



Icarus Workshop Syngas to SAF

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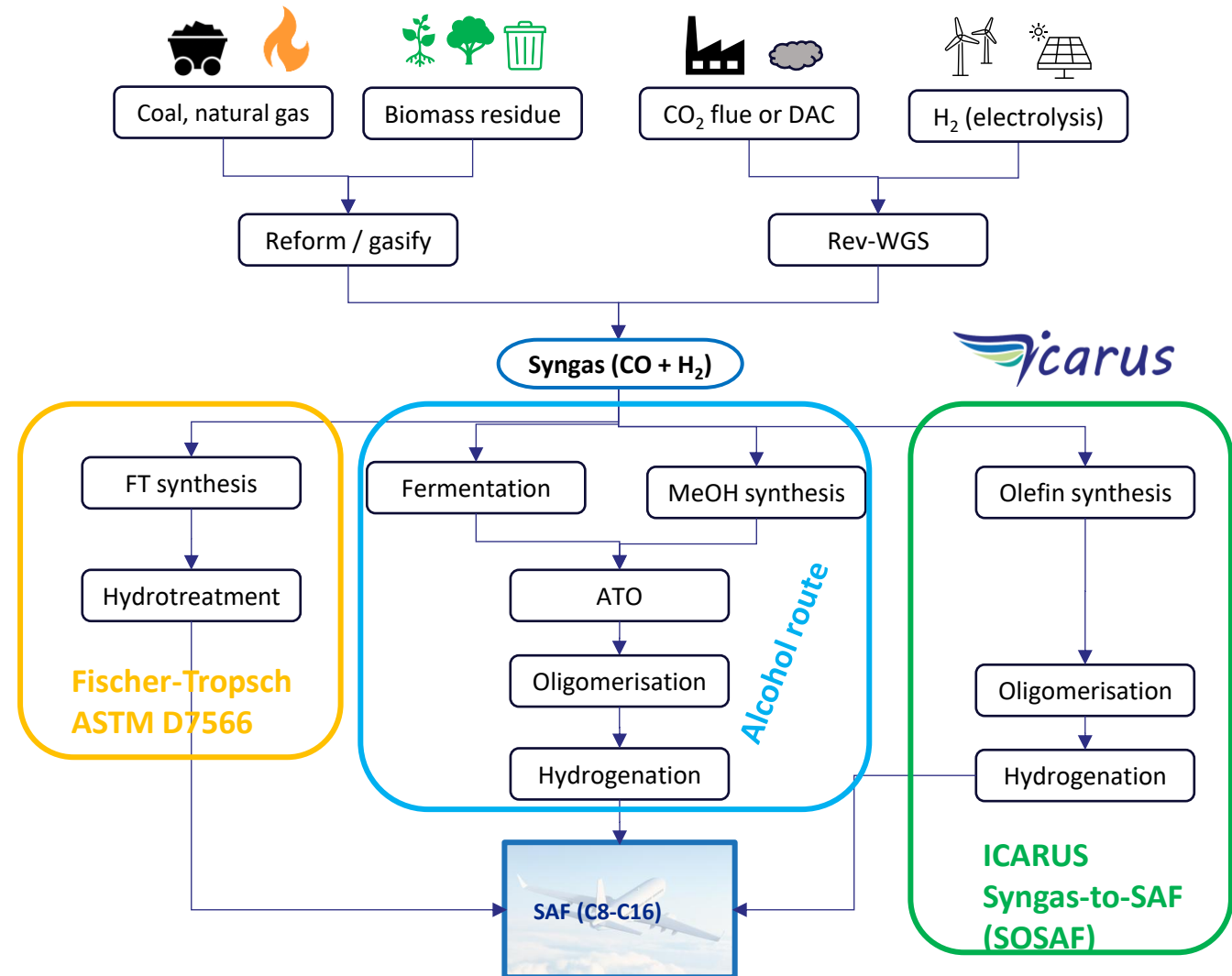
25th September 2026

