Effect of accelerated ageing and mechanical recycling on the structure and properties of PHBV formulations

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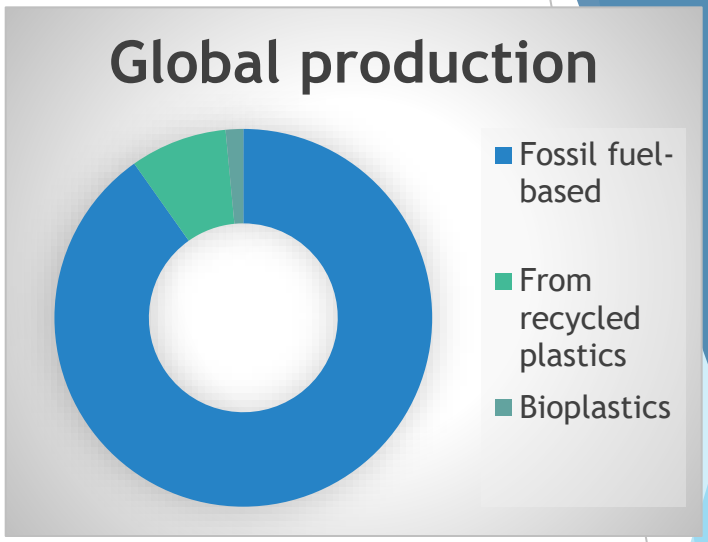
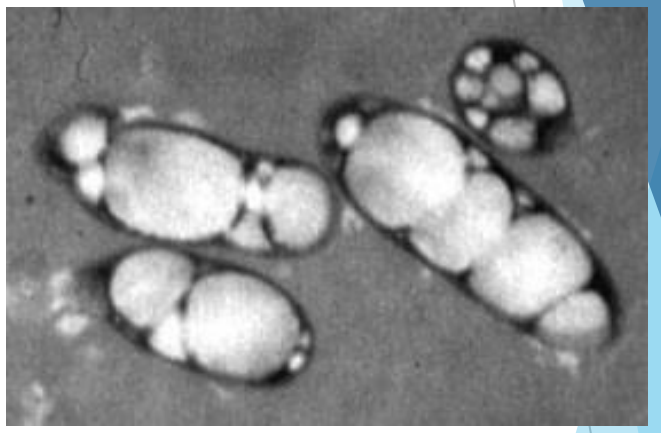
Plastics and bioplastics

- More than 390 Mt of plastics are produced worldwide.
- Most of these plastics are fossil fuel-based. They result in an important consumption of non-renewable resources, and also lead to environmental issues.
- Bioplastics emerge as a potential alternative in some applications.

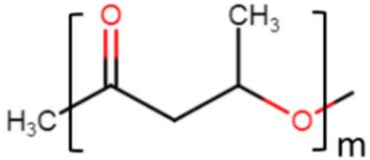


Plastics and bioplastics

- Bioplastics are materials either biobased, biodegradable or both.
- Among the biobased and biodegradables bioplastics are the polyhydroxyalkanoates family (PHAs).
- PHAs are aliphatic polyesters produced by microorganisms as carbon reserves under stress conditions.
- There are more than 150 monomers, but the most commons members are PHB and PHBV.
- Their wide properties range, biocompatibility, biodegradability have made PHAs interesting candidates for several applications.

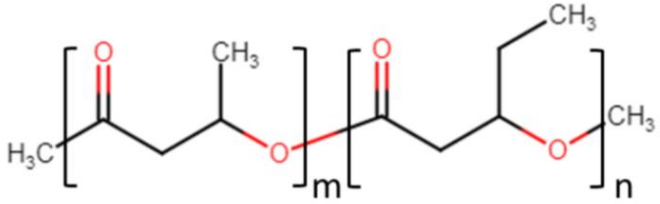


a. PHB structure



3HB (C_4 monomer)

b. PHBV structure



3HB (C_4 monomer) 3HV (C_5 monomer)

End-of-life scenarios: mechanical recycling

- Waste management is still important for bioplastics.
- Mechanical recycling is an interesting option for some applications and grades.
- **Two barriers: Performance after service life and recycling and low market share.**

Objective

Analyze the effect of accelerated ageing and melt reprocessing on the structure and properties PHBV based formulations.

