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Low temperature co-pyrolysis of polypropylene and coffee wastes to fuels

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Motivation

Coffee in capsules

- *espresso* with standard machines
- Optimal coffee flavor extraction and cream/foam production

- Large amount of poorly accepted waste → **valuable products?**

Capsule concept

PP structure + Coffee (and a thin paper filter)

59% PP out of 16 g total, 37 mm high

Experimental approach

1. Orientation by TA
   DSC of single components and mixtures → **pyrolysis conditions**
2. Set-up and characterization of a pyro reactor (fixed bed)
3. Tests
   - PP/coffee
   - T
4. Liquids product analysis (GC-MS)

Materials

Isotactic PP (virgin)

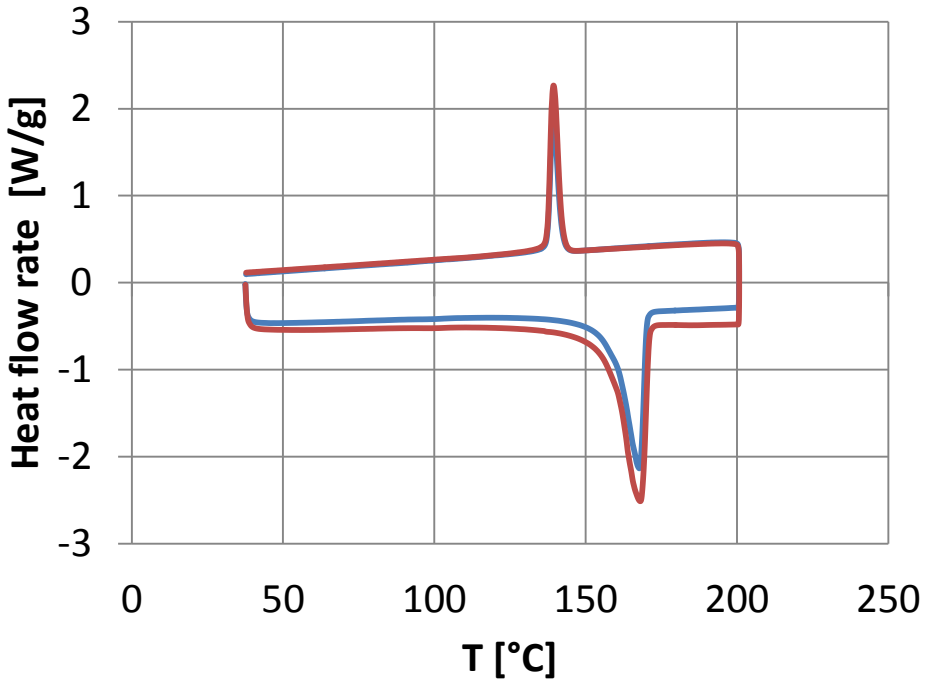
Coffee ground

Singles components, to investigate composition

Thermal Analysis

DSC

1 - PP characterization (2°C/min)

