

Tratamiento termoquímico de residuos. Estrategias de proceso para producir building bloks



Thermochemical Processes Group. GPT

gpt.i3a.es

ISMAC

Innovación sostenible:
Materiales y Circularidad

19 de noviembre 2024





Thermochemical Processes Group. GPT **Research Lines**



**PRODUCTION OF BIOPRODUCTS AND BIOFUELS FROM
BIOMASS AND WASTE**



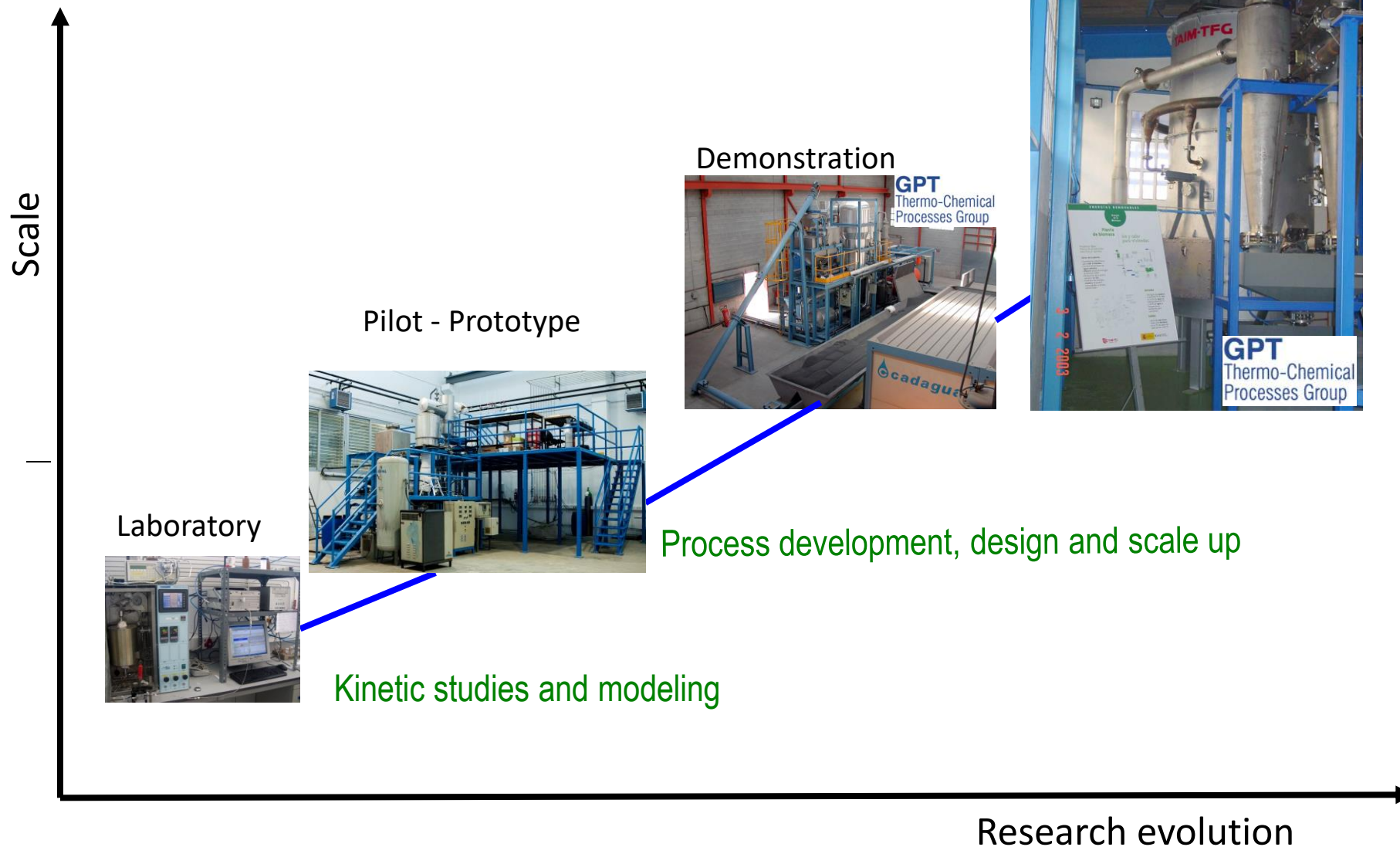
**FUEL CONVERSION AND MINIMIZATION OF
POLLUTING EMISSIONS**

ISMAC

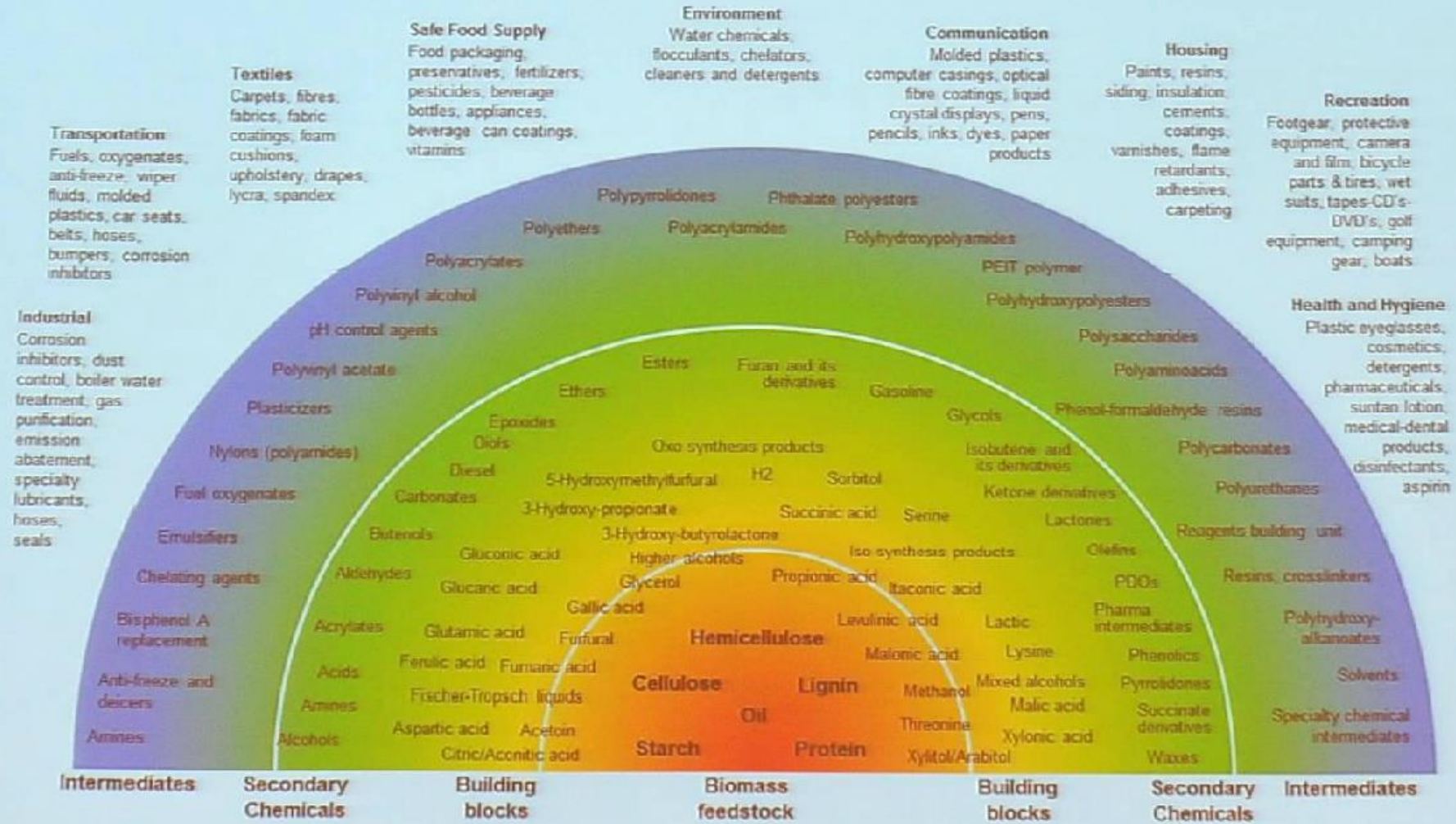
Innovación sostenible:
Materiales y Circularidad