End-Goal for Syngas to SAF

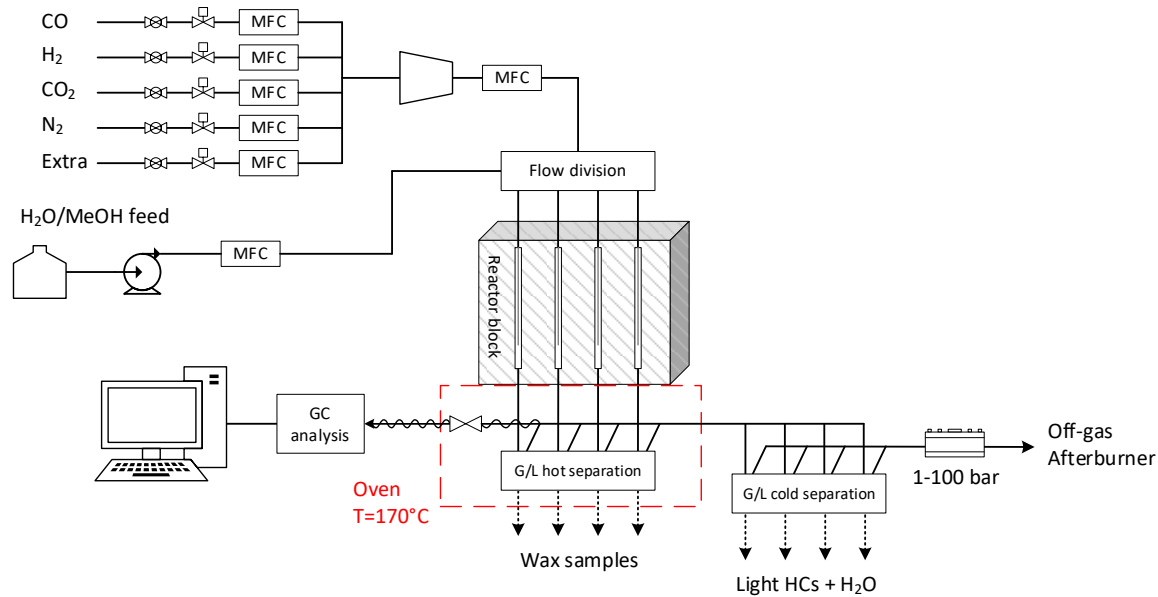
- Technology better fitted to smaller syngas producers
- Maximize liquid SAF product, CO-conversion and selectivity (less additional units needed)
- Minimize wax formation (reduction in upgrading units)
- Minimize C1 product (smaller recycle, less compressor duty)

Syngas-to-SAF overview

- Fischer-Tropsch ASTM D7566 approved
 - Large scale, still fossil based, SAF as co-product
- MeOH route MtJ ASTM approved (as of July 2026)
 - Exxon/UOP/Topsoe in lead
 - MeOH and MeOH-to-olefins established processes
 - Oligomerisation of C₂-C₃ olefins challenging compared to higher olefins (still low TRL to SAF)
- Direct olefin synthesis intermediary system identified as promising
 - Direct olefins from syngas
 - Low C₂-C₃ olefins for more facile oligomerisation



