MNEXT

LUNCH &LEARN

From lignin to bio-aromatics: challenges and prospects

April 18, 2024

WELCOME!

WE WILL START AT 12:15H

avans hogeschool

UNIVERSITY OF APPLIED SCIENCES

LUNCH &LEARN

Program

12:15h: Introduction by Han van Kasteren, Professor Biobased Building Blocks & Products - MNEXT

12:20h: Presentations by Sandra Corderí Gándara, Researcher Biobased Building Blocks & Products - MNEXT

12:45h: Questions/discussion

13:00h: Closure

- Please ask your questions via the chat
- Presentation slides will be shared afterwards
- This Lunch & Learn will be recorded

MNEXT

LUNCH &LEARN

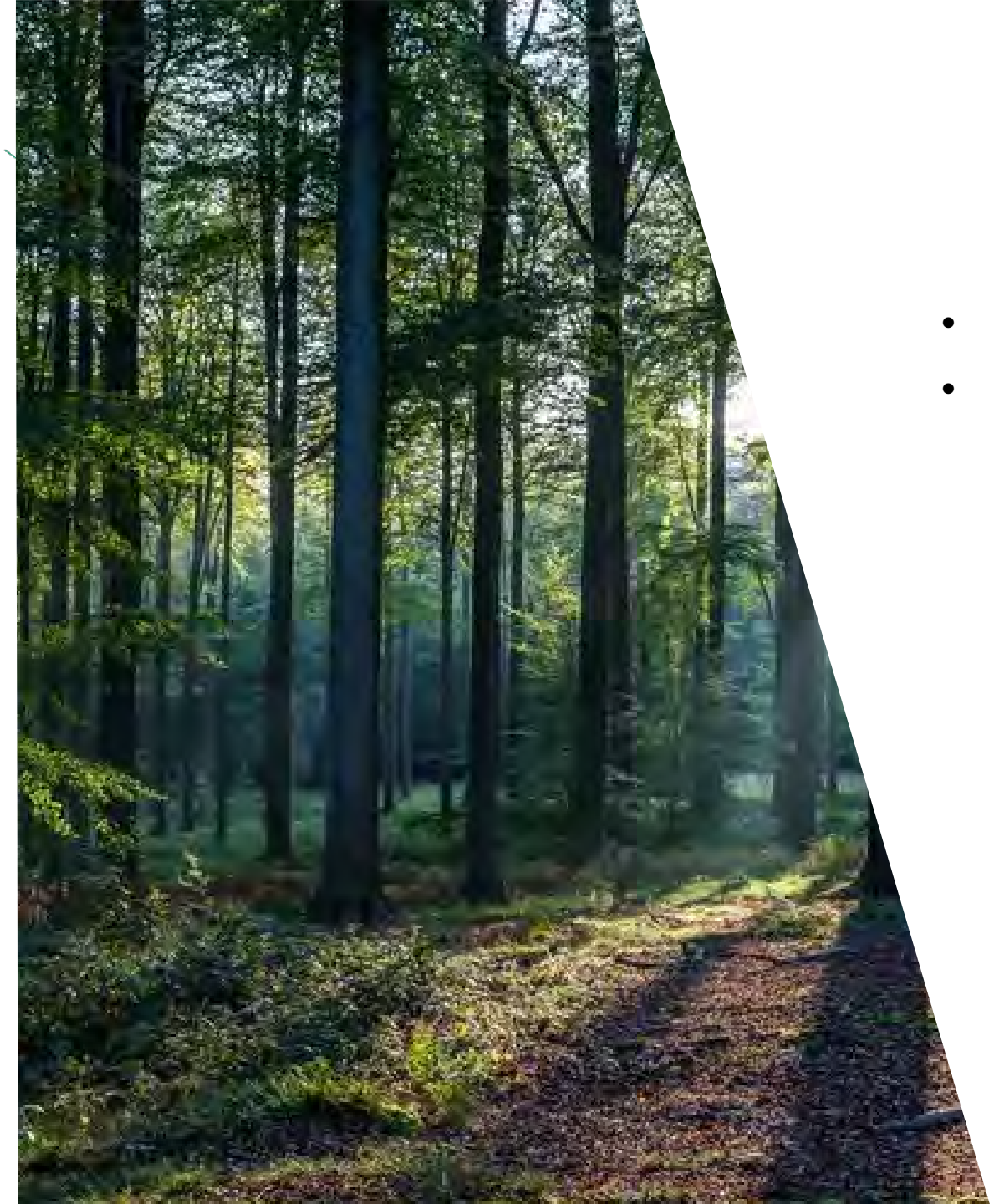
From lignin to bio-aromatics. Challenges and Prospects

Dr. Sandra Corderí Gándara

s.corderigandara@avans.nl

MNEXT: Biobased Building Blocks & Products Team

18-04-2024



Agenda

- MNEXT: Biobased building blocks & products team
- From lignin to bio-aromatics
  - Lignin
  - Applications
  - Challenges
  - Current projects on Bio-aromatics
  - Future prospects


MNEXT

RESEARCH GROUPS MNEXT

Centre of Expertise for Materials and Energy transition

ENERGY

MATERIALS

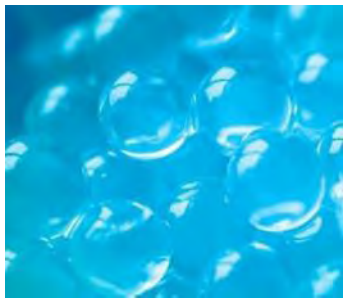
RENEWABLE ENERGY CARRIERS

SMART ENERGY

BIOBASED RESOURCES & ENERGY

BIOBASED TRANSITIONS

BIOBASED BUILDING BLOCKS & PRODUCTS



BIOBASED CONSTRUCTION

MARINE BIOBASED CHEMISTRY

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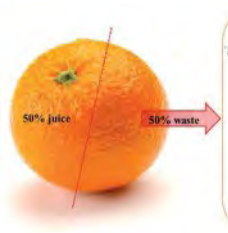
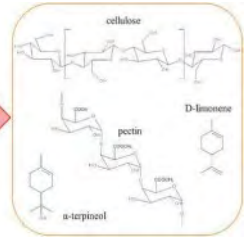
Research group:
Biobased Building Blocks & Products

Han van Kasteren

Research themes:

- **Bio Additives**
  - Extraction, upgrading and application of biobased additives: natural dyes, antioxidants, flame retardants and stabilizers
- **Bio(based) polymers & building blocks**
  - Biocircular Design: upgrading, application and recycling of biobased polymers



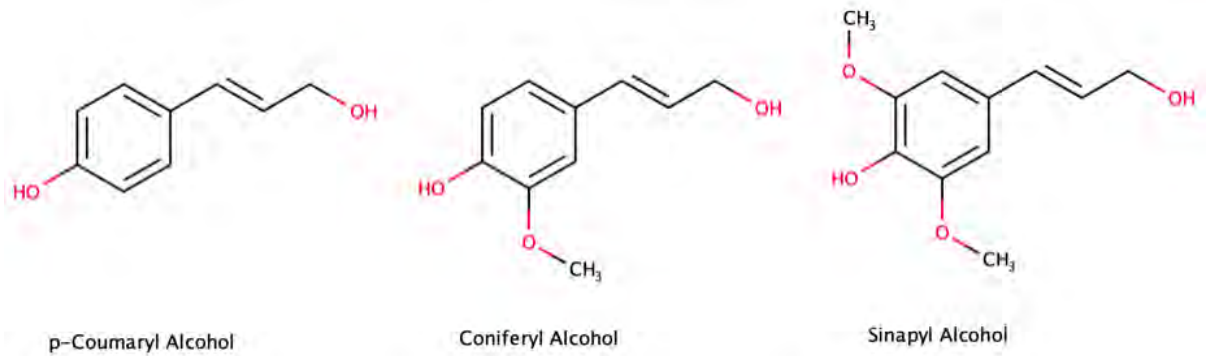


Research group:
Biobased Building Blocks & Products

From lignin to Bio-aromatics. Challenges and Prospects

Lignin

- Most abundant natural, renewable aromatic polymer on earth
- Different potential sources:
  - Technical lignins from pulp & paper industry (60-70 M tons/year, globally)
  - Hydrolysis lignins from 2G biorefineries
  - Wood based products/grasses
- Only ~1% of technical lignins is recovered for uses other than energy

