

Polymer Research at University of Borås

“Polymer Materials for the Circular Economy”

Professor Mikael Skrifvars

**Faculty of Textiles, Engineering
and Business, University of Borås**

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SuPRA Event Days Södertälje
September 4 – 5, 2024



UNIVERSITY OF BORÅS
SCIENCE FOR THE PROFESSIONS

Faculty of Textiles, Engineering and Business

Department of Resource Recovery and Building Technology

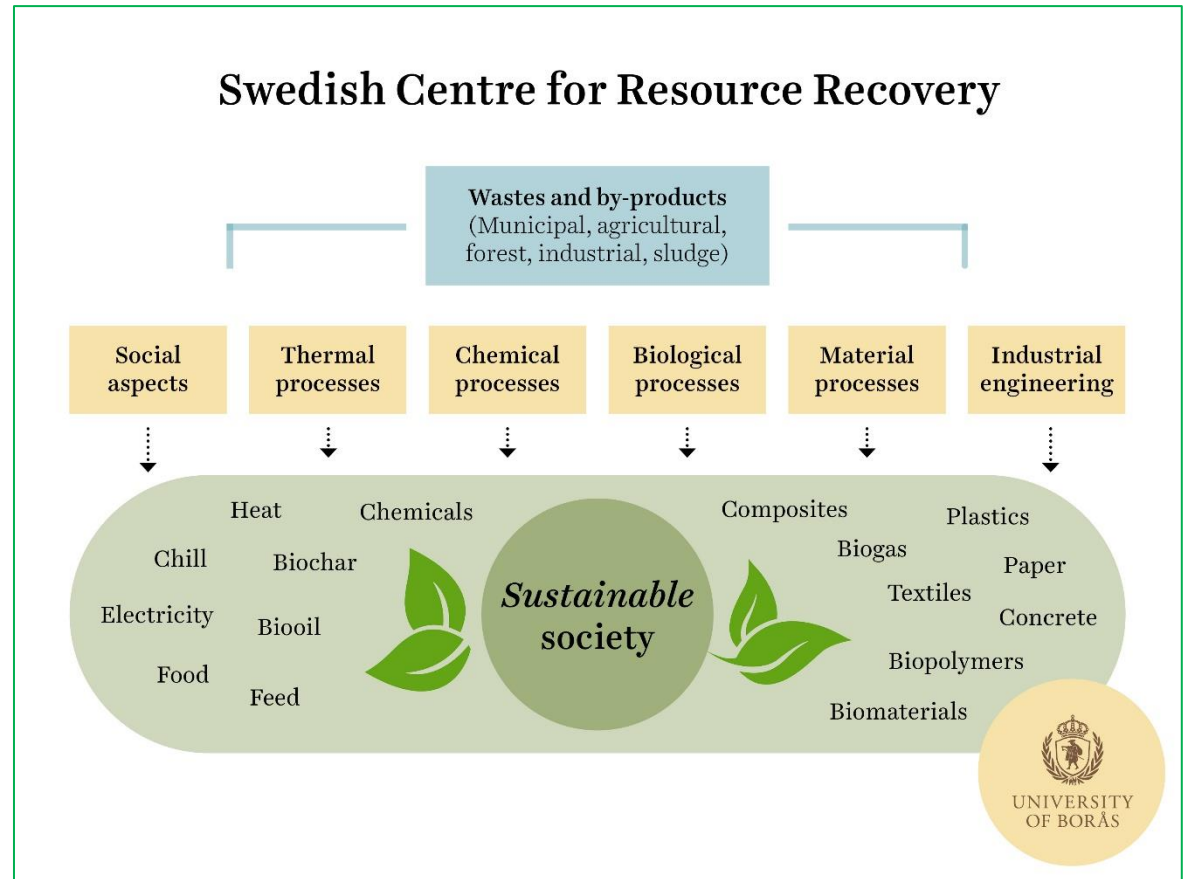
Four research groups led by professor:

- Biotechnology
- Polymer Technology
- Combustion and Thermal Processes
- Resource Management

**1200 square meters labs,
5 lab technicians**

PhD School Resource Recovery

34 ongoing PhD students
34 PhD completed



Polymer technology research group

Dep of Resource Recovery:

