Wood Modification

Callum Hill
Forest Products Research Institute
Edinburgh Napier University

Why Modify Wood?

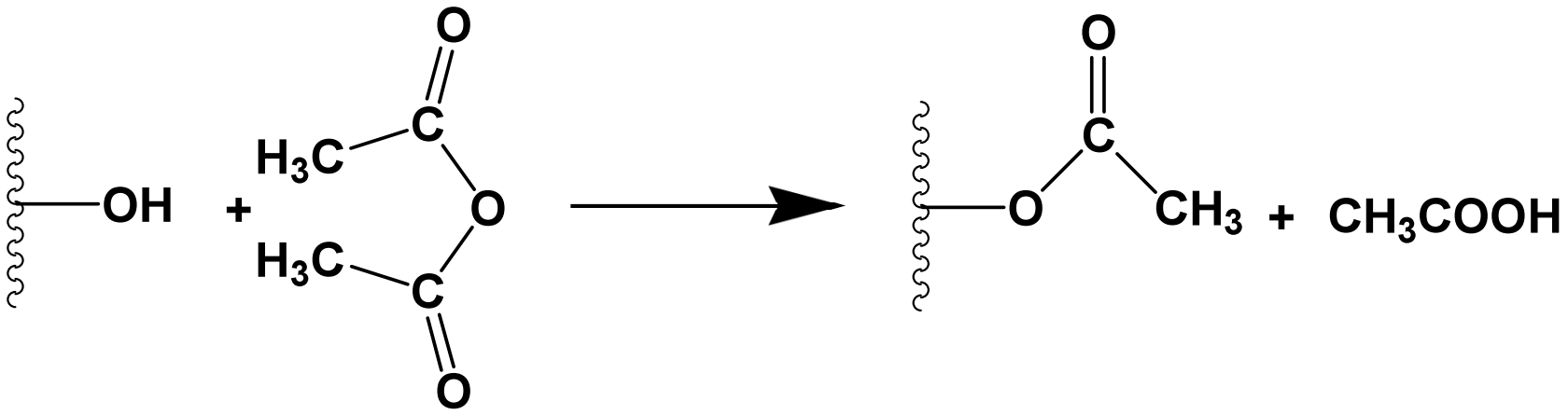
- Hygroscopicity
- Dimensional instability
- Mechanosorptive properties
- Durability
- Weathering Resistance

What is Wood Modification?

- Strictly speaking involves a change to the macromolecular chemical composition of the wood cell wall (chemical modification or thermal)
- Can also include ‘impregnation modification’ where the cell wall is filled with an occluding substance

Chemical Modification

- Only commercially available product is acetylated wood
- Increases naturally occurring acetyl content of wood (from 1-3% to 20%)



TITAN WOOD

the pioneers of

accoya™

www.accoya.info

Accoya™

- Highly resistant to biological attack
- Very dimensionally stable (ASE 80-90%)
- Good weathering resistance under clear coatings
- Strength is retained (but exhibits brash failure mode)
- But contains residual acetic acid (stainless steel fastenings)

Accoya™

Accoya™

Accoya™

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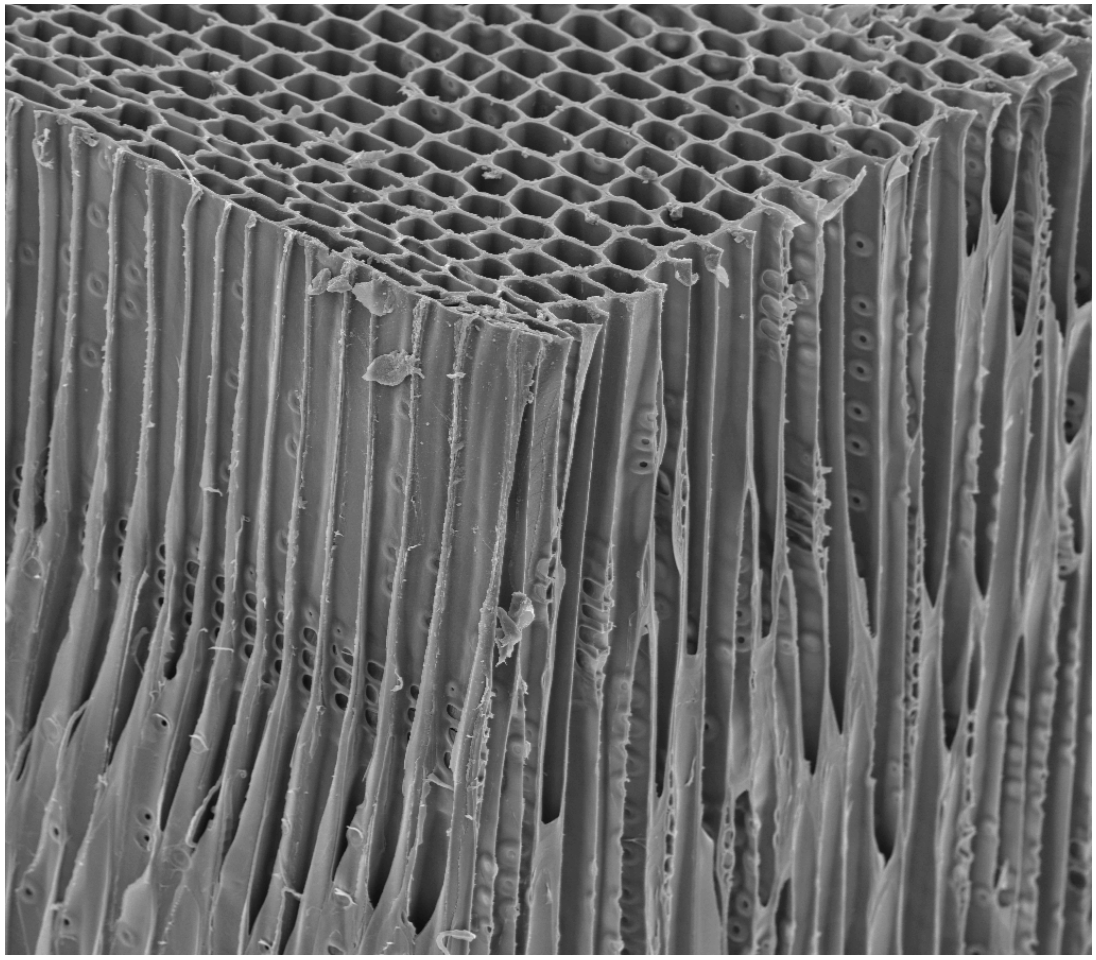
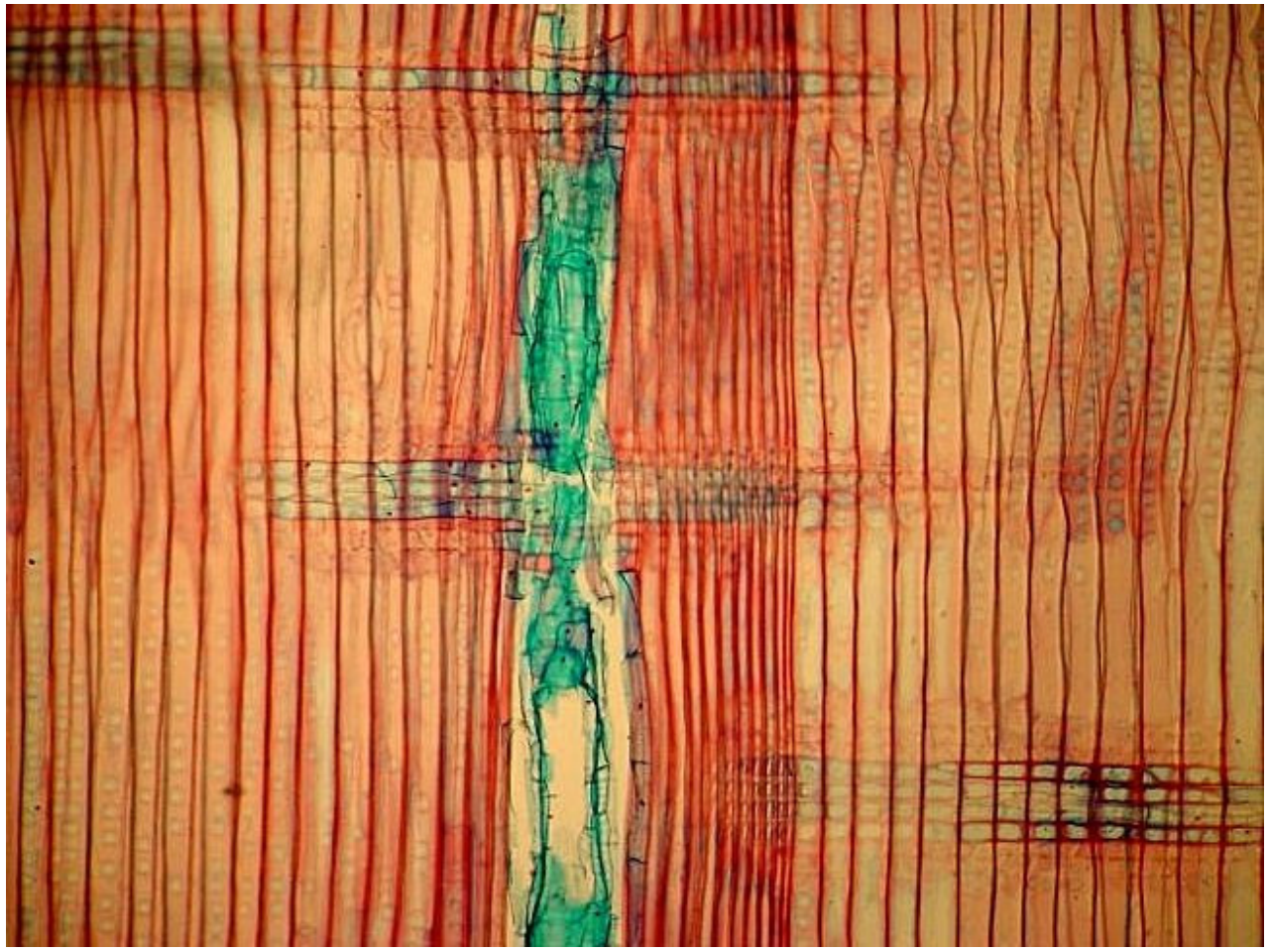
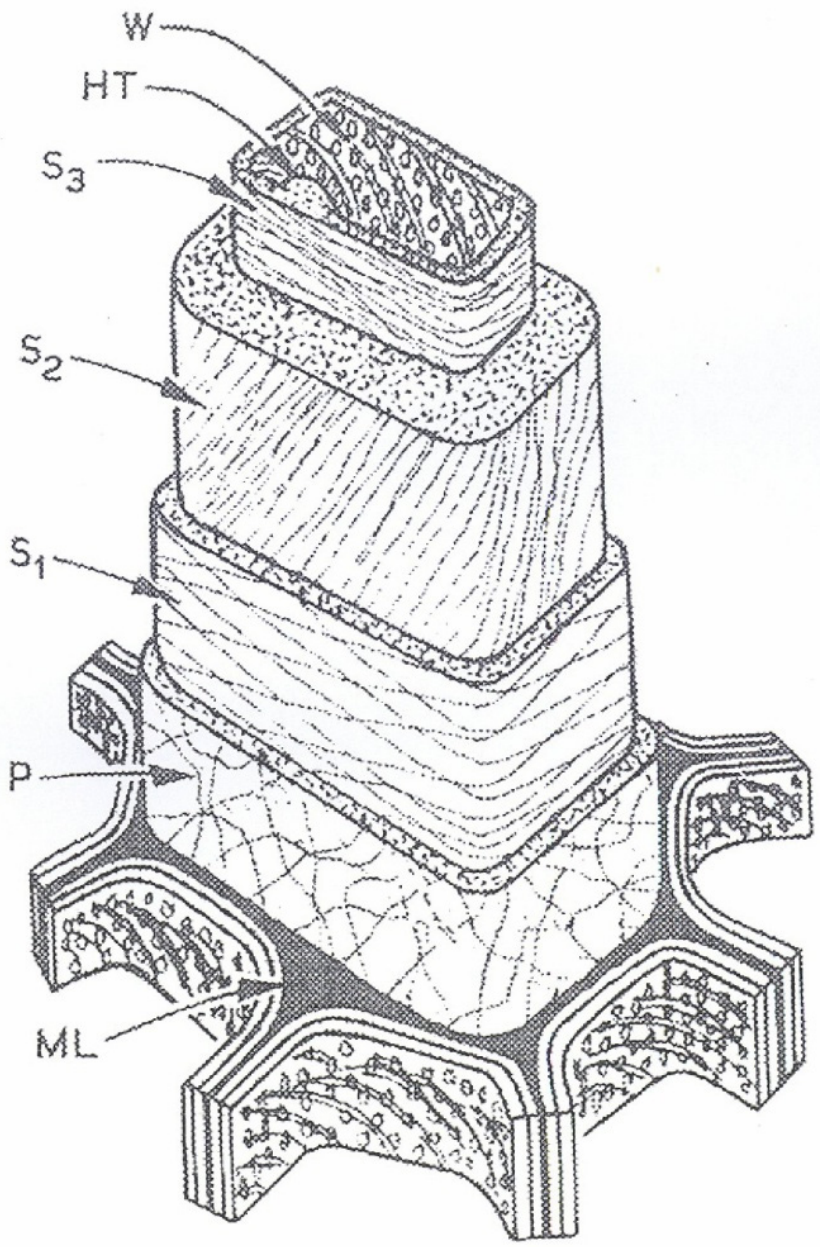
Accoya™

