IEA Bioenergy

Task 34 - Pyrolysis

Welcome to Task 34

PyNe 36

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By Doug Elliott, Task 34 Leader

The IEA Bioenergy Task 34 for Pyrolysis is at the midpoint of the current triennium, which runs from 2013 to 2015. Participants in the Task are Germany, Netherlands, Sweden, Finland, the UK, and most recently Norway, with leadership provided by the US. This newsletter is produced by the Task to stimulate the interaction of researchers with commercial entities in the field of biomass pyrolysis.

Aims & Objectives

The overall objective of Task 34 is to improve the rate of implementation and success of fast pyrolysis for fuels and chemicals by contributing to critical technical areas and disseminating relevant information, particularly to industry and policy makers. The following remain as the Priority Topics identified for the triennium by the Task:

- Review of bio-oil applications;
- Bio-oil standardisation;
- Round Robin for analytical method development;
- Technoeconomic assessment of thermochemical liquefaction technologies.

Since the initiation of the Task for the current triennium, the Task Members have been busy with the identified activities. Applications for bio-oil have been reviewed and new information gathered and prepared for the Task website: http://www.pyne.co.uk/?_id=1. The Round Robin has been organised and is underway. Three feedstocks were prepared and distributed to 20 laboratories wherein fast pyrolysis bio-oils will be prepared for analysis and comparison. Support to the CEN working group, which is developing standards for bio-oil for use in Europe, has been ongoing, with two of the Task Members actually serving as members of the working group and all Task Members serving as technical consultants to the standards development effort. In recent collaborations with other IEA Bioenergy Tasks, the life cycle analysis produced by two of the members is being reviewed in Task 38 and other participants in Task

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34 have provided review of the bioenergy fact sheets being developed as part of the Task 42 work. Finally, a new web-based interactive database of pyrolysis demonstration plants is being developed and should become an active element on the Task website this year.

In this issue of the newsletter there are several articles from the participants describing the latest developments in fast pyrolysis including exciting news of the bio-oil production and delivery contracts from Ensyn to two entities in the US. Also from the US we have contributions on hydrogenation, co-processing, and mobile pyrolysis; from Finland a report on Valmet's new heating plant; and from non-member countries we have a contribution from Spain discussing conical spouted bed technology. We have a report on the recent TCS2014 conference, along with two other meeting reviews. There is also an updated calendar of events of interest to the biomass pyrolysis community.

Please also be aware of the Country Reports located elsewhere on the Task 34 website. These are short introductory articles from the national team leaders from each of the participating countries summarising the particular biomass pyrolysis efforts in their countries. In addition, the latest Task meeting report summarises the developments within each of the Priority Topics of the Task.

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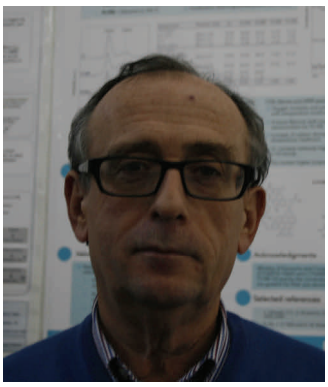
Development of the conical spouted bed technology for biomass flash pyrolysis



From top: Maider Amutio, Gartzen López, Javier Bilbao and Martin Olazar.

Maider Amutio, Gartzen López, Javier Bilbao and Martin Olazar of the University of the Basque Country, Spain, give us an insight into the advantages of the conical spouted bed reactor (CSBR)

Throughout recent decades, biomass flash pyrolysis has been widely studied as a way for large scale production of renewable energy, fuels and valuable chemicals. Several reactor configurations have been developed, with those scaled up to demonstration or industrial plant level being: fluidised bed, transport and circulating fluidised bed, rotating cone, ablative, auger and vacuum moving bed reactors.

The conical spouted bed reactor (CSBR) is presented as an alternative to fluidised beds, given that its building and operational costs are lower due to the lower volume requirements of the reactor for the same production rate and the simpler design, i.e., no distributor plate is required. In addition, the CSBR allows operating with much higher biomass particle diameters than fluidised beds, and with a wide particle size distribution. The CSBR thus avoids the exponential increase in energy consumption required to reduce particle size to below 1mm.

Figure 1 displays a diagram of the CSBR for biomass pyrolysis. The gas rises through the spout and annulus whereas the particles descend countercurrently through the annular region, leading to a vigorous particle cyclic movement that gives way to high heat and mass transfer rates between phases. This allows handling particles of irregular texture, low density, and wide size distribution. Furthermore, the great versatility concerning gas flow rate allows operating with short gas residence times (as low as milliseconds), thus minimising secondary cracking reactions that reduce bio-oil yield. Furthermore, the CSBR allows continuous operation by selectively removing the char from the bed due to the segregation that occurs in the fountain region.

Biomass pyrolysis in continuous mode in the CSBR

The CSBR has been proven to be a versatile reactor for biomass flash pyrolysis in continuous mode, given the char removal capacity described above. Studies carried out at the laboratory bench-scale plant (2g/min) in the University of the Basque Country UPV/EHU with pinewood sawdust revealed that high bio-oil yields, with a maximum of 75wt% at 500°C, can be achieved with this technology. The bio-oil has similar properties and composition to that obtained with other technologies, such as fluidised beds.[1] Furthermore, high bio-oil yields have also been obtained by feeding other biomass materials, such as rice husk[2] or forest shrub wastes.[3]

Vacuum pyrolysis

Scaling-up of biomass flash pyrolysis to industrial scale involves solving several problems related to the energy requirements of the process. Accordingly, vacuum operation is proposed for improving the operational capacity of the CSBR technology. A mild vacuum (0.25atm) decreases the mass flow rate of the fluidising gas required for operation, reducing the energy demand for heating the gas and simplifying bio-oil collection, thus reducing associated costs.

Slightly higher bio-oil yields (77wt%

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Development of the conical spouted bed *...continued*

at 500ºC) than under atmospheric pyrolysis with pinewood sawdust are obtained when operating under 0.25atm at the laboratory scale conical spouted bed plant.[4] Vacuum operation enhances the desorption and diffusion of the volatiles formed within the porous structure of biomass particles towards the outside, which reduces their residence time inside the particle and therefore limits secondary and cracking reactions and increases bio-oil yield. The bio -oil has similar properties to that produced under atmospheric pressure, although it is slightly less oxygenated and has a higher quantity of heavier compounds and lower water content. Furthermore, a char fraction with improved surface characteristics is also obtained.

Oxidative pyrolysis for autothermal operation

Heat supply to the pyrolysis reactor can be solved by adding small oxygen amounts into the fluidising gas in order to operate autothermically. Oxidative pyrolysis is proposed as a simple and economical way to improve process adaptation to industrial scale, given that the energy required for the process is supplied in the pyrolysis reaction itself by the combustion of part of the pyrolytic products.

The special features of the CSBR make it suitable for oxidative pyrolysis, given that the oxygen concentration that has to be added for the process to operate autothermically is lower when the operation scale is higher, therefore limiting the effect of combustion reactions on product yields and composition. The energy required for the pyrolysis process is obtained mainly by the partial combustion of the char in the reactor.

