Comparative TEA for Indirect Liquefaction Pathways to Distillate-Range Fuels via Oxygenated Intermediates

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Abstract

This poster and associated journal article presents a comparative techno-economic analysis of five conversion pathways from biomass to gasoline-, jet-, and diesel-range hydrocarbons via indirect liquefaction with specific focus on pathways utilizing oxygenated intermediates (derived either via thermochemical or biochemical conversion steps). The four emerging pathways of interest are compared with one conventional pathway (Fischer-Tropsch) for the production of the hydrocarbon blendstocks. The processing steps of the four emerging pathways include: biomass-to-syngas via indirect gasification, gas cleanup, conversion of syngas to alcohols/oxygenates, followed by conversion of alcohols/oxygenates to hydrocarbon blendstocks via dehydration, oligomerization, and hydrogenation. We show that the emerging pathways via oxygenated intermediates have the potential to be cost competitive with the conventional Fischer-Tropsch process. The evaluated pathways and the benchmark process generally exhibit similar fuel yields and carbon conversion efficiencies. The resulting minimum fuel selling prices are comparable to the benchmark at approximately $3.60 per gallon-gasoline equivalent, with potential for two new pathways to be more economically competitive. Additionally, the coproduct values can play an important role in the economics of the processes with oxygenated intermediates derived via syngas fermentation. Major cost drivers for the integrated processes are tied to achievable fuel yields and conversion efficiency of the intermediate steps, i.e., the production of oxygenates/alcohols from syngas and the conversion of oxygenates/alcohols to hydrocarbon fuels. Pathways assessed are as follows:

Pathway 1A: syngas to molybdenum disulfide (MoS2)-catalyzed alcohols followed by fuel production via alcohol condensation (Guerbet reaction), dehydration, oligomerization, hydrogenation

Pathway 1B: syngas fermentation to ethanol followed by fuel production via alcohol condensation (Guerbet reaction), dehydration, oligomerization, hydrogenation

Pathway 2A: syngas to rhodium (Rh)-catalyzed mixed oxygenates followed by fuel production via carbon coupling / deoxygenation (to isobutene), oligomerization, hydrogenation

Pathway 2B: syngas fermentation to ethanol followed by fuel production via carbon coupling/deoxygenation (to isobutene), oligomerization, and hydrogenation

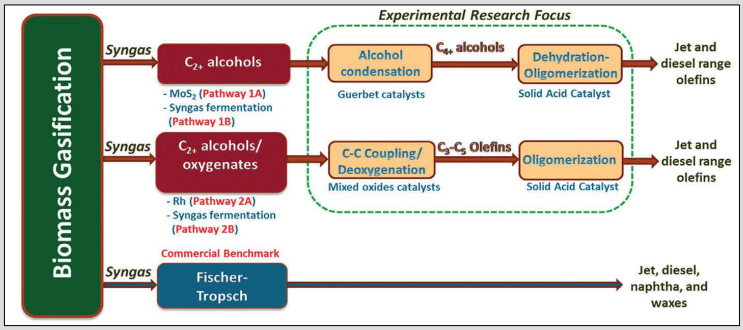
Commercial benchmark: syngas to liquid fuels via Fischer-Tropsch technology as commercial benchmark for comparisons

References

This poster is based on the full published article in BioFPR:

Tan, E. C. D., Snowden-Swan, L. J., Talmadge, M., Dutta, A., Jones, S., Ramasamy, K. K., Gray, M., Dagle, R., Padmaperuma, A., Gerber, M., Sahir, A. H., Tao, L. and Zhang, Y. (2016), Comparative techno-economic analysis and process design for indirect liquefaction pathways to distillate-range fuels via biomass-derived oxygenated intermediates upgrading. Biofuels, Bioprod. Bioref.. doi:10.1002/bbb.1710

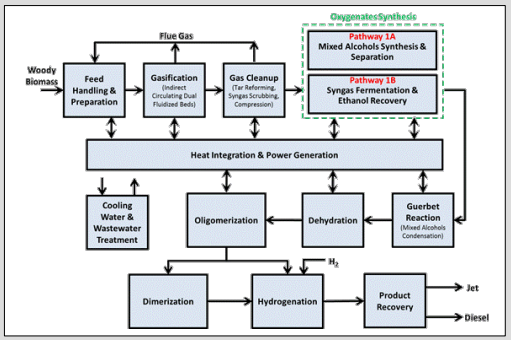
Overview of Indirect Liquefaction Pathways Assessed in the Project



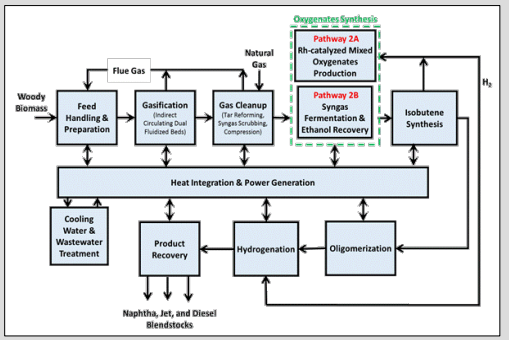
The emerging research pathways from biomass to fuels and products assessed in the analysis are based on oxygenate intermediates produced from gasification of biomass to syngas and subsequent synthesis. The oxygenate intermediates are then converted to fuels and products through further processing steps.

The Fischer-Tropsch (FT) TEA scenario serves as the benchmark for comparative analysis with the other pathways of focus.

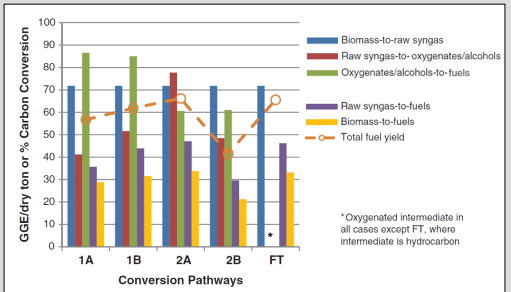
PFD for Pathways 1A / 1B



PFD for Pathways 2A / 2B

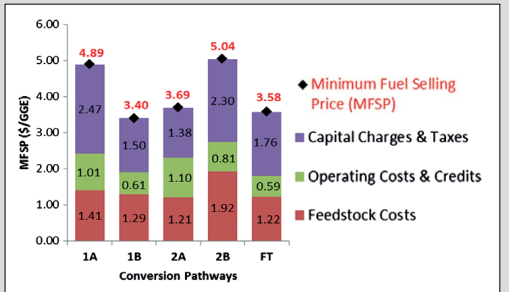


Estimated C-Efficiencies and Yields



Carbon conversion efficiencies (CCE) and fuel production yields from the comparative pathway TEA.

Comparative TEA Results



Minimum fuel selling prices (MFSPs) and cost contributions from the comparative pathway TEA.

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