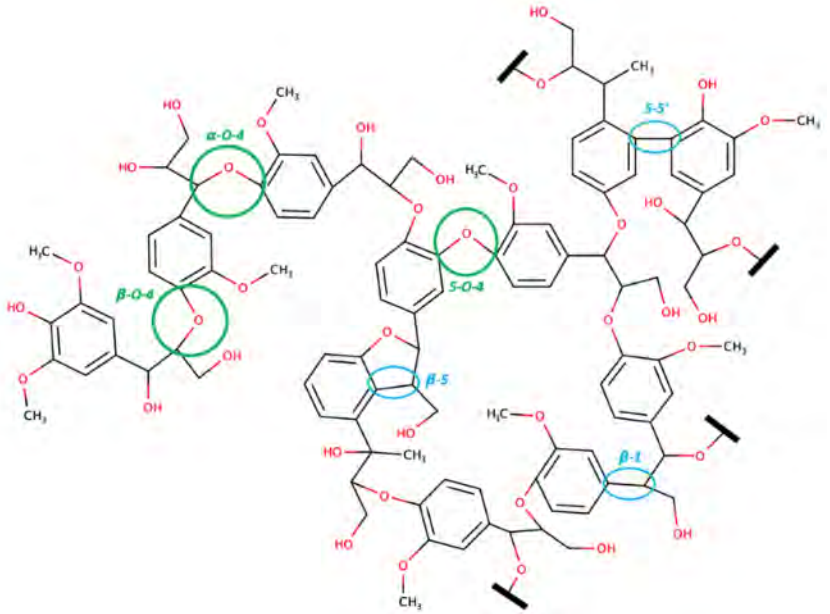


Pulp and paper

Miscanthus

BIOREFINERY

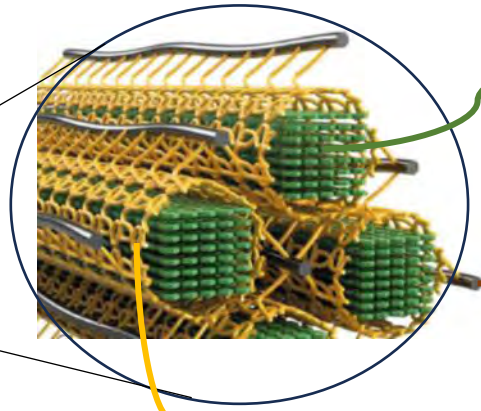
Waste wood



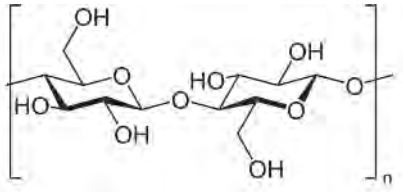
Lignin from biomass

Lignocellulosic feedstock

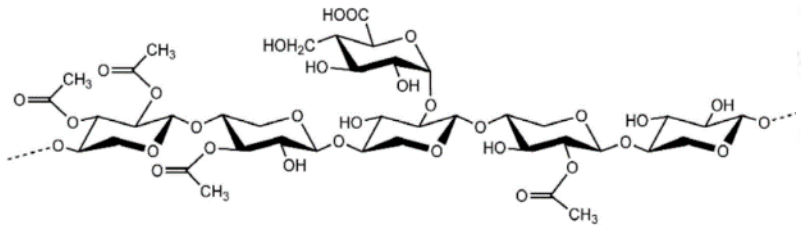
Plant cell wall



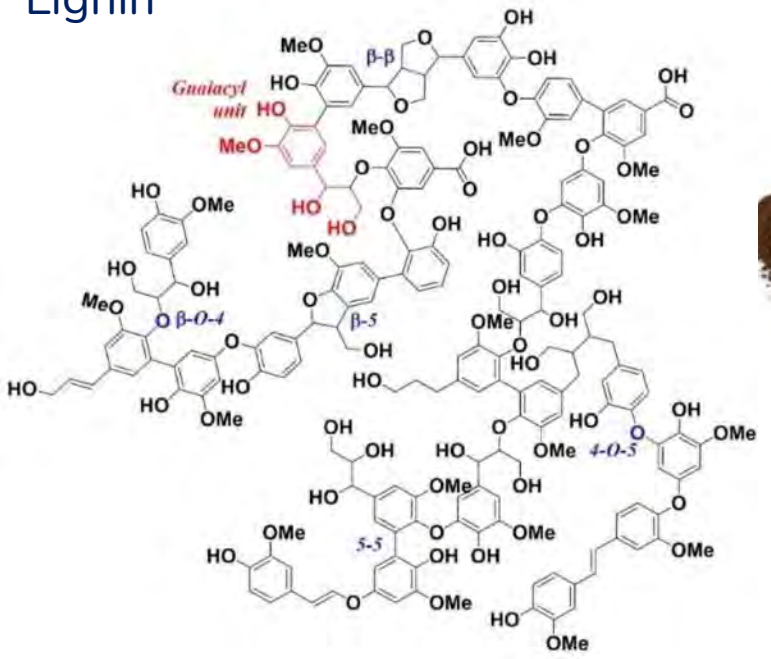
Cellulose



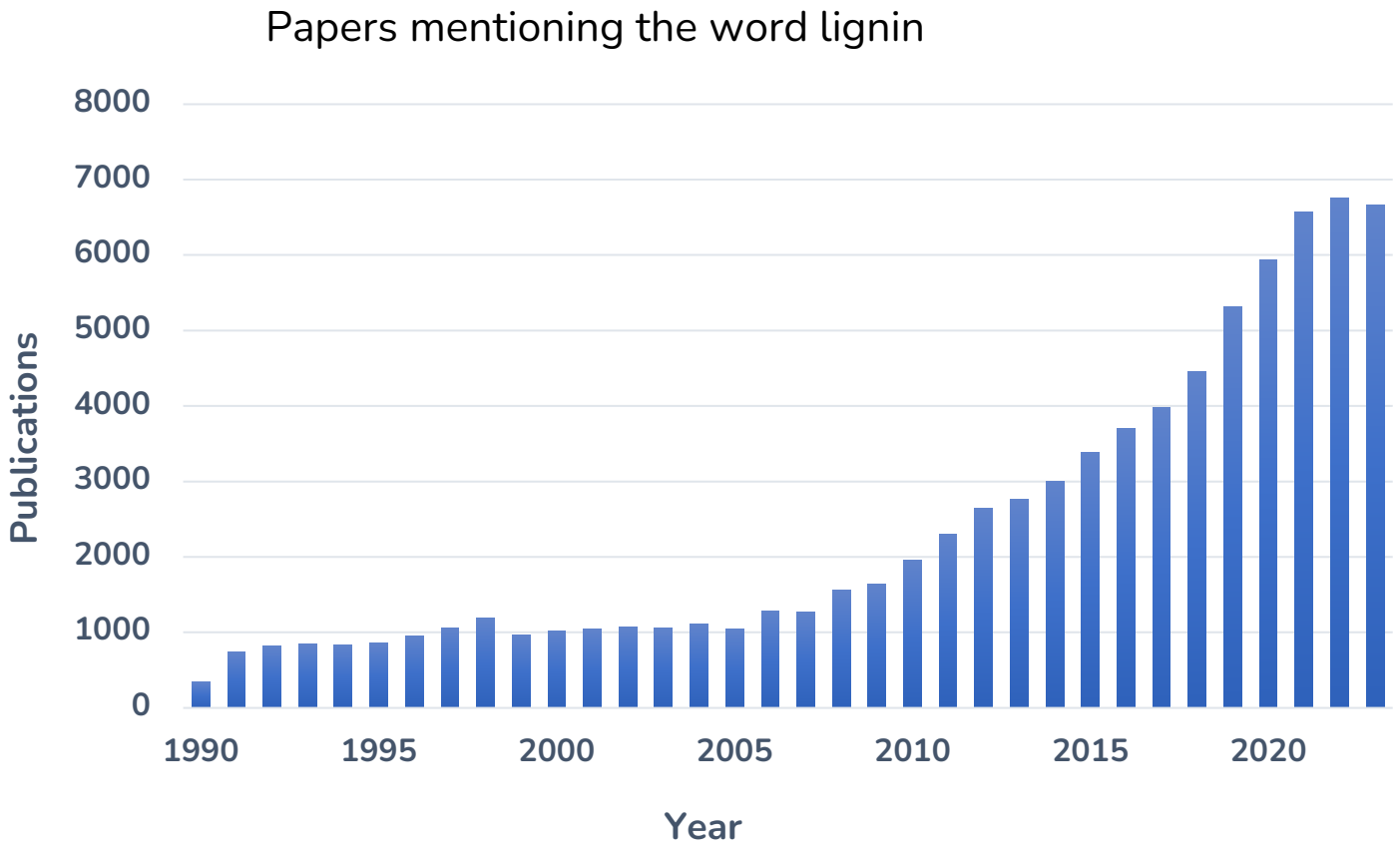
Hemicellulose



Lignin



Lignin interest is increasing



Major drivers for using lignin:

- Economical aspects (attributing value to a by-product from pulping or biorefinery)
- Sustainability (replacing fossil-based materials with bio-polymers)
- Aromatic

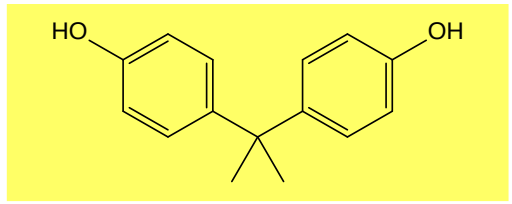
