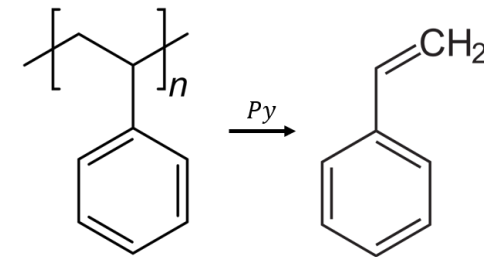
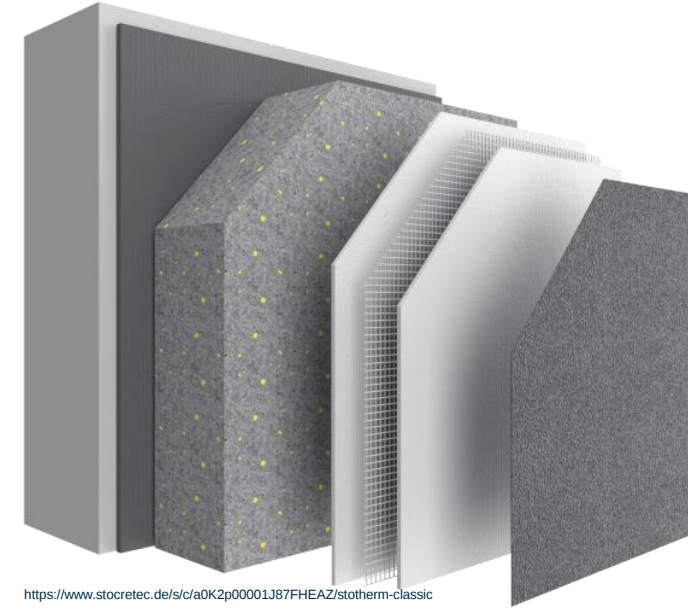


Pyrolysis of Polystyrene with Mineral Fillers:

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

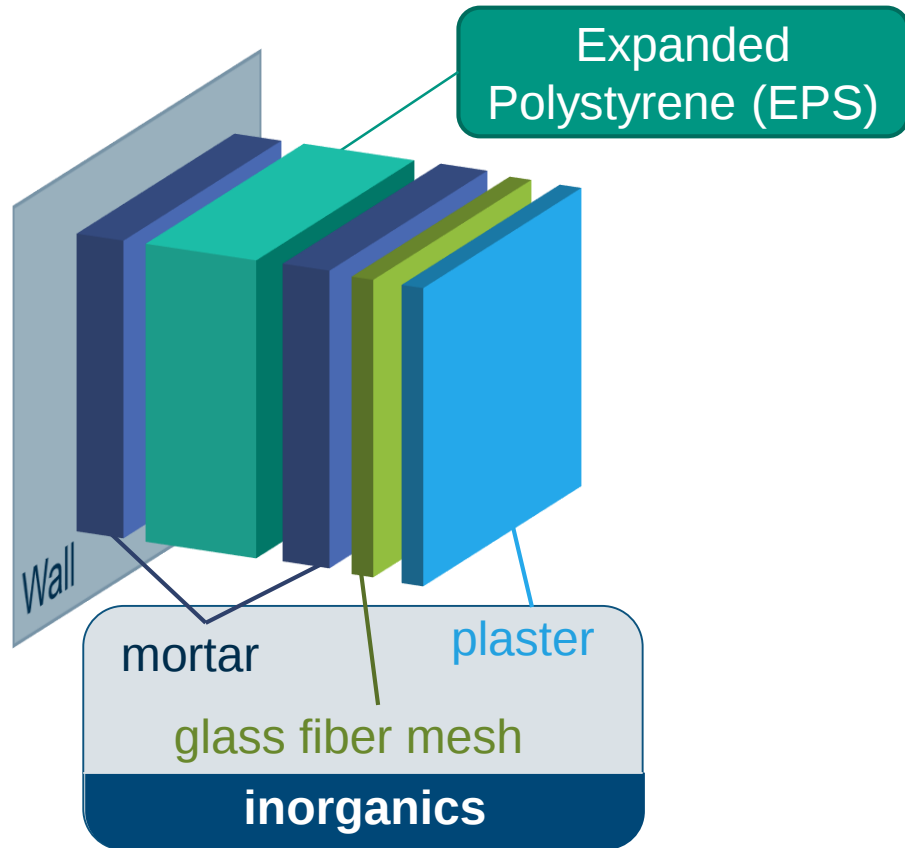
Tim Kurtz, Daniela Merz, Krassimir Garbev,
Razan Alsharqawi, Peter Stemmermann, Salar Tavakkol,
Dieter Stapf
Karlsruhe Institute of Technology

