Synthesis of jet fuel hydrocarbons using furfural and bio-oxygenates

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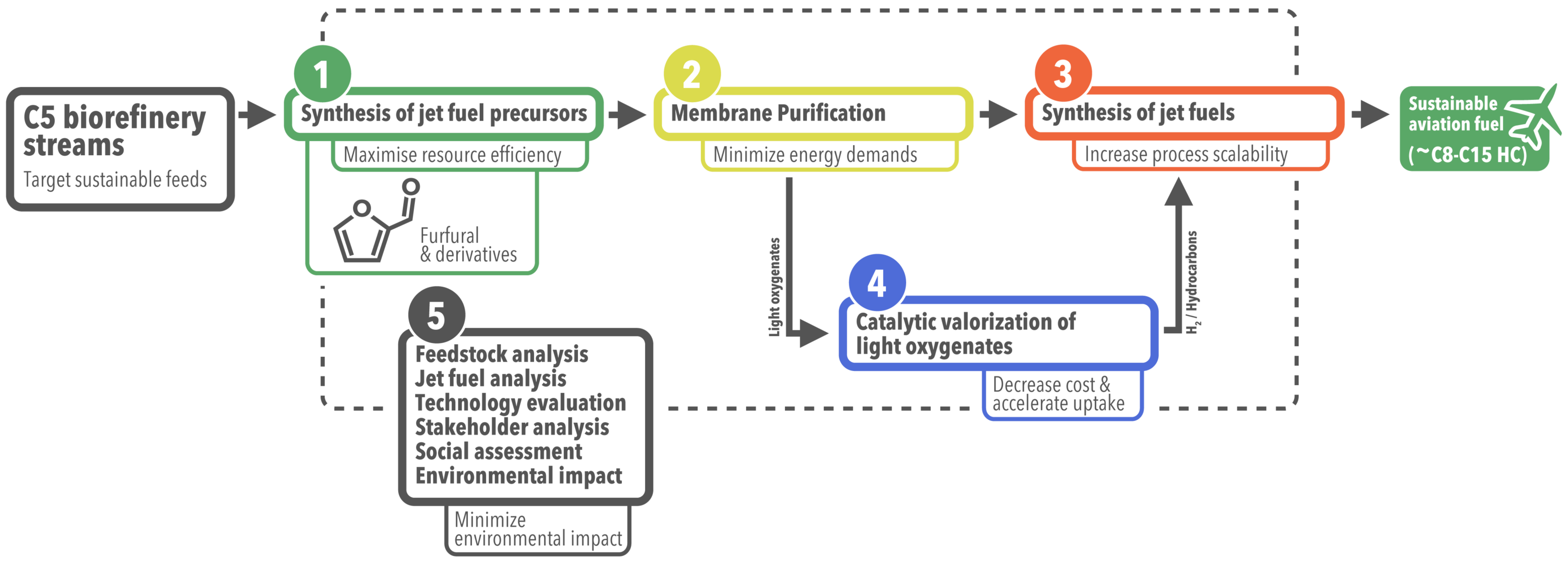
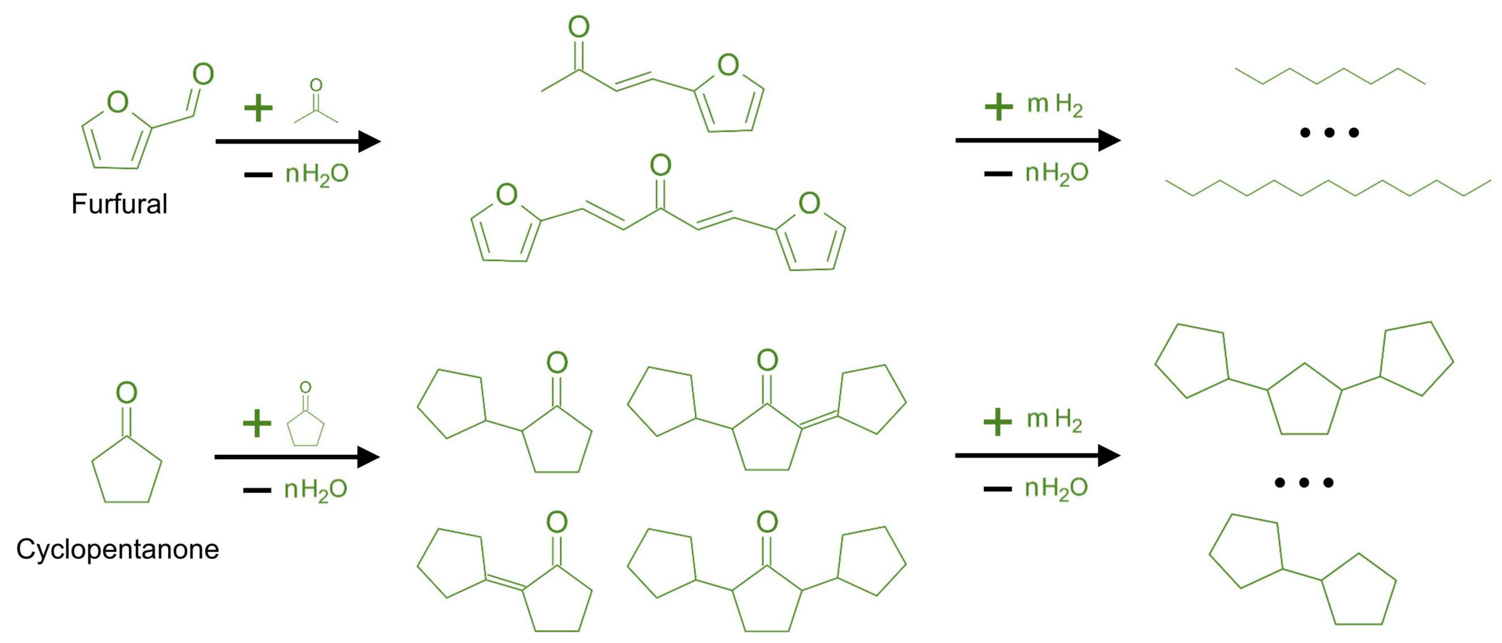
HIGFLY concept

