CIRCULAIR

DROP-IN FUELS FROM MANURE AND STRAW HTL: A SCALABLE STRATEGY FOR UPGRADING RAW BIOCRUDES WITH HIGH SOLID AND OXYGEN CONTENT

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Funded by
the European Union

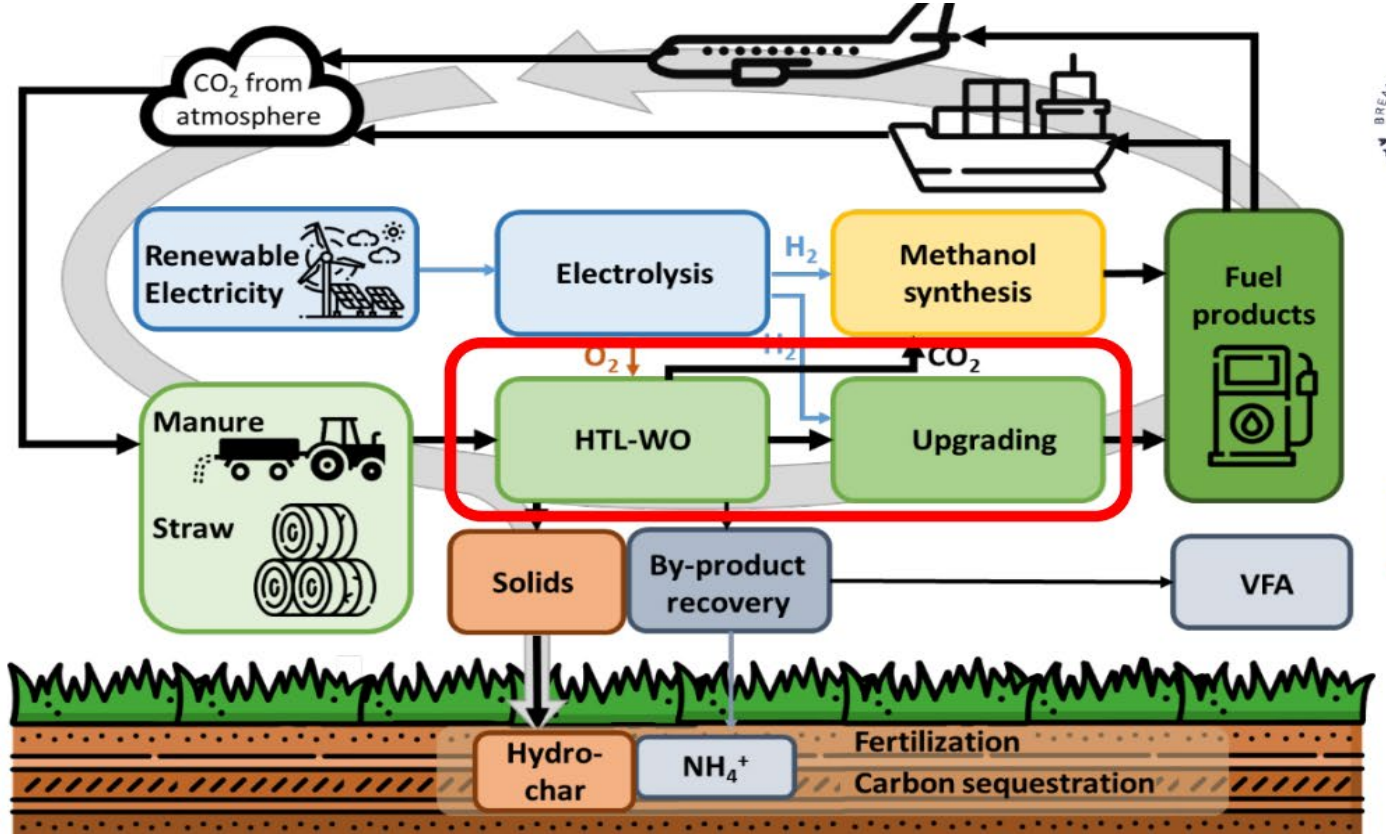
CONTENTS

CIRCULAIR CONCEPT

CIRCULAIR- Funded by the European union, Duration from the year 2023 – 2026

Objectives:

A cost-effective pathway to produce high-spec jet fuel from HTL biocrudes, enabling full biomass utilization and carbon-negative transportation fuels.



