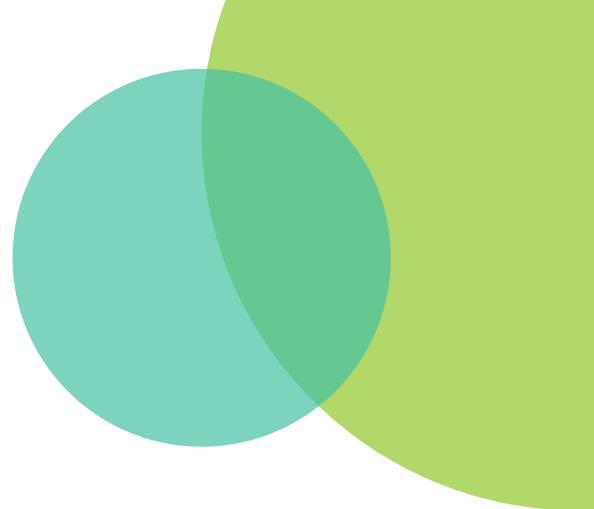




Sustainability Circle

13.12.2023

www.lignopure.de



Key impacts on sustainable value chains

Global goals

The European Bioeconomy

Long term goals

- Moving from fossil based to a bioeconomy
- New, greener value chains & effective industry
- **Using well what we don't use yet**

