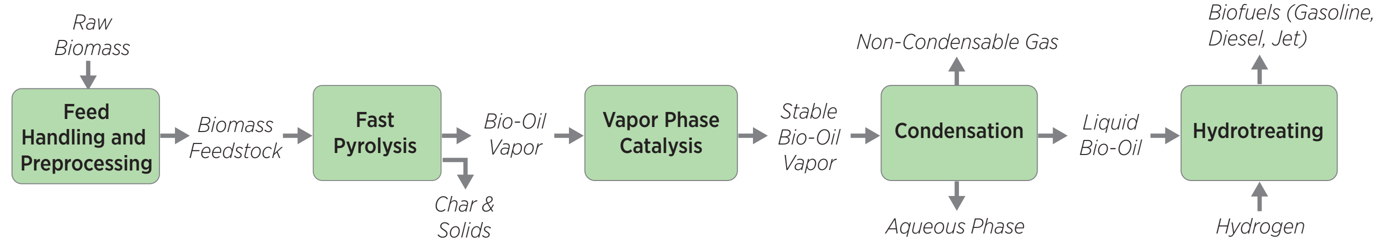
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BIOENERGY TECHNOLOGIES OFFICE

Ex-Situ Catalytic Fast Pyrolysis

In the ex-situ catalytic fast pyrolysis pathway, biomass is rapidly heated in a fluidized bed reactor containing a catalyst to yield vapors, which are catalytically modified and condensed into a partially stabilized and deoxygenated liquid bio-oil. This stable bio-oil is subsequently upgraded to produce hydrocarbon biofuel blendstocks.

Process Block Diagram



Process Design Details

- Biomass containing 30 percent weight (wt%) water is dried to approximately 10 wt% moisture, and the size is reduced to 2–6 millimeters to produce an acceptable biomass pyrolysis feedstock.
- The biomass feedstock is rapidly heated to approximately 500˚C in less than one second—usually in a fluidized bed reactor and in the absence of oxygen (i.e., fast pyrolysis).
- The biomass vapor is cycloned to remove char and solid particulates, and it is passed through a fixed catalyst bed to deoxygenate and stabilize it. The catalyst acts to partially deoxygenate and stabilize the pyrolysis vapor. Typically, the catalysts crack the vapor and can be zeolite, doped zeolite, superacid, solid acid, or other catalyst types. One way to recycle/regenerate a catalytic fast pyrolysis catalyst is in a circulating fluidized bed reactor.
- The resulting bio-oil vapor is condensed into a liquid and spontaneously phase separates into aqueous and organic phases.
- The organic fraction of bio-oil is hydrotreated in one or more stages. The number of stages and severity will be dependent upon the level of oxygen and oxygenated species in the intermediate catalytic pyrolysis bio-oil. The severity of hydrotreating is expected to be lower than those used to upgrade conventional fast pyrolysis oils. Cobalt molybdenum is a hydrotreating catalyst that may be used in this process.
- Hydrotreated bio-oil is expected to be a wide-boiling range stream that can be distilled into appropriate blend-stock ranges (e.g., naphtha and diesel). Hydrocracking may not be necessary depending on the extent of cracking that occurs during vapor phase upgrading.
- The aqueous phases resulting from vapor phase catalysis and hydrotreating can contain up to 40% of the biogenic carbon; therefore, maximizing carbon efficiency through-out (for higher fuel product yields) is essential.

Rationale for Selection

Conventional fast pyrolysis with vapor phase upgrading research and development (R&D)—the existing design case—as well as the R&D in the ex-situ pathway design case, will facilitate under-standing of the upgrading step chemistry and optimum catalyst/operating conditions for in-situ. Therefore, it's a natural segue to move from fast pyrolysis, to ex-situ catalytic fast pyrolysis, and then to in-situ fast pyrolysis as a technology development pipeline.

Next Steps

Techno-economic analysis models based on new data becoming available will be developed in 2014. These analyses will be made publicly available and will be used to develop 2022 technical and cost targets.

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