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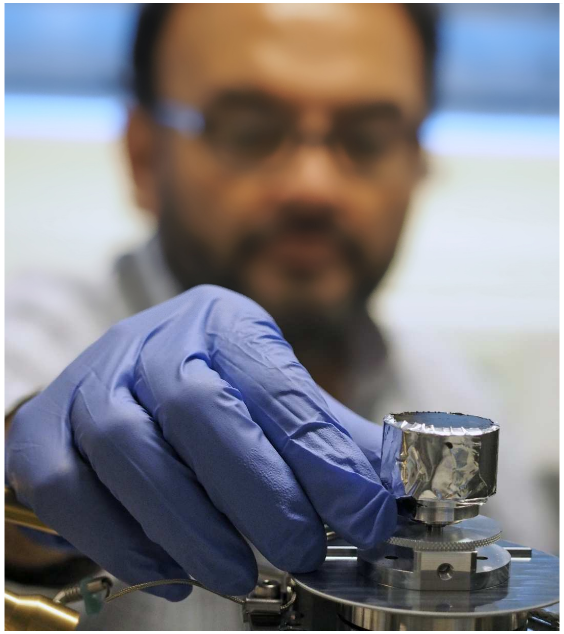
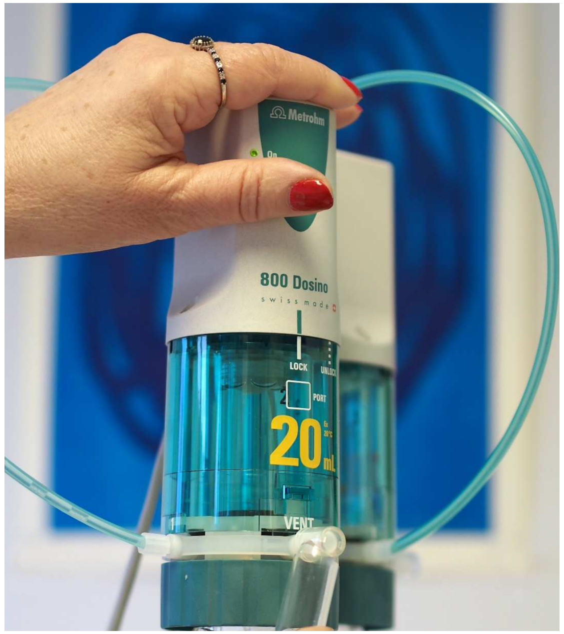


Production of olefins and monoaromatics through catalytic fast pyrolysis of biomass and plastics



Javier Celaya Romeo
Kai Toven
Ingebjørg Leirset
Anne Marie Reitan
Benjamin Kleppe

tcbiomassplus2019, Rosemont, IL (USA). 9/Sept/2019.

RISE PFI AS

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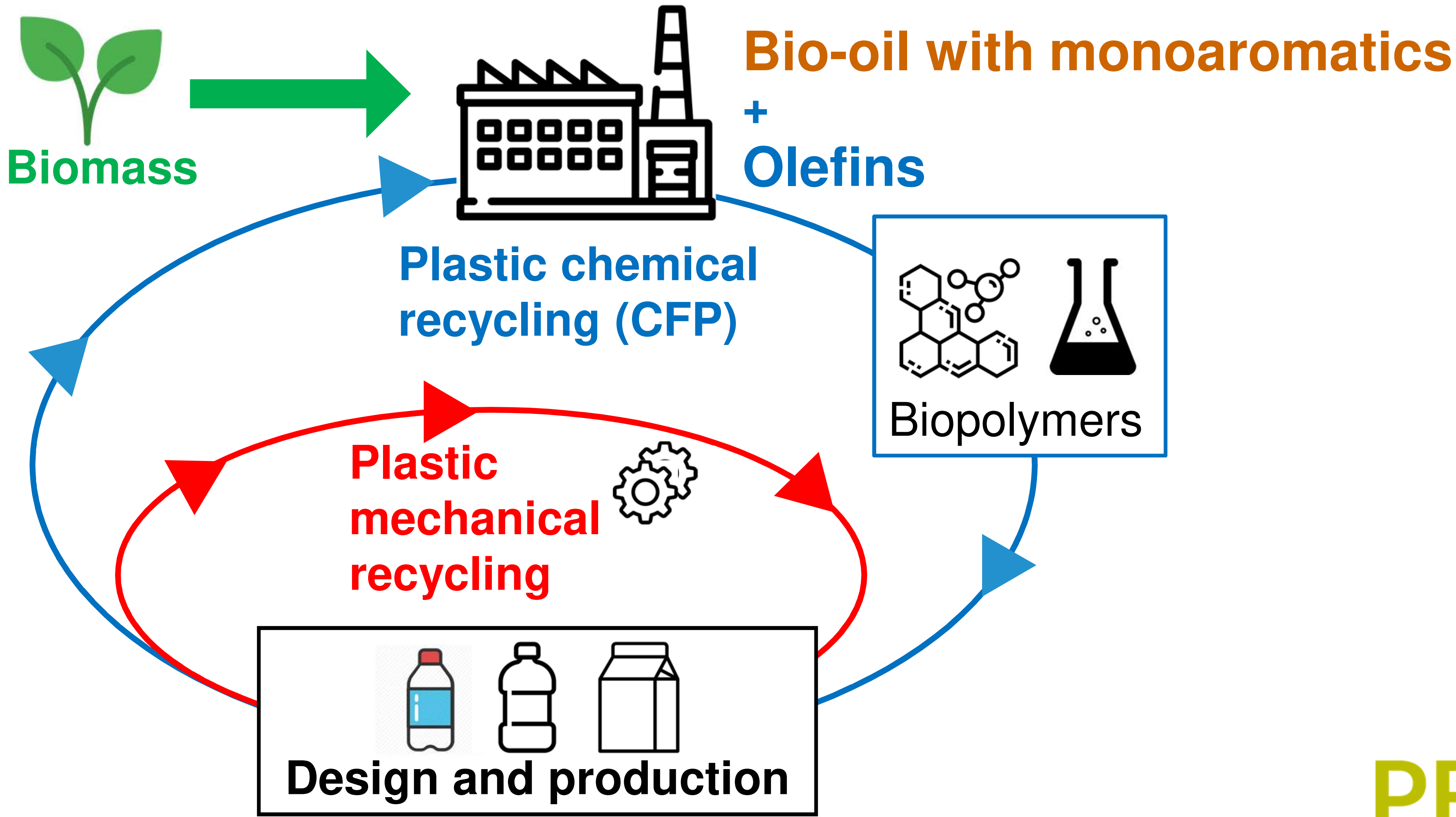
FuturePack project: future plastic packaging in the circular economy



Catalytic fast pyrolysis (CFP)

pyrolysis: Thermal decomposition in an inert atmosphere

fast High heating rates and low gas residence time

Catalytic Product gases treated with a catalyst

Which plastic?

Which biomass?

Which catalyst?

In-situ or ex-situ?