Sustainability



From industrial residues



Renewable source



Non food competition

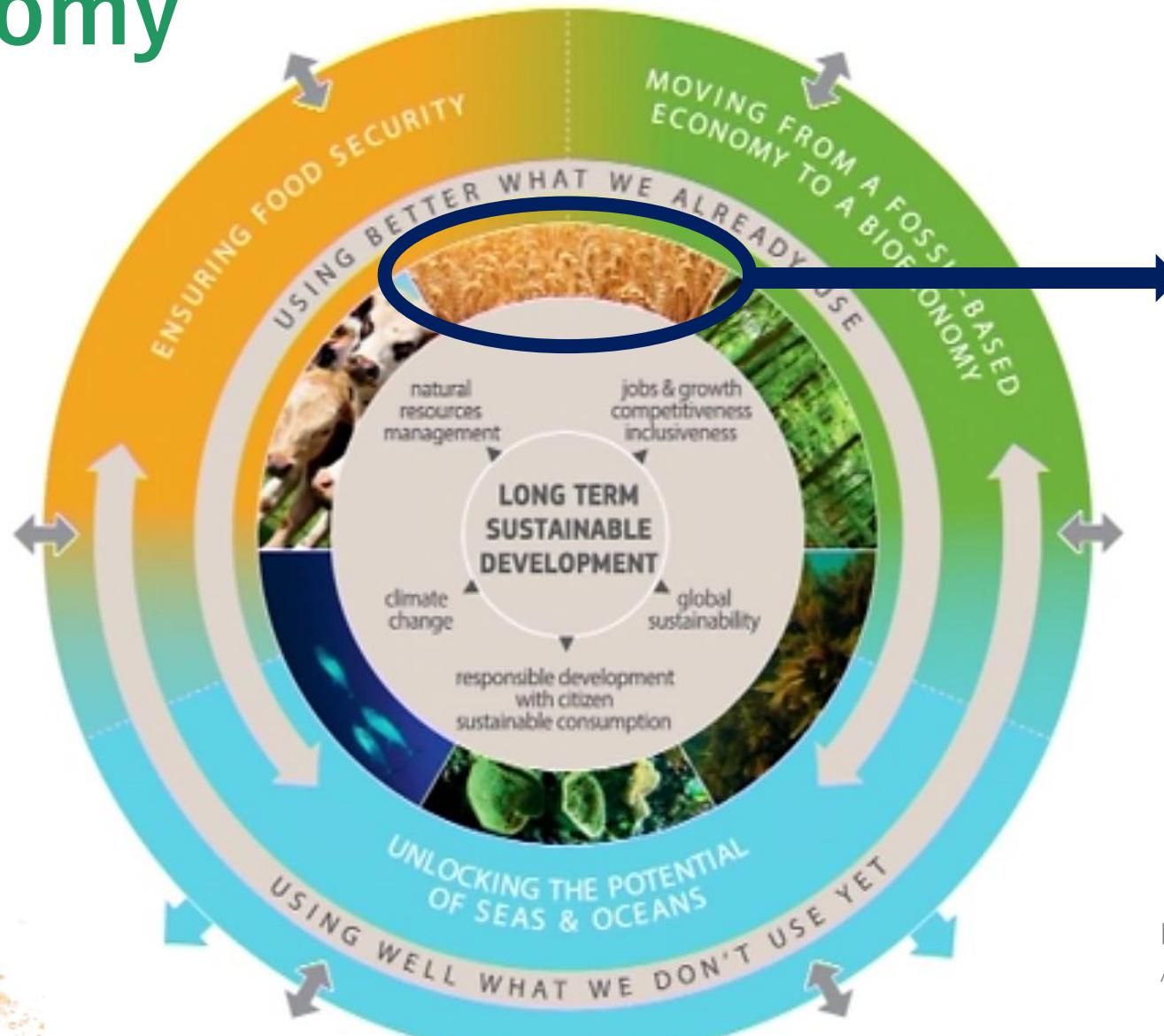


SUSTAINABLE DEVELOPMENT GOALS

3 GOOD HEALTH AND WELL-BEING	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	5 GENDER EQUALITY
		

8 DECENT WORK AND ECONOMIC GROWTH	13 CLIMATE ACTION	14 LIFE BELOW WATER
		

Bioeconomy

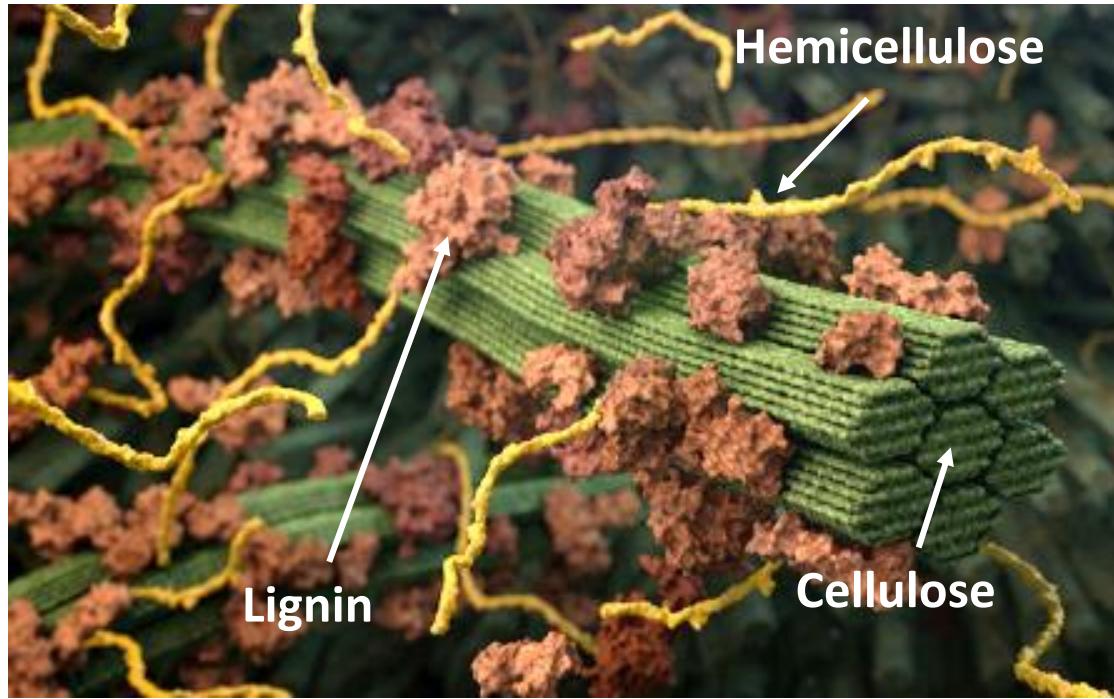


Lignocellulosic biomass

1. Woody biomass, agricultural sidestreams
2. Connecting food and material markets

Lignocellulosic biomass

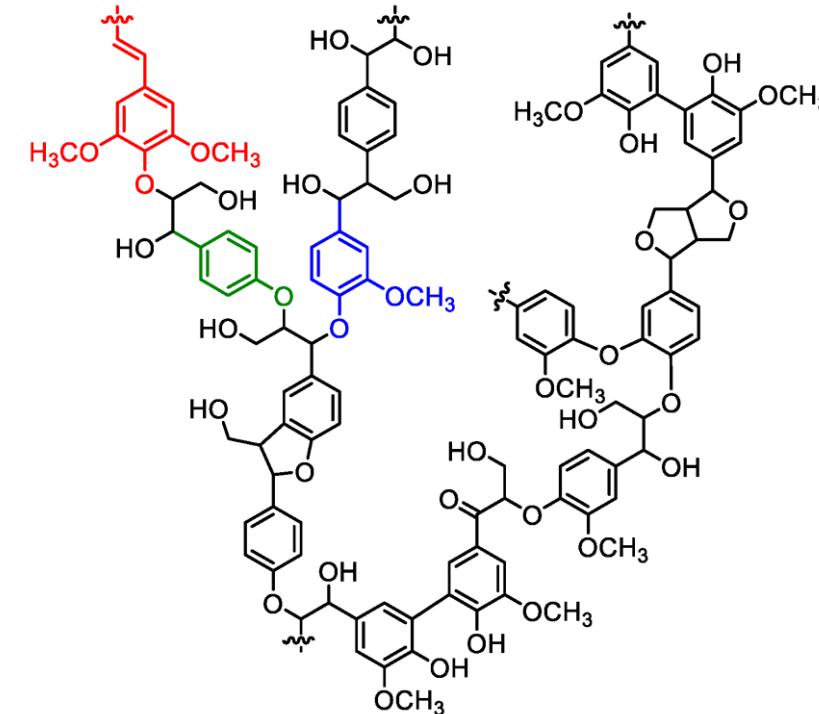
Lignocellulose structure illustration¹



Plus smaller amounts of pectin, oils, fats and waxes, proteins, starch or inorganic constituents, depending on plant species

Lignin

- Phenolic, heterogeneous polymer
- 2nd most abundant biopolymer on earth
- Biggest plant-based carbon source



Pulp/paper & biorefining industry



Lignocellulose processing

Pulping:

Isolation of polymeric cellulose
(dissolving of lignin &
hemicellulose)

Biorefining:

Hydrolytic degradation of
(hemi-)cellulose to fermentable
sugars

Hybrid processes:

Lignin solubilization &
fermentable sugar production

Almost no “lignin-first” biorefineries so far...

- Energetic lignin use: > 97 %
- Low value applications

Dessbesell et al., Renew. Sust. Energy Rev. 2020

- High interest of application producers but
ready-to-use lignin is fairly available



Roadmap Bioraffinerien

The opportunity

Already existing lignin products



UPM GERMANY [Über UPM >](#)

UPM BIOFORE
BEYOND FOSSILS

**UPM führt UPM BioMotion™
Renewable Functional Fillers (RFF) ein –
holzbasierte Funktionsfüllstoffe
verbessern die CO2 Bilanz von Gummi-
und Plastikprodukten**



≡



Animal health and nutrition

Today's challenges in the livestock industry are manyfold. The public health hazards from consuming foods with high antibiotic residues will remain a critical issue. In addition, rising feed and energy costs are a concern. Phytaxis SA, a subsidiary of Tanovis AG, offers workable solutions for this market.



LIGNIN-PHENOL-FORMALDEHYDE RESIN IN PLYWOOD



TaNovis
the lignin company

Lignopure

The opportunity

Already existing lignin products



sappi

Products & Services Sustainability & Impact Innovation & Collaboration News About us



Home / Products and services / Biomaterials / Lignin / Lignosulphonate application areas

Lignosulphonate application areas



The uses for lignosulphonate cover a wide area of applications with only some primary areas cited here.

We offer several products for a vast array of applications, and we can further modify our products to suit specific customer needs.



Dust control (LIGNEX 100/101/201)

LIGNEX 100/101 are high lignin content liquid products, providing superior surfactant (wetting) and binding performance in road dust management and soil stabilisation applications.

LIGNEX 201 is a neutral pH, high lignin content powder product which provides superior surfactant (wetting) and binding performance in road dust management and soil stabilisation applications.



Ceramics/Refractory/Clay bricks (LIGNEX 110/111/211)

Use of lignosulphonate in the production of ceramics, refractories and clay bricks is beneficial for processing, product properties and energy consumption, because the dispersing effect supports mechanical homogenisation of the raw mixture and improves workability at reduced free water content.

Consequently, less energy is needed for processing, drying and firing. In addition, the binding property of lignosulphonate increases green and final strength, resulting in reduced cracking of the final product.