Bench-scale studies with pinewood sawdust at 500°C and adding 15% stoichiometric oxygen (ER=0.15,

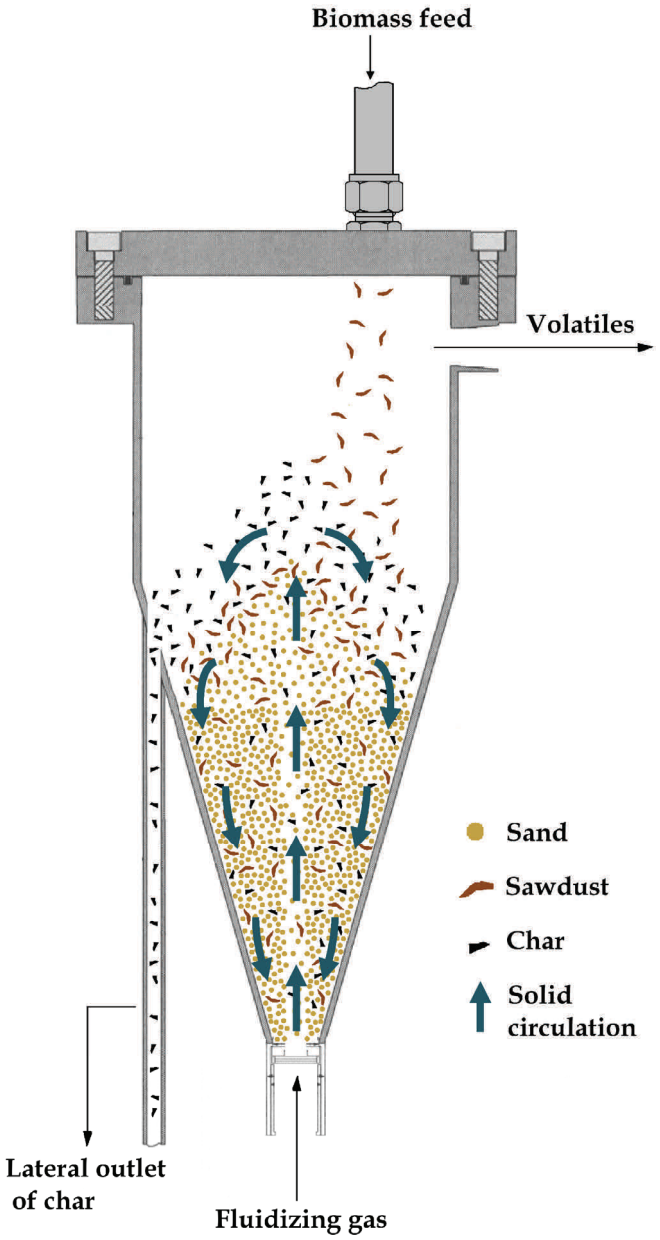

Figure 1: Schematic diagram of the solid circulation in the CSBR.

which corresponds to a 2.5vol% oxygen in the gas stream) show that bio-oil yield increases from 75 to 85g/100g biomass, although this increase is due to a higher water yield.[5] Nevertheless, the yield of organic oxygenated compounds is hardly affected, so this does not compromise its quality. Figure 2 shows the bio-oil yields obtained when operating in the bench-scale plant following the different operation strategies studied.

Scale up of the CSBR to a 25 kg/h pilot plant

The development of the CSBR technology for biomass flash pyrolysis has led to the design, construction and operation of a 2kg/h pilot plant at the IK4-Ikerlan Research Centre, with the collaboration of the University of the Basque Country (UPV/EHU). The plant is shown in Figure 3.[6]

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Development of the conical spouted bed *...continued*

The scale up of the process has been accomplished based on several improvements carried out regarding the hydrodynamic performance of the reactor.[7] Thus, the incorporation of internal devices solves problems related to bed stability, decreases the fluidising gas flow rate required for operation, and reduces the attrition of the inert material in the bed. These improvements ensure stable operation in the biomass flash pyrolysis in continuous mode, obtaining high bio-oil yields.

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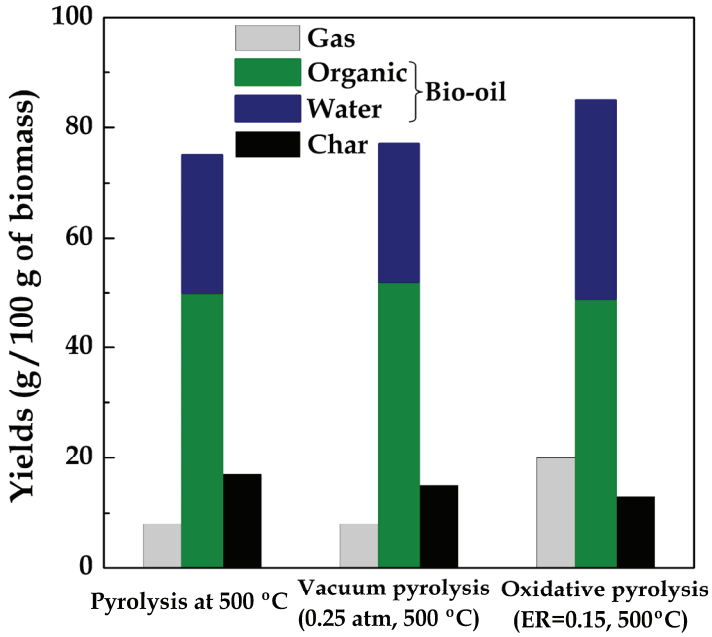

Figure 2: Bio-oil yields for pinewood pyrolysis in the CSBR with different strategies.

Figure 3: 2 kg/h pilot plant at the IK4-Ikerlan Research Centre.

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Pyrolysis demonstration in Washington State

Alan Zacher of Pacific Northwest National Laboratory in the USA reports on a recent mobile pyrolysis demonstration in Washington State

There is growing interest in mobile pyrolysis in Washington State for converting opportunity feedstocks into bio-oil and char products.

In a demonstration sponsored by the United States Department of Agriculture (USDA) Forest Service, Amaron Energy demonstrated their 20t/d mobile pyrolysis unit in Cle Elum, Washington, at the Willis Enterprise Chip Plant. The event was held on 22nd and 23rd October 2014 and was open to the public for viewing and participation in a discussion which was followed by questions and answers by subject matter experts from Amaron Energy, the Department of Natural Resources, Washington State University, University of

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Figure 1: Public visitors queue up to enter the pyrolysis control station.

Pyrolysis demonstration
...continued

Figure 2: View of the indirectly fired pyrolysis kiln.

Figure 3: Alternative view of the indirectly fired pyrolysis kiln.

Utah, and Forest Concepts Inc. The event was attended by over 100 people representing the public and various stakeholders in forestry and alternative energy.

The feedstock for this demonstration was made up of forest residues. These included a variety of mixed wood and forest thinnings from the local community efforts to remove materials in the local forests that could be potential wildfire fuel, with reports that the timber from an old, abandoned cabin had been included in the mix. For the most part, the feedstock contained wood and bark with a lower concentration of green forest residue, with a relatively low amount of inorganic ash through careful handling. The wood was ground to less than 1.25cm and dried to less than 10% moisture content for the test. The feed was prepared by Forest Concepts using typical methods, with adjustments to the grinding process to reduce long aspect ratio particles. In addition, they also provided feedstock for testing in the week before the demonstration using a trademarked method that produces a kind of square shaped particle. The feed rate during the observed portion of the demonstration on the afternoon of the 23rd was substantially lower than the 20t/d design rate.

The pyrolysis demonstration plant was constructed inside a shipping container and consisted of an indirectly fired rotary kiln with propane burners impinging on the exterior of the rotating kiln, which were regulated to a target temperature via infrared (IR) pyrometers measuring the exterior of the shell. Pyrolysis vapour and gases were drawn through a series of oil collection units by an inductive fan as they were formed inside the kiln.

Solids residence time within the kiln was reported to be around ten minutes, presumably with shorter vapour residence times, which puts the process in the intermediate pyrolysis range. The oil collection system consisted of a recirculated bio-oil spray quench followed by two condensers, a four element electrostatic precipitator (ESP), and filter units prior to entering the draw fan. Spray quench was normally brought up with diesel fuel until a sufficient amount of bio-oil could be collected in the spray.

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Pyrolysis demonstration
...continued

Figure 4: Char cooling in open beds in the foreground as visitors ask questions about the feeding system (background) and oil recovery (right).

Following the fan, the offgas was vented and flared – although the system was configured to recycle the offgas for burner fuel to heat the kiln it was not operating in that configuration for the demonstration. The primary condenser was operating at around 130°C, resulting in a thick pyrolysis oil from the spray quench and condenser. A translucent water phase of typical consistency and odour was collected from the secondary condenser and ESP.

