WWSC
WALLENBERG WOOD SCIENCE CENTER

New sustainable materials from trees

Annual report 2024

KTH VETENSKAP OCH KONST · CHALMERS · LiU LINKÖPINGS UNIVERSITET · TREESEARCH · Knut och Alice Wallenbergs Stiftelse

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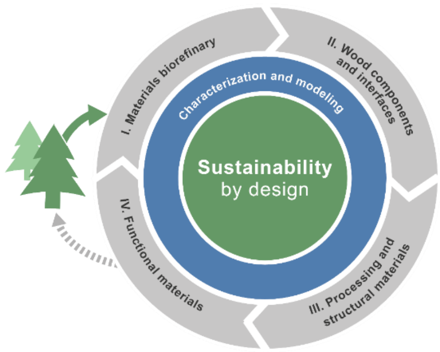
Wallenberg Wood Science Center

The Wallenberg Wood Science Center (WWSC) is a multidisciplinary research initiative funded by the Knut and Alice Wallenberg Foundation and jointly run by KTH, Chalmers and Linköping University with participation from Luleå University of Technology, Stockholm University and Umeå University. The center's overarching mission is to develop new sustainable materials from forest biomass, with a strong emphasis on advancing a circular bioeconomy and reducing global dependence on fossil resources. The center currently gathers approximately 70 researchers, 50 PhD students and 25 postdoctoral fellows. The PhD students are enrolled at their home universities but meet twice per year in WWSC Academy, a research graduate school, that intend to provide the PhD candidates with a strong knowledge base in areas related to WWSC's research.



WWSC 2024

During 2024, WWSC pursued an ambitious and diverse research agenda in which chemistry, materials science, biology and device engineering were tightly integrated. The result is a portfolio that combines fundamental discoveries with applied developments in areas ranging from microbial valorization and green chemistry to composites, energy storage and biomedical applications.

A central theme in 2024 was the quest for more selective and resource-efficient ways of separating and valorizing the different components of wood. Researchers explored enzymatic and microbial routes for breaking down bark and other underutilized fractions, identifying new bacterial species and fungi capable of deconstructing resin acids, suberin and other complex polymers. These discoveries yielded novel enzymes with potential for tailored release of long-chain fatty acids and for improved breakdown of lignocellulosic tissue, while studies of microbial communities degrading pulp mill sludge opened pathways to upcycle industrial residues into valuable flame-retardant materials. At the same time, new chemical fractionation concepts were investigated, such as glycerol-based delignification under mild conditions and oxidative extraction routes designed to provide aldehyde-functionalized polysaccharides. These methods not only enhanced the efficiency of biomass separation but also offered access to functional building blocks that can feed into advanced materials development.

The valorization of lignin and hemicelluloses was another unifying thread. Lignin nanoparticles were tested as UV-absorbing stabilizers in sunscreen formulations, as components in thermoplastic and thermoset gels, and as precursors for carbonaceous materials for energy storage. Novel solvent-free mechanochemical strategies for lignin modification complemented more traditional chemical approaches, providing scalable routes toward functional additives. In parallel, cellulose and hemicellulose chemistries were pushed forward, with gas-phase esterification, oxime ligation and enzymatic oxidation offering mild and selective pathways for tailoring reactivity. Sophisticated analytical methods—including advanced NMR, MALDI-TOF mass spectrometry and electron microscopy—were refined to probe molecular structure and surface reactions in unprecedented detail, ensuring that modifications could be understood and controlled down to the nanoscale.

Molecular-level efforts were closely linked to advances in polymer and composite science. Researchers designed recyclable wood-plastic composites through reactive extrusion, integrated enzymatic catalysis into polyester degradation, and developed vanillin-based monomers that gave rise to recyclable high-performance polymers. Hybrid materials combining cellulose with conjugated polymers were engineered for use in organic electronic devices, where the addition of nanocellulose improved ion transport and mechanical integrity. In the field of biocomposites, spun cellulose filaments infused with lignin-based resins yielded materials with exceptional stiffness and toughness, while transparent cellulose fiber composites and mycelium-based boards emerged as promising alternatives for packaging and insulation. The interplay of structure, processing and functionality was a recurring theme, explored using advanced rheology, synchrotron-based SAXS/WAXS, and molecular simulations of water–cellulose interactions.

Energy and electronic applications represented another major focus. Cellulose-based membranes were investigated as sustainable alternatives to fluorinated polymers in redox flow batteries, with new analytical tools guiding optimization. Biodegradable hydrogels and cellulose separators were incorporated into zinc-ion batteries, enhancing their performance and recyclability. Conductive wood veneers were transformed into ionic diodes and studied for their anisotropic transport properties, while CNF-based aerogels were developed as multifunctional sensors. In parallel, research on photonic and optical applications combined wood templates with conducting polymers to control thermal radiation and exploit solar heating or evaporative cooling for energy harvesting. Biomedical applications also advanced: cellulose-based composite electrodes were fabricated as flexible neural interfaces, showing improved electrochemical properties and stability, and research on biodegradable adhesives, coatings and surface-engineered interfaces underscored the potential of wood-based materials to replace fossil-derived systems in healthcare and packaging alike.

Across these activities, WWSC maintained a clear emphasis on circularity and sustainability. Projects on compostable lignin-based materials and recyclable conjugated polymers highlighted the importance of designing for reuse and end-of-life, while the exploration of biobased barriers and filters connected wood science directly to pressing needs in packaging and clean air technologies. High-impact publications in leading journals underlined the scientific reach of the work, while collaborations with industrial and international partners ensured that discoveries were aligned with application pathways.

Taken together, the 2024 research portfolio demonstrates how WWSC integrates fundamental science with applied innovation. By coupling enzyme discovery with advanced spectroscopy, green chemistry with polymer processing, and biocomposite development with device engineering, the center is steadily advancing the vision of a forest-based bioeconomy. The activities of the year reveal not only remarkable progress in valorizing lignin, cellulose and underutilized biomass fractions, but also an expanding frontier where wood-derived materials contribute to energy storage, biomedical devices, packaging, and photonic systems. In this way, WWSC continues to position Sweden at the forefront of sustainable materials research, demonstrating the power of cross-disciplinary collaboration to create high-value, circular solutions from one of the country's most abundant natural resource.

