ETIP Bioenergy
European Technology and Innovation Platform

Hydrocarbon fuels from sugars

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

DEFINITION

Isolated sugars, today from crop or starch sources, but in the future possibly also from lignocellulosic sources, are the starting point for a number of pathways to biofuels. Up to now, most developments have used sugar cane or crop starch as feedstocks, because sugar-containing products produced via enzymatic hydrolysis of lignocellulose contain more inhibitors and C5 sugars. The production of synthetic hydrocarbons is based on two types of processes, one involving fermentation by engineered microorganisms and one via aqueous chemical reactions.

PROCESS TECHNOLOGY

As also described in PVC 5 factsheet (alcohol fuels from sugars value chain), the first step in the processing of lignocellulosic feedstocks to synthetic hydrocarbons is a pre-treatment consisting of a physico-chemical step and an enzymatic liquefaction step, which fractionates the feedstock into its three main components (cellulose, hemicellulose and lignin). The most common method is steam explosion with or without an acid catalyst, but also acid and base treatment and organosolv processes can be used. Afterwards, hydrolysis and saccharification of the cellulose and hemicelluloses oligomers take place. This step uses specifically developed enzyme cocktails, but also acid hydrolysis has been used. Afterwards there are two possible steps:

1. Fermentation with engineered microorganisms (yeasts) can be used to

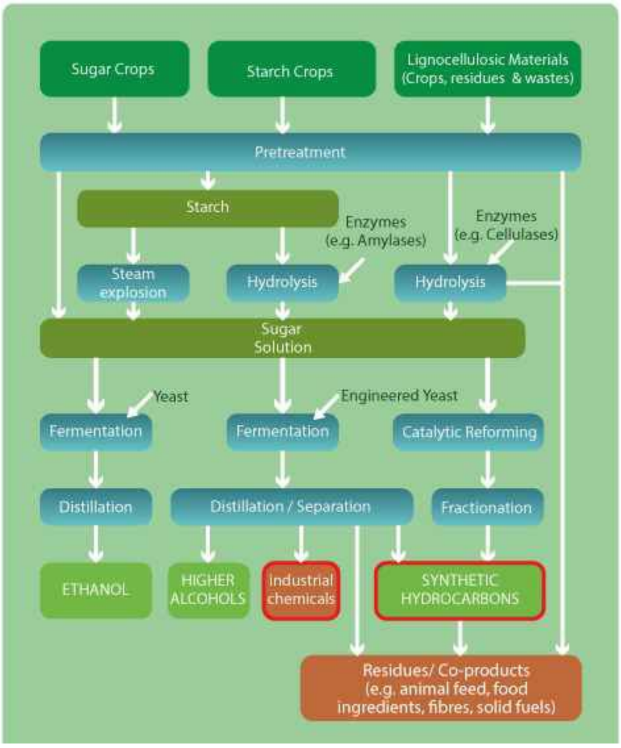

Figure 1: Hydrocarbon fuels from sugars value chain

ferment sugar into a class of compounds called isoprenoids. One of these isoprenoids is a 15-carbon hydrocarbon, beta-farnesene, which can be hydrogenated to farnesane.

2. Aqueous phase reforming (APR) utilizes heterogeneous catalysts including zeolites, metals and noble metals at temperature and pressure (200-250°C, 3-5 MPa) to reduce the oxygen content of the carbohydrate feedstock. This involves hydrodeoxygenation reactions (reforming to generate hydrogen; dehydrogenation of alcohols/hydrogenation of carbonyls; deoxygenation; hydrogenolysis; cyclization) that consume hydrogen simultaneously produced *in-situ* from the carbohydrate feedstock.

APPLICATIONS

1. Fermentation with engineered yeasts produces isoprenoids that have use for pharmaceuticals, nutraceuticals, flavours and fragrances and chemical intermediates, as well as fuels. In particular:
   - Beta-farnesenes can be chemically derivatized into diesel, lubricants, a surfactant used in soaps and shampoos, a cream used in lotions, or a variety of other useful chemicals.
   - Farnesane is accepted for 10% blending in jet fuel as Synthesized Iso-Paraffinic fuel, (SIP).
2. The product from the APR step is a mixture of chemical intermediates including alcohols, ketones, acids, furans and other oxygenated hydrocarbons as well as paraffins. These intermediates can undergo further processing:
   - Catalytic process using zeolites to generate a mixture of non-oxygenated hydrocarbons.
   - Reaction over a zeolite catalyst (ZSM-5) to produce a high-octane gasoline blend-stock that has a high aromatic content similar to a petroleum-derived reformate stream.
   - Conversion into distillate range hydrocarbon components through a condensation step followed by conventional hydrotreating.

A by-product of the overall sugar-to-hydrocarbons process is lignin, which is usually dried to and later combusted to produce process heat and/or for power generation. Lignin also serves as feedstock for a variety of chemical products or materials.

EXAMPLES OF DEMOPLANTS

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

Location: Leuna, Germany

Plant: Isobutene demo plant of **Global Bioenergies,** started operation in 2017 (TRL 6-7)

Technology: hydrocarbon fuels from sugars and alcohols

Feedstock: cane sugar, beet sugar, starch

Products: isobutene, 100 t/y

Link:https://www.global-bioenergies.com/first-success-in-scaling-up-the-isobutene-process-in-the-leuna-demo-plant/?lang=en, https://www.global-bioenergies.com/?lang=en

Location: Örnsköldsvik, Sweden

Plant: Demoplant of Sekab, operational since 2004 as part of the Örnsköldsvik refinery

Technology: CelluAPP® technology (pre-treatment, separation and washing, enzymatic hydrolysis, fermentation, product recovery)

Feedstock: Forestry and agricultural residues

Products: integrated biorefinery capable of producing hemicellulose sugars, lignin, cellulosic glucose, biogas, bio-oils, alcohols, acids

Link:https://www.etipbioenergy.eu/images/SPM10_Presentations/Day2/1_ETIP-Bioenergy-SPM10_M.-Normark_SEKAB.pdf

More information on www.etipbioenergy. eu.

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