formicobio™
The cellulosic ethanol technology

The future is

NON-FOOD CELLULOSIC ETHANOL

chempolis®
Sustainable Results

SUSTAINABLE ETHANOL FROM RESIDUES

ADVANCED THIRD-GENERATION BIOREFINERIES

People will need fuel from renewable sources in increasing volumes in the future. We need to be able to produce this without impacting the food chain or causing erosion through felling forests or depleting resources of water or fossil fuels.

Thanks to **formico**bio™ technology, transportation fuel can be produced from agricultural residues both cost-effectively and sustainably.

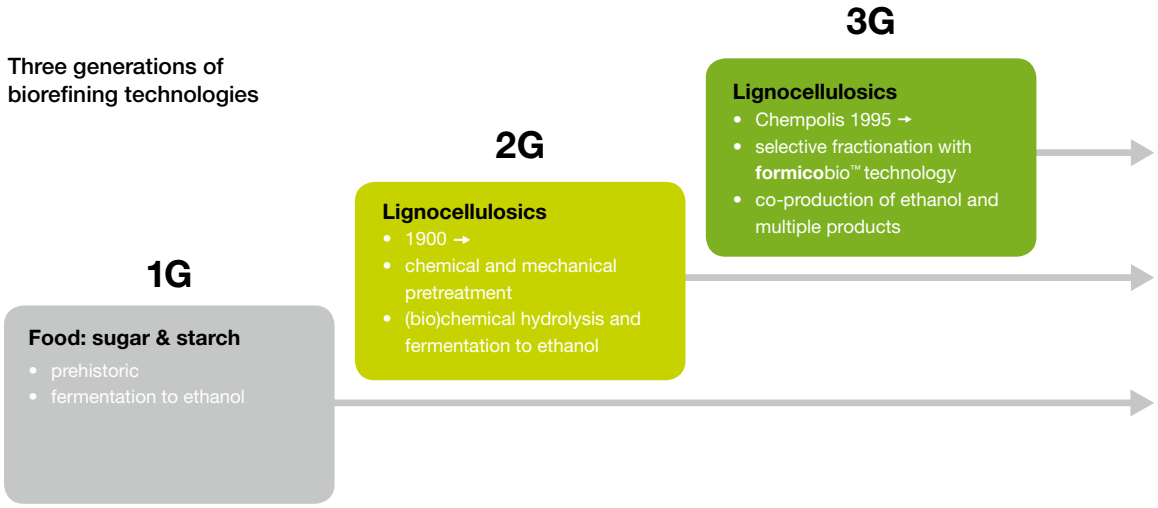
A biorefinery based on **formico**bio™ technology meets the three key aspects of sustainability – environmental, economic, and social – and can convert residues into a range of products. Based on the use of lignocellulosic biomass, Chempolis' **formico**bio™ technology does not have any negative impact on food production and can also provide a source of valuable additional income to rural areas.

Corn stalk

Bagasse

Wheat straw

Straw, corn stalks, bagasse, reeds, and similar agricultural by-products represent a valuable resource.



*"**formico**bio™ is an energy self-sufficient, effluent-free, low-carbon third-generation biorefining technology that offers excellent profitably through its ability to convert residual raw materials into valuable products."*

SUPERIOR PROCESSING OF VARIOUS RESIDUAL CELLULOSIC RAW MATERIALS

Our unique **formico**bio™ technology can process a variety of non-food biomass generated as agricultural by-products, including wheat straw, corn stalks, reeds, bagasse, and residue from palm oil production. All of these materials offer massive, unutilized potential for cellulosic ethanol and biochemical production thanks to the technology that Chempolis has developed.

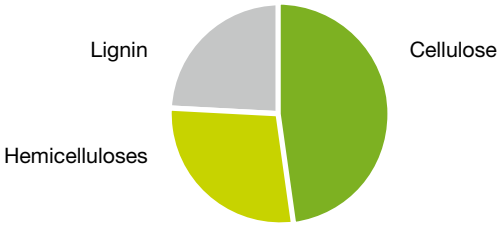
THE BENEFITS OF
formicobio™ technology:

- High profitability
- High conversion to bioproducts
- 40 % more sales revenues
- Very low operation costs
- Low-carbon technology
- Self-sufficient in terms of energy
- Effluent-free

A true third-generation biorefining platform

SELECTIVITY DELIVERS PROFITABILITY

formicobio™ technology fractionates all the main components present in lignocellulose into cellulose, hemicelluloses, and lignin. The selectivity of the process means that we can apply optimised processes for each fraction and achieve high conversion levels and pure products – delivering some 40% of higher sales revenues to customer than 2G technologies do.



