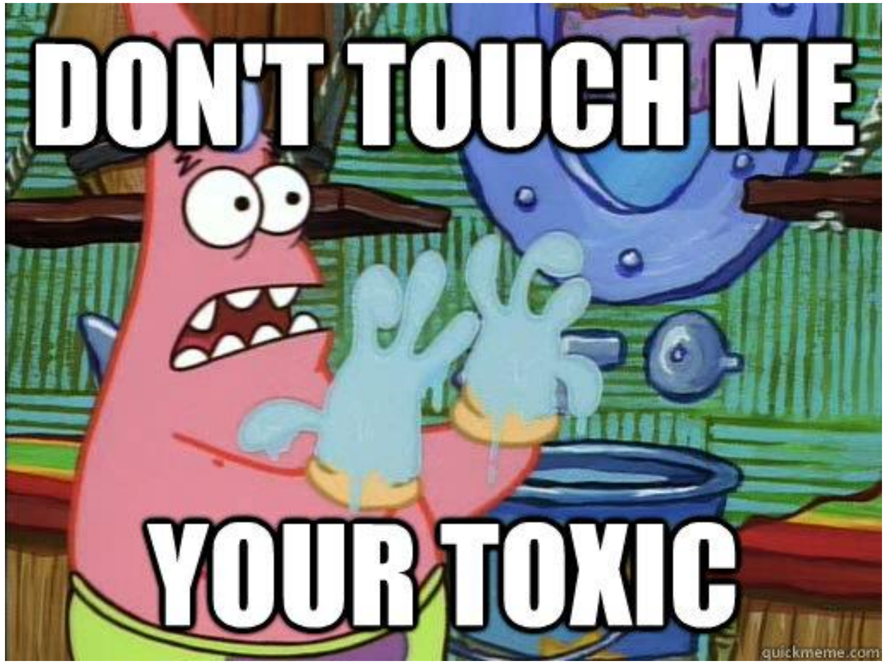
What is wood modification?

- The alteration of wood at the molecular level to achieve a desired property change
- Active modification relies upon a chemical change induced by reactive chemistry, physical, or biological means
- Passive modification does not alter the chemical constituents of wood, but changes the wood permanently by a treatment (impregnation-polymerisation)



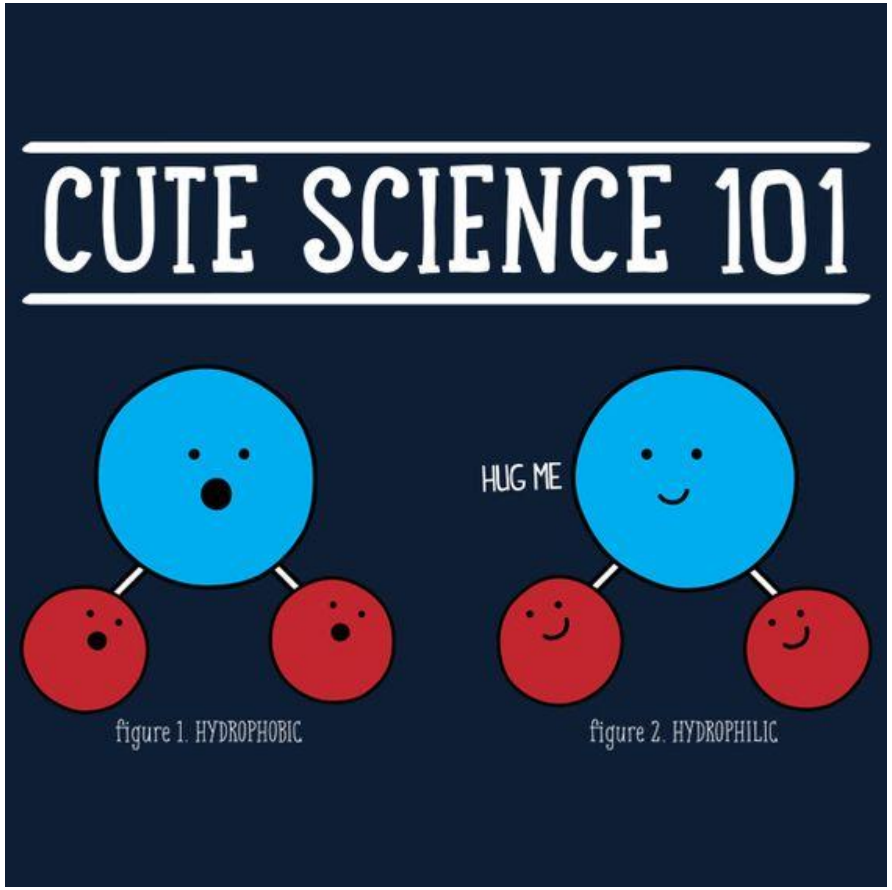
Properties of Wood modification

- It is an essential requirement that the wood should not exhibit toxicity in service
- The modified wood should not release toxic materials at the end of service (e.g. when recycled or in worst case, incinerated)
- For biological resistance, the mode of action of the modified wood should be non-toxic (non-biocidal)



Properties of Wood modification

- It should have enhanced properties, such as:
- Greater moisture stability



Properties of Wood modification

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- Greater dimensional stability

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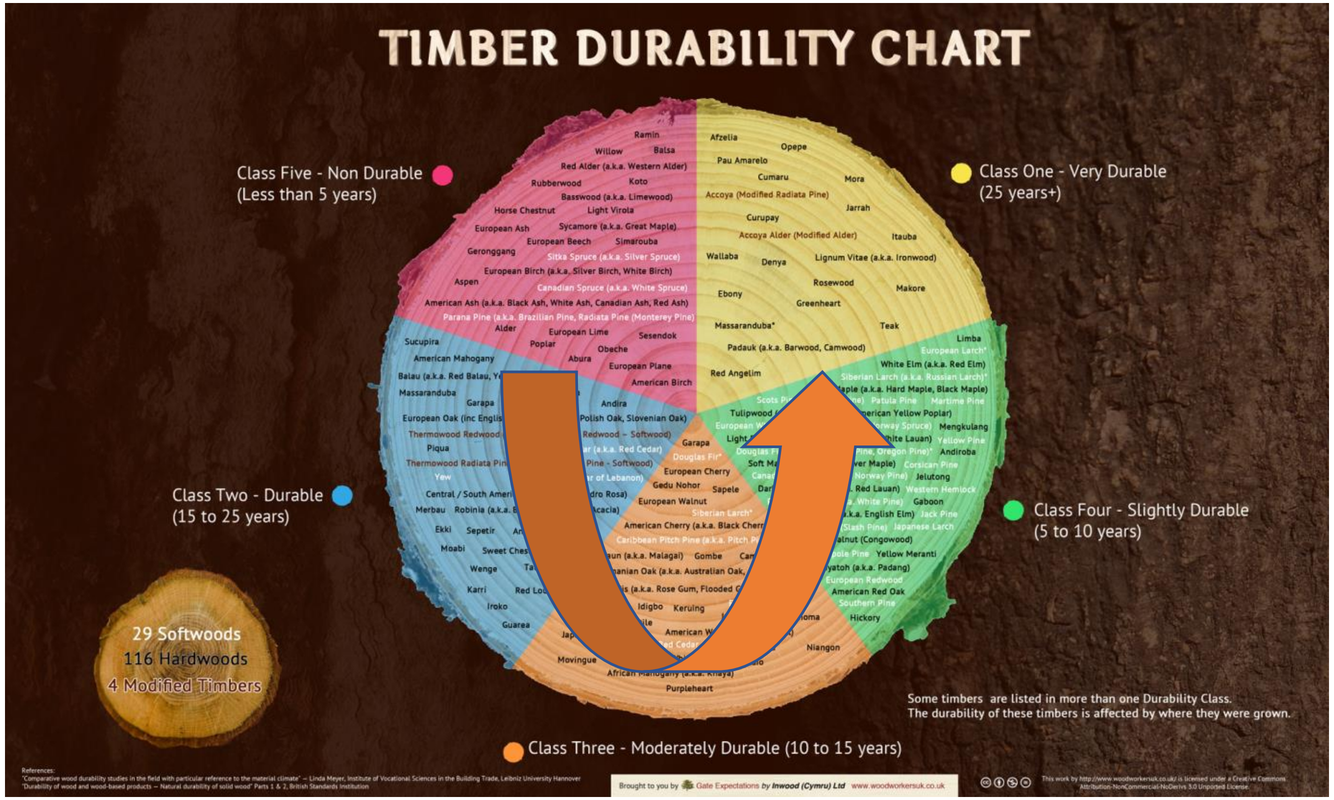
- It should have enhanced properties, such as:

- Greater moisture stability
- Greater dimensional stability
- Improved durability



Properties of Wood modification

- It should have enhanced properties, such as:

- Greater moisture stability
- Greater dimensional stability
- Improved durability
- Coating stability

(affects other materials as well !!!)

Properties of Wood modification

- It should have enhanced properties, such as:

- Greater moisture stability
- Greater dimensional stability
- Improved durability
- Coating stability
- Colour of material

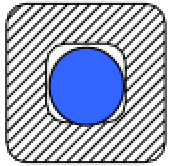
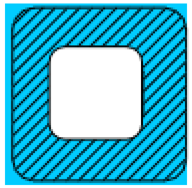
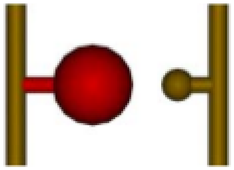
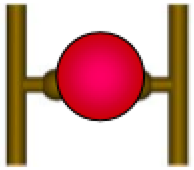
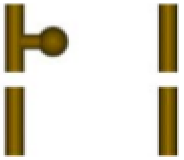
Properties of Wood modification

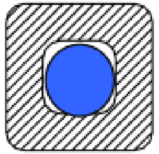
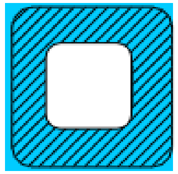
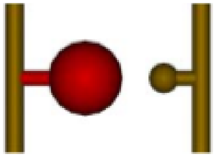
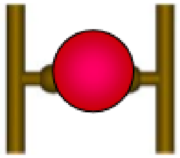
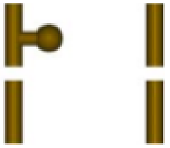
- It should have enhanced properties, such as:

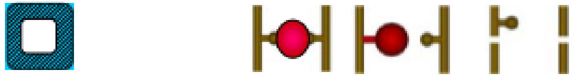
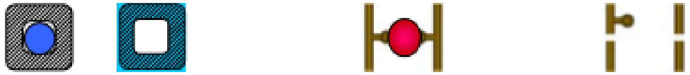
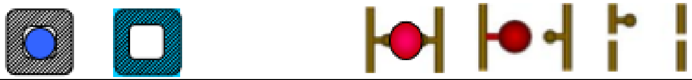
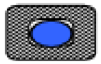
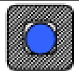
- Greater moisture stability
- Greater dimensional stability
- Improved durability
- Coating stability
- Colour of material
- Local sustainability

