Pyrolysis of Polystyrene with Mineral Fillers:

Perspectives for Recycling of the Plastic-rich Fraction from Thermal Insulation Construction Material

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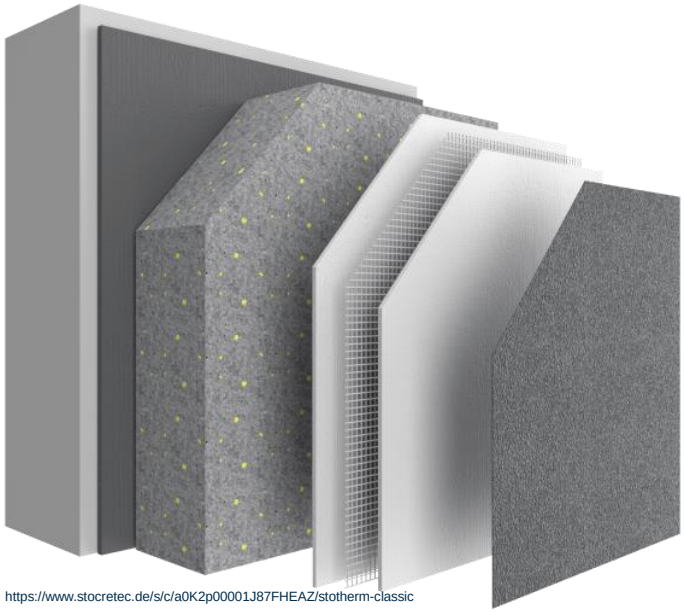
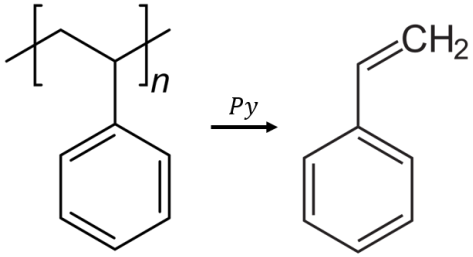
18.03.2025



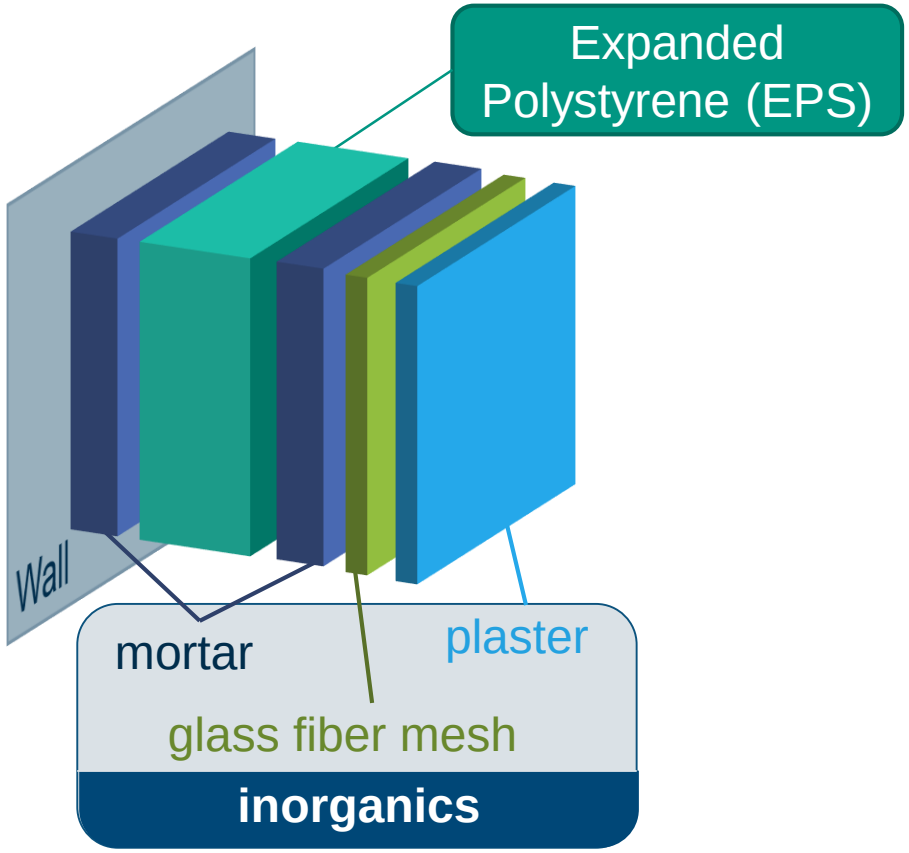
https://www.stocretec.de/s/c/a0K2p00001J87FHEAZ/stotherm-classic



