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UPGRADING OF SEWAGE SLUDGE DERIVED PYROLYSIS OIL TO SUSTAINABLE AVIATION FUEL

Innovation Fund Denmark

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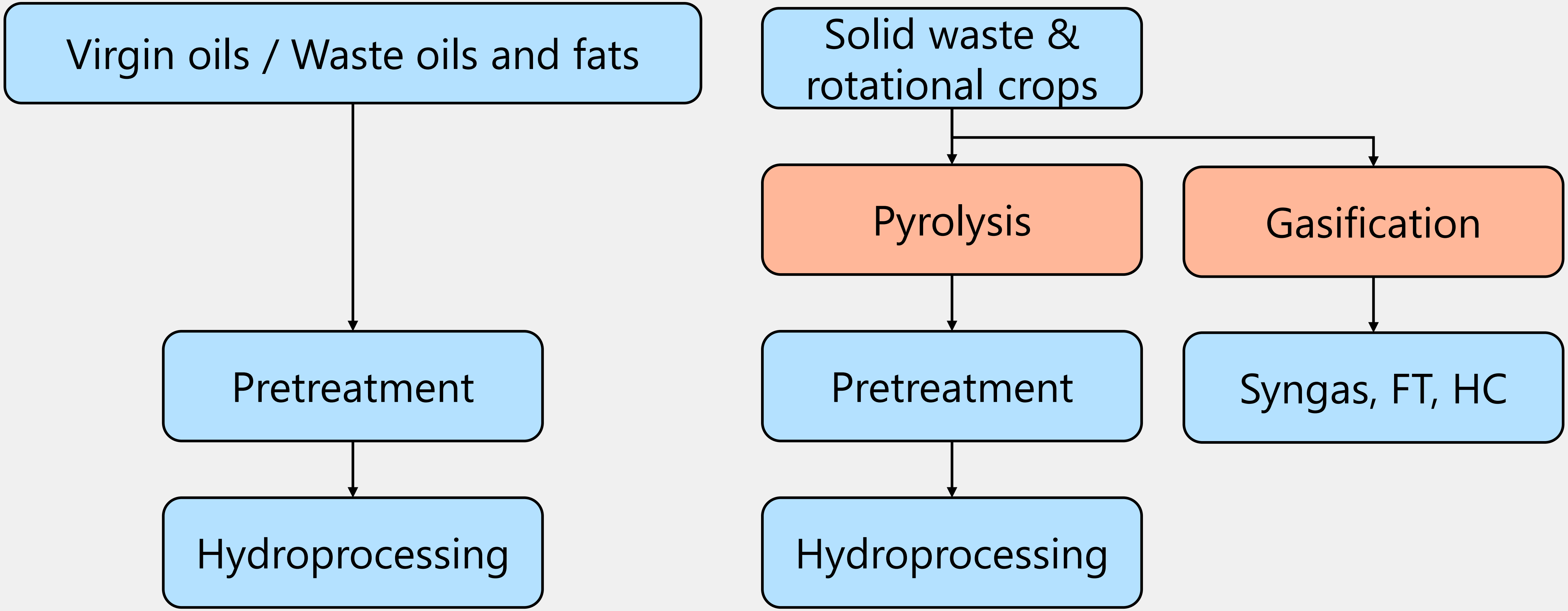
UPGRADING OF VARIOUS TYPES OF BIO FEEDSTOCKS



