GLUABILITY OF THERMALLY MODIFIED ASPEN, BIRCH, AND POPLAR VENEERS WITH SUBERINIC ACIDS ADHESIVE

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Birch

(*Betula pendula* Roth.)

53% of Latvia`s area is covered by forests, with birch being the most common species, accounting for 30% of the forested land. Mainly used for joinery timber, plywood production, firewood, tanning, racecourse jumps, and brooms.

https://en.wikipedia.org/wiki/Betula_pendula

Aspen

(*Populus tremula L.*)

Aspen makes up to 7% of Latvia`s forests. It is a fast-growing species, particularly its hybrid varieties, which are primarily used for matches, wood chips, and pellets.

https://lv.wikipedia.org/wiki/Parast%C4%81_apse

Poplar

(*Populus x canadensis* Moench)

Canadian poplar or Carolina poplar, is a natural hydrid, originally selected in France. It is a fast-growing tree that can be used for windbreaks and construction industry.

https://en.wikipedia.org/wiki/Populus_%C3%97_canadensis

Rotary cut veneers

A whole log is mounted on the center of the lathe and turned against the sharp blade, much like unwinding a roll of paper. It is the most economical method of cutting. Rotary cut veneer can be wide enough to produce a full-sheet, or single piece faces

https://www.plywoodexpress.com/blog/p/veneer-cuts/

Adhesives in plywood

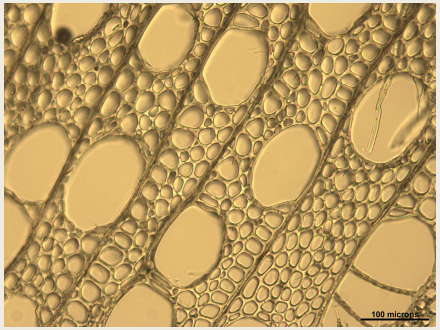
Adhesives are essential for bonding veneers in plywood, impacting durability and performance. The choice of adhesive must consider the type of wood, application method, and intended use, ensuring compliance with industry standards. Most common adhesive for plywood production - phenol - formaldehyde resin.

https://makerstock.com/products/baltic-birch-plywood

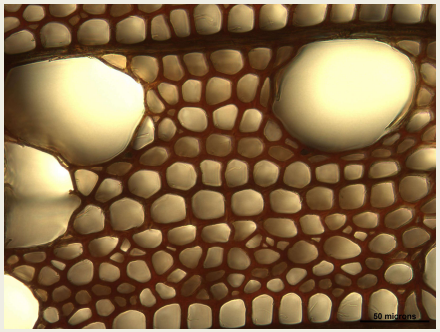
Thermally modified wood

Thermally modified wood undergoes heat treatment (150°C - 240°C) to enhance its properties, including durability and water resistance. The intensity of thermal modification is indicated by color changes—the harsher the modification conditions, the darker brown the veneer becomes.

