
COUNTLESS
extending the biobased chemicals portfolio

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Project Details

Type of project	Innovation Action – Demonstration
Project title	Cost-effective production of lignin platform chemicals: Extending the biobased chemicals portfolio
Project period	01 September 2023 – 31 August 2027
Project focus	Bio-based chemicals
Feedstock origin	Forest-based
Feedstock type	Lignin & wood residues
CBE JU contribution	5 400 014 EUR

Project Summary

COUNTLESS will access lignin, an abundant natural resource, to produce platform chemicals and demonstrate their applicability and cost-effectiveness in a variety of end-use cases from bulk to specialty applications.

This will enable the transition from fossil-based to bio-based chemical building blocks – supporting sustainability and climate action goals.

The **COUNTLESS** project is supported by the Circular Bio-based Europe Joint Undertaking and its members. Grant agreement ID: 101112453.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CBE JU. Neither the European Union nor the CBE JU can be held responsible for them.

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

Co-funded by the European Union

Introduction to the Project

Europe's ambitious sustainability and climate goals rely heavily on the transition from fossil-based to bio-based chemical building blocks.

Lignin as abundant natural resource has substantial potential to become the starting material to produce functionalized aromatic compounds. It is a by-product of the pulp-and-paper and forestry industry, but currently, only 1–2% of the annual lignin production is used as a feedstock in chemical conversion. The critical challenge yet to be overcome is the heterogeneous and complex nature of isolated lignins, hampering their full exploitation.

COUNTLESS will demonstrate the first catalytic hydrogenolysis process operated in continuous mode at industrially relevant scale for the cost-effective and sustainable production of lignin-based platform chemicals. The project partners will demonstrate the applicability of these chemicals and their cost-effectiveness in a variety of end-use cases from bulk to specialty applications. COUNTLESS specifically targets applications from the construction and the cosmetics industry. These learnings and demonstrators will lead to new opportunities in other applications and polymer systems. Thus, COUNTLESS is creating a substantial leverage effect, adding to the diversification in the range of EU-produced chemicals and the bio-based chemicals portfolio.

In the project, the 13 partners cover the entire value chain including feedstock suppliers, technology development experts, well-recognized industry players in several application fields, experts in dissemination, communication and exploitation, and experts in integrated sustainability, environmental, and techno-economic assessments.

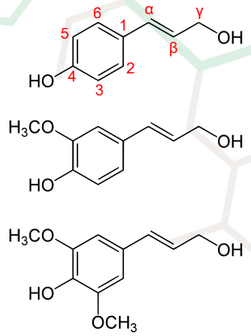
COUNTLESS Objectives

- Demonstrate the continuous conversion of lignin, via catalytic hydrogenolysis, into platform chemicals at industrially relevant conditions (TRL 7).
- Produce and demonstrate a range of construction and cosmetics products using the lignin-based platform chemicals.
- Use digital tools for process monitoring and decision support related to product quality.
- Prove the sustainability of the lignin-based value chain and its improved environmental impact, cost-effectiveness and cost competitiveness compared with fossil-based or other bio-based value chains.
- Maximise exploitation of the COUNTLESS technologies.
- Develop strategies to ensure market uptake of the project results.

Lignin

Our Feedstock

Bio-based feedstocks are one of the mainstays of the circular bioeconomy. The natural world uses energy from sunlight to make a range of molecules from water and CO2 which are useful to humans and provide us with food, fuel, and also materials. If you take a closer look at plant biomass itself, it can be divided into three different materials: cellulose, hemicellulose, and lignin. The latter is of particular interest for the COUNTLESS project.