- **Professor Mikael Skrifvars**
- Dr Dan Åkesson, docent
- Dr Pooria Khalili, docent
- Dr Faranak Bazooyar, lecturer
- Dr Sunil Kumar Lindström Ramamoorthy, lecturer
- Dr Mina Arya, post doc
- Ville Skrifvars, lab technician
- Jonas Hansson, lab technician

Dep of Textile Technology:

- Dr Tariq Bashir, lecturer
- Dr Behnaz Baghaei, lecturer

Dep of Engineering:

- Dr Fathi Gouda, lecturer

External members:

- Professor Hom Dhakal, University of Portsmouth
- Dr Juliana Aristeia de Lima, RISE, docent
- Dr Adib Kalantar, MuoviTech



PhD students:

- Matilda Johansson
- Sabrina Kopf
- Samira Akbari
- Emmanuel Kalu
- Shahab Nasr
- Giulia Simao de Sousa
- Jeevan Joseph

MSc Program in Resource Recovery – Polymer Materials for the Circular Economy

Year 1 - Semester 1

30 credits courses on resource recovery:

- Resource recovery I
- Resource recovery II
- Circular economy
- Life cycle assessment
- Theory of science and research methodology

Year 1 – Semester 2

30 credits courses on polymer materials:

- Polymer technology
- Polymers and textiles in composites
- Polymeric and textile materials in the environment
- Experimental methods for polymers and textiles

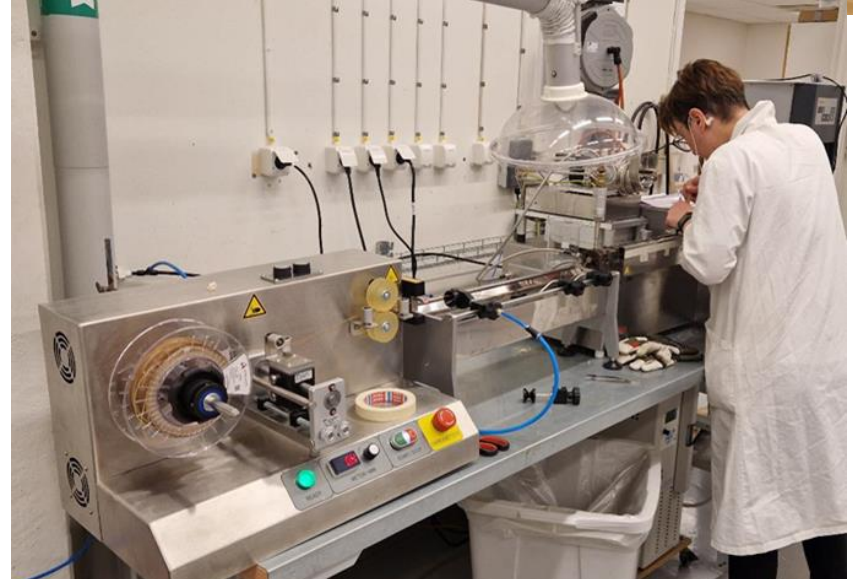
Year 2 – Semester 1 and 2

- 60 credits MSc thesis project or 30 credits elective courses + 30 credits MSc thesis project



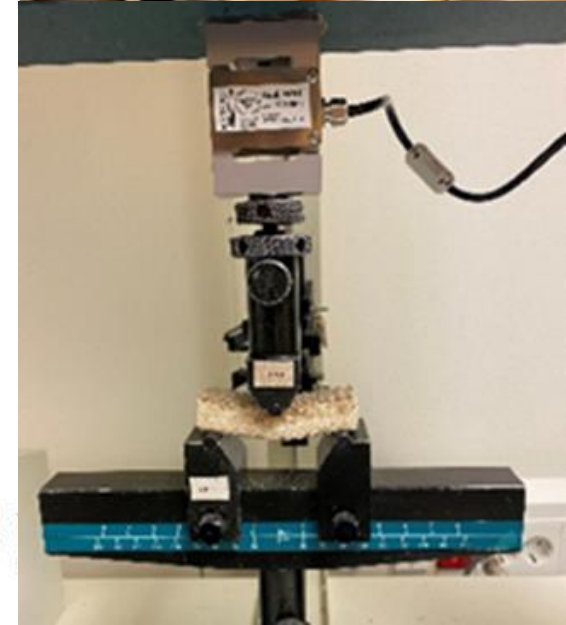
Lab equipment – Polymer and composite manufacturing and processing