Valorization

Methodology

Starting Materials
PHBV: Ercros PH016
Impact modifier: Oligomeric lactic acid → Condensia Glyplast OLA 2

Mechanical recycling process scheme

Processing
- ❑ Extrusion
- ❑ Compression molding

PHBV-V formulations

Ageing
- ❑ Photochemical
- ❑ Thermal
- ❑ Hydrolytic

Washing
- ❑ At 85 °C
- ❑ NaOH and a Triton X-100

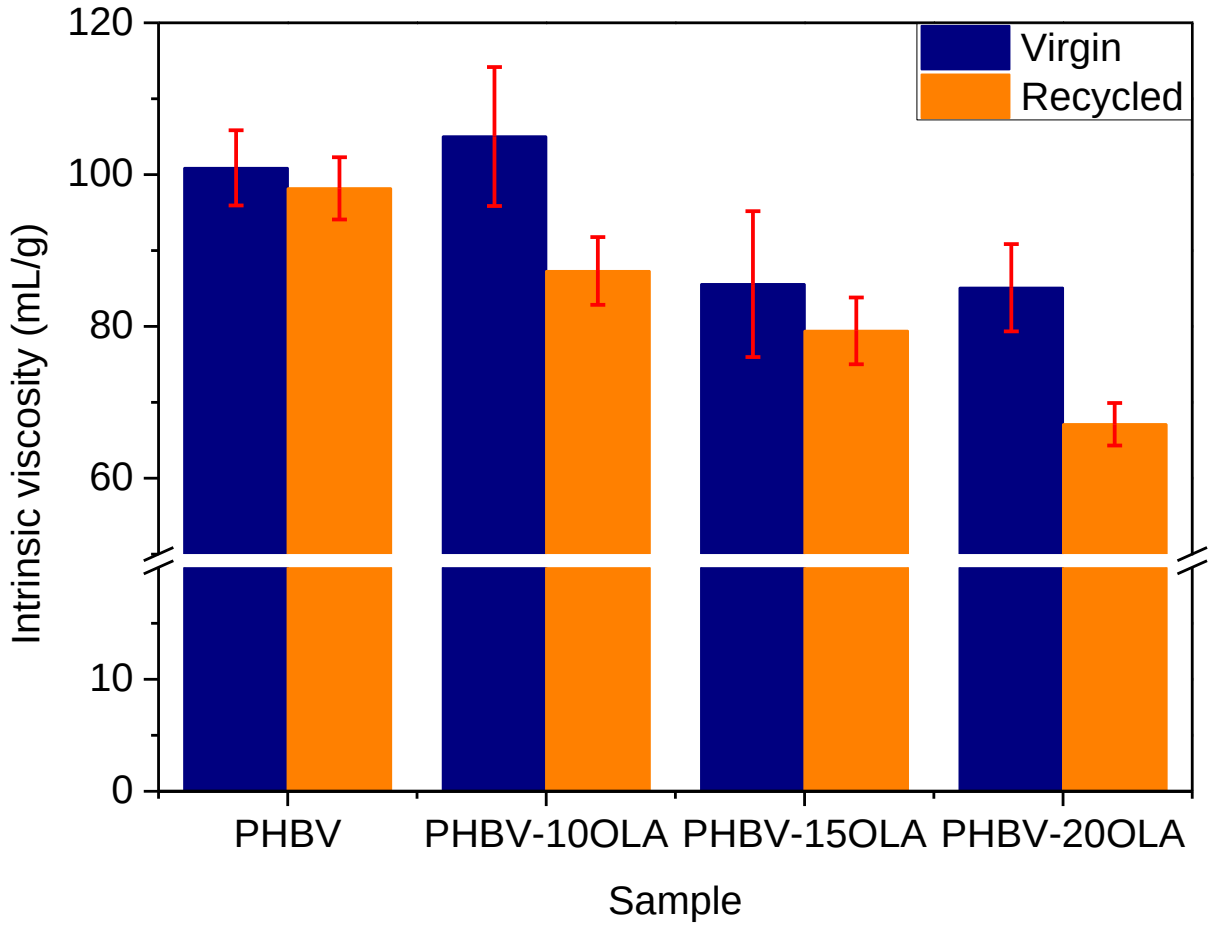
Reprocessing
- ❑ Extrusion
- ❑ Compression molding