The char collected from the process was spread out on a cooling pad, and had retained much of the physical structure of the feed wood. The char was relatively free of volatiles from having been exposed to heat for around ten minutes in the kiln, and had no residual odour. Some of the char was reported to be used as the filtering media in the polishing filters prior to the inductive fan. Bio-oil products were collected by Washington State University graduate students for ongoing research into uses for the oil, with a particular focus on potential chemical products. The product yield and quality results of the demonstration will be available at a later date.

The products desired by Amaron Energy were equivalent amounts of both the bio-oil for fuel or chemicals and char for soil amendment or filtration applications. The event was sponsored by the USDA in partnership with the Washington State Departments of Natural Resources, Department of Commerce and University Energy Programme as well as the Oregon Department of Forestry and Oregon Department of Energy.

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Pacific Northwest
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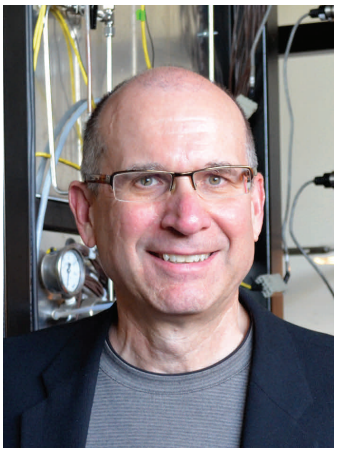
Bio-oil hydrogenation at Iowa State University



Robert Brown and Ryan Smith of Iowa State University, USA, discuss work on hydrogenation of bio-oil

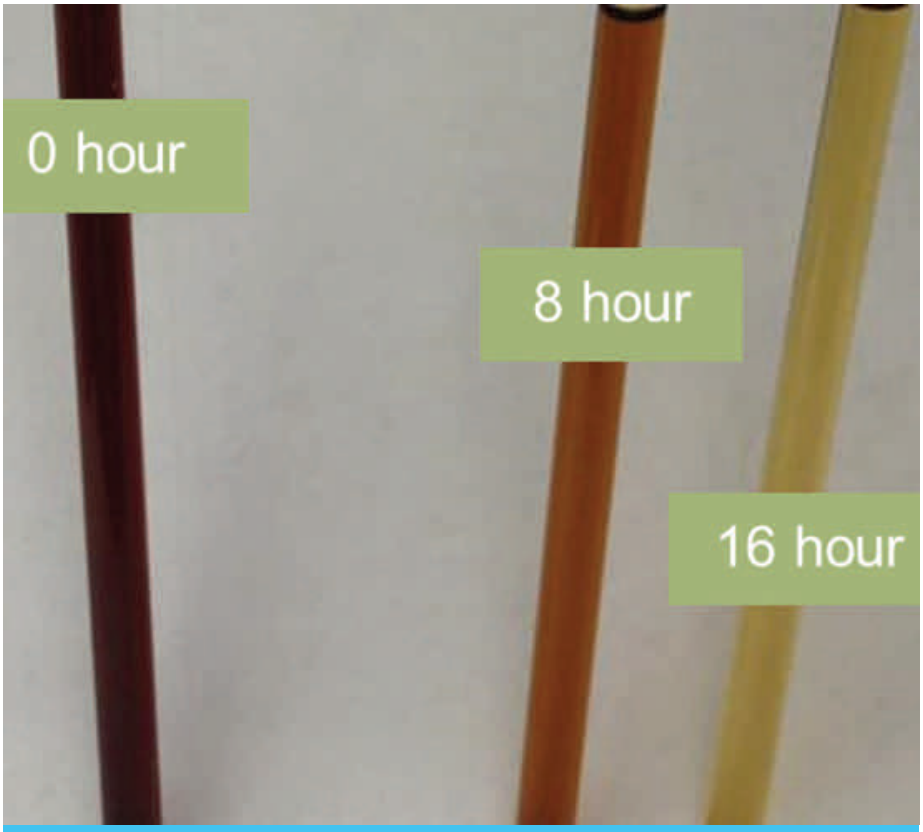


Figure 1: Colour change of phenolics dissolved in methanol and subjected to low temperature, low pressure (LTLP) hydrogenation after 0, 8, and 16 hours gives visual evidence of loss of conjugated C=C bonds (chromospheres).

Iowa State University's (ISU) Bioeconomy Institute (BEI) is investigating novel methods to hydrogenate bio-oil, easing the path from biomass to fuels and chemicals. Called low-temperature, low-pressure (LTLP) hydrogenation, the process begins by recovering bio-oil as stage fractions using a fractionating bio-oil recovery system in conjunction with a fast pyrolysis reactor. The heavy ends of the fractionated bio-oil are a mixture of sugars and phenolic oligomers. Washing these heavy ends separates the water-soluble sugars from water-insoluble phenolic oligomers.

The phenolics are then hydrogenated under conditions as mild as ambient temperature and atmospheric pressure, converting

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"Called low-temperature, low-pressure (LTLP) the process begins by recovering bio-oil as stage fractions using a fractionating bio-oil recovery system in conjunction with a fast pyrolysis reactor."

Bio-oil hydrogenation
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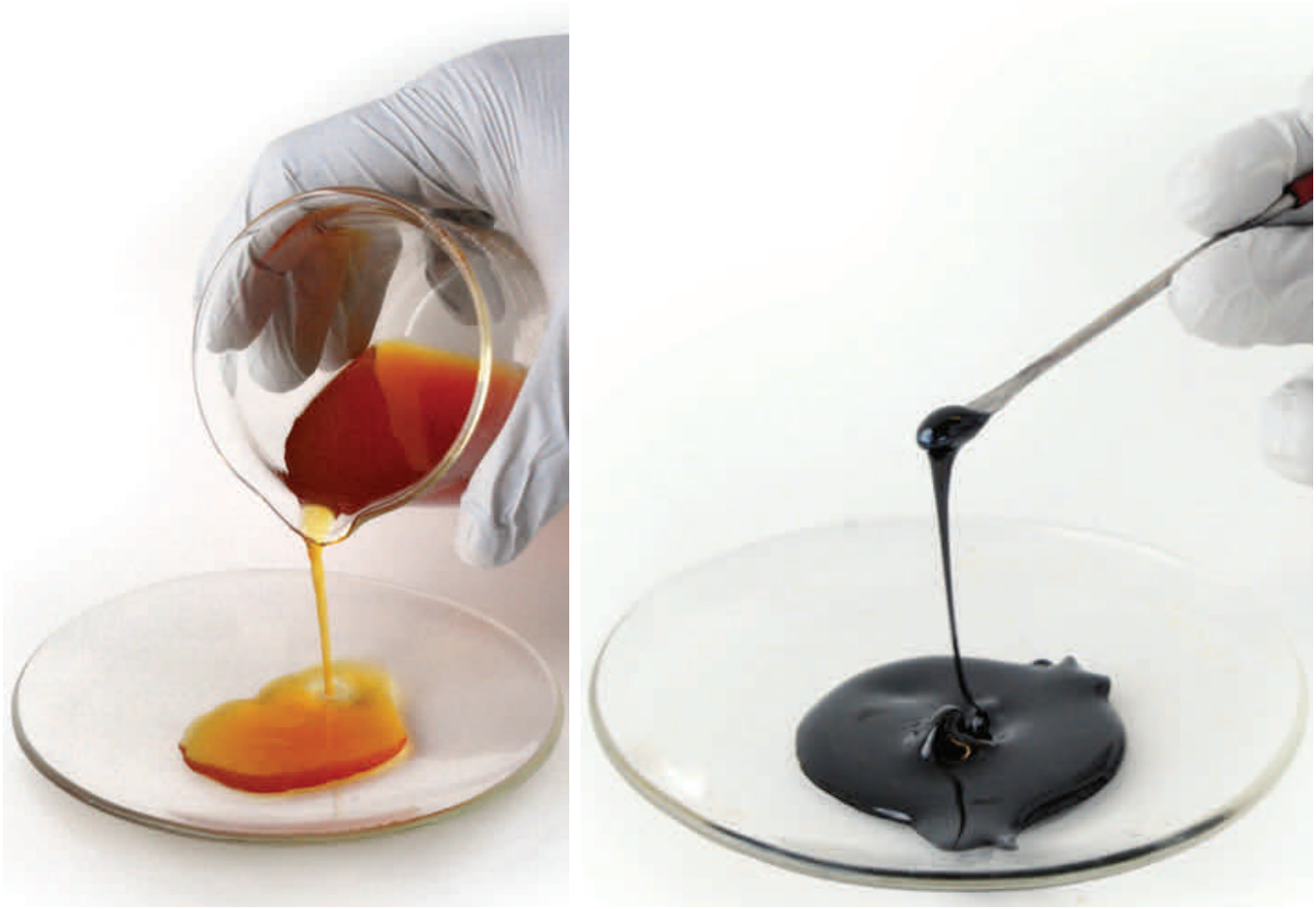