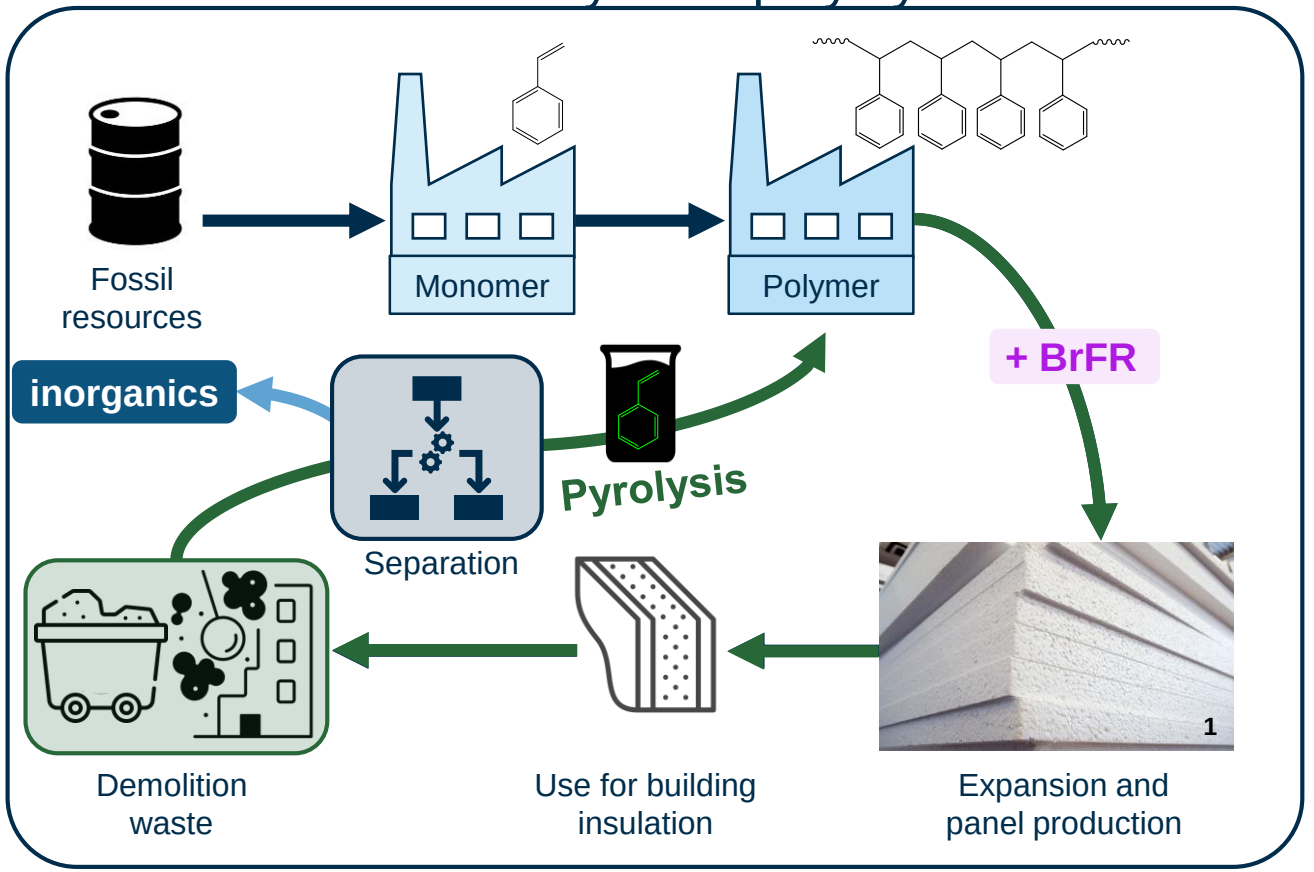
FINEST

Institut für Technische Chemie

Background:
External Thermal Insulation Composite Systems

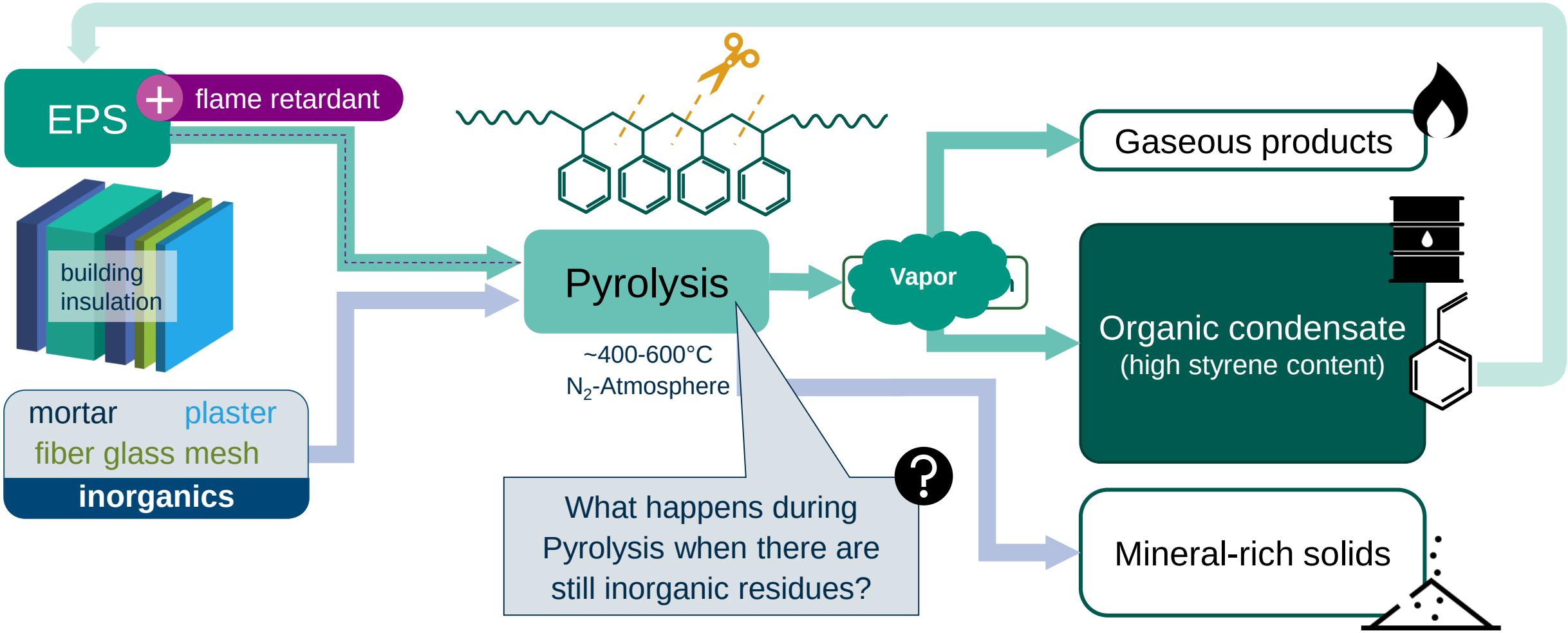


Goal: clean cycle of polystyrene

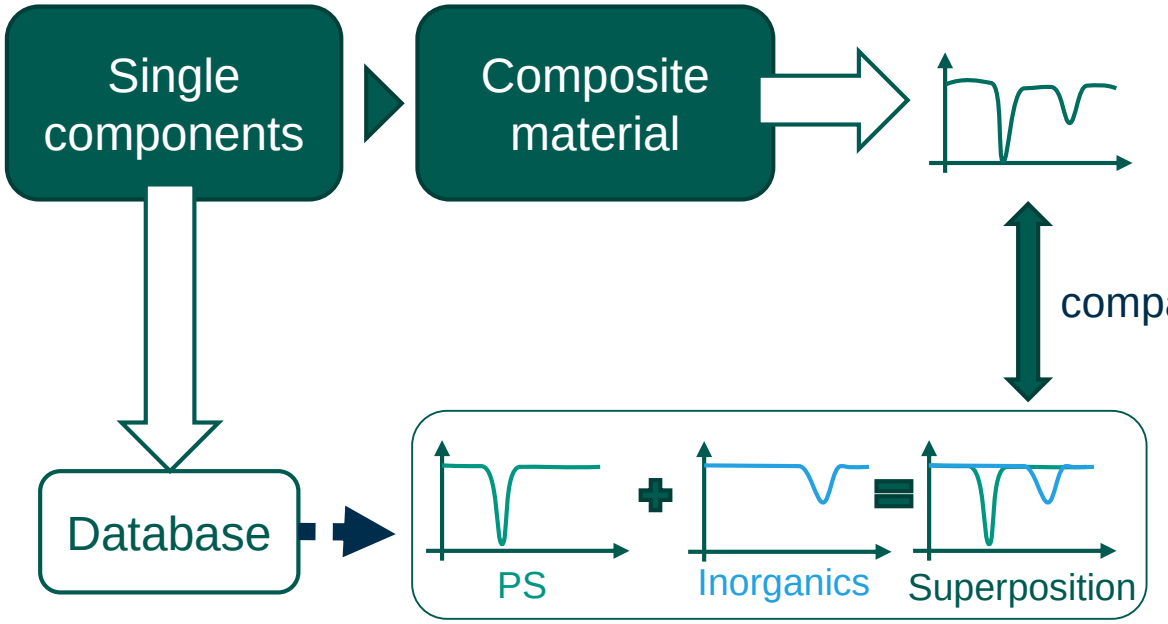


[1] https://poytherm.com/de/was-ist-eps-und-wei%C3%9Fes-eps/blog/344, accessed on 10.03.2025

How to transform waste into a new raw material?



Thermogravimetric Analysis (TGA)
Degradation of Polystyrene (PS)



comparison

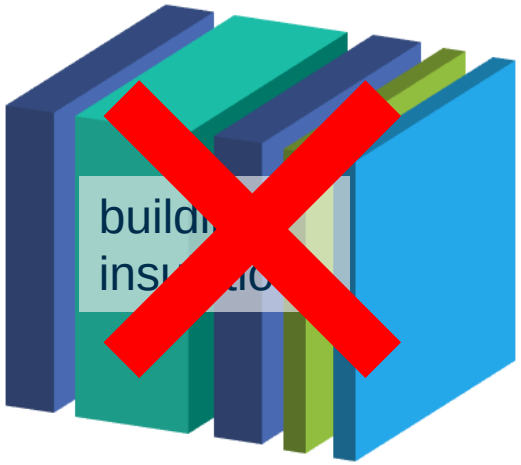
No difference:
no effect on formation rate of volatiles

