ForestValue

ForestValue Research Programme - Midterm Seminar
Tuesday 17th – Wednesday 18th November, 2020, GoToMeeting

A Novel Material Concept for High Strength Cellulose Composites

PIs: Ingo Burgert (ETH Zürich/Empa), Andreas Hafner (BASF), Markus Linder (Aalto University), Lennart Bergström (Stockholm University), Wolfgang Gindl-Altmutter (BOKU), Gottfried Steiner (IB Steiner), Mikael Hannus (Stora Enso), Mark Röthlisberger (Röthlisberger AG)

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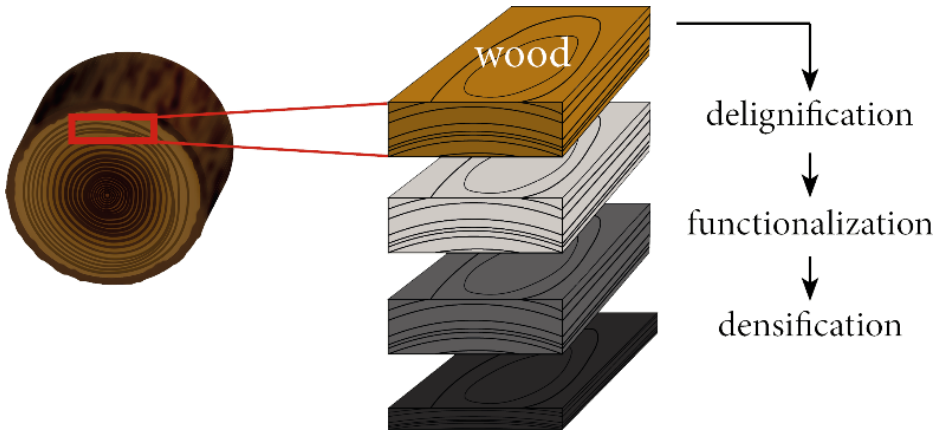
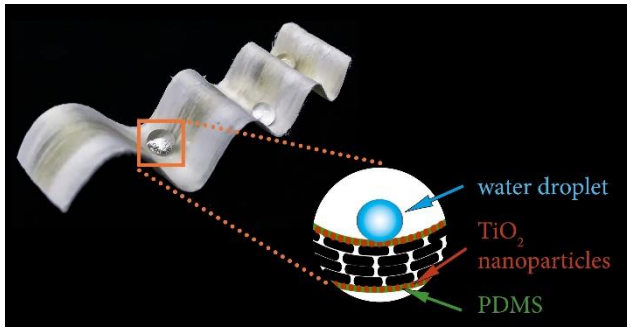
The material concept