Thermally modified veneers

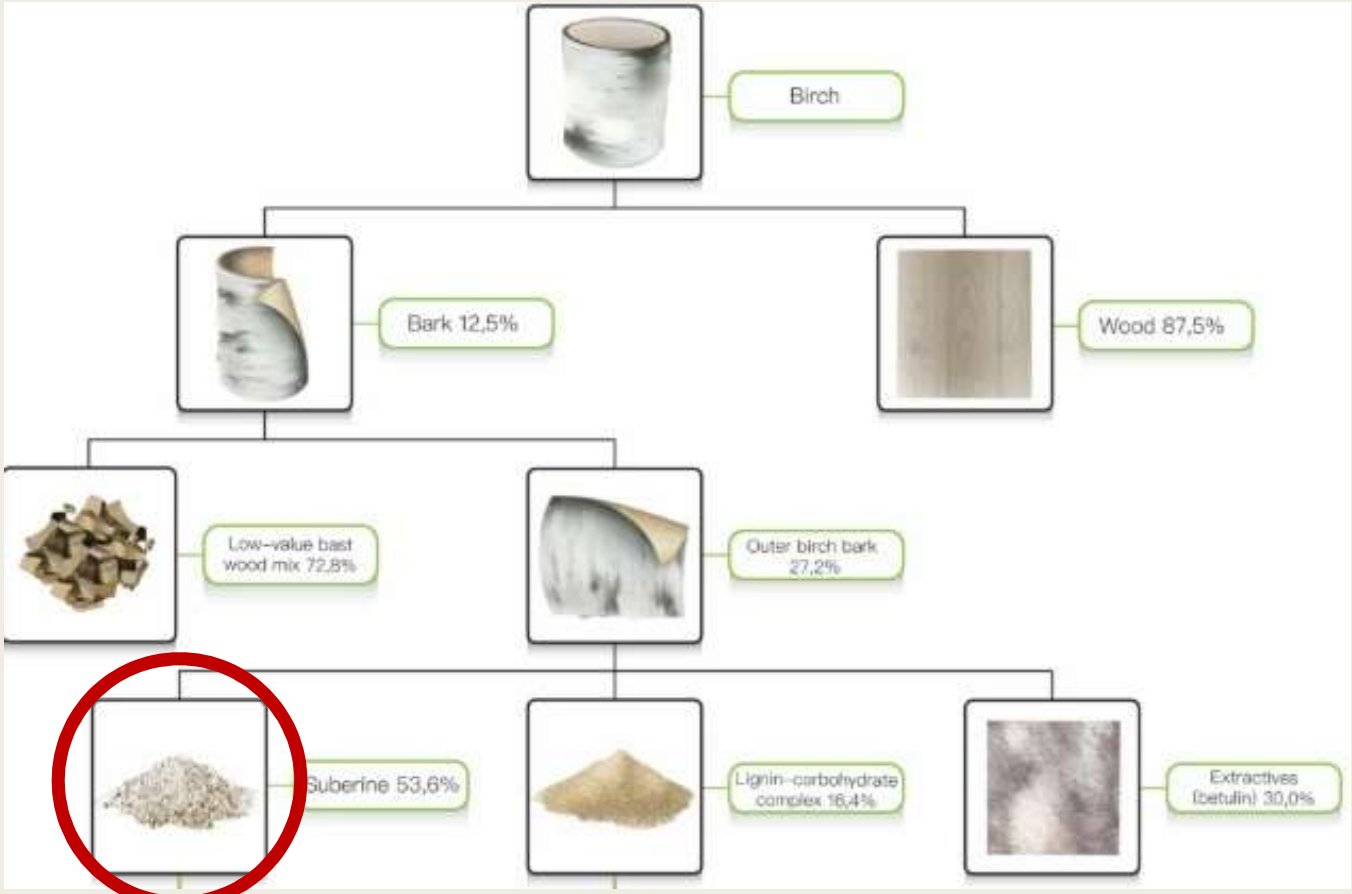


Unmodified poplar



TV 217/180 poplar

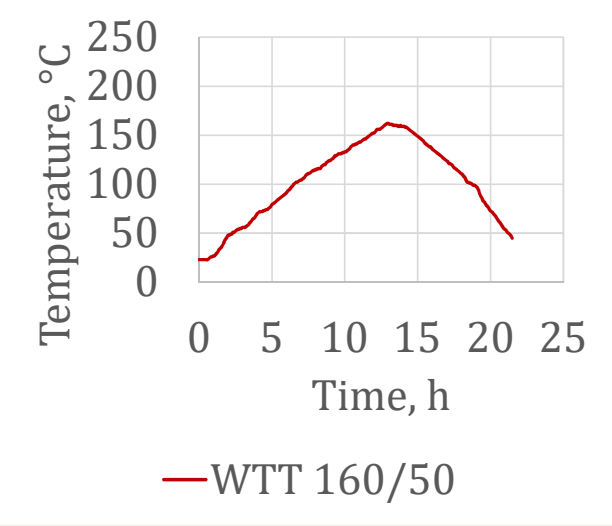
Suberinic acids adhesive



MATERIALS AND METHODS

WTT thermal modification

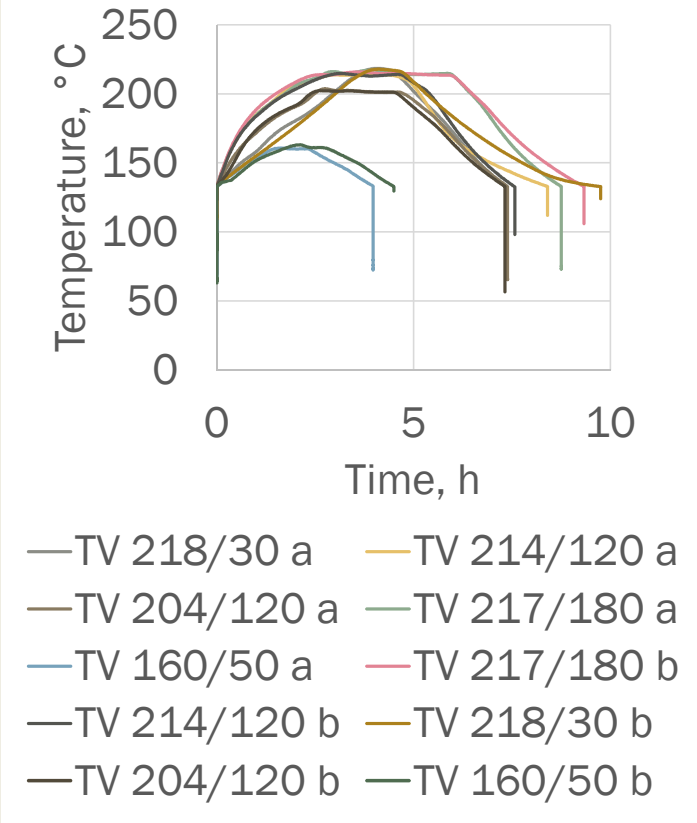
Aspen, birch, and poplar veneers were rotary-cut for the study and thermally modified in water steam environment at 160°C for 50 minutes



