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Green Lignovation Process: Recovery of Lignin Fractions & Bulk Chemicals from Kraft Black Liquor

Motivation & Concept:

- Goal: Economic and sustainable process for recovery of valuable products from black liquor (BL) and improvement of pulping chemical recycling
- Revamping of an existing pulp & paper plant with a capacity of 45 t/h BL which is currently thermally utilized

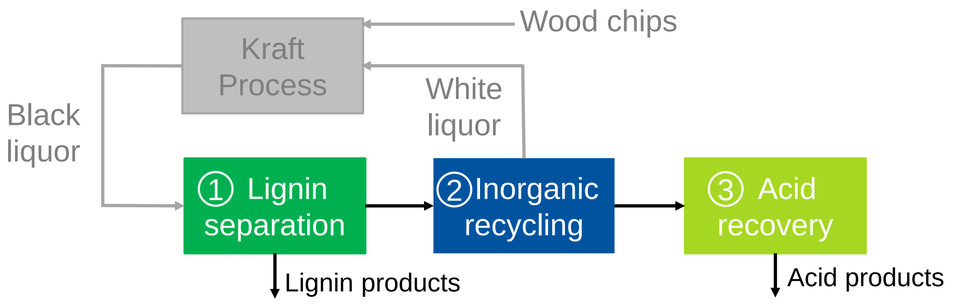
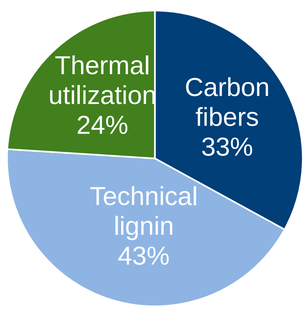


Fig. 1: *Green Lignovation* process structure: First, lignin is separated from BL, then the inorganic chemicals are recycled and finally acids are recovered.

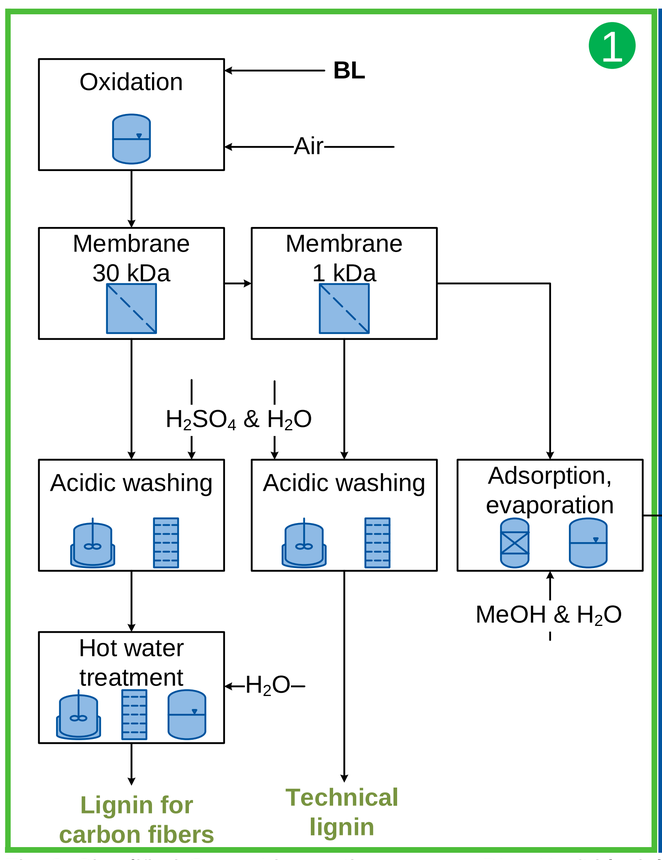
① Lignin Utilization:

