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

With the oil price that has fallen from 140 $ per barrel in July 2008 to 40 $ per barrel in January 2009, many advanced-biofuel startups will have a lot of difficulties, especially those that attracted investments last summer, while oil price was well above 100 $ per barrel.
Furthermore, the recent drop in oil prices together with the credit markets crisis are going to make it difficult for advanced biofuel companies to move ahead with plans for scaling up technologies and building commercial-scale production plants.
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.
The efficiency in biofuel production, together with the possibility of selling value added by-products, could make the difference for the survival of many new biofuel firms.

BIOSYNERGY update by work-packages

WP 1: Advanced physical / chemical fractionation

The subject of this WP is the lab-scale experimental development and optimisation of technologies for physical and chemical pre-treatment and fractionation of biomass into separate C5/C6 sugar and lignin fractions. The R and D progress to date includes:

- Comprehensive literature review of available fractionation technologies and related knowledge completed
- Proof of principle of three fractionation routes presented
- Enzymatic hydrolysis protocols developed for both lignocellulosic biomass, and DDGS
- Delivery of fractionized products to other WP's
- Delivery of relevant data on fractionation to other WP's
- Benchmarking of fractionation routes defined and applied to fractionation routes
- Initial modeling of three fractionation routes completed

Pilot-scale facilities A&F (left: co-rotating twin screw extruder for continuous fractionation, middle: 250L vessel for extraction, right: 150L hydrolysis/fermentation vessel)

WP 2: Innovative thermochemical conversion

Within WP2 'Innovative thermochemical conversion' the emphasis lies on lab-scale experimental development of (catalytic) staged thermochemical processing ('degasification') and pyrolysis processes for the fractionation / conversion of lignin / biomass into chemical intermediates and / or secondary energy carriers according to the following objectives:

1. Development of thermochemical conversion technologies that produce fuels and (high) added value chemicals and materials,
2. Development of staged (catalytic) thermochemical processing ('degasification') concepts for the production of fuels and chemicals from biomass and lignin and
3. Development of efficient and cost-effective separation technologies for chemical intermediates from thermochemically derived product mixtures.

Since the original staged degasification concept has proven to result in limited yields and selectivity for value-added chemicals, an alternative concept has been investigated.
This concept involves biomass pretreatment followed by a (catalytic) fast pyrolysis. A hybrid staged degasification process, involving a specific aqeous-based pretreatment (aquathermolysis), yielded much better results when compared to the original staged degasification approach. Target chemicals and materials that have been identified are furfural, levoglucosan, phenolic compounds and pyrolysis-oil.

The Proof of Principle of the hybrid thermolysis approach has been delivered and is submitted for publication in the International Journal of Chemical Reactor Engineering.
From fast pyrolysis experiments it has been proven that all the project feedstocks can be successfully pyrolysed yielding bio-oil of different qualities. From spruce derived bio-oil a specific fraction has been produced that is suitable for resins and wood preservatives production.
The production of this fraction from pyrolysis-oil will be in-depth investigated. For the coming period lab-, bench- and pilot-scale fast pyrolysis and hybrid degasification experiments are foreseen with pretreated feedstocks. These activities will be supported by analytical characterisation work. Upgrading of bio-oil using catalysts for de-oxygenation of bio-oil, bio-oil viscosity reduction, improved stability and lignin cracking will also be addressed.

Multifunctional bubbling fluidised bed reactor for pyrolysis, gasification and combustion at ECN

To evaluate oil-injector material performance, long duration tests with pyrolysis-oil are planned. 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, resulting 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.
In the first half of 2008 the work was concentrated on the fluidised bed gasification technology combined with specific pretreatments (torrefaction and/or pre-hydrolysis). Progress has been also achieved in the research and experimental activities on bio-oil upgrading, phenolic fraction separation, catalysis & catalysts for pyrolysis and alternative staged degasification concepts.

WP 3: Advanced biochemical conversion

This WP focuses on the development of advanced biochemical processes for conversion of sugars and lignin into value-added products or intermediates including higher alcohols, platform chemicals and functional lignin derivates.

The main achievements to date include:

1) Acetone-butanol (ABE) fermentation:
   a) definition of conditions for rapid screening of strains,
   b) determination of the capacity of several strains to convert glucose and xylose,
   c) evaluation of the performances using various wheat straw hemicellulose hydrolysates,
   d) first tests on DDGS,
   e) extraction of ABE from aqueous mixtures using rotating disc separators and pervaporation systems.

2) Xylonic acid production from xylose:
   a) selection of acid resistant strains of yeast, filamentous fungi and bacteria,
   b) batch, fed-batch and continuous conversion performed,
   c) production of xylonic acid using DDGS.

3) Lignin to functional derivates:
   a) lab-scale production and characterisation of nanoparticles from model lignins,
   b) functionalisation of model lignins using various laccases,
   c) proposal of a reaction mechanism for functionalization on lignans.

WP 4: Innovative chemical conversion and synthesis

This WP develops various promising chemical conversion technologies for the valorisation of C5 and C6-sugars, lignin and thermo-chemically derived intermediates. Furthermore the WP addresses process analysis and development for the synthesis of final products from intermediates (furanics and phenolics chemicals) produced.