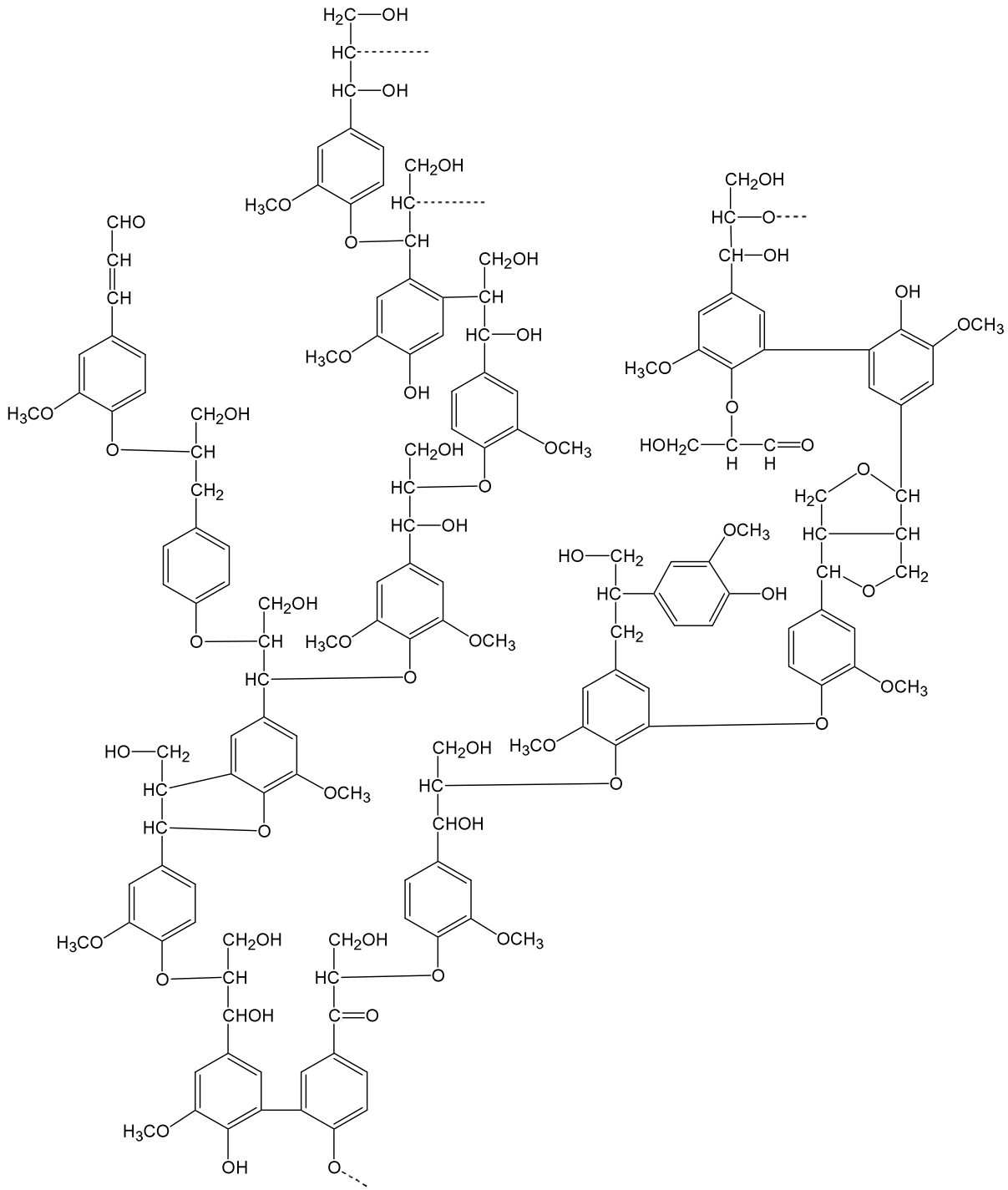
Pinus sylvestris

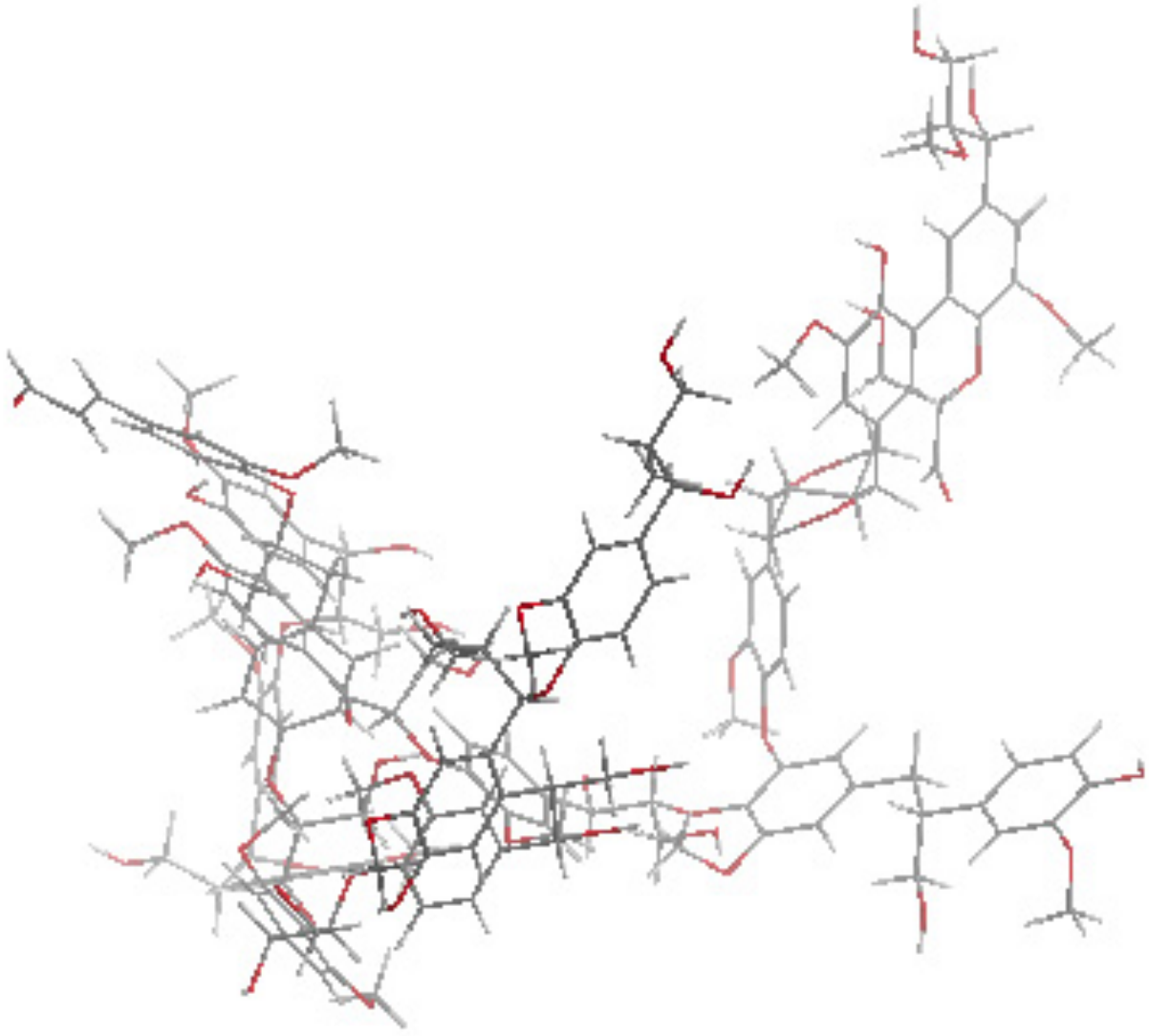


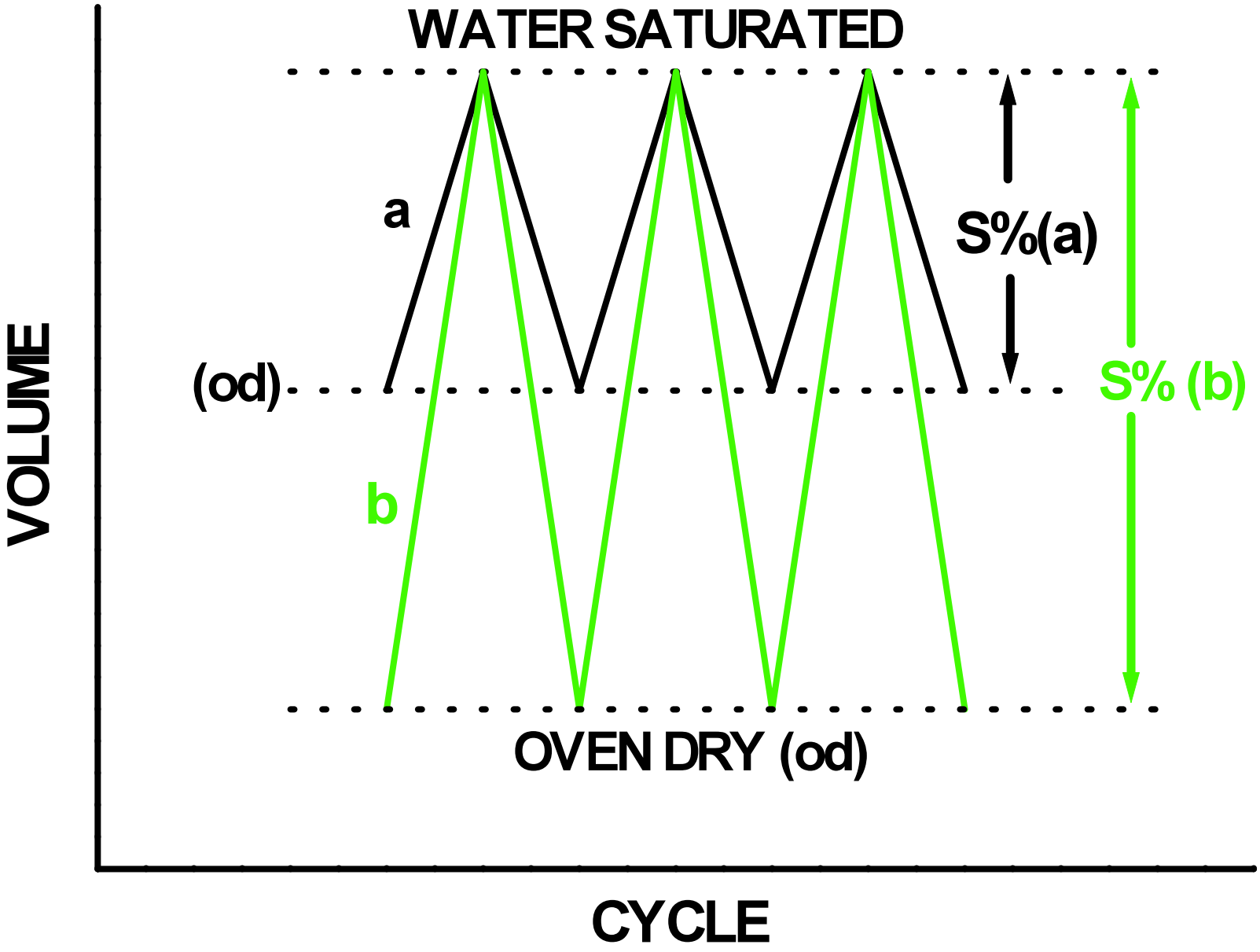
Pinus sylvestris



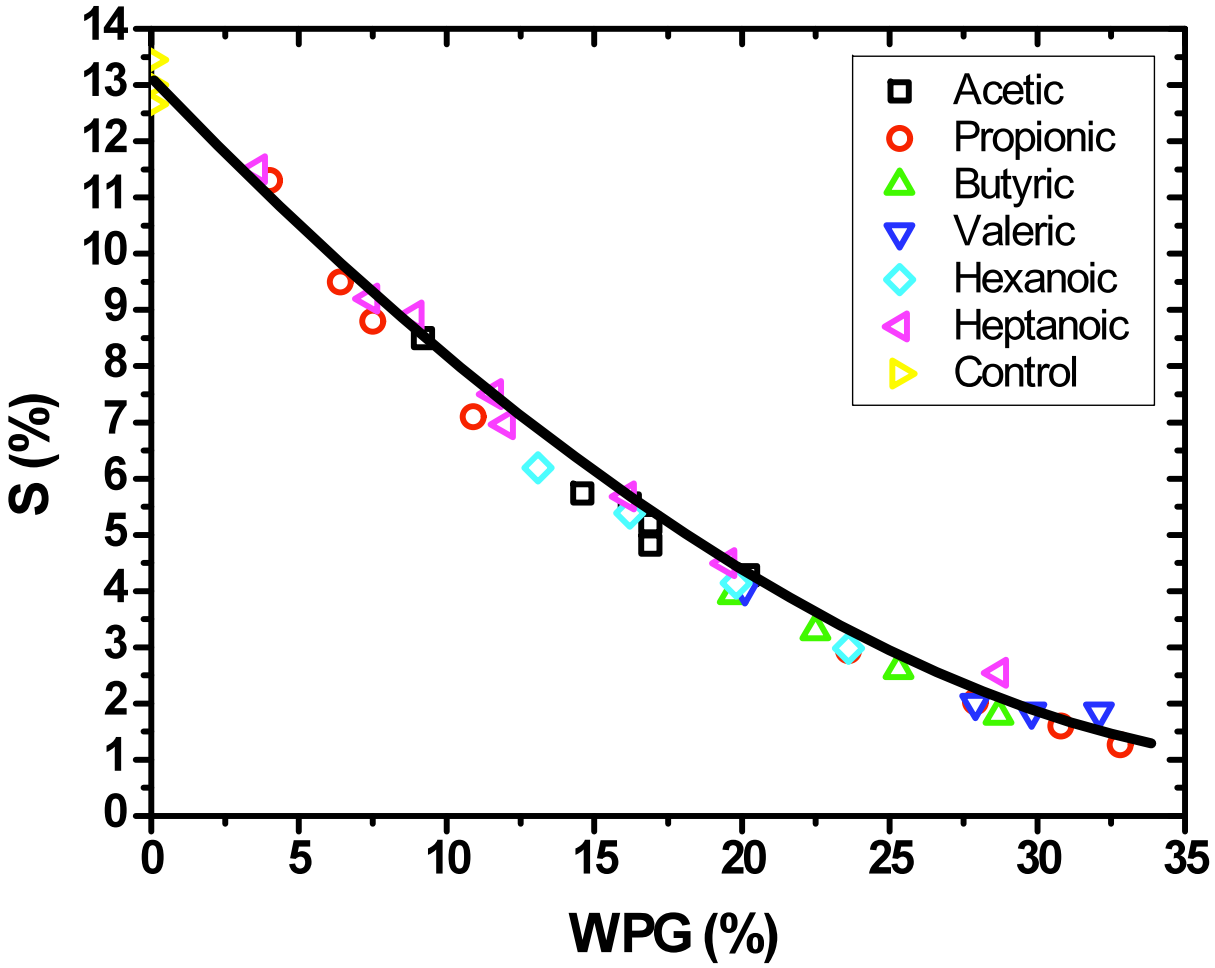

W
HT
S3
S2
S1
P
ML



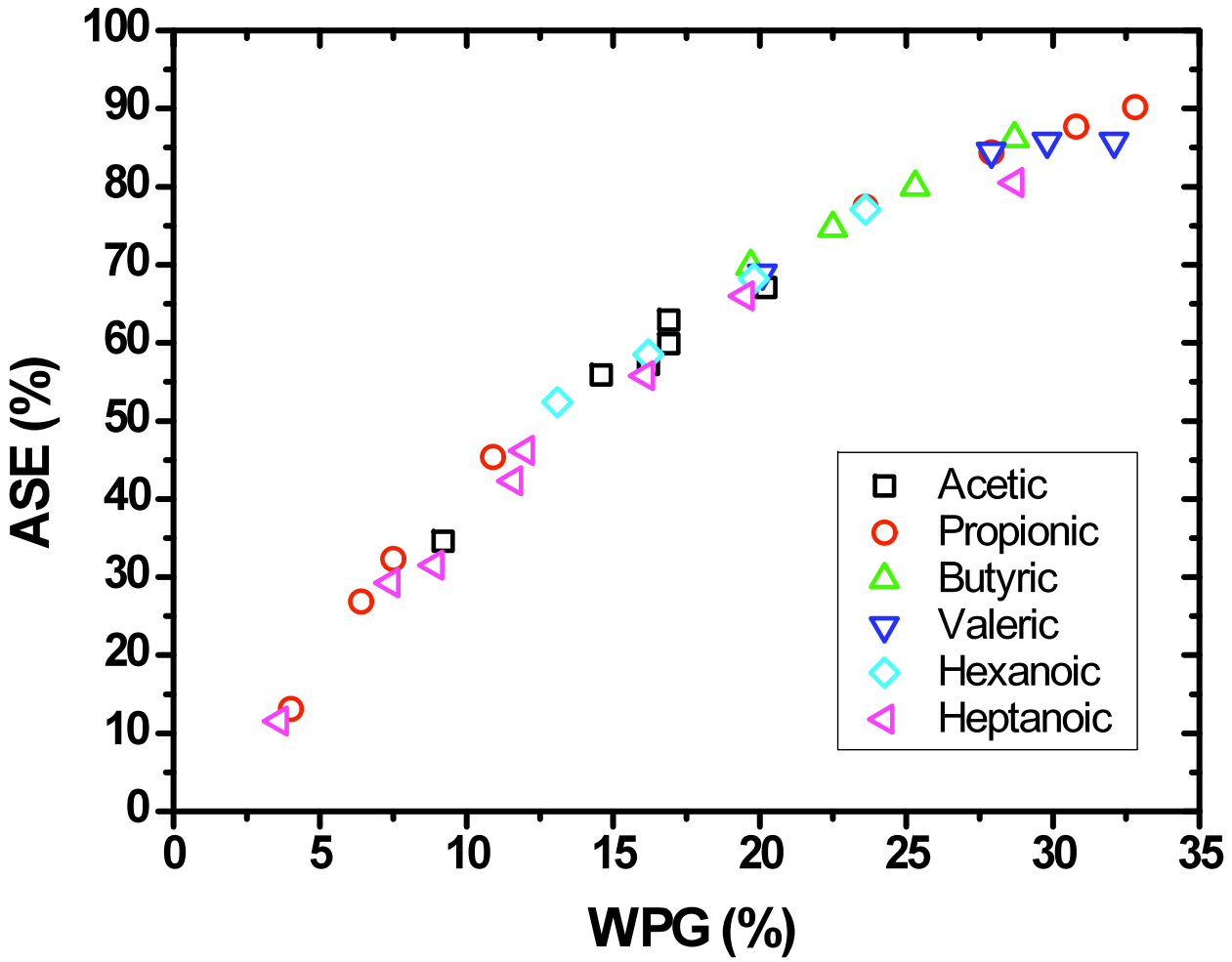



WATER SATURATED
a
S%(a)
(od)
S% (b)
b