TV thermal modification

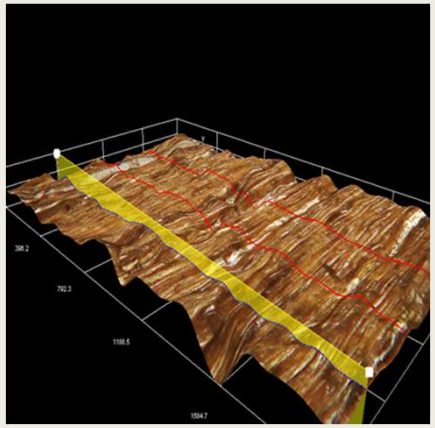
Aspen, birch, and poplar veneers were rotary-cut for the study and thermally modified in reduced pressure:

- 160 °C for 50 min
- 204 °C for 120 min
- 214 °C for 120 min
- 217 °C for 180 min
- 218 °C for 30 min

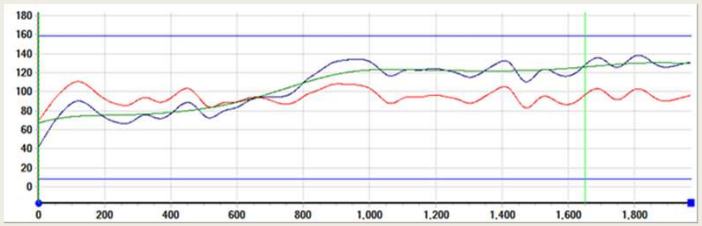


Surface roughness

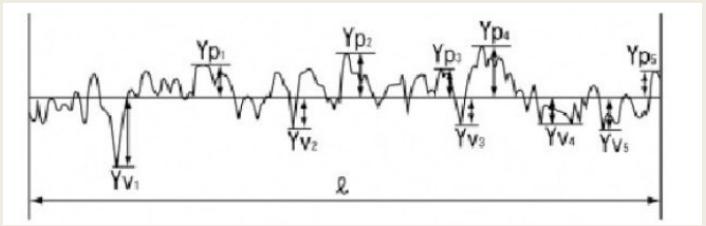
Surface profile determination was performed using a digital optical microscope. The captured 3D images were mathematically processed, and the 10-point average roughness was calculated.



3D surface depth profile image



Surface depth profile in MS EXCEL



10-point average roughness calculation

Plywood production

Suberinic acids adhesive:

- Fraction size: ≤1.0 mm
- Solids content: 20 wt%
- Ash content: 5 wt%
- Acidity: pH 3
- Colour: dark brown

Three-layer plywood samples were obtained after pressing the veneers at a temperature of 215 °C and pressure of 1.4 MPa and maintaining the pressure for 5 minutes

Pre-treatments

Plywood performance indicators were determined using three pre-treatment methods:

- 24h: Immersion in water at 20±3 °C for 24 hours
- 4h+16h+4h+1h: Immersion in boiling water for 4 hours, drying in a ventilated oven at 60±3 °C for 16 hours, repeated boiling water immersion for 4 hours, followed by cooling in water at 20±3 °C for 1 hour.
- 72h+1h: Immersion in boiling water for 72±1 hours, followed by cooling in water at 20±3 °C for 1 hour.