Pelletising (LIGNEX 120/121/221)

LIGNEX 120/121/221 are excellent bonding agents for pelletising applications like the manufacture of coal briquettes and egg coal. Today, lignosulphonate is used in large amounts for the pelletising of animal feed, pet food and fertilisers, as well as metal ores.

The use of the appropriate additives enables the reduction of the pressing force on pelletising machines and this reduction of mechanical effort results in corresponding energy savings.



Crop protection (LIGNEX 130/131/231)

LIGNEX 130/131/231 are high purity lignosulphonate products. When used in crop protection suspensions, lignosulphonate acts as a surfactant by coating the surface of the active substances, simultaneously manipulating the charge of the active substance to ensure



Pigment dispersion (COLLEX 110/111/211)

Dispersing agents or a combination of binder and dispersing agents are indispensable in the engineering of pigment master batches.

The dispersion properties of COLLEX 110/111/211 facilitate fine dispersion of the pigment particles in the suspension, thereby helping to achieve the desired visual effects and overall performance.



Gypsum plasterboard (COLLEX 120/121/221)

When added to natural and REA plaster suspensions, COLLEX 120/121/221 enhances dispersion and promotes significant liquefaction of the slurries, thereby promoting lower slurry viscosity (given an equal ratio of water to solids) and enabling easier processing.



Process water treatment (COLLEX 130/131/231)

If process water contains insoluble components, these can agglomerate and result in the build-up of deposits on the components of the plant through which the water flows. This can lead to disruptions in the process water cycle and thus to disruption of the overall process.

COLLEX 130/131/231 act as dispersants, preventing agglomeration of the undissolved suspended particles, thereby eliminating or at least minimising these unwanted effects. In this application, lignosulphonate acts as an anionic tenside and also offers high thermal load as well as high stability in the acidic and basic pH range.



Leather tanning (COLLEX 140/141/241)

The phenolic structure of COLLEX 140/141/241 yields benefits in tanning and leather applications.

Excellent water solubility and dispersing properties as well as suitable molecular mass distribution and low viscosity of aqueous solutions of COLLEX 140/141/241 support fast, nearly complete penetration of hides, with physio-chemical reaction progressing over time.



Fertiliser (PERMASOL 100/101/201)

PERMASOL 100/101/201 are bonding agents used to assist pelletisation and granulation during the manufacture of mineral fertiliser. Their adhesive strength offers excellent binding and low abrasion qualities, while their excellent water solubility allows for good release of components during weather exposure.



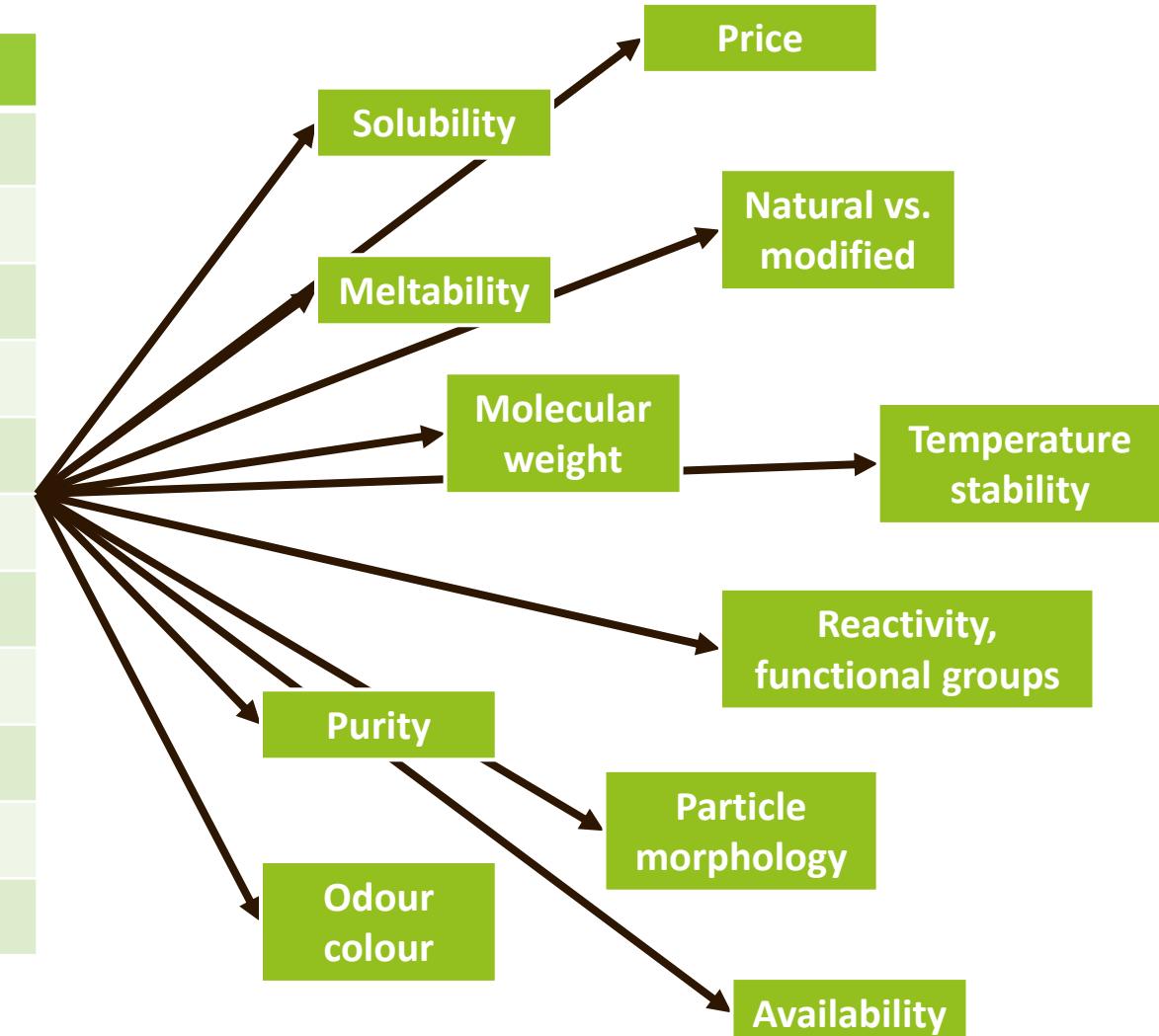
Recycled packaging (ZEWILEX 100/101/201)

