

Deliverable report

D2.2 Report covering state-of-the-art lignin conversion technologies

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Working Group 2

1 Introduction– Upstream production and downstream conversion methodologies

Working group 2 was tasked with generating an overview of existing and novel lignin production and conversion technologies, i.e. technologies concerned with the 'upstream' part of biorefining (separating biomass into its constituent components and generating the lignin) and the 'downstream' part of biorefining (further conversion and valorization of isolated technical lignins). The exercise was technology agnostic and thus would cover all up- and downstream examples. In addition, a major recent development in lignin valorization, i.e. the so-call lignin strategies, combines up- and downstream conversion in a one-step process, liberating the lignin and rapidly converting it away to a more stable end product. As the field has (re)exploded in the past 10 years or so, the numbers of pretreatment (upstream) technologies, the number of downstream conversion technologies and the number of examples of lignin-first strategies has also exploded; this is not only the case in terms of the technology/conversion method used, but also in terms of the feedstock and process operations involved in the lignin valorization efforts. Furthermore, while some of these efforts are part of the public domain, many are not; the examples of pioneering as well as further developed (i.e. higher TRL) private activities in this field are also numerous. Please note that as of March 2023 >4500 original review papers are available in the public domain that cover the field of lignin valorization (scopus search); this is testament to two things: one is the amount of original work published and the second is the large body of literature that is already available (and to a large extent also actively collected by WG1's lignin kiosk) and that should not be duplicated.

2 Approach

Given the above, it was deemed unfeasible (and unnecessary) to provide a comprehensive overview of all activities, and instead a different approach was adopted. As part of the overall efforts of the LignoCOST action it was deemed more useful to come to a system in which info sheets on existing or new lignin production or conversion processes could be produced and put in perspective and in the context of the wider actions of the LignoCOST action. This was part of an iterative approach and the best way to organize this evolved over the time course of the action. Originally, inspiration was drawn from a similarly burgeoning field, that is chemical recycling of plastics. A study of German activities in the field of plastics recycling was organized in a chart that provide insight into the nature of the recycling activity as well as in its development stage, i.e. its technology readiness level (see **figure 1**, left). First the WG opted to adopt an approach and create a graph for various lignin production and valorization schemes similar to the plastics one, with the intention to create an interactive, growing and open access-oriented data system that would be fed with first examples and could grow based on self-submitted input from the field (see **figure 1**, right).

LITERATURE REVIEW

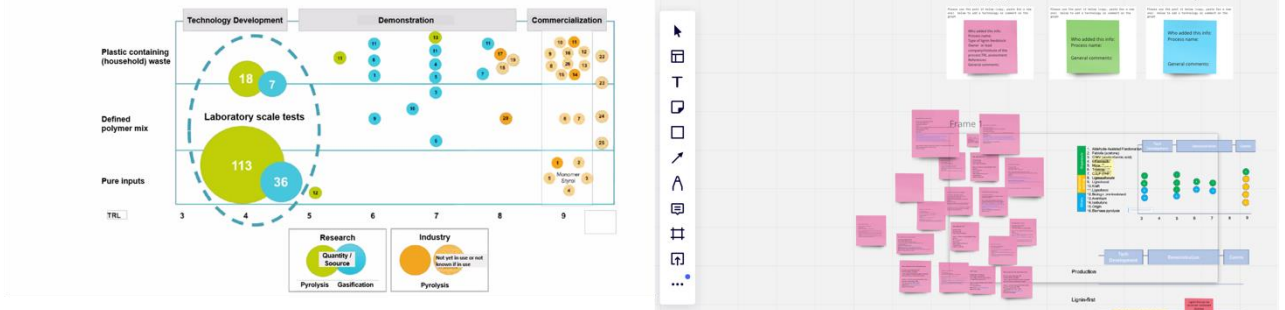


Figure 1. Overview of literature landscaping exercise involving an inventory of plastics recycling activities in Germany as function of feedstock and development maturity (expressed as TRL) that served as original inspiration for a similar exercise on the production technologies for lignins and on the conversion technologies for lignin.

To this extent, information collection sessions were held with WG members at several different LignoCOST meetings and an interactive, open white board was set up to accumulate and organize the data (**figure 1**, right). Eventually, this approach was abandoned though, as a results of issues with some of the technical aspects and considerations concerning the hosting of the platform, and the curation and reviewing of the data in such an, as ultimately targeted, open access setting.

In the Tallinn meeting in summer 2022 it was therefore decided to take a different approach and to connect the efforts in WP2 on this topic to the lignin wiki efforts of WG1 and to instead collect/collate the different input material on the production and conversion processes of lignin into information sheets that could be fed into the wiki lignin book under construction in WG1. This way the information would become better part of the information flow of the various WGs in LignoCOST (see **figure 2**).

