ETIP Bioenergy
European Technology and Innovation Platform

Transport fuels via pyrolytic and thermolytic conversion

LAB SCALE | BENCH SCALE | PILOT PLANT | DEMONSTRATION | PRODUCTION

DEFINITION

In this factsheet three different conversion routes are presented: (1) Pyrolysis to bioliquid intermediates (2) Hydrothermal liquefaction (HTL) to bioliquid intermediates (3) Lignin to bioliquid intermediates.

PROCESS TECHNOLOGY

Pyrolysis

Pyrolysis is the chemical decomposition of organic matter by heating in the absence of oxygen. The feedstock decomposes into organic vapours, steam, non-condensable gases and char. The feedstock potential for producing advanced biofuels lies in forest and forest industry residues, as well as agricultural and agro-industrial residues. More details about the pyrolysis process are given in the factsheet of Value Chain 4 (Intermediate bioenergy carriers for power and heat).

In addition to the pyrolytic or thermolytic conversion to intermediates, pyrolysis plants may also include severe or complete hydrotreatment, directly providing transport fuels. However, in most cases, the resulting oils are upgraded into transport fuels through co-processing in refineries. Here, the main routes from Fast Pyrolysis Bio Oil (FPBO) to a drop-in hydrocarbon biofuel are by fluid catalytic cracking (FCC) or by hydrodeoxygenation (HDO). In the FCC route, oxygen is expelled from the FPBO as CO and CO_2 and the H/C ratio adjusted by coke formation to result in a hydrocarbon mixture where gasoline is the main fraction. The HDO route is basically a treatment with hydrogen whereby oxygen is expelled as water: Hydrotreatment to Hydrotreated Vegetable Oil (HVO), and the resulting hydrocarbon mixture predominantly gives a diesel product. Another pathway combining these routes are an initial hydrotreatment to stabilize the FPBO followed by FCC treatment. The benefit is that both acidity and oxygen are reduced, and the blend ratio for co-processing can be increased significantly.

Hydrothermal liquefaction

Hydrothermal liquefaction (HTL) is a thermochemical conversion process of biomass into a liquid intermediate by processing in a hot, pressurized water environment, typically at 250-370°C and 4-20.06 MPa (i.e. water sub-critical conditions), for sufficient time (10-60 minutes) to break down biopolymeric structure to liquid and gaseous components. The HTL process usually produces four different product fractions, a gas phase, a solid residue, a liquid aqueous phase and a liquid oily phase, i.e. bio-crude. The produced bio-crude intermediate separates from water but still has 10-20% oxygen and still has a relatively high acidity. The HTL bio-crude has several more or less direct utilization routes e.g. low-blends into bunker fuel, but it can also be upgraded as an integrated process step or by co-feeding in refinery units to produce drop-in biofuels. The upgrading technology for this type of bio-crude is in principle similar to the upgrading of pyrolysis oil.

Lignin

Lignin is one of the three main components of lignocellulose, and it is a polymeric substance composed of phenolic monomers that can be used as an intermediate for the production of biofuels.

- Lignin from pulping processes is dissolved in the pulping (black or brown) liquor and currently used as a fuel in the recovery boiler, where pulping chemicals are recovered for re-use. Pulping lignin can be separated from the liquor (up to an estimated 10-20% of the total amount) by precipitation or by membrane filtration for further separate treatment.
- Hydrolysis lignin from lignocellulosic ethanol production is also a by-product and is available as a solid after the pre-treatment or after fermentation, depending on the process configuration.

The processing of separated lignin is in the liquid phase so that precipitated lignin is dissolved. First, de-polymerization to phenolic mono- and oligomers is accomplished by chemical catalysis using bases or acids in combination with thermal or HTL processing and/or hydrogen treatment. The oligomeric and monomeric substances are then dissolved in a fossil or a triglyceride feed fraction or reacted via esterification with e.g. mixed fatty acids to allow mixing with a fossil fuel fraction. Finally, the lignin-derived feed is co-fed to a refinery and is hydro-treated to remove oxygen and to produce cyclical aromatic or aliphatic hydrocarbons, depending on the process severity. The upgrading technology for this type of oil is in principle similar to the upgrading of pyrolysis oil.

EXAMPLES OF DEMOPLANTS

https://www.etipbioenergy.eu/databases/production-facilities

Location: Tofte, Norway

Plant: **Demoplant of Silva Green Fuel** (Joint Venture of Statkraft and Sodra) under construction, start-up planed in 2021 (TRL 6-7)

Technology: Hydrothermal Liquefaction (Steeper technology)

Feedstock: forest residues

Products: bio-oil 1,400 t/y

Link:https://www.statkraft.com/about-statkraft/where-we-operate/norway/silva-green-fuel/, https://demoplants.best-research.eu/

Location: Backhammar, Sweden

Plant: Demoplant of Renfuel, operational since 2016 (TRL 6-7)

Technology: catalytic process on lignin

Feedstock: lignin 0.1 t/y and mixed fatty acid

Products: bio-oil (LIGNOL®) 3,200 t/y to be refined into green gasoline, diesel and jet fuel

Link: https://renfuel.se/, https://demoplants.best-research.eu/

More information on www.etipbioenergy.eu.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825179