The three monolignols

As one of the most abundant natural materials on Earth, lignin is found in plants and especially trees where it provides strength and stability. However, there is no clearly defined “lignin” that can be found uniformly in all plants but rather a variety of different lignins. First, all lignins are organic biopolymers integrated into the plant cell walls. Although there are only three predominant monomers as building blocks (coniferyl alcohol, sinapyl alcohol, and p-coumaryl alcohol) in the polymer, these are arranged and modified in different and complex ways to form lignin. Consequently, lignin comes in many different types, which can differ significantly in their molecular structure as well as their properties and characteristics – and even their colour or smell. Each plant has a different, characteristic lignin polymer structure, which also depends on the ecosystem the plant grows in. Large differences exist between hardwood lignins, such as those from beech, and softwood lignins, for example from pine trees. Cereal straws or grasses are also sources of lignin. All these complex molecular lignin structures contain a range of aromatic compounds and are their most abundant source in nature.

Of course, there is great interest in utilising lignin commercially. It is conceivable to utilise lignin in its complex structure as a polymer, to break it down into smaller subunits, the oligomers, or even to break it down to the basic monomers and process these further. These polymers, oligomers, or monomers can add additional properties to different materials and products. In theory, these molecules could replace many aromatics of fossil origin currently being used in the chemical industry.

Nowadays, lignin is a by-product of the manufacture of wood pulp and paper, and of second-generation bioethanol (for example from straw). According to estimates, 60 - 70 million metric tonnes of lignin are available from wood pulp and the paper industry annually. However, around 95 % of that is currently being burned and only 1 -2 % is used as a feedstock for chemicals. In a circular bioeconomy, the cascading use of biomass is favoured. This means that the most valuable use of any biomass should be prioritised before it is burned to recover energy.

Lignocellulosic biomass, being the most abundant organic raw material in the world, will play a central role in the future when it comes to the production of chemicals and materials.

But why is lignin not yet being used as a material on a large scale?

Lignin quality can be an obstacle. Because lignin is a side-product, its quality is often not a priority in the production process. Each biorefinery type processes the lignocellulosic biomass to maximise the fraction it will utilise. Currently, that means focussing on the cellulose fraction for pulp or the hemicellulose fraction for sugar extraction to ferment ethanol. As a result, the lignin side-stream is often of insufficient yield or quality for high-value applications. To tackle this problem, the COUNTLESS project partners have optimised their processes to yield high-quality lignin which will be the ideal feedstock to produce bio-based aromatics.

The other main reason is the high degree of complexity of the molecule. While this complexity is great because it offers many opportunities to utilise lignins for different applications, it is also a major hurdle in processing and manufacturing processes. A large challenge is the process of depolymerisation – a major focus of the COUNTLESS project.

The project partners work on making this bio-based raw material more accessible to industry: by demonstrating the continuous conversion of lignin into platform chemicals.

Properties of lignin

Different lignins add different properties to materials. These are for example:

- Stability
- Rigidity
- Improved scratch resistance
- Anti-bacterial and anti-microbial properties
- Waterproofing
- Increased UV blocking
- Anti-oxidative properties
- Adhesion
- Thermal resistance

Wood, and side-streams from wood processing, can be burned for energy – but using lignin to make materials offers a better cascading use!

Aromatic Compounds

Our Product

Aromatic chemicals make up a significant share (40 %) of today's chemical building blocks with approx. 120 million tons of global annual production (at 4 – 5 % annual growth). They are used for a wide array of day-to-day products and applications, ranging from plastics to textiles. These aromatic compounds can give these products a range of properties: increasing the UV-absorbance, exhibiting antimicrobial, antigenotoxic, or even antimutagenic effects, providing stiffness, scratch resistance, and stability, or they themselves are used as flavourings and fragrances.

The current production routes of aromatics from fossil-based feedstock are energy-intensive and have a significant environmental footprint. Hence, the search for alternative, natural resources for the production of aromatics maintaining the requirements and quality of those obtained by conventional methods is of high importance.

Among others, the increasing interest in bio-based products originates from their benefits in relation to the depletion of resources and climate change. Bio-based products could provide additional product functionalities, stem from less resource intensive production and be an efficient use of all-natural resources. As they are derived from renewable raw materials such as plants and trees, bio-based products can help reduce CO_2 emissions and offer other advantages such as lower toxicity or novel product characteristics.