Figure 2: *Left:* Pyrolytic sugar water-extracted from the heavy ends of bio-oil from ISU's fractionating recovery system. *Right:* Phenolics recovered as raffinate from water washing the heavy ends of bio-oil from ISU's fractionating recovery system.

carbonyl bonds to alcohols and saturating carbon-carbon double bonds to aliphatics. Mass yields of LTLP hydrogenated bio-oil are in the range of 85 to 99.8%. The viscosity of the heavy-end phenolics is reduced by as much as 47-99%. Accelerated aging studies show dramatically improved stability as well. Moreover, hydrogen/carbon and oxygen/carbon ratios are within the Pyrolysis Liquid Biofuel Fuel Oil Standard Specifications (ASTM D7544-12). Whole bio-oil can be also be hydrogenated utilising the same LTLP approach.

An article discussing the award of a patent to this technology can be found at https://www.biorenew.iastate.edu/2014/01/08/fractionationpatent/.

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IOWA STATE UNIVERSITY

Optimising coprocessing of bio-oil in refinery unit operations using a Davison Circulating Riser (DCR)

Figure 1: The Davison Circulating Riser (DCR) pilot plant at W.R. Grace.

Alan Zacher of Pacific Northwest National Laboratory in the USA discusses collaborative work on integrating fast pyrolysis bio-oil into the conventional refinery set up

W.R. Grace and Pacific Northwest National Laboratory (PNNL) are co-leading an industry/academic collaboration to evaluate methods for the integration of fast pyrolysis bio-oil derived from biomass into a conventional refinery.

This collaboration includes both industry and academia across two continents, bringing together petroleum industry representatives such as Tesoro and W.R. Grace as well as prominent research organisations including Aston University, VTT Technical Research Centre of Finland, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and PNNL.

The objective of the project is to understand the technical challenges present when coprocessing pyrolysis oils with vacuum gas oil in a fluid catalytic cracking unit to produce transportation fuels.

The role of W.R. Grace is in providing expertise and operation of the Davison Circulating Riser Reactor (DCR), while Tesoro is contributing via refinery perspective and supply of various VGO, VTT is providing pyrolysis expertise and supplying bio-oil, PNNL and Aston University are providing expertise in hydrotreating and stabilisation, ORNL is contributing corrosion analysis and materials of construction evaluation, and LANL is bringing expertise in tracking biogenic carbon and methods development for demonstrating the renewable content of the liquid transportation fuels produced during co-processing, ensuring that the biogenic carbon has a positive impact on the final product and is not just ending up as additional coke.

For the first phase of the project, pine based pyrolysis oil was used with a dry basis oxygen content of ~38wt%. Various combinations of hydrotreating catalysts in a continuous catalytic hydrotreater were used to stabilise the pyrolysis oil and produce an equilibrium feedstock at targeted levels of residual oxygen content and composition. Mild catalytic

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Optimising co-processing of bio-oil *...continued*

hydrotreating resulted in an oxygen content of ~22wt%, medium hydrotreating resulted in an oxygen content of ~11wt%, and severe hydrotreating resulted in an oxygen content of ~2wt%.

The processing characteristics of the raw and each of the stabilised pyrolysis oils were evaluated by testing them in a continuous pilot scale circulating riser pilot plant. A typical vacuum gas oil (VGO) was used as the co-feed. When baseline runs were done with raw pyrolysis oil, it proved very difficult to coprocess. Significant feed system modifications were necessary to prevent nozzle and reactor plugging. The maximum percentage of pyrolysis oil that could be coprocessed was ~5wt% and the maximum VGO feed preheat temperature was ~93°C. Typical FCC (fluid catalytic cracking) feed preheat temperatures were between 150°C and 370°C. Use of surfactants was attempted, but was not successful. Based on these results, it was clear that hydrotreating was necessary to improve the processing characteristics of pyrolysis oil.

The mildly hydrotreated pyrolysis oil proved more difficult to run than raw pyrolysis oil. Concentrations of only 3wt% could be run and feed preheat temperatures were limited to below 93°C. The medium and severely hydrotreated pyrolysis oils proved much easier to run. VGO feed preheat temperatures of up to 370°C could be used and coprocessing was possible at concentrations of 10wt%. Levels greater than 10wt% could be run, but were not tested in detail since refineries are unlikely to coprocess more than 10wt% pyrolysis oil due to feedstock limitations. The raw pyrolysis oil and mildly hydrotreated pyrolysis oil resulted in increased coke yield and decreased gasoline yield compared to 100% vacuum gas oil. The medium and severely hydrotreated pyrolysis oils had yield structures similar to the conventional vacuum gas oil they were co-processed with.

Ongoing work on this project includes: evaluation of hydrotreated crop residue bio-oils, completing analysis of corrosion coupons of different alloys exposed to the operating conditions during coprocessing, and development of carbon isotope accounting methods to positively demonstrate and verify the distribution of biogenic carbon in the resulting liquid transportation fuel products from coprocessing. The project is scheduled to be completed in 2015 and is a result of a competitively awarded solicitation from the Bioenergy Technology Office, part of the Office of Energy Efficiency and Renewable Energy in the U.S. Department of Energy. FOA-DE-0000686.

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Table 1: Summary of DCR/FCC coprocessing experience as a function of bio-oil stabilisation.

Stabilisation	Max preheat temp. w/o nozzle plug	% pyrolysis oil co-processing	Co-processing observations
None ~38wt% O	~200°F	Up to 5wt% w/ difficulty	Increased coke, reduced gasoline
Mild ~22wt% O	~200°F	Up to 3wt% w/ difficulty	Increased coke, reduced gasoline
Medium ~11wt% O	Up to 700°F	10wt%	Yields similar to VGO
Severe ~2wt% O	Up to 700°F	10wt%	Yields similar to VGO

Ensyn providing RFO heating oil to New Hampshire hospitals

Ensyn Corp and Ensyn Fuels celebrate their work in providing RFO based heating to two hospitals in New Hampshire, USA

A recent ribbon-cutting ceremony at Memorial Hospital in North Conway, New Hampshire, celebrated the commissioning of Memorial's heating system conversion from traditional petroleum fuels to Ensyn's renewable liquid fuel known as RFO™ heating oil.

Ensyn is supplying Memorial under a five-year, renewable contract that provides for the delivery of 300,000 gallons per year of Ensyn's RFO cellulosic biofuel. This contract allows Memorial to fully displace its petroleum heating fuels with Ensyn's renewable fuel, reducing Memorial's greenhouse gases from heating fuels by approximately 85%. In addition, adoption of Ensyn's RFO provides Memorial with substantial cost savings. Memorial's boiler has been operating successfully on 100% RFO since September 2014.

Following close on to the Memorial announcement was the subsequent announcement that Ensyn Fuels, a wholly owned subsidiary of Ensyn Corporation, has signed a contract with Valley Regional Hospital in Claremont, New Hampshire, for the supply of

Ribbon cutting ceremony at Memorial Hospital, North Conway, New Hampshire.