https://www.webofscience.com/

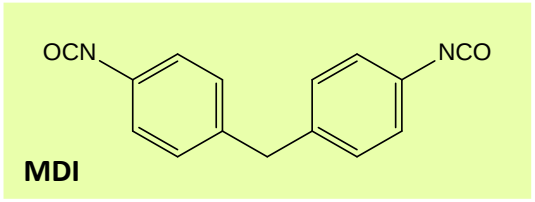
Aromatics are everywhere!

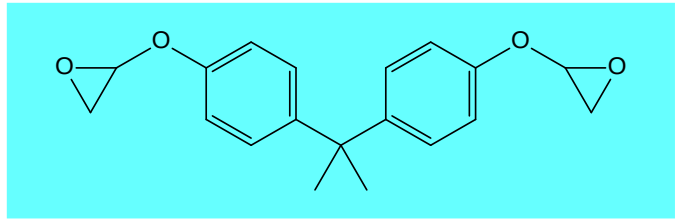
AS THEY BRING SPECIFIC FUNCTIONALITIES TO MATERIALS (STABILITY, RIGIDITY…)

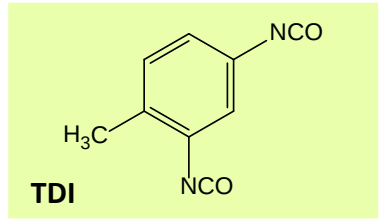
40%

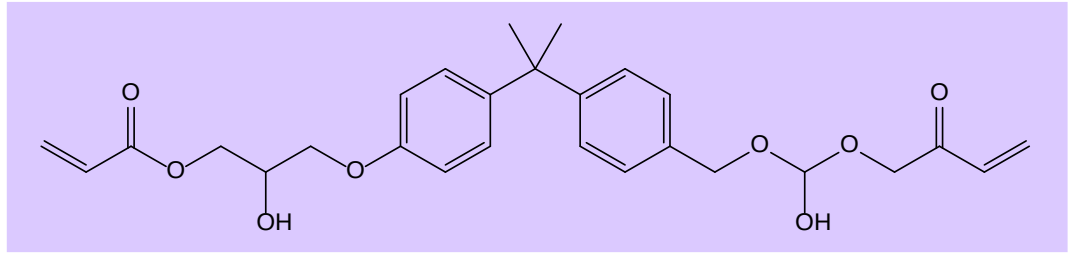
Of all chemicals produced are aromatics

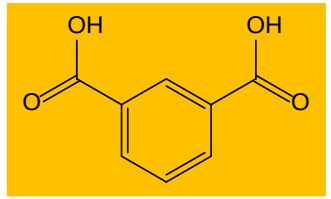


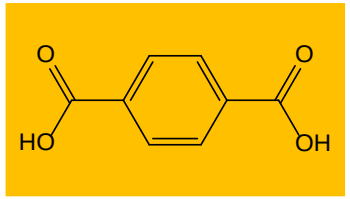


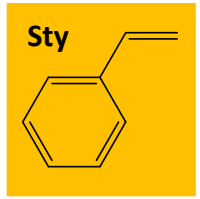


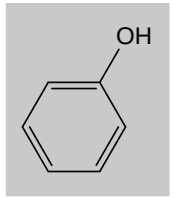












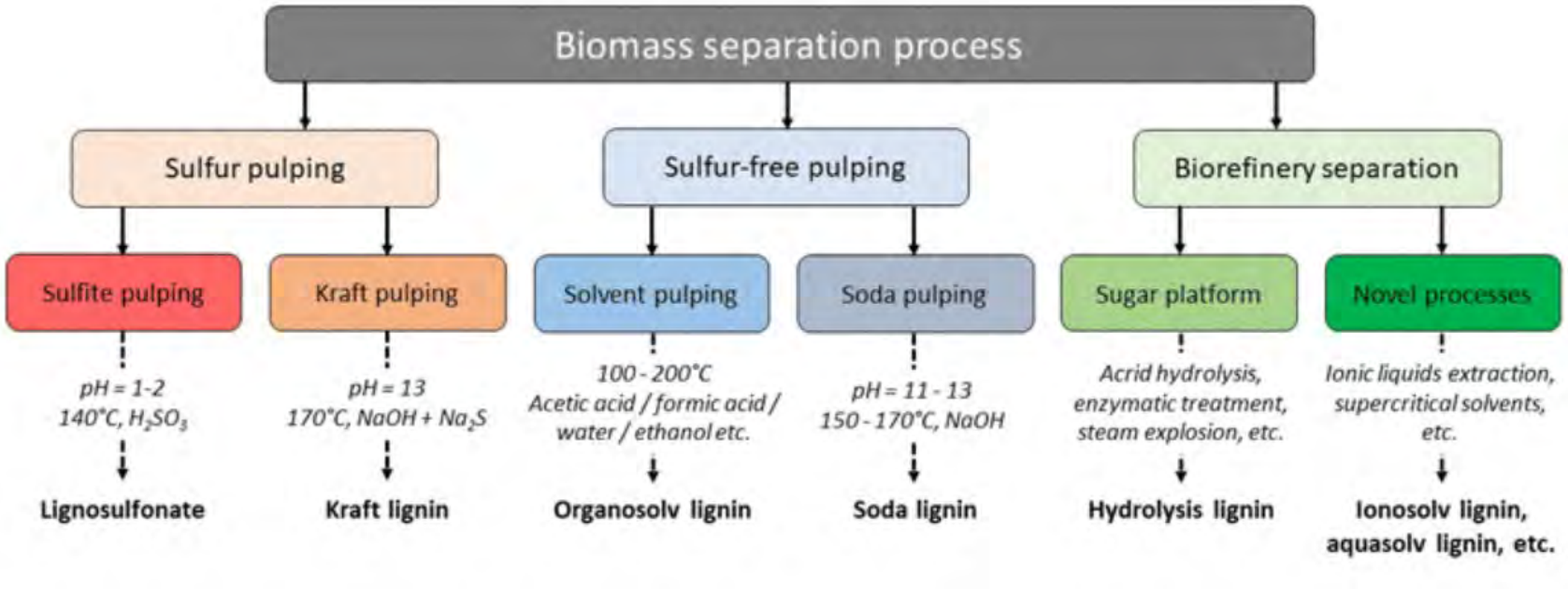
- Polycarbonate
- Polyurethane
- Vinyl esters
- Epoxy
- Polyesters
- PF resins