OVEN DRY (od)
VOLUME
CYCLE

Dimensional stabilisation



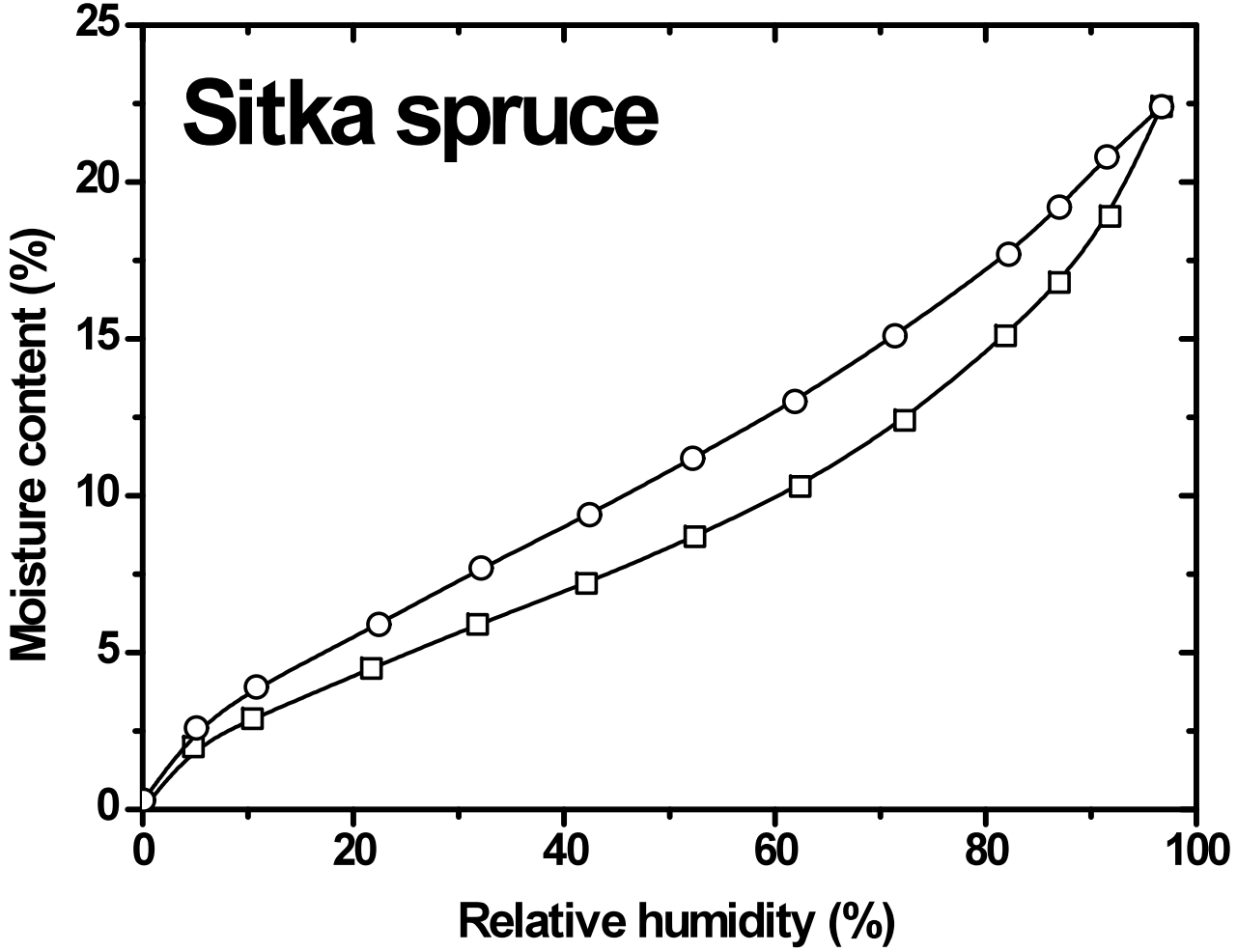
Anti-swelling efficiency



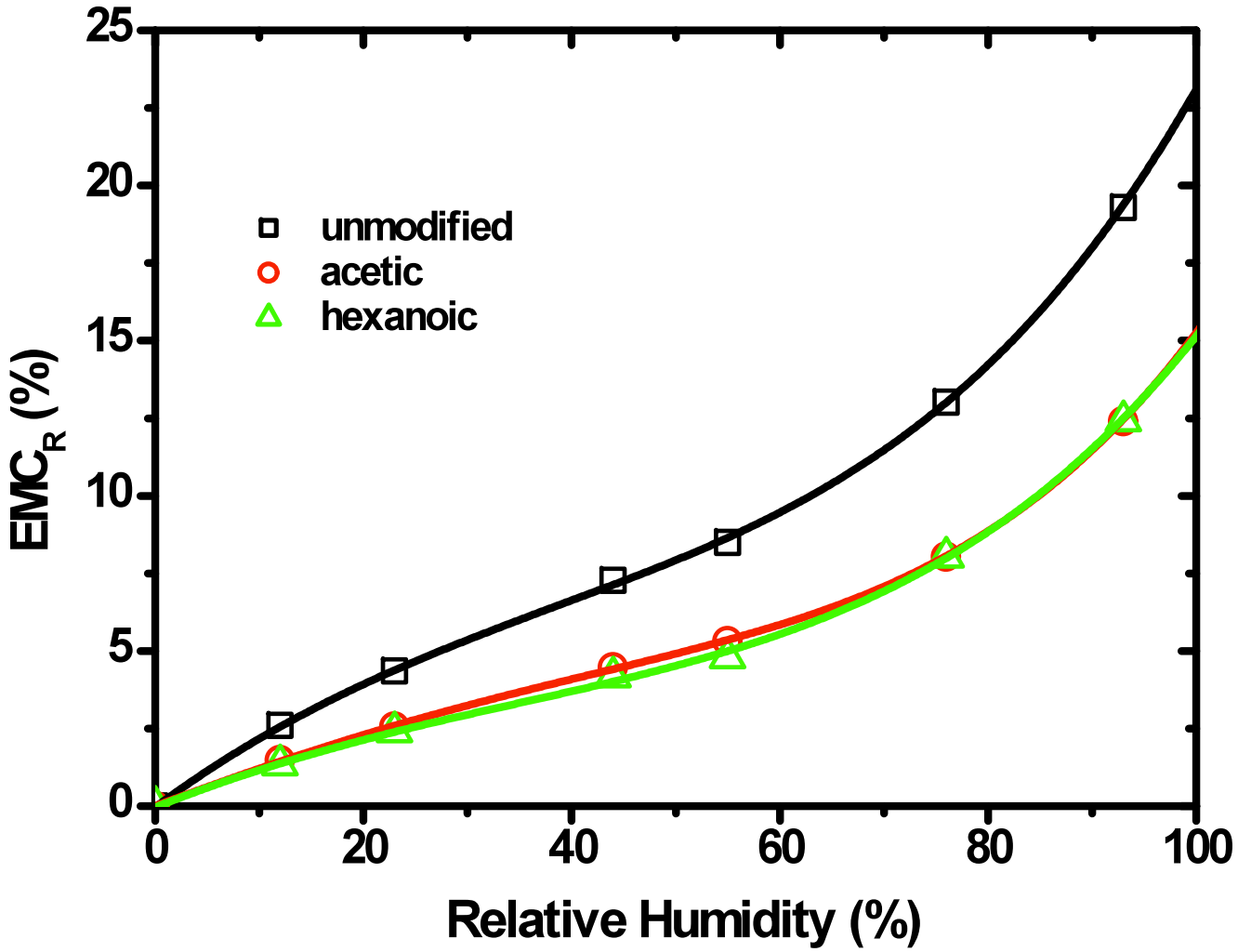
Conclusions

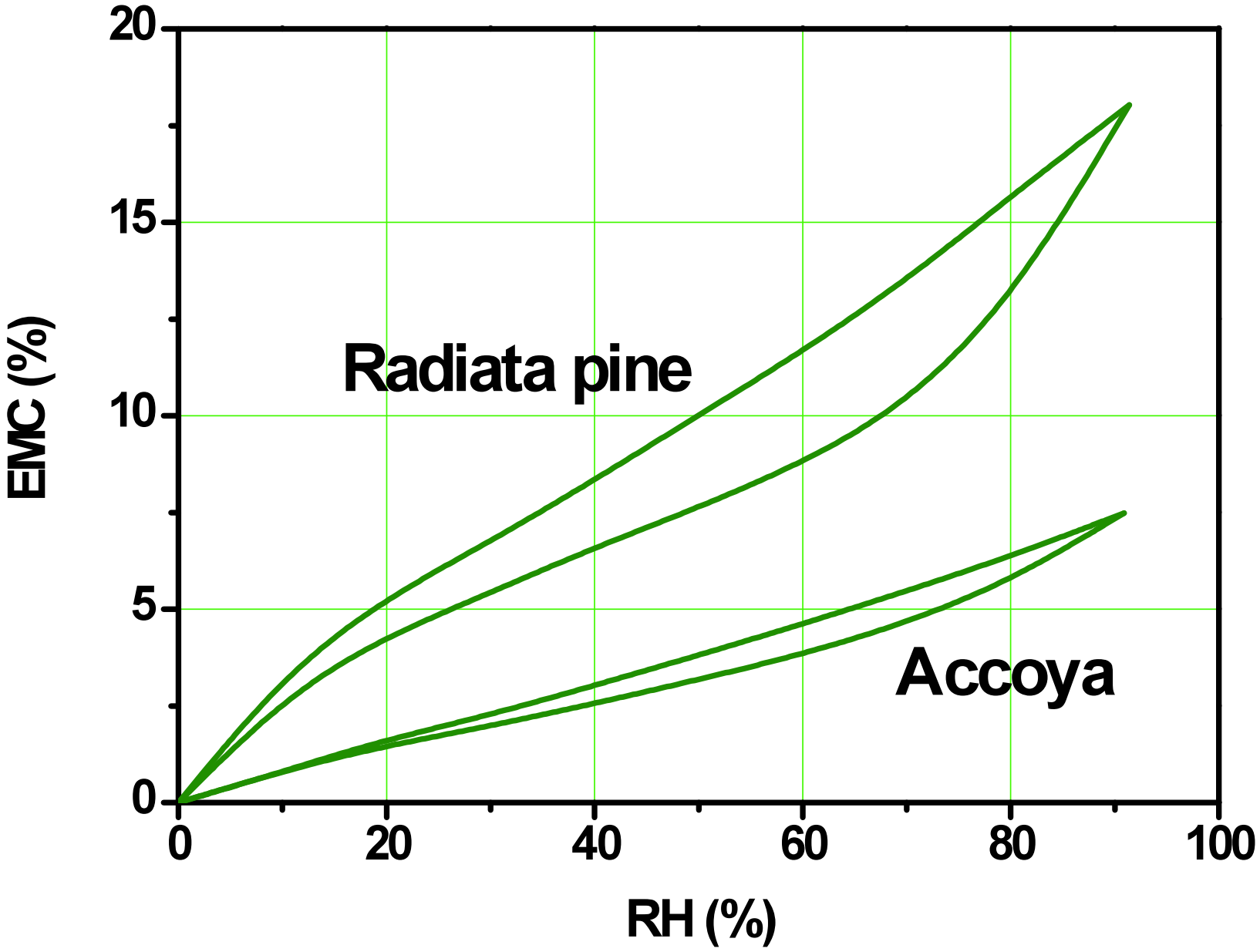
- Dimensional stability is a bulking effect
- It is not related to the extent of OH substitution