Ensyn providing RFO heating oil *...continued*

RFO. Ensyn Fuels will provide the hospital with approximately 250,000 gallons/year of RFO for a renewable term of seven years, commencing deliveries by April 2015. This contract will allow Valley Regional to convert its entire heating requirements from petroleum fuels to Ensyn's renewable fuel, lowering the hospital's greenhouse gases from heating fuels by approximately 85% and reducing the hospital's operating cost.

Memorial is using its existing boiler for RFO combustion operations. In addition, Ensyn installed on-site tankage and an RFO delivery system, including an innovative new burner that provides Memorial with the flexibility to switch back and forth, at will, between petroleum fuels and RFO. The burner was supplied and installed by Cleaver-Brooks.

Ensyn is producing RFO at its three million gallons per year facility in Ontario, Canada. In the future, the production for these New Hampshire hospitals may be replaced by Ensyn projects currently in development closer to the hospitals. Ensyn's Ontario facility has recently been qualified by the US EPA under the US renewable fuel standards (RFS) programme. Ensyn expects that renewable identification numbers (RINs) generated at Memorial under the RFS2 program will enhance contract economics. The RFO is produced from non-food solid biomass including forest and mill residues.

This article was sourced from Ensyn press releases, dated September 30 and October 8, 2014.

http://www.ensyn.com/2014/10/08/ensyn-and-valley-regional-hospital-new-hampshire-sign-rfo-biofuel-supply-agreement/

http://www.ensyn.com/2014/09/30/ensyn-memorial-hospital-commission-rfotm-heating-operations/

Progress at Ensyn

Bob Graham of Ensyn in the USA reflects on the company's successes and looks to the future

Ensyn reached a number of important milestones in 2014 and we have an ambitious development plan ahead of us for 2015 and 2016. In 2014 we celebrated the 30th anniversary of the incorporation of the first Ensyn company, as well as the 25th anniversary of continual commercial operations. In addition, these anniversaries have coincided with our company progressing through an important inflexion point in 2014, providing a platform for significant growth in production and sales in the years to come.

Ensyn's core technology, rapid thermal processing or RTP®, is a fast thermal process that converts solid biomass (principally wood residues) into high yields of a liquid fuel known as RFO™. Our process does not require catalysts, hydrogen or significant pressure. These are characteristics that lead to low capital and operating costs and small minimum economic scale.

Production to date using our RTP technology exceeds 37 million gallons, generated primarily in facilities in Wisconsin for the production of natural chemicals, with co-product liquids used for heating fuels.

Ensyn is now in the process of building out significant additional production capacity dedicated to the production of fuels. The first step in this process was to enhance the production capacity, automation and efficiency of our own RTP facility in Renfrew,

Progress at Ensyn
...continued

Figure 1: Ensyn has recently enhanced its Ontario facility, converting it to a dedicated fuel facility with a capacity of three million gallons/year.

Ontario. This work was completed in October 2014. Our Ontario facility can now produce approximately three million gallons per year of RFO. Larger plants are being developed to meet increasing demand, including a 20 million gallon per year facility in Aracruz, Brazil (with our partner Fibria Celulose, S.A.) and additional projects in Quebec and the US. Our business model for these projects is to build-own-operate together with strategic partners, including fibre owners. The RTP units for these projects are being supplied to the projects, with performance guarantees, by Envergent Technologies, a joint venture between Ensyn and UOP, a Honeywell company.

Figure 2: Ensyn's Ontario facility, with a production capacity of three million gallons/year of RFO cellulosic biofuel.

Ensyn's RFO, essentially "liquid wood," has two principal fuel applications. It is a heating fuel that directly displaces petroleum heating fuels, including #6, #4 and

Progress at Ensyn
...continued

Figure 3: Ensyn and Fibria Celulose are developing a 20 million gallon/year RFO production facility at Aracruz, Fibria's 2.5 million ton/year pulp plant in Espirito Santo, Brazil.

#2 fuel oil, and is also a renewable feedstock for conventional refineries for the production of gasoline and diesel in an application known as refinery coprocessing ("coprocessing").

Heating Oil

Ensyn's RTP liquids have a long history of industrial use. We are now building on that experience by securing heating oil contracts from a broader range of industrial and institutional clients in the northeast US and in eastern Canada. These contracts are initially being serviced via existing production capacity in Ontario. In 2014 we signed a contract with Memorial Hospital in North Conway, New Hampshire, and since early September 2014 Memorial has been running its heating operations on 100% Ensyn RFO. A similar contract has been signed with Valley Regional Hospital in Claremont, New Hampshire and negotiations with additional targeted clients are in progress.

Refinery coprocessing

Coprocessing represents a game-changing approach to the production of gasoline and diesel from solid biomass. This application is in the final stages of commercialisation.

Coprocessing involves the feeding of RFO directly into the Fluid Catalytic Cracker unit ("FCC") at conventional refineries, alongside conventional FCC feedstocks (e.g., vacuum gasoil), in proportions of up to approximately 5%. The net result is the production of spec gasoline and diesel.

Ensyn has been developing coprocessing for a number of years and is now commercialising the application in conjunction with UOP, a global leader in FCC technology. Multiple trials have been carried out by independent entities in Canada, the US, Europe and South America, including UOP, Government agencies, independent laboratories and major oil companies. These demonstrations have taken place in facilities ranging from small-scale FCC test equipment to large pilot and demonstration facilities, as well as in commercial FCCs. The result of this work has been

Progress at Ensyn
...continued

Figure 4: Fibria is the world's leading producer of eucalyptus pulp, operating a total forest base covering 969 thousand hectares, of which 343 thousand hectares are native forests that have been set aside for environmental conservation.

tremendously positive, including surprisingly strong overall yields of gasoline and especially diesel, and an attractive overall balance of products. The result has been the generation of a significant body of intellectual property. Indications are that the value of our RFO in a coprocessing application, based on standard linear programing methodologies, is comparable on a volumetric basis to the value of the petroleum that it displaces.

In early 2015 we will be carrying out extended commercial demonstrations of coprocessing in one or more commercial refineries, to be followed by contracts for commercial supply. Initial commercial deliveries are expected to be met from our existing production capacity, followed by production from capacity we will be bringing on stream through new-build projects in Canada, Brazil and the US.

Coprocessing represents a straightforward and simple solution for refineries seeking to integrate cellulosic biofuels into their product mix. It allows cellulosic biofuel targets to be met using existing refinery and downstream infrastructure, avoiding the need to build expensive dedicated upgrading infrastructure and downstream blending and distribution.

The use of Ensyn's RFO for heating or coprocessing is eligible under the EPA's RFS2 program for the generation of D3 and/or D7 cellulosic renewable identification numbers (RINs). In coprocessing, D3 and D7 RINs are generated by the refiner at the refinery as opposed to at blending stations downstream of the refinery, providing advantageous control. In heating applications, Ensyn's RFO sales generate D7 cellulosic RINs. We believe Ensyn is currently the leading generator of D7 RINs.

Ensyn's history has been driven by alliances with leading industrial partners with progressive vision, and this is our plan for the future. Our current strategic relationships include those with UOP, Fibria Celulose, Chevron Technology Ventures, Petrobras/NREL and Credit Suisse. We look forward to working with these valued partners and adding others as we work to make Ensyn the world's leading producer of cellulosic liquid fuels.

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Valmet delivers biomass based fast pyrolysis bio-oil heating plant

Matti Kytö of Valmet Power in Finland discusses its new bio-oil based district heating plant

Valmet has delivered a complete, commercially usable district heating plant unit for using biomass based fast pyrolysis bio-oil. Valmet also successfully combusted the bio-oil in an industrial fast pyrolysis bio-oil boiler of its own design. The bio-oil was produced at Fortum's combined heat and power (CHP) and bio-oil production plant in Joensuu, Finland. The rate of combustion was up to 2420kg/h. Over 10MW of heat was produced and fed to the local district heat network. This is unofficially the national Finnish record of fast pyrolysis bio-oil combustion from one single unit and over long periods of time. The burner and boiler were both designed and developed by Valmet (Figure 1).