Preparation

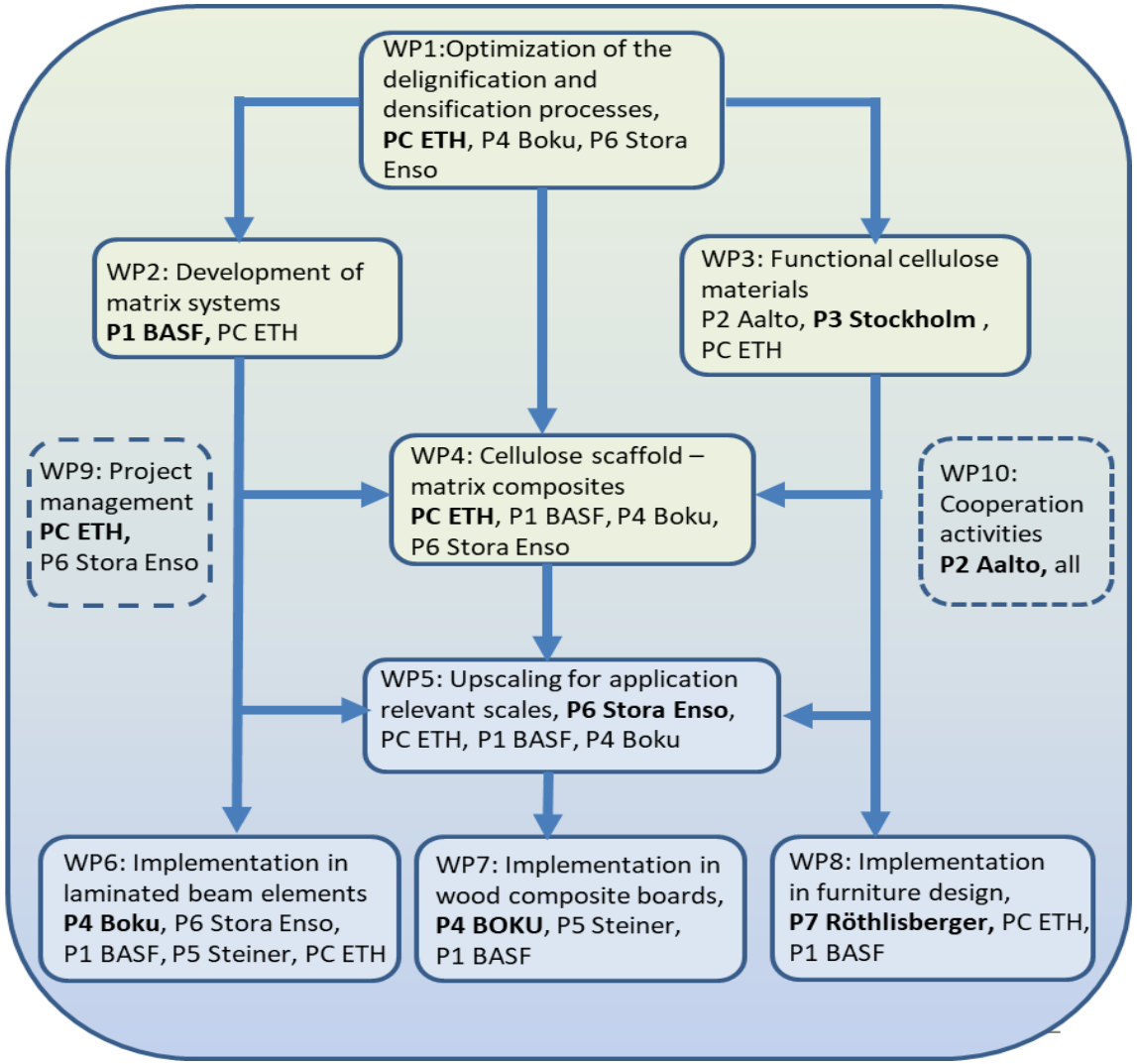


Functionalization



Frey et al. 2019 Advanced Science

Work Programme

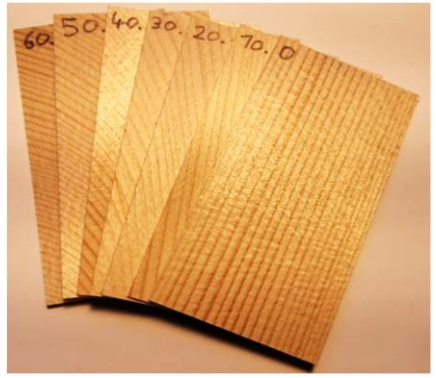


WP1: Optimization of the delignification and densification processes

Achieve targeted material densities and mechanical performances with different delignification processes

Bulk wood

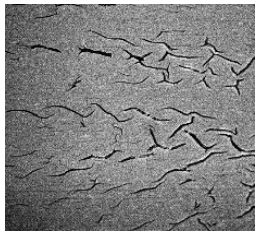
Sliced veneers

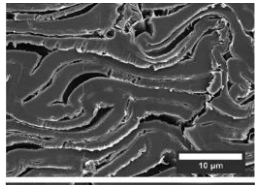


Partial delignification in alkaline medium (Sodium hydroxide, sodium sulfite)

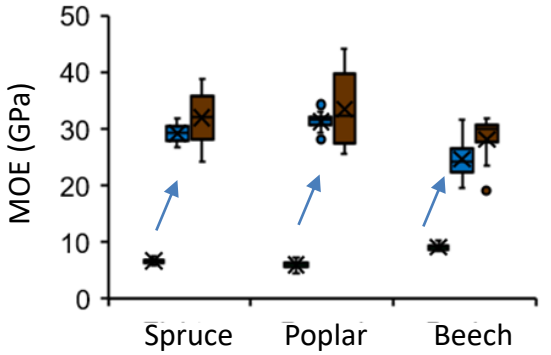
Full delignification in acidic solution (Hydrogen per-oxide, acetic acid)