ZEWILEX 100/101/201 are lignin-based products which enhance polymeric strength when used in the production of recycled packaging paper. They are used in the paper machine size press to partially displace more expensive starch. This not only saves costs, but also

The challenge

Lignin diversity and heterogeneity

Process group	Process type
Pulping	Kraft pulping
	Sulfite pulping
	Soda pulping
Hybrid processes	Organosolv
	Acetosolv
	<i>Ionic liquids</i>
	<i>Deep eutectic solvents</i>
	<i>Supercritical water</i>
Biorefining	Steam explosion, hot water
	Dilute/mild acid
	<i>Concentrated acid</i>

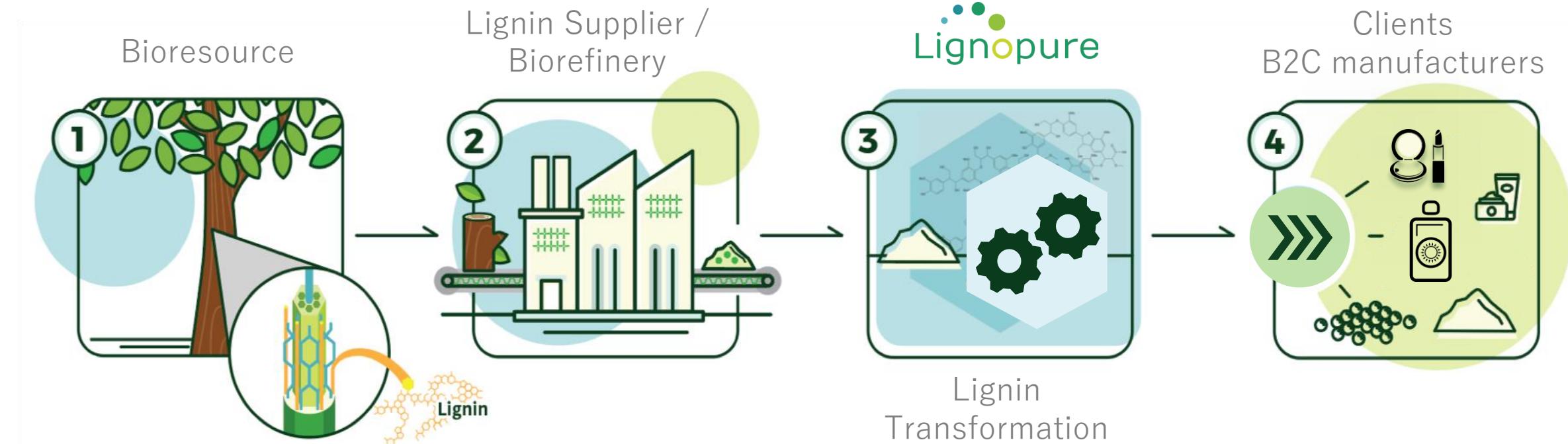


Lack of readily available drop-in solutions

Our impact in the value chain



We close the technology gap between biorefineries and the market

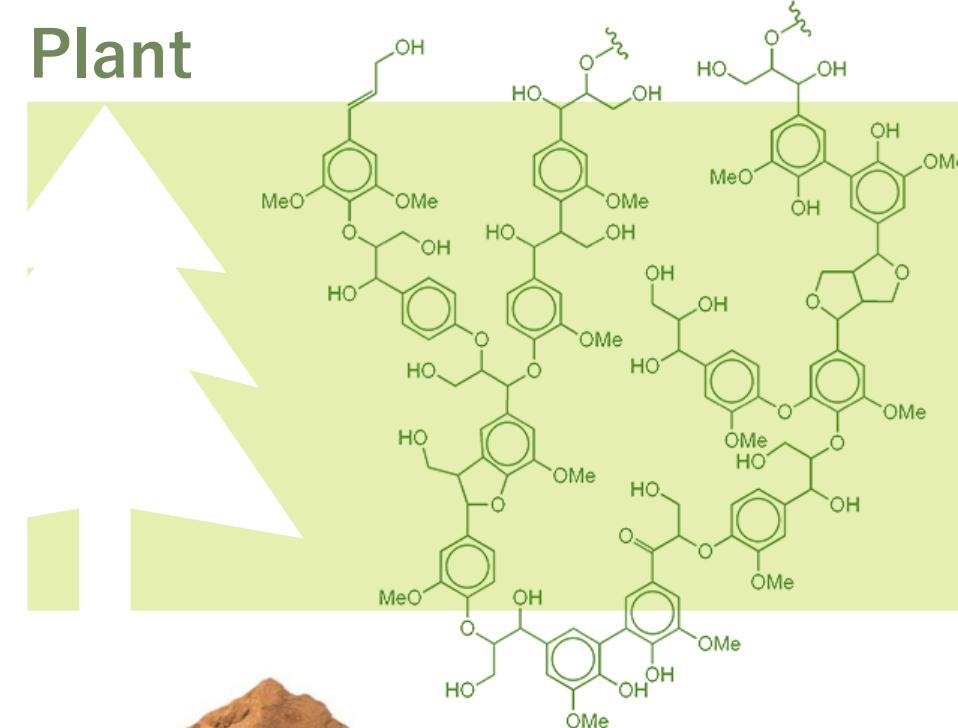


Enabling the valorization of the world's largest biorefinery waste, while
accelerating the transition towards a biobased economy.

