CO-PYROLYSIS OF BIOMASS AND PLASTICS FROM WASTE IN AN INDUCTION HEATED REACTOR

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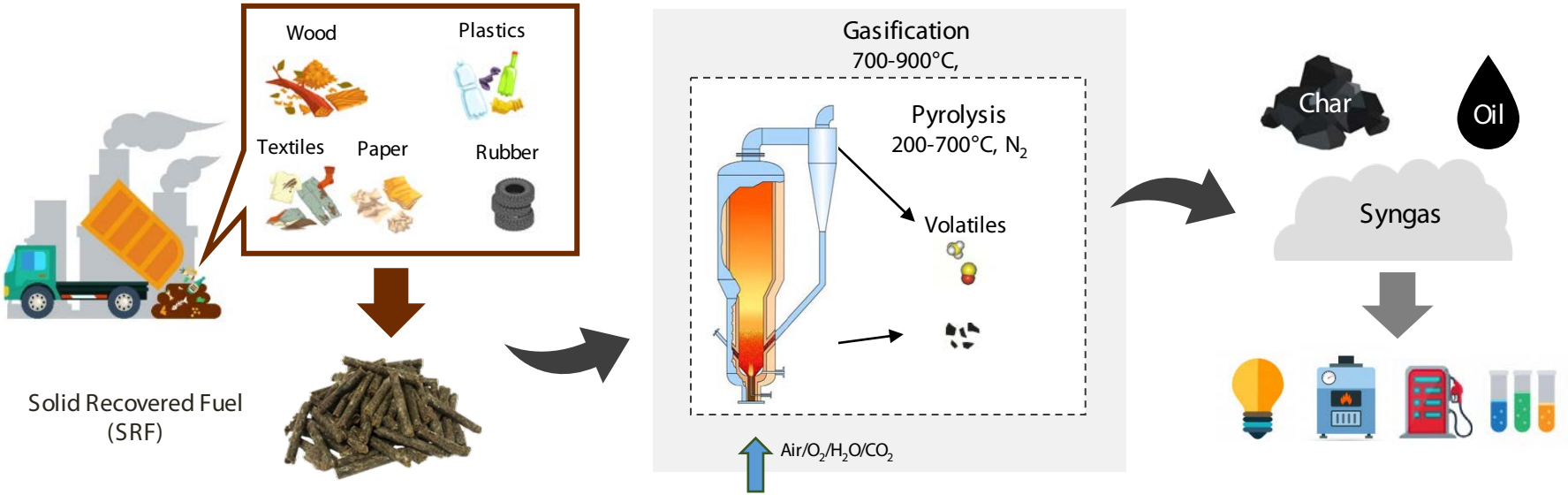
Solid waste valorization: thermochemical processes



Yield and composition of oil/syngas/char are strongly influenced by feedstock:
Interaction effects during co-pyrolysis of waste materials must be studied deeply!

Co-pyrolysis of waste materials: State of the art

- Several studies show synergistic effects between waste materials:
  - Minimal between components of the same category [1]
  - Mainly binary (plastic/biomass) [2 - 4]
  - Overall negative synergy during pyrolysis of a MSW mixture (Paper/wood waste/mixed plastics/rubber) [5]

- Previous studies at lab scale(mostly TGA) does not have representative process conditions of pilot/industrial scale:
  - Heat and mass transfer limitations

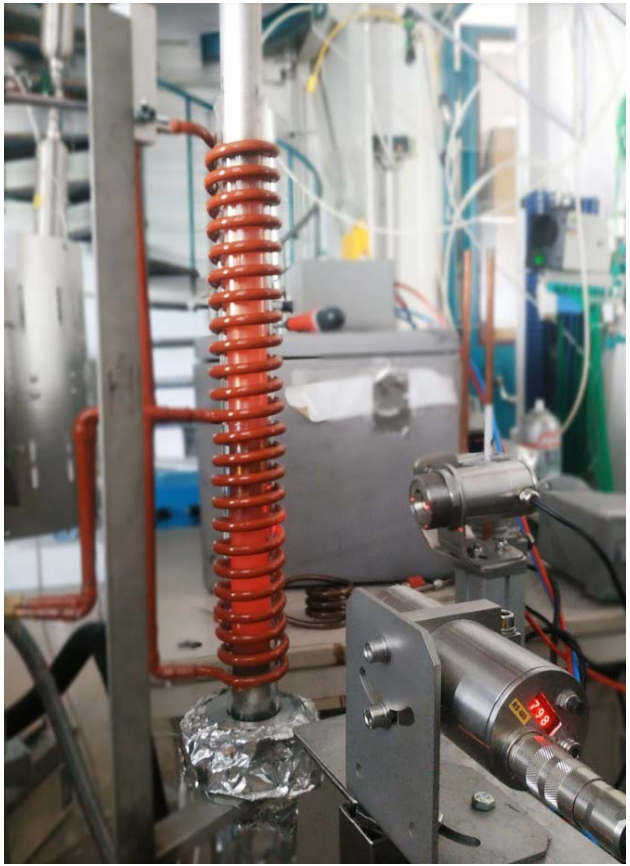
- Reaction products are usually not quantified or analyzed:
  - Samples in TGA studies are usually between 20-100 mg