18.03.2025

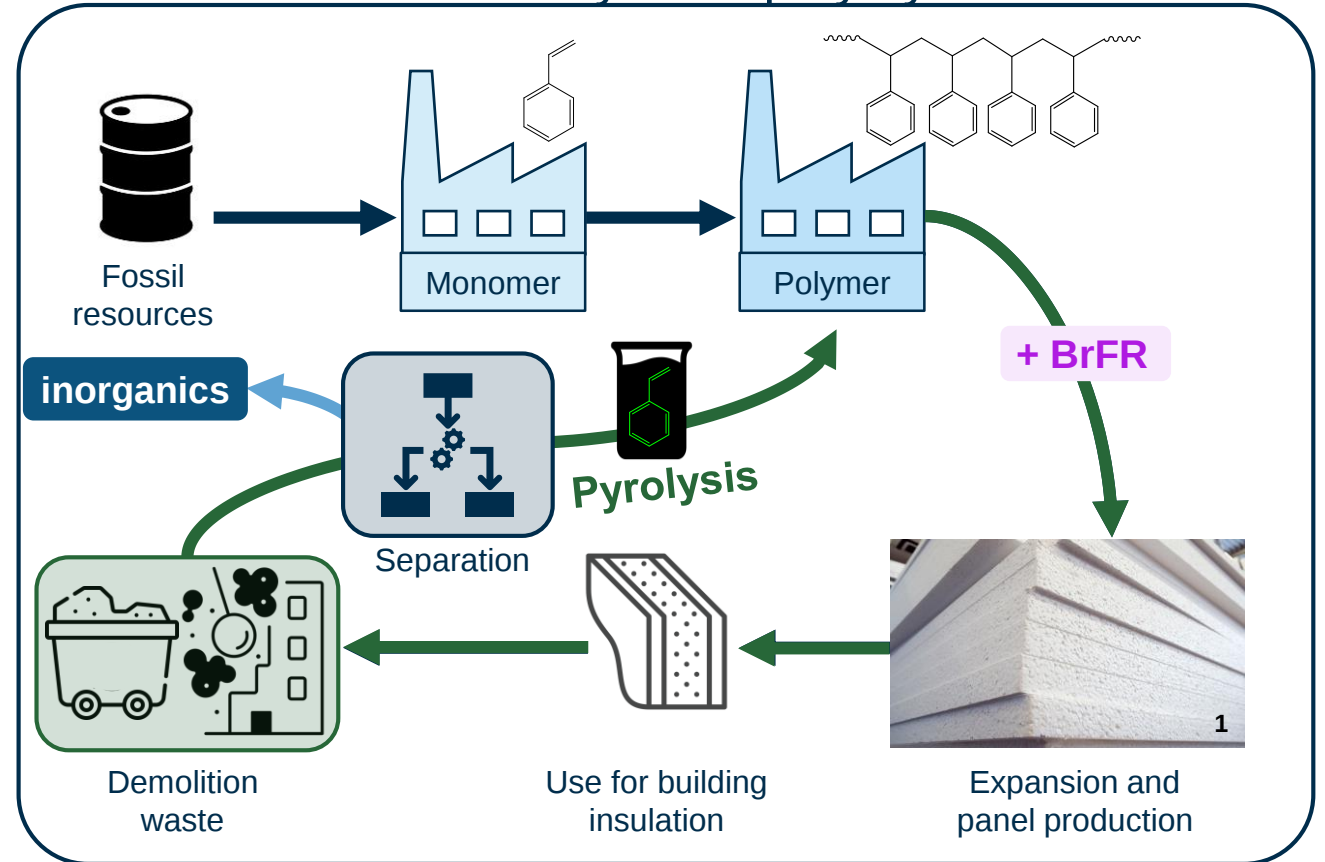


 **FINEST**

Background: External Thermal Insulation Composite Systems

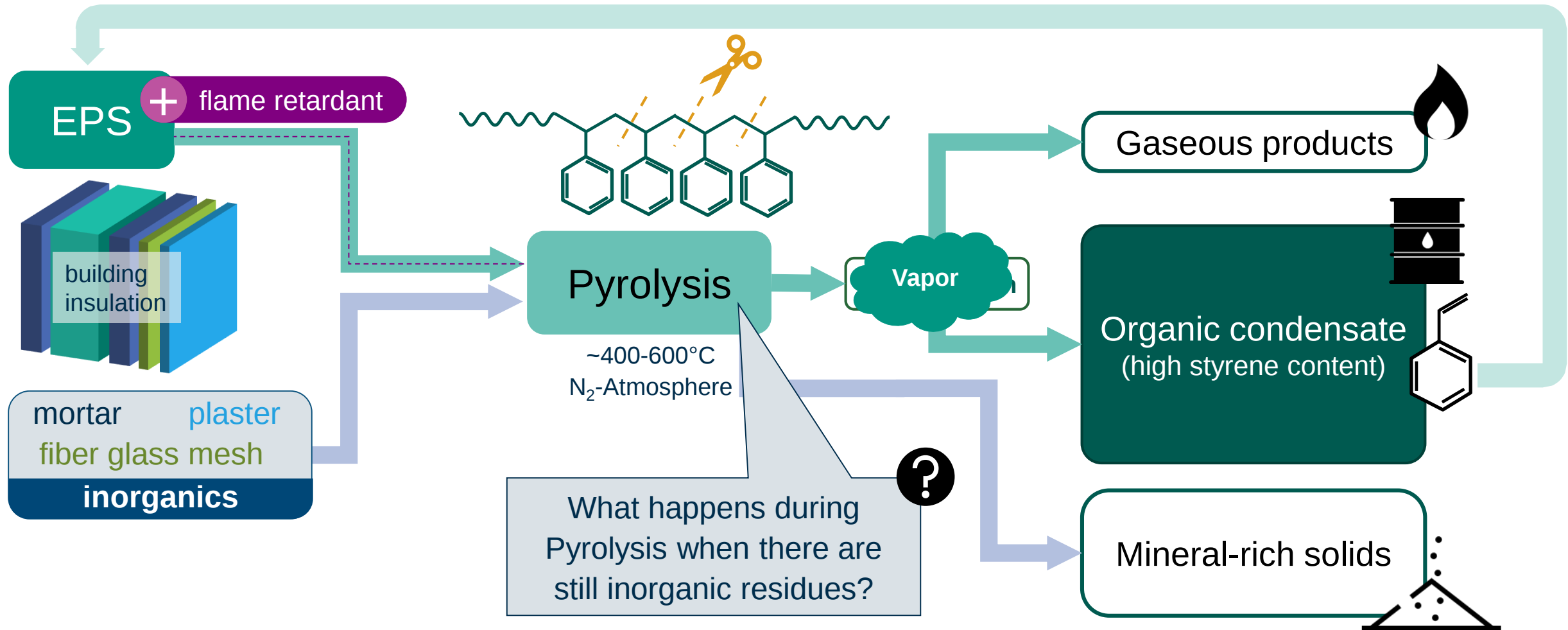


Goal: clean cycle of polystyrene

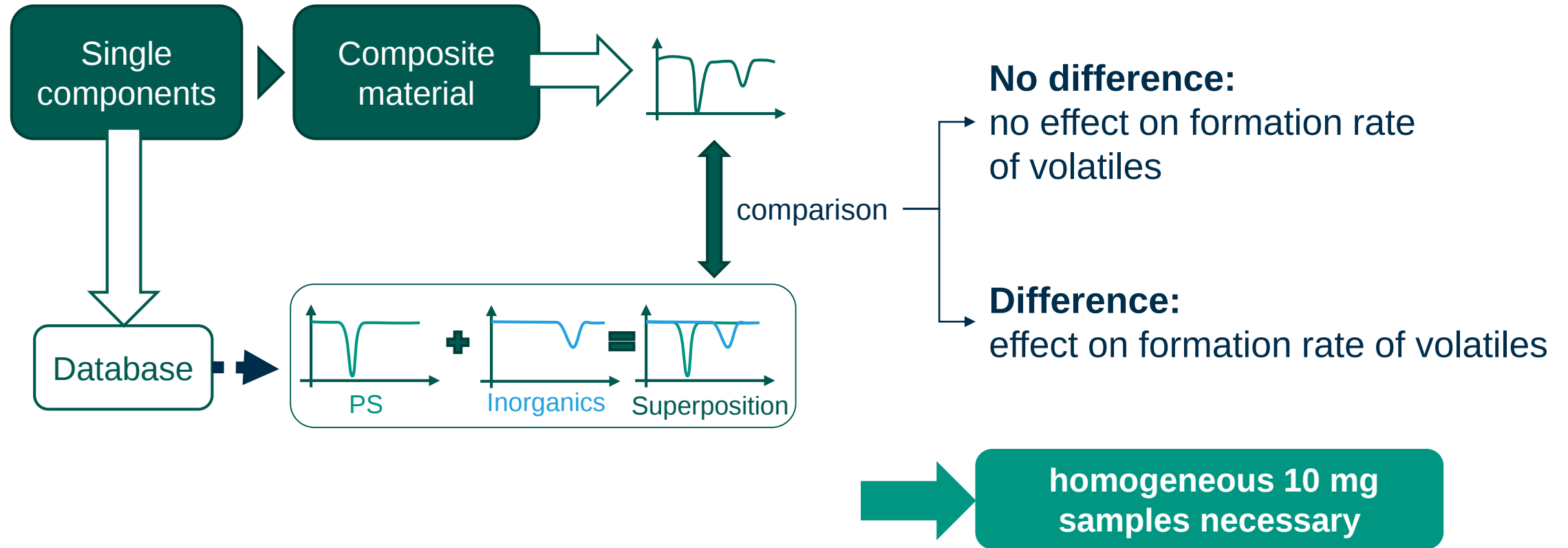


¹ <https://poytherm.com/de/was-ist-eps-und-wei%C3%9Fes-eps/blog/344>, accessed on 10.03.2025

How to transform waste into a new raw material?

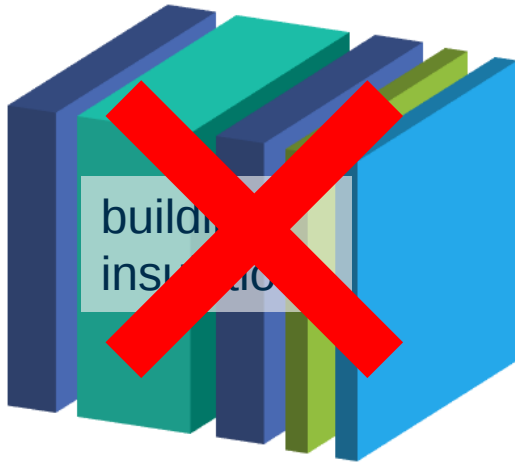


Thermogravimetric Analysis (TGA) Degradation of Polystyrene (PS)



Sample Preparation

ETICS

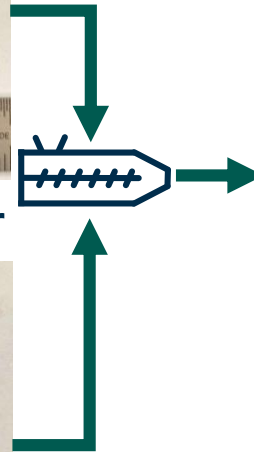


- too bulky
- too inhomogeneous

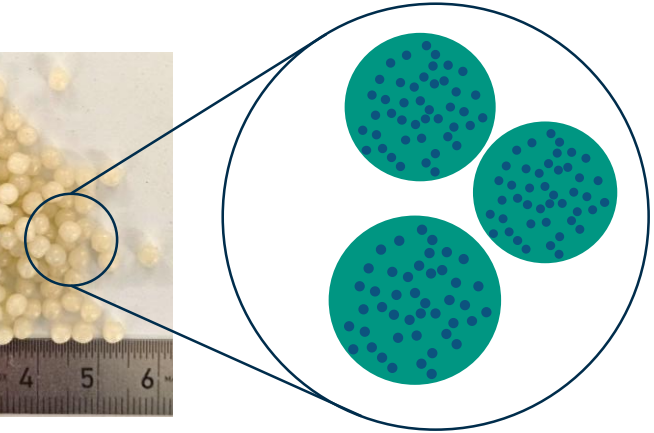
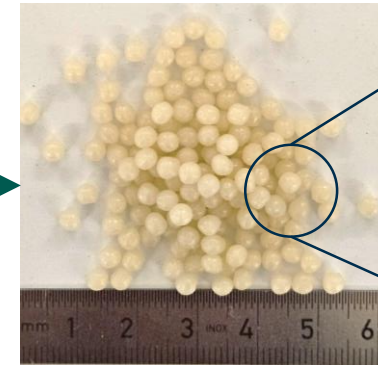
Virgin PS