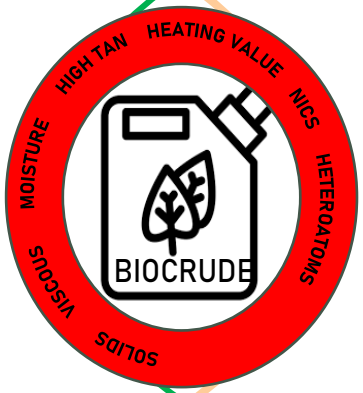
HTL BIOCRUDE CHALLENGES

AARHUS UNIVERSITY

AALBORG UNIVERSITY

(1:1)WHEAT STRAW- COW MANURE

HTL PROCESS



HYDROTREATMENT

Resemble "Oil Sands"

FROM BIOCRUDE TO JET FUEL: MY PHD RESEARCH

STEP I: SOLVENT EXTRACTION

STEP II: DEMINERALIZATION

STEP III: HYDROTREATMENT

- Use of solvents for solid separation
- Acid/Sorbent washings for the removal of inorganics
- Introduction of ”multi-step process” to stabilize biocrude
- Application of selective catalyst targeting O and N removal during hydrotreating
- Ensuring minimal carbon loss.

STEP I- SOLVENT EXTRACTION

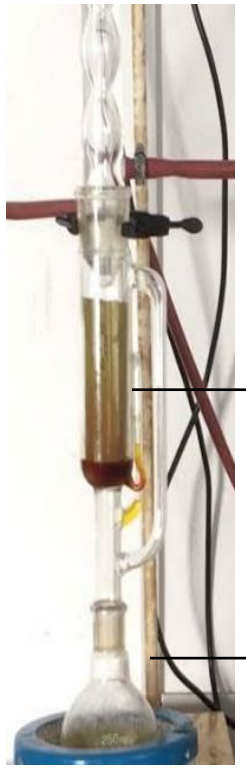
Solvent extraction is crucial for refining HTL biocrude, enhancing its quality and yield.

Small-scale: Soxhlet extraction (20 g)

Large- scale: (4 kg)

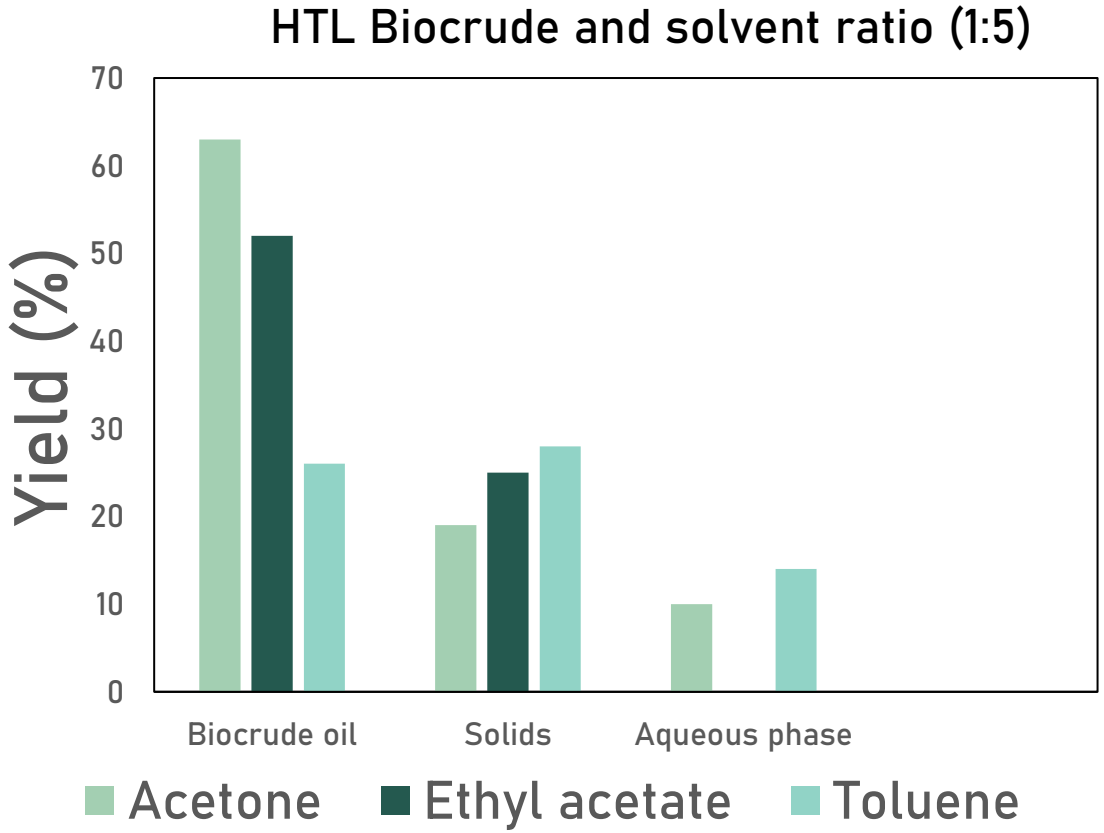
STEP I- SMALL SCALE SOLVENT EXTRACTION

Soxhlet method: experimental results



Biocrude
straw:manure
(1:1)