Difference:
effect on formation rate of volatiles

homogeneous 10 mg samples necessary

Sample Preparation

ETICS



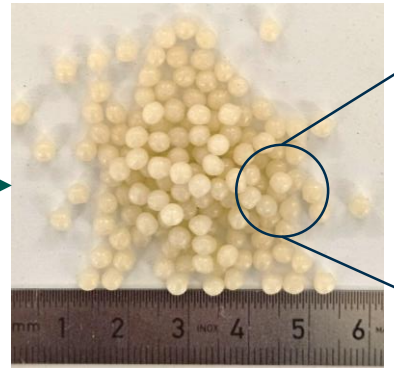
- too bulky
- too inhomogeneous

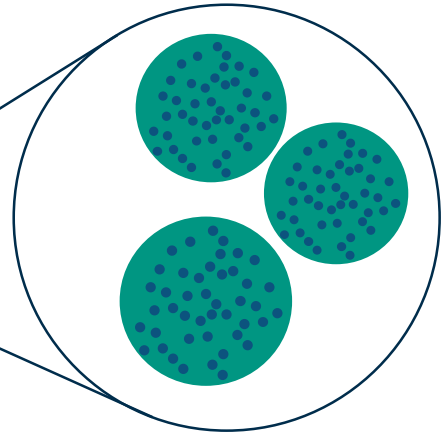
Virgin PS

Inorganic filler

Model

Compounds

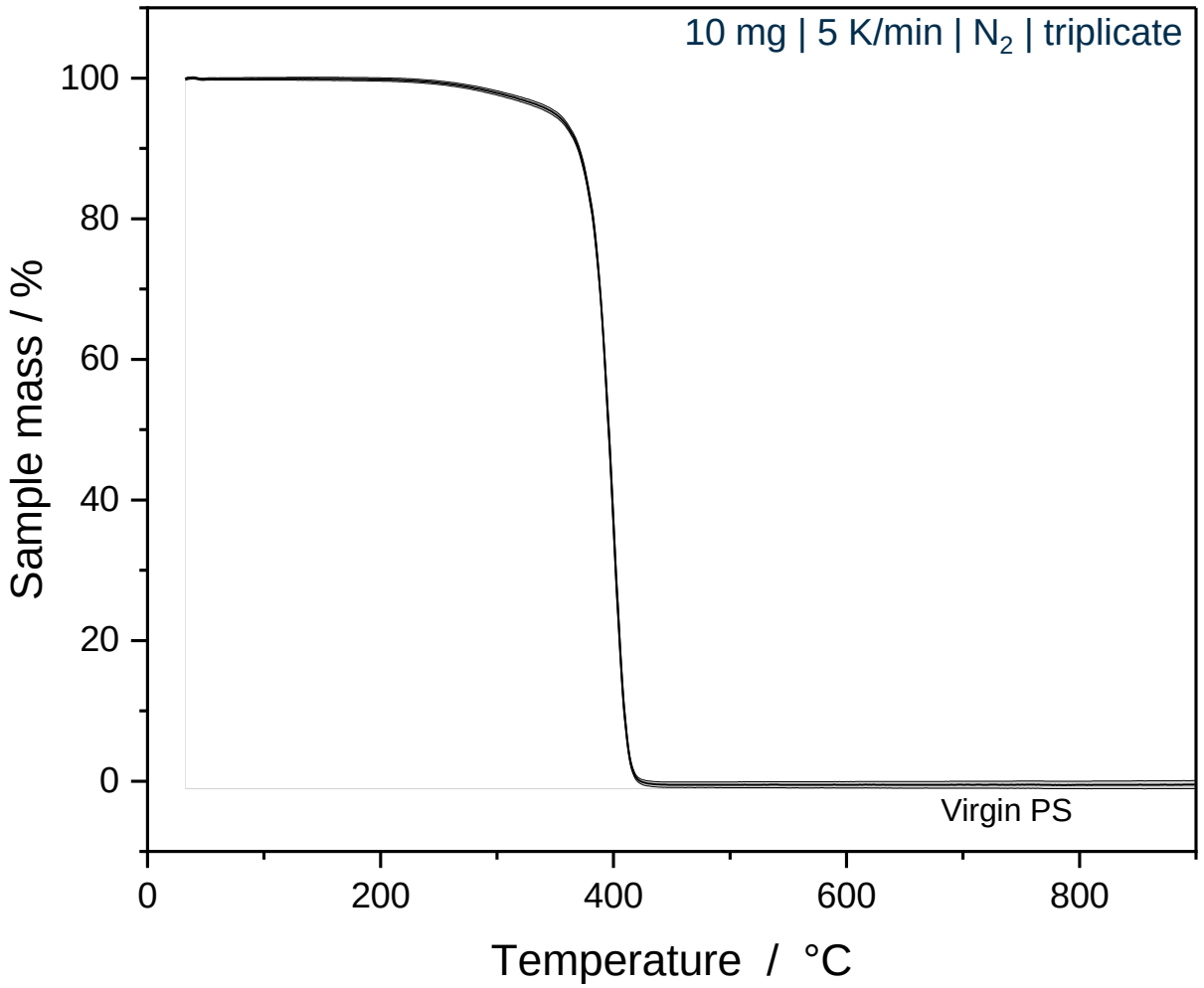




PS + Inorganic

- $CaCO_3$
- $Ca(OH)_2$
- TiO_2

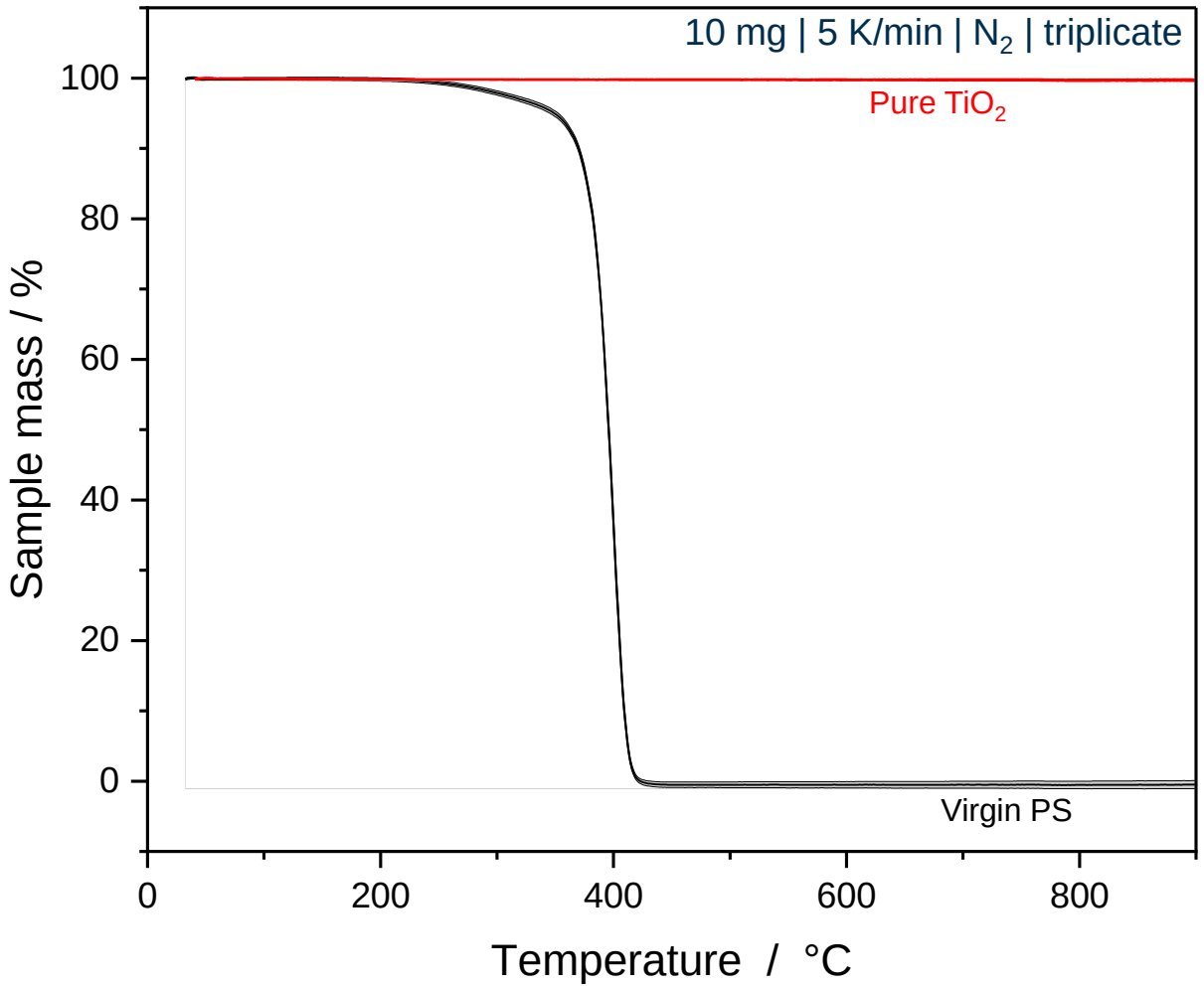
TGA Results – PS with 10% TiO_2 (Anatase)