From lignin to bio-aromatics

Biomass → Fractionation → Isolated lignin → Downstream processing → Purified lignin/oil → Upgrading → Bio-based materials

Isolated lignin → Depolymerization → Depolymerized lignin oil → Downstream processing

Lignin types

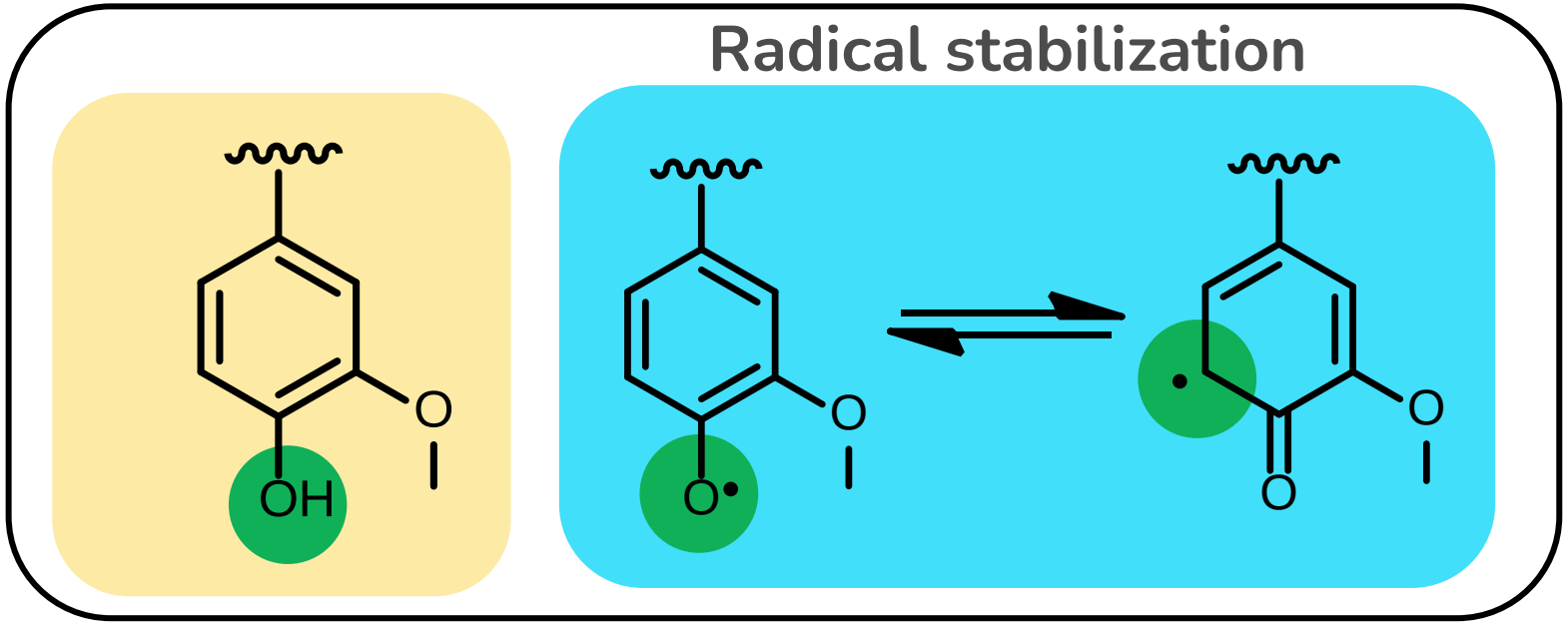


Multiple processes and biomass types → Different lignin properties

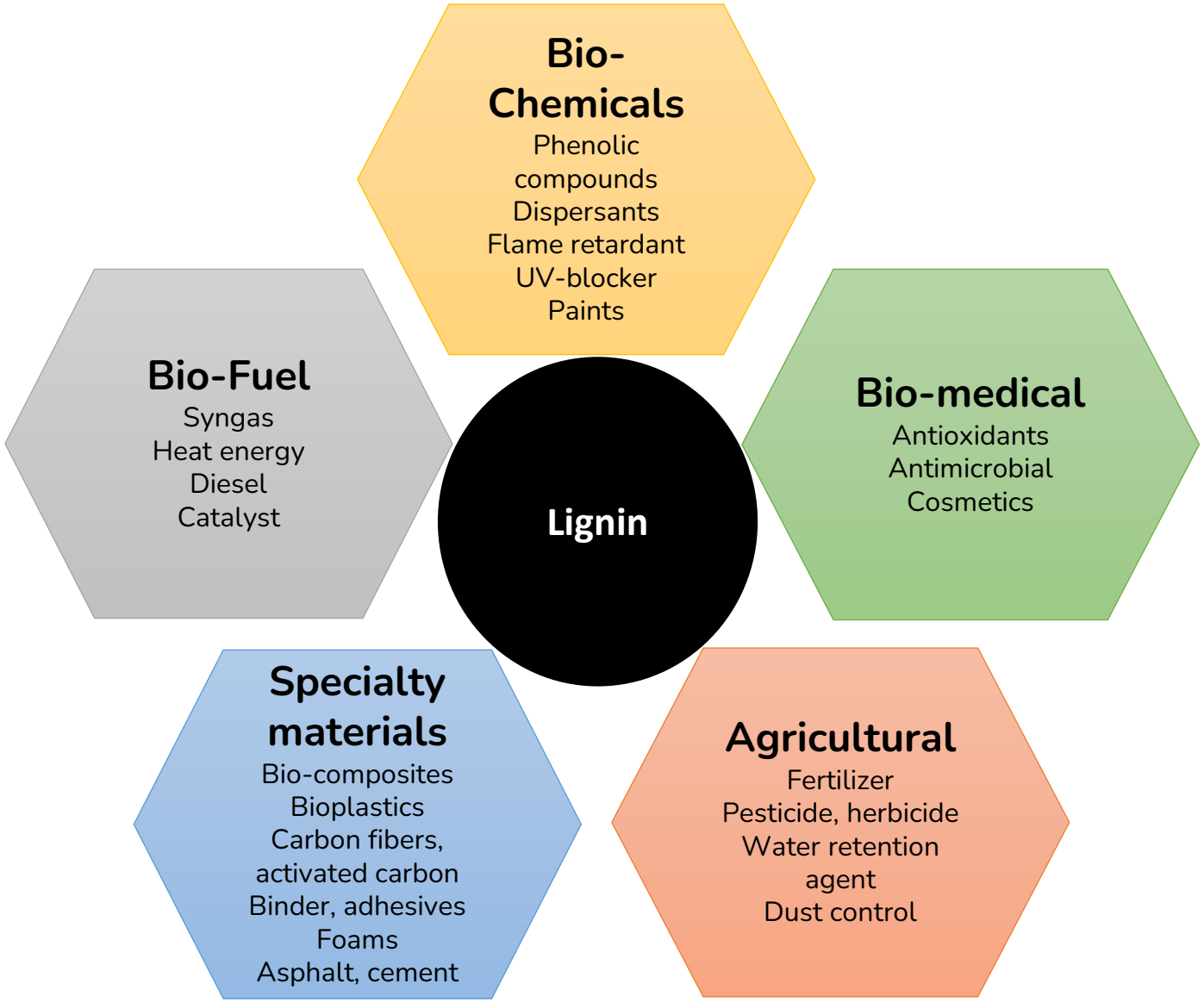
RSC Adv., 2023, **13**, 12529-12553

Lignin key for its functional properties

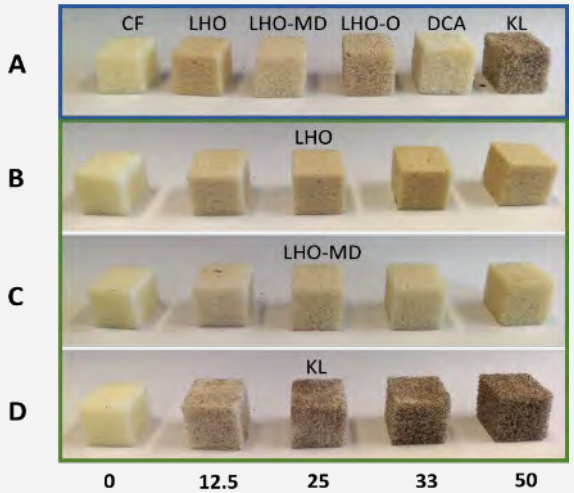