PHBV-R formulations

Results and discussion

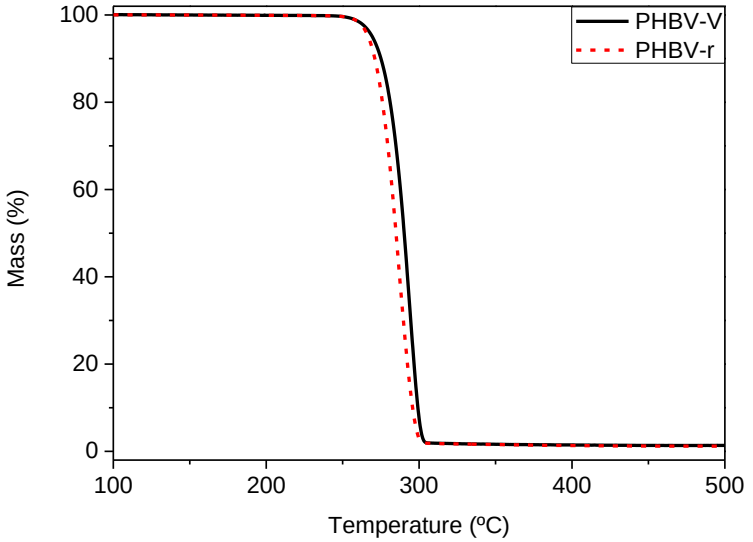
Results: Intrinsic viscosity

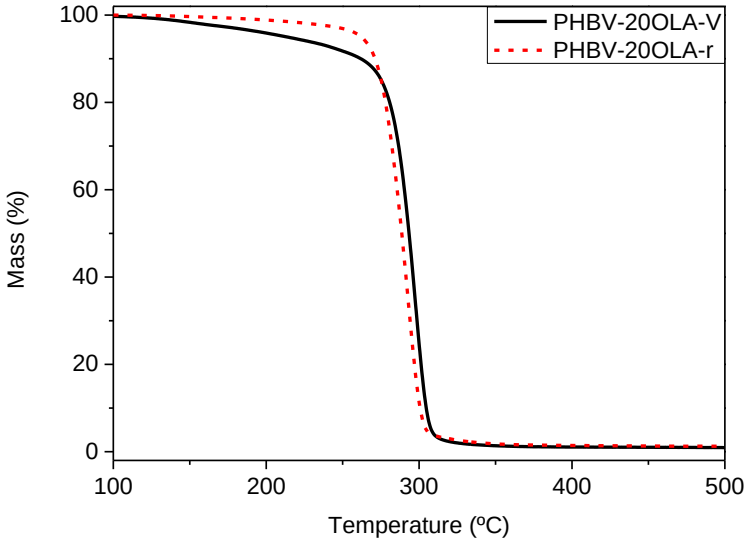
- Addition of OLA leads to a decrease in the intrinsic viscosity → Low molecular weight of oligomers.
- Mechanical recycling leads to a decrease of intrinsic viscosity in all formulations.
- The presence of OLA seems to lead to larger decreases of the viscosity.



