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A biorefinery concept for the transformation of biomass into 2nd generation fuels and polymers

NEWSLETTER

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Welcome to the first BIOCORE newsletter! BIOCORE, a FP7 European project which begun in March 2010, is a 4 year program that aims to demonstrate the **industrial feasibility of a biorefinery concept**. The BIOCORE concept describes the use of several types of **lignocellulosic biomass** (cereal by-products, forestry products and short rotation woody crops) for the production of a wide spectrum of products including **2nd generation biofuel, chemical intermediates, polymers** and **materials**.

This newsletter presents an overview of the **highlights** and **progress** made by the 24 partners during the first **12 months**. We hope you find the information contained within this newsletter useful and we encourage you to visit the BIOCORE web site in order to obtain more information.

Assessing the regional availability of non-food lignocellulosic biomass resources in Europe and in India – supplying a BIOCORE biorefinery

To reveal how biorefineries can be implemented within defined local contexts, BIOCORE researchers have assessed **the availability of targeted biomass feedstocks both in Europe** (hardwood, wheat straw, **Short Rotation Coppice** (SRC) poplar, maize straw, and Miscanthus) **and in India** (rice and wheat straw) using available data from a variety of reliable sources. Three locations are in Europe (EU27) and two are in India.

The next step will focus on **detailed local-level analyses** that will assess the environmental and logistical constraints and describe social impacts of biorefinery implementation within the defined feedstock collect zones.

Multi-criteria evaluation of ligno-cellulosic niche crops for use in biorefinery processes

BIOCORE researchers from the Nova Institut have evaluated the potential of lignocellulosic niche crops for biorefinery processes. Using twenty one criteria grouped into the three categories, ecology, economy and process suitability, it has been possible to conclude that SRC poplar and SRC willow are most promising. According to this analysis, Miscanthus is also highly promising, chiefly due to high yields and well-developed agronomical experience.

Highlights on biomass availability

- Potentially harvestable wheat straw in Europe represents 35 million tonnes of dry matter. This can be completed by 15 million tonnes of maize straw.
- Up to 50% of potentially harvestable straw residues are located in 3 countries: Germany, France and Ukraine (and 70% in 6 countries: Poland, UK and Spain).
- Potentially harvestable hardwood in Europe is located in France, Germany Italy, Poland, and Romania, where the woody biomass availability for biorefineries varies from 2.5 to 5.5 million tonnes per country.
- Central and Eastern Europe present the highest potential for cultivation of SRC poplar.
- The Indian states of Punjab and Haryana present significant biomass resources. The paddy-wheat rotation forms at least 60% of total cultivated land and so rice and wheat straw are the abundant local biomass feedstocks.

Extending the feedstock base of CIMV organosolv technology – towards a multi-feedstock BIOCORE biorefinery

In order to achieve a flexible pretreatment, BIOCORE activities have focused on the use of feedstocks other than the previously tried and tested wheat straw. Attention was paid to various parameters including the optimization of the preliminary biomass size reduction.

Highlights

- Rice straw can be treated in the same way as wheat straw, with highly similar operating parameters.
- Hardwood and short rotation coppice poplar wood need to be reduced to 1 cm particles for CIMV organosolv refining.
- Wood refining requires minor modifications both to the CIMV organosolv solvent system and operating parameters such as temperature and residence time.
- Debarking of SRC poplar is unnecessary prior to CIMV organosolv refining.
- A small amount of softwood (up to 10% dry weight) is tolerated in hardwood feedstock mixtures.

Engineered yeast strains for the production of xylitol and D-xylonic acid

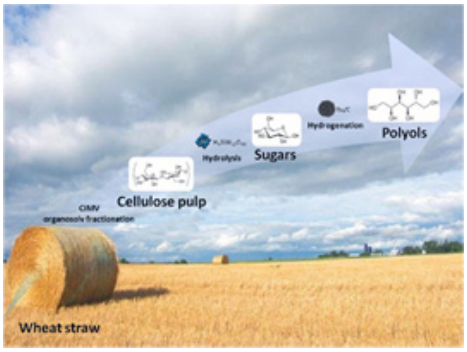
BIOCORE researchers at VTT have pursued the development of engineered microbes that will use the C5 syrup obtained from the CIMV organosolv refining process to produce **xylitol**, a sugar alcohol that is currently commercialized as a sweetener and **D-xylonate**, a potentially useful platform molecule. Several yeast strains have been constructed and tested for the production of xylitol or D-xylonate. So far, the best strains procure titers of over 90g/l and **yields of 85-92%** (g product/ g xylose used).

These results are highly encouraging for the future pilot testing and open up **interesting valorization routes for pentose sugars**, which are derived from the hemicellulose component of lignocellulosic biomass.

