Multi-functional high consistency nanocellulose for various applications

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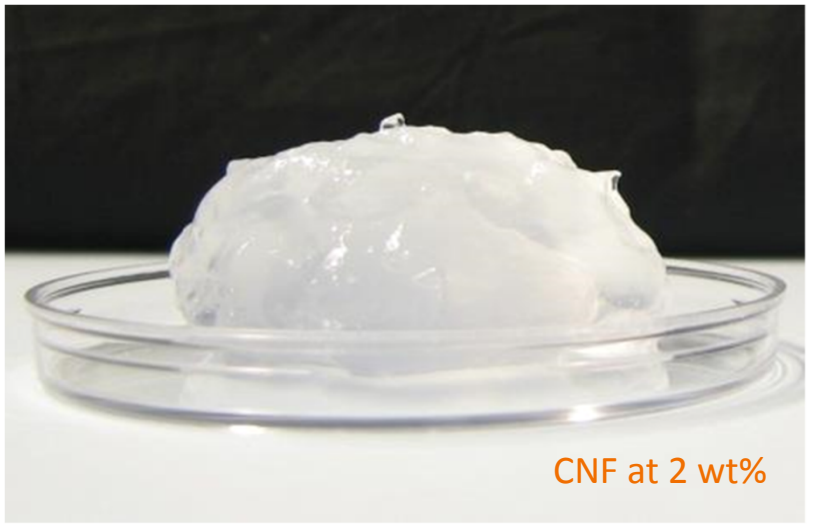
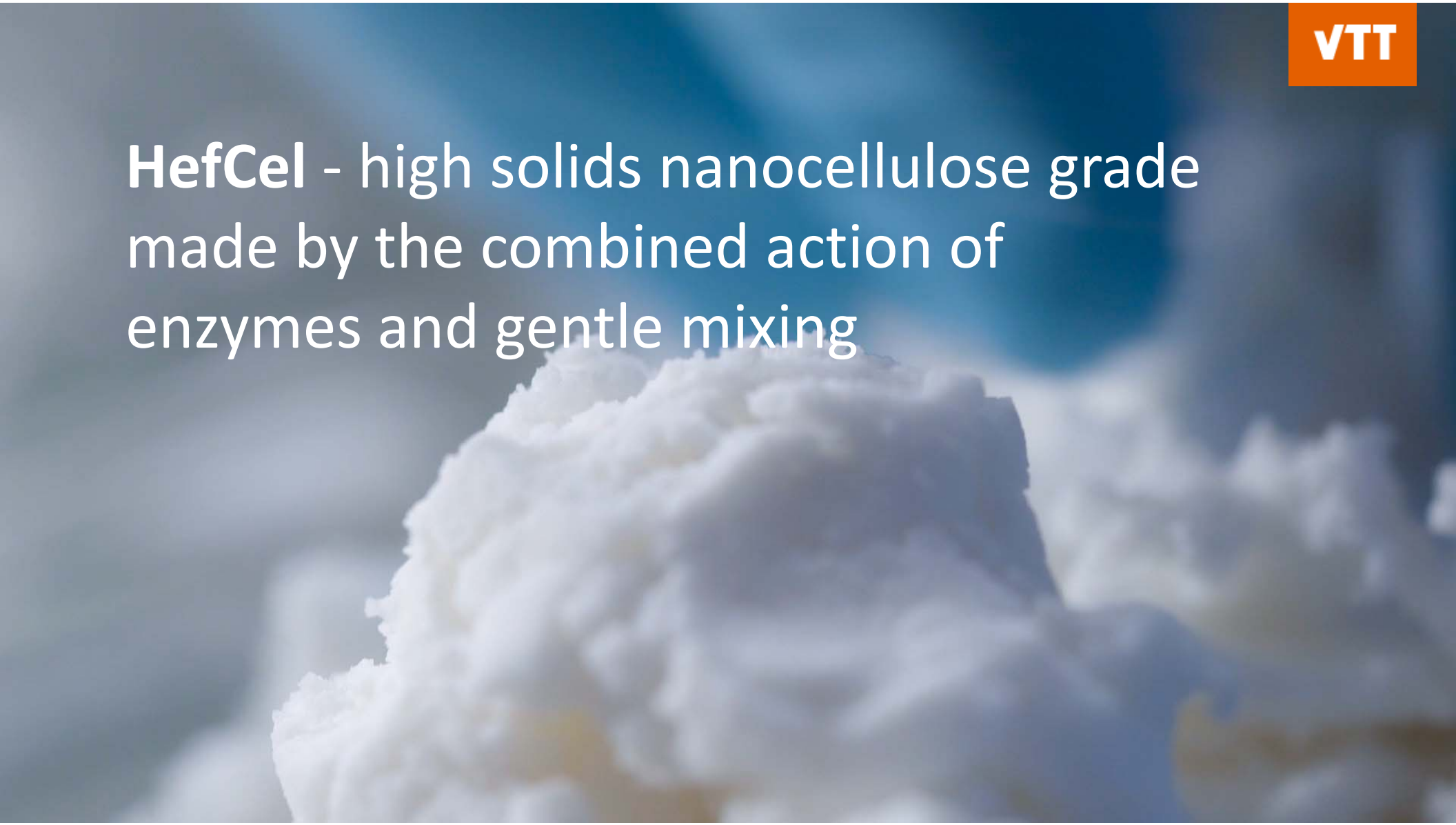
Challenges with existing cellulose nanomaterials