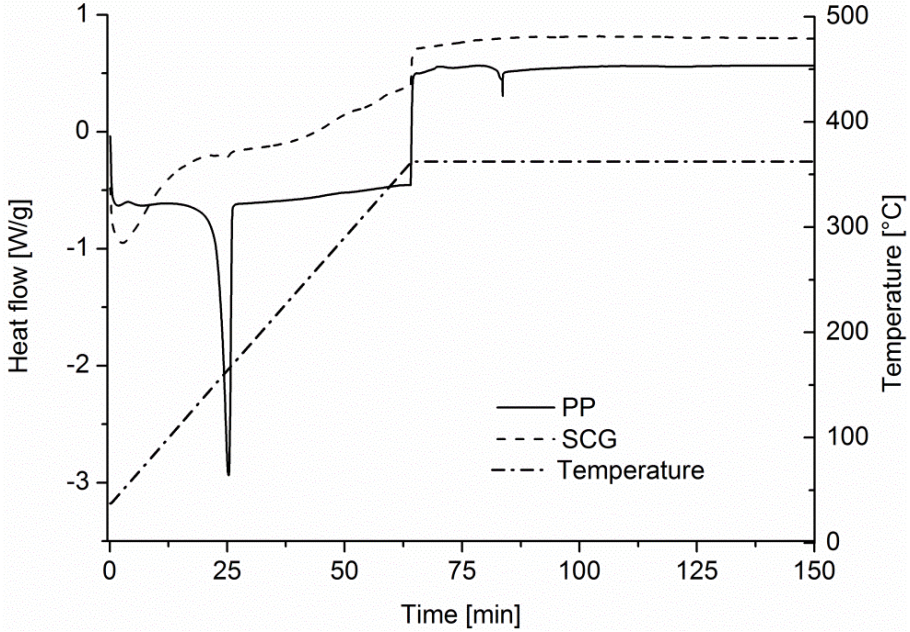


T_m = 167°C ΔH_m = 2.9 kJ/mol α = 33%

Thermal Analysis

DSC

2 – decomposition (in air or inert)

