HTL OF COMMON POLYMERS IN PRESENCE OF ALKALINE CATALYST AND LIGNOCELLULOSIC MATERIALS

AARHUS UNIVERSITY
DEPARTMENT OF ENGINEERING

tcbiomassplus 2019

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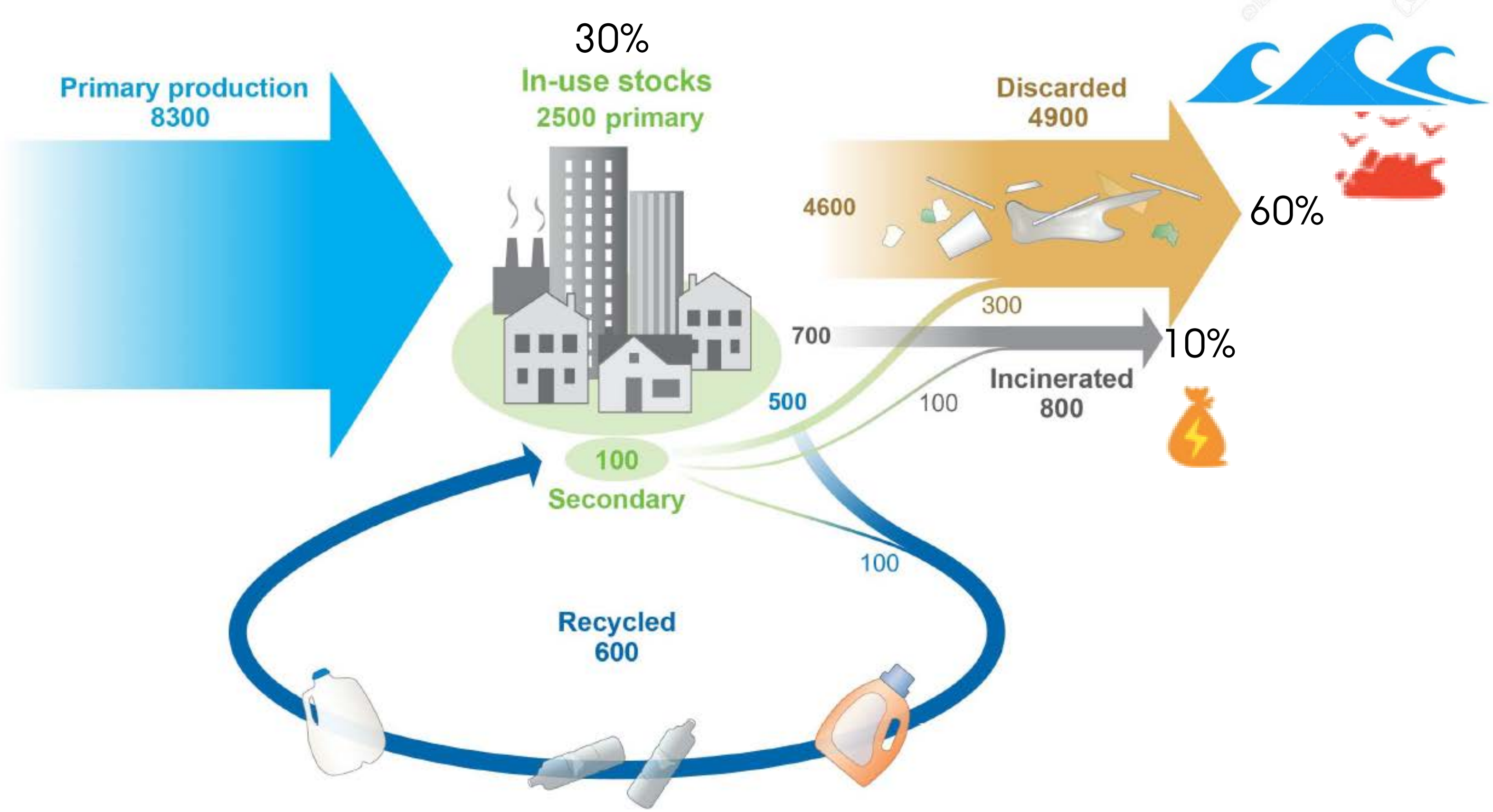
PLASTIC WASTE



Plastics – the Facts 2017. PlasticsEurope
Geyer, Jambeck, Law Sci. Adv. 2017; 3: e1700782

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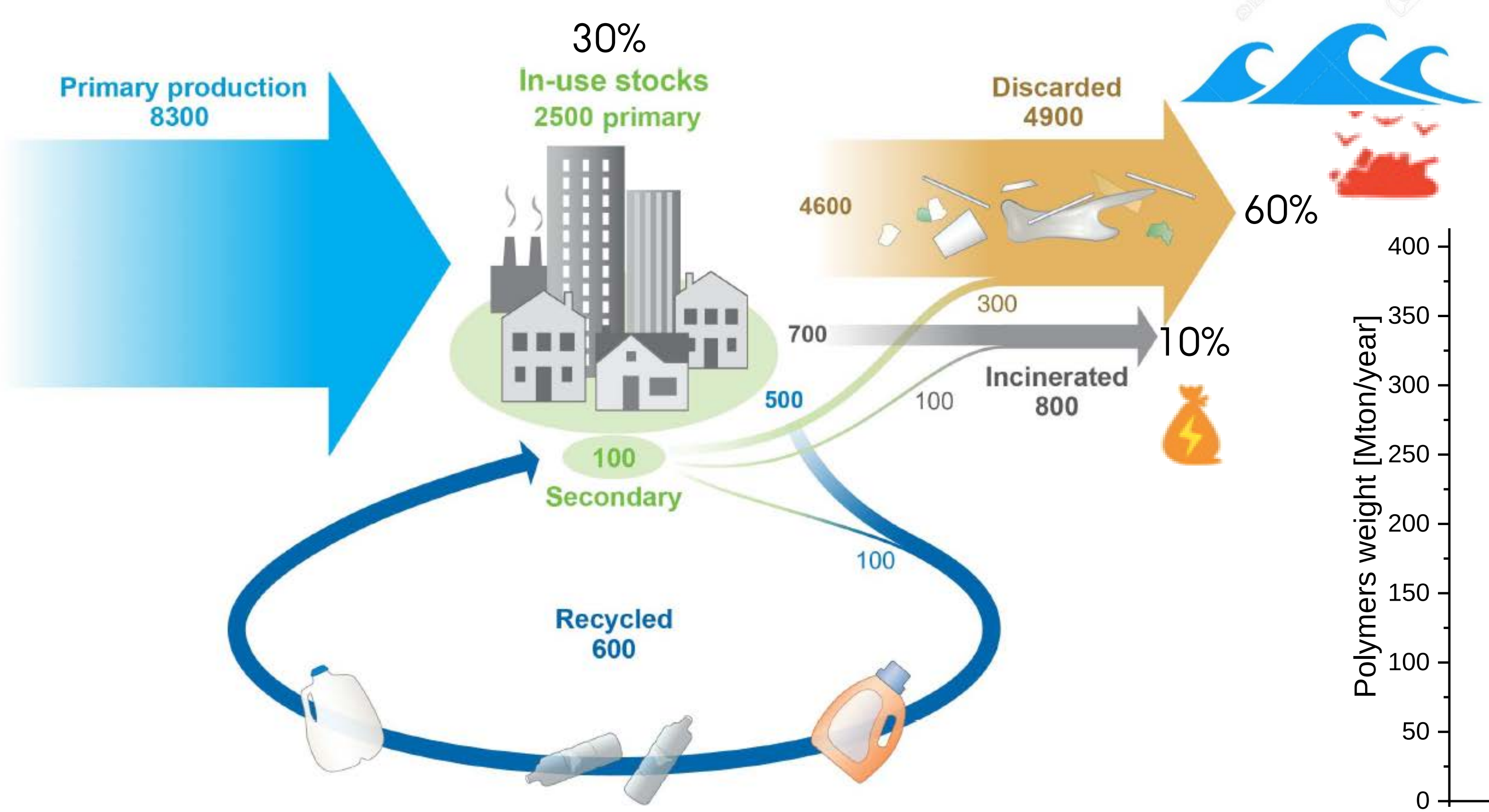
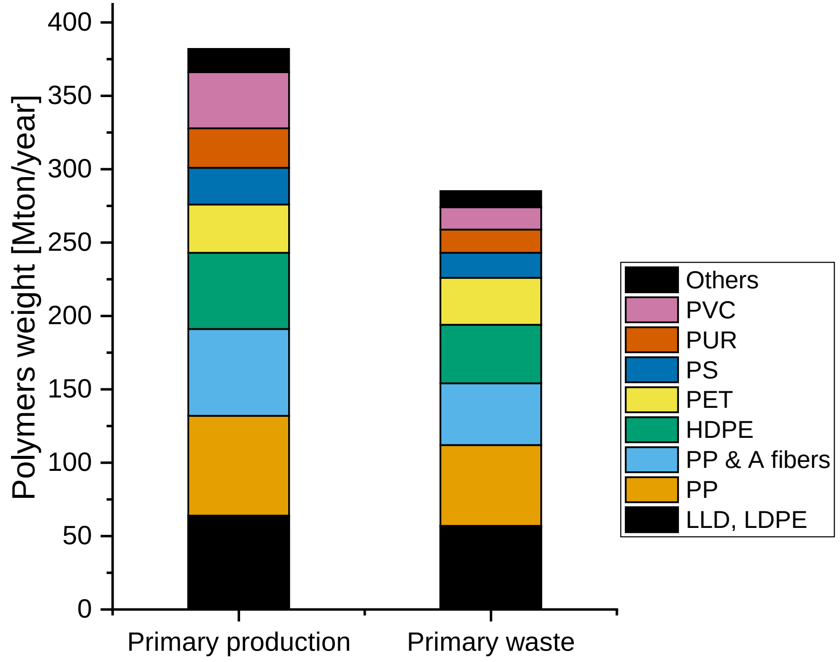
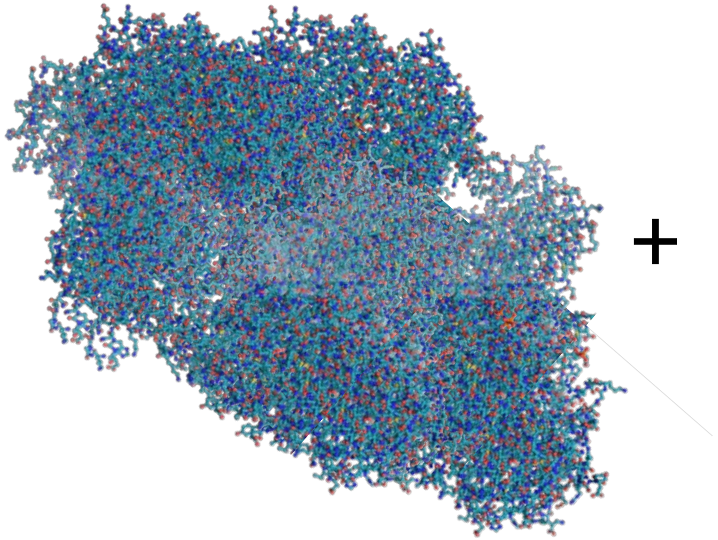




Plastics – the Facts 2017. PlasticsEurope
Geyer, Jambeck, Law Sci. Adv. 2017; 3: e1700782

HYDROTHERMAL LIQUEFACTION (HTL)