BIO CRUDE COMPOSITION – AN EXAMPLE

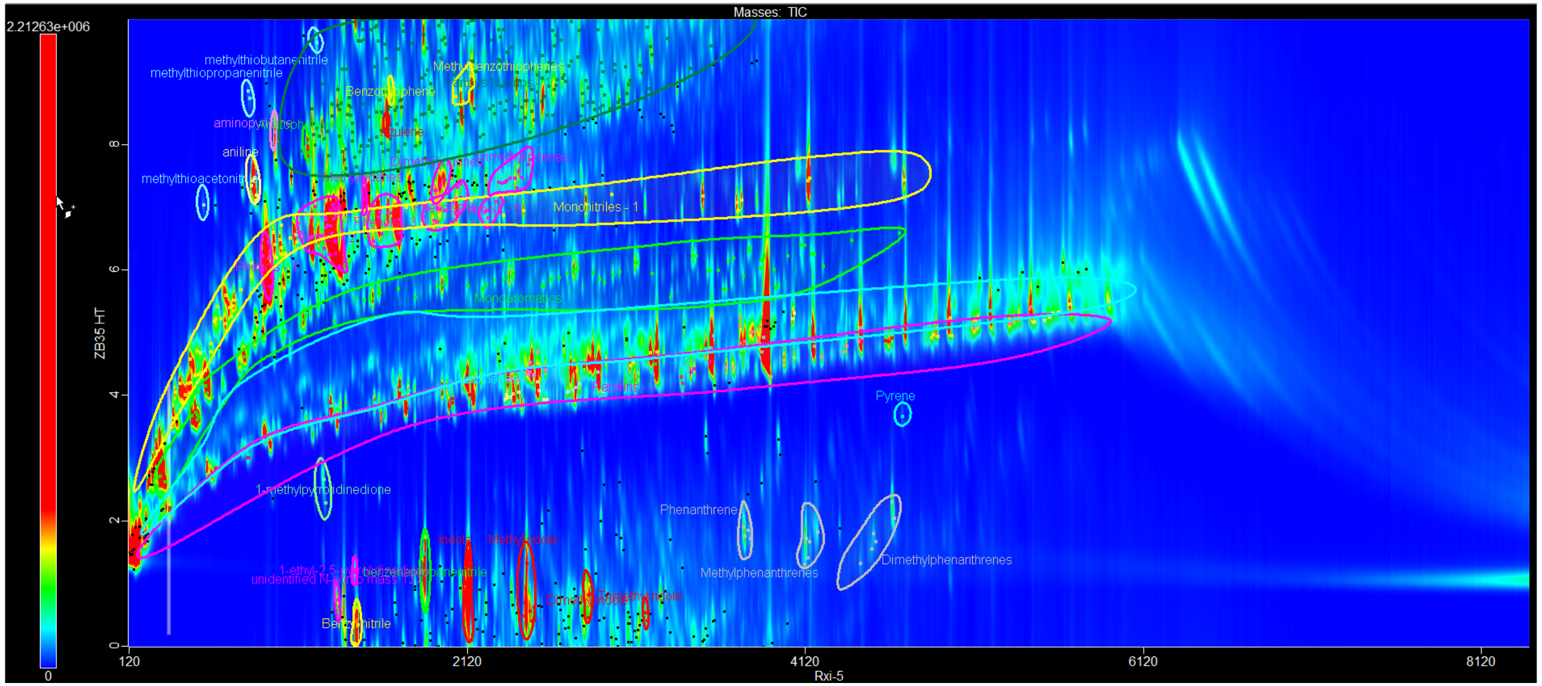
	Soybean oil	Crude Tall oil	Sewage sludge derived PO oil	High quality jet
C, wt%	77.35	77.44	75.42	84.7
H, wt%	11.55	11.21	8.80	15.3
H/C atomic ratio	1.79	1.73	1.40	2.15
O, wt %	11.10	10.95	6.30	-
S, wt ppm	1	370	7,800	-
N, wt ppm	2	44	86,500	-
Others, wt ppm	<2	<5	~500	-