WWSC Program I: Materials biorefinery

Active PIs

Chalmers: Merima Hasani – Program I responsible, Johan Larsbrin – Program I co-responsible, Lisbeth Olsson, Liyang Liu, Amparo Jimenez-Quero; KTH: Gunnar Henriksson, Martin Lawoko, Lauren McKee, Francisco Vilaplana, Olena Sevastyanova; LiU: Reverant Crispin

Overview of the activities within the program

The work in Program I is focused on establishing structural and processing knowledge critical for highly selective and sustainable decoupling of the forest biomass with structure and functionality control. Having resource efficient biomass utilization as a priority, a particular focus is on recovery and valorization of underutilized resources (ranging from lignin and bark to pulp mill sludge) and gaining a deep mechanistic understanding of the decoupling processes.

The work on bark valorization relies on identifying microbial pathways for its deconstruction and modification of individual components. Larsbrink *et al*. focus on understanding degradation pathways of resin acids, as one of the initial deconstruction steps and utilizing this knowledge for their functionalization. The newly discovered bacterial species *Pseudomonas abieticivorans* (eater of abietic acid) and the *P. abieticivorans* gene cluster are in focus, from which new active enzymes have been successfully produced, future focus being on structural product characterization to identify modifying action of the enzymes. In addition, long-term studies of microbial wood degradation are performed to identify key microorganisms and pathways steering the process. Enzyme discovery is also central in the research of Olsson *at el.* working on identifying esterases that can be used to release long chain fatty acids (LCFA) from suberin in bark, In collaboration with the Food Industries Research Institute in Hanoi, Vietnam and by extensive bioprospecting two filamentous fungi (*Talaromyces* sp2. AS616-3 and *Talaromyces* sp4. ASM115) that can grow on suberin-like sources and secrete esterases (potentially releasing LCFAs) have been identified. Insight in intermolecular bonding between suberin and other bark polymers is envisioned to enable development of efficient enzyme cocktails for releasing LCFAs. The group works also on lytic polysaccharide monooxygenases (LPMOs), from *Thermoascus aurantiacus* (*Ta*LPMO9A) that has been shown to increase the glucose yield during enzymatic decomposition of steam-explosion treated wood. Jiménez-Quero *et al.* work on wood degradation by ligninolytic fungi. *Pleurotus ostreatus*, *Ganoderma lucidum*, and *Fomes fomentarius* species are grown on spruce and birch wood chips via solid state fermentation accompanied by characterization of extracts (to identify active extracellular enzymes) and solid residue for insight in degradation routes. A complementary solid-state fermentation of wheat and corn bran is studied using three fungal species: *Pleurotus ostreatus, Fomes fomentarius* and *Ganoderma lucidum,* aiming to correlate substrate composition to enzymatic activity and their potential for bio-composite applications. McKee *et al.,* on the other hand, work on discovering microbial species and enzymes capable of metabolizing organic sludge material generated in pulp and paper mills. An extensive microcosm study of precipitation sludge metabolism has been completed including gene profiling of all sludge degrading microcosms. Use of the lignin rich residual slurry (after microbial degradation) is explored in collaboration with Liu *et al.* with the focus on flame-retardant materials.

Another focus area of the program is developing new decoupling concepts enabling selective and versatile recovery of building blocks with functionality control. In this respect, a glycerol-based delignification investigated by Henriksson *et al*. can potentially provide access to as well cellulose pulp as a new type of lignin separated under atmospheric conditions. Results show high temperature dependency of the delignification process yielding pulp comparable to conventional qualities. With the prospect of obtaining aldehyde functionalized polysaccharides, oxidative extraction of hemicelluloses is employed in the work of Hasani *et al.* The efforts aim at promoting solubility and mass transport of hemicelluloses in the wood tissue by a partial oxidative opening of their pyranose rings. Comparative investigations of the coupled oxidation-extractions on birch and spruce have pointed out different amounts and oxidation levels of the extracted carbohydrates. While extractions of birch generate higher amount of oxidized extracts, higher overall extraction yields were obtained from spruce. Accessibility of the wood tissue along with the decoration pattern of hemicelluloses are likely highly influential and will be in focus in the continued work expanding also to other oxidation routes. Vilaplana *et al*. focus on the action of oxidizing enzymes on hemicelluloses as a means of promoting functionalization and separation of cellulose fibres, aiming to develop a mild method for the production of holocellulose with good defibration properties. Efficiency of three laccases for the delignification of wood under harsh alkaline conditions has been demonstrated with ongoing characterization of the material structure and defibration behaviour.

Development of functional building blocks and materials from lignin in the program comprises both novel functionalization routes and use of lignin nanoparticles (LNP) as promising well-defined nano-building blocks. Sevastyanova *et al.* explore use of LNPs from spruce (SKL-NPs) and eucalyptus (EKL-NPs) kraft lignin as additives for sunscreen formulations. SKL-NPs yield smaller (~100 nm), more compact particles, while EKL-NPs form larger (~160 nm) particles, both showing a broad UV-VIS absorbance, along with enhanced emulsion stability (Pickering stabilization) and improved rheological behaviour of the lotions. Crispin *et al.* use functionalized lignin for carbonization to hydrochar that could be applied for charge storage. Lignosulfonates are utilized as precursors due to their water solubility and ability to act as acid catalysts during hydrothermal carbonization, where focus is on optimizing the functional characteristics of lignosulfonate-derived hydrochar, refining the carbonization parameters and analyzing the resulting structural changes. Use of lignin as a functional additive has also been the focus of Liu *et al*. working on thermoplastic and thermoset materials and their structure-property relationship. Modified technical lignin is employed as a crosslinker to copolymerize with acrylic acid in the preparation of gels, where the branched lignin structure is envisioned to create reinforcing networks. Modification with organic carbonates has been demonstrated successful in modifying lignin - acrylic acids interactions for optimized gel preparation. Complementary lignin modification activities revolve around a solvent-free approach through ball-milling-based mechanochemistry targeting esterification. A range of organic acids capable of effectively solubilizing and esterify lignin has already been identified.

Lawoko *et al*. develop new analysis techniques for lignin capable of providing structural information beyond the average characteristics of samples. Combining NMR spectroscopy and MALDI-TOF mass spectrometry enables discerning of linear and branched lignins in samples, while protocols for water-based capillary electrophoresis aim at discerning molar mass and inter-unit linkage sequence correlation to charge and hydrodynamic volume. Another important analytical effort, by Olsson *et al*. revolves around electron microscopy methods to reveal the enzymatic reaction mechanisms on the cellulose nanocrystal surface, where monitoring of the surface desulfation relies on labelling of the surface sulfate groups with silver and gold.

