

„Modification of the wood surface with different tannin polymers“

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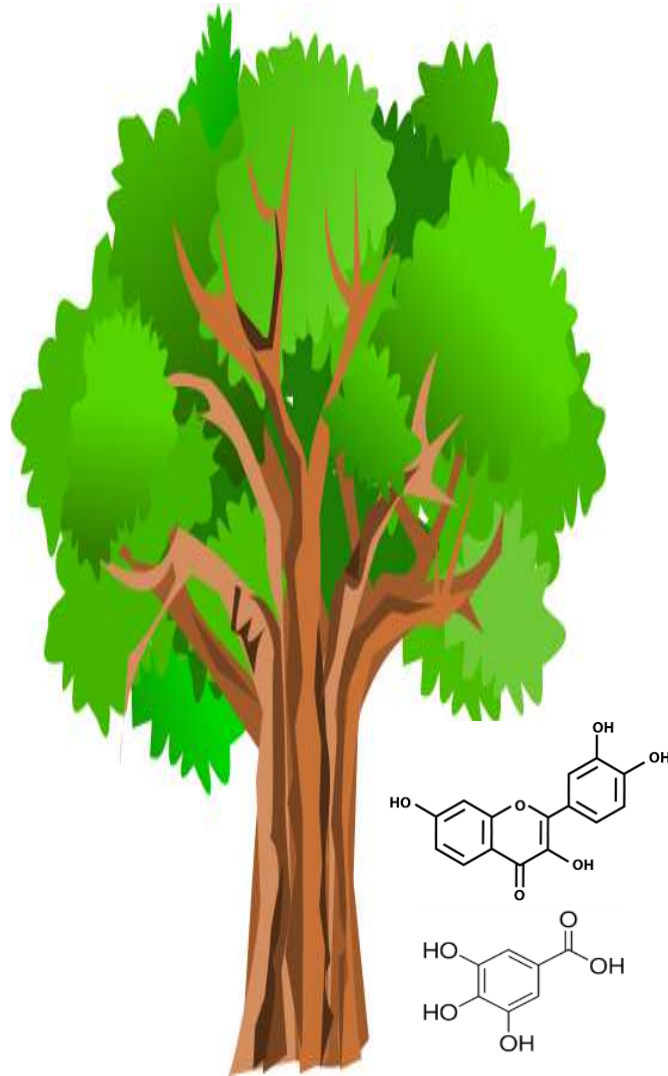
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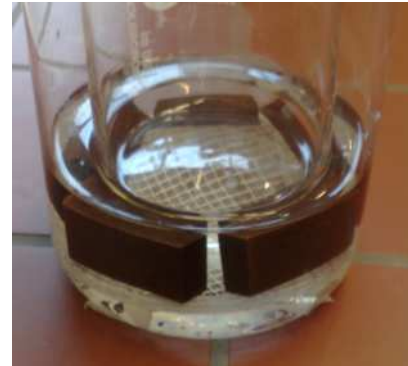
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Tannins in wood

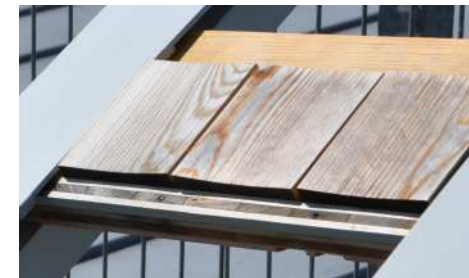
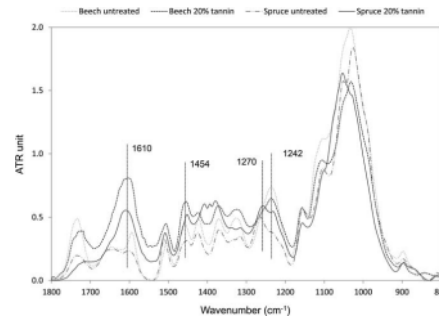


- Tannins are polyphenols that protect the tree against radiative and biological degradation.
- Cradle-to-cradle concept
- The solubility of tannins carries advantages for the application but also drawbacks for waterproofing.

