GLAMOUR

GLycerol to Aviation and Marine prOducts with sUstainable Recycling

Updates on GLAMOUR progress

GLAMOUR celebrates its fourth year of implementation!

Check out the 8th project newsletter to explore the interesting discoveries made by the consortium in each Work Package and to delve into the latest advancements towards converting bio-waste feedstock into jet fuel and marine diesel oil!

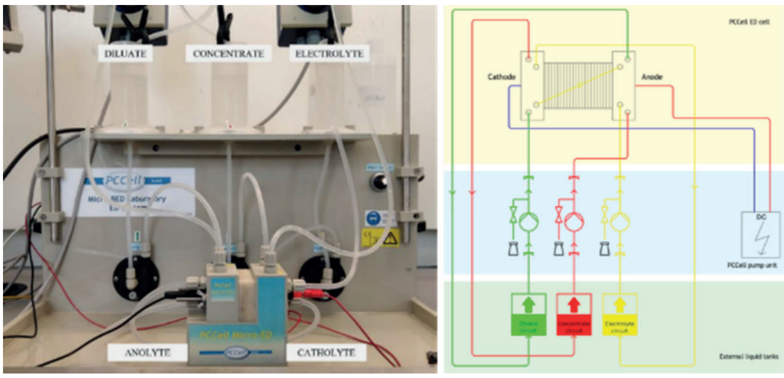
Remember to subscribe to the GLAMOUR newsletter and follow the main updates visiting the project website and LinkedIn and Twitter accounts!

INDUSTRIAL APPLICATIONS

This work package is almost completed with the last deliverable on the full process integration being finalized by the University of Manchester. Most of the activities in this work package are now moving in WP5 and WP6 where the detailed engineering, economic, environmental and societal assessment is being completed. In the last month, the University of Manchester and Argent Energy have published a new research paper on the techno-economic impact of low-grade glycerol purification.

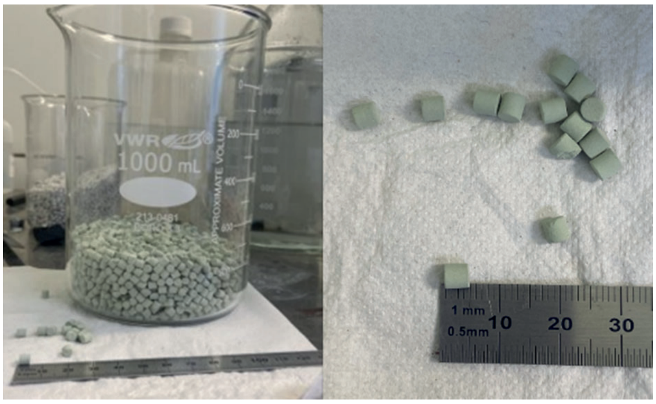
SYNGAS GENERATION

Along the Glamour project WP3 has been working on determining the operational window for the syngas production via chemical looping reforming in packed beds (CLR-PB). This work has included the design and optimisation of the crude glycerol purification train, the synthesis of functional materials to be scaled-up for theTRL5 plant and the development and validation of reactor models. The findings from the work performed by Argent Energy in collaboration with UNIMAN suggest that electrodialysis is a feasible crude glycerol purification technique that has been able to reduce ash content below 1.5 % wt for pre-treated industrial glycerol samples producing consistent glycerol purities in the range of 42.03 ± 1.15 % wt.