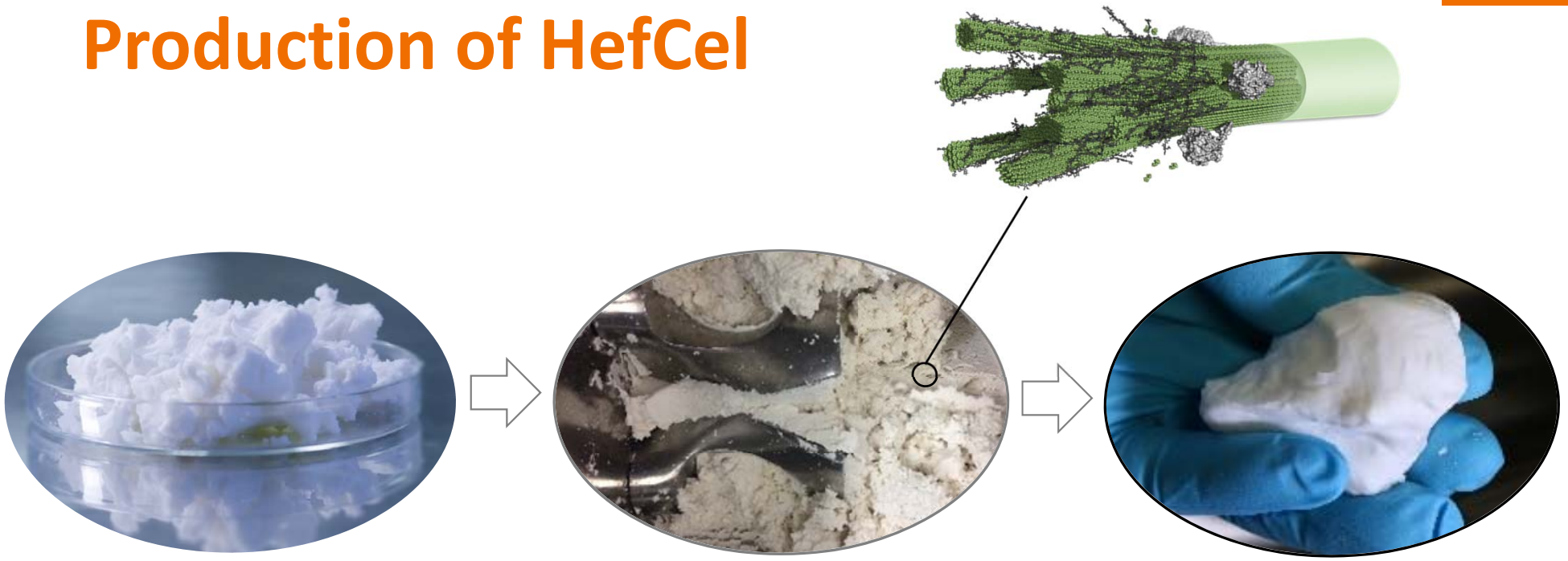
- Characteristic to traditional cellulose nanomaterials is LOW solids content
- Drawbacks due to high water content
  - Expensive production – water use, energy consumption
  - Difficult to dewater
  - Off-site production not feasible
  - Post-treatment troublesome
  - Restricted applicability e.g. in polymer composites, paints and coatings





HefCel - high solids nanocellulose grade made by the combined action of enzymes and gentle mixing

