Impact of Thermal Compression Recycling on the Combustion Behavior of FR-PLA/Flax Composites

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Abstract:

This work investigates the recyclability of flame-retardant poly(lactic acid) reinforced with flax fibre composites (FR-PLA/Flax) through thermal compression moulding. It evaluates the influence of recycling on the structural stability of the incorporated flame-retardant system. The recycling of flame-retardant composites is of particular importance, as their increasing use in transportation, construction, and electronics raises concerns about waste management, resource efficiency, and fire safety during end-of-life treatment.

The FR-PLA/Flax bio-composite was subjected to thermo-compression under controlled pressure and temperature conditions to simulate closed-loop recycling. The cone calorimetry indicates that the recycling process changes the combustion behaviour, the recycled materials burn faster and more intensely, producing a higher pHRR (an increase of 22% and 20% in pHRR for virgin and FR-composites, respectively) but for a shorter duration compared to their virgin forms, which burn more steadily with a lower pHRR and extended burning time. However, the recycling caused a negligible effect on THR. This is due to the shorter flax fibers in the recycled material, which promote faster heat transfer and pyrolysis, leading to more volatiles and a sharper pHRR peak. These findings underline the dual challenge of designing recyclable bio-based composites while maintaining fire safety standards, offering critical insights for advancing sustainable materials engineering and circular economy strategies.