Inorganic filler



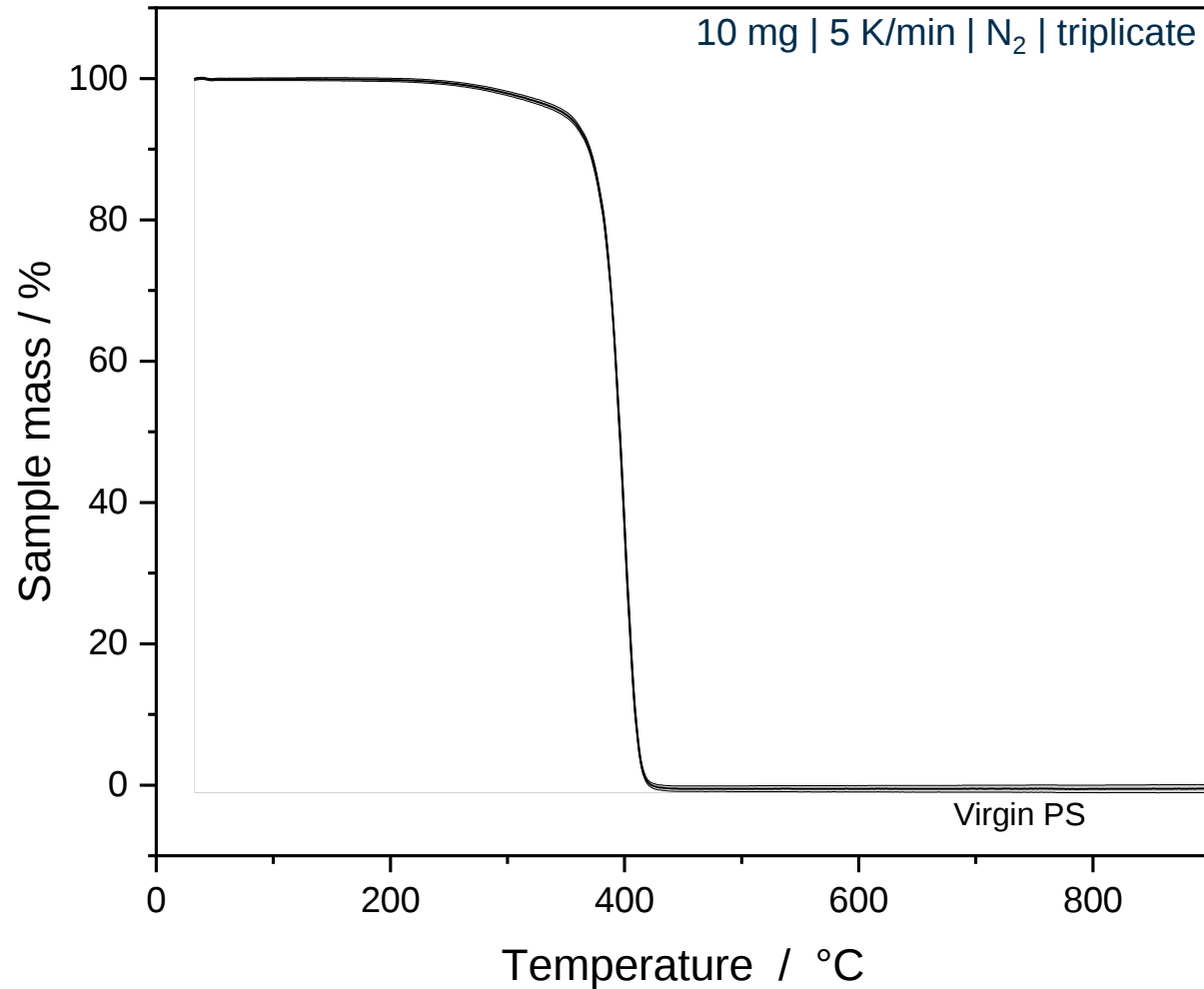
Model *Compounds*



PS + Inorganic

- CaCO_3
- Ca(OH)_2
- TiO_2

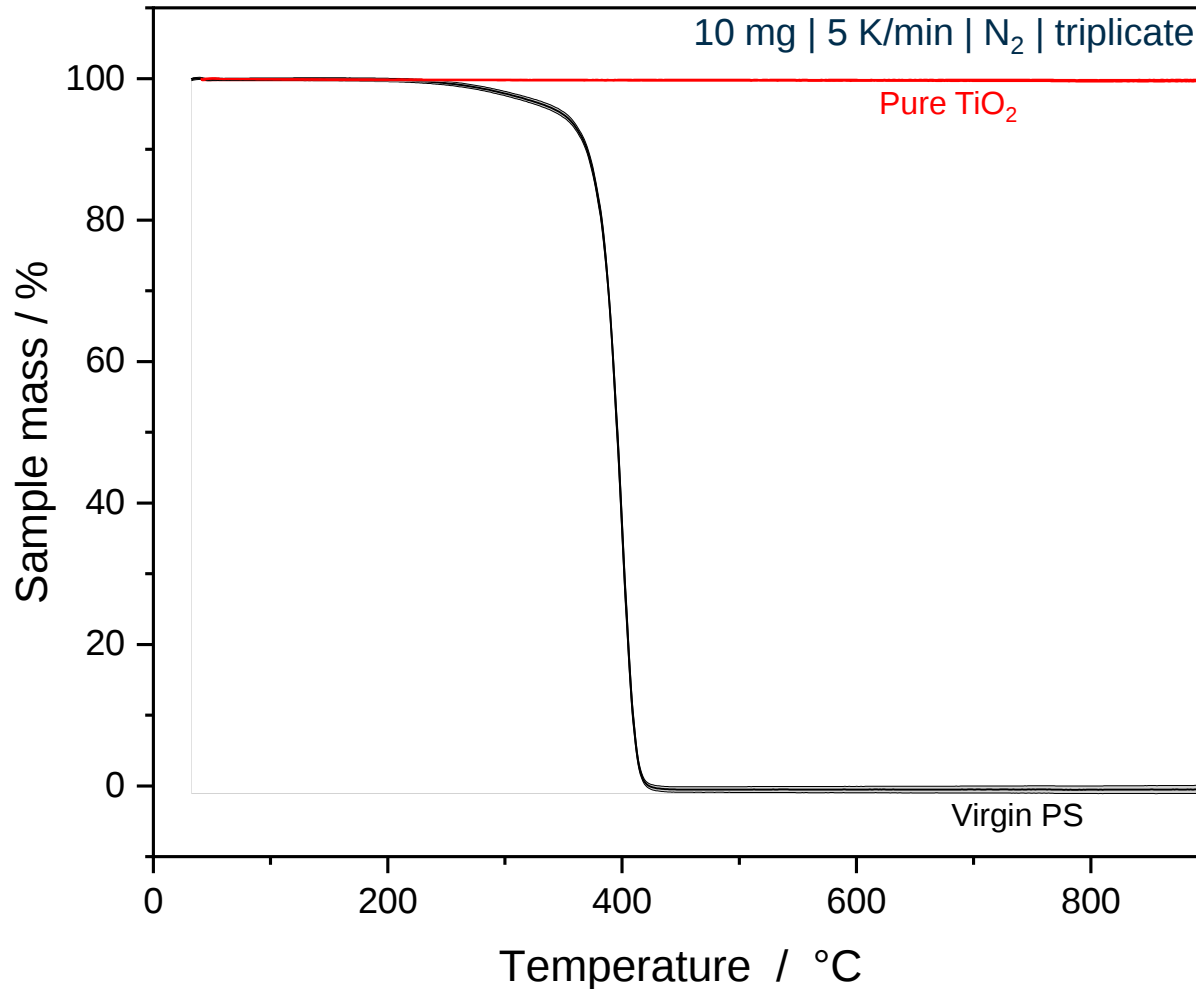
TGA Results – PS with 10% TiO₂ (Anatase)



