Biorefinery 2021 – Phase III

Extension of usable biomass resources

As the amount of fossil raw materials are drawing to a close, different biorefinery concepts are emerging, which utilize renewable biomass to produce energy and feedstock for the industry. In order to tap the full potential of the sustainable resources, a cascade utilization approach is very promising regarding the energetic and substantial biomass usage. As such, innovative biotechnological treatments have been developed for integrated biorefineries during the **Biorefinery 2021** cluster project, funded by the German Federal Ministry of Education and Research (BMBF) with a project volume of 1,38 Mio€ for the third phase of the project.

In Phase I of **Biorefinery 2021** a total of 7 industrial and 9 academic partners participated in the collaboration, in which Module II of the project focused on the separation of valuable material streams from lignocellulosic biomass, i.e. C5-, C6-sugars and lignin, particularly from wheat straw. For that purpose, a linked conversion concept, the Aquasolv process, has been developed and optimized, which only utilizes environmentally neutral materials and measures (water, pressure, heat and biocatalysts). By using a hydrolytic (liquid hot water) and subsequent enzymatic treatment of the biomass, the value added streams were successfully fractionated with high yields in lab scale (Fig. 1).

These successful results led to the continuation of the project (Phase II) with the main point of interest in recovering lignin and other hydrolysate products from wheat straw for further valorization.

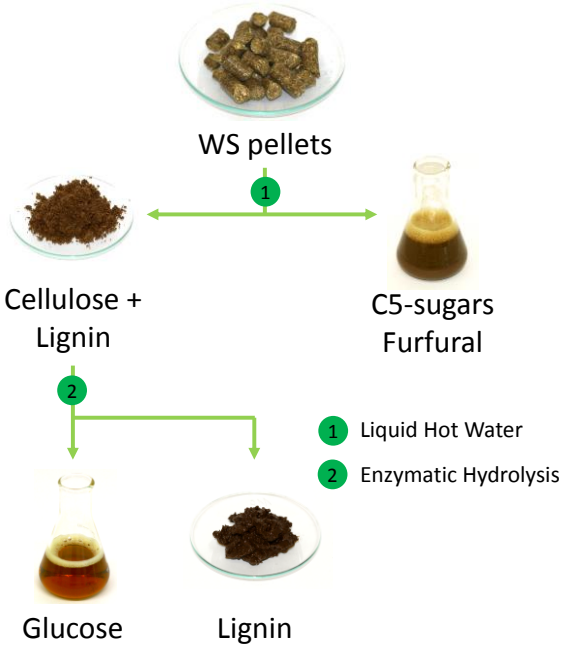

Figure 1: Aquasolv process with wheat straw (WS)

In order to produce material streams in larger quantities, a pilot scale plant (Fig. 2) has been conceptualized, constructed and commissioned, which made a batchwise lignin production of several kilograms possible. As an additional process option, the deodorization of the lignin fraction has been successfully realized in lab scale and a patent has been granted for the invention (DE102014108841B3). This treatment procedure allows the lignin to be integrated in a wider range of consumer goods, due to the elimination of volatile organic compounds (VOCs).

The valuable hydrolysate streams (C5- and C6-sugars) were characterized regarding their conversion into fine chemicals, such as levulinic acid (from C6) for the cosmetic application, aside from the traditional fermentation into second generation bioethanol.

The lignin from the Aquasolv process emerged as a raw material with high potential for a diverse variety of industries, e.g. petro-chemical, pharmaceutical and adhesives. *Tesa SE*, one of the major manufacturers of adhesive tapes and as part of the project consortium, is interested in incorporating the lignin into their adhesive formulas. The operation of the pilot scale hydrolysis plant allowed the successful production of lignin-containing, adhesive tape prototypes on a reasonable scale.

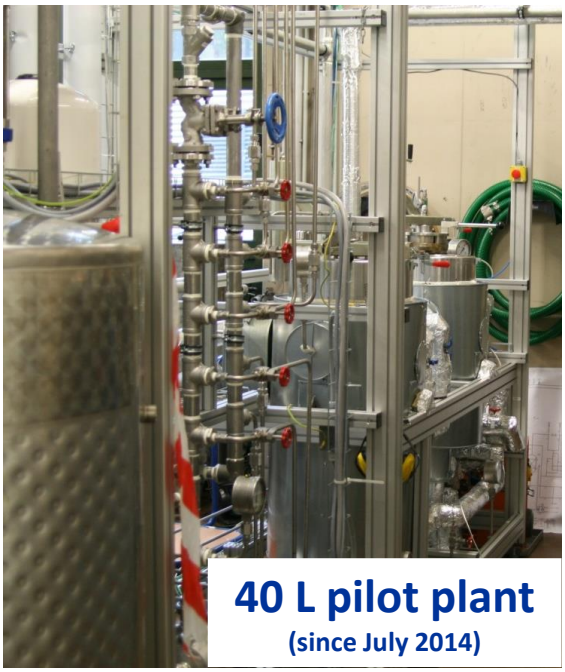

Figure 2: Pilot scale plant for biomass treatment

The current Phase III of **Biorefinery 2021** proceeds with the extension of usable biomass resources and focuses on further applications of wheat straw lignin produced by the Aquasolv process. Also, other sources of large-scale producible lignins are being considered for valorization. One of them presented itself with the addition of the new consortium partner *Verbio AG,* a biofuel production company, which operates a biogas plant based on the substrate straw. Since the lignin fraction of the straw cannot be degraded during the biogas production process, it is accumulated with the other fermentation residues and can be processed for further usage.

Different lignocellulosic substrates, aside from wheat straw, such as softwoods, sugarcane bagasse, rapeseed straw, are being tested with the Aquasolv process, as the lignin properties are dependent on biomass species.

It is hypothesized, that lignins isolated from other biomass possess diverging characteristics. Hence, a more diverse variation of lignins with different properties, e.g., reactivity, melt- and glass transition temperature, can provide the market with a wider spectrum of application possibilities. In that regard, chemical and/or enzymatic modification of the different lignins is another viable option, which is being currently studied. The customization of lignin properties with additional treatment measures and the initial choice of raw biomass material allow the production of tailored lignin feedstock to fulfill individual product requirements.

Simultaneous to the technological advancements of this project, techno-economic and environmental studies are conducted to determine the economic viability and environmental impact of an industrial scale Aquasolv process, which is a further step towards the realization of a highly promising biorefinery concept.

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Perez-Cantu, Lilia; Schreiber, Andreas; Schütt, Fokko; Saake, Bodo; Kirsch, Christian; Smirnova, Irina (2013): *Comparison of pretreatment methods for rye straw in the second generation biorefinery: effect on cellulose, hemicellulose and lignin recovery.* In: *Bioresource technology* 142, S. 428–435. DOI: **10.1016/j.biortech.2013.05.054**.

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