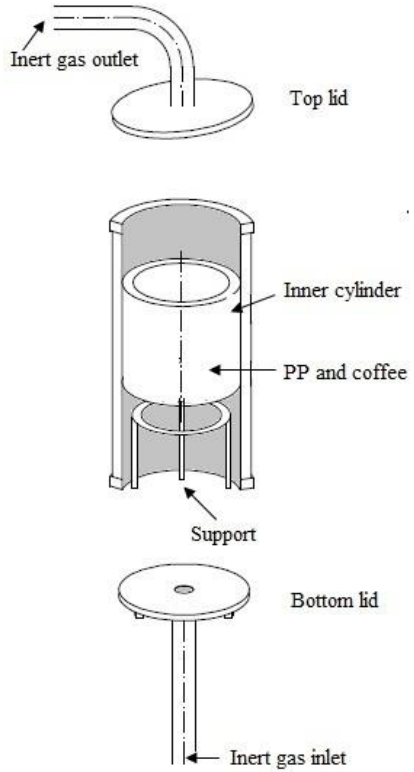


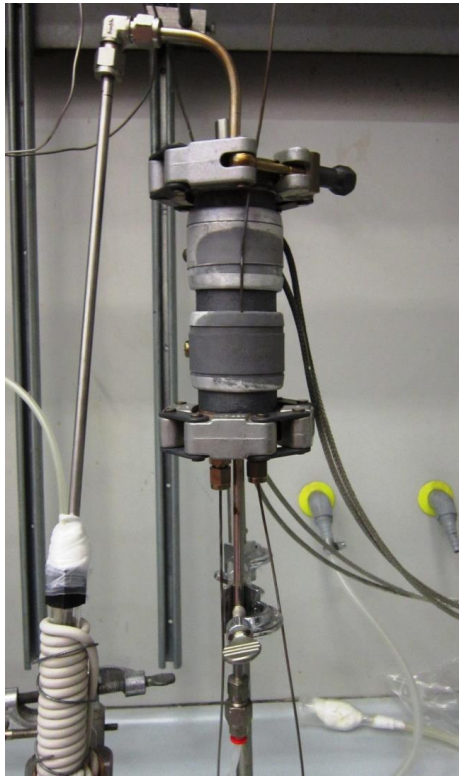
Degradation of **coffee** T> 250 °C

Degradation of **PP** T> 360 °C

Pyrolysis Reactor

upflow fixed bed



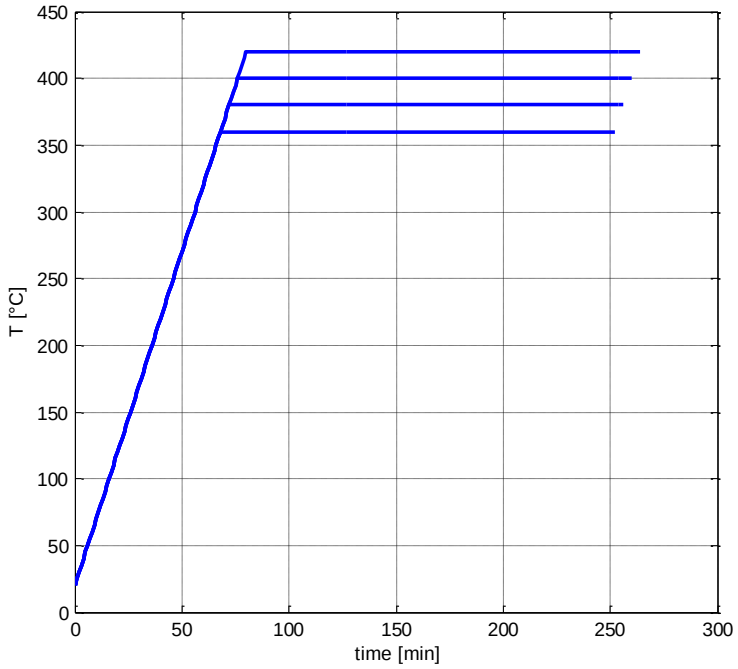


from mg to tens of g (ID = 38mm)

products condensation @ 65, 25,-20 °C

Heating policy

'isothermal'



HR = 5°C/min

3h at max T (360, 380, 400, 420°C)

Experimental design

% and T effect

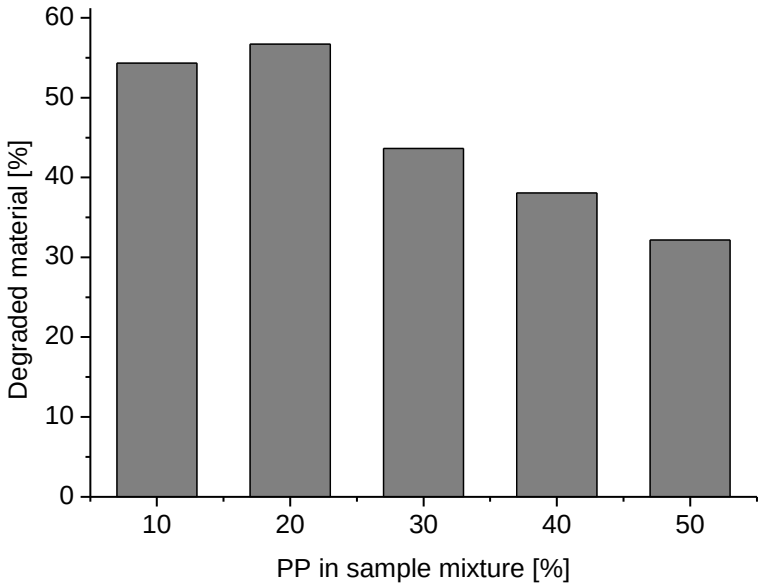
	# test	Composition [% vol]		T [°C]	WL [%]	liquid yield [% wt]
		PP	coffee			
set 1	1	10	90	360	54.3	34.9
	2	20	80	360	56.7	29.0
	3	30	70	360	42.9	27.6
	4	40	60	360	38.1	26.3
	5	50	50	360	34.0	25.6
set 2	6	50	50	360	34.2	25.6
	7	50	50	380	74.2	42.0
	8	50	50	400	83.8	63.7
	9	50	50	420	93.1	71.7