[1] Zheng J., et al. (2009). Waste Management, 29(3), 1089–1094.
[2] Sørum et al. (2001). Fuel, 80(9), 1217–1227.
[3]Zhou et al. (2015). Waste Management, 38, 194–200.
[4] Win et al. (2020). Journal of Material Cycles and Waste Management, 22(2), 547–555.
[5] Chhabra et al. (2019). Waste Management, 90, 152–167.

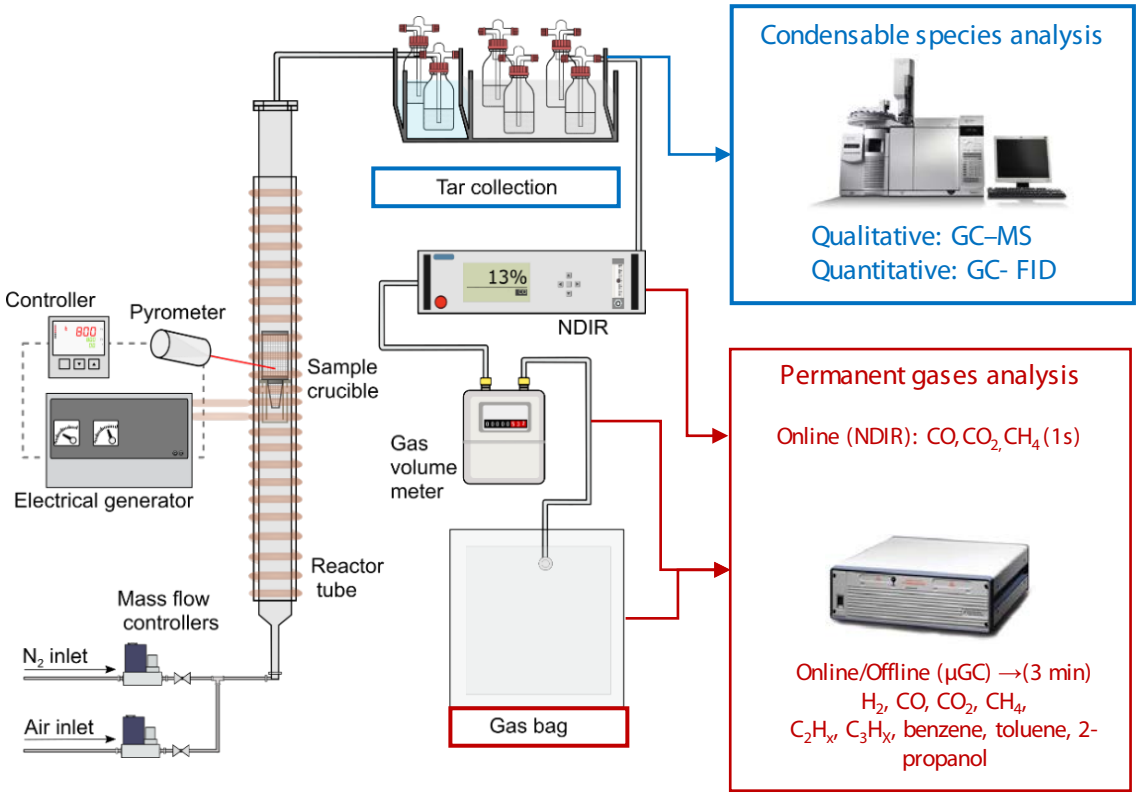
Materials and methods: Experimental Setup

