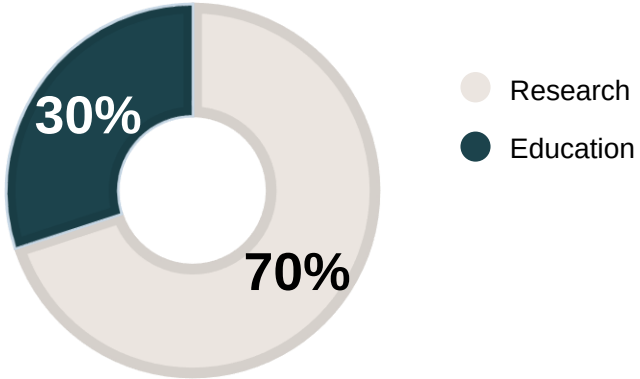


KTH Royal Institute of Technology and Advanced Biobased Materials

Eva Malmström

Sweden’s largest technical university

Funding (6,000 msek)



Students

15,200
Degree seeking students

34%	3,700	1,700
Women	International students	Doctoral students

Alumni

175,000
alumni in 115 countries

20
International alumni associations

Staff

4,100
Staff (FTE)

700
Faculty

368	2,900	1,300
Professors	Staff within research	Doctoral students with employment

KTH's School and Departments

ABE

Architecture and the Built Environment

- Architecture
- Civil and Architectural Engineering
- Philosophy and History
- Real Estate and Construction Management
- Sustainable Development, Environmental Science and Engineering
- Urban Planning and Environment

EECS

Electrical Engineering and Computer Science

- Computer Science
- Electrical Engineering
- Human Centered Technology
- Intelligent Systems

ITM

Industrial Engineering and Management

- Energy Technology
- Industrial Economics and Management
- Learning in Engineering Sciences
- Engineering Design
- Materials Science and Engineering
- Production Engineering

CBH

Engineering Sciences in Chemistry, Biotechnology and Health

- Biomedical Engineering and Health Systems
- Chemistry
- Chemical Engineering
- Engineering Pedagogics
- Fibre and Polymer Technology
- Gene Technology
- Industrial Biotechnology
- Protein Science

SCI

Engineering Sciences

- Applied Physics
- Engineering Mechanics
- Mathematics
- Physics

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- Applied Physics
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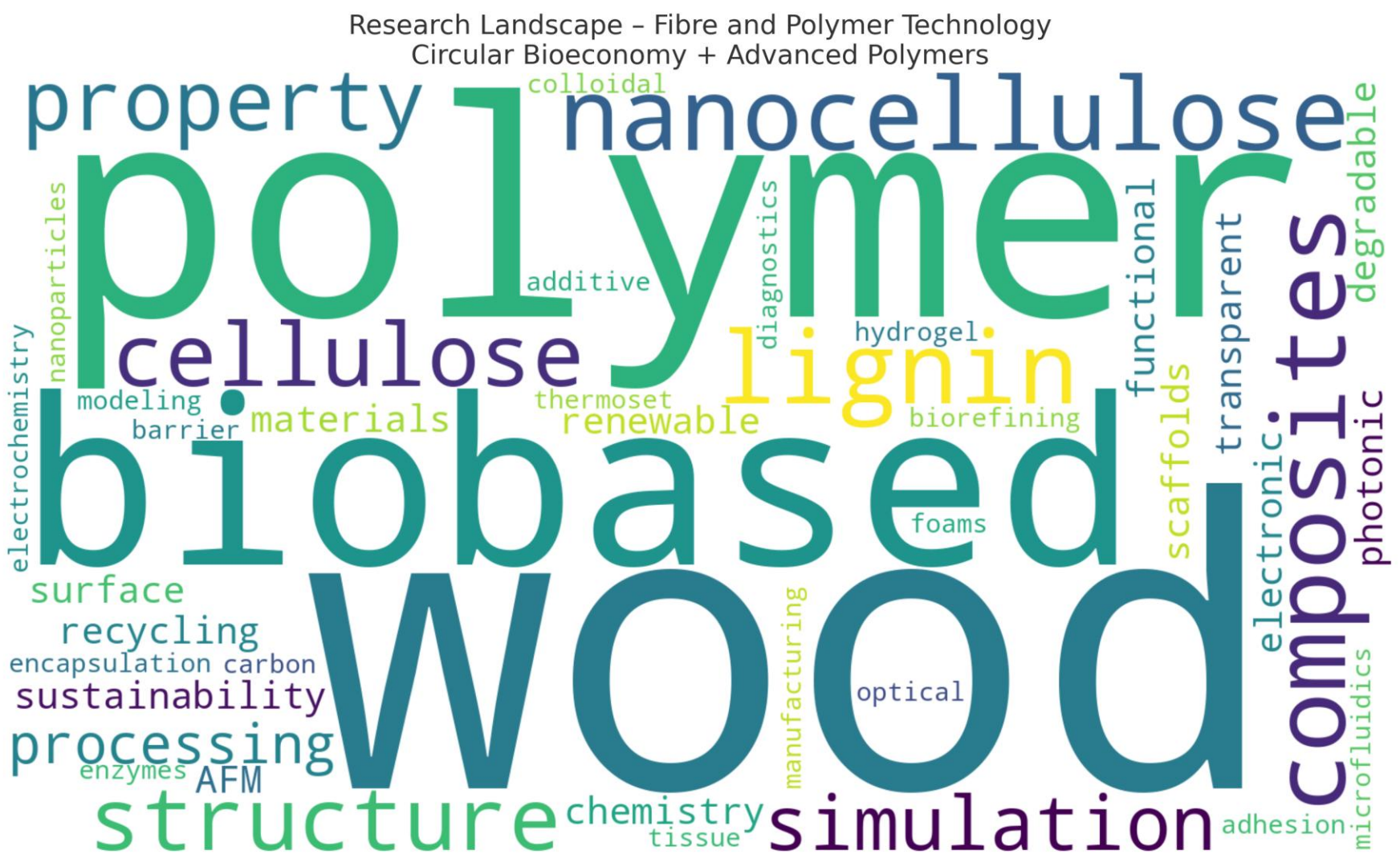
Fibre and Polymer Technology @KTH