The mark of responsible forestry

Types of wood modification

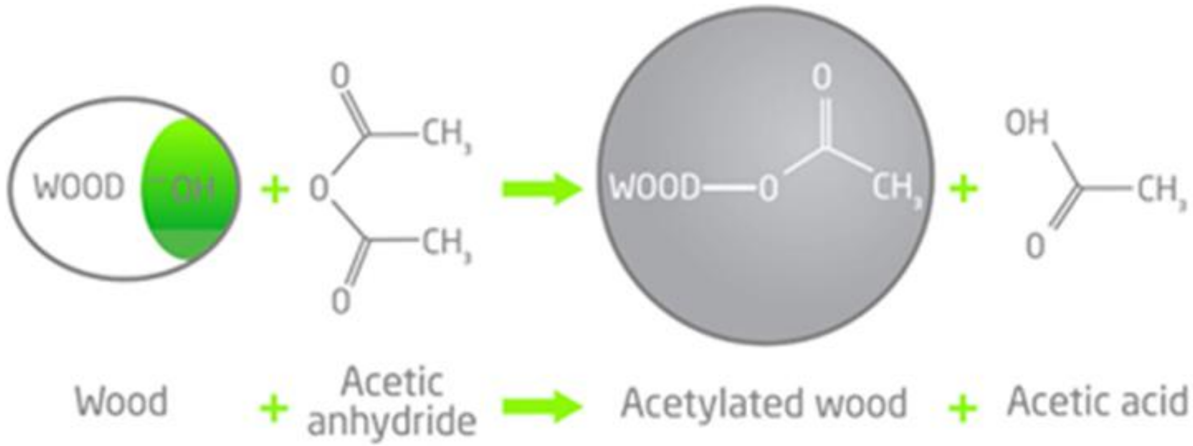
Lumen filling	Cell wall filling	Reaction with wood polymers	Cross linking	Degradation of cell wall
				

Lumen filling	Cell wall filling	Reaction with wood polymers	Cross linking	Degradation of cell wall
				

Modification method	**Commercial**	**Principle**
Heat treatment	X	
Acetylation (Accoya)	X	
Melamine resin	(X)	
DMDHEU (Belmadur)	X	
Furfurylation(Kebony)	X	
Silicone/Silane	(x)	
oil / wax/ parafins	X	
Chitosan		

Acetylation

- Uses acetic anhydride without catalyst
- Acetic acid produced as a by-product
- Presence of acetic acid beneficial up to about 30% in anhydride by volume because it swells the cell wall
- Excess acetic acid must be removed from anhydride
- Acid by-product must be removed from wood
- Process uses radiata pine

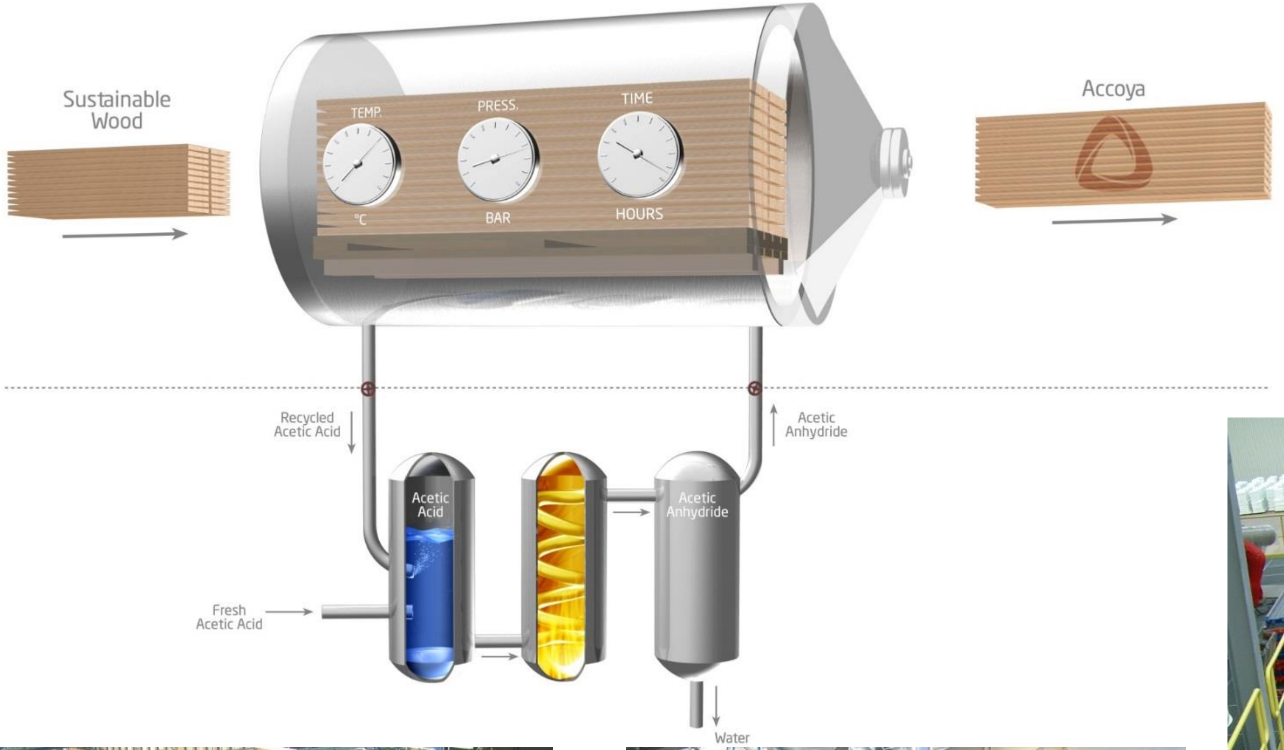


Commercialisation Background

- Titan Wood Limited was formed on April 17th 2003 by Accsys Technologies PLC
- From 2003 – 2006 technology development and design of a large scale production plant
- 2006 – 2007 construction of the plant
- 2007 production commenced

- This is the world’s first plant producing acetylated wood on large scale at a commercially viable cost

Acetylation process



Branding

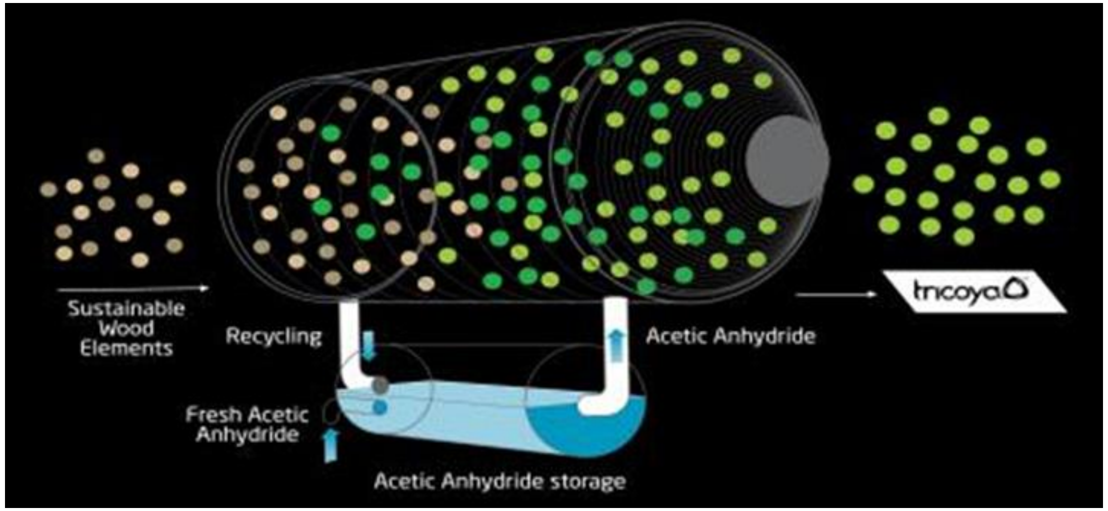
accoya™

- From sustainable sources
- Durability class 1
- Extraordinary dimensional stability
- Measurable and guaranteed performances
- Natural color and strength properties
- High UV resistance
- Environmentally friendly (non toxic)
- 100% recyclable

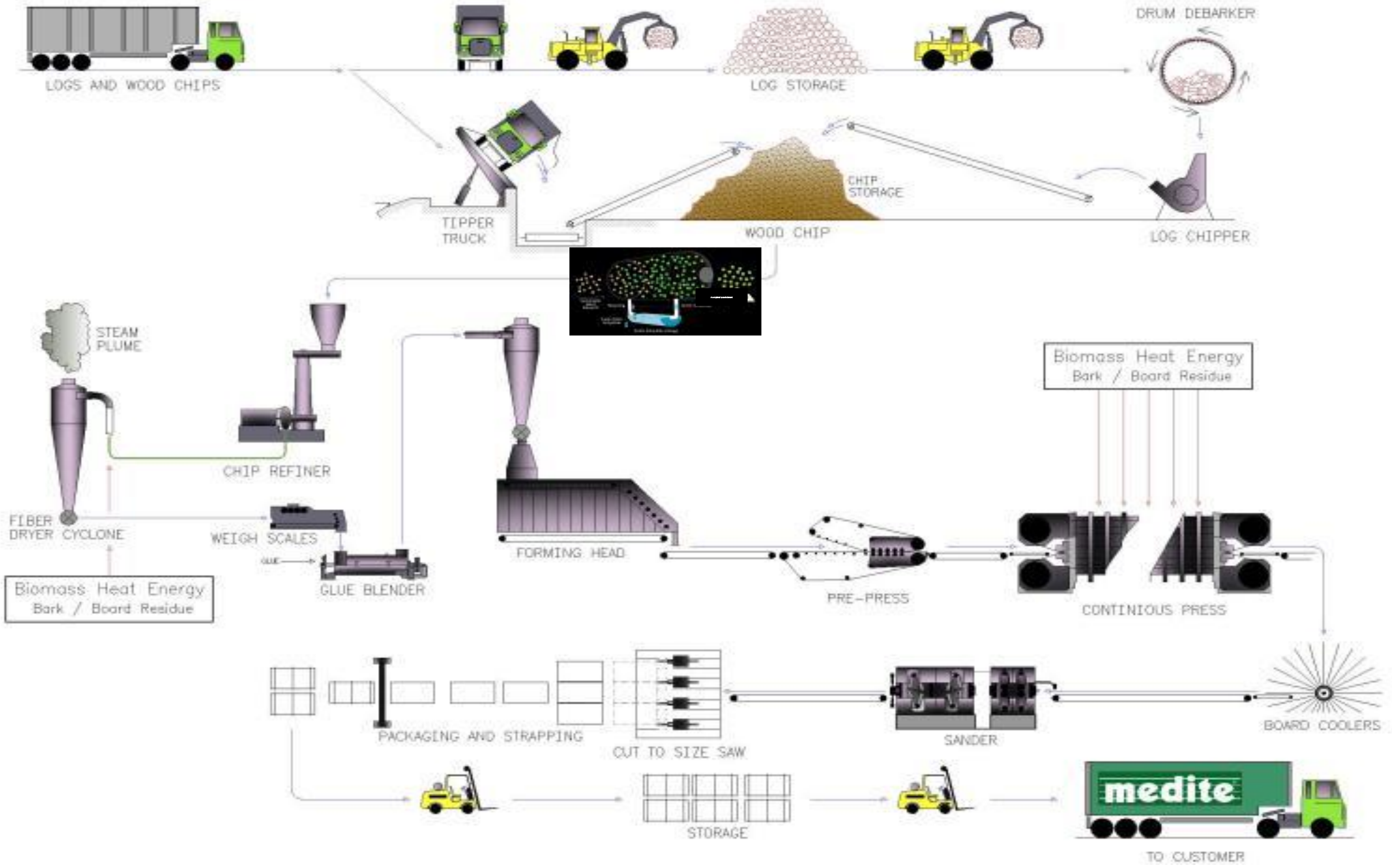
Widely used in solid form

But what about fibres?

Treatment of fibres, chips and flakes



What is wood modification via acetylation method?



