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Improvement of PLA fire properties with autopolymerizable additives

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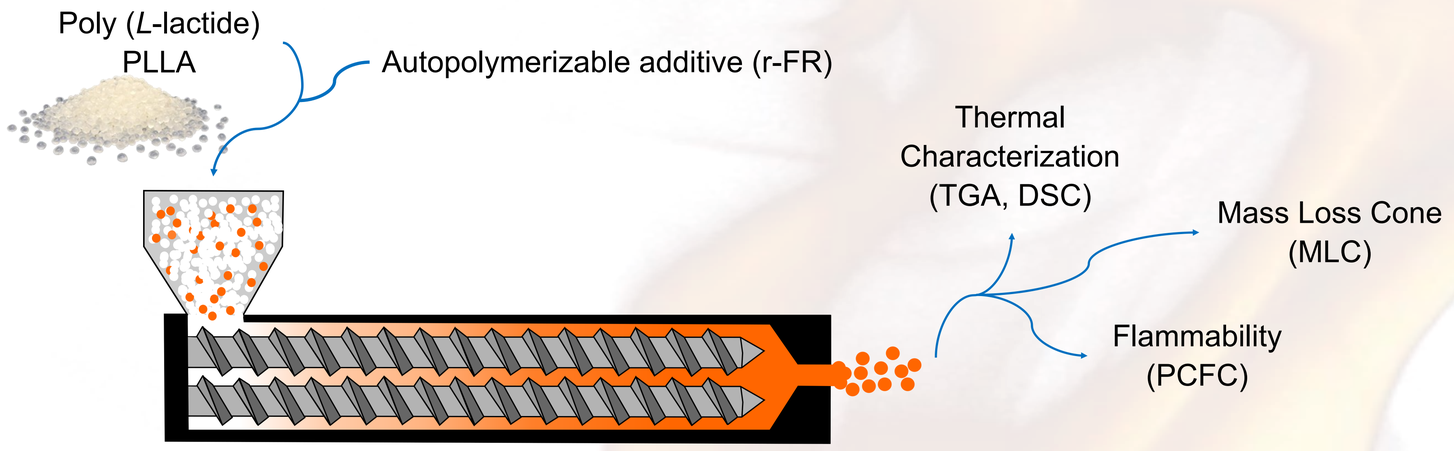
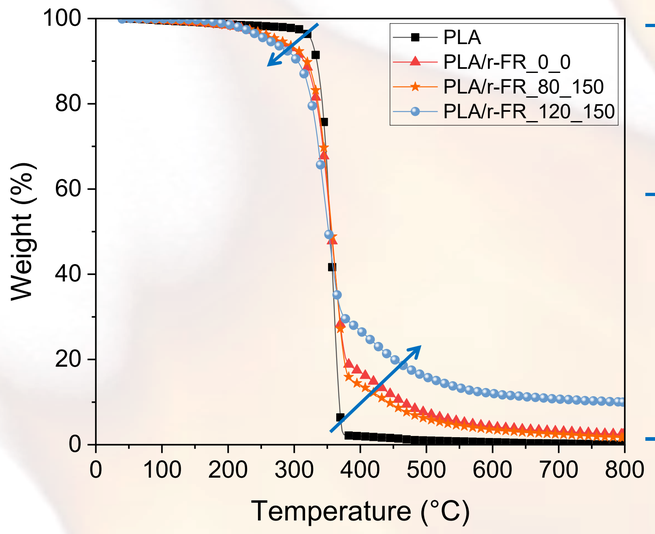
Context



Formulations

Sample Name	[PLA]/[r-FR] (wt%)	Pre-curing	
		Time (min)	*Temperature (°C)*
PLA	100/0	-	-
PLA/r-FR_0_0	80/20	-	-
PLA/r-FR_80_150	80/20	80	150
PLA/r-FR_120_150	80/20	120	150