Single component measurements

- Virgin PS

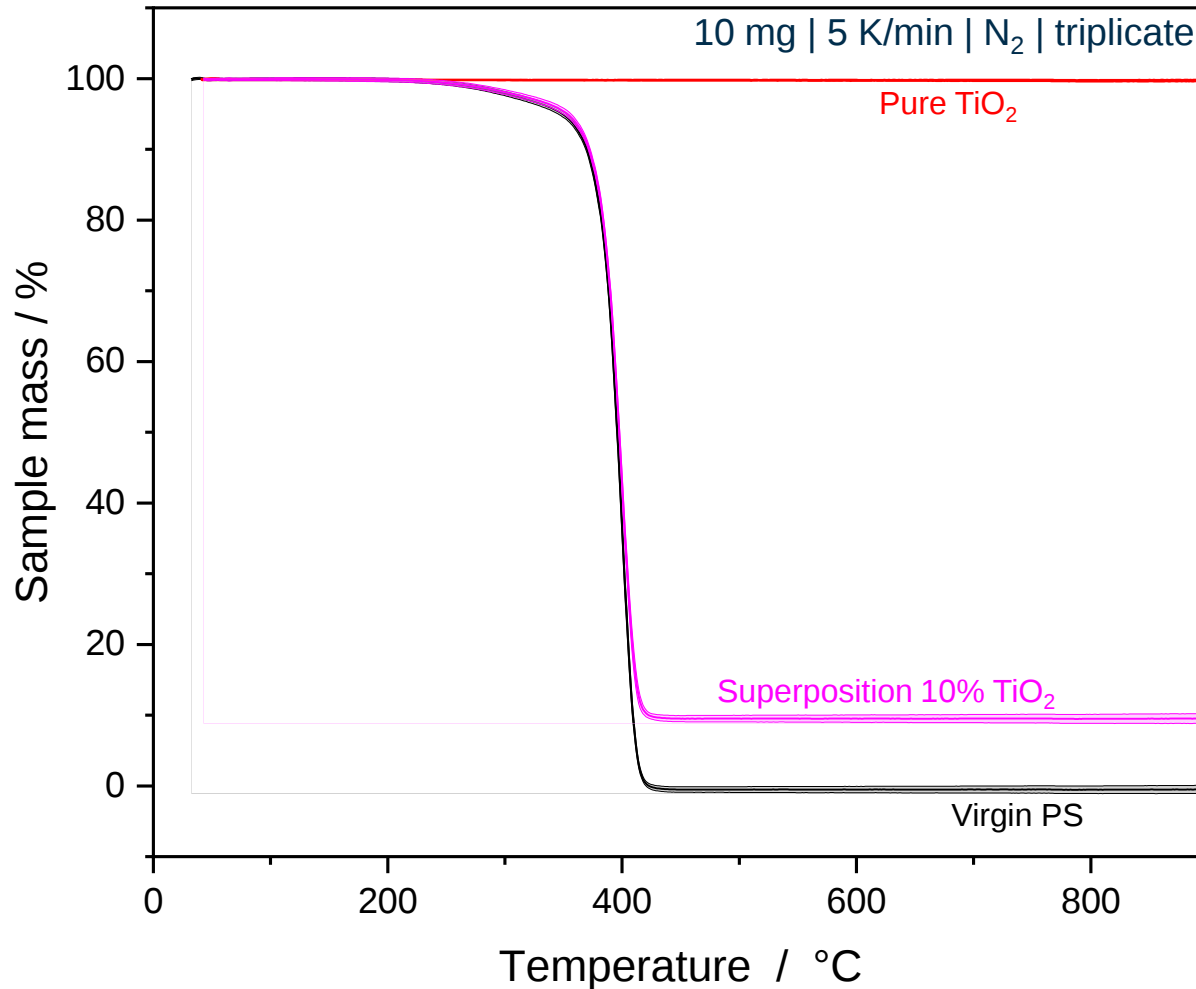
TGA Results – PS with 10% TiO₂ (Anatase)



Single component measurements

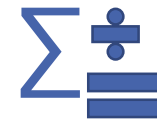
- Virgin PS
- TiO₂ (BET Surface: 8.7 m²/g)

TGA Results – PS with 10% TiO₂ (Anatase)



Single component measurements

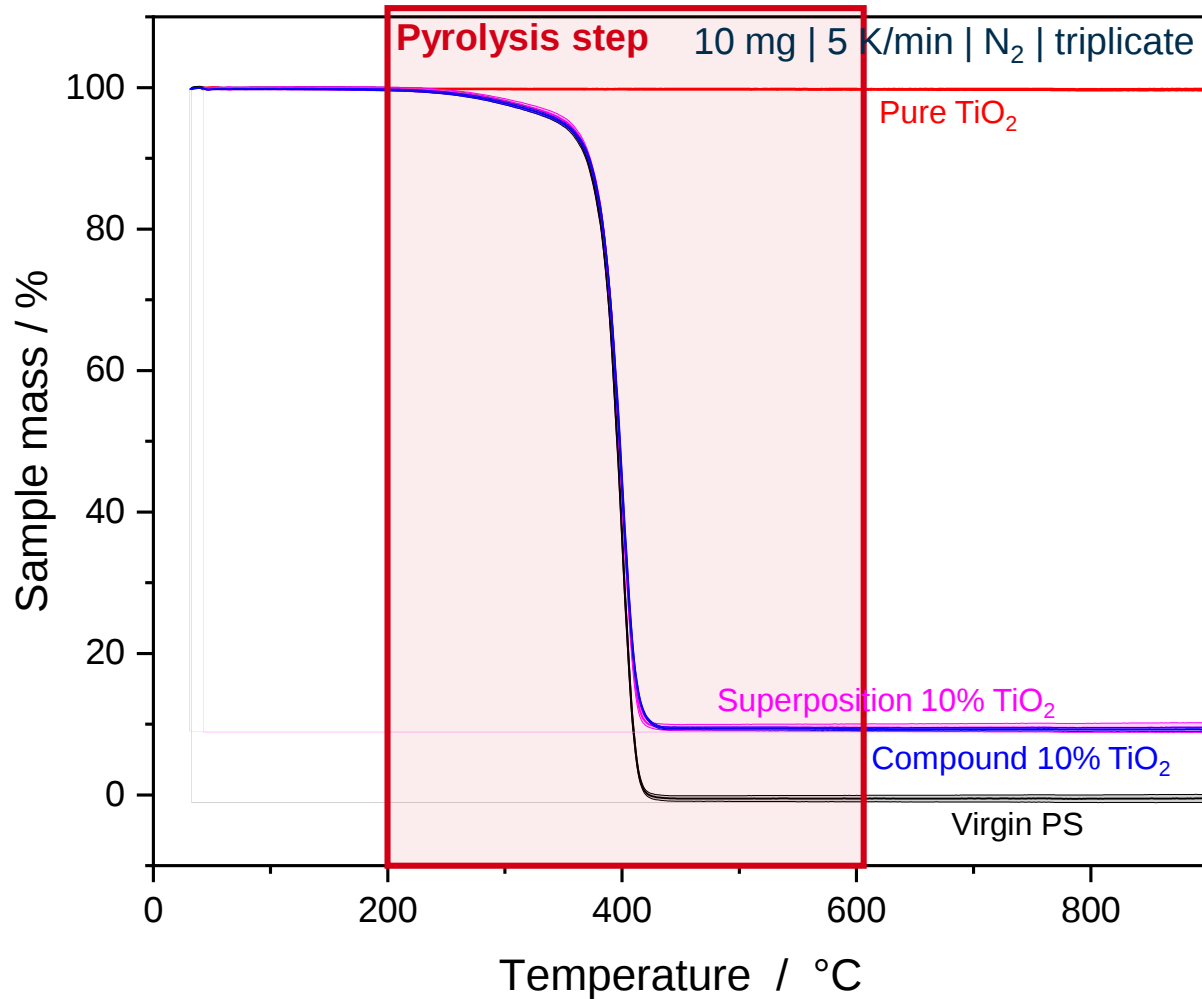
- Virgin PS
- TiO₂



superposition

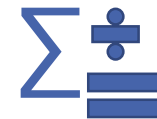
= addition of single curves

TGA Results – PS with 10% TiO₂ (Anatase)