How we do it

A true transfer of lignin's protective properties **from nature into products**

Plant



Product



UV
protection



Natural
color



Antioxidant

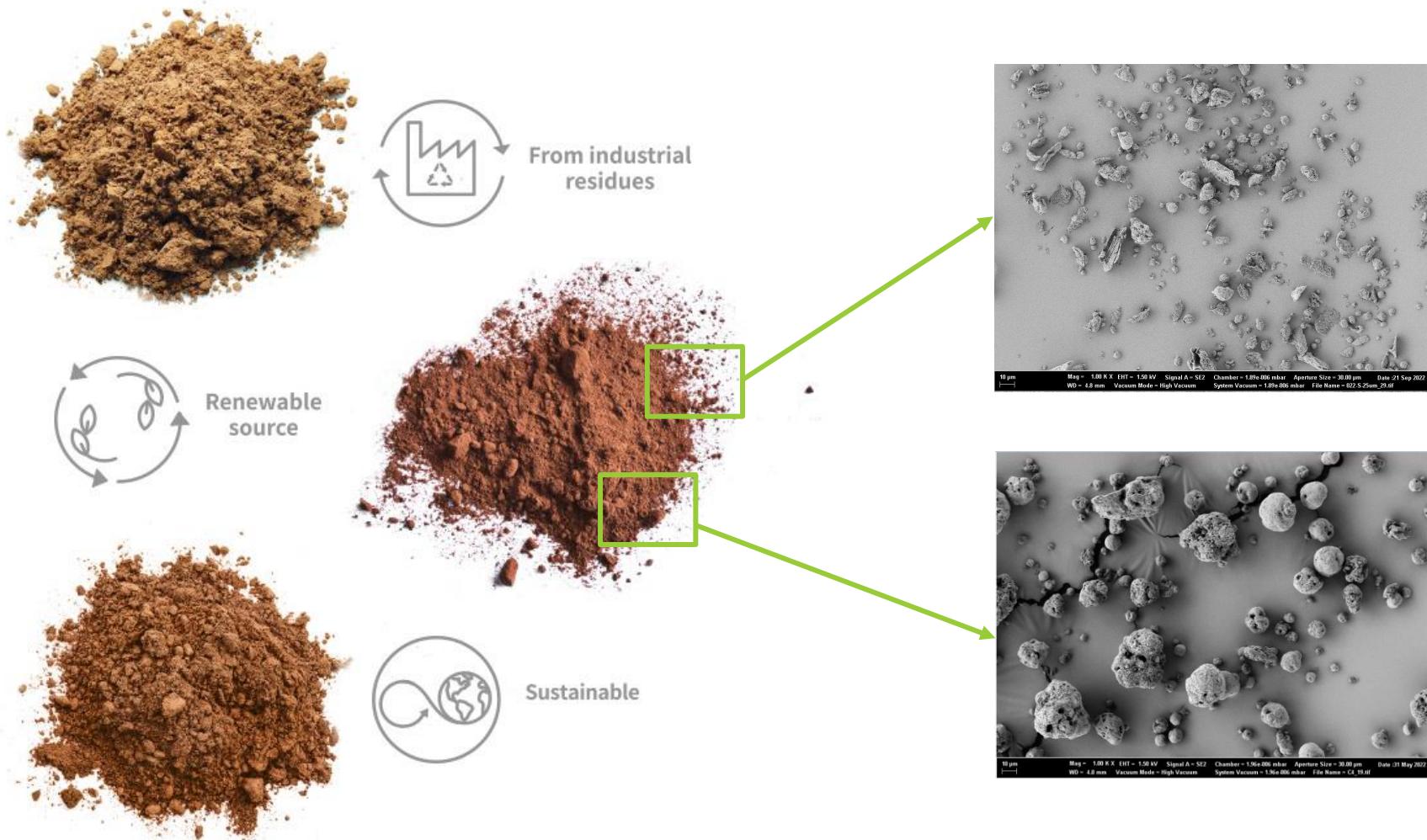


The potential

An underutilized natural polymer with multifunctionality

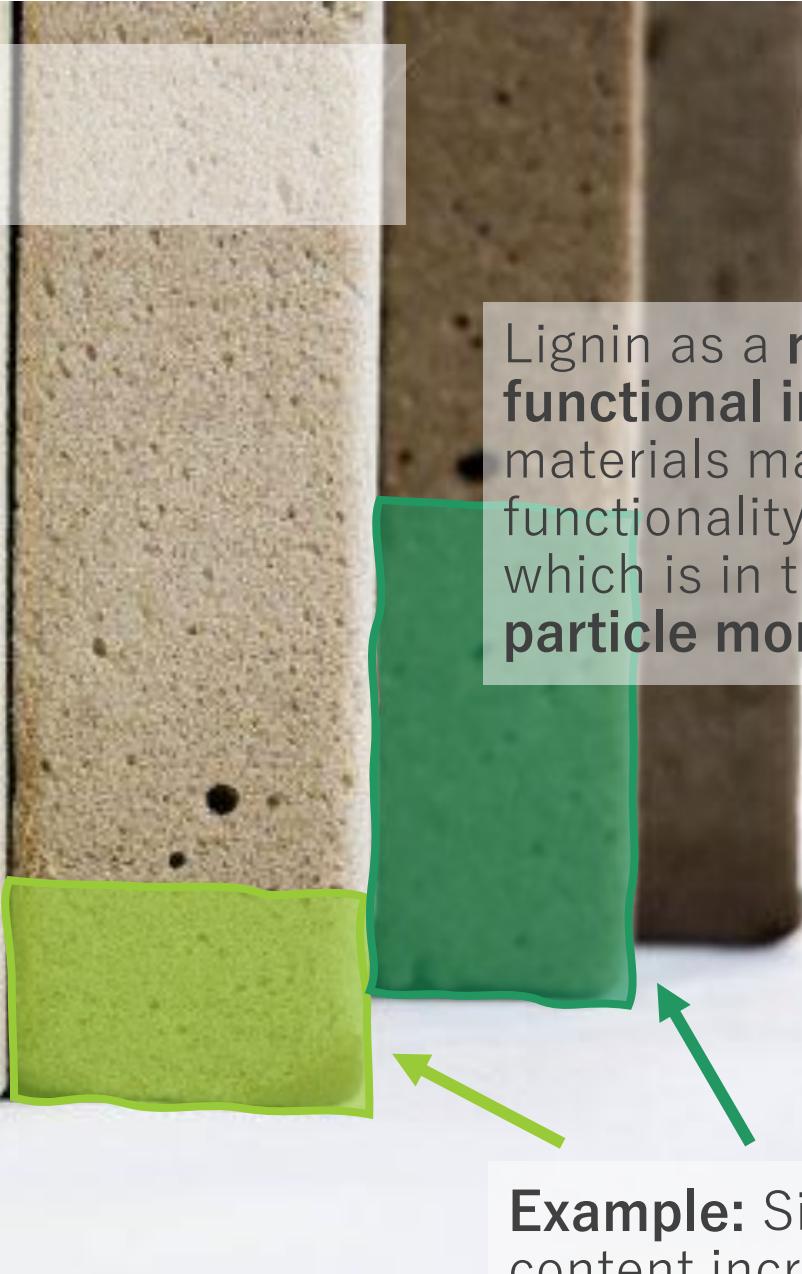
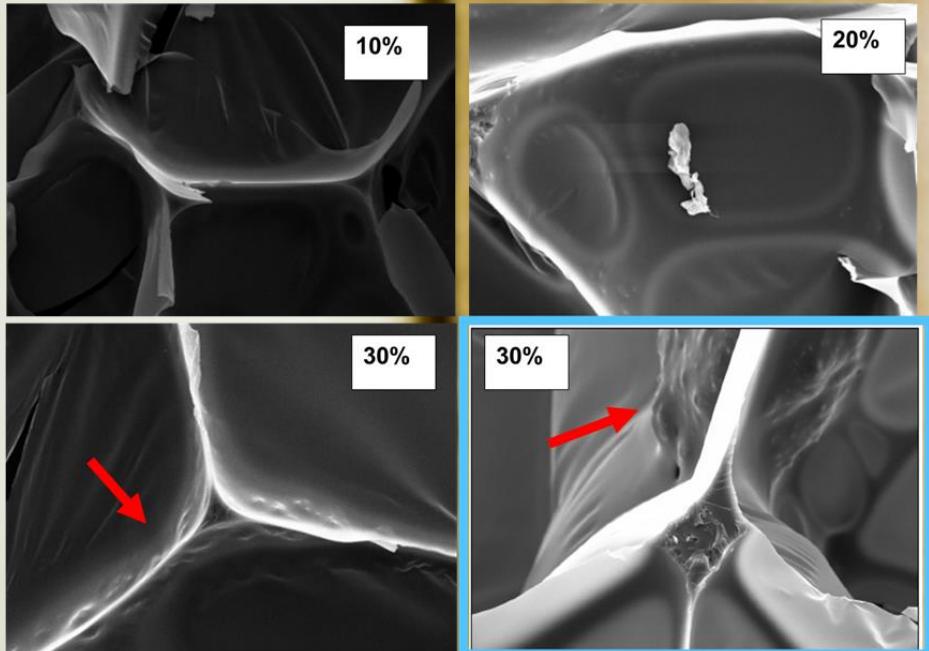


