Sustainability assessment of lignocellulosic biomass utilization for the production of added value products through a biorefinery concept

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ABSTRACT

Lignocellulosic materials containing cellulose, hemicellulose, and lignin as their main constituents, are one of the most abundant renewable organic resources presented on the earth. The utilization of these materials to produce environmentally friendly products in order to replace the fossil-based counterparts, received considerable attention. In this study the process sustainability of lignocellulosic biomass utilization through a biorefinery concept was evaluated. The recalcitrant structure of lignocellulosic biomass was disrupted using steam explosion process. The lignin fraction was recovered with methanol dissolution followed by enzymatic hydrolysis (EH) of the remaining solids. The methanol soluble lignin fraction used as a substitution material of bisphenol for the production of epoxy resins (ER). The sugar rich hydrolysate form EH used for the production of succinic acid (SA) through fermentation process. The sustainability of the process was evaluated in terms of economic and environmental feasibility. The first step of evolution is the design of the whole process in appropriate software (UniSim). The yields of the different process steps (pretreatment of biomass, enzymatic hydrolysis, ER production, SA production) were derived from the literature[1-2]. Techno-economic evaluation is based on preliminary economic analysis (accuracy up to ± 30%). The methodology for the estimation of techno-economic metrics in various plant capacities is implemented following well-known procedures and rules of thumb. As regards the environmental performance, a Life Cycle Assessment (LCA) is performed using the GaBi software and common LCA methodology (ReCiPe 1.08) for the analysis. The system boundaries for the analysis is “cradle to gate” and the functional unit is 1 kg of produced. The implementation of biorefinery concept for utilization of the lignocellulosic biomass indicates an eeconomic feasible process (Net Present Value M$800, Discount Payback Period 7 years). Low epoxy resin minimum selling price estimated at $1/kg where the fossil-based counterpart are $3-6/kg and lower environmental impact for the lignin-based epoxy resin in comparison to fossil-based epoxy resins.

KEYWORDS: Sustainability assessment, Lignocellulosic biomass, epoxy resin, Succinic acid, Biorefinery

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