HIGFLY

HIGEE TO FURANIC-BASED JET-FUEL TECHNOLOGY

Newsletter 4

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THE HIGFLY PROJECT

As the **HIGFLY** project concludes on December 31, 2024, we proudly reflect on its transformative contributions to the development of **Sustainable Aviation Fuel (SAF)** technologies. Over the past four years, a consortium of nine partners, led by Eindhoven University of Technology, has worked to design cost-effective methods for converting **second-generation biomass** into SAF by designing state-of-the-art technologies, materials and chemo-catalytic processes.

HIGFLY focused on two primary pathways to maximise carbon efficiency and reduce environmental impacts:

1. C5 Sugar Conversion to Furfural

This pathway transformed lignocellulosic biomass into furfural through aldol condensation with acetone, producing SAF precursors. Subsequent hydrogenation and hydrodeoxygenation processes yielded hydrocarbons fit for aviation fuel, achieving an **88% carbon yield**—a significant step toward sustainable aviation solutions.

2. Cyclopentanone Pathway

Cyclopentanone, derived from furfural, underwent gas-phase condensation and hydrotreating to produce cyclic hydrocarbons. Operating at high temperatures with tailored catalysts, this pathway achieved near-complete hydrodeoxygenation, resulting in a hydrocarbon-rich product with minimal waste.

Central to these efforts was the **HiGee reactor**, an innovative technology developed to enhance furfural production. By employing high-gravity operations and advanced catalyst designs, the reactor has the potential to **increase furfural yield up to 90%** whilst reducing energy consumption and reactor size significantly compared to conventional methods.

Fuel samples from both pathways are rigorously being tested by SkyNRG to ensure compliance with aviation standards, including critical properties like freezing point and flash point. These tests aim to validate HIGFLY's SAF as a viable alternative to fossil kerosene.

Beyond fuel production, the project explored advanced purification techniques using **deep eutectic solvents** and **supported liquid membranes**, enhancing extraction efficiency and overall sustainability. A comprehensive Life Cycle Assessment demonstrated considerable greenhouse gas emission reductions, whilst the project's socio-economic analysis highlighted benefits such as rural job creation and economic growth.

HIGFLY's groundbreaking work advances the EU's climate goals and supports the aviation industry's transition toward a **net-zero future**. By unlocking the potential of renewable chemicals like furfural, HIGFLY has set the stage for sustainable innovations across aviation and related industries.

Keep reading to learn more about HIGFLY's potential impact on the future of sustainable aviation.

PROJECT PROGRESS

Optimising Aqueous Phase Reforming for Sustainable Hydrogen Production from Aqueous Side Streams

The report, "Valorisation of Light Oxygenates Present in Aqueous Side Streams via Aqueous Phase Reforming", details Johnson Matthey's research on converting oxygenates in aqueous side streams to hydrogen (H2) through aqueous phase reforming (APR). This work involves testing various model aqueous feeds and catalysts...

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Pioneering Biofuel Production: Transforming Biomass into Sustainable Aviation Fuel

In an effort to advance sustainable aviation, researchers from TNO and Fraunhofer UMSICHT have developed innovative methods to produce biofuel from biomass feedstocks, focusing on converting five-carbon saccharide fractions from lignocellulosic biomass into jet fuel. The aim is to demonstrate these technologies...

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Sustainability Assessment of the HIGFLY Process: Advancing Sustainable Aviation Fuel Production

The HIGFLY project aims to develop advanced technologies for producing sustainable aviation fuels (SAF) using hemicellulose C5 sugar streams from lignocellulosic biorefineries. Researchers from ifeu have evaluated the sustainability performance of the HIGFLY process through environmental...

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SCIENTIFIC PUBLICATIONS

Catalytic Condensation of Biobased Molecules for Jet Fuel Synthesis

This work evaluates a process for the production of renewable jet fuel hydrocarbons using biobased precursors derived from 2nd generation biomass hemicellulose. A set of promising basic solid formed catalysts was benchmarked in lab-scale continuous fixed bed reactors to evaluate their catalytic performance in the cross-condensation of furfural and acetone and the self-condensation of cyclopentanone at two different temperature regimes.

