Press release
22 June 2021, 08:00 Hrs

Advanced biofuel breakthrough:

HyFlexFuel converted sewage sludge and other biomasses into kerosene by hydrothermal liquefaction (HTL)

The EU funded research project HyFlexFuel recently succeeded to produce biocrudes via hydrothermal liquefaction (HTL) from a variety of biomasses, including sewage sludge, food waste, manure, wheat straw, corn stover, pine sawdust, miscanthus and microalgae in a pilot-scale continuous HTL plant at Aarhus University (Denmark). "It has been a real milestone in HyFlexFuel to demonstrate biocrude production from such a variety of feedstocks in the hundreds of kg's scale", says Patrick Biller, who leads the pilot-scale HTL research at Aarhus University. Biocrudes from three representative feedstocks, Spirulina (micro-algae), sewage sludge, and wheat straw, were further upgraded to a mixture of hydrocarbon fuels at Aalborg University (Denmark). "Thanks to the expertise of several project partners, HyFlexFuel proved that HTL biocrudes can be successfully upgraded to drop-in fuels in an industrially-relevant environment, achieving hundreds of hours of continuous operations", adds Daniele Castello of Aalborg University. Analyses of the kerosene fractions of the upgraded biocrude show promising compositions for a use as aviation fuel. "The production of HTL fuels from three different feedstock classes shows the flexibility of the process," says project coordinator Valentin Batteiger of Bauhaus Luftfahrt (Germany), "Meeting jet fuel specifications is an appropriate target to validate that high-performance transportation fuels can indeed be produced from a broad range of residue and waste streams via hydrothermal liquefaction."

HTL as key-enabler for sustainable biofuel production

The decarbonization of the transportation sector will require large volumes of renewable fuels. So far, renewable diesel and jet fuels are mainly derived from plant oils, but the EU Renewable Energy Directive limits the use of biofuel from food and feed crops since they do not meet sustainability requirements when produced at large scale. For the future, it will be important to commercialize advanced biofuel conversion technologies, which utilize a broader and more sustainable feedstock base.

The HTL process

Hydrothermal liquefaction (HTL) is an upcoming biofuel technology to produce transportation fuels from a broad variety of bio-wastes and other biomasses.

HTL has several key-advantages, of which the most important are:

- Flexible production potential: The HTL conversion technology taps into a huge global bio-resource with local variety of primary biomasses. The technology is compatible with a broad variety of organic wastes and residues, lignocellulosic energy crops or aquatic biomasses and can adapt to specific regional feedstock availabilities.
- Cost-effectiveness: It can produce advanced biofuels, from marine fuels to kerosene, potentially at lower cost than most competing renewable fuel pathways.
- Sustainability: The HTL technology has the potential to produce fuels with a low carbon footprint over the entire life cycle, without competing with food and feed production. It has the potential to recycle waste streams and thereby contribute to a more circular economy.

The pilot-scale HTL plant processes aqueous biomass slurries (~20% dry matter content) at temperatures up to 350°C and pressures around 200 bar, where water does not boil but remains in a liquid state. Under these conditions, biomass is converted into a crude bio-oil, which is separated from the process water behind the reactor. In a second step, the HTL biocrude is upgraded to transportation fuel products via catalytic treatment with hydrogen at high temperature and pressure (hydrotreating). Thereby, oxygen and nitrogen are removed from the biocrude, which is in turn converted into a mixture of hydrocarbons. Distillation of the upgraded HTL biocrudes yields drop-in capable fuels in the gasoline, kerosene and diesel range.

Laboratory demonstration of key process steps by European consortium

Within the EU-project HyFlexFuel all key steps along a HTL fuel production chain are investigated at the premises of several European research institutions and companies. The potential availability of residues and waste streams across Europe is analysed by DBFZ, the German institute for biomass research, using a geospatial approach. Aarhus University further develops and optimizes HTL conversion at lab-scale and transfers the results to a pilot-scale continuous HTL plant, which also produced all samples for the downstream processes. Aalborg University, supported by Haldor Topsøe (Denmark), implemented the upgrading of various biocrudes to transportation fuels via catalytic hydrotreatment, while Eni (Italy) investigated the perspective of co-processing HTL biocrudes in conventional crude oil refineries.

Solid particles and process waters, which also evolve during HTL conversion, contain a significant fraction of the carbon and the nutrients from the initial biomass. Two options to produce biogas from the organics in these process waters are investigated by Paul Scherrer Institute (Switzerland), via catalytic hydrothermal gasification on their Energy System Integration Platform, and by OWS (Belgium), via anaerobic digestion. The recovery of phosphorus is particularly important for the HTL of sewage sludge in order to close nutrient cycles. University of Hohenheim (Germany) has demonstrated the precipitation of struvite, a fertilizer product, from HTL solids and process waters. Bauhaus Luftfahrt coordinates the project and analyses the economic and environmental impact of HTL fuel production. ARTTIC Innovation GmbH (Germany) serves as a project management partner and supports dissemination activities.