- Temperature stability
- UV stability
- Flame-retardant
- Antibacterial
- Antioxidant
- Anti-static
- Rigidity
- Waterproofing



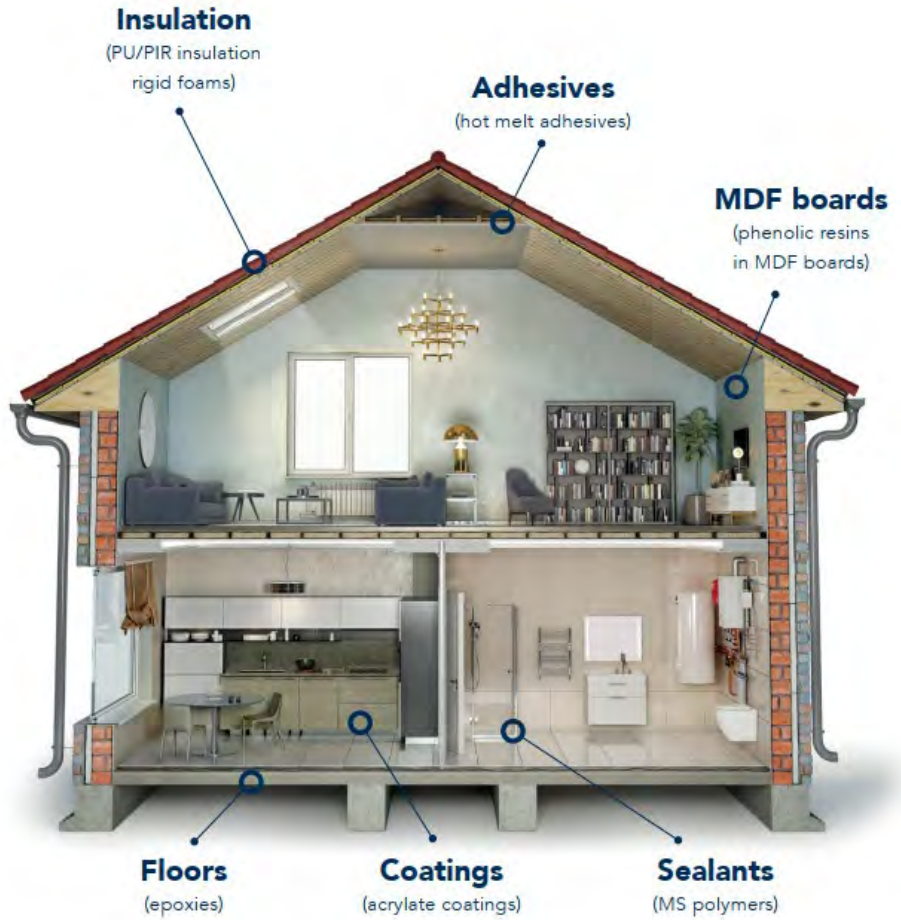
Lignin applications



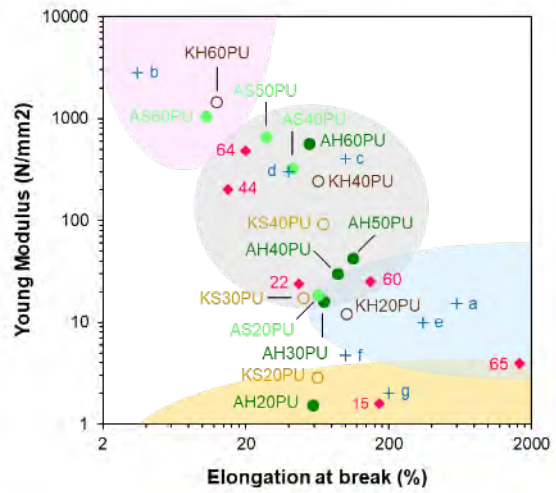
Lignin applications: PU FOAMS



Up to 50 wt % polyol replacement



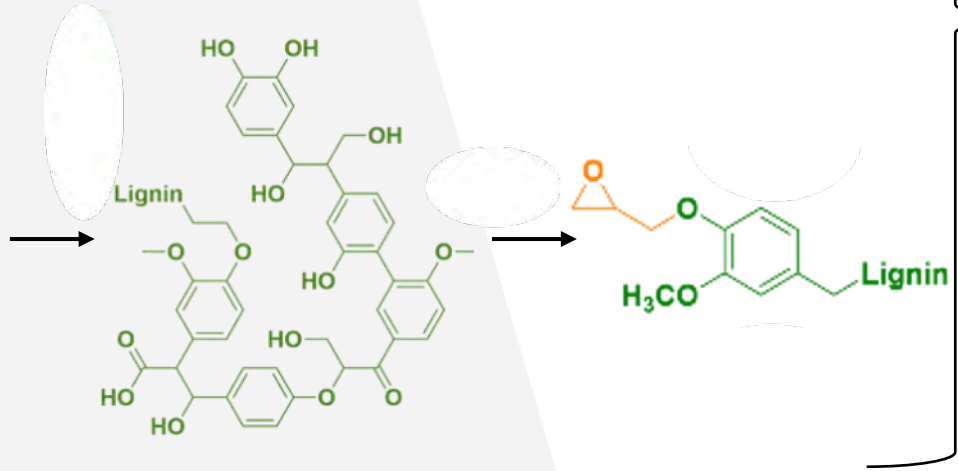
Tunable materials



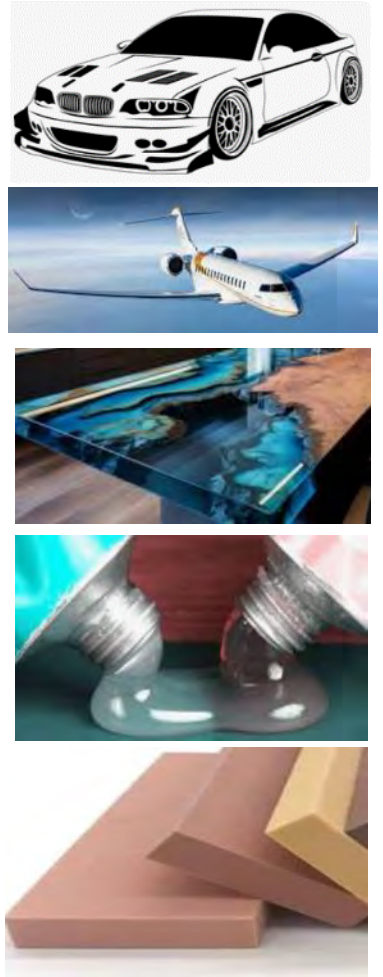
Biomacromolecules, 2022, 23, 11, 4562–4573; ACS Appl. Polym. Mater. 2021, 3, 11, 5845–5856