For the low temperature liquid process (80-120 °C), a hydrotalcite and a metal-organic-framework catalyst were most active and stable up to 53 h on stream, with high conversions (> 85 %) and favouring the formation of C13 over C8 products. For the high temperature gas-phase process (280-360 °C), a metal doped alumina catalyst was most active, with stable conversion (40-45 %) and a product distribution favouring C10 over C15 molecules.

The two process regimes (low and high temperature) can provide flexibility in the production of biobased hydrocarbons for use in the aviation sector. Catalyst deactivation was observed due to strong carbon adsorption; however, most active materials could be regenerated via calcination.

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https://zenodo.org/records/8362547

Intensifying cyclopentanone synthesis from furfural using supported copper catalysts

This work addresses catalytic strategies to intensify the synthesis of cyclopentanone, a bio-based platform chemical and a potential SAF precursor, via Cu-catalyzed furfural hydrogenation in aqueous media. When performed in a single step, using either uniform or staged catalytic bed configuration, high temperature and hydrogen pressures (180°C and 38 bar) are necessary for maximum CPO yields (37 and 49%, respectively). Parallel furanic ring hydrogenation of furfural and polymerisation of intermediates, namely furfuryl alcohol (FFA), limit CPO yields.

Employing a two-step configuration with optimal catalyst bed can curb this limitation. First, the furanic ring hydrogenation can be suppressed by using milder conditions (i.e., 150°C and 7 bar H2, and 14 seconds of residence time). Second, FFA hydrogenation using tandem catalysis, i.e., a mix of β-zeolite and Cu/ZrO2, at 180°C, 38 bar H2 and 0.6 gFFA g−1 cat hr−1, allows sufficient time for CPO formation and minimises polymerisation of FFA, thereby resulting in 60% CPO yield. Therefore, this work recommends a split strategy to produce CPO from furfural. Such modularity may aid in addressing flexible market needs.

View and download the full publication >
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TECHNICAL POSTERS

Introduction of biogenic carbon into sustainable aviation fuels: applying aldol condensation and selective hydrodeoxygenation technologies to oxygenated bio-intermediates

Within the fuel sector, aviation is the fastest growing greenhouse gas emission source and the most difficult to decarbonise. Alternative technologies and feedstocks are essential to meet global demand whilst achieving 2050 net zero targets, with chemo-catalytic routes considered attractive given their potentially high carbon yield.

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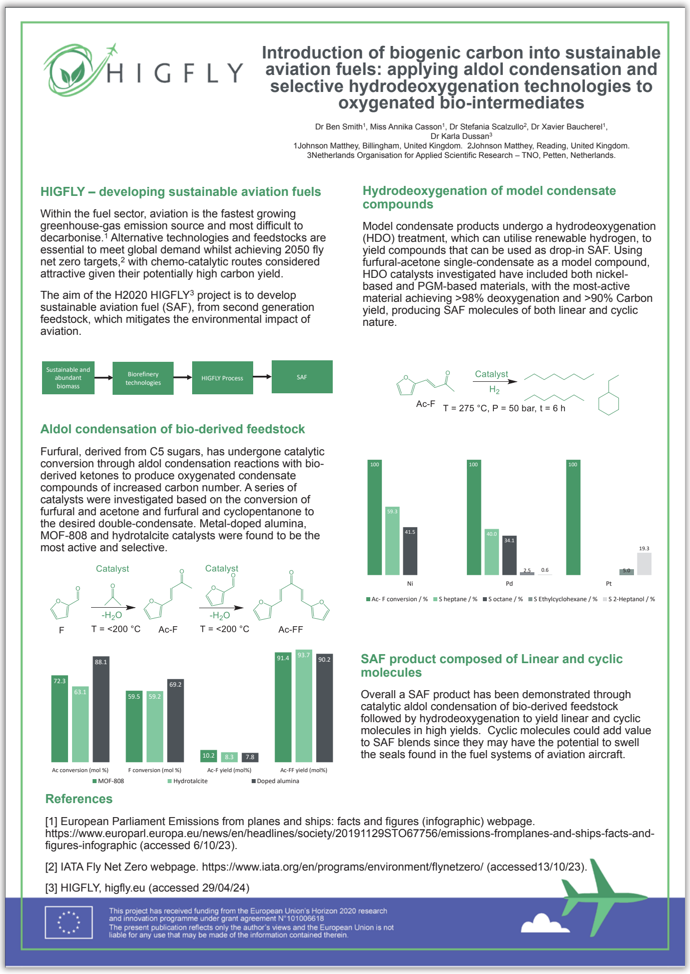