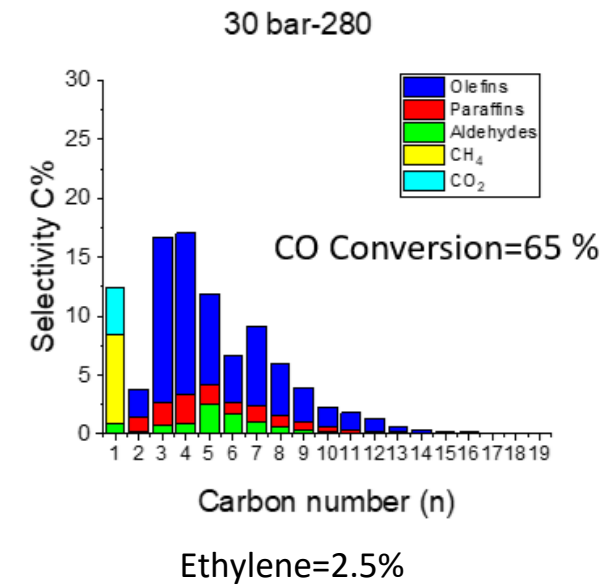
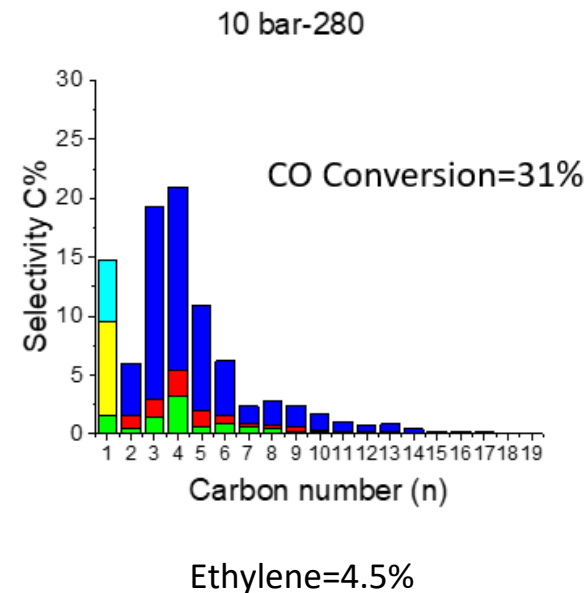
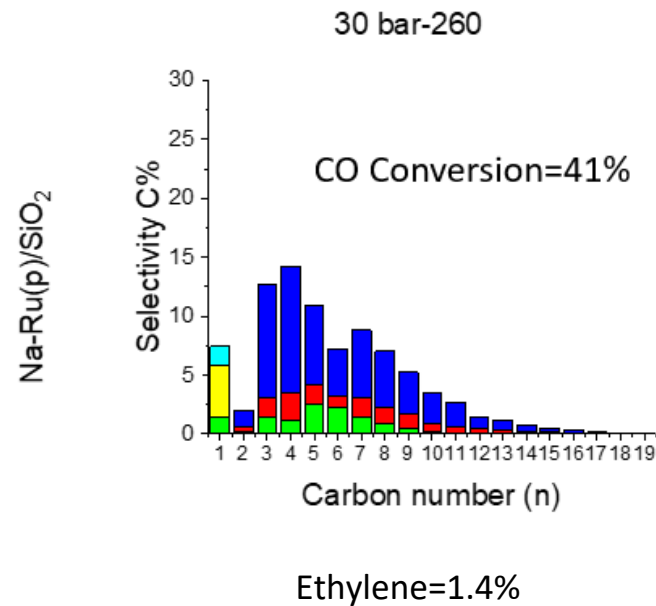
Reactor system applied in syngas-to-olefins



- 4 isothermal fixed bed (FT) reactors, ca. 1.5 g catalyst per reactor. Up to 100 bar, 600 °C, 4-200 g/h gas.
- **Determination of product HC distribution C_1 - C_x**
 - Online GC hot gas analysis (calibrated for syngas and C₁-C₆, incl. alcohols olefins)
 - Collected liquid product offline GC-MS/FID, HPLC, other physicochemical
- Initial catalyst testing included Mixed oxide OX-ZEO, confined Co NPs, and Ru-based systems
 - **Ru-based syngas-to-olefin superior in terms of productivity (CO conv. x C-Selectivity)**