Set 1: PP from 10→ 50% @ 360°C

Set 2: T from 360 → 420°C @ 50% PP/coffee

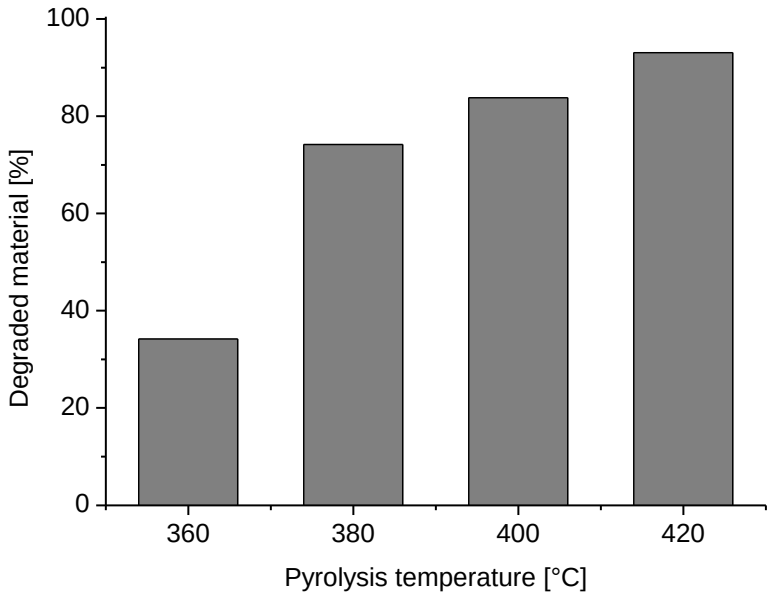
Feed composition

overall degradation



@ 360°C the fraction of PP severely limits degradation

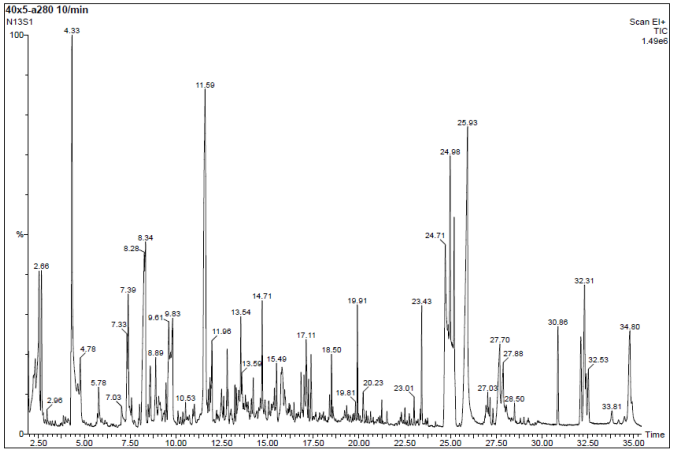
Temperature
overall degradation



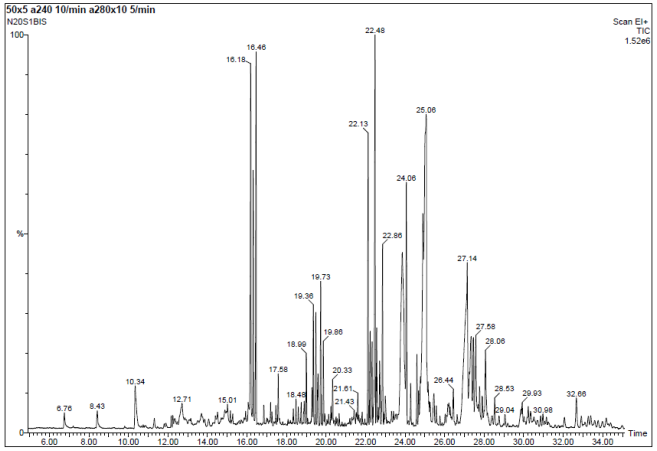
@ 50/50% the temperature dramatically supports degradation

Products

GCMS of condensible prod.



80% coffee



50% coffee

- Linear HCs
- Low MW aromatics and eterocycles
- linear alcools C_{12}-C_{13} and groups of isomers
- water <4% (coffee dependent)