SOLVENTS
- Acetone
- Ethyl Acetate
- Toluene



Acetone > Ethyl acetate > Toluene

STEP I- LARGE SCALE SOLVENT EXTRACTION

PHASE SEPARATION

ACETONE

RAW HTL BIOCRUDE

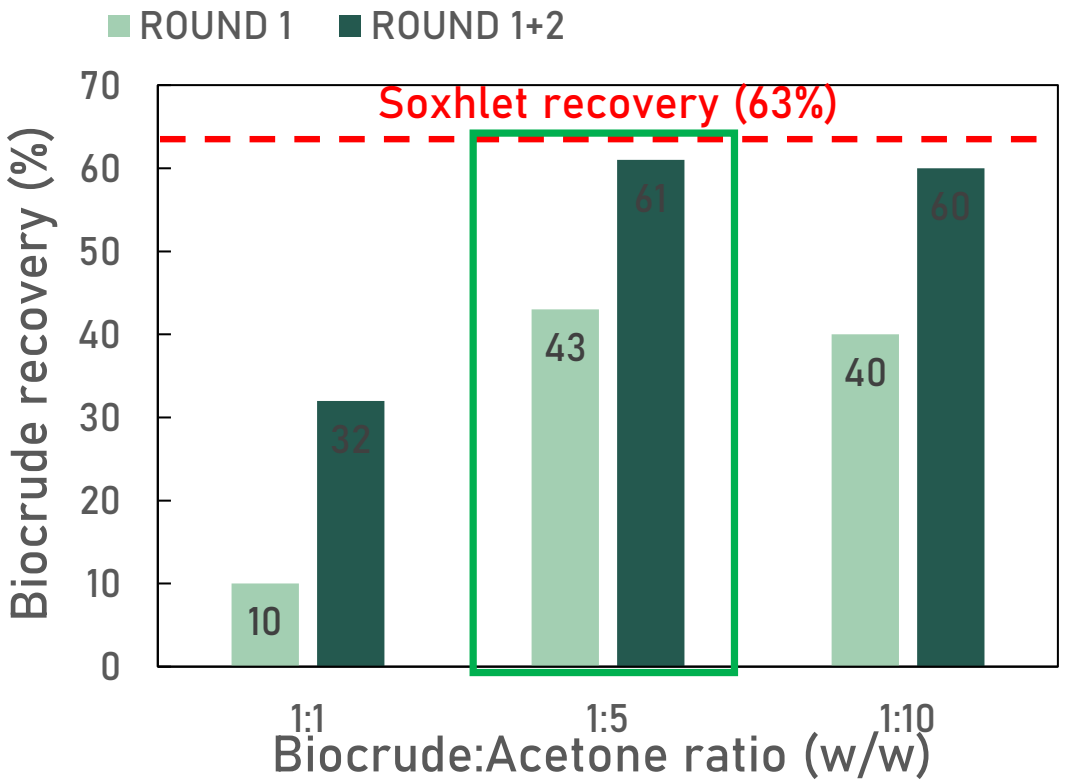
ASH: 1.98%

EVAPORATION OF ACETONE

PRETREATED BIOCRUDE OIL

ASH: 0.3%

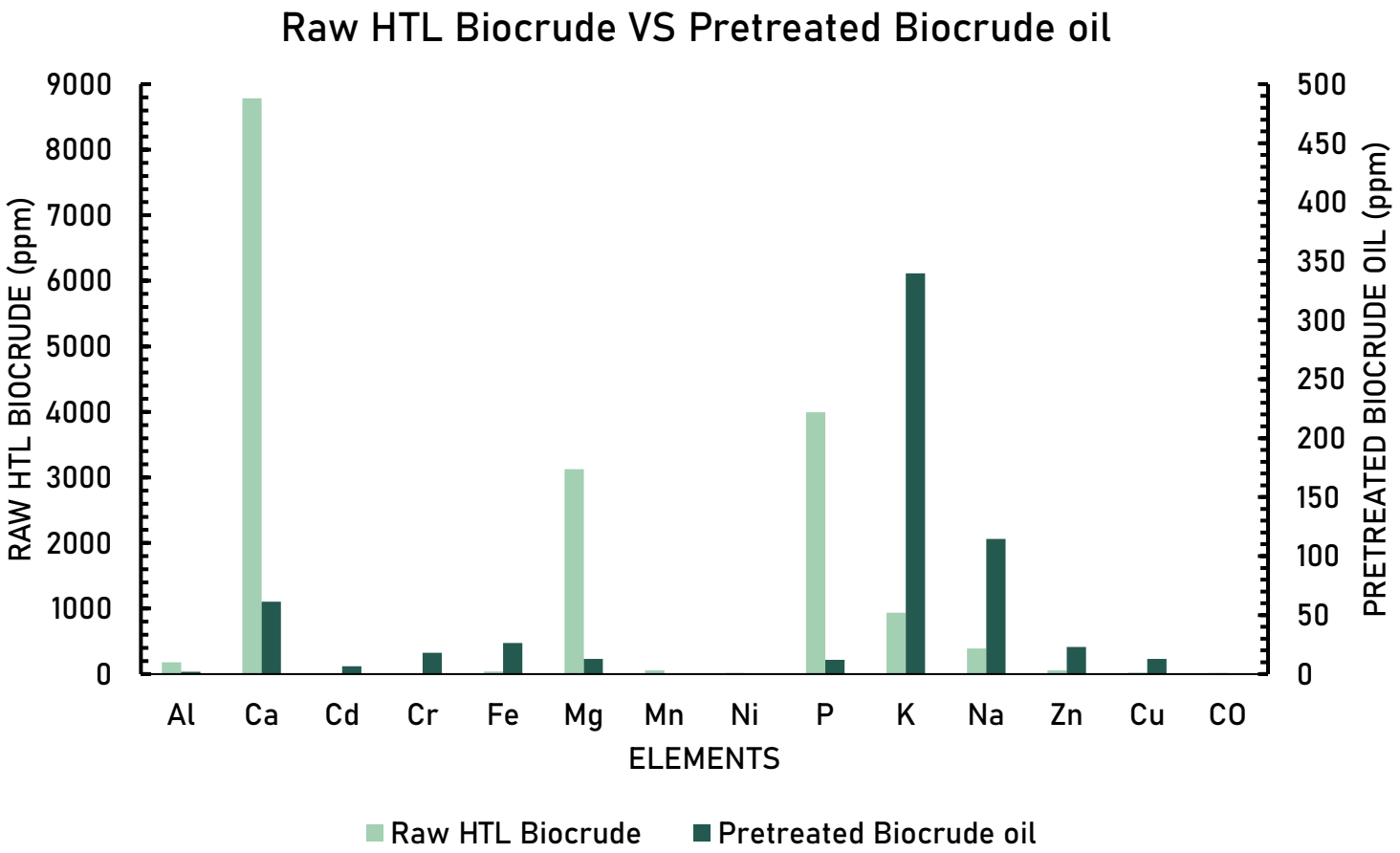
SOLIDS & AQUEOUS PHASE REMOVED



0.3% : still high !!