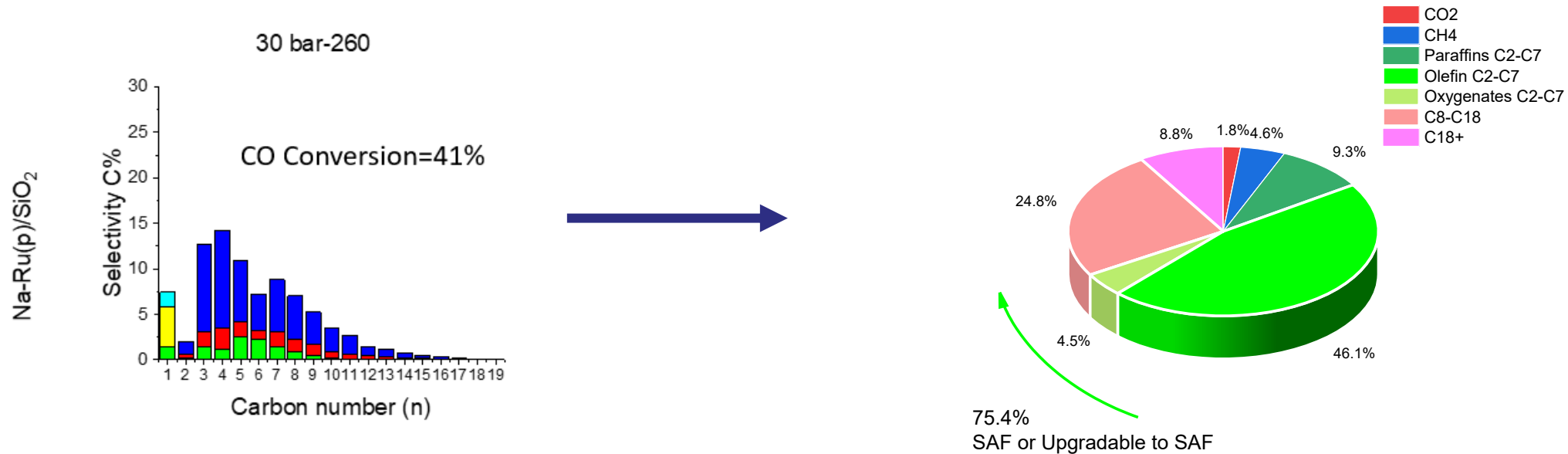
STO (Na-Ru) product distribution

- The Na-Ru / SiO₂ catalysed STO results
 - Up to 75 C% selectivity to olefins (especially C₃-C₆) at 60% conversion
 - Little CO₂ and CH₄ and ethylene formation
 - High potential for SAF production through oligomerization



STO (Na-Ru) product distribution

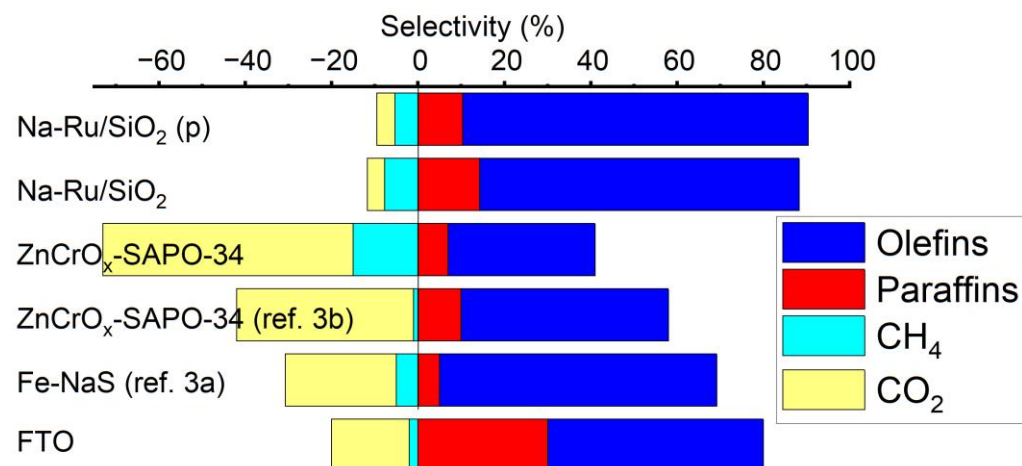
- Main by-products are aldehydes (hydroformylation) and minor acids
 - Room for improvement, good enough for proceeding



*Patent by Haldor Topsøe A/S-WO2022063994A1 –stream of olefin and oxygenates can be upgraded to jet fuel.

STO compared

- Selectivity comparison between the different syngas-to-olefin catalytic systems
- Na-Ru demonstrates high olefin selectivity at low WGS and C_1 formation
 - Additionally higher olefin production ideal for acid-catalysed oligom. to SAF