Synthesis of jet fuel hydrocarbons using furfural and bio-oxygenates

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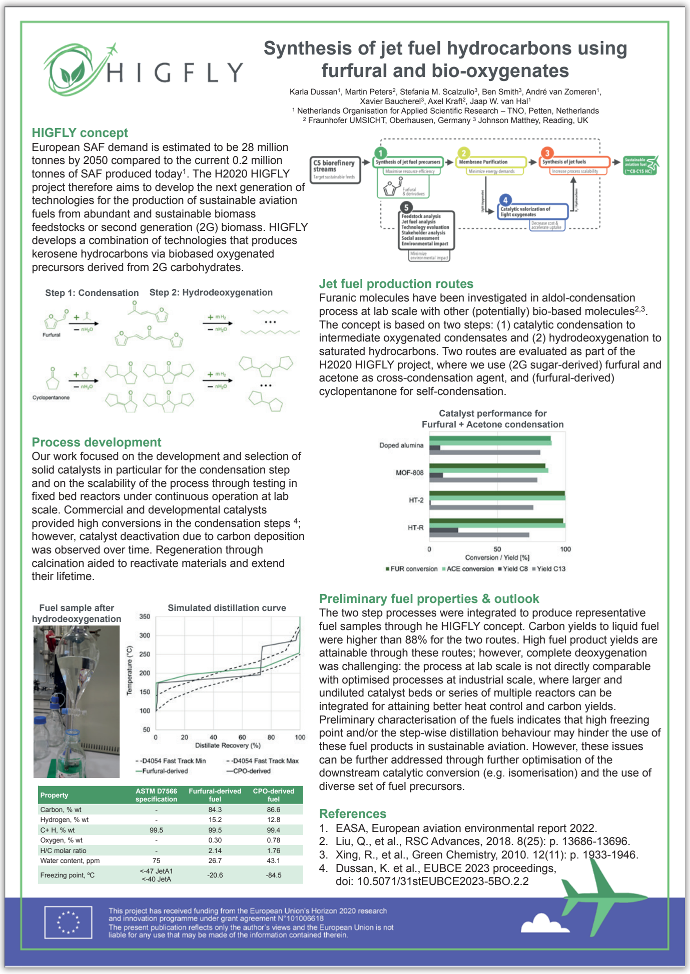

European SAF demand is estimated to be 28 million tonnes by 2050 compared to the current 0.2 million tonnes of SAF produced today1. The H2020 HIGFLY project therefore aims to develop the next generation of technologies for the production of sustainable aviation fuels from abundant and sustainable biomass feedstocks or second generation (2G) biomass. HIGFLY develops a combination of technologies that produces kerosene hydrocarbons via biobased oxygenated precursors derived from 2G carbohydrates.