The pure cellulose produced can be enzymatically hydrolysed into pure glucose very easily, using less enzymes. Pure glucose can be fermented into ethanol rapidly. In addition to providing the base for bioethanol, glucose is also a platform for various biochemicals.

Pure hemicellulose sugars can be processed into ethanol, furfural, and acetic acid, for example. A versatile xylose platform can be tailored according to customer needs.

The pure lignin produced can be used in energy generation, to make a biorefinery based on **formico**bio™ technology self-sufficient in energy or can be refined into end-product.

SELECTIVITY MEANS NO WASTE

formicobio™ technology is based on the use of a novel sulphur-free biosolvent, which enables the biosolvent and water circulation within the process to be fully closed, preventing the generation of waste. As the biosolvent is completely recoverable and the process requires a low level of enzyme input and is self-sufficient in terms of energy, **formico**bio™ offers excellent cost-effectiveness combined with high sustainability and low carbon footprint.

MAKING IT HAPPEN

with **formico**deli™, **formico**pure™ and **formico**cont™

formicobio™ selectively fractionates biomass, enabling the fractions to be converted into high-purity ethanol, biochemicals, and energy. The main components of the process are:

- Selective fractionation of biomass using the **formico**deli™ system
- Efficient hydrolysis of washed cellulose and fermentation of glucose into ethanol
- Generation of biochemicals and recovery of biosolvent, biochemicals and water through evaporation and the **formico**pure™ system
- **formico**cont™ is a unique and reliable process control system that ensures a high degree of capacity utilization and provides a continuous optimization of process.

formicodeli™ FOR SUPERIOR FRACTIONATION

By dissolving the desired biomass components, **formico**deli™ can selectively fractionate them into pure cellulose, hemicelluloses, and lignin. Cellulose is separated from the biosolvent and the dissolved components by washing. **formico**deli™ is highly efficient and capable of removing up to 99% of lignin and hemicelluloses, which translates into around 90% cellulose content after biomass fractionation.

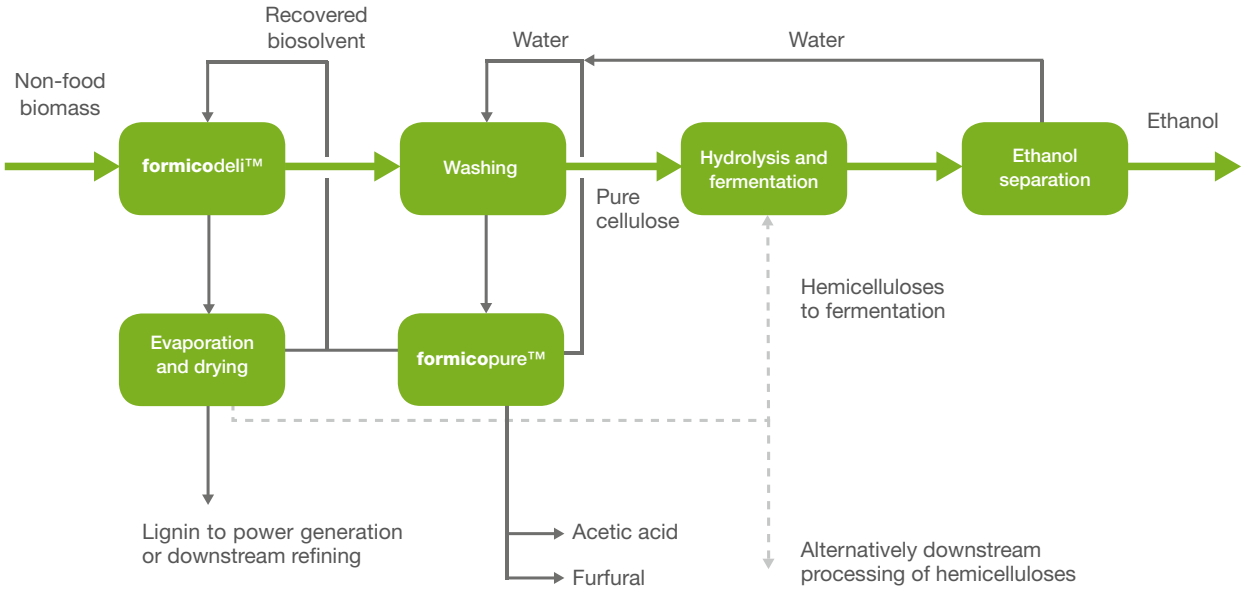
EFFICIENT ENZYMATIC HYDROLYSIS OF CELLULOSE INTO GLUCOSE

The design of the **formico**bio™ technology makes the enzymatic hydrolysis of cellulose into glucose very easy.