WWSC Program II: Wood components and interfaces

Active PIs

KTH: Eva Malmström – Program II responsible, Lars Wågberg – Program II co-responsible, Monica Ek, Linda Fogelström, István Furó, Minna Hakkarainen, Mats Johansson, Martin Lawoko, Michael Malkoch, Karin Odelius, Torbjörn Pettersson, Per-Olof Syrén, Francisco Vilaplana
SU: Mika Sipponen
Chalmers: Lars Evenäs, Giada Lo Re, Gunnar Westman.
LiU: Viktor Gueskine, Renee Kroon, Mikhail Vagin.

Overview of the activities within the program

Program II aims at acquiring deeper knowledge regarding lignin, hemicellulose, small molecules and modifications thereof in an effort to pave the way for wood-based bioplastics, coatings, adhesives, and property-enhancing additives as well as tailored polymers for interfacial engineering. Further, biomimetic and synthetic approaches for engineering of surface properties will be investigated since interfacial adhesion between components is of utmost importance, both to accomplish durable, as well as recyclable/reusable materials. An overarching goal is to develop materials or material additives that can support a decreased dependence of fossil-based materials, and hence to accelerate the transition into circular materials.

The research activities within WWSC PII during 2024 reflect a strong and expanding commitment to developing sustainable, bio-based materials from lignocellulosic resources. Together, the projects span lignin, nanocellulose, polymers, composites, and energy systems, with common goals of valorisation, circularity, and improved functionality. By advancing both fundamental understanding and applied solutions, the portfolio positions forest-based resources as critical enablers of the circular bioeconomy.

Esterified lignin nanoparticles were developed for controlled delivery of agrochemicals, showing promising plant uptake and release. Lignin was also tailored for advanced thermosets and coatings, while studies on biodegradation highlighted both potential and challenges of designing compostable lignin-based materials. Lignin–protein nanocomposites were engineered into bio-based adhesives resilient to moisture and heat, offering a sustainable alternative to petroleum-based systems.

Methods to enhance cellulose reactivity for derivatives identified strategies to prevent hornification, thereby improving large-scale processing. Functionalisation routes were developed through gas-phase esterification, while advanced DNP-NMR was applied to study modification homogeneity at the fiber level. Investigations into CNF gel structures under liquid exchange revealed that organic solvents yield stiffer, more homogeneous networks, while oxime ligation was introduced as a selective, water-compatible chemistry for carbohydrate-derived polymer functionalisation.

Circular wood-plastic composites were designed via reactive extrusion and enzymatic integration, enabling recyclability and biodegradation. Complementary work demonstrated enzymatic catalysis in polyester degradation and biocomposite processing. Vanillin-based monomers were engineered into recyclable high-performance polymers under sustainable conditions, while dehydrovanillin-derived polyethers showed potential for self-healing and recyclability. Conjugated monomers such as furan and thiophene were developed for optoelectronic applications, and cellulose derivatives were combined with conjugated polymers to create hybrid organic electrochemical transistors, improving ion transport through nanocellulose integration.

Wood-based colloidal nanoparticles were produced via aqueous RAFT-PISA, aiming at incorporating degradable functionalities with cyclic ketene acetals—an important step toward degradable nanolatexes.

Aqueous flow batteries using cellulose-based membranes have been explored as sustainable alternatives to Nafion membranes. While early tests were challenging, robust analytical tools were established to track degradation and guide improved designs.

Scientific output ranged from exploratory, method-development work to high-impact publications in ACS Applied Materials & Interfaces, ACS Sustainable Chemistry & Engineering, ChemSusChem, and related journals.

In summary, the 2024 WWSC portfolio demonstrates how cross-disciplinary approaches—from green synthetic chemistry and enzymatic catalysis to advanced spectroscopy, nanotechnology, and energy systems—are converging toward the vision of a sustainable, circular bioeconomy. Lignin valorisation, cellulose modification, renewable polymers, and functional bio-based composites are emerging as particularly impactful directions, with strong potential for industrial translation in food, agriculture, packaging, energy storage, and high-performance materials.

WWSC Program III: Processing and structural materials

Active PIs

KTH: Jakob Wohlert – Program III responsible, Daniel Söderberg, Lars Berglund, Yuanyuan Li
Chalmers: Anette Larsson, Roland Kádár, Amparo Jimenez Quero
LiU: Igor Zozoulenko, Feng Gao, Alexander Holm
LTU: Kristiina Oksman
MIUN: Birgitta Engberg

Overview of the activities within the program

The focus areas in Program 3 have been the liberation and chemical modification of the fibrils in the fiber wall of cellulose-rich fibers and the development of filaments and fibril-based materials with a controlled structural organization of the fibrils in the fibers and continuous filaments. The comprehensive research efforts detailed in this report summarizes a multifaceted exploration into the diverse applications of nanocellulose based materials.

WWSC researchers have spent a lot of efforts studying the dynamics of nanocellulose structures in fibers under extreme conditions, particularly through dynamic compression studies. By elucidating the intricacies of pressure effects on cellulose fibers, it has been possible to obtain significant insights into the structural evolution of these materials under extreme conditions. Such findings deepen our fundamental understanding of material behavior and hold substantial promise for applications necessitating resilience, durability and property developments.

In parallel, efforts have been dedicated to identify the fundamental interactions of irreversible interactions between cellulose fibrils, with a specific focus on hornification in cellulose-rich materials. Through careful experimentation and analysis, using a range of high-resolution measuring techniques it has been possible to quantify the kinetics of hornification and identification of possible molecular mechanisms behind the phenomena. This line of investigations not only elucidates fundamental processes but also opens avenues for the development of novel materials with tailored properties.

Moreover, the synthesis of hybrid materials from cellulose nanofibrils and precision dendrimers has emerged as a new development in materials science. These hybrid materials, characterized by their antibacterial properties and biocompatibility, hold promise for applications in biomedicine and environmental remediation. By harnessing the synergistic properties of cellulose and dendrimers, it has been possible to tailor the cellulose based filaments both from a mechanical in biological interaction point of view.

Additionally, the polymerization of functional polymers and hydrogels within the cellulose fiber wall has led to the development of fiber-reinforced hydrogels with exceptional mechanical properties. This innovation expands the repertoire of sustainable materials and offers solutions for applications requiring robustness and flexibility.