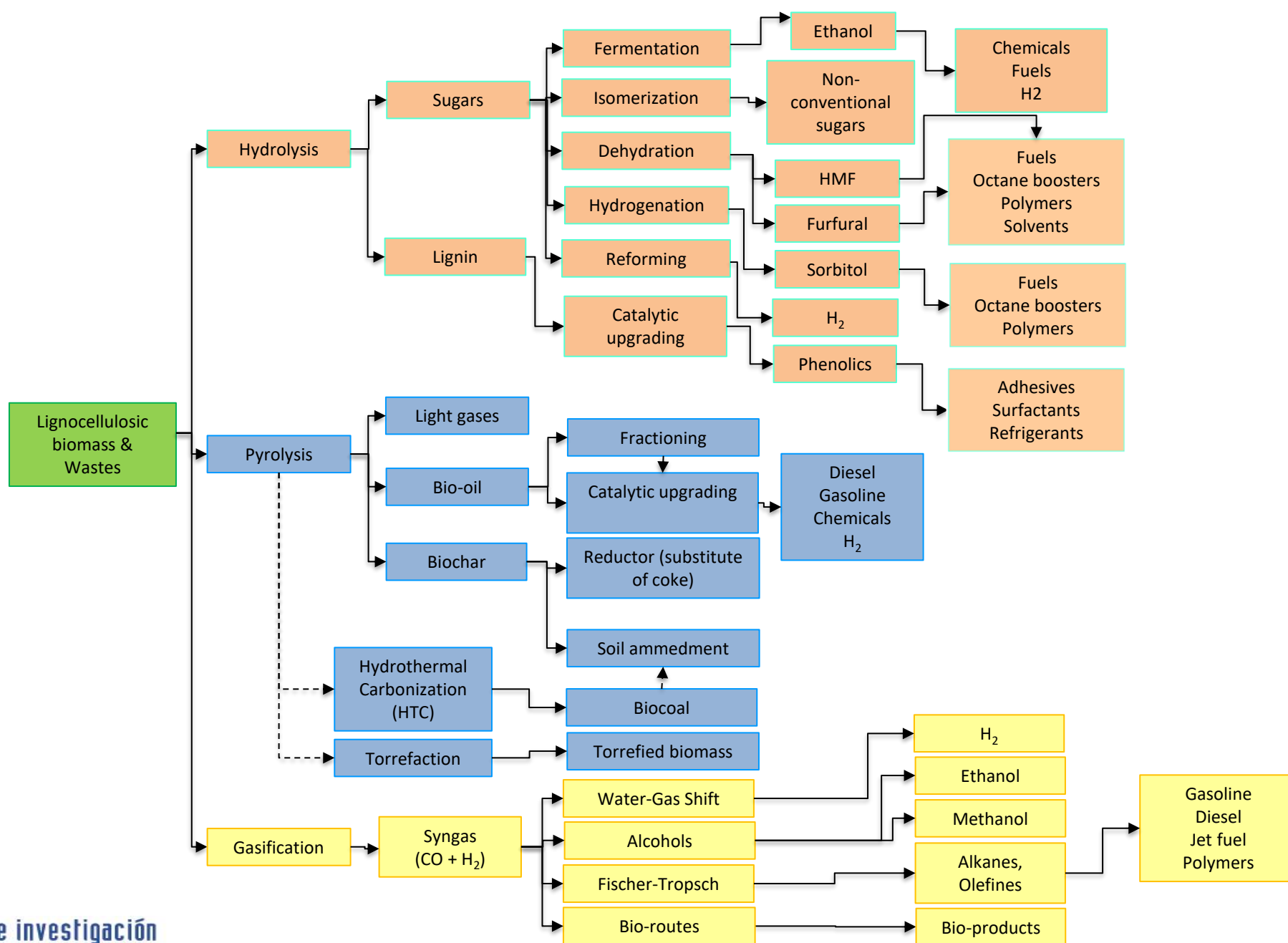
19 de noviembre 2024

Research and Processes Development



PÖYRY BIOFAN





Our research lines...

THERMO-CHEMICAL CONVERSION



PYROLYSIS

GASIFICATION

AQUEOUS PHASE
REFORMING

COMBUSTION

BIOGAS-H₂

Our research lines...

THERMO-CHEMICAL CONVERSION

PYROLYSIS

GASIFICATION

AQUEOUS PHASE REFORMING

COMBUSTION

BIOGAS-H₂

- Fast pyrolysis
- Catalytic pyrolysis

BIO-OIL



Raw materials

- ✓ Meat and bone meal
- ✓ Sewage sludge
- ✓ Manure / Digestate
- ✓ Wood chips
- ✓ Tetrapack

Funding sources and collaborations

Fluidized bed



Auger



Fixed bed



Our research lines...