- Microcompounder (15 g batch size)
- Double screw extruder equipped with 3D filament and film extrusion capability (2 kg/h throughput)
- Two injection moulding machine for lab scale
- Piston spinning equipment for polymer filaments (120 g capacity/batch)
- Several 3D printers for additive manufacturing
- Two hydraulic presses for compression moulding
- Equipment for thermoset processing (RTM and vacuum infusion)



Lab equipment – Characterisation and mechanical testing

- Two DSCs, two TGAs and a DMTA from TA Instruments
- Tensile testing machine for tensile and flexural testing
- Impact testing machine, pendulum
- FT IR spectrometer with TGA connection
- Laser cutting and CNC machine for specimen preparation
- Nikon Eclipse LV150 microscope with polarisator, xyz-motorized sample table and Linkam LTS420 hot stage
- Nikon SMZ800 stereomicroscope
- Climate chambers and heating cabinets for environmental conditioning



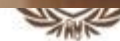
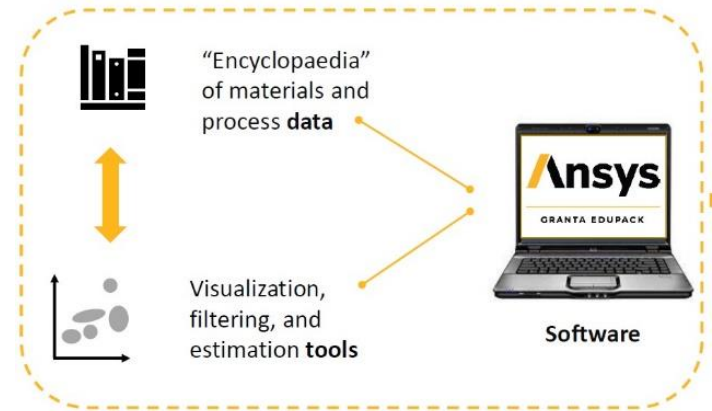
Digital Material Lab

Digital Material Lab – Tasks:

- Experimental equipment for material processing and characterization
- Computing resources for modeling and simulation
- Prototype workshop for construction and evaluation

Digital Material Lab for students:

- Test a material idea for a product
- Do an innovative thesis
- Explore new ways of doing material development
- Test a material solution for a current material challenge
- Be able to be close to research resources and companies