- **Lignin valorization** is a key action towards a **biobased economy**
- **Best use** of already available sources
- **Pioneering in high-value lignin applications**



Reaching maximum value by lignin particle design

Particles matter!



Lignin as a **non-soluble functional ingredient** of novel materials mainly exhibits its functionality via **surface area**, which is in turn controlled by **particle morphology and size**

Example: Significant lignin content increase in PUR foams by optimized particle properties

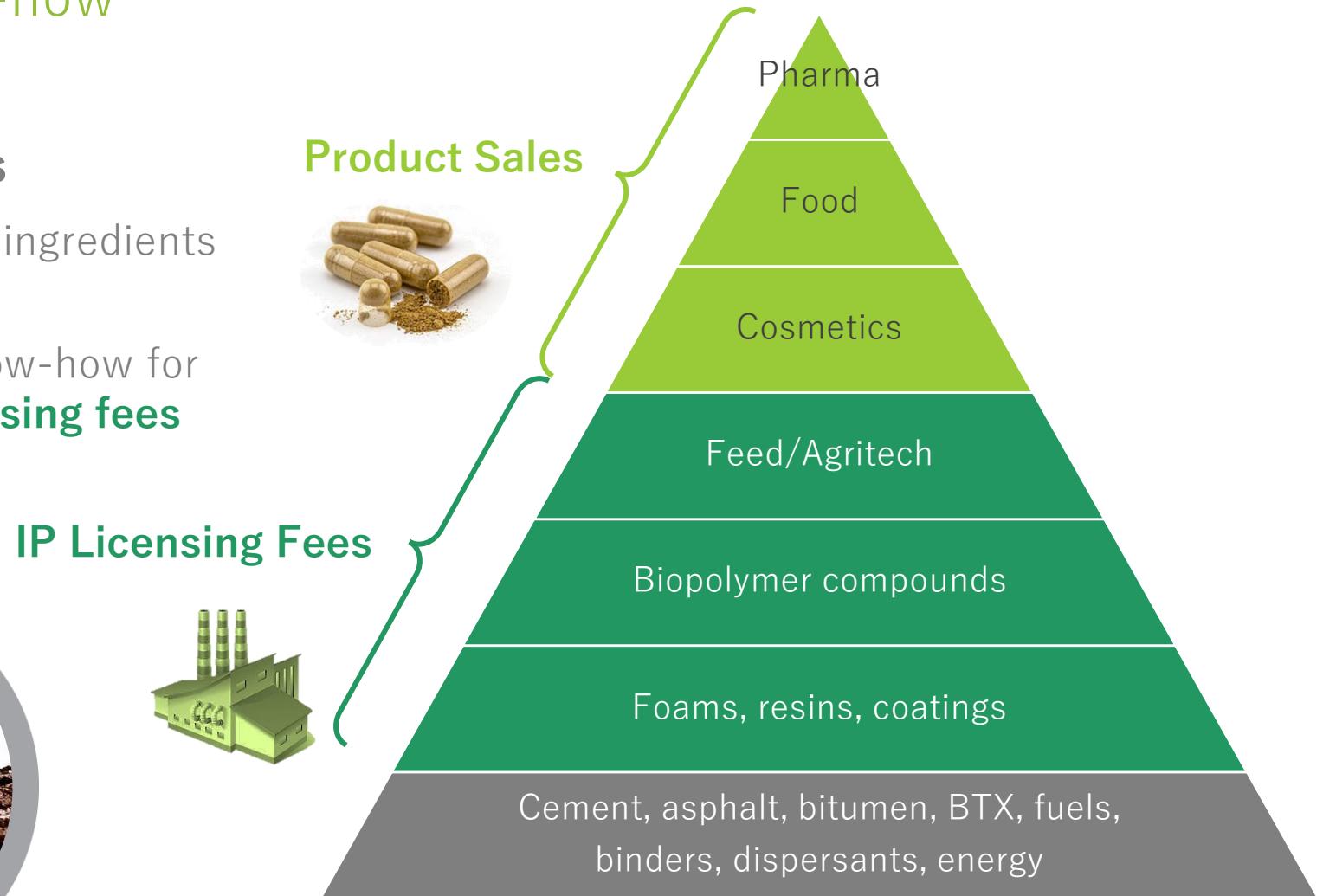
Lignin markets

Lignopure's diversity in know-how



Revenue streams/ Lignopure focus

1. Lignopure **produces and sales** lignin ingredients for high value markets
2. Lignopure licenses out the IP and know-how for bulk applications and generates **licensing fees**

