UNIVERSITÉ DE SHERBROOKE

Thermo Bio Plasma Pharma
GR
GROUP OF RESEARCH ON TECHNOLOGIES AND PROCESSES

A novel solid waste autothermal pyrolysis and reformer platform to produce carbon nanofilaments: Operation, Results and Industrial transferability

Keynote address from
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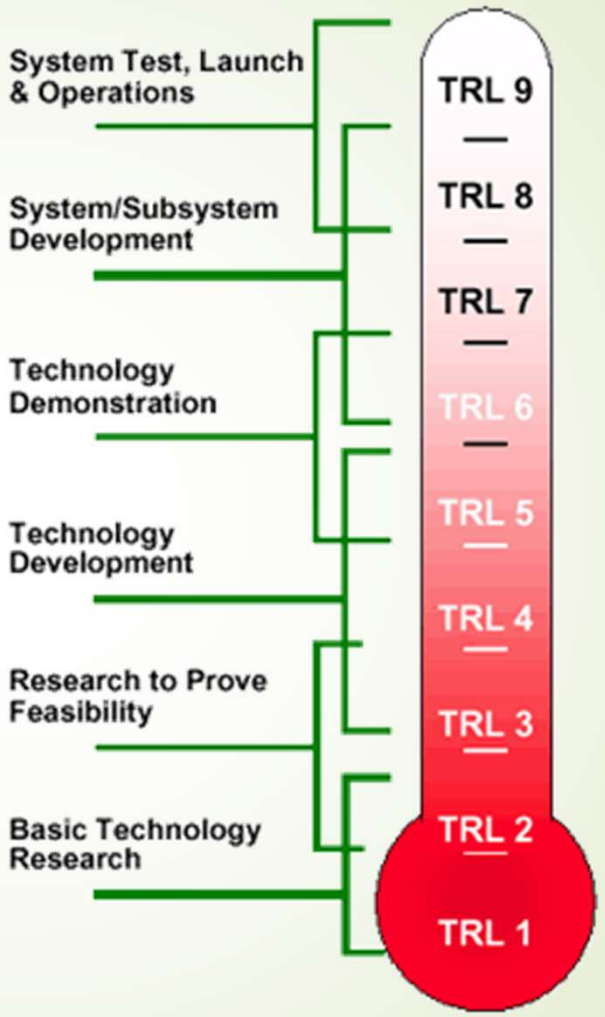
Partners
CRD & INNOV/NSERC; PRIMA-Québec; Axelys; UDS; KWI; GOLD/HORIZON 2020; FNFR