Results: Thermogravimetric analysis

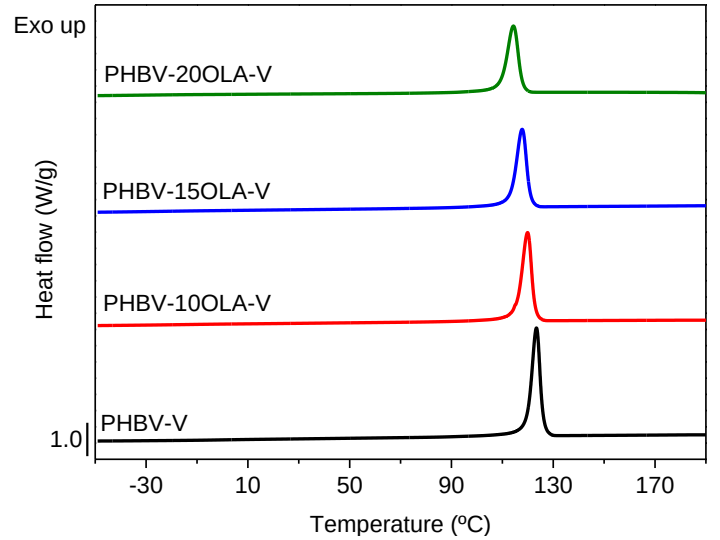
- Addition of OLA decreases the thermal stability of the materials → low molecular weight of oligomers.
- Mechanical recycling leads to a slight decrease of thermal stability of pure PHBV.
- Formulations with OLA show an increased thermal stability → OLA is eliminated during the mechanical recycling process.

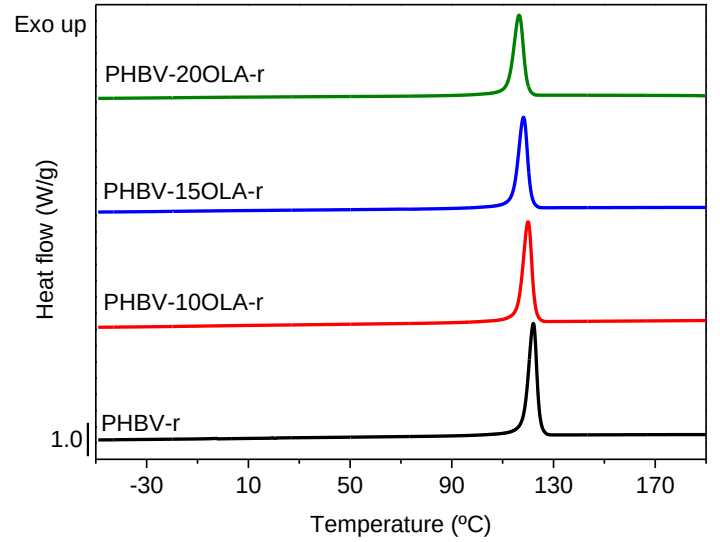




Results: Differential scanning calorimetry

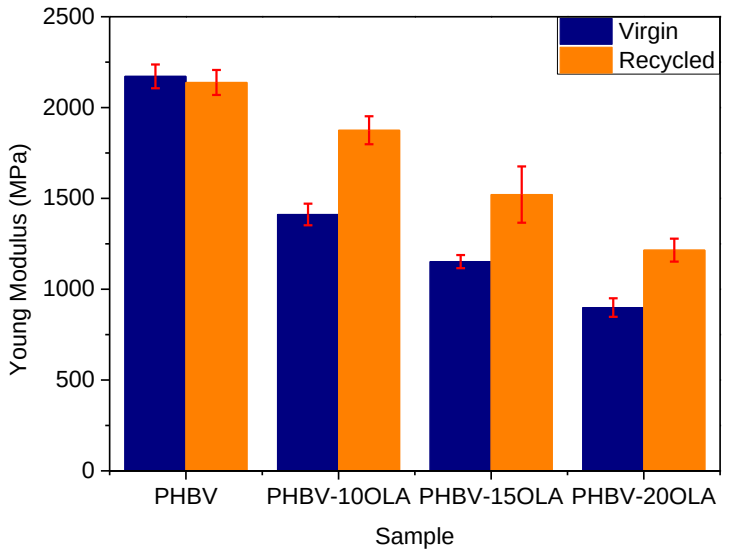
- Addition of OLA seems reduces crystallization temperature → More difficulties to form crystals.
- Mechanical recycling results in slight increases of crystallization temperatures → Specially in formulations with OLA.
- Could be attributed to the degradation of the matrix or by elimination of OLA during recycling.