Production of HefCel

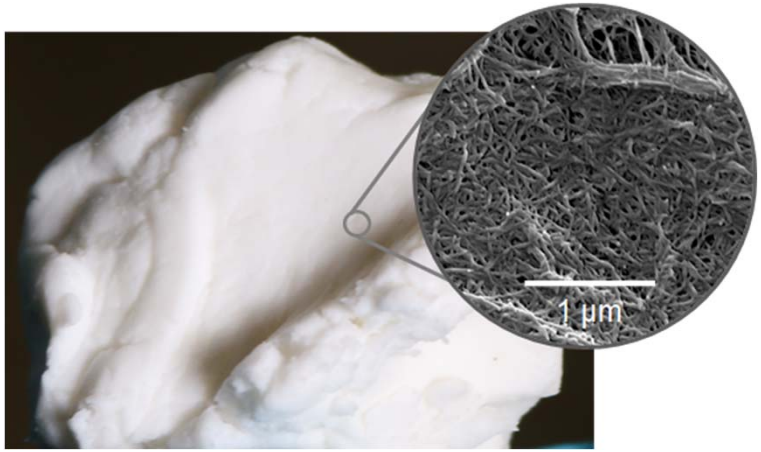


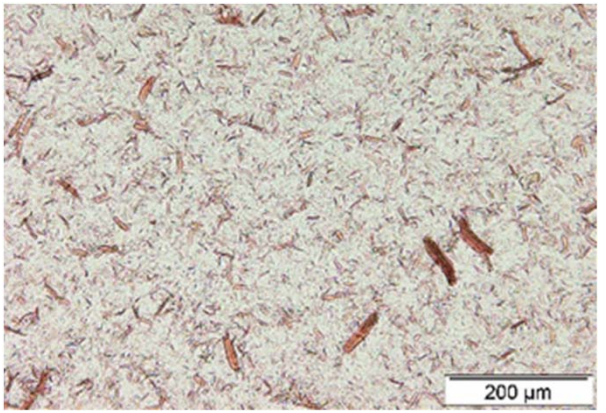
Exploits the efficiency of enzymatic actions to disintegrate pulp fibers at notable high solids content (20-40%) without the need of high shear disintegration.

Pere et al. 2020, *ACS Sustainable Chem. Eng.*

Size of HefCel

- After fibrillation, broad size distribution with respect to both width and length
- HefCel grade is falling into a nanocellulose category of cellulose microfibrils (CMF)
- According to SEM and AFM imaging the lateral width of the fibrils is typically between 15nm and 20nm
- The overall fine structure is in nanoscale resulting the distinctive performance of HefCel





Pere et al. 2020, *ACS Sustainable Chem. Eng.*

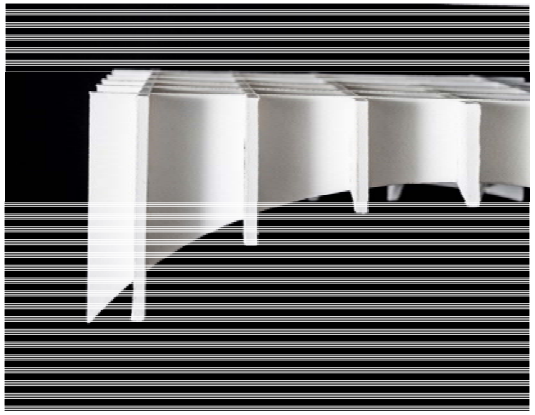
Key factors of the process

- **Simple up-scalable process for nanocellulose**
  - 20-40% dry matter content during treatment
  - Low energy consumption in manufacturing
  - Commercial enzyme product available
  - Diverse feed stocks possible; wood and non-wood pulps, recycled fibres, textile waste, agro-based residues etc.
- **High yield of fibrillated cellulose together with valuable cello-oligosaccharides**

HefCel – benefits

- **Unique properties** differentiating from other nanocellulose products
- **Low water content and low viscosity** at high consistency allows its use in new applications
- Material properties are tunable on a wide range of dimensions
- Reduced transportation costs due to naturally high consistency → off-site production feasible

Application examples



Adhesive for layered structures

3D printing[1]

Barrier coatings

Structured surfaces

Fire retardant coating

Paints and coatings[2]

Photos: Eeva Suorlahti, Juha Hakulinen[1], Design: Susanna Kettunen[1], Heidi Turunen[2]