Densification at ambient or elevated temperature (120°C)

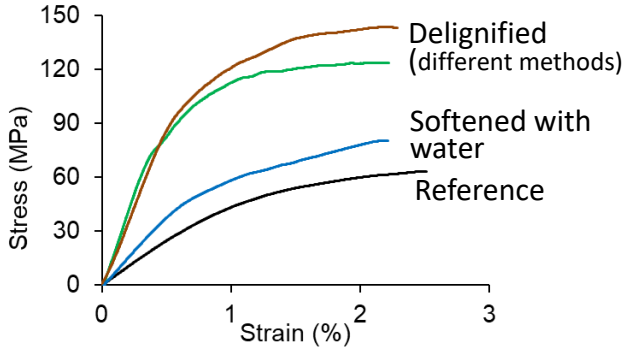




Low-density species more suitable



Treated with alkaline medium



WP2: Development of matrix system

Initial focus was on non-biobased matrix systems to have data on established performance in related applications as reference:

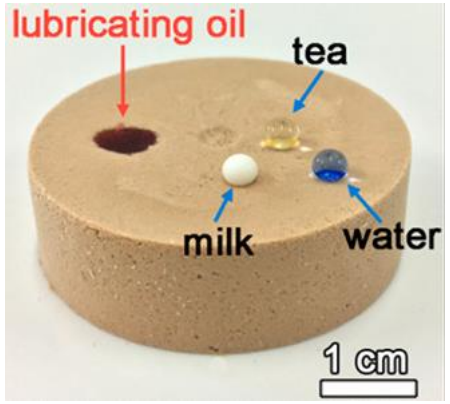
- **Melamine resins**
  established for the impregnation of paper
- **DMDHEU** (Dimethyloldihydroxyethyleneurea)
  established for wood modification
- **Epoxy resins**