Converting bio-based cyclopentanone into jet fuel hydrocarbons

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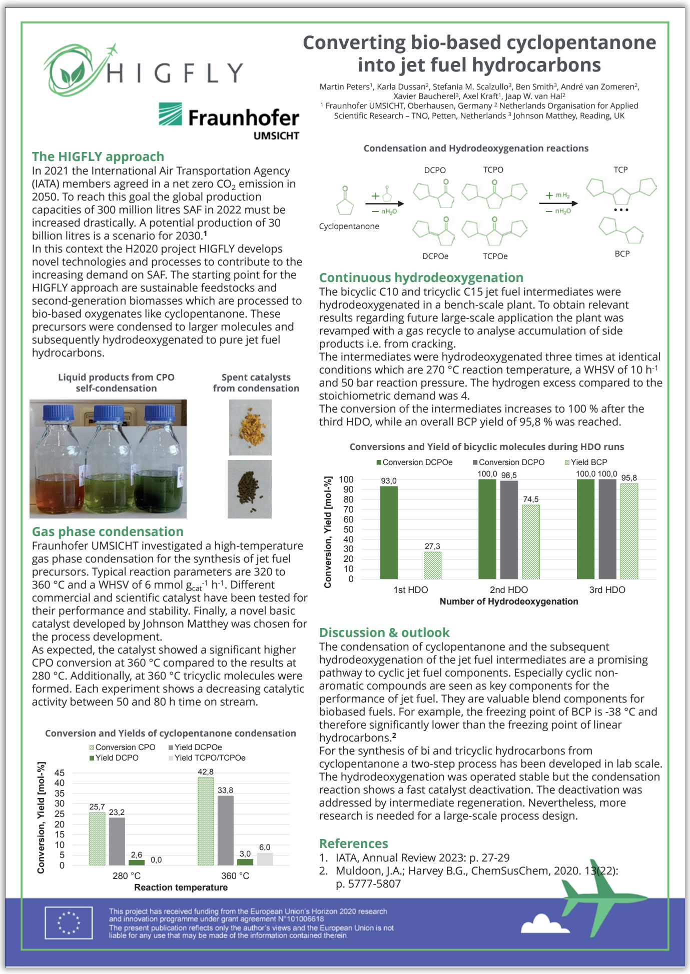

In 2021 the International Air Transportation Agency (IATA) members agreed to a net zero CO2 emissions target by 2050. To reach this goal the global production capacities of 300 million litres SAF in 2022 must be increased drastically. A potential production of 30 billion litres is a scenario for 2030.In this context the H2020 project HIGFLY develops novel technologies and processes to contribute to the increasing demand on SAF. The starting point for the HIGFLY approach are sustainable feedstocks and second-generation biomasses which are processed to bio-based oxygenates like cyclopentanone. These precursors were condensed to larger molecules and subsequently hydro-deoxygenated to pure jet fuel hydrocarbons.

Assessment of Bio-Advanced Synthetic Aviation Fuel Hydrocarbons Production from Biorefinery Streams using Furfural and Ketones: A Techno-Economic Analysis

Biomass plays a crucial role in reducing greenhouse gas emissions within the aviation industry. The European Commission, through the REfuelEU aviation initiative as part of the Fit for 55 package, acknowledges this and encourages investments in cleaner technologies for sustainable aviation fuels. In this context, the HIGFLY project aims to develop advanced bio-jet fuels by converting underutilised hemicellulose (C5) fractions into hydrocarbons suitable for blending with jet fuel. Supporting experimental work, the current work presents process design for

