Industrial scale demonstration biorefinery on lignin-based aviation fuel

Welcome to the third BIOREFLY newsletter issue.

BIOREFLY is co-funded by the European Commission under the 7th Framework Programme (Project No. FP7-612747).

The duration of the project is from January 2015 until December 2018.

In this issue we would like to present you the development of the project, during the last months. Please do not forget to visit our website www.biorefly.eu.

About BIOREFLY

Aviation is one of the fastest growing transport sectors and this trend will continue in the coming years. According to the International Air Transport Association (IATA), global aviation is expected to grow by 5% annually in the period up to 2030. Currently, petroleum derived liquid fuels are the main energy carrier in the aviation sector. Due to different environmental and economic concerns, there is a need for the sustainable supply of aviation fuels.

Bioenergy will play a key role in the EU's long-term energy strategy for all applications, especially in the transport sector. The supply of feedstock and the biofuel conversion technologies which are currently deployed already provide a significant contribution, but diversification of feedstock and advanced technologies will be necessary for further development.

The aviation industry considers aviation biofuels to be one of the primary means to reduce the carbon footprint of the industry. In this context, the BIOREFLY project will develop and build the first industrial scale demonstrative lignin-to-jet fuel facility in Italy.

The combined production of a high annual volume of cellulosic ethanol and lignin-based jet fuel through sustainable and innovative technologies will be the first step towards biofuel commercialisation and market deployment.

The overall goal of the BIOREFLY project is to develop technologies allowing an increased and more economical utilization of selected renewable lignocellulosic raw materials for the production of second-generation biofuel for aviation. The sustainable supply chain will be demonstrated, environmental and socio-economic impacts will be assessed and results gathered from tests in engines and demonstration flights will be disseminated to relevant stakeholders.

For further information please contact the project coordinator or visit our website www.biorefly.eu

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BIOREFLY and BIOJETMAP

BioJetMap.eu is a Biokerosene flight database initiated since 2012. The initial idea behind of this platform was to keep track of the evolution on aviation biofuels, providing relevant information of current and former projects. It presents alliances, airlines, articles, and a worldwide interactive map that presents the interconnections between projects and companies involved in the biokerosene development.
BIOREFLY is part of this database. The search criterion is easy to use, and while searching, a ban with further information slides down to filter the project information. The users will obtain all the necessary information; from the name and contacts of the coordination, till a general overview of the project, considering the work of each WP.

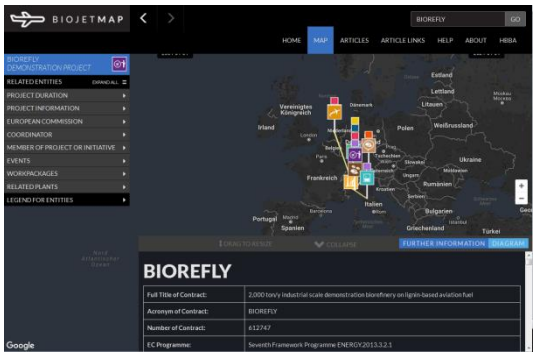

Figure 1: BIOREFLY in the database

The idea of keeping track on the evolution of biofuels for aviation it's consider as a positive development to be able to interact with different stakeholders, support similar projects with each other, and provide the necessary information to the public.

Scale-up of the technology

The research activity is still on-going at the lab and the pilot scale in order to establish and optimize the working parameters for engineering scale-up. The basic engineering study is almost completed for the first step of the BIOREFLY project. Anyway further research activity has already been scheduled because the optimization of the process remains open to new possible improvements.
The experimental plans carried out on the pilot plant in the last months have been useful to provide the data necessary to develop the mathematical model of the process.
Alternative research and development solutions are still under evaluation in order to produce jet fuel from 2G lignin through other thermochemical processes different from dehydrogenation. Several future activities have been scheduled then on 2G lignin in order to customise its characteristics and let it suitable for different applications and different chemical processes.