Single component measurements

- Virgin PS

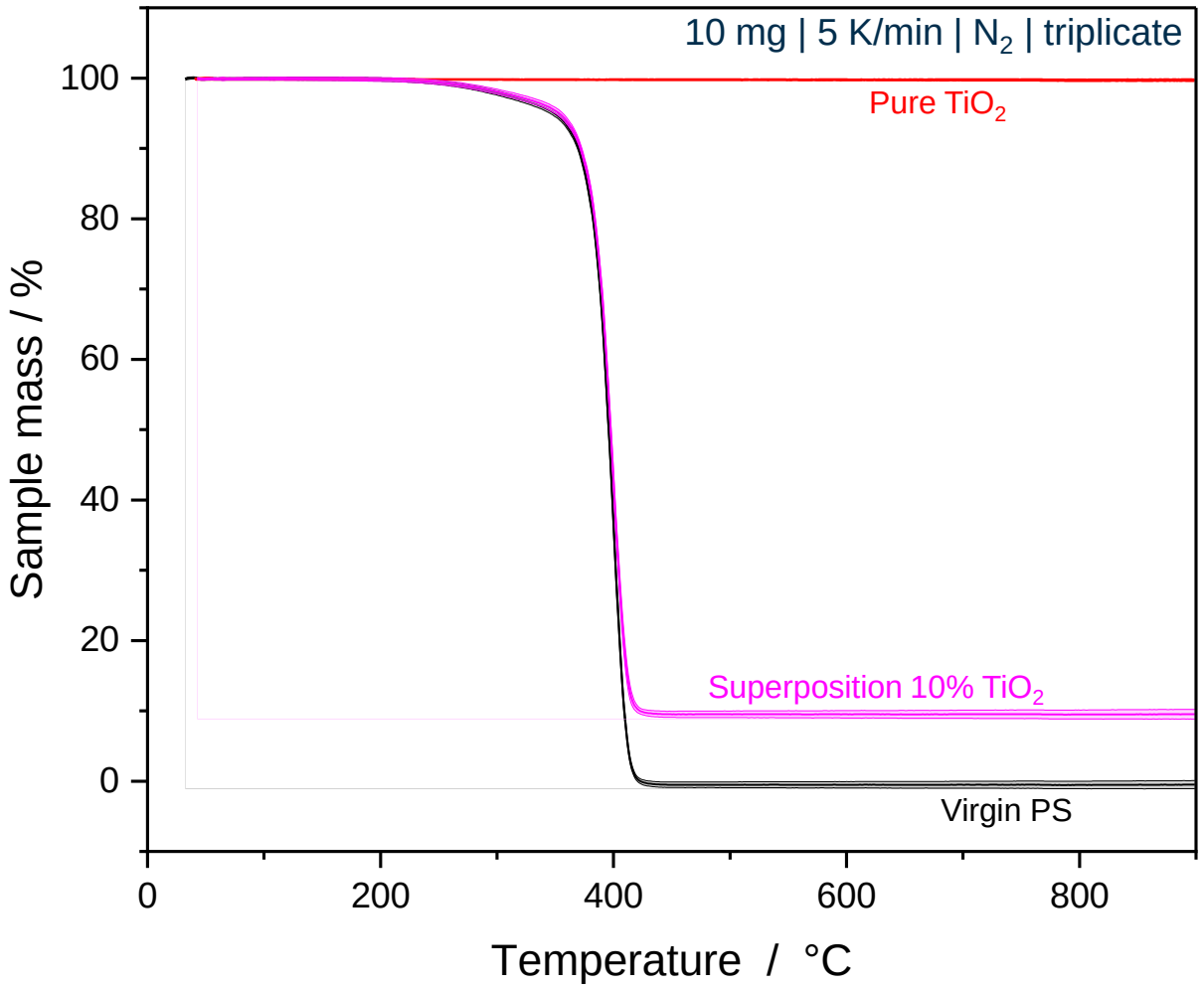
TGA Results – PS with 10% TiO_2 (Anatase)



Single component measurements

- Virgin PS
- TiO_2 (BET Surface: 8.7 m²/g)

TGA Results – PS with 10% TiO_2 (Anatase)

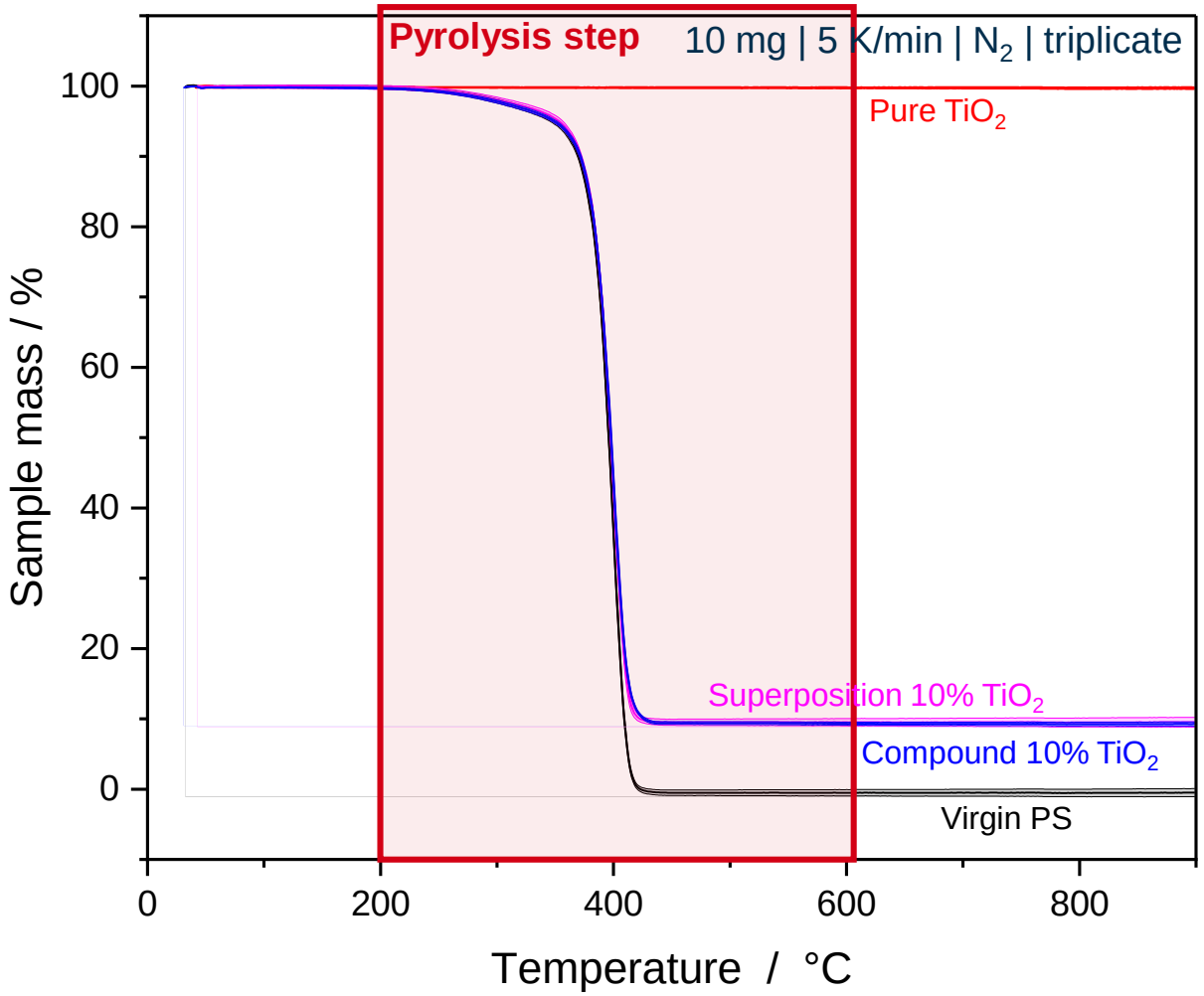


Single component measurements

- Virgin PS
- TiO_2

superposition
= addition of single curves

TGA Results – PS with 10% TiO_2 (Anatase)