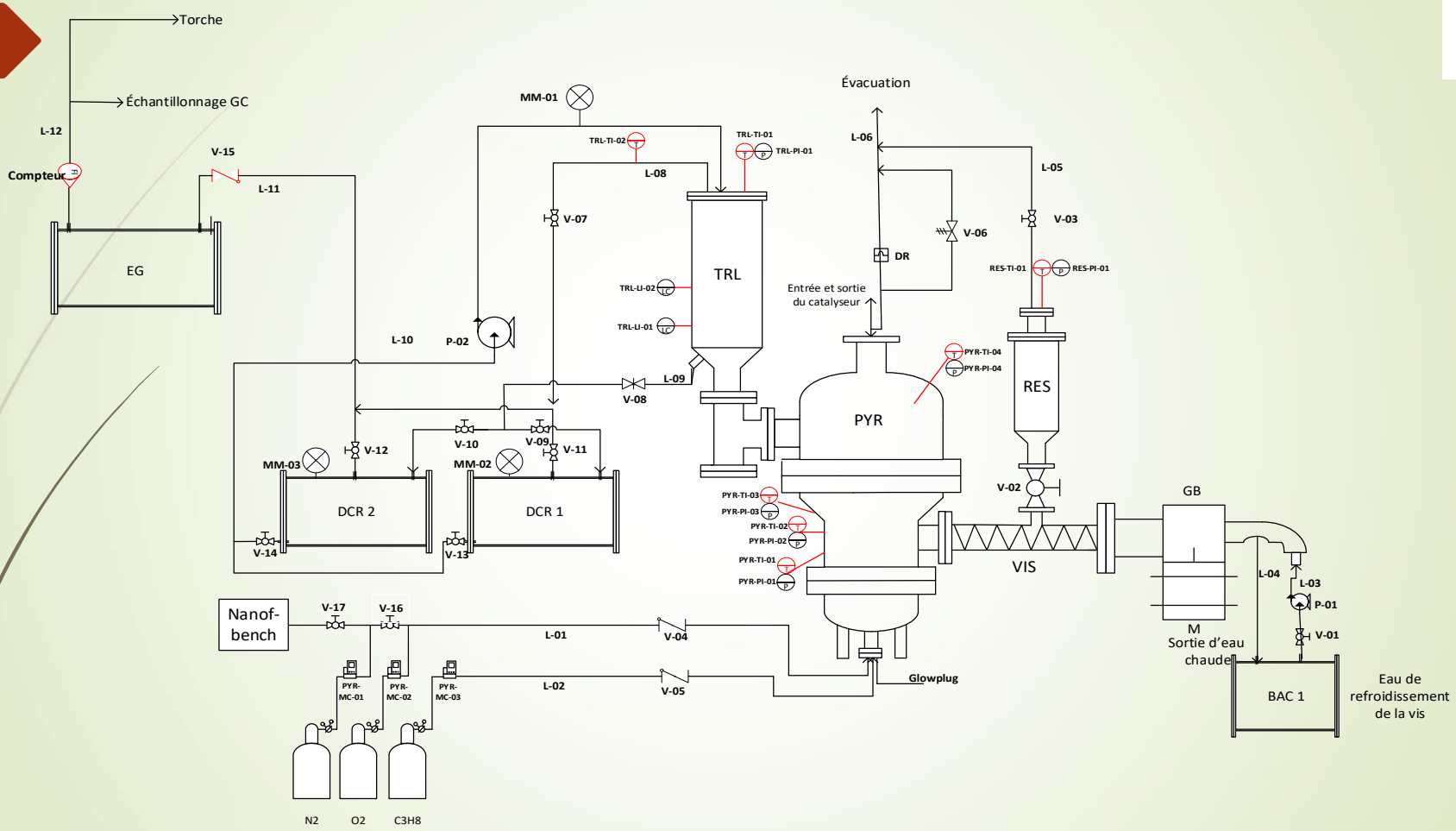
Overview

- GRTP's kg-lab scale ATP platform (TRL 5)
- GRTP's kg-lab CNF production platform (TRL 4-5)
- GRTP's kg-lab catalytic reforming platform (TRL 4-5)
- Operation Protocols
- Results
  - ATP
  - CNF production
  - Reforming
- Industrial transferability (TRL 6-7) and next steps