Different commercial tracks

- Fibre

EXTREME
medite® tricoya®

- Chips

MEDITE® SMARTPLY®
INNOVATIVE TIMBER PRODUCTS

Performance of Medite Tricoya Extreme?

DURABLE™
Longer lasting, perfect for external and internal wet environments

50 YEAR GUARANTEE™
Peace of mind with a 25 year in-ground and 50 year above ground Medite Tricoya guarantee

ENHANCED STABILITY™
Swelling and shrinking dramatically reduced

DESIGN FREEDOM™
All the design, fixing and machining flexibility of medium density fibreboards

LOWER MAINTENANCE COST™
Extended periods between exterior coatings maintenance

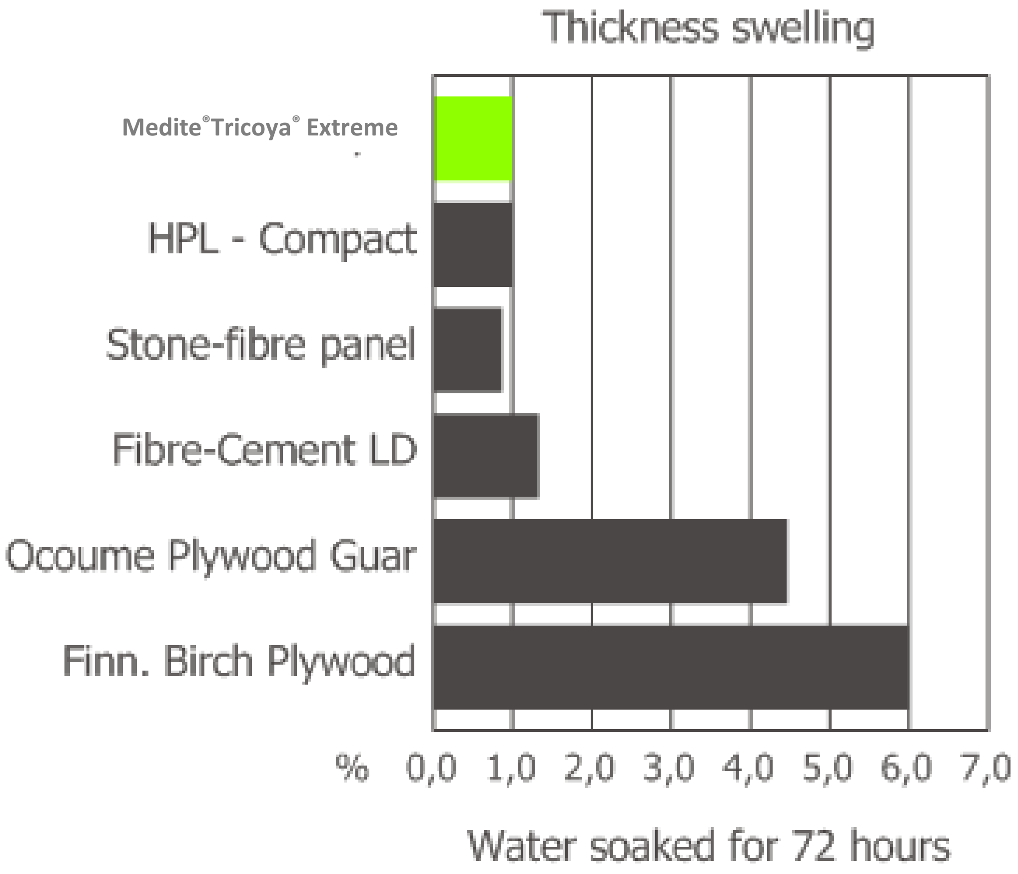
PERFECT FOR COATING™
Improved stability and durability enhances service life of the coating. Damaged coating will not affect core durability.

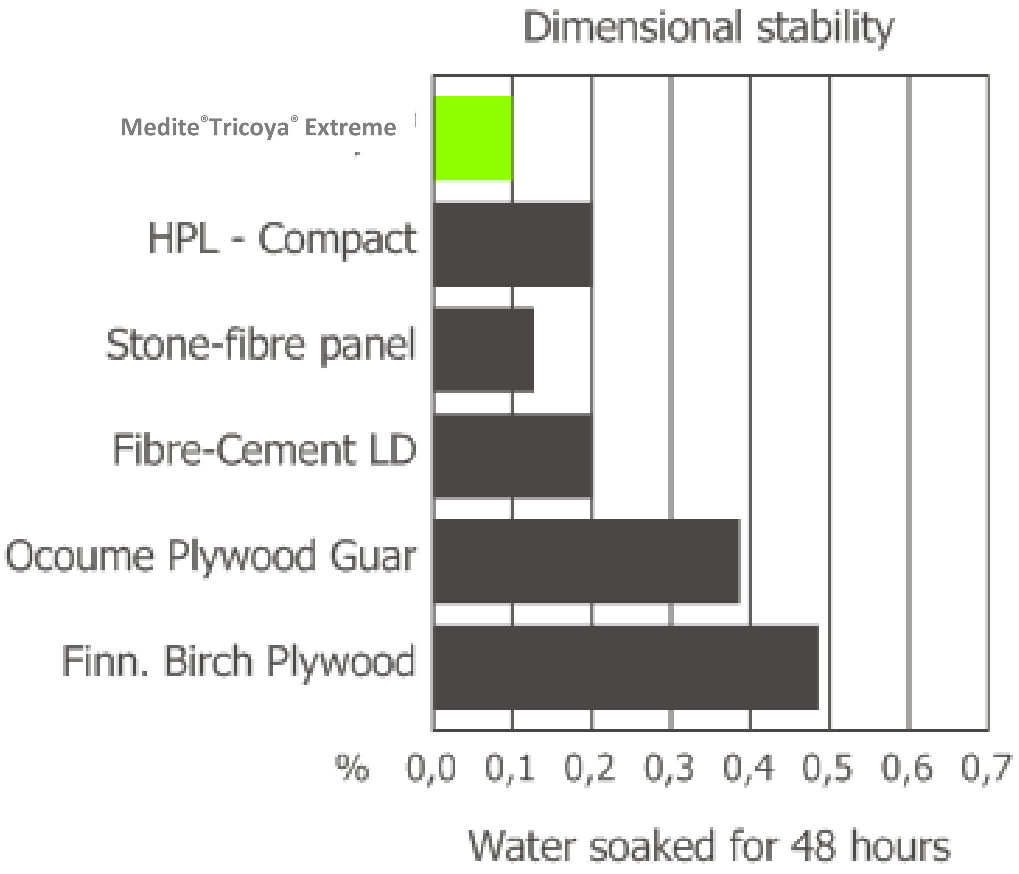
SUSTAINABLY SOURCED™
FSC® certified. Wood used from sustainable sources

RESISTANT TO FUNGAL DECAY™
Effective barrier to fungal decay

DESIRED SERVICE LIFE OF 60 YEARS™
Independent testing by BRE shows an expected service life of 60 years for exterior use

Stability tests on Medite Tricoya Extreme





Processing tests have been done on Medite Tricoya Extreme?

Fabricating

The panel may be cut, machined and used in exactly the same way as the rest of the Medite (MDF) range.

Coating

Conventional water-based paint coatings may be used to decorate the panel.

Laminating

Melamine papers, high pressure laminates and foils can be adhered to the product.

Sanding

The acetylated wood fibreboard panel is delivered ex-mill with a 150 grit sanded finish and can be sanded with fine sandpaper to achieve a smooth finish.

Gluing

Since acetylated MDF is drier than other wood panel products and absorbs water in a different manner, curing times of adhesives may be different. Recommended adhesives are PU, Epoxy, PRF and EPI.

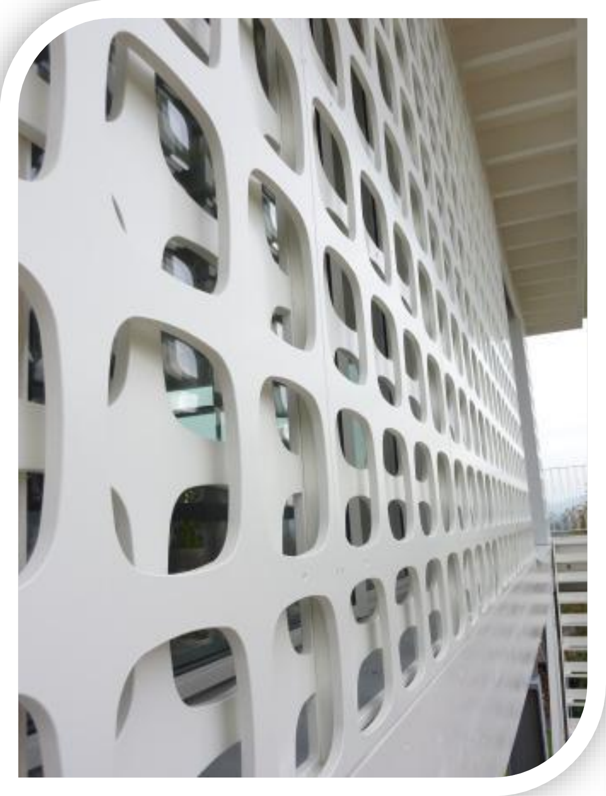
Fixing

Due to some residual acetic acid in the panel, stainless steel fasteners & fixings with A2 or A4 (EN1008-1) quality or AISI type 304 or 316 should be used

Fire rating

Panels achieve a fire class rating of euro class D within the Euro classification as with most wood-based panel products

Facade Cladding- Switzerland



Acetylation other fibres: Oil Palm Empty Fruit Bunch Coir

- 15-18% WPG
- Use in WPC
- Greater matrix interaction
  - Interfacial shear strength

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European Polymer Journal 37 (2001) 1037–1045

EUROPEAN POLYMER JOURNAL

The effect of acetylation on interfacial shear strength between plant fibres and various matrices