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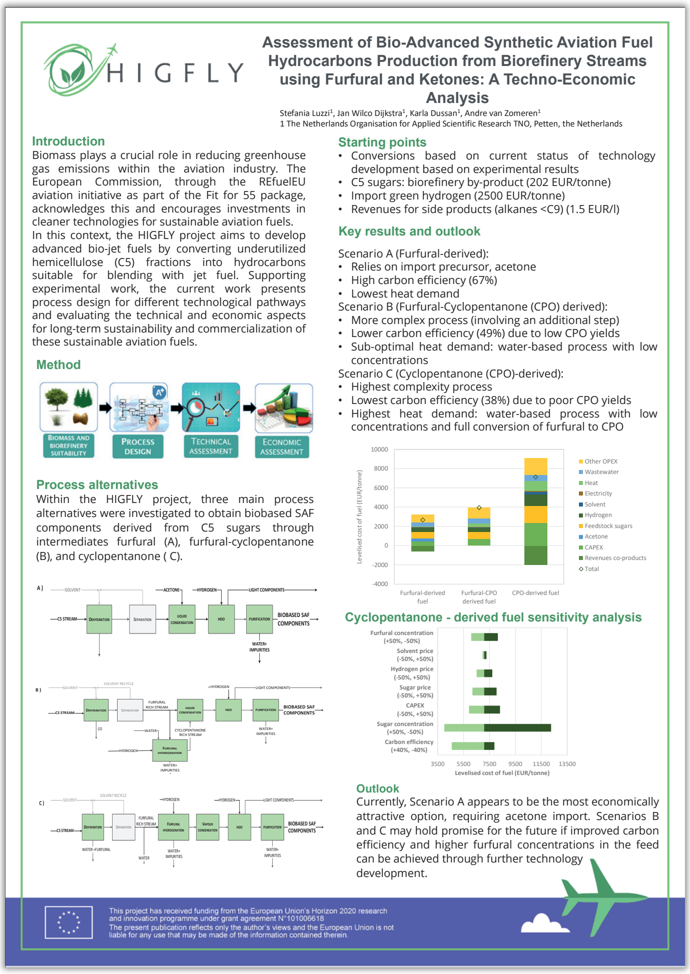

RELATED PROJECTS

The **TAKE-OFF** project, funded under the European Union's Horizon 2020 research and innovation program, is focused on developing advanced technologies to produce next-generation **Sustainable Aviation Fuel (SAF)**. This project employs an innovative process that captures **CO_2** from industrial flue gases or directly from the air, combines it with **renewable hydrogen**, and converts it into light olefins—chemical intermediates that are subsequently upgraded into SAF. This method offers significant advantages in terms of energy efficiency and cost compared to existing power-to-liquid alternatives.

TAKE-OFF aims to significantly reduce the carbon footprint of aviation by replacing conventional fossil-based jet fuels with synthetic SAF. The project is expected to achieve a **25% improvement in carbon and hydrogen efficiency,** a **36% reduction in production costs**, and a **20% reduction in total** emissions compared to current alternatives. Additionally, it eliminates sulphur emissions entirely, aligning closely with European Green Deal targets and the Renewable Energy Directive II objectives.

The project also focuses on demonstrating the economic and environmental viability of its technology through pilot-scale implementation and comprehensive life-cycle assessments. By advancing the production technologies from Technology Readiness Levels (TRLs) 3 to 5, TAKE-OFF supports the broader adoption of SAF within the aviation industry.

To learn more, visit their website >

https://takeoff-project.eu/

UPCOMING EVENTS

Fuels of the Future 2025

Berlin, Germany
20th – 21st January 2025

Over the past 20 years, the "Fuels of the Future" international conference has become established as the top event for the European biofuels industry and likewise an important forum for discussions on developing renewable mobility in Germany, Europe and internationally.

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LIGNOFUELS 2025

Helsinki, Finland
12th – 13th February 2025

Building on the success of Lignofuels 2024 which brought 150+ senior level industry professionals to Helsinki in February 2024, we are delighted to be returning to Finland for the 5th consecutive year for the 2025 edition of the conference, taking place on 12th & 13th February 2025 in Helsinki, Finland.
The conference will once again bring together key lignofuels and advanced biofuels and materials stakeholders to join our forum discussions and networking, representing the entire value chain of the industry.

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Bio360 Expo

Nantes, France
5th – 6th February 2025

Bio360 is the reference meeting point for international professionals from multi-disciplinary backgrounds who embody the conviction and an unswerving resolve to find and develop through collaboration and vision, the urgently needed sustainable solutions to the biggest problems of our time, of our history. To transition us away from our fossil dependence to a world where atmospheric CO2 is reduced to safe levels and carbon circulates freely and renewably within the biosphere and where our energy and material needs are met.