Polymer technology PhD students – ongoing

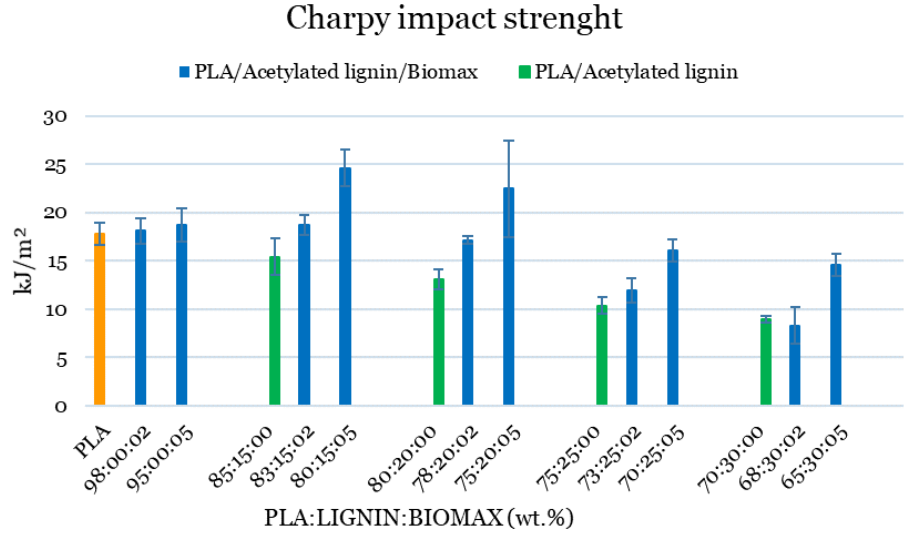
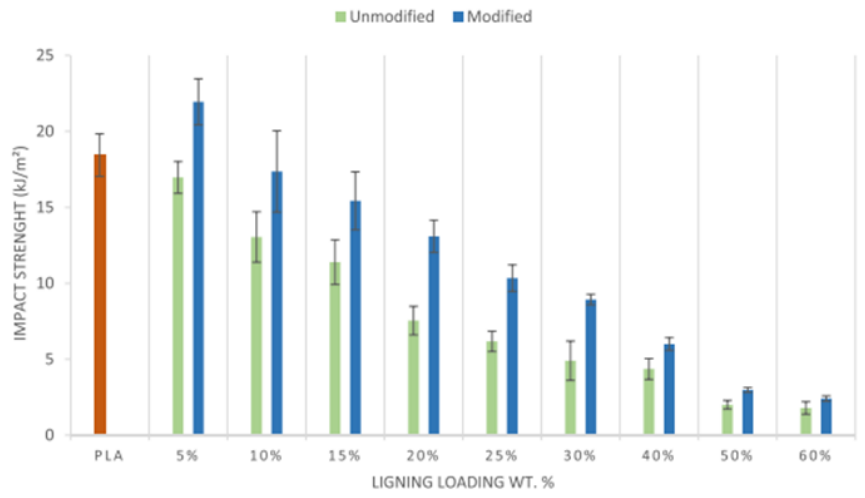
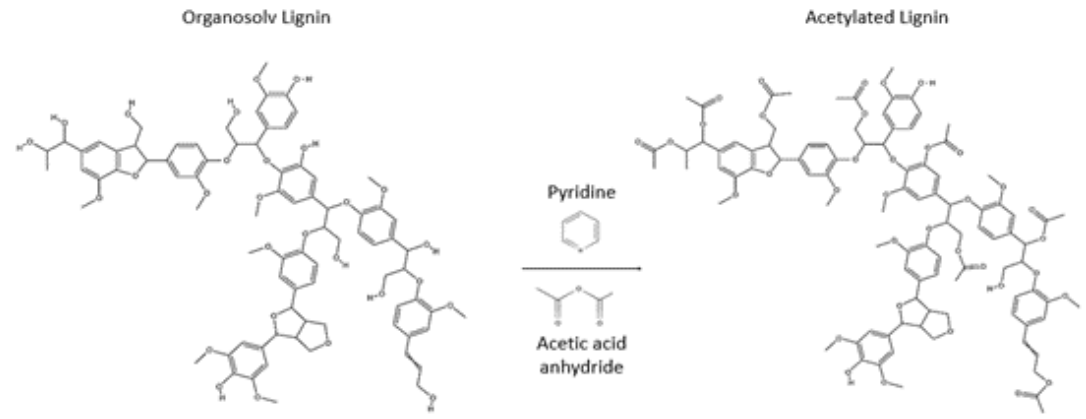
- **Matilda Johansson:** *Lignocellulosic biocomposites for structural high impact applications*, planned graduation 2025
- **Sabrina Kopf:** *Synthesis and development of biopolymeric polyhydroxyalkanoate textile fibres for bone tissue engineering*, planned graduation 2025
- **Emmanuel Kalu:** *Development and studies on biobased sandwich composites for load bearing applications*, planned graduation 2026
- **Shahab Nasr:** *Development of nanocellulose modified emulsion polymers for coating latex applications*, planned graduation 2026
- **Jeevan Joseph:** *Low carbon footprint polypropylene*, planned graduation 2025 (PhLic, Jönköping University)
- **Samira Akbari:** *Synthesis and characterization of bio-based thermoset resins*, planned graduation, 2027



Matilda Johansson: Polylactic acid – lignin blends for use in structural high impact applications (planned PhD defence 2025)

Lignin extracted from wheat straw by organosolv method provided by Fortum, Finland