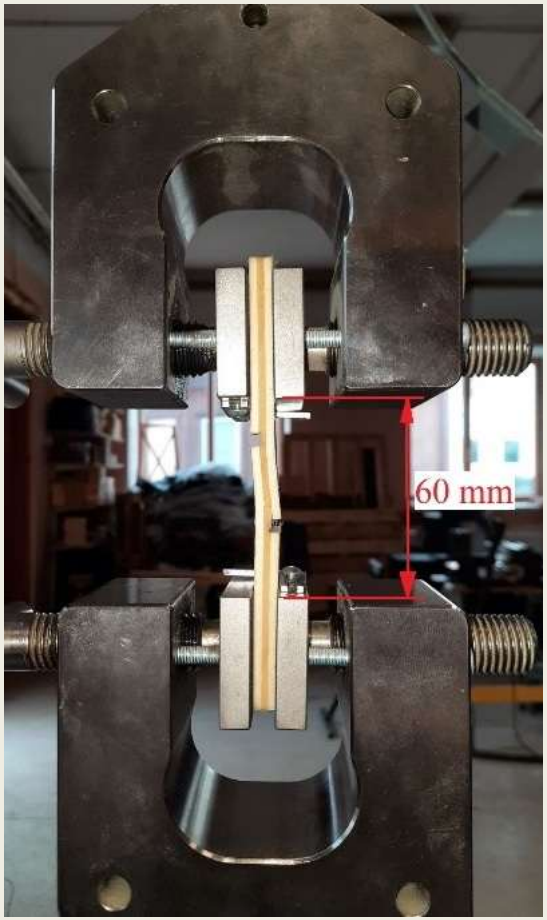
Immersion

Boiling

Drying

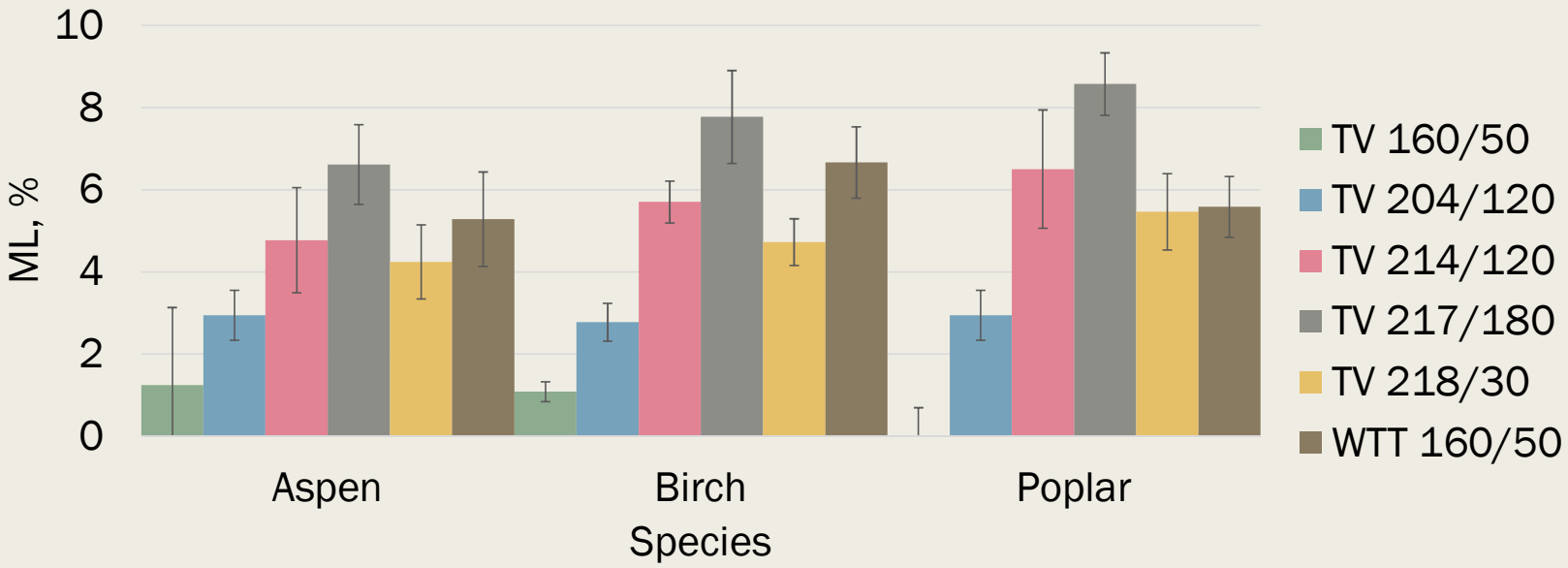
Tensile-shear testing

Tensile—shear strength in MPa and cohesive wood failure in percentage according to standard EN 314-1:2004 were determined, and conformity with bonding Class 3 according to EN 314-2:1993 was evaluated.

