Novel method for producing ultra-pure nanocellulose via hydrothermal pre-treatment for biomedical and cosmetic applications

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Market need

Growing need for **green** and **biobased** constituents.

CNF hydrogels have been pointed out as attractive materials for biomedical, cosmetic and 3D bioprinting because they are

- Biocompatible
- Show low cytotoxicity
- High water content gives them a structural similarity to extracellular matrix
- Non-animal based

Examples of nanocellulose applications

Nippon Paper
Asahi Kasei
FiberLean
Oji Holdings
Borregaard
JeNaCell
Mitsubishi Pencil
UPM Biomedicals
Stora Enso & Elopak
American Process Inc.
Aditya Birla Carbon
Daio Paper

Source: Stora Enso

Source: UPM Biomedicals

Healthcare
Therapeutics
Diapers
Cosmetics
Non-Wovens
Paints
Food
Gel rollerball pen
Cell culture media
Packaging
Tires

Source: Nippon Paper

Source: Daio Paper

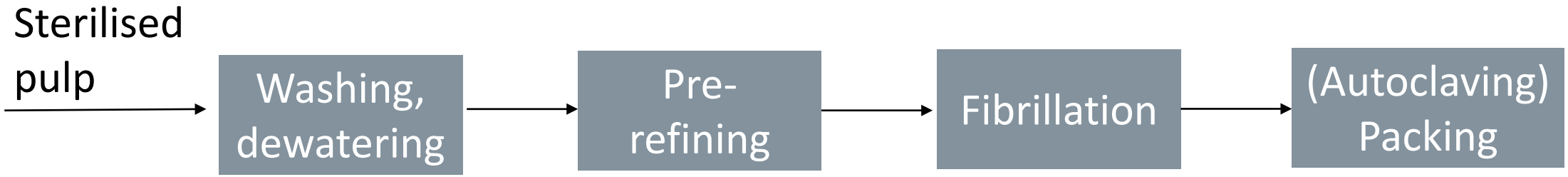
Source: Deleon Cosmetics

Source: Natural Friends

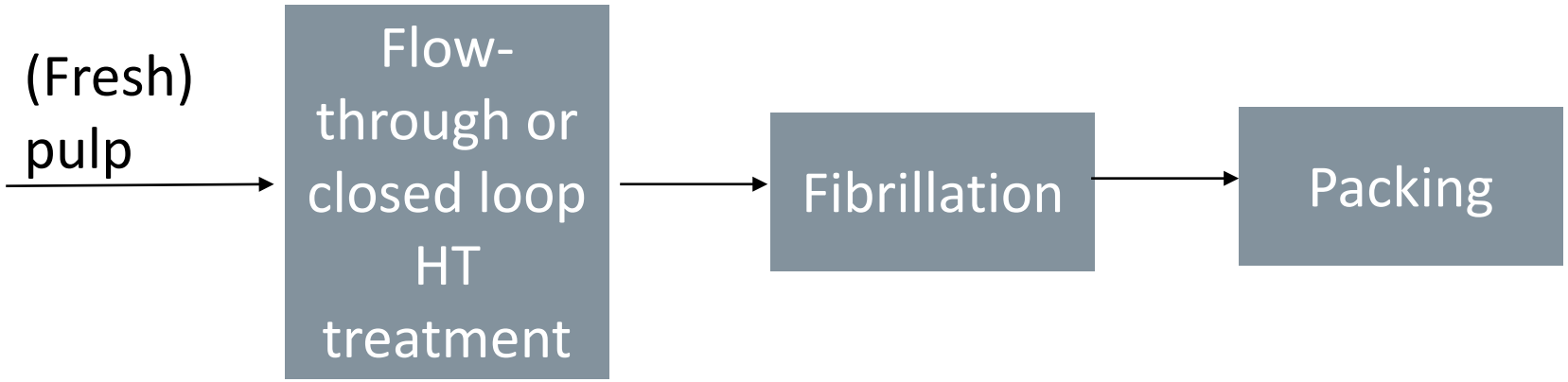
Demonstration of ultra-pure CNF production

New improved process for ultra-pure CNF

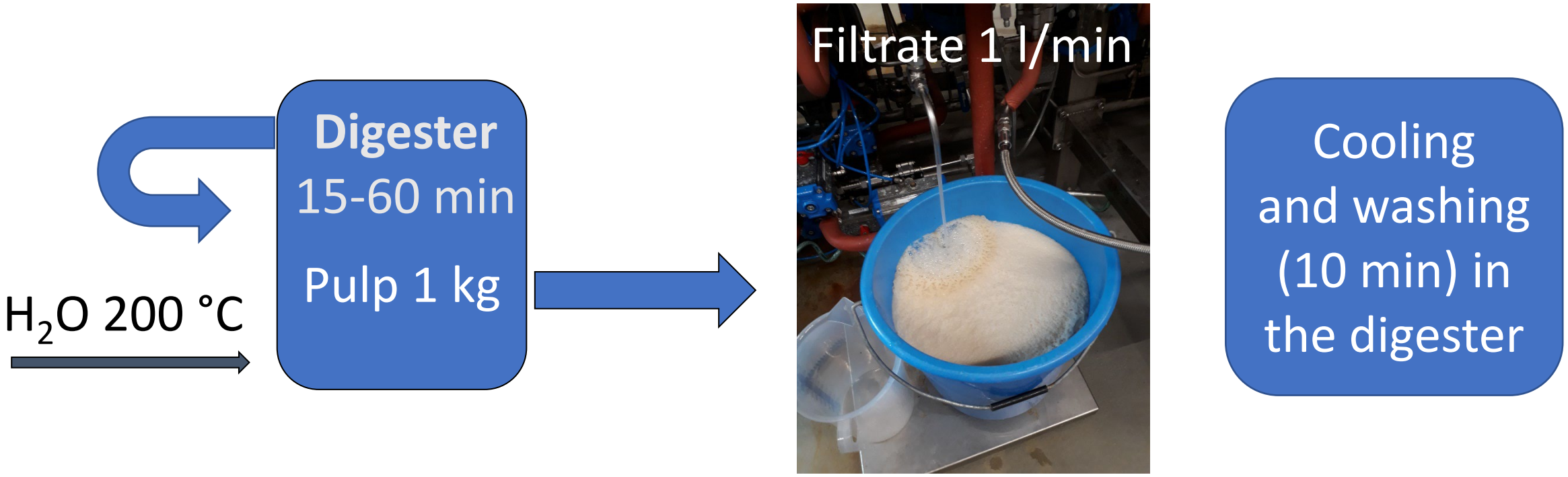
Conventional method



Alternative method



Flow - through and closed loop hot water treatment



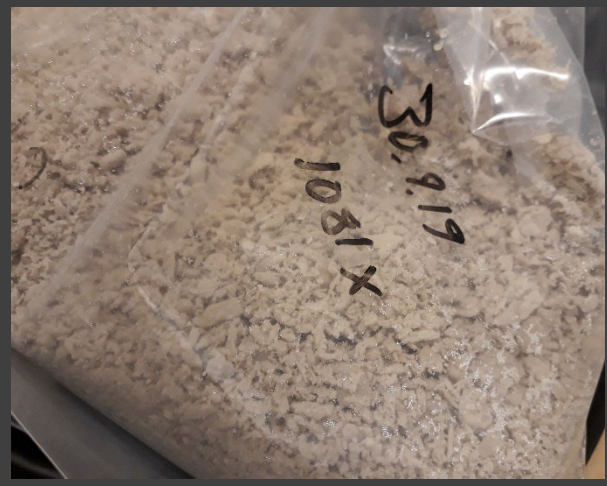
- Extraction temperature was 200 °C
- After the washing pulp was centrifuged and homogenized

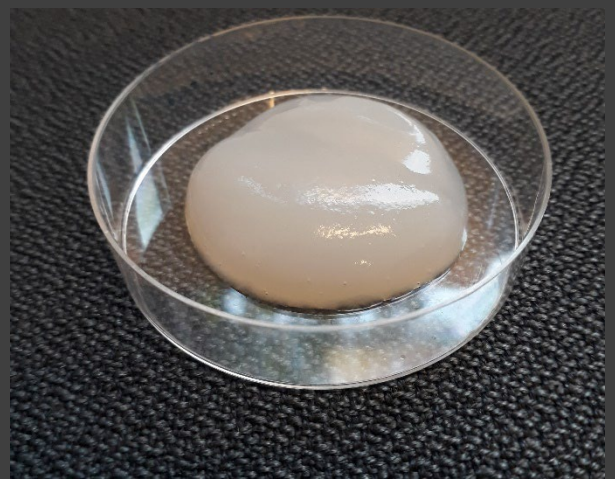
Borrega&Sixta. Purification of cellulosic pulp by hot water extraction, Cellulose (2013)
Borrega&Orelma. Cellulose Nanofibril (CNF) Films and Xylan from Hot Water Extracted Birch Kraft Pulps. Appl. Sci. (2019)

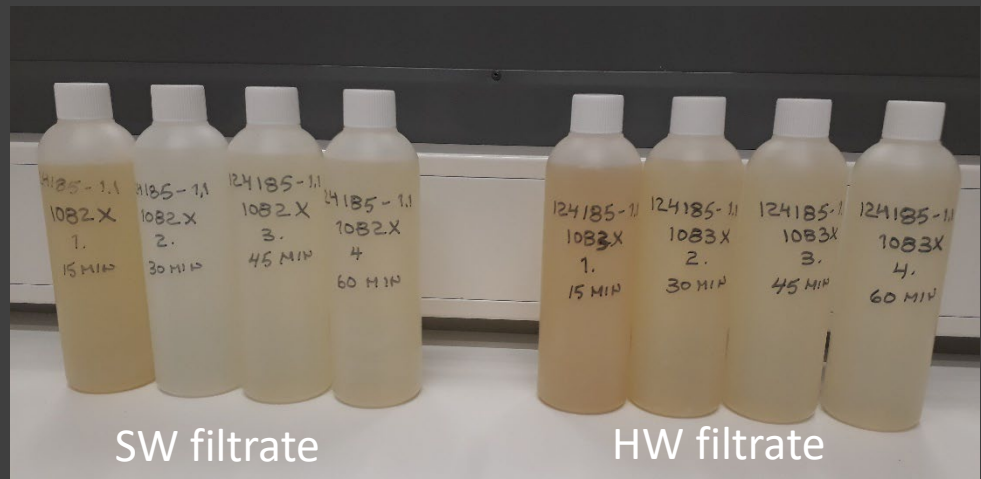
Fibrillation methods

- HT treated pulps fibrillated with two methods
  - Low consistency (1.7%), Microfluidizer
  - High consistency (25%), Mechano-enzymatic fibrillation
- Pulp types tested
  - SW kraft
  - HW kraft
  - Oxygen bleached HW kraft
  - Cotton waste

Sample images





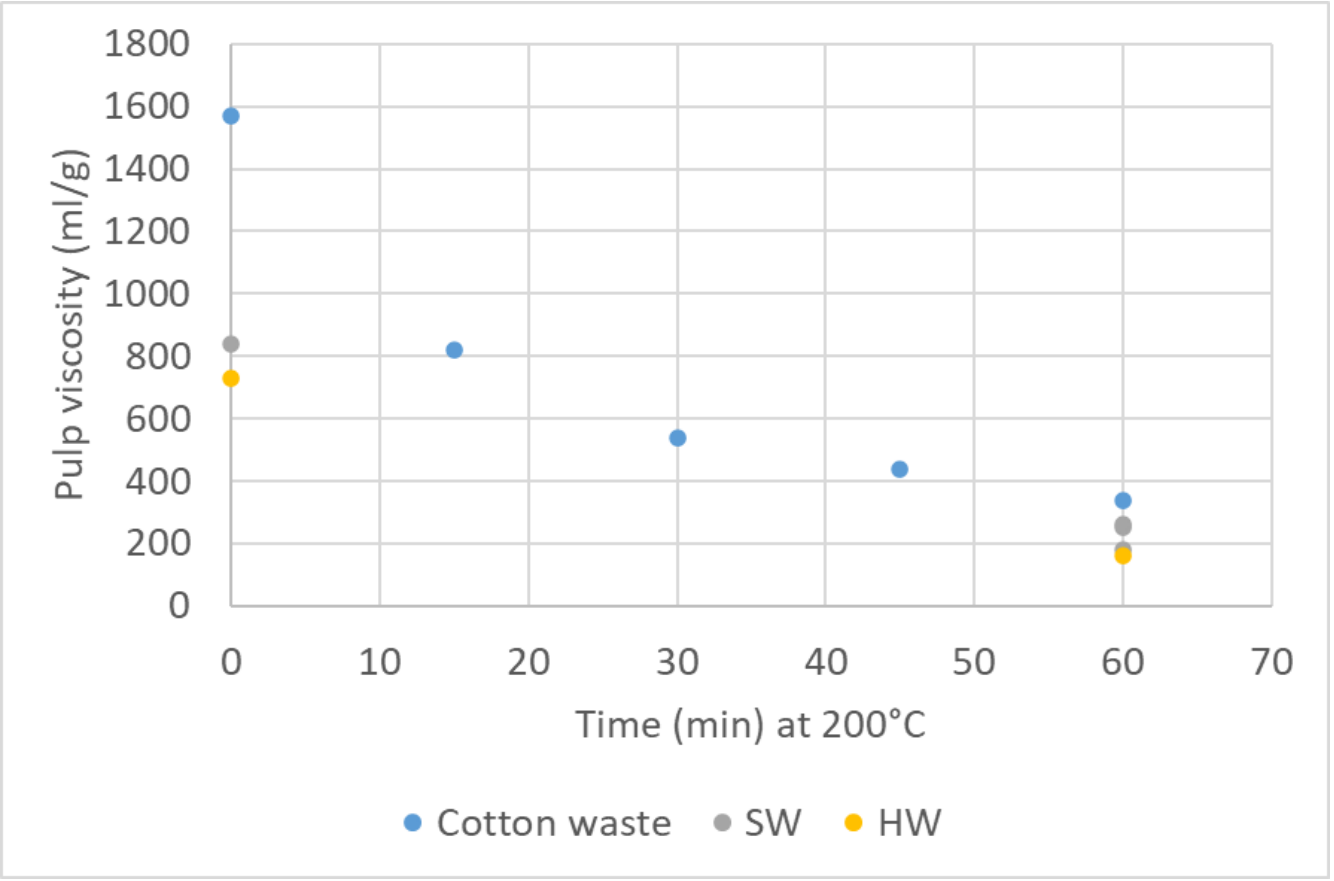


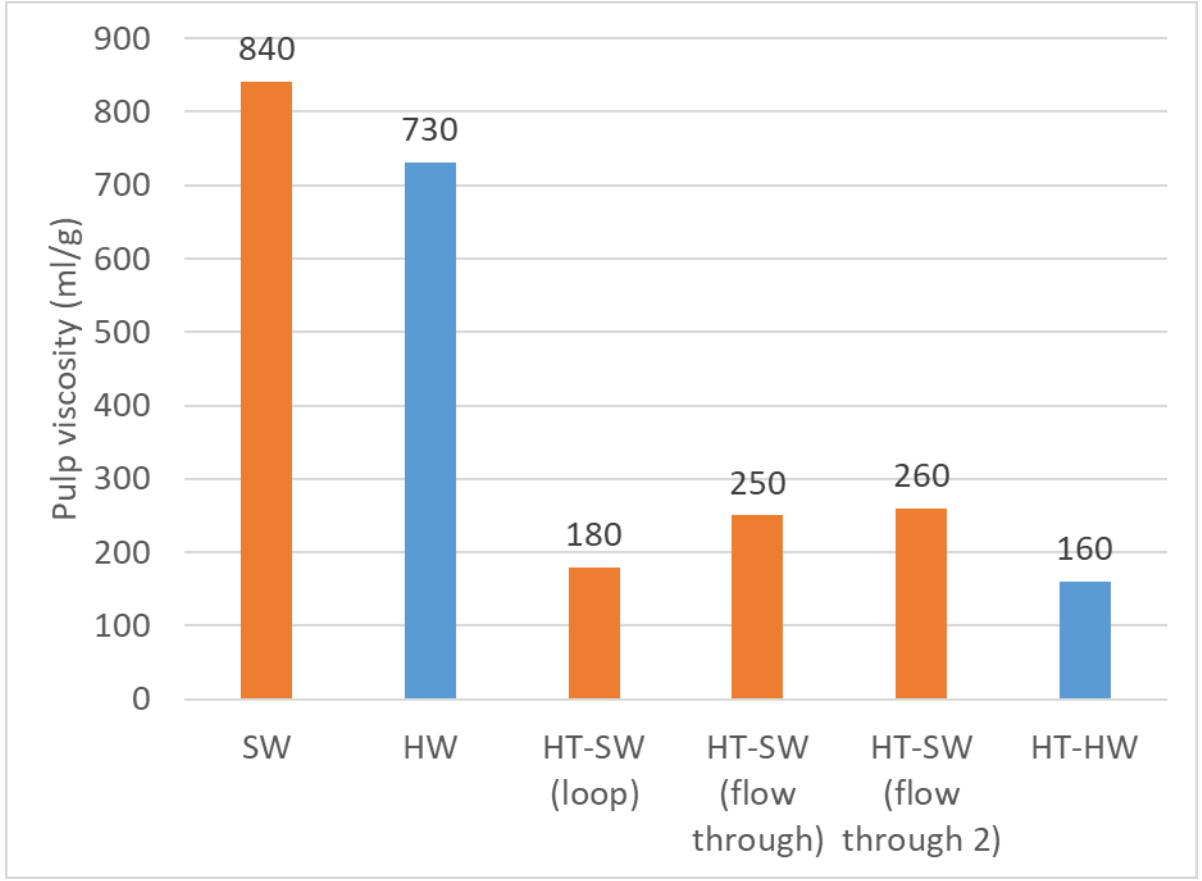
SW filtrate

HW filtrate

The effect of HT treatment on pulp viscosity

ISO 5351:2010





Chemical composition of pulps

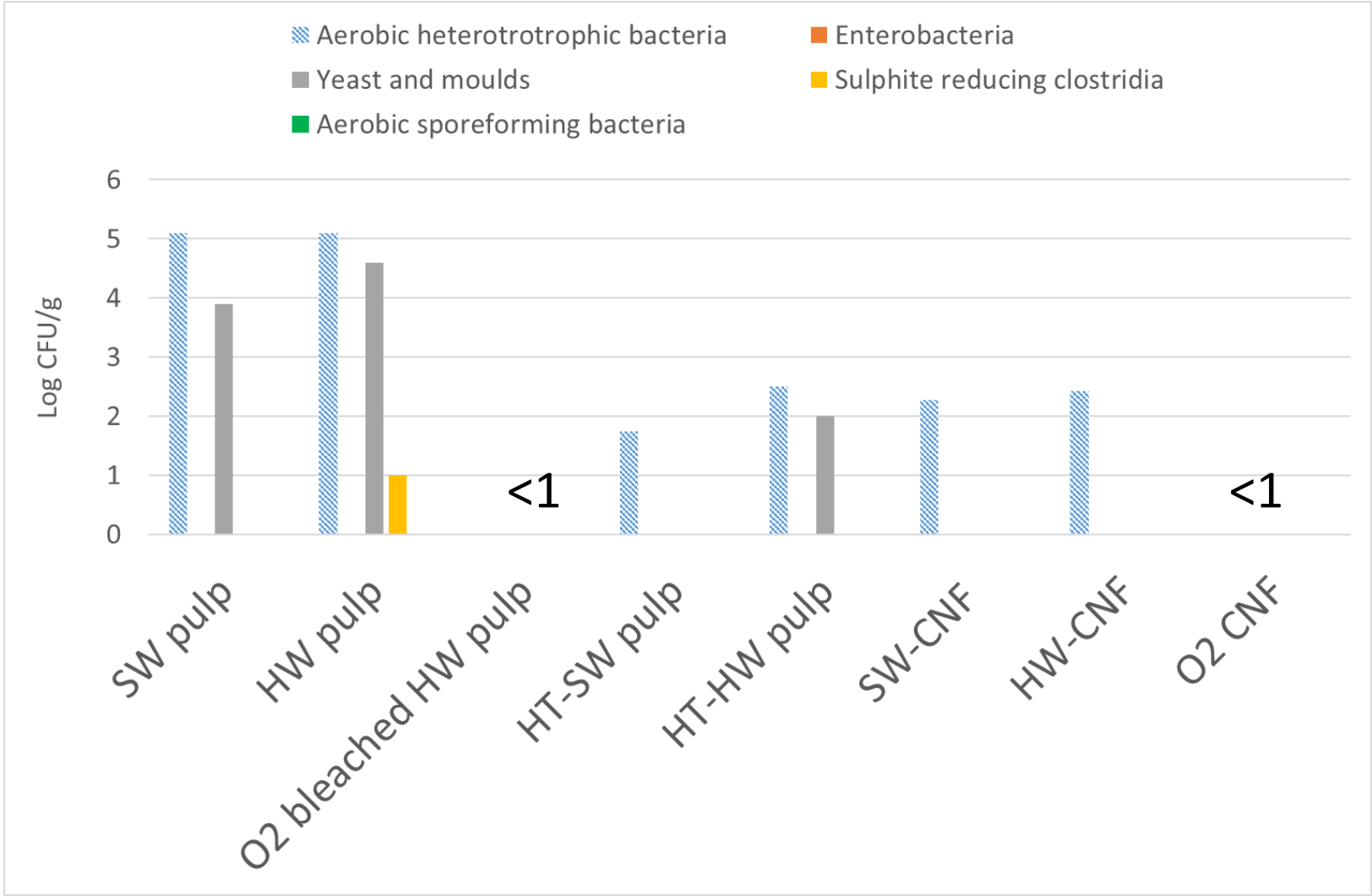
HT treatment removed major part of hemicelluloses from HW and SW pulps

Sample	SW	HT SW	HW	HT HW
Total lignin (%)	<0.5	<0.5	<0.5	<0.5
Arabinose (%)	0.7	<0.3	<0.3	<0.3
Galactose (%)	0.3	<0.3	<0.3	<0.3
Glucose (%)	83.0	90.7	77.2	90.2
Xylose (%)	7,4	4,3	21,4	8,8
Mannose (%)	6,7	5,0	1,4	1,1

SCAN-CM 71:09 for carbohydrates, TAPPI T 222 cm-06, modif. for lignin

Examples of microbiological quality

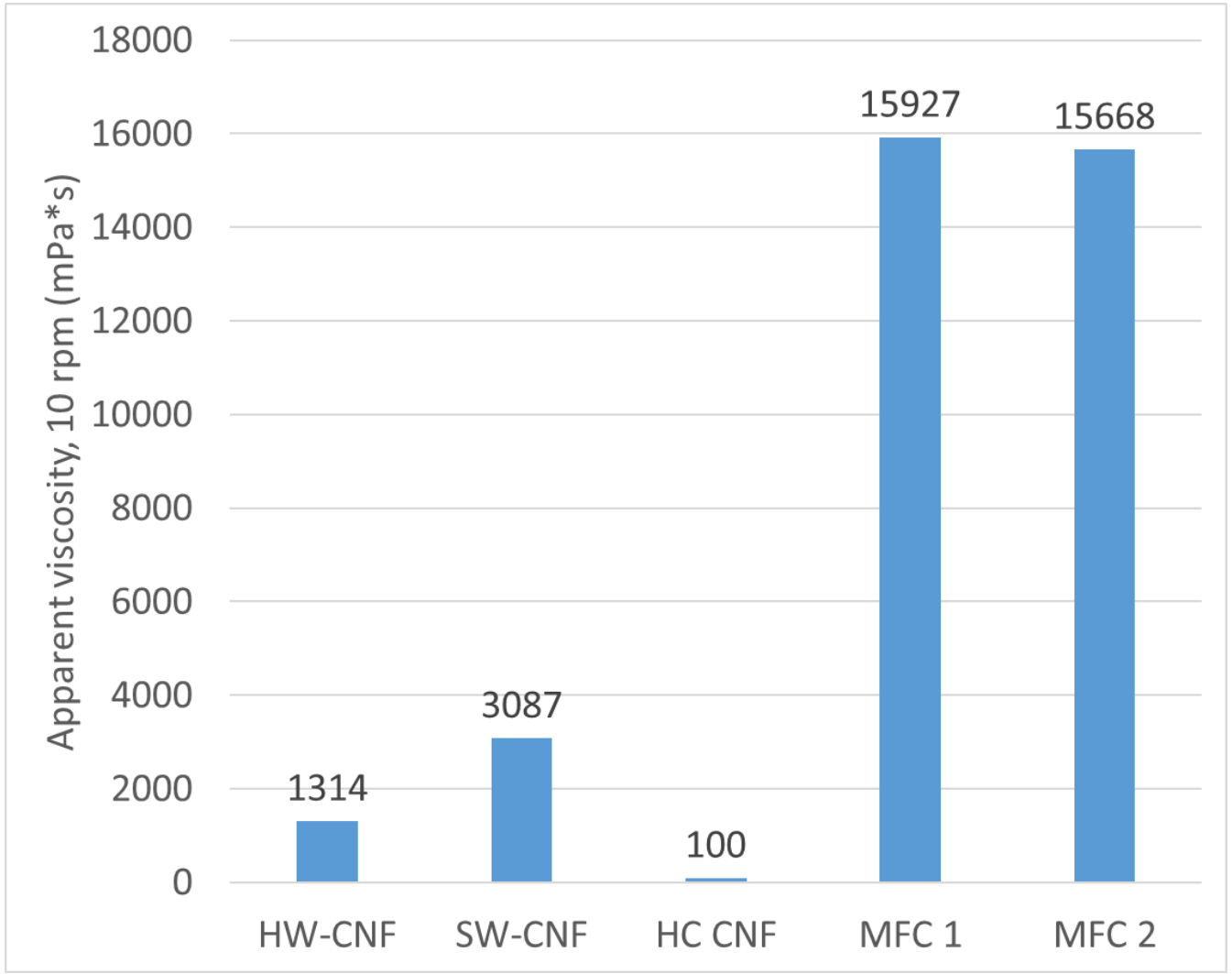
- After the HT treatment colony forming units in HW and SW pulps dropped from 10^5 level to 10^2, which is a low level of impurities.
- Aseptic sample can be produced from fresh pulp (e.g. O_2 bleached HW)



CNF characteristics – Rheology

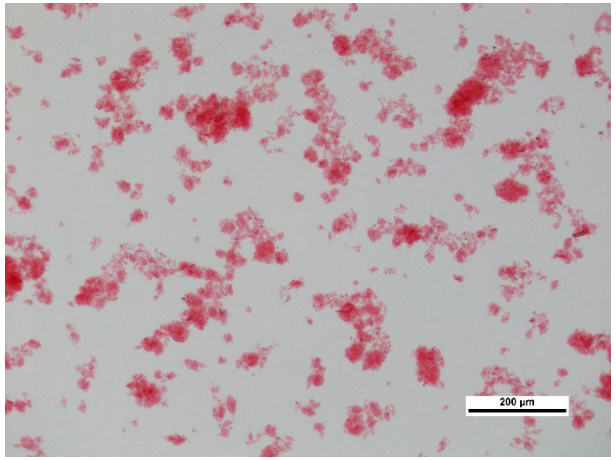
Brookfield method at 1.5% solids

- Low viscosity gels
- Mechano-enzymatically fibrillated HC CNF was paste at 29% solids
- Benchmarking with two commercial MFC grades

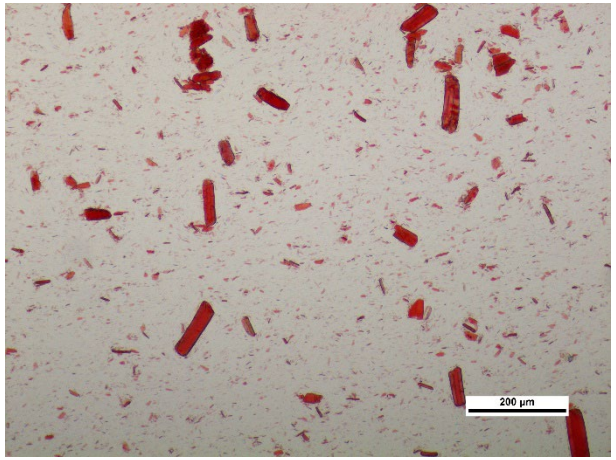


CNF characteristics – Residual fibres

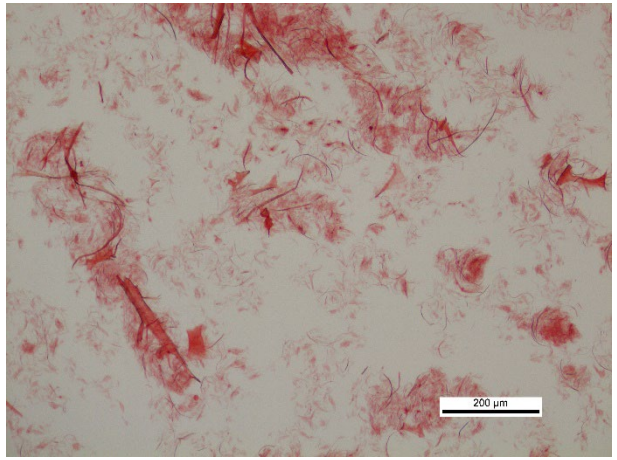
Valmet FS5 fiber analyzer



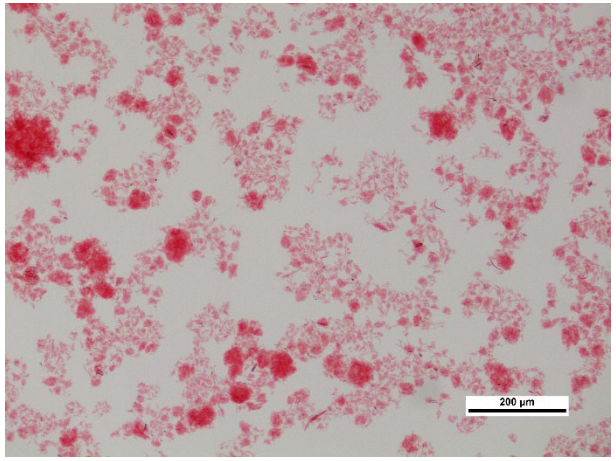
HW-CNF (104 psc/mg)



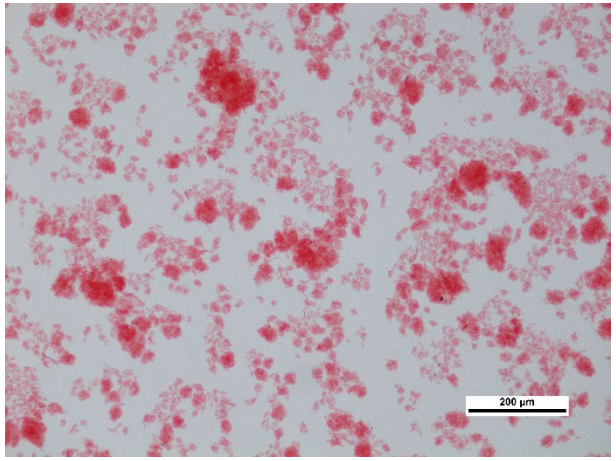
HC-CNF (117000 pcs/mg)



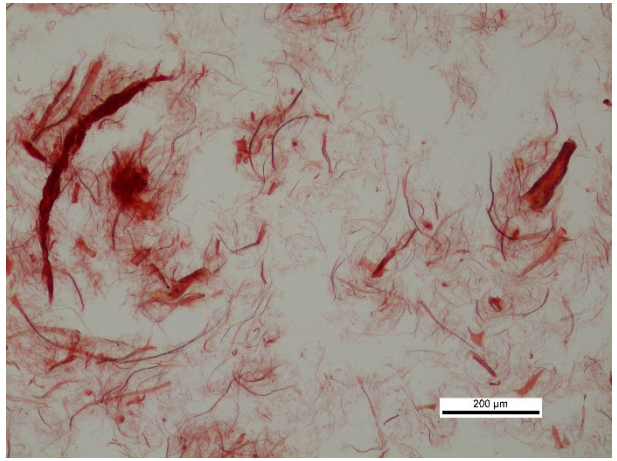
MFC1 (15900 pcs/mg)



SW-CNF (1548 pcs/mg)



O2-CNF (5 pcs/mg)

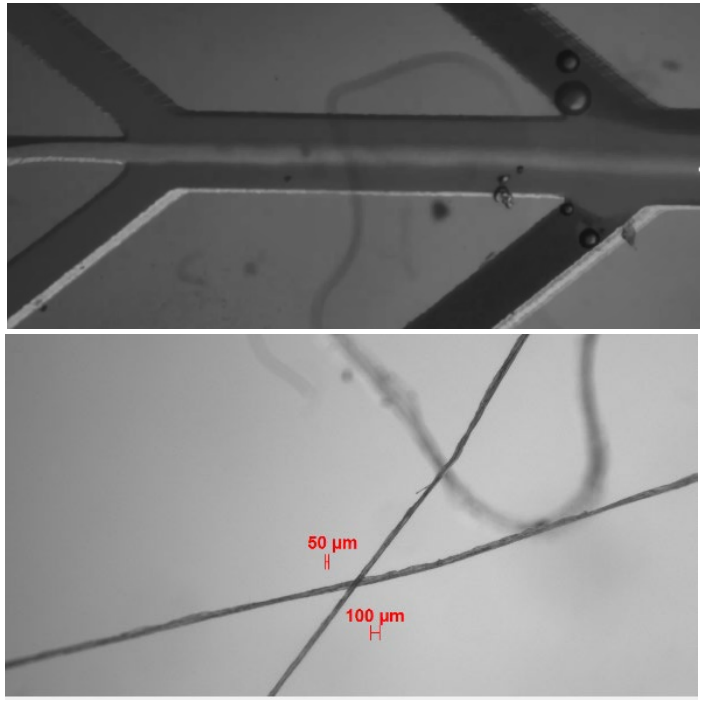


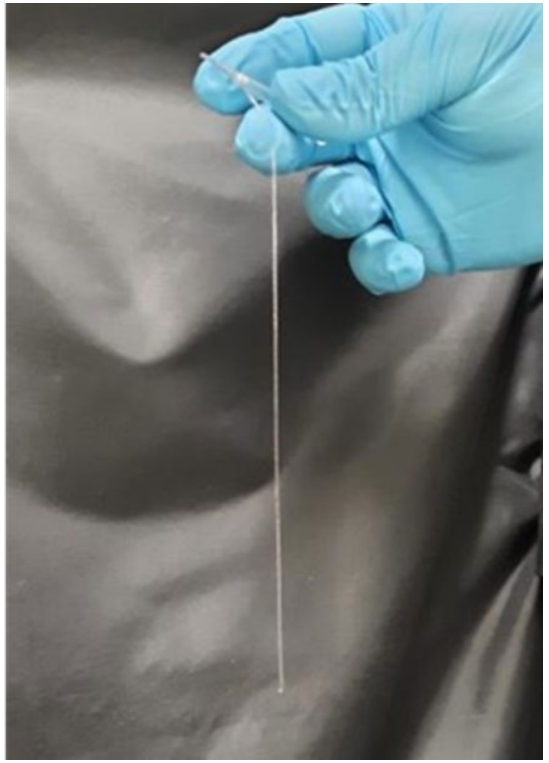
MFC2 (15700 pcs/mg)

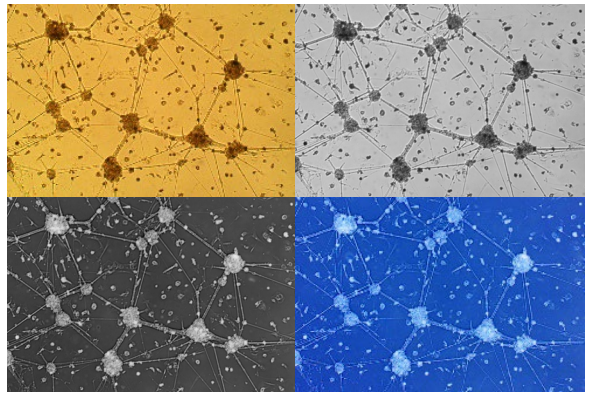
Potential application in promoting neuron regeneration

VTT iBEX early-stage innovation program Spider Spindles

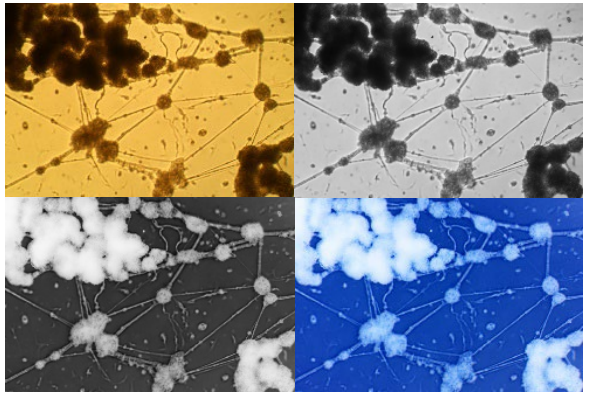
- Microfluidic CNF treads
- Endotoxins 7.9 EU/ml of CNF



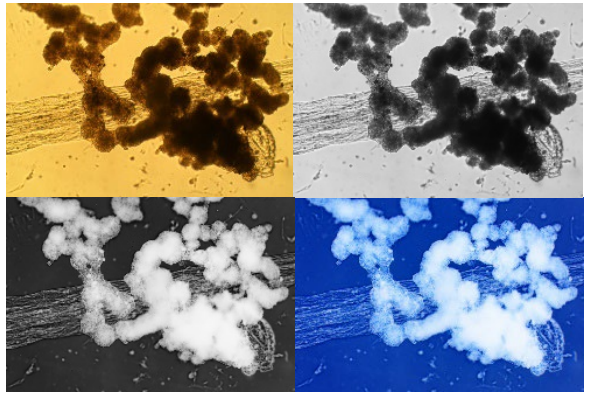




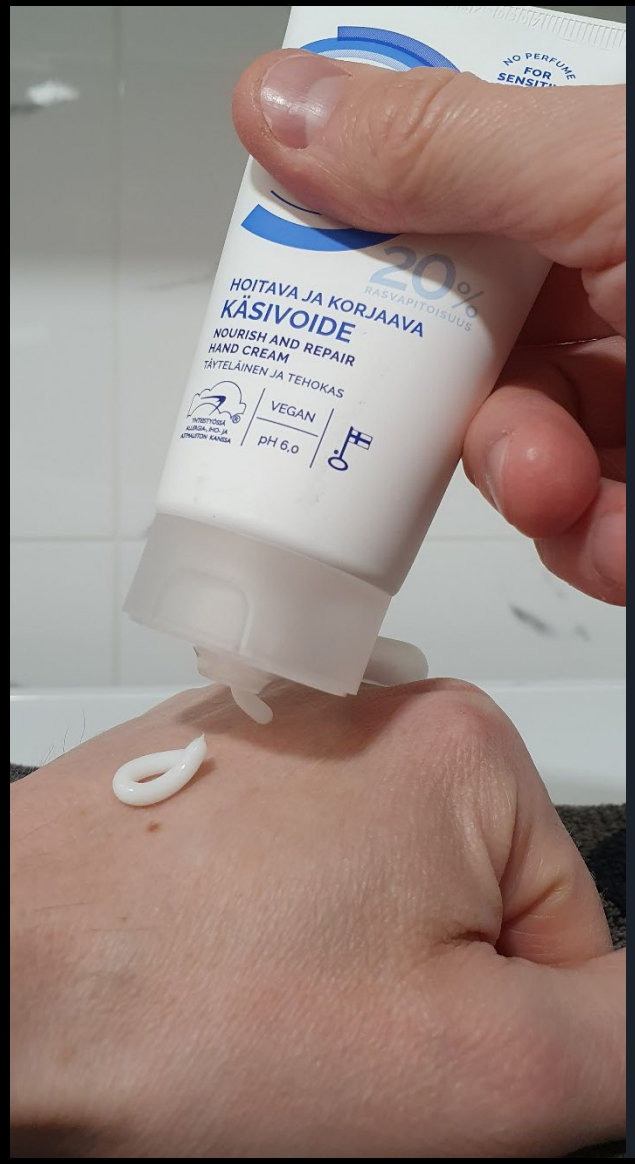
Neurons (D9), 5X magnification



Neurons (D16) without CNF thread or NGF (D12), 5X magnification



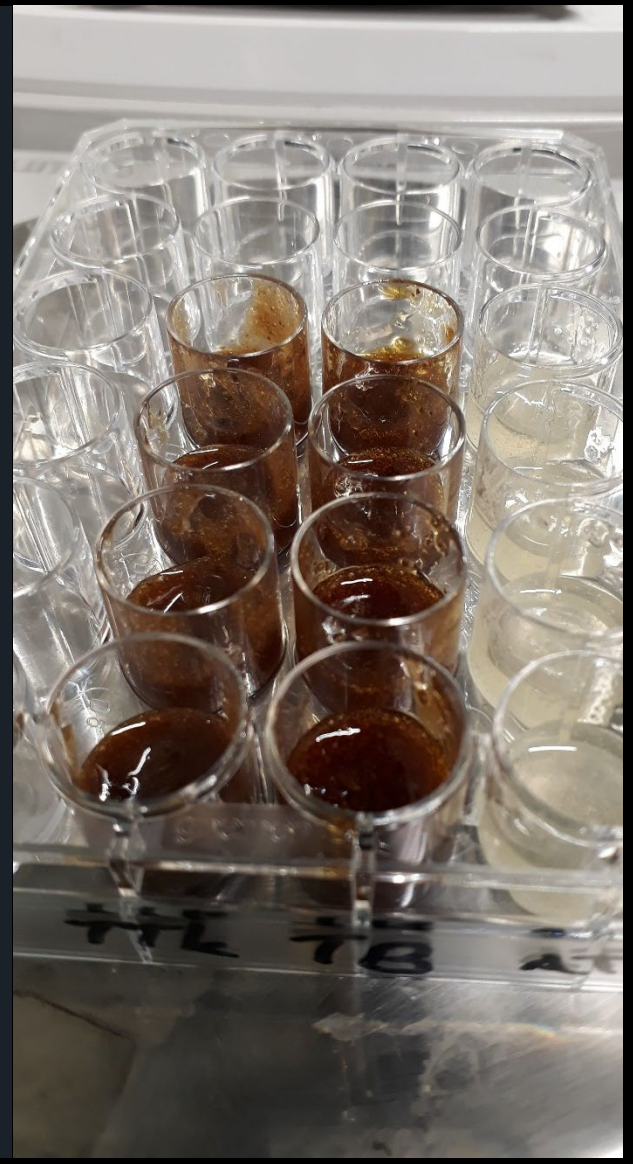
Neurons (D16) with lysin-CNF thread + NGF (D12), 5X magnification



Modified hydrothermal treatment (HT) as a pre-treatment method for the ultra-pure CNF production

Conclusions

- New chemical free process integrates purification of the initial raw material and pre-refining of the pulp
- Ultra-pure natural and non-toxic cellulosic hydrogel constituent
- Can be combined with chemical modifications and high-consistency fibrillation
- Simultaneous fractionation of hemicelluloses



Contact us for more information about nanocellulose technologies

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