PROPERTIES OF SEWAGE SLUDGE DERIVED BIOCRUDE

Slow pyrolysis process for converting sewage sludge to biocrude

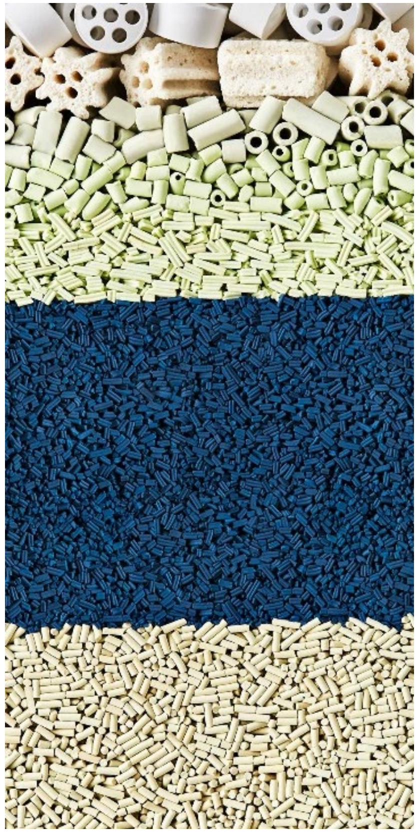
Typical properties of biocrude

Element	wt%
C, wt%	75.4
H, wt%	8.8
N, wt%	8.7
S, wt%	0.8
O, wt%	6.3

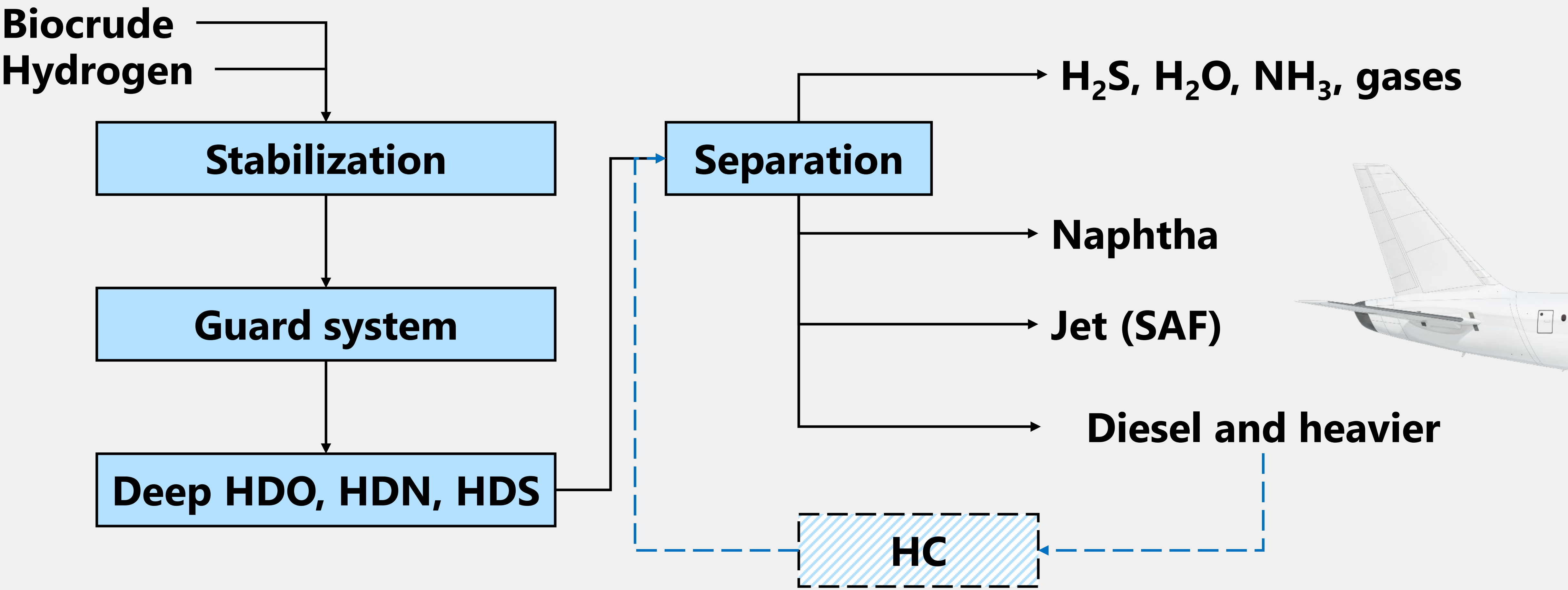