STEP I: INORGANICS BEFORE AND AFTER SOLVENT EXTRACTION

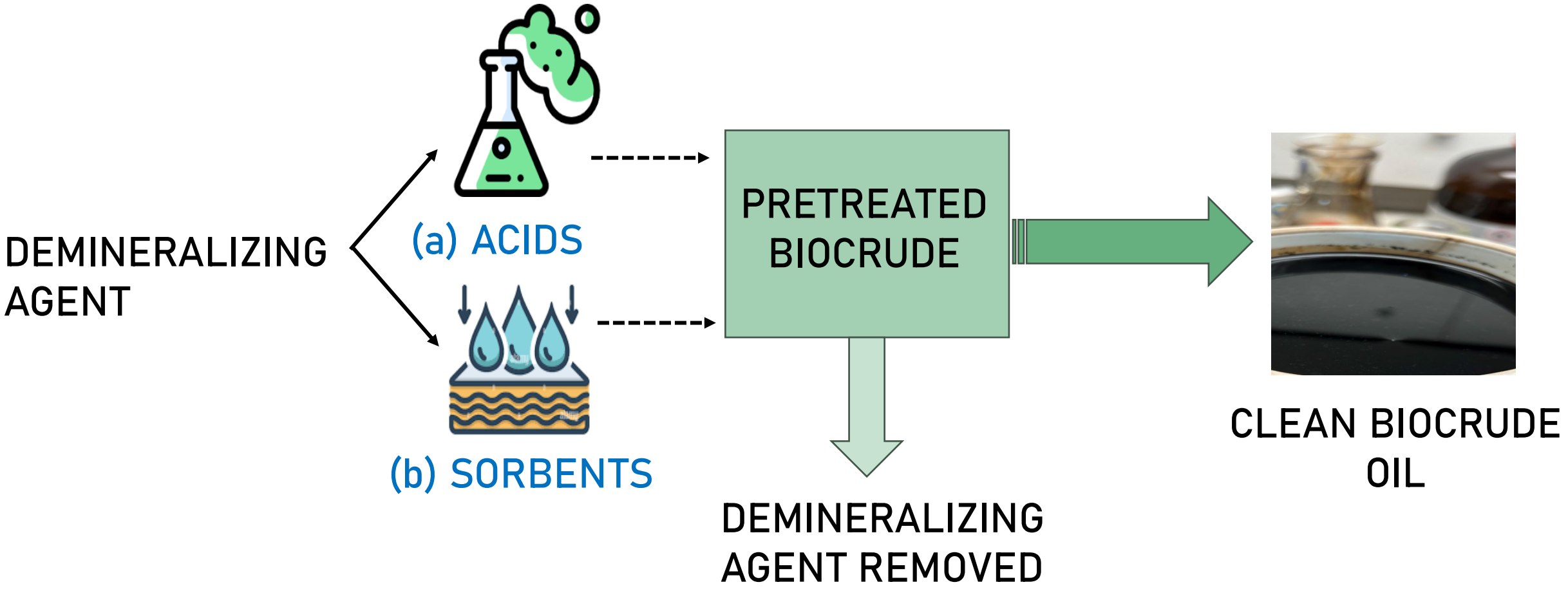
ICP analysis was carried out for raw HTL Biocrude and pretreated biocrude oil