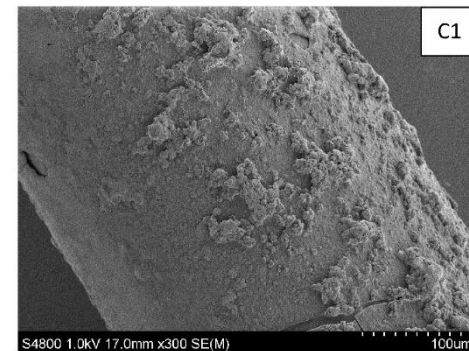
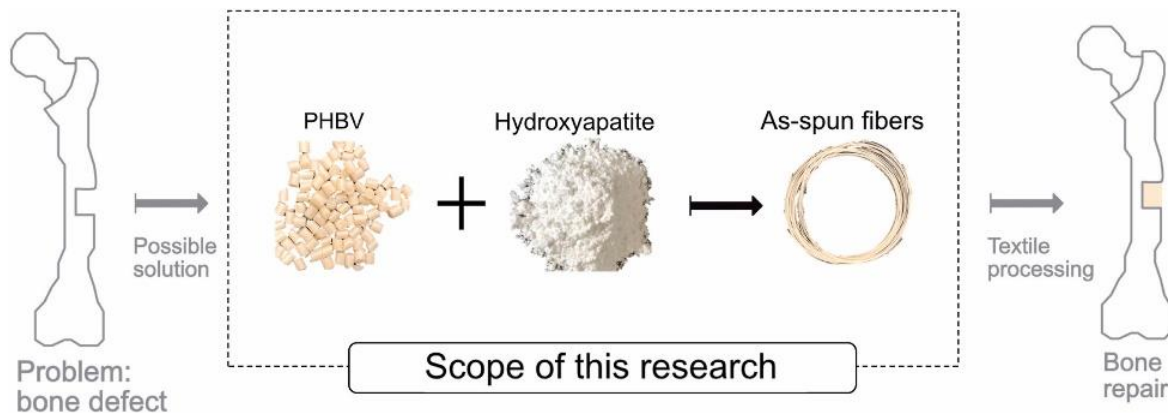
1. Lignin acetylation
2. Compounding with PLA
3. Modification with impact modifier



Composites Part C 14 (2024) 100502
 Industrial Crops and Products 202 (2023) 117049

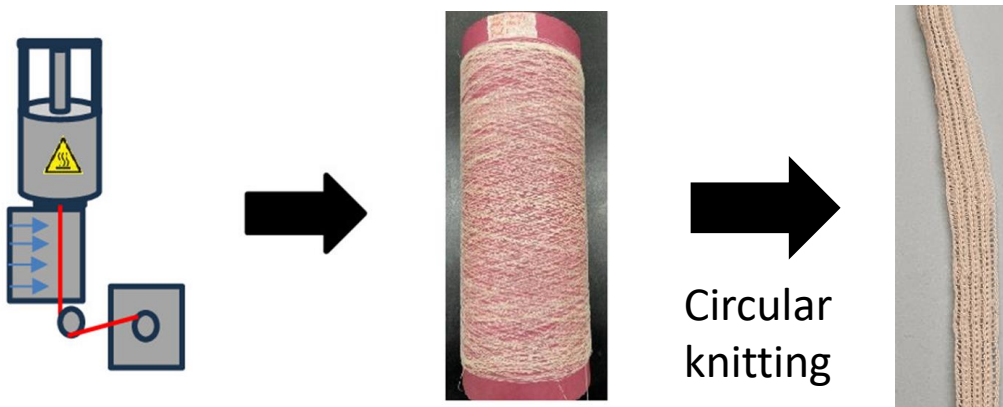
Sabrina Kopf: Synthesis and development of biopolymeric polyhydroxyalkanoate textile fibres for bone tissue engineering (planned PhD defence 2025)