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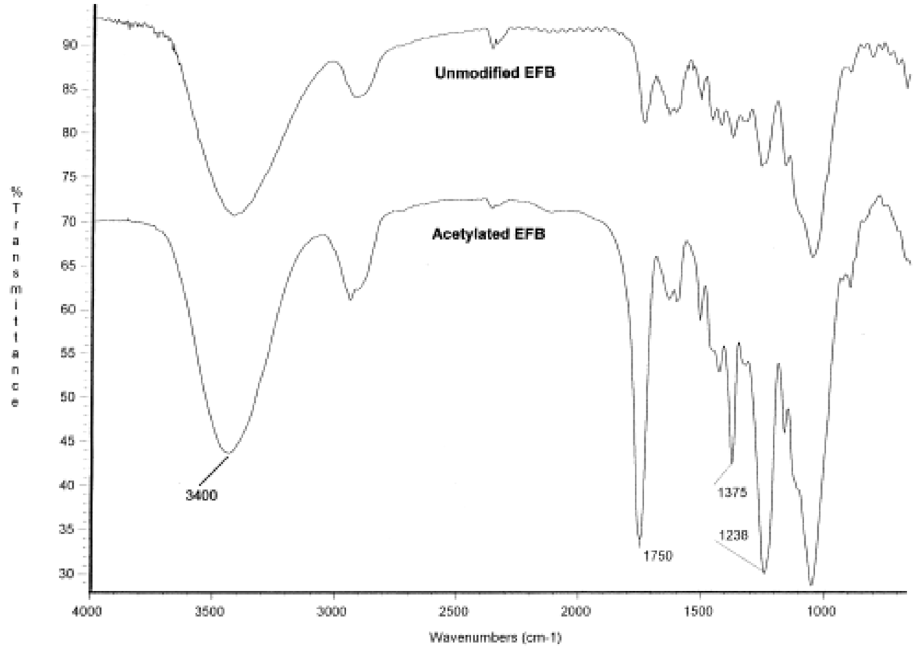
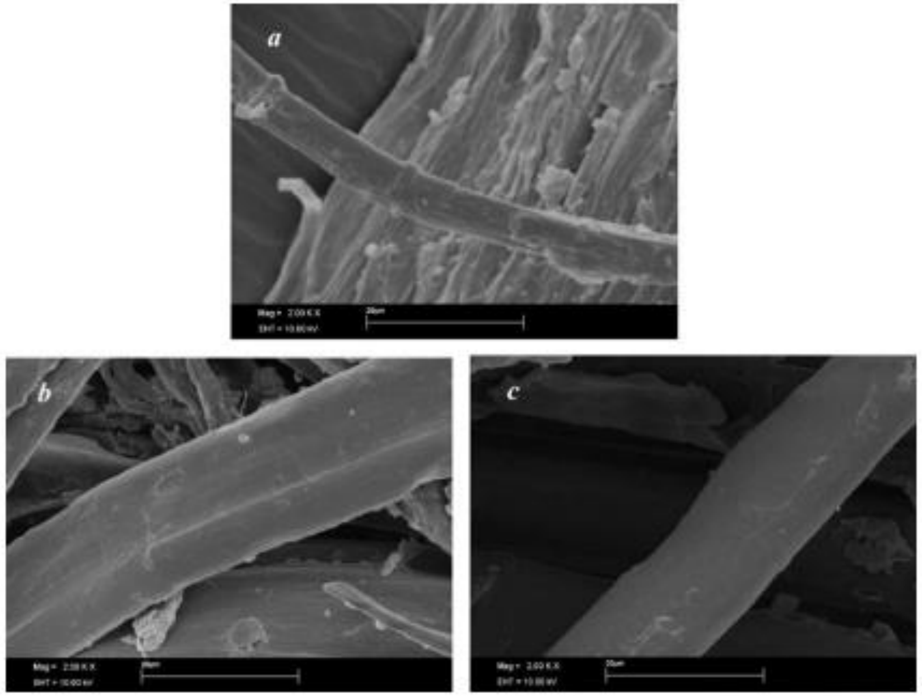
Received 6 January 2000; received in revised form 22 May 2000; accepted 26 June 2000



Acetylation other fibres: Hemp and Flax

- Reduced EMC
- Removal of waxes
- Smoother fibre surfaces



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Composites: Part A 36 (2005) 1110–1118

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A study of the effect of acetylation and propionylation surface treatments on natural fibres

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Received 28 May 2004; revised 16 November 2004; accepted 6 January 2005

	EMC wt %					
	Flax fibres		Hemp fibres		Wood fibres	
	60 RH	90 RH	60 RH	90 RH	60 RH	90 RH
Untreated	9.1	17.1	9.1	17.3	6.6	12.8
Acetylated	8.3	14.5	8.4	14.7	5.8	9.9
Propionylated	8.6	14.7	8.6	14.9	6.1	10.1

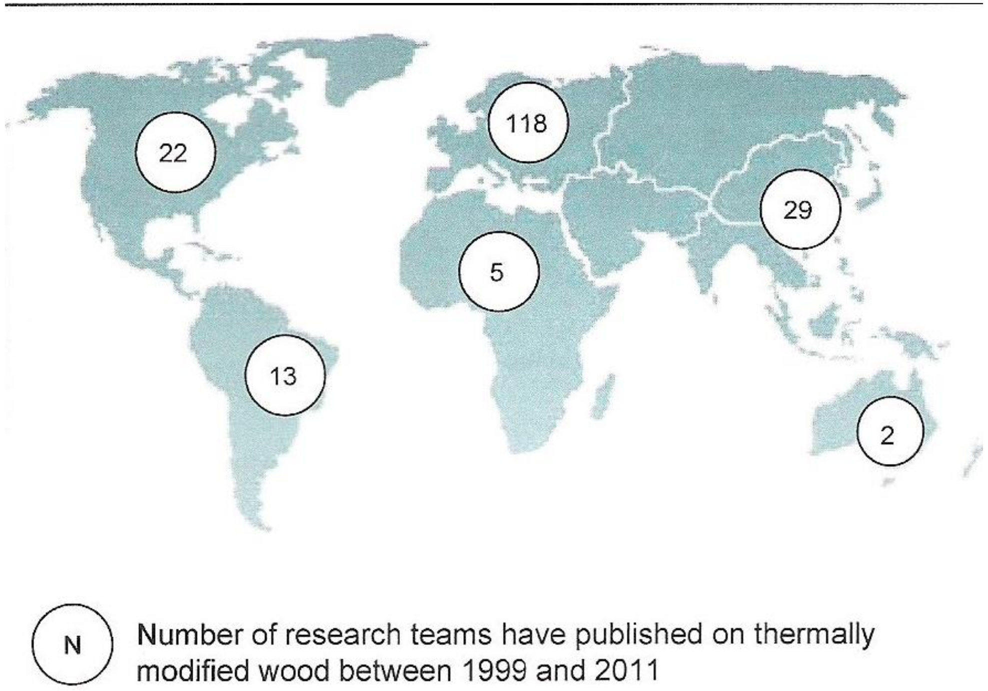
And many other species:
Sisal, kapok, jute etc.

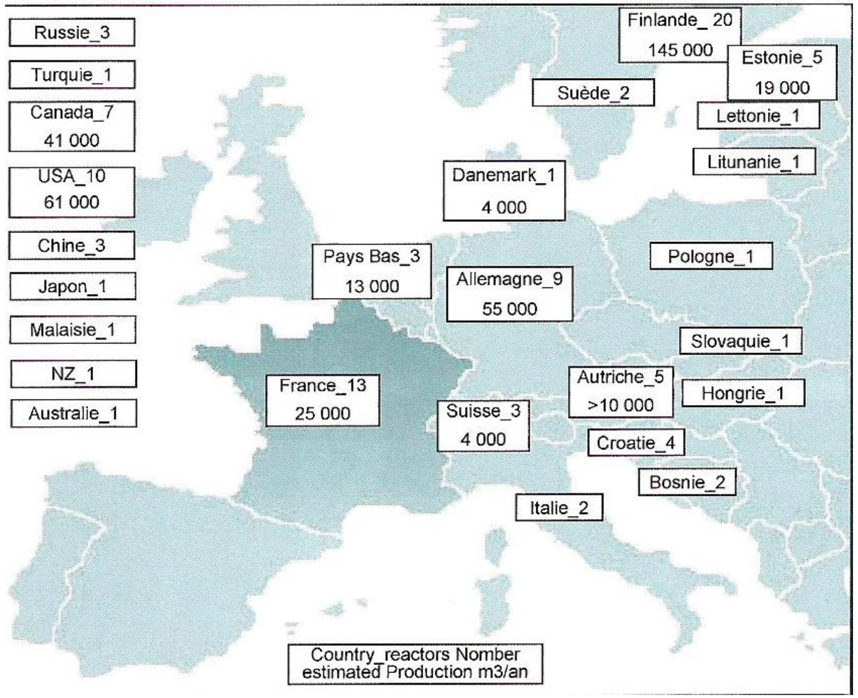
Thermal modification

- First study dates back to 1916
- No commercial interest until relatively recently
- First commercialised in Finland ‘Thermowood’ (sales over 31,000 m^3 in 2004)
- Also processes developed in France: ‘Retified wood’ and Quebec ‘La Bois Perdure’

TMT production

- Produced on a global level
- 2010 estimates

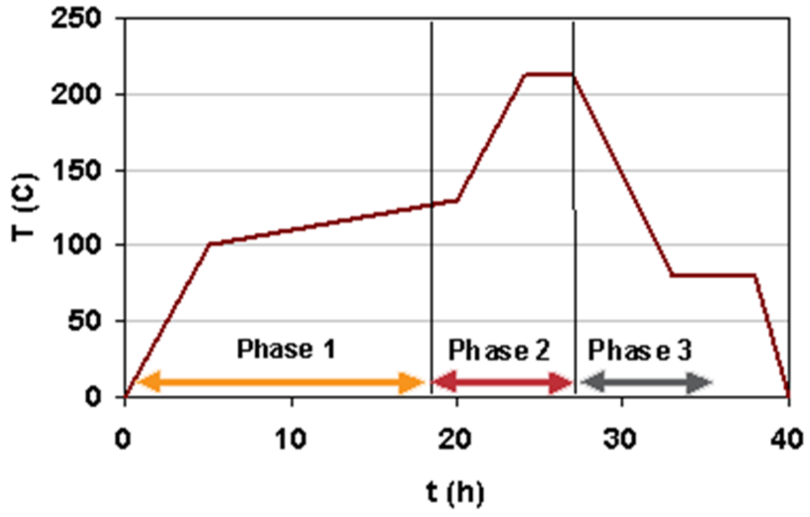




http://holz.fordaq.com/fordaq/news/TMT_Thermoholz_Frankreich_29275.html

Thermally modified wood

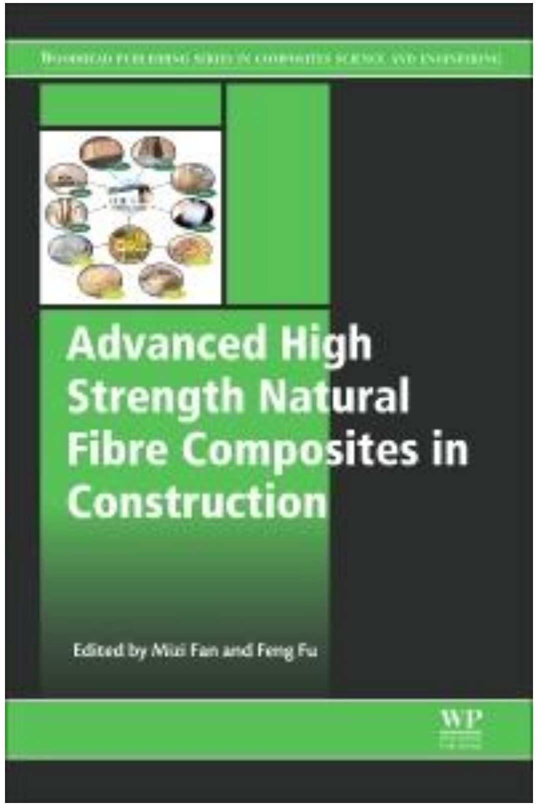
- Usually involves heating wood at temperatures of 180 deg C up to 240 deg C in the absence of air
- Can be done under a steam blanket (hygrothermal modification), under nitrogen, or in a vacuum
- Thermal modification results in degradation of the hemicelluloses primarily
- Cracking/splitting an issue
- Loosening of knots



Thermal modification

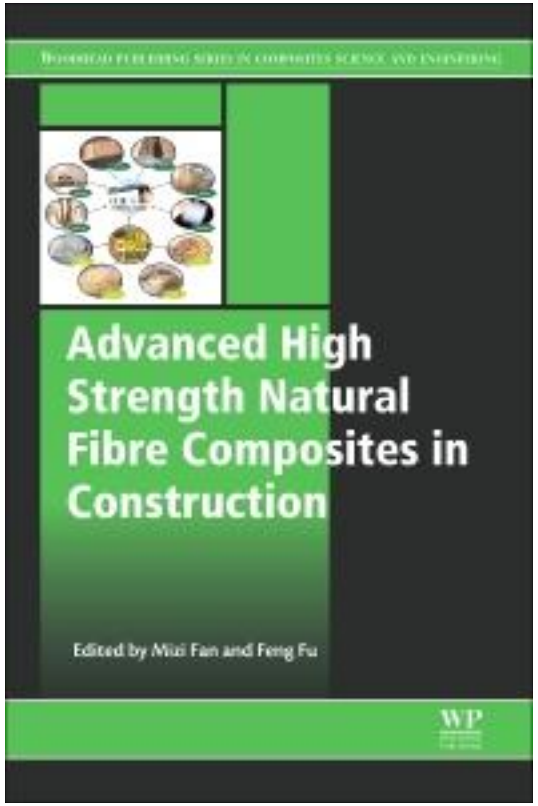
- Thermally modified wood is dark brown
- Wood becomes brittle (non load bearing)
- Wood has low abrasion resistance
- Wood splits easily