Furthermore, research efforts have focused on clarifying the dissolution and coagulation behavior of cellulose in aqueous alkaline systems, paving the way for the development of novel solvents and cellulose-based materials. The development of these new chemistries and processes holds great potential for applications both for the preparation of new advanced materials and for the development of new environmentally friendly processes for cellulose dissolution and regeneration.

Moreover, molecular modeling studies have provided unprecedented insights into the behavior of wood-based materials at the molecular level. By using and developing new computational tools, it has been possible to attain a deeper understanding of structural, electronic, and photonic properties, enabling the design of materials with enhanced performance and functionality.

In conclusion, the combined efforts of the research in the field of nanocellulose and fibers composed of assemblies of nanocellulose underscore the vast potential of these materials to meet pressing societal needs and drive innovation across different application areas where biobased solutions are urgently needed for our future society.

WWSC Program IV: Functional materials

Active PIs

LiU: Mats Fahlman – Program IV responsible, Klas Tybrandt, Mary Donahue, Simone Fabiano, Renee Kroon, Isak Engquist, Eleni Stavrinidou, Magnus Jonsson
Chalmers: Aleksandar Matic, Christian Müller, Gunnar Westman, Maria Asplund
KTH: Qi Zhou, Mikael Hedenqvist; MIUN: Christina Dahlström

Overview of the activities within the program

The annual report for 2024 from Program IV highlights significant advancements in the development of sustainable and biodegradable materials for various electronic and biomedical applications. We summarize progress and achievements of the different projects below, with more details to be found in the individual project reports.

Wood-based Stretchable Electronics
Klas Tybrandt and his team at LiU has been working on developing sustainable biodegradable rechargeable batteries. The focus has been on creating stretchable and biodegradable hydrogels for zinc ion batteries and biodegradable electrode bio-composites. Significant progress includes achieving good adhesion between nanographite paper current collectors and electrode composites through surface modifications. The project aims to finalize the development of these batteries by summer 2025.

Biomedical Devices Based on Cellulose Nanocomposites
Mary Donahue and her group at LiU, collaborating with Klas Tybrandt's group at LiU and Lars Wågberg's group at KTH, have been working on integrating electronic devices with biodegradable materials to improve the tissue/electronic interface for biomedical devices. The team has successfully fabricated flexible microelectrodes coated with a cellulose/PVA/PEDOT:PSS composite hydrogel. These electrodes show improved electrochemical properties and stability, making them suitable for neural interfaces and non-invasive vagus nerve stimulation.

Sustainable and Scalable Synthesis of Conductive Polymers
Simone Fabiano and his team has been developing conductive polymers derived from natural resources, synthesizing poly(benzodifurandione) (PBFDO) using benzoquinone-based catalysts and explored alternatives from natural origins. They have also worked on replacing dimethyl sulfoxide (DMSO) with more sustainable solvents, achieving significant progress in creating water-soluble n-type conductive polymers.

Cellulose-Based Electrodes and Solid Electrolytes for Sustainable Battery Technologies
Aleksandar Matic and his team at Chalmers have focused on improving zinc metal anode stability through separator design. They have developed a cellulose separator that enhances electrochemical performance in zinc batteries. The team plans to further investigate the role of the separator in regulating zinc deposition morphology using advanced microscopy techniques.

Wood-Based Energy Storage Materials & Fundamentals of Conductive Wood
In a collaboration between Qi Zhou's group at KTH and Isak Engquist's group at LiU, the team have designed a wood veneer-based bipolar membrane ionic diode by integrating anionic and cationic wood veneers. This innovative design shows promise for low-cost, sustainable electronics, with long-term rectification performance confirmed through various

measurements. In a second collaborative project, the team has investigated the anisotropic conductivity of conductive wood veneers. Preliminary analysis shows significant anisotropy in out-of-plane vs in-plane conductivity, and the addition of S-PEDOT to wood treated with PEDOT:PSS has improved conductivity further. The project also explores CNF-based conductive aerogels for dual sensing of temperature and pressure.

Synthesis of Functionalized Conjugated Polymers for Advanced Forest-Based Materials
In a collaboration between Renee Kroon's and Peter Olséns groups at LiU, PCAT-K, an polymer used in electroactive cellulose coatings that allows for reversible crosslinking and improved interaction with cellulose substrates, has been developed. The project demonstrates a circular design for conjugated polymers, emphasizing benign manufacturing, good lifetimes, and recoverability of components.

Conducting Cellulose Scaffolds for Plant Interface
Eleni Stavrinidou and her team at LiU are studying the effects of electrical stimulation on plant growth using cellulose-based conducting aerogels. They aim to elucidate the underlying mechanisms through transcriptomics analysis and also investigate calcium signaling in response to electrical stimulation in plants.

Sustainable Energy-Regulating Photonic Materials
Magnus Jonsson and his team at LiU are exploring the combination of wood templates and conducting polymers for optical applications. They have achieved promising results in dynamically controlling thermal radiation and using solar heating and evaporative cooling to drive thermoelectric devices.

Wood-Based Barriers for Wood-Based Materials
In a collaborative effort between the groups of Mikael Hedenqvist, Anna Sagan and Monica Ek at KTH, the team has focused on synthesizing polyester films for packaging applications using suberin from birch bark. They have developed a new synthesis protocol and characterized the films' mechanical properties and barrier performance.

Electrochemically Triggered Recyclability of Polymer Nanocellulose Composites
The groups of Christian Müller and Maria Asplund at Chalmers have teamed up to prepared composites of conjugated polymers and cellulose nanofibrils, achieving significant reinforcement and reversible softening upon exposure to humidity. They are now examining the mechanical properties during electrochemical cycles.

Cellulose-Based Filter Materials
Christina Dahlström and her team at MiUN have been working on triboelectric air filtering using regenerated cellulose. Initial results show that modifying the cellulose surface with laser printing enhances triboelectric output. The study is ongoing, with further exploration of cellulose derivatives.

Elastic Cellulose Hydrogels as Stretchable Electrolytes for Organic Electrochemical Transistors
In a collaboration between the groups of Christian Müller and Aleksandar Matic at Chalmers, the team has developed hydrogels with reversible stretchability and are using them as substrates for conjugated polymer films. They are also studying hydrogel-based electrolytes for zinc ion batteries together with researchers from LiU.