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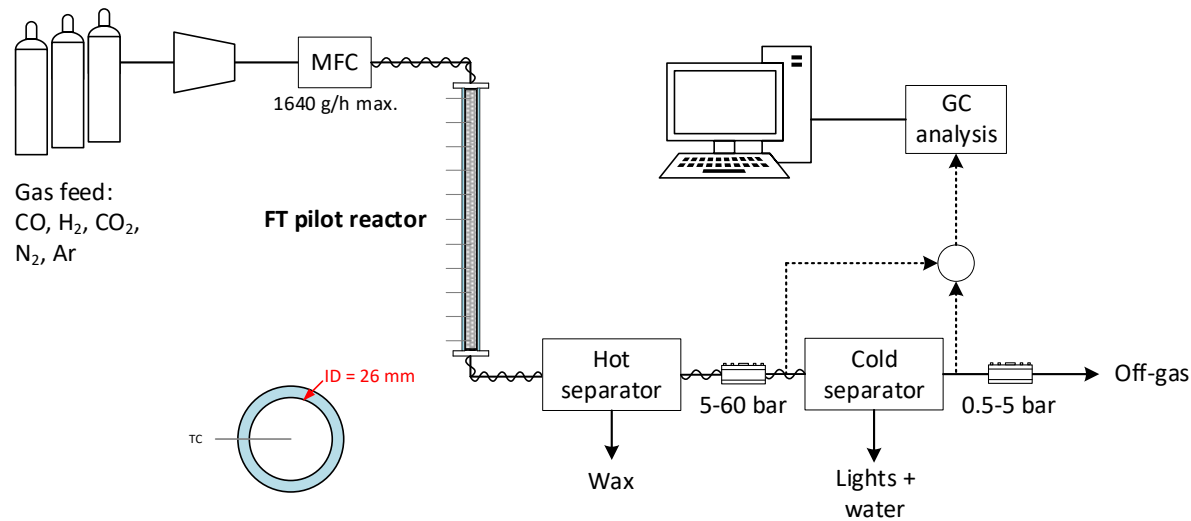
Optimization of Sustainable Aviation Fuel Production through Experiment-Driven Modeling of Acid-Catalyzed Oligomerization

Florent J. Dubray, Vladimir Paunovic, and Jeroen A. van Bokhoven*

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"To maximize SAF-range products, a feed composed of C_4 and C_5 olefins is most desirable, while controlled C_3 , C_6 , and C_7 olefin cofeeding and C_4/C_5 olefin feed ratio are required to finely tune the SAF product composition."

Scale-up to TRL-5 (mini-)pilot



Aim: 50+% CO conversion

Produce light (C3-C7) and heavy (C8-C16) olefins

Conditions: 500-700 g catalyst pellets (with diluent),
1000 NL/h syngas, 260 °C, 30 bar, 48h+



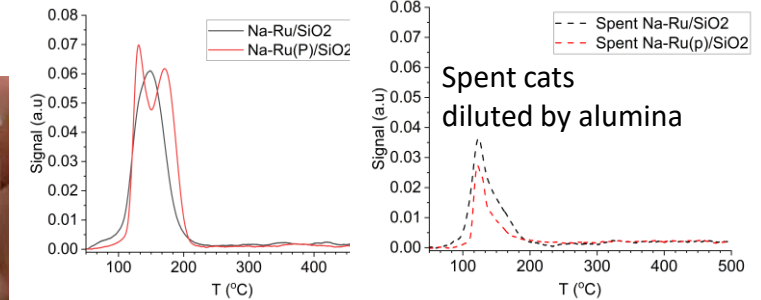
- Wall-cooled fixed-bed reactor
- 11 axial thermocouples
- L = 2.5 m, ID = 26 mm, max 350 °C, 100 barg and 1700 NL/h

Scale-up

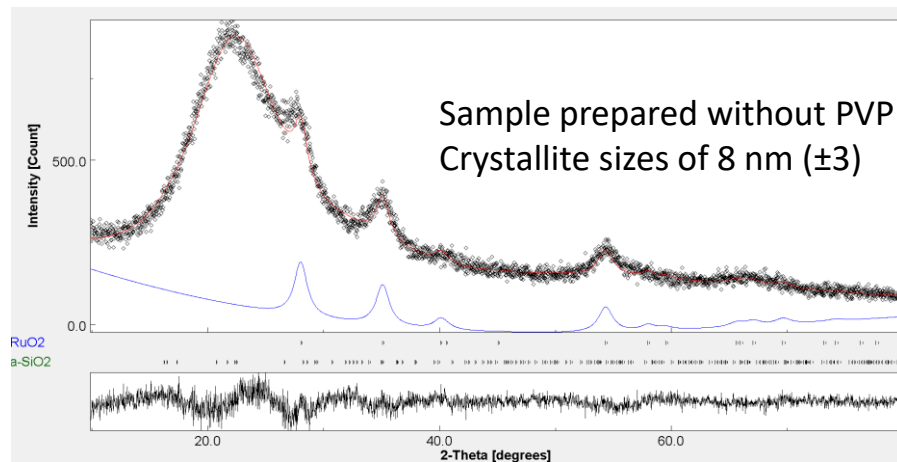
- Prepare catalyst on 700 g scale in pellet form ongoing (EHU/TNO)