Design features:

- Induction system:
  - ✓ High heating rates
  - ✓ Accurate control
  - ✓ Short heating and cooling times
- Preheater assemble:
  - ✓ Enhanced gas/solid contact
  - ✓ Uniform temperature profile
- Large sample capacity:
  - ✓ up to 5 grams of sample
  - ✓ Products can be recovered and analyzed



Materials and methods: Experimental Setup



Materials and methods: Feedstocks

Solid recovered fuel (SRF)

Model materials:

Polyethylene (PE)

Polypropylene (PP)

Beech wood

Size reduction: Grounded in a cutting mill

Sieving: 1.2mm ⦰

Mixing: 1:1 ratio

Pressing: Hydraulic press(3 ton)

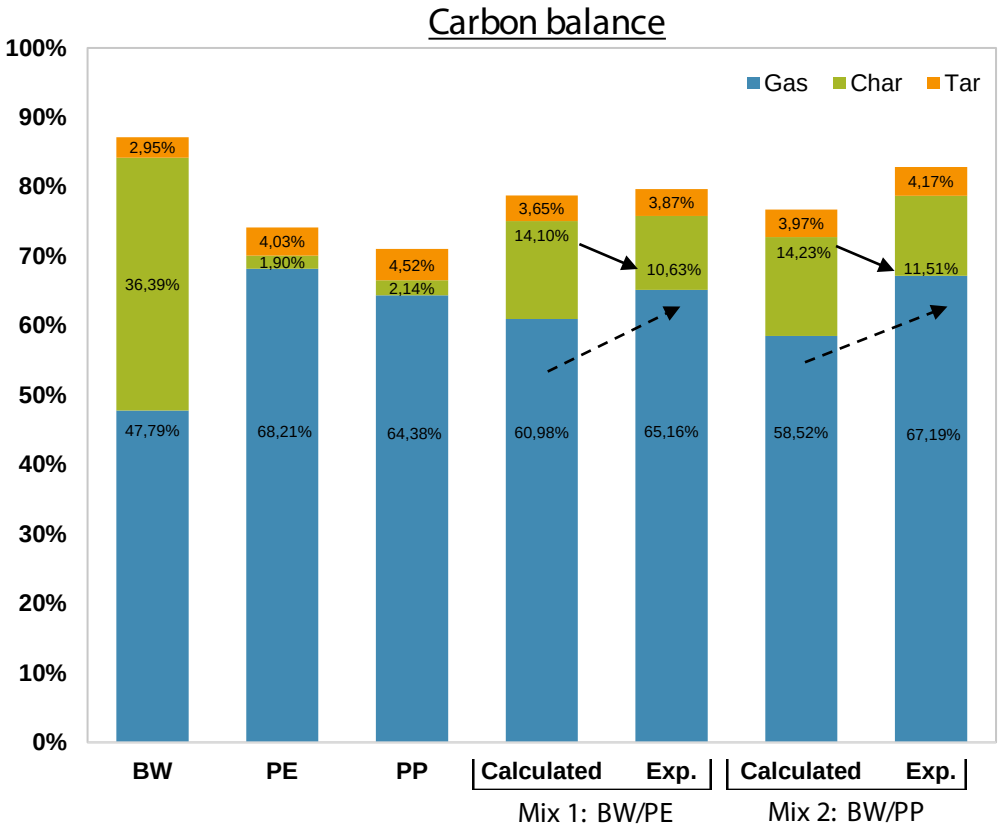
Mixture 1
PE/Wood(1:1)

Mixture 2
PP/Wood(1:1)

Samples characterization:

- Chemical composition (%)
- Moisture content (wt%) (105°C)
- Ash content (wt%) (815 °C)

Results: Co-pyrolysis of biomass/plastics



Calculated: addition by non-interactive model

$$Xc_{mix,calc} = \frac{Xc_{wood} \times \%C_{wood} + Xc_{Plastic} \times \%C_{Plastic}}{\%C_{wood} + \%C_{Plastic}}$$

Two synergetic effects are observed!