WWSC Academy

Persons involved

Anette Larsson, Chalmers, Lauren McKee, KTH, Igor Zozoulenko, LiU

Objectives

The WWSC Academy is a fundamental part of WWSC, playing a crucial role in nurturing a new generation of scientists poised to lead the transition towards a circular bioeconomy based on forest resources. Its primary mission is to:

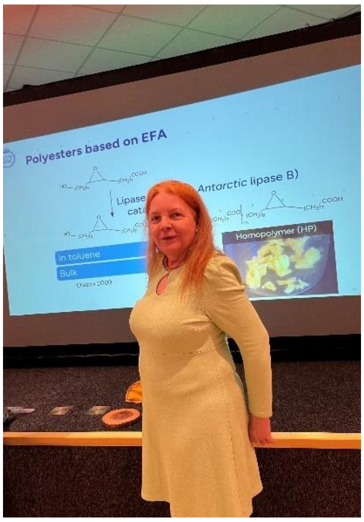
- offer WWSC PhD students graduate courses that focus on the fundamental understanding of fractionation and isolation of wood components, wood biopolymers, fibers, fibrillation into nanocellulose, and the assembly of components into wood-based materials. With over 30 degrees awarded in 2014/15, 32 students in 2018, and more than 52 students enrolled since January 2023, the WWSC Academy enhances participants' scientific development and serves as a vital complement to the comprehensive postgraduate education provided by partner universities.
- provide WWSC PhD students with two courses per year, in total seven courses, which they must attend.

Activities

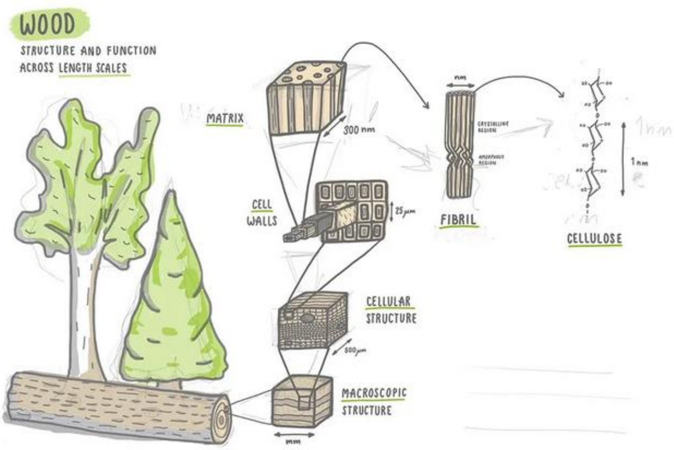
In April and October, 2024, the WWSC Academy organized the course "Wood cell walls, their components and and how to study them" and "Characterisation techniques, innovation for industry, and sustainable development", respectively.

The spring course was held in Umeå together with students from Finland, mainly Åbo Academy University. The course included presentations of the wood components and the characterization methods by well-established researchers from both Finland (3) and Sweden (5). All students made a site-visit to Umeå plant science centre and Obbola Paper Mill, SCA. A total of 58 PhD students participated: 39 from WWSC Academy, 4 from Treesearch and 15 from Finland. The PhD students came from various universities in Sweden: KTH (13), Chalmers (10), LiU (14), SU (3), MIUN (2), and LTU (1).

The course during the autumn was held in Lund and focused on scattering techniques, the theoretical background, how to analyze data and how to apply for beam time on international infrastructures. Furthermore, students were introduced to Tetra Pak and the way this company work with development of sustainable packaging solutions.
A total of 43 PhD students participated: 41 from WWSC Academy, and 2 from Treesearch. The PhD students came from various universities in Sweden: KTH (14), Chalmers (12), LiU (14), SU (2), and LTU (1).



Pictures from course 2.
Left: lecturer Monika Ek, KTH; Middle: plants growing at Umeå Plant Science Center; Right: Obbola paper mill.



Pictures from course 3.
Top left: summary of WWSC course 3; Top right: the students participating in the course; Bottom left: lecturer Stephan Roth, DESY, Hamburg/KTH Royal Institute of Technology.

Graduated WWSC PhD students during 2024

Maria Cortes Ruiz	KTH	Tailoring and Characterization of Polymer-linked Fibrillar Structures
Seyed Ehsan Hadi	SU	Colloidal Processing and Alignment of Wood-Based Dispersions and Hybrid Functional Foams
Mohsen Mohammadi	LiU	Stretchable electronics using wood-based functional materials
Rebecca Östmans	KTH	The properties of hydrated nanocellulose network structures
Farhiya Alex Sellman	KTH	Characterization and Utilization of Interactions in Wet and Dry Cellulose Nanofibrillar Networks
Mohammad Morsali	SU	Site-specific reactions of softwood kraft lignin for biobased vitrimers and reactive colloidal particles
Ahmad Reza Motezakker	KTH	Dynamics and interactions in entangled nanofibre dispersions
Angelica Avella	Chalmers	Reactive extrusion of lignocellulose-polyester biocomposites
Emilia Heinonen	KTH	Structural basis for the recalcitrance and molecular packing of hemicelluloses
Alessio Truncali	KTH	Lignin towards thermoset applications
Saeed Davoodi	KTH	Hydrodynamic assembly and alignment of bio-nanofibers
Changbai Li	LiU	Advances in bioelectronic interfaces through controlled polymerization of tri-thiophene monomers
Luísa Rosenstock Völtz	LTU	Use of co-rotating extrusion process for the development of resource-efficient biocomposites
Rohan Ajit Kulkarni	KTH	Structural changes in cellulose fibres under extreme pressure

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WWSC Summer Workshop 2024

Vildmarkshotellet, Kolmården
June 17-19, 2024

Monday June 17

09.00	Bus leaving Stockholm Cityterminalen
10.00	Bus leaving Katrineholm C
11.30	*Lunch*
12.30	Welcome address, Eva Malmström, WWSC Director
12.40	Orlando Rojas, University of British Columbia, Vancouver, Canada: "Nanopolysaccharide Gelation in Bioproduct Development and Advancing Circularity"
13.20	Gil Garnier, Monash University, Melbourne, Australia: "Engineering Nanocellulose for Biomedical and Agriculture Applications"
14.00	Amparo Jimenez Quero, Chalmers: "Fungi: Nature's Biotechnological Marvels for Biomass Valorization"
14.20	*Break*
14.50	Ulrike Wegst, Northeastern University, Boston, USA: "Engineering Materials for a Circular Economy"
15.30	*Minibreak*
15.40	Pitch session
16.50	Poster session
19.30 –	*Dinner*

