



Bark-Derived Nanocelluloses for Sustainable Heavy-Duty Plywood Coatings

Wood Coatings Congress

Veronika Zeller, Anna Gadner, Albert Rössler,
Boris Forsthuber, Panu Lahtinen

Softwood bark

antioxidant

self-healing

weather resistant

resistant to microbial attacks



Motivation



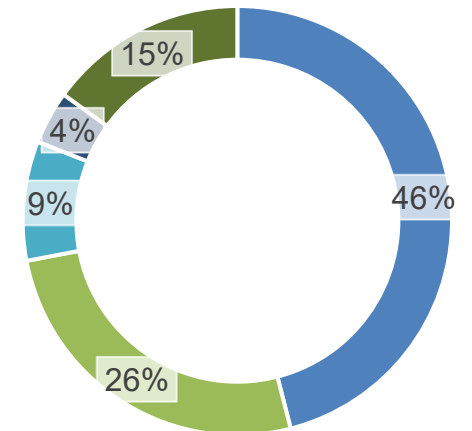
Softwood bark:

- sidestream of the forest industry
- >14 M tons/year in EU
- mostly burned for energy

SuperBark idea:

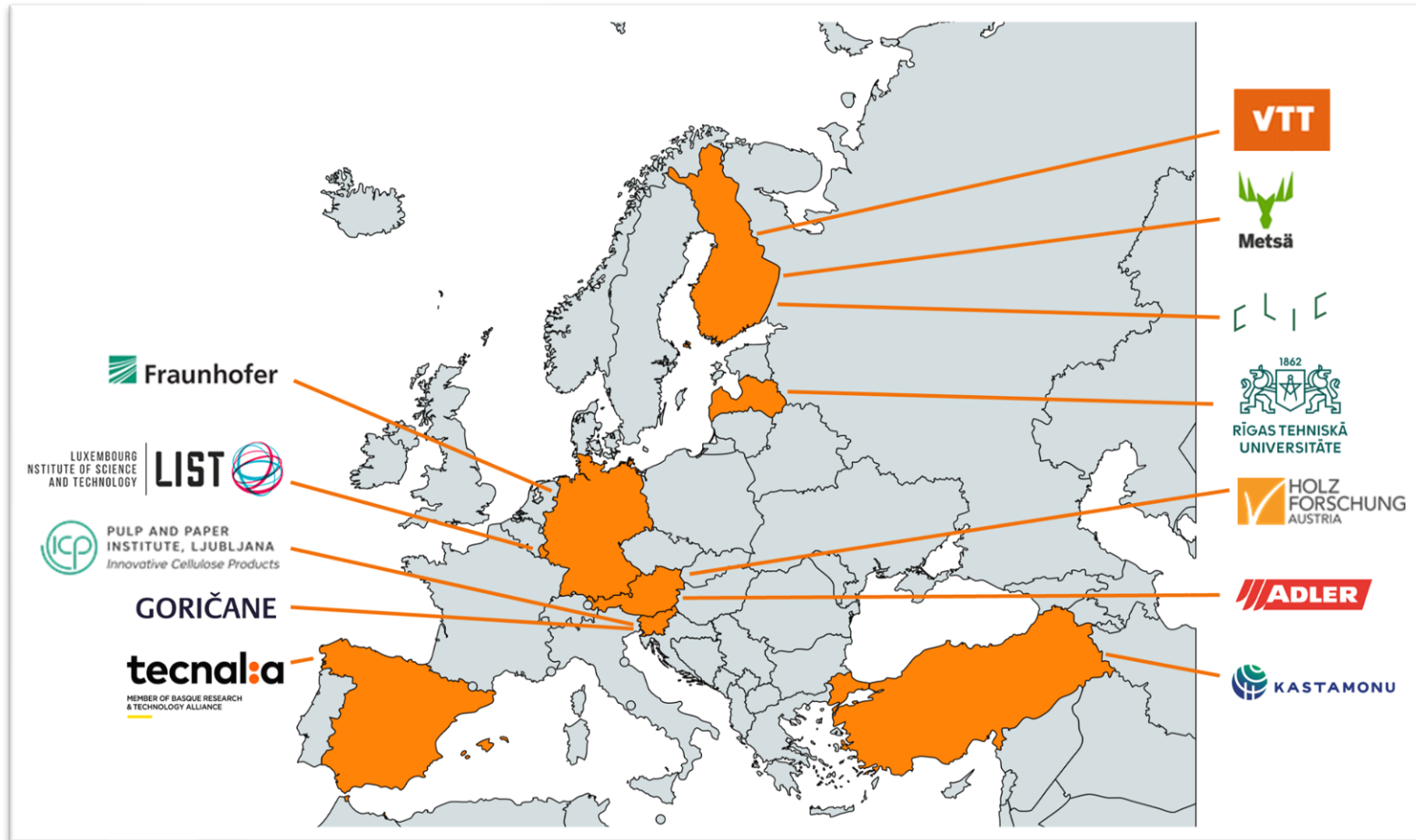
Use softwood bark as source for functional **>95 % bio-based** components for adhesives and coatings

- Tannins
- Polyphenol-rich Cellulose Nanofibers (CNF)



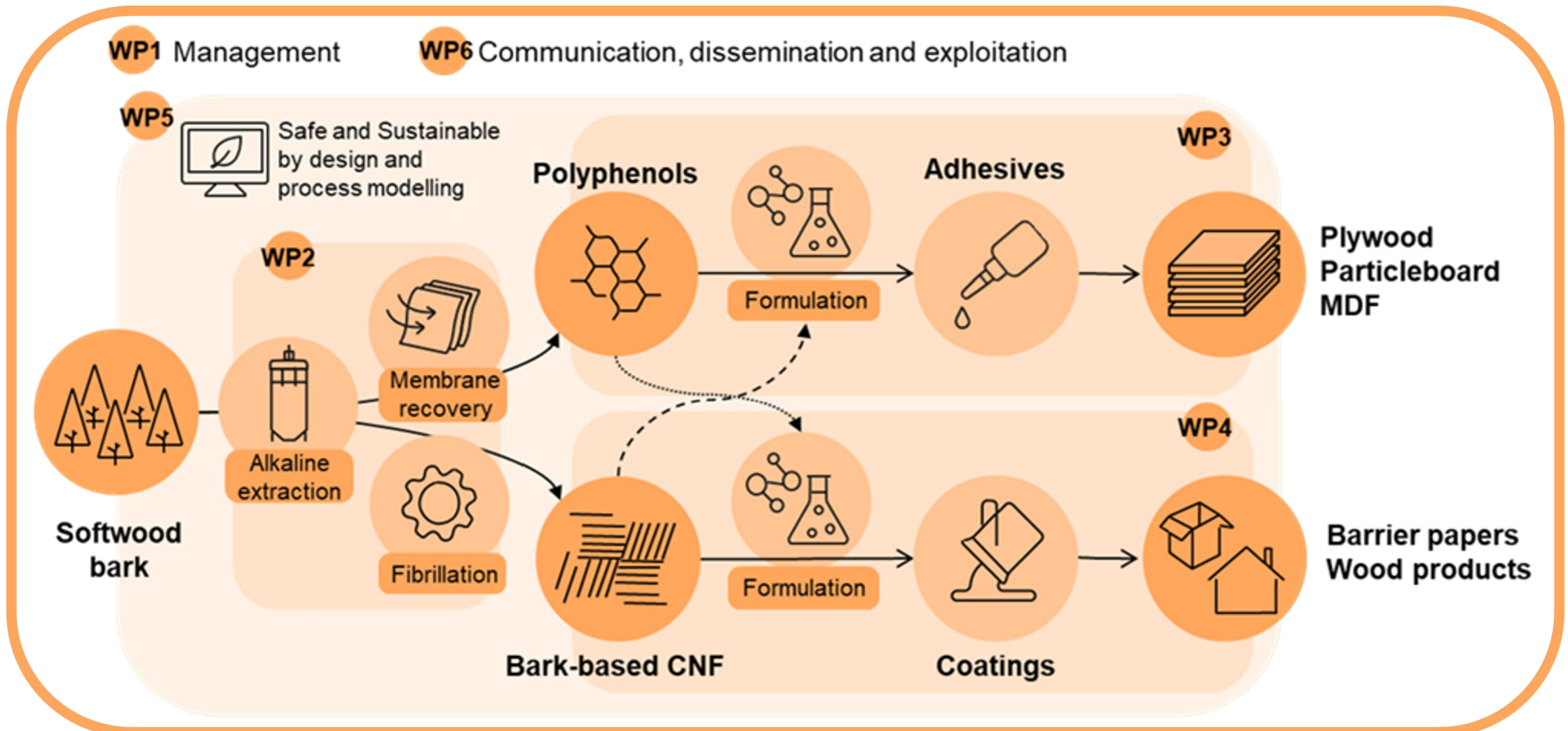
- Carbohydrates
- Tannin
- Lignin
- Ash
- Others

SuperBark



- 12 partners
 - 8 European countries
 - 4 industrial partners
 - 6 research and technology organizations
 - 1 small and medium size enterprise
- 2023-2027