CONTAMINANTS: SEWAGE SLUDGE DERIVED BIOCRUDE

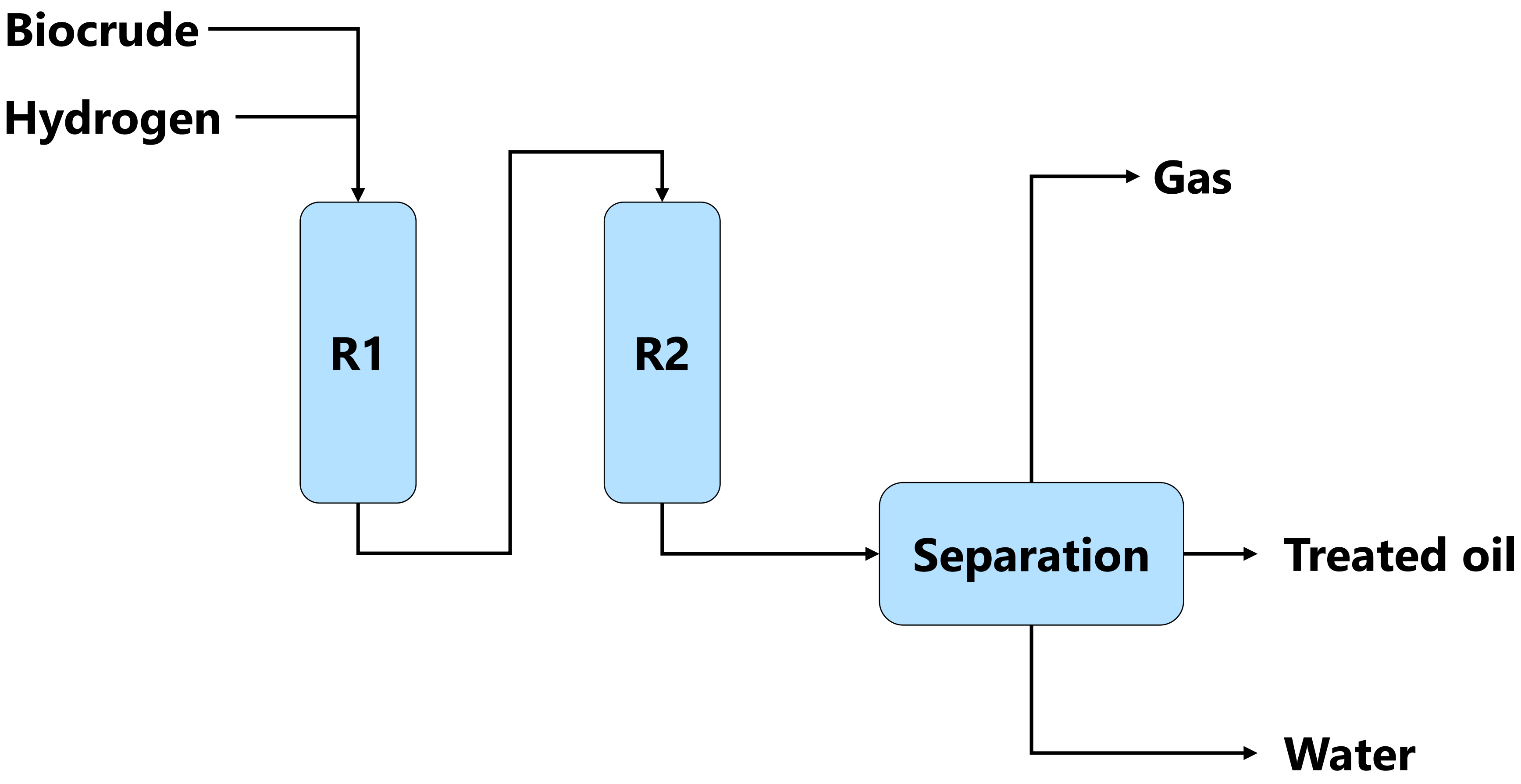
Analysis	Method	Biocrude
As, wt ppm	ICP-MS	4.6 – 6.8
Ca, wt ppm	ICP-MS	0.9 – 1.4
Cu, wt ppm	ICP-MS	0.2 – 4.9
Fe, wt ppm	ICP-MS	2 - 345
Si, wt ppm	ICP-MS	200 - 460
Zn, wt ppm	ICP-MS	0.8 - 9
Cl, wt ppm	D 7359	60-300
F, wt ppm	D 7359	20-50