PROPERITIES OF PRETREATED BIOCRUDE OIL

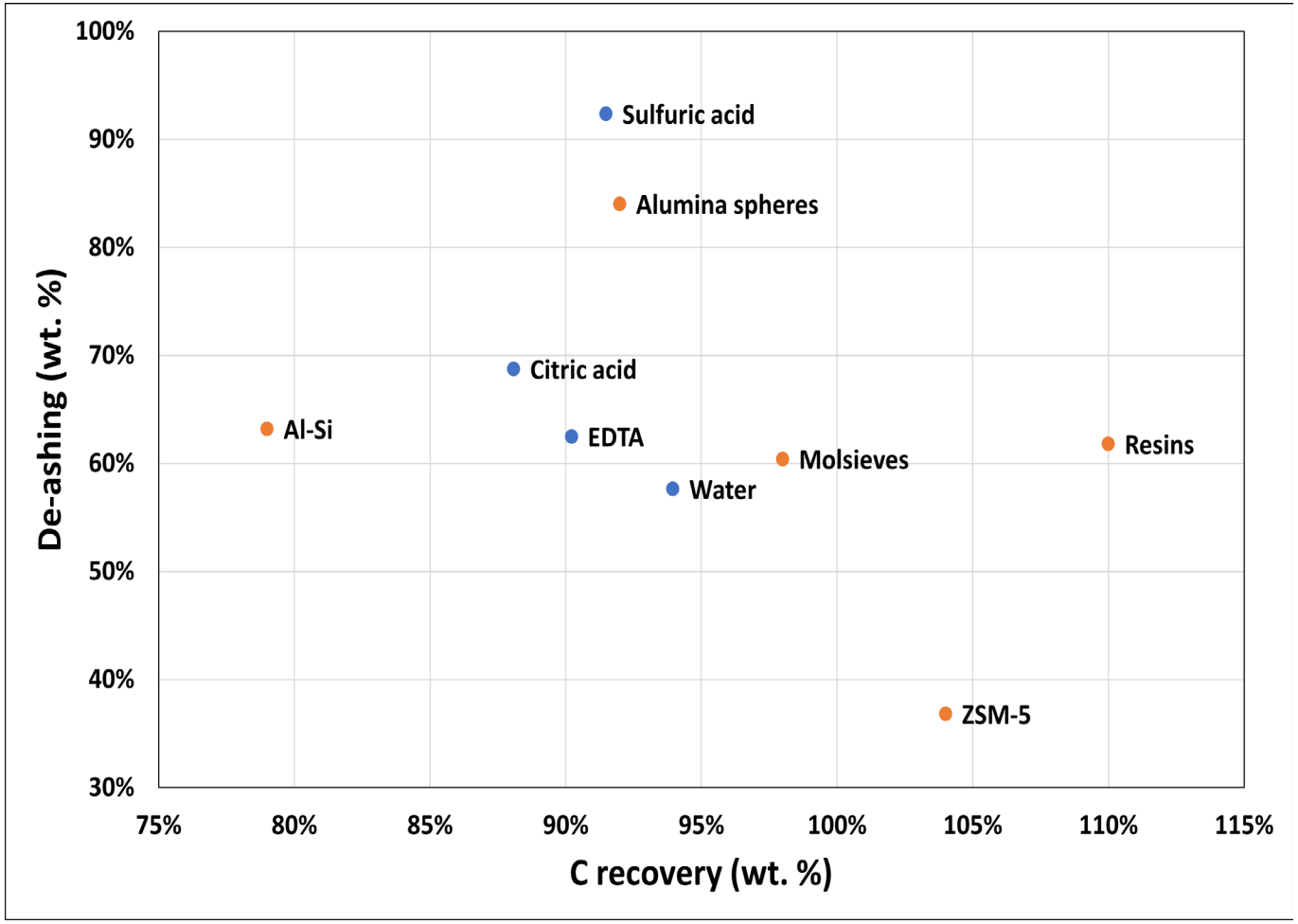
Property	Value
Ash content (ppm)	3000
Water content (%)	3
C (%)	70.1
H (%)	7.6
N (%)	2.3
*O (%)	20
HHV (MJ/kg)	30.9