The SuperBark Project

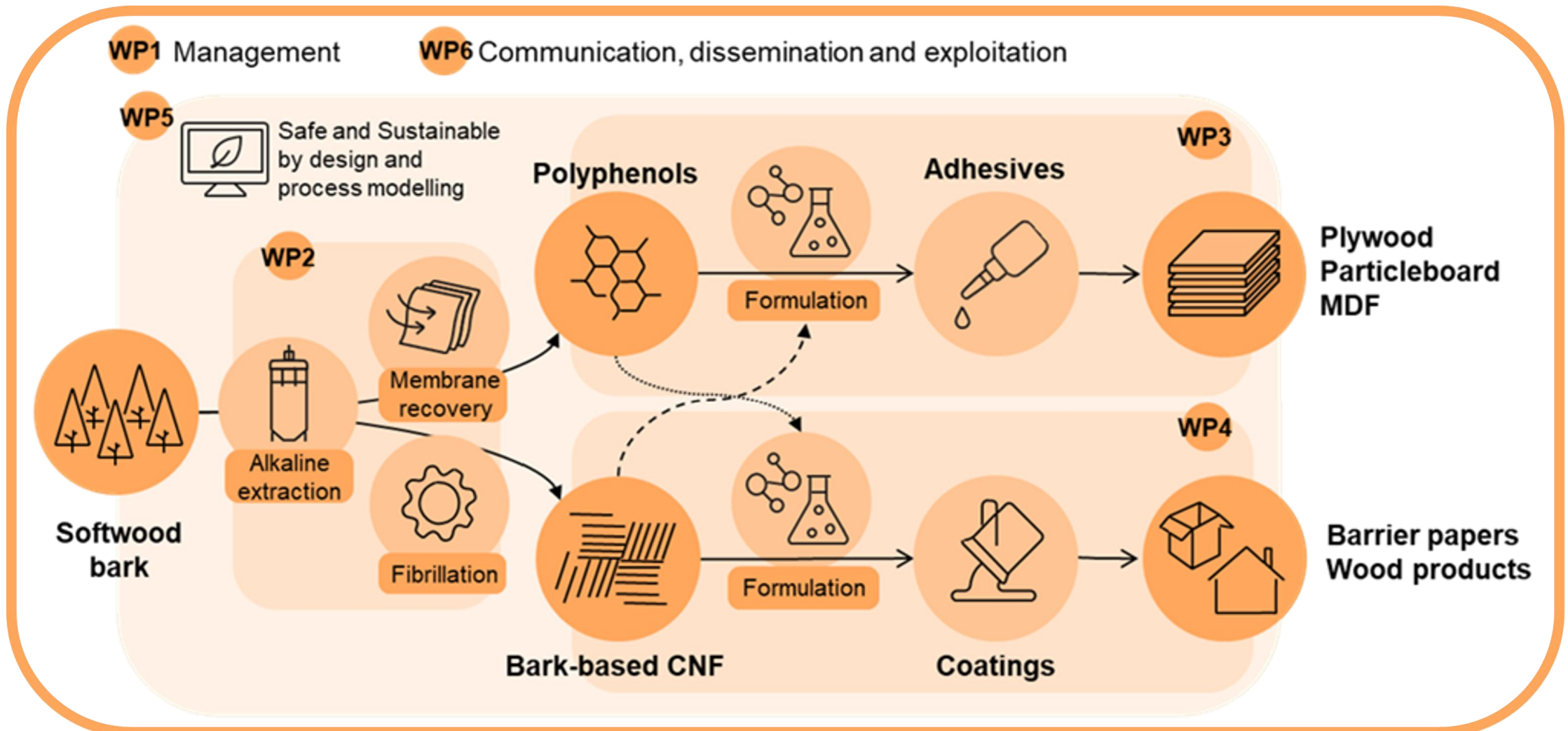


Components from spruce bark

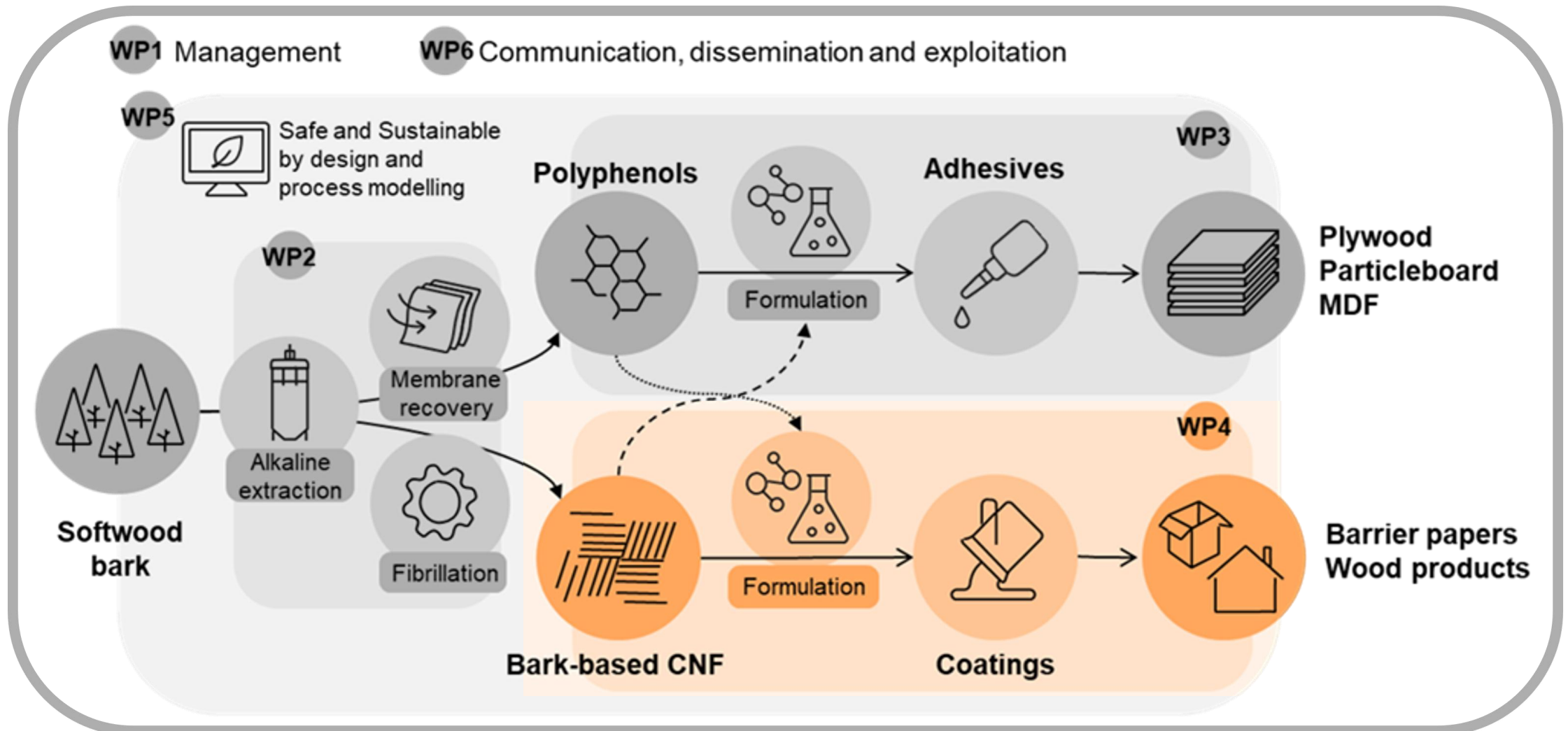


- Processing of softwood bark at VTT research center
- Alkaline extraction of softwood bark yields polyphenols used for adhesive development
- Bark residue: Polyphenol-rich cellulosic material, can be fibrillated to produce CNF