Aromatics are everywhere. Some of the common uses in your home include insulation, adhesives, floors, MDF boards, coatings, and sealants.

Sustainability

COUNTLESS contributes to sustainability

COUNTLESS contributes to sustainability in several ways:

- It will increase the valorisation of sustainably sourced biomass.
- The substitution of fossil-based products.
- The development of bio-based high-value products with at least the same technical performance, substituting their current fossil-based counterparts.
- A techno-economic proof-of-concept of the process technology for the production of lignin-based platform chemicals.
- Insights into sustainability criteria via tracking of relevant measurements at demonstration scale, laying the foundation for a further, sustainable commercial scale-up.

COUNTLESS will produce aromatic bio-based building blocks. These can replace phenolic compounds from fossil origin used in a range of applications today:

- Flame retardants in wood panels and waterproofing membranes
- Lignin-based UV filters
- Waterproofing membranes
- PU insulation foams
- PU coatings
- Wood panels
- Automotive and windmill blades

Project Partners

Covering the Entire Value Chain

The COUNTLESS Consortium of 13 partners covers the entire value chain, from wood to final product.

- VITO (Coordinator)
- Bloom Biorenewables SA
- Braskem Europe GmbH
- Cluster Industrial Biotechnology e.V.
- Daren Laboratories & Scientific Consultants Ltd
- Fibenol OU
- IFEU – Institute for Energy and Environmental Research Heidelberg gGmbH
- Kastamonu Entegre
- Soprema
- VTT
- Utrecht University

13 Partners Entire Value Chain

VITO (Coordinator)

Sustainable Polymer Technologies (SPOT) Team | SPOT

VITO is an independent Flemish research organization in the area of cleantech and sustainable development, with its head office in Mol, Belgium. It implements customer-oriented research and develops innovative products and processes for both the public and private sectors in the areas of chemistry, environment, materials, food, and energy.

The multidisciplinary business unit Separation and Conversion Technology (SCT) has organized its strategic research program around the theme 'Sustainable Chemistry'. One of the focus points on innovation for sustainable chemistry is the use of alternative feedstocks, such as lignin, carbohydrates, to create new value chains. SCT has been active in the lignin field since 2012 and continuously improved its expertise, related to both lignin processing and application (polymer) development. Additionally, VITO initiated Biorizon, a shared research centre focusing on technology development to produce functionalized biobased aromatics for performance materials, coatings and chemicals. In this context, VITO has launched in 2018 the ERDF LignoValue Pilot project aiming at the design and construction of a pilot plant for the depolymerization of lignin into a mixture of biobased aromatics.

Role in the Project
Coordinator
Process development and demonstration at industrial relevant environment for the production of lignin-based platform chemicals (de-risking and scale-up). Integrated sustainability assessment. Support in application development.

Project Coordinator
Kelly Servaes

Web
vito.be/en
spot.vito.be/en

Bloom Biorenewables

Bloom is a Swiss chemical company with the mission to create the most sustainable and high performing molecules for a green and viable chemical industry. The company, a spin-off from a leading European university (EPFL), developed a scalable, highly efficient biomass conversion technology – Aldehyde-Assisted Fractionation (AAF) – to separate plant-based materials, such as wood or agricultural wastes, into chemical building blocks while preserving their natural potential. The breakthrough biorefinery process turns up to 75% of all biogenic carbon into cost-competitive specialty chemicals which can be used in a myriad of applications from textiles to fragrances, over cosmetics, bioplastics, composites and fuels.

The company's business model includes the direct sale of specialty chemicals combined with licensing of the technology.

Role in the Project
Bloom Biorenewables will supply lignin from its own fractionation process.