Products

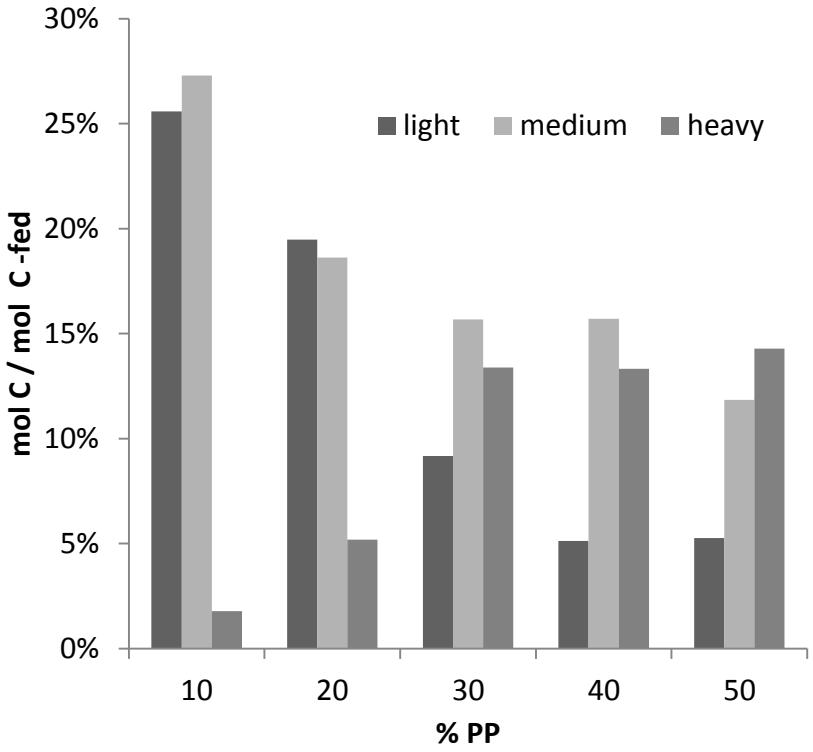
clustering of products

	C atoms	Elution time
Light	< C_6	< 12 min
Medium	C_6 and C_{16}	between 12 and 26 min
Heavy	> C_{16}	> 26 min

Common classification
Rough but effective

Feed composition

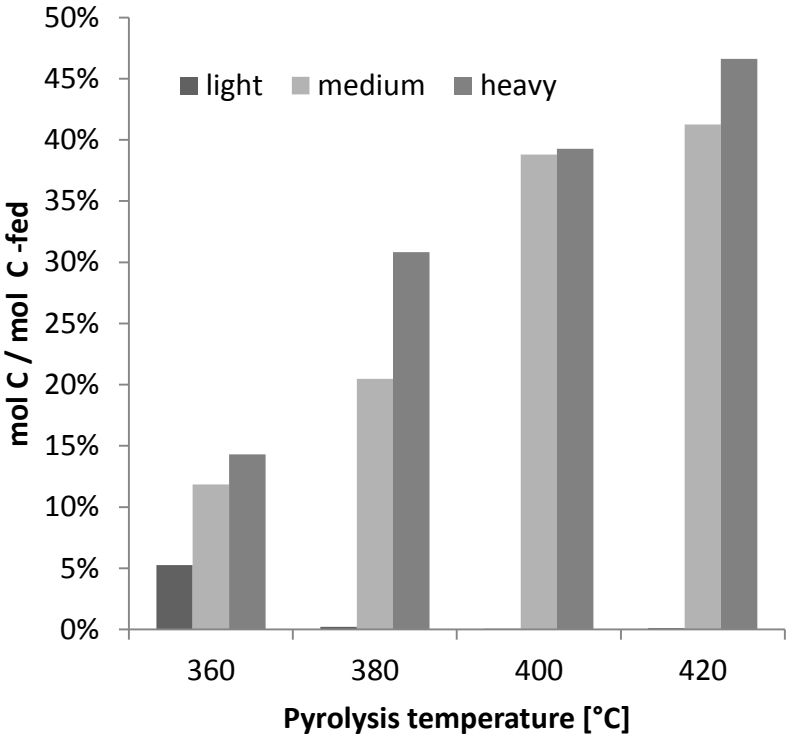
yield by groups



more PP → products shift to higher MW

@360°C PP yields mostly high MW products

Temperature
yield by groups



Light species degrade to gas
(char might help)

Conclusions

1. The degradation of coffee anticipates PP
2. Higher coffee/PP →
   lower MW of the products, larger conversion
3. T> 360°C affects the PP degradation, while products of coffee degradation is believed to support its cracking
4. Products vs. fossil fuels:
   similar: Aliphatic HCs and aromatics, $C_{14} – C_{30}$
   different: oxigenated and acids species

Issues worth exploring

1. a ‘fractional’ pyrolysis of biomass/PP, at 2 T’s
2. Effect of HR on the distribution of products
   Interactions of melt polymer and non-wettable biomass
   → modelling
3. Characterization of gas, for energy balance

Thank you for the attention!

Keep drinking good coffee