Bio-based resin system development finalized

➡ tests on cellulose composites start Q4/2020 - Q1/2021

WP3: Functional cellulose materials by biotechnical and chemical approaches

- **Chemical separations**



ACS Sustainable Chem. Eng. **2018**, *6*, 9047–9055

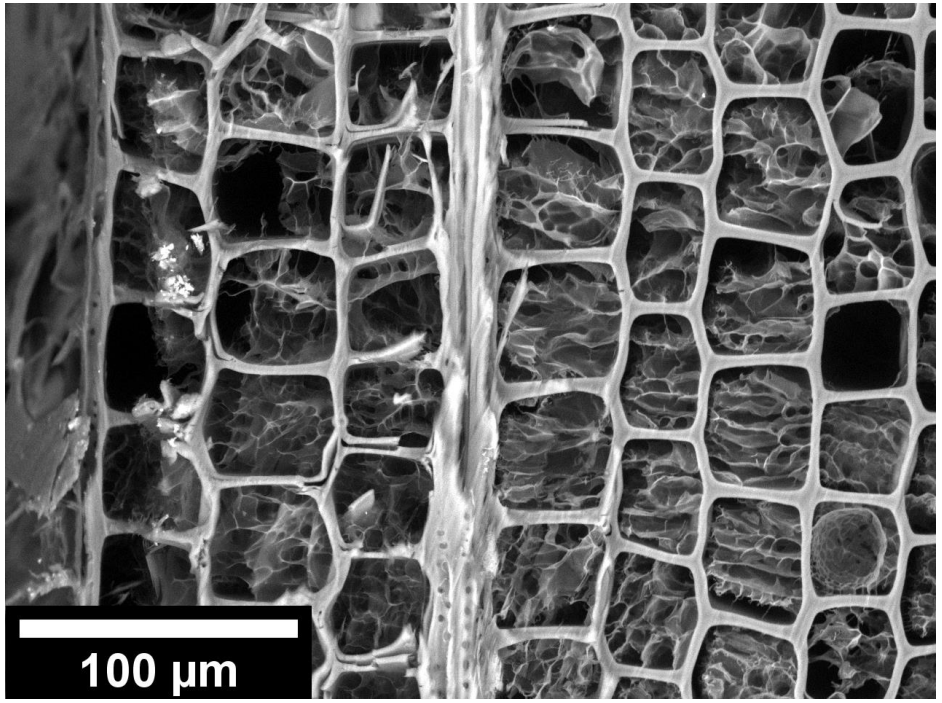
- **Flame resistance**

Nat. Nanotechnol. **2015**, *10*, 277–283

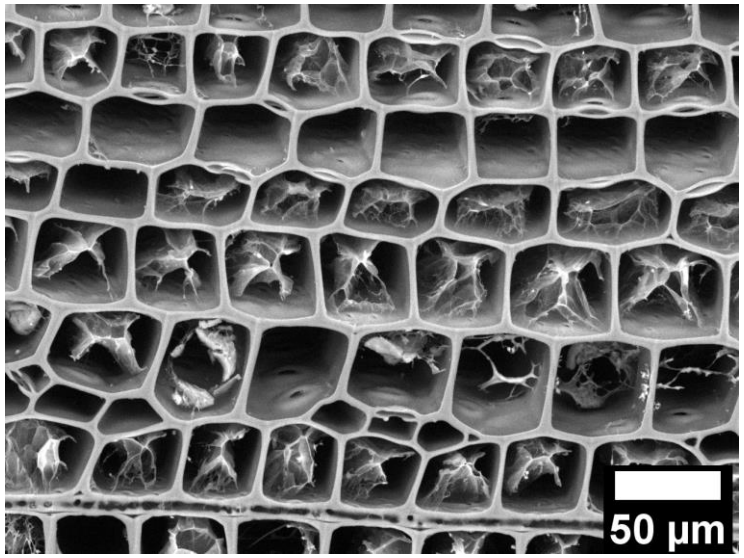
- **Insulation**

Embedding of nanocellulose foams (CNC/CNF) in the cellulose scaffolds

CNC foam in spruce