Water vapour sorption



Water vapour sorption

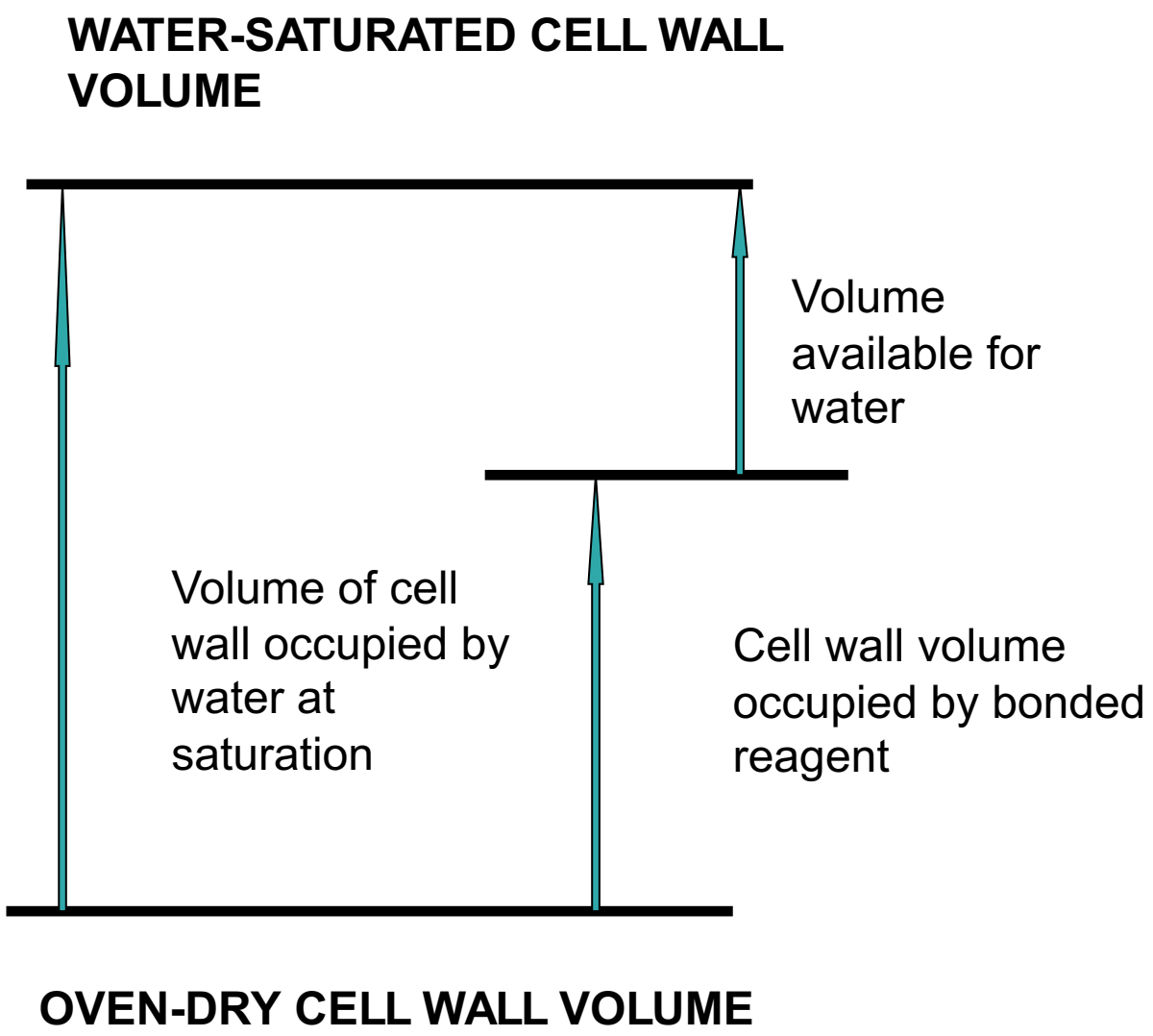



20
15
10
5
0
EMC (%)
Radiata pine
Accoya
0
20
40
60
80
100
RH (%)

Conclusion

- Reduction in water vapour sorption is due to a bulking effect
- It is not related to level of OH substitution

Principle

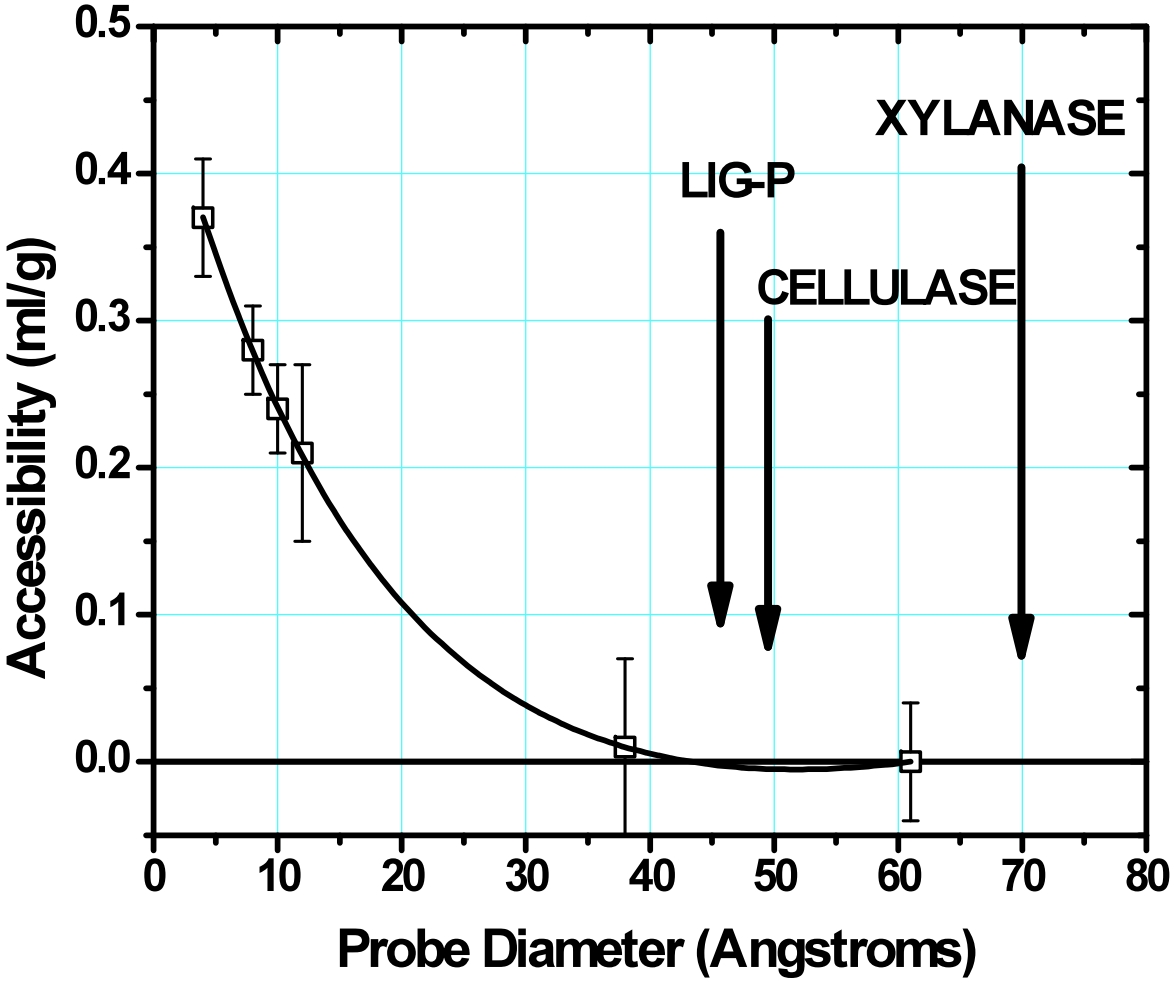

WATER-SATURATED CELL WALL VOLUME
Volume available for water
Volume of cell wall occupied by water at saturation
Cell wall volume occupied by bonded reagent
OVEN-DRY CELL WALL VOLUME

Decay resistance

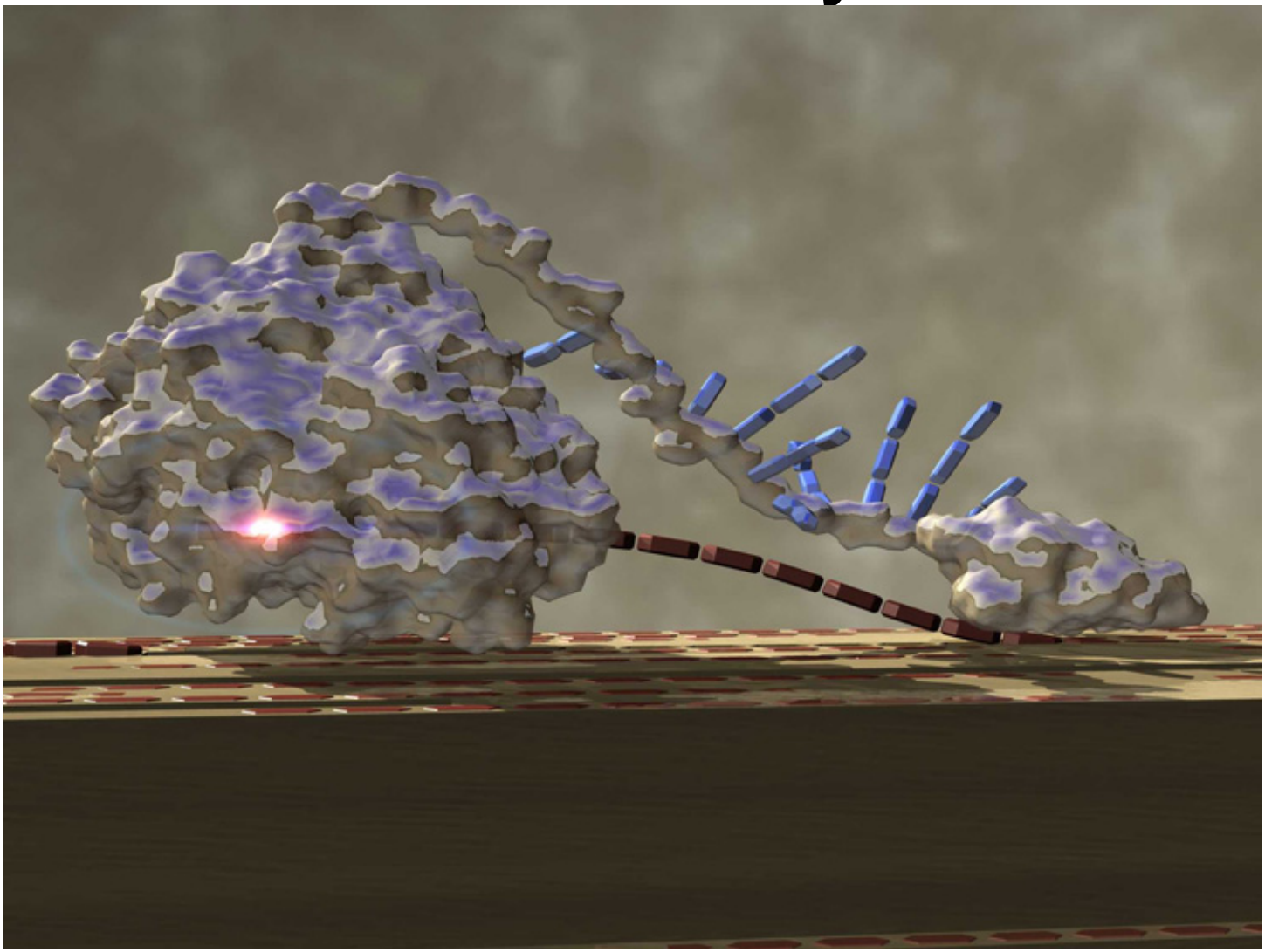
- OH groups are modified and cannot be recognised by the enzymes that degrade the cell wall
- The cell wall is bulked by bonded acetyl and consequently there is less room for water molecules (too dry)
- The bonded acetyl groups physically prevent access of the cell wall to degrading agents