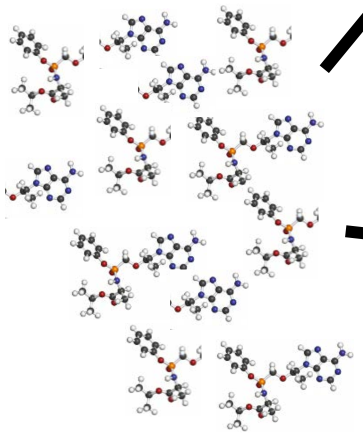


Synthetic- and bio-polymers

+ H_2O

20 min @ 350 °C (180 bar)

w/ wo/ KOH



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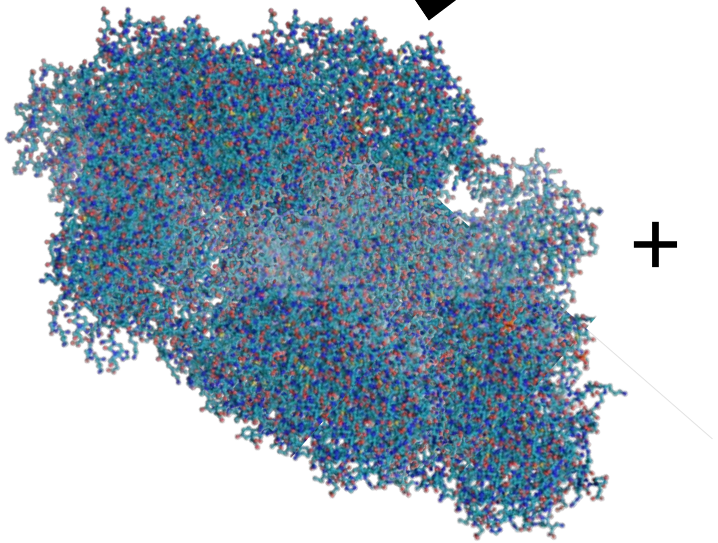


Synthetic- and bio-polymers

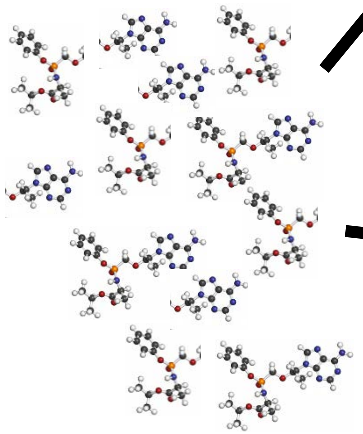
+ H_2O

20 min @ 350 °C (180 bar)