Innovation in polyurethane formulation

The BIOCORE partner Synpo has developed a **solvent-free method** allowing for the production of **polyurethane elastomers** containing CIMV organosolv-extracted lignin from wheat straw. The resulting elastomers display **interesting mechanical properties**, such as increased **tensile strength** (compared to a benchmark polyurethane elastomer), which may make them particularly adapted for the manufacture of flexible **floorings** or **electrical appliances** such as **condensers**.

One-pot conversion of straw-derived cellulose into polyols

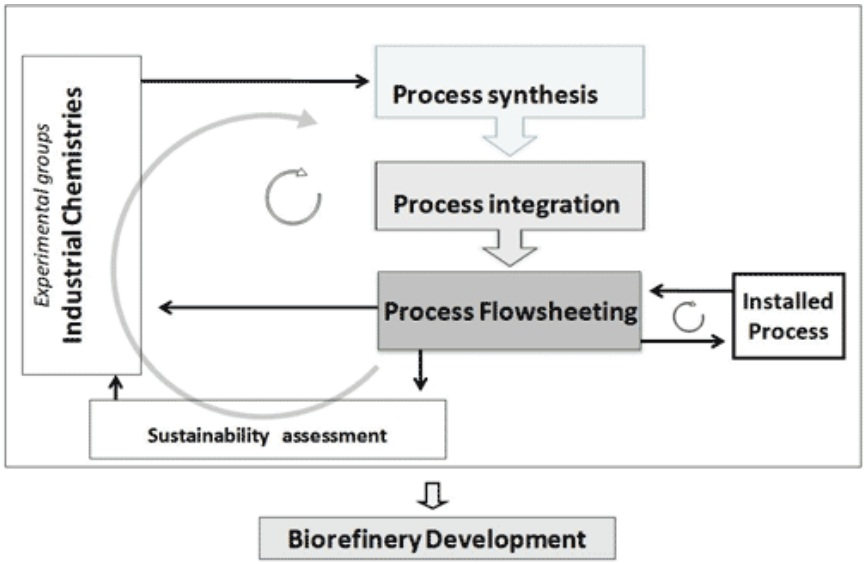


Using advanced **catalytic methods** developed by BIOCORE researchers in KULeuven, it has been possible to demonstrate the feasibility of a **one-step conversion** of cellulose (extracted from wheat straw using CIMV organosolv technology) into a **range of hexitols**. These are obtained in **high yields** (>70 mol% carbon).

BIOCORE establishes a design paradigm to build biorefineries

Conventional industrial design problems assume defined feedstocks and products. In this respect, the design of biorefineries is a much more complex problem, as it involves **multiple feedstocks** and an **extensive portfolio of products**. To cope with these challenges, the BIOCORE design team has developed the **structured application** of a variety of methods for process synthesis, process integration, optimization and modeling at different scales. Using the CIMV process as a pilot (installed process), the approach has been applied in order to upgrade industrial processes and incorporate new technology, thus further optimizing the product portfolios. In general terms, the strategy can be considered as a generic method that establishes structured links between

experimental groups, screening (synthesis) and scoping stages (targeting/process integration) and the final biorefinery flowhseet. The decomposition of the developmental stages simplifies the problem, while ensuring a structured approach and an exhaustive screening of options.



The BIOCORE layered approach

Establishment of conceptual design for a full-scale BIOCORE biorefinery - setting targets for energy efficiency and water use

A concerted effort involving BIOCORE partners from NTUA and CIMV has provided a comprehensive **flowsheet description** of the CIMV process. This model constitutes the base case for further flowsheet designs and modeling. Using the base case model, NTUA researchers have already studied key operations and scoped for process integration leading to improved energy and water use. The process integration studies produced energy and water targets and provided recommendations for process changes that will allow these targets to be reached.

Preliminary results have provided particularly encouraging results, with the Pinch analysis indicating savings of up to **70% and 85%** associated with the heating and the cooling of the process streams. The results of our studies indicate that **energy-free evaporation** will be possible, but the distillation unit remains a target for further improvement. Possible routes for this are the deployment of double-effect columns or side units (e.g. side-rectifiers, side-condensers, Petluk columns). Regarding water integration, our analysis indicates that a **55% reduction in water use** can be achieved if water re-use, recycling and regeneration technologies are integrated into the process design.

Towards a multi-criteria analysis of the BIOCORE concept

A key ambition of the BIOCORE project is to demonstrate the sustainability of the concept. Therefore, during the first year of the project, partners have laid the foundations for the future multicriteria sustainability assessment. This study will investigate the **sustainability** of the processes and the overall concept, taking into account various considerations such as **economics, environmental constraints and social impacts**. The initial phase of this study has focused on the definition of the boundary settings (e.g. timeframes, scale of biorefinery etc) for the study and the precise description of the different value chains.

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