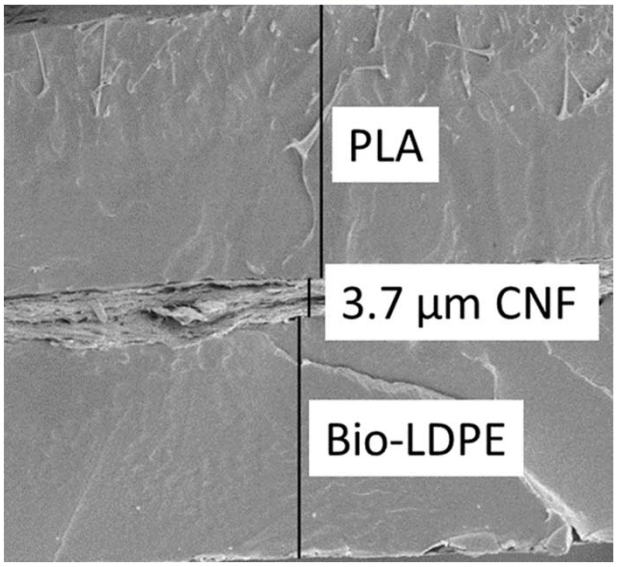
Additive manufacturing

- Printability
- Shape fidelity
- Mechanical properties

Photos: Panu Lahtinen

Barrier properties

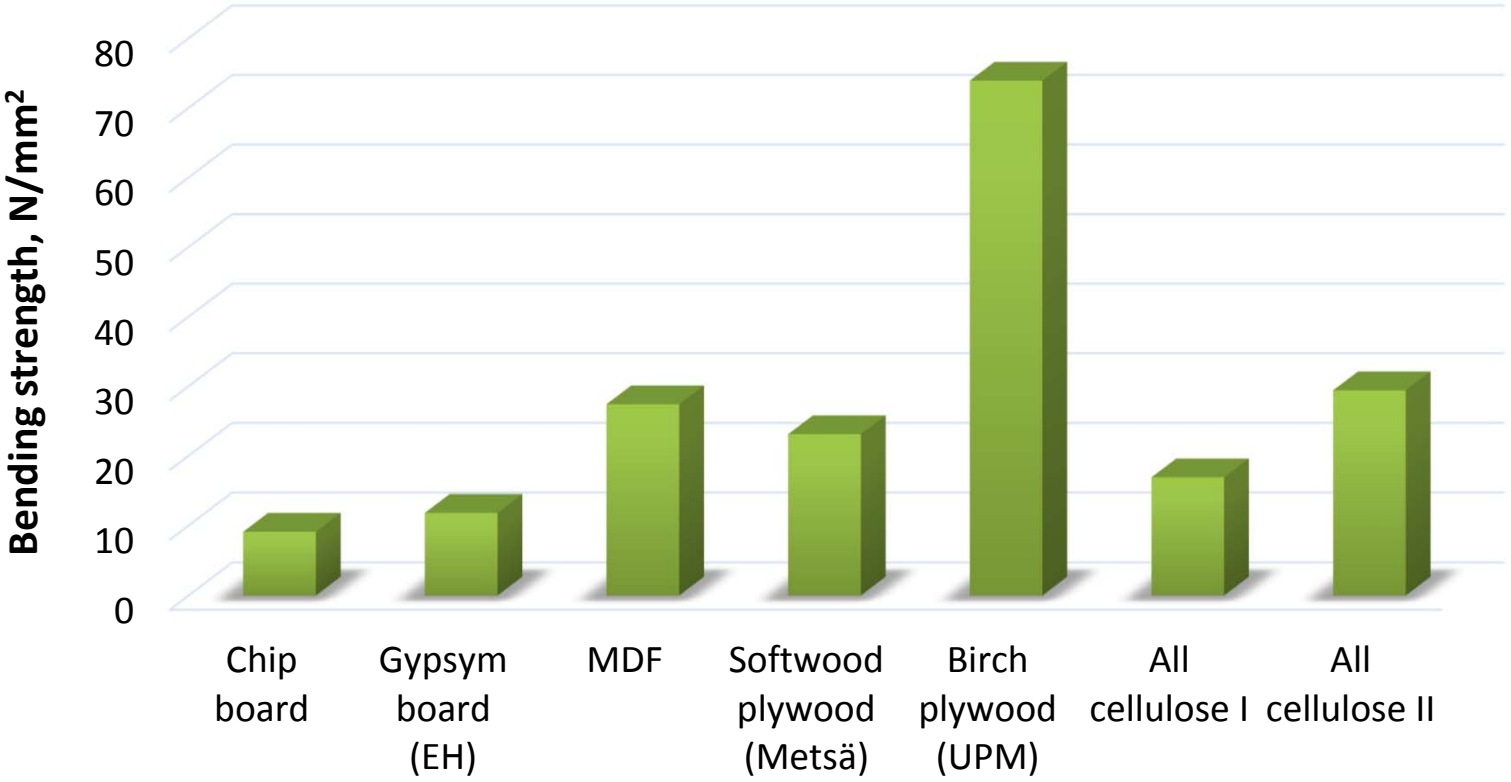
- Lightweight 100% bio- and paper-based stand-up pouches
  - Paper / PLA / **HefCel** / Bio-LDPE
- High performance in barrier properties:
  - OTR 1 cm^3/m^2,d (23 °C, 50% RH)
  - WVTR 17 g/m^2,d (38 °C, 90% RH)
  - Seal strength 320 N/m (sealing 140 °C)