The SuperBark Project



The SuperBark Project



Application: Metsä Transportation plywood



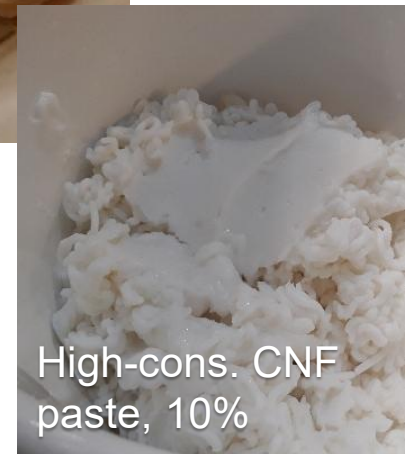
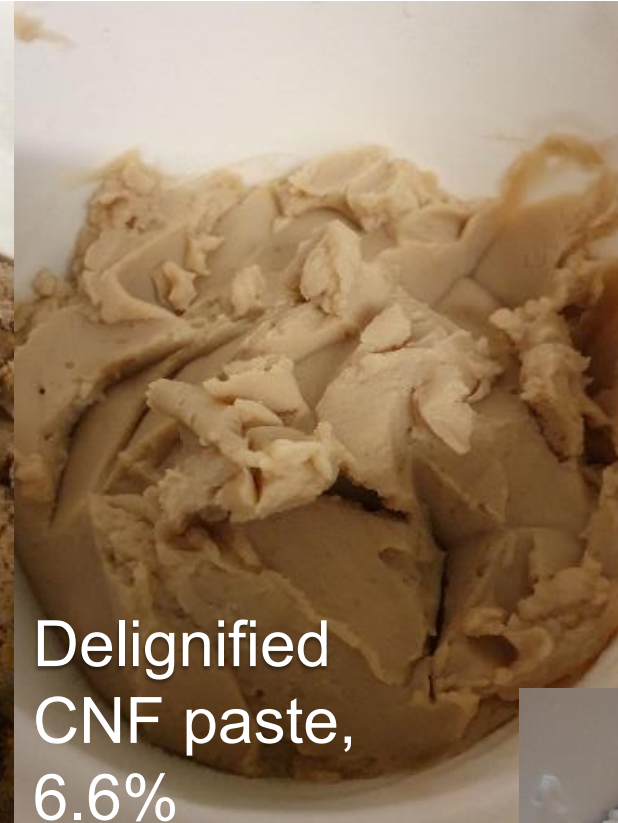
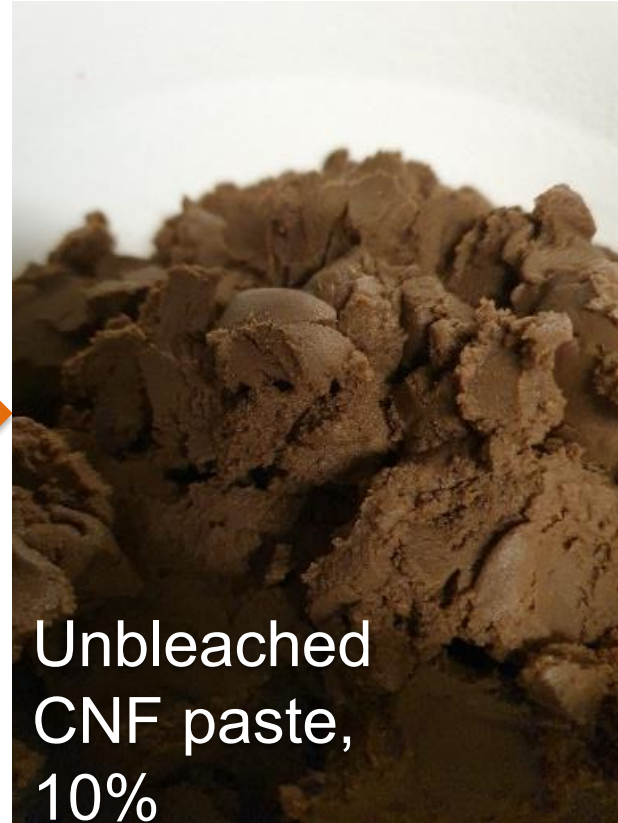
Currently used for this use case:

- Phenol formaldehyde impregnated paper overlay

Requirements:

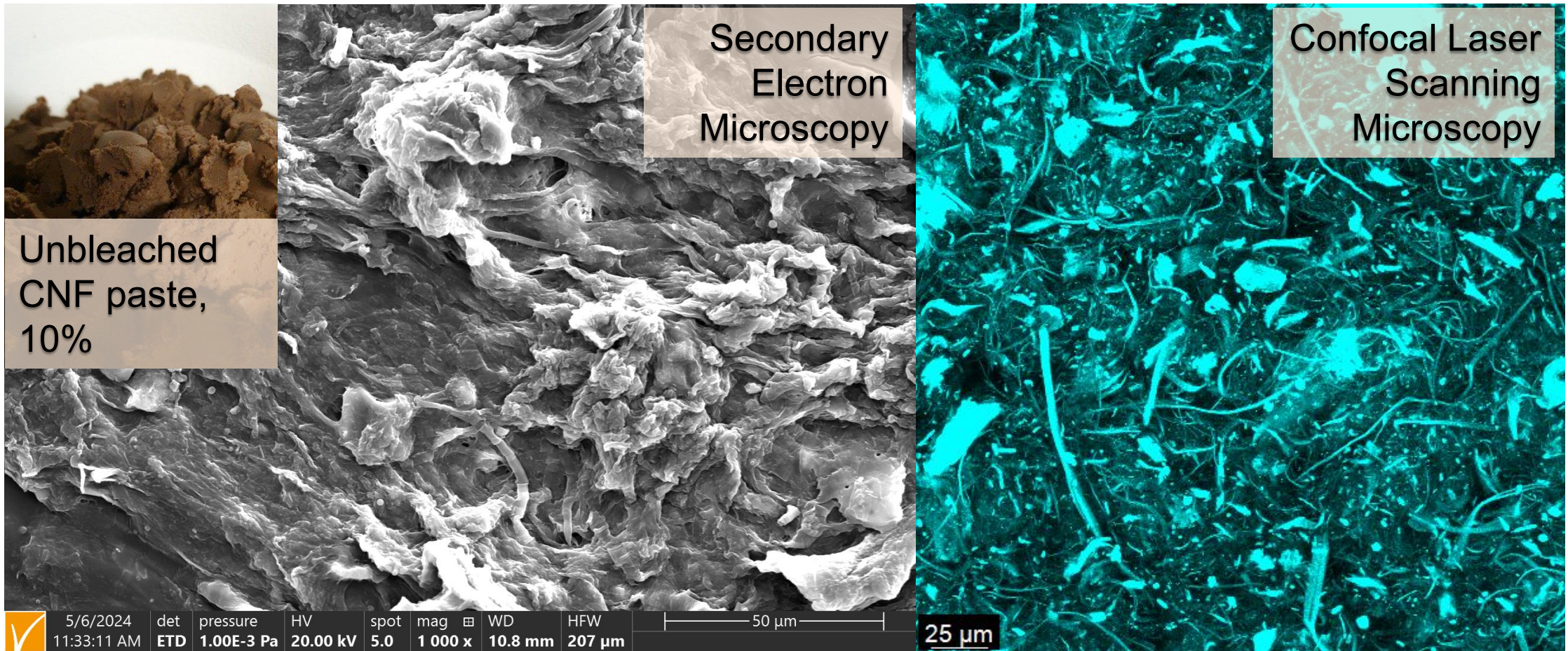
- Coating/impregnation (with or without overlay) with
 - Brinell hardness of 3-4
 - Abrasion resistance of 225 to 450+ rotations according to EN 438
 - Scratch resistance of Level 4+ according to EN 438

Bio-based functional fillers: The Nanocellulose

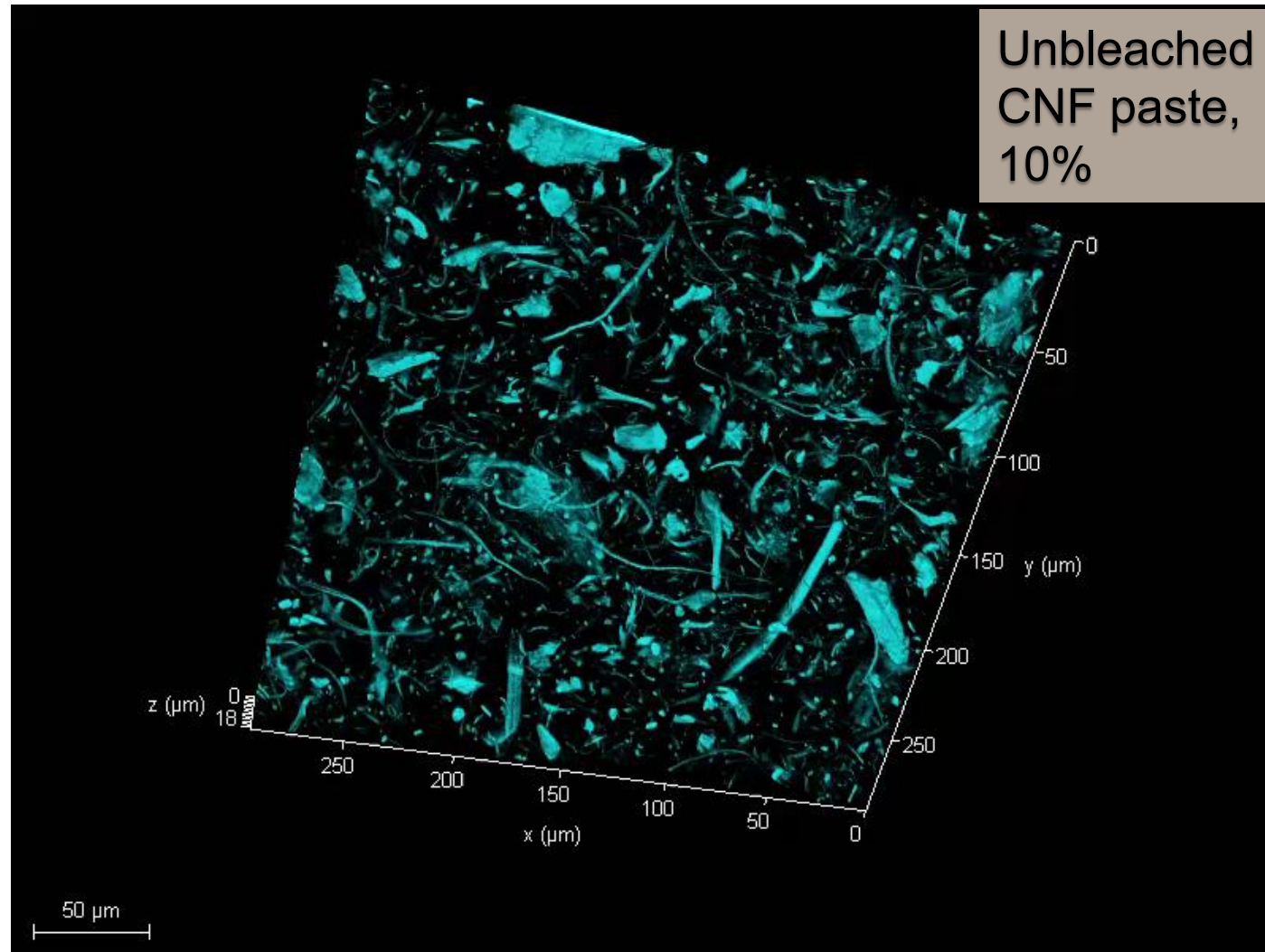


- Unbleached and delignified CNF paste produced by VTT from spruce bark
- High consistency softwood bark as a reference