Single component measurements

- Virgin PS
- TiO₂



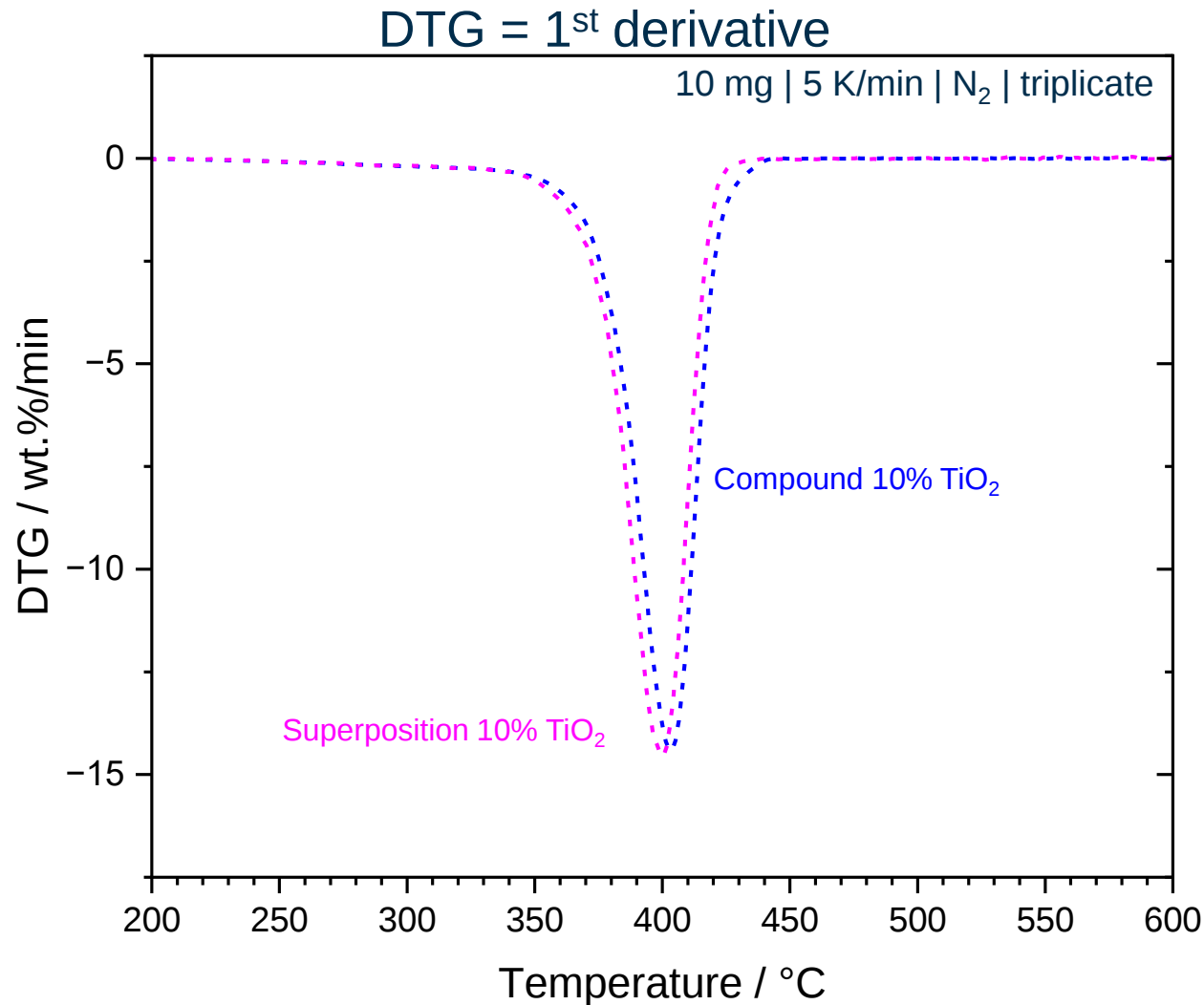
superposition

= addition of single curves



Compounded and milled sample

TGA Results – PS with 10% TiO₂ (Anatase)

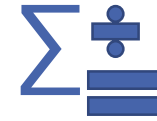
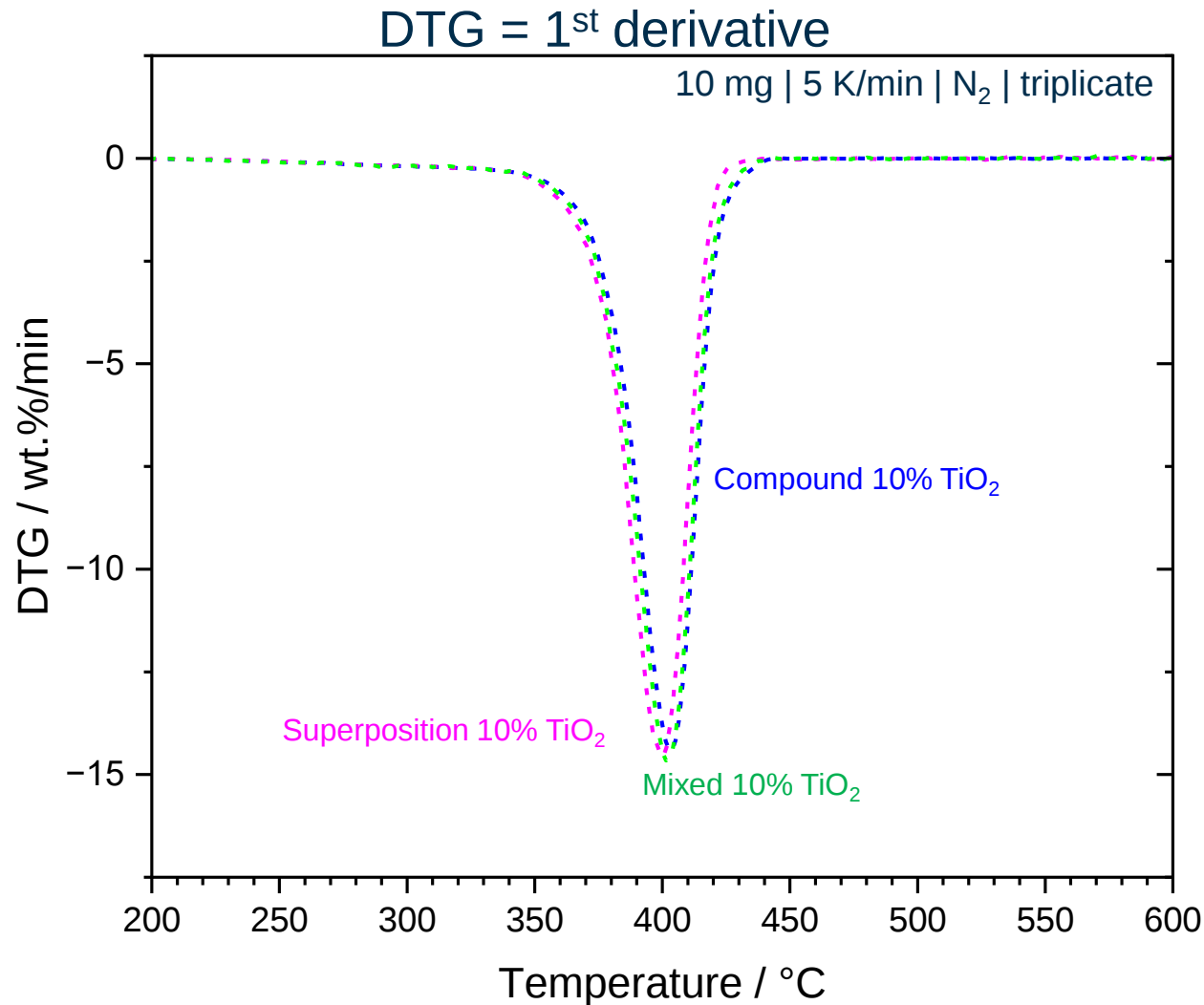


superposition
= addition of single curves



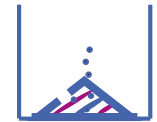
Compounded and milled sample

TGA Results – PS with 10% TiO₂ (Anatase)

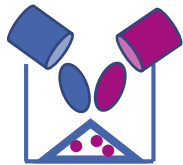


superposition

= addition of single curves



Compounded and milled sample



Mixed

= single components hand-mixed
in one crucible

Minor deviations

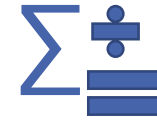
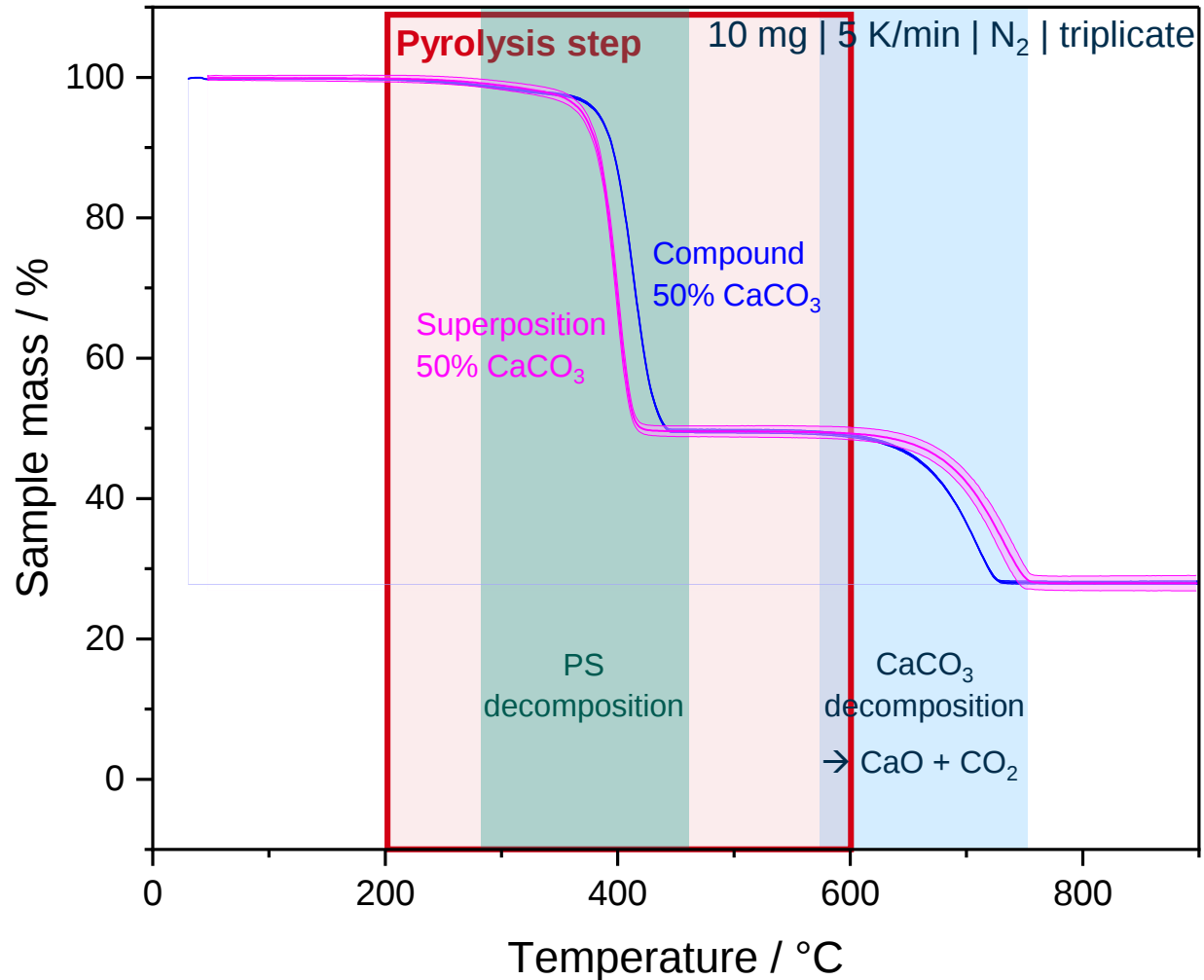
→ No significant effect on formation rate of volatiles