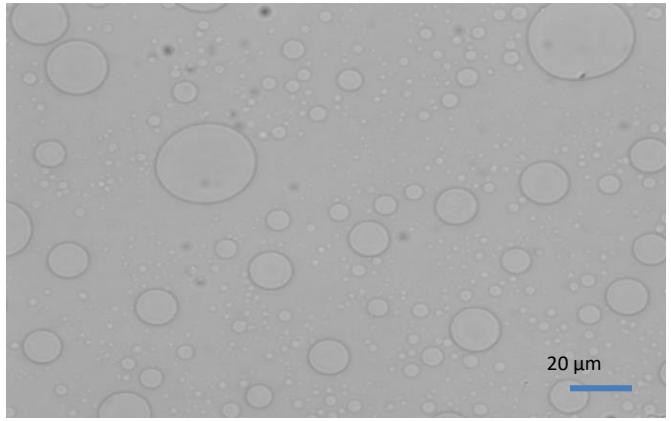


CNF foam in spruce

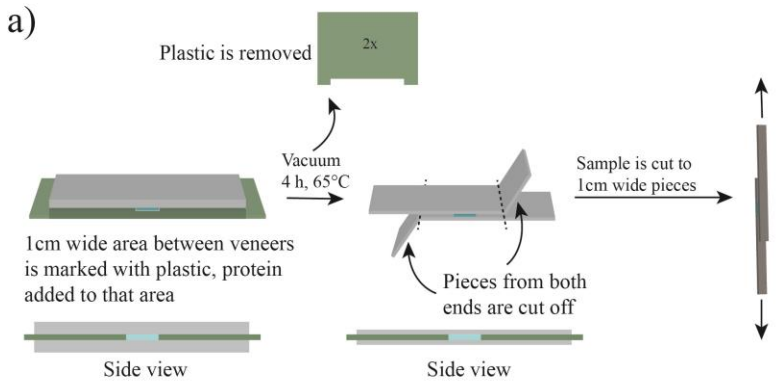


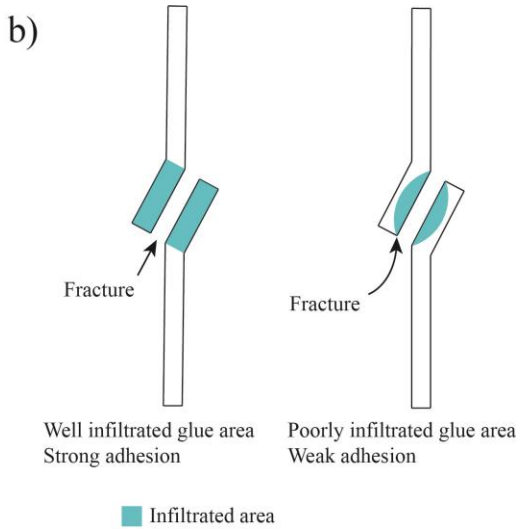
WP3: Functional cellulose materials by biotechnical and chemical approaches

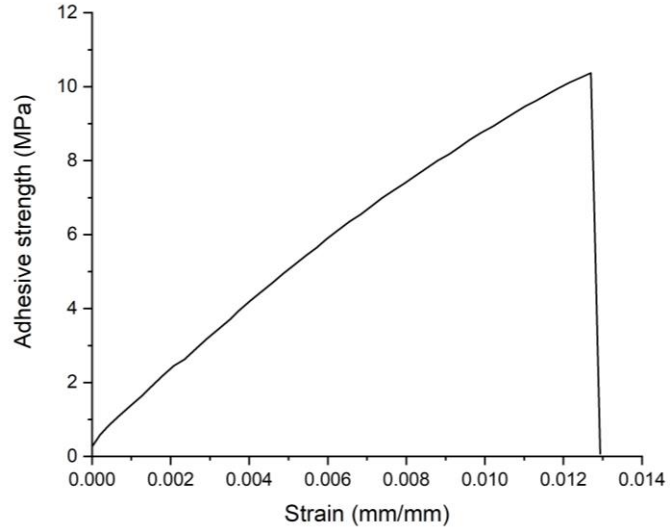
Recombinant spider silk protein as wet adhesive for delignified wood



Recombinant silk proteins undergo liquid-liquid phase separation at high concentration.







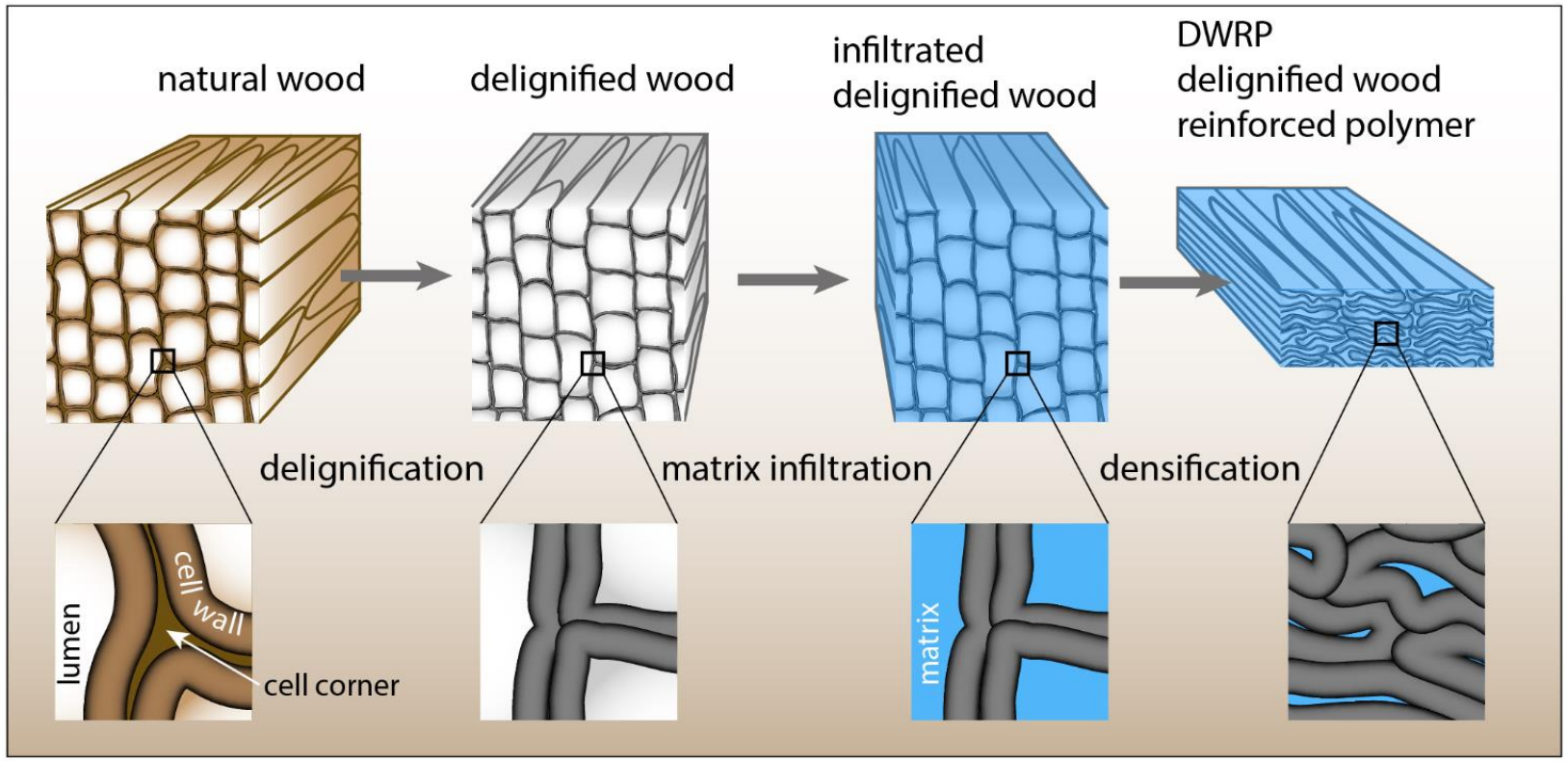
Highest single sample so far gave over 10 MPa adhesive strength.

