Newsletter
January 2019

4refinery

Dear 4Refinery reader

We are pleased to welcome you to our 4Refinery newsletter. 4Refinery is a project funded by the European Commission under the Horizon 2020 (GA 727531). The project started on May 1st 2017 and it will last 48 months. It involves 8 partners from 8 European countries. 4REFINERY will develop and demonstrate the production of next generation biofuels from more efficient primary liquefaction routes integrated with upgraded downstream (hydro)refining processes.

In this newsletter we would like to share some of the latest projects results with you. More background information on the 4Refinery project can be found at our website: www.sintef.no/4refinery, but also in previous newsletters :

- PyNe Newsletter 42, 2018 http://task34.ieabioenergy.com/wp-content/uploads/2018/10/PyNe-Issue-42-October-2018-Final.pdf
- BE-Sustainable Magazine 9/10/2018 http://www.besustainablemagazine.com/

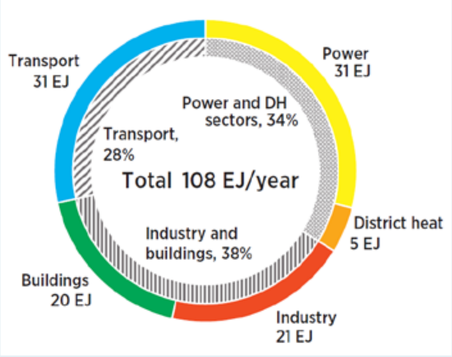
Dive into the exiting world of biocrudes & bioliquids with this 4Refinery newsletter

Scenarios for integration of bio-liquids in existing refinery processes

Biofuels can provide 28% of total transport fuel by 2050, achieving reductions of more than 2 gigatonnes of CO_2 emissions per year when produced sustainably. The increasing demand for biofuels implies the need for transformation of diverse bio-resources into liquid fuels, which poses challenges in process development to improve conversion efficiency, while decreasing the production cost.

To meet the timescale and quantity needed while keeping cost effectiveness, biomass implementation should be done through integration into existing refineries and infrastructure rather than requiring investment in new large bio-refinery units and infrastructures to support them.

The complexity of conversion of biomass compared to fossil oils (due to the presence of heteroatoms mainly as oxygen, as well as geographic diversity and availability) requires a primary conversion – liquefaction – step to allow easier and cheaper processing for transport, as well as for introducing these for upgrading in such existing refineries. The most promising options today are fast pyrolysis and hydrothermal liquefaction; both facing a common challenge for implementation at industrial scale.



Breakdown of global biomass demand by sector in REmap 2030. from the International Renewable Energy Agency (IRENA), 2014

4Refinery Objectives

- To develop new biofuels production technology while at the same time increase understanding and control of the entire value chain
- To scale up testing procedures and define scenarios for the best further implementation in existing refineries
- To develop solutions to answer key societal & environmental challenges

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New HDO unit at BTG

In order to produce large amounts of upgraded bio-liquids BTG commissioned a new high-pressure hydrogenation unit, based on a packed bed reactor concept. The setup has a total catalyst volume of 6 L volume, allowing processing 1-2 L/h pyrolysis liquids. The left figure shows a photograph of the large set-up with the intermediate collection vessel (left), the four reactors in series (middle; each 1.5 L), the gas-liquid separator and the intermediate product collection (right side).

Successful runs were carried out for periods of around 30 h, converting pyrolysis liquids into so-called 'stabilised pyrolysis oils' (SPO) at a temperature ramping from the 1^{st} to 4^{th} reactor, also demonstrating the flexibility of operation. . Main conditions applied in these runs were typical 200 bar H_2, reactors 1 to 4 set at temperatures 75, 100, 150 and 200°C, resp.. Accurate overall elemental balances were obtained with net hydrogen consumptions at these conditions ranging from an 100 up to 125 $L/kg_{Pyrolysis\ Liquid}$.

4Refinery visits AAU facilities

After their last project meeting in November 2018, the members of the 4Refinery project took the opportunity to visit the research facilities of the Energy department of Aalborg University, one of the project partners.