Lignin applications: Epoxy

25-50 % BPA reduction by using biobased



Epoxy resin



Feghali et al., *Biomacromolecules*, 2020; Pappa et al., Current Opinion in Green and Sustainable Chemistry 2022

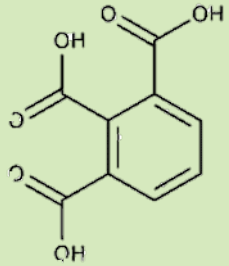
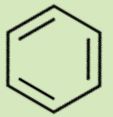
Challenges of lignin valorization

- Related to structure:
  - Heterogeneous polymeric nature (plant source and extraction process)
  - High molecular weight
  - Impurities (polysaccharides, Na, …),
  - Low solubility
  - Low compatibility with surrounding matrix
  - Color
- Availability of lignin at scale
- Technology maturity (emerging)
- Demand of bio-based products (need to switch from oil to biomass refinery)

Mitigation strategies

- **Lignin selection and characterization**
- **Lignin depolymerization**
- **Lignin upgrading**

How we make bio-aromatics at scale – Biorizon initiative

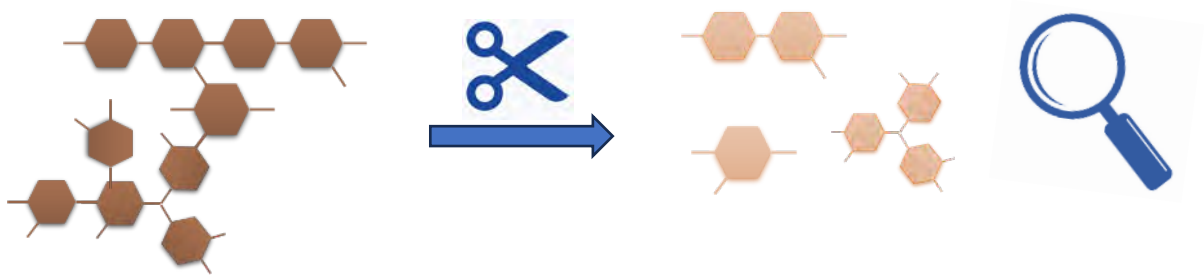
Horizons	Feedstock	Conversion Technology	Bio-Aromatics	Applications
Sugar to Bio-Aromatics	 C5 Sugars/ Furfural	Diels-Alder	 Specialty €€€	       
Lignin to Bio-Aromatics	 Lignin	Catalytic Depolymerization		
Thermochemical Conversion of Biomass to Bio-Aromatics	  Biomass residues & Recycle streams	Pyrolysis Gasification	 Bulk €	

Biorizon
The way to aromatics

TNO

vito

Lignin depolymerization



Lignin oils properties

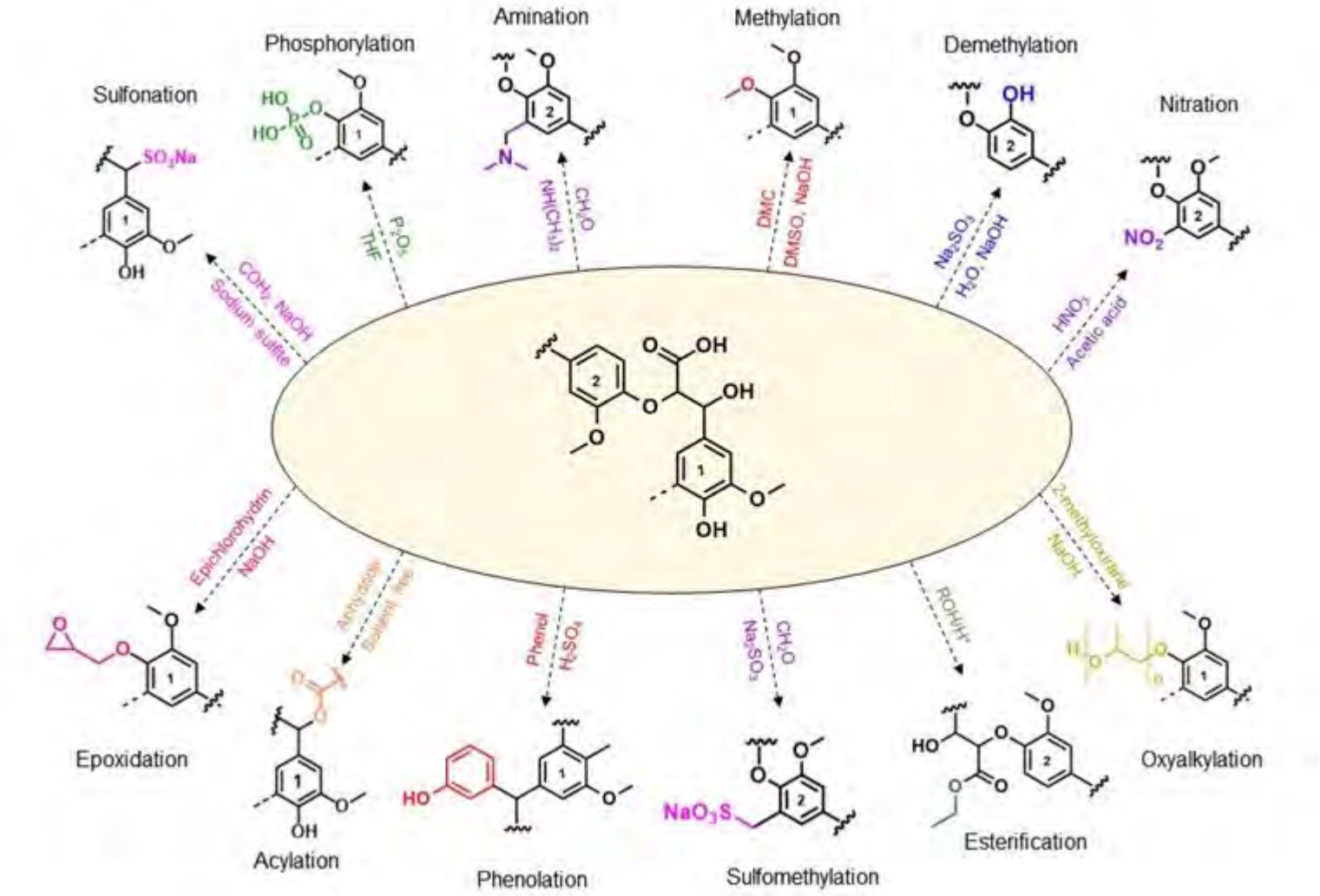
	ACD		BCD		Solvolysis		RCD	
	Average	Range	Average	Range	Average	Range	Average	Range
Monomers (%)	20	3 to 60	13	3 to 21	19	3 to 48	26	5 to 81
bio-oil yield (%)	68	28–90	47	13–78	56	15–87	71	31–98
Mw (Da)	866	500–1500	1031	300–2600	962	300–1600	636	220–1881
HHV (MJ/Kg)	30,9	29–34	27,9	26–29	28,4	31–25	32,2	22–39
OH (mmol/g)	–	–	–	–	6,5	6,5	7,8	9,3–6,3