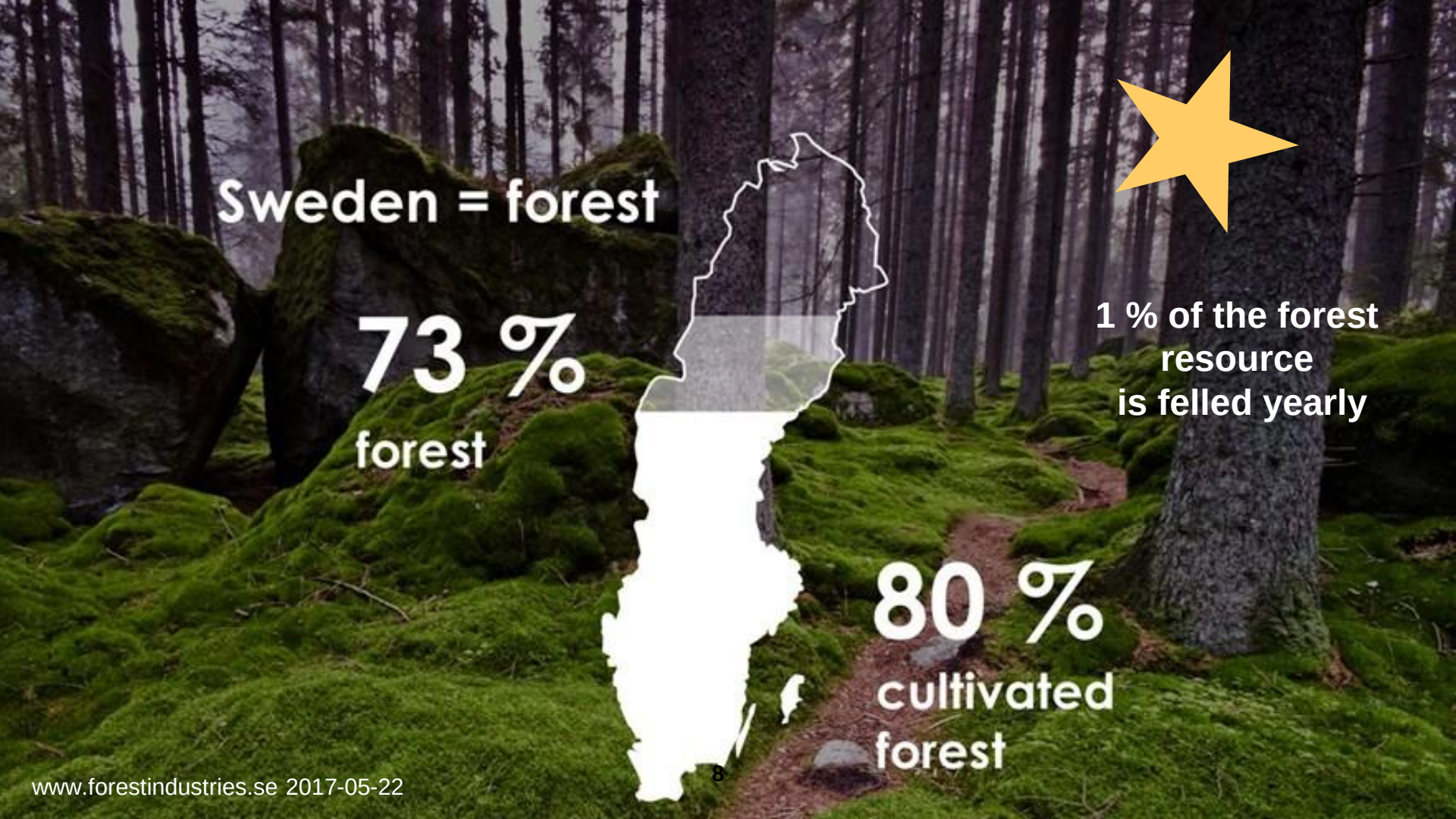
December 2025

Fibre and Polymer Technology

Research areas and scientific impact

- Sustainable materials science
  - From molecules to devices: synthesis, characterisation, modelling, processing, mechanics
  - Focus on sustainability: circularity, green processes
- Strategic research areas (~65 PhD students and ~30 postdocs)
  - Advanced materials: Nanostructures, composites, transparent wood, aerogels
  - Life science: Tissue scaffolds, adhesives, antibacterial surfaces
  - Energy: Structural batteries, high-voltage insulation
  - Environment: Water purification, recycling, green adhesives
- Scientific impact
  - Leadership in sustainable polymers and fibre-based materials, 17 professors
  - Several breakthroughs in biopolymer materials
- Societal impact
  - Many graduates (M.Sc. and Ph.D. injecting competence into existing and start-up companies
  - A very large network of industrial collaborators and partners (FibRe, BioGlue, DCC, etc.)


Research Landscape – Fibre and Polymer Technology
Circular Bioeconomy + Advanced Polymers
property
colloidal
nanocellulose
polymer
nanoparticles
additive
diagnostics
functional
degradable
electrochemistry
cellulose
lignin
hydrogel
transparent
modeling
barrier
materials
thermoset
renewable
biorefining
biobased
composites
scaffolds
photonic
electronic
foams
surface
wood
recycling
encapsulation
carbon
sustainability
optical
processing
manufacturing
microfluidics
enzymes
AFM
structure
chemistry
simulation
adhesion
tissue


Sweden = forest
73 %
forest
1 % of the forest resource is felled yearly
80 %
cultivated forest
8

https://www.forestindustries.se/forest-industry/facts-and-figures/ (2025-02-07)

The Forest – Sweden's green gold



- About 70% of the land area is forest (~ 28 million hectares, ~75% cultivated)
- 300,000+ forest owners (~48% individuals, ~24% privately owned AB, ~20%) state AB + state
- The volume of forest has doubled in 100 years
- Sweden is one of the world's largest exporters of pulp, paper and sawn wood products - important for Sweden's economy
- In 2023, the total export value of Swedish forest products amounted to ~184 billion SEK. (2022: 186 billion, 2020: 145 billion)
- The forestry industry accounts for 9-12% of Sweden's GDP
- The forestry industry employs 140,000 people





Creating knowledge and building competence of innovative use of wood raw materials

WWSC

WALLENBERG WOOD SCIENCE CENTER

A joint research center at KTH Royal Institute of Technology, Chalmers University of Technology and Linköping University. Running since 2009.

The base is a donation from Knut and Alice Wallenberg Foundation.
The forest industry is supporting via the national platform Treesearch.

WWSC WALLENBERG WOOD SCIENCE CENTER

Knut och Alice Wallenbergs Stiftelse

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CHALMERS

LINKÖPINGS UNIVERSITET

Wallenberg Wood Science Center



Merima Hasani
Chalmers



Eva Malmström
KTH





Mats Fahlman
LiU



Jakob Wohlert
KTH



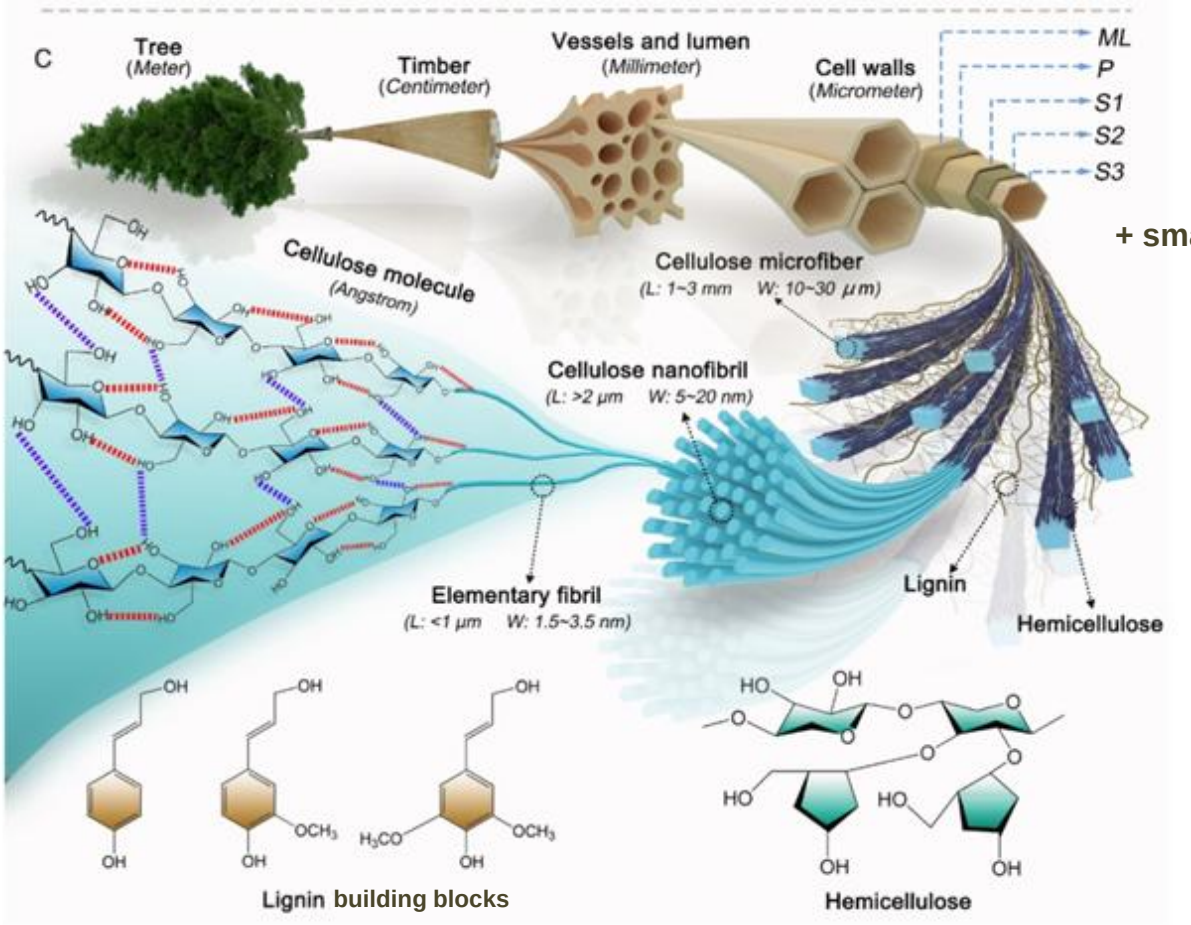
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CHALMERS
LINKÖPINGS UNIVERSITET