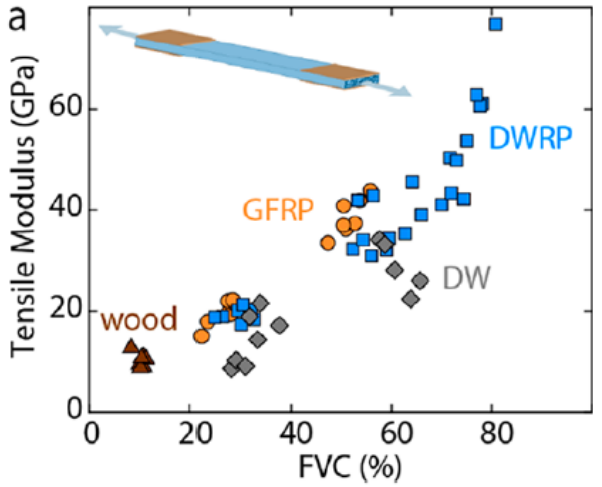
Phase separated protein solution can be used as a wet adhesive to glue delignified cellulose plates together.

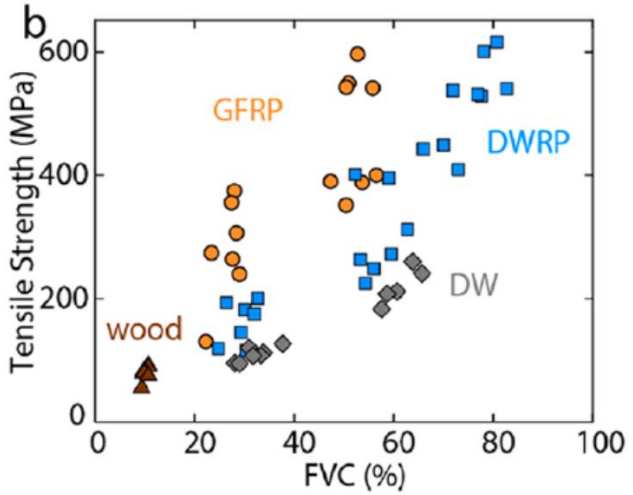
WP4: Cellulose composites preparation

Delignified Wood Reinforced Polymers (DWRPs)