ACD: acid catalyzed depolymerization
BCD: base catalyzed depolymerization
RCD: reductive catalytic depolymerization

Current Opinion in Green and Sustainable Chemistry 2023, 40:100781

Lignin depolymerization pilot at VITO

Lignin upgrading, functionalization

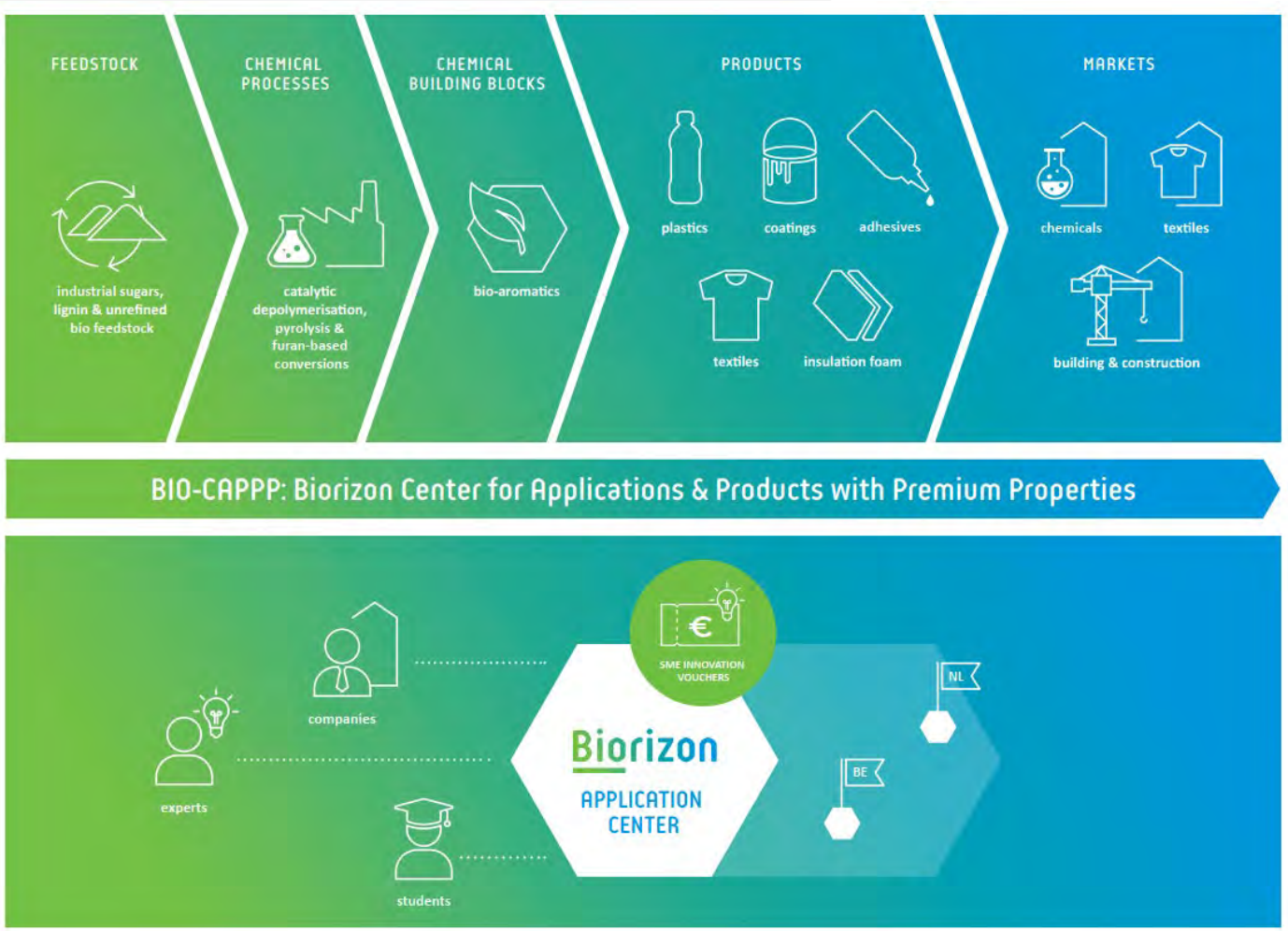


BioResources 16(3), 2021, 6471-6511

BIO-CAPPP project- Biorizon Centre for Applications & Products with Premium Properties

Interreg Vlaanderen-Nederland
Gefinancierd door de Europese Unie

BIO-CAPPP



- Establishment of Biorizon Application Center
  - Developments by and with companies (voucher system)
  - Own developments focusing on textile and construction industry
- Total budget: € 4.308.351,32
- Project start 15/6/2023; 3 years

Partners:

vito TNO Biorizon CENTEXBEL KAMP C avans MNEXT GREEN CHEMISTRY CAMPUS

Interreg Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling
EUROPESE UNIE

VLAIO
Ministerie van Economische Zaken en Klimaat
provincie Oost-Vlaanderen
Provincie Noord-Brabant
Provincie Antwerpen