Thermal Characterization

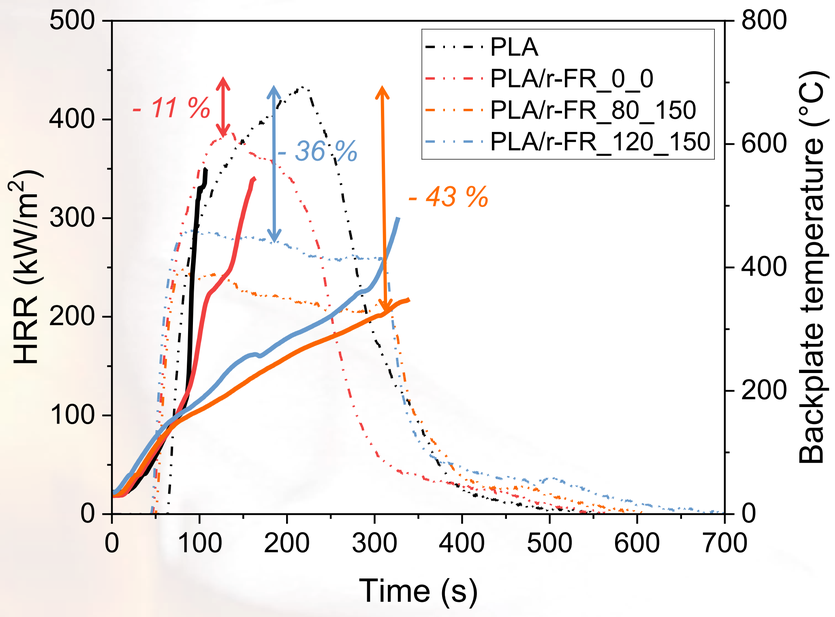


Sample Name	DSC				TGA	
	T_g (°C)	T_{cc} (°C)	T_f (°C)	χ_C (%)	$T_{5\%}$ (°C)	wt_{final} (%)
PLA	59	104	171	4	325	0
PLA/r-FR_0_0	56	113	167	6	272	2
PLA/r-FR_80_150	58	107	168	6	275	3
PLA/r-FR 120_150	58	108	168	6	280	10

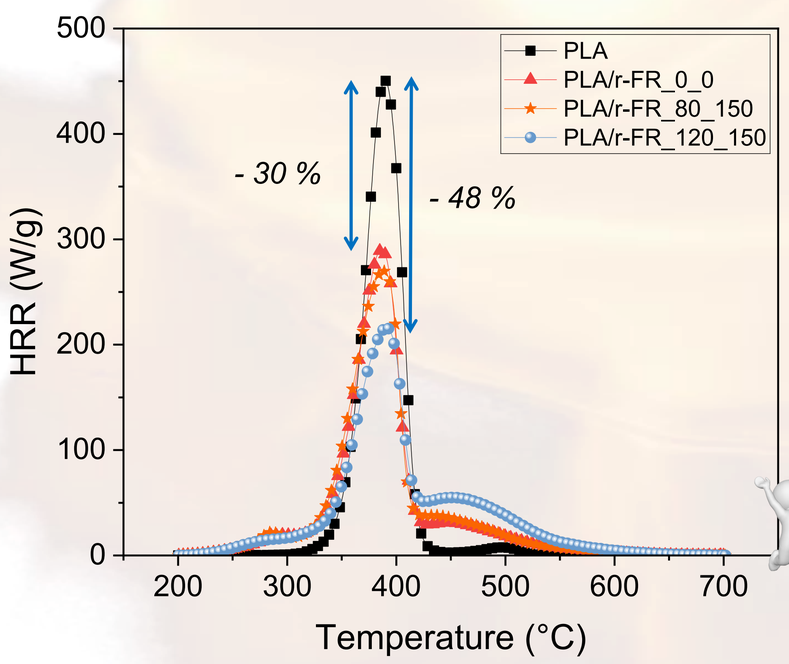
→ low influence on the T_g and T_f
→ higher residue

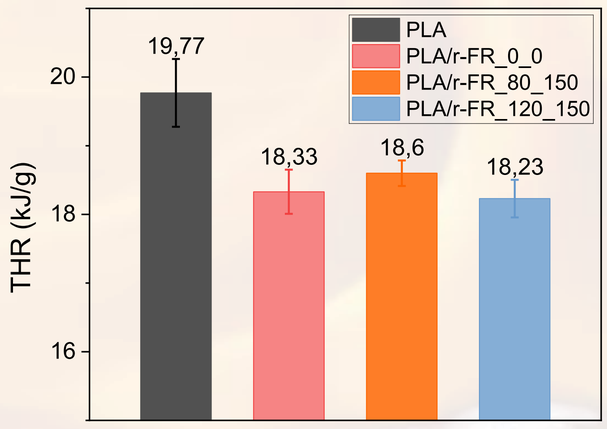
→ $T_{5\%}$ ↓ with the addition of r-FR

Mass Loss Cone



Pyrolysis Flow Combustion Calorimeter





→ Reduced flammability
→ Higher residue
→ Gas phase action

Sample Name	t_i (s)	t_{fo} (s)	t_{flame} (s)	pHRR (kW/m²)	THR (MJ/m²)
PLA	62	390	328	434	89
PLA/r-FR_0_0	44	558	514	386 (- 11 %)	76 (- 15 %)
PLA/r-FR_80_150	48	599	551	248 (- 43 %)	69 (- 23 %)
PLA/r-FR 120_150	47	657	591	279 (- 36 %)	79 (- 12 %)

→ Significant reduction of pHRR & THR for PLA/r-FR_80_150
→ Slower increase of backplate temperature with r-FR → thermal barrier

Conclusion & Perspectives

20% of pre-cured (80', 150 °C) r-FR with PLA:

→ no influence on T_g and the T_f of PLA
→ reduced flammability
→ effective thermal barrier

Further study :

→ Influence of r-FR on mechanical properties
→ Decomposition mechanisms of r-FR & PLA/r-FR

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The authors would like to thank Milijana Jovic (EMPA) for the PCFC analysis.
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