Towards an approval of HTL kerosene for civil aviation

So far, seven alternative fuel production pathways have been approved as a blend component for civil aviation by the ASTM D-7566 specification[1]. The HyFlexFuel consortium prepares the approval of HTL kerosenes in collaboration with key partners in Europe and the US. Kerosene samples from the HyFlexFuel project were analysed by the H2020 project JETSCREEN (coordinated by DLR, Germany) and the University of Dayton. The results show that all basic physicochemical properties of jet fuel, such as energy density or cold flow properties are already met, while the concentration of specific trace components needs to be further reduced to comply with stringent jet fuel specifications.

[1]: Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

Project background

HyFlexFuel is a four-year project (10/2017 – 9/2021) supported by the European Union's Horizon 2020 research and innovation programme. HyFlexFuel joins leading European research organizations and companies in the field of HTL research, namely Aarhus University, Aalborg University, Paul Scherrer Institute, University of Hohenheim, DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Haldor Topsøe, Eni, and OWS. Bauhaus Luftfahrt e.V. coordinates the project and ARTTIC Innovation GmbH supports the research consortium with project management and communication.

For more information, visit www.hyflexfuel.eu
Project video
Project images
Project logo

Bauhaus Luftfahrt (project coordinator)

Bauhaus Luftfahrt is an interdisciplinary research institution funded by the four aerospace companies Airbus Group, Industrieanlagen-Betriebsgesellschaft (IABG), Liebherr-Aerospace and MTU Aero Engines as well as grants of the Bavarian Ministry for Economic Affairs, Media, Energy and Technology. The non-profit association is an internationally-oriented think tank. The team of around 50 employees deals with the future of mobility in general and with the future of air travel in particular. The goal of the research work is to consider the complex system of aviation from different points of view. In every project, the technical, economic, social and ecological aspects are considered holistically. www.bauhaus-luftfahrt.net

Aarhus University

Aarhus University was founded in 1928 and covers the entire research spectrum from fundamental research towards applied and strategic research plus research-based advice to authorities. Aarhus University has about 38,000 students, (including 1,800 PhD students and almost 700 postdoctoral scholars) and about 8,000 employees. The university has strong international connections, and one out of four PhD students are international.

Aalborg University

Aalborg University was founded in 1974 as Aalborg Universitetscenter (AUC – 1974-1994) with a student population of only 1,600, which has grown to almost 20,000 in 2020, including more than 3,000 international students. Almost 50% of the students are within engineering and natural sciences. In 2020, there were just under 1,000 PhD students enrolled in the Aalborg University doctoral programmes. Aalborg University is a campus-based university, with main campus in Aalborg and satellite campuses in Esbjerg (major off-shore city in Denmark) and Copenhagen.

At Times Higher Education, Aalborg University is ranked no. 207 in the overall World University Ranking, and no. 23 in Top 100 under the age of 50. In THE Impact Ranking, Aalborg University is ranked as no. 6 in the world, and as the worlds best university at SDG 4: Quality Education, and no. 2 at SDG 6: Clean Water and Sanitation. Finally, Aalborg University (AAU) is the best university in Europe in engineering, according to U.S. News & World Report's recently published "Best Global Universities 2021".

Paul Scherrer Institut

The Paul Scherrer Institute is the largest research facility for natural and engineering sciences in Switzerland and conducts cutting-edge research in three main areas: matter and materials, energy and environment and human health. The Paul Scherrer Institute develops, builds and operates complex large research facilities, which are used by more than 2500 scientists from Switzerland and around the world every year to carry out experiments that are not possible anywhere else. The Paul Scherrer Institute is committed to the training of future generations. About one quarter of our staff are apprentices, post-graduates or post-docs. The Paul Scherrer Institute employs 2100 people. It is primarily financed by the Swiss Confederation as part of the ETH Domain.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH

The DBFZ works as a central and independent thinker in the field of energy and material use of biomass on the question of how the limited available biomass resources can contribute to the existing and future energy system with sustainability and high efficiency. As part of the research the DBFZ identifies, develops, accompanies, evaluates and demonstrates the most promising fields of application for bioenergy and the especially positively outstanding examples together with partners from research, industry and public. With the scientific work of the DBFZ, the knowledge of the possibilities and limitations of energy and integrated material use of renewable raw materials in a biobased economy as a whole should be expanded and the outstanding position of the industrial location Germany in this sector permanently secured.

University of Hohenheim

The University of Hohenheim has strong activities in agricultural science, but also in economics and natural science. In Germany, University of Hohenheim is the university with the largest faculty of agricultural science, and the leading German university in this field. This university was founded in 1818 and has now a focus on bio-economy. One of the areas of Hohenheim's research work is conversion technology of renewable resources. It covers new products and new production processes, made of renewable feedstock. Of particular interest here is the substitution of fossil fuel by biomass and valorisation of waste streams by the recovery of nutrients.