Bio-based functional fillers: The Nanocellulose

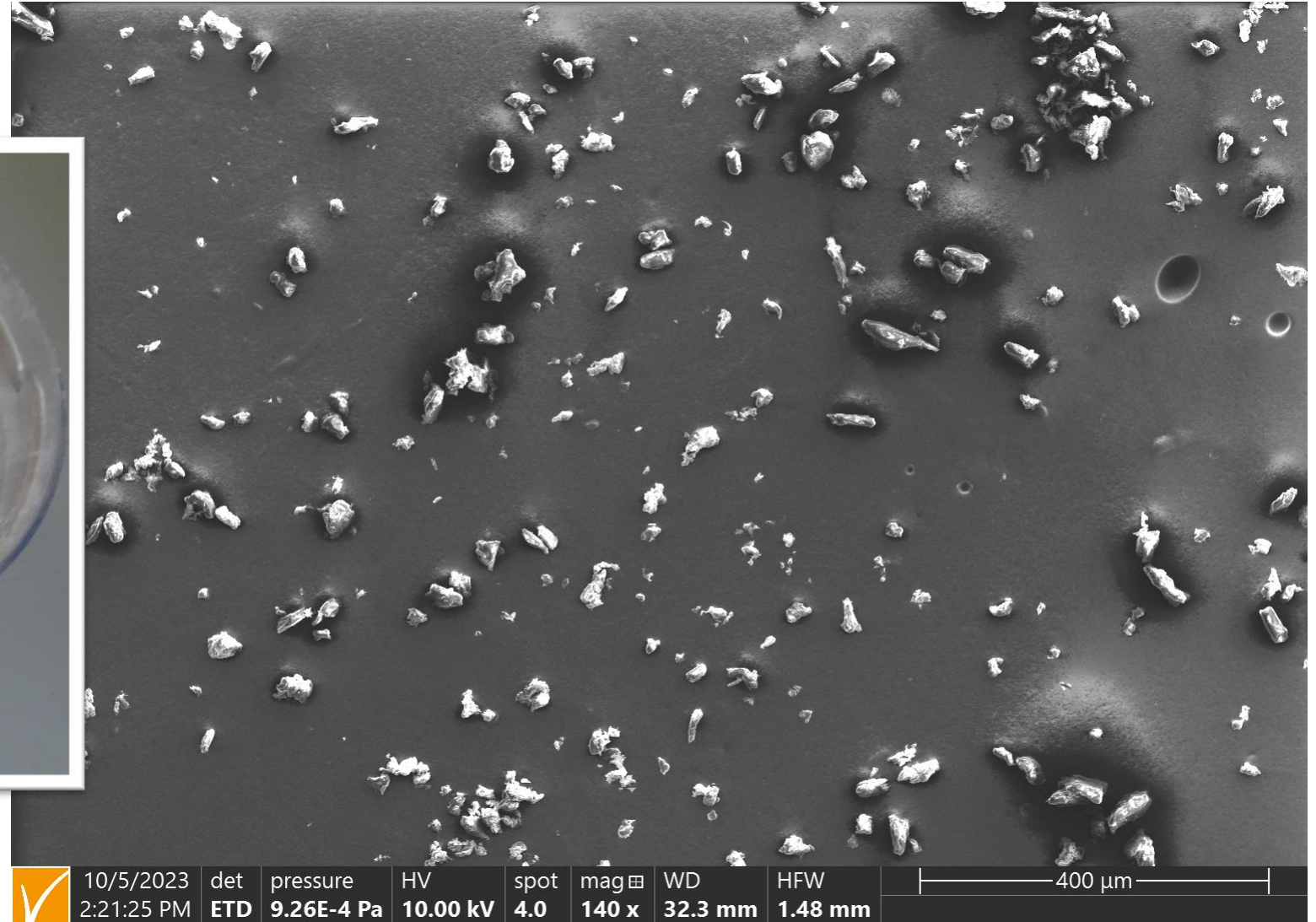
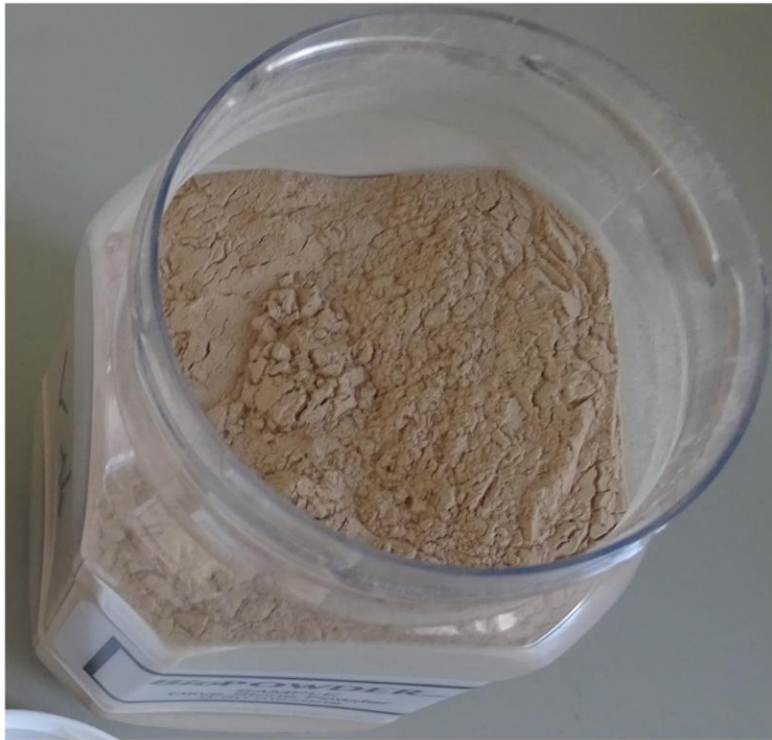


