Starch and sugar-based bioethanol

Lab Scale | Bench Scale | Pilot Plant | Demonstration | Production

Lignocellulosic bioethanol

Bioethanol C_2H_5OH

Bioethanol is the most commonly used biofuel for transportation. It can be produced from many different raw materials and through different production processes. Today, mainly technologically conventional methods are used, such as fermentation from sugar- and starch-based feedstock. Production of so called second generation, or advanced, bioethanol utilizes methods developed to make use of lignocellulosic types of biomass, e.g. residues from the forestry and agriculture sector and waste material.

Primary area of use

Bioethanol and synthetic ethanol are chemically the same molecule, and therefore identical from a usage perspective. Low blending of ethanol into vehicle fuel was introduced as an oxygen agent to reduce CO_2 emissions. The usage is spread and extensive around the world, mainly as low blending in gasoline. Ethanol can be mixed with gasoline in different properties. Today, blends up to E25 are marketed and used in conventional cars, meaning that 25% of the volume is ethanol. In Europe as well as in many countries around the world, E5 to E10 are the most commonly used blends. In the U.S. most of the gasoline is E10, with E15 lately being introduced to increase the ethanol use. In Brazil E20 to E25 is used in all gasoline.

Ethanol is also used in flexi fuel cars that can run on any mixture from pure gasoline up to E95, i.e. ethanol with 5% water. This market is so far most developed in Brazil, U.S., and Sweden. In Brazil, 90% of new car sales are flexi fuel. A similar trend can be seen in the U.S., however not on the same level. In Europe, the development has been slower. The extra cost for the flexi fuel technology in a car is less than € 100 compared to a normal gasoline car. If the car manufacturer chooses to charge the extra cost depends on the current situation for competition.

For heavy vehicles, a slightly modified diesel engine with compression ignition can use ED95, an ethanol fuel with 5% water and addition of 3-5% ignition improver.

The suitability and flexibility of ethanol for transportation is good compared to gasoline and diesel of today. The thermal efficiency of ethanol when used in gasoline engines (Otto-engines) is higher than for pure gasoline, especially if the high octane number is utilized in the design of the engine. However, the energy content per liter is 34% lower in ethanol than in gasoline. When ethanol is used as E5 these effects equals out and the ethanol substitutes the same volume of gasoline. For higher ethanol blends, the fuel volume increases, leading to shorter driving range with the same tank size. In the diesel engine, ED95 has the same thermal efficiency as diesel, which means 20–30% higher than an Otto-engine.

Feedstock and production

Ethanol can be produced from almost all types of biomass. Today's commercial plants use sugar and starch rich biomass like

Properties

Chemical formula:	C_2H_5OH
Molecular mass:	46.07 g/mol
C (%wt)	52.2
H (%wt)	13.1
O (%wt)	34.7
Density at 20°C:	794 kg/cm³
Viscosity at 20°C:	1.2 µPa s
Heating value:	26.8 MJ/kg

Ethanol is a volatile, colorless, flammable liquid that burns with an almost invisible flame and has a characteristic odor. As a versatile solvent, ethanol is miscible with many organic components as well as water. It can also be used to produce ETBE an oxygen agent in gasoline.

sugarcane, sugar beet, corn, wheat, and other grains. The process used for production of ethanol is fermentation of sugars. For grains, an enzyme hydrolysis of the starch is needed. Cellulose biomass needs a pre-treatment step to open up the structure before enzymatic hydrolysis and fermentation of the formed sugars can be performed.

Another route to produce ethanol is by gasification of biomass to carbon oxide and hydrogen. The gas is catalytically reformed or biochemically transformed to ethanol. In the US there are some ongoing demonstration projects with this technology.

Current production volumes

Ethanol is the most commonly used biofuel today, and in terms of volume it counts for about 90% of global consumption. The global ethanol production in 2013 was approximately 23 429 Millions of US Gallons, with the US as the largest producer.

Production and use of ethanol has during the last decade increased drastically, but due to the world finance crises and a massive media blackening, it has leveled.

Distribution system

The distribution of E5 to E25 and E85 is generally handled by the normal gasoline and diesel companies in each country, since ethanol is blended in the oil depot. The risk handling and classification are almost the same as for gasoline. The distribution of ED95 is adapted to the customer as they mainly consist of fleet owners.

Transporting of ethanol over long distances is done in tankers and implies no problem. Dewatered ethanol for blending in gasoline is hydroscopic (meaning it takes up water) and during storage and transportation nitrogen is used to replace air and minimize breathing in the tanks, caused by temperature differences.

Recent cellulose-to-ethanol projects

Technology to produce ethanol from cellulosic biomass has been developed and verified by several companies, e.g. SEKAB, DONG/Inbicon, Chemtex, Abengoa, Poet-DSM, and Iogen, in pilot scale and small demo scale up to 5 million liters/year.

In Crescentino, Italy, Beta Renewables (earlier M&G/Chemtex) opened the first commercial scale plant in Europe in October 2013. It produces bioethanol from agricultural residues and energy crops, using enzymatic conversion.

In Emmetsburg, Iowa, US, Poet-DSM's first commercial cellulosic bioethanol plant, Project Liberty, opened in September 2014. The Liberty Project plant produces biofuels from crop residues provided to the plant from local farmers.

Iogen Corp. announced in December 2014 the production start of cellulosic ethanol at Raízen's newly expanded Costa Pinto sugar cane mill in Piracicaba, São Paulo, Brazil. The facility will convert biomass such as sugar cane bagasse and straw into 40 million litres per year of advanced, second generation cellulosic biofuel.

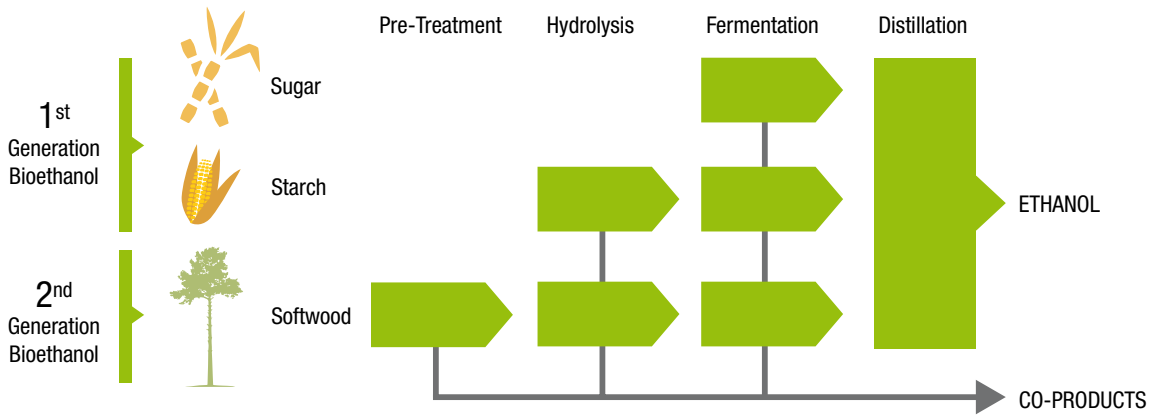

Figure: Overview of ethanol production processes