Tuesday June 18

09.00	Allocated time for research project meetings/WWSC LG meeting
10.00	Eleni Stavrinidou, LiU: "Plant Bioelectronics and Biohybrids"
10.40	*Break*
11.10	Benny Freeman, The University of Texas at Austin, USA: "Revisiting Ion Selectivity of Cellulose Acetate Membranes"
11.50	Entrepreneurial session: Jowan Rostami and Rebecca Östmans, Cellufy; Karl Håkansson, CelluXtreme; Joanna Wojtasz, TreeToTextile; Johannes Bintinger, n-ink
13.00	*Lunch*
14.00	Tassia Lopes Junqueira, LNBR/CNPEM, Brazil: "Sustainability-Driven Research and Development for Innovative Solutions"
14.40	WWSC Program meetings (PI-IV) including coffee break
16.30	Science-as-Art
19.30 –	Dinner

Wednesday June 19

09.00	Chunlin Xu, Åbo Akademi, Finland: "Wood-based photocurable biopolymers"
09.40	Oihana Gordobil, University of the Basque Country (UPV/EHU), San Sebastian, Spain: Impact of emulsification parameters and ingredients on the characteristics of O/W pickering emulsions stabilized by colloidal lignin particles"
10.00	*Break*
10.30	Ludvig Edman, Umeå University: "Light-Emitting Electrochemical Cells: Basic Understanding for Functional and Sustainable Devices"
11.10	Concluding remarks
11.30	*Lunch*
13.00	Buses leaving Vildmarkshotellet, arriving at Katrineholm C ca 14.00, Stockholm C ca 15.00

KTH CHALMERS LiU LINKÖPINGS UNIVERSITET

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WWSC Winter Workshop 2024
Skogshem & Wijk, Lidingö
November 26-28, 2024

Tuesday November 26

11.00	Bus leaving Stockholm Cityterminalen
12.30	*Lunch*
13.30	Welcome address, Eva Malmström, WWSC Director
14.00	Lisbeth Olsson, Chalmers: "WWSC Bibliometry"
14.30	Antje Potthast, BOKU, Austria: "Lignin and cellulose - still a challenge for analysis"
15.10	*Coffee break*
15.40	Mikael Hannus, Stora Enso: "Stora Enso – part of Bioeconomy"
16.10	Science-as-Art
16.20	*Short break*
16.30	Pitch and poster session 1
19.30 –	*Dinner*

Wednesday November 27

09.00	Ronald Österbacka, Åbo Akademi University, Finland: "Understanding charge-transport layers for improved efficiency and lifetime in next generation solar-cells"
09.40	Martin Lawoko, KTH: "Linkage Sequencing of Lignin Populations (LILIPOPS): Advancing Lignin Analytics"
10.20	*Coffee break*
10.50	Scott Mazurkewich, Chalmers: "Understanding substrate interactions & biological roles in Carbohydrate Esterase family 15 (CE15)"
11.30	Ann-Sofie Fonsen, Boreal Bioproducts, Finland: "From side stream to main stream"
12.10	Science-as-Art
12.30	*Lunch break*
13.30	WWSC Program meetings (PI-IV)
15.10	*Coffee break*
15.40	Lars Wågberg, KTH: "An understanding of the colloidal properties of nanocellulose and its use in preparation of new materials"
16.30	Pitch and poster session 2
19.30 –	Dinner

Thursday November 28

09.00	Mats Johansson and Martin Lawoko, KTH: "Materials from Lignin"
09.40	Feng Gao, LiU: "Perovskite solar cells: the use of wood-based materials and beyond"
10.20	*Coffee break*
10.50	Mikael Hedenqvist, KTH: "Plant-based barriers for wood-based materials"
11.30	Anastasia Riazanova, KTH: "Electron Microscopy Methods for Materials from Trees"
12.10	Concluding remarks
12.30	*Lunch*
14.00	Bus leaving Skogshem & Wijk, arriving at Stockholm Cityterminalen ca 15.00

WWSC Bibliometry

Aim: To follow the impact of the research conducted in WWSC in the scientific community and determine the development. The bibliometric data can serve as a comparison basis with other groups, centers, and universities.

The basis for this bibliometric report is the curated list of publications from Chalmers, KTH and LiU for 2019-2024. Measures used are: the number of publications, the standing of the journals they are published in, and the number of citations.

Number of publications

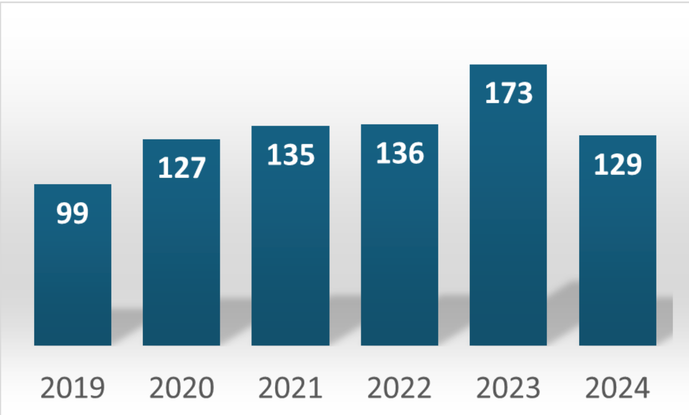

Figure: Number of publications from WWSC per year 2019-2024.

During 2019-2024, WWSC published 799 publications in total, which is a 60 % increase in publication volume per year compared with the 2014-2018 time period.

FWCI – Field-Weighted Citation Impact

FWCI measures how well-cited the publications are compared with the subject area as a whole. FWCI > 1.0 means an above average citation rate.