Call for participation

Interreg Vlaanderen-Nederland

Gefinancierd door de Europese Unie

BIO-CAPPP

- Interreg VL-NL BIO-CAPPP

Innovation voucher system

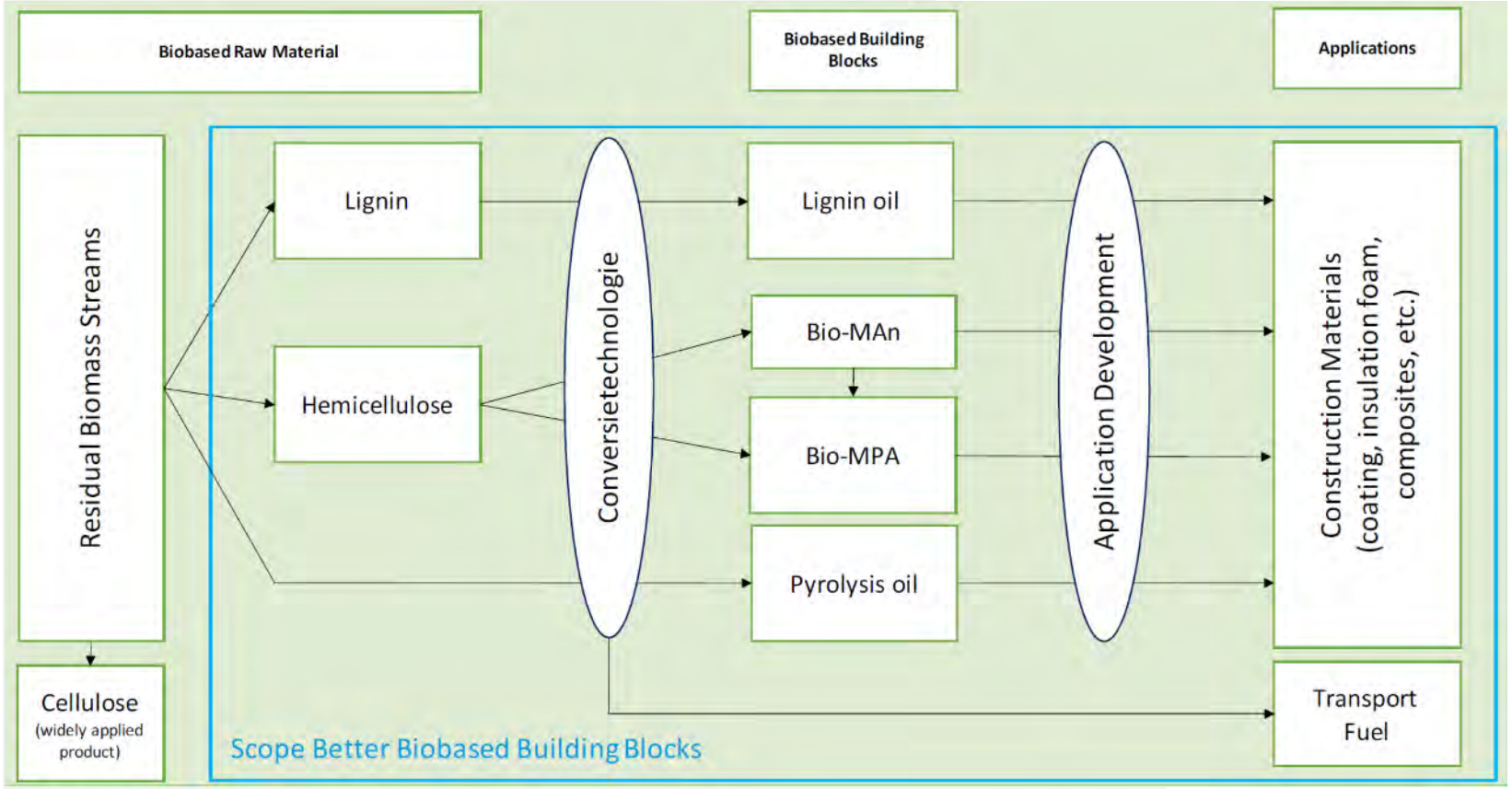
Specifically for SMEs

Looking for bio-aromatic samples, either sugar-derived or lignin-derived?
Looking for potential replacements in applications?

Please contact us! → vouchersbiocappp@vito.be

For more information or to discuss project ideas, always open for discussion!

JTF-B4 project: Better Biobased Building Blocks



- **Goal**: Develop sustainable value chains from (residual)biobased feedstock to biobased building blocks for application in construction sector
- Total **budget**: 4,37 M€
- Project **start**: 01-10-2023
- 3 years

Project partners: TNO, Biorizon, vito, avans university, MNEXT Materials Energy X Transition, Green Chemistry Campus, Westlake Epoxy, Worlée, Relement, Progression-Industry, Bodewes Material Solutions, Baril

Funded by the European Union

JTF Just Transition Fund

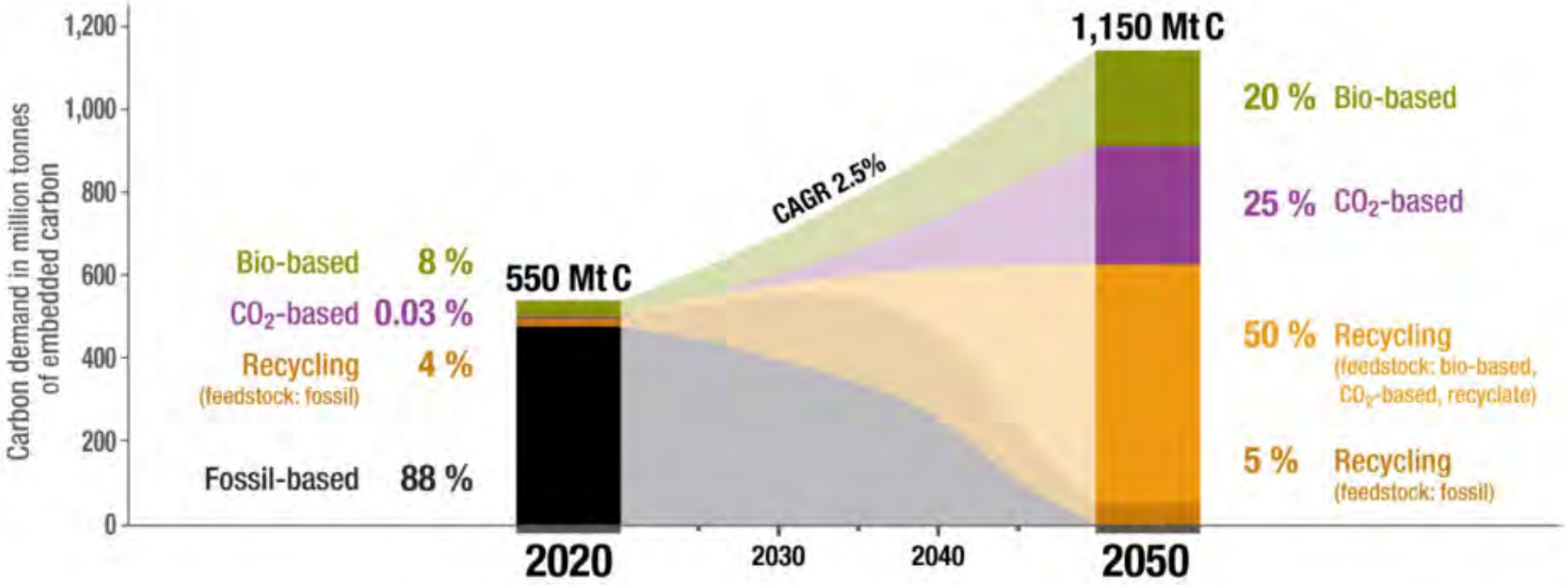
Provincie Noord-Brabant

Ministerie van Economische Zaken en Klimaat

Ministerie van Sociale Zaken en Werkgelegenheid

Future prospects- Biobased chemicals & materials

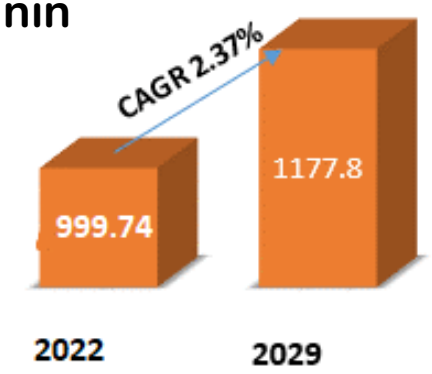
Carbon Embedded in Chemicals and derived materials



available at www.renewable-carbon.eu/graphics

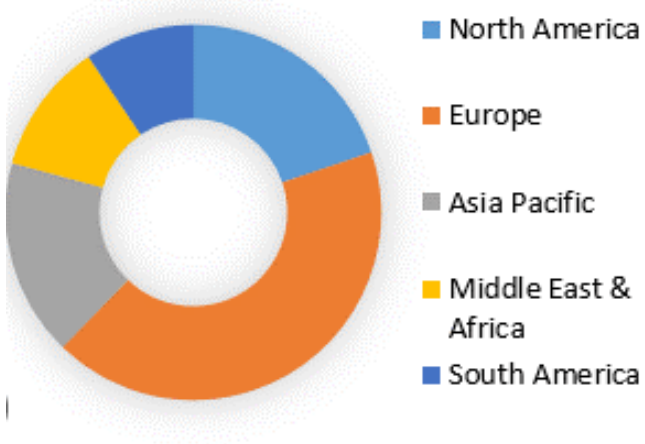
Future prospects- Lignin chemicals & materials

Lignin



Market Size in US$ Million

Regional Analysis in 2021 (%)



MAXIMIZE MARKET RESEARCH PVT. LTD.

- ✓ Lignin supply security (consistent quality)
- ✓ Technology at scale (isolation, depolymerization, functionalization..)
- ✓ Growing demand for renewable raw materials

Lignin could play a vital role in the global shift towards a greener economy

Research group:
Biobased Building Blocks & Products

Thank you !

MNEXT

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Dr. Sandra Corderí Gándara

s.corderigandara@avans.nl

MNEXT: Biobased Building Blocks & Products

18-04-2024

Questions?

LUNCH &LEARN

NEXT LUNCH & LEARN

Mycelium biocomposites... a circular and biobased insulation material

Fran Ortega Exposito, researcher
Biobased Construction

Thursday May 23, 12:15h