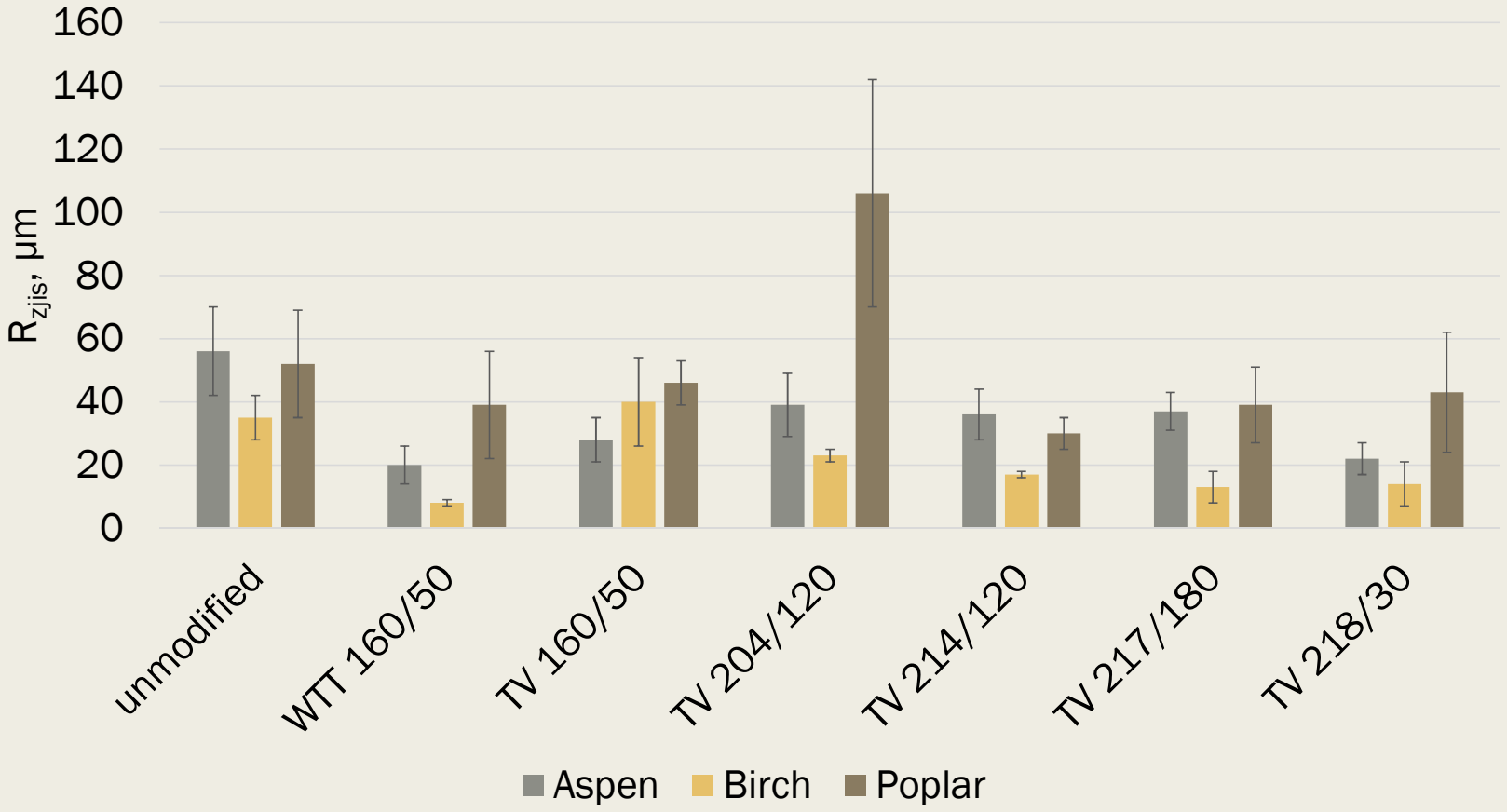


RESULTS