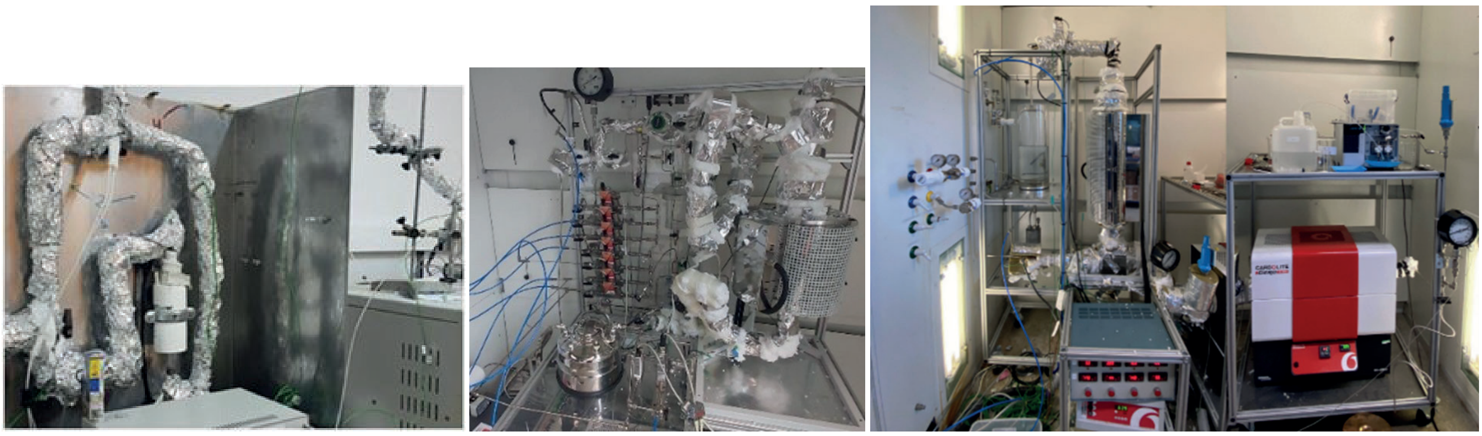
Electrodyalisis setup

An important effort by C&CS has been done on the design and synthesis of a Ni-based catalyst/OC capable of providing sufficient catalytic activity for the glycerol steam reforming and efficient redox properties to sustain the CLR-PB process. As a result, a European patent application No. EP22205194.8 was filled in collaboration with CSIC. C&CS has produced 15 kg of the catalyst/OC material that presented an outstanding performance as catalyst in a wide range of conditions and with high resistance to sintering.



Electrodyalisis setup

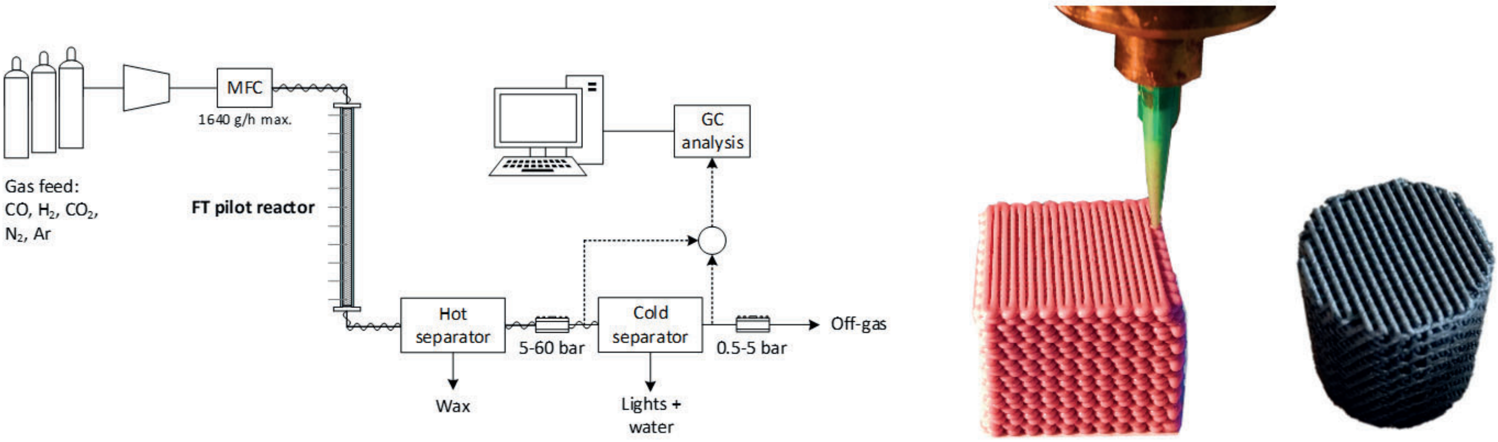
Up to 4 experimental plants have been used in the WP to test the catalysts/OCs produced: from a micro-fixed bed (left) that served to perform an initial material screening at CSIC, up to the TRL4 fixed bed reactor at UNIMAN (right) that served to validate the reactors models developed and to find relevant conditions for the testing of the CLR-PB process at TRL5 at TUE. At the TRL4 reactor, a wide range of conditions for the three process stages: oxidation, reduction and reforming have been investigated. It was proved that a flexible ratio H2/CO could be produced ranging from from 11.7 during steam reforming to 2.3 during combined glycerol/CH4 reforming. The characterisation of the chemical looping glycerol steam reforming catalyst (XRD, SEM-EDX, BET and side crush strength measurements) after multiple reduction, reforming and oxidation cycles in the TRL 4 reactor (total operating time of approx. 460 h) has shown that a high dispersion of the catalytically active component is maintained in the catalyst and the initial mechanical resistance of the tablets has not changed. The results also proved the the thermal-balancing nature of the three stages (oxidation/reduction/reforming) and the effectiveness of the material to store heat and drive the reforming of glycerol, thus delivering a strong foreground for investigating CLR-PB pseudo-continuous operation.