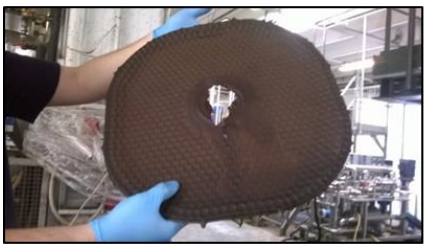

Figure 2: Different shape of 2G lignin.

Modelling of hydrodeoxygenation of phenolic oil

The model intendeds to provide a quantitative estimation of the oil composition changes during the function process of process-variables (temperature, time, etc.).

The challenges of the mathematical modelling are:

- Phenolic oil is a complex mixture which contains a lot of different compounds;
- From both experimental and modelling points of view, it is challenging to characterise the changes in concentrations of all species
- Few literature data available

The model aims to describe the changes in compositions of the entire phenolic oil (light and heavy fractions). The modelling approach proposed by ETH intends to use the main functional groups to monitor the changes in compositions. A lumped effective kinetic scheme is then proposed assuming an instantaneous adsorption of the species on catalyst, which is rather reasonable at steady state; the effect of adsorption is not treated explicitly but lumped in the kinetic constants; hydrogen is in excess and is not explicitly included in the kinetic rate; the kinetic constants of all reactions are to be verified during the fitting of experimental data; kinetic constants are express according to Arrhenius formulism.

At the light of these considerations, 12 parameters must be estimated:

6 pre-exponential factors: k_1^0, k_2^0, k_3^0, k_4^0, k_5^0, k_6^0

6 activation energies: $E_{att,1}$, $E_{att,2}$, $E_{att,3}$, $E_{att,4}$, $E_{att,5}$, $E_{att,6}$

The experimental activity concerning HDO process has been carrying out by BioChemtex, and the analytical results have been used for parameters estimation. A first part of the work has already been done in the last months of 2016 and gave preliminary information for the development of the model. Nonetheless, further experimental activity is needed in order to complete and well define all the model parameters. The influence of the most relevant process-variables (temperature, pressure and residence time) will be assessed.

Micro gas turbine rig for renewable jet fuel tests

BIOREFLY working plan includes a testing campaign of the lignin-based renewable jet fuel in a small scale turbine. RE-CORD selected an APU-derived military unit, a Garrett GTP 30-67 model that has a similar structure in respect to engines for aviation application. The fuel characterization in terms of turbine combustion performance, emissions and hardware post-inspection is crucial before ASTM D4054 certification pathway. The Garrett test rig is based on an overhauled centripetal micro gas turbine powering a military auxiliary power unit (APU) by AiResearch-Garrett Corporation. The model consists of a single injector, pressure swirl, reverse

flow silo combustor chamber, fixed rotational speed at approximately 53,000 rpm and AC output of 25 kVA, 0.8 pF, 400 Hz, 120/208 Volt. The test rig is composed by the engine sub-assembly, multi-fuel injection line, control panel and an AC generator, all together mounted on a mobile frame which is assembled with anodised aluminium profiles (as shown in Figure 3). Data acquisition is performed by National Instrument modules for operative data, supported by the NI c-DAQ chassis, while emissions are monitored by an on-line gas analyser.