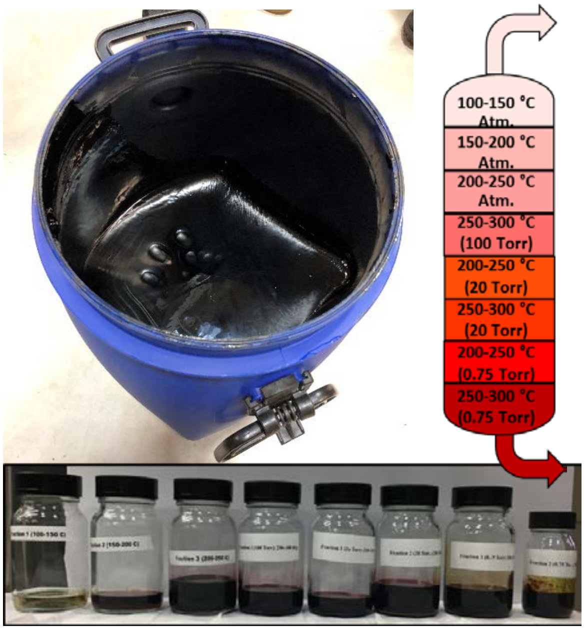
The facilities include a lab with small scale HTL (hydrothermal liquefaction) reactors. These reactors can be operated up to 400°C and 300 bar. They are used for rapid screening of different operating conditions and feedstocks as well as for initial hydrotreating studies.

The lab further contains a small-scale continuous 2-stage hydro-deoxygenation unit for further upgrading of biocrudes, as well as distillation columns for biocrude fractionation. Fuel cuts can be tested in jet or IC engine test rigs within the lab.

Besides these small scale units AAU hosts and operates a pilot scale continuous HTL unit. It has a biocrude production capacity of approx. 2 kg/h. It is one of the few continuous HTL units of this capacity in the world. It is currently operated in collaboration with Steeper Energy.

Visit of the AAU research facilities, Aalborg, Danmark

From wood to bio-liquids



4Refinery will focus on three major biomass feedstock types for the production of bio-liquids: forest residue, straw and eucalyptus. In the first part of the project two primary conversion process, fast pyrolysis and hydrothermal liquefaction (HTL) have been applied to forest residu to provide all project partners of sufficient bio-liquids for further refinery processes.

Pyrolysis is the thermal conversion of biomass at around 450-500 ˚C, inert atmosphere, and ambient pressure to yield a liquid pyrolysis product. Depending on the feedstock, carbon efficiency of pyrolysis (biomass carbon to bio-liquid carbon) varies between 55 to 65%, while the remaining energy can be largely used for heat and power generation. Challenges include the removal of water and residual ash, reduction of acidity, reduction of the tendency of these liquids to re-polymerize and form char, and diversification of the feedstock basis while maintaining adequate quality liquids at high yields.

Hydrothermal liquefaction is the high pressure (50 - 350 bar) mild temperature (<450°C) conversion of biomass, and yields a viscous but liquid product. Depending on feedstock and operating parameters, carbon efficiencies will typically be in the range of 45-65% while a significant part of the carbon from the aqueous phase can be retrieved into the oil product by full or partial recycling of this fraction. For lignocellulosic feedstocks, HTL produces a liquid with high aromatic content. Challenges include feeding biomass at elevated pressures (and reduce pressure), improvement in the product quality (amongst others viscosity, aromaticity) and improvement in overall process performance and reliability.

The biocrude produced by HTL, as shown in the Figure on the right, has been fractionated by distillation for further analysis. However, large scale fractionation is also planned to provide the best fractions for co-refining.

Recent publications

Check out the latest scientific results in these open access articles:

- "Modeling and Analysis: Renewable hydrocarbon fuels from hydrothermal liquefaction: A techno-economic analysis.", T.H. Pedersen, N.H. Hansen, O.M. Pérez, D.E. Villamar-Cabezas, L.A. Rosendahl, Biofuels, Bioprod. Bioref. 12 :213–223 (2018); https://doi.org/10.1002/bbb
- "Continuous Hydrothermal Liquefaction of Biomass: A Critical Review", Daniele Castello, Thomas Helmer Pedersen and Lasse Aistrup Rosendahl, Energies 2018, 11(11), 3165; https://doi.org/10.3390/en11113165

4Refinery Profile

Funding Programme
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