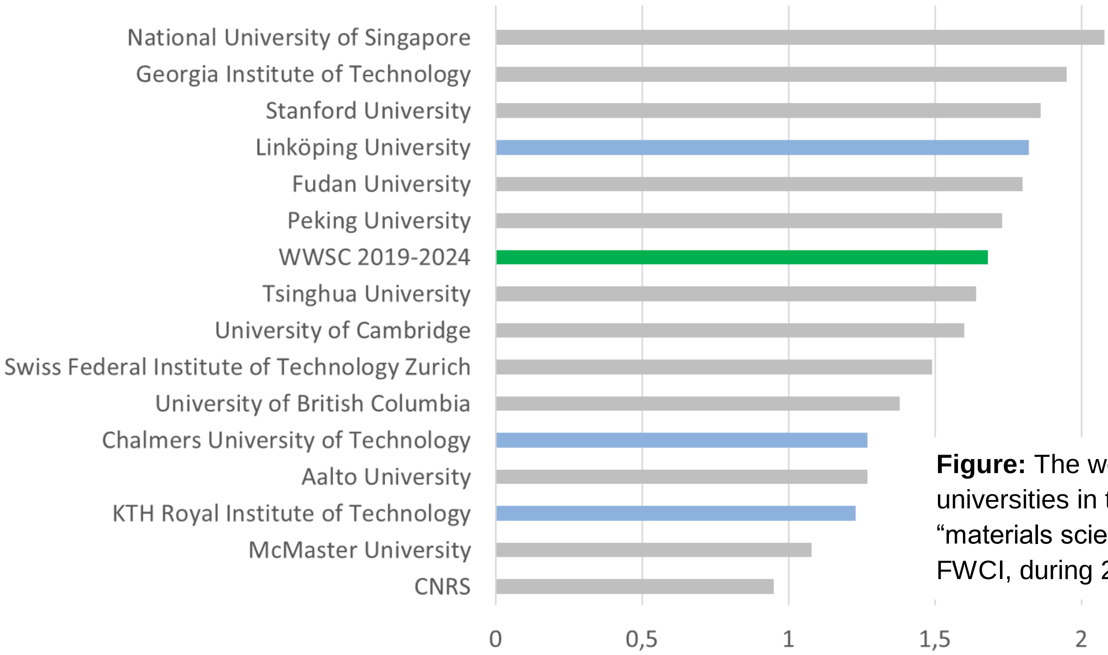

Figure: The world-leading universities in the subject area “materials science” according to FWCI, during 2019-2024.

For 2019-2024 the FWCI of WWSC was 1.68, which places WWSC on place 7 compared with other leading instutions (with a focus on wood science) in the subject area of “materials science”.

SNIP – Source-Normalized Impact per Publication

SNIP measures the citation impact of scientific journals. The indictor corrects for differences in citation practices between fields. SNIP > 1.0 means that the journal’s citation rate is above the average.

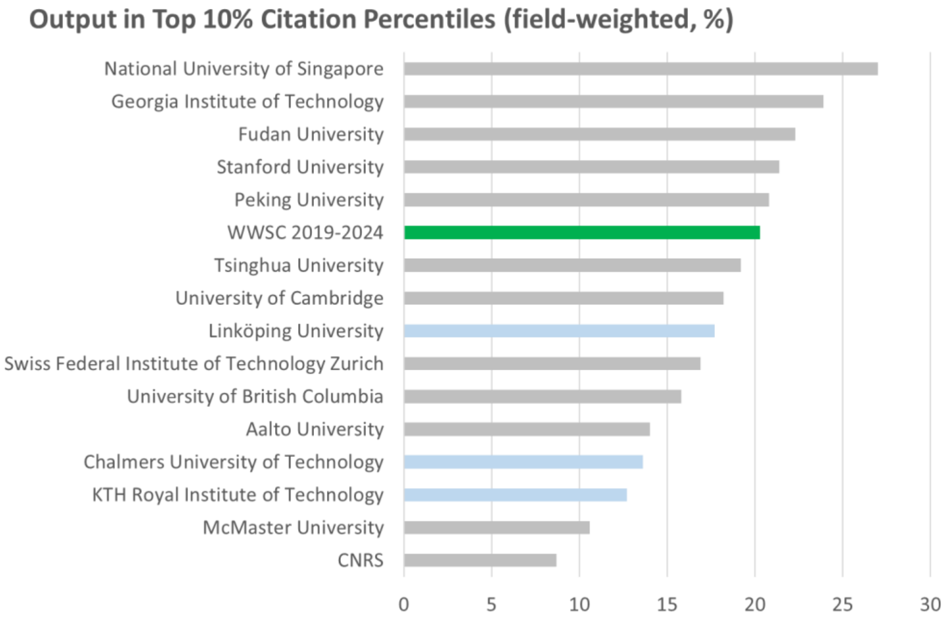

Figure: Output in top 10 % citation percentiles by SNIP for the world-leading universities in the subject area of materials science during 2019-2024.

The figure shows that 21 % of WWSCs publications are published in journals that are in the top 10 % citation percentiles by SNIP, which places WWSC on place 6 compared with other leading instutions (with a focus on wood science) in the subject area of “materials science”.

Journals we prefer to publish in

In comparison with 2014-2018, during 2019-2024 WWSC published in more high-impact application-oriented journals and less in wood- and composites science journals such as Holzforschung and Composites Science and Technology.

Scopus Sources	Scholarly Output	Field-Weighted Citation Impact	Output in Top 10% Citation Percentiles (%)	SNIP 2024
Carbohydrate Polymers	40	1.52	40.0	2.03
ACS Sustainable Chemistry and Engineering	35	1.21	45.7	1.25
Cellulose	33	1.43	15.2	1.09
Biomacromolecules	26	1.62	34.6	1.01
ACS Applied Materials and Interfaces	22	1.60	45.5	1.26
Advanced Functional Materials	16	2.93	81.2	2.59
ACS Nano	15	6.39	80.0	2.34
Green Chemistry	15	1.23	33.3	1.67
Journal of Materials Chemistry A	14	1.08	57.1	1.33
Advanced Materials	13	4.40	92.3	3.87

also popular 2014-2018

not in top 10 2014-2018

Figure: Publication data for the top 10 journals with most WWSC publications.

WWSC Board

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Professor

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Chalmers
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WWSC Management team

The WWSC management consists of representatives from the three member universities: KTH Royal Institute of Technology, Chalmers University of Technology, and Linköping University.