Many examples:



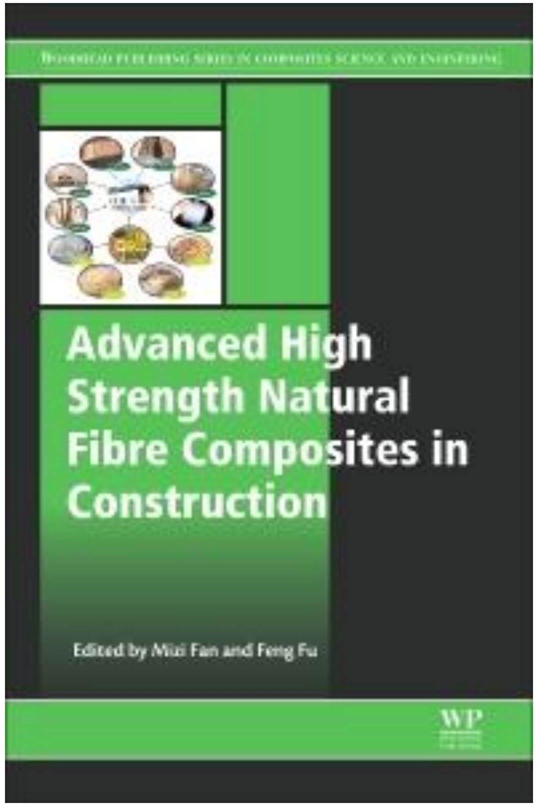
Species	Thermal treatment applied	References
Oak (*Quercus petraea* Lieb.)	$T = 130, 180, 230°C$; $t = 2, 8$ h	Akyildiz and Ates (2008)
Oak (*Quercus robur*)	$T = 160°C$; steam	Wikberg and Maunu (2004)
	$T = 160, 180, 210, 240°C$	Barcík et al. (2015a,b)
Silver oak (*Grevillea robusta*)	$T = 210–240°C$; $t = 1–8$ h	Srinivas and Pandey (2012)
Beech (*Fagus sylvatica* L.)	$T = 180, 200, 220°C$; $t = 4$ h	Bächle et al. (2010)
	$T = 160, 190°C$	Boruszewski et al. (2011)
	$T = 125–130°C$; $t = 6.5$ h; steam	Dzurenda (2013)
	$T = 170, 180, 190, 212°C$; $t = 2$ h	Kol and Sefil (2011)
Beech (*Fagus moesica* C.)	$T = 170, 190, 210°C$; $t = 4$ h	Todorović et al. (2015)
Beech (*Fagus Orientalis*)	$T = 150, 160, 170°C$; $t = 1, 3, 5, 7$ h	Charani et al. (2007)
	$T = 130, 150, 180, 200°C$; $t = 2, 6, 10$ h	Yildiz et al. (2005)
Aspen (*Populus tremula*)	$T = 195°C$	Wikberg and Maunu (2004)
	$T = 170°C$; $t = 1$ h, pressure = 0.6 MPa; water vapour medium	Cirule et al. (2016)
	$T = 160–170°C$; $t = 1, 3$ h; pressure = 6.5–7.6 bar; steam	Grinins et al. (2013)
Poplar (*Populus cathayaha*)	$T = 180–220°C$; $t = 4$ h	Ling et al. (2016)
	$T = 160, 180, 200, 220, 240°C$; $t = 4$ h	Wang et al. (2015)
Lime (*Tilia cordata*)	$T = 140°C$; RH = 10%; $t = 0–504$ h	Popescu et al. (2013a,b), Popescu and Popescu (2013)
Birch (*Betula pendula*)	$T = 195°C$	Wikberg and Maunu (2004)
	$T = 160, 180, 210, 240°C$	Barcík et al. (2015a)
	$T = 140, 160, 180°C$; $t = 1$ h	Biziks et al. (2013)
	$T = 160–170°C$; $t = 1, 3$ h; pressure = 6.5–7.6 bar; steam	Grinins et al. (2013)

Many examples:



Birch (*Betula pubescens* Ehrh.)	$T = 160, 190°C$	Boruszewski et al. (2011)
Pear (*Pyrus elaeagnifolia* Pall.)	$T = 160, 180, 200°C$; $t = 3, 5, 7$ h	Gunduz et al. (2009)
Hazelnut (*Corylus colurna* L.)	$T = 120, 150, 180°C$; $t = 2, 6, 10$ h	Korkut and Hiziroglu (2009)
Chestnut (*Castanea sativa* Mill.)	$T = 130, 180, 230°C$; $t = 2, 8$ h	Akyildiz and Ates (2008)
	$T = 160, 180°C$; $t = 2, 4$ h	Korkut et al. (2012)
Alder (*Alnus glutinosa* L.)	$T = 150, 180, 200°C$; $t = 2, 6, 10$ h	Yildiz et al. (2011)
Grey alder (*Alnus incana*)	$T = 160–170°C$; $t = 1, 3$ h; pressure = 6.5–7.6 bar; steam	Grinins et al. (2013)
Red-bud maple (*Acer trautvetteri* Medw.)	$T = 120, 150, 180°C$; $t = 2, 6, 10$ h	Korkut et al. (2008a,b), Korkut and Guller (2008)
Narrow-leaved ash (*Fraxinus angustifolia* Vahl.)	$T = 160, 180°C$; $t = 2, 4$ h	Korkut et al. (2012)
	$T = 140, 180, 200, 220°C$; $t = 2, 4, 6$ h; steam	Yalcin and Sahin (2015)
Paulownia (*Paulownia elongata*)	$T = 150, 170°C$; pressure = 20, 22.5 bar; $t = 45$ min	Candan et al. (2013)
	$T = 160, 180, 200°C$; $t = 3, 5, 7$ h	Kaygin et al. (2009)
Gympie messmate (*Eucaliptus cloeziana*)	$T = 180, 200, 220, 240°C$; $t = 4$ h	de Cademartori et al. (2013a)
Eucalyptus grandis	$T = 180, 200, 220, 240°C$; $t = 4, 8$ h	de Cademartori et al. (2013b)
Rubberwood (*Hevea brasiliensis*)	$T = 210–240°C$; $t = 1–8$ h	Srinivas and Pandey (2012)
Acacia hybrid (*Acacia mangium* × *auriculiformis*) sapwood	$T = 210–230°C$; $t = 2–6$ h; nitrogen	Tuong and Li (2011)
Western red cedar (*Thuja plicata*)	$T = 220°C$; $t = 1, 2$ h	Awoyemi and Jones (2011)
Norway spruce (*Picea abies* L.)	$T = 200°C$; $t = 5, 30, 60$ min	Follrich et al. (2006)
	$T = 113, 134, 158, 187, 221, 237, 253, 271°C$; $t = 90$ min	Kačíková et al. (2013)
	RH = 50, 65, 80, 95%; $T = 200°C$; $t = 2, 4, 8, 10, 24$ h; $T = 100, 150°C$; $t = 24$ h	Bekhta and Niemz (2005)

Many examples:



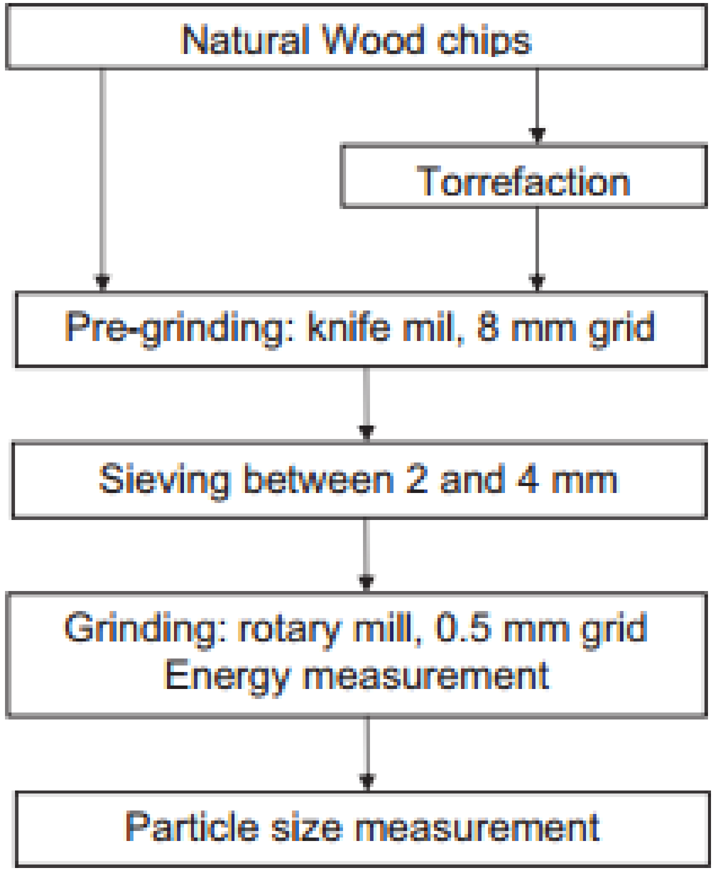
Species	Thermal treatment applied	References
	$T = 195°C$	Wikberg and Maunu (2004)
	$T = 180, 200, 220°C; t = 4$ h	Bächle et al. (2010)
	TERMOVUOTO® technology $T = 160, 220°C$; vacuum	Allegretti et al. (2012)
	$T = 160–260°C; t = 2–8$ h	Kotilainen et al. (2000)
Black spruce (*Picea mariana*)	$T = 190, 200, 210°C$	Lekounougou and Kocaefe (2014)
Fir (*Abies alba* Mill.)	TERMOVUOTO® technology $T = 160, 220°C$; vacuum	Allegretti et al. (2012)
	$T = 170, 180, 190, 212°C; t = 2$ h	Kol and Sefil (2011)
Calabrian pine (*Pinus brutia* Ten.)	$T = 130, 180, 230°C; t = 2, 8$ h	Ates et al. (2009); Akyildiz and Ates (2008)
Black pine (*Pinus nigra* Arnold.)	$T = 130, 180, 230°C; t = 2, 8$ h	Akyildiz and Ates (2008)
Scots pine (*Pinus sylvestris* L.)	$T = 120, 150, 180°C; t = 2, 6, 10$ h	Korkut et al. (2008a,b)
	$T = 180, 200, 240°C$	Kekkonen et al. (2010)
	$T = 160–260°C; t = 2–8$ h;	Kotilainen et al. (2000)
	$T = 160, 180, 210, 240°C$	Barcík et al. (2015a)
Maritime pine (*Pinus pinaster*)	$T = 170–200°C; t = 2–24$ h	Esteves et al. (2008)
Oil palm mesocarp fibre	$T = 190–230°C; t = 1, 2, 3$ h	Nordin et al. (2013)
Bamboo (*Dendrocalamus barbatus* and *Dendrocalamus asper*)	$T = 130, 180°C; t = 2, 5$ h	Nguyen et al. (2012)
	$T = 130, 220°C; t = 2, 5$ h	Bremer et al. (2013)
Bamboo (*Dendrocalamus asper*)	$T = 140–200°C; t = 30–120$ min – coconut oil medium	Manalo and Garcia (2012)

