ECO-DESIGN OF RECYCLING AND REUSE CHANNELS FOR BIOBASED AND BIODEGRADABLE PLASTICS:

A STRUCTURE-PROPERTIES RELATIONSHIP APPROACH

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Context - ECO2R project

• Supports a **circular economy** by advancing recycling routes beyond composting
• Focuses on **biobased**, **biodegradable plastics** for food packaging applications
• Addresses **structural**, **chemical**, and **environmental barriers** to reuse
• Investigates **degradation**, **decontamination**, and **stabilization** mechanisms
• Aims to design **safe**, **recyclable materials** for **closed-loop** end-of-life strategies **[1] [2]**

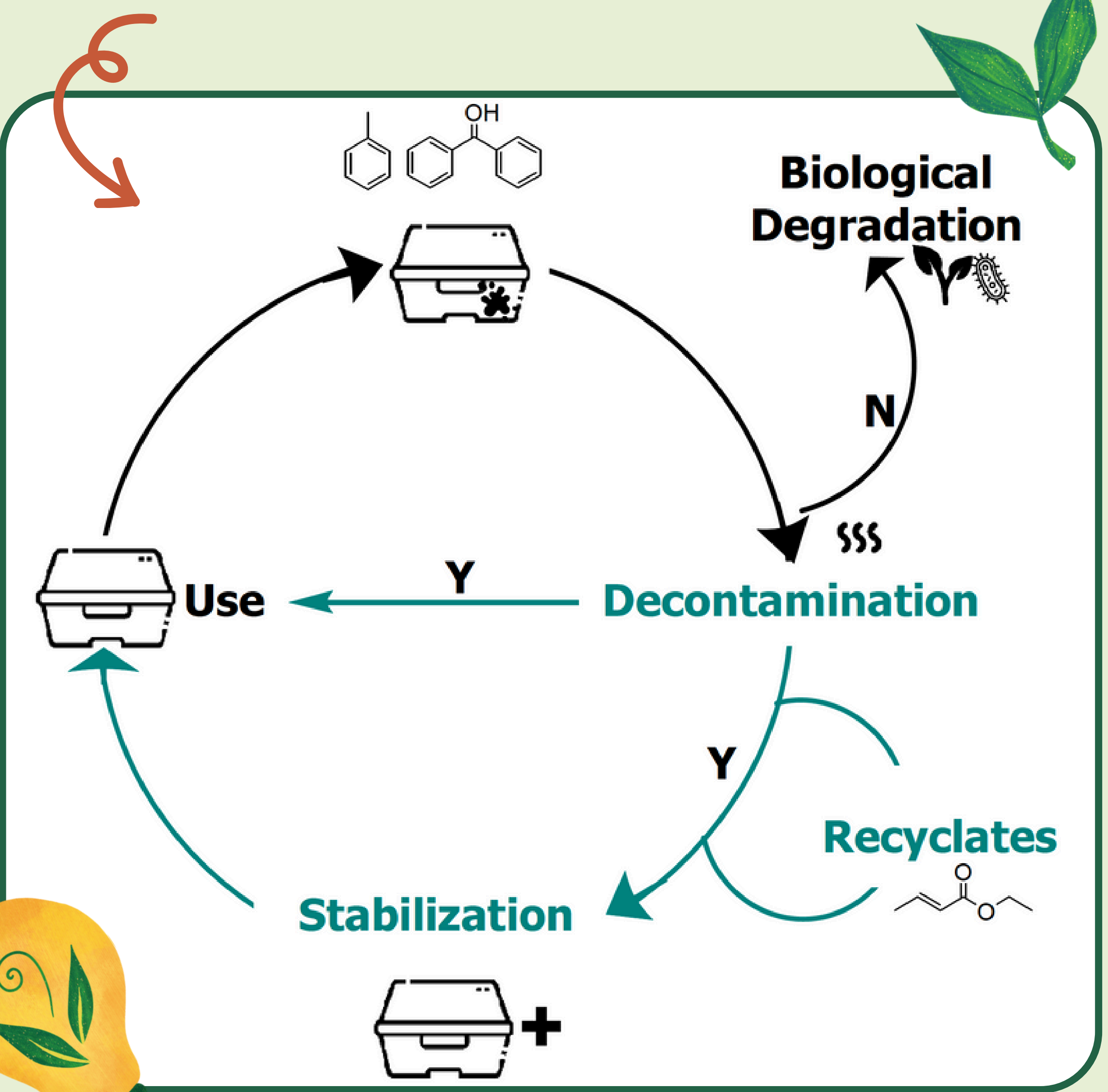
Objectives

• Identify **structural markers** influencing the **recyclability** of biodegradable plastics
• Develop **stabilization strategies** based on **degradation products**
• Assess the impact of **recycling** on **biodegradability**
• Design **safe**, **recyclable**, and **compostable materials [3]**
• Target applications in **sustainable food packaging [4]**

Methodology

• Developing a **structure–properties relationship approach**
• Tracking effects of **aging**, **contamination**, and **recycling** on polymer structure and performance
• Using techniques like **TGA**, **DSC**, **DMA**, **tensile**, **FSC**, **XRD**, **FTIR**, **SEC**, and **PLOM**
• Assessing **crystallinity**, **molecular weight**, and **morphology**
• Linking **microstructural changes** to **recyclability** and **decontamination**

Enhanced recycling strategy for biodegradable plastics: research strategy (black + green) compared to the current situation (black).