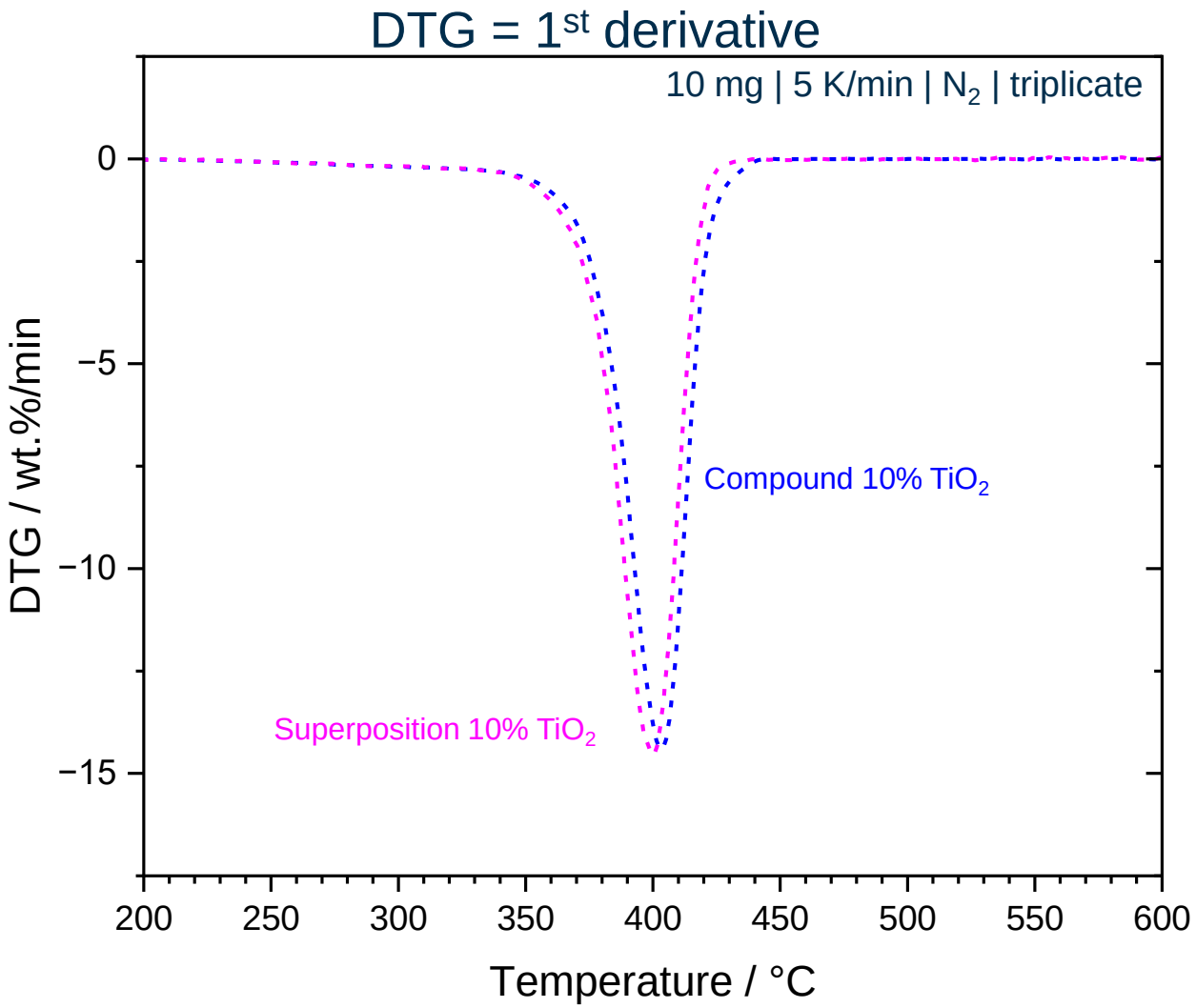
Single component measurements

- Virgin PS
- TiO_2

superposition
= addition of single curves

Compounded and milled sample

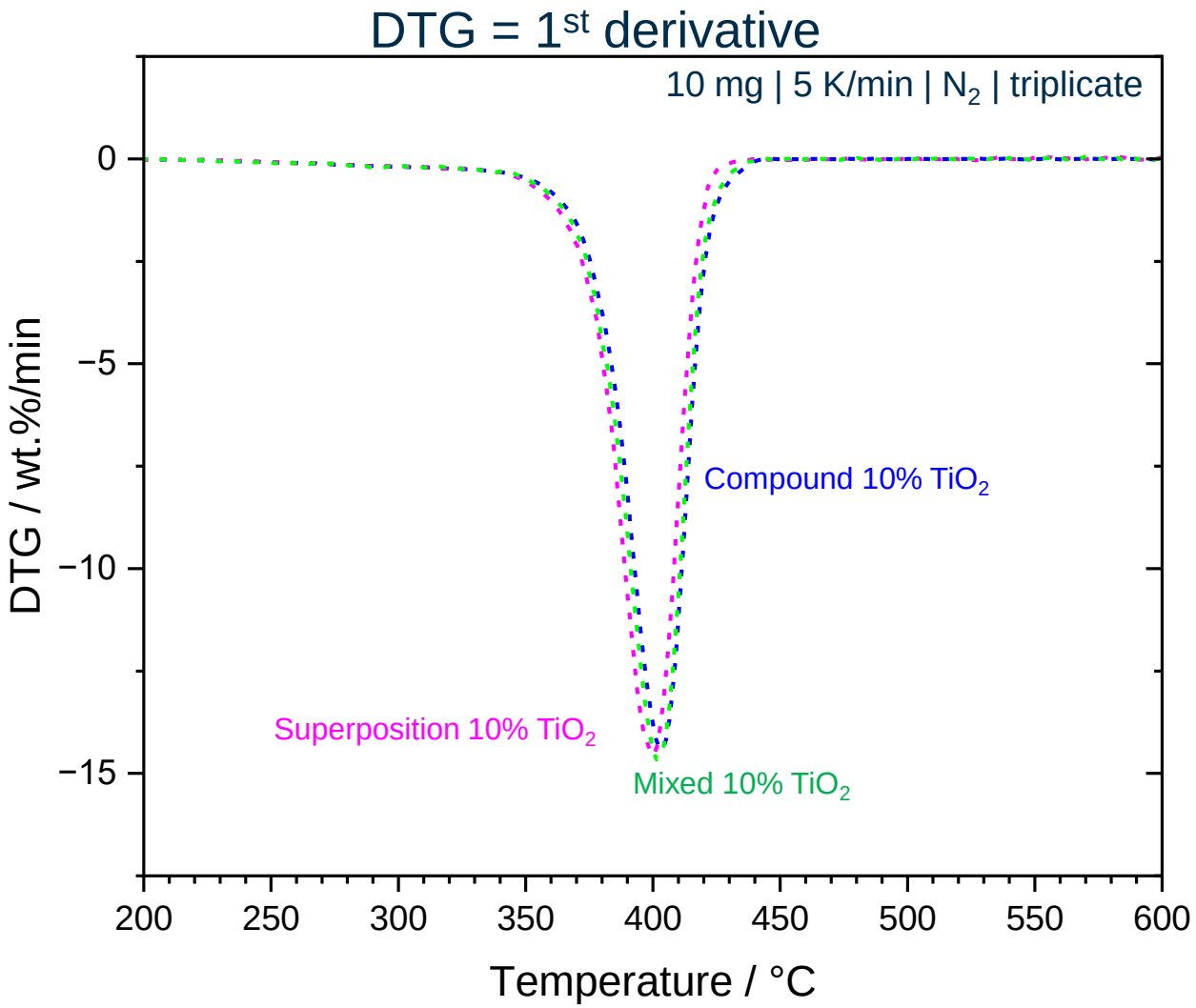
TGA Results – PS with 10% TiO_2 (Anatase)

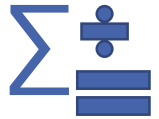


superposition
= addition of single curves

Compounded and milled sample

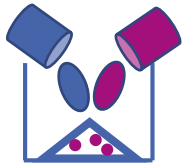
TGA Results – PS with 10% TiO_2 (Anatase)