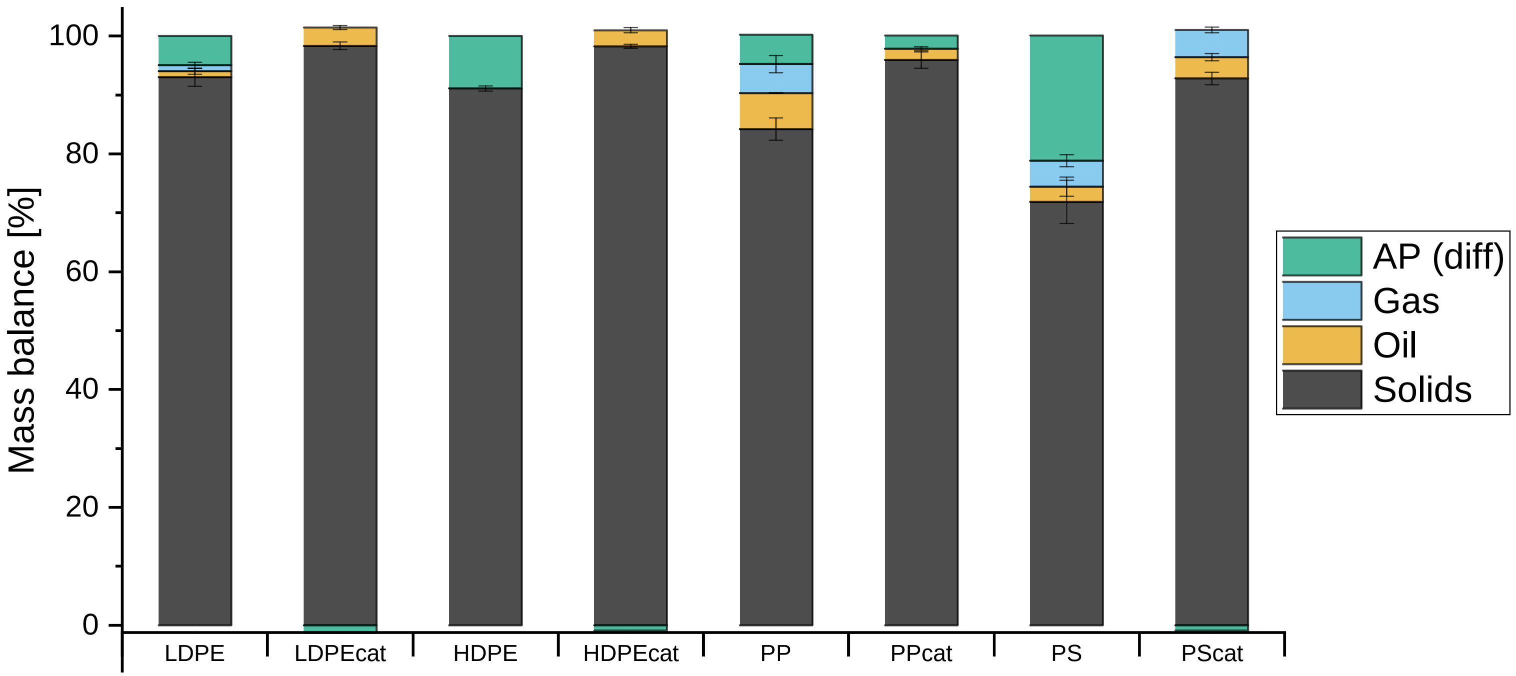
w/ wo/ KOH

Batch HTL

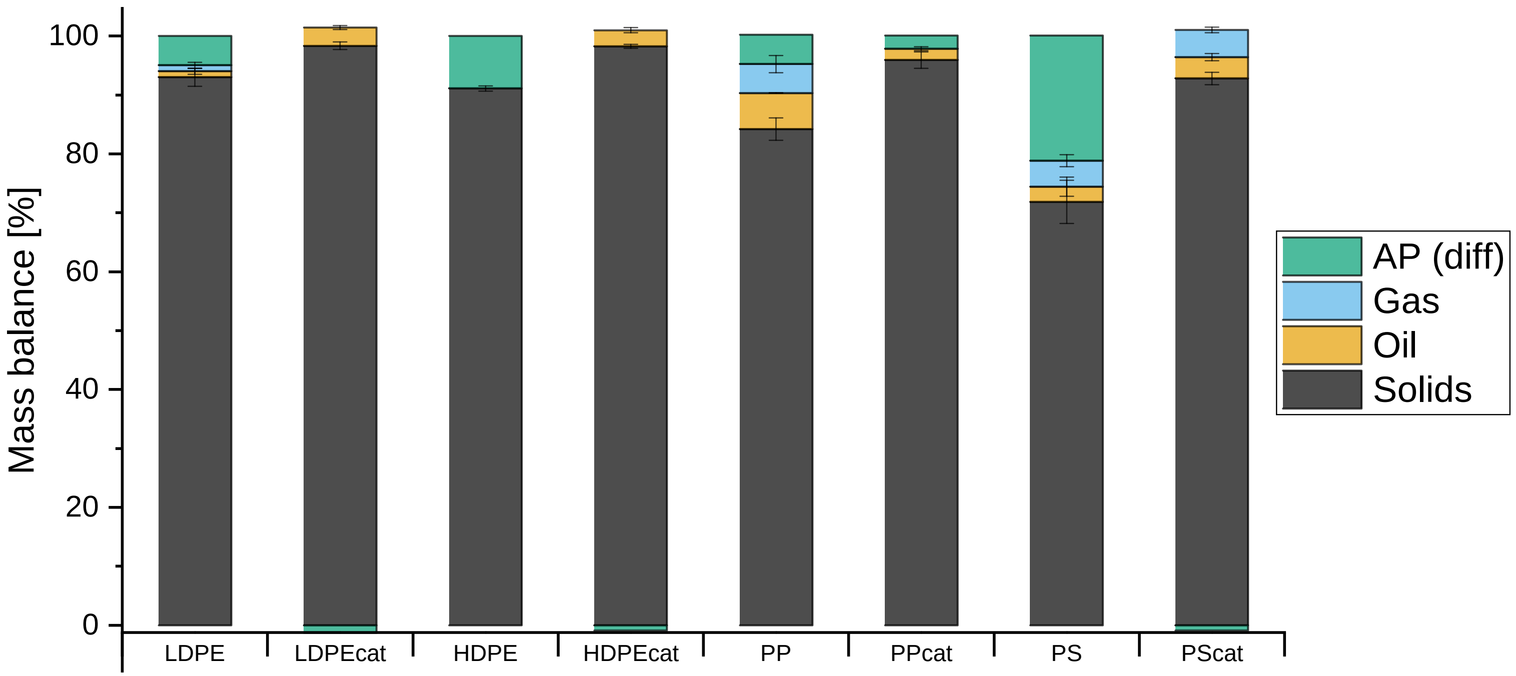
- Gas
- Aqueous Phase
- Oil
- Solids



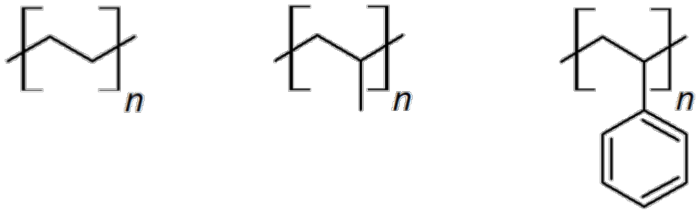
POLYOLEFINS AND PS



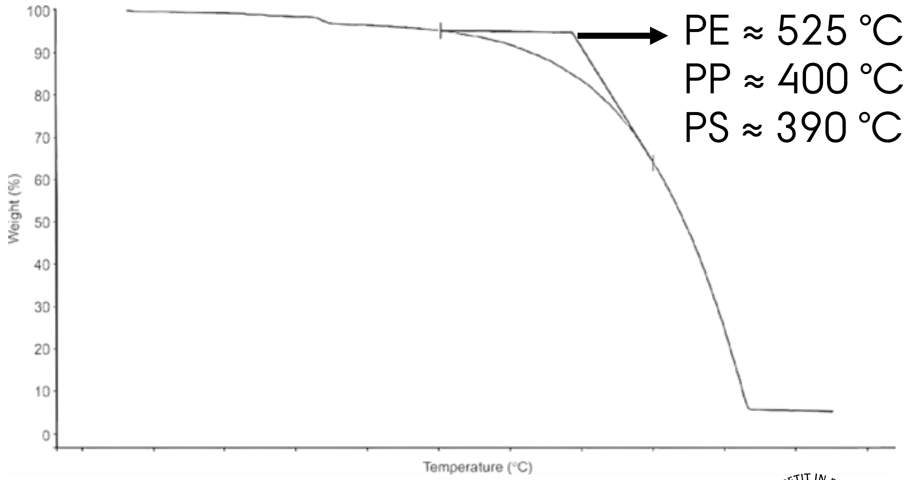
POLYOLEFINS AND PS



PE PP PS



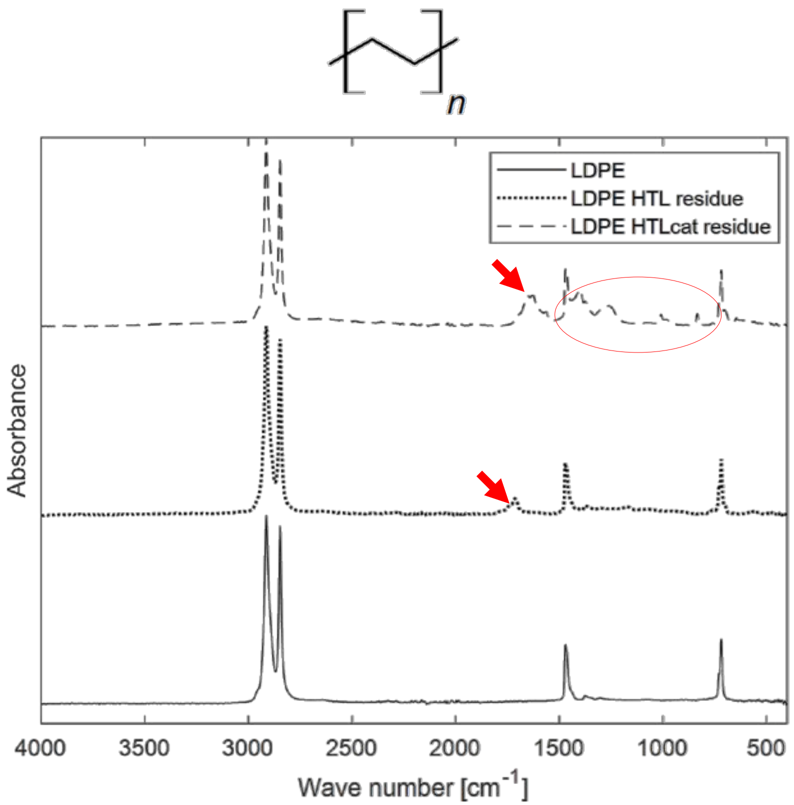
- No reactive sites
- Depends on thermal cracking
- Onset decomposition > 350 °C for all