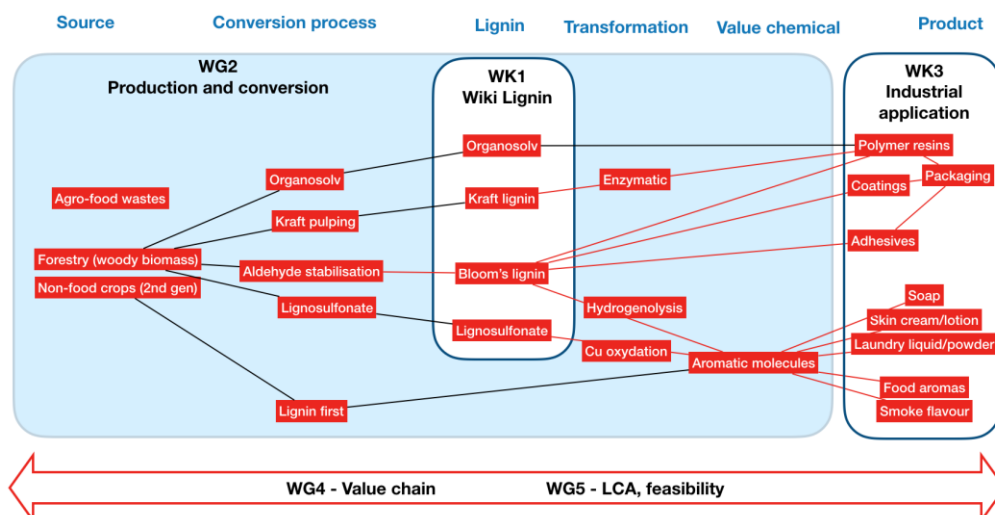
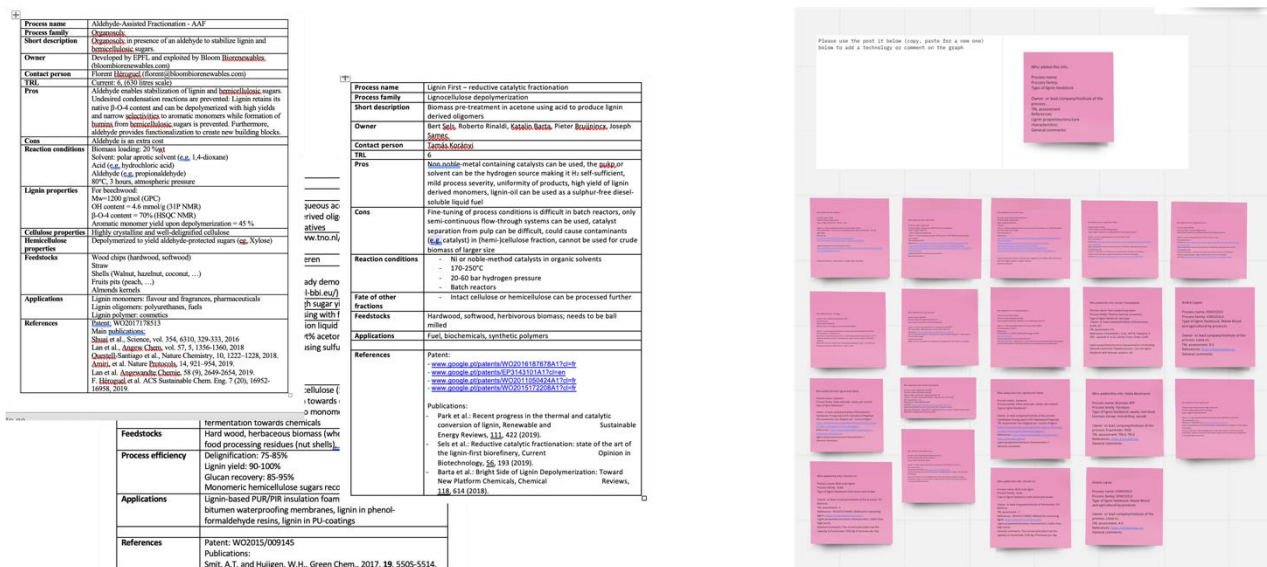


Figure 2. Revised approach showing how the information collected in WG2 on deliverable 3.1 could inform and be put to good use in WG1's wiki lignin efforts (Figure courtesy of F. Heroguel).

3 Results

Four sessions of WG2 at LignoCOST meetings were (partly) devoted to discussions on what information needed to be collected to be useful and on the actual input of information on the open access white board on processes the WG members present at those meetings (participation varied) had knowledge of. Please note that TRL scale had to be separately defined and made applicable to lignin chemistry processes, please see deliverable 2.2 for a discussion on this topic. This resulted in both more extensive information sheets collected separately from WG2 members and in more concise info notes added to the open access white board in the various meetings. Please see **figure 3** for an impression. The data collected is now available for incorporation in the wiki lignin book (see deliverable D1.4).



4 Conclusions and outlook

The comprehensive review of the field of lignin production and valorization as a whole, regardless of technology, feed or application, as originally envisaged was ultimately considered unfeasible, but valuable information has been collected on various processes that can be used for further dissemination through the wiki lignin book (see deliverable D1.4). The diversity of processes, the different levels of development and a certain lack of uniformity in reporting technical details and in definitions of e.g. efficiency hamper collation of consistent and complete information sheets, something that the field needs to address in future efforts.