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)

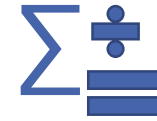
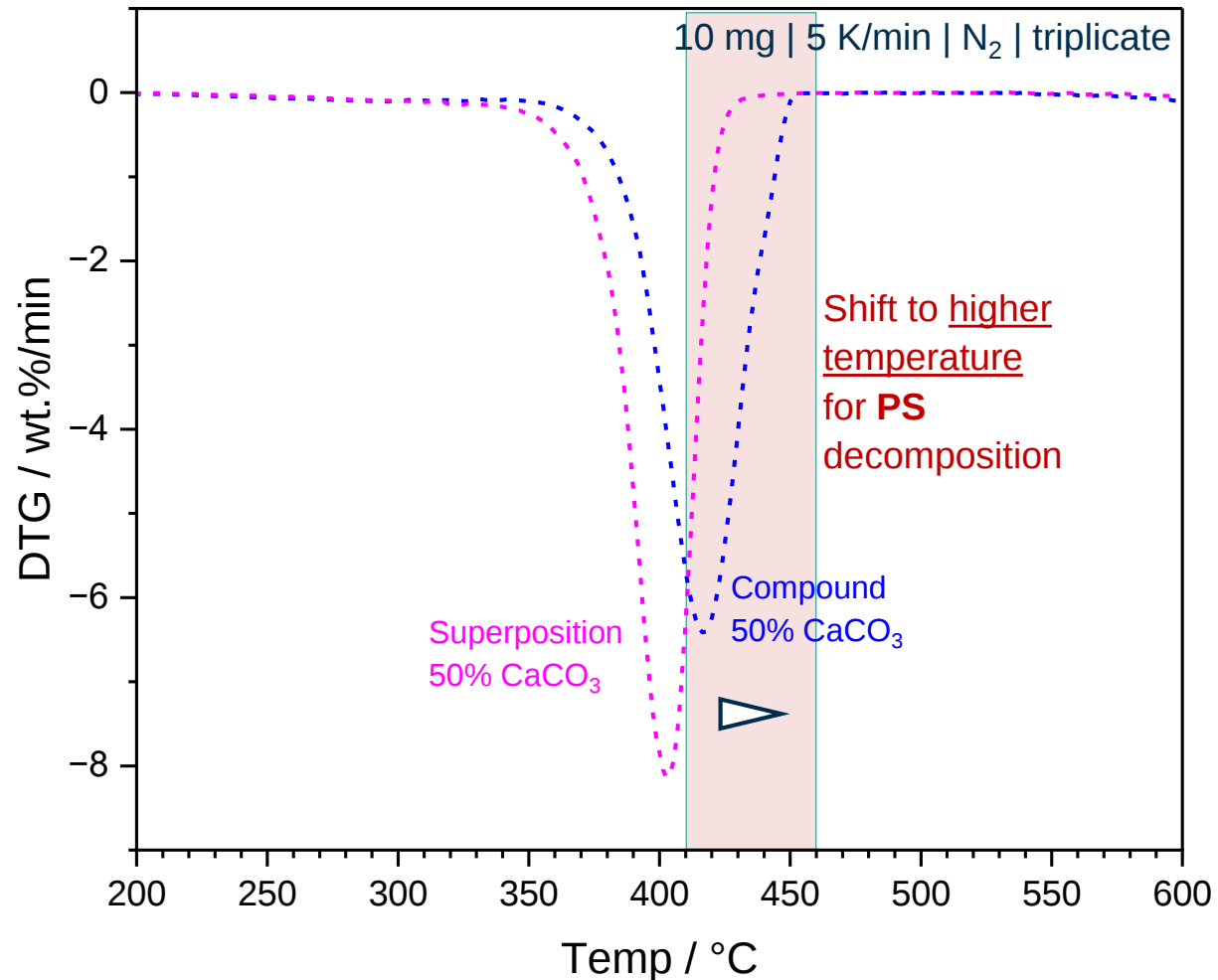


superposition
= addition of single curves

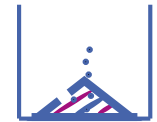


Compounded and milled sample

TGA Results – PS with 50% CaCO_3 (Calcite)

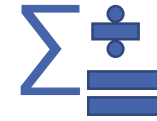
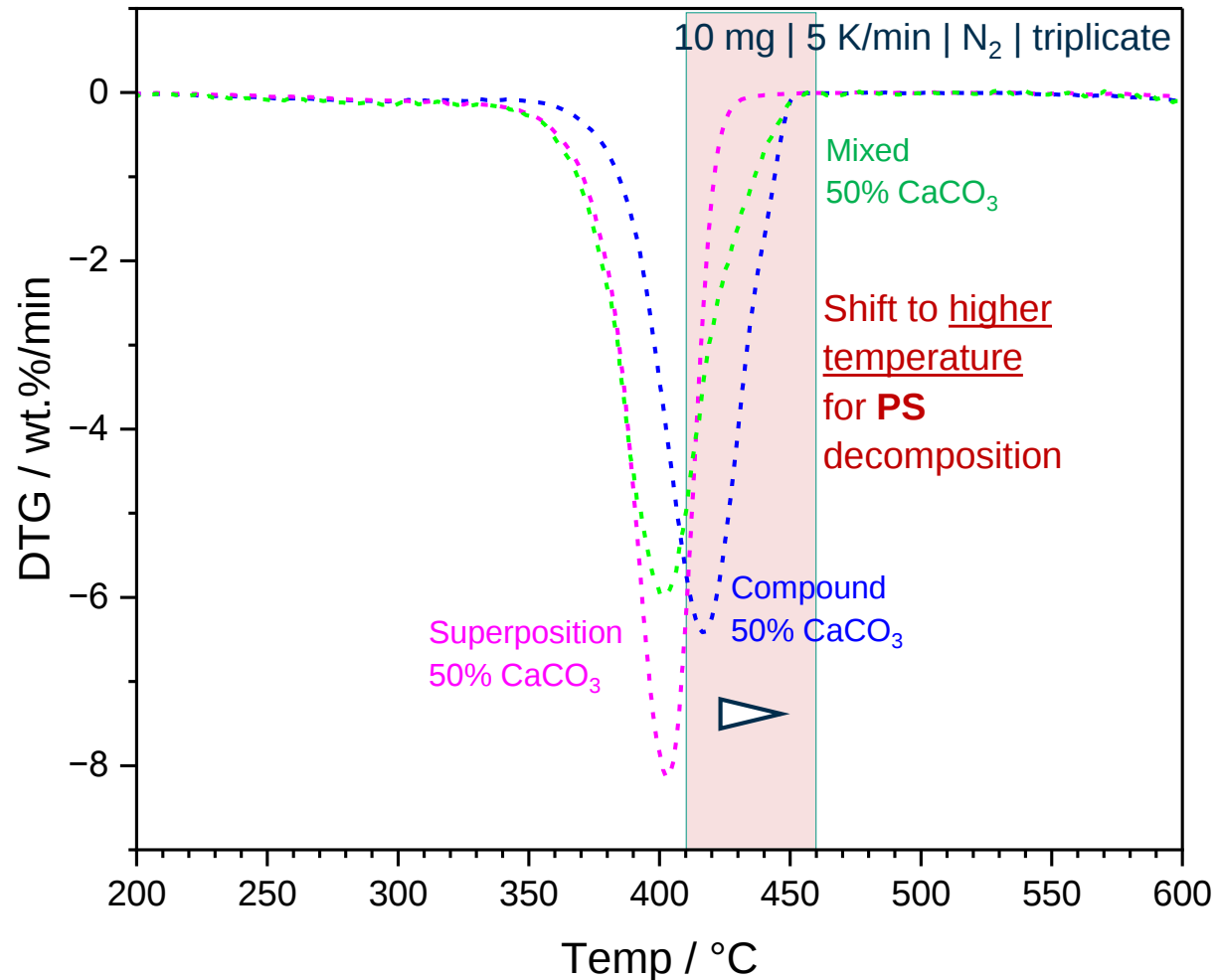