Adopted from Wei, Wan, Wu Green Chem. **2023**,25, 3322–3353

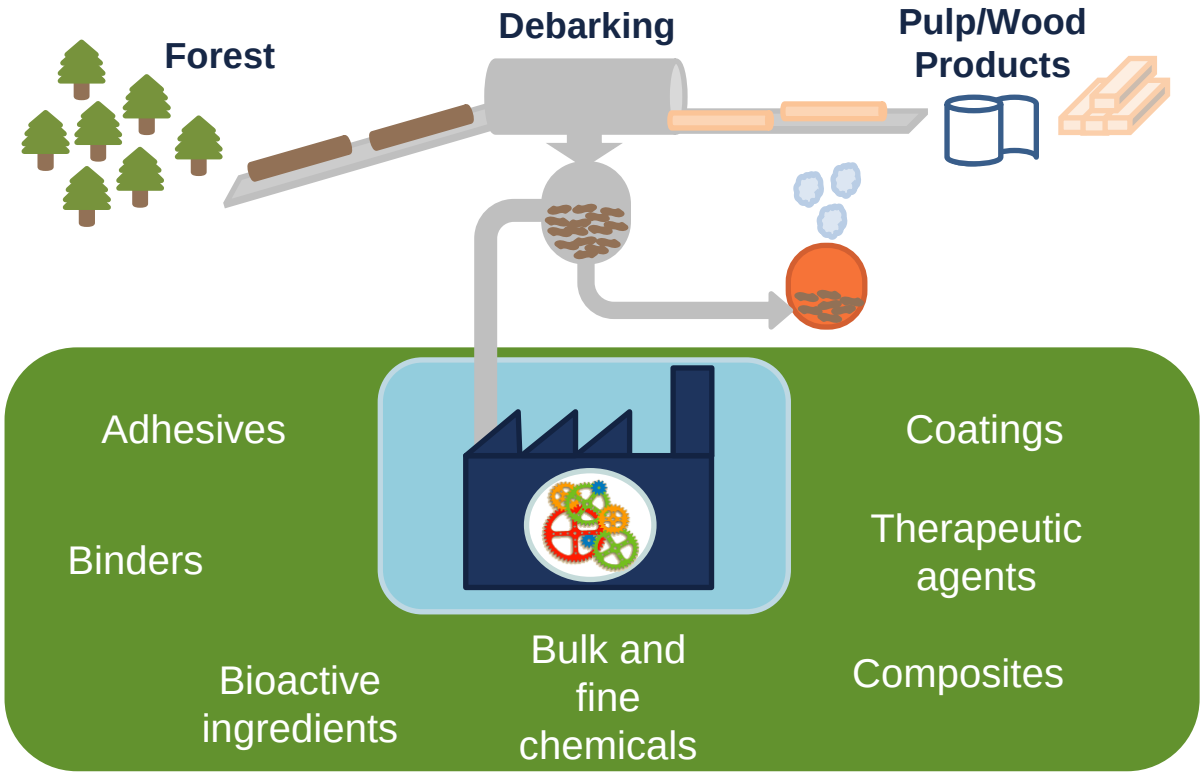
Wood is an amazing, hierarchical material





+ small molecules

Bark biorefinery





Ek

Biocomposites Based on Birch Suberin



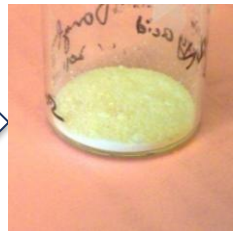
Ek

Birch outer bark



Isolation

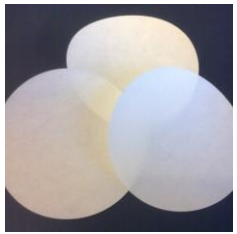
Epoxy fatty acid (8% w/w)



Lipase catalyzed polymerization 5 h

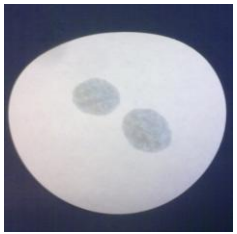
Homo-polyester (wax-like, DP=142)

Cellulose



Hot press 150°C

Non-hydrophobic





Hydrophobic biocomposite

Contact angle=142°

Hydrophobic cellulose

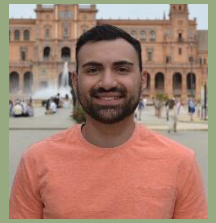


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LINKÖPINGS UNIVERSITET



Raffaele

Project IV-10: Wood-based barriers for wood-based materials

Bio-inspired barrier material from birch bark

Supervisor: **Mikael Hedenqvist**

Collaborators: Isabella Kwan, Veerababu Polissetti, Monica Ek, Anna J.



Hedenqvist



Birch

Background

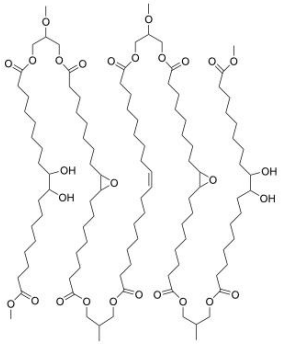
Sweden alone produces 2 million tons of bark each year, mainly exploited for energy production.

Objectives

Bark is rich in suberin, a biopolyster that has the potential to become a renewable feedstock of monomers for synthesis of packaging materials.

1 Extraction

Strucure based on fatty acids cross-linked with glycerol

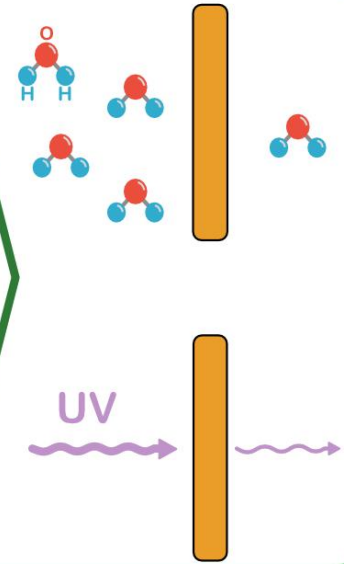


2 Synthesis

Thermoforming step to obtain thin and flexible films



3 Charcterization



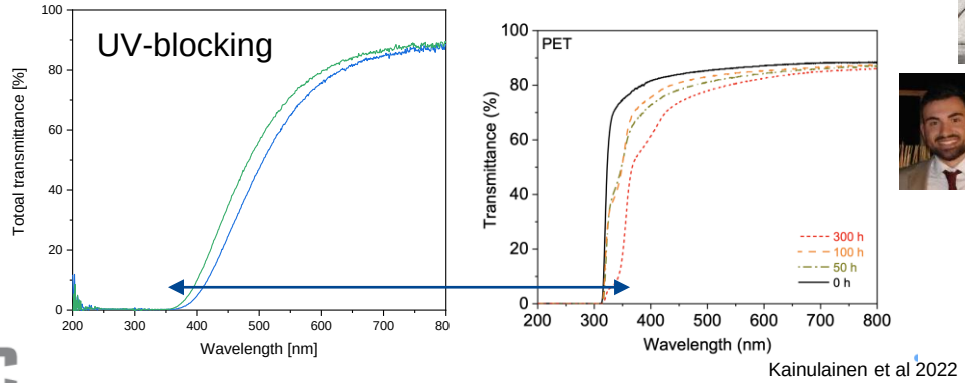
Barrier/packaging film from birch bark



Hedenqvist







Kainulainen et al 2022

Raffaele Perrotta, PhD student

Co-supervisors

Monica Ek



Anna Hanner



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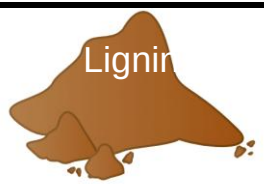
Perrotta et al, *ACS Sust. Chem. Eng.*, 13 (2025) 9206-9217.