Eva Malmström


Daniel Söderberg


Linda Fogelström


Lars Wågberg


Lars Berglund


Lisbeth Olsson


Merima Hasani


Christian Müller

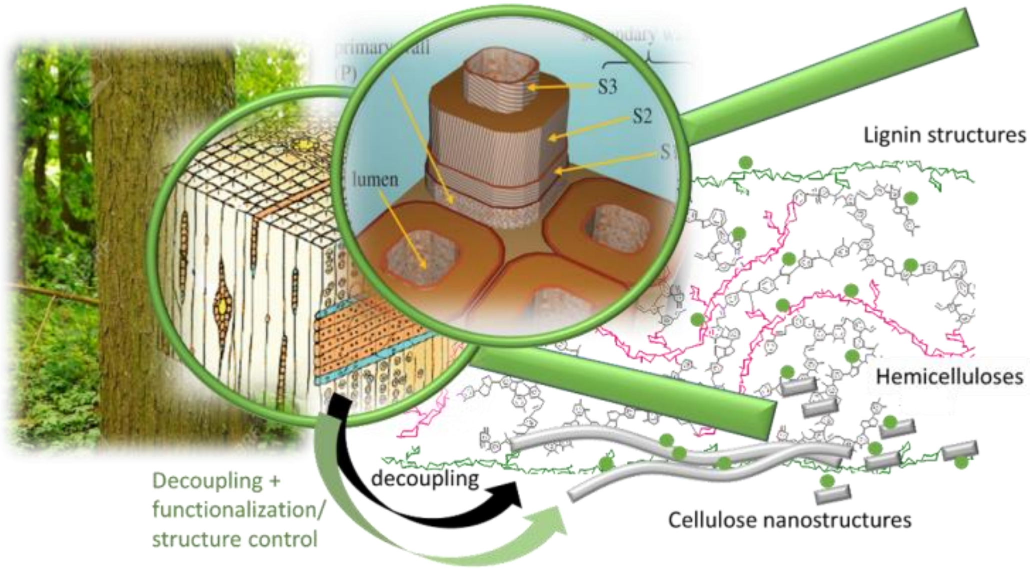

Mats Fahlman


Isak Engquist


Marina Kaspiarovich

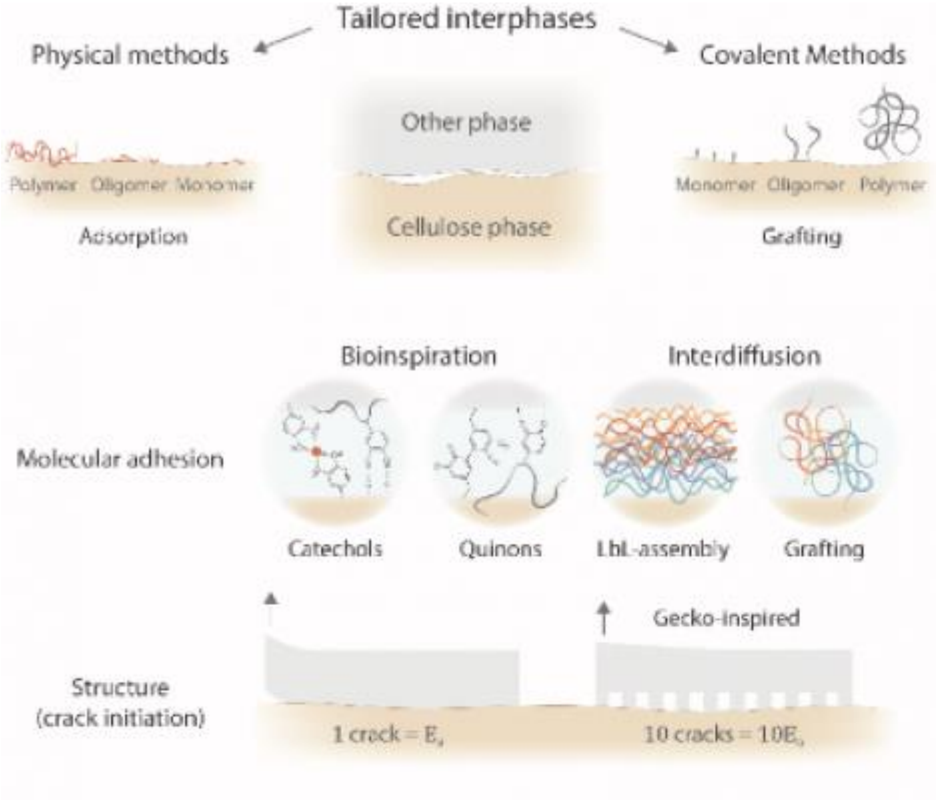
Subprojects WWSC Program I

Materials biorefinery



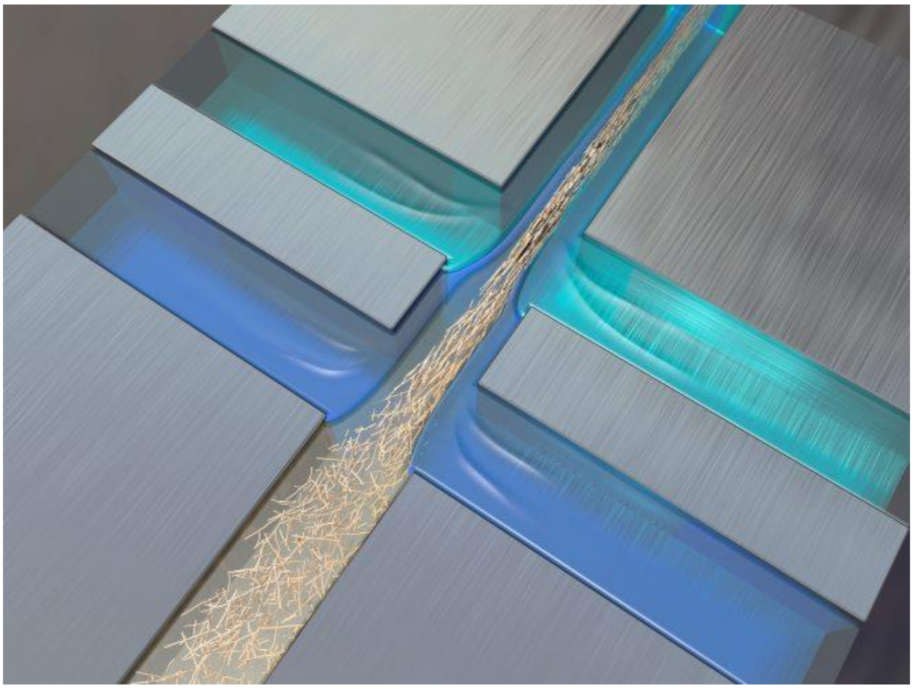
Subprojects WWSC Program II

Wood components and interfaces



Subprojects WWSC Program III

Processes and structural materials



Subprojects WWSC Program IV

Functional materials