Left) Micro-fixed installation, CISC, centre) TRL3 fixed reactor, right) TRL4 fixed-bed reactor both at UNIMAN

FUEL SYNTHESIS

At the end of October 2023, work package 4 has been finalized with two deliverables on the scale-up of the 3D-printed catalyst system towards TRL-4. This included the rational design of 3D-printed catalyst structures (VITO) supported by 2D reactor modelling (TU/e) and the experimental validation at TRL-4 (TNO). This crucial step in the scale-up towards the TRL-5 demonstration plant has provided a catalyst system based on a thermally conductive 3D-printed structure. Under Fischer-Tropsch synthesis conditions, a liquid fuel productivity of over 0.9 gC5+/gcat/h was achieved, which is excellent compared to a maximum 0.2 gC5+/gcat/h obtained with a conventional packed bed. Crucial in this was the excellent heat management obtained through the 3D-printed structures. Some supporting images can be found in the Figure below. Efforts of the WP4 partners will now focus on taking the next step in the scale up to TRL-5, demonstrating the complete processing train of the GLAMOUR process.

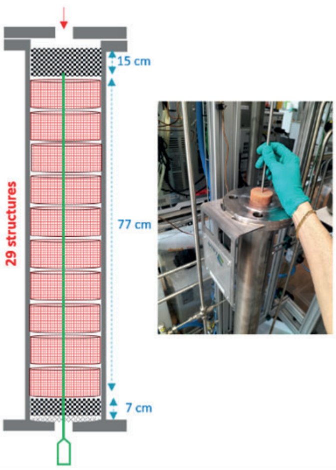


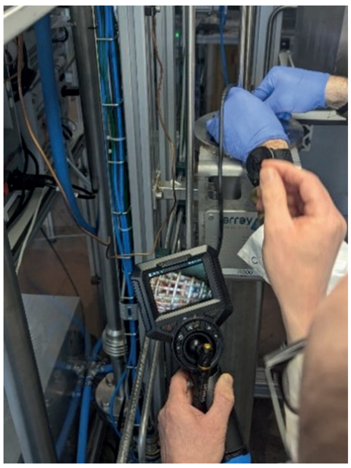
The TRL-4 FTS reactor setup (left) and an example of a 3D-printed (robocasting) catalyst (right).

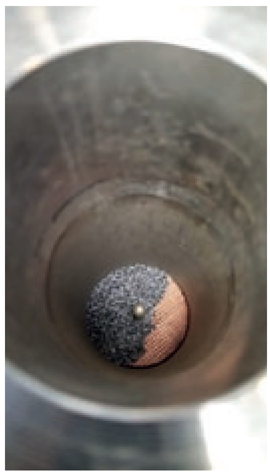
DEMONSTRATION

A glycerol-based auto-thermal chemical looping reforming system integrated with a Fischer-Tropsch reactor has been successfully developed and implemented at TRL5 scale in TUE. The primary objective is to produce 0.5 kg/h of high-value kerosene from a maximum feedstock of 2.5 kg/h of glycerol within 1000 hours of continuous operation. The setup comprises three reactors: two for the chemical looping process and one for the Fischer-Tropsch process. The reforming reactors can operate at pressures and temperatures of up to 30 bar and 1000°C, respectively.