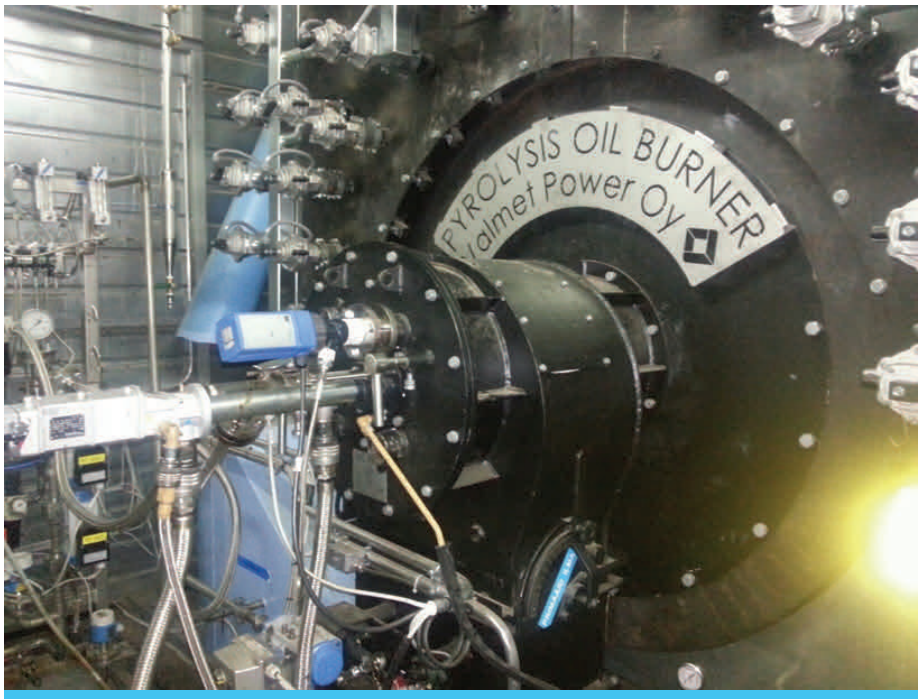

Figure 1. Valmet's PyroHOB pyrolysis oil burner in Valmet container package heating boiler.

The combustion equipment, including valve stations and automation system, performed well. The shape of the flame was stable, tight and uniform and fitted perfectly into the furnace. Only bio-oil was combusted with no support fuel. Residual oxygen at full power was as low as 1.5% and clean combustion was still achieved. CO was a maximum of 8ppm and NO_x emissions were far below guaranteed values while at the same time much lower than with a typical heavy fuel oil (HFO) boiler. A combustion rate of 500kg/h was easy to reach, providing turn down of about 1:5 with no difficulties. The boiler remained clean and no impurities were deposited on the heat transfer surfaces after a long run period. Old fossil fuel oil boilers could be retrofitted for using this fuel with relatively small modifications, although every case must be evaluated individually in order to realise a cost effective method of conversion.

The Valmet delivery scope included the boiler and systems in a container (with all accessories), ready to use remotely in unmanned mode via the central control room of the major plant. The unit was run successfully with the help of Fortum specialists, bearing in mind the natural challenge of the specific CO_2-neutral biofuel and its totally different behaviour compared to fossil fuel oils. VTT's strong support to these industrial parties was behind the concept and fuel quality development.

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TCS 2014

Doug Elliott of Pacific Northwest National Laboratory in the USA reviews TCS2014

The TCS2014 Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products was recently held in Denver, Colorado, USA (September 2-5, 2014). There were 238 attendees representing universities (45%), research institutes (34%), and industrial entities (21%). Of the attendees there were 46 from outside the US. The symposium consisted of 60 oral presentations in 15 sessions. The sessions were divided among gasification (5), pyrolysis (4), catalytic pyrolysis (2), catalytic upgrading (3), and hydrothermal processing (1). The split among the presentations was 40% universities, 50% institutes, and 10% industrial.

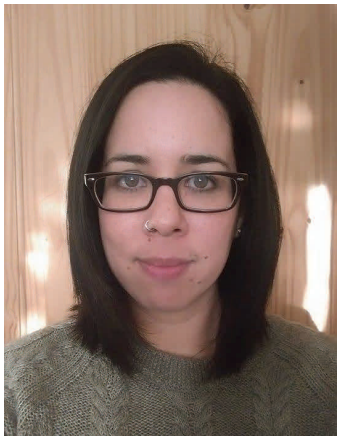
There was a student poster competition sponsored by Frontier Labs. The Young Scientist Awards given to the best student posters, as determined by the panel of judges, were:

- 1st Place: Martin Haverly, Iowa State University;
- 2nd Place: Matthew Smith, Washington State University;
- 3rd Place: Paige Case, University of Maine.

Of the 42 student posters, 11 were from non-US institutions. There were also 42 non-student posters presented by universities (43%), institutes (50%), and industry (7%).

More details of the symposium can be found on the website. www.tcs2014.org

IEA Bioenergy Task 34 Meeting, Finland



Katie Chong of the European Bioenergy Research Institute at Aston University, UK, takes us through the events of the latest IEA Bioenergy Task 34 Meeting

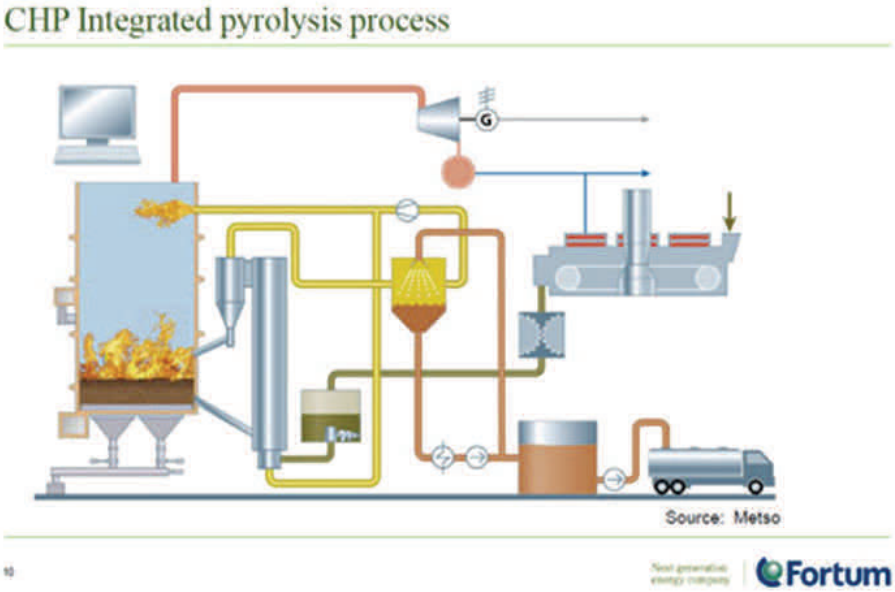


Figure 1: Block diagram of the process at Fortum.

Figure 2: Meeting delegates having a tour of the Fortum plant.

I was invited to the IEA Bioenergy Task 34 meeting in Finland in order to learn about fast pyrolysis from experts in their field. As part of this meeting a day was spent in Joensuu visiting various facilities and hearing from relevant researchers and companies.

The first stop of the day was the Fortum plant. At Fortum a bio-oil plant has been integrated into the facility's combined heat and power (CHP) plant in order to boost the site's heat and power capabilities as well as to produce bio-oil as a product. This product has been given the trade name of Fortum Otso® and will be sold as an alternative boiler fuel. The bio-oil plant, installed by Valmet, includes feedstock reception, feedstock preparation in the form of drying and milling, a fluidised bed fast pyrolysis reactor and storage silos. The bio-oil may then be pumped to an allocated bio-oil boiler to provide additional heat, or the oil may be sold. The bio-oil boiler has the potential to supply an additional 15MW boost for district heating, which will be used when the weather is particularly cold. The plant will produce around 50,000 tonnes of bio-oil per year from forestry residues.

