Optimization and Evaluation of Different Pathways to Produce Biofuel from Biomass

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Abstract : In this study, Aspen Plus was used to simulate the whole process of biomass conversion to liquid fuel in different ways, and the main results of material and energy flow were obtained. The process optimization and evaluation were carried out on the four routes of cellulosic biomass pyrolysis gasification low-carbon olefin synthesis olefin oligomerization, biomass water pyrolysis and polymerization to jet fuel, biomass fermentation to ethanol, and biomass pyrolysis to liquid fuel. The environmental impacts of three biomass species (poplar wood, corn stover, and rice husk) were compared by the gasification synthesis pathway. The global warming potential, acidification potential, and eutrophication potential of the three biomasses were the same as those of rice husk > poplar wood > corn stover. In terms of human health hazard potential and solid waste potential, the results were poplar > rice husk > corn stover. In the popular pathway, 100 kg of poplar biomass was input to obtain 11.9 kg of aviation coal fraction and 6.3 kg of gasoline fraction. The energy conversion rate of the system was 31.6% when the output product energy included only the aviation coal product. In the basic process of hydrothermal depolymerization process, 14.41 kg aviation kerosene was produced per 100 kg biomass. The energy conversion rate of the basic process was 33.09%, which can be increased to 38.47% after the optimal utilization of lignin gasification and steam reforming for hydrogen production. The total exergy efficiency of the system increased from 30.48% to 34.43% after optimization, and the exergy loss mainly came from the concentration of precursor dilute solution. Global warming potential in environmental impact is mostly affected by the production process. Poplar wood was used as raw material in the process of ethanol production from cellulosic biomass. The simulation results showed that 827.4 kg of pretreatment mixture, 450.6 kg of fermentation broth, and 24.8 kg of ethanol were produced per 100 kg of biomass. The power output of boiler combustion reached 94.1 MJ, the unit power consumption in the process was 174.9 MJ, and the energy conversion rate was 33.5%. The environmental impact was mainly concentrated in the production process and agricultural processes. On the basis of the original biomass pyrolysis to liquid fuel, the enzymatic hydrolysis lignin residue produced by cellulose fermentation to produce ethanol was used as the pyrolysis raw material, and the fermentation and pyrolysis processes were coupled. In the coupled process, 24.8 kg ethanol and 4.78 kg upgraded liquid fuel were produced per 100 kg biomass with an energy conversion rate of 35.13%.

Keywords : biomass conversion, biofuel, process optimization, life cycle assessment
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