FROM BIOCRUDE TO TRANSPORTATION FUEL



PILOT TESTING AND TEST STRATEGY



- Pilot with one reactor
- Pilot with two reactors
- 4 different pilot units
- Product collected and used as feed in another test
- > 6,000 test hours
- > 15 pilot tests

STABILIZATION – TAILORMADE STABILIZATION STRATEGY CRITICAL

First experience in testing

- High reactor temperature resulted in plugging in stabilizer reactor
- Feed MCR: 5-10 wt%

Dedicated stability testing

- Low activity catalyst
- One reactor setup with HPS/LPS
- Investigated variations in LHSV, T, and H_2/oil ratio

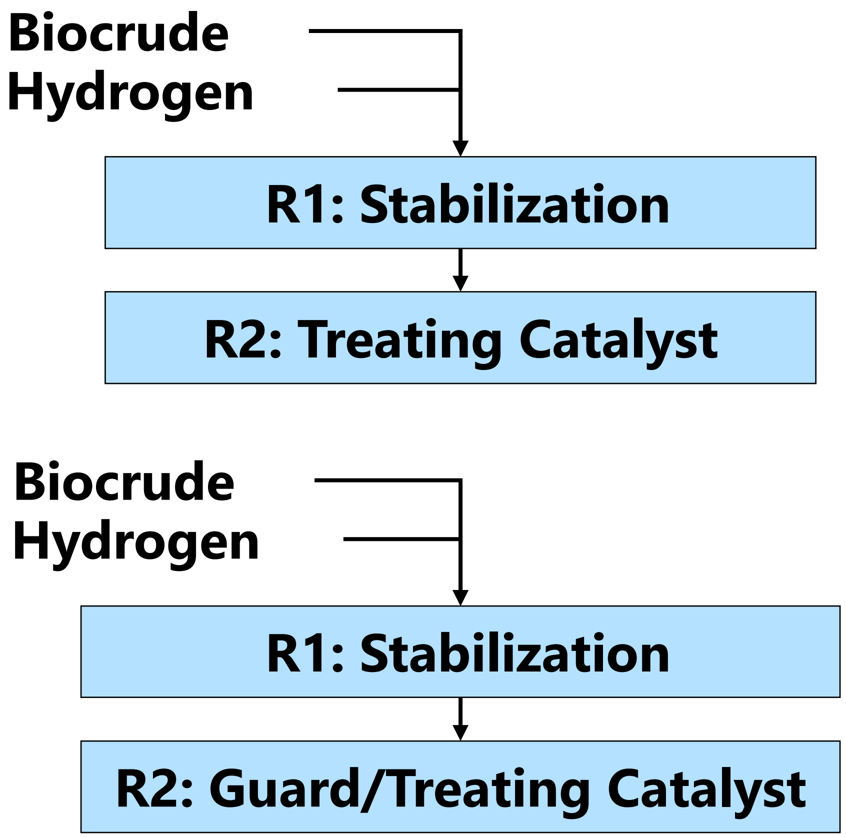
Test results

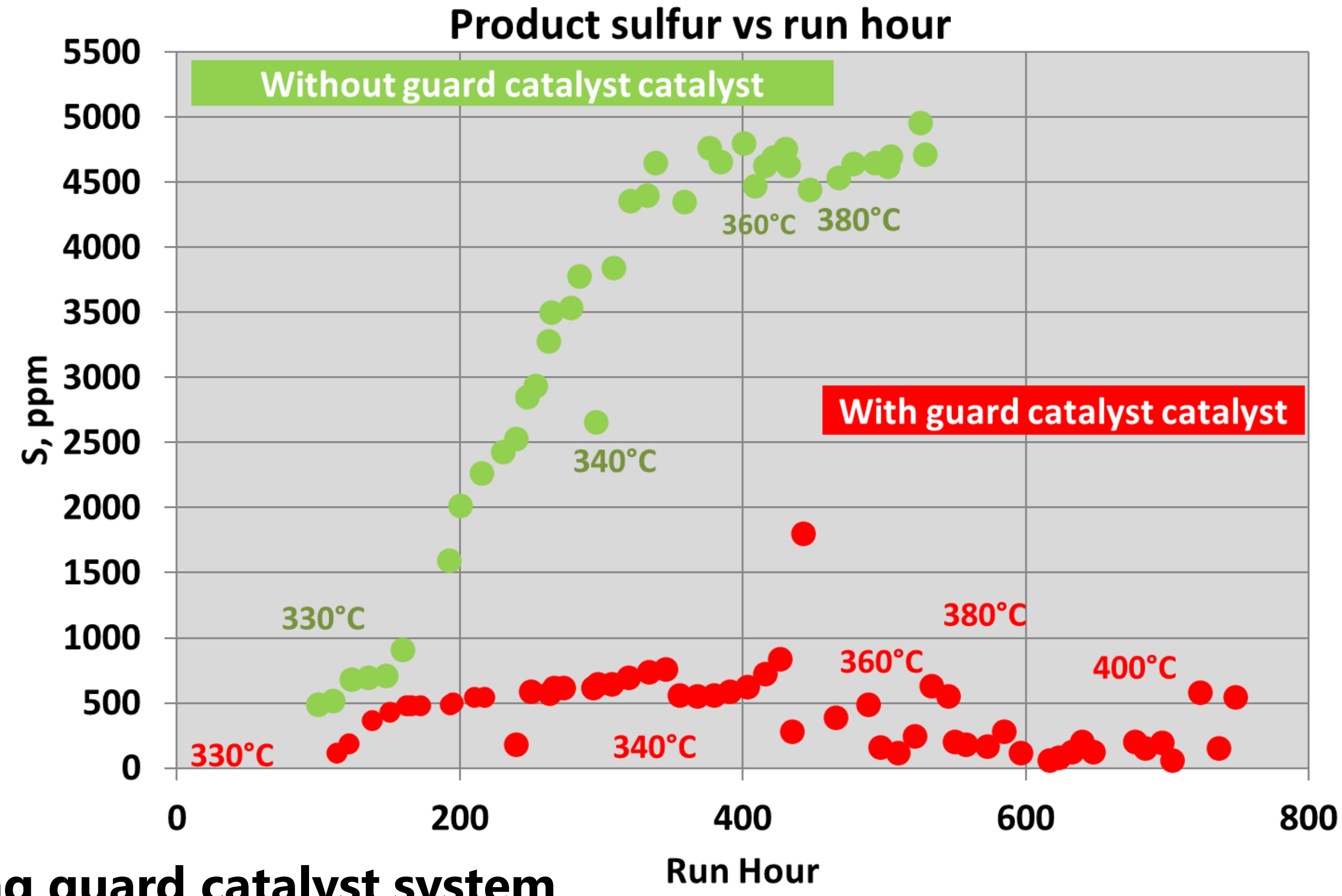
- MCR reduction up to 60%
  - ➢Increased with increasing temperature
  - ➢Almost same reduction: LHSV: 0.5-2 h^{-1}
- Reactivity: HDS>HDO>HDN
- Modest reduction of contaminants
- Chlorine removal starts at 220°C
- Low deactivation rate