The next stop was the Joensuu Science Park which aims to bring together companies and institutions involved in the forest bio-economy. The University of Eastern Finland, based at the Science Park, presented to the meeting attendees about its work on spectrometry and photonics. There were some interesting discussions amongst the group about how these specialist techniques could be applied to bio-

(Continued on page 21)

IEA Bioenergy Task 34 Meeting
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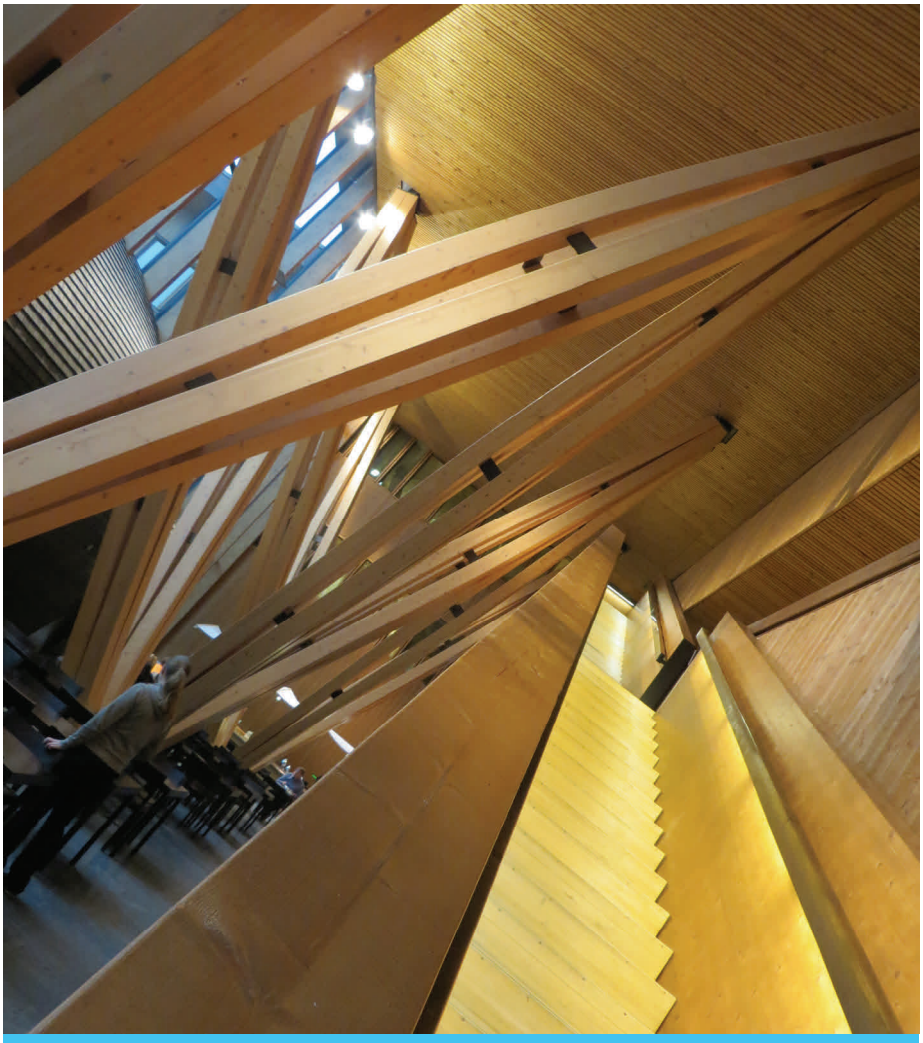

Figure 3: The Finnish Forest Research Institute (Metla building).

Figure 4: Meeting room at the Metla building.

oil, for instance in the measurement of bio-oil quality. A short laboratory tour followed in which attendees got to experience first-hand how the human eye and colour theory work.

The final stop of the day was at the Finnish Forest Research Institute (Metla). This stunning building is built almost entirely of wood, including the imposing structural beams and the “upside down boat” conference facilities. The meeting room itself was also impressive with its own fireplace and sauna (not used during the Task meeting!). Some fascinating presentations from Metla and the University of Eastern Finland were enjoyed by the attendees on topics such as the availability and value chains of biomass feedstock, as well as research and education for future engineers/scientists. One of the most interesting comments was that as we increase the use of our forests, this increases the forest productivity; and due to the increased interest and use of forestry resources, the growing stock has been increasing in many countries in the EU.

A most interesting and informative day was enjoyed by all the Task 34 meeting attendees with thanks to Anja Oasmaa (VTT) for making such excellent arrangements.

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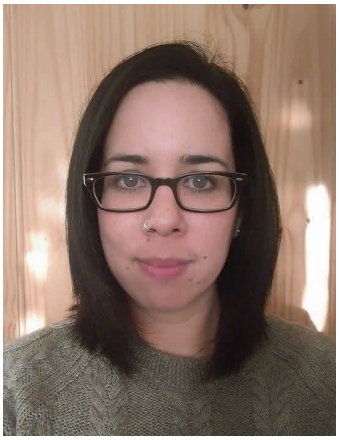
EBRI European Bioenergy Research Institute — Aston University Birmingham

Specialists' Workshop on Fast Pyrolysis of Biomass



Katie Chong and Scott Banks of the European Bioenergy Research Institute, Aston University, UK, review the recent Specialists' Workshop on Fast Pyrolysis of Biomass in Ghent, Belgium

Figure 1: Delegates gathered during one of the keynote presentations.

Figure 2: Breakout group B discussing issues raised in the preceding talk.

The Specialists' Workshop on Fast Pyrolysis of Biomass, organised by Wolter Prins and Tony Bridgwater, took place on 8th and 9th December 2014 in Ghent, Belgium. The aim of the workshop was to bring together a relatively small group of those active in the field of fast pyrolysis to discuss the current situation in science, technology, and project implementation, and to elucidate the opportunities and limitations of biomass fast pyrolysis to identify the best ways to progress in research and development in the future. The workshop was held at the Europahotel in Ghent, and was attended by 49 delegates from 17 countries selected from a large number of applicants for their knowledge, experience, and ability to contribute to the workshop.

The workshop was structured into four sessions, each beginning with a keynote presentation on one of the most important issues facing biomass pyrolysis development and followed by delegates breaking out into four separate groups with their own chair and secretary in order to discuss points raised in the presentations. Delegates then came together as one group to

(Continued on page 23)

Specialists' Workshop
...continued

Figure 3: Delegates gathered outside the conference venue.

present the most important conclusions reached during their breakout discussions.

Keynote topics presented and discussed were "Feedstocks, characteristics, preparation and pretreatment" (Tom Miles), "Reaction and process engineering of fast pyrolysis reactors and liquid collection" (Sascha Kersten), "Product analysis and characterisation; and norms and standards" (Dietrich Meier), and "Process integration, project development, implementation and commercialisation" (Ralph Overend).

After the first two sessions, commencing on Monday 8th, participants boarded a boat for a tour of the historic town of Ghent, concluding with a dinner. This was followed by a further full day of discussions on the 9th, with the workshop closed by Tony Bridgwater, with thanks given to the speakers and secretaries in particular.

Due to the intense nature of the workshop and the concentration of expertise available, the time proved valuable and thought provoking. A publication based on the outcomes of the workshop will be made available.