Reference system: epoxy resin







Frey et al. 2019 ACS AMI

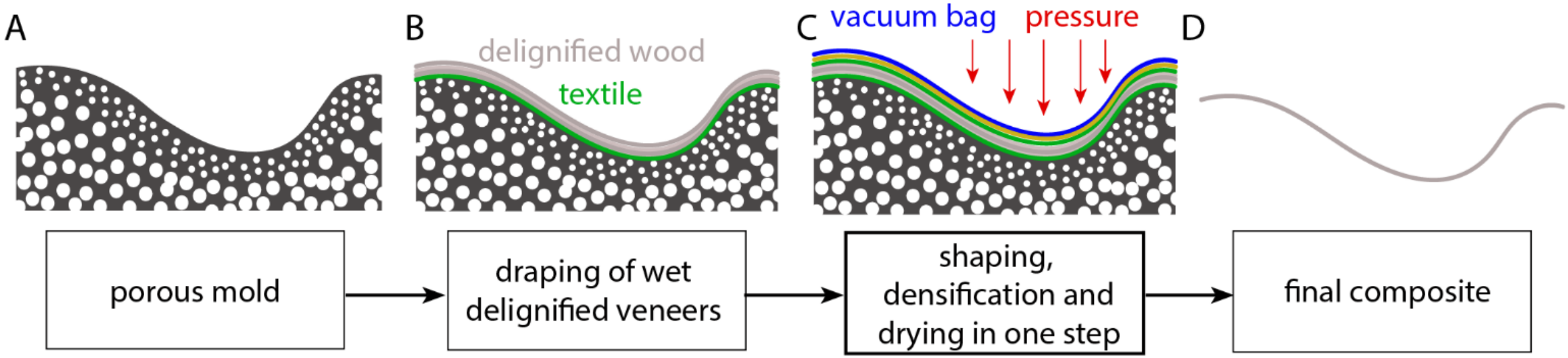
WP4: Cellulose composites preparation

Goal

-bio-based resin system, which penetrates into cell walls and acts as adhesive between veneer layers

-water-based system to infiltrate veneers in wet state

-compatibility with vacuum-densification approach



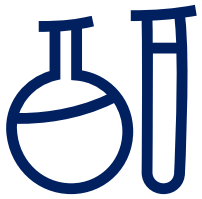
WP5: Upscaling for application relevant scales

Upscaling of the delignification process (wood veneers)

Alkaline medium –
Upscaling of the process at academic partner finalized

1 m scale

Acidic medium –
upscaling at industrial partner

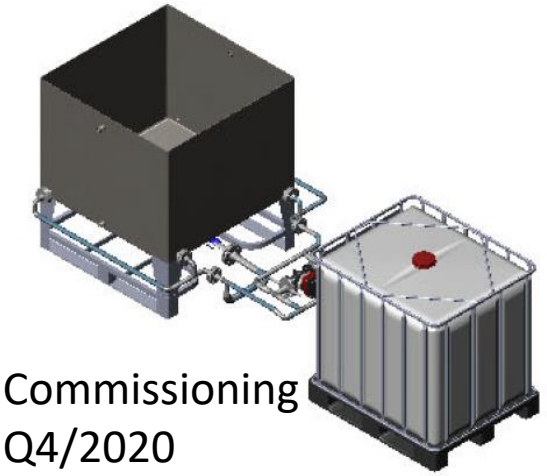


Starting with the delignification step – replicating laboratory process in larger scale

Design for…

- Safety
- Functionality
- Automatisation

1 m^3 vessel



Commissioning Q4/2020

WP6: Implementation in parallel-laminated beam elements

First studies on side impact beams

Veneers produced

Beam currently being produced for 1:1 test 12/2020

WP7: Implementation in flat and curved wood flake boards

WP8: Implementation in furniture design

to be started after successful industrial upscaling

WP 9: Project management

WP10: Transnational dissemination activities

Ongoing activities

https://www.cellulosecomposites.com

Thanks for your attention

ETH Eidgenössische Technische Hochschule Zürich Ecole polytechnique fédérale de Zurich Politecnico federale di Zurigo

BASF We create chemistry

IB STEINER

Aalto University School of Chemical Engineering

Stockholm University

BOKU

storaenso

Rö

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