European SAF demand is estimated to be 28 million tonnes by 2050 compared to the current 0.2 million tonnes of SAF produced today[1]. 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.



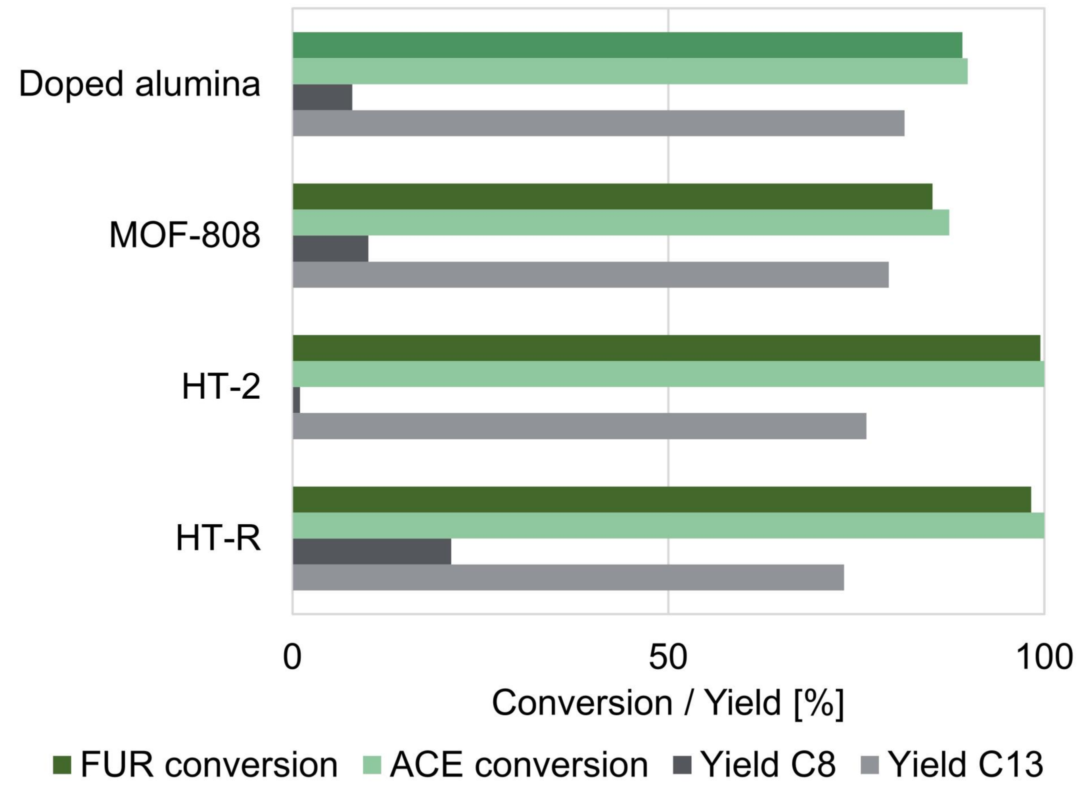
Step 1: Condensation Step 2: Hydrodeoxygenation