TRP reminder

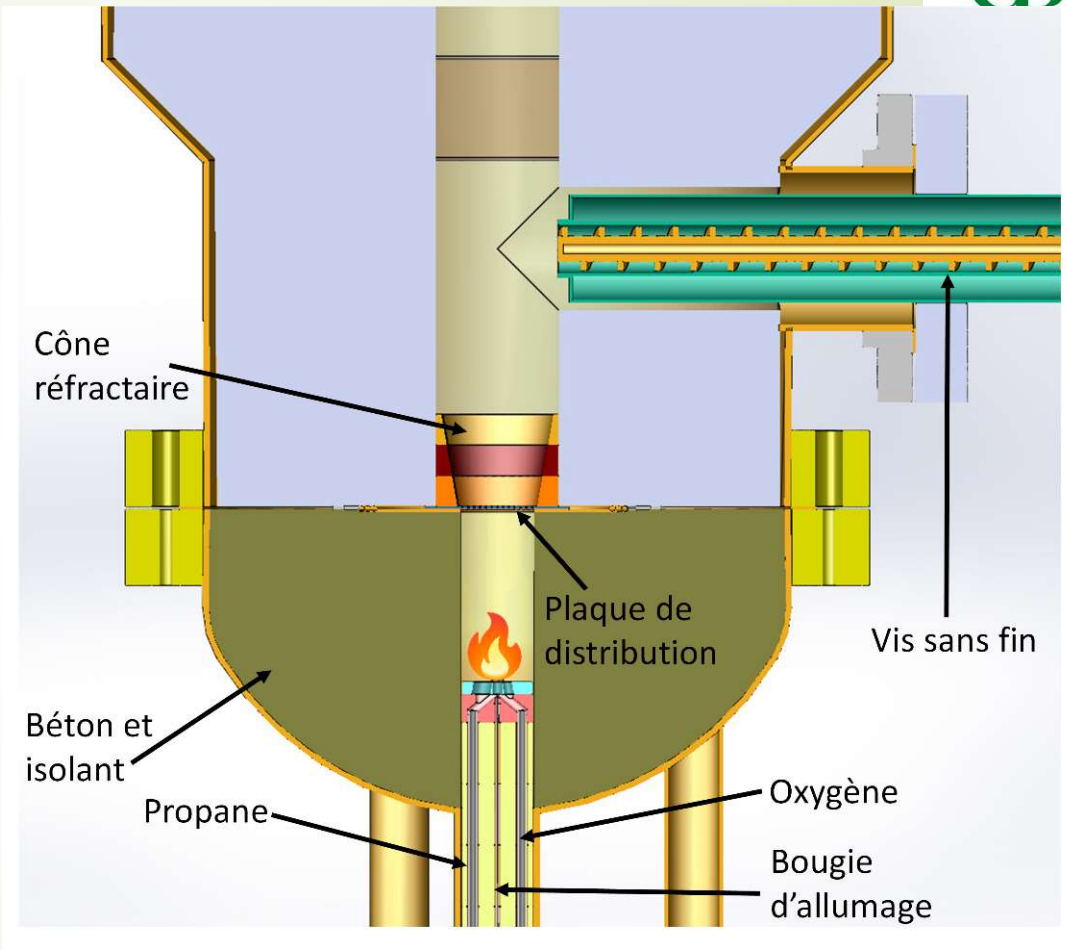


GRTP's kg-lab scale ATP platform

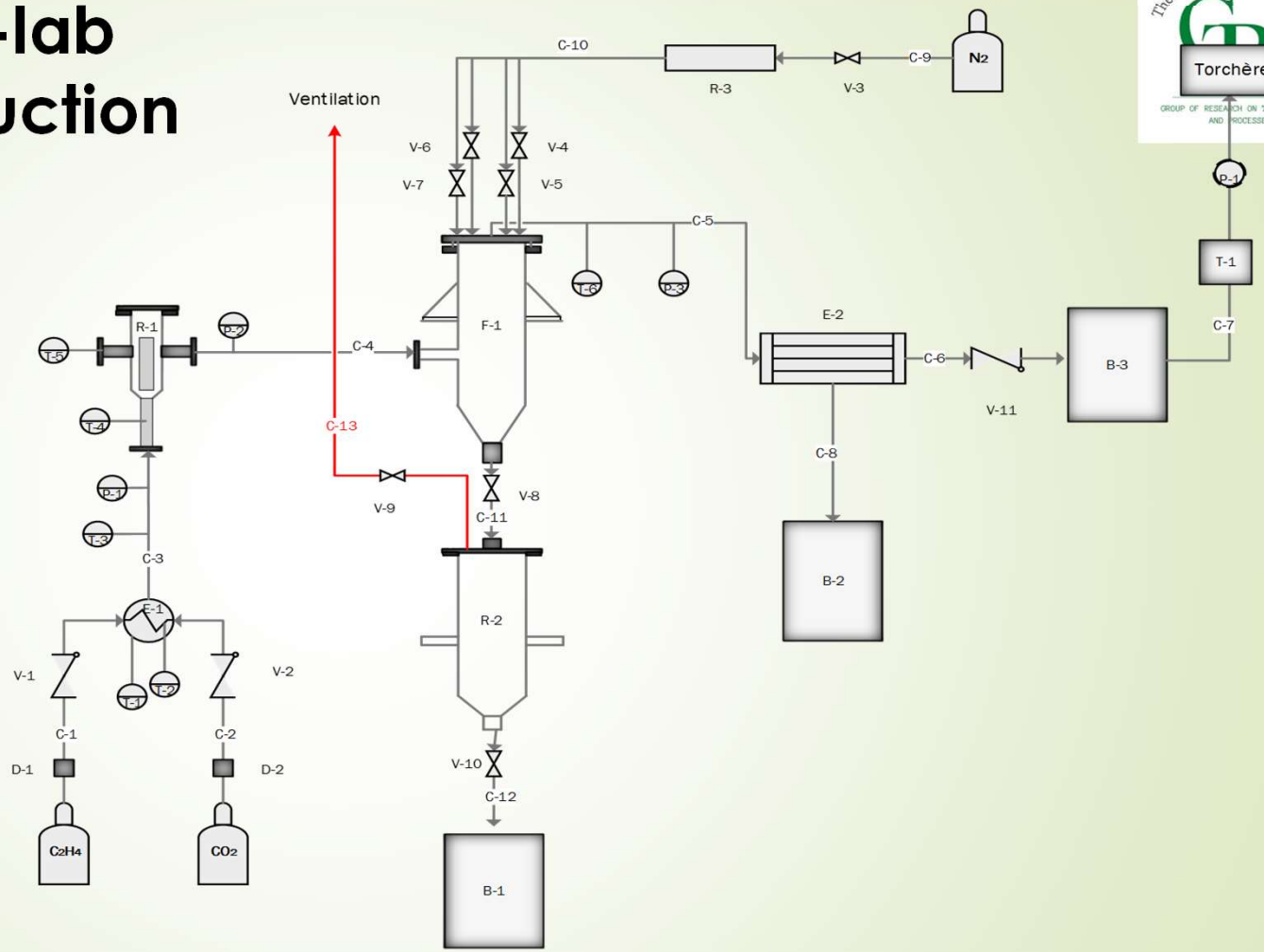


ATP Pilot FB reactor (5 kg/h nominal capacity)

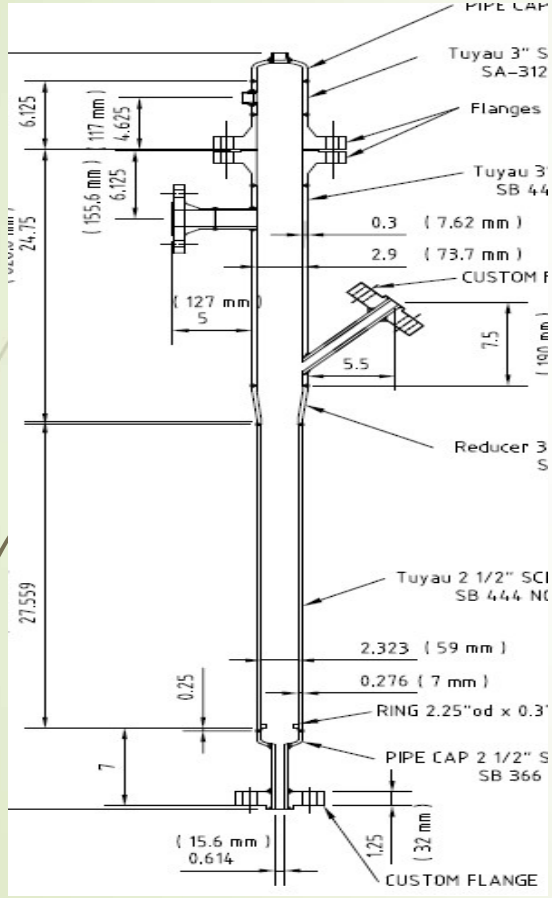
Key element for ATP reactor heat transfer-1