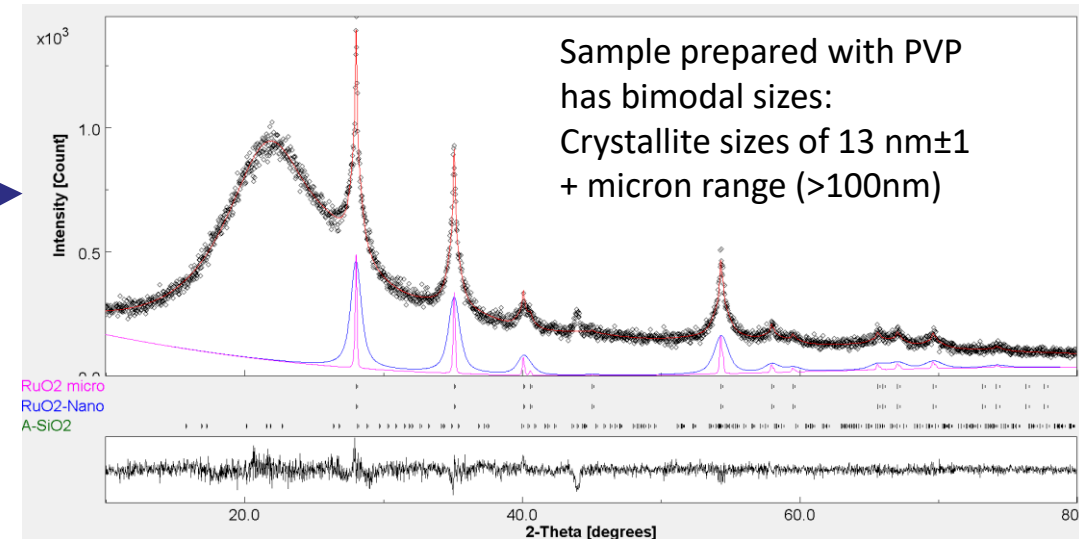
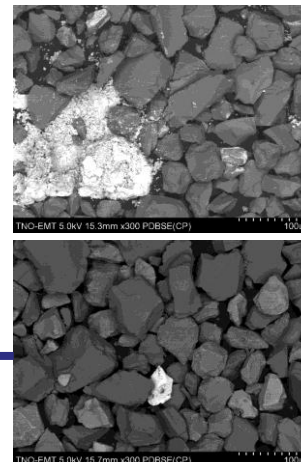
H₂-TPR