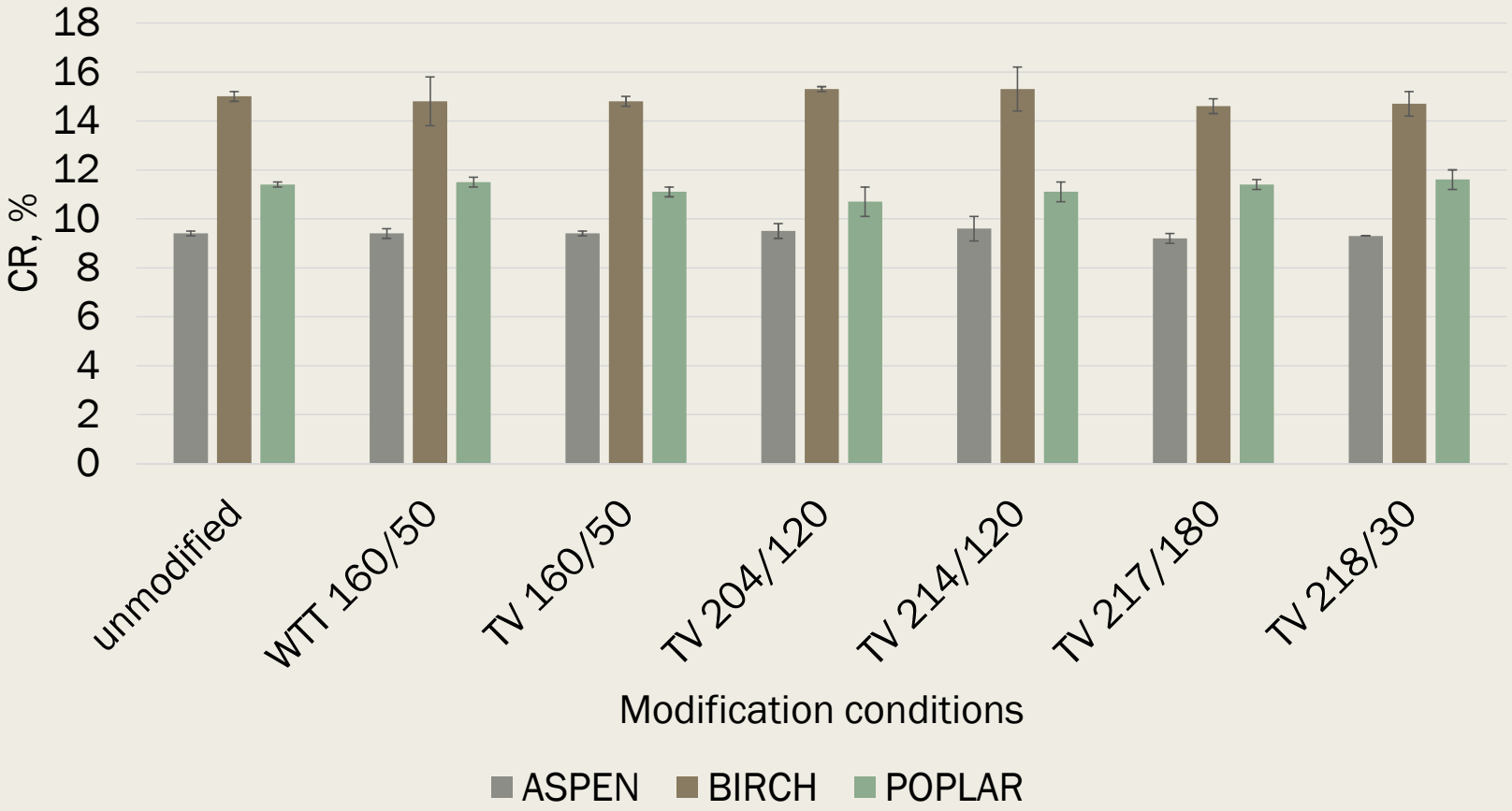
Mass loss (ML) during thermal modification



