Deliverable report

D3.3 Identification of potential promising lignin product-resource combinations

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Working Group 3

1 Introduction – how to identify potential promising lignin produc-resource combinations?

Lignin, as indicated in former deliverables, is an abundant natural aromatic heteropolymer, that can be obtained from a variety of natural sources, including woody biomass, agricultural residues, and energy crops and thus much research has been spent on valorizing lignin. Regardless of the type of lignin, there are typically two approaches for lignin valorization: (1) One pathway uses the lignin as a macro-polymer to produce valuable materials and (2) another approach involves the depolymerization of lignin into low-molecular weight fractions including oligomers, dimers and monomers.

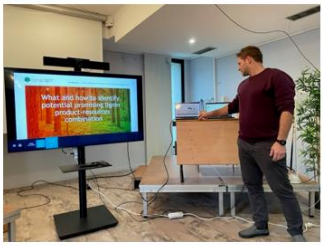
Different quotes exist like 'you can make anything out of lignin except money' which has been true for many years. However, a shift in the potential use of lignin for industrial relevant applications is observed, driving by the increased drive of consumers and big brand owners to include biobased content in the application as well as the search for more safer, sustainable and more functional performant compounds. However still different hurdles exist that prevent lignin from being a commodity chemical that can be used as any bulk chemical building block.

2 Approach and suggestions

A working group session in REIMS Lignocost meeting in February 2023 was organized, where 4 different taskforces were established with people from different backgrounds to reflect on the question:
What and how to identify potential promising lignin product-resources combination?

Identification of potential promising lignin product-resource combinations.

- Different taskforces – different angles



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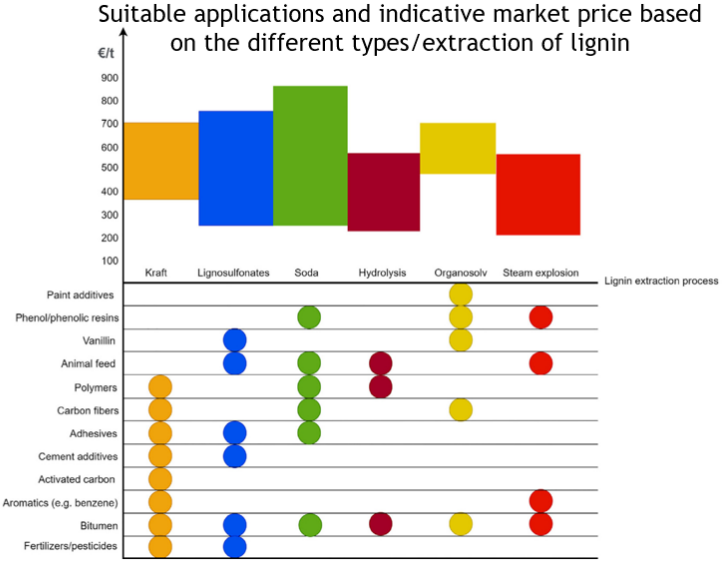
A first discussion showed the main requirements come down to feedstock quality, price and availability.

Main requirements

- Lignin availability
- Lignin type
- Key properties depending on applications
- Product performance
- Product price

Suitable applications and indicative market price based on the different types/extraction of lignin



Moretti et al./Science of the Total Environment 770 (2021) 144656

A similar conclusion was made in a second task force:

- Important criteria:
  - Commercial availability (lignin)?
    - Kraft and lignosulfonate hydrolysate lignin (other type) available on the market,
    - Emerging tech but price???
    - Conversion of waste stream to side stream?
  - Amount (TRL)?
    - 50 Ton/ years
  - Price ?
    - Depend on the product/application

->The gap:Exchange between the BM supplier and biorefinery

- Action

After lignocost make a trading showcase event or seminar with commercials, in order to know which lignins can be available/quantity and how much it costs (see with producer)

Similarly, a third task force also described the lignin quality as the most important parameter for potential product resource combination – but mainly referring to impurities and solubility.

Type of technical lignin	Purity (sulfur, contaminants, sugars, ashes, nitrogen…)	Solubility	Mw	Structure (functional groups)	Industrial abundance	Type of application (according to législation)
Sulfur free lignin	Organosolv Soda lignin	Soluble in organic solvents	Lower	Hydroxyl (Phenolic OH content…)	(Bioethanol…)	Food packaging, cosmetic industry
Lignins containing sulfur	Kraft lignin Lignosulfonate	Organic solvents & Water solubility	Higher		Higher (paper & pulp…)	Others

Finally, a fourth task force also described a list of aspects linked to lignin quality, price and availability as main aspects – while also referring to other issues like the lack of legislative information and driving force.