GRTP's kg-lab CNF production platform



GRTP's kg-lab catalytic reforming platform



The Reforming platform of the GRTP

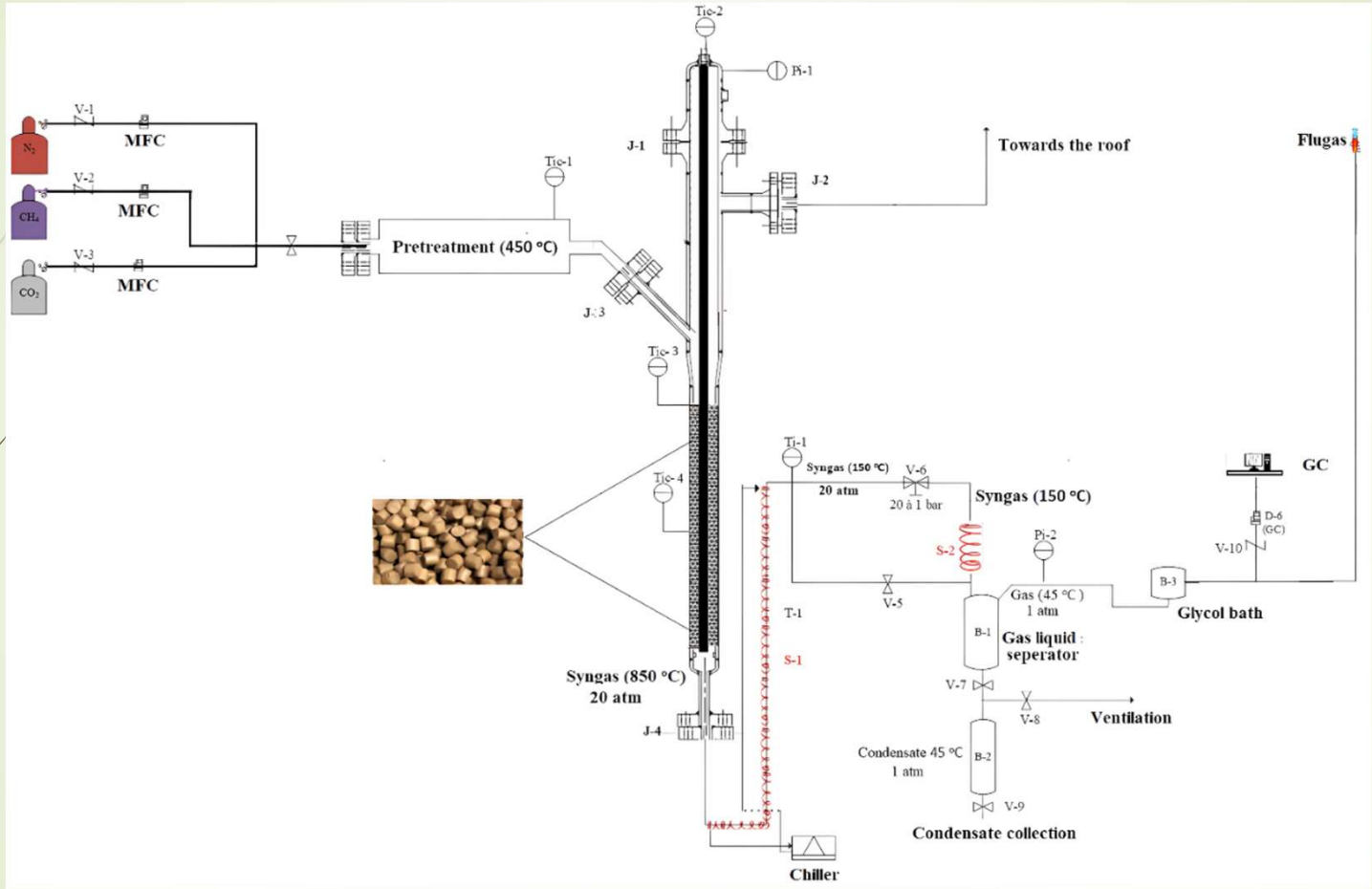


Figure 1. Schematic diagram of the Kg-based packed bed reactor.