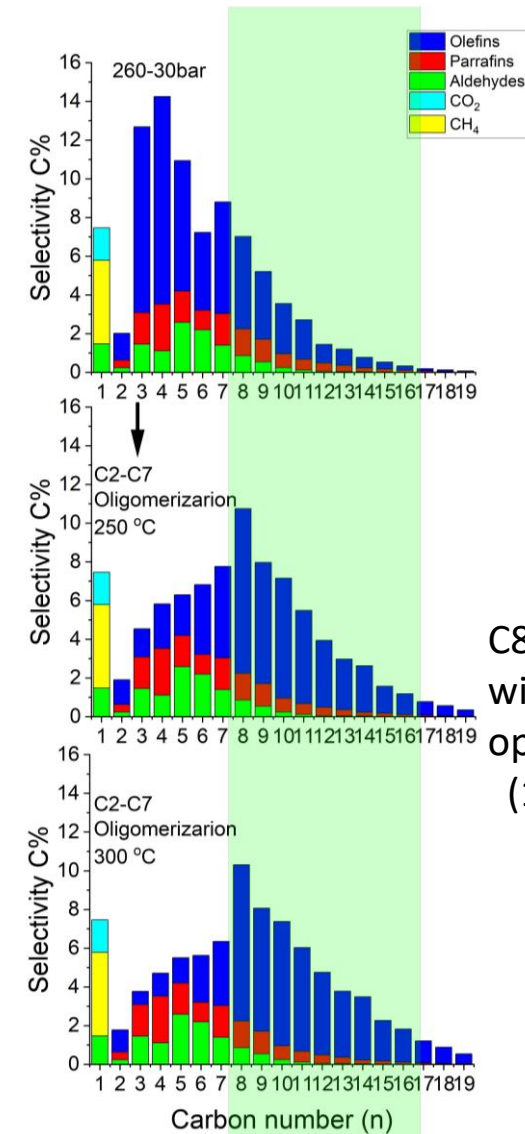
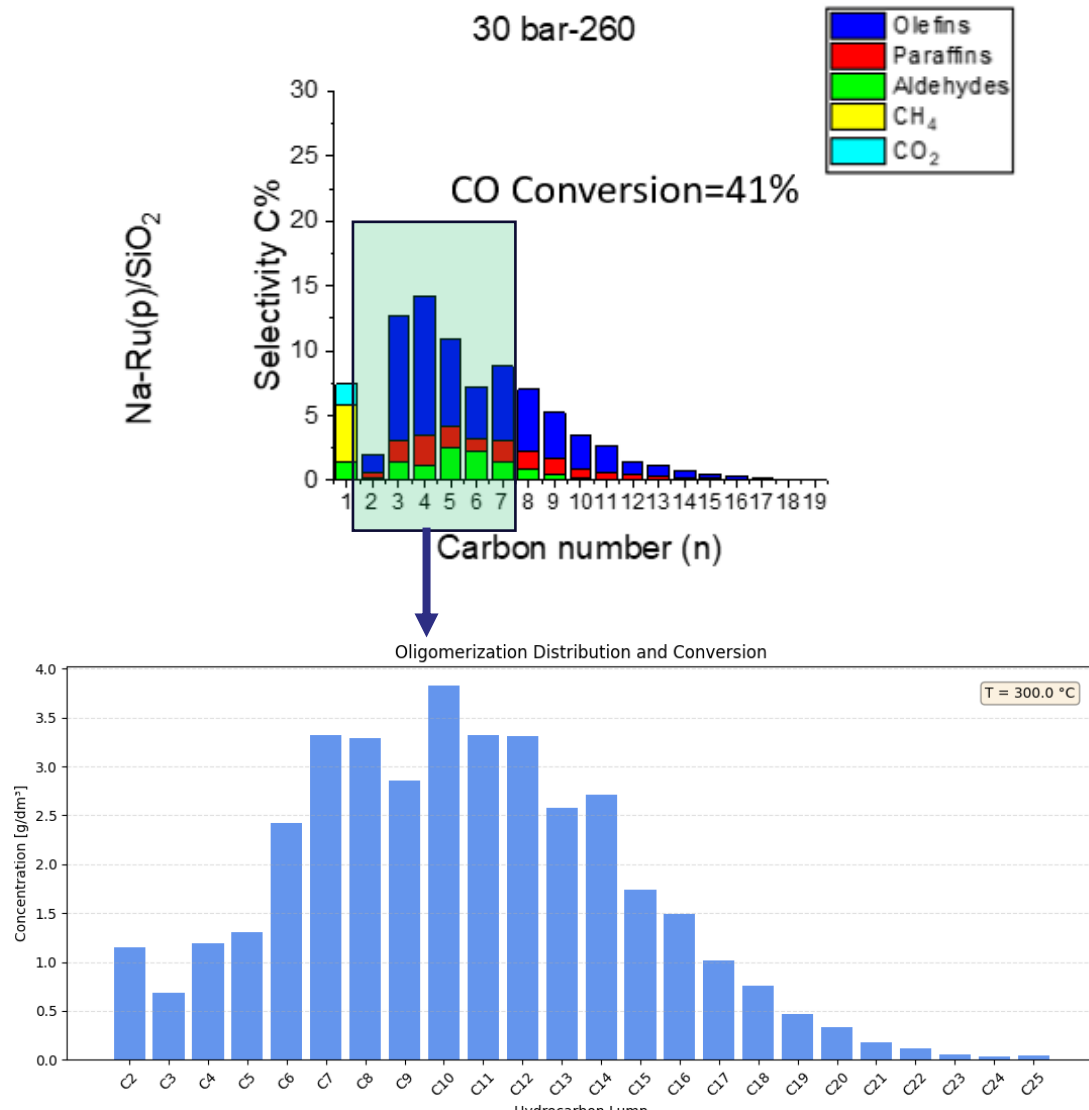
TOS change Ru status!



