Hybrid Biological/Catalytic Processes Are Advantageous for Cellulosic Biofuels

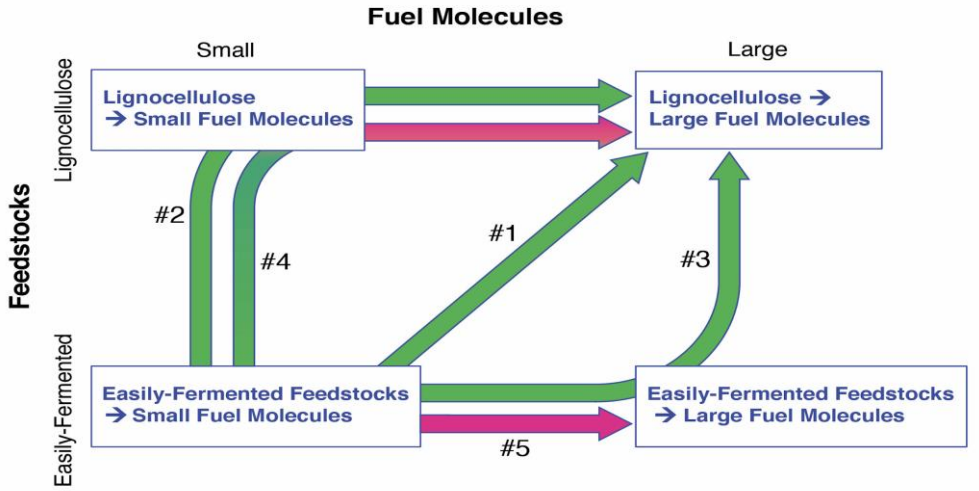
U.S. DEPARTMENT OF ENERGY | Office of Science

Background. Economical, scalable, and sustainable technologies for conversion of lignocellulosic to liquid fuels are a centerpiece of the bioeconomy, and these technologies are a key part of a multipronged approach to achieve carbon neutrality.

Approach. This paper covers distinctive features of cellulosic biomass conversion with respect to feedstocks, products, and processes. Challenges and opportunities are addressed for microbial deconstruction, cellularly-mediated transformations, product recovery, post-biological catalytic processing, and fuel utility. The closing section provides strategic perspectives on paths to achieve low-cost cellulosic biofuel production.

Outcomes

- There are emerging processing paradigms with potential to produce low molecular weight fuels or fuel precursors at much lower cost than the conventional paradigm.
- If biorefining is to impact climate change, it is likely that fuels will be the primary products, chemicals will be co-products, and lignocellulose will be the preferred feedstock.
- Low-cost cellulosic biofuel production likely requires anaerobic processing in the presence of solid lignocellulose, giving rise to important constraints.
- Anaerobic biological processing has to date simultaneously realized high product yield and titer for molecules with ≤4 carbons. Biology appears better at making small molecules than large ones.
- Hybrid processes involving biological production of small molecules with subsequent catalytic conversion to larger fuel molecules are promising for producing fuels for aviation & other difficult-to-electrify transport modes, representing about 50% of anticipated fuel demand.
- Ethanol occupies a singular space in the bioproduct landscape, is the lowest cost liquid fuel or fuel intermediate produced biologically today and is in our view likely to remain so.



Alternative research and commercialization paths.
Biological conversion. Catalytic conversion.
#4 is the only path leading to cellulosic biofuels that does not require biological production of large fuel molecules.

Significance

- Small molecules are less expensive to produce biologically than large molecules, and this is particularly true for production from lignocellulose. Yet the fuels the world would most value producing from lignocellulosic biomass to address climate stabilization are large reduced molecules.
- Hybrid processes are a promising approach to resolving this discrepancy.

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