Who Degrades First? Biopolyesters Face the Heat

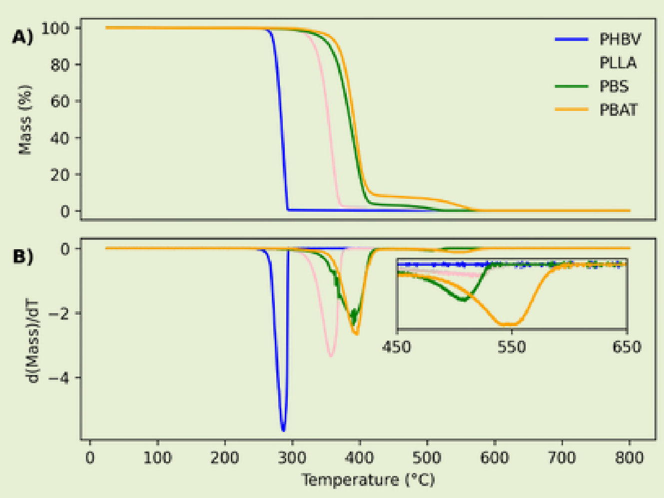


Figure 1. TGA (A) & dTG (B) curves.

• **TGA** shows **PHBV** degrades earlier (~280°C) than PLLA, PBS, and PBAT (~350–370°C) (*Figure 1*)
• Contradicts expected groupings based on **melting temperatures**
• **PHBV** follows a **single-step**, **nucleation-controlled** instead of **PLLA**, **PBS**, and **PBAT** which exhibit **multi step degradation pathways**

• **Conversion analysis** confirms **PHBV** shows **rapid**, **sharp mass loss** (*Figure 2*)
• **PBS** and **PBAT** degrade more **gradually**
• Indicates **overlapping**, **multi-step degradation mechanisms** for PBS and PBAT

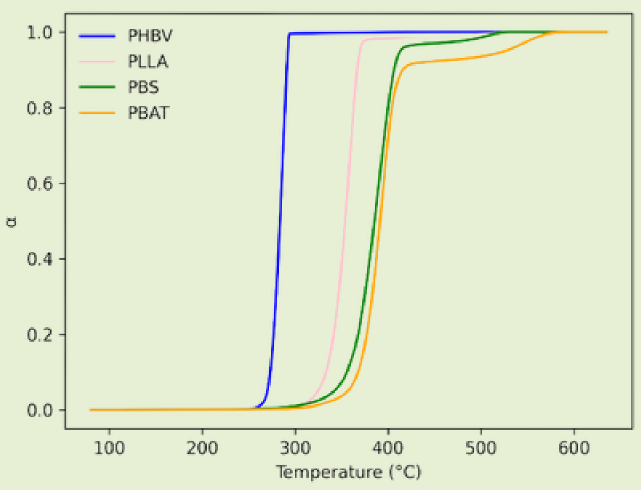


Figure 2. Conversion (α) vs. Temperature.

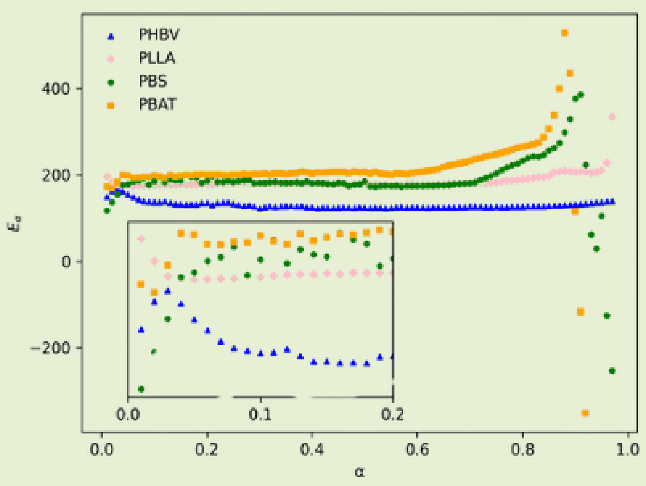


Figure 3. Activation Energy (Ea) vs. α.

• **Activation energy (Ea)** remains **constant** for **PHBV** (~140–150 kJ/mol) (*Figure 3*)
• Confirms PHBV follows a **simple**, **single-step degradation mechanism**
• Ea increases significantly for **PBS** and **PBAT** at **high conversions**
• Reaches over **400–500 kJ/mol**, indicating **energy-intensive secondary reactions**

Conclusion & Perspectives

PHBV degrades uniquely, unlike **PLLA**, **PBS**, and **PBAT**. Understanding **structure–kinetics relationships** guides **stabilization** and supports **circular strategies** for **recyclable**, **food-contact biodegradable plastics**.

Let's keep in touch?

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References

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