

BIOSYNERGY Newsletter No. 3

Welcome to the third newsletter of the Integrated Project BIOSYNERGY on biorefineries, co-funded under the 6th Framework Programme for Research and Technological Development of the European Communities.

The rally of world oil prices continued in the first half of 2008, reaching all-times high of USD 140 per barrel. Gas and coal joined oil in the soaring prices and we have had to learn living in a completely different world of high prices for energy. These new realities coupled with the increasingly visible impacts of global warming and climate change, give further boost to the search of new and alternative energy sources and their sustainable uses. In this context, the BIOSYNERGY project that is looking for market competitive and environmentally friendly synthesis of various products from biomass, using novel technologies within advanced biorefinery concept, becomes even more relevant and important.

BIOSYNERGY update by work-packages

WP 1: Advanced physical / chemical fractionation

The literature review of physical/chemical fractionation processes has been completed.

Enzymatic hydrolysis on DDGS, steam-exploded wheat straw, organosolv samples and alkaline pretreated wheat straw has been performed.

A datasheet summarising the review of the experimental lab scale and bench scale data for the conceptual design of the demo-plant (WP5) has been created and continuously updated with data and information on the pre-treatment routes (mass flow, equipment, reactor design, degree of conversions, etc).

The selection of pretreatment routes for further characterisation has been completed. The selected routes are: 1) Hemicellulose hydrolysis and recovery during fractionation; 2) Enzymatic degradability of cellulose fractions; 3) Lignin removal during fractionation.

The benchmarks for comparing fractionation routes (depending on application of fractionated products) have been identified. These are: 1) C5 sugar-based route e.g. C5 fermentation to Acetone / Butanol / Ethanol (ABE), furfural, etc; 2) C6 sugar-based route e.g. C6 fermentation to ethanol 3) Lignin-based route e.g. chemicals from lignin;

WP 2: Innovative thermochemical conversion

It has been decided the work in WP2 to focus on a limited number of feedstocks and (reactor) technologies in order to avoid an excessively wide spread of activities that may result in superficial research results. WP2 will therefore concentrate on the pathways to chemicals and fuels from ligno-cellulose biomass and lignin. The (co)-production of power and heat will not be considered. Owing to a better overall performance, the original staged (catalytic) *degasification* approach has been replaced by a staged (catalytic) *thermo-chemical* processing concept.



Experimental pyrolysis facility at ECN (Photo: ECN)

In the first half of 2008 the work concentrated on the fluidised bed gasification technology combined with specific pretreatments (torrefaction and/or pre-hydrolysis). Progress has also been achieved in the research and experimental activities on bio-oil upgrading, phenolic fraction separation, catalysis & catalysts for pyrolysis and alternative staged degasification concepts. A brief literature review has been performed on the separation and purification issues, too.

WP 3: Advanced biochemical conversion

The work on acetone-butanol (ABE) fermentation has focused on the fermentation of DDGS and wheat straw hemicellulose hydrolysates obtained from steam explosion in mild acidic conditions. Tests with DDGS as carbon and nutrient source for ABE fermentation have started. The analysis of ABE performance of several *Clostridium* strains using synthetic media and various concentrations of wheat straw hemicellulosic hydrolysates has been completed.

The research work on the bioconversion of sugars and functionalisation of lignin has been progressing. DDGS hydrolysate has been used as a substrate to identify suitable micro-organisms and conversion strategies for converting sugars. Novel straw and poplar lignins have been tested as substrates for laccase. Lignin functionalisation using laccase activation has been obtained and lignin nanoparticles have been prepared at lab-scale.



DDGS (Photo: A&F)

The work on the membrane separation based Multiphase Rotating Contactors has been focused on the separation of single components (alcohols) in water solutions, with aim to boost productivity. The process parameters and the separation of multi-component mixtures and fermentation media have been evaluated. A mathematical model of the Rotating Disk Contactors elementary isothermal system to obtain the basis for comparison of different separation methods has been adopted from published simulation works.

WP 4: Innovative chemical conversion and synthesis

The work on the production and characterisation of platform chemicals at lab-scale has been advanced:

- Lignin depolymerisation in supercritical CO₂ and co-solvent (ethanol with / without organic acid as catalyst) and study of phenolics oil obtained in various applications for manufacturing of materials.
- Lab-scale reactor design to analyse furfural synthesis and kinetics from xylose;
- Hydroxymethylfurfural production from glucose;

Products from selected platform chemicals have been obtained at lab-scale:

- Synthesis of 2,5-FDA and various organic acids;
- Synthesis of butanediol oligomers;

Pentose valorisation as feedstock for surfactants – an emulsion technology has been developed at lab-scale to convert pentoses by glycosylation into feedstocks for surfactants.

Samples of pentoses surfactants for test in applications for manufacturing of materials have been produced.

A literature overview of innovative concepts for membrane reactors for potential use in product recovery has been performed.