ATP, CNF & Reforming tests

Results

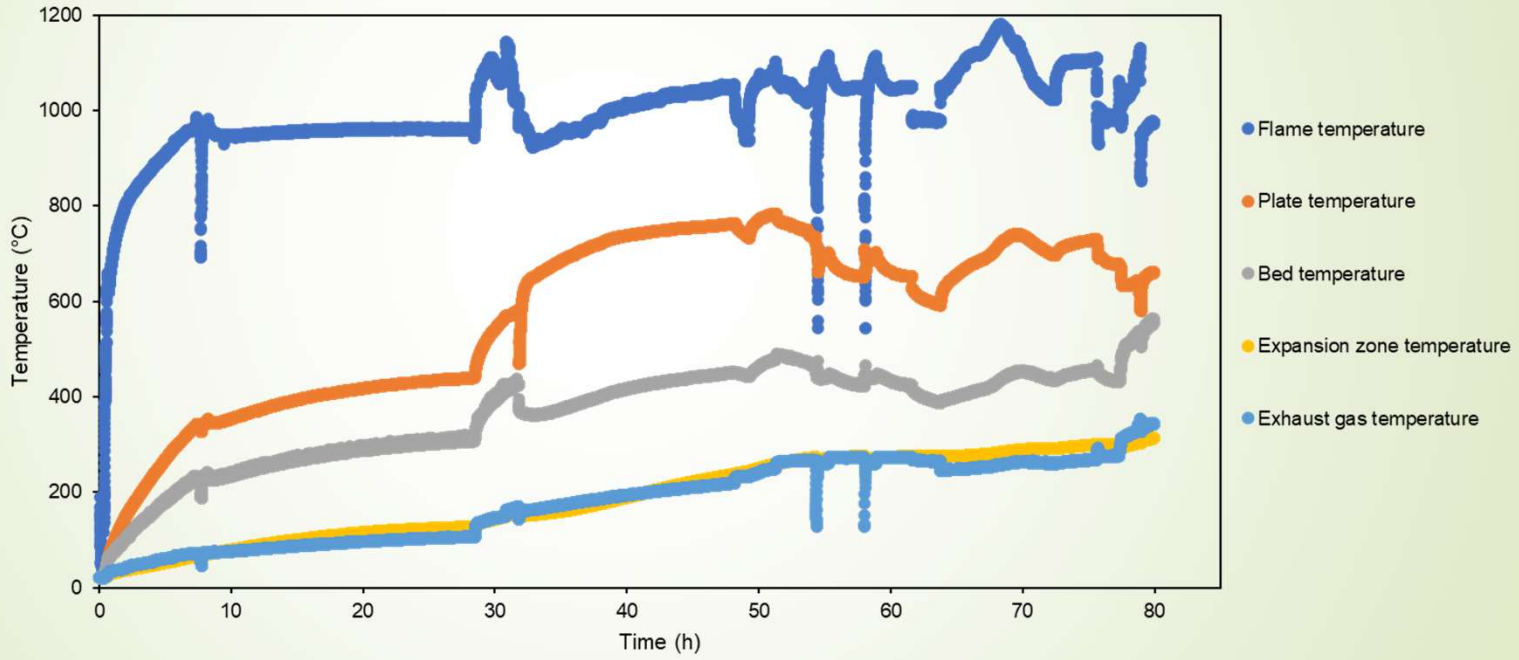
Waste plastics ATP at kg-lab scale

Fluidized-bed pyrolysis of HDPE

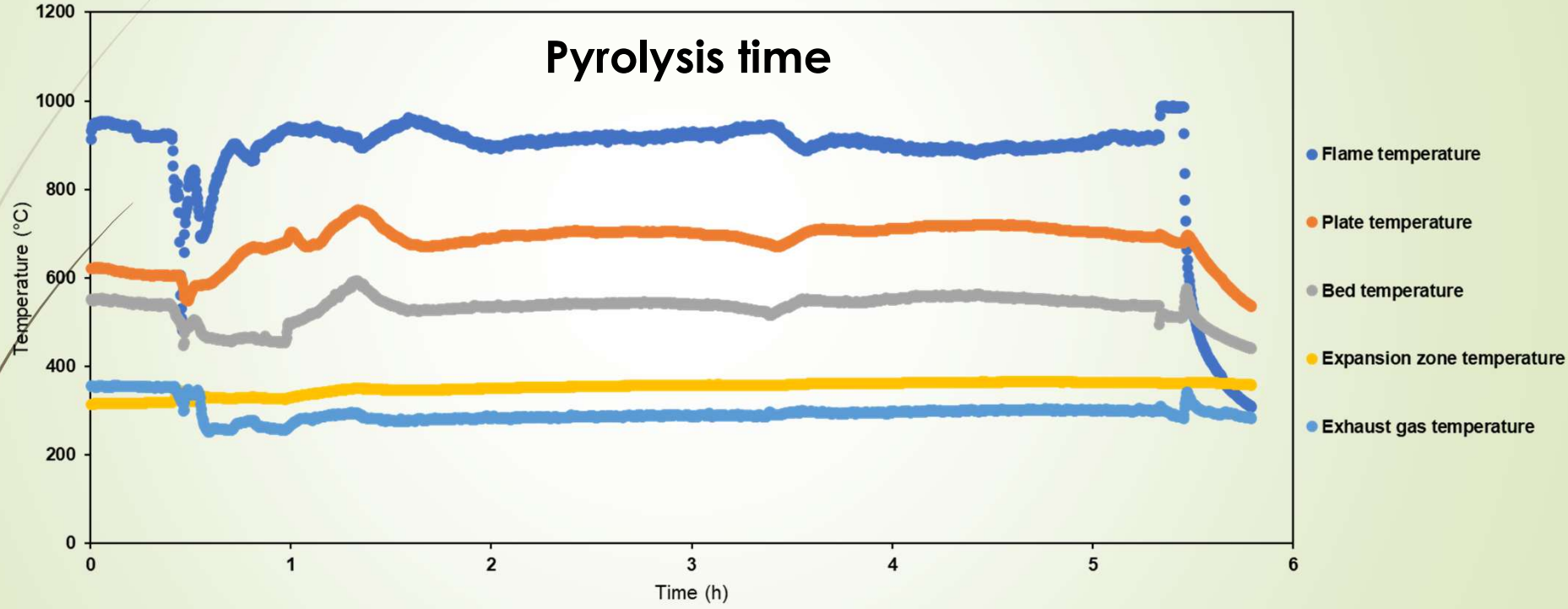
Heating of the reactor

- Propane : 2.7 LPM
- Air : 67 LPM
- Duration: 80 hours

Heating of the reactor



Fluidized-bed pyrolysis of HDPE



GRTP's ATP of HDPE

Pre-heating of the reactor
- Propane : 2 LPM
- Air : 80 LPM
- Duration: 48 hours

- HDPE (2 kg/h)
- AIR (50 LPM)

HDPE : High-density polyethylene

ATP
2.5 hours of pyrolysis

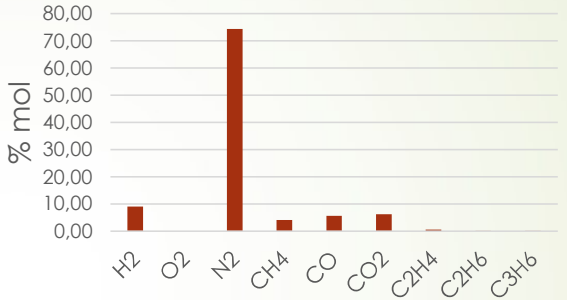
Gas
6.5 m³ /h

Solids
0.83 kg

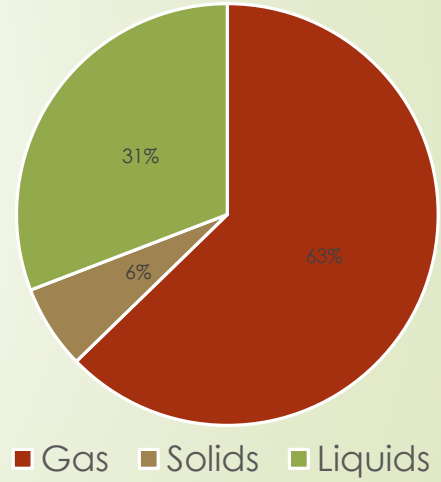
Liquids

Liquids were determined by difference

Molar gas composition



Mass composition of effluents



GRTP's ATP of HDPE

- HDPE (3.22 kg/h)
- Combustion gases (1.40 kg/h)