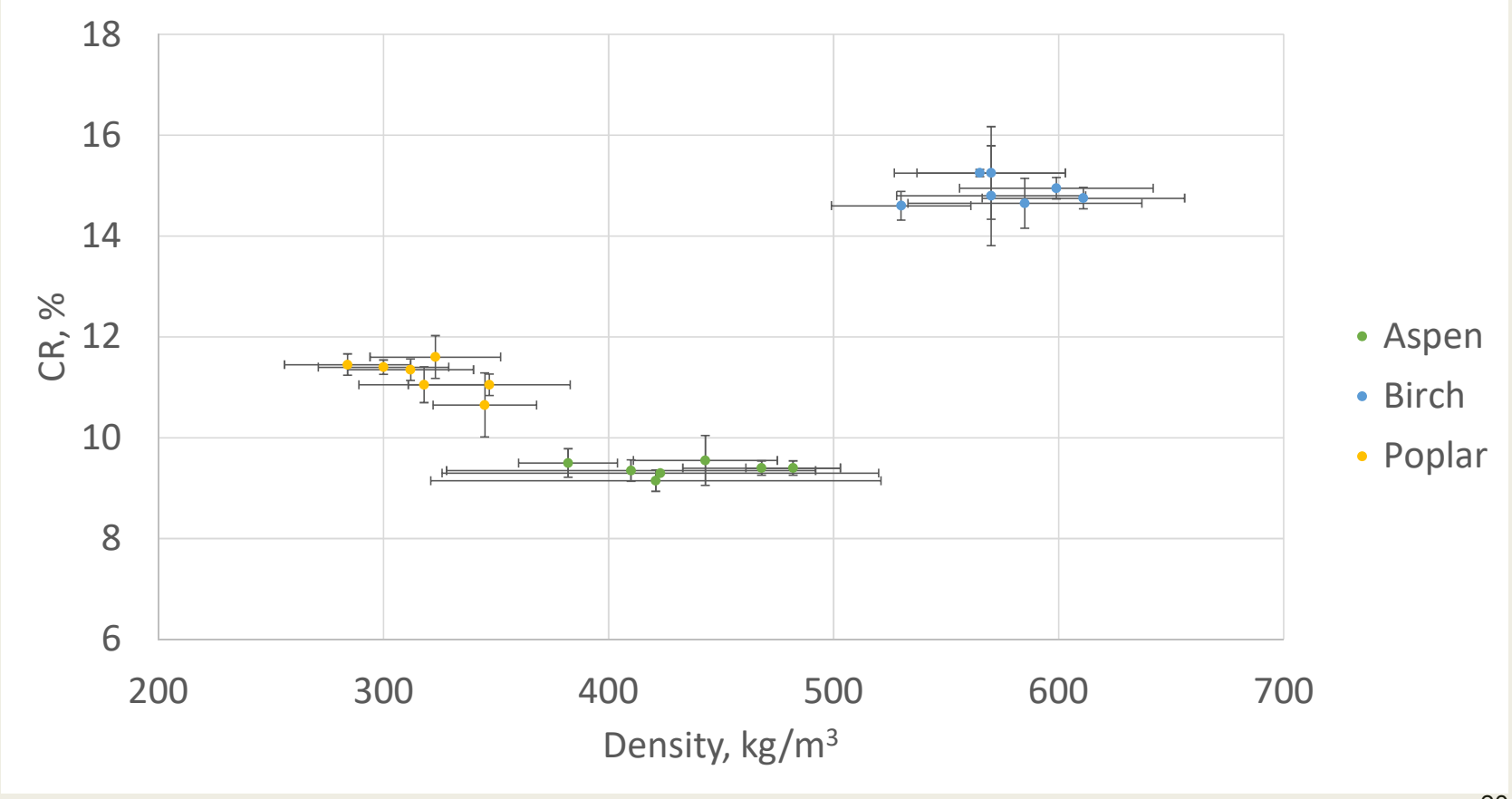
Veneer surface roughness



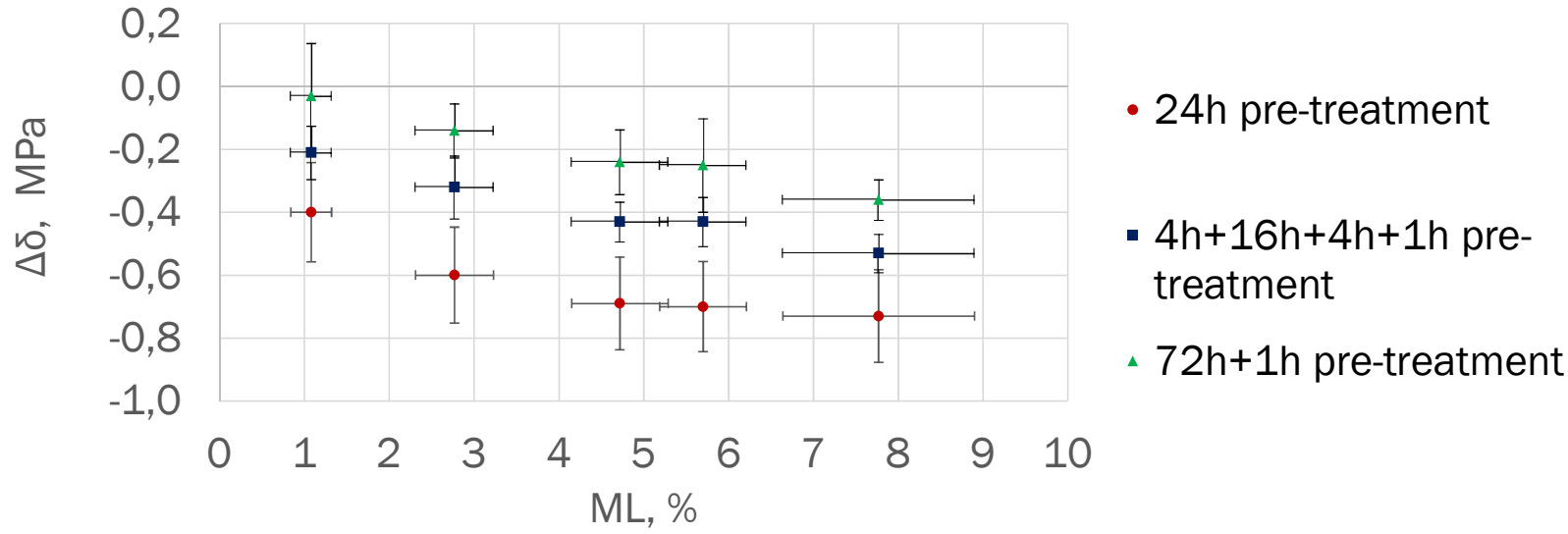
Compression ratio (CR)