Thermal stability of feedstock

- Decreased with increasing MCR

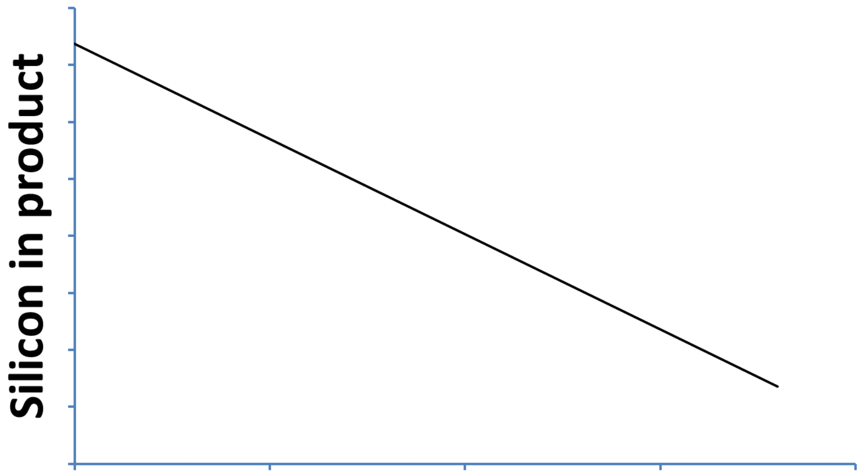
ROLE OF GUARD CATALYST SYSTEM

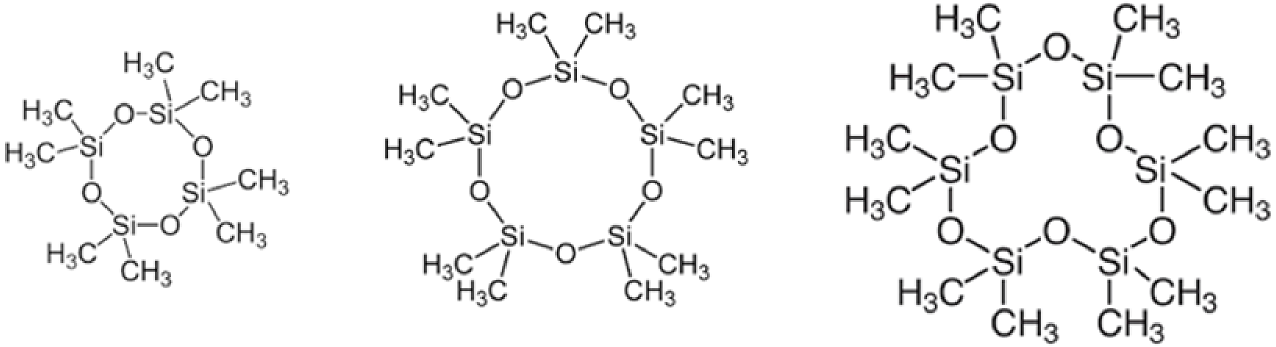




It is crucial to have a well-functioning guard catalyst system

GUARD CATALYST SYSTEM





- As and Si dominant contaminants
- Dedicated and tailormade guard catalysts needed for As and Si capture

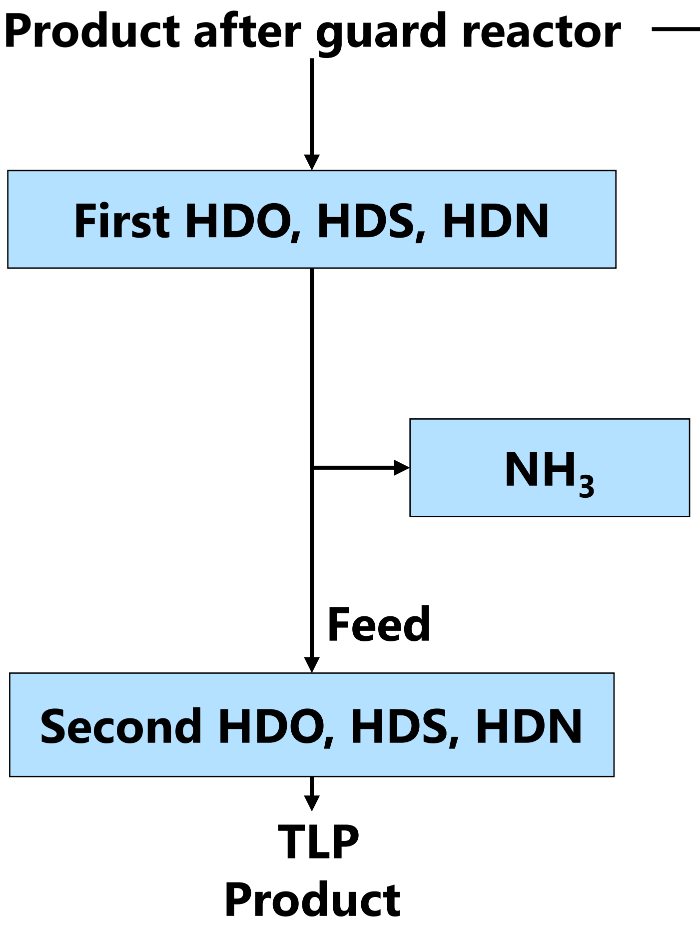
10 tons/h for 6 months (one way: CPH-BKK)