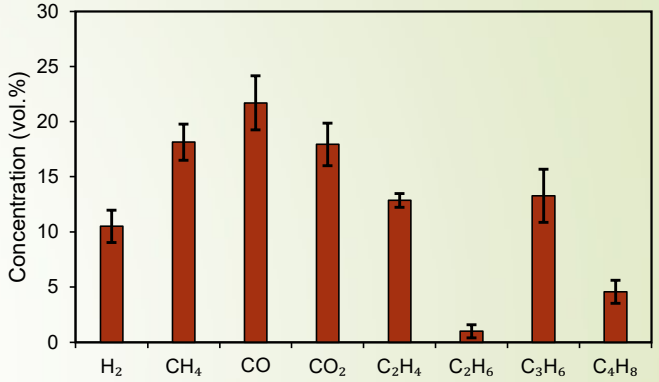
ATP
4 hours of pyrolysis

Gas
2.05 kg/h

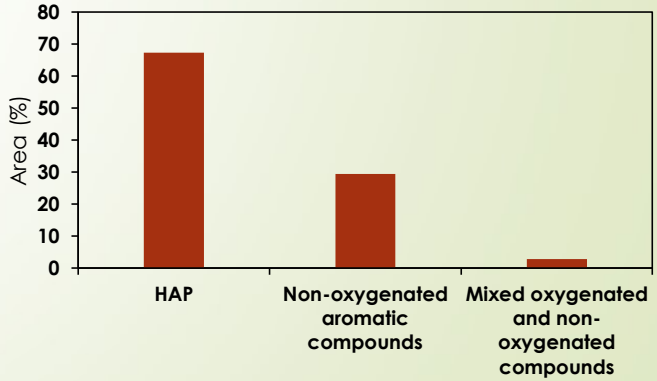
Solids
0.01 kg/h

Liquids (water + pyrolysis liquids)
2.56 kg/h

Molar gas composition



Bio-oil composition



Pyro-Liquids analysis with GC-MS (%wt)

Anthracene	11,6
7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	3,9
Naphthalene, 2-phenyl-	1,6
Fluoranthene	10,8
Pyrene	13,2
1,8-Diazacyclotetradecane-2,9-dione	5,9
7-Methyl-Z-tetradecen-1-ol acetate	1,5
1-Dodecanol, 3,7,11-trimethyl-	3,0
Benz[a]anthracene	2,9
Tetradecane, 2,6,10-trimethyl-	2,1
Phenol, 2,2'-methylenebis[6-(1,1-dimethylethyl)-4-ethyl-	3,7
Benzo[k]fluoranthene	4,2
Benzo[a]pyrene	2,9
Perylene	3,5

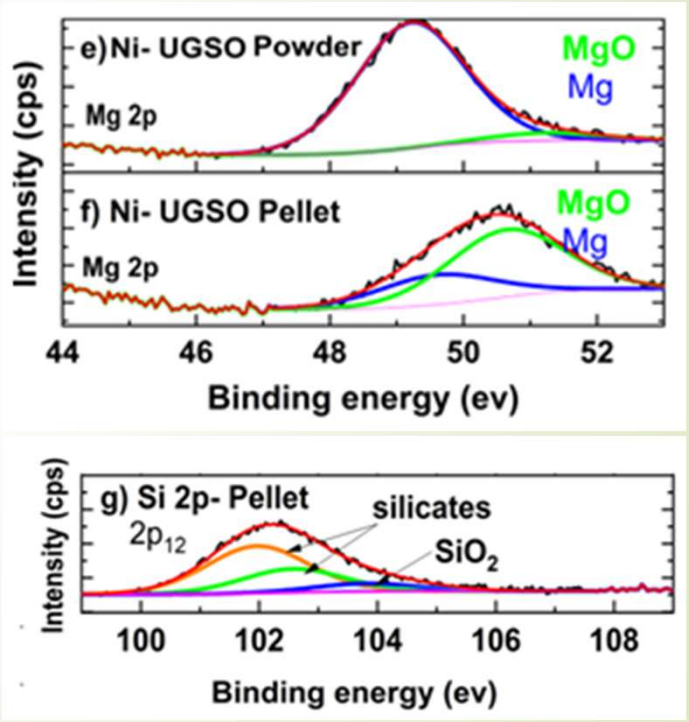
Dry reforming at High T and P over Ni-UGSO powder & pellets catalyst

UGSO Catalyst Pellets formulations

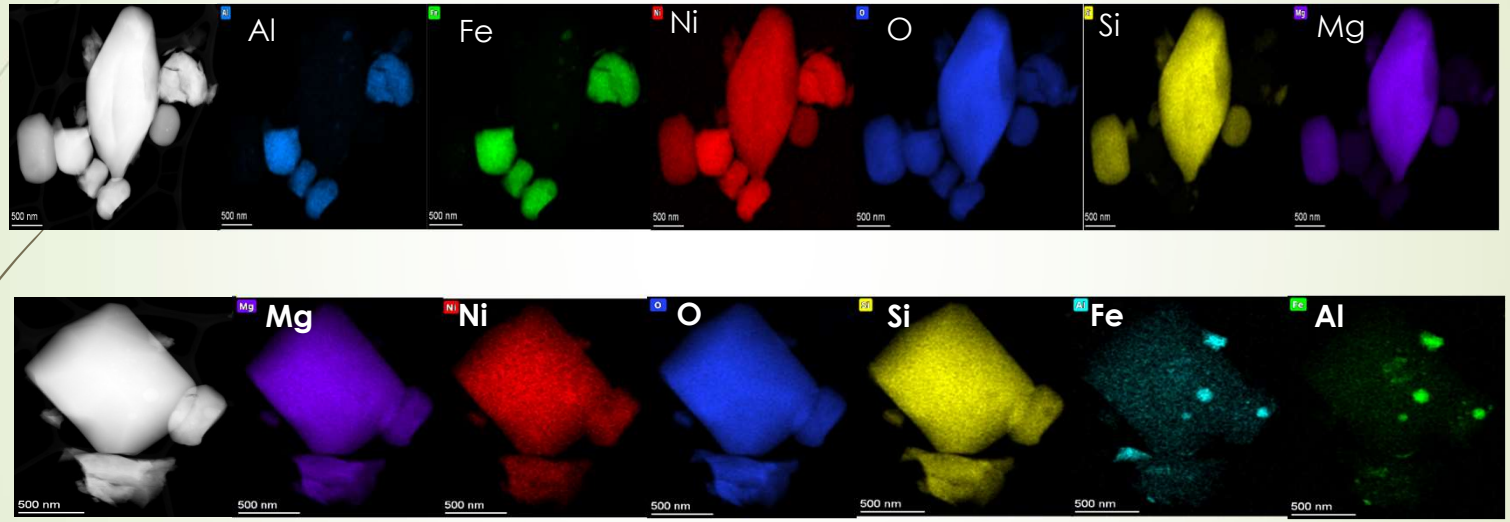
- 2*5 mm Ni-UGSO pellets (UGSO + Clay)
- Pellets have better dispersion of Ni in spinels
- Silicate-rich surface (MgO-SiO_2-NiO)
- Higher availability of Lattice O_2 on the pellet