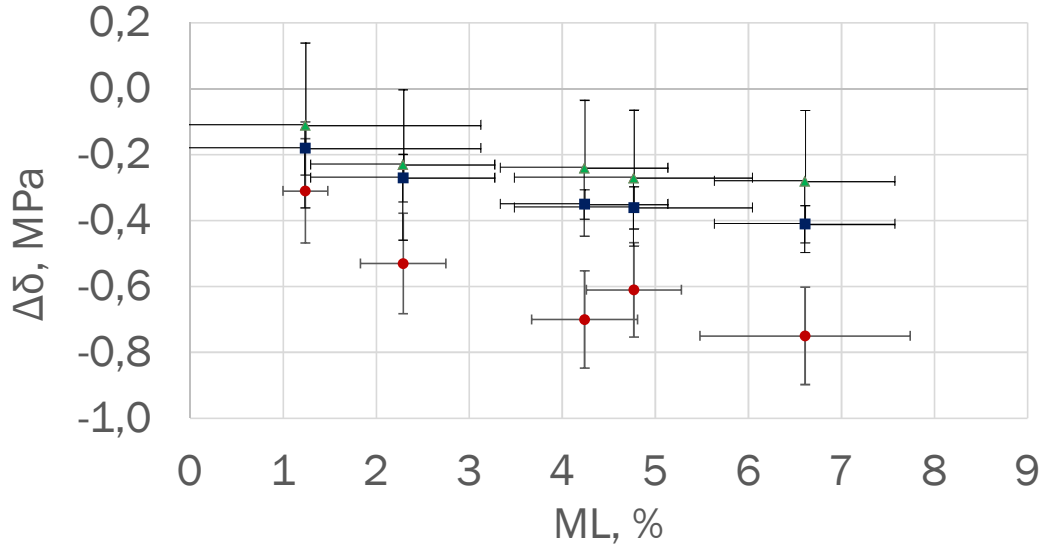
The correlation between CR and density



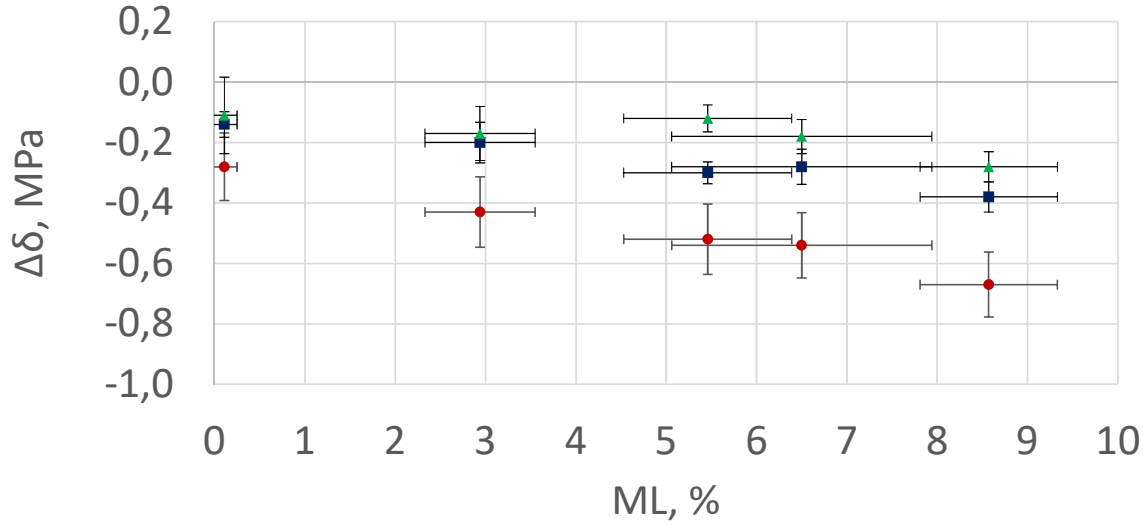
Tensile-shear strength reduction compared to unmodified birch samples (Δδ) vs ML



Tensile-shear strength reduction compared to unmodified aspen samples (Δδ) vs ML



Tensile-shear strength reduction compared to unmodified poplar samples (Δδ) vs ML



The average apparent cohesive wood failure percentage

	Aspen			Birch			Poplar		
	24h	4h+16h +4h+1h	72h+1h	24h	4h+16h +4h+1h	72h+1h	24h	4h+16h +4h+1h	72h+1h
unmodified	100	70	65	100	70	65	100	70	65
TV 160/50	50	70	65	75	60	60	95	70	65
TV 204/120	55	60	65	80	70	65	100	65	75
TV 214/120	70	60	75	80	60	75	100	60	75
TV 217/180	90	60	65	80	50	65	70	60	80
TV 218/30	70	60	65	80	55	75	60	80	75

Conformity with bonding Class 3 according to EN 314-2:1993

CONCLUSIONS

1. Unmodified birch plywood exhibits lower surface roughness (35±7 µm) than unmodified aspen (56±14 µm) and poplar (52±17 µm). Thermal modification of birch reduces surface roughness in all regimes except TV 160/50 (40±14 µm); thermal modification of aspen and poplar decreases surface roughness across all modification conditions compared to unmodified ones.
2. Veneers thermally modified in the TV process under all selected modification conditions successfully bonded with the SA under the chosen bonding conditions (press plate temperature of 215 °C, pressing pressure of 1.4 MPa, and pressing time of 5 minutes). However, veneers modified in the hydrothermal process under the WTT 160/50 regime could not be glued under the same bonding conditions.
3. Birch plywood exhibited the highest CR, at 15.3% in TV 204/120 and TV 214/120 conditions. In comparison, aspen plywood had a CR of 37.3 % lower at TV 214/120, while poplar plywood had a CR of 30 % lower at TV 204/120, and CR is not depending on density only as it was believed before.

3. Aspen, birch, and poplar veneers, as well as veneers modified in the TV process under all tested conditions and bonded with SA under the parameters of 215 °C temperature, 1.4 MPa pressure, and 5 minutes of pressing time, meet the requirements of standard EN 314-2:1993. Therefore, they are suitable for use in environmental conditions classified as bonding Class 3.

4. After PT 72h + 1h, unmodified birch plywood reveals the highest tensile-shear strength values (0.90±0.05 MPa) followed by TV 160/50 (0.87±0.16 MPa), TV 204/120 (0.76±0.07 MPa), TV 218/30 (0.66±0.09 MPa), TV 214/120 (0.65±0.14 MPa), and TV 217.180 (0.54±0.04 MPa).

Next steps

1. The preliminary study conducted in this research can serve as a foundation for future investigations aimed at optimization of the technological parameters of suberinic acids adhesive bonding, including variations in pressing temperature, pressure, and duration.
2. WTT thermally modified veneers need an alternative pressing technology to avoid delamination.

THANK YOU FOR YOUR ATTENTION

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