→ Char production is inhibited: Suppresion of cyclation and aromatization reactions [6][7]

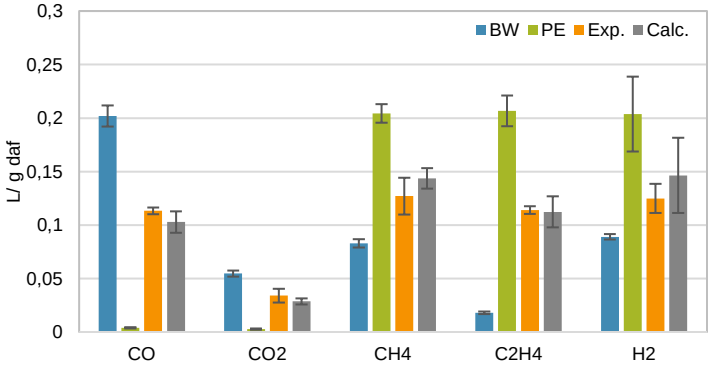
--→ Enhanced gas yield: CO formation through decarbonylation reactions [6]

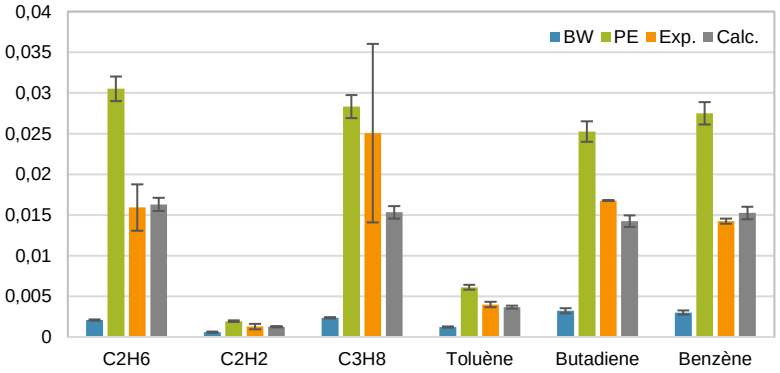
[6] Kasataka et al. (2020).Bioresource Technology Reports, 11, 100431.
[7] Liu et al. (2020). Applied Energy, 279, 115811.

Results: Co-pyrolysis of biomass/plastics

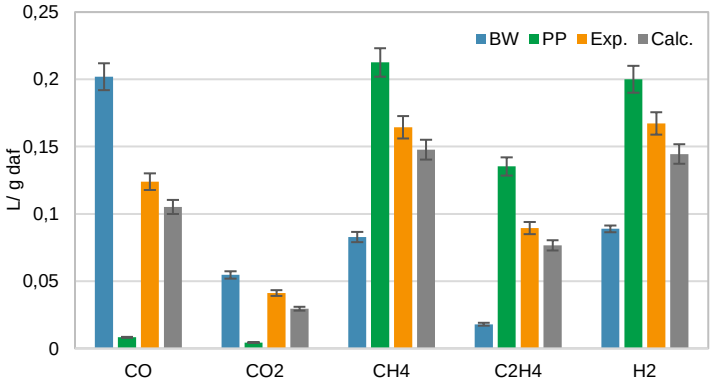
Gas yield (L / g daf)

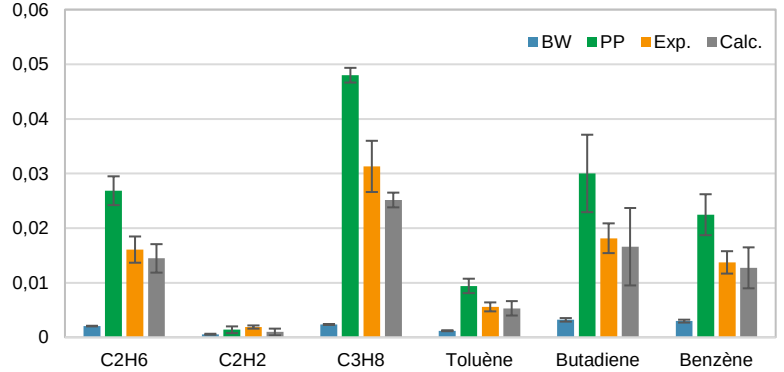
Mix 1 (BW/PE):





Mix 2 (BW/PP):