Accoya™

Enzyme accessibility

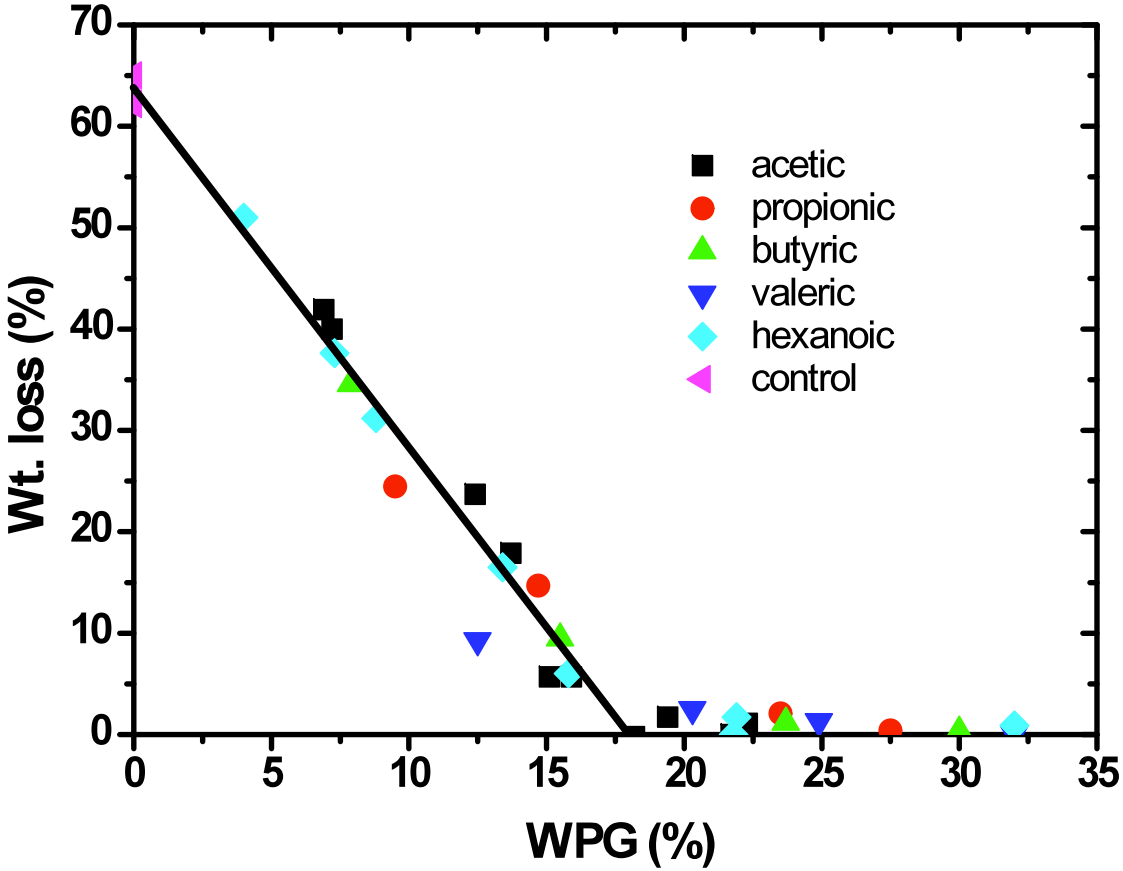


Cellulase enzyme



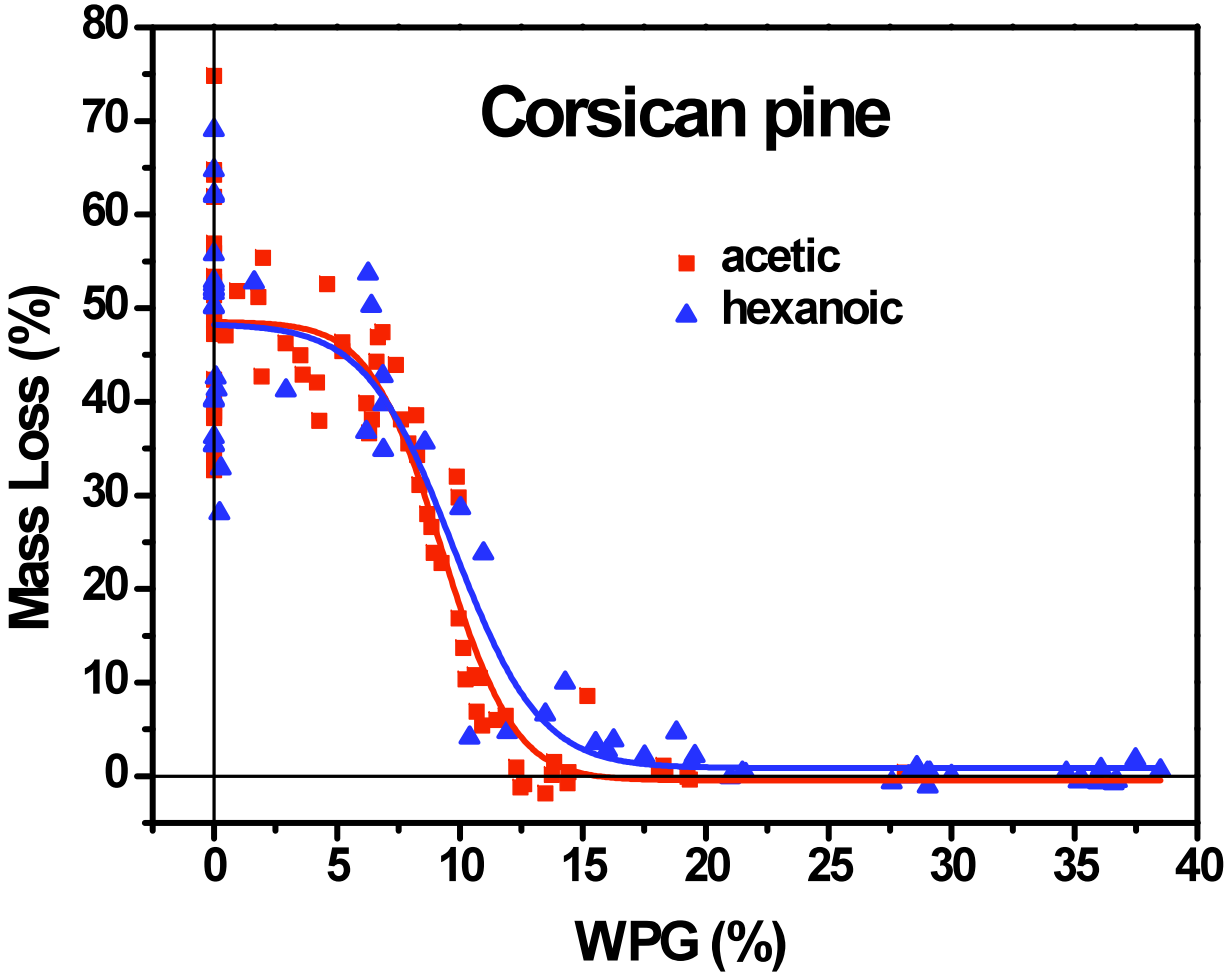
US Department of Energy

Decay resistance (*Coniophora puteana*)

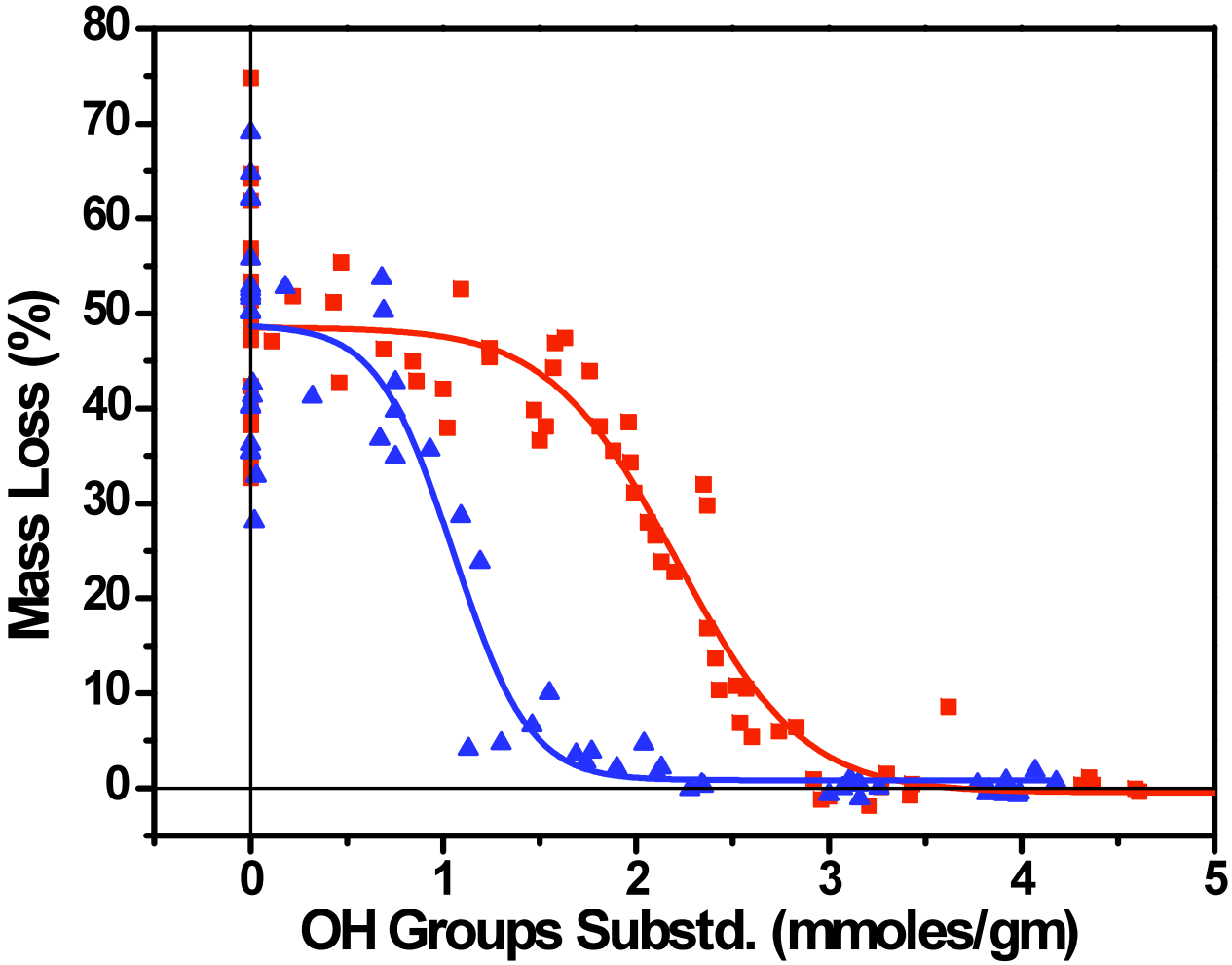


Papadopoulos, A. And Hill, C.A.S. *Hols als Roh- und Werkstoff*, **60**(5), 329-332, (2002)

