Cellulosic ethanol from agricultural residues

THINK AHEAD, THINK SUNLIQUID®

what is precious to you?
Market ready and highly efficient

**SUNLIQUID® PROCESS FOR THE PRODUCTION OF CELLULOSIC ETHANOL**

By developing sunliquid® technology, Clariant has cleared the way for cellulosic biofuels. Its process converts lignocellulosic agricultural residues, such as cereal straw, into cellulosic ethanol or other biobased chemicals in a way that is highly efficient, extremely economic, energy-neutral and sustainable.

**sunliquid® opens up new feedstocks**

Until now, agricultural residues have held little attraction as a feedstock for the production of biofuels, since the stable structure of this lignocellulosic material is difficult to break down by conventional methods. As a result, the sugars contained in straw have remained largely unused until today.

Thanks to Clariant’s sunliquid® process, this will change. Its key technology is based on feedstock-specific biocatalysts, which efficiently provide access to the sugars contained in the straw, an integrated enzyme production, simultaneous C5 and C6 fermentation and an energy-saving ethanol separation method. This gives rise to an efficient, extremely economic and therefore competitive process for the production of cellulosic ethanol.

**Cellulosic ethanol – biofuel of the future**

The efficient sunliquid® technology is key for an economic and sustainable process. The facts:

- The production costs are comparable with those of first-generation bioethanol – currently the world’s most important biofuel.
- The flexibility of the sunliquid® process allows all lignocellulosic feedstocks to be converted – from wheat and corn stover to sugarcane bagasse or energy crops, such as miscanthus and switchgrass.
- The ethanol yield lies between 75% and 95% of the theoretical maximum.
- The entire process energy is generated from accumulated residues – mainly lignin. No fossil-based energy sources are used.
- The greenhouse gas balance is almost carbon neutral. Greenhouse gas emissions are reduced by 95% compared with fossil-based fuels.
- No “food versus fuel” debate – the sunliquid® process converts agricultural residues which are not suitable for either food or animal feed. Feedstocks are available from existing agricultural production, meaning that no valuable arable land has to be converted.

**sunliquid® efficiency in figures**

- **4.4-4.5 tons straw**
- **5400-6100 kwh Energy**
- **700-800 kg cellulosic ethanol**
- **40-45% yield**

**Production costs**

- Minimum enzyme costs
- No energy costs
- Biomass is the main driver for production costs
- Production costs are competitive to 1st generation bioethanol
Complete turnkey process FOR UP TO 150,000 TONS OF CELLULOSIC ETHANOL PER YEAR

The sunliquid® process is now fully developed, being designed for industrial plants with a production capacity of 50,000 to 150,000 tons of cellulosic ethanol per year. Clariant provides the know-how and technology for all unit operations on a turnkey basis, coupled with the expertise required for successful implementation.

Pre-treatment
Chemical-free pre-treatment lowers production and investment costs. At the same time, environmental, health and safety risks are minimized.

Hydrolysis
A bespoke enzyme mixture hydrolyses cellulose and hemicellulose chains to form sugar monomers. This step is also termed saccharification. The enzymes are highly optimized based on feedstock and process parameters, resulting in maximum yields and short reaction times under optimal conditions.

Enzyme production
A small percentage of the pre-treated feedstock is used for enzyme production, which is an integrated part of the process and takes place on-site at the ethanol plant. This makes a major contribution to the economic efficiency of the overall process, resulting in a significant reduction in production costs and ensuring independence from supply shortages and price volatility.

Fermentation
Using optimized microorganisms, the sunliquid® process provides for efficient fermentation, giving rise to maximum ethanol yields. This highly-optimized, one-pot system simultaneously converts both C5 and C6 sugars to ethanol, delivering up to 50% more ethanol than conventional processes which convert only C6 sugars.

Separation
The innovative and highly energy saving purification method reduces energy demand by up to 50% compared with conventional distillation. It is based on thorough process planning and energy integration, resulting in an entirely energy self-sufficient process.
Licences and services
EVERYTHING YOU NEED – FROM A SINGLE SOURCE

The sunliquid® process opens up new opportunities on the booming global market for second-generation biofuels. The potential is enormous – in the EU alone, around 25% of the demand for petrol could, according to various studies, be met by sustainably produced cellulosic ethanol as early as 2020. Clariant has already begun to issue licences for construction of commercial sunliquid® plants, as well as providing all the technology needed for their successful implementation.

Based on our expertise in the fields of biocatalysis, strain and enzyme optimisation, the customised plant concept is rounded off by a regular supply of starter cultures for enzyme production and yeast propagation, as well as all other components needed for cost-effective operation of the plant.

High sugar yield through feedstock and process specific enzymes
Process-integrated enzyme production
Simultaneous C5 and C6 fermentation
Energy-saving separation technology

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You would like to learn more about sunliquid®? If so, we look forward to talking to you. You can reach us at:

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Direct link to www.sunliquid.com

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