1. Melt spinning of poly(3-hydroxybutyrate-co-3-hydroxyvalerate)/hydroxyapatite composite fibers



Ca/P biomineralisation in synthetic bodyfluid

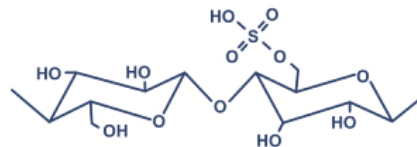
2. Production of textile from melt-spun poly(3-hydroxybutyrate)/poly(3-hydroxybutyrate-co-4-hydroxybutyrate) blend monofilaments



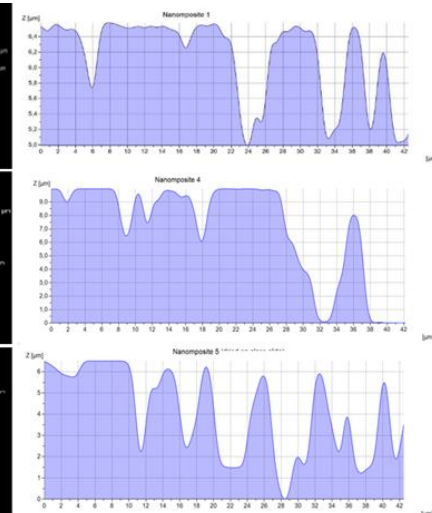
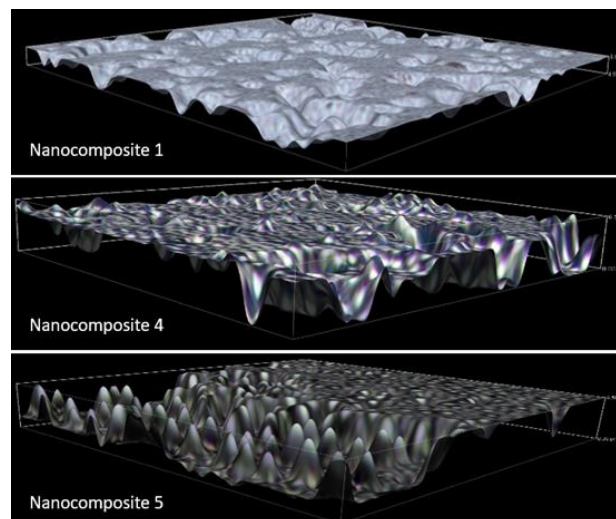
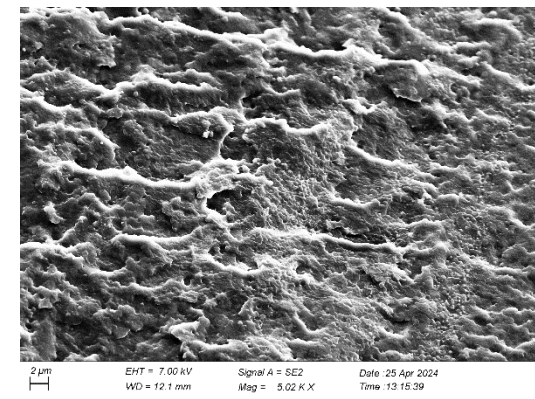
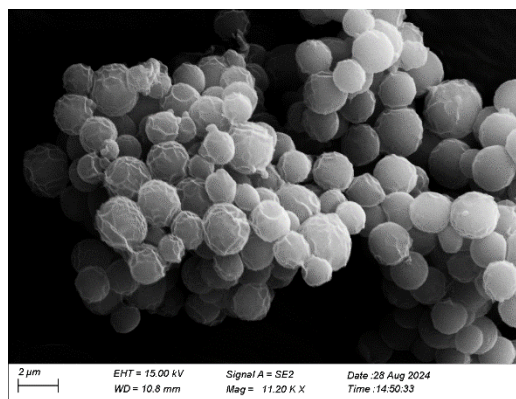
Results in Materials 20 (2023) 100465
ACS Omega 9 (2024) 27415

Shahab Nasr: Synthesis of CNC nanocomposite PVA latex by emulsion polymerisation (planned PhD defence 2026)

CelluForce sulfate-half-ester CNC



Emulsion polymerisation of vinyl acetate



Adib Kalantar: Thermally conductive high-density polyethylene composites for ground heat exchangers (PhD thesis 2020)