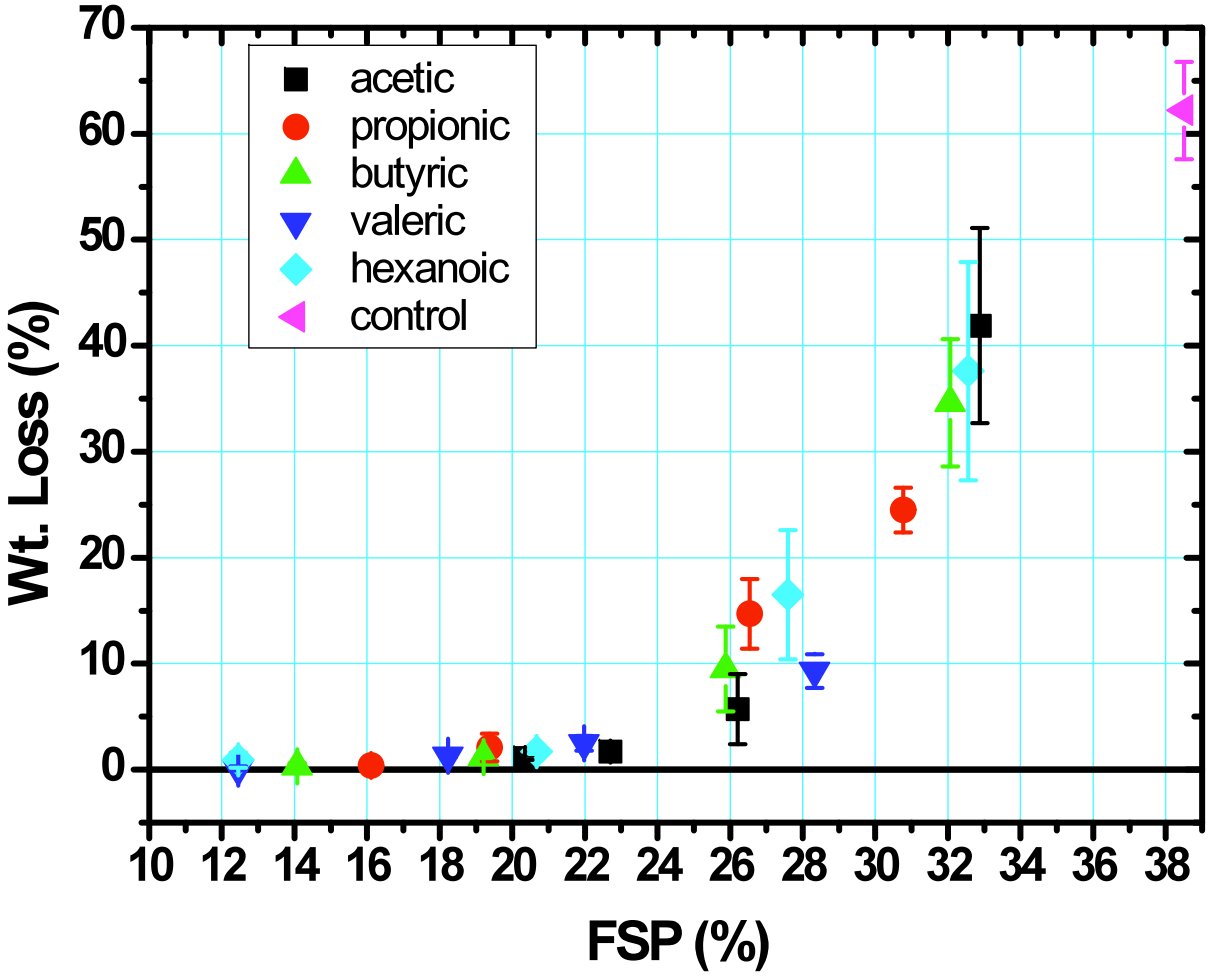
Decay resistance



Decay resistance



Cell wall moisture content

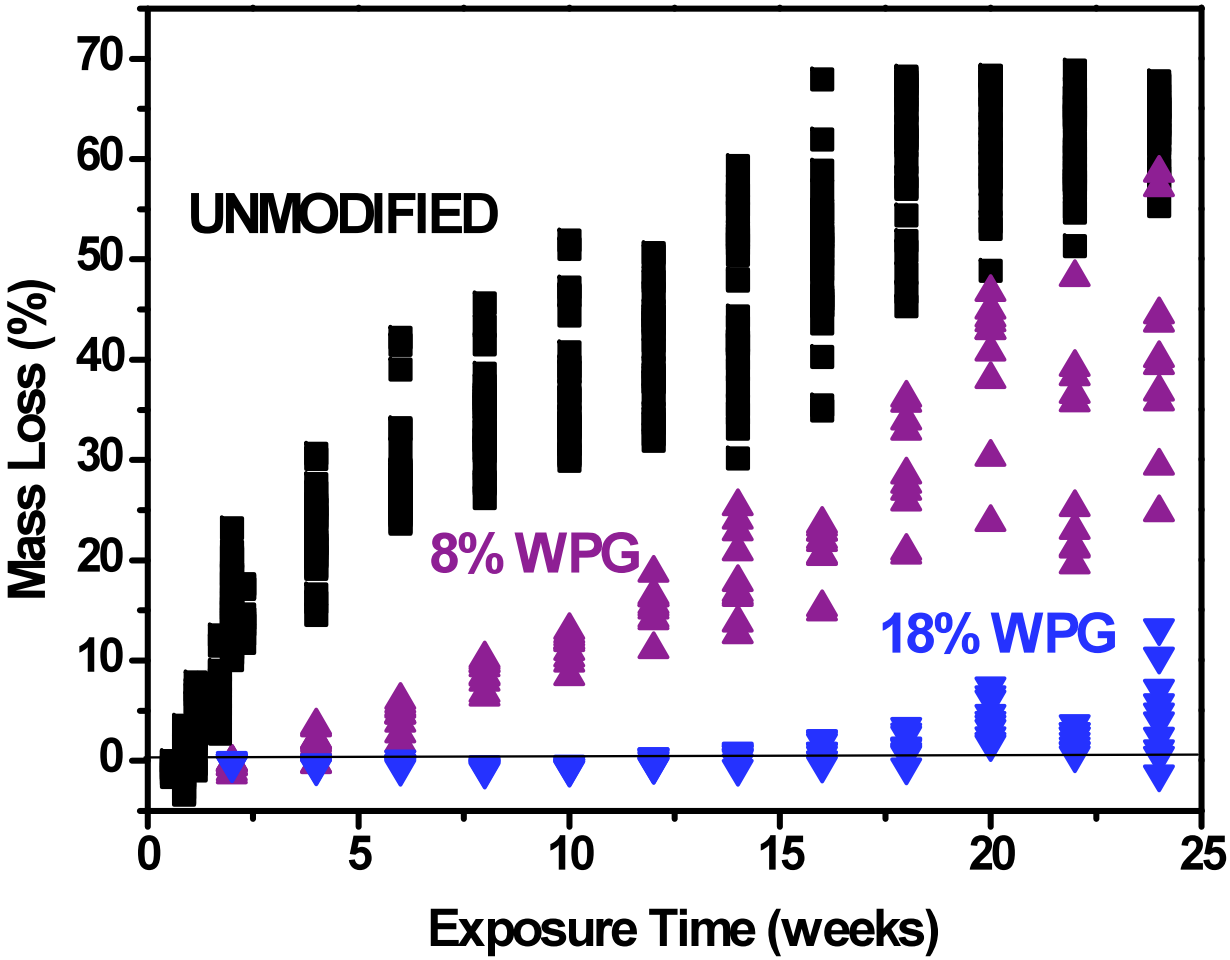


Conclusions

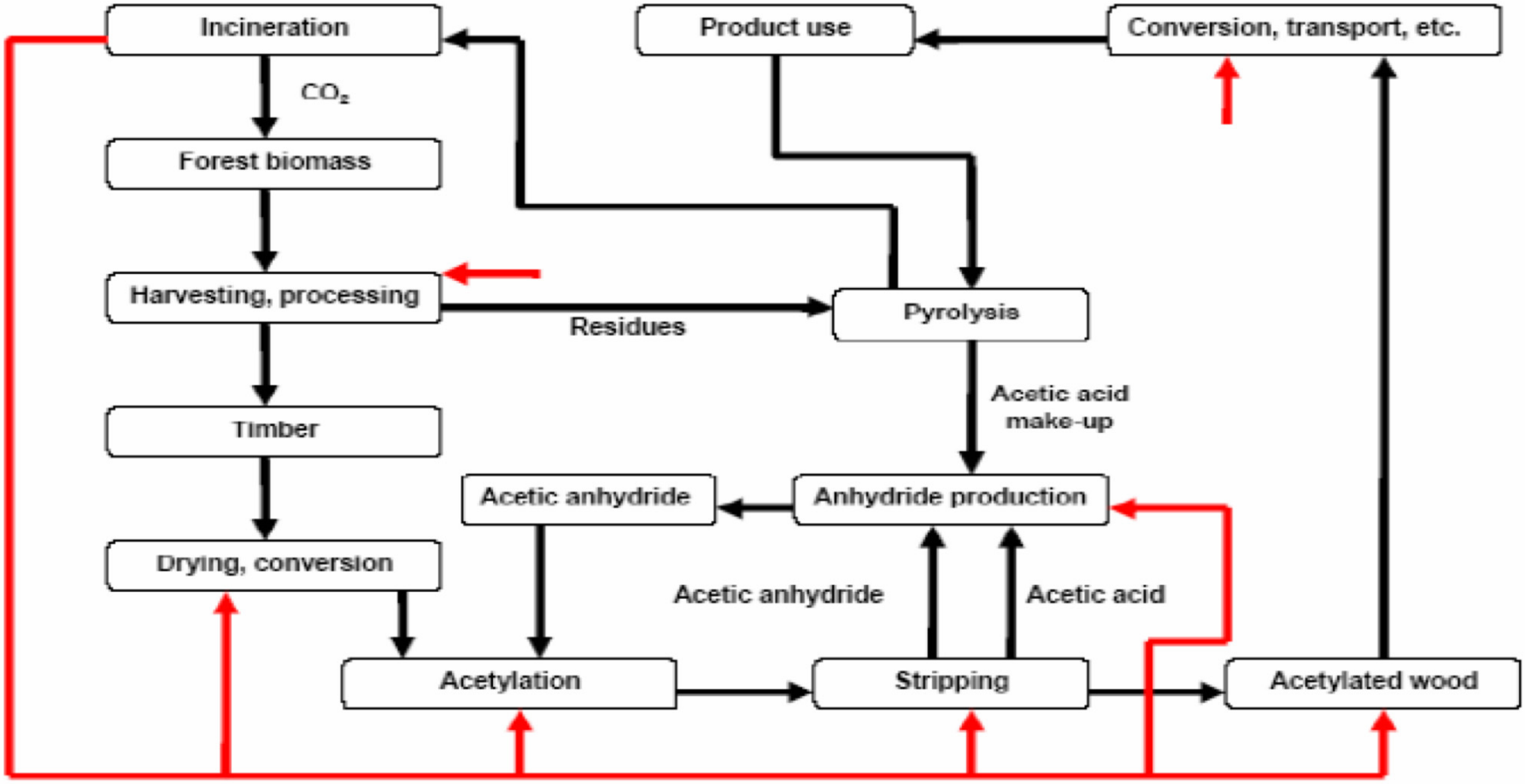
- Decay resistance is a bulking effect
- OH substitution is unimportant
- Probably related to cell wall moisture content being below decay threshold

BUT

Decay resistance



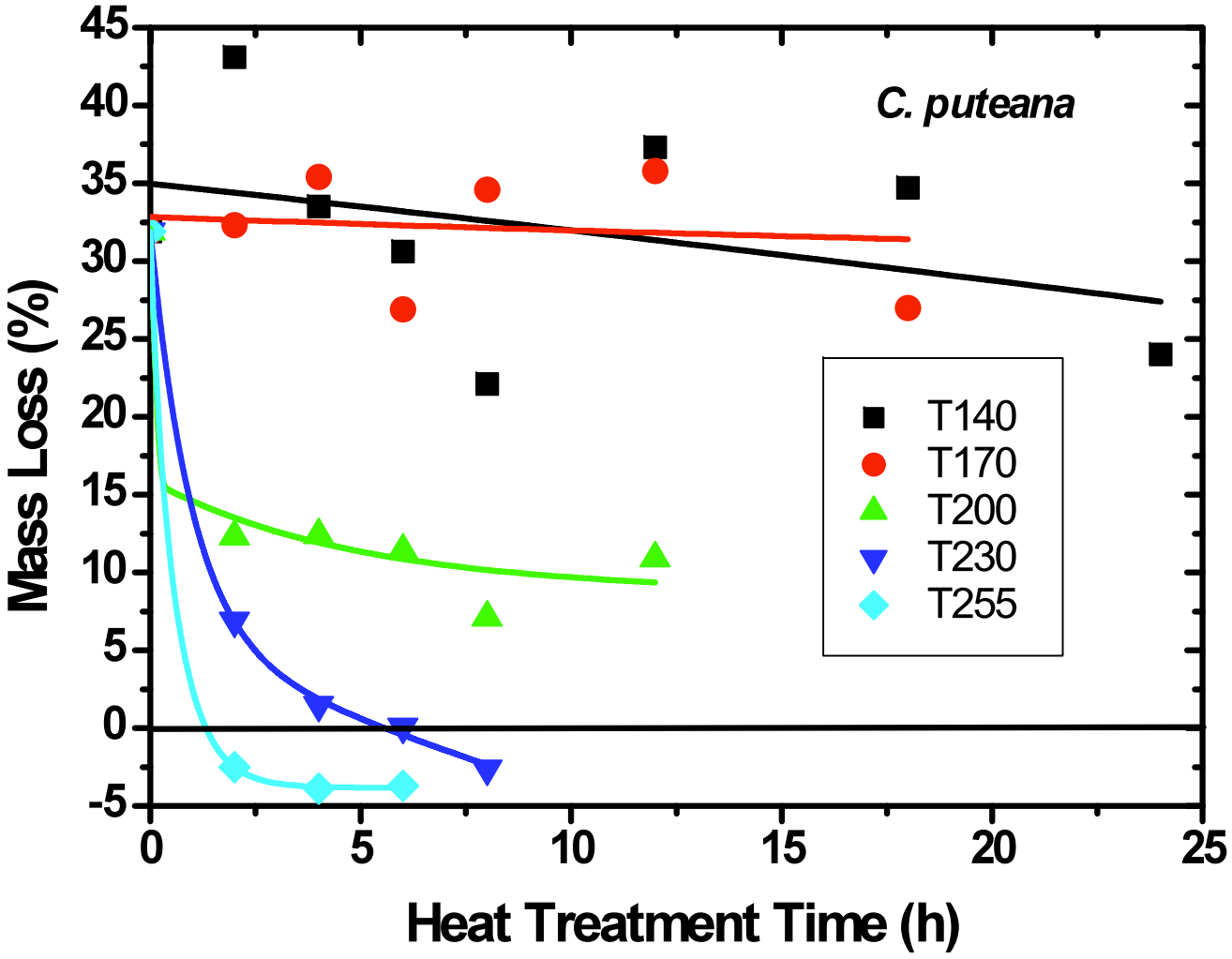

© Titanwood


Incineration
Product use
Conversion, transport, etc.
CO_2
Forest biomass
Harvesting, processing
Residues
Pyrolysis
Acetic acid
make-up
Timber
Acetic anhydride
Anhydride production
Drying, conversion
Acetic anhydride
Acetic acid
Acetylation
Stripping
Acetylated wood

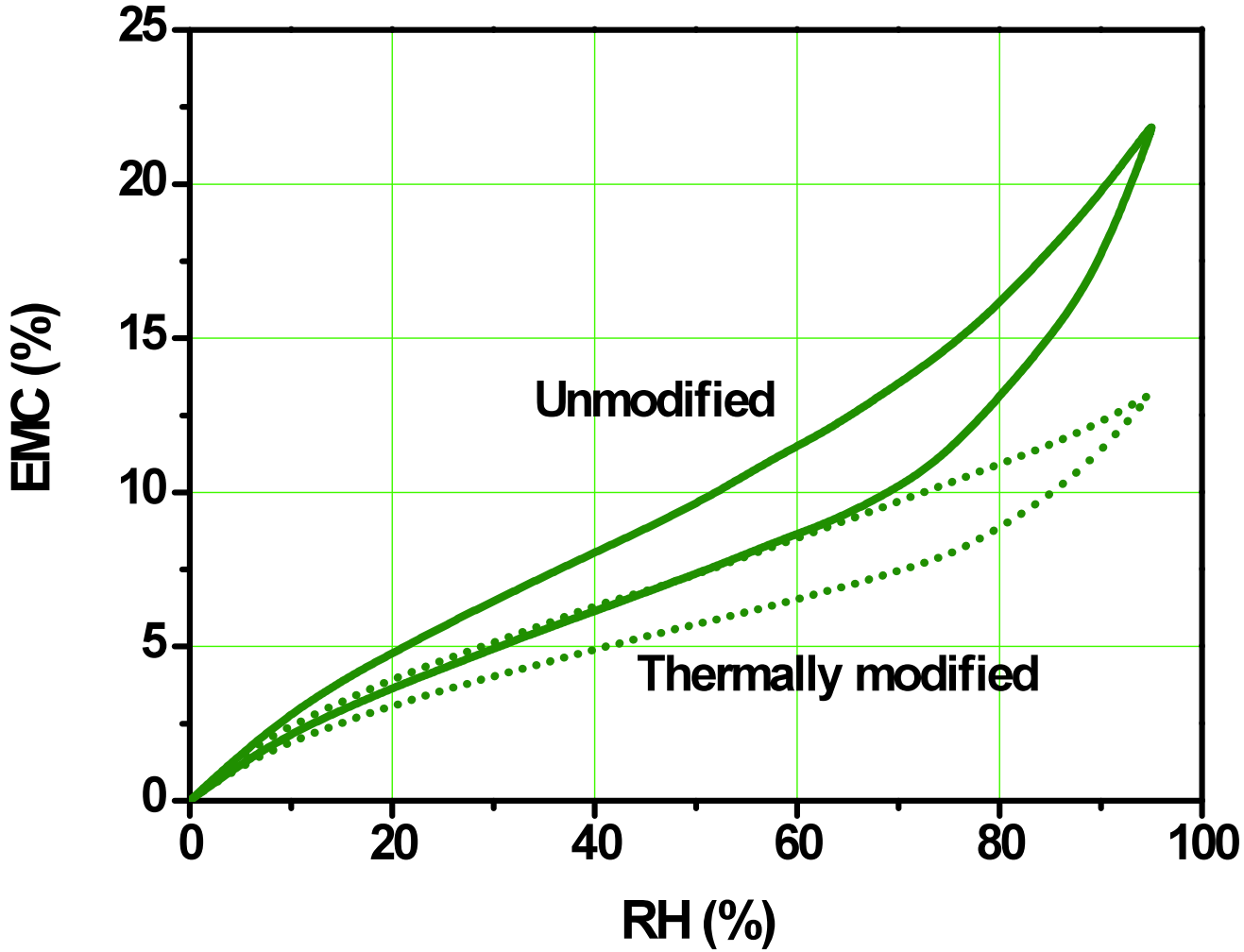
Thermal Modification

- Involves heating wood in absence of air in temperatures exceeding 180 ^{o}C
- Results in colour change and substantial loss of strength
- Should NEVER be used in structural applications
- Needs stainless steel fixings
- Thermowood™, Platowood™, Retiwood™, Perdure™, others