Fluorescence CLSM – unbleached CNF



Bio-based functional fillers: Olive stone powder

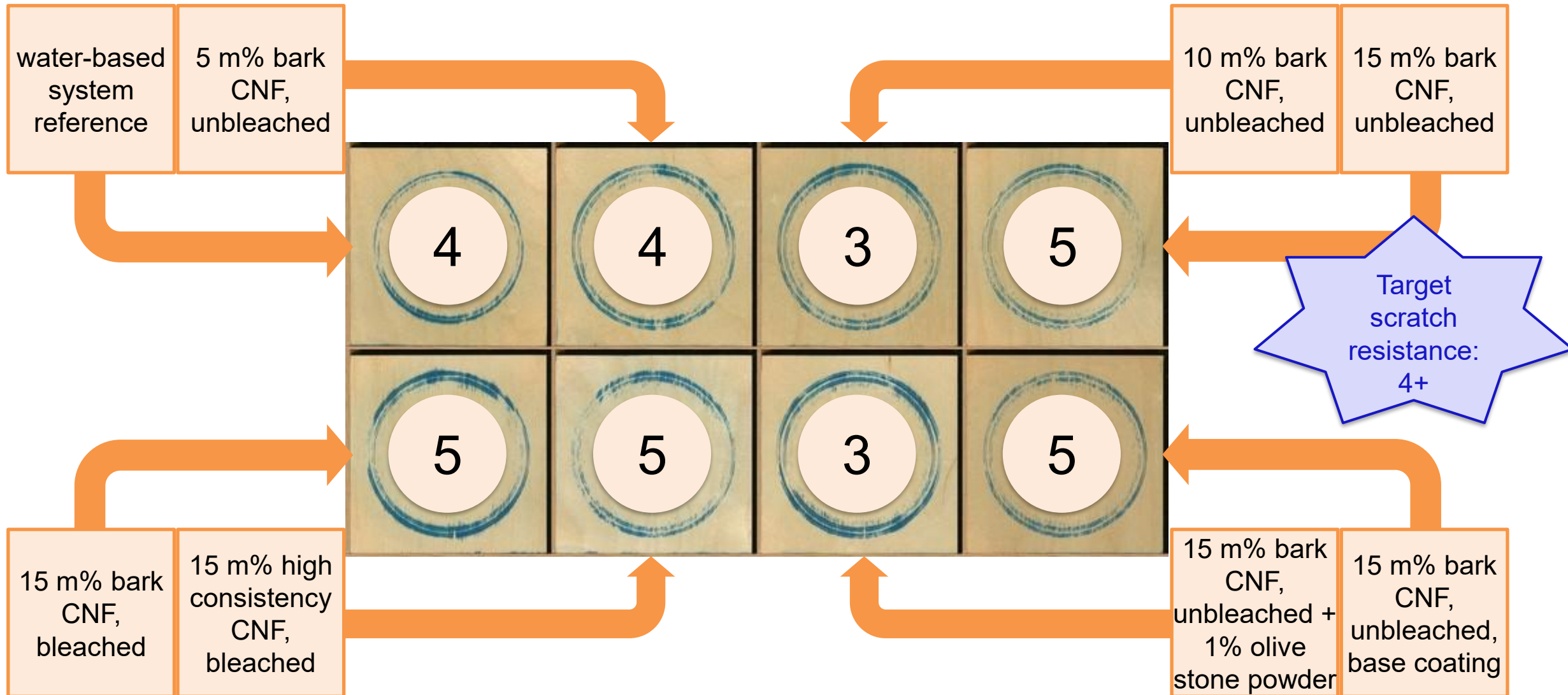
Size distribution: 0-25 μm



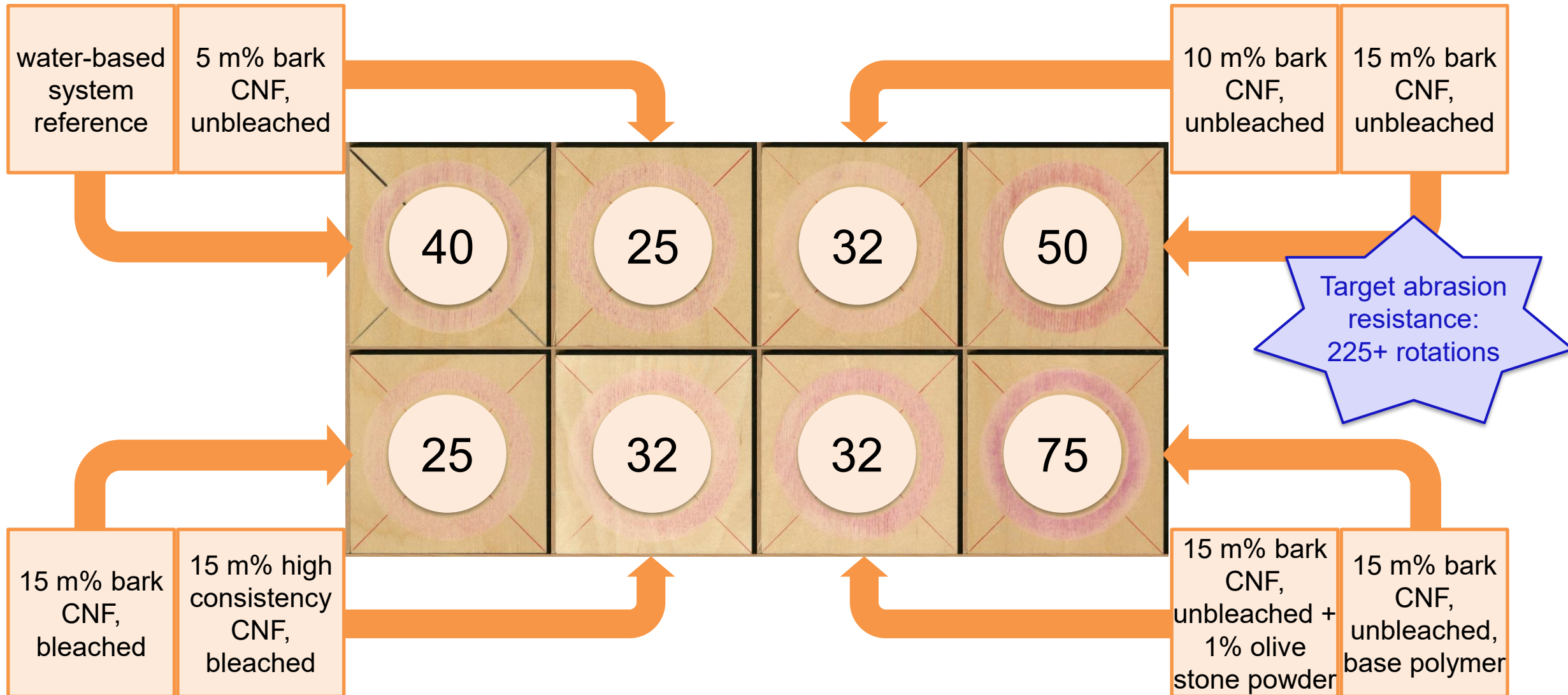
Small scale coating trials



Cellulose nanofibers in water-based coating

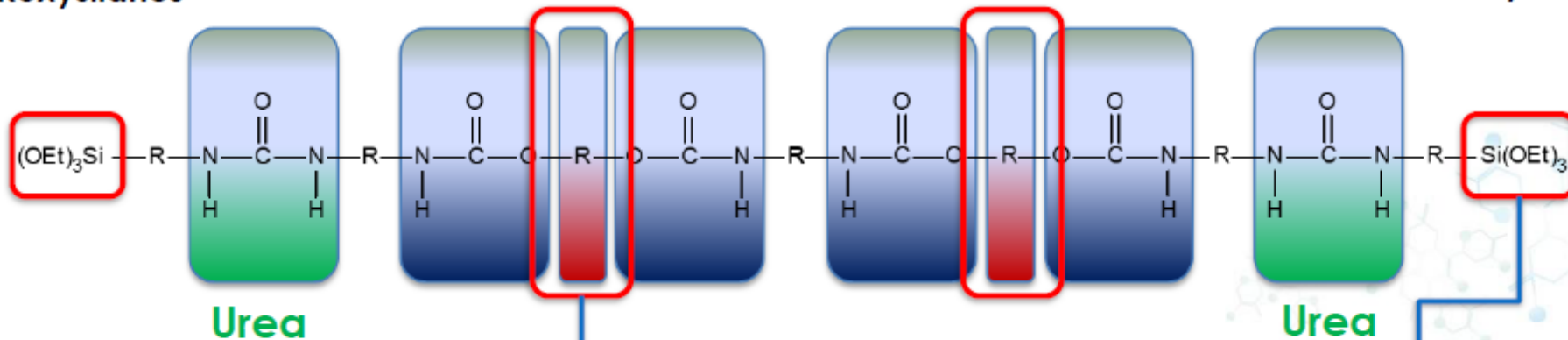


Cellulose nanofibers in water-based coating

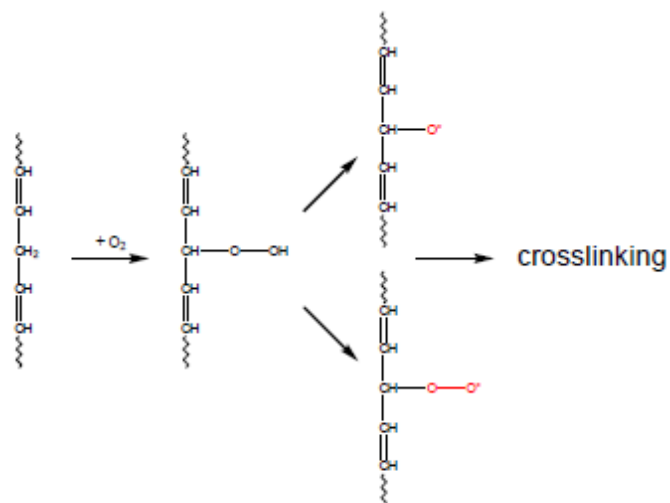


The binder dries oxidatively and additionally moisture cures.