Due to the high purity of cellulose, only a small amount of enzyme is needed and less residual solids are generated. There is also no need for detoxification before enzymatic hydrolysis and fermentation. The high conversion rate and absence of enzymatic hydrolysis inhibitors improves profitability and reduces sugar loss and waste.

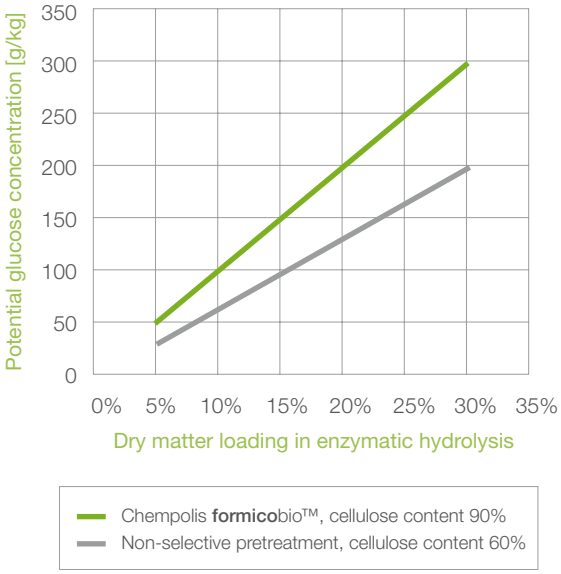
The dry matter of the cellulose fraction has a high glucan content of around 90%. The high glucose concentration during hydrolysis, achieved with a moderate solids loading,

formicobio™ technology



represents a significant benefit, as mixing typically becomes challenging when dry matter loading exceeds 15%.

Effect of cellulose content of pretreated raw material to potential glucose concentration of enzymatic hydrolysis



RAPID FERMENTATION OF GLUCOSE INTO ETHANOL

The pure, concentrated glucose that is produced can be fermented into ethanol rapidly, using a traditional high-yield, yeast-based fermentation. There is also no need for detoxification prior to fermentation. The combination of selective fractionation and efficient enzymatic hydrolysis followed by rapid fermentation makes highly cost-effective and sustainable production of cellulosic ethanol a reality.

FULL RECOVERY OF BIOSOLVENT BY EVAPORATION AND **formico**pure™

The lignin and hemicelluloses, which dissolve in the **formico**deli™ are separated from the volatile biosolvent by evaporation.

The resulting lignin is an excellent solid fuel with a high dry matter (>90%) and a net heating value of 20 MJ/kg, close to that of coal.

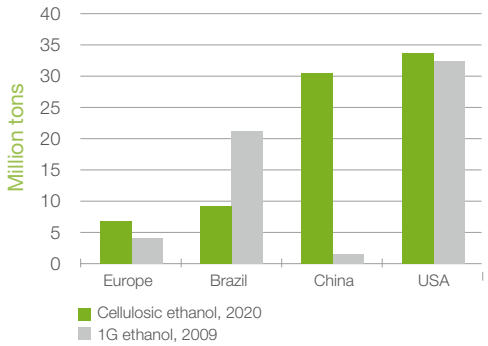
During the biosolvent recovery stage, hemicelluloses are processed into acetic acid and furfural and are purified using **formico**pure™. Alternatively, hemicellulose sugars can be separated and fermented into ethanol or converted into other products further downstream, such as xylitol.

A **formico**pure™ system also recovers water further minimising operating costs and ensuring that no waste is generated.

GLOBAL NEED FOR BIOFUELS

Huge volumes of ethanol are currently produced from food crops around the world. As this type of production has a number of drawbacks, however, further increases in ethanol production will need to come from processing lignocellulosic biomass.

Cellulosic ethanol market potential at 2020



Sources:

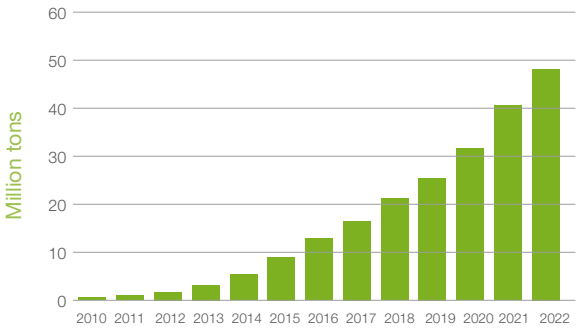
- World Biofuels Markets, Belgium, March 2009, Novozymes presentation
- BOAO Forum, China, April 2009, Novozymes presentation
- World Biofuels Markets, The Netherland, March 2010, Novozymes presentation
- Chempolis bioethanol inaguration ceremony, Finland, May 2010, Danisco presentation

THE LATEST TECHNOLOGY

As **formico**bio™ enables ethanol and biochemicals to be co-produced from lignocellulosic biomass using its own bioenergy, the technology represents a true low-carbon approach and a true third-generation technology for producing liquid biofuels. By avoiding the main problems associated with other technologies, **formico**bio™ opens up the opportunity for highly profitable and sustainable biorefining.