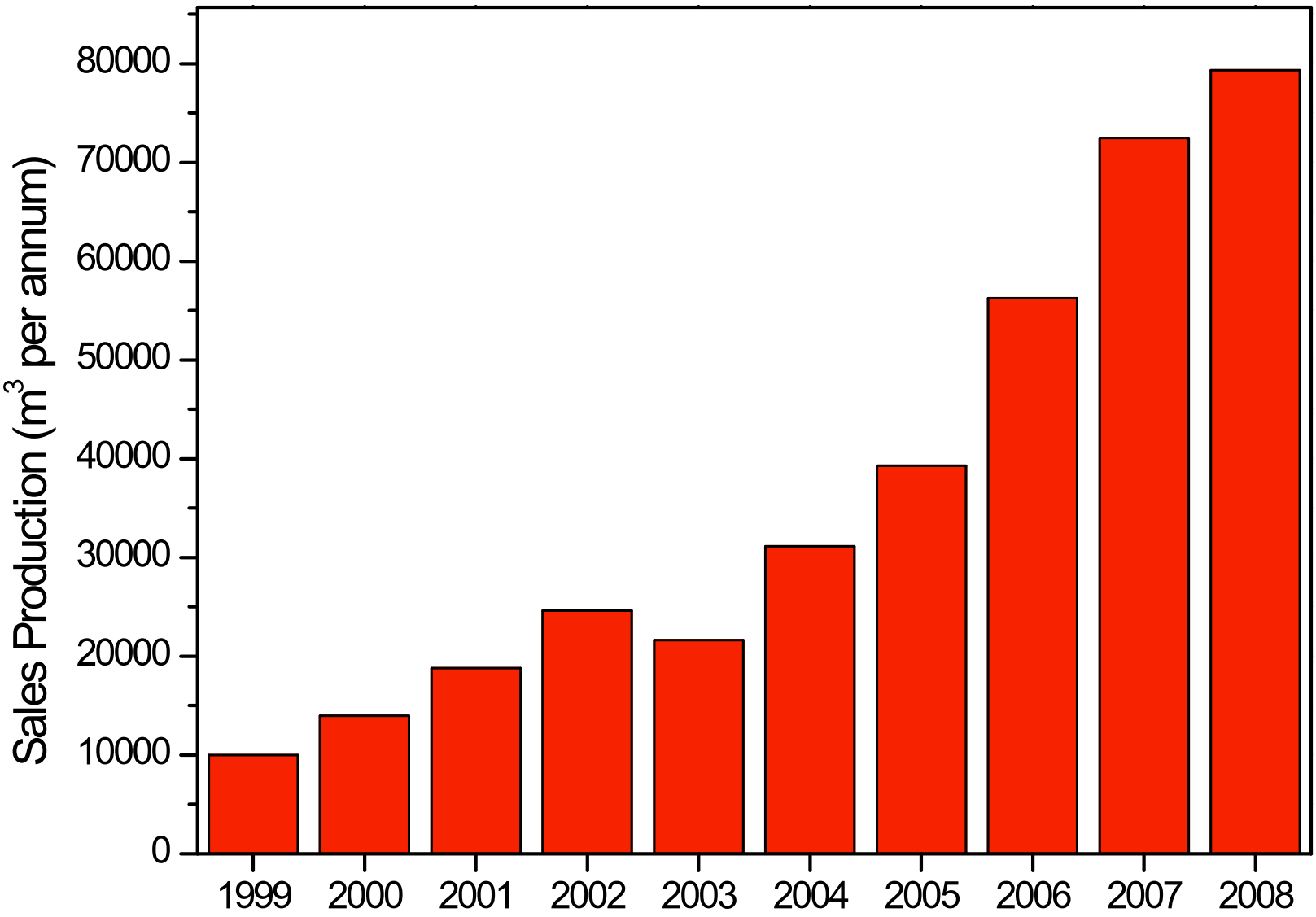
Decay resistance



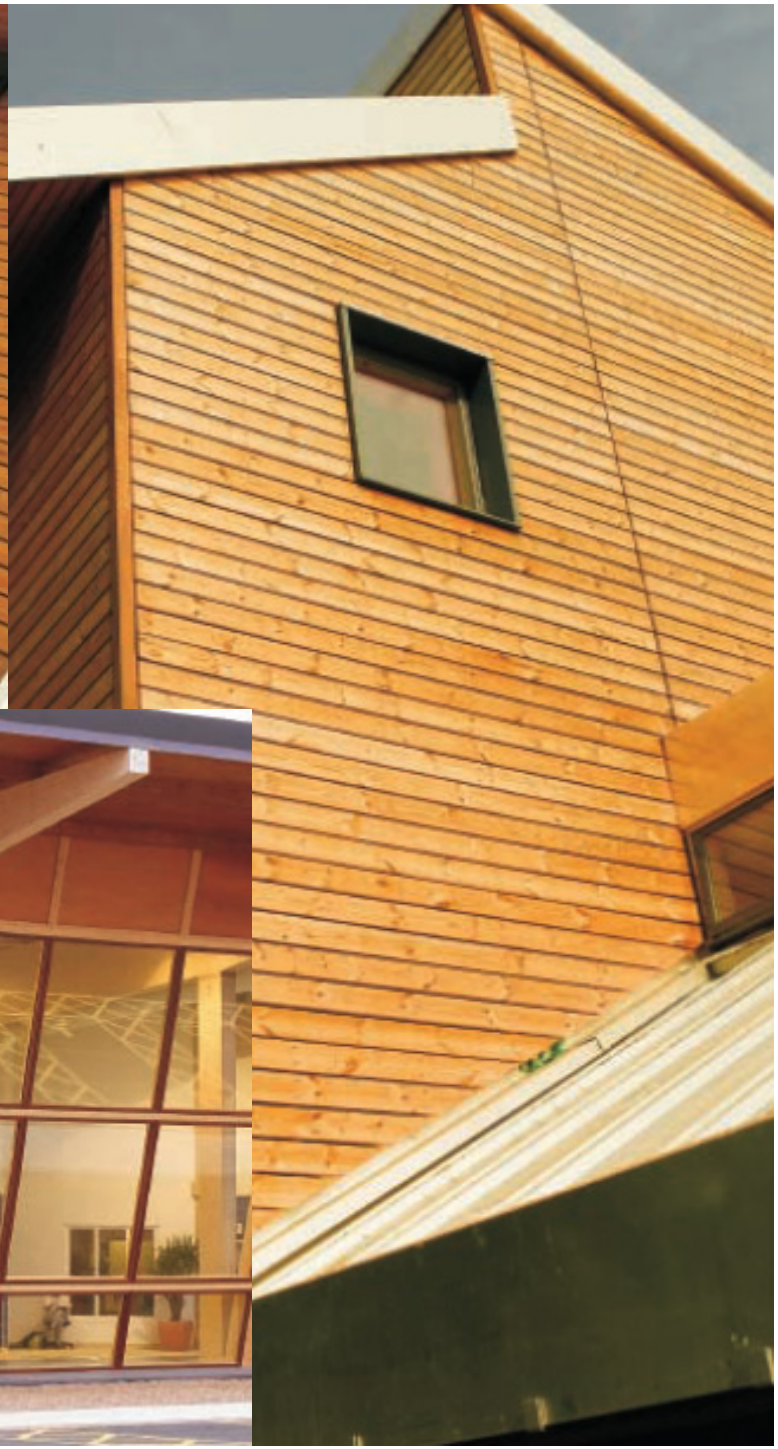
Water vapour sorption



ThermoWood®


Sales Production (m^3 per annum)
0
10000
20000
30000
40000
50000
60000
70000
80000
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

ThermoWood®




Plato®
WOOD
Sustainable inspiration

Thermal Modification

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Cambia by Greenleaf™

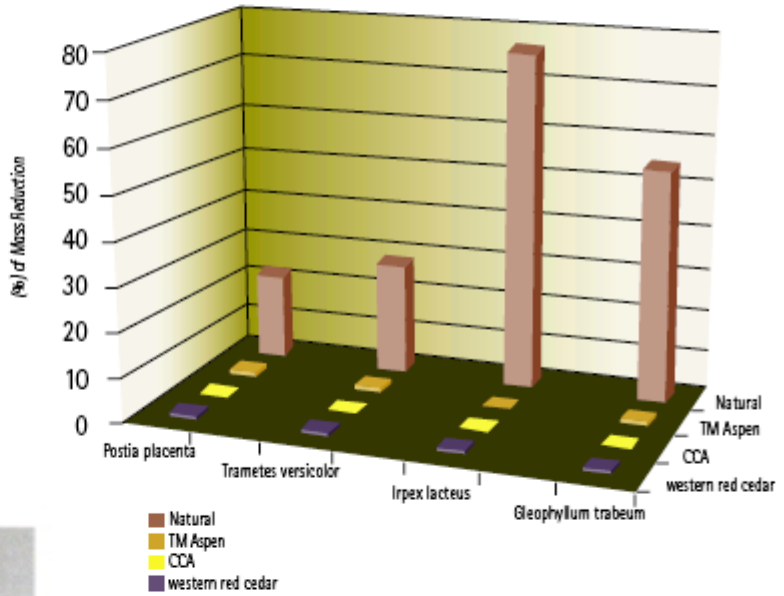
wood. made better.

FEATURING PERDURE TECHNOLOGY

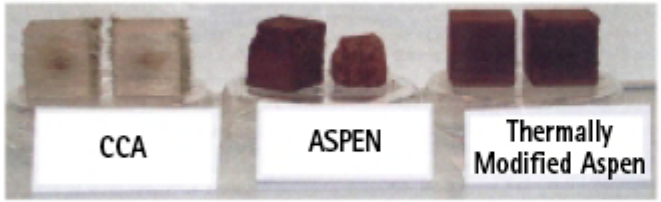
DETERMINATION OF RESISTANCE TO FUNGUS DEGRADATION

Wood undergoes a significant reduction of its mass when exposed to fungi. For example, the mass loss of trembling aspen is 20 to 75 times greater than the mass loss of thermally modified aspen, depending on the type of mushroom. In fact, thermally modified aspen demonstrated mass losses ranging between 1% and 1.15%, which is comparable CCA pressure treated and western red cedar samples.

The Mass Reduction of trembling aspen is a function of the type of Mushroom and the Type of Treatment



Trembling Aspen Exposed to Decay Fungi



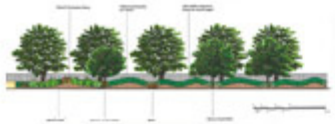
DETERMINATION OF RESISTANCE TO AGING

The erosion of the stain used on thermally modified trembling aspen was less than the erosion of stain used on natural wood.

Visual Assessment Following an Accelerated Aging Process

Retiwood

retified wood



Retimade

bois rétifié

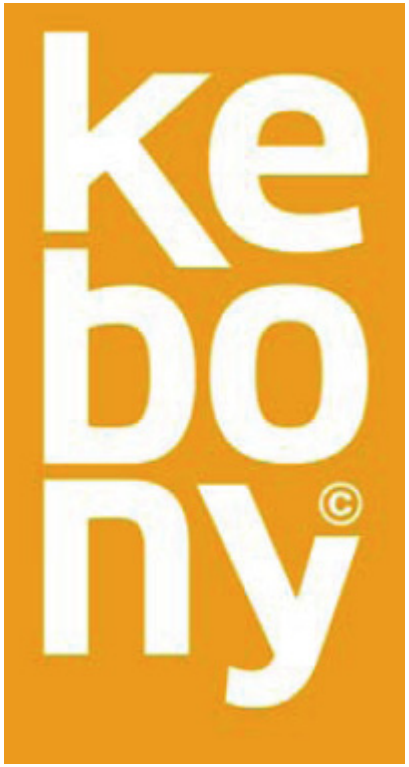
LABEL RETIMADE

Other manufacturers

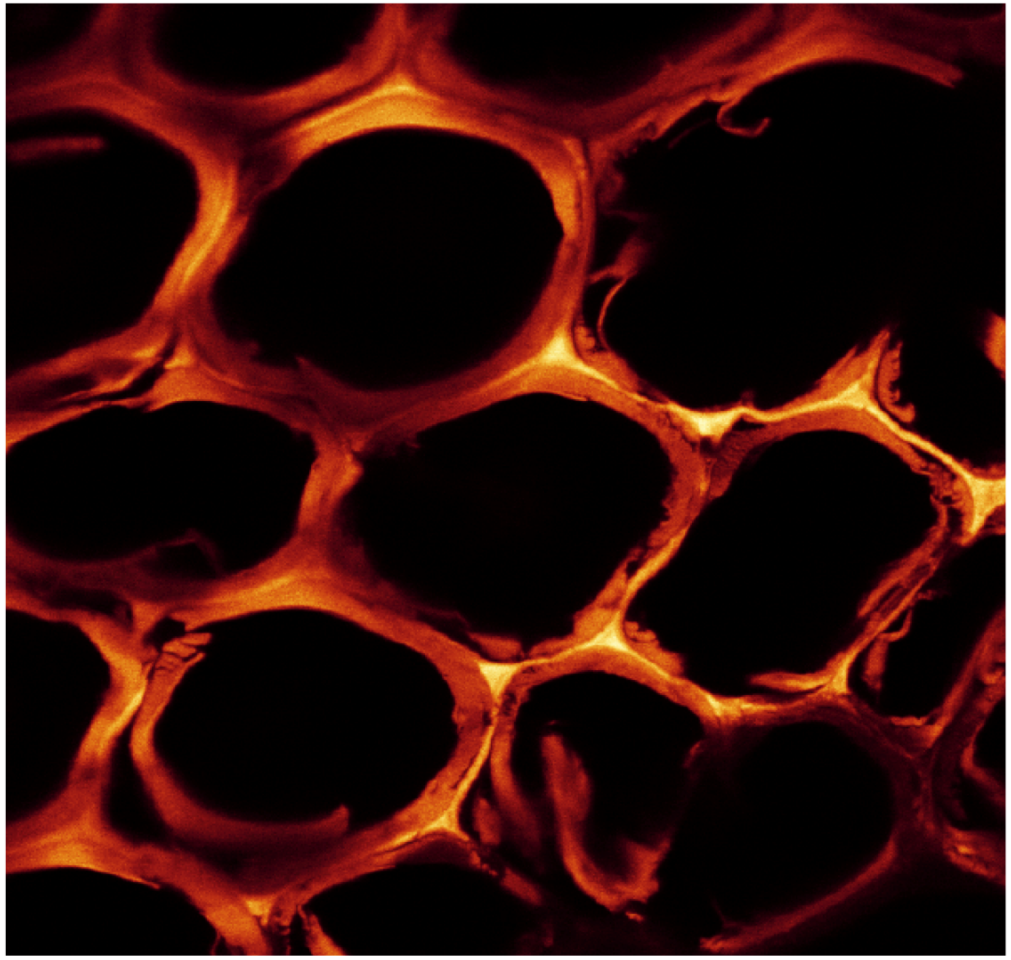
- NFS Ltd (Estonia)
- ESTW (Russia)
- Novawood (Turkey)
- Superior Thermowood, Ohlin Thermotech (Canada)
- Lambowood, Lignius (Netherlands)
- Westwood Heat Treated Lumber Corp. (USA)

Impregnation Modification

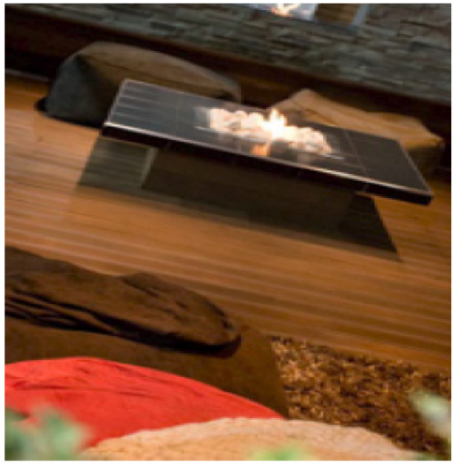
- Kebony (Visorwood) (WPT, Norway)
- Indurite™, Indurite Advanced™ (Osmose, UK)
- Kurawood™, Vecowood™ (PGI, NZ)
- Lignia™ (Fibre7, NZ)
- Belmadur (BASF)
- Timbersil

