

From pilot to refinery. New developments in biofuel production and co-processing

Production of 300 L SPO

As part of the REFOLUTION project, a major technical milestone was achieved with the pilot-scale production of 300 liters of Stabilized Pyrolysis Oil (SPO). This process transforms raw, highly oxygenated pyrolysis oils into a stable intermediate suitable for the aviation and marine sectors. Using the specialized nickel-based catalyst **Picula™**, the system operates at mild temperatures (200–250°C) and high pressures (near 200 bar) to selectively hydrogenate aldehydes.

Operational results confirm a high carbon yield of 93–96% and a significant improvement in oil properties, including a reduction in water content to 5–10 wt.% and a decrease in Micro Carbon Residue (MCRT) to below 10%, which effectively minimizes charring and polymerization risks.

The resulting SPO is now ready for refinery integration, such as co-processing in Fluid Catalytic Cracking (FCC) units, or for full deoxygenation into advanced biofuels.

These data-driven results are currently guiding the scale-up of the technology toward a prototype scale unit.



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Stability Optimization: Catalyst Testing and Process Chemistry

Pyrolysis oil derived from biomass and lignocellulosic waste represents a promising intermediate for biofuels, but its high instability and acidity require preliminary stabilization treatment before use in the refinery. Colleagues at **CNRS**, in collaboration with **BTG**, conducted intensive tests in a continuous fixed-bed reactor, identifying the ideal equilibrium point for the process at 70°C and 60 bar. The main chemical reaction observed in the liquids is the transformation of aldehydes into alcohols, a crucial step that dramatically improves the energy density and reduces the corrosiveness of the product, facilitating its storage and transportation. Despite the challenge of progressive catalyst deactivation, our research has led to crucial discoveries: compounds such as acetic acid, methylfurfural, and thiophene have been shown not to act as direct catalyst poisons. These results rule out carbonyl groups and carboxylic acids as primary degradation causes, directing future efforts toward analyzing more complex components such as levoglucosan, dicarboxylic acids, and minerals. The stabilized oil is now ready for effective co-processing in FCC units, paving the way for the production of sustainable fuel for the automotive, marine, and aviation sectors.



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Refinery Integration & Scale-up Progress in Co-processing

To make pyrolysis oil compatible with fossil fuels, the REFOLUTION project focuses on co-processing within existing Fluid Catalytic Cracking (FCC) units in refineries. This approach is advantageous because it does not require additional hydrogen, requires minimal infrastructure modifications, and reduces logistics costs by promoting decentralized production close to biomass sources.

To overcome the critical issues related to the poor thermal stability and immiscibility of bio-oil, partner **VTT** is conducting tests in a 10-20 kg/h pilot unit equipped with a 10-meter-long circulating fluidized bed (CFB) reactor.

The technical solutions adopted include:

- **Cold feed:** the use of a lance with a cooled nozzle prevents polymerization and line blockages.
- **VGO optimization:** the vacuum gas oil is preheated to 200°C to ensure proper atomization.
- **Operational flexibility:** The ability to vary injection points optimizes process yield.

These advances are crucial for the transition to industrial production of advanced biofuels for the aviation and marine sectors, effectively integrating renewable carbon into conventional refining processes.



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Evaluation of fuel blend related to marine fuel standards on the basis of analytical results

REFOLUTION has taken a key step towards decarbonizing the maritime sector, which will require drop-in fuels fully compatible with existing engines and infrastructure well beyond 2040. Analysis of HPO has demonstrated that, from a purely formal standpoint, it is fully suitable for use in the maritime sector, in full compliance with the ISO 8217 standard. Accelerated aging tests have shown that 30% HPO blends maintain high chemical stability, with density and viscosity remaining within safe limits over a simulated one-year storage period. The project also looks to the future by exploring innovative applications, such as the use of HPO as a pilot fuel for methanol ignition, thus improving options for achieving maritime climate goals.

The next phase of the project will focus on refinery co-processing to mitigate microsediment formation and consolidate HPO as a cornerstone of the energy transition.

To support this transition, advanced molecular characterization has already identified over 1,000 compositions, linking insoluble deposits to phenolic structures that could clog high-precision injection systems. These chemical insights are combined with the exceptional properties of HPO, ensuring high-quality performance even at low temperatures. Extensive trials at the FCC co-processing facility will ultimately verify whether refinery integration can permanently eliminate these sedimentation phenomena for industrial use, marking a decisive step before the project's conclusion in December 2026.



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Carbon Tracking: A Digital Model for European Refining Efficiency

To ensure a cost-effective energy transition, BTG Bioliquids, in collaboration with SINTEF, has developed an advanced digital carbon tracking model specifically designed to optimize the integration of fast pyrolysis oil (FPBO) into the Fluid Catalytic Cracking (FCC) units of existing European refineries. This innovative tool represents a reliable and cost-effective alternative to traditional analytical methods, which are often too time-consuming and resource-intensive. By integrating real-time experimental data, the model can monitor and predict the behavior of renewable carbon with surgical precision throughout the transformation process. Tests conducted so far have shown an extremely satisfactory match between model outputs and experimental results, particularly regarding final product yields and actual biobased carbon content. This digital approach not only enhances operational efficiency and resource use, but also ensures complete transparency on supply chain sustainability, facilitating biofuel certification for the maritime and aviation sectors.

Through careful selection of variables and molecular characterization of feedstocks, the carbon tracking tool simplifies complex processes and accelerates the industrial-scale adoption of advanced, low-emission fuels.



Source: Canva

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The REFOLUTION project started in January 2023 and will end in December 2026. Coordinated by SINTEF, the project brings together 14 partners from 8 European countries, driven by strong industrial leadership, the consortium includes key market players across the resource-process (upstream/reactor/catalyst/downstream) product spectrum. This ensures a powerful driving force for technology development throughout the entire production chain, addressing challenges in critical EU sectors related to energy and transportation.

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