# Tailored holocellulose fibers from spruce wood chips: Influence of temperature in peracetic acid pulping

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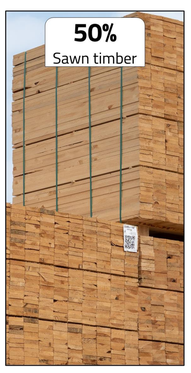
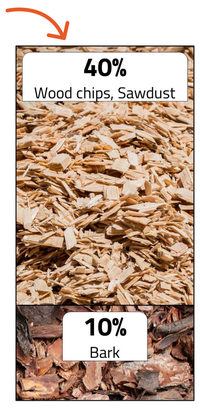
## Background and Motivation:

- Up to **50% sawmill by-products** (SBP) are generated during the production of sawn timber from round timber [1,2].
- Most of SBP are used energetically and the stored $CO_2$ is released.



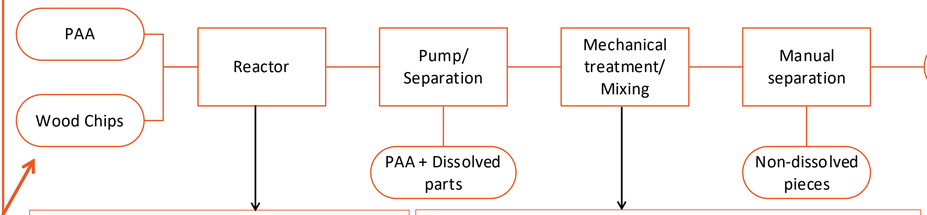

Wood fiber structure has outstanding load-bearing properties!

**Materials** for fiber production:

Spruce wood chips (HS Timber, Austria)

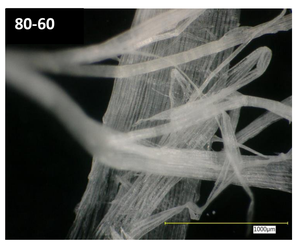
- Testing the **fibers as reinforcement material** for **biocomposites**.
- Biocomposites with fibers as reinforcement material **require long and intact single fibers**, which **peracetic acid pulping** can provide.
- Employing **standard paper production methods** and identifying modifications **for testing biocomposites**.

## Experimental plan:

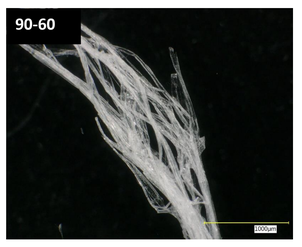



Specific parameters for the reactor [3]
- Temperature: 70, 80, 90 °C
- Time: 60, 120, 180 min
- Solid Load: 3 wt%
- Mixing: 60 min axial 700 rpm

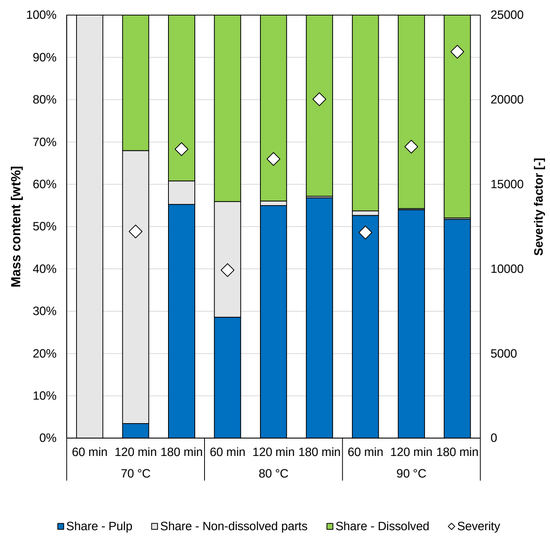
Specific parameters for the mechanical treatment
- Room temperature
- Solid Load: 1.5 wt%
- Mixing 1: 20 min axial 1700 rpm
- Mixing 2: 5 min with electric whisk