(As ~ 4 wt ppm, Si ~ 250 wt ppm)

Capture: As ~ 173 kg, Si ~ 10,800 kg

A lot of guard catalysts is needed

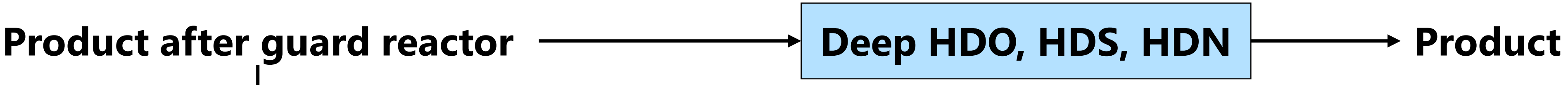
DEEP HDO, HDS, HDN – CASE 1

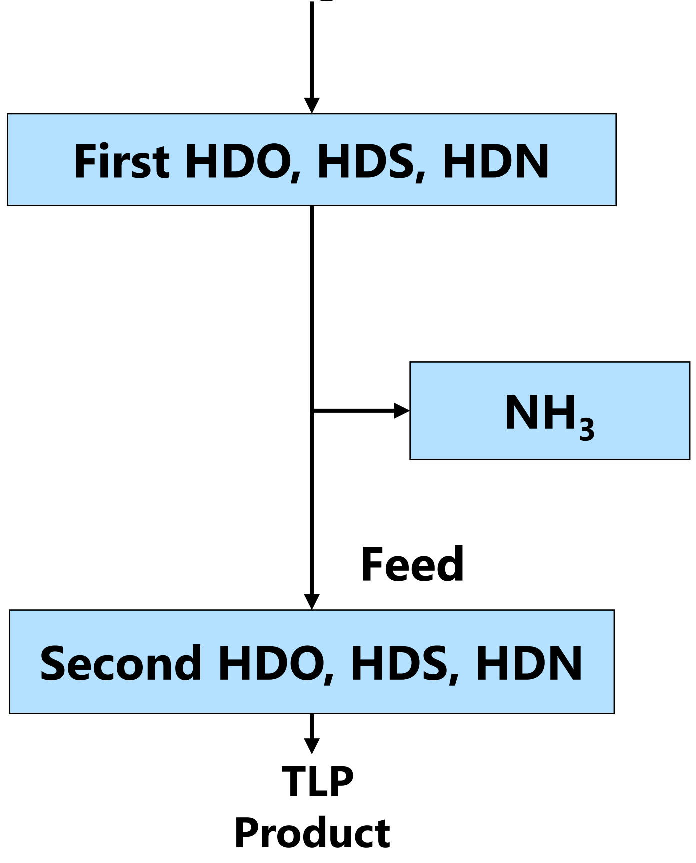


	SG	S, wt ppm	N, wt ppm	Aromatics, wt%	Smoke point, mm
Feed	0.8418	608	4,131	34.7	
TLP	0.8277	1.5	104	22.9	
Jet	0.8168	0.6	65.6	22.6	22.3
“Jet spec”	0.77-0.84	<2	<2	<25 vol%	>18.0

Nitrogen is difficult to remove

DEEP HDO, HDS, HDN – CASE 2





	SG	S, wt ppm	N, wt ppm
Feed	0.8535	126	6,220

	Operating conditions			TLP	Jet (150-250°C)
		T	P	N, wt ppm	N, wt ppm
1	$LHSV_1$	T_1	P_1	26	49.2
2	$LHSV_1$	T_1+20	P_1	0.5	0.6
3	1.15*$LHSV_1$	T_1+40	P_1	0.1	
4	$LHSV_1$	T_1+40	0.58*P_1	15	

Severe conditions needed for deep removal of nitrogen

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TAKE-HOME MESSAGES

- **Upgrading of biocrude derived from sewage sludge is by far trivial.**
- **Removal of contaminants must be removed for successful upgrading to SAF.**
- **Successful upgrading requires use of several catalysts with different functionalities.**
- **TOPSOE has the technology to upgrade sewage sludge derived biocrude to SAF**

THANK YOU

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