Alkoxysilanes Urethane Urethane Alkoxysilanes

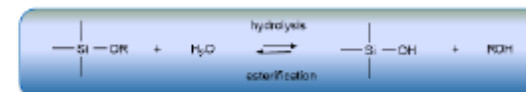


Oxidative drying via the double bonds of the vegetable fatty acids of the base polyol



Hydrolysis and polycondensation of the ethoxysilane groups

Hydrolysis

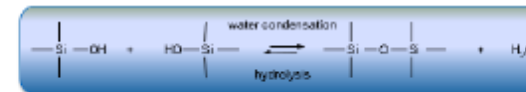


Polycondensation

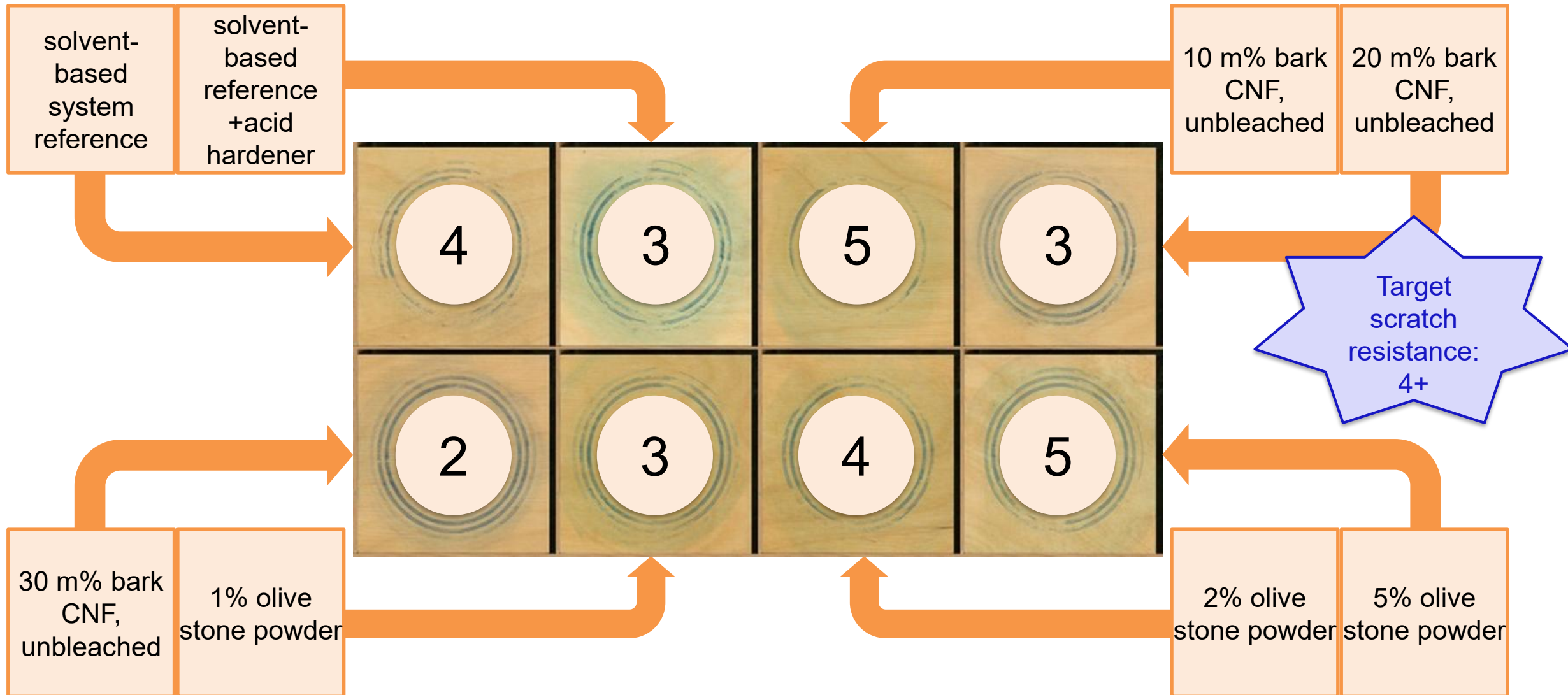
- Condensation with alcohol ($\text{Si-OH} > \text{H}_2\text{O}$)



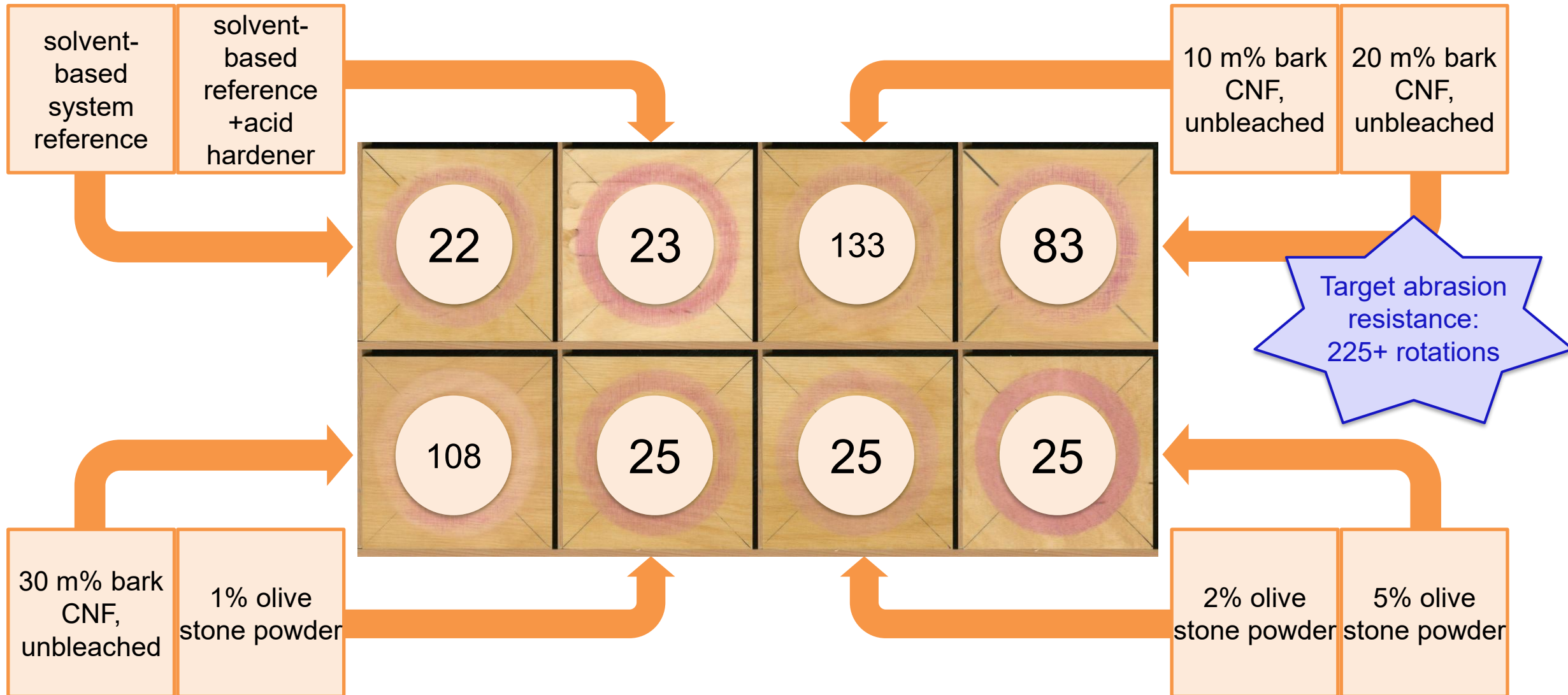
- Condensation with water ($\text{H}_2\text{O} > \text{Si-OH}$)



Cellulose nanofibers in solvent-based coating

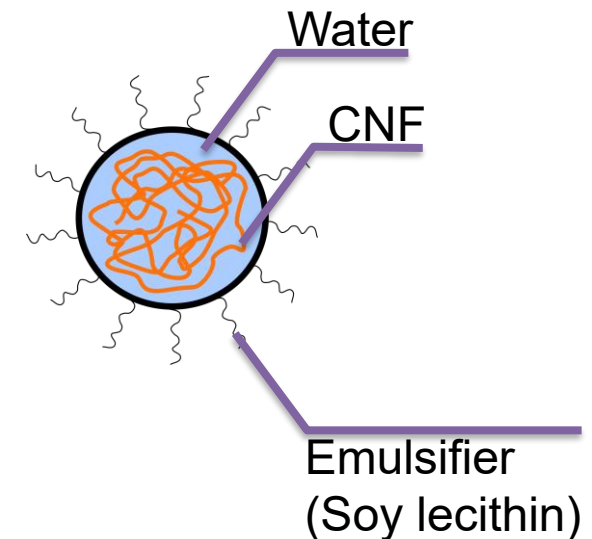
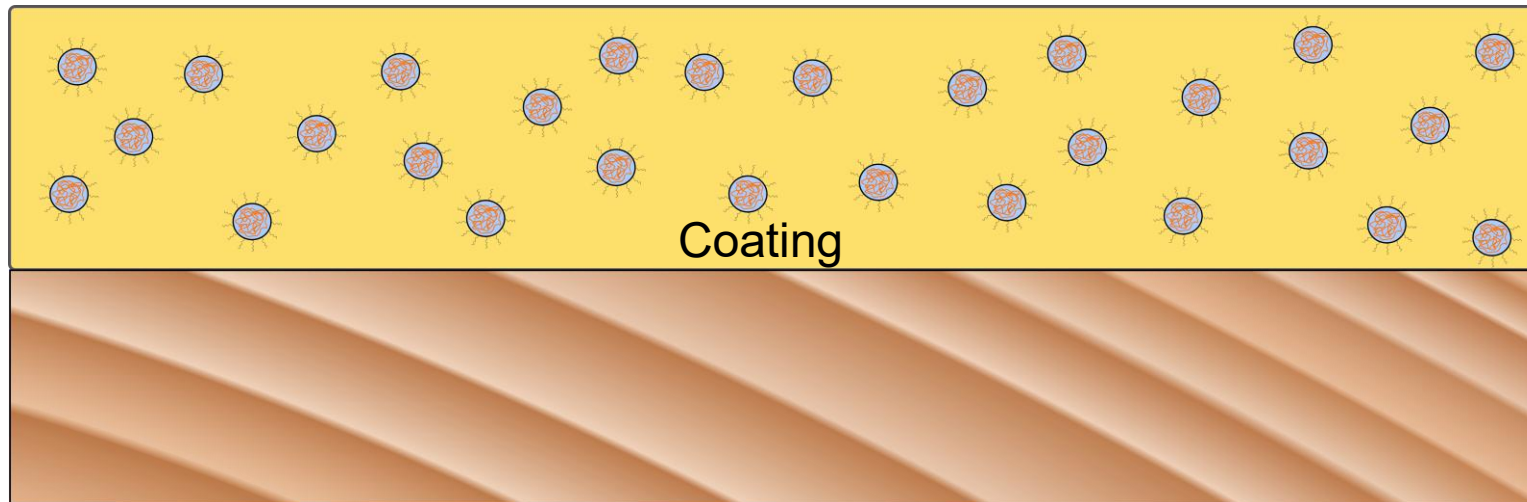