Advancing Lignin Analytics: High Precision Structure Determination



Lawoko

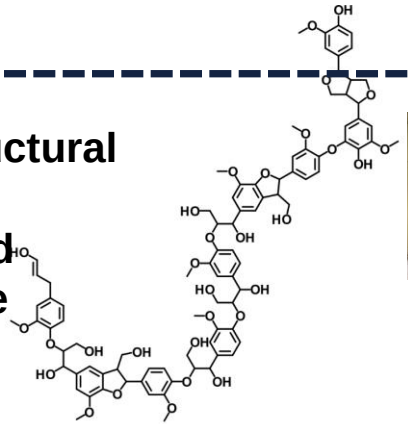
Established Literature

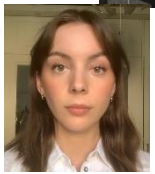


NMR



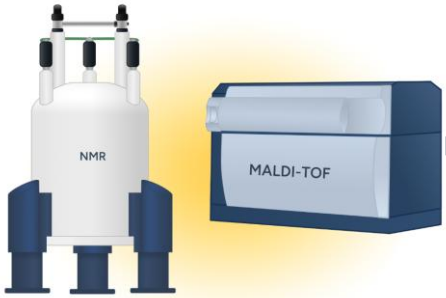
- **One Structural Motif**
- **Averaged structure**



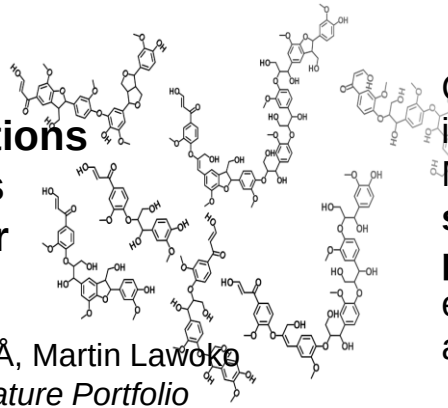


Filippa Ludwig

NMR + MALDI-TOF



- **Oligomer Populations**
- **Exact Molar Mass**
- **Precise Molecular Structure**



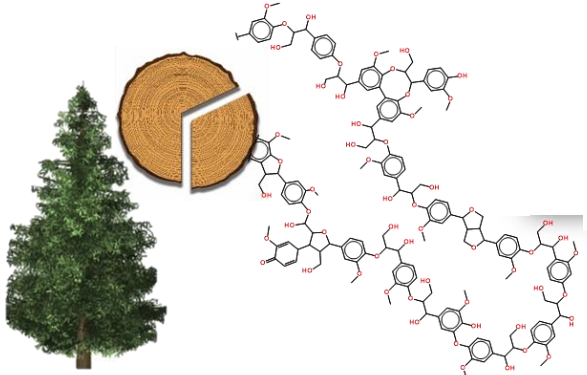
Filippa Ludvig , Åsa Emmer Å, Martin Lawoko
Accepted ChemCommun. Nature Portfolio

Combining structural information from NMR with MALDI TOF to **individually study molecular populations** of lignin - an essential milestone in lignin analytics.

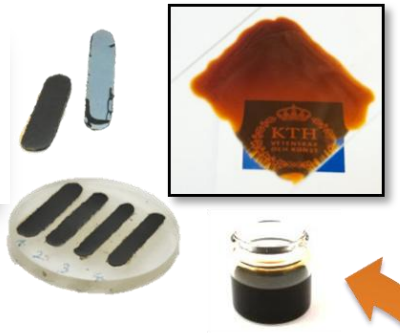
Lignin-based thermosets



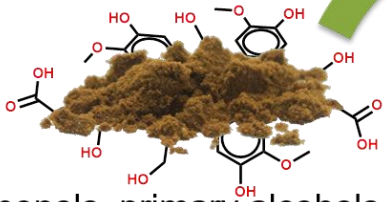
Johansson



Lignin – Aromatic & abundant



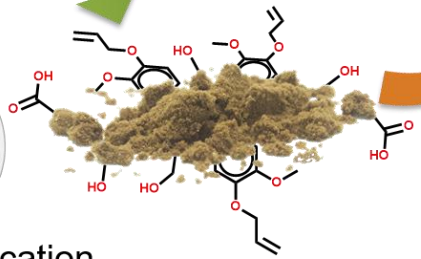
Thermosetting reactions



Phenols, primary alcohols & Carboxylic acids



Chemical modification



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Scale-up and demonstrator, Bioform


Hedenqvist

Compounding



LIGNIN INDUSTRIES AB™

Over 500 kg

Sheet Extrusion

5 mm thick sheet



Röchling



Evaluation

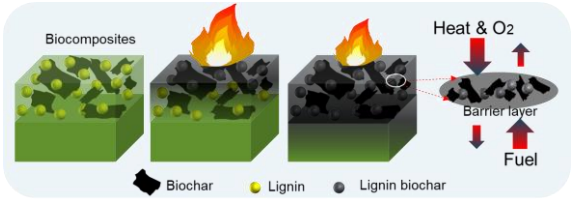
SLU SCANIA KTH VETENSKAP OCH KONST

Vacuum Forming



autoform

ABS and 20 % lignin



Wei et al., *Ind. Crops Prod.*, 233 (2025) 121402

Formaldehyde-free biobased wood adhesives

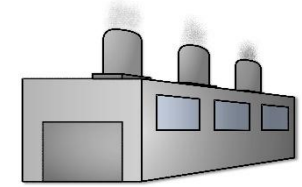


Fogelström



Malmström



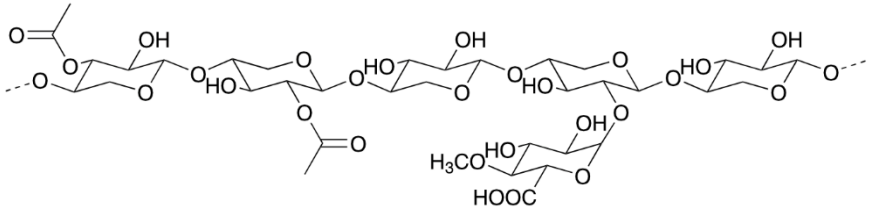


Pulp industry

Pulp



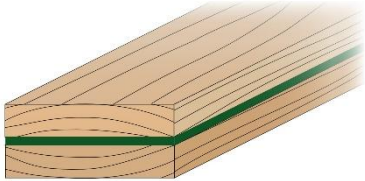
USD 5.3 billion (2022)



Pulp-process hemicelluloses



Adhesive

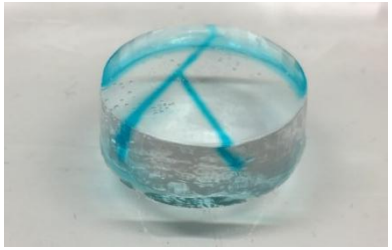


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Green Chem. **2021**, 23, 3322
ACS Sustainable Chem. Eng. **2022**, 10, 47, 1527