STEP II- REMOVAL OF INORGANICS



STEP II- REMOVAL OF INORGANICS: EXPERIMENTAL DATA

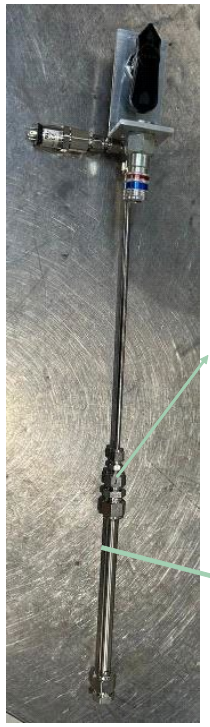
ACID AND SORBENT WASHING @ 50°C



CONTENTS	ACID WASH	SORBENT WASH
Carbon loss	High 	Low
Ash removal	Sulphuric acid (93%)	Alumina (85%)

Necessary optimization needed to lower ash content !!

STEP III- HYDROTREATING THE PRETREATED BIOCRUDE OIL



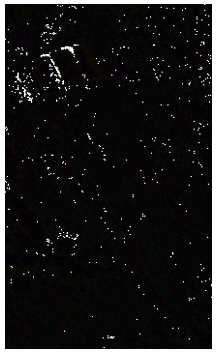
PRE -TREATED BIOCRUDE

80 bar H_2

SULFIDED -NiMo Al_2O_3 CATALYST

REACTION SOLIDS

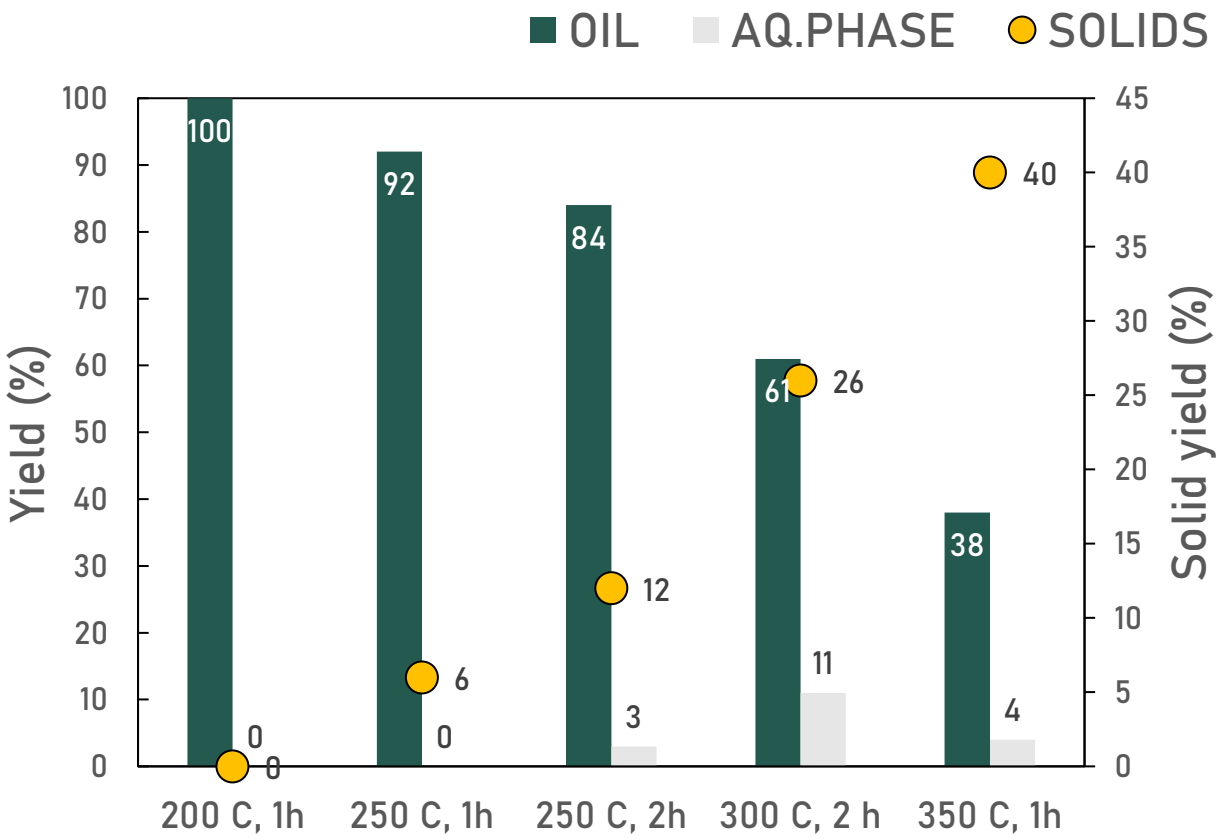
AQUEOUS PHASE



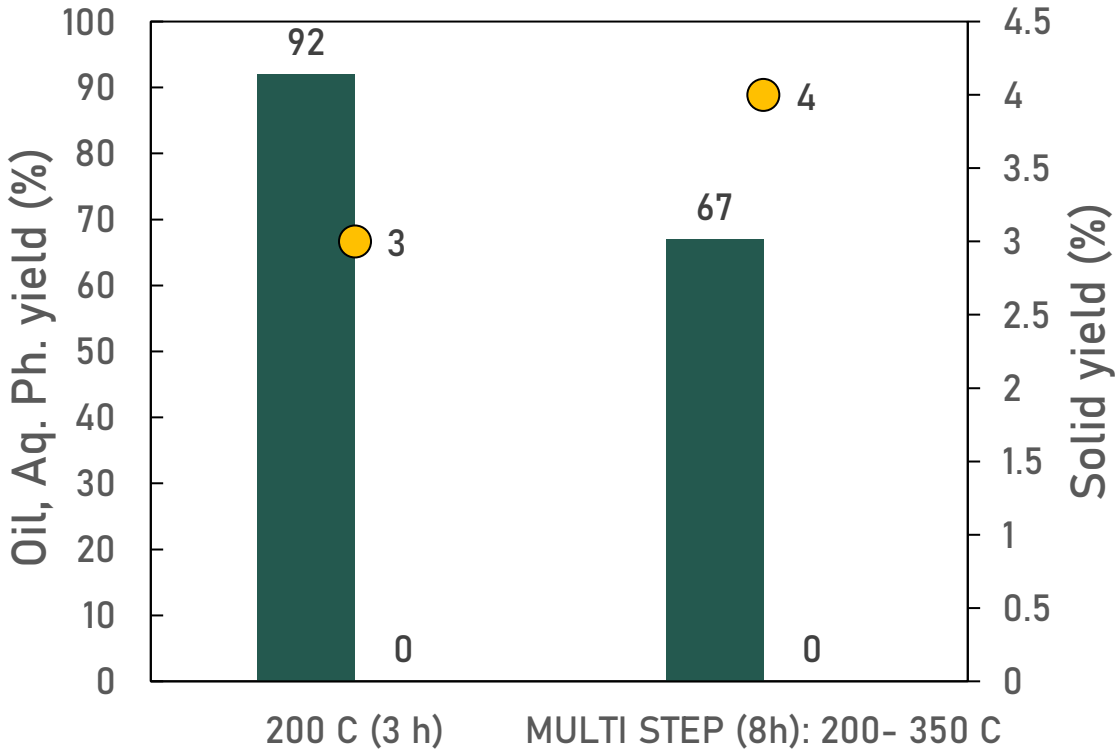
UPGRADED OIL

STEP III: STABILIZATION OF HIGHLY UNSTABLE OIL

Catalyst-to-Biocrude (1:2)