Pellets synthesized using the wet impregnation method and extrusion

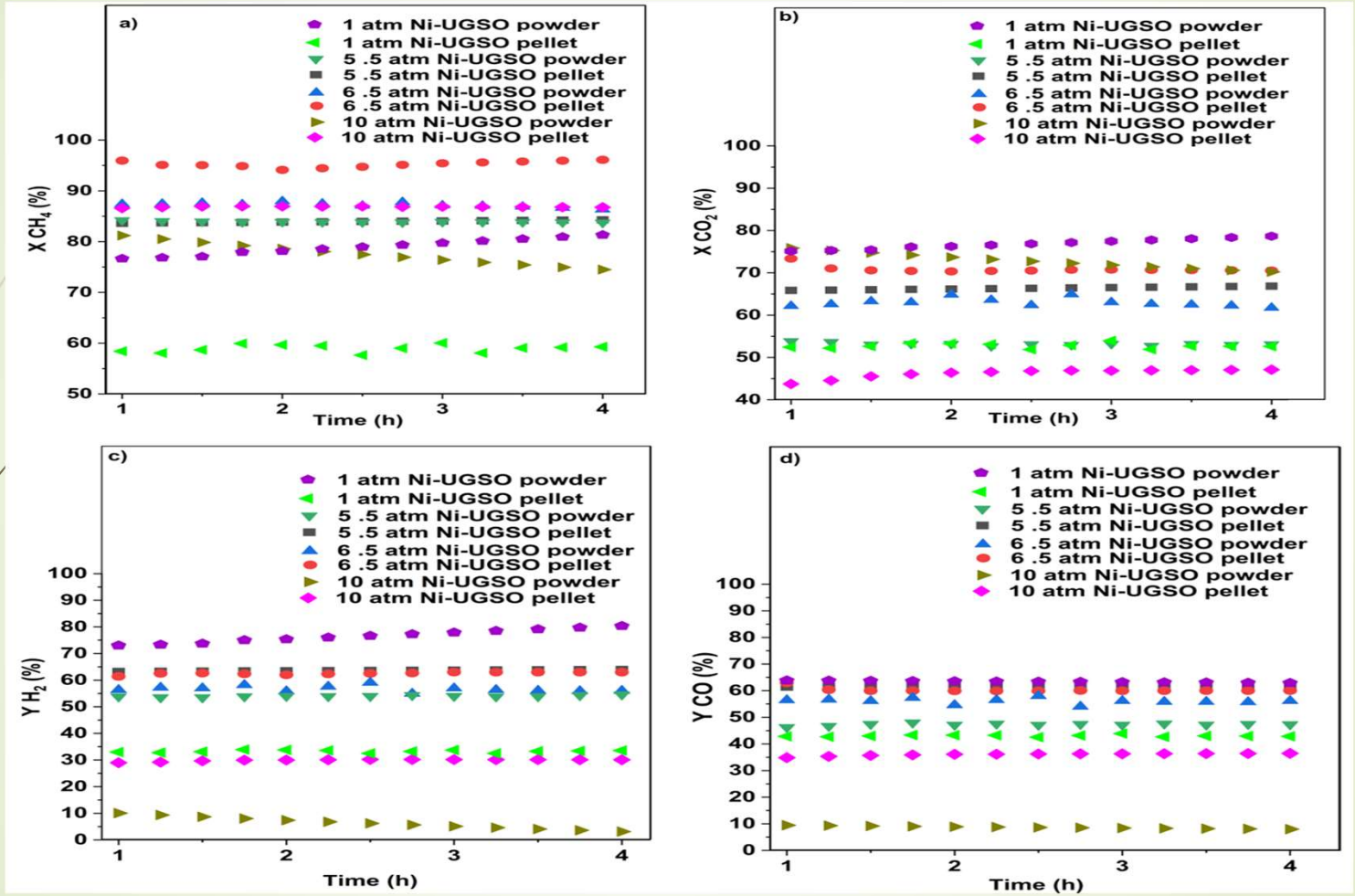
XPS Analysis



Pellets EDXS and elemental mapping analysis

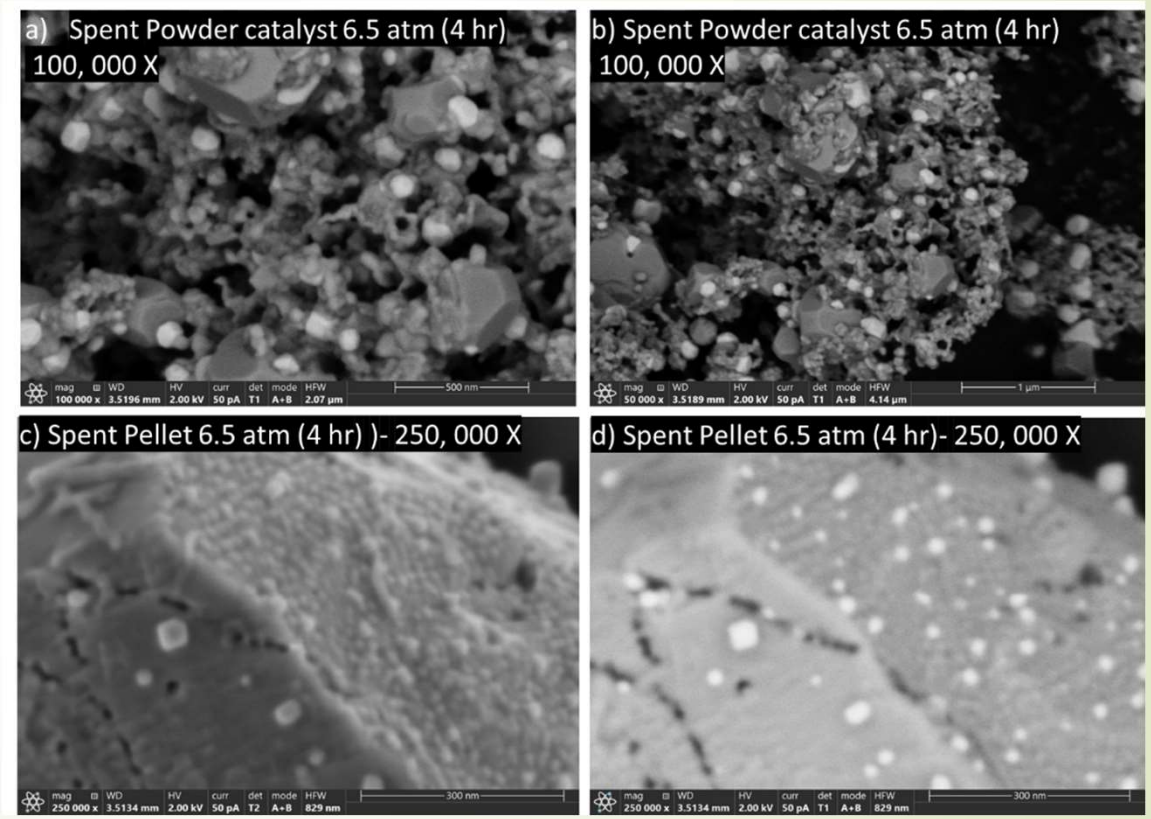


Catalytic reforming: Results and Discussion-1



Results and Discussion-2

- **Pellets performed better at higher pressure (5-10 atm)**
- **Lower ss is offset by better Ni dispersion**
- **Less coke formation over the pellet is attributed to silicate dispersion.**
- **The powder performs better at lower pressure (1 atm)**



SEM analysis validating better dispersion in pellets

Industrial transferability

- The novel ATP platform for waste conversion to platform-chemicals has now produced data at TRL min 5
- The next step (1 y) is the optimization of the yields
- First proofs of conversion to CNF are now a reality and optimization of the yield is ongoing (1 y)
- Based on the above the industrial partner (KWI) is engaged with GRTP to raise the required capital for a scaled-up semi-industrial unit (100 kg of CNF/h)
- Interested users of the CNF are contacted to test the CNF as additives to elastomers and other materials (NDAs are negociated)
- This ATP technological platform is the equivalent of the fossil carbon-based resources pretreatment step (i.e.; heavy crude oil).
- The combination of residual (waste) plastic with biomass adds a significant flexibility to the proposed technology.


PRIMA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axelys