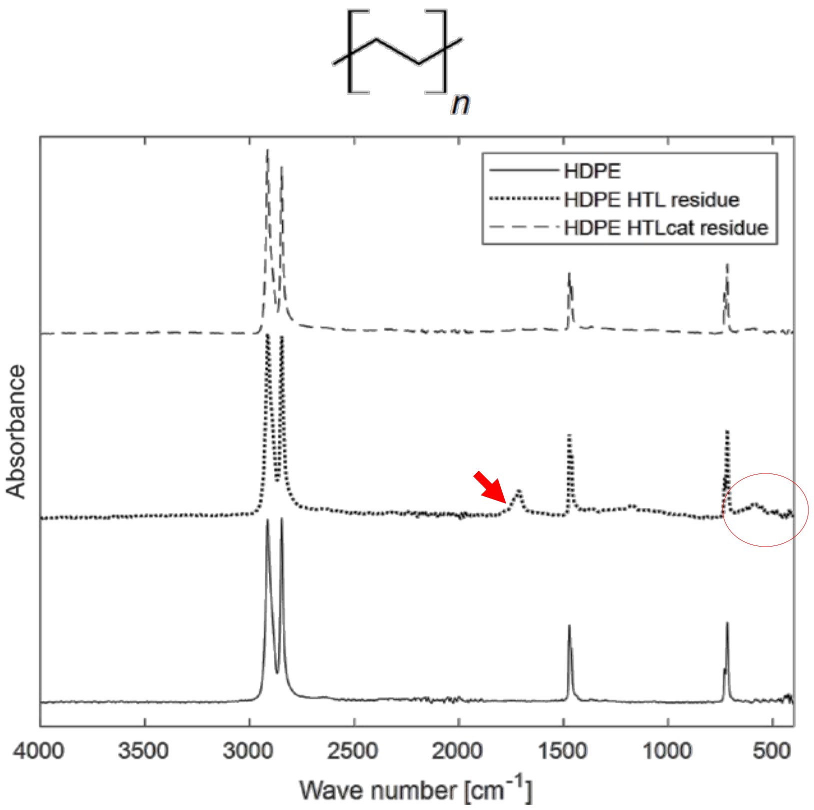
PE ≈ 525 °C
PP ≈ 400 °C
PS ≈ 390 °C

POLYOLEFINS

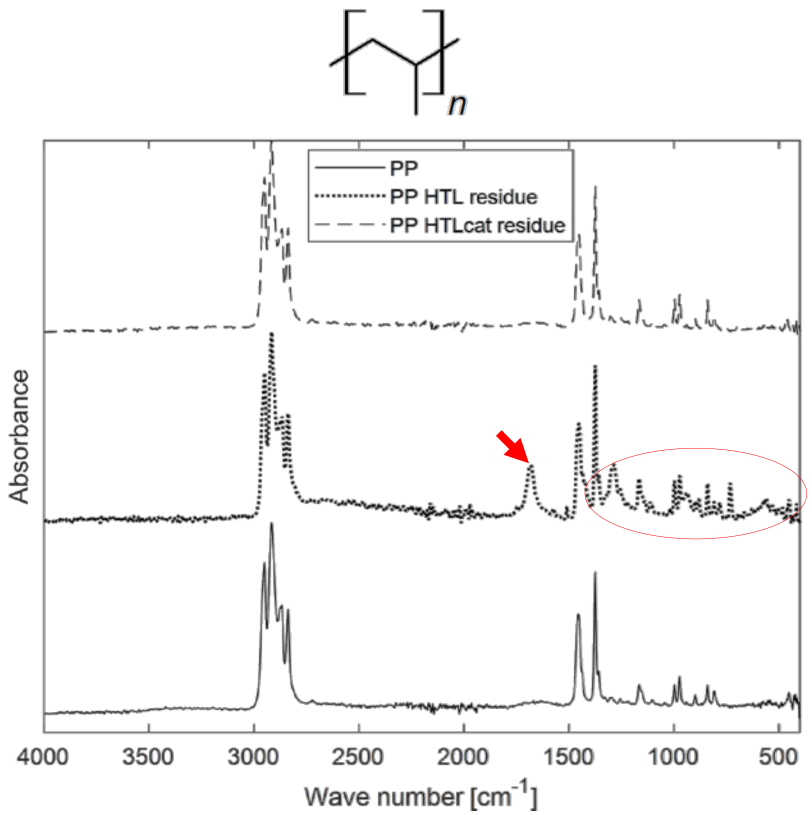
LDPE



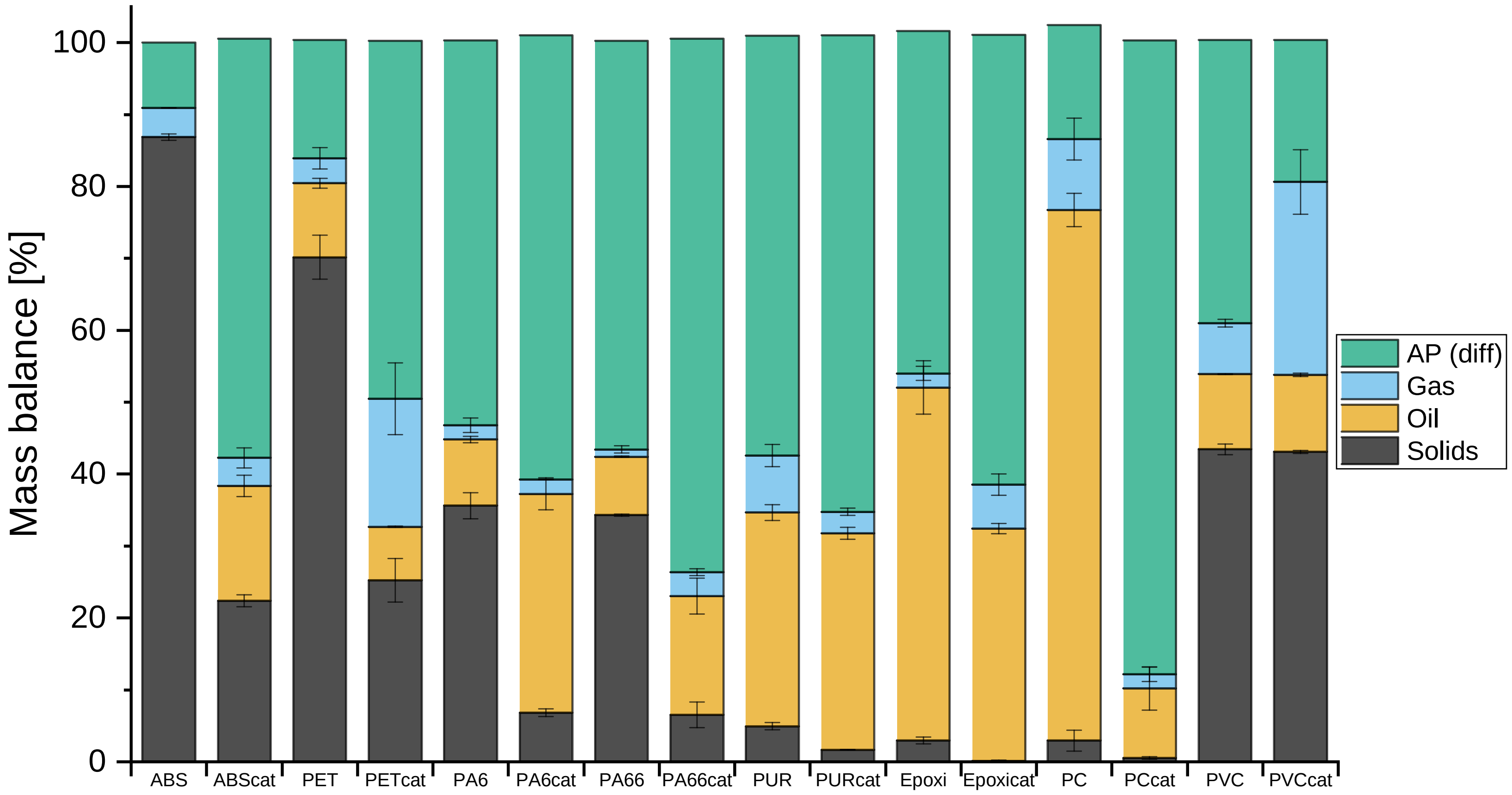
HDPE



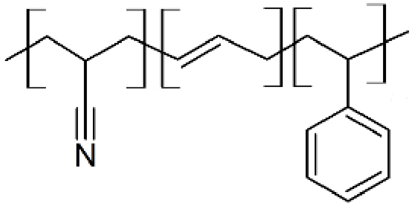
PP

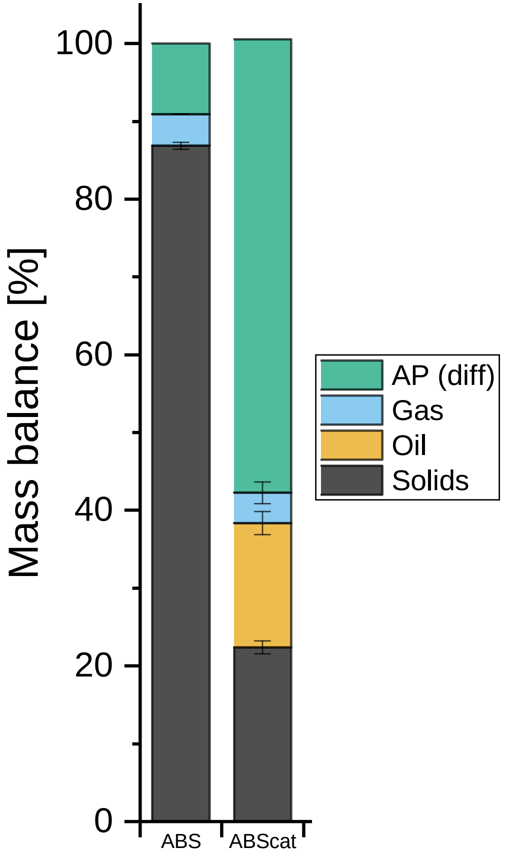


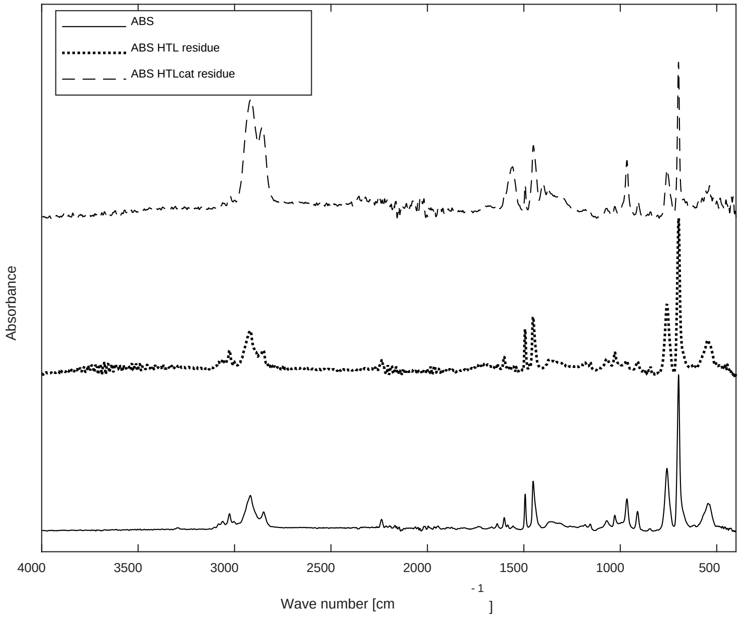
OTHER POLYMERS



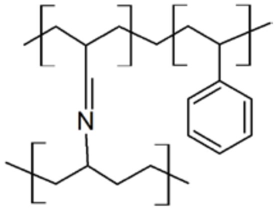
ABS



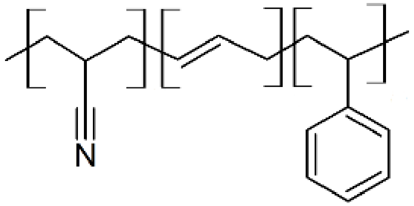




Suggestion:



ABS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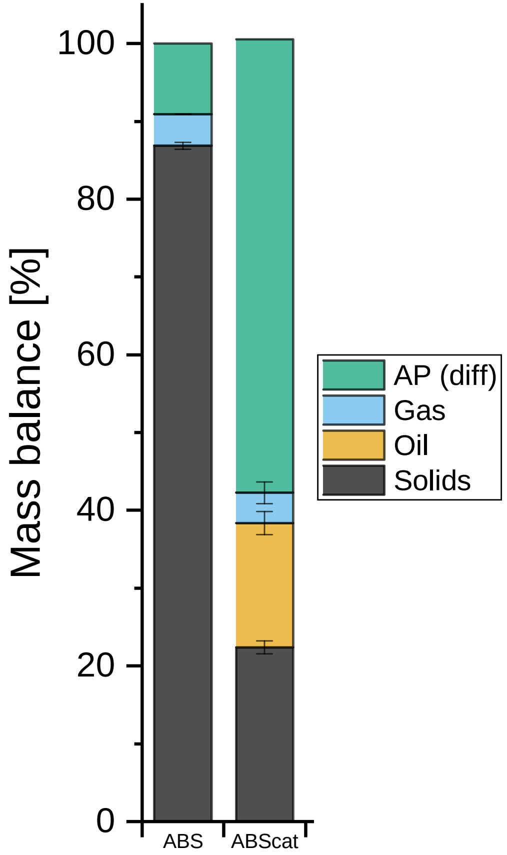
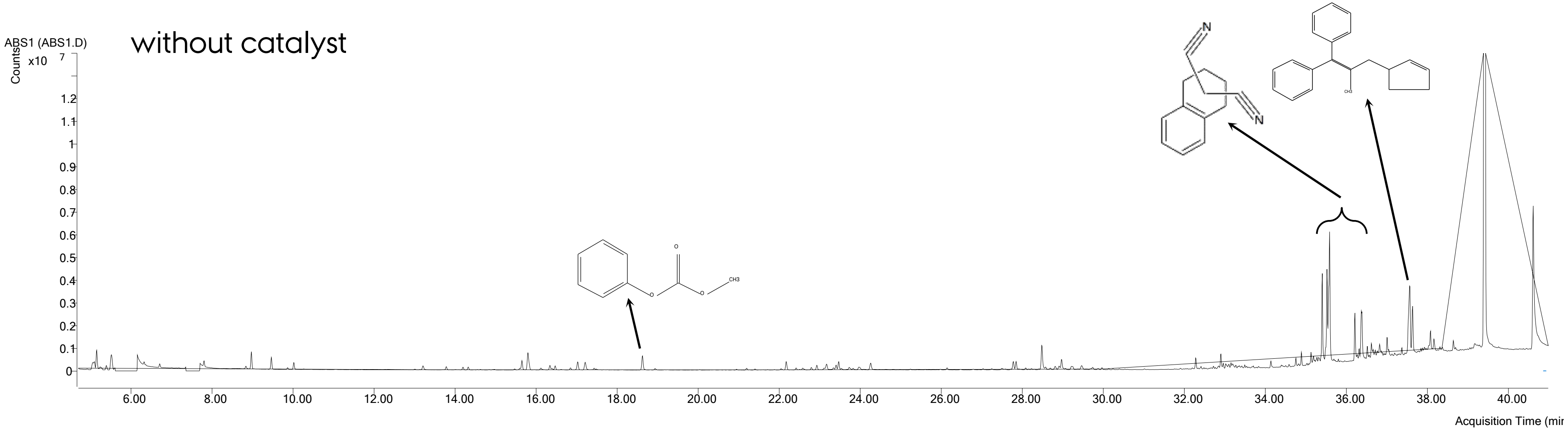
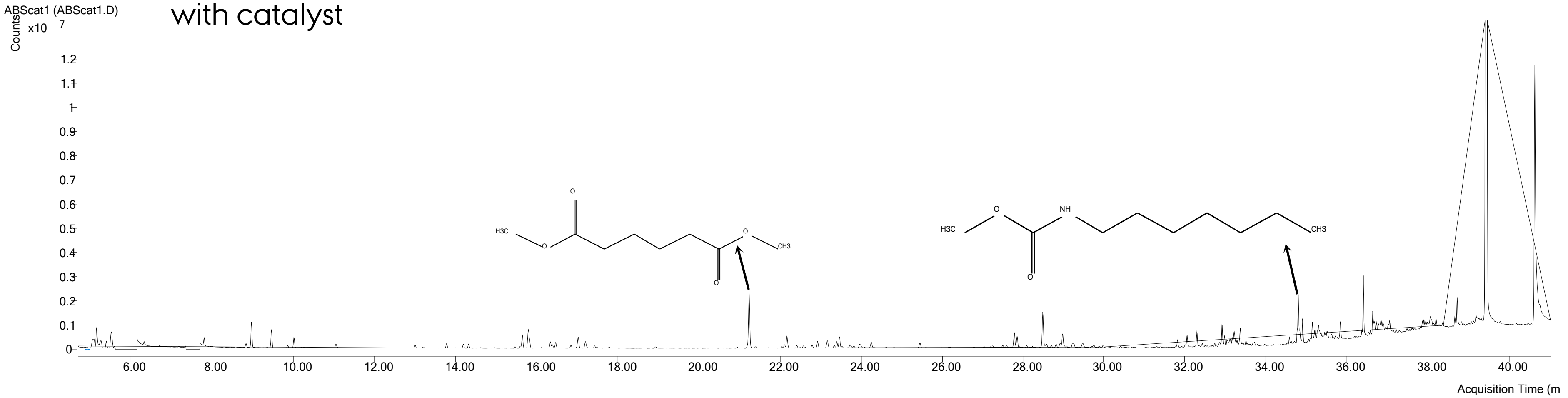