superposition
= addition of single curves

Compounded and milled sample



Mixed
= single components hand-mixed in one crucible

Minor deviations
→ No significant effect on formation rate of volatiles

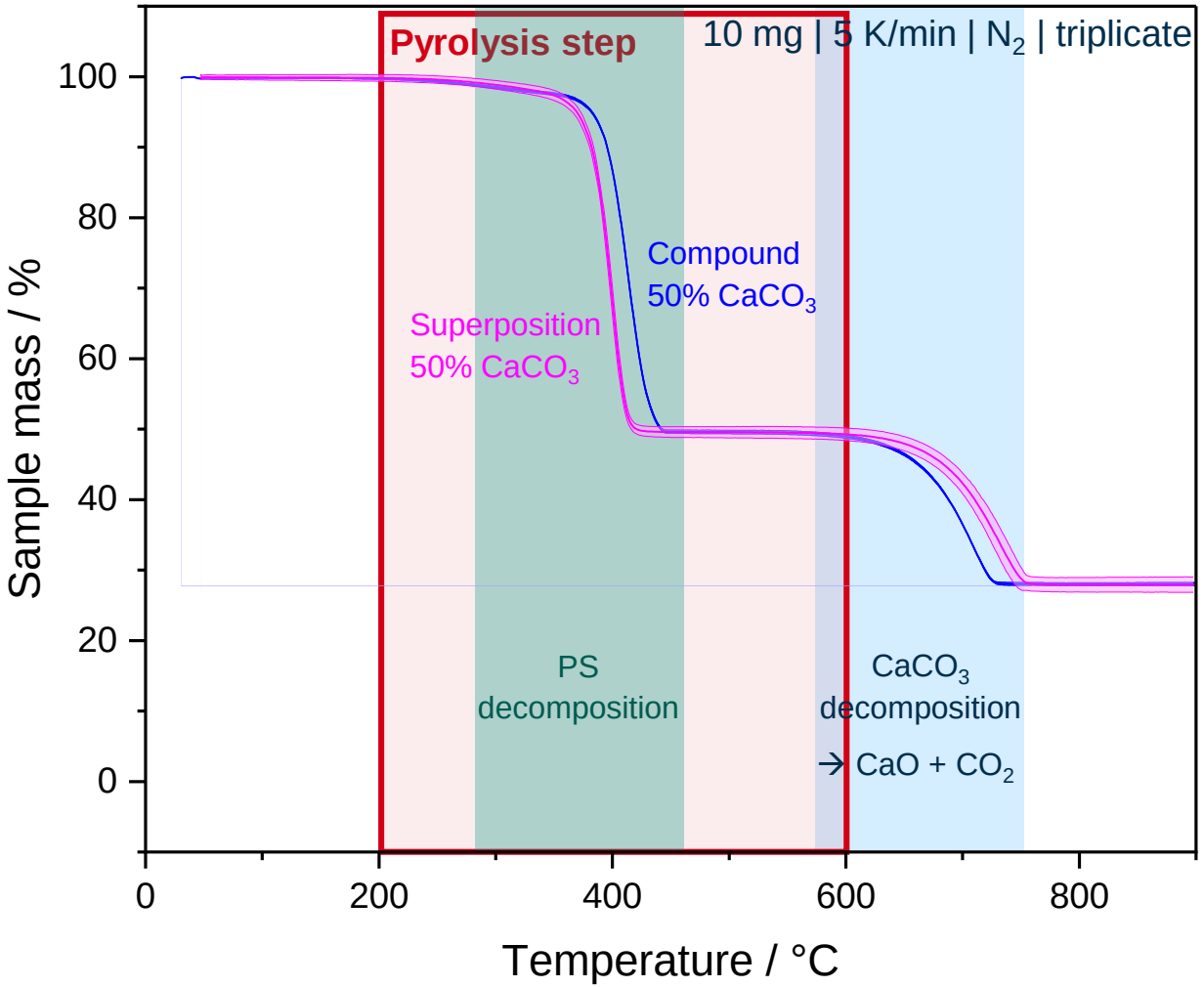
TGA: Polystyrene with $CaCO_3$

BET Surface **$CaCO_3$**: 1.8 m²/g

vs. BET Surface **TiO_2**: 8.7 m²/g

Ca. x 5

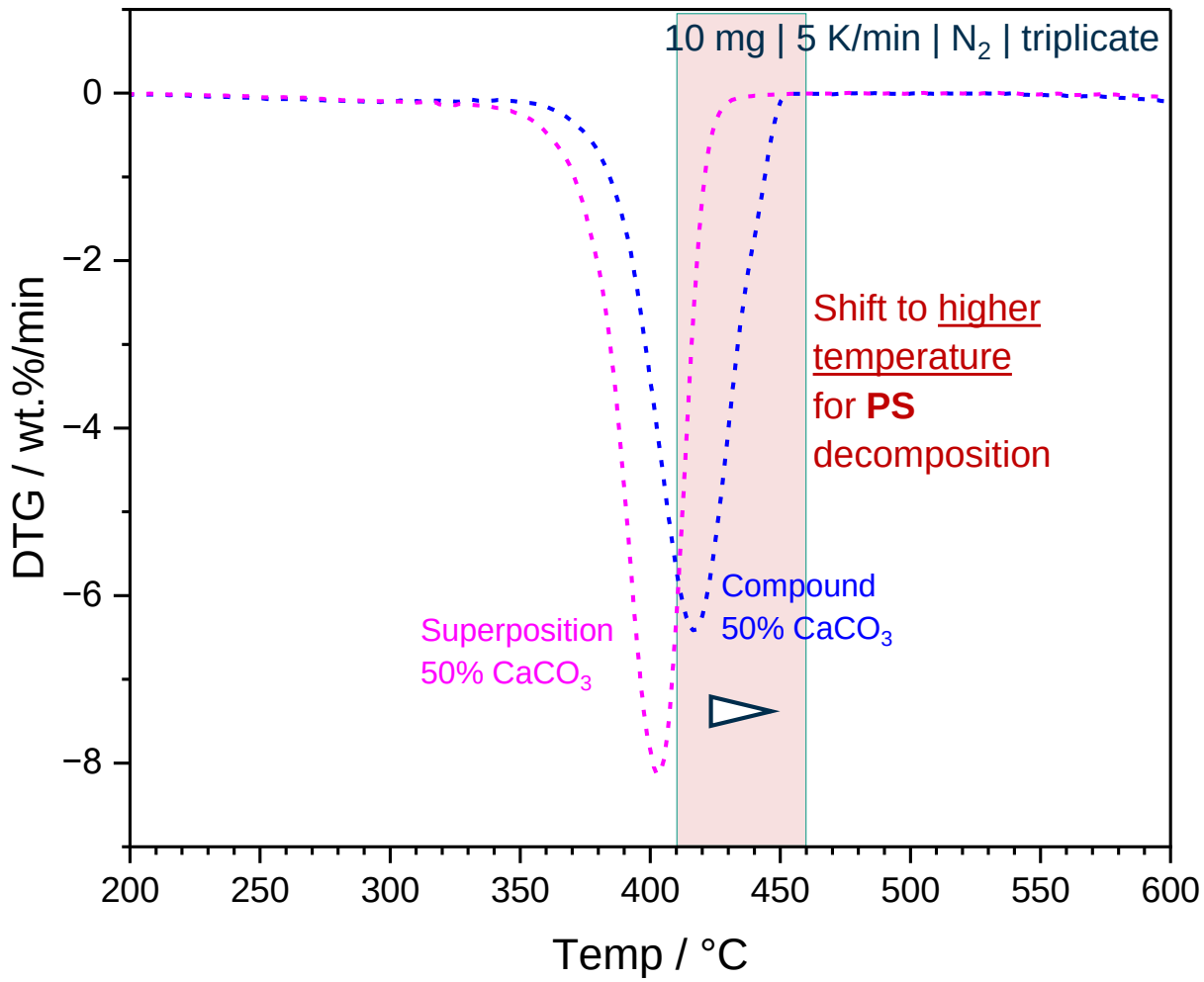
TGA Results – PS with 50% $CaCO_3$ (Calcite)

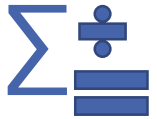


superposition
= addition of single curves

Compounded and milled sample

TGA Results – PS with 50% $CaCO_3$ (Calcite)

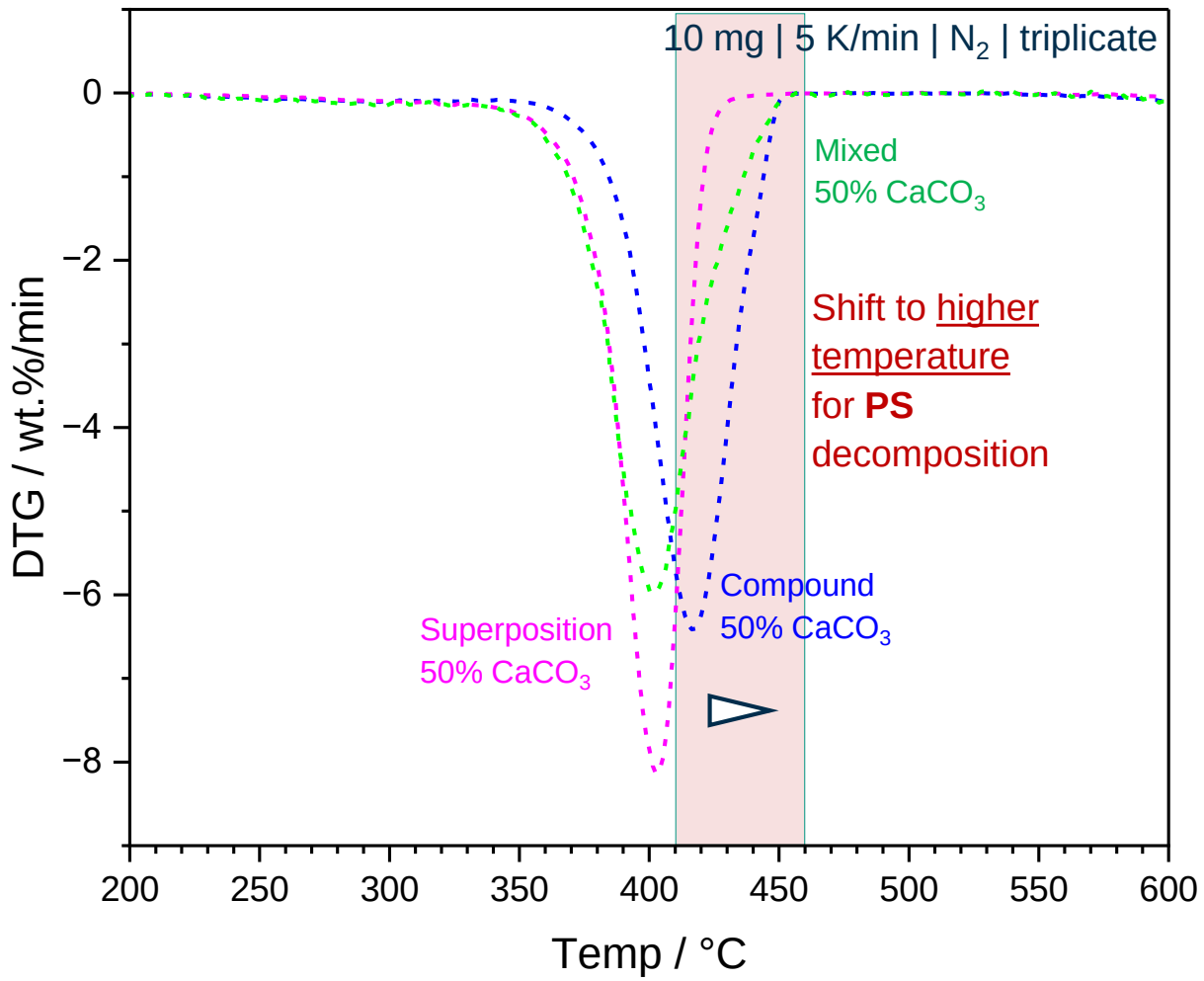




superposition
= addition of single curves

Compounded and milled sample

TGA Results – PS with 50% $CaCO_3$ (Calcite)