CRSNG
NSERC


KWI
polymers

Contributions

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- Professor: François Gitzhofer and Inès Esma Achouri
- HQP
  - Tchini Séverin Tanoh, PDF
  - Khadija Olivia Ogoula Igouwe, PhD student
  - Dr Abir Azara
  - Dr Salma Belbessai
- Professionals & Technicians
  - Jacques Gagné
  - Marc G. Couture
  - Mohamed Chouaib Achouri, technician
- KWI
  - Dr Jasmin Blanchard, KWI
  - Michel Horth, KWI
  - Dr Pierre Breton, KWI
- Plateforme de recherche et d'analyse des matériaux: PRAM/UdS
- UdS for new buildings
  - Prof. Patrik Doucet, ex-Dean of Engineering
  - Prof. Jean-Pierre Perrault, Vice-Rector, Research and Graduate studies

Patents

Abatzoglou, N., Fauteux-Lefebvre, C., Blanchard, J., Gitzhofer, F. (2011) Steam reforming of hydrocarbonaceous fuels over a Ni-alumina spinel catalyst, Application number: WO2010CA01284 20100819

Abatzoglou, N., Fauteux-Lefebvre, C. (2015) Metal-Functionalized Carbon Nanofilaments And Process For Removing Sulfur From Gaseous Fuels, provisional patent application, USPTO No 61894033.

Abatzoglou, N., Gitzhofer, F., Gravelle, D., Blanchard, J., De Oliveira-Vigier, K., Oudghiri-Hassani, H., Gauvin, H. (2010) Carbon sequestration and dry reforming process and catalysts to produce same, US Patent 7,794,690.

Abatzoglou, N., Bureau, J., Mincic, A., Chornet, E., (2002) Mobile granular bed filtration apparatus for hot gas conditioning, UStates Patent 6,436,161.

Thanks for your attention!

Questions?