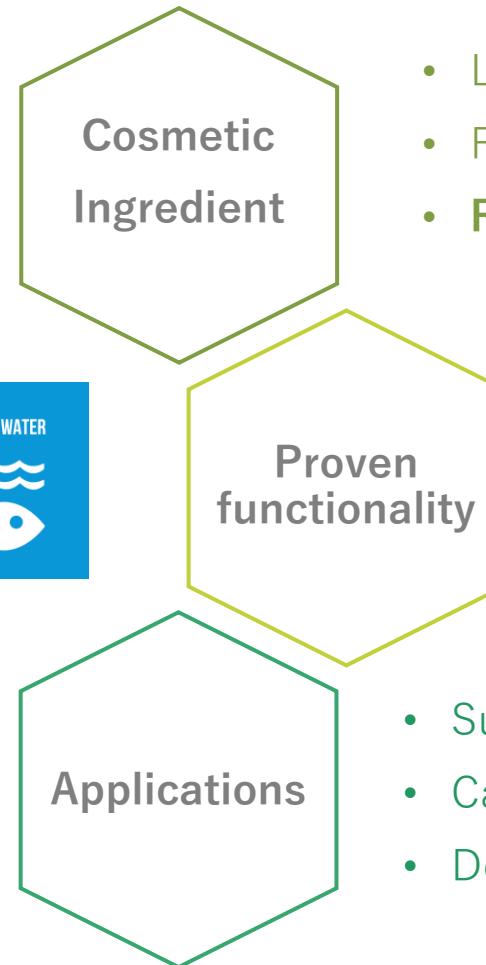


Our flagship product – LignoBase™

Multifunctional natural ingredient



LignoBase™
INCI: Lignin/Cellulose



- Lignin microparticles
- Ready to incorporate in complex formulations
- **Reduction of undesired chemical ingredients**

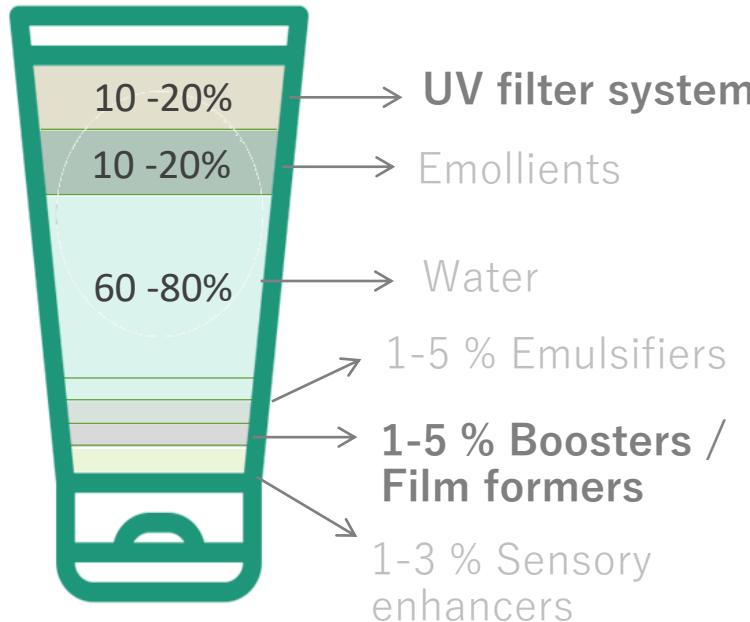
- **SPF booster**
- **Antioxidant**
- Natural color

- Sun protection
- Care products
- Decorative cosmetics



Toxic chemicals in our sunscreens

Harmful to our health & environment



Composition of a sun care product **with conventional chemicals**

UV filter system

- Organic UV filters
 - Homosalate (3-10%*)
 - Oxybenzone (3-6%*)
 - Octinoxate (7.5-10%*)
 - Octisalate (5%*)
 - Avobenzone (3-5%*)
- Inorganic UV filters
 - Titanium dioxide (up to 25%*)
 - Zinc oxide (up to 25%*)



Irregular skeletal growth



Creates deformities

Boosters / Film formers

- Hollow polymeric spheres
 - Styrene/acrylates copolymer (1-5%)
- VP/MA derivatives
 - VP/hexadecane copolymer (1-5%)
- Acrylic-, silicone-, PU based film formers



Vulnerability to bleaching



DNA Damage

How we work for biorefineries

Customer Life-Cycle towards technology licensing



Close customer co-development from lab to industrial scale



- Crude lignin analysis
- **Quality** benchmarking
- **Application potential**
- Improvements

1. Lignin assessment

2. Lab scale processing

- Process tailoring
- Particle design
- **Proof of concept**
- Powder production
- Quality assessment

3. Pilot scale processing

- Process scale-up to ind. relevant TRL 6 - 7
- Provision of **powder product prototypes** for customer sampling

4. Technology Licensing

- Know-how & IP package licensing
- Continuous scale-up and implementation support