THERMO-CHEMICAL CONVERSION

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BIOGAS-H₂

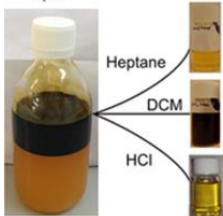
- Fast pyrolysis
- Catalytic pyrolysis

BIO-OIL

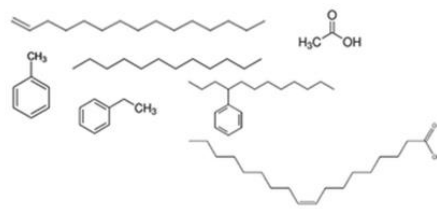


- Fuel
- Value-added product recovery
- Aqueous phase → use as fertilizer (phytotoxicity tests)
- HDO of bio-oil → BioJet fuel

SS pyrolysis
liquid



Chemicals



Phytotoxicity tests



HDO of bio-oil

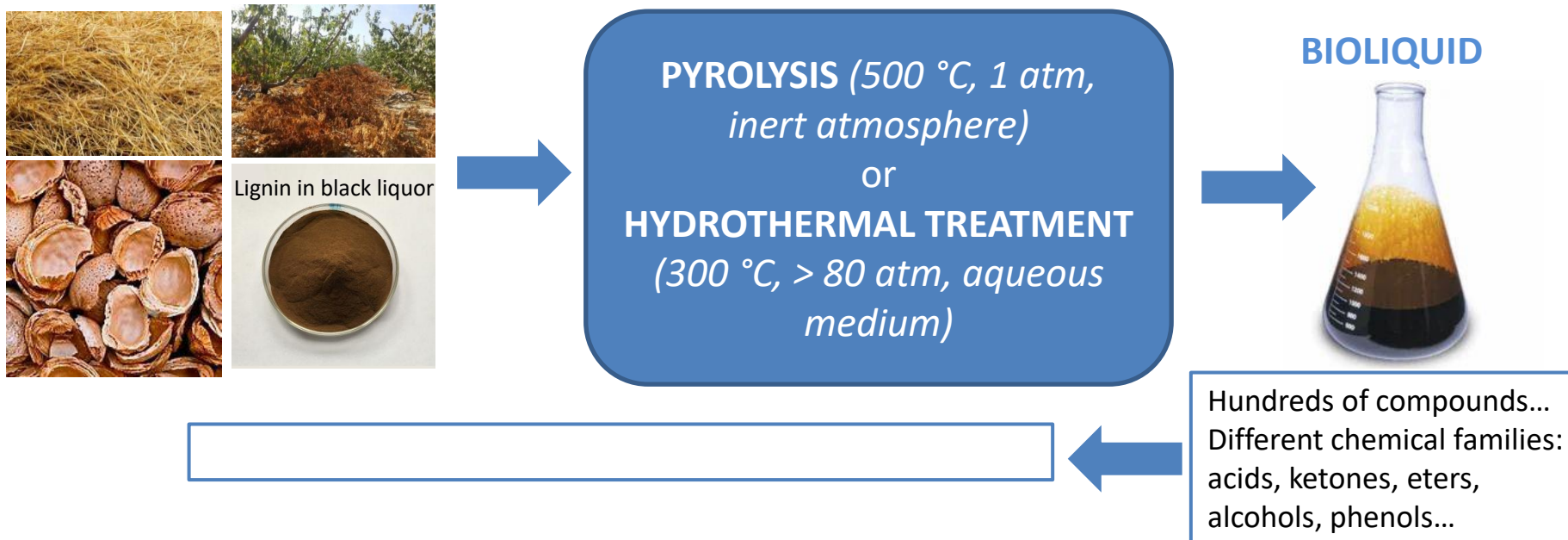
From lignocellulosic materials to Sustainable Aviation Fuels (SAF)

- SAF is expected to have a similar composition to that of jet fuel (around 20% by volume of n-paraffins, 40% iso-paraffins, 20 cycloalkanes and **20% aromatics**).



Lignin is the only **renewable source** of aromatics (in the form of phenolics)

OUR RESEARCH LINE: obtaining added-value aromatics from lignin-rich residues.



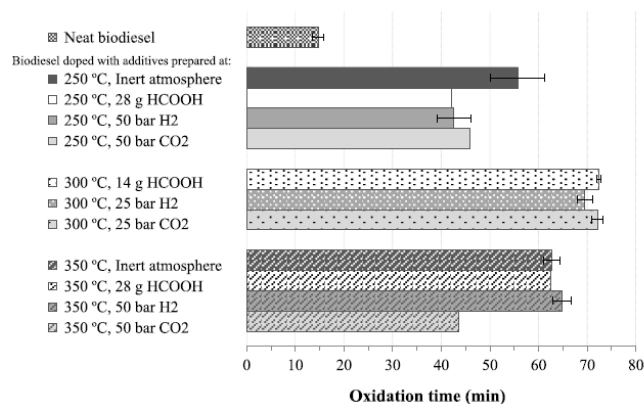
From lignocellulosic materials to Sustainable Aviation Fuels (SAF)

Work already done in our group:

Extraction of phenolic-rich fractions from bioliquids with excellent antioxidant abilities.

One of our published works:

Biodiesel oxidation stability can be improved by 400% with small dosages of additives coming from the hydrothermal treatment of argan shells.

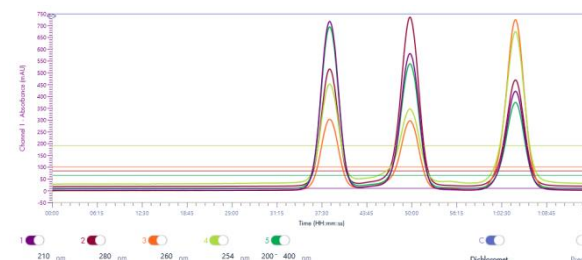


<https://doi.org/10.1021/acs.energyfuels.1c01705>
Energy Fuels 2021, 35, 17149–17166



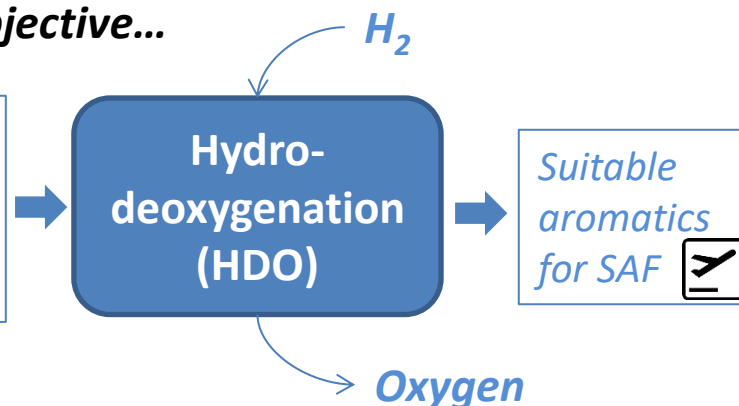
What are we focused on now:

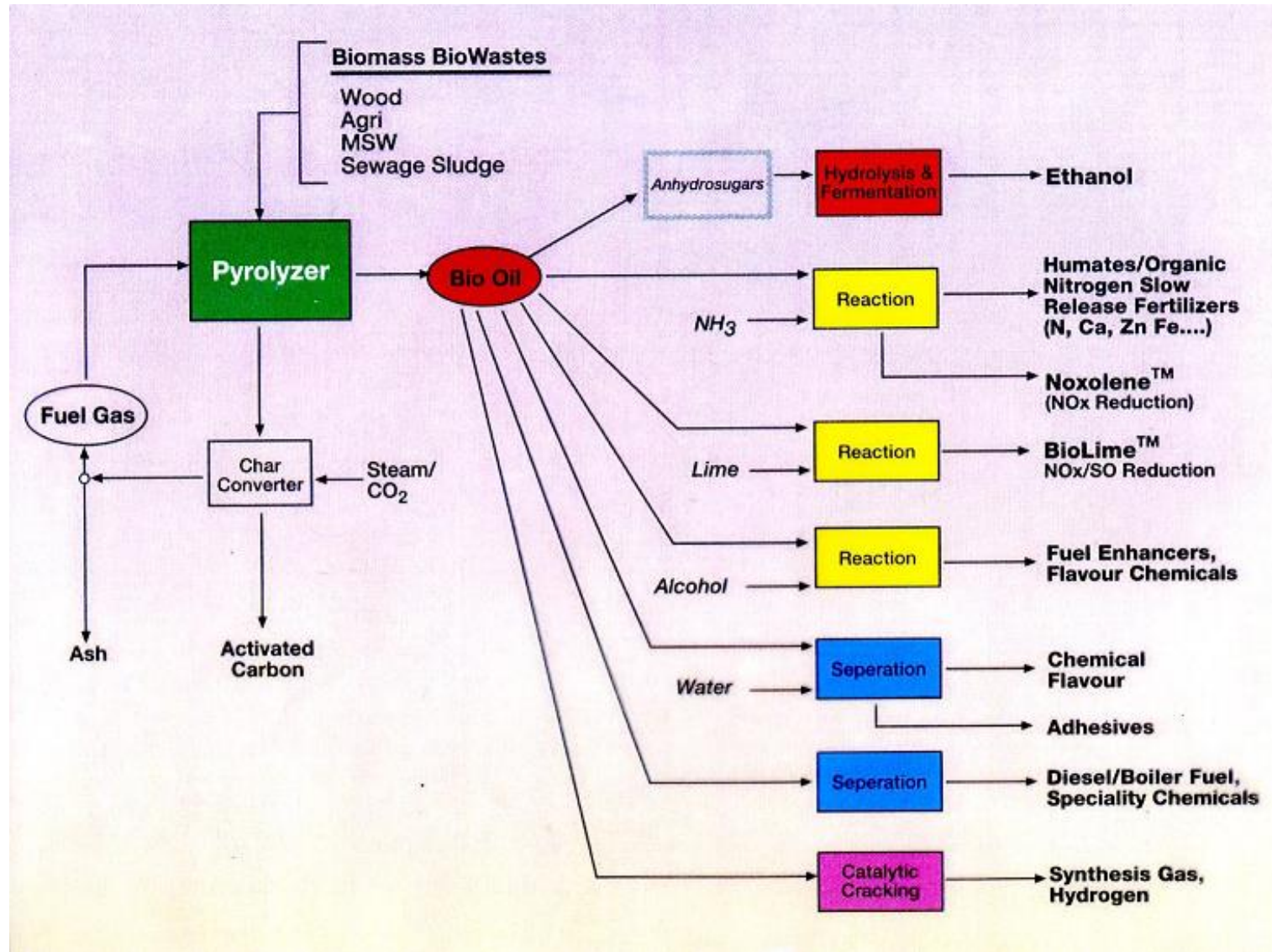
Improving procedures for separating bioliquids into different chemical families according to polarity and/or molecular size (preparative HPLC).



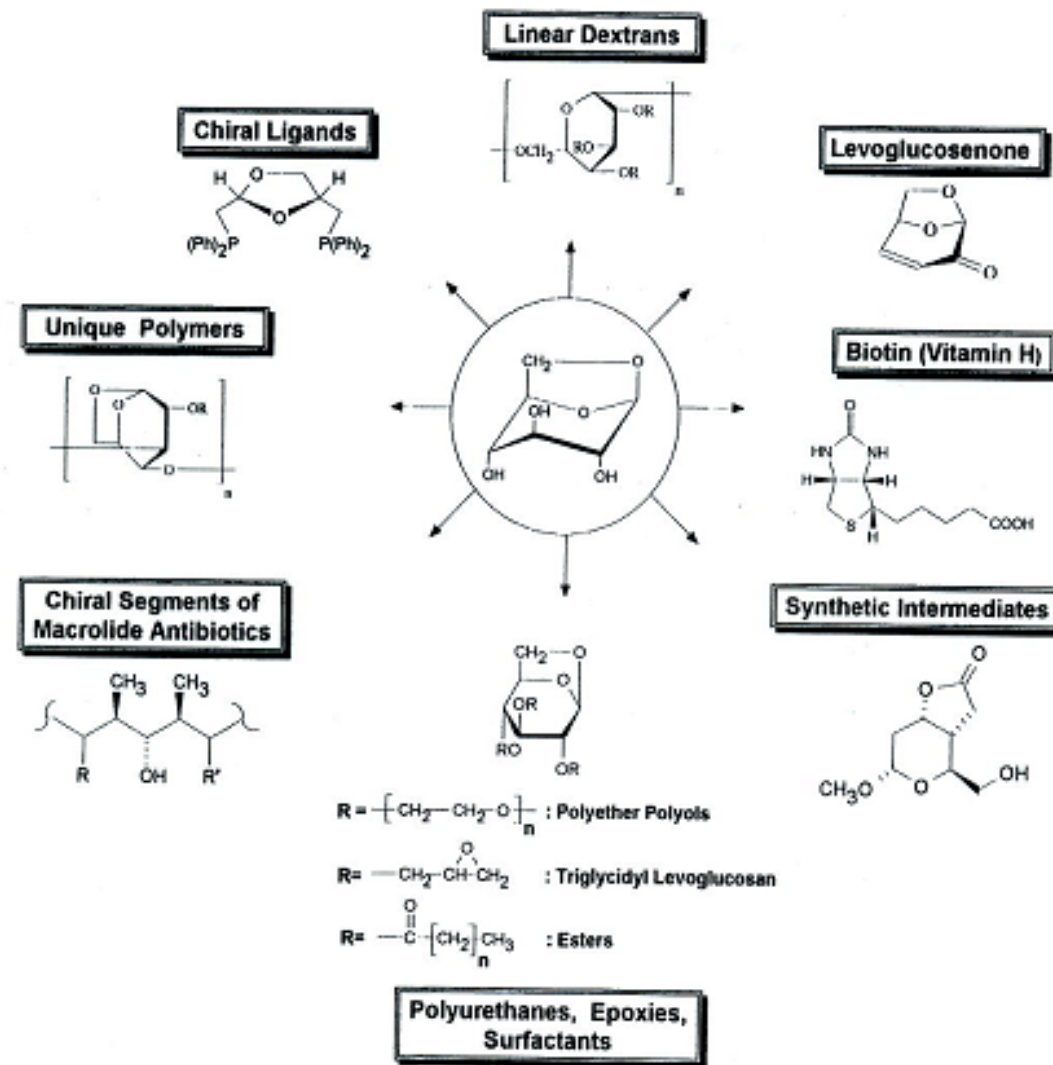
Our final objective...