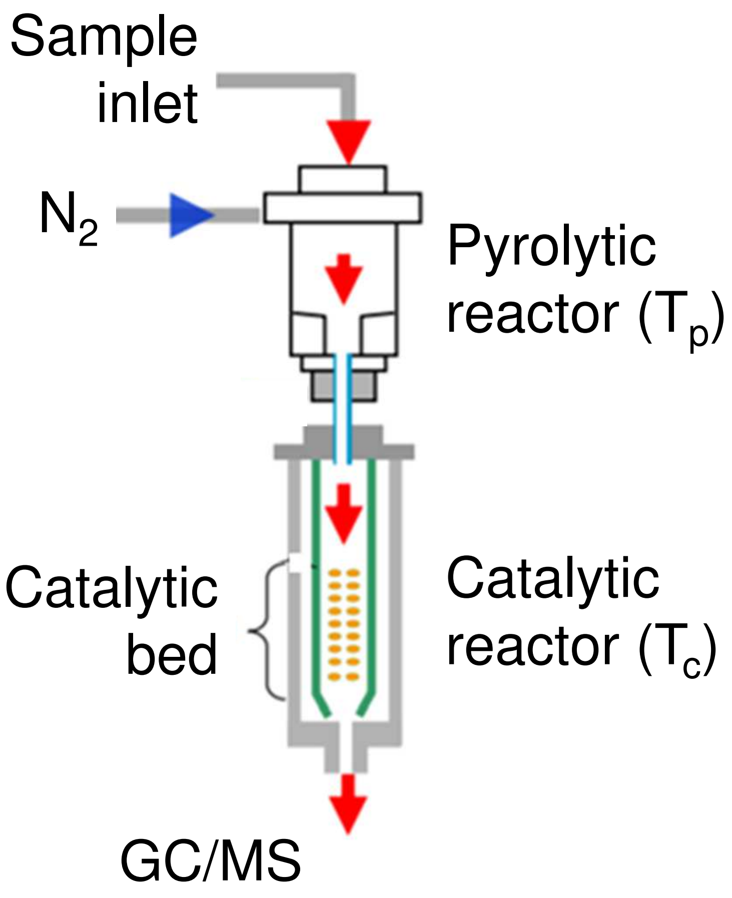
T_{pyr}?

T_{cat}?

Catalyst/feedstock ratio?

Blends of feedstocks? Proportions of feedstock?...

Tandem micro reactor – GC/MS



Advantages:

- ✓ Small amounts of catalyst required (<<1 g)
- ✓ **Quantification** of yields (calibration)
- ✓ Short experiment times
- ✓ Independent reactor temperatures (up to 900 ºC)
- ✓ In-situ and ex-situ catalysis mode

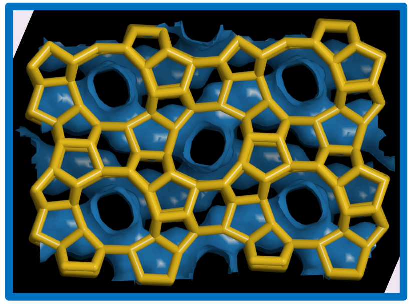
Disadvantages:

- ✗ No further characterization of products
- ✗ Batch process
- ✗ Difficult evaluation of char/coke

Material for the experiments

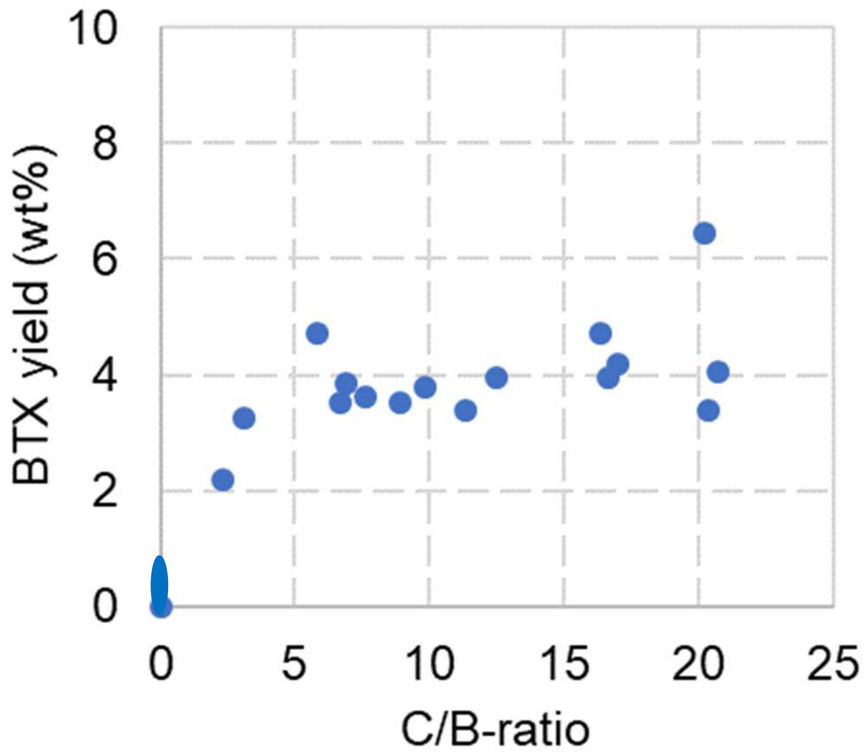
- Feedstocks:
  - Straw
  - Spruce wood
  - Polyethylene (PE)
  - Polypropylene (PP)

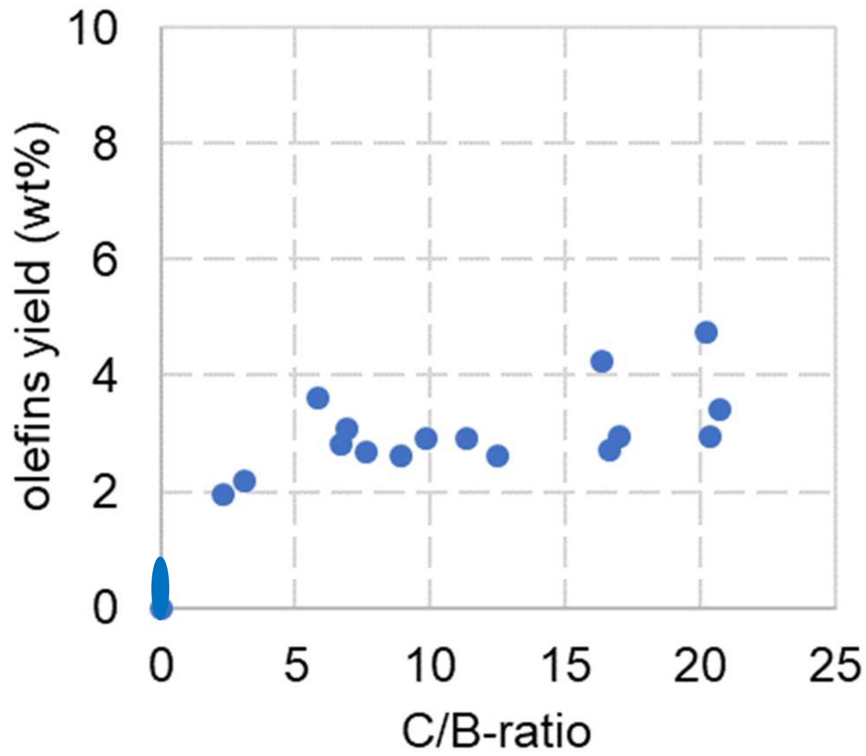
- Catalyst: ZSM-5 zeolite (*)
  - $SiO_2/Al_2O_3 = 30$
  - Pelletized, crushed and sieved for 0.25 mm < dp < 0.7 mm
  - Calcined at 550 ºC for 4 hours to obtain the proton form (H-ZSM-5)
  - Supplier: Zeolyst International