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International Events

January 2015

19th-20th
Fuels of the Future 2015
Berlin, Germany

February 2015

12th
Cleantech Innovate
London, UK

24th
Next Steps for the UK Renewable Energy Sector
London, UK

25th-27th
The Energy and Materials Research Conference—EMR2015
Madrid, Spain

March 2015

10th-14th
21st International Symposium on Alcohol Fuels (ISAF)
Gwangju, Korea

18th-19th
Green Polymer Chemistry 2015
Cologne, Germany

25th-26th
Gasification 2015
Prague, Czech Republic

April 2015

7th-10th
10th European Conference on Industrial Furnaces and Boilers (INFUB-10)
Gaia, Portugal

13th-15th
8th International Conference on Bio-based Materials
Cologne, Germany

May 2015

3rd-7th
ISGC 2015 International Symposium on Green Chemistry
La Rochelle, France

4th-6th
6th AEBIOM Bioenergy Conference 2015
Brussels, Belgium

7th-8th
2nd International Conference on Renewable Energy Gas Technology (REGATEC 2015)
Barcelona, Spain

19th
INFRES
Rome, Italy

19th-20th
COGEN Europe
Brussels, Belgium

June 2015

1st-4th
23rd European Biomass Conference and Exhibition (EUBCE 2015)
Vienna, Austria

15th-19th
BiobasedWorld at ACHEMA 2015
Frankfurt am Main, Germany

August 2015

26th-28th
Biofuels-2015
Valencia, Spain

September 2015

26th September-1st October
ECCE10
Nice, France

27th September-2nd October
Biorefinery I: Chemicals and Materials from Thermo-Chemical Biomass Conversion and Related Processes
Chania, Greece

November 2015

2nd-5th
tcbiomass2015
Chicago, USA

International events

IEA Bioenergy Conference 2015 – Registration now open

International Bioenergy Conference taking place from 26 to 29 of October 2015 in Berlin – Realising the world's sustainable bioenergy potential

Under the auspices of the German Federal Minister of Food and Agriculture, Christian Schmidt, the bioenergy conference of the International Energy Agency (IEA) will take place from 26 to 29 of October 2015 in Berlin. The conference offers information on the latest developments in the bioenergy sector to experts from industry, academia and policy making. Under the slogan "Realising the World's Sustainable Bioenergy Potential" you can expect over 40 lectures and four field trips covering ten thematic fields.

Registration is open as of now until 29 September 2015 through the conference website ieabioenergy2015.org. We would like to show your outstanding achievements and results in the bioenergy sector through visual presentations - please apply with your poster by 30 April 2015 on the website.

Every three years, the experts of the Implementing Agreement Bioenergy of the International Energy Agency (IEA) organise the "IEA Bioenergy Conference". From 26 to 29 of October 2015, renowned international experts report on the status quo as well as progress made in the bioenergy sector. The industrial developments and applications are at the centre of the event's programme.

More than 40 speakers will talk about challenges within the bioenergy value chains, from biomass production and conversion to energy carriers to different end uses. Furthermore cross-cutting topics like trade, socio-economic issues and sustainability will be discussed. Policy makers will benefit from the latest recommendations on state-of the-art bioenergy technologies and applications. The German Agency for Renewable Resources (FNR) as organiser of the conference, will give special attention to the coverage of innovative German bioenergy technologies.

Moreover, the event offers an attractive framework programme for the participants and experts from around the world. Additional programme details can be found at: ieabioenergy2015.org.

The conference takes place in the heart of Berlin. The participation fee is 350 € (250 € reduced fee) and includes the evening events. Field trips are an additional 50 €. The deadline for registration is 29 September 2015. The conference language is English.

Press contact:

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International events

EVENT SCOPE

Improved logistics will help create a market for biomass feedstocks such as agricultural residues, forestry residues, and energy crops. In the three EU-funded projects INFRES, LogistEC and EuroPrunning (combined value €15 million; EU contribution €10 million) 63 organisations and companies, including many SMEs, collaborate to develop such smart logistics. They field-demonstrate practical solutions implemented in rural communities to harvest, store and transport lignocellulosic biomass for the production of bioenergy and biomaterials.

Further to developing technologies and adapting machines, the three projects also assess the environmental, economic and social sustainability of the proposed supply chains, as well as the barriers to innovation in the respective sectors. The one day conference will showcase key results from the three projects.

Participation in the conference is free of charge and open to all.

19th May 2015

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You can send an email that you are interested in the conference to workshop@infres.eu. More information is available at www.infres.eu.

BiobasedWorld at ACHEMA 2015

15th-19th June 2015

Learn about products, technologies, new ideas and strategies for the bio-based economy!
Visit the focal point of the bio-based economy and experience first-hand the vibrant industrial biotechnology community. Learn the latest on products, technologies and strategies in the fields of biomass, bio-based chemicals, biofuels, biogas and biorefineries.
BiobasedWorld at ACHEMA is the launch-pad for industrial biotechnology investments and new ventures.

ACHEMA 2012 in review

- 3,800 exhibitors from 50 countries
- 170,000 visitors from 100 countries
- 27,000 congress participants

Features of
BiobasedWorld at ACHEMA 2015

- Exhibition
- Partnering
- Congress

Join **ACHEMA's BiobasedWorld** to learn how to:

- Derive benefits from new bioprocessing technologies
- Source feedstocks and starting materials
- Make bio-based products profitable

Contact **Website**

International events

ECI

Celebrating 52 years of international, interdisciplinary engineering conferences

Biorefinery I: Chemicals and Materials From Thermochemical Biomass Conversion and Related Processes

A New ECI Conference Series

September 27-October 2, 2015 • Atlantica Caldera Crete Paradise Hotel • Chania (Crete), Greece

About This Conference

Biorefinery I will provide an international forum for presentation of commercial and emerging technologies and scientific advancements in the area of chemicals and materials production from renewable resources. The speakers and attendees will come from academia, industry or other research organizations (e.g., institutional and government).
The conference will profit from the exceptionally high profile and international network of the chairs and members of the international and local organizing committee. Moreover, the proximity of the Department of Environmental Engineering of the Technical University of Crete will provide an excellent environment and support with the involvement of several key Greek and, more generally, European actors of the Biorefinery field.

To register interest, click here. To visit the event website, go to www.engconf.org.

tcbiomass2015
The International Conference on Thermochemical Conversion Science

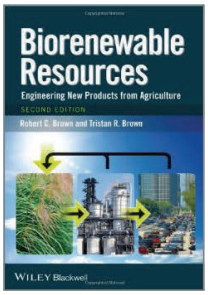
Save the Date
November 2-5, 2015
Westin River North
Chicago, IL USA

The Gas Technology Institute (GTI) is pleased to announce tcbiomass2015, the International Conference on Thermochemical Biomass Conversion Science, to be held 2-5 November 2015 in downtown Chicago, IL USA.

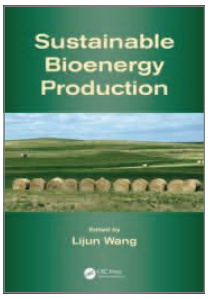
Mark your calendars and plan to connect with many of the world's leading researchers, scientists, and engineers. The scientific forum will focus on putting research into action as emerging integrated biorefineries are being built across the globe. Be at the centre of dramatic change to discuss, learn, and assess the progress and promise of this exciting area of bioenergy.

Contact to receive more information on tcbiomass2015 as it becomes available

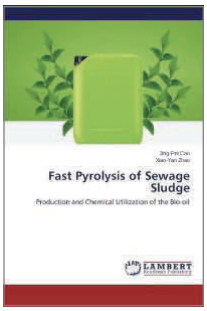
Publications



Biorenewable Resources: Engineering New Products from Agriculture
Published by Wiley-Blackwell
Publication date: (2nd Edition) 21 Feb 2014
Authors: Robert C Brown, Tristan R Brown



Sustainable Bioenergy Production
Published by CRC Press
Publication date: 15 April 2014
Editor: Lijun Wang



Fast Pyrolysis of Sewage Sludge
Published by Lambert Academic Publishing (LAP)
Publication date: 15 July 2014
Authors: Cao Jing-Pei, Zhao Xiao Yan

Fuel Processing Technology - Volume 128
Published by Elsevier
Publication date: December 2014

Within this journal is the following paper:
Fast pyrolysis processing of surfactant washed *Miscanthus*
Authors: SW Banks, DJ Nowakowksi, AV Bridgwater

IEA Bioenergy News - Volume 26(2)
The newsletter of the International Energy Agency (IEA)
Publication date: December 2014

BRISK Newsletter - Issue 6
Published by Aston University
Publication date: December 2014

PyNe 34

PyNe 35

Further Information

If you require further information about the PyNe newsletter, or you would like to contribute to future editions, please contact the Editor:

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Past editions of PyNe newsletters are available on the website.

www.pyne.co.uk

IEA Bioenergy

Task 34 - Pyrolysis