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Solid water

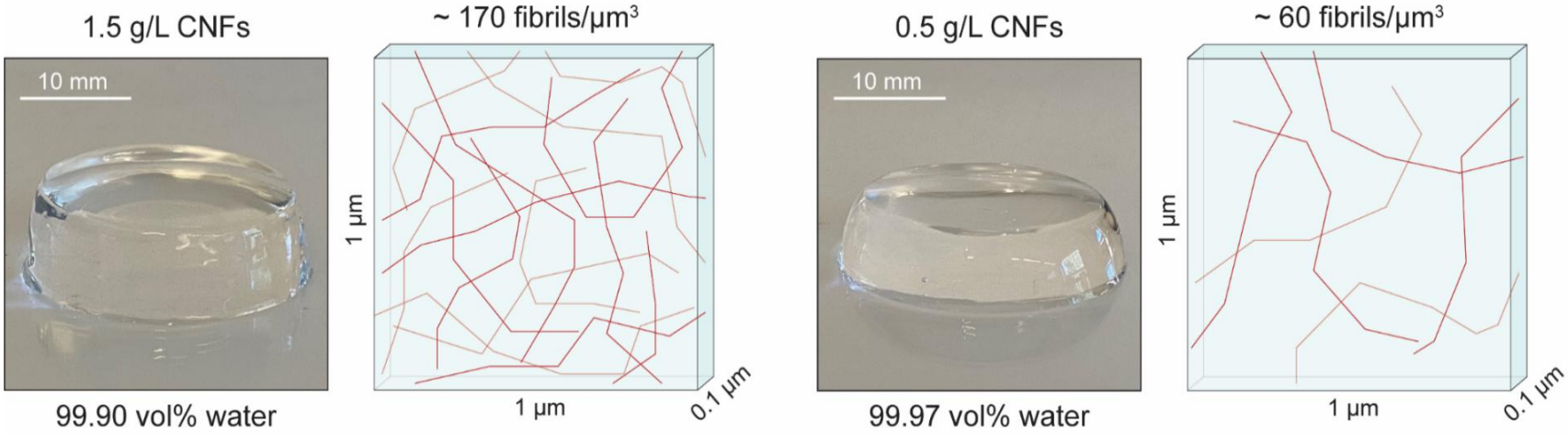




Rebecca Östmans
KTH



Lars Wågberg
KTH



99.1 – 99.7 vol% H_2O in the Baltic Sea

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Östmans et al., Materials Today Nano, 2024

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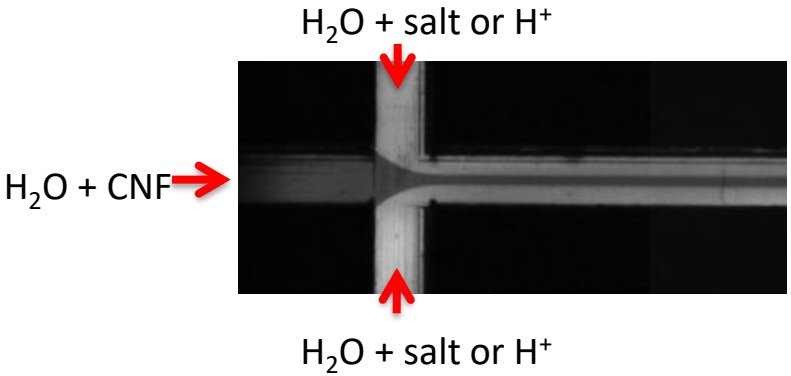
CHALMERS