Cellulose nanofibers in solvent-based coating



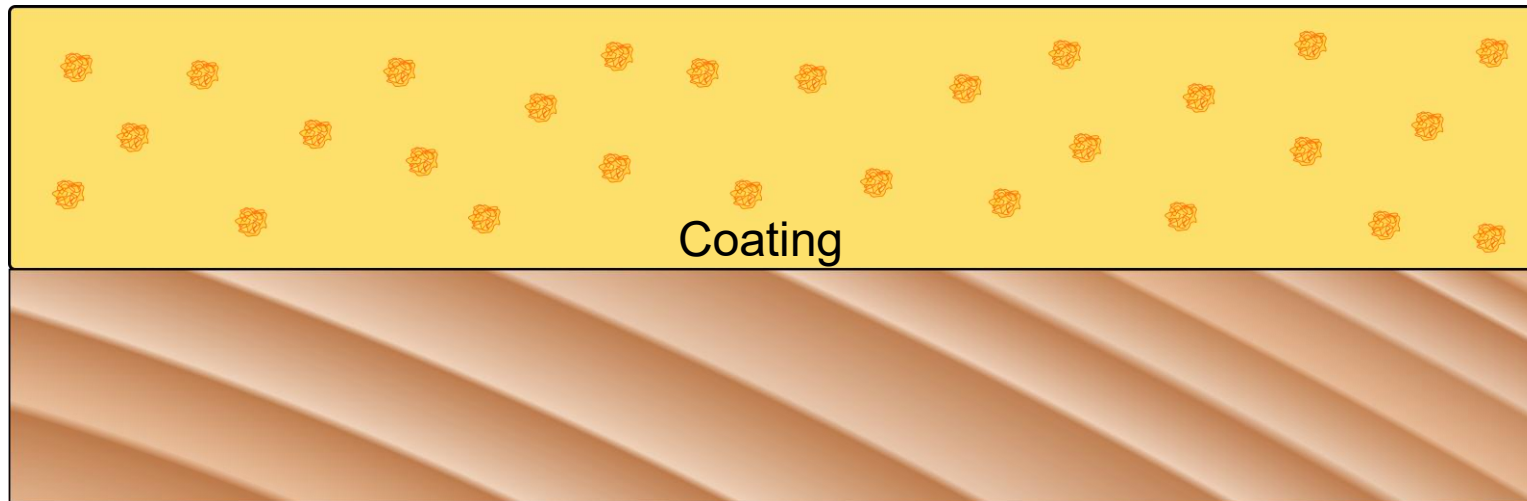
Compatibility issues

- Used coatings are solvent-borne
- To mix wet nanocellulose into the coating formulation, an emulsifier is required: soy lecithin



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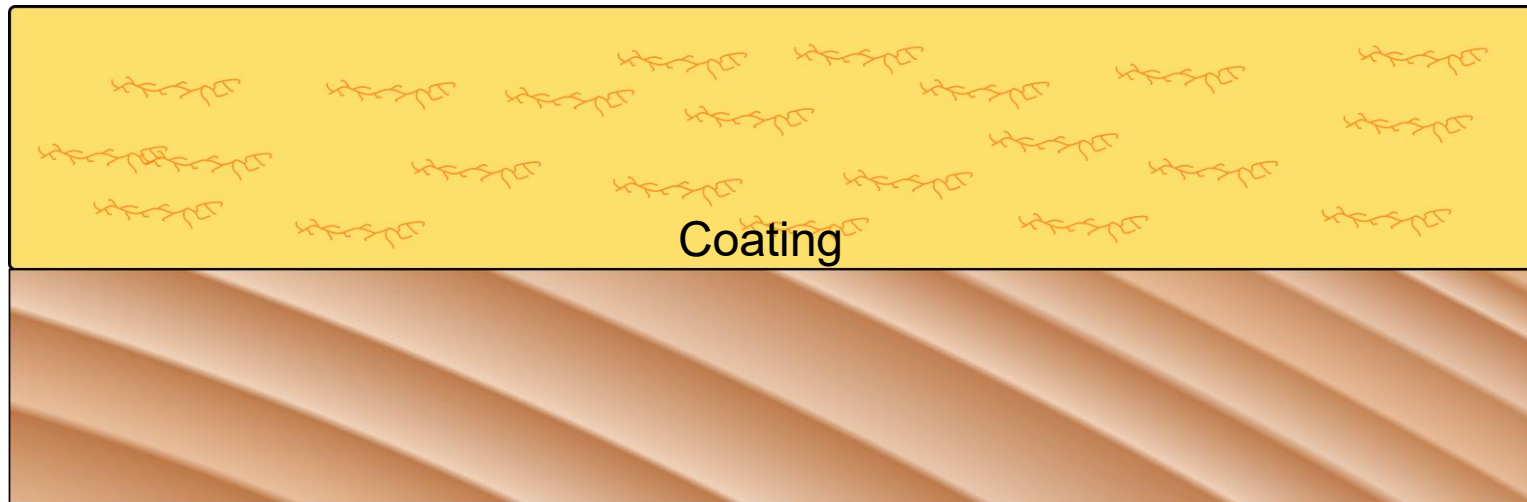


Hypothesis:

- Entangled CNF particles in coating after drying

Compatibility issues

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Hypothesis:

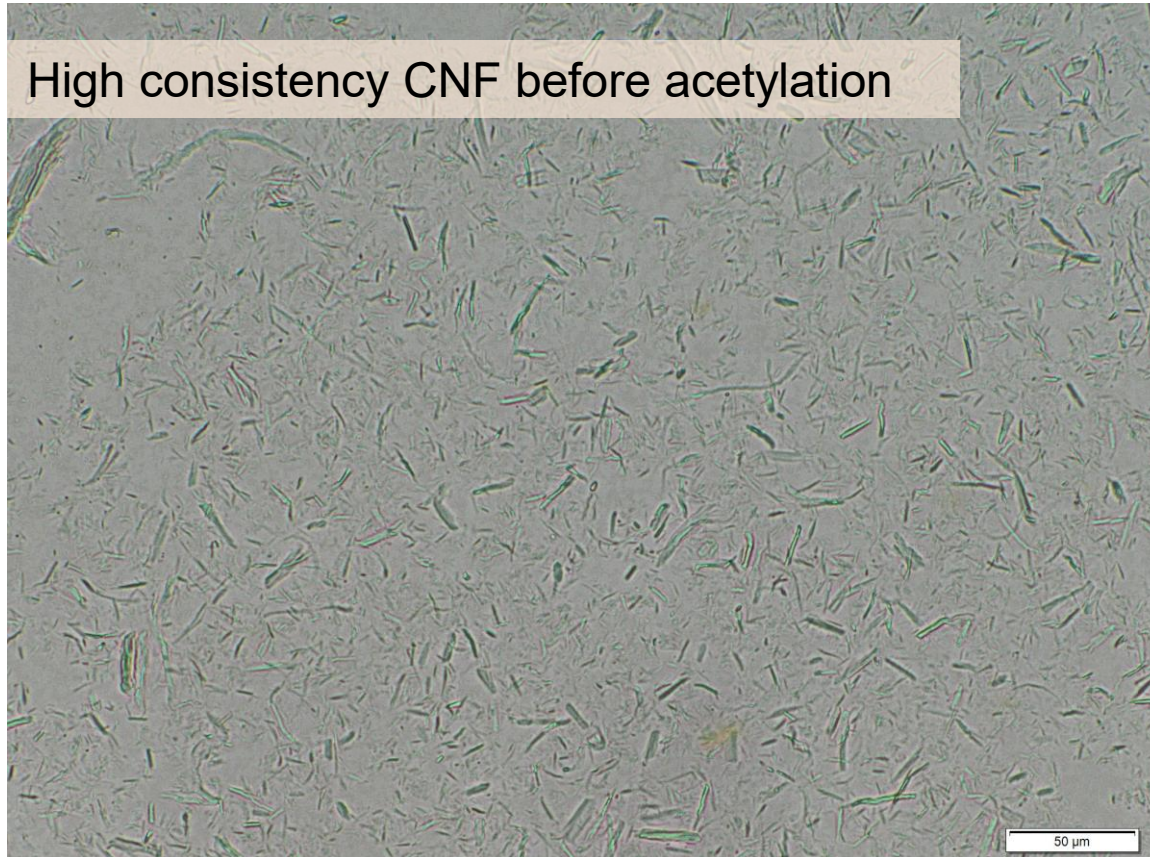
- Better reinforcing in the untangled state