Web
www.bloombiorenewables.com

Braskem Europe

With a strategy centered on people and sustainability, Braskem is engaged in contributing to the value chain to strengthen the Circular Economy. Braskem's 8,000 team members dedicate themselves every day to improving people's lives through sustainable solutions in chemicals and plastics. With its corporate DNA rooted in innovation, Braskem offers a comprehensive portfolio of plastic resins and chemical products for diverse industries, such as food packaging, construction, manufacturing, automotive, agribusiness, health and hygiene, and more.

With industrial units in Brazil, the United States, Mexico and Germany, Braskem exports its products to clients in over 70 countries.

Role in the Project

Application development and upscaling support.

Web

www.braskem.com/europe

CLIB

The Cluster Industrial Biotechnology, CLIB is an international open innovation cluster of large companies, SMEs, academic institutes and universities, as well as other stakeholders active in biotechnology and the circular bioeconomy as a whole. The cluster comprises over 100 members with a share of about 25% international members.

The overall goal of CLIB is to network stakeholders along and across value chains and to identify new opportunities for innovation, projects, and business. Through its strong network, we help develop cross-sectoral biotech and bio-based solutions for sustainable processes and products.

In COUNTLESS, we are responsible for the Communication, Dissemination, and Exploitation Work Package.

Role in the Project

Responsible for managing CDE activities and fostering open innovation in the project.

Web

www.clib-cluster.de

Daren Labs

Daren Laboratories is based in Ness Ziona, Israel, strategically located near the renowned Weizmann Institute. It operates at the intersection of academia and industry, offering practical solutions to complex research challenges. Our mission began with the aim of resolving intricate R&D issues in diverse fields such as chemistry, materials, biopolymers, synthesis, and industrial processes.

Daren Labs has evolved into an innovation hub, fostering collaborations and driving research. At the core of our operations lies the Daren Innovation Center, accommodating more than twenty start-ups, highlighting our commitment to nurturing pioneering ideas. Our partnerships extend globally, encompassing governmental authorities, major industry players like Teva and Orbotech, and emerging start-ups. With our unique positioning, we possess the ability to convert visionary concepts into tangible products. Our expertise ranges from biochemistry to chemical physics, enabling us to offer a diverse set of capabilities.

DAREN LABS

Role in the Project

Development and scale-up of new, high value, lignin-based products, especially lignin-based functional additives.

Web

www.darenlabs.com

Fibenol

Fibenol is an Estonian origin wood residues valorisation and green technology industrial company. Our flagship demo plant is situated in Imavere in Estonia.

Our goal is to shift the chemical and materials industry to sustainability by replacing fossil chemicals with high-performance low-carbon hardwood residues-based biomaterials – lignin, wood sugars and specialty cellulose in various industry fields from construction sector, energy saving and packaging to cosmetics and pharmaceuticals.

Fibenol

Role in the Project

Fibenol will supply lignin from its own fractionation process.

Web

www.fibenol.com

IFEU

IFEU – Institute for Energy and Environmental Research Heidelberg conducts research and provides a worldwide consultancy service in relation to all major environmental and sustainability issues. With more than 40 years of experience, IFEU is one of the most important environmental research institutes in Germany. It has an extensive track record in areas such as waste management and packaging materials, transport & mobility, renewable energies and energy efficiency as well as food and bio-based systems.

IFEU is especially renowned for its expertise (>25 years) in the field of life cycle assessment (LCA) and environmental impact assessment (EIA) as well as on integrated life cycle sustainability assessment (ILCSA) since it came on place. IFEU is and has been leading work packages on sustainability assessment in numerous EU-funded projects. Our work is characterised by experience and independence combined with a practical and target-based approach.

IFEU currently employs about 100 staff with a background in natural sciences, engineering and social sciences at its sites in Heidelberg and Berlin.

Role in the Project

Leader of Integrated Lifecycle Sustainability Assessment.