Each reforming reactor was loaded with 3.5 kg catalyst. Each reforming reactor is equipped with two ovens, each capable of providing 5 kW of heating capacity. The gas feeding system utilizes 12 mass flow controllers, 8 for reforming reactors, 4 for Fischer-Tropsch to offer flexibility in utilizing gases such as H2, CH4, CO, CO2, N2, and air for the reduction and reforming cycles. 3-D printed structues along with catalysts were also loaded in Fischer-Tropsch reactor. Various sensors, valves, and regulators were integrated into the setup to monitor and control temperature, pressure, and fluid flow. Two Gas Chromatograph were utilized for comprehensive analysis of the syngas product from reforming reactors as well as for analyzing the output of the Fischer-Tropsch reactor.





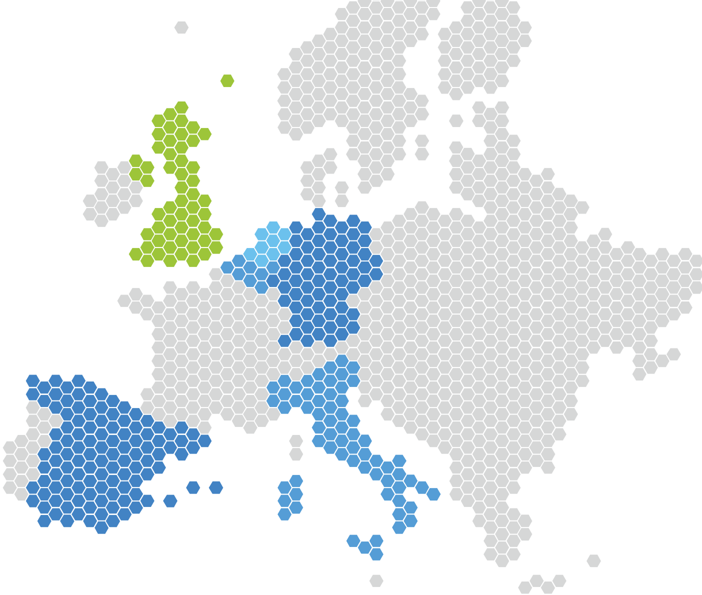


LIFE CYCLE SUSTAINABILITY ASSESSMENT

The environmental and social sustainability of GLAMOUR fuels was completed within WP6 by carrying out life cycle assessment (LCA) and using the social sustainability indicators, including carbon savings, human health, worker rights and public acceptance. Both the LCA results and social sustainability assessment of the industrial-scale production of GLAMOUR fuels showed that their sustainability depends highly on the source of electricity used in the glycerol purification process. For instance, the carbon footprint of GLAMOUR fuels would be net-negative if renewable (e.g. wind) electricity is used for the glycerol purification process. This would also lead to significant savings in social mitigation and GHG abatement costs. Moreover, compared to the fossil fuels, GLAMOUR fuels would achieve significant reductions in 12 out of 18 environmental impacts. However, if the electricity for the purification process is supplied by the EU grid, GLAMOUR fuels would not be able to achieve the required 70% reductions in greenhouse gases (GHG) for sustainable aviation fuels. They would also have significantly higher environmental impacts in 14 categories than the fossil fuels. The results of the social sustainability assessment also revealed that GLAMOUR fuels would have significantly lower human health impacts and slightly lower injury rates along the supply chain, if renewable electricity is used. The findings for worker rights revealed high compliance with labour laws and no child and forced labour risks associated with the production GLAMOUR fuels. This is due to the stringent legislation on these issues within the EU and the UK, where the supply chain is assumed to be based for GLAMOUR fuels.

EXPLOITATION & DISSEMINATION

In recent months, CIAOTECH has been working to support the consortium in consolidating exploitation strategies. In particular, during the last project meeting, an internal workshop called GLAMOUR Exploitation: Risks & Opportunities was organized. The aim of the workshop has been to engage the whole consortium in a brainstorming exercise to identify potential risks for exploitation, assess their impact in the short and long term and outline related strategies to mitigate those risks as well as to discuss on possible opportunities to continue the R&D activities of GLAMOUR after the project end to fill the gap from research to industrialisation. Now the consortium is working towards another important step in exploitation: the final workshop with external stakeholders, which will take place in May at TUE, where the operational demo plant will be showcased. In Addition, CIAOTECH is also leading the Dissemination and Communication activities, ensuring the maximum visibility of the project, its results and progress. Discover more about GLAMOUR visiting the project website.



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