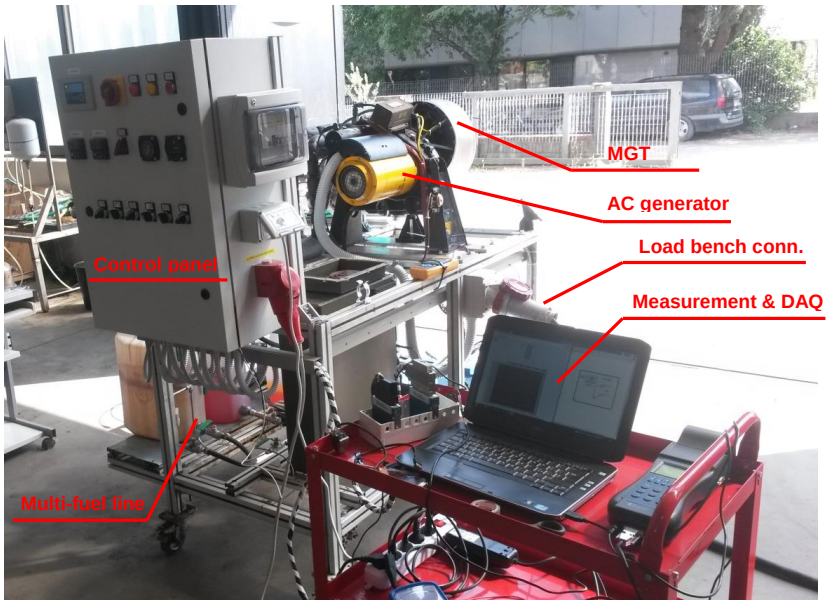

Figure 3: MGT test rig with measurement system during commissioning.

After two years of activities, a pump and nozzle test bench and micro gas turbine test rig were set up for tests by RE-CORD. The lignin-based fuel will be characterised in terms of spray and combustion behaviour, and compared to commercial Jet A-1 performance. The generated data will be crucial to determine if the fuel will be suitable to endure the certification process of the most recent standards. Currently RE-CORD experimental equipment is ready for renewable jet fuel tests.

BIOREFLY Dissemination Activities

In 2016 WIP together with the US Commercial Aviation Alternative Fuels Initiation (CAAFI) and the project CORE-JetFuel dedicated to coordinate the research and innovation of jet and other sustainable aviation fuel supported by the EU, organised a workshop in Alexandria, US, focusing on facilitating discussions among experts from the United States and Europe in the area of alternative fuels for aviation.

As part of the expertise exchange, projects like BIOREFLY were mentioned; due the project is part of the activities at EU level working on the development for supply chains for alternative aviation fuels, together with some other project like SOLAR-JET, ITAKA and BSFJ. All projects are helping together to meet the 2020 binding targets of the EU climate and energy policy, in

addition to produce the target of 2 million tonnes of biofuels blend with kerosene per year by 2020. It is uncertain that meeting these goals will be achievable, however, as Mr Denos from the European Commission, DG Energy mentioned; the way to go forward goes in hand with the importance of further activities in the RTD areas, demonstration and scaling-up entries value chains, together with the need to certified production pathways for alternative aviation fuels and that the sustainability criteria can be harmonised at international level.

The workshop presented four panel discussions within the following themes:

- Supply chain development and deployment of alternative fuels
- Promising production technologies and value chains
- Sustainability
- Stakeholder initiatives for alternative aviation fuels – progress and perspectives

The results could be highlighted in the follow ideas: (i) in order to ensure long-term programmes, the initiatives on alternative aviation fuels need to be integrated in existing mechanisms; (ii) Customers and end users of alternative aviation fuels need to be closely involved in support programmes in order to ensure market demand; (iii) stable policy frameworks are needed for the development of alternative fuels; (iv) exchange of successful information on off-take agreements is needed between producers, airlines and the public; (v) a need to assess the proper potential of regional and local feedstock opportunities and the corresponding value chain; (vi) the technology assessments need to include potential co-products and their markets; (vii) GHG emission threshold exist in the US (RFS2) and the EU (RED); (vii) pathways with better performances should be rewarded; (ix) the further development of alternative aviation fuels should focus on no/low cost feedstock, conversion technologies bases on not too complicated pathways, and complementary incentives for local and federal authorities; (x) increase the cooperation between the US and Europe in the ASTM certification of alternative aviation fuel pathways field is needed.
BIOREFLY will support the results of this workshop by considering the implementation in the extent to its possibilities.

BIOREFLY Communication and Dissemination

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