Thusfar the main results include:

- Platform chemicals production and characterisation at laboratory scale
- Lignin depolymerisation
- Lab-scale reactor design to analyse furfural synthesis and kinetics from xylose
- Hydroxymethylfurfural production from glucose
- Lab scale synthesis of products from selected platform chemicals;
- Pentose valorisation as raw materials for surfactants;an emulsion technology was developed at lab-scale to convert pentoses by glycosylation into raw materials for surfactants. Production of kilogram samples of pentoses surfactants for tests in materials manufacturing applications.
- Literature overview of innovative membrane reactor concepts for potential use in product recovery.

ARD facilities for pilot-plant trials on surfactant production.

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

During the last period, the conceptual design of a 100% ethanol biorefinery, that integrates biomass gasification for heat, power and biofuels production into the Base Case, has continued.

Three scenarios have been defined for the conceptual design of a 100% ethanol biorefinery:

- Enzymatic Hydrolysis plant combined with gasification for heat production (Scenario 1)
- Enzymatic Hydrolysis plant combined with gasification for heat and power production (Scenario 2)
- Enzymatic Hydrolysis plant combined with gasification and catalysis for ethanol synthesis (Scenario 3)

At present, the work in the 100% ethanol biorefinery is focused on the development of an Aspen model for biomass gasification and alcohol catalytic synthesis. A first model including the gasification step for heat production is currently available and has been integrated into the Base Case simulation model (Scenario 1).
The elaboration of an economical model for evaluation of the design scenarios has also been completed, as well as a comprehensive spreadsheet recording all the equipment required in a lignocellulosic biomass to bioethanol plant with associated costs. The data has been obtained from the demonstration and pilot lignocellulosic ethanol facilities owned by Abengoa Bioenergy.
The spreadsheet has been integrated in the Base Case model developed by ABNT.
Regarding the up-grading of the Base Case, the design of the first biorefinery concept chosen (Biorefinery products: C6 to ethanol, C5 to furfural, lignin to phenols) has been started.

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

The objective of Work Package 6 is to perform a comprehensive (technological, economic, environmental and socio-economic) assessment and optimisation of biorefinery chains from feedstock to end-products.
The initial focus is placed on cellulose ethanol based biorefinery cases, to create maximum added value for the project in close coordination with Work Package 5. The ultimate goal is to identify the most promising biorefinery chains within a future European biobased economy, and the possibilities for their integration with conventional petrochemical oil refineries.
The progress so far includes:

1) The creation and validation of a process synthesis methodology and modelling tool to identify the optimum process chain design.
   The methodology consists of 3 steps:
   a) Biorefinery chain generation (Process Synthesis)
   b) Process modelling and LCA assessment
   c) Chain comparison (MCDA analysis)

2) Definition of the main structure of the Life Cycle Assessment model and collection of data,
3) Selection of an agreed 10 initial biorefinery concepts for more detailed modelling and LCA assessment,
4) Creation of data collection templates to facilitate the sharing of information between work packages.

WP 7: Demonstration at pilot scale

The pilot-scale demonstration in this WP includes the use of pilot-scale facilities 1) to produce market sound samples of bio-based intermediates for the lab and bench-scale technology developments in WPs 1-4, and 2) to examine the potential for scaling-up the developed technologies in WPs 1-4.
The main progress includes:

- Production and distribution of pre-treated (steam explosion) wheat straw by ABNT to be used as raw material for downstream technology developments.
- Production of 280 kg pyrolysis bio-oil – for downstream technology development – in a fast pyrolysis installation.
- Scale-up of lab scale technology developments to pilot scale will take place from 2009 onwards depending on the R&D progress made

By the end of 2007, 160 kg pre-treated straw was produced by ABNT in their York plant in Nebraska (US). Both pre-treated straw, raw straw (1.25 tonne), and DDGS (3 tonnes) were distributed to the partners early 2008. ABNT also offered to provide lignin/stillage from the BCyl-plant in Salamanca (ES) for R&D activities to be performed by Aston, ECN and ARD.
Scale-up of lab-scale technology developments in WPs 1-4 to pilot-scale will take place from 2009 onwards depending on the R&D progress made. For the time being initial bench-scale work has been performed by the partners as initiating phase for the pilot-scale work. BTG already alraedy processes 500 kg pine wood to produce 280 kg pyrolysis oil in their available batch fast pyrolysis facility. For the coming period large-scale production of pyrolysis oil from wheat and barley straw and DDGS is foreseen.

WP 8: Training and knowledge dissemination.

The objective of WP8 is to ensure the two-way communication of the project with the outside world. This includes general promotion of project results, exchange of views and information with external stakeholders, training of persons in relevant industries and institutions, dissemination of policy options and recommendations to national and European stakeholders and policy-makers.

Results to date include:

- establishment of a project website http://www.biosynergy.eu
- Procedures for key activities (workshops, IT learning web-module, road show) developed
- production of a project brochure and periodic newsletters (download at project website)
- scientific publications and presentations at various international events (conferences, workshops)
- organisation of the first project workshop - an Enlargement and Integration Workshop on biorefineries by the JRC-IE in Petten, The Netherlands on April 17 and 18, 2008.

The Biosynergy WP leaders and EC project officer Maria Georgiadou at the 2nd Annual Progress Meeting, November 2008.

Legal notice

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BIOSYNERGY started on 01.01.2007 and will last for four years, until the end of 2010.

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