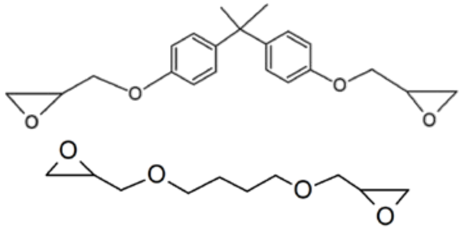
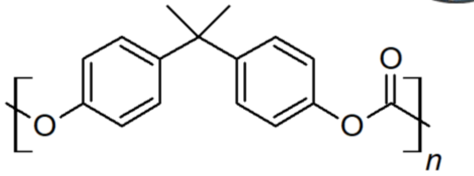

Mass balance [%]
100
80
60
40
20
0
ABS
ABScat
AP (diff)
Gas
Oil
Solids

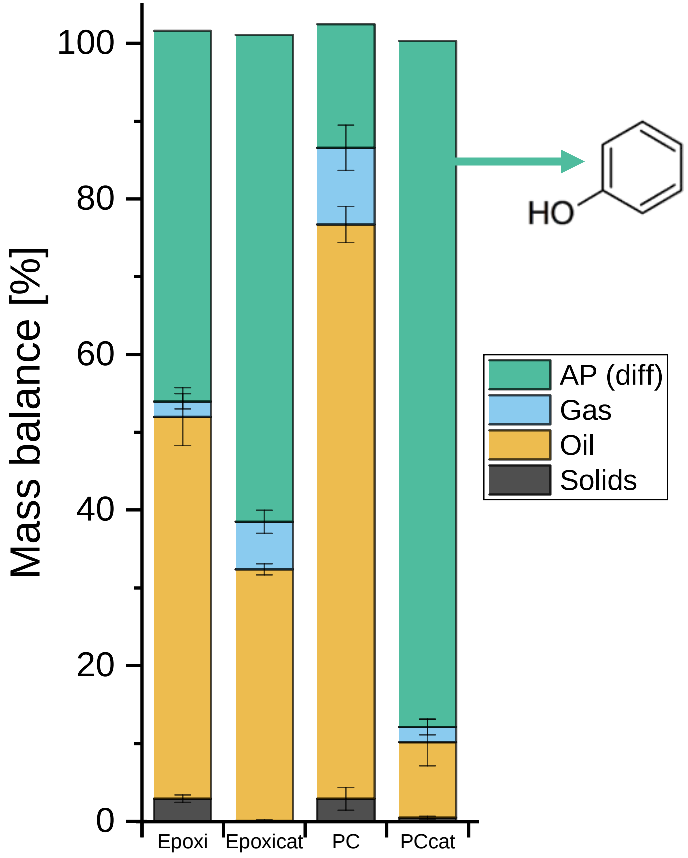

without catalyst
ABS1 (ABS1.D)
Counts
x10 7
Acquisition Time (mir

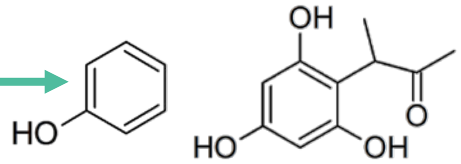

with catalyst
ABScat1 (ABScat1.D)
Counts
x10 7
H3C
CH3
NH
Acquisition Time (m

EPOXY AND PC





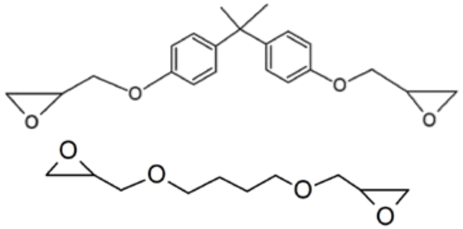




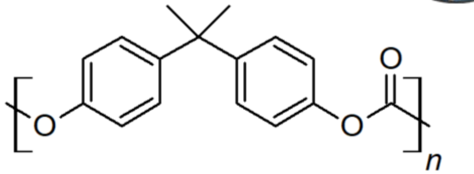
		C	H	N	S	O*
PC	Polymer	75.7%	5.5%	0.0%	0.0%	18.8%
	Oil	77.5%	6.9%	0.0%	0.0%	15.6%
Epoxi	Polymer	68.5%	8.2%	3.2%	0.0%	20.1%
	Oil	72.6%	8.0%	2.6%	0.1%	16.7%