Jet fuel production routes

Furanic molecules have been investigated in aldol-condensation process at lab scale with other (potentially) bio-based molecules[2,3]. The concept is based on two steps: (1) catalytic condensation to intermediate oxygenated condensates and (2) hydrodeoxygenation to saturated hydrocarbons. Two routes are evaluated as part of the H2020 HIGFLY project, where we use (2G sugar-derived) furfural and acetone as cross-condensation agent, and (furfural-derived) cyclopentanone for self-condensation.

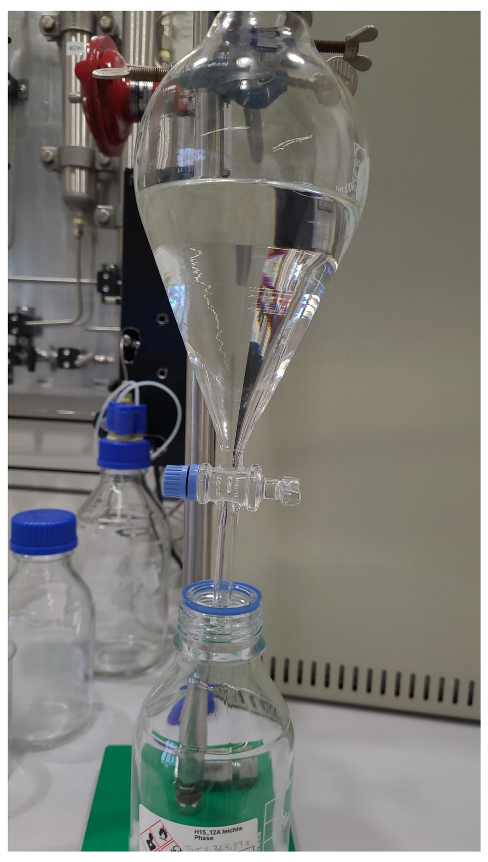
Catalyst performance for Furfural + Acetone condensation