Suitable
phenolic
fractions
from bio-oil





Rutas de síntesis a partir de levoglucosan



Our research lines...

THERMO-CHEMICAL CONVERSION

PYROLYSIS

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COMBUSTION

BIOGAS-H₂

**Slow pyrolysis
(carbonization)**

BIO-CHAR



Raw materials

- ✓ Meat and bone meal
- ✓ Sewage sludge
- ✓ Manure / Digestate
- ✓ Agricultural residues: banana rachis, cocoa, cashew nutshell, olive mill waste, vine shoots

Fluidized bed



Auger



Fixed bed



Funding sources and collaborations



Our research lines...

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BIOGAS-H₂

**Slow pyrolysis
(carbonization)**

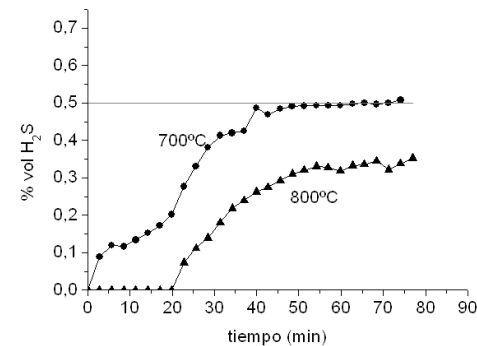
BIO-CHAR



- Fuel
- Addition to soils (phytotoxicity tests)
- Carbon materials: adsorbents (H₂S) and catalysts supports
- Phosphorous recovery



Phytotoxicity tests



H₂S adsorption

Procedimiento experimental



P recovery

Our research lines...

THERMO-CHEMICAL CONVERSION

PYROLYSIS

Raw materials

- ✓ Wood chips
- ✓ Meat and bone meal
- ✓ Sewage sludge
- ✓ Manure / Digestate
- ✓ Black liquor
- ✓ RDF / MSW

Fluidized bed (Lab scale)



GASIFICATION

GAS



- Gas-to-energy or syngas (FT)
- Gas cleaning
- NH₃ production

Pilot plants (BFB)



SAICA
PAPER | NATUR | PACK



urbaser

AQUEOUS PHASE REFORMING

Demonstration plant (BFB)



Cadagua

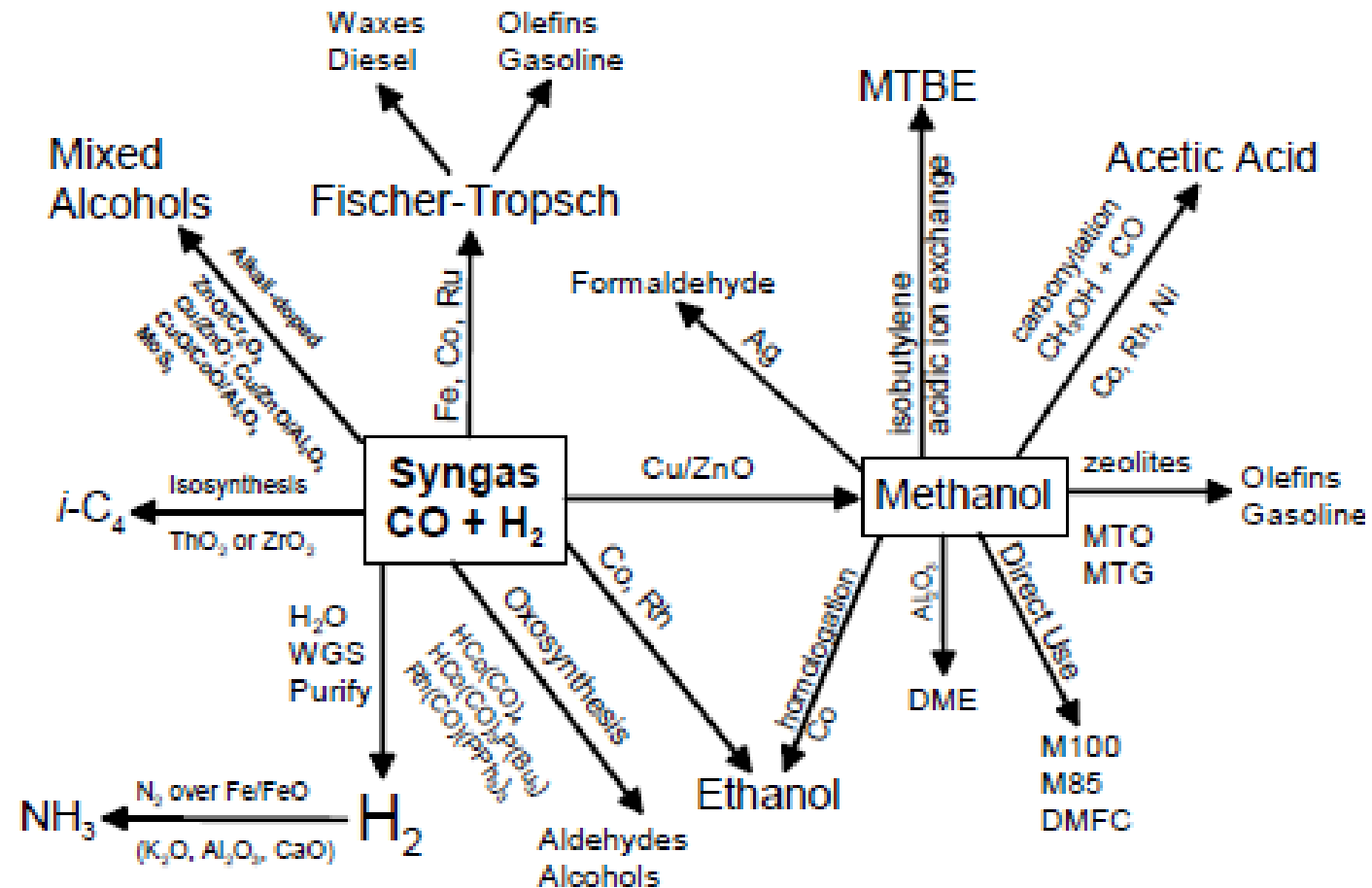
Commercial plant (Down draft)



BIOGAS-H₂

Funding sources and collaborations

Síntesis química:



Our research lines...