*Oxygen by difference

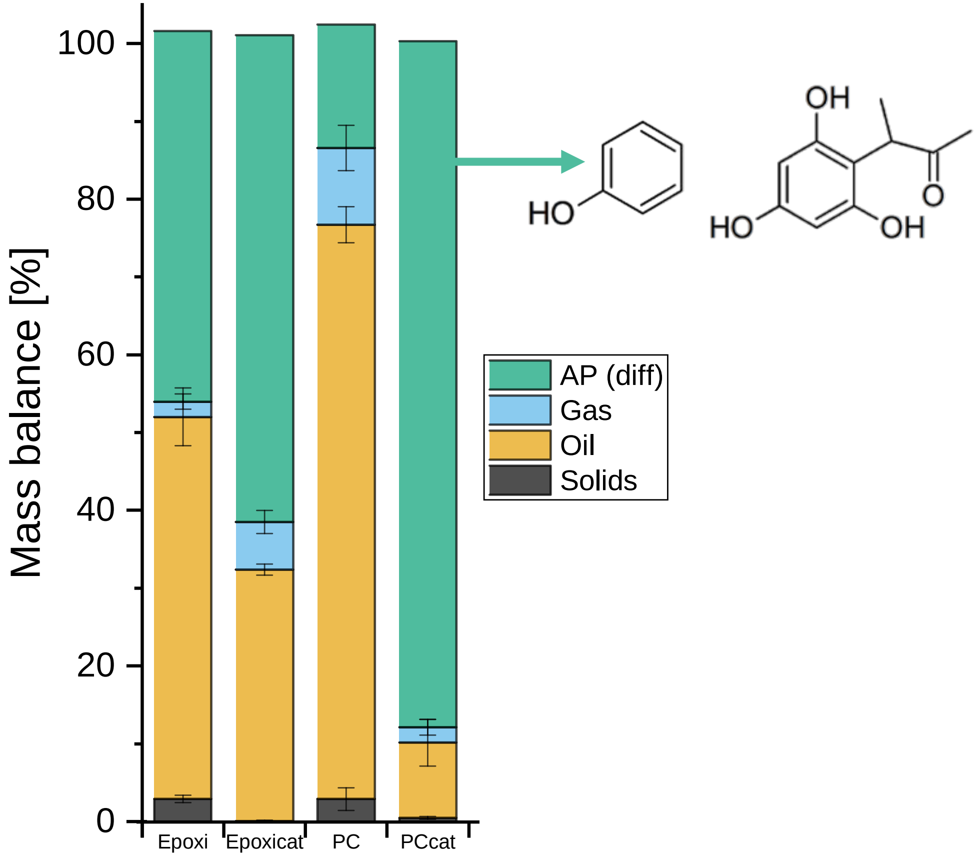
EPOXY AND PC



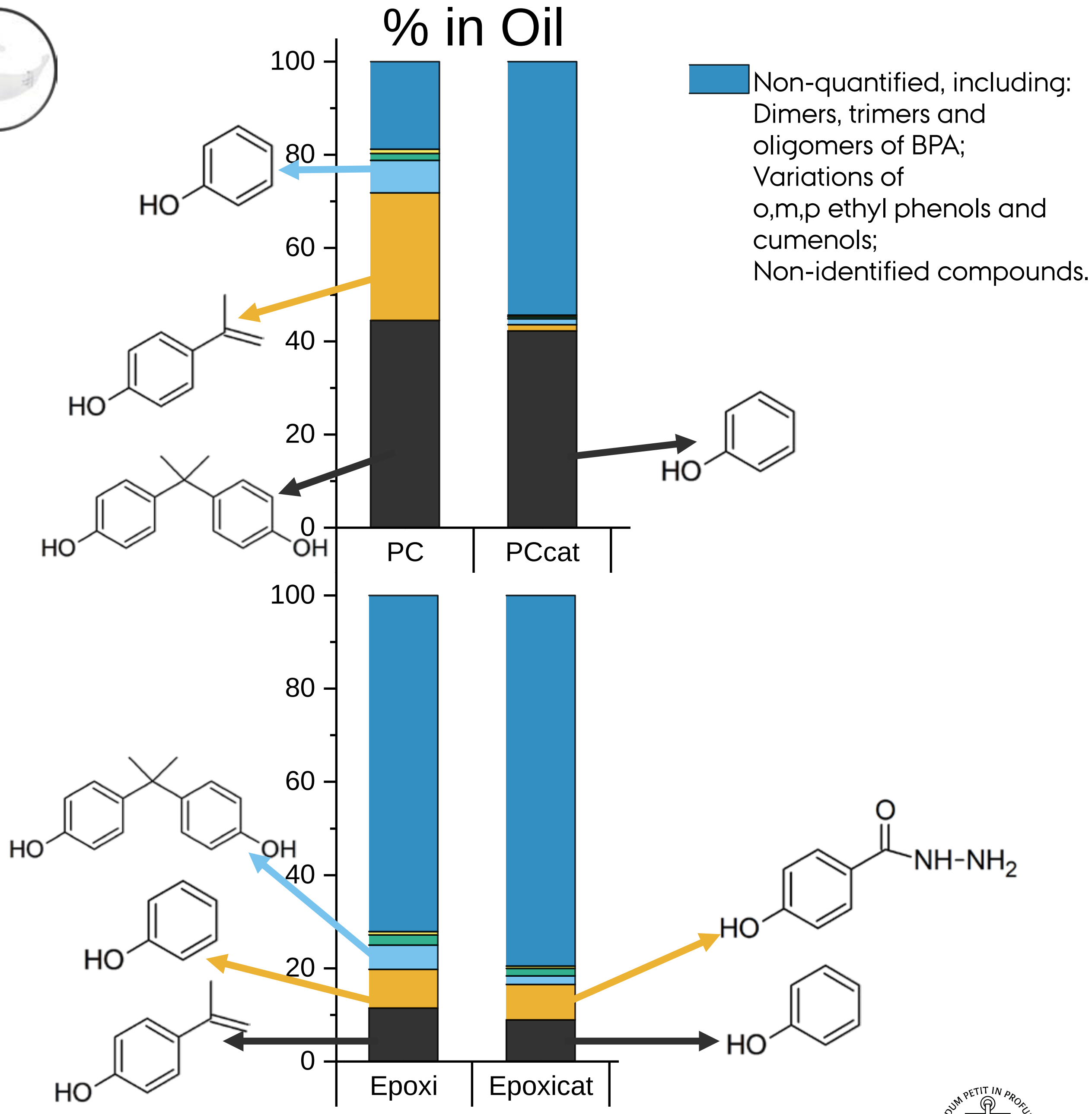
O
O
O
O
O
O
O
O



O
O
O
n

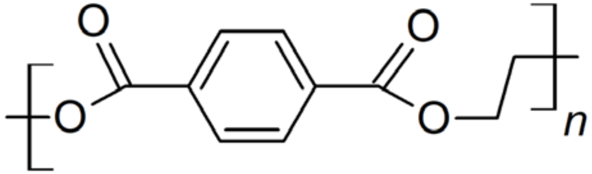


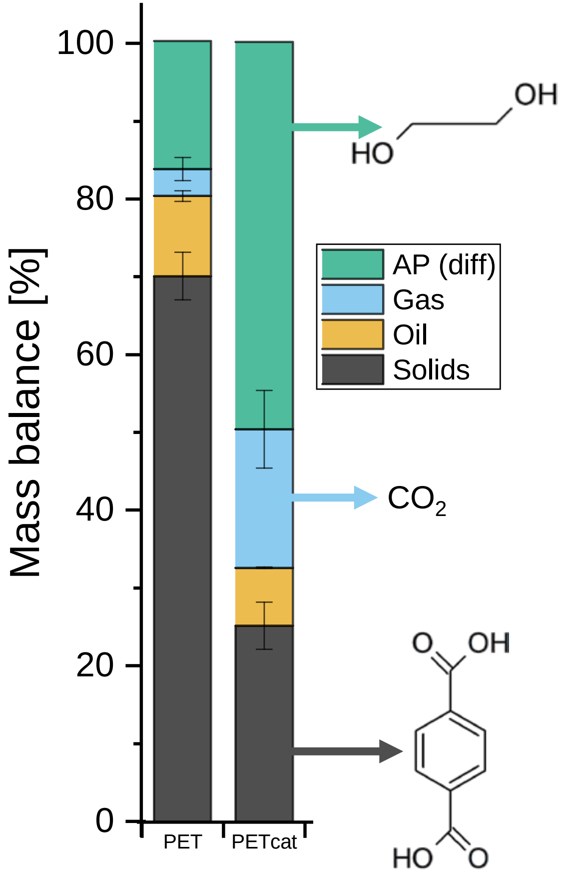
Mass balance [%]
100
80
60
40
20
0
Epoxi
Epoxicat
PC
PCcat
AP (diff)
Gas
Oil
Solids
HO
OH
HO
OH
O



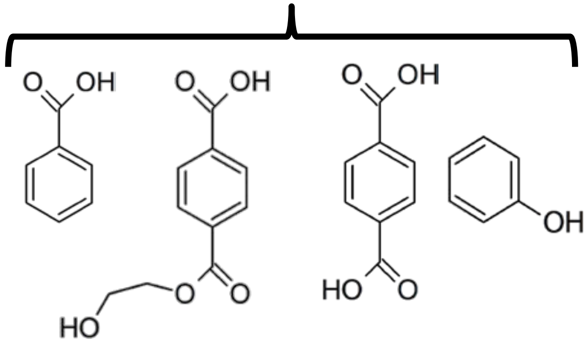
% in Oil
100
80
60
40
20
0
PC
PCcat
Epoxi
Epoxicat
Non-quantified, including:
Dimers, trimers and
oligomers of BPA;
Variations of
o,m,p ethyl phenols and
cumenols;
Non-identified compounds.
HO
OH
O
NH-NH2