Organic Waste Systems NV (OWS)

OWS is a world leading company in the construction and operation of anaerobic digestion plants, in the biodegradability and compostability testing of different types of materials and in waste management consultancy. OWS is a private company constituted in 1988 with headquarters in Ghent (Belgium) and subsidiaries in the USA, Germany and Japan. OWS designs and constructs anaerobic digestion (AD) plants with an emphasis on the treatment of organic municipal waste streams (DRANCO and SORDISEP – with post-treatment of digestate to produce qualitative compost and recyclables from unsorted MSW). Processes for the treatment of energy crops and agro/industrial waste are also offered (DRANCO-farm, BES). Further, OWS offers extensive biological support in AD-related projects, ranging from feasibility over start-up of AD-plants to routine analyses and biological monitoring of the process.

OWS also offers diverse consulting services in the field of biodegradation and composting, waste composition, waste separation, recycling, integrated waste management and related legislation in both Europe and the USA. The strictly independent OWS laboratory (working conform ISO 17025) provides testing under strict quality conditions for the determination of the biodegradability and compostability of different types of materials and is recognized by all certification bureaus worldwide working in the field of biodegradability and compostability.

Eni

Eni is an energy company operating in 66 countries worldwide and employing around 32,000 people. The company operates in oil and gas exploration, development and production, refining and marketing, trading and shipping, chemical, renewable energies and innovative solutions in circular economy. Eni's mission is inspired by the UN 2030 Agenda and these values are reflected in its business model, itself based on three pillars of long-term carbon neutrality, operational excellence and the creation of alliances for local development. Decarbonization is structurally embedded in Eni's overall strategy and ambitions, as the company is leader in energy transition with its new target of Net Zero emissions at 2050.

Haldor Topsøe

Haldor Topsøe is a global leader in supply of catalysts, technology, and services to the chemical and refining industries. Topsøe aims to be the global leader within carbon emission reduction technologies by 2024. By perfecting chemistry for a better world, we enable our customers to succeed in the transition towards renewable energy. Topsøe is headquartered in Denmark and serves customers around the globe. In 2020, our revenue was approximately DKK 6.2 billion, and we employ around 2,100 employees. www.topsoe.com

ARRTIC Innovation GmbH

ARTTIC Innovation GmbH, a company of the PNO Consultants Group, the European leader in collaboration engineering, consultancy and management services for international research and technology related partnerships. The team at ARTTIC Innovation GmbH has been built since 2006 and has set up and managed numerous projects in EU funding programmes. Currently, ARTTIC Innovation GmbH is collaborating with multi-national consortia in 28 EU funded projects. ARTTIC Innovation GmbH builds and assists collaborative undertakings and in particular European research consortia and networks from all businesses and research sectors, small and large, private and public, to ensure their collaborative innovation ventures are as successful as possible.

Partner logos

Our contacts

Press contacts	Scientific contacts
Bauhaus Luftfahrt e.V. Florian Riegel +49 89 3 07 48 49 18 florian.riegel@bauhaus-luftfahrt.net	Valentin Batteiger +49 89 307 4849 61 valentin.batteiger@bauhaus-luftfahrt.net
Aarhus University Jesper Bruun +45 4240 4140 bruun@au.dk	Patrick Biller +45 52745340 pbiller@bce.au.dk
Aalborg University Hiva Ahmadi +45 9940 3520 hiah@adm.aau.dk	Daniele Castello +45 50 33 02 11 dac@et.aau.dk
Paul Scherrer Institut Dr. Mirjam van Daalen +41 56 310 56 74 mirjam.vandaalen@psi.ch	Prof. Dr. Frédéric Vogel +41 56 310 21 35 frederic.vogel@psi.ch
Deutsches Biomasseforschungszentrum gemeinnützige GmbH. Paul Trainer +49 341 2434-437 paul.trainer@dbfz.de	Franz-Fabian Bellot +49 341 2434-586 franz-fabian.bellot@dbfz.de
University of Hohenheim Dr. Dorothea Elsner +49 711 459 22003 presse@uni-hohenheim.de	Gero Becker +49 711 459 24785 gero.becker@uni-hohenheim.de
OWS Bruno Mattheeuws bm@ows.be	
Eni Press Office: Tel. +39 0252031875 ; +39 0659822030 Freephone for shareholders (from Italy): 800940924; Freephone for shareholders (from abroad): +80011223456 Switchboard: +39-0659821 ufficio.stampa@eni.com ; Web site: www.eni.com	Stefano Chiaberge stefano.carlo.chiaberge@eni.com
Haldor Topsoe Ulrik Frøhlke, Media Relations Manager +45 27 77 99 68 ulfr@topsoe.com	Per Zeuthen +45 22754138 pz@topsoe.com
ARTTIC Innovation GmbH Andreas Schweinberger hyflexfuel-arttic@eurtd.com	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764734