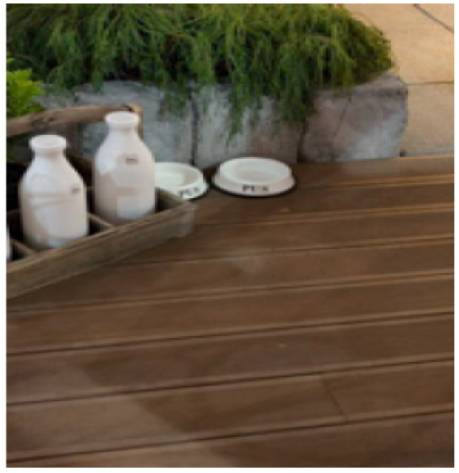

kebony©

Kebony™



Kebony™





Kebony™

Kebony™

www.hri-architects.com

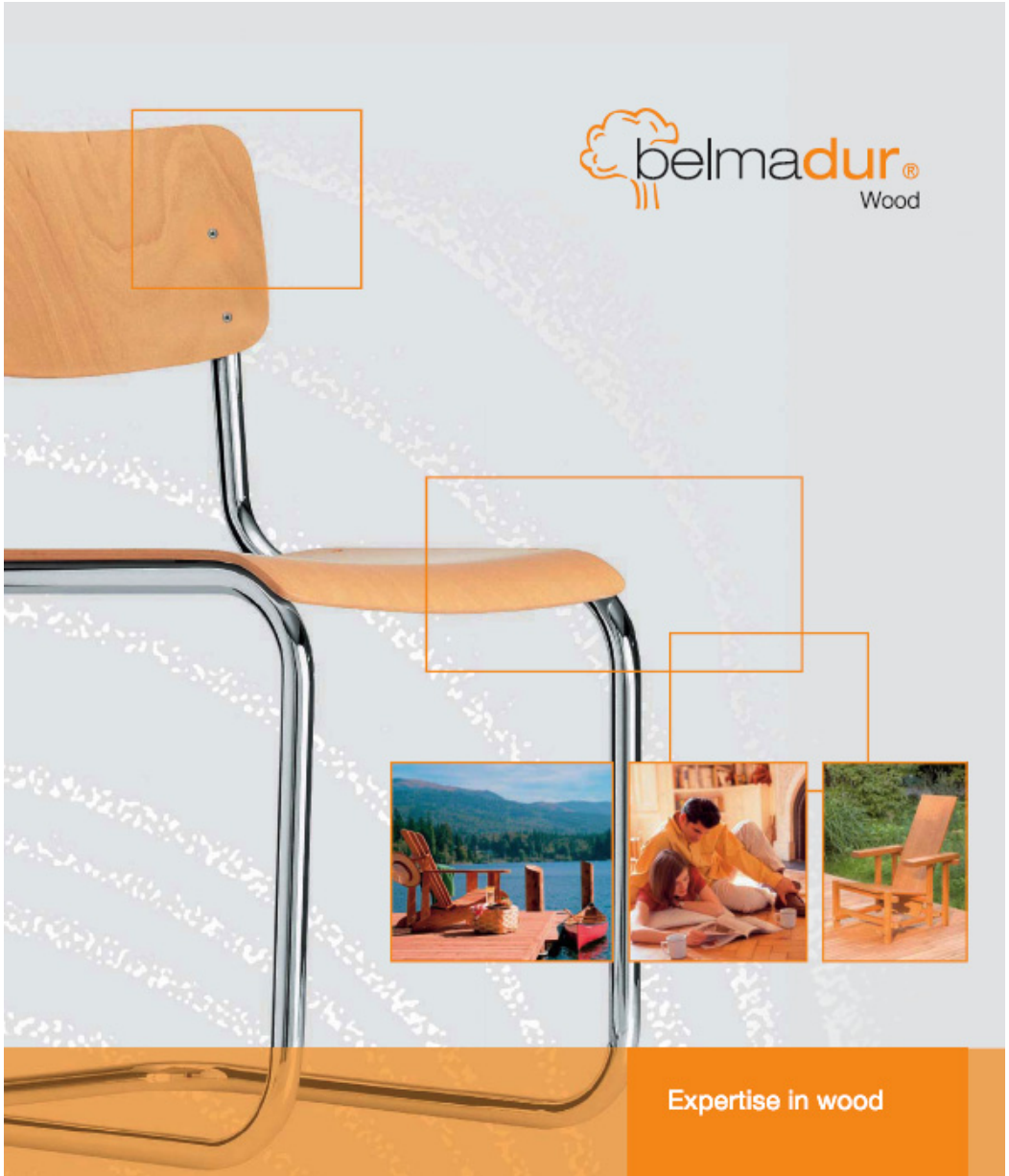
belmadur®

Technology

BASF

The Chemical Company

belmadur®
Wood



Belmadur® Wood:
Harder than oak – durable like teak!

Expertise in wood

BASF
The Chemical Company

Osmose®

Timber Technologies

KŪRA

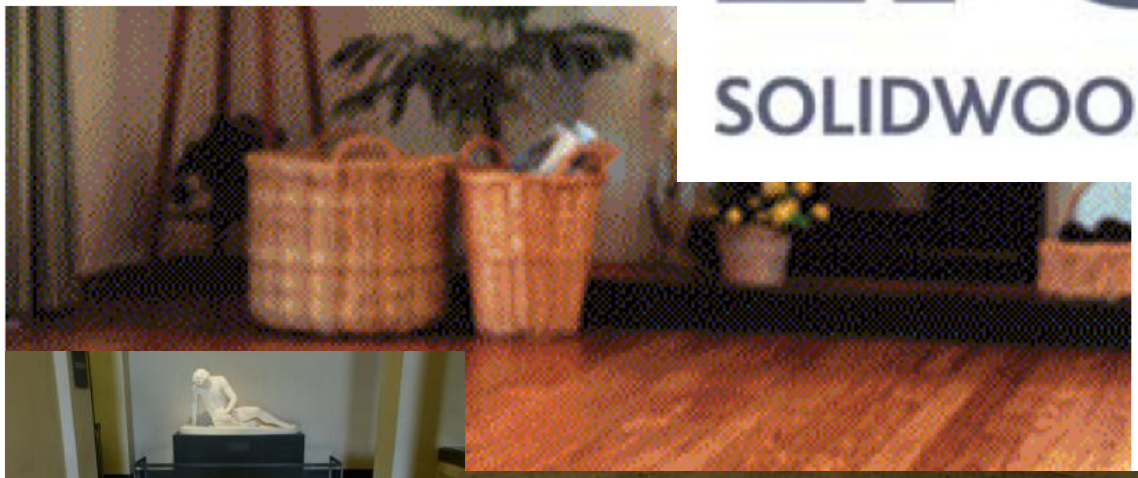
DESIGN & INNOVATION WITH BEAUTIFUL TIMBER

Fibre 7

CREATING HARDWOOD FOREVER

LIGNIA®

SOLIDWOOD WITHOUT EQUAL



Fortified Timber Systems NZ

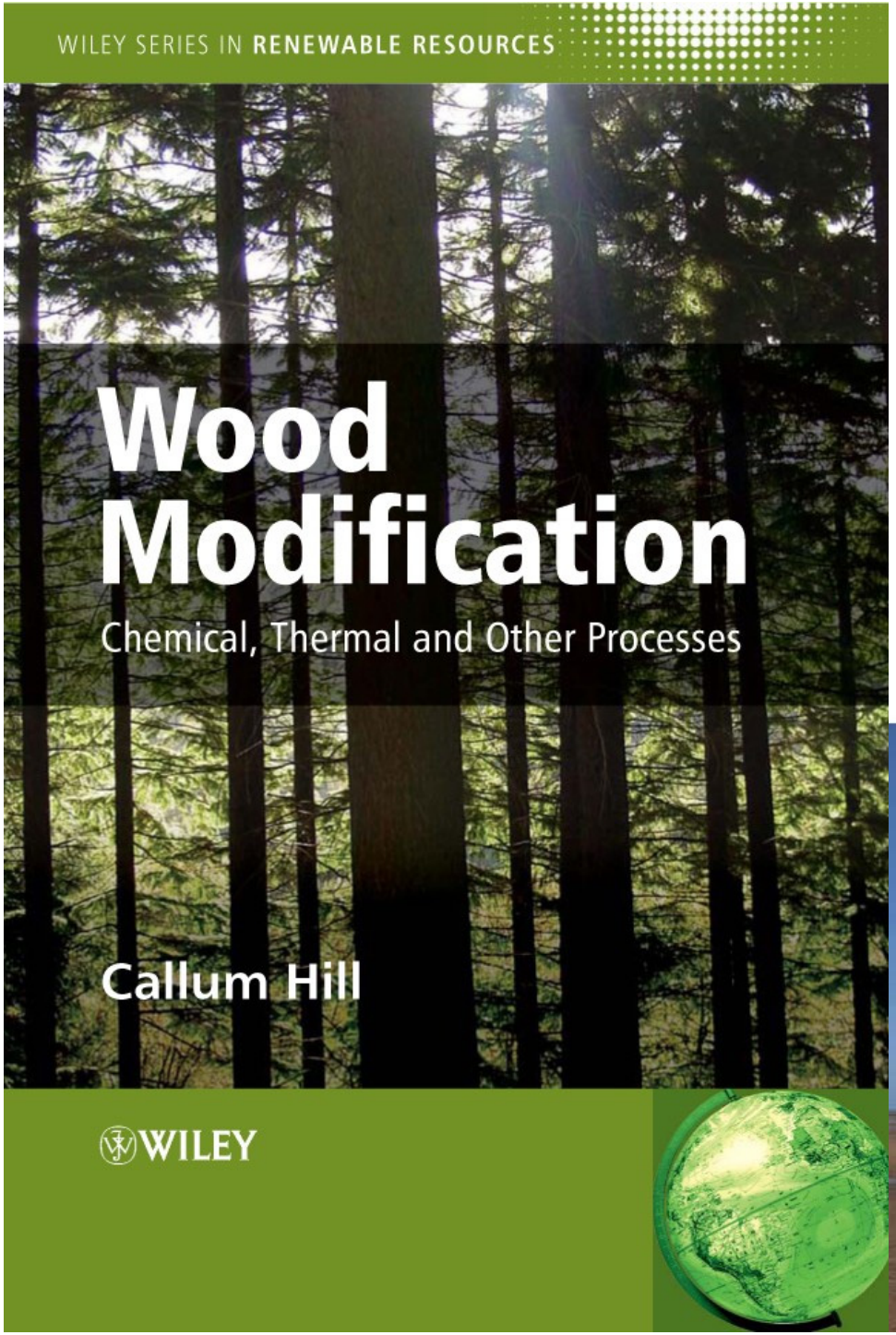
TimberSIL® Products
safer solutions through science

Installation of TimberSIL® GlassWood Boards, Decking and Lumber

What about the TimberSIL® process?

TimberSIL® is a solid, DRY, southern yellow pine lumber product which has amorphous glass microscopically infused on the interior and exterior surfaces of the lumber. Molecules-thin ribbon barriers of non-toxic amorphous, silicon dioxide (glass) intimately commingled with wood fibers and cell walls adds significant strength, resilience, dimensional stability, resistance to fire, biological inertness, sustainability, and permanent carbon sequestration to wood.

It is entirely non-toxic, non-corrosive and non-leaching. This patented process also adds unique characteristics to how the lumber material behaves in the environment. It looks and feels like normal lumber, but the difference is the glass content. There is enough glass added throughout the board to produce significant advantages in durability, strength, hardness, stiffness and resistance to insects and fire.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Wood Modification
Chemical, Thermal and Other Processes
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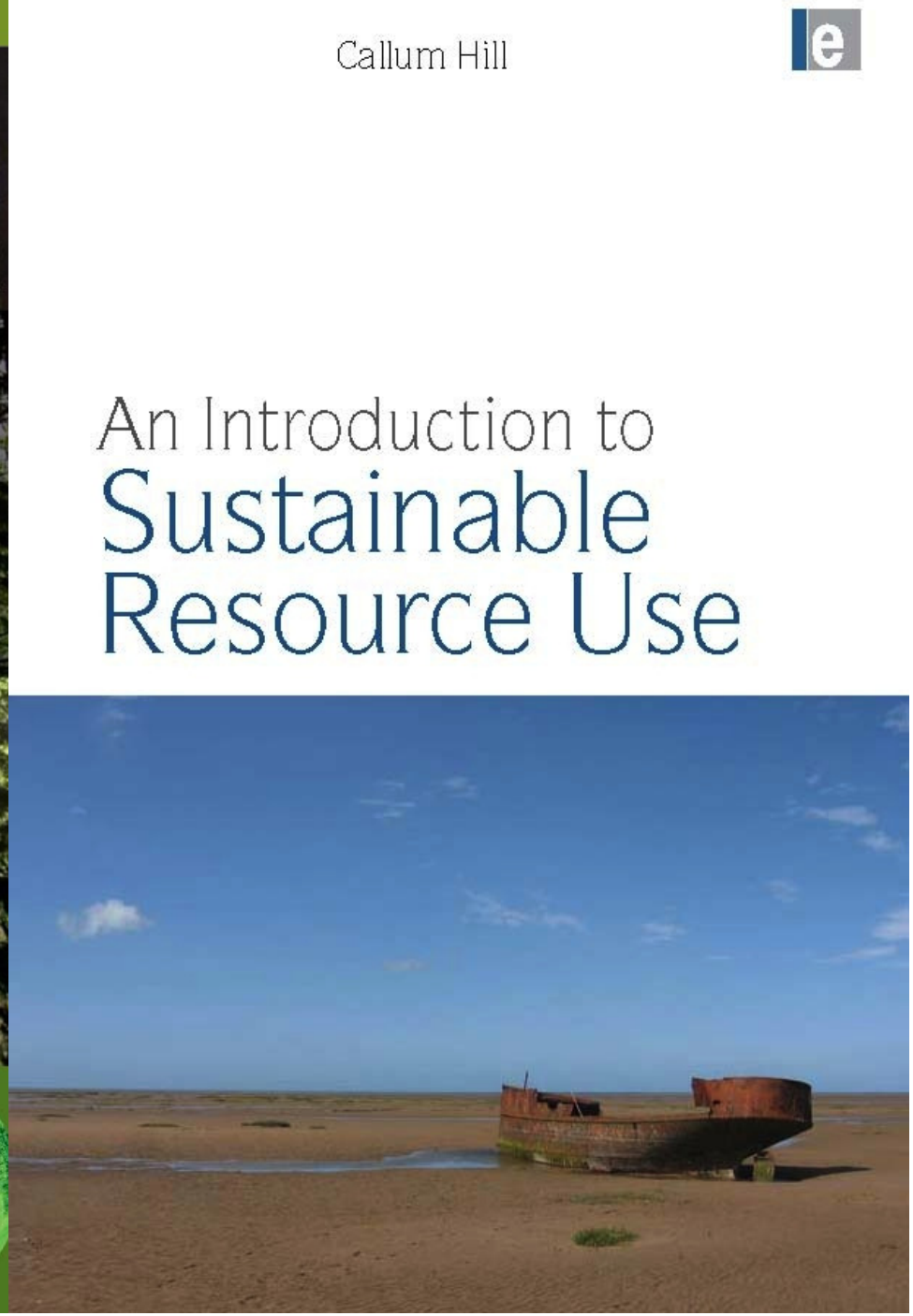
Callum Hill
An Introduction to
Sustainable
Resource Use