Thermal modification

- Main applications are for cladding
- Wood is slightly acidic, due to production of acetic acid from degradation of hemicelluloses – requires stainless steel fixings
- Wood has improved dimensional stability
- Slightly improved decay resistance, but thermally modified wood is not suitable for ground contact applications

TMT in use

Fibres from solid TMT



BIOMASS AND BIOENERGY 34 (2010) 923–930

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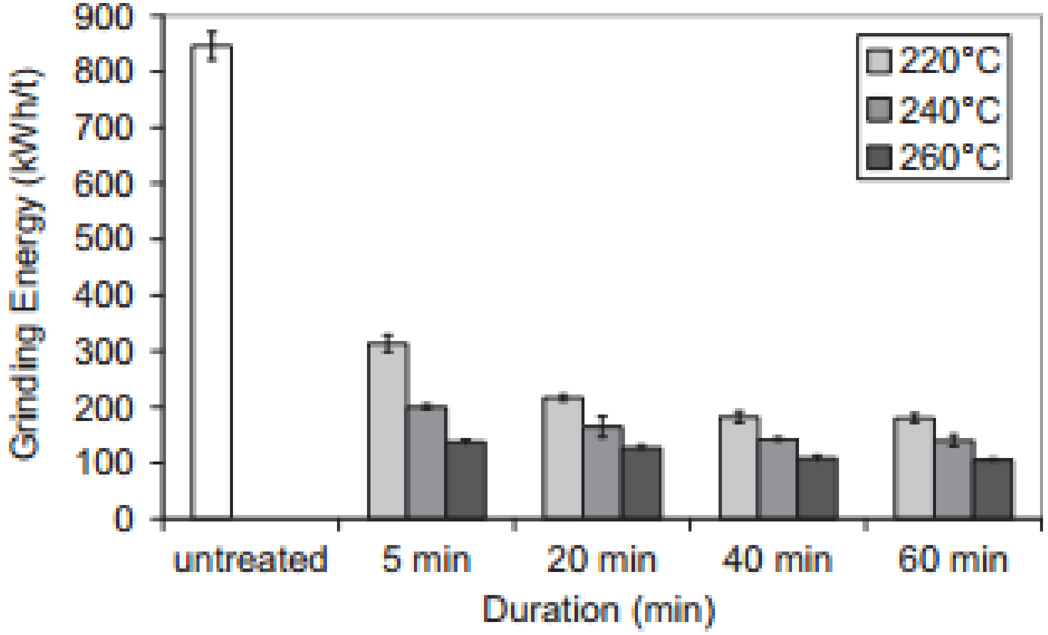
Energy requirement for fine grinding of torrefied wood

Vincent Repellin[a], *Alexandre Govin*[a,*], *Matthieu Rolland*[b], *René Guyonnet*[a]

[a] *Department of Powder and Multi-Components Materials (PMMC), SPIN Research Center, Ecole des Mines de Saint Etienne (EMSE), 158 Cours Fauriel, F-42023 Saint-Etienne, France*

[b] *Process Developments and Engineering Division, Chemical Engineering Department, Institut Français du Pétrole (IFP-Lyon), F-69390 Vernaison, France*



TMT of chips

- Option for processing
- Typical weight losses
- Strength reduction

BIOMASS AND BIOENERGY 34 (2010) 602–609

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BIOMASS & BIOENERGY

Modelling anhydrous weight loss of wood chips during torrefaction in a pilot kiln

Vincent Repellin [a], *Alexandre Govin* [a,*], *Matthieu Rolland* [b], *René Guyonnet* [a]

[a] *Department of Physico-chemistry of Multi-components Materials (PMMC), SPIN Research Center, Ecole des Mines de Saint Etienne (EMSE), 158, Cours Fauriel, F-42023 Saint-Etienne, France*

[b] *Process Developments and Engineering Division, Chemical Engineering Department, Institut Français du Pétrole (IFP-Lyon), F-69390 Vernaison, France*

Fibre examples

- Few examples on modifying wood fibres.

Polymer Degradation and Stability 96 (2011) 818–822

ELSEVIER

Contents lists available at ScienceDirect

Polymer Degradation and Stability

journal homepage: www.elsevier.com/locate/polydegstab

Effect of thermal-treatment of wood fibres on properties of flat-pressed wood plastic composites

Nadir Ayrilmis [a,*], Songklod Jarusombuti [b,1], Vallayuth Fueangvivat [c,2], Piyawade Bauchongkol [c,2]

[a] Istanbul University, Forestry Faculty, Department of Wood Mechanics and Technology, Bahcekoy, Sariyer, 34473 Istanbul, Turkey
[b] Kasetsart University, Forestry Faculty, Department of Forest Products, Chatuchak, 10903 Bangkok, Thailand
[c] Wood Research and Development Office, Royal Forest Department, 61 Phaholyothin Rd., Lad-Yao, Chatuchak, 10903 Bangkok, Thailand

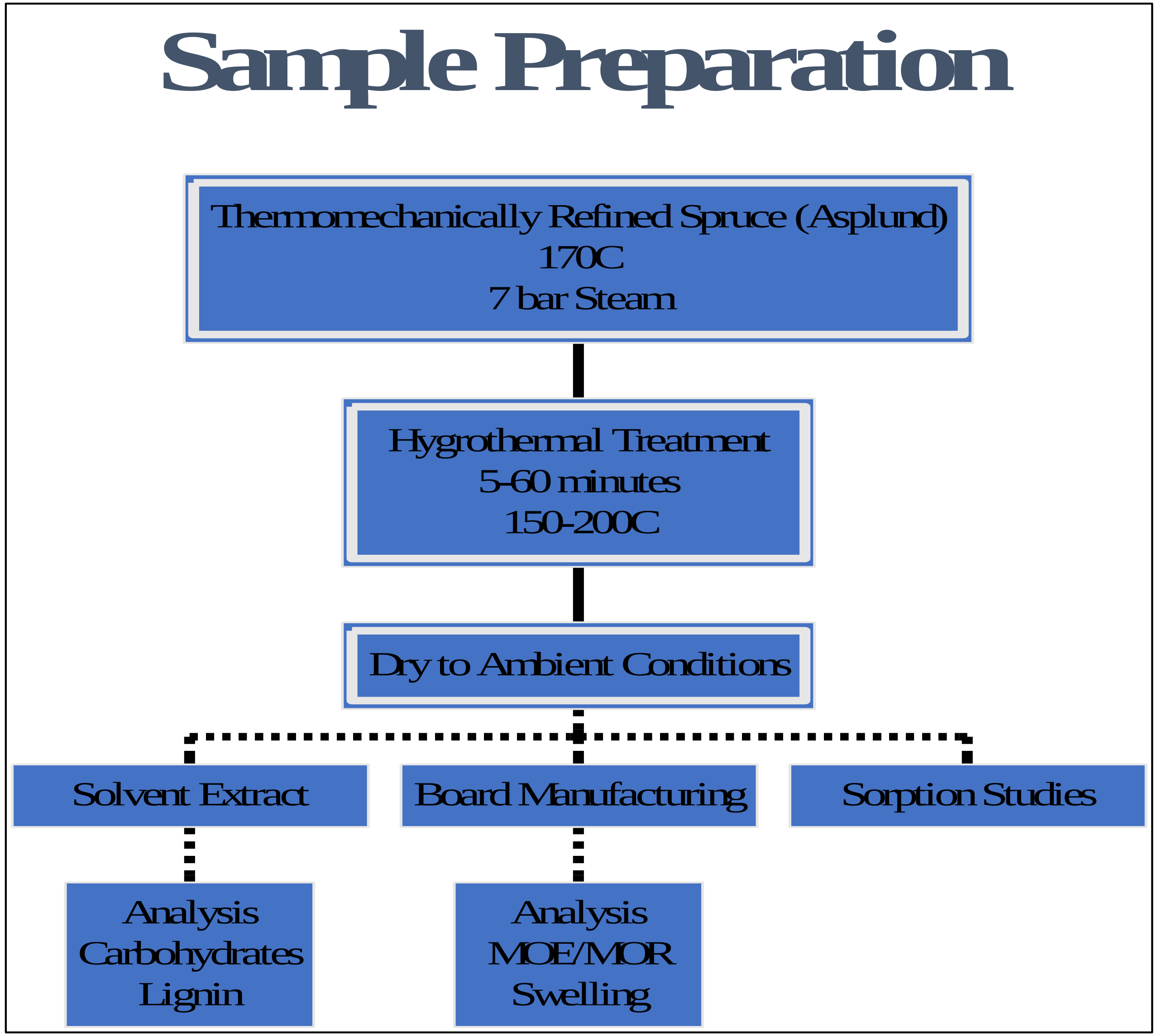
- HOWEVER..
- This was proposed in 1999 (European Panel Products Symposium, Llandudno, UK)

The Hygrothermal Treatment of Natural Fibres - Part 1. Spruce

D. Jones, K. Strømdahl, P. Hoffmeyer
DTU, Denmark
P. Folting, A.B. Olesen, G. Fischer
KVL, Denmark

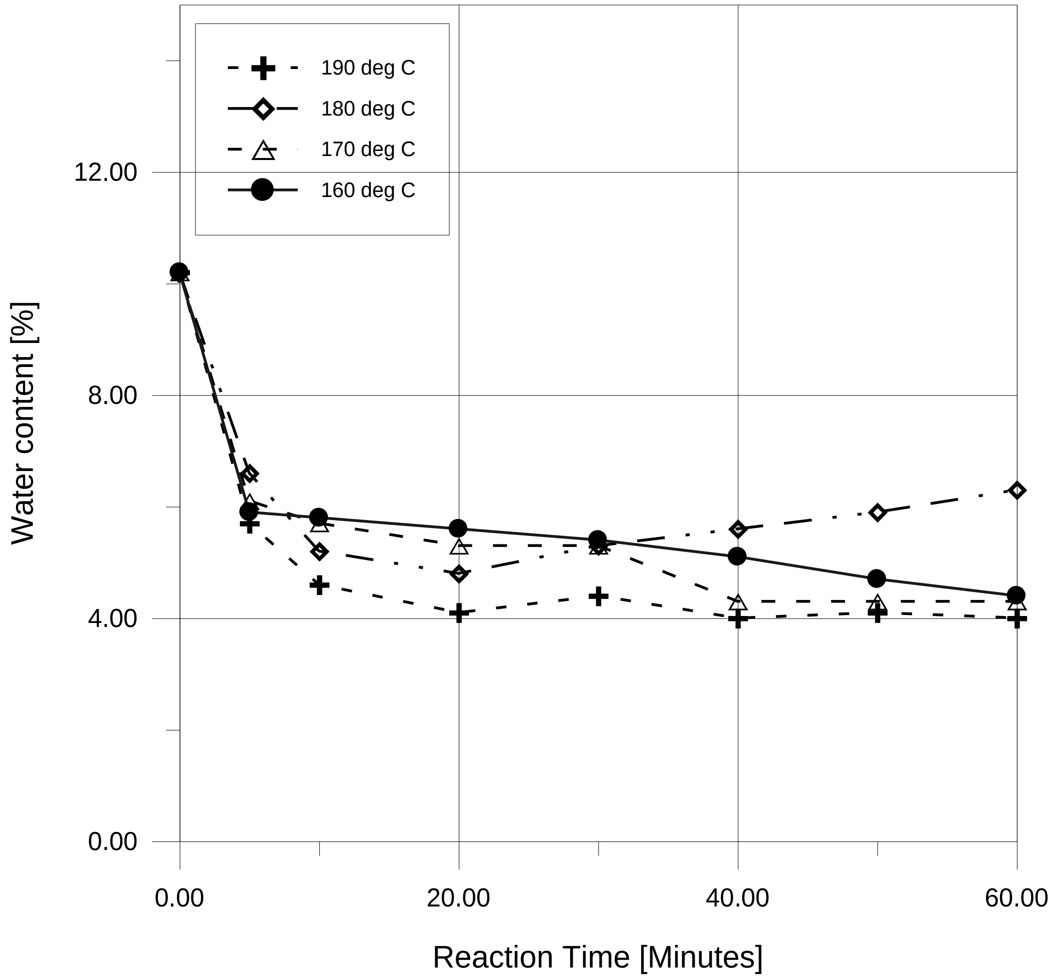
What is Hygrothermal Treatment

- Treatment of materials using steam at:
  - Elevated temperature.
  - Elevated pressure.
- Avoids the use of potentially harmful chemicals.
- Produces a more dimensionally stable material.