J. Vartiainen et al., Multilayer packaging films 2016

All cellulose alternative for commercial layered structures

- HefCel as additive



Fire retardancy for textiles and wood

Cotton fabric

Reference

Silk-screen printed

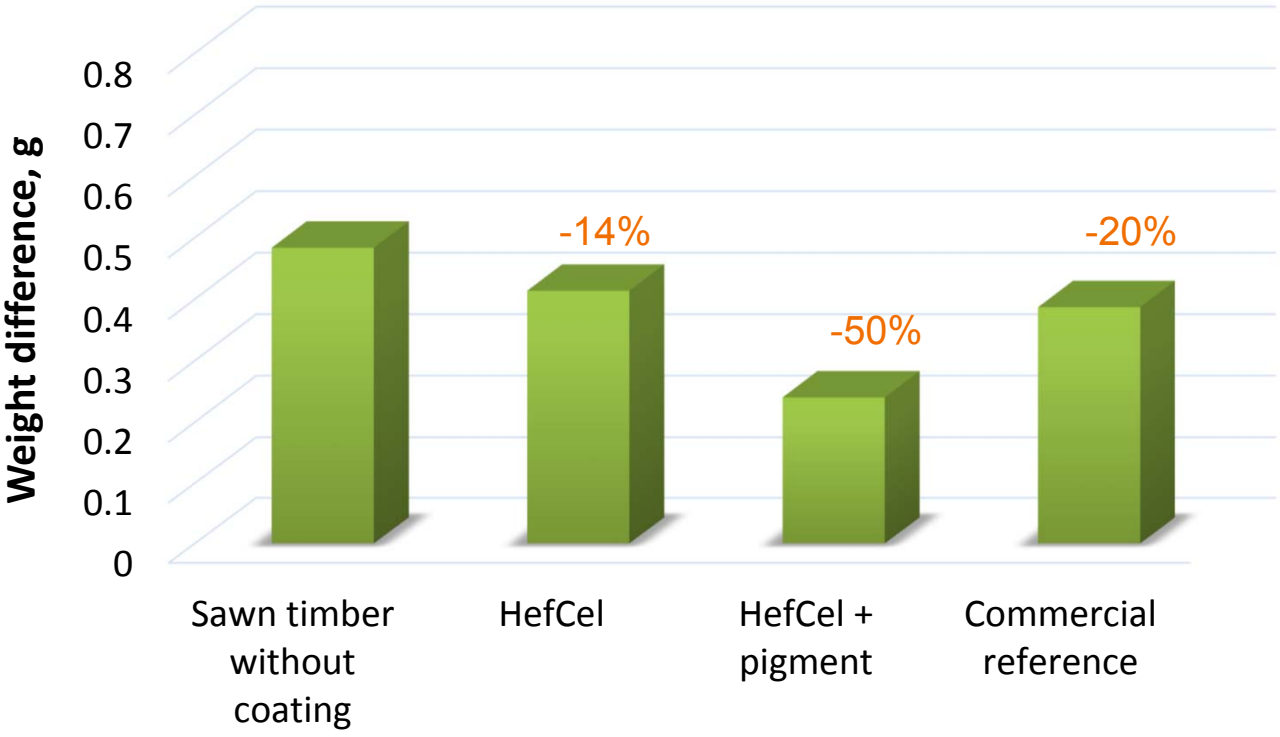
Sawn timber 2x4

Reference after
15 seconds

FR coated after
240 seconds

Photos: Vesa Kunnari

Fire retardant coating on sawn timber



Conclusions and value propositions

- Sustainable process and natural product
- Suitable for wide range of applications
- Processable at high consistencies like no other nanocellulose grade
- Significantly reduced need for drying energy
- Competitive production cost

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