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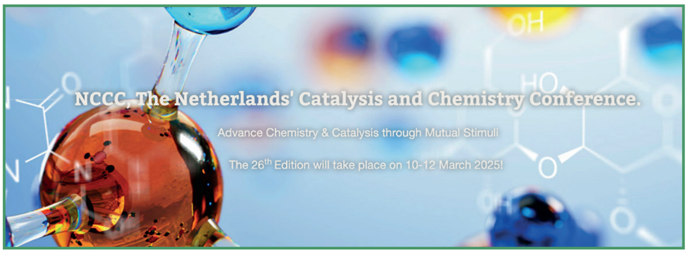
The Netherlands' Catalysis and Chemistry Conference

Noordwijkerhout, The Netherlands
10th – 12th March 2025

NCCC attracts about 500 participants, including around 100 scientists from industry. The meeting comprises plenary and keynote lectures by invited speakers and selected oral papers and posters. Scientists, and especially PhD-students, are encouraged to submit abstracts so they can present their work, discuss it with leading scientists and representatives from industry. NCCC offers a unique, international forum to exchange innovative ideas between academic and industrial scientists in a broad area of catalysis and chemistry research and technology.



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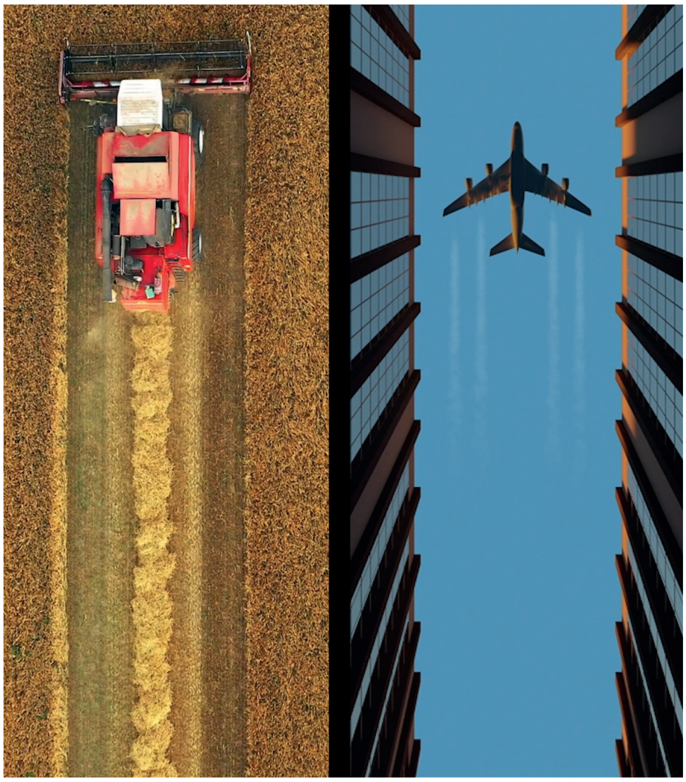
PROJECT FINAL VIDEO

Advancing Sustainable Aviation Fuel & Biobased Chemicals: Results from the HIGFLY Project

Discover the groundbreaking advancements of the HIGFLY project, a collaboration of nine partners coordinated by Eindhoven University of Technology, dedicated to transforming second-generation biomass into sustainable aviation fuel. Over four years, HIGFLY developed two innovative production pathways designed to maximize carbon efficiency, minimize waste, and produce high-quality advanced biofuels. At the heart of this effort is the HiGee reactor, a revolutionary technology helped by novel catalyst design improving furfural production—a versatile platform chemical with vast industrial applications. Learn how these breakthroughs align with EU climate goals, fostering greener aviation and a more resilient bio-based economy.

WATCH THE VIDEO



FUTURE DEVELOPMENTS

Although the HIGFLY project officially concludes on December 31st, 2024, there are still a number of scientific papers that will be published on our communication channels and further development and testing of the HiGee reactor to be reported.
You can stay up to date with these developments by visiting the HIGFLY Community on the Zenodo online repository.
Also, we will notify you through our website and social media channels whenever there are any research updates. See you there!

ZENODO

WEBSITE

Don´t forget you can stay up to date by visiting our website:

www.higfly.eu/

And you can follow us on our social networks:

HIGFLY_H2020

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