Web

www.ifeu.de

Kastamonu

Maintaining its uninterrupted production for half a century in the wood-based panel industry, Kastamonu Entegre is a global-scale company engaged in production in 6 countries, with investments in Romania, Bulgaria, Bosnia and Herzegovina, Russia, Italy and Turkey. In the USA, it has a company that carries out wood chip supply and logistics processes. Kastamonu Entegre has become the world's fifth largest company in the wood-based panel industry with its overseas investments for 25 years, and has been among the top three manufacturers in Europe. It is one of the four largest manufacturers in the world with each of its main product groups: Medium-density fibreboard (MDF), particle board, laminate flooring, and door panels. It produces 6% of the world laminate flooring production alone.

Acting with the mission of preserving natural balance and contributing to the society, the company is one of the three companies that prepared the sustainability report in the industry. It carries out studies on product and process development, efficiency increase, efficient resource utilization and advanced material technologies in its R&D center in Istanbul, which it has set up to develop technologies of the future.

Role in the Project

Application testing, especially flame retardancy and thermoset adhesives for wood panel production.

Web

www.kastamonuentegre.com/tr_en

SOPREMA

SOPREMA is a family-owned construction materials company based in France with more than 100 years of history. With 120 plants in the world, SOPREMA designs and produces numerous technologies for waterproofing and insulation materials.

SOPREMA employs more than 10,000 people in the world and has a turnover of 4.8 billion €. The group operates in 90 countries, has 23 R&D centers focused primarily on sustainable development and 46 training centers spread across 16 countries. Identifying alternatives fossil-based materials has been one of the key research topics at SOPREMA for more than 10 years. Several biobased and recycled products are part of the current portfolio, and the development of other sustainable solutions is in the works especially for polyurethane materials and their equivalents.

Role in the Project

Development and scale-up of new, high value, lignin-based products.

Web

www.soprema.com/en

University of Utrecht

A better future for everyone. This ambition motivates our scientists in executing their leading research and inspiring teaching. At Utrecht University, the various disciplines collaborate intensively towards major strategic themes. Pathways to Sustainability is one of our focus areas. Shaping science, sharing tomorrow.

At the Institute for Sustainable & Circular Chemistry, we (re)design, synthesize and investigate molecules and materials for circularity and sustainability. Through both fundamental and more applied chemistry research, we take on the three major challenges that our society faces: the energy, resource, and materials transitions. We adopt a systems approach to the sustainability transition, reaching out across disciplines using chemistry as a bridging and key enabling science.We believe in training and educating a new generation of chemists by giving them a strong foundation in chemistry, coupled with the ability and curiosity to look across the boundaries of science and to connect different disciplines. By making these fundamental connections through research and education, we aim to reinvent chemistry for a sustainable future, building the foundations of circularity into the molecular and material blueprint.

Role in the Project

The UU team aims to develop digital models and spectroscopic tools for online process analysis.

Web

www.uu.nl/en

VTT

VTT Technical Research Centre of Finland Ltd is a state owned and controlled non-profit limited liability company established by law and operating under the ownership steering of the Finnish Ministry of Employment and the Economy.

VTT is a Research and Technology Organisation (RTO) whose activities are focused on three areas: i) Carbon neutral solutions, ii) Sustainable products and materials, and iii) Digital technologies. VTT is impact-driven and takes advantage from its wide multi-technological knowledge base to strengthen Finnish and European industrial competitiveness. VTT can combine different technologies, produce information, upgrade technology knowledge, and create business intelligence and value added for its stakeholders.

VTT has a staff of 2,213, net turnover in 2022 was 165 M€ and other operational incomes were 96 M€. Over the years, VTT has gained vast experience from participation and coordination of numerous European projects including R&D Framework Programme projects and other programmes. VTT is ranked among the leading European RTOs. In December 2017, VTT has been recognised with the “HR Excellence in Research” award by the European Commission.

Role in the Project
Development of new, high value, lignin-based products for coatings and cosmetics.

Web
www.vttresearch.com/en

Imprint

Contact & Disclaimer

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