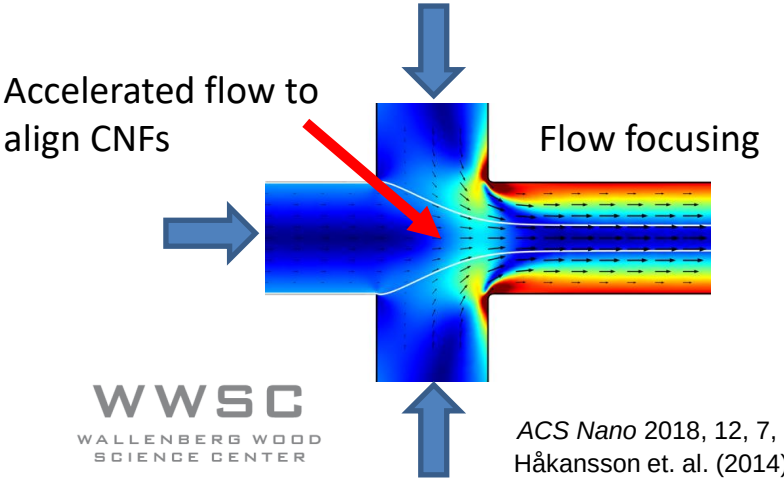
LINKÖPINGS UNIVERSITET

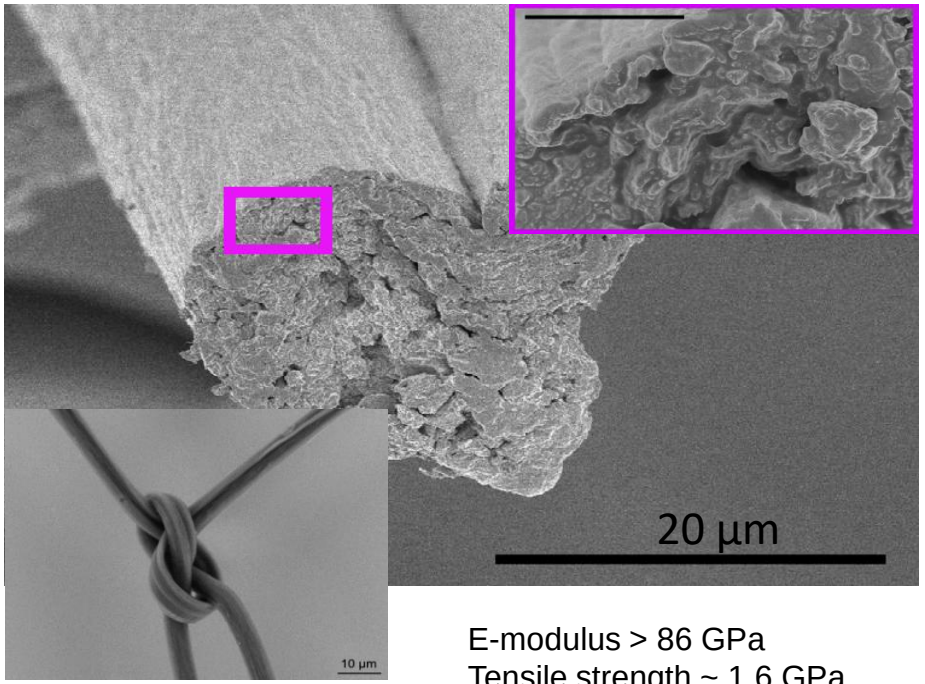
Super strong fibers



Daniel Söderberg
KTH







E-modulus > 86 GPa
Tensile strength ~ 1.6 GPa

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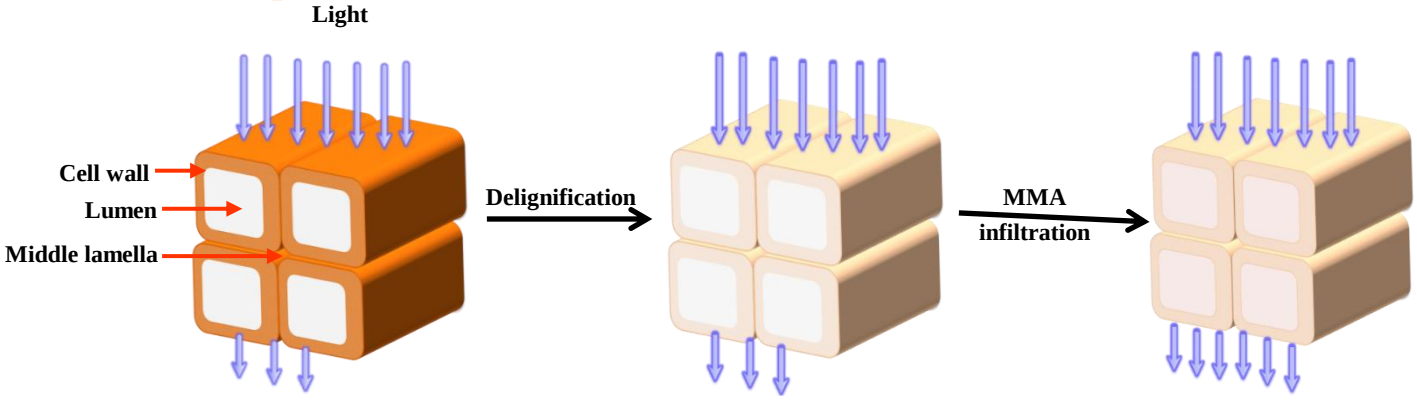
ACS Nano 2018, 12, 7, 6378–6388
Håkansson et. al. (2014), *Nature Communications*

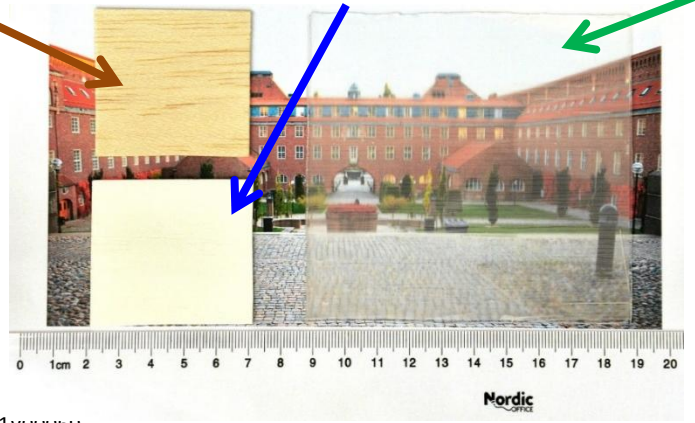
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CHALMERS
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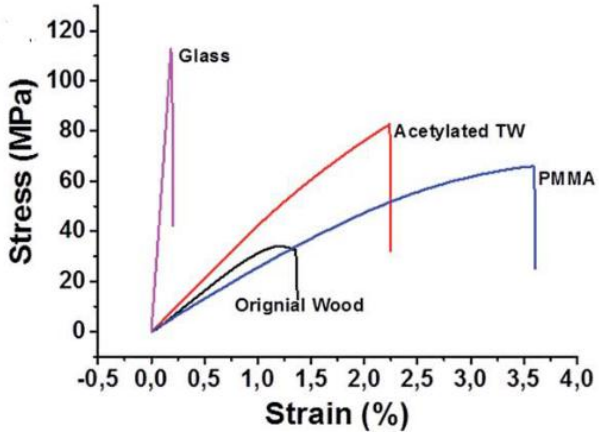
Transparent wood



Lars Berglund
KTH



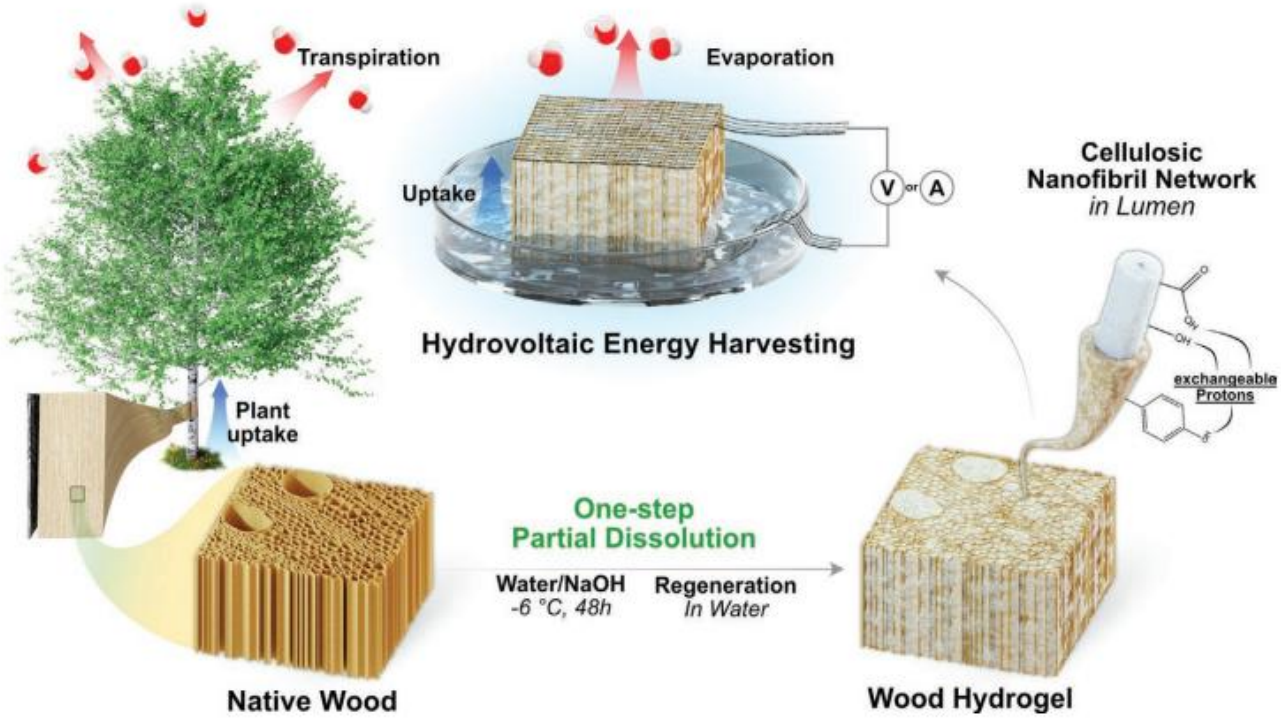




Adv. Optical Materials, 2018, **6**,14, 1800559
J. Mater. Chem. A, 2018, **6**, 1094-1101

Cell wall nanoengineering for hydrovoltaics

Adv. Funct. Mater. 2023, 33, 2208933



Open-circuit potential
≈140 mV
10x that of native wood



Li

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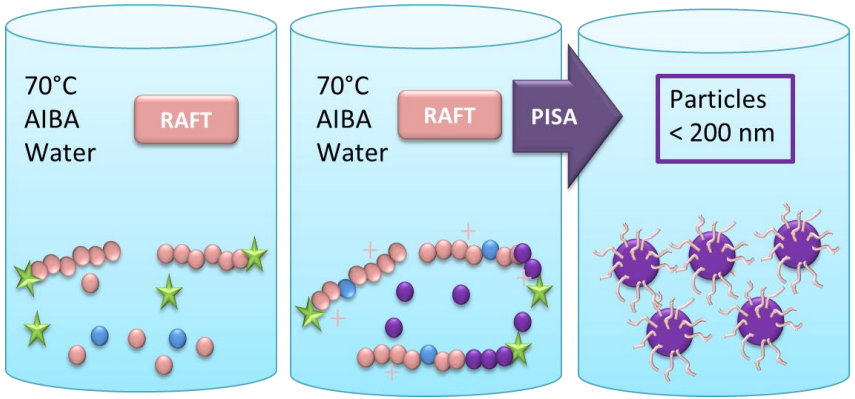
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Well-defined nanoparticles