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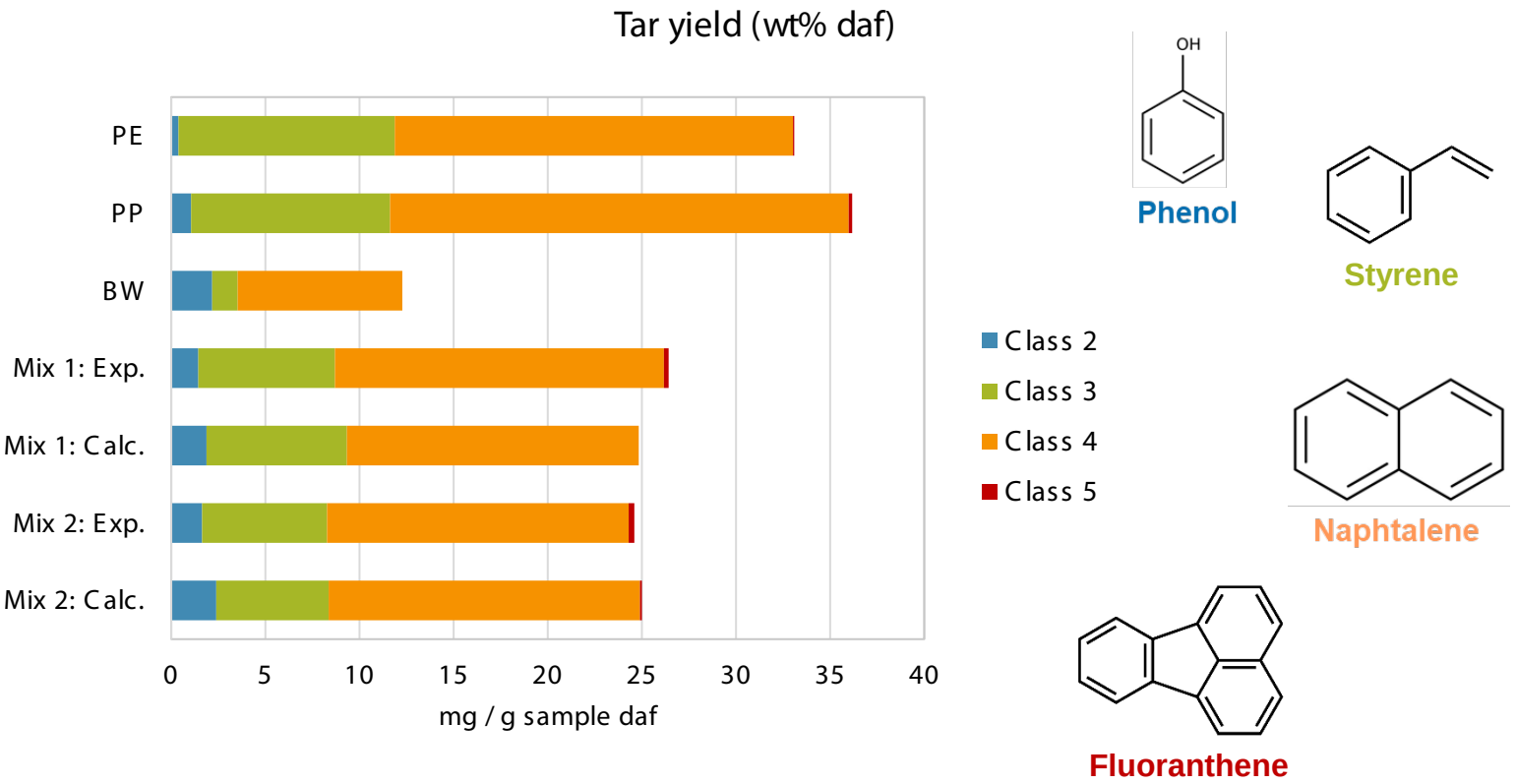

Conclusions/Perspectives

- Pyrolysis tests of SRF and selected modeled materials were successfully carried out in a specifically developed induction heated reactor at 800°C.

- Synergetic effects were observed in both Plastic/Wood mixtures.

    - Enhanced conversion to gas:
        - For the PE/BW mixture (Mix1) total gas yield was enhanced by 5%
        - For the PP/BW total gas yield was enhanced by 15%

    - Inhibition of char

      Reduced char yield due to inhibition of condensation and aggregation reactions

- Perspectives:
    - Test other "model materials", and gasification conditions (in presence of oxidation agent)

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Thanks for your attention!

Any questions?

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