Treatment and Extractives

- Weight losses noted for most experiments.
- Increase in fibre acidity.
- Higher water extractives, ethanol extractives, acetone extractives.
- Toluene extractives unchanged.

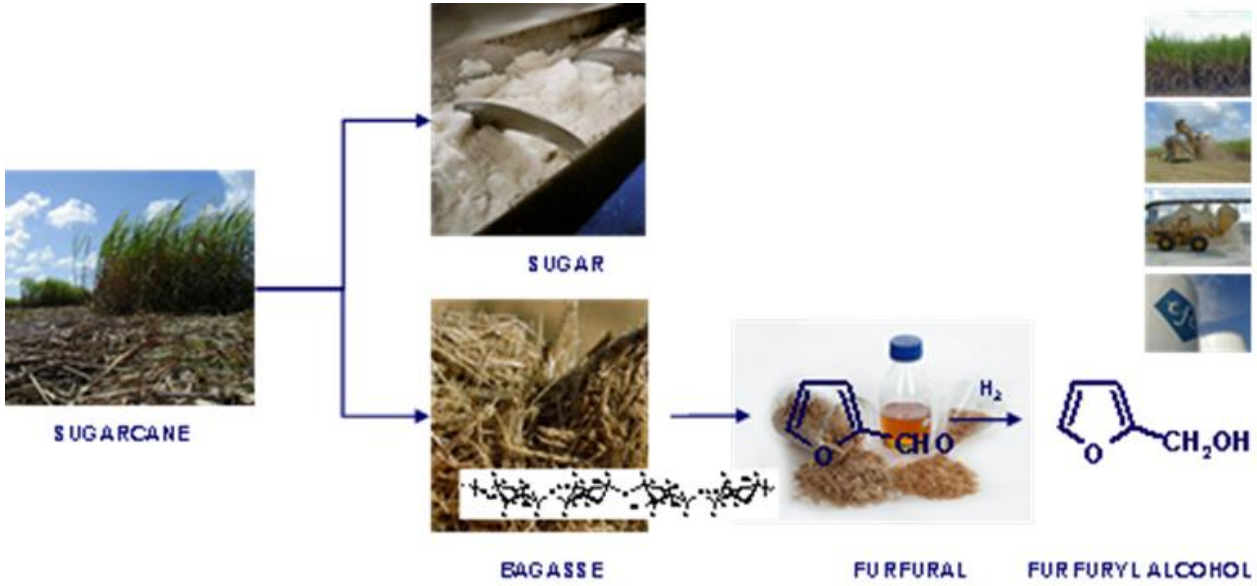


Furfurylation

- Developed in the 1940’s
- Problems with process, which were solved in the 1990’s
- Now used to modify wood by Wood Polymer Technologies ASA (Norway)
- Marketed by Kebony Products DA

Furfurylation

- Furfuryl alcohol is derived from corn cobs or sugar cane residues
- Impregnation using conventional impregnation plant
- Curing in conventional kiln
- Relatively low capital cost

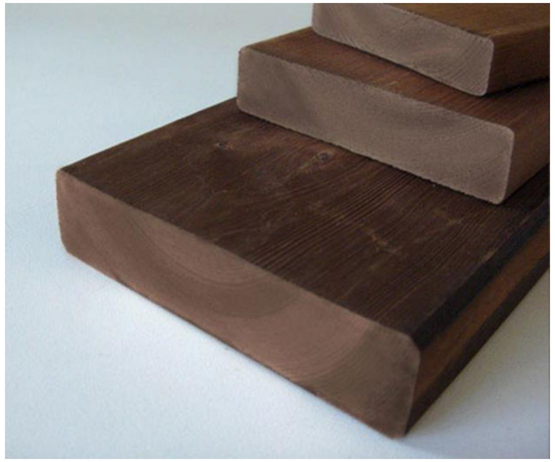


Products

- Visorwood, Kebony 30, Kebony 100
- Different levels of loading of the furfuryl alcohol
- Kebony 100 has the highest loading and is almost black in colour
- Virowood and Kebony 30 have lower loading levels and are golden brown in colour

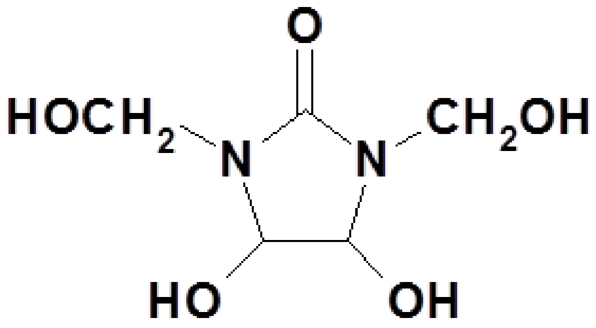
Products

- Kebony 100 is highly dimensionally stable and highly decay resistant, also highly resistant to biological attack in a marine environment (unusual for a modified wood)
- Kebony 30 has lower dimensional stability and decay resistance compared to Kebony 100
- Production is around 20,000 m^3 per annum



Belmadur

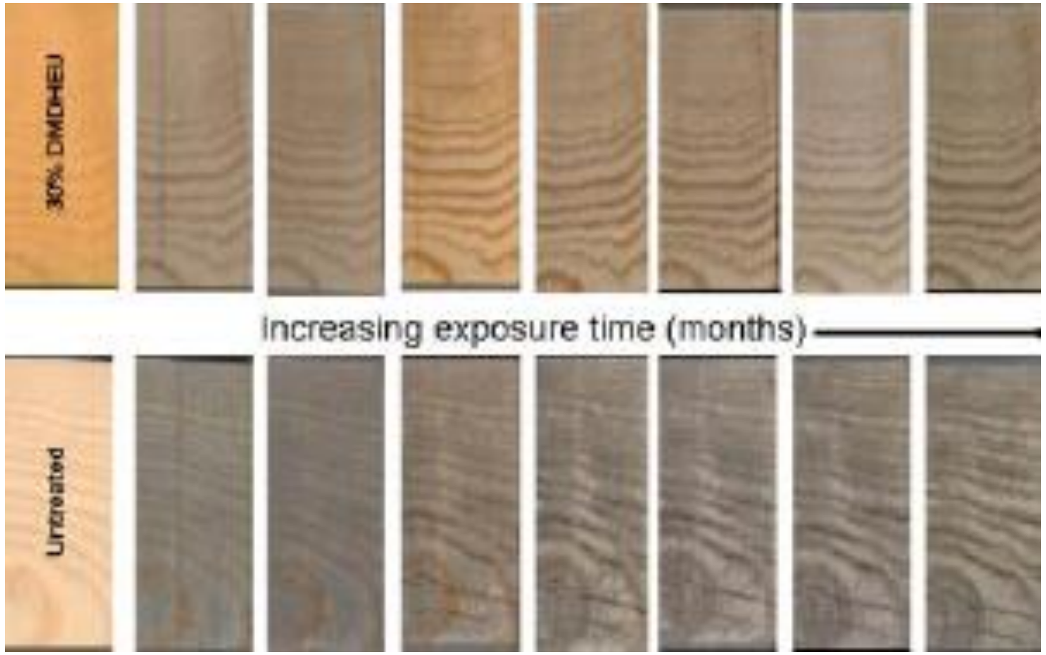
- Manufactured by BASF (2006)
- Impregnation of wood with aqueous solution of m-DMDHEU (Methylolated Dimethoyl Di-hydroxy Ethylene Urea)
- Impregnated wood is heat-cured in conventional kiln



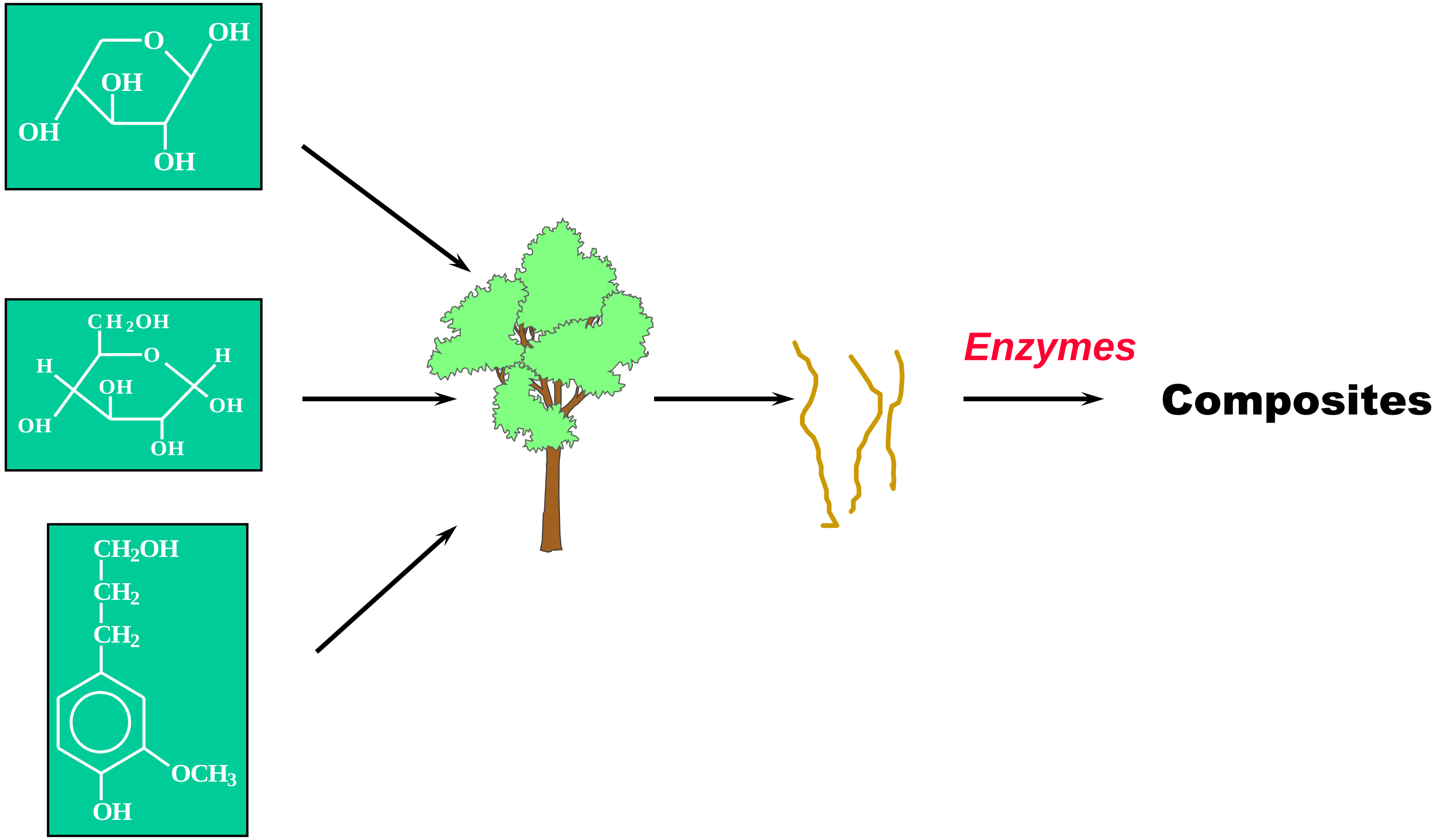
Chemical structure of DMDHEU
(Dimethyloldihydroxyethyleneurea)