THERMO-CHEMICAL CONVERSION

PYROLYSIS

GASIFICATION

**AQUEOUS PHASE
REFORMING AND
STEAM
REFORMING**

COMBUSTION

BIOGAS-H₂

Raw materials

- ✓ Cheese whey (lactose)
- ✓ Glycerol
- ✓ Bio-oil

H₂

Fixed bed



Fluidized bed



Funding sources and collaborations

THERMO-CHEMICAL CONVERSION

PYROLYSIS

GASIFICATION

AQUEOUS PHASE
REFORMING

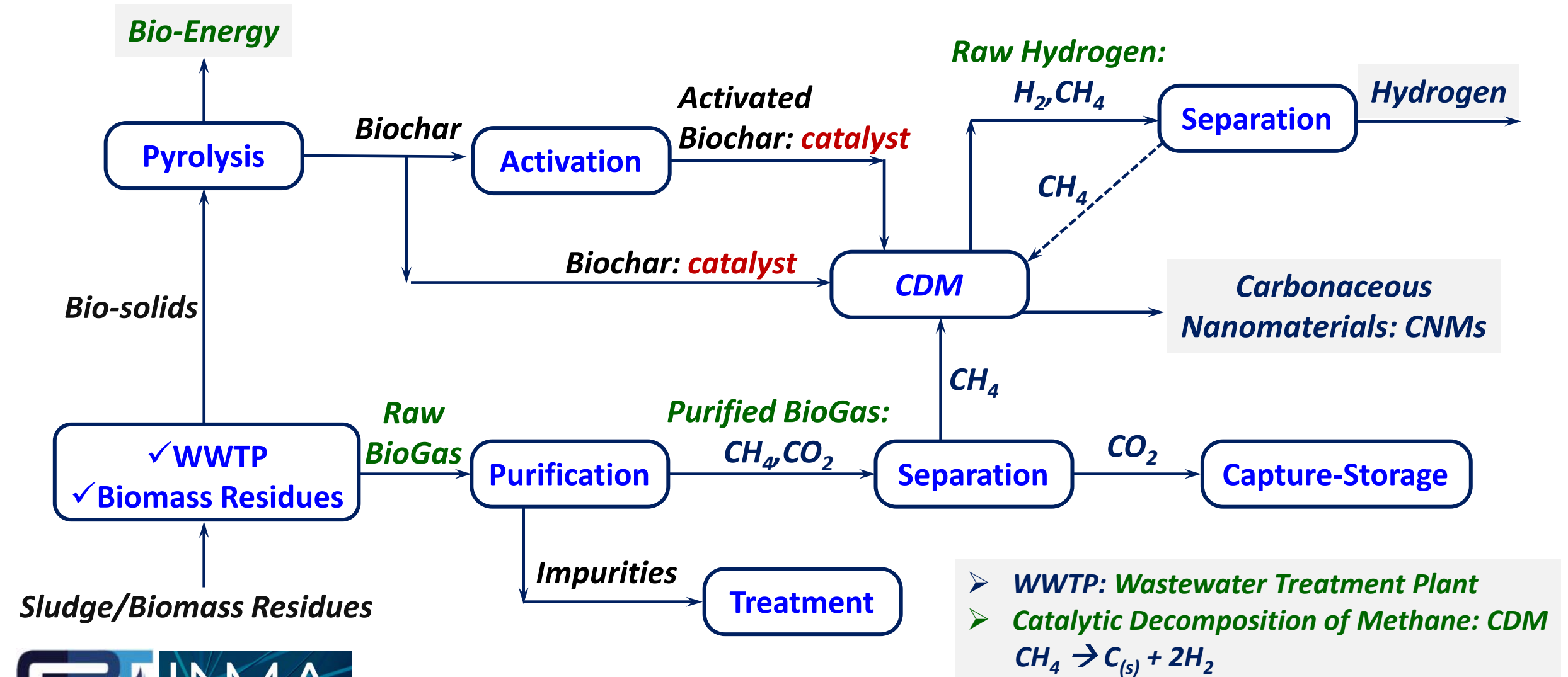
COMBUSTION

BIOGAS-H₂

Green Hydrogen from BioGas by Catalytic Routes

- ✓ ***Green Hydrogen from BioGas by Dry Reforming (BDR)***
- ✓ ***Green Hydrogen from BioGas by Steam-Dry Reforming (BSDR-Dual Reforming)***
- ✓ ***Green Hydrogen from BioGas by Tri-Reforming (BTR)***
- ✓ ***Green Hydrogen from BioGas by Catalytic Decomposition of Methane (CDM)***

Green Hydrogen from BioGas by Catalytic Decomposition of Methane (BCD)





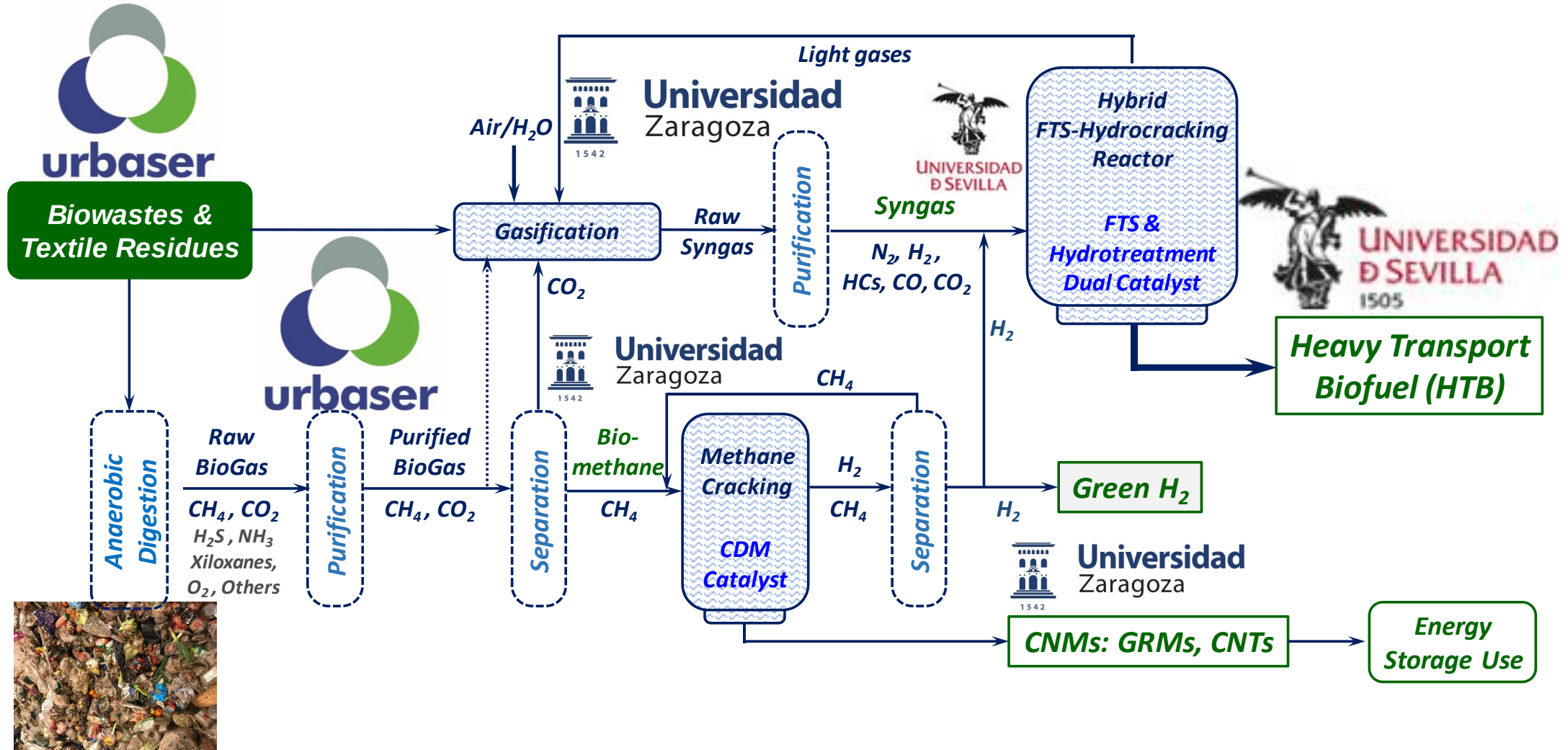
In Europe **12.6 million tonnes** of textile waste per year are produced