- Some tannin formulations were deeply studied in the previous investigation of the group.



- The use of hexamine as hardener carried to good results, but also to brittle networks.



- The addition of **caprolactam** and **PEG**, as charges, slightly improved this phenomenon but the response against weathering still need to be improved.

Study approach

- In the present study we compare hexamine with other hardeners to find more elastic tannin-based copolymers.
- Many chemicals were considered for copolymerizing flavonoids, but only some of them could develop a polymer-like network.

Hardener	pH	Hardening temperature (°C)	Leaching resistance (%)
Tannin – Hexamine	9	50	84,6
Tannin – Furfuryl alcohol	4,5	103	98,3
Tannin- Furfural	4,5	70	83,3
Tannin- Maleic Anhydride	2	103	73,0

- A selection of these polymers was then tested for the impregnation of the wood samples.

- 15 samples of 25 x 15 x 5 mm³ of beech and pine were dried and vacuum impregnated with 10% tannin solutions with different hardeners.



- The mass uptake, the leaching resistance, the mechanical properties and the color were evaluated.

Mass uptake

Wood species	Treatment	Wet uptake (g)	Wet uptake (%)	Dry uptake (g)	Dry uptake (%)
Beech	Hexamine	1,28	107%	0,13	11%
Beech	Furfuryl alcohol	1,31	109%	0,17	14%
Beech	Furfural	1,31	107%	0,15	12%
Beech	Maleic anhydride	1,32	109%	0,19	15%
Pine	Hexamine	1,32	123%	0,26	24%
Pine	Furfuryl alcohol	1,39	129%	0,29	27%
Pine	Furfural	1,44	133%	0,27	25%
Pine	Maleic anhydride	1,40	132%	0,33	31%

- Principal observations:
1. Formulation uptakes is similar.
 2. After impregnation, pine keep water trapped in the cells.

Possibly due to closing of some pits...

Leaching resistance

Wood species	Treatment	Polymer Leaching loss (%)	Treated wood Leaching loss (%)
Beech	Hexamine	15,4	12,3
Beech	Furfuryl alcohol	1,7	28,0
Beech	Furfural	16,7	32,8
Beech	Maleic anhydride	27,0	25,5
Pine	Hexamine	15,4	8,7
Pine	Furfuryl alcohol	1,7	27,3
Pine	Furfural	16,7	36,2
Pine	Maleic anhydride	27,0	19,6

Principal observations:

1. Hexamine polymers leach less in wood than as a polymer
2. Furanics cannot crosslink properly in the wood cells
3. Maleic anhydride crosslinks in wood with similar extent



Brinell Hardness

Wood species	Treatment	Increase of Hardness (%)	Leaching effect (%)
Beech	Hexamine	2,9	-1,9
Beech	Furfuryl alcohol	5,7	+0,9
Beech	Furfural	3,8	+1,6
Beech	Maleic anhydride	4,5	+0,2
Pine	Hexamine	10,2	-9,3
Pine	Furfuryl alcohol	11,4	+1,5
Pine	Furfural	28,5	-14,5
Pine	Maleic anhydride	20,4	-16,4



Principal observations:

1. Higher increase of hardness is observed for pine
2. Leaching affects the most the hardness of pine

Possibly due to opening of some pits...



- Treated samples get brownish
- Different tones of brown are observed
- Once treated the color of the samples become similar between beech and pine.
- The color of the „maleic“ treated samples depends on the original color of wood.

After leaching the color:

- Become generally lighter (up to 10% of L*)
- a* has the higher variability (up to 23% for hexamine)
- Generally low ΔE variation < 3 (Furfuryl alcohol has the higher with 5.5)



Conclusions

- Uptake achieved is similar for all treatments in beech and pine.
- Pine samples traps the formulations which could be partially released after leaching.
- Furanic formulations are significantly more water resistant as polymers than as wood preservatives.
- Hexamine and maleic anhydride hardened tannin formulations show similar leaching resistances as polymer and in wood.
- The tannin formulations modify the colour of wood significantly, but only the „maleic anhydride“ depends on the original colour of wood.



Does the maleic anhydride in this condition reacts directly with wood as well?

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