WP 5: Conceptual design biorefinery validation pilot-plant of Abengoa in Salamanca

The development of the conceptual process design has been advanced with the completion of the base case (the ligno-cellulose bioethanol plant). Starting from the base case, various alternative (biorefinery) cases are being considered.

These alternative cases are based on ligno-cellulose biorefinery for combined production of ethanol and other chemicals. The alternative concepts will be built upon three core pathways: 1) Production of ethanol from C6-sugars; 2) Production of ethanol and/or furfural and/or other chemicals from C5 sugars; 3) Production of fuels and chemicals (e.g. ethanol, phenol) from lignin. Biomass / lignin gasification for fuels (ethanol), chemicals, power and heat will also be considered as additional option for the alternative (biorefinery) case. At first, steam explosion has been identified as the most suitable pretreatment option for the three core pathways. The integration of staged de-gasification and ABE fermentation into the three pathways could be suitable and useful.

The development of a process economics spreadsheet model for evaluation of various process design scenarios and the preliminary process economic analysis has been advanced.

The collection and analysis of data of common interest to both WP5 and WP6, such as reaction parameters, molar and energy balances, including LCA data, has been ongoing.

WP 6: Integral biomass-to-product chain design, analysis and optimisation

WP6 has short-listed the following core concepts for desktop (without any experimental activities) characterisation and optimisation:

- Straw – steam explosion – C6 to ethanol / C5 to furfural / Lignin to phenols;
- Soft wood – steam explosion – C6 to ethanol / C5 to furfural / Lignin to phenols;
- Straw – steam – ABE;

- Straw – gasification – syngas – ethanol & other alcohols;
- Wood – fast pyrolysis – bio-oil – upgraded oil refinery;
- Straw – organosolv pre-treatment – ABE & phenols;
- Straw – pre-treatment – C6 to ethanol / C5 to furfural / Lignin to phenols;

The number of concepts for characterisation may be slightly increased, with emphasis on ethanol streams. DDGS will not be examined as potential feedstock for the time being.

The characterisation and optimisation are entirely based on exogenous data and information inputs, i.e. no dedicated database is being developed within WP6. The collection of techno-economic data is ongoing.

The work on the opportunities for integration of biorefinery products in conventional petrochemical refinery has been initiated.

Events

BIOSYNERGY Progress Meeting, Alkmaar (NL) and Technical Training Tour, 15-16 April 2008, Petten (NL)

The third plenary BIOSYNERGY Progress Meeting was held on 15th and 16th April 2008 in Alkmaar. The project coordinator ECN hosted the meeting. Besides the administrative part, the meeting included in-house project workshops by work-packages to discuss the results achieved so far and map the workplan till the next plenary meeting scheduled for November 2008. The workshop discussions and the general assembly gathering has noted a good and on-time progress in achieving project goals and milestones as per the original Work Plan.

The project coordinator ECN has organised a technical training tour for the consortium partners at its experimental facilities in Petten. The tour



*Photo from the technical tour at the experimental site of ECN at Petten, 16 April 2008
(Photo: Jasper Lensselink)*

began with a presentation by Programme Manager Mr. Jaap Kiel on the ongoing R&D in the field of biomass conversion and biorefinery at the Biomass, Coal and Environmental Research Unit of ECN. The tour continued with a visit to the biomass laboratories and technical facilities of ECN. These included the pressure reactor system for physical / chemical pre-treatment R&D, the Bubbling Fluidized Bed thermal converter for gasification, pyrolysis and combustion R&D, the Milena indirect biomass gasifier unit at lab-scale (25 kW) and the new 800 kW pilot-scale installation, the Pyromaat auger reactor for biomass pyrolysis, and the oil-based gas cleaning system OLGA at both lab- and pilot-scale (200 mn³/hour). The tour also included a visit to the new Torrefaction pilot plant (approximately 400 kW) for thermal pre-treatment of biomass.

The first BIOSYNERGY Workshop took place in Petten on 17-18 April 2008

The aim of the workshop, entitled “Advanced Biorefinery Concepts: A Feasibility and Reality Check” was to disseminate BIOSYNERGY advanced biomass concepts and technologies beyond EU borders, in countries and regions that have promising biomass / bioenergy potential. On average, the EU new member states, candidate countries and potential candidate countries have larger land area per capita, lower level of bioenergy penetration and higher import dependence on fossil fuels (oil and gas) than the elder EU-15/25 member states. The goal of the workshop was to exchange views and information on the potential of bio-refineries in the new member states, candidate countries and potential candidate countries, targeting policy makers, industrial stakeholders and researchers, including NGOs, and to have a brief SWOT snap-shot on the perspectives of biorefinery concepts in these countries.

The workshop managed to attract a wide range of experts from Bulgaria, Romania, Croatia, Turkey, FYROM, Albania, Bosnia & Herzegovina, Montenegro and Serbia. The proceedings of the workshop, as well as other publications from the project, are available in the “Publications” section of the BIOSYNERGY website, <http://www.biosynergy.eu/publications/>.

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