Techno-economic analysis and life cycle assessment for the production of lignin-based adhesives from softwood kraft lignin via base-catalysed depolymerization.

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Lignin is an abundant natural biopolymer on Earth The alkylphenolic structure of the lignin molecule can be catalytically converted into low molecular weight compounds such as phenols, alkylphenols, and phenol resins to replace those obtained from fossil resources (Rößiger et al., 2017). Due to this, the valorization of lignin is one of the most important challenges for the development of cost-effective biorefinery processes based on lignocellulosic biomass. This study focusses on the evaluation of the techno-economic feasibility and environmental performance of lignin-based adhesives production from softwood kraft lignin via base-catalysed depolymerization. Process design on the catalytic reaction and the downstream separation and purification process was based on literature-cited information (Rößiger et al., 2017). Preliminary techno-economic evaluation was carried out for the estimation of the fixed capital investment and the cost of manufacture (COM) using well-known procedures. A discounted cash flow (DCF) analysis was carried out in order to estimate the minimum selling price (MSP) of the process. The discounted payback period (DPP) as well as the optimum plant capacity (OPC) for the investment plant are defined. Life Cycle Assessment (LCA) has been performed using the GaBi software and common LCA methodology (ReCiPe 1.08). The system boundaries for the analysis is “cradle to gate” and the functional unit is 1 kg of product.

The base-catalysed depolymerization (BCD) process results in two different products from lignin, namely the BCD-oil (liquid phenolic fraction) and BCD-oligomers (solid phenolic fraction) which are used as adhesives. The techno-economic metrics for these products indicates a MSP for the BCD-oligomers at \$0.6/kg and for the BCD-oil at \$0.8/kg at the optimum annual production capacities of 50 kt and 20 kt, respectively. The global warming potential (GWP) was estimated at 2.16 kg CO_2-eq for the BCD-oligomers and for the BCD-oil at 2.36 kg CO_2-eq. The abiotic depletion fossil (AP) was estimated at 40.25 MJ and 46 MJ for BCD-oligomers and BCD-oil respectively. The aforementioned technoeconomic and environmental metrics of the proposed process are lower than the petroleum-derived counterparts (GWP 3.13 kg CO_2-eq and AP 64 MJ).

References

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