USA Cellulosic ethanol forecast

(Energy Independence and Security Act of 2007)



Comparison with other technologies

	2ND GENERATION ETHANOL TECHNOLOGY	3RD GENERATION ETHANOL TECHNOLOGY, **formico**bio™
Biomass processing	Chemical and mechanical pretreatments ➝ Slurry of cellulose + hemicelluloses+lignin ➝ Difficult hydrolysis and high waste generation ➝ Difficult fermentation	**formico**deli™:Selective fractionation of biomass ➝ Clean cellulose, no impurities ➝ Easy enzymatic hydrolysis and fermentation ➝ Effective lignin and hemicelluloses separation and utilization
Products	Ethanol	Ethanol, furfural and acetic acid ➝ More product value, up to 40%
Carbohydrate utilisation	Partial utilisation or challenging co-utilization of C5 and C6 sugars under compromised process conditions	Optimized process for full and separate C5 and C6 utilization
Enzyme cost	Moderate	Lower than 2G technologies ➝ Cellulose fraction is cleaner ➝ Easy accessibility to enzymes
Chemical recovery	No real chemical recovery ➝ Loss of chemicals ➝ Waste from neutralization of pre-treatment chemicals	Full recovery of fractionation chemicals ➝ No waste ➝ Practically no chemical cost
Residual biomass for combustion at power plant	Dry solid content < 50% Net heat value < 10 MJ/kg	Dry solid content ~ 90% Net heat value ~ 20 MJ/kg ➝ No external energy costs

TECHNOLOGY TRANSFER

Chempolis' **formico**bio™ technology, combined with **formico**deli™, **formico**pure™, and **formico**cont™ process systems, provides a biorefinery offering smooth process operations free of bottlenecks and unexpected shutdowns.

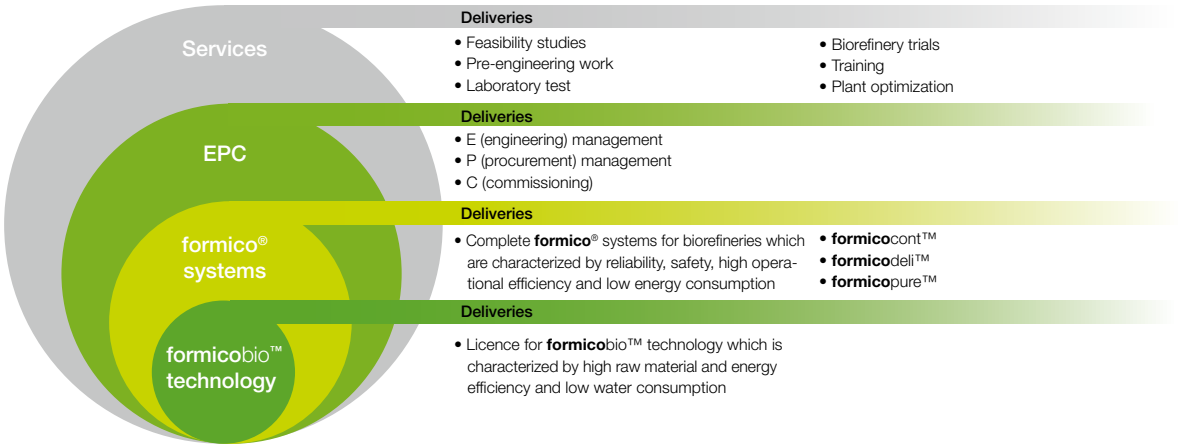
Our technologies and solutions deliver optimised sustainable results and reliability. Third-generation biorefineries based on **formico**bio™ technology are designed to be the most economical solutions over their entire lifetime, with guaranteed performance.

We tailor our proprietary technologies to customers' process requirements to give you a complete technology transfer package that delivers in terms of both process and financial capabilities.

Chempolis' expertise covers the entire processing chain – from biomass to biofuels and other end-products – which means that we can deliver sustainable results at every stage of a project. Our engineering and project implementation expertise is a major plus for customers, and extends from conceptual engineering and process and plant engineering to equipment design, supplying our proprietary systems, and turnkey plant deliveries.

Supervising installation work, commissioning, and initial operations are also an integral part of Chempolis' skills set. By relying on us as a one-stop shop technology partner, customers can rest assured that their plants will perform at their best from the very start.

"We deliver sustainable results."



chempolis®

Chempolis is a technology leader providing innovative and sustainable solutions and services for a wide variety of customers in the biomass and biorefining areas, as well as related process industries.

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