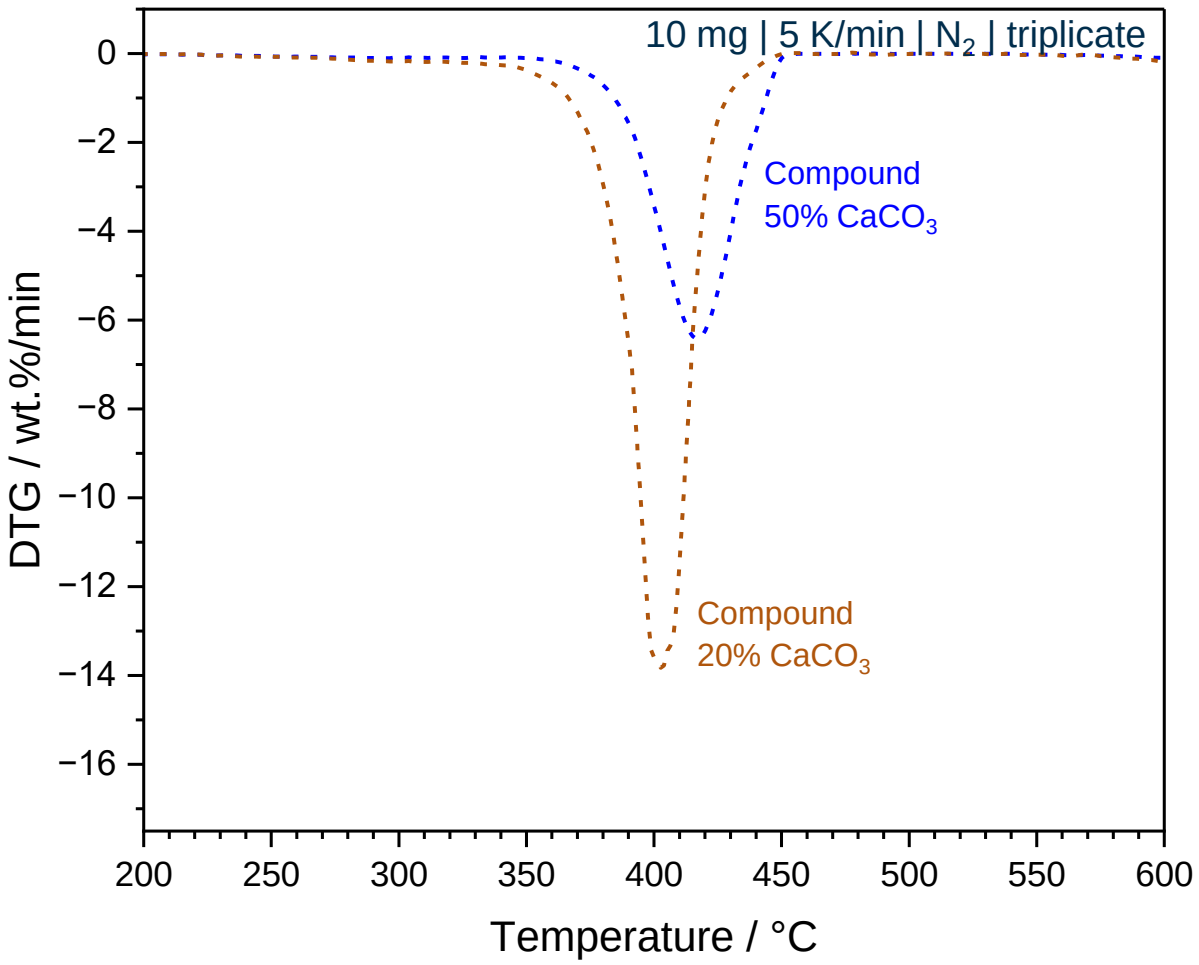
superposition
= addition of single curves

Compounded and milled sample

Mixed
= single components hand-mixed in one crucible

Comparison with lower concentrations

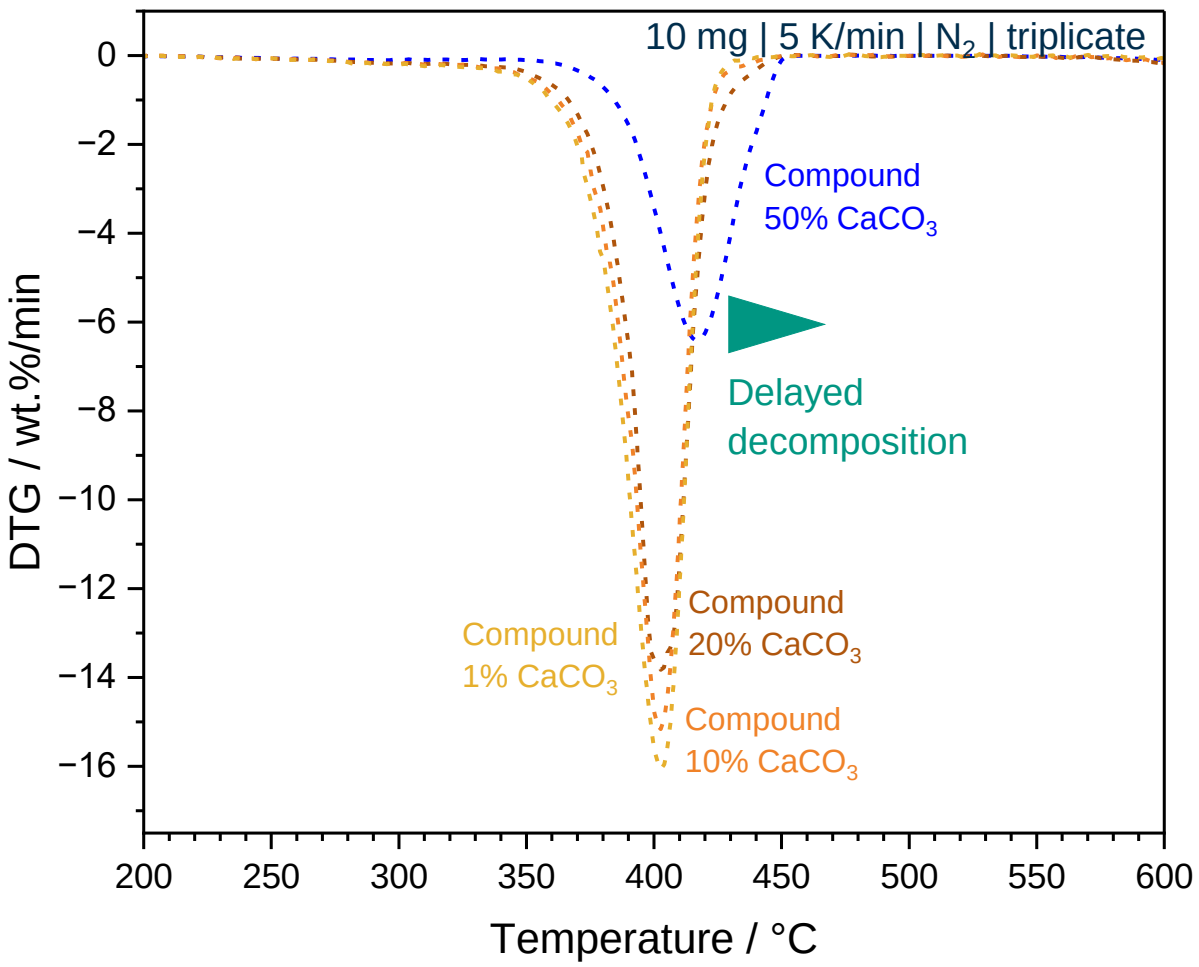
PS with $CaCO_3$ concentration dependence