Currently, only **22%** of textile waste is collected for re-use or recycling, the remainder is often incinerated or landfilled

- » Approximately **70%** of textile waste has the potential to be fiber-to-fiber recycled to create new textile products. However, currently, less than **1%** is actually recycled due to technologies are only starting to emerge
- » The remaining **30 %** would require other solutions like producing **syngas through thermo-chemical recycling**
- » About **60 % of the textile waste** consists of **plastic**, including polyester, acrylic, and nylon

Gasification as waste to energy technology for textile waste treatment

General Scheme





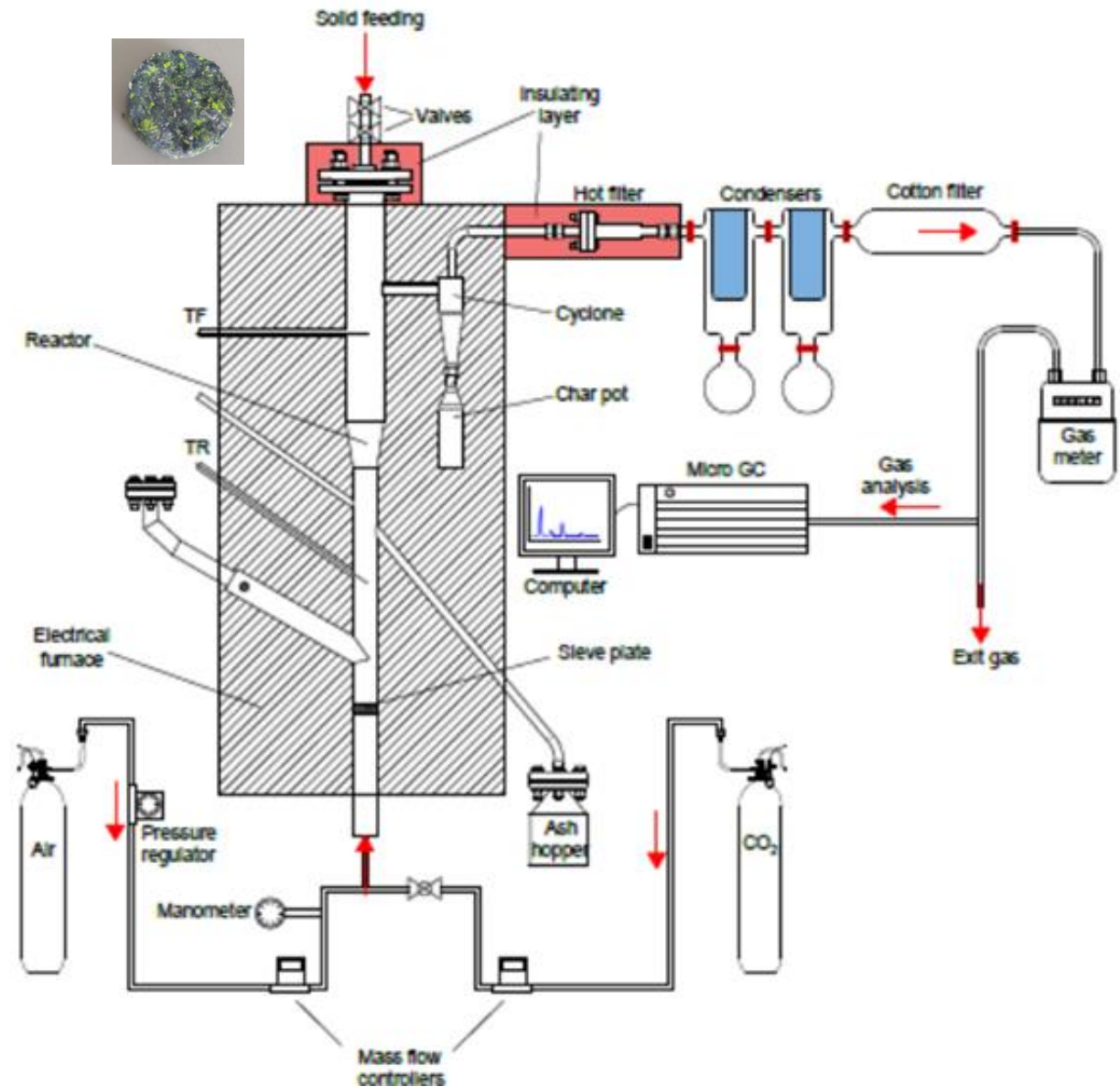
11 different samples

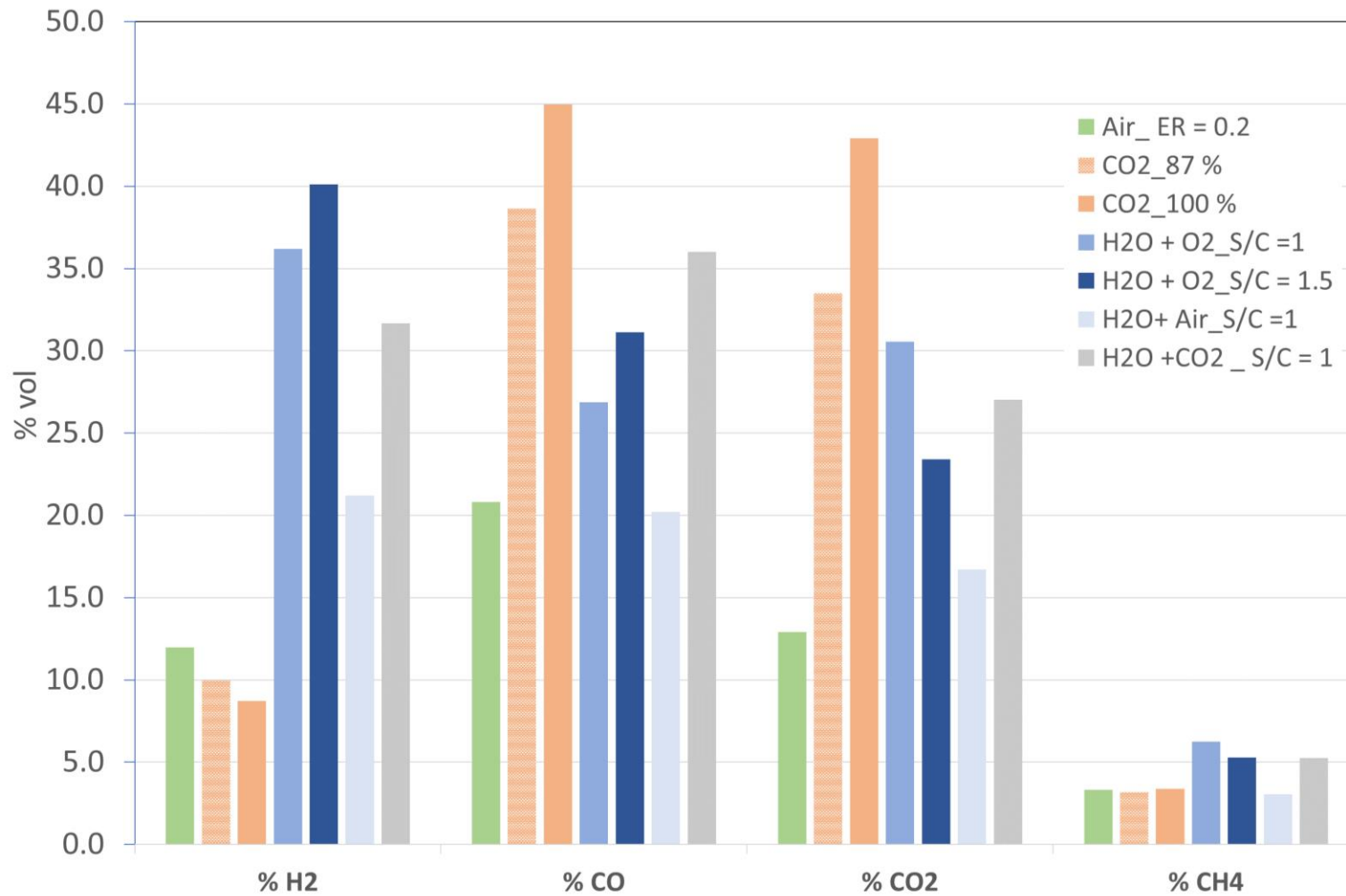
Operational conditions

Temperature (°C)	900
Total flowrate (L_{STP}/min)	0.31
WT feed rate (g/min)	0.3
Run duration (min)	60

Gasifying agent

Air	ER = 0.2
CO ₂	67 % vol
	100 % vol
Steam + O ₂	H ₂ O/C = 1 ER = 0.2
	H ₂ O/C = 1.5 ER = 0.2
Steam + air	H ₂ O/C = 1 ER = 0.2
Total flowrate = 0.51 (L_{STP}/min)	