Back scattered FE-SEM
Bright Parts=Ru rich



Dubray prediction based on C₂-C₇



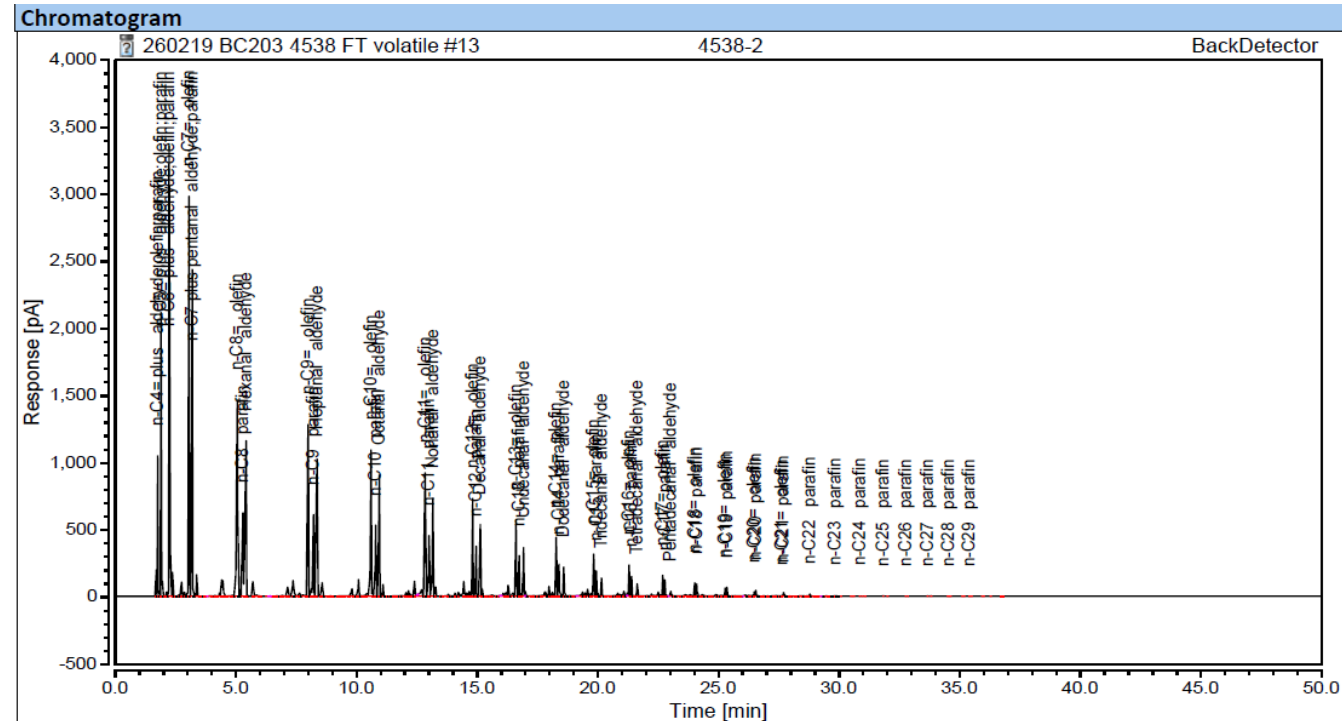
C8-C16 selectivity=65%
without recycle and
optimization
(1 step oligomerization)

- Oligomerization product mainly determined by feed composition
- Two step/Sequential oligomerization and recycling of light olefins from outlet is necessary to get high selectivity to SAF

Produced liquid (SAF precursor)



2 L of liquid produced
(Olefin-rich SAF precursor)



Preliminary GC-FID results

- Composition 100% C5+, olefin, paraffin, aldehyde
- Less than 1 wt% C19+

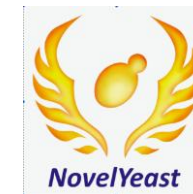
Overall conclusions

- SOSAF origin: screening of potential syngas-to-SAF routes based on %C
 - Over 65% carbon conversion in a single pass – still room for improvement
 - High selectivity towards olefins – excellent to obtain branching in SAF
 - Limited CO₂ and CH₄ formation and also limited ethylene
 - Less than 1% wax formed
- SOSAF catalyst validated at TRL 5 maintaining its good performance
- SOSAF scale up via intermediate steps possible, Green Gasoline, Surfactants, Chemicals and/or Plastics

Thank you



Partners



Associated Partners



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