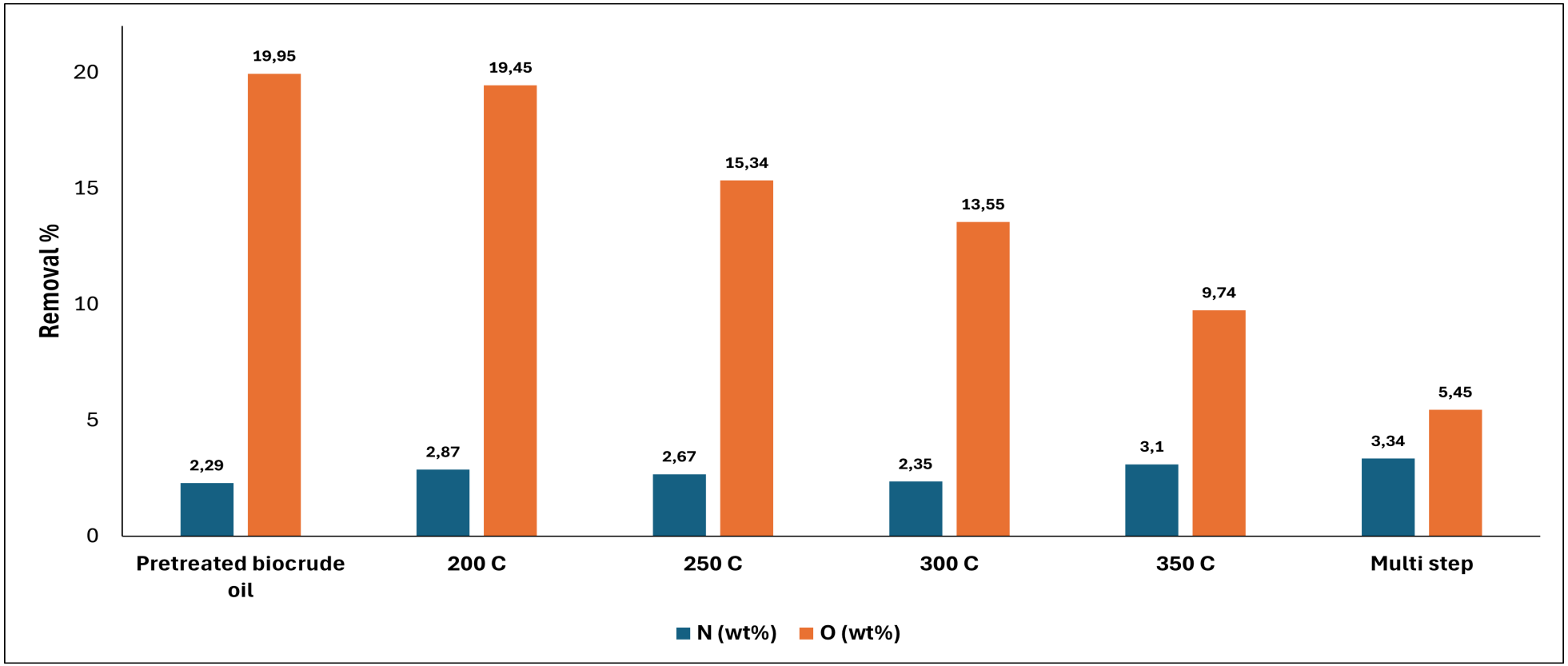


Excessive Solid Formation



Stabilizes the oil; preventing excess solid formation

STEP III- HYDROTREATED BIOCRUDE: RESULTS



Higher temperature increases the removal of oxygen

CONCLUSION

- Step 1: Acetone extracted the maximum oil from raw HTL biocrude
- Step 2: Pretreatment for inorganic removal reduced levels from 3000 to 500 ppm via acid wash (0.1 M Sulphuric acid) with 9% carbon loss, while sorbent treatment (alumina spheres) reduced them to 1150 ppm with only 2% carbon loss.
- Step 3: A multi-step approach stabilized the oil during hydrotreatment; high temperature reduced oxygen content significantly (from 20 to 4 wt%) but did not affect nitrogen levels.

FUTURE WORK

- To work on adsorbent for complete removal of inorganics and heteroatoms prior to hydrotreating process
- Introduction of catalyst for the removal of nitrogen from oil at lower temperature

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Thank you

Bauhaus Luftfahrt
The Aviation Think Tank

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