Compounded and milled sample

- 50% $CaCO_3$
- 20% $CaCO_3$

PS with $CaCO_3$ concentration dependence



Compounded and milled sample

- 50% $CaCO_3$
- 20% $CaCO_3$
- 10% $CaCO_3$
- 1% $CaCO_3$

Minor deviations for low concentrations
Significant deviations for high concentrations
→ effect on formation rate of volatiles

What we know ✓

Formation Rate of Volatiles

TiO_2: No significant effect

$CaCO_3$: Decomposition at higher temperature

What we don’t know ✗

Information of Product Distribution

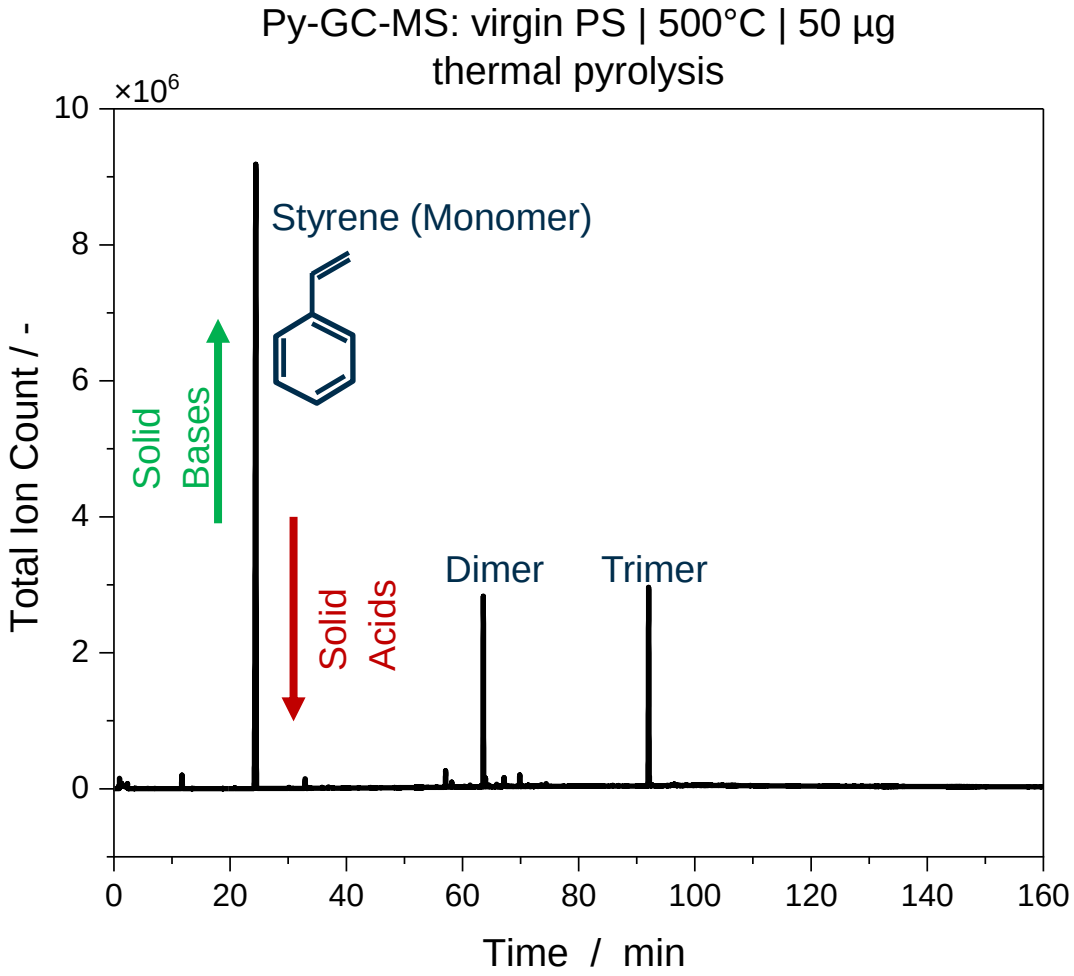
→ Styrene Yield

Polystyrene Pyrolysis products Identification by µ-Pyrolyzer

Catalytic Pyrolysis

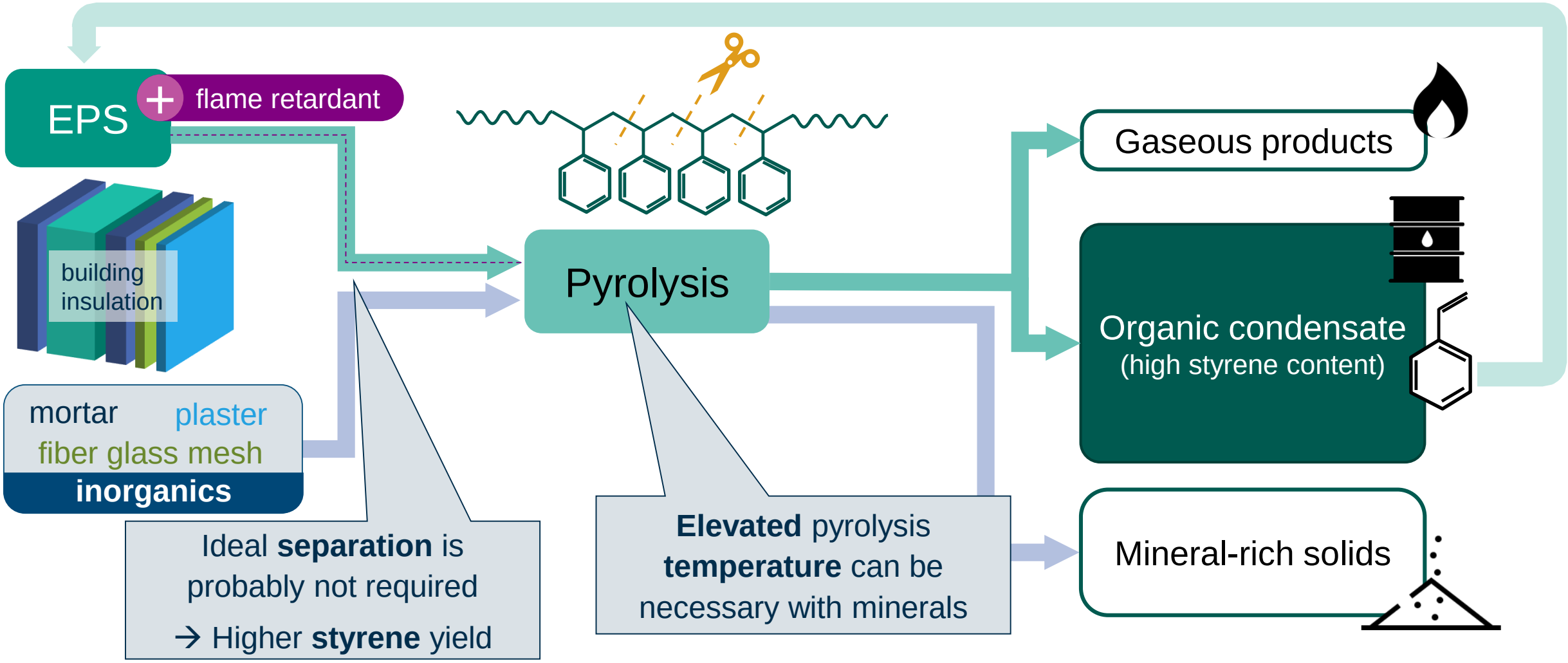
Solid acids:		Solid bases:
•Coke[1] ↑		•Depolymerization[2] ↑
•Hydrogen[1,3] ↑		
•**Styrene** ↓		•**Styrene** ↑

Component	Area%
Monomer	70
Dimer	9
Trimer	15



[1] Marczewski, M et al., 2013 DOI: 10.1016/j.apcatb.2012.09.027.
[2] Ukei, H et al., 2000 DOI: 10.1016/S0920-5861(00)00409-0.
[3] Lin, R et al.,1997 DOI: 10.1002/(SICI)1097-4628(19970307)63:10<1287::AID-APP7>3.0.CO;2-G.

Conclusion


EPS
flame retardant
building insulation
mortar
plaster
fiber glass mesh
inorganics
Pyrolysis
Gaseous products
Organic condensate
(high styrene content)
Mineral-rich solids
Ideal **separation** is probably not required
→ Higher **styrene** yield
Elevated pyrolysis **temperature** can be necessary with minerals

Thank You!

Any Questions?