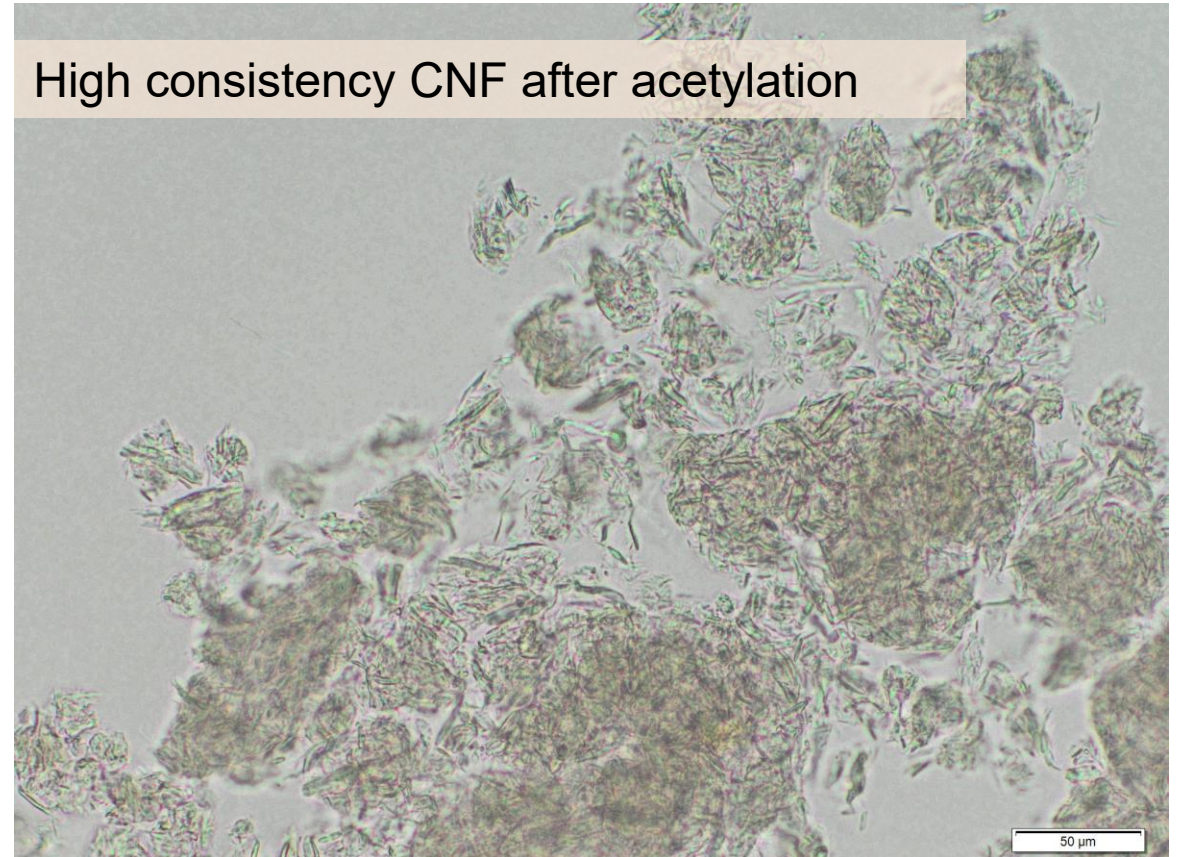
Proposed solution: **Chemical modification of CNF**

Acetylation with acetic anhydride IV (Ashori et al. 2014)

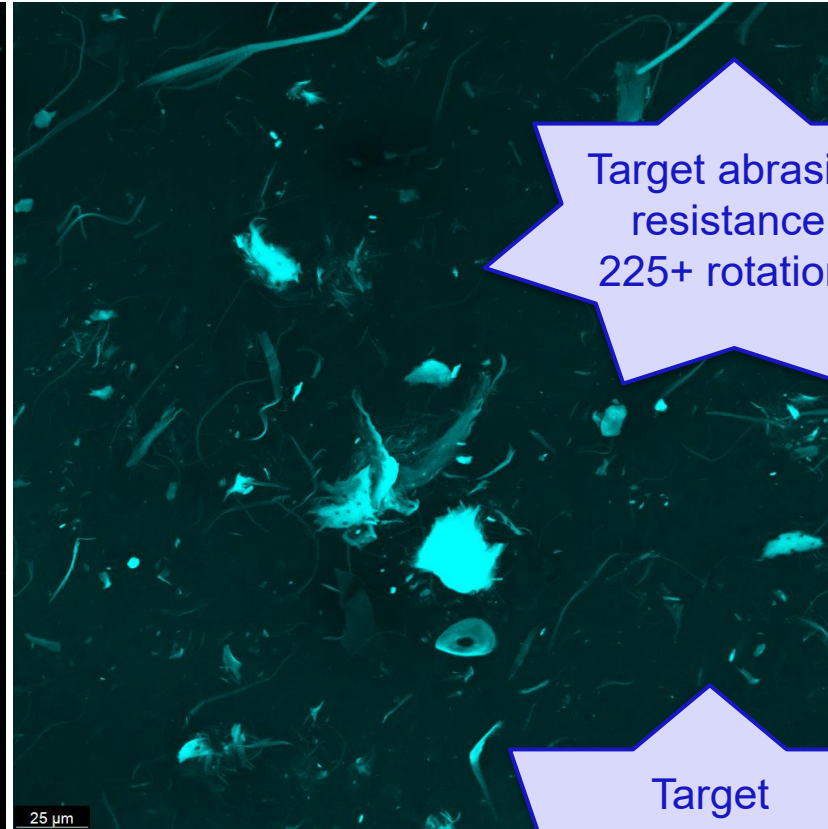
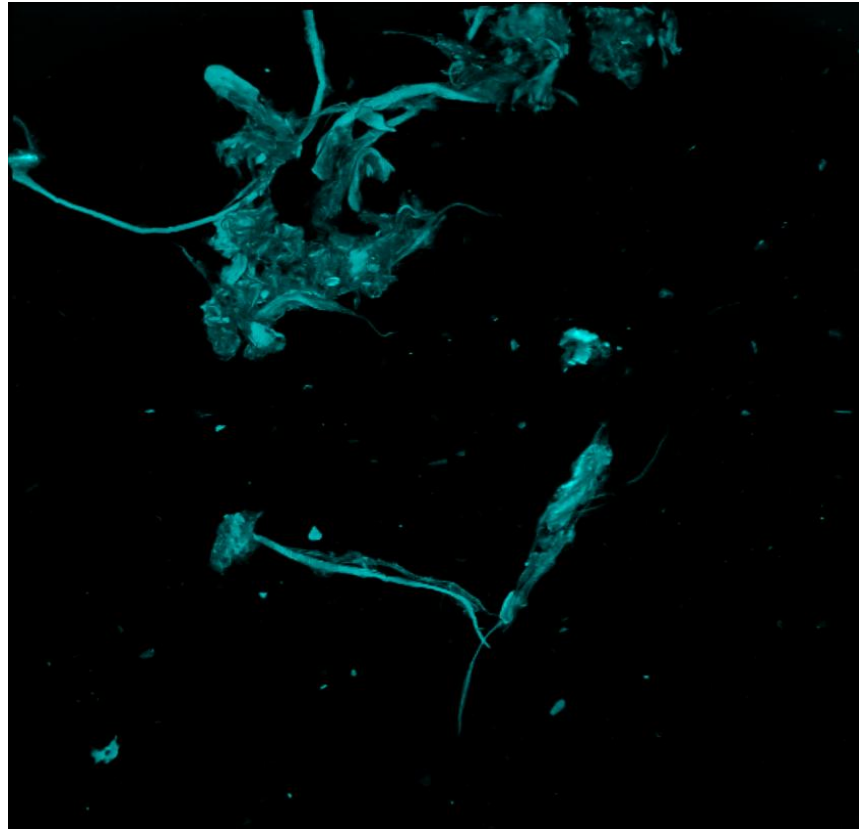
High consistency CNF before acetylation



High consistency CNF after acetylation



CNF before and after modification – better distribution in solvent-based coating



Target abrasion
resistance:
225+ rotations

Target
scratch
resistance:
4+

solvent-
based
system
reference

Acetylated
CNF

22

50

4

4

Summary and Outlook

- Some indications that CNF could improve the mechanical properties of coating systems
- Compatibility issues between water-based cellulose paste and water-free coating bases
- Modification: improves distribution, effect on mechanical properties not yet sufficiently studied



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Bio-based
Europe**
Joint Undertaking



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Bio-based Industries
Consortium

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DI Veronika Zeller

v.zeller@holzforschung.at

Tel. +43/1/798 26 23-43

www.holzforschung.at