Identfy the critical properties of the product first and correlate with critical properties of lignin.

Identify the price and the price that consumers are willing to pay.

Availability of lignin of the desired properties.

Performance to be as close to initial material as possible.

Price to be competitive to the fossil products to replace.

Purity that will not affect the performance of the final product (such as sulfur free)

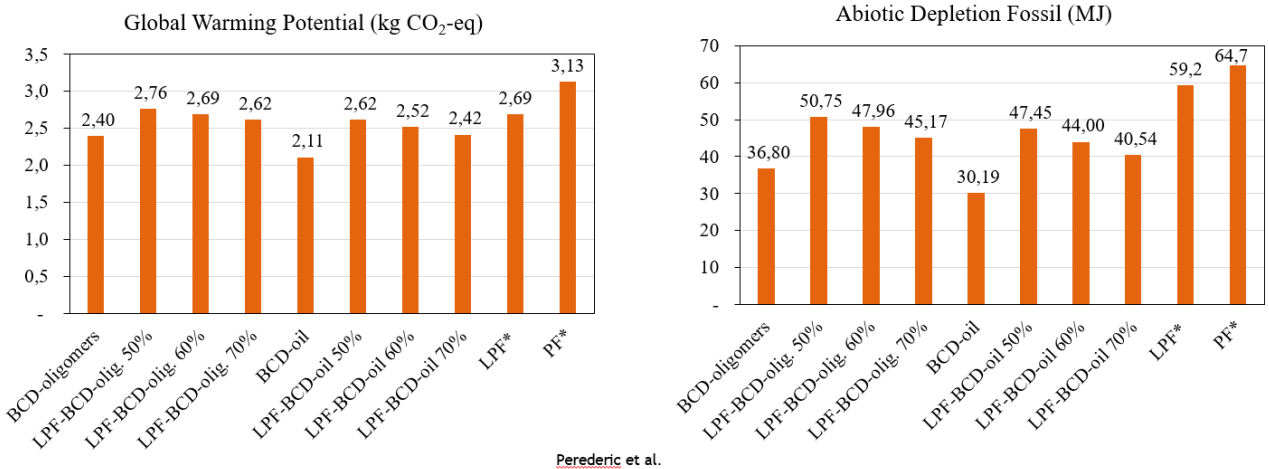
Other issues/challanges beyond the source/quality of ligning:

- Lack of legislation to force replacement of fossil based phenolics
- Energy situation and revised RED might prohibit the use of forest residues (connected to CO2 sequestration and enhanced biodiversity)

HENCE IMPORTANT TO FIND A PORTFOLIO OF DIFFERENT LIGNIN SOURCES THAN ONLY FOREST – needs to be adjusted to scale and value of final product

The sustainability and greenness of the lignin replacement for a fossil based product is important, and as point of discussion in WG5, results in amongst others relevant figures on LCA and CO2 footprint (see figures below).

Environmental performance (bio-based adhesives)



Perederic et al.
Computer Aided Chemical Engineering 48 (2020) 607-612

3 Conclusions and outlook

Based on the different discussions within WG3 and with other WGs, we can conclude that the angles to assess why certain lignin-product combinations will look more successful, trickles down to 3 main aspects:

1. Technical properties of the lignin:
    - C/O vs C/C bonds (ratio of both is important for solubility)
    - Tg
    - OH content
    - Mechanical strength
    - …

2. Functional properties of the end product:
    - Flame retardancy
    - Antimicrobial
    - Antioxidants
    - UV scavenging
    - Rigidity
    - …

3. Sustainability/greenness for introducing lignin as a replacement in the end product:
    - Industrially chemistry/processes (infrastructure existing)
    - Co-reactants not sustainable (eg fossil based, toxic,…)
    - Harsh conditions (high T/P,..)
    - …

Future research could further quantify these criteria to assess the greenness of lignin based products and value chains.

In order to get more lignin introduced in novel applications and increase awareness of potential end users, a matchmaking event will be organized at the Biorizon event (https://www.biorizon.eu/agenda/10th-biorizon-annual-event-on-bio-aromatics) as a follow up of the LignoCOST network to provide the lignin providers with the chance to present their feedstocks/resources and get companies from the materials side connected to them.