PET



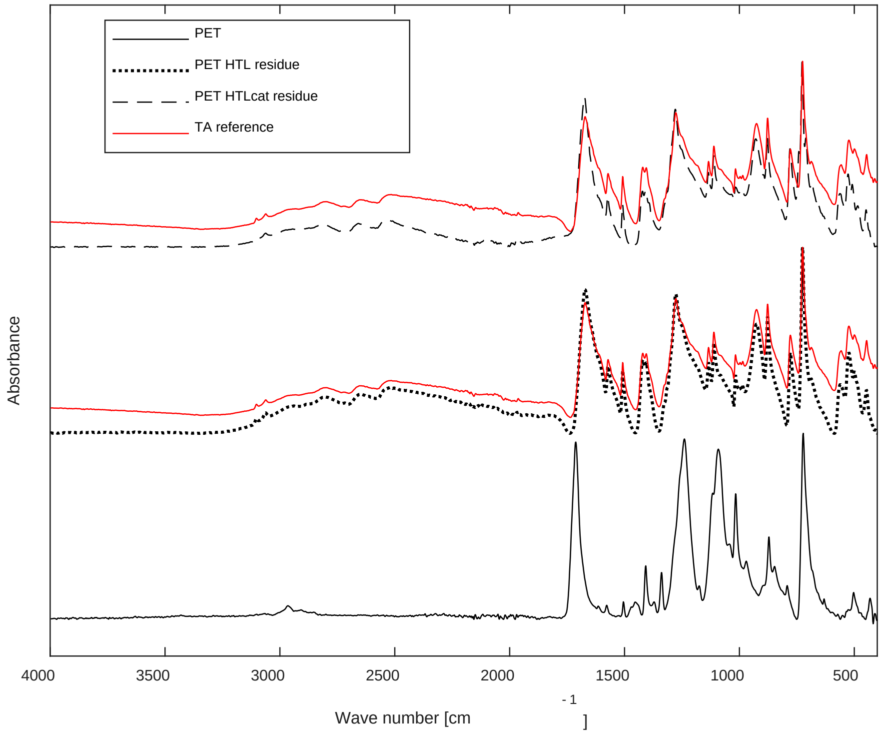


Catalytic

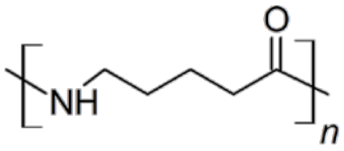


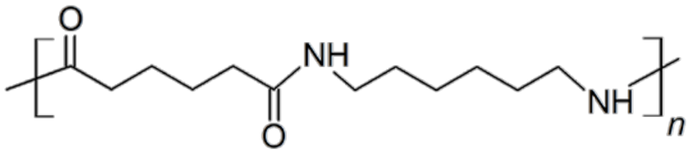
Soluble salts

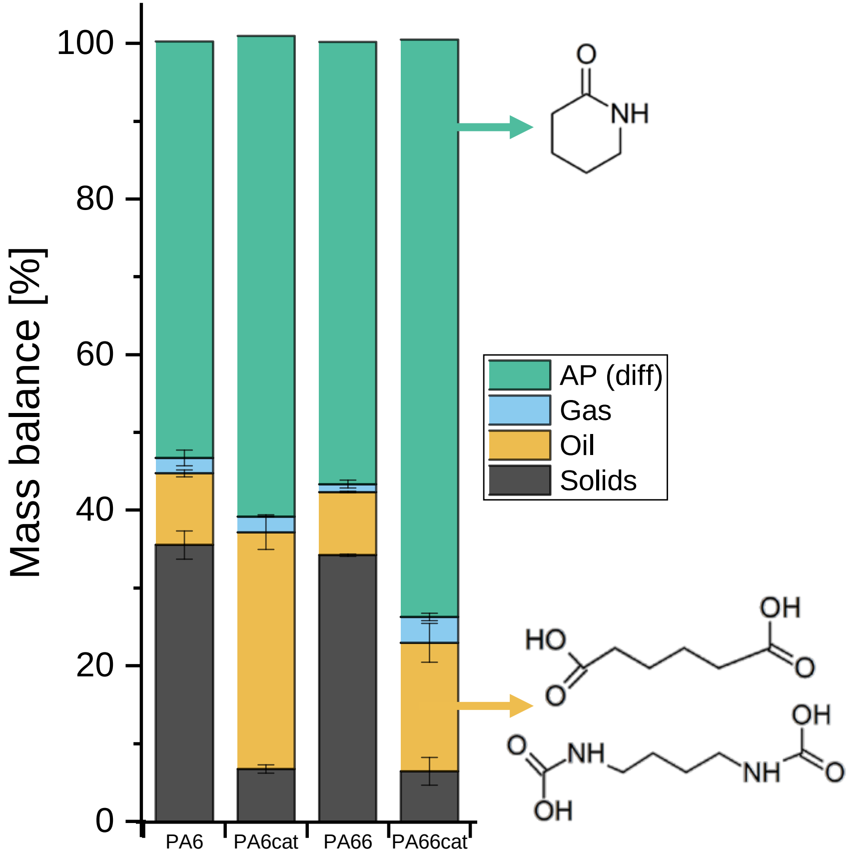
Solids FTIR



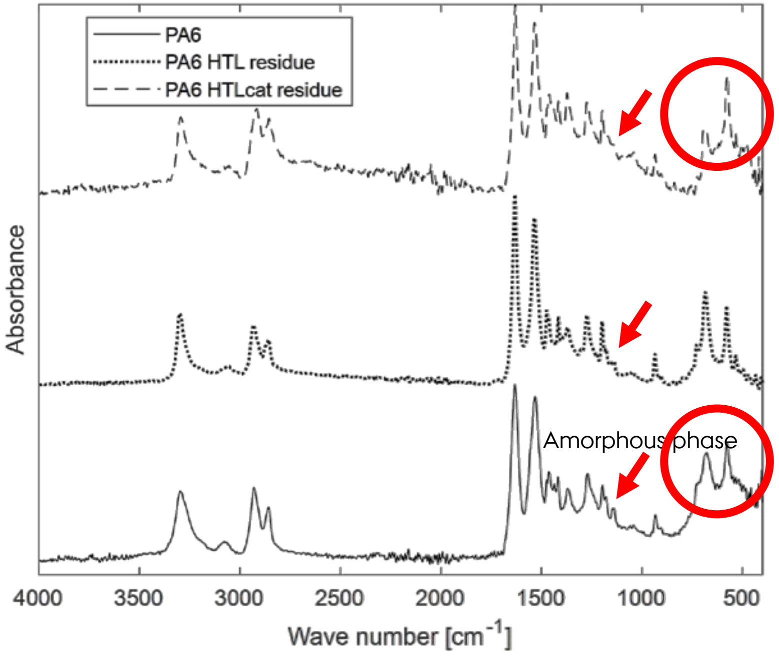
PA6 AND PA66

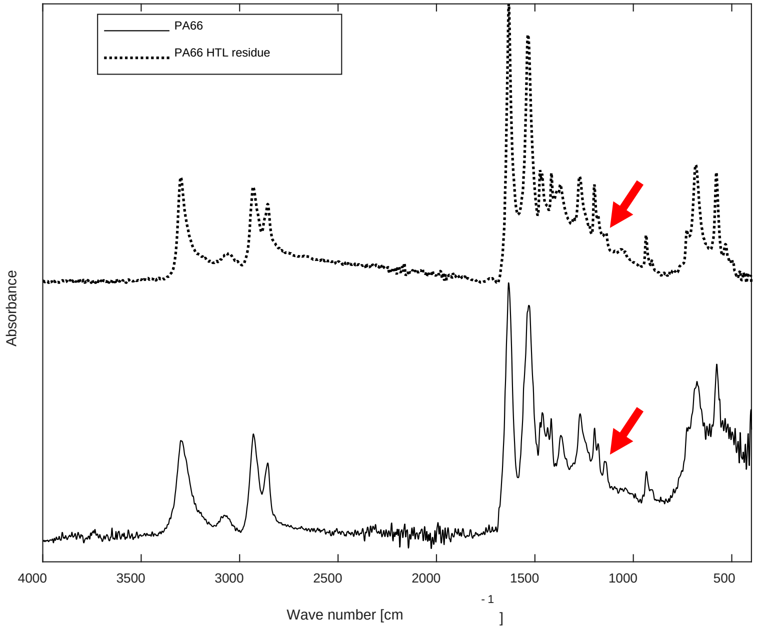




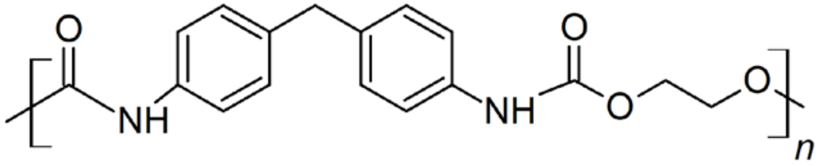


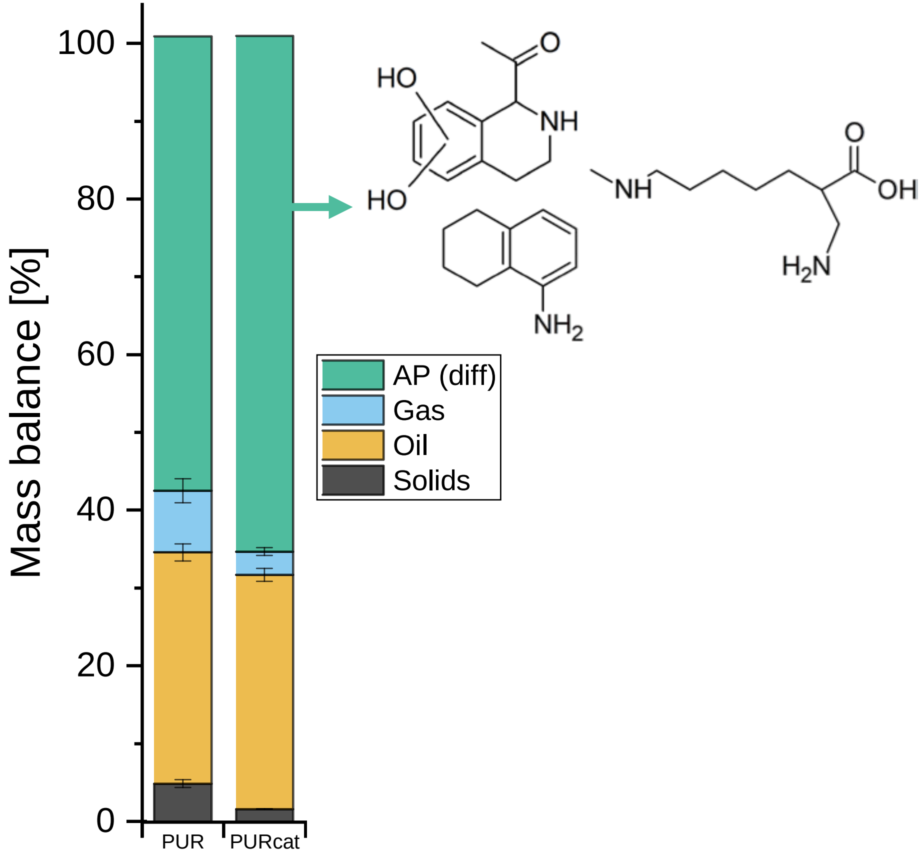
γ depolymerizes more than α

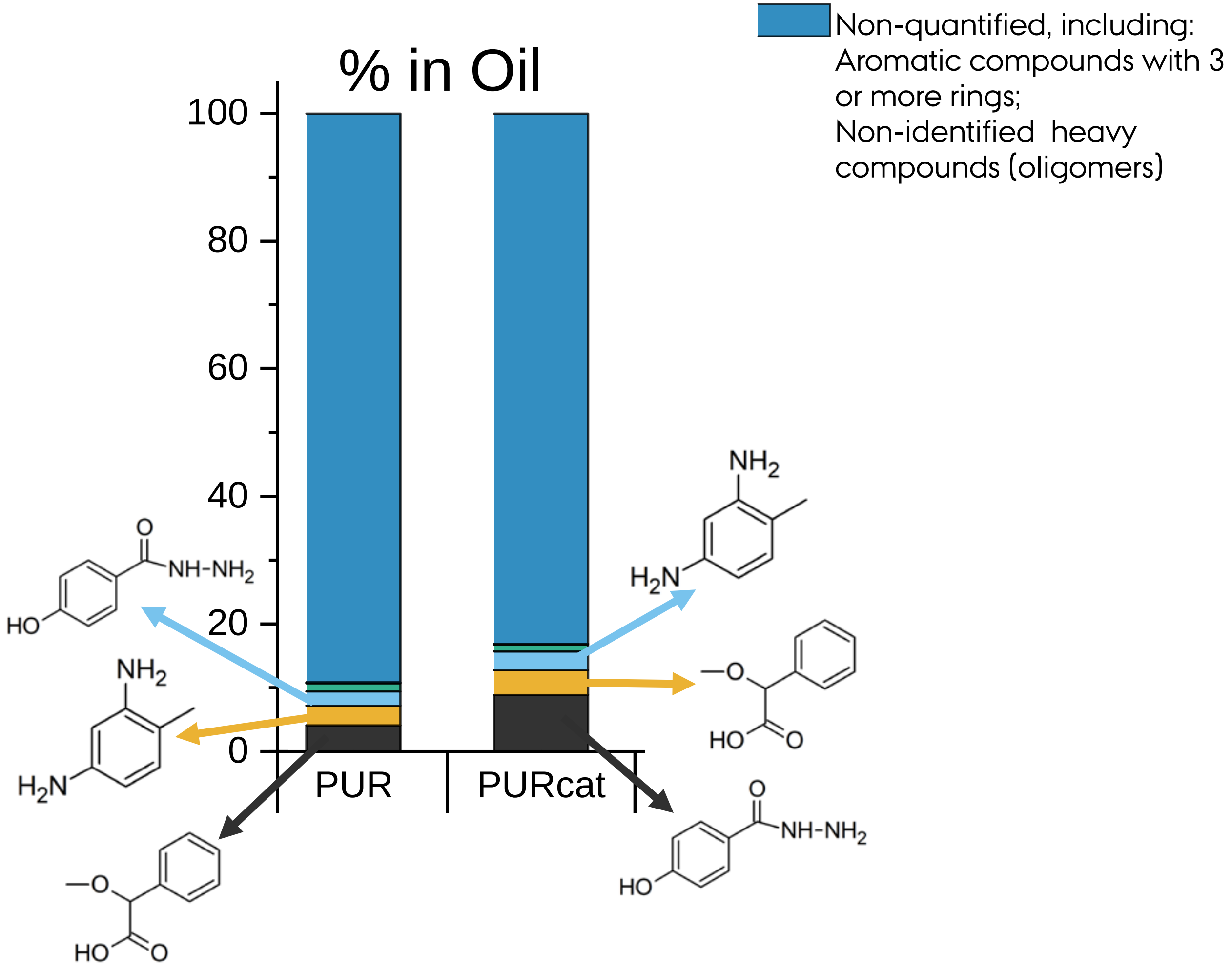




PUR


O
NH
NH
O
O
O
n


Mass balance [%]
100
80
60
40
20
0
PUR
PURcat
AP (diff)
Gas
Oil
Solids
HO
HO
O
NH
NH
O
OH
H_2N
NH_2


% in Oil
100
80
60
40
20
0
PUR
PURcat
Non-quantified, including:
Aromatic compounds with 3 or more rings;
Non-identified heavy compounds (oligomers)
HO
O
NH-NH_2
NH_2
H_2N
HO
O

LIGNOCELLULOSIC WASTE FOR CO-LIQUEFACTION

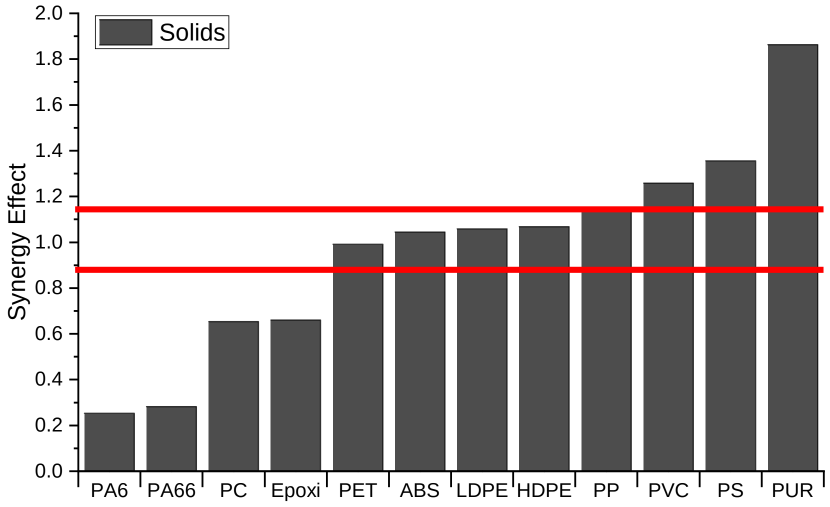
LIGNOCELLULOSIC WASTE FOR CO-LIQUEFACTION

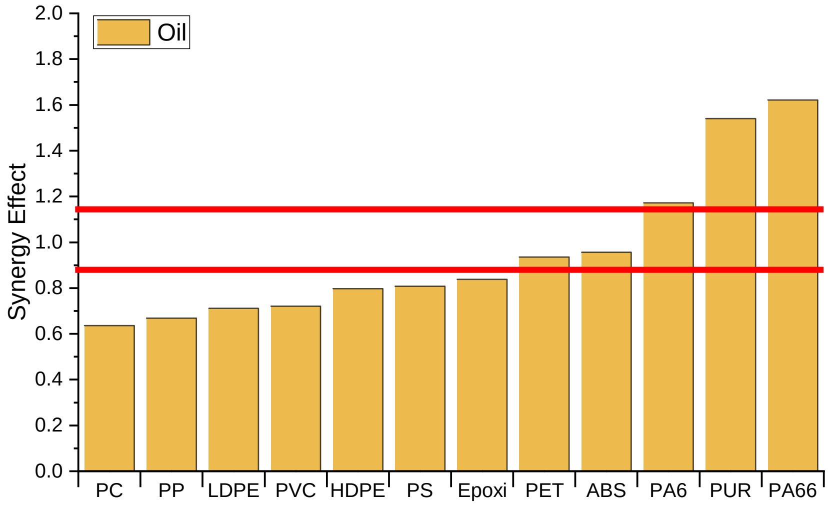
Feedstock	Potential (MtD/y)[3]
Cereal (wheat) straw	241
Sugarbeet leaves	128
Final fellings from conifer trees	129
Final fellings from nonconifer trees	93
Switchgrass	66
Thinnings from conifer trees	64
Maize stover	63
Miscanthus*	62
Unused grassland cuttings	58
Stumps from final fellings from conifer trees	51
Thinnings from nonconifer trees	47
Logging residues from final fellings from conifer trees	40
Sunflower straw	34
Cereal bran	34
Stumps from final fellings from nonconifer trees	30
Logging residues from thinnings from conifer trees	26
Non hazardous post consumer wood	25
Logging residues from final fellings from nonconifer trees	25
Other residues (conifers)	22
Oil seed rape straw	21

* - Potential according to area available

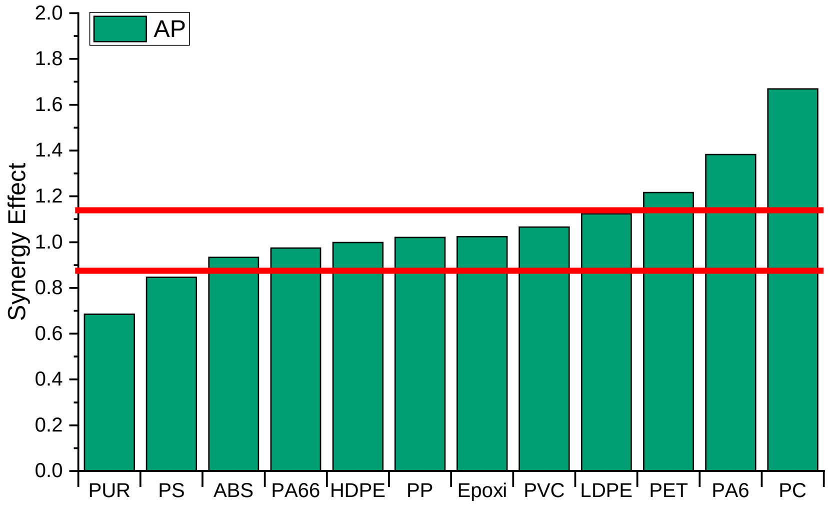
3 - DBFZ - German Biomass Resarch Centre