superposition
= addition of single curves



Compounded and milled sample

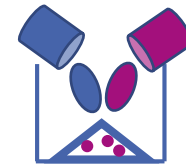
TGA Results – PS with 50% CaCO_3 (Calcite)



superposition
= addition of single curves



Compounded and milled sample

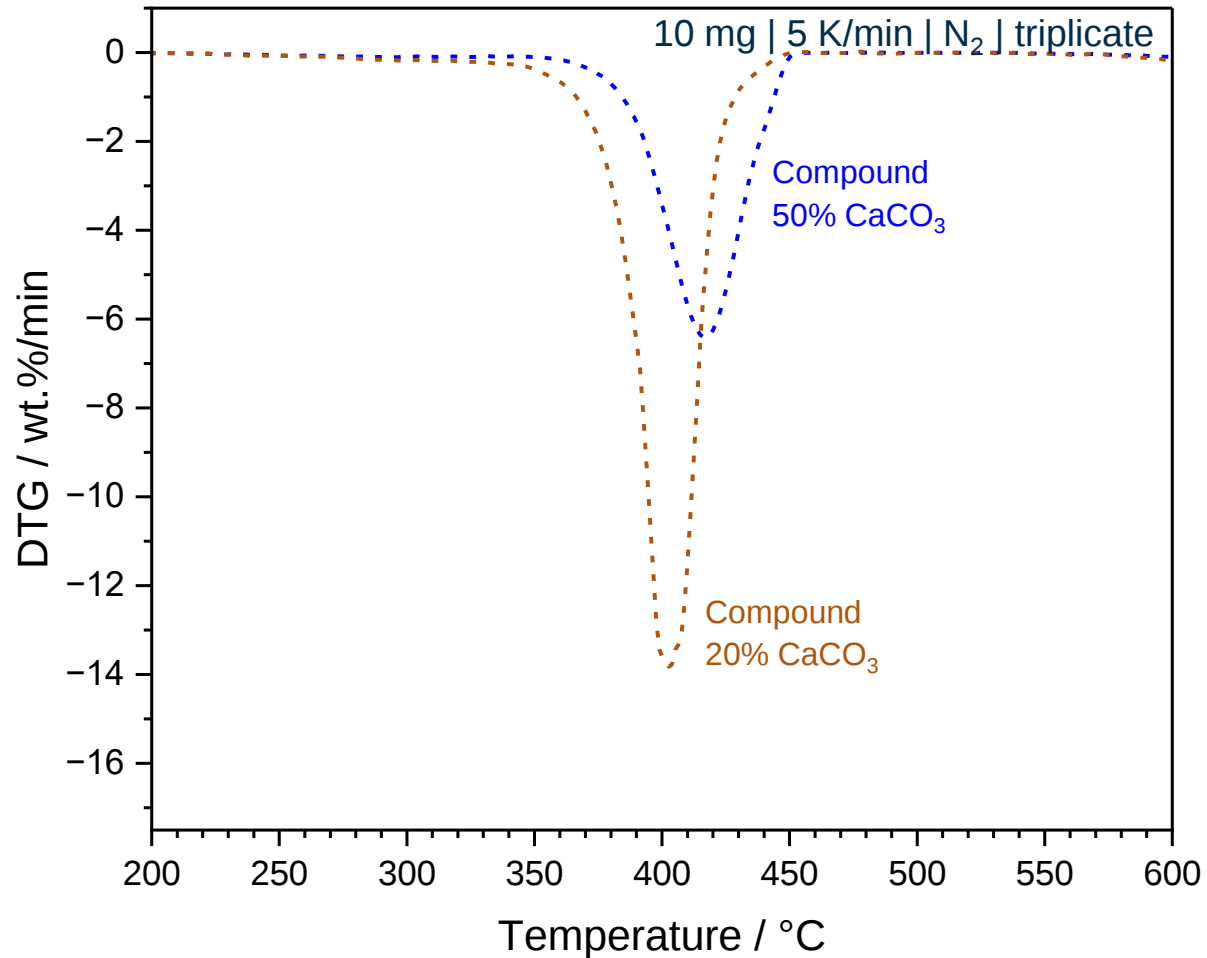


Mixed
= single components hand-mixed in one crucible



Comparison with lower concentrations

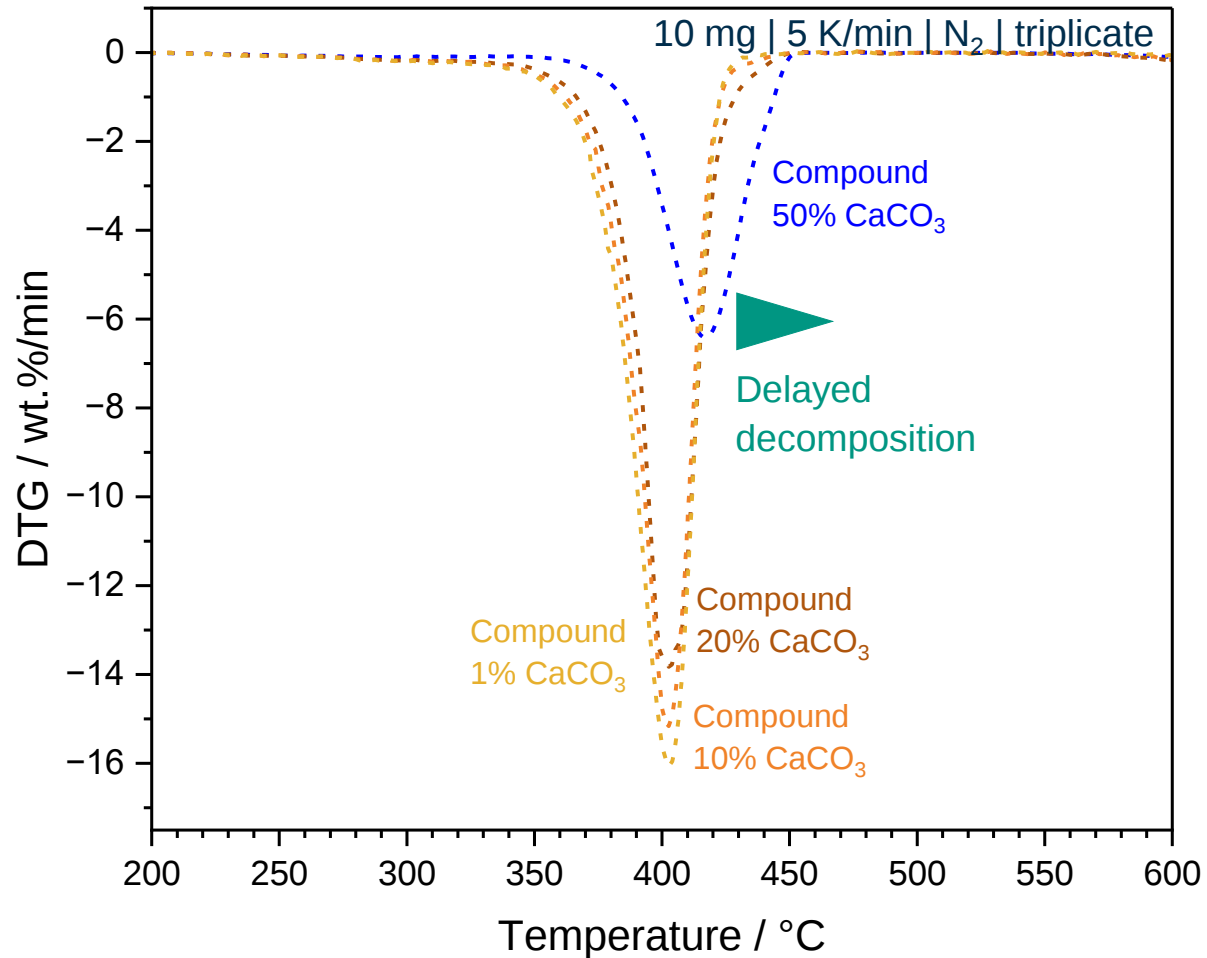
PS with CaCO_3 concentration dependence



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

TiO₂: No significant effect

CaCO₃: Decomposition at higher temperature

What we don't know ✗

Information of Product Distribution

→ Styrene Yield

Polystyrene Pyrolysis products Identification by μ -Pyrolyzer

Catalytic Pyrolysis

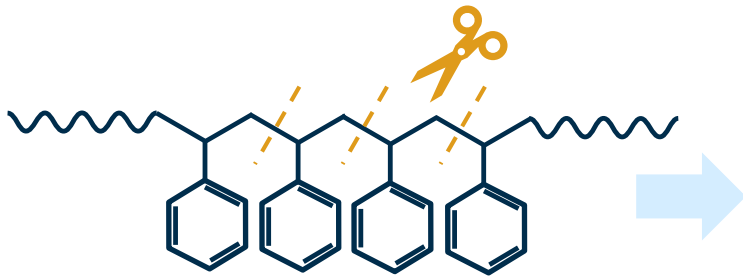
Solid acids:

- Coke¹ ↑
- Hydrogen^{1,3} ↑
- Styrene ↓



Solid bases:

- Depolymerization² ↑
- Styrene ↑



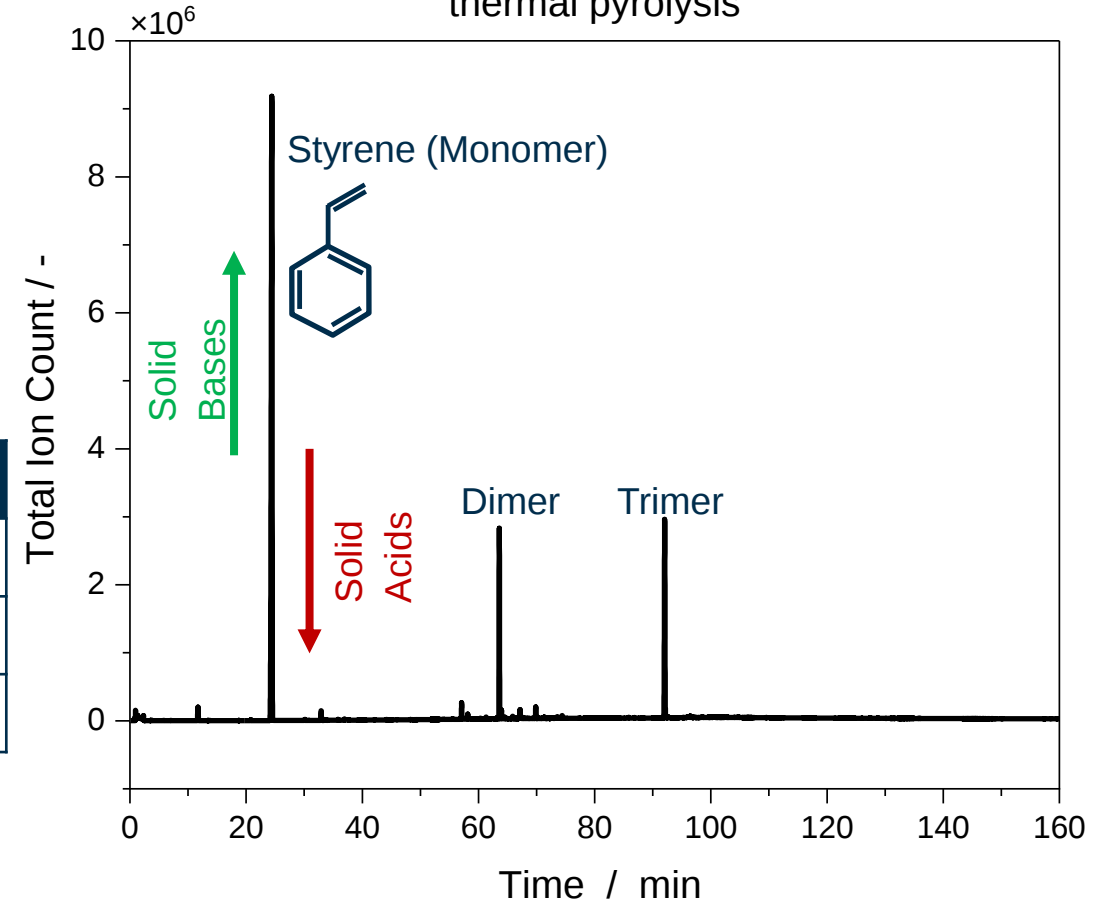
Component	Area%
Monomer	70
Dimer	9
Trimer	15

¹ Marczewski, M et al., 2013 DOI: [10.1016/j.apcatb.2012.09.027](https://doi.org/10.1016/j.apcatb.2012.09.027).

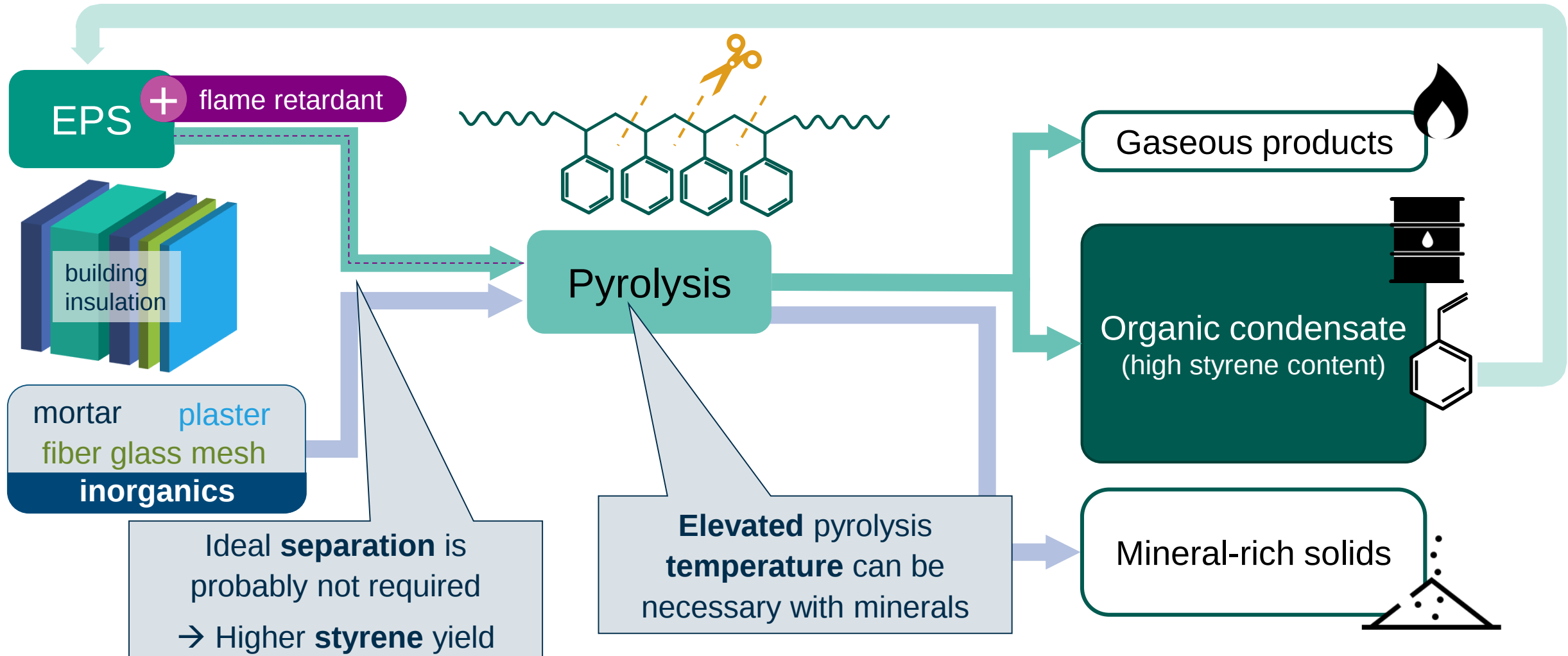
² Ukei, H et al., 2000 DOI: [10.1016/S0920-5861\(00\)00409-0](https://doi.org/10.1016/S0920-5861(00)00409-0).

³ Lin, R et al., 1997 DOI: [10.1002/\(SICI\)1097-4628\(19970307\)63:10<1287::AID-APP7>3.0.CO;2-G](https://doi.org/10.1002/(SICI)1097-4628(19970307)63:10<1287::AID-APP7>3.0.CO;2-G).

Py-GC-MS: virgin PS | 500°C | 50 μ g
thermal pyrolysis



Conclusion



Thank You!



Any Questions?