Malmström



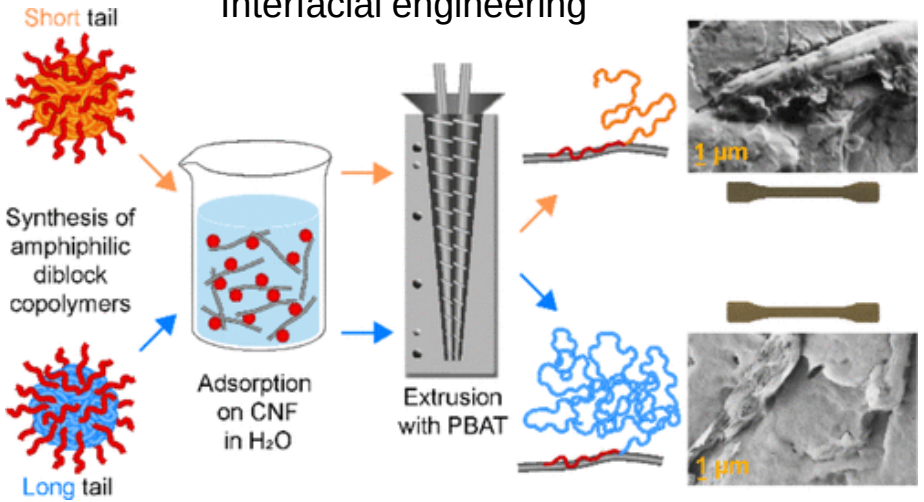
Biodegradability



Controlled radical polymerization
Self-stabilized particles by copolymerization

Malmström *et al.*
Polym. Chem. **2014**, 5, 6076-6086
Polym. Chem. **2017**, 8, 1061-1073

Interfacial engineering



Designed to attach to cellulose
Improve the load transfer

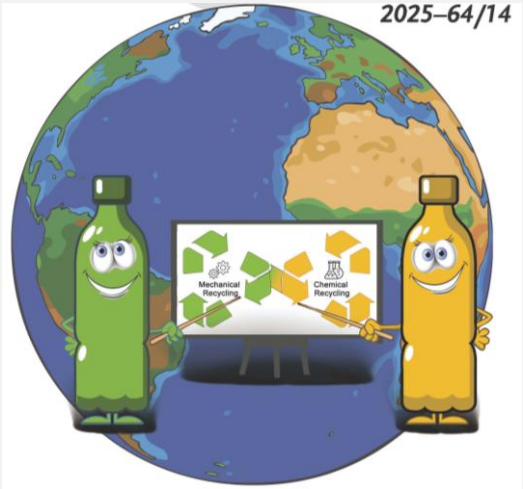
Lo Re, Malmström, Alexakis… *et al.*
ACS Applied Materials & Interfaces **2025** *17* (1), 2602-2614
DOI: 10.1021/acsami.4c17899

Design from biobased for circular end-of-life

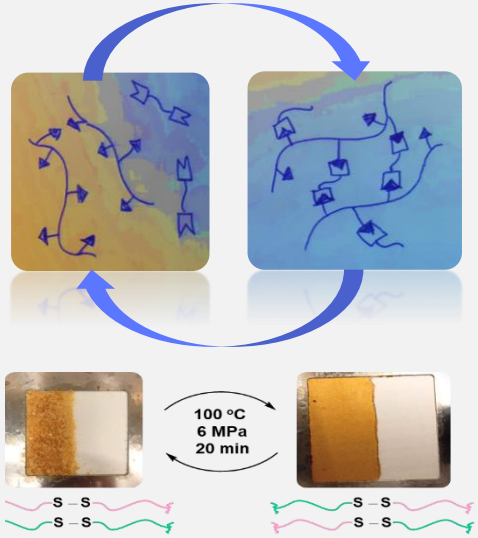

Hakkarainen


Odelius

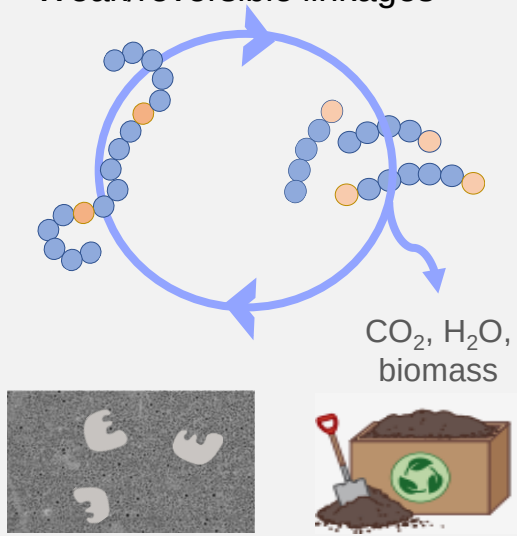
Molecular design for closed-loop mechanical and chemical circularity



Design for recycling with dynamic covalent chemistry.



Design for (bio)degradation:
Embedded enzymes
Weak/reversible linkages



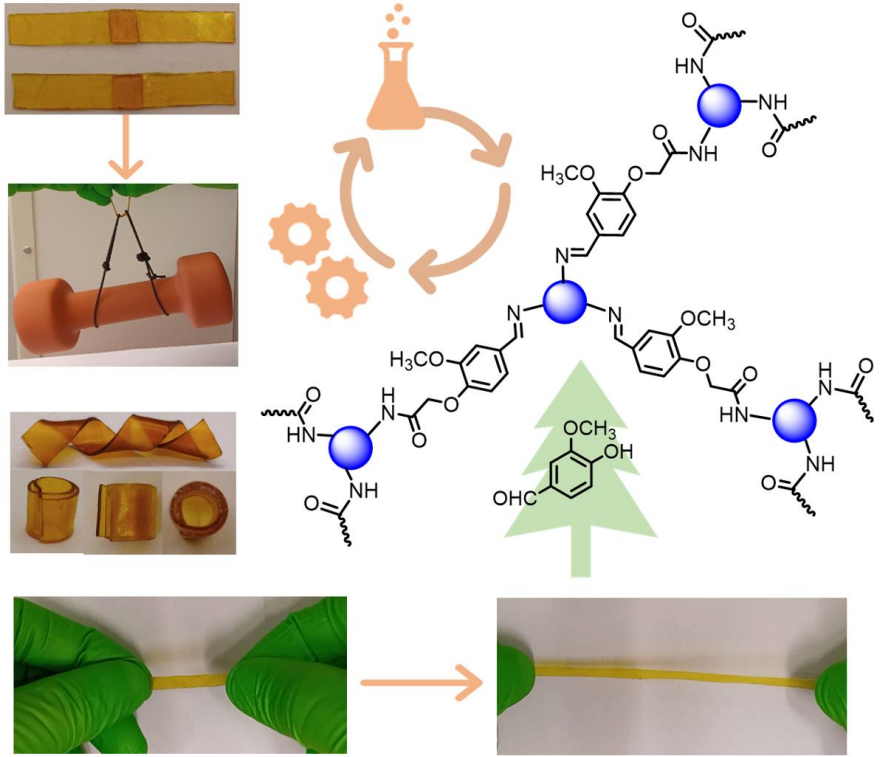
C. V. Aarsen, A. Liguori, R. Mattsson, M. Sipponen, M. Hakkarainen. *Chem. Rev.* 124 (2024) 8473-8515
Y. Han, P. Zhang, H. Zhou, T. Zhao, K. Odelius, M. Hakkarainen *Angew. Chem. Int.* (2025) e202421431

Biobased vitrimers -vanillin-derived polyimine-amides




Hakkarainen Syrén

- Easy and scalable synthesis
- Attractive mechanical & thermal properties
- Mechanically & chemically recyclable
- Self-healable & shape memory



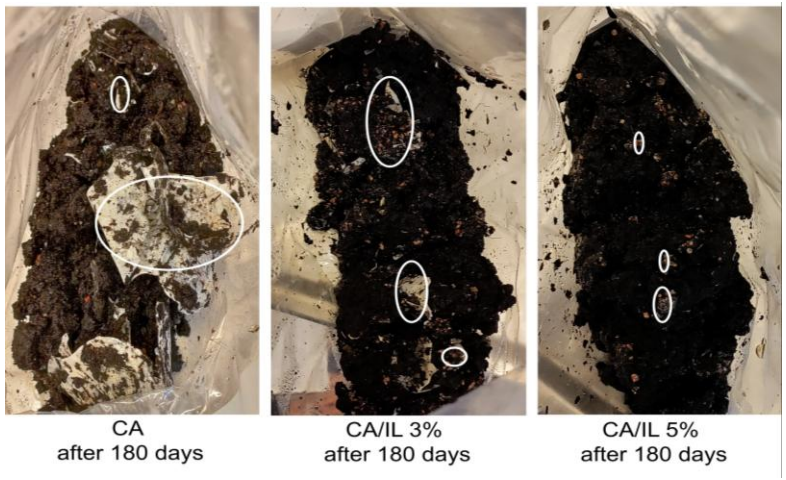
S. Subramaniyan, B. Zhang, P.-O. Syrén, M. Hakkarainen, *Chem. Eng. J.* 501 (2024) 157632.