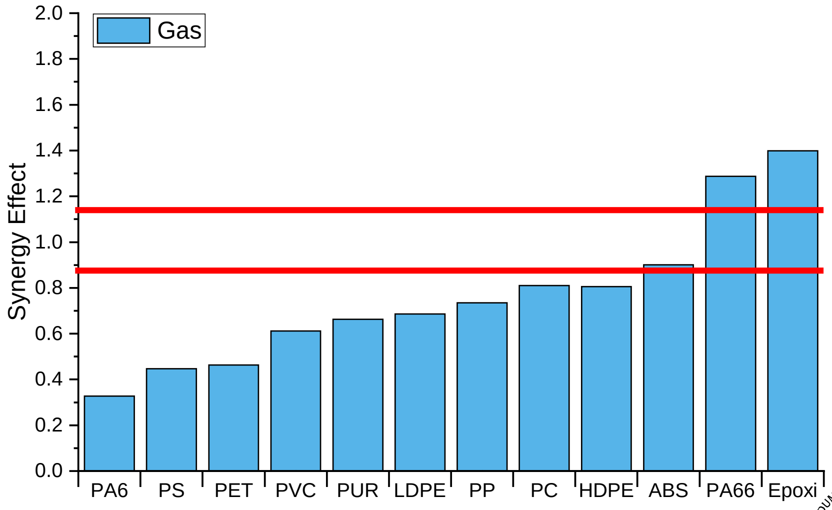
MISCANTHUS + POLYMERS





$$Synergy\ effect = \frac{yield_{experiment}}{yield_{expected}}$$





$$Synergy\ effect > 1 \ \rightarrow Positive$$

$$Synergy\ effect < 1 \ \rightarrow Negative$$

$$Synergy\ effect \approx 1 \ \rightarrow Neutral$$

MISCANTHUS + POLYMERS

$$Synergy\ effect = \frac{yield_{experiment}}{yield_{expected}}$$

$$Synergy\ effect > 1 \ \rightarrow Positive$$

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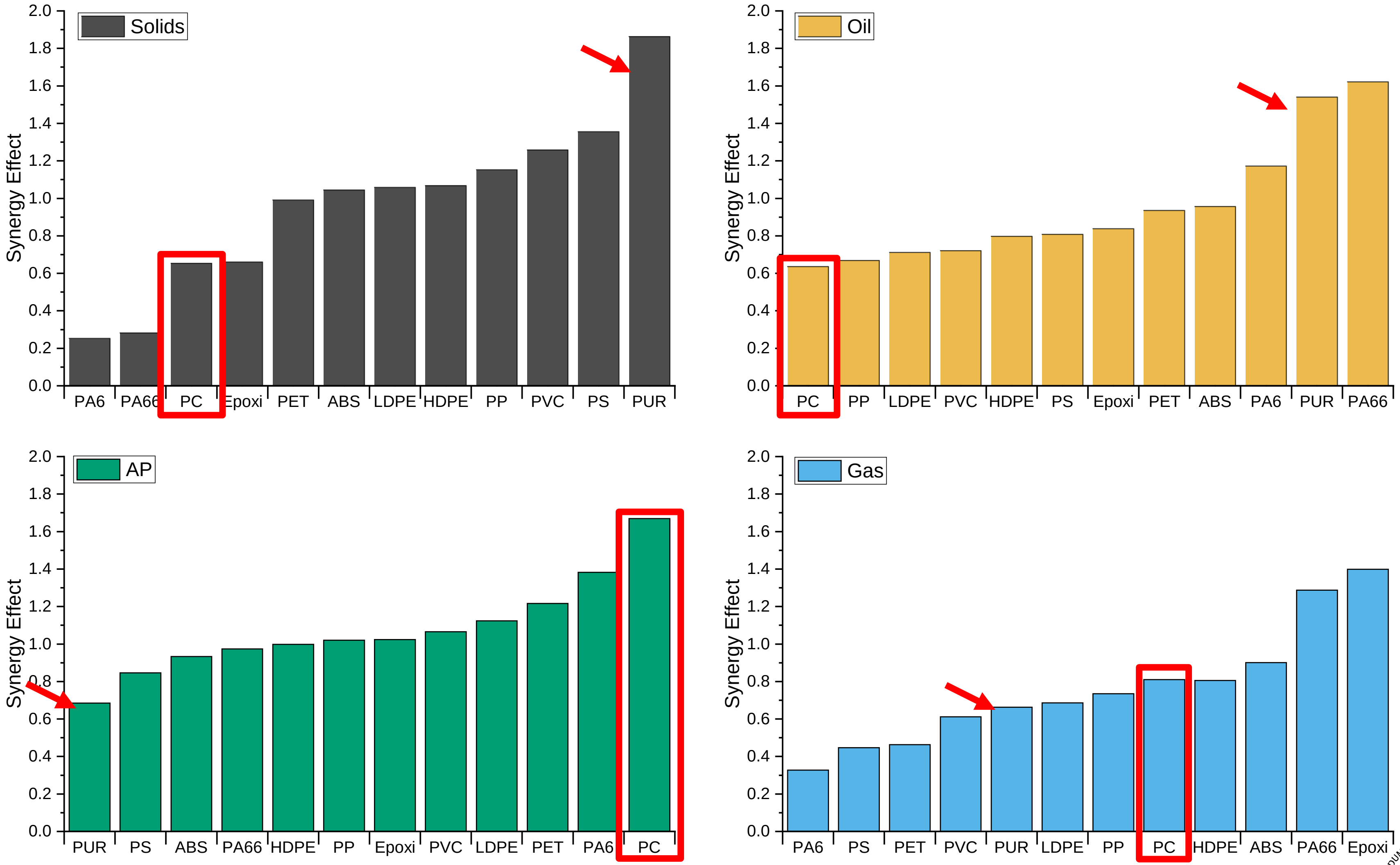
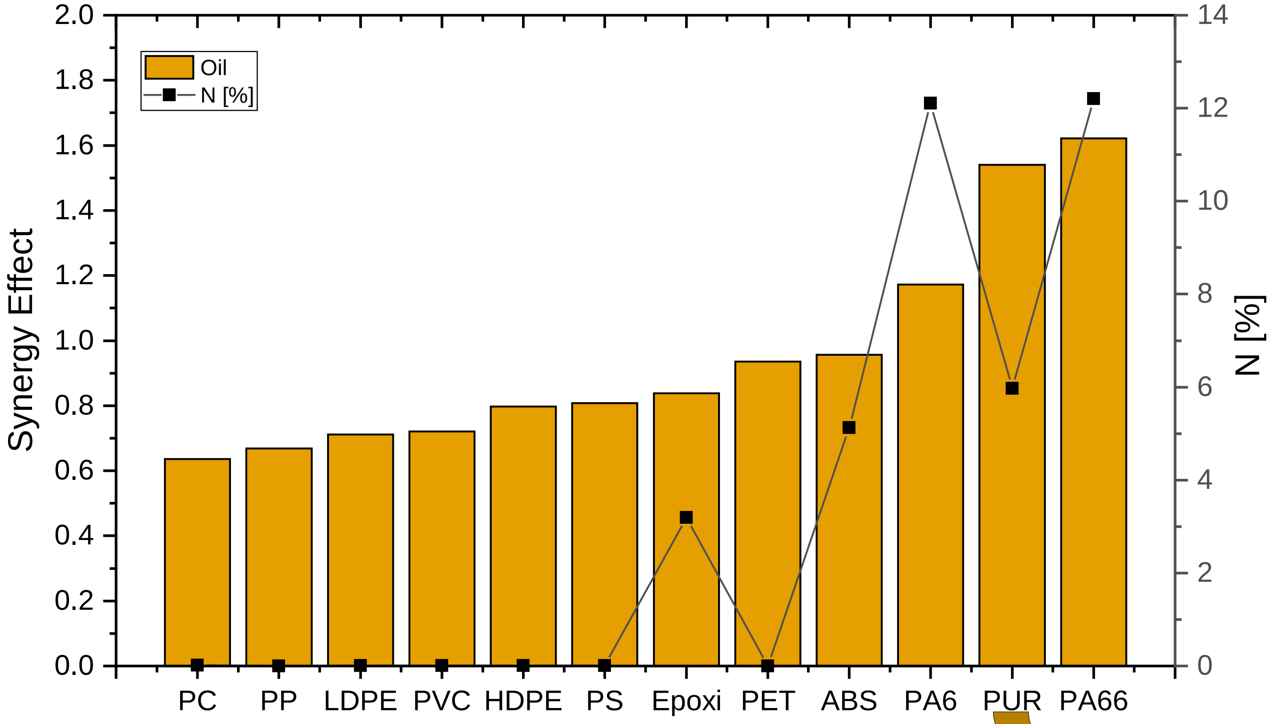
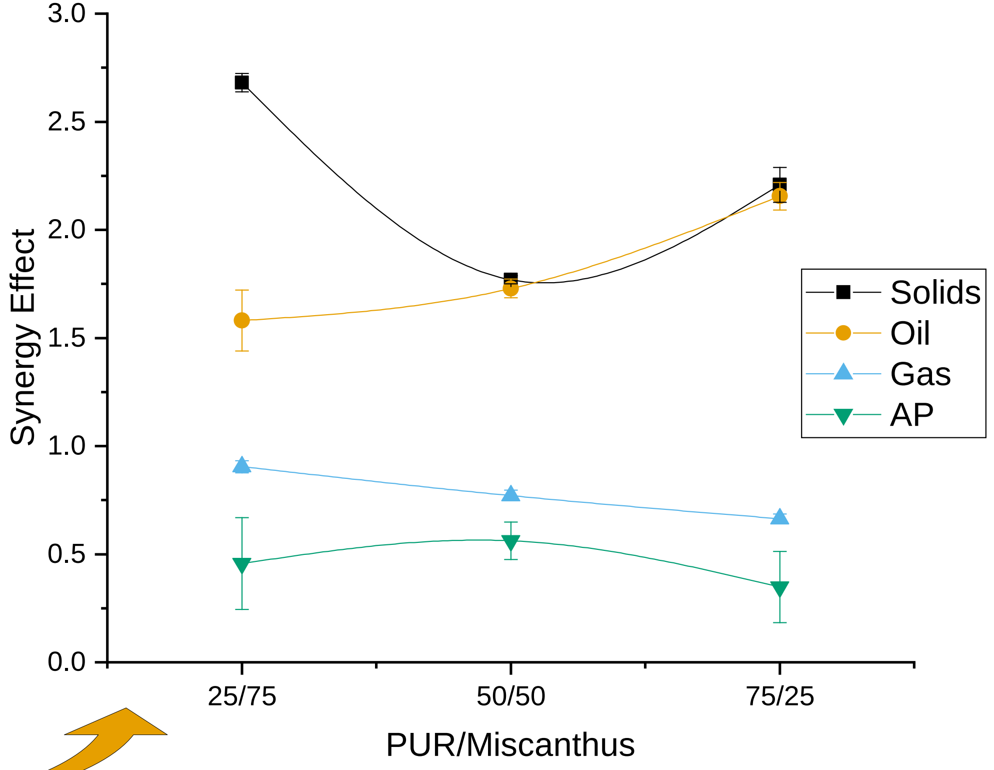


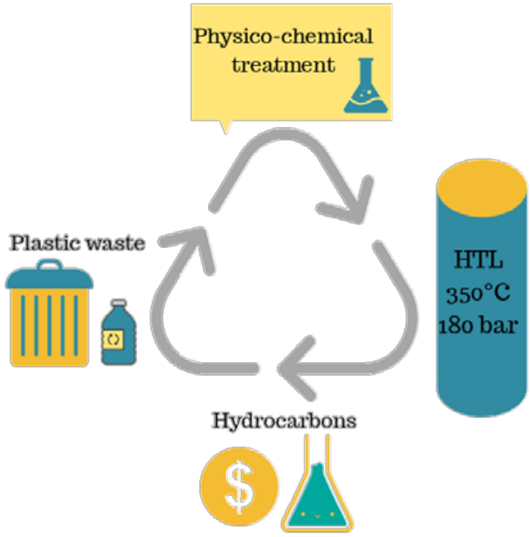
MISCANTHUS + POLYMERS

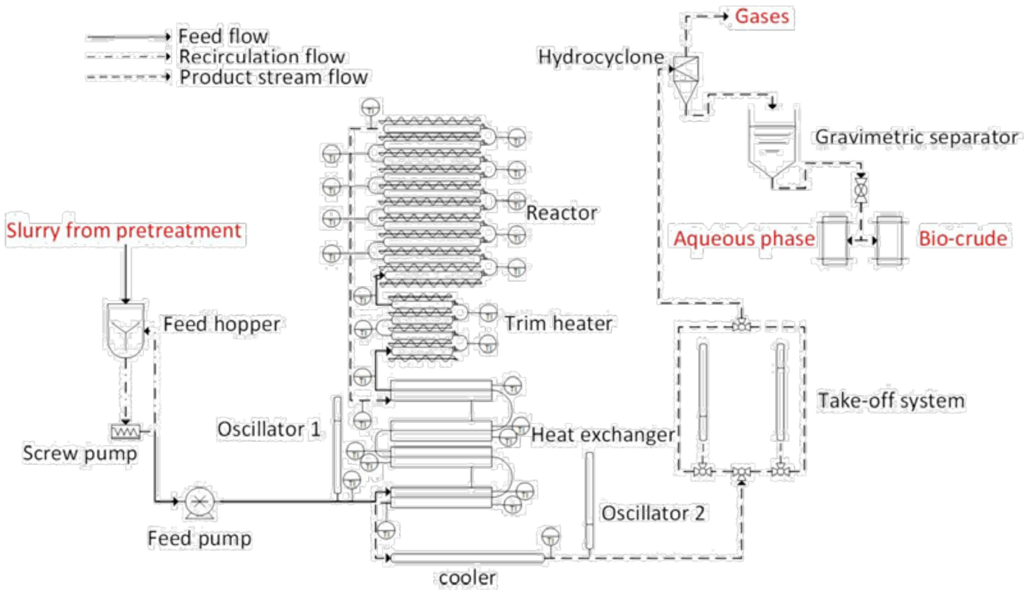




NEXT STEPS

Polyolefins solutions?





Upscaling and its consequences

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HyFlexFuel

AARHUS UNIVERSITY
DEPARTMENT OF ENGINEERING

tcbiomassplus 2019

CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

SOLIDUM PETIT IN PROFUNDIS · UNIVERSITAS ARHUSIENSIS