Steam + CO ₂	H ₂ O/C = 1 CO ₂ : 35 % vol

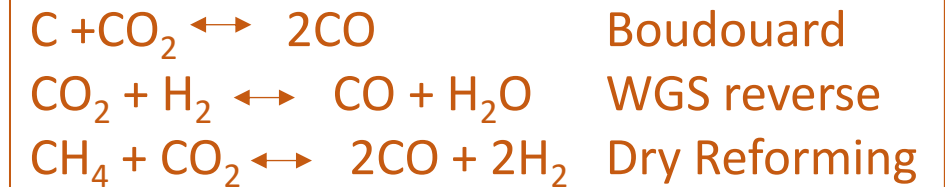




Air gasification: $\approx 45\% \text{ N}_2$

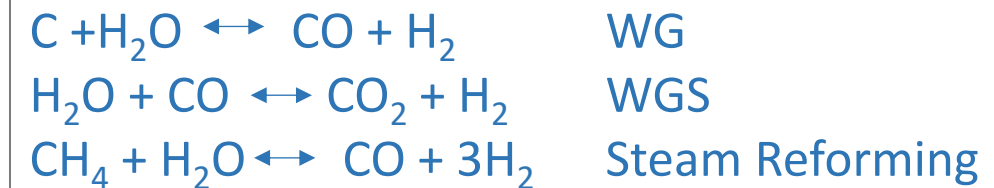
CO₂ gasification:

- Produces CO-rich syngas
- Inhibits H₂ production



Steam gasification:

- Enhances H₂ production



Steam + CO₂ produces higher quality gas than **Steam + Air** gasification

	H ₂ /CO	Tar content g/m ³ _{STP}
Air_ER = 0.2	0.6	4
CO ₂ _87 %	0.3	5
CO ₂ _100 %	0.2	3
H ₂ O + O ₂ _S/C = 1	1.3	8
H ₂ O + O ₂ _S/C = 1.5	1.3	
H ₂ O + Air_S/C = 1	1.0	
H ₂ O + CO ₂ _S/C = 1	0.9	

No Fulfill specifications for FT process. It is required:

- H₂ addition (H₂/CO ≈ 1.5-2)
- Tar reduction (< 1 mg/Nm³)

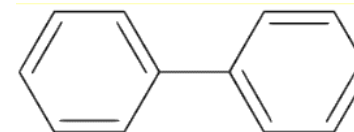
H₂/CO ratio:

- Steam + O₂ > Steam + CO₂ > Air > CO₂

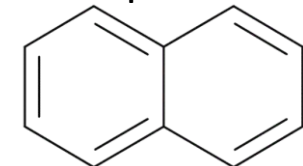
Tar content:

- High Tar content
- Steam > Air ≈ CO₂
- High CO₂ concentration is required to reduce tar content
- Main tar components:

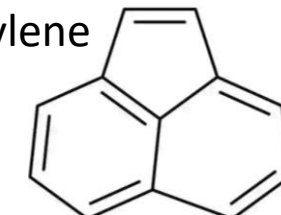
Biphenyl



Naphthalene



Acenaphthylene



Pilot Plant



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