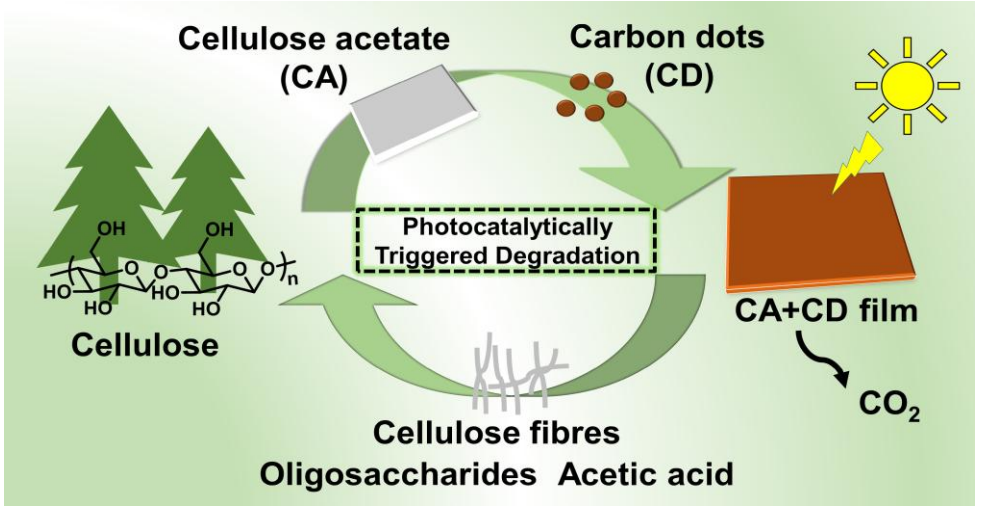
Green additives as degradation triggers



Hakkarainen

Embedded enzymes or photocatalytic carbon dots to trigger deacetylation of cellulose acetate





Compost soil after 180 days of degradation of cellulose acetate with or without embedded enzymes (IL-immobilized lipase)

N. K. Kalita, M. Hakkarainen. *Biomacromolecules* 24 (2023) 3290.
N. B. Erdal, M. Hakkarainen. *Biomacromolecules* 23 (2022) 2713.
N. Yadav, K.H. Adolfsson, M. Hakkarainen. *Biomacromolecules* 22 (2021) 2211.

Strong and tough gluten/glycerol





S. Liu, M. Bettelli et al., Macromol. Mater. Eng., 308 (2023) 2200630

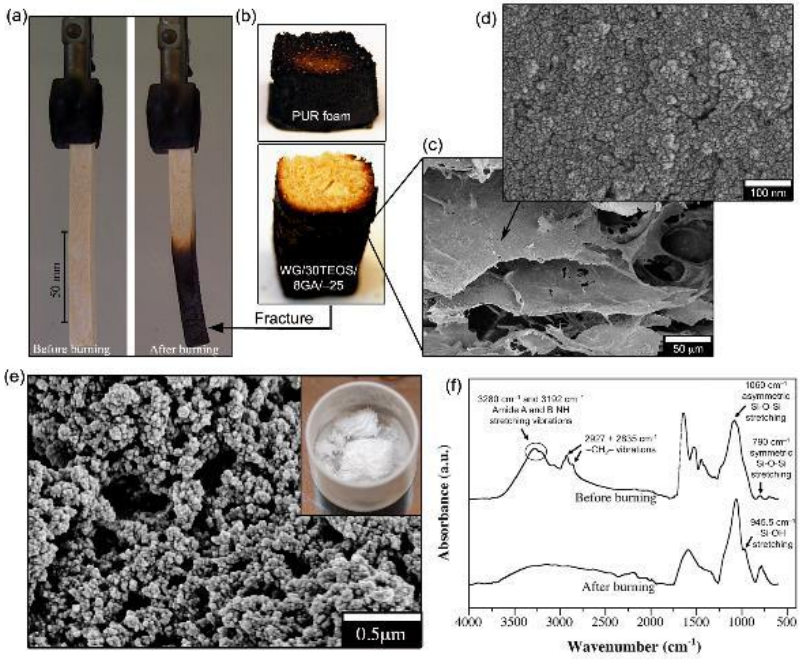


Hedenqvist

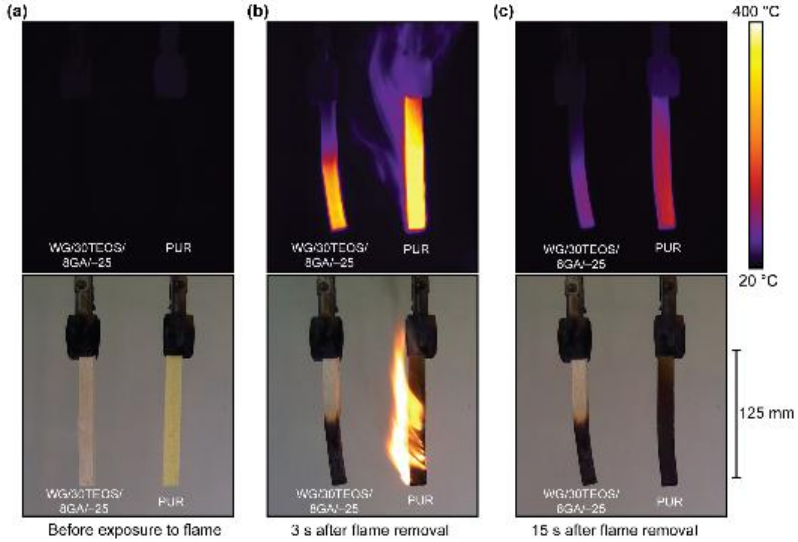
Hybrid films and foams
In-situ polymerized silica

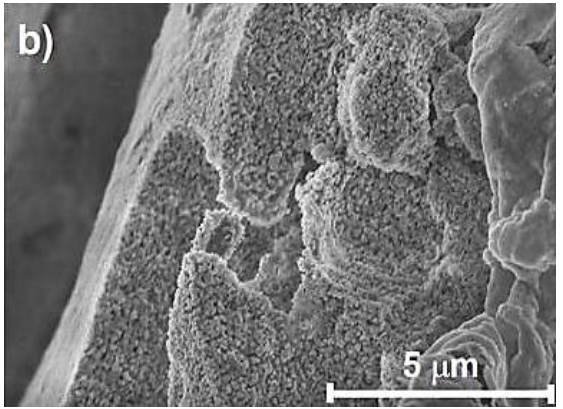
fire properties

Gluten



Q. Wu et al., *J. Mater. Chem. A* **2** (2014) 20996–21009.





H. Türe et al., *Macromol. Chem. Phys.* **214**, (2013) 1131-1139.



THANK YOU

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WWSC

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