### Process parameters:




## Results:

### Influence of the process parameters

#### Inter-fiber bonding

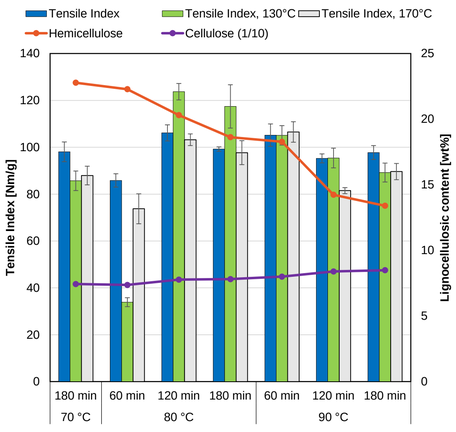



**Figure 4**. Inter-fiber bonding: Tensile index and hemicellulose

#### WRV

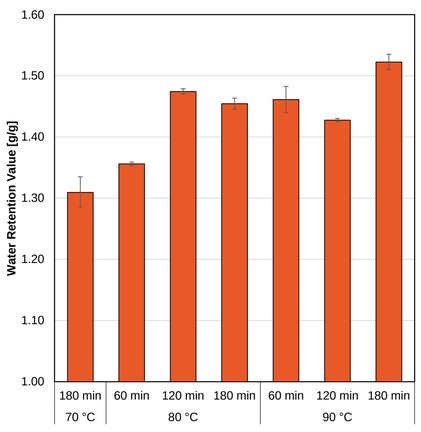



**Figure 3.** Water retention value (WRV)

#### Fiber morphology

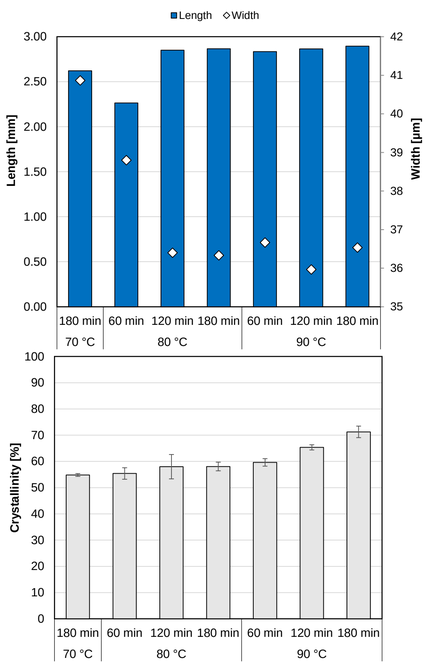



**Figure 2.** Fiber morphology: Morphology, Wide Angle X-ray Diffraction (WAXD), Light-microscopy

#### Chemical composition

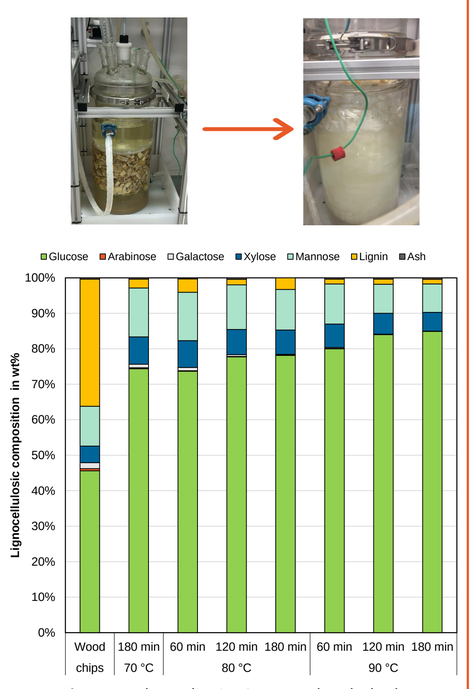



**Figure 1.** Klason lignin, Structural carbohydrates, Ash

## Methods:

**Methods** to investigate the **fiber properties** of the **single fibers**

Chemical composition

Lignin/carbohydrates/ash content

Physical properties

Water retention value, fiber morphology

Paper making


**Methods** to investigate the **fiber properties** in a **network (paper sheets)**

Physical properties

WAXD - Crystallinity

Mechanical properties

Tensile/Tensile Energy Absorption Index, Elongation

## Discussion:

- **Process Parameters**: Optimal conditions focus on 70°C-180min, 80°C-120min, and 90°C-60min, balancing severity and pulp yield
- **Chemical composition:** As expected, the hemicellulose content remains largely preserved, while the selective extraction of lignin increases with both time and temperature.
- **Morphology:** Fiber length is consistent across pulps except for 80°C-60min; fiber width indicates some bundles remain below 80°C-120min, confirmed by microscopy.
- **Crystallinity:** 90°C-180min shows the lowest amorphous content, with reduced lignin and hemicellulose.
- **WRV:** 80°C-120min and 90°C-60min exhibit similar water retention, while 70°C-180min performs the poorest.
- **Inter-Fiber Bonding:** Tensile strength and elongation are strong across all three conditions, with 80°C-120min and 90°C-60min performing slightly better, especially in elongation. After hot pressing at 130°C there is a visible increase in the tensile index for 80°C-120min, but also for 80°C-180min.

## Main findings:

- **Identified conditions** that improved **tensile index** of the fiber network when **hot pressed.**
- **Improvement** cannot be directly attributed solely to **the presence of hemicellulose.**
- **Further analysis** needed to determine the **specific parameters** and **variables** contributing to this **enhancement.**

## What's next?

- Identifying key parameters for enhancing the inter-fiber bonding.
- Testing the fibers in a matrix material.

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## References:

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[3] Adapted from: WESTIN, Per-Oskar, et al. Single step PAA delignification of wood chips for high-performance holocellulose fibers. Cellulose, 2021, 28. Jg., Nr. 3, S. 1873-1880.