Lignin's benefits in various applications

Making use of lignin's natural functionality

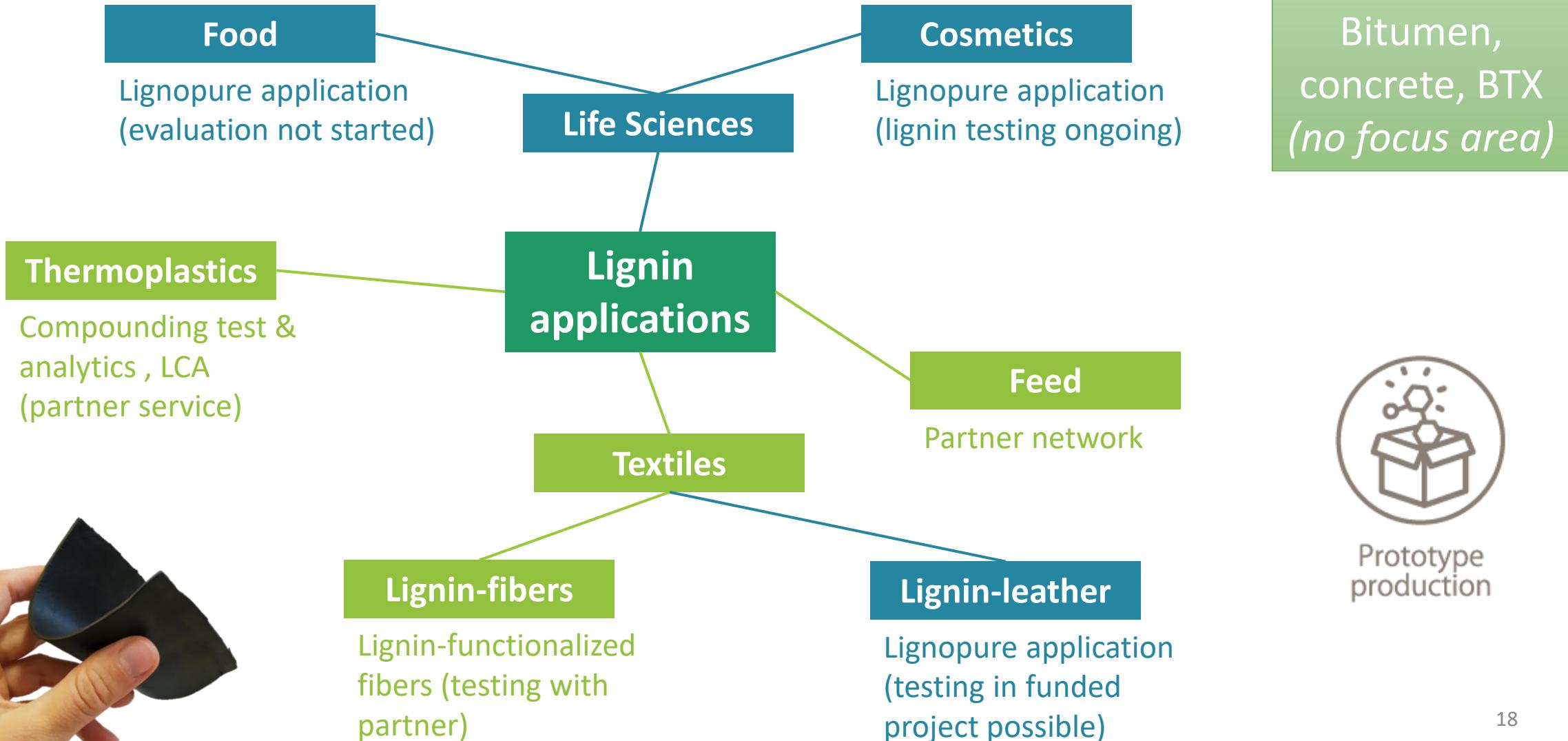


- Ideal: **drop-in solution** (Product & process)
- Why lignin? **Functionality!**
 - **Improved CO₂ footprint** with increasing lignin content
 - No food competition
 - **Antioxidant, anti-aging**
 - **UV protection, ozone protection, barrier**
 - Mechanical **reinforcement**
 - Potentially **flame retardant**, ...
- **Problem: Color acceptance, odor**



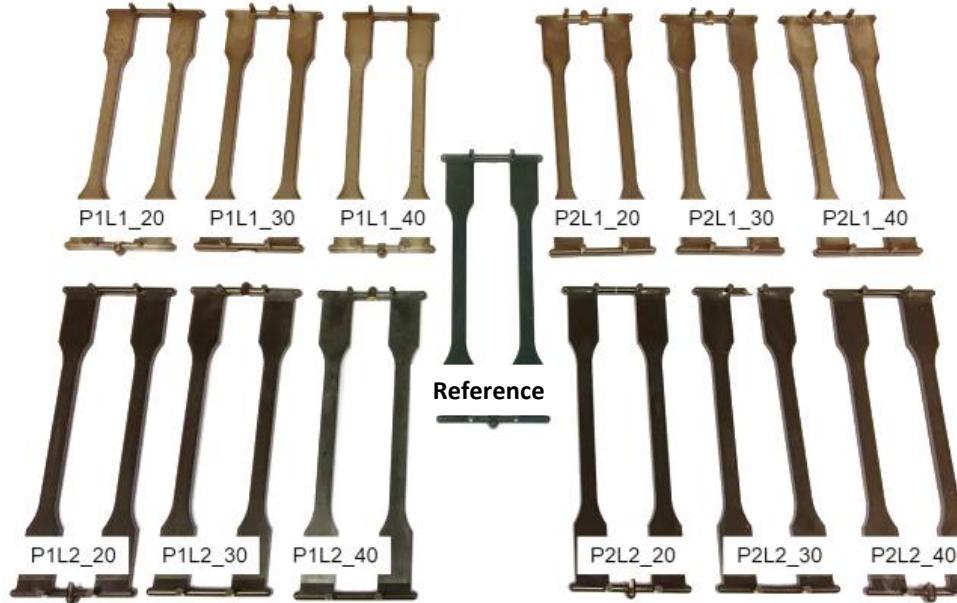
Application testing

Application potential identification & testing



Application example

Thermoplastics



- Basic compound can be realized on TRL 6
- targeted adaptation to customer needs

Lignin PLA compounds

Raw Materials	High to 100 % biobased content
Lignin origin	Softwood, hardwood, annual plant residues
Lignin content	10 – 50 wt.%
Properties	Thermoplastic
Possible modifications	Mechanical properties, desired processing, chemical properties, biodegradability, color, food contact etc.
Application fields	Injection molding , foam injection molding, films, expanded foams, melt-spinning, 3D-printing
Degradability	Inherent biodegradability
Density	1200 – 1600 kg/m ³
Melt flow Index	Melt flow rate (g/10 min, 2.16 kg, 190 °C) = 10 - 80
Mechanical properties/ Bending behavior	<ul style="list-style-type: none">• E modulus: E_f (MPa) = 3400 – 4300 (DIN EN ISO 178)• Stretch limit: σ (MPa) = 50 – 85, ε (%) = 1.8 – 2.4• Break limit: σ (MPa) = 50 – 85, ε (%) = 1.6 – 2.4
Notched impact strength	a_k (kJ/mm ²) = 5 – 15 (Charpy, DIN EN ISO 179)
Thermal Properties	<ul style="list-style-type: none">• Glass transition: T_g (°C) = 60 – 70• Melting point: T_m (°C) = 170 – 190• Decomposition: T_d (°C) = 340 – 380
Fire behavior	Horizontal Burn Test (UL 94): Low fire speed, short extinction times, low tendency to falling droplets, low soot formation
Media resistance	Limited resistance to oxidizing agents & organic solvents
Water uptake	0.25 – 1 wt%, no further impact of pure water

Company development

Since 2019

Lignopure

Lignopure

2019
Company
founding

2019
Equity free
funds

IFB
HAMBURG

High-Tech Gründerfonds
IFB
HAMBURG
TaNovis

2020
Seed
financing
round

1st
GMP Plant in Europe for
lignin transformation

90 t/a



2021
Own GMP
production



2022
Production &
market readiness

2023
Series A



Be part of the transition!

www.lignopure.de
info@lignopure.de