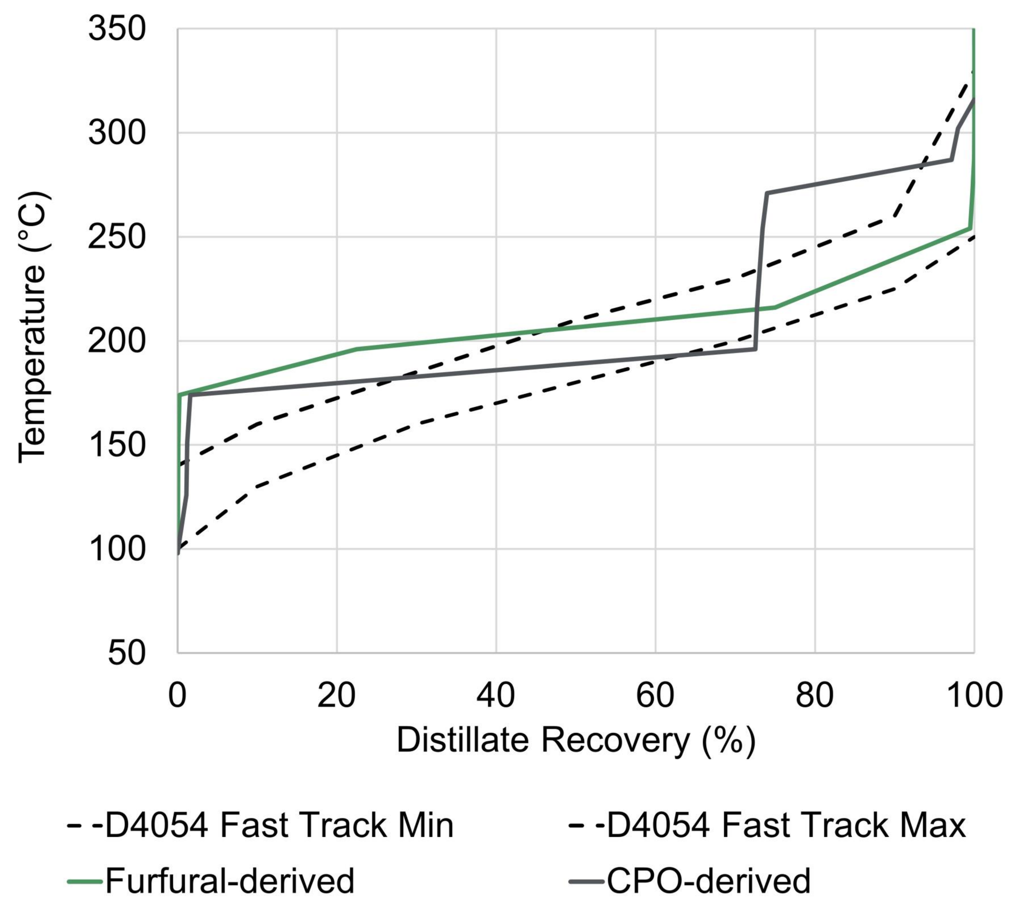
Process development

Our work focused on the development and selection of solid catalysts in particular for the condensation step and on the scalability of the process through testing in fixed bed reactors under continuous operation at lab scale. Commercial and developmental catalysts provided high conversions in the condensation steps [4]; however, catalyst deactivation due to carbon deposition was observed over time. Regeneration through calcination aided to reactivate materials and extend their lifetime.

Fuel sample after hydrodeoxygenation



Simulated distillation curve



Property	ASTM D7566 specification	Furfural-derived fuel	CPO-derived fuel
Carbon, % wt	-	84.3	86.6
Hydrogen, % wt	-	15.2	12.8
C+ H, % wt	99.5	99.5	99.4
Oxygen, % wt	-	0.30	0.78
H/C molar ratio	-	2.14	1.76
Water content, ppm	75	26.7	43.1
Freezing point, ºC	<-47 JetA1 <-40 JetA	-20.6	-84.5

Preliminary fuel properties & outlook

The two step processes were integrated to produce representative fuel samples through he HIGFLY concept. Carbon yields to liquid fuel were higher than 88% for the two routes. High fuel product yields are attainable through these routes; however, complete deoxygenation was challenging: the process at lab scale is not directly comparable with optimised processes at industrial scale, where larger and undiluted catalyst beds or series of multiple reactors can be integrated for attaining better heat control and carbon yields. Preliminary characterisation of the fuels indicates that high freezing point and/or the step-wise distillation behaviour may hinder the use of these fuel products in sustainable aviation. However, these issues can be further addressed through further optimisation of the downstream catalytic conversion (e.g. isomerisation) and the use of diverse set of fuel precursors.

References

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101006618
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