Properties

- Wood is not discoloured
- Dimensionally stabilised
- Hard surface
- Moderate decay resistance
- Suitable for outdoor applications (such as garden furniture)

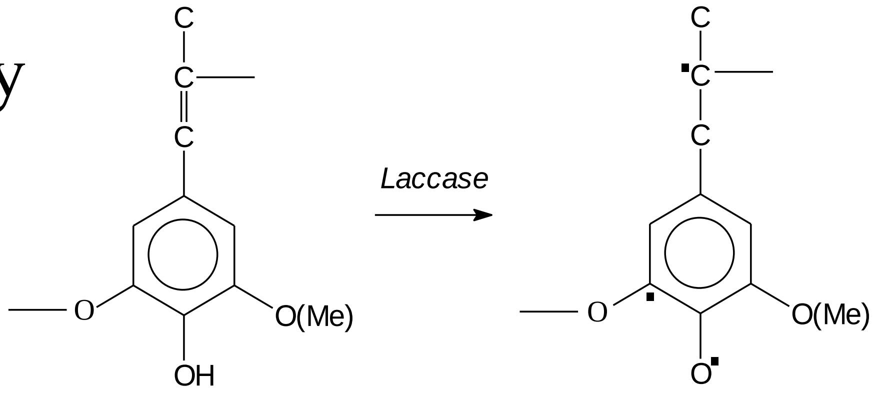


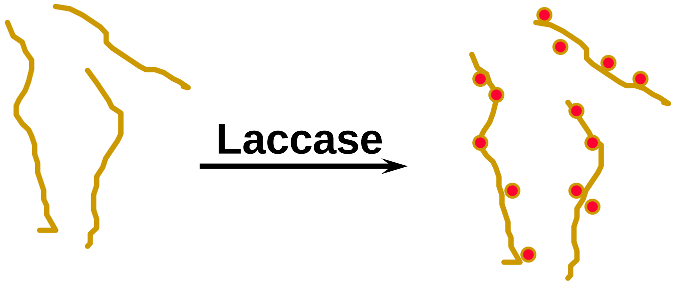
Obtaining Enzymatic Treated Fibres



How does this work?

- The enzyme laccase will “activate” the fiber surface by oxidation of lignin thereby creating radicals.
- The auto-adhesive properties of the fibers are enhanced
- The radicals on fibers will crosslink during the hot-pressing of fibers to boards and panels





Where does modified wood 'sit'?

Durability Class	**Wood species**	**Modified wood type**
1	teak, iroko	Accoya® Perennial Wood™, Kebony®, maple & beech, Plato® Norway spruce Keywood™
2	European oak, iroko, Western red cedar	Thermo®Wood D, Celloc® Norway spruce, Kebony® ash & radiata pine, Plato® Scots pine
3	Douglas fir, larch, Scots pine	Thermo®Wood S, Plato® radiata pine
4	Scots pine, radiata pine	
5	radiata pine	

Source: Andrew Pitman, TRADA (UK)

Modified wood and possible uses

Product range	Possible treatment process
Garden Wood	Thermally modified wood
Window Companies	Acetylated wood / Polymer impregnated
Exterior Door Companies	Acetylated MDF
Flooring Companies	Modified wood / MDF / Polymer impregnated
Wet Room & Façade Panels	Acetylated fibres
Building products etc.	Acetylated / Heat modified wood
Automotive / Nautical industry	Furfurylated wood
Architects /Gov. organizations	Acetylated /Heat modified wood
Furniture manufacture	Acetylated / Furfurylated / Polymer impregnated

Possible markets other than solid wood

- Plywood
  - Exterior grade
  - Marine use

- Veneers easily treated
  - Acetylation
  - DMDHEU

- Large market
  - Est. 1.5 million m^3 exterior grade / year
  - Capture 1% of this market
  - 15,000 m^3 demand for modified veneers

- MDF / Fibreboard

- Fibres easily treated
  - Acetylation
  - Possible continual process

- Large market
  - MDF 10 million m^3 / yr
  - 0.1% capture
  - 10,000 m^3 / yr

What modification treatments?

Likelihood

	Solid wood	Veneer	Fibre
Acetylation •Commercial production begun •Fibre production to follow	Yes	Yes < 5 yrs	Yes
Furfurylation •Wood /veneer treatments already possible •No work to date on fibres	Yes	Yes <10 yrs	Possible
Belmadur / Indurite •Wood / veneer work already demonstrated •No published work on fibres	Yes	Yes <5yrs	Possible
Heat treatment •Solid wood commercially available •Fibres from off-cuts, process residues	Yes	Yes <5 yrs	Possible <10 yrs

Developing new ideas

- *new technologies generally breed new approaches to design*
- *new applications are conceived & developed*
- *architects and engineers often lead scientists in this*
- *nothing would have been achieved without all three contributing their knowledge & experience & working together*

The way forward

- *build upon the vast amount of past and current research into modified wood*
- *stimulate the connection between product development & professional development*
- *coordinate the relationship between academics, practicing construction professionals,, forest, timber and construction industry members and funding bodies*

The future

- Greater incorporation of modified wood with conventional wood
- New hybrid structures
- Incorporporate smart technologies (self cleaning glass, PV coatings)
- Focus on design and performance

Looking for a good book to read?

Published by this COST Action

1: Introduction

2: Bio-based building materials

3: Non-wood bio-based building materials

4: Protection of the bio-based material

5: Performance of the bio-based materials

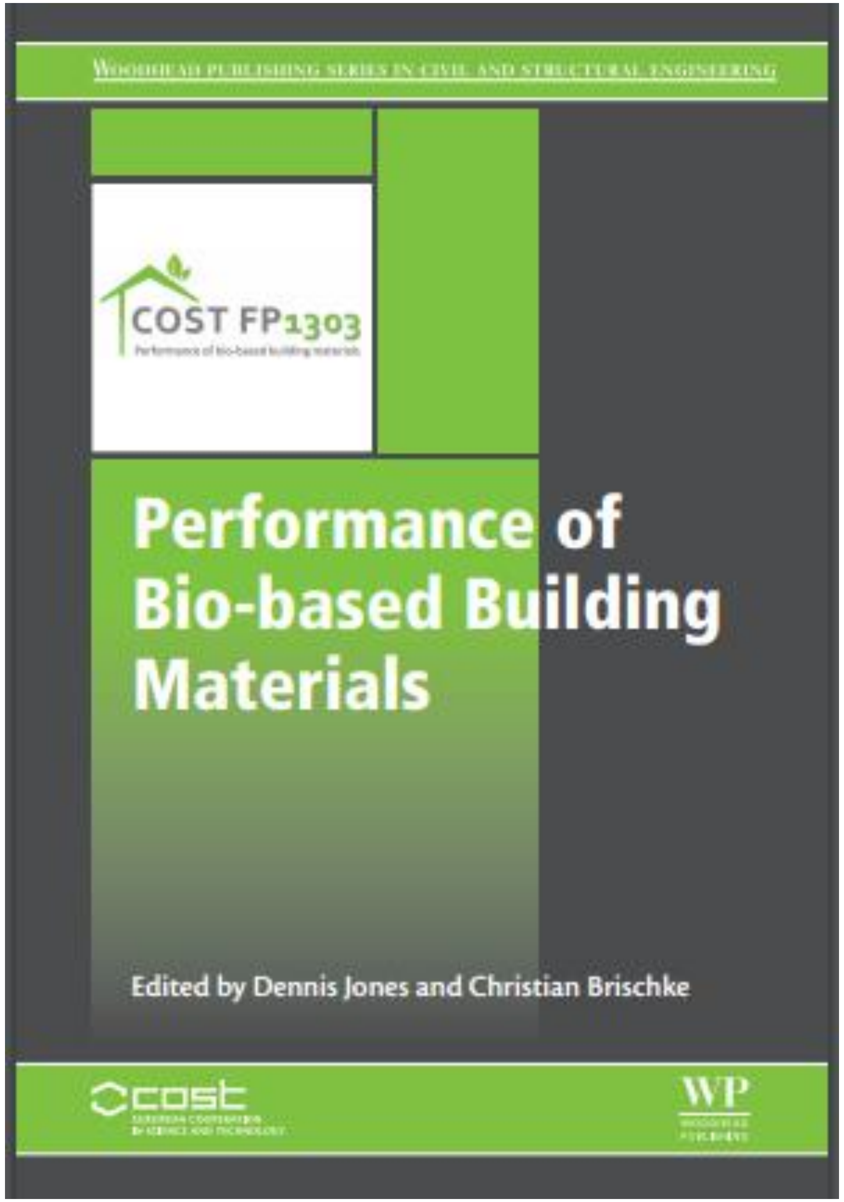
6: Performance of buildings

7: Test methods for biobased building materials

8: Modelling

9: Bio-based building materials meeting current and future requirements

10: Evaluation and standardisation



Dear friends and colleagues,

Cost FP1303 "Performance of bio-based building materials" is nearing its conclusion. Started in October 2013, it finishes in October 2017, and this meeting represents the final main activity in the Action.

To date, the Action has held meetings in Paris, Kranjska Gora, Zurich, Llandudno, Lisbon, Tallinn, Madrid, Helsinki, Poznan and Sofia. Now for our final meeting we will visit our 11th country with this forthcoming meeting in Zagreb, Croatia.

The aim of the meeting will be to assess developments over the four years of the COST Action, and what has been acheived in that time in terms of best practice for bio-based materials in construction, how research and development has helped increase awareness, and commercial opportunities that now exist.

On behalf of the core group of the Action and the Local Organisers, we look forward to welcoming you to this meeting, to learn more about what the Action has achieved, to share your knwoelge in the area of bio-based building materials and to build new collaborative links.

Dennis Jones

Chair, COST Action FP1303

About Croatia and Zagreb

Croatia acceded to the EU on January 1, 2013 and has a long history, its first king was Tomislav back in 925. Zagreb is the capital and the largest city of Croatia. First mentioned by name in 1134, it is located in the northwest of the country, along the Sava river, at the southern slopes of the Medvednica mountain. Zagreb lies at an elevation of approximately 122 m (400 ft) above sea level.

Local organisers

This COST FP1303 meeting will be organised by the University of Zagreb, Faculty of Forestry .

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FIRST ANNOUNCEMENT AND CALL FOR PAPERS

COST FP1303

BUILDING WITH BIO-BASED MATERIALS: BEST PRACTICE AND PERFORMANCE SPECIFICATION

6-7 September, 2017

ZAGREB, CROATIA

COST FP1303
Performance of bio-based building materials

COST
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY