UNIVERSITY OF OULU

Hamppuseminaari Tyrnävällä

Korkean jalostusasteen kuitutuotteet

Henrikki Liimatainen
Professor, Head of the unit
Fiber and Particle Engineering Research Unit

Fiber and Particle Engineering (FPE)

Staff: 56 (16 trainees)

External funding: 78 %

Education in the field of particle engineering, and circular and bioeconomy

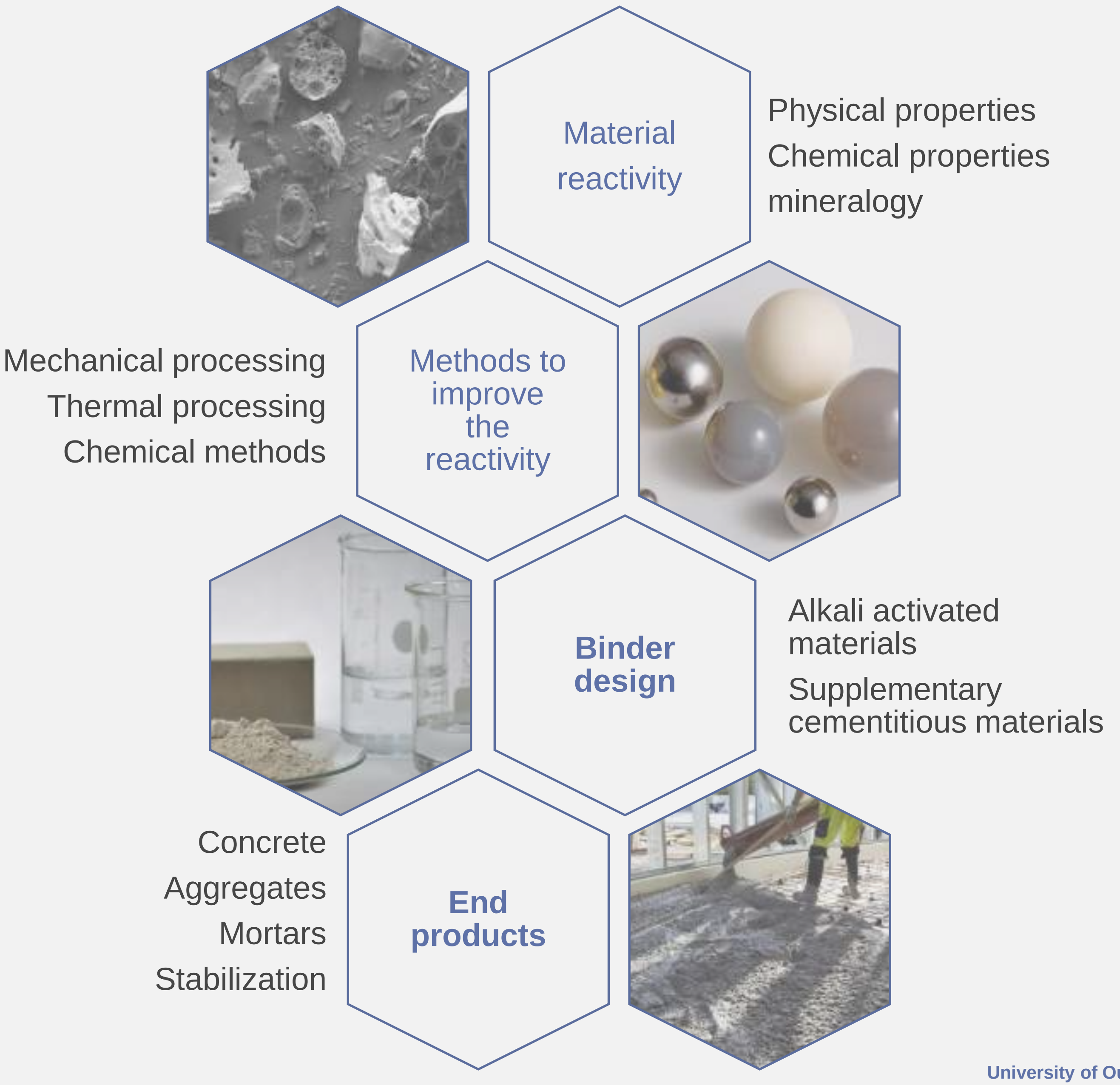
Research groups

- **Inorganic circular materials** (Prof. Illikainen, Assoc. Profs. Luukkonen and Yliniemi, Dr. Ohenoja, Dr. Perumal)
- **Magnesia-based materials and systems** (Prof. Kinnunen)
- **Nanostructured lignocelluloses** (Prof. Liimatainen, Head of the Unit)

Inorganic circular materials research group

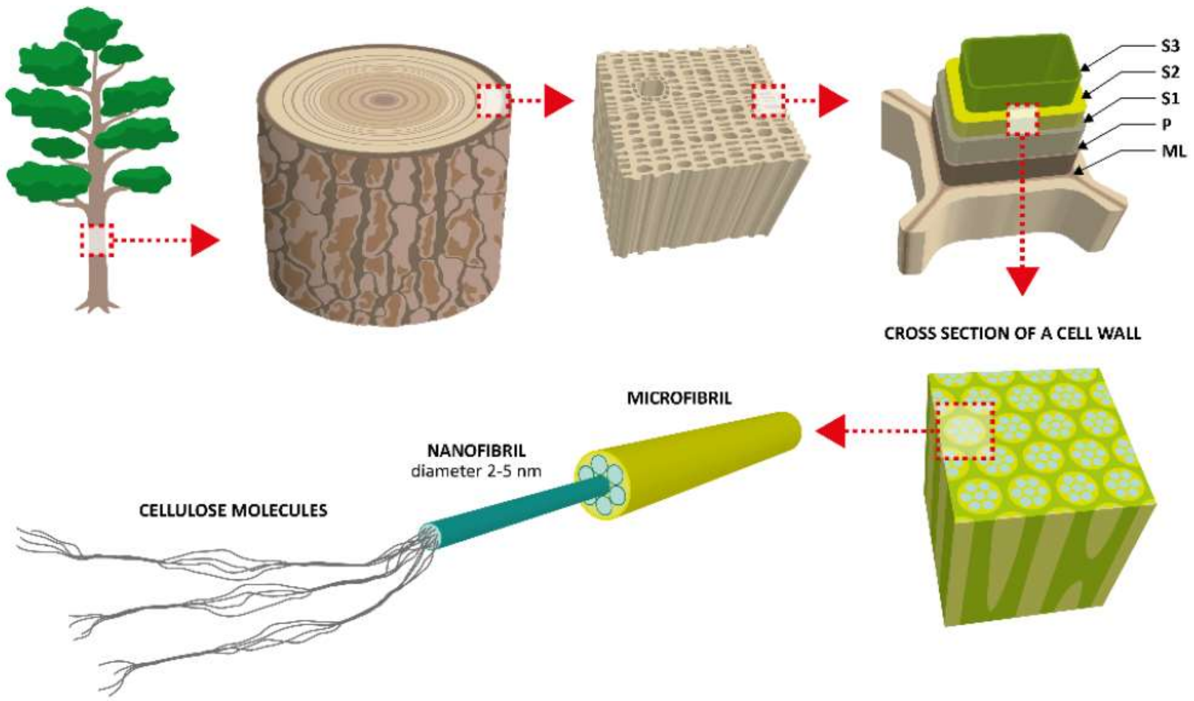
Research focus – Construction materials

Professor Mirja Illikainen



Nanostructured lignocelluloses research group

Research focus



- Understanding how lignocelluloses can be harnessed to create future green and nanostructured materials
  - Isolation of nano-sized and molecular level entities
- Tailoring the features of lignocelluloses to obtain advanced functionalities
  - Green chemistry approaches in lignocellulose modification
- Addressing the behavior of novel lignocelluloses in different applications
  - From nano-size to hierarchical materials

Applications

Technical

- Packaging & barrier materials
- Paper products
- Textile and technical filaments
- Filters & membranes

Environmental

- Water purification (dye, metal & micropollutant removal, wwt treatment)
- Oil spill response (dispersing agents, adsorbents)

Green electronics

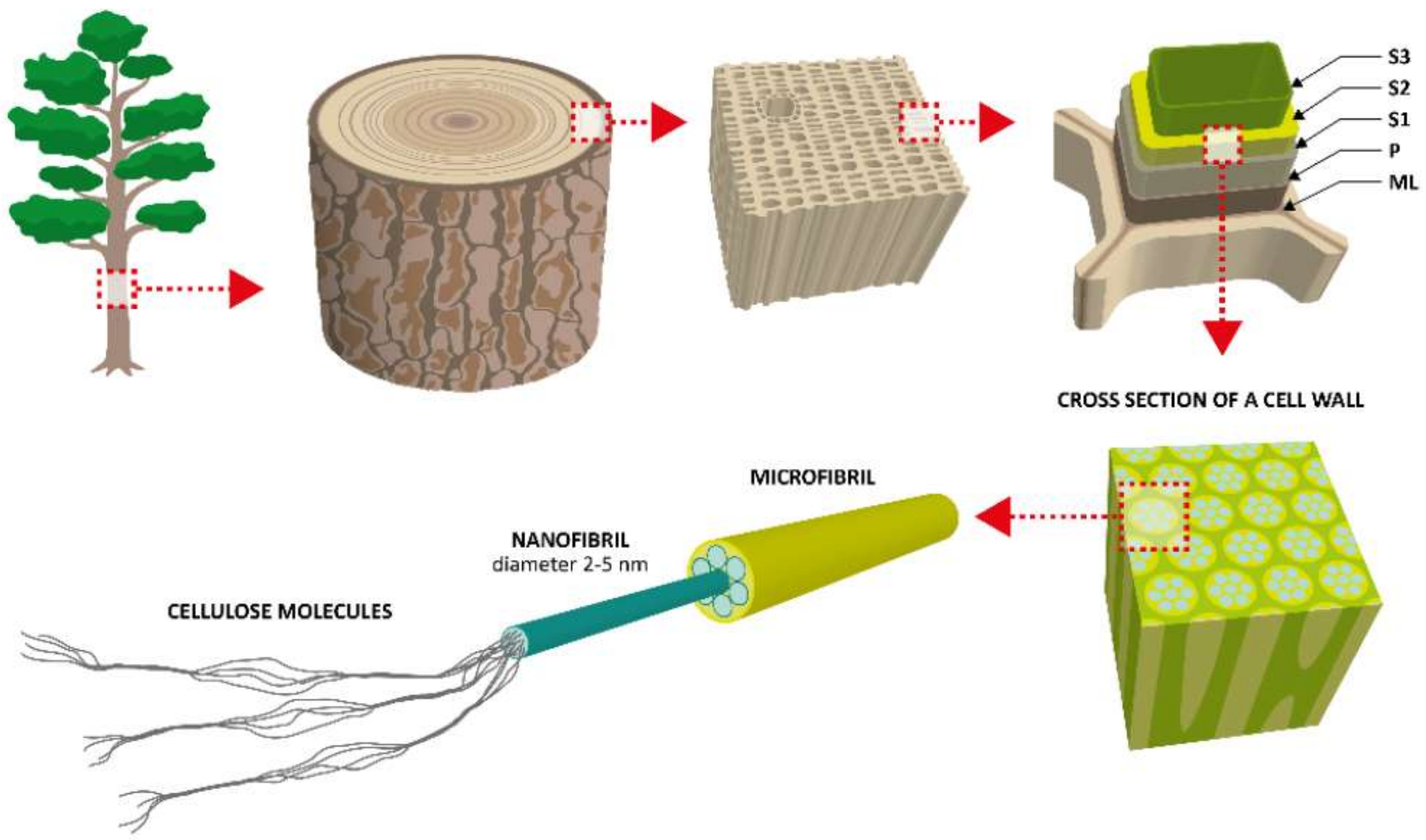
- Printable materials & supports (antennas, 3D printing etc.)
- Flexible electronics (sensors)
- Conductive filaments & films
- EMI shielding
- Inks etc.

Biomedical

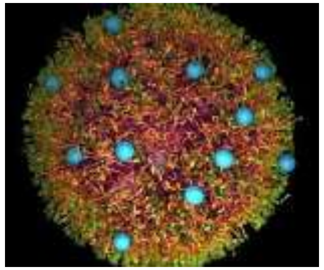
- Cell culture, tissue engineering & scaffold
- Drug delivery
- Transinfection
- Isolation & enrichment of EV's
- Wound healing
- Antimicrobial materials

High-value fiber products from lignocelluloses

Lignocelluloses: Source of fibers, microfibers and nanocelluloses

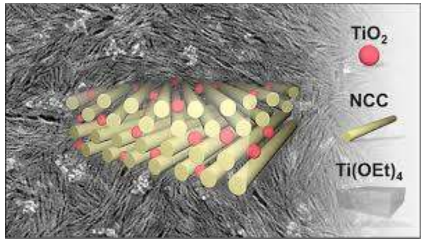


Wide range of applications



Pharmaceutical, drug delivery

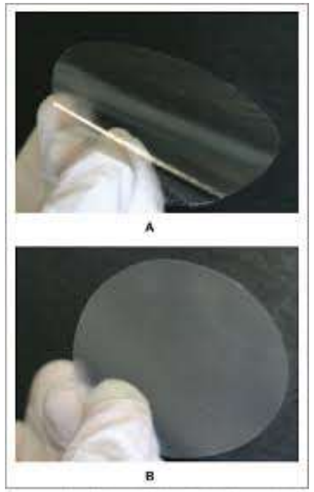
Paper and board



Templates

Fiber/Microfiber/Nanocellulose

Energy storage

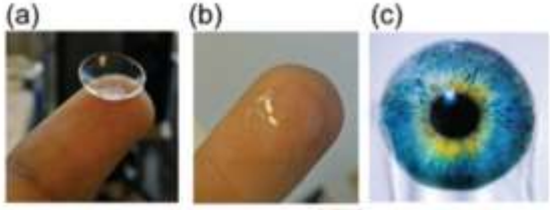


Packaging films & barriers

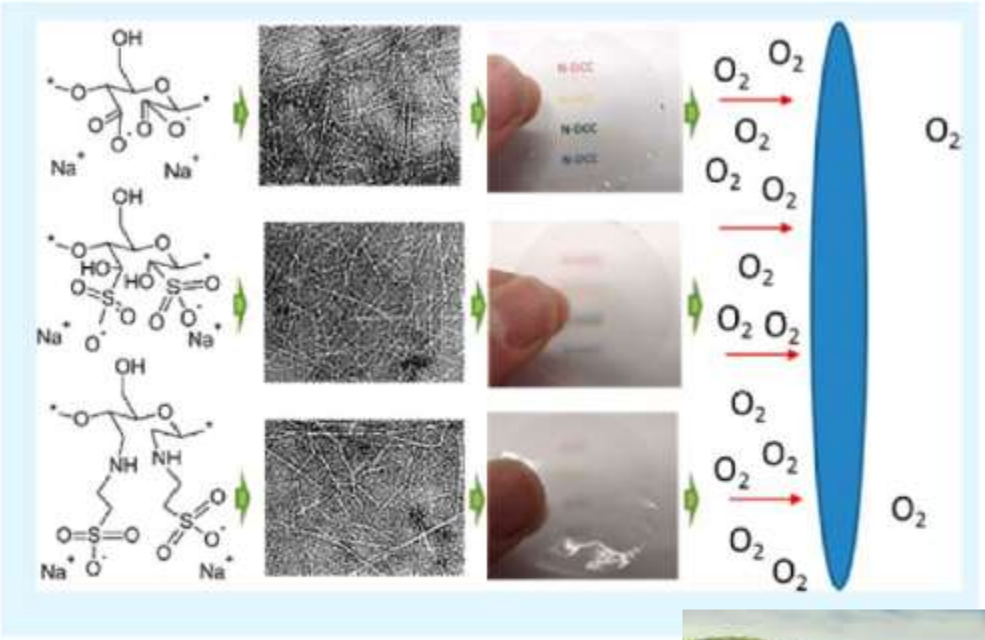
Reinforcing for polymers

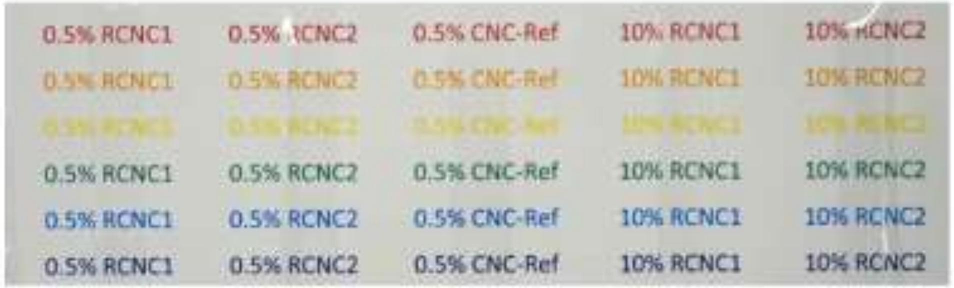
Electronics

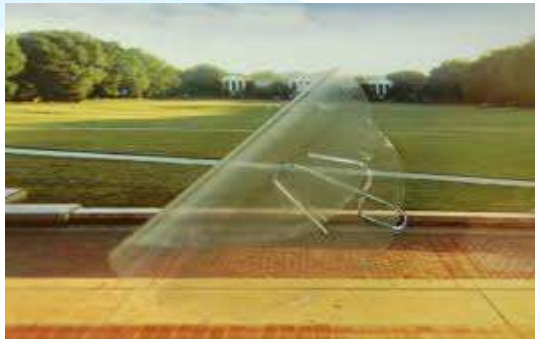
Biomedical



Transparent and flexible packaging, biocoatings and films



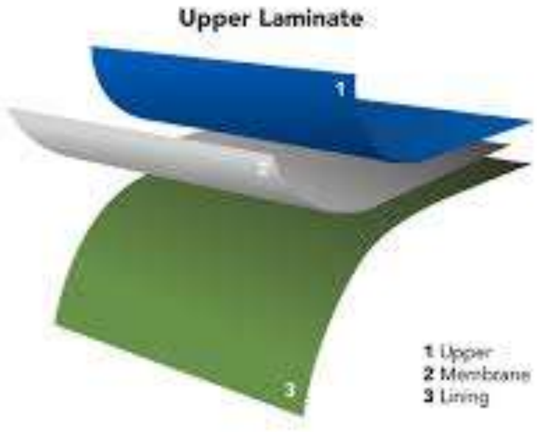




Sirviö et al. ACS Applied Materials & Interfaces, 2014

Lakovaara M, Sirviö JA, Sliz R, Vida J, Homola T & Liimatainen H. (2022) Modification of Nanocellulose Films in Deep Eutectic Solvents Using Vinyl Esters. *Cellulose*.

Barrier films in packaging



More with less with MFC

Building on a long partnership, Stora Enso is supporting Elopak with renewable innovations that can help them remain competitive. One such innovation is the New Natura Concept (NNC), based on Micro Fibrillated Cellulose (MFC).

PUBLISHED: 2/17/2016 9:30 AM

Aiming to make packaging as light as possible, Elopak initiated trials once MFC was available from Stora Enso's Imatra Mills.

"By using MFC, we get the maximum yield out of the raw material and thus more packaging material per ton of board. Important properties, such as stiffness and internal strength, are maintained, with less weight. Within Europe, there are various incentives and regulations to reduce the weight of packaging material. The partnership with Stora Enso makes it easier for us to reach these targets," says Tom Egenes, Director Strategic Sourcing at Elopak.

RELATED ARTICLES

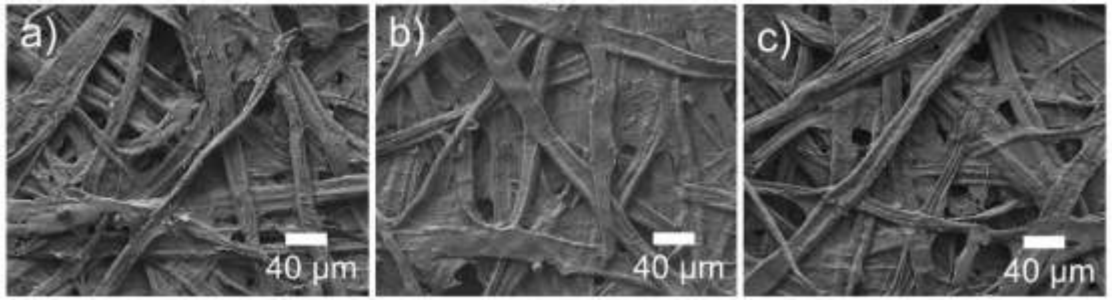
Innovating with our customers

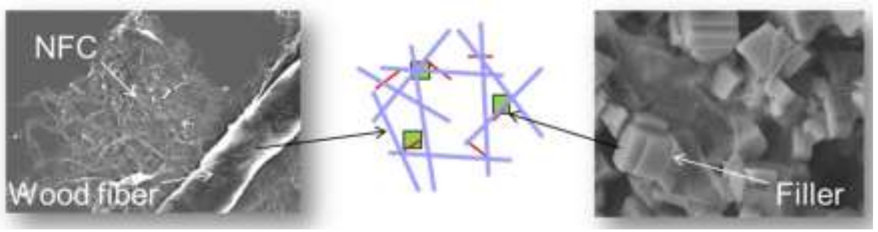
Lignin of tomorrow

Campus of OMICRON electronic GmbH

Additives in paper & board

- Cellulose nanofibers increase the strength properties with low dosages
  - In graphical papers increased strength can be used in increasing filler level
- Smoother surface
- Light weight
- Increased elastic modulus could provide bending stiffness in layered products
- Drawbacks: Decrease in drainage of pulp, decrease in porosity (e.g. affect drying and sizing)





Hietala et al. Cellulose, 2015

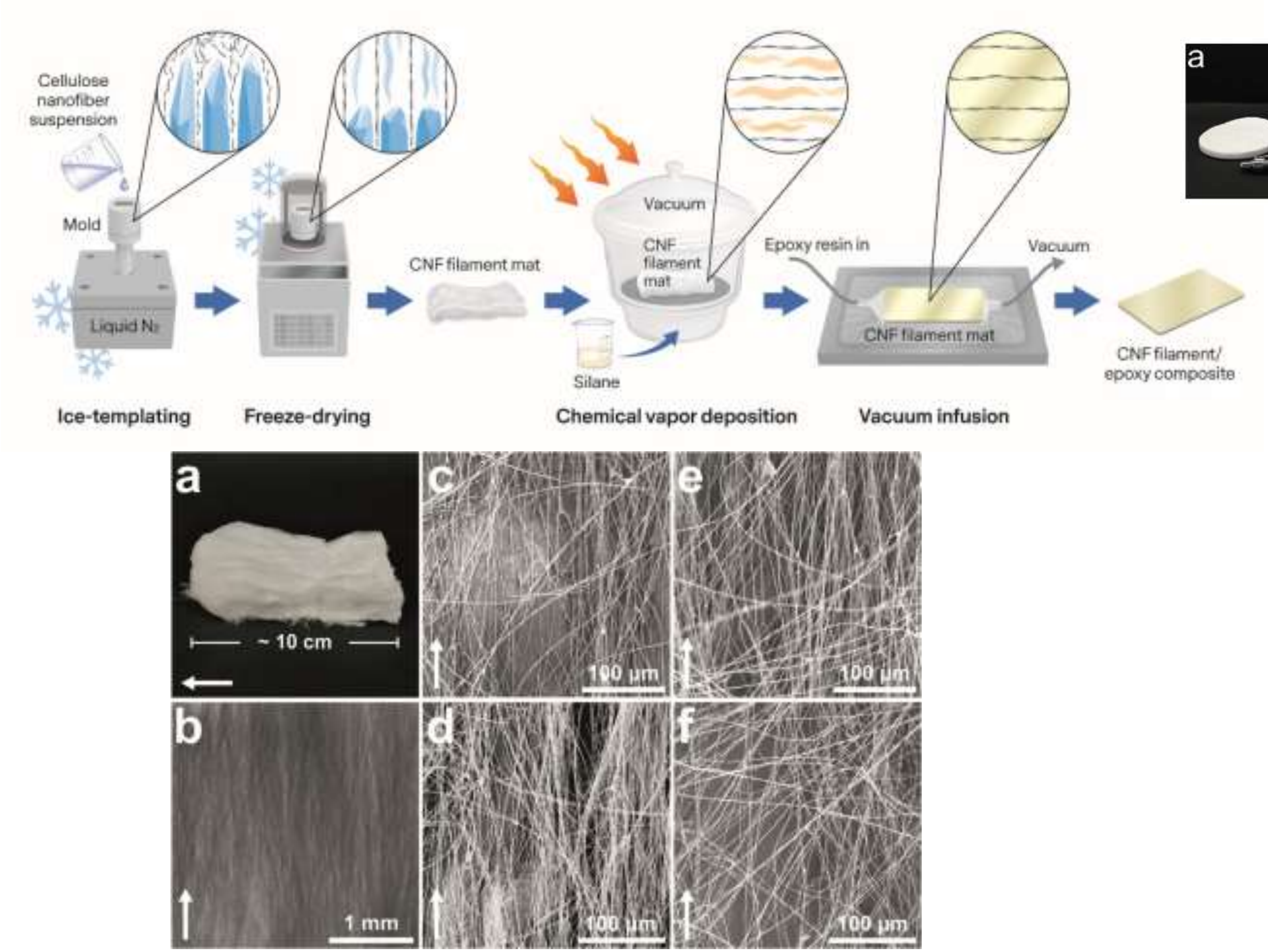
Biocomposites

- Very good mechanical properties
- Light weight

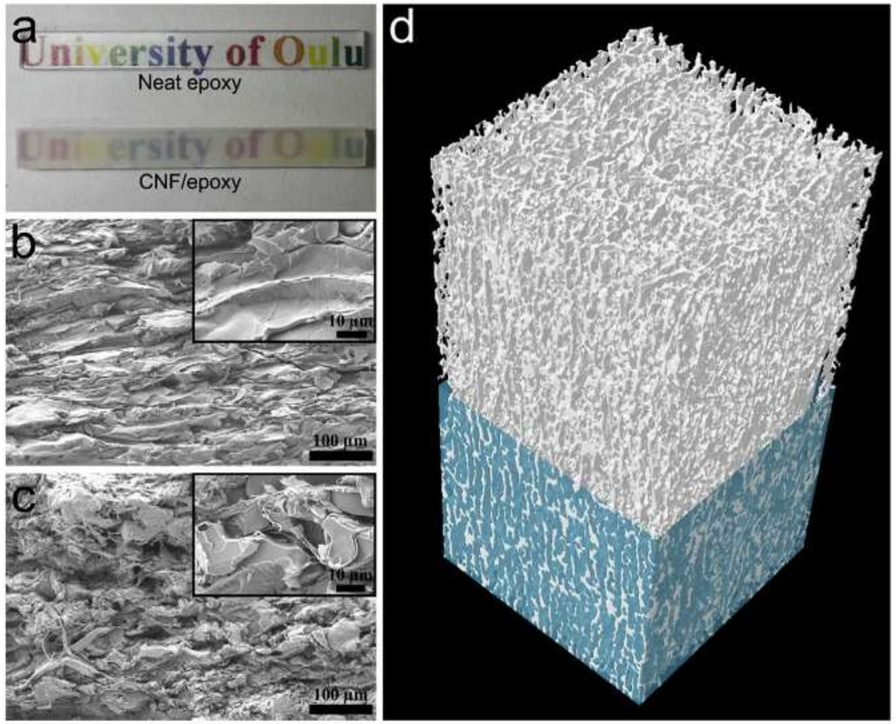




Nanocellulose composites

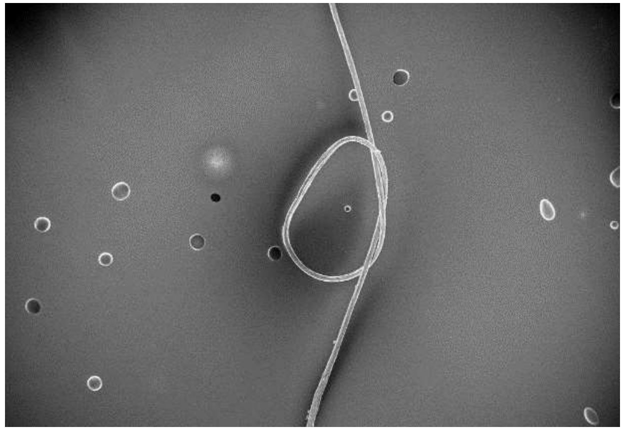


Nissilä et al. (2021) Nanomaterials 11, 490



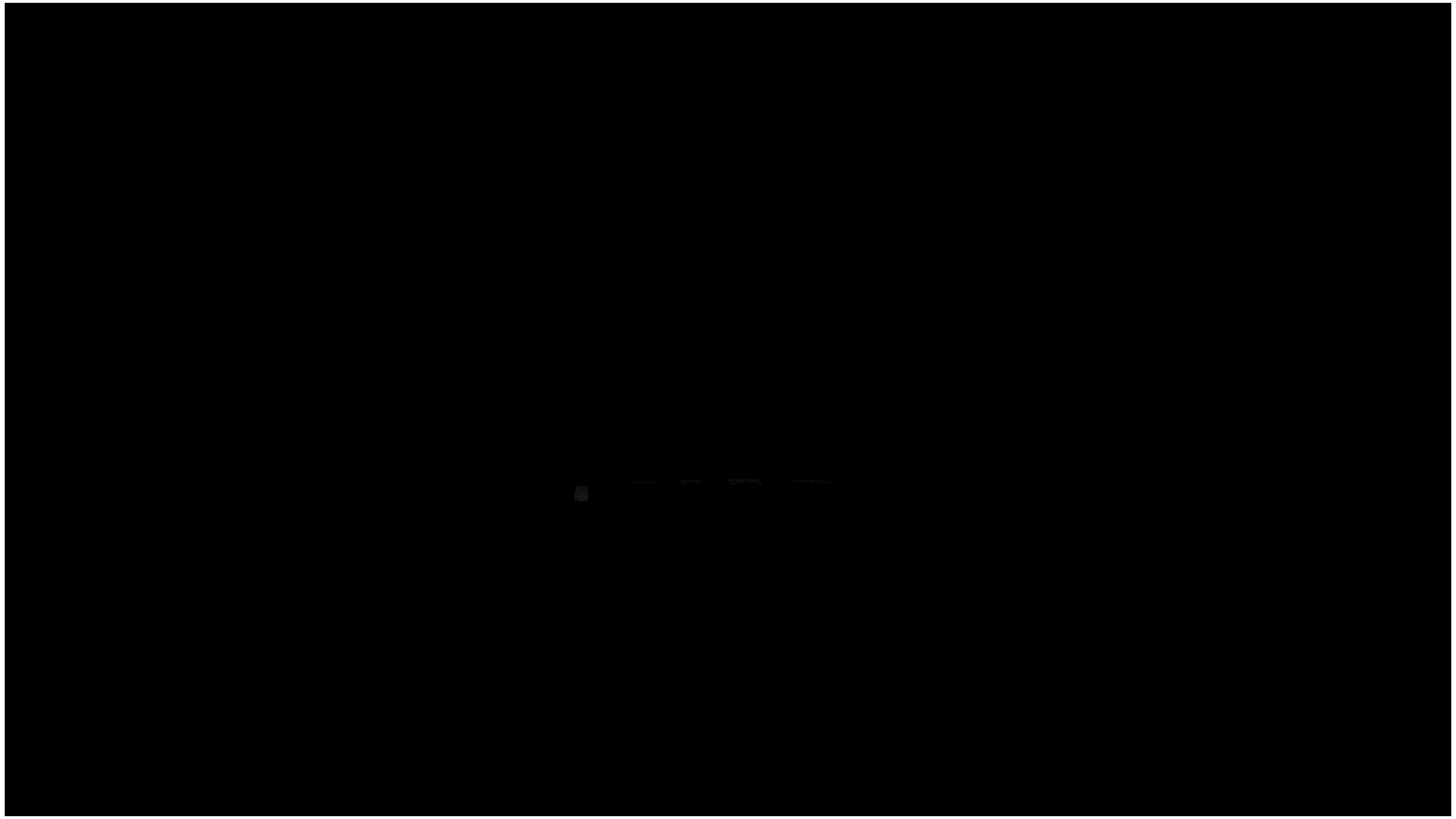
Nissilä et al. (2018) Composites Science and Technology 155, 64–71

Continuous filaments and yarns for textiles



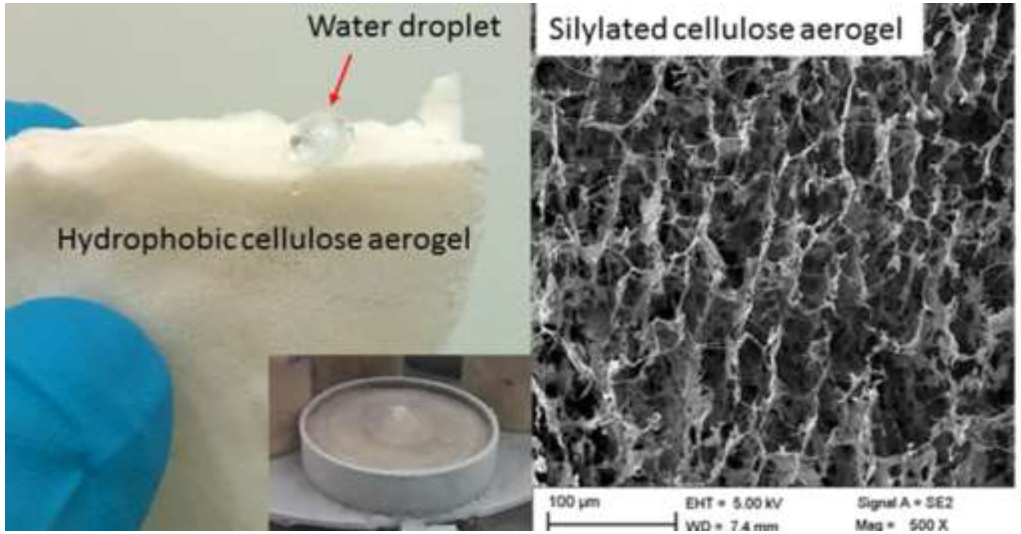
Zhang K, Hujaya SR, Järvinen T, Li P, Kauhanen T, Tejesvi MV, Kordas K & Liimatainen H. A. (2020) Interfacial nanoparticle complexation of oppositely charged nanocelluloses into functional filaments with conductive, drug release or antimicrobial property. *ACS Applied Materials & Interfaces* 12, 1765-1774.

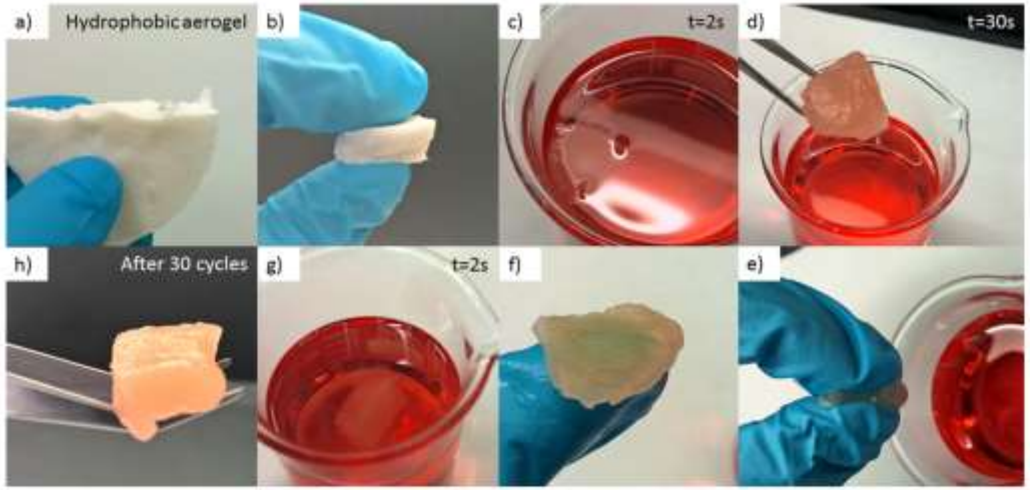
Continuous filaments from nanocelluloses



Zhang K & Liimatainen H. (2018) Hierarchical Assembly of Nanocelluloses into All-cellulose Filaments by Interfacial Complexation. *Small* 14, 1801937.

Porous materials

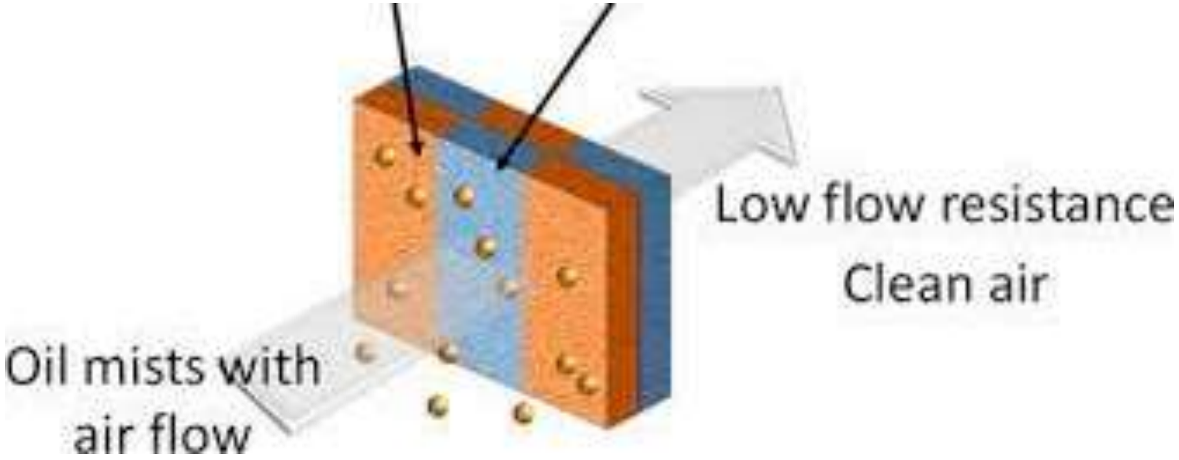


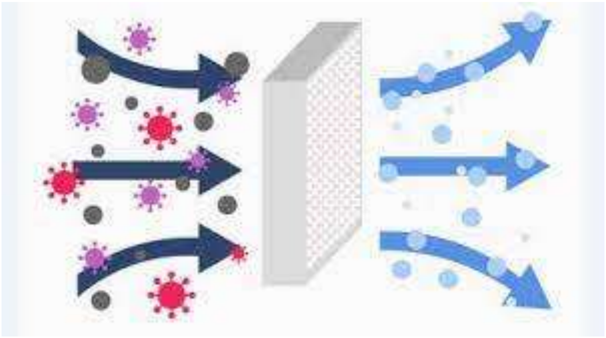


Akhlamadi G, Goharshadi EK & Liimatainen H. (2022) Ultrahigh Fluid Sorption Capacity of Superhydrophobic and Tough Cryogels of Cross-Linked Cellulose Nanofibers, Cellulose Nanocrystals, and $Ti_3C_2T_x$ MXene. *Journal of Materials Chemistry A*.

Reference: Laitinen O, Suopajärvi T, Österberg M & Liimatainen H. (2017) Hydrophobic, superabsorbing aerogels from choline chloride-based deep eutectic solvent pretreated and silylated cellulose nanofibrils for selective oil removal. ACS Applied Materials and Interfaces 9, 25029-25037.

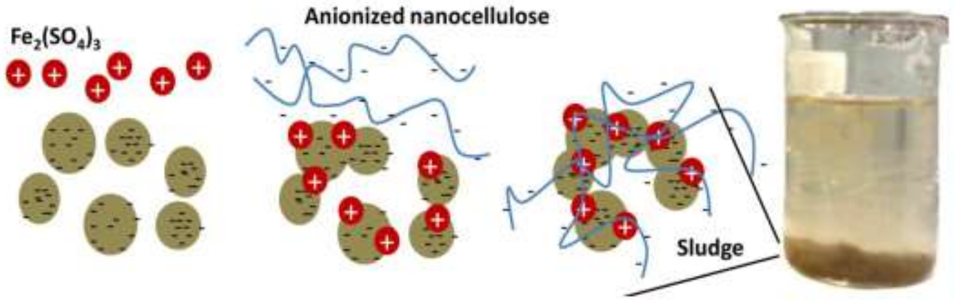
Porous materials – Insulation and air filtration





Ukkola J, Lampimäki M, Laitinen O, Vainio T, Kangasluoma J, Siivola E, Petäjä T & Liimatainen H. (2021) High-Performance and Sustainable Aerosol Filters Based on Hierarchical and Crosslinked Nanofoams of Cellulose Nanofibers. Journal of Cleaner Production 310, 127498.

Biochemicals - Water purification



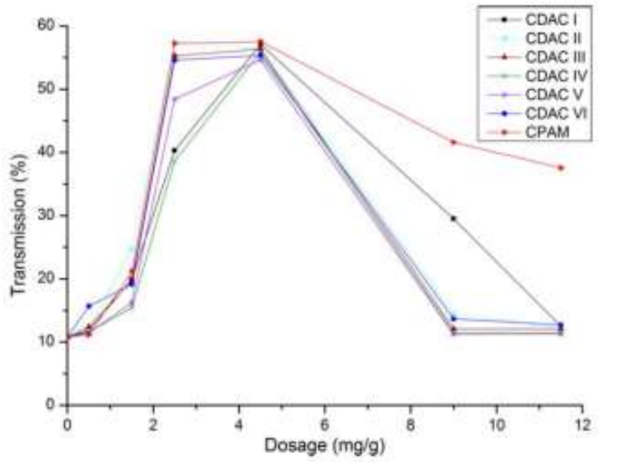
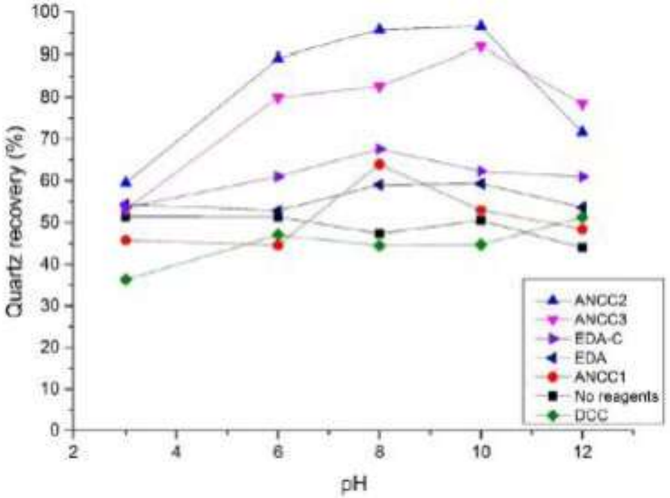
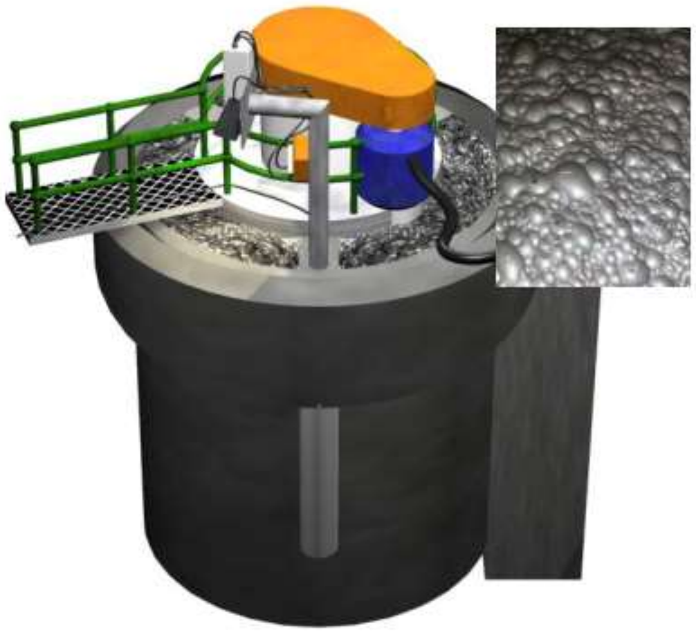


Fig. 2. Residual transmission of flocculated clay suspension as a function of flocculant dosage after analytical centrifugation (400 rpm for 300 s at 20 °C).

Liimatainen et al. Carbohydrate polymers, 2014;
Suopajärvi, Liimatainen et al. Chemical Engineering Journal 2013

Biochemicals – Flotation chemicals for mining



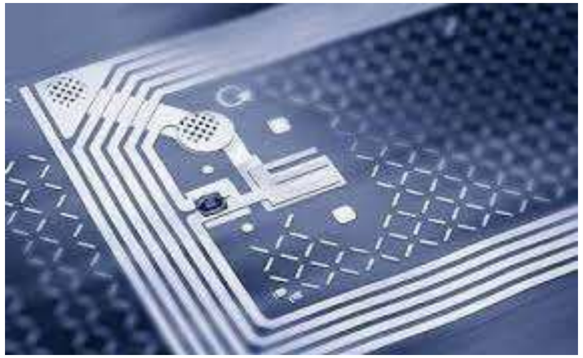


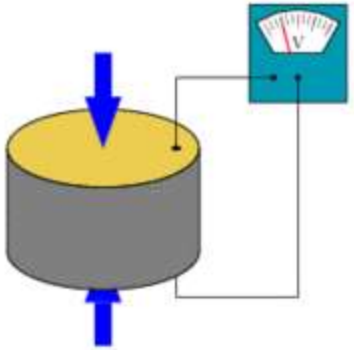
Laitinen et al. 2014. Industrial & Engineering Chemistry Research 53, 20092-20098.

Ludovici et al. (2022) Cellulose.

Green electronics

- Flexible electronics
- Touch screens
- Transparent electrodes
- Printable electronics
- Sensors





Substrates for 6G telecommunication

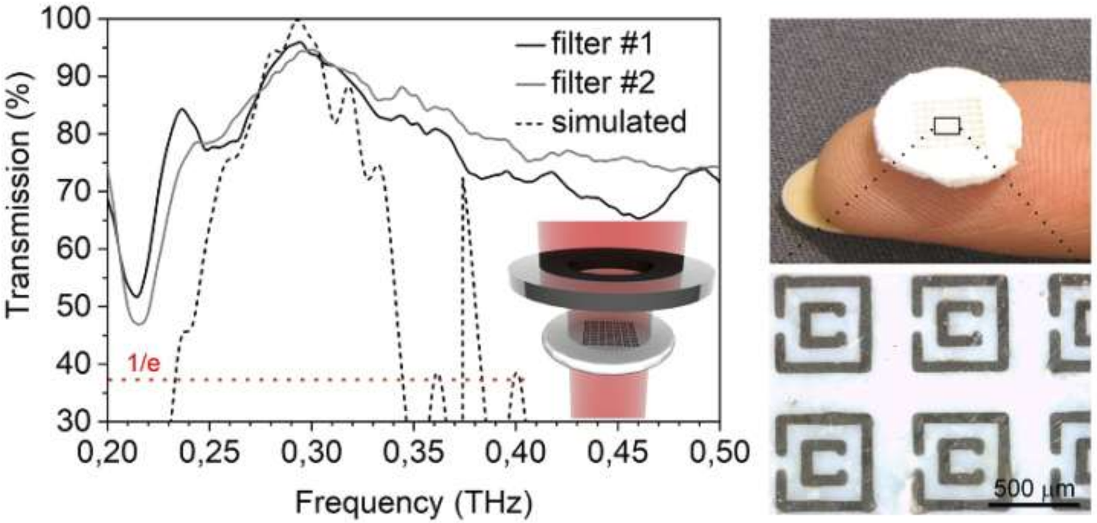


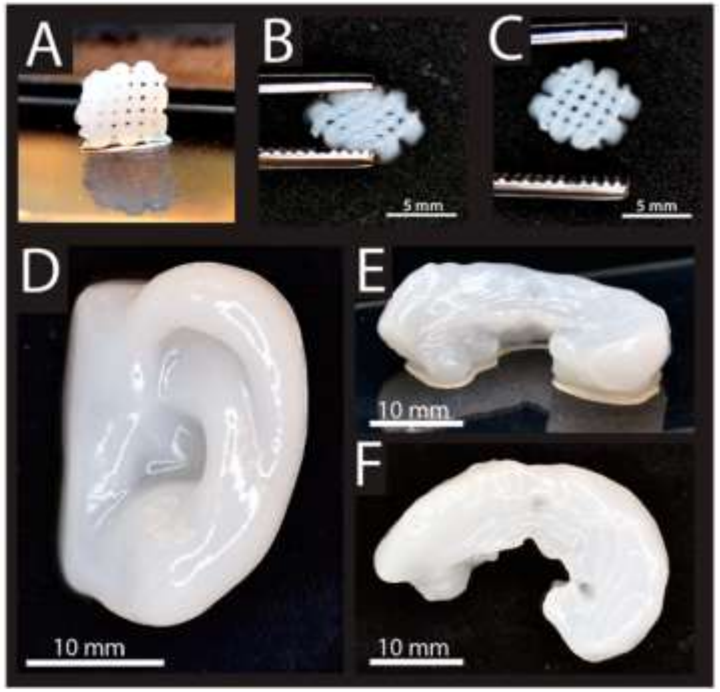
Figure 5. Experimental and simulated high frequency transmission of planar filter structures. Schematic drawing of the measurements setup is displayed in the inset of the plot. Panels on the right show a camera image and an optical micrograph of the filter device and double split-ring resonators, respectively.

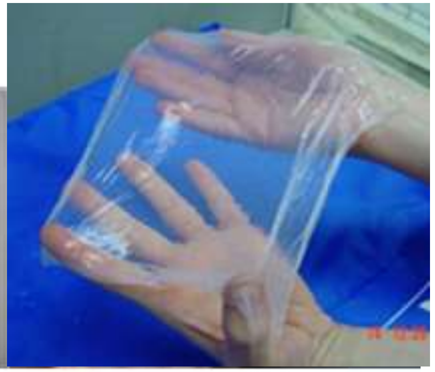
Nelo M, Liimatainen H, Ukkola J, Juuti J & Jantunen H. (2019) Solid air - Low temperature manufacturing of ultra-low permittivity composite materials for future telecommunication systems. Frontiers in Materials 6, 94.

Palvolgyi P, Nelo M, Pitkänen O, Liimatainen H, Myllymäki S, Jantunen H & Kordas K. (2020) Ultra-low permittivity porous silica-cellulose nanocomposite substrates for 6G telecommunication. *Nanotechnology*.

Biomedicine

- Biocompatible, antimicrobial, 3D printable
- Drug delivery, controlled release, cell growth media, diagnostics, analysis





Ukkola J, Pratiwi FW, Kankaanpää S, Abdorahimzadeh S, KarzarJeddi M, Singh P, Zhyvolozhnyi A, Makieieva O, Viitala S, Samoylenko A, Häggman H, Vainio S, Elbuken C & Liimatainen H. (2022) Enrichment of bovine milk-derived extracellular vesicles using surface-functionalized cellulose nanofibers. Carbohydrate Polymers, 297, 120069..

Thank you!