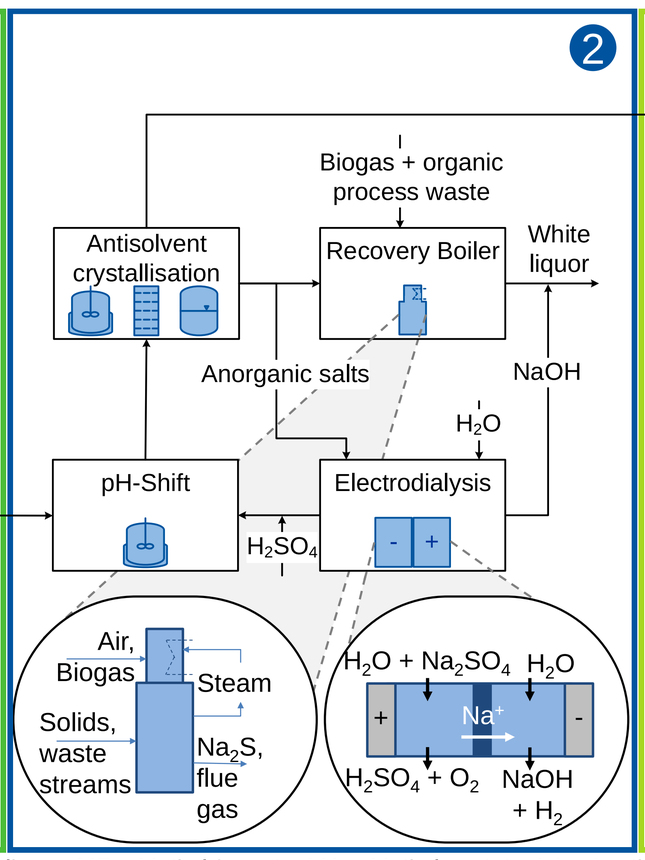


Fractioning of birchwood lignin using membrane separation utilizing its large molecular size:

- High molecular weight fraction for carbon fibers (30kDa)
- Low molecular weight fraction for technical lignin (1 kDa)
- Hot water treatment to achieve purities above 99 % for high molecular weight lignin

[1]





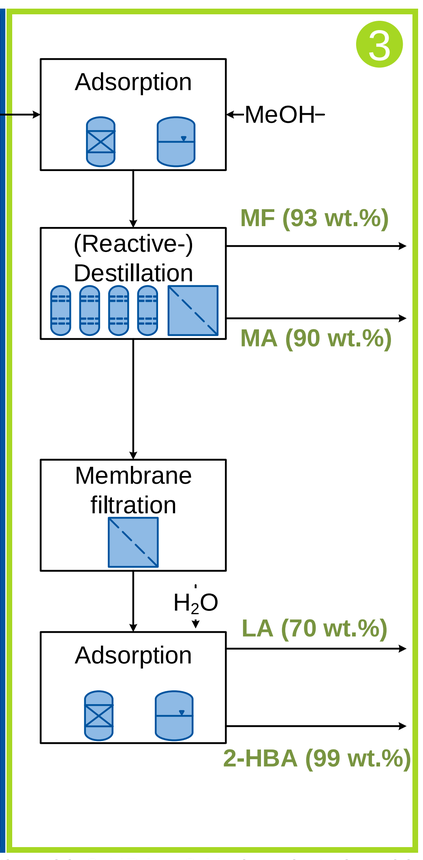


Fig. 2: Simplified *Green Lignovation* process. BL = Kraft black liquor, MF = Methyl formate, MA = Methyl acetate, LA = Lactic acid, 2-HBA = 2-Hydroxybutyric acid.

② Inorganic Recovery and Recycle:

- White liquor deadload reduced: 11.7 to < 1 mol.%
- Full inorganic recovery and 65 % H_2SO_4 recovery
- Flexible inorganic composition
- Partial electrification of recovery process

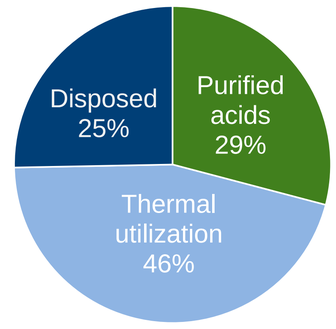
[3]

③ Acid Recovery and Purification

Adsorption yields a pure acid stream and enables purification of valuable acids:

- Reactive distillation to purify MF & MA
- Distillation columns, combined with membrane filtration and adsorption to purify LA and 2-HBA

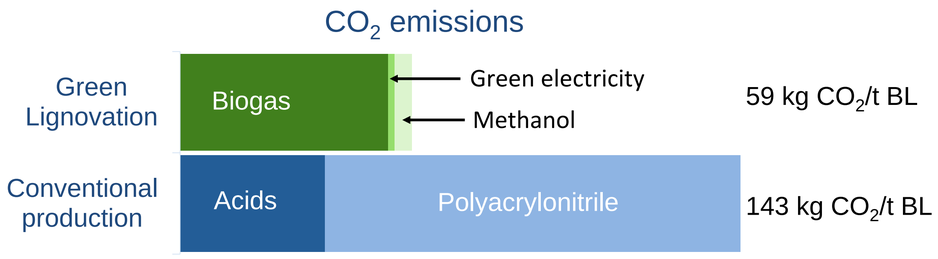
Utilization of 40% of the acids is feasible. In the *Green Lignovation* process 29% are purified.



[2]

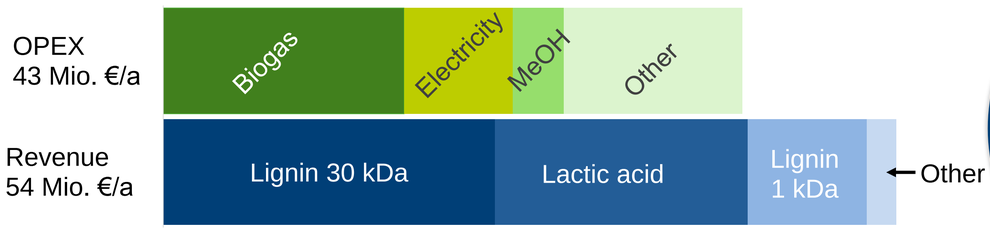
Sustainability Assessment:

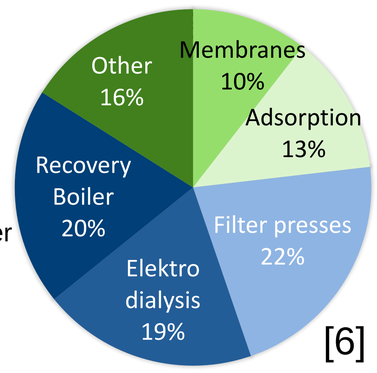
- Burning BL is considered CO_2 neutral[4]
- Biogas and additional energy sources increase the process CO_2 emissions
- 60% less CO_2 emissions compared to conventional production of *Green Lignovation* products
- High CO_2 emission contribution of carbon fibers, conventionally produced from Polyacrylonitrile[5]



Economic Evaluation:

The consideration of CAPEX and OPEX, based on simulation results and literature data result in a payback period of 7.5 years and yields a ROI of 17.8%.





[6]

Conclusion

- Revamping of the existing pulp & paper production process
- Improved recycling of pulp chemicals with decreased deadload
- Sustainable & economic production of carbon fibers and bulk chemicals
- Rapid implementation is feasible due to high technology readiness

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Bibliography:

[1] Jing Jin et. al. “Carbon Fibers Derived from Fractionated–Solvated Lignin Precursors for Enhanced Mechanical Performance”. (2018)
[2] Qiang Fu et. al. “Recovery and Enrichment of Organic Acids from Kraft Black Liquor by an Adsorption-Based Process”. (2022)
[3] Esa K. Vakkilainen. Kraft recovery Boiler. Principles and practice. Suomen Soodakattilayhdistys r.y., (2005)
[4] World Resources Institute and WBCSD. “Greenhouse gas protocol”. https://ghgprotocol.org/ (visited 23. 06. 2023).
[5] Kotaro Kawajiri et. Al. “Environmental impact of carbon fibers fabricated by an innovative manufacturing process on life cycle greenhouse gas emissions”. (2022)
[6] Donald R. Woods. Rules of thumb in engineering practice (2010)