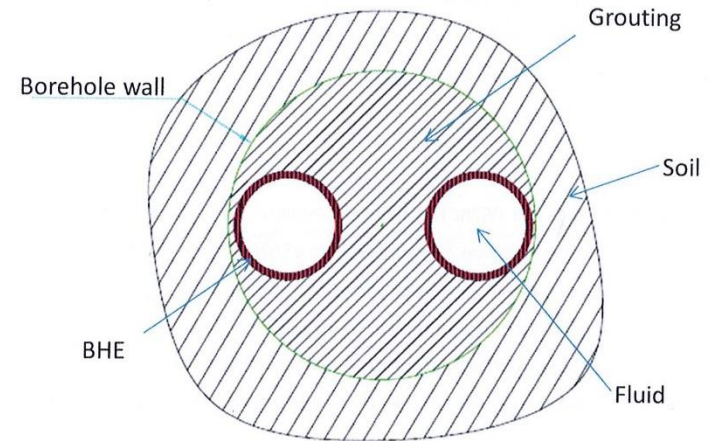


Figure 8. Cross section of a borehole. In Scandinavia, grouting is not obligatory, and the borehole is water filled

Challenges for large diameter and thick wall pipes:

- Slow cooling process - > inhomogeneous wall thickness due to sagging of melted polymer
- Thermal gradient in the wall leading to inhomogeneous crystallisation and shrinkage
- Formation of residual stresses in wall which might lead to accelerate pipe failure

$\Phi = 32$ to 50 mm

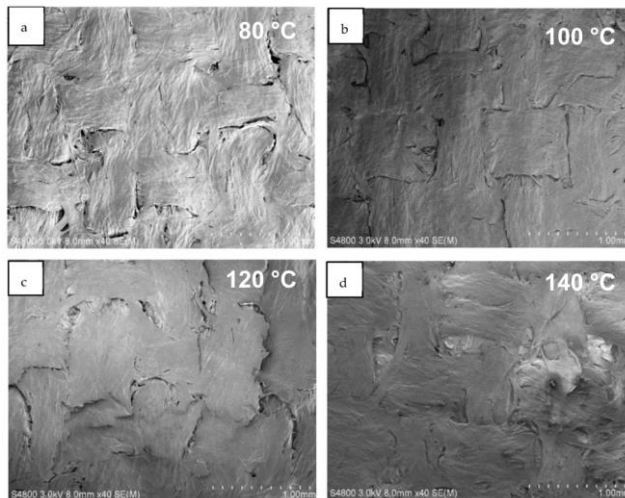
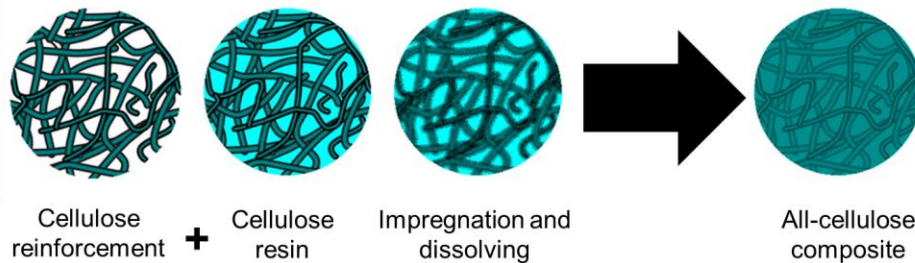
560 to 500 m length

Bimodal HDPE pipe grade PE100



All-cellulose composites

Cellulose fibre reinforcements embedded in a cellulose resin (matrix)



SEM of nanocellulose modified all-cellulose composite surfaces – effect of press temperature

Potential benefits

- Biobased and renewable
- Perfect chemical bonding and compatibility between matrix and reinforcement
- Possibility to have high reinforcement content and very good mechanical properties
- Single material composite, which facilitates end-of-life treatment and recycling

Industry co-operation

Juteborg

Ecoist

Borealis Polymers

Loop Factory

Albany International

GKN Aerospace

Biofiber Tech

Volvo Construction Equipment

Muovitech

DINAIR

Stena Recycling

Borgstena

Polestar

Texla



Thank you for the attention!



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