(*) MFI framework type. Structure graph extracted from: http://europe.iza-structure.org/IZA-SC/framework_3d.php?STC=MFI

Catalyst/feedstock ratio (spruce in-situ CFP, 500 ºC)





No catalyst ➔ negligible BTX and olefins (ethylene+propylene)

No significant change in the rango 5-20 catalyst/biomass ratio

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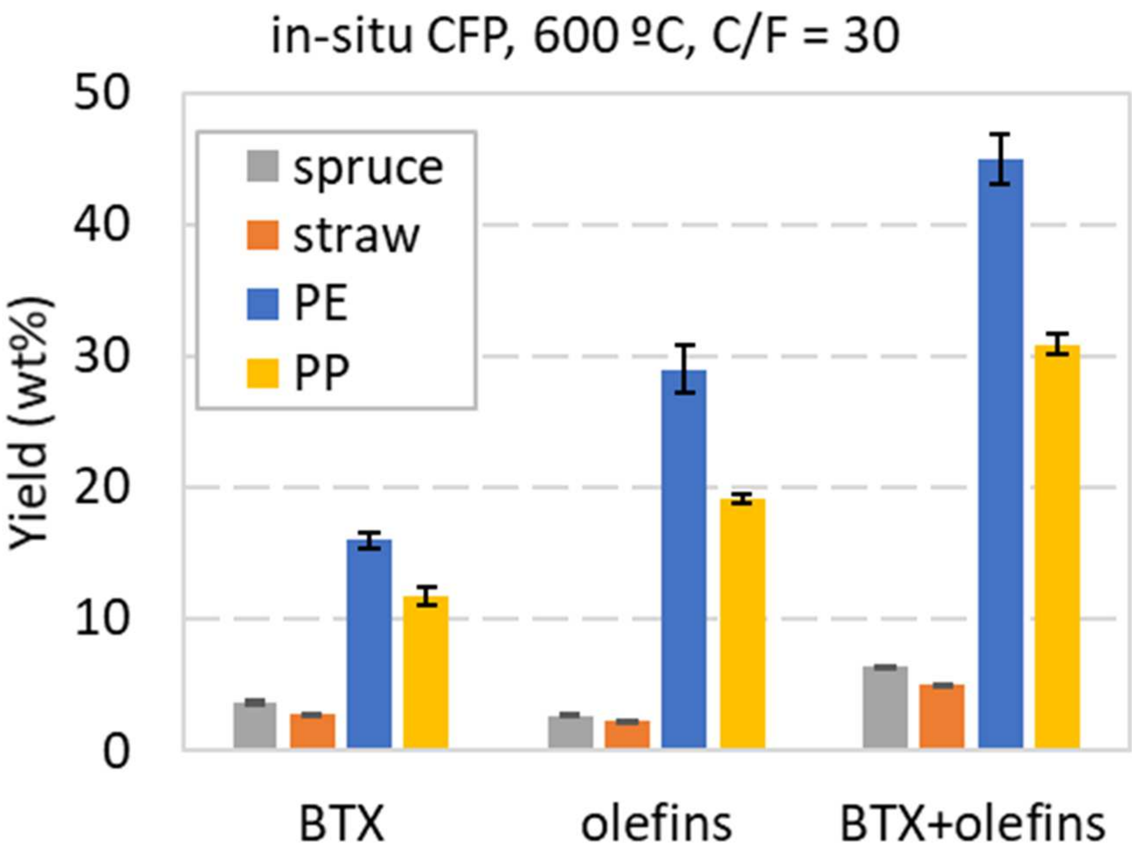
Feedstocks: straw, spruce, PE and PP



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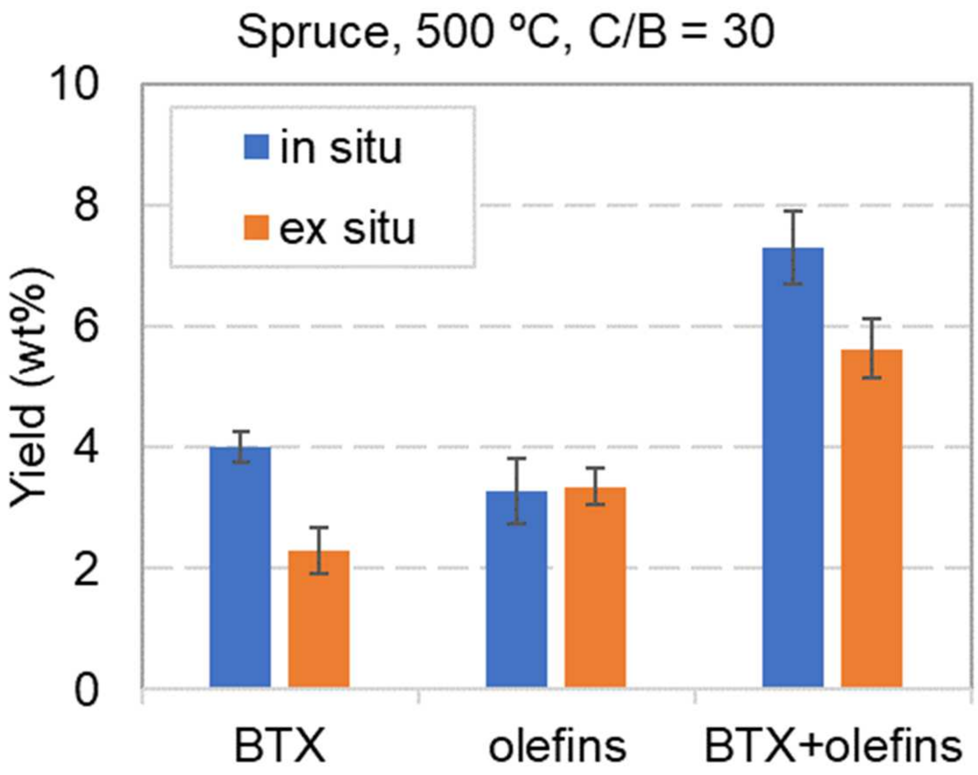
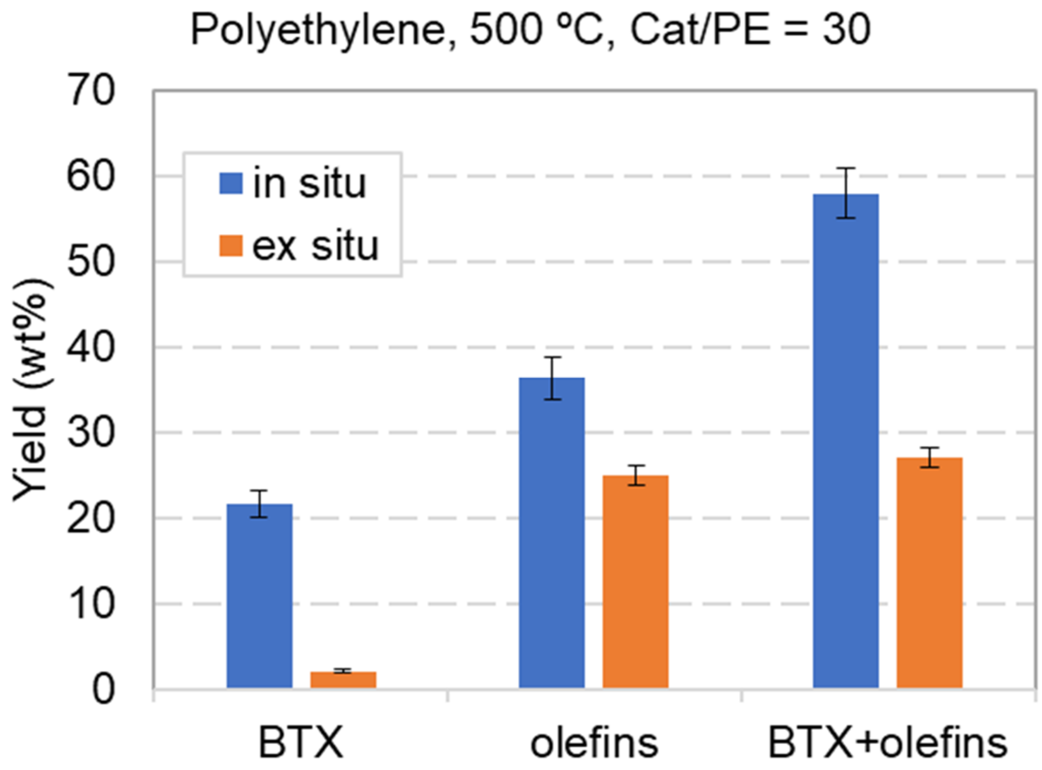
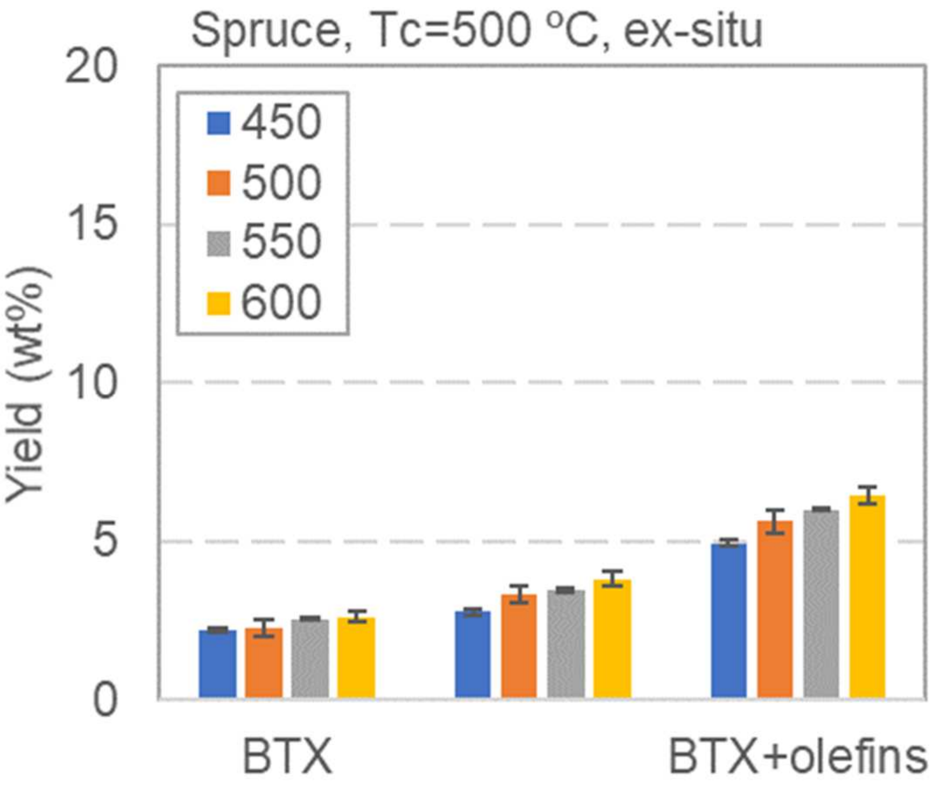
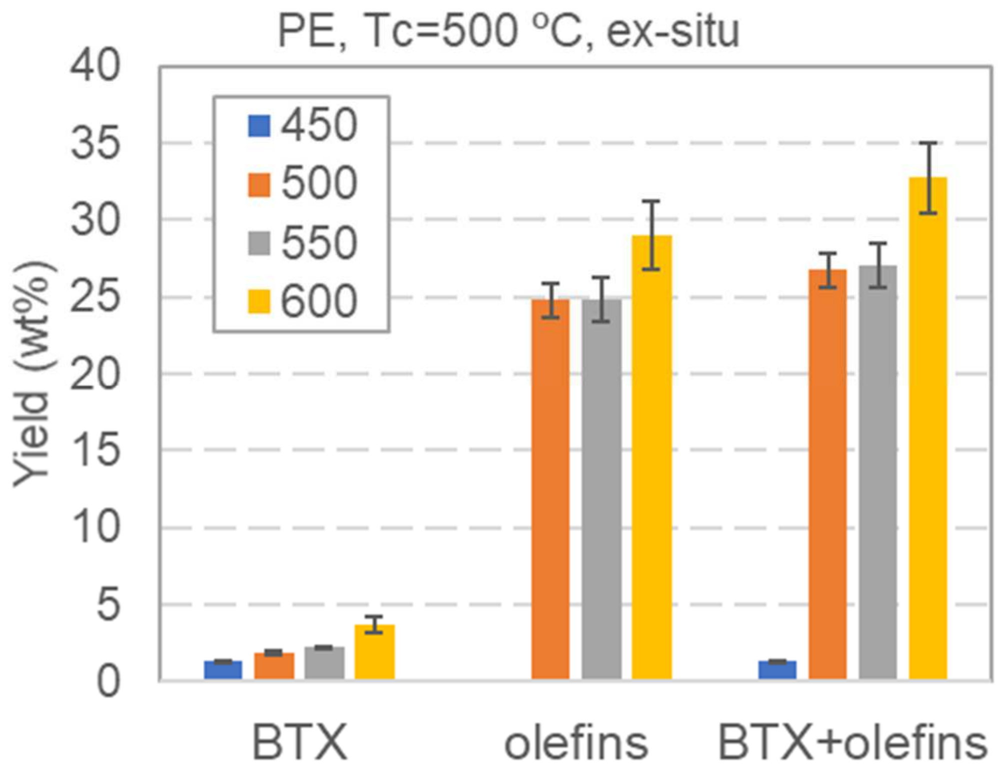
In situ vs. ex situ CFP



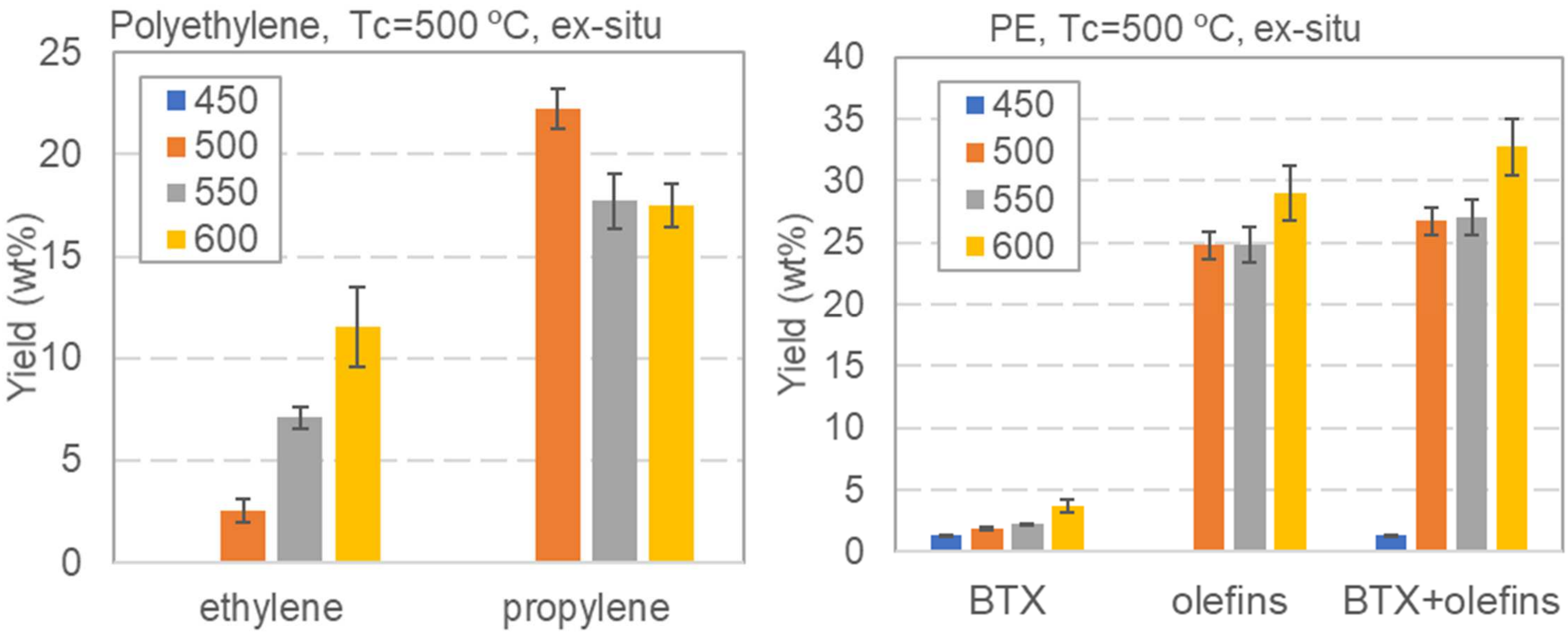


Pyrolysis temperature (T_{cat}=cte)

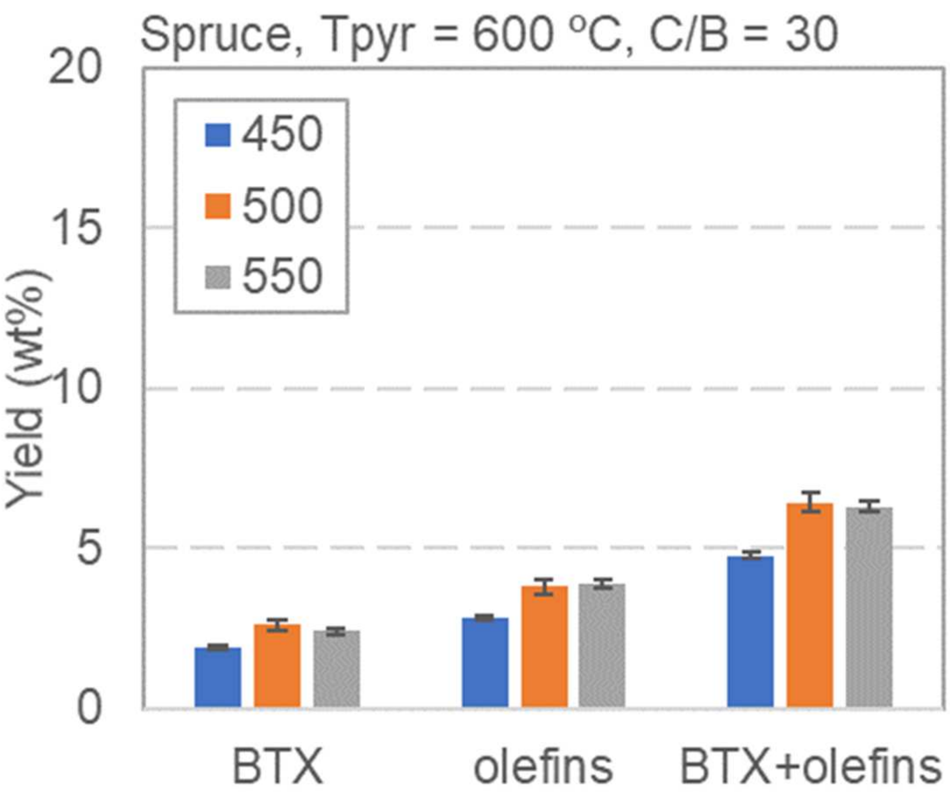


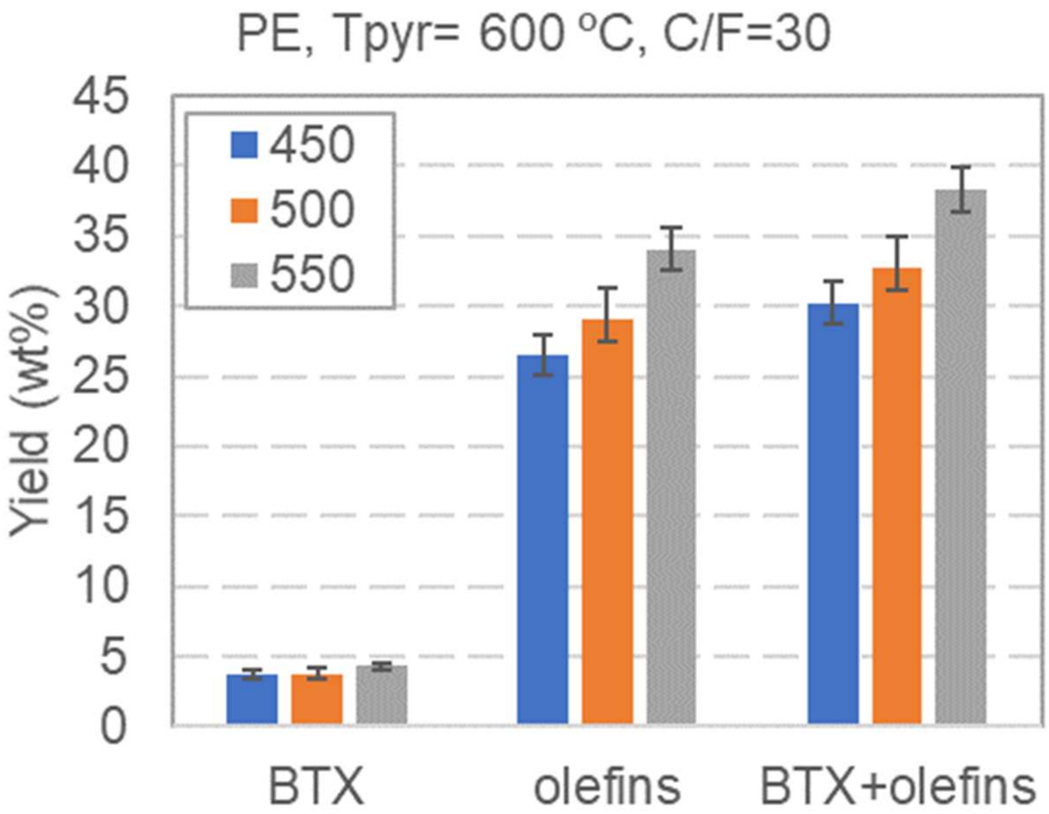


Pyrolysis temperature (T_{cat}=cte)

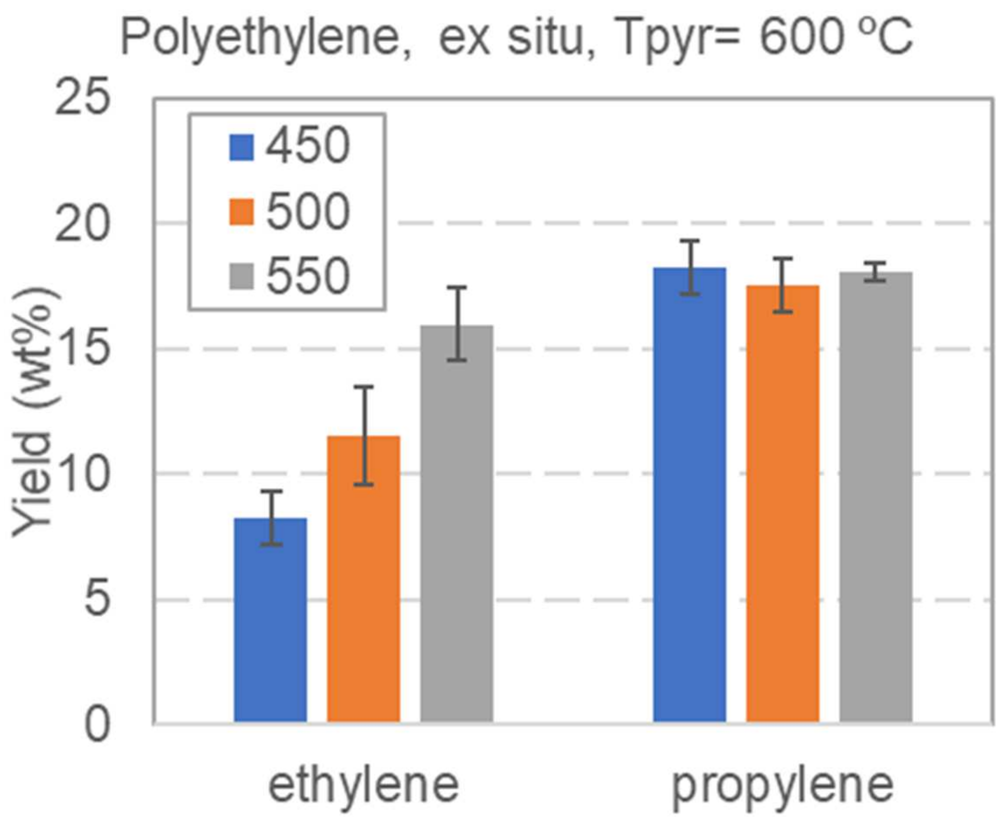


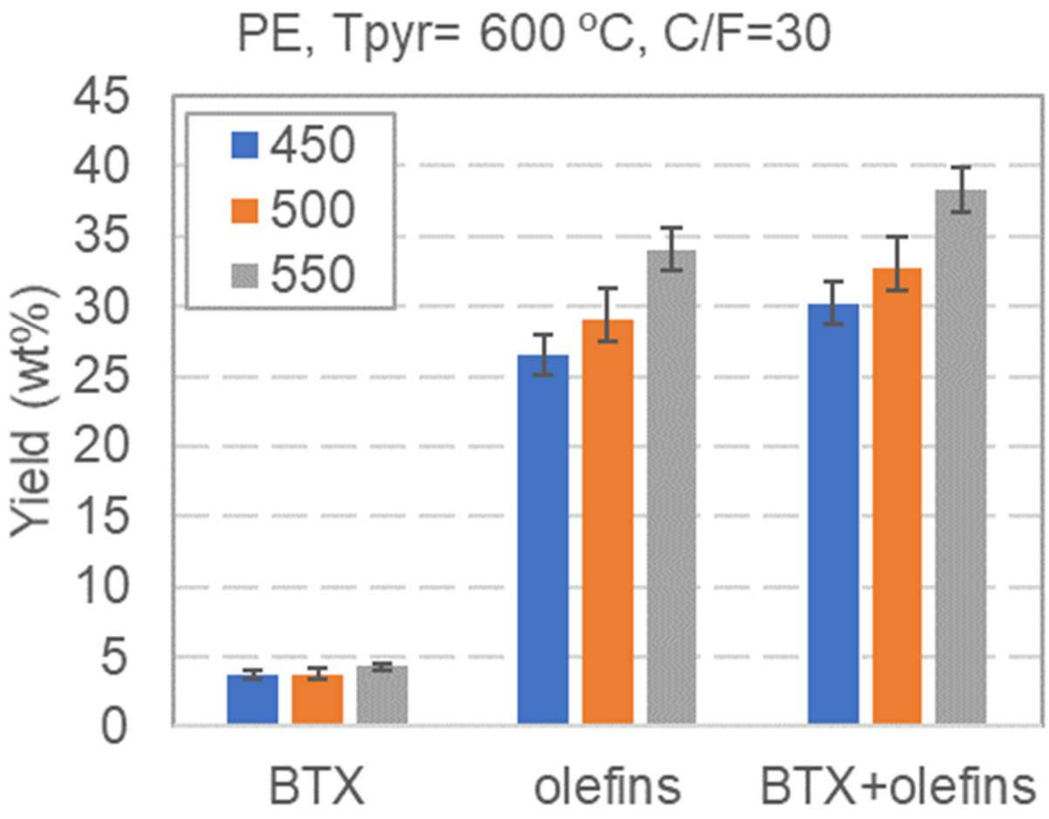
Catalysis temperature (T_{pyr} = cte)





Catalysis temperature (T$_{pyr}$ = cte)

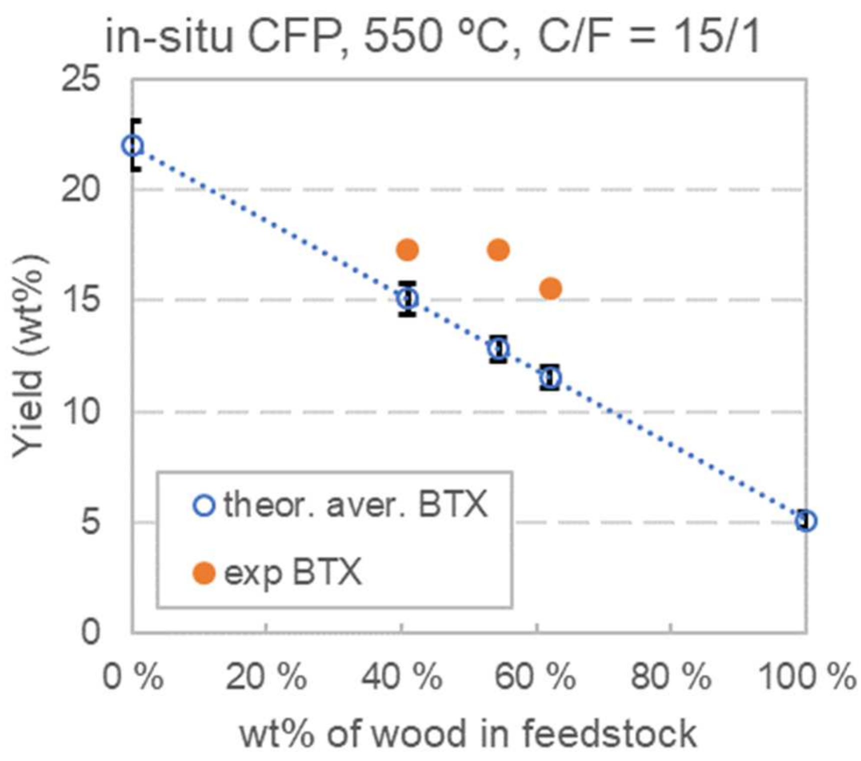


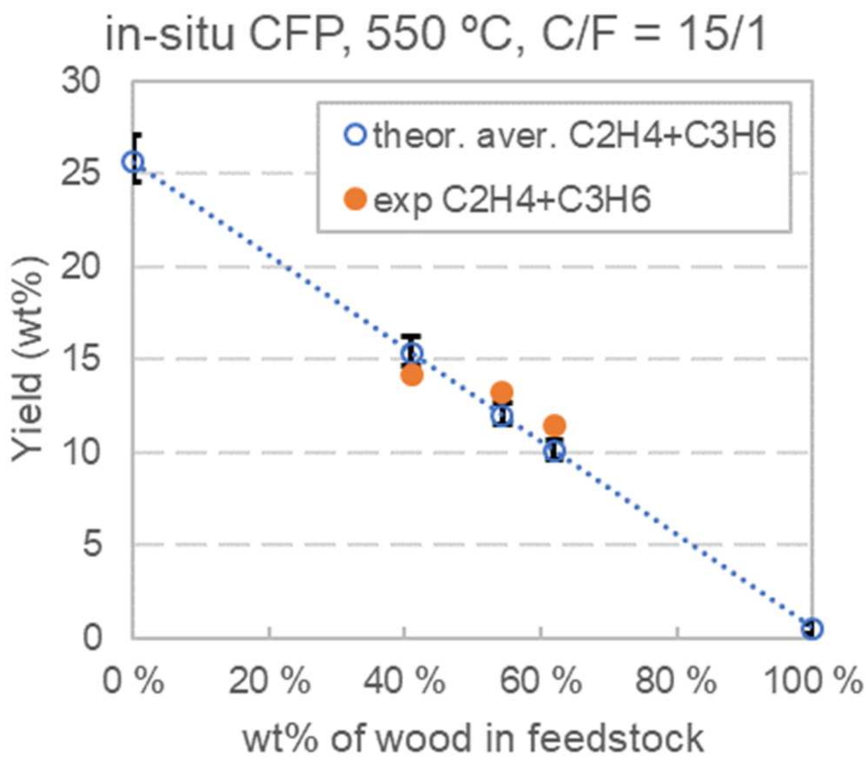


Co-pyrolysis and synergy effect

	C (wt%)	H (wt%)	O (wt%)	$\left(\frac{H}{C}\right)_{eff} = \frac{H - 2O}{C}$
Biomass	~45 – 50	~5 – 7	~ 45 – 50	~ 0 … -1
Plastics	~ 85	~ 15	0	~ 2
Olefins	~ 85	~ 15	0	~ 2
BTX	~ 91	~ 9	0	~ 1

Co-pyrolysis and synergy effect (wood and laminate plastic)





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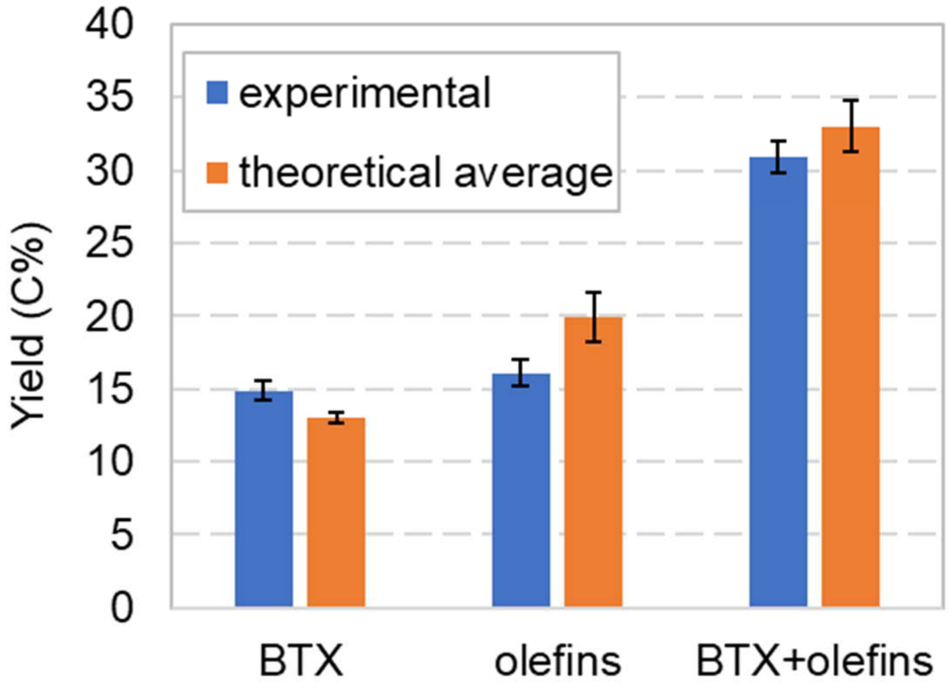
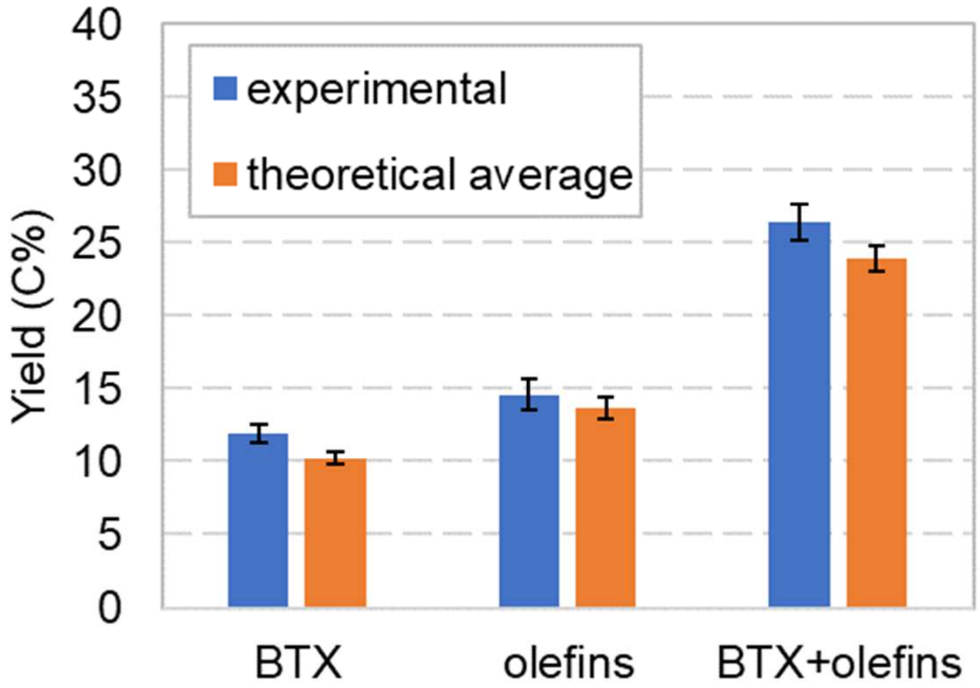
Co-pyrolysis and synergy effect

Spruce/PE = 1/1; 600 ºC, in situ

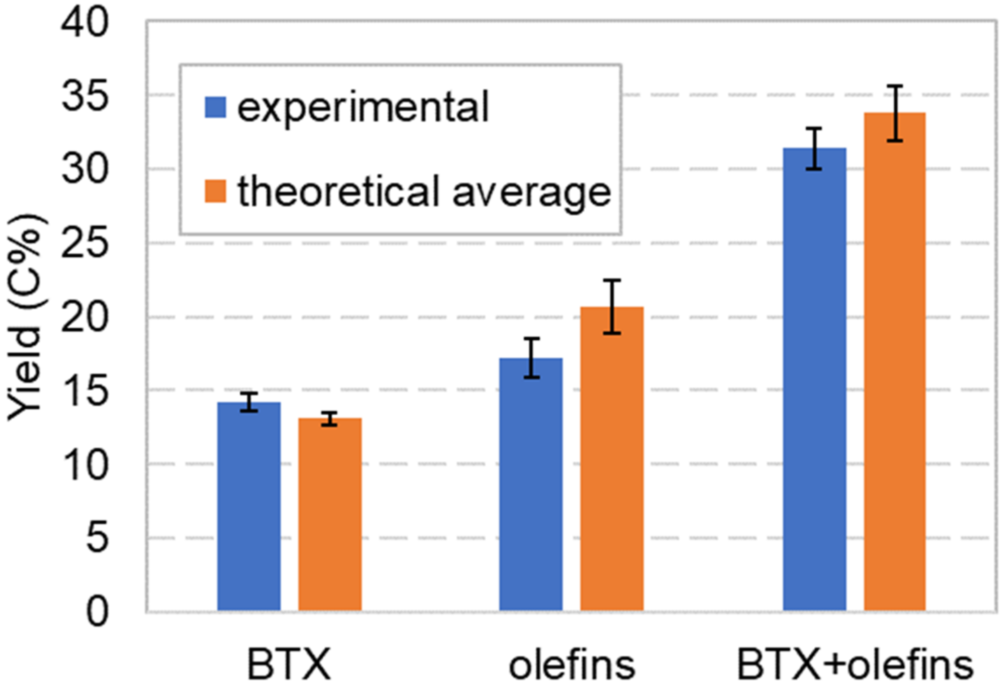


Spruce/PP = 1/1; 600 ºC, in situ

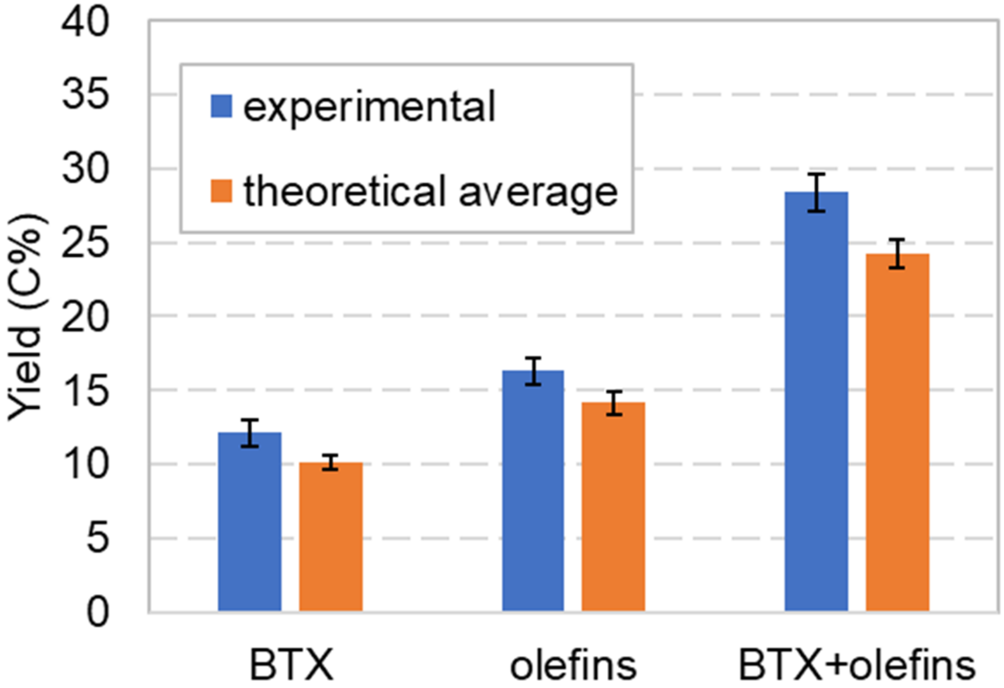


Co-pyrolysis and synergy effect

Straw/PE = 1/1; 600 ºC, in situ



Straw/PP = 1/1; 600 ºC, in situ



SUMMARY

- A quantitative method to evaluate CFP conditions and catalysts has been established.
- Yields: PE > PP > spruce and straw (also in C%)
- In situ CFP promotes higher yields than ex situ (2-steps)
- Minimum temperature for production of olefins through polyethylene CFP: 500 ºC
- Ethylene yield is more sensitive to temperature (both pyrolytic and catalytic) increasing gradually between 450 – 550 ºC. Propylene yield stays stable.
- Not significant synergetic effects during co-pyrolysis observed (…yet!).

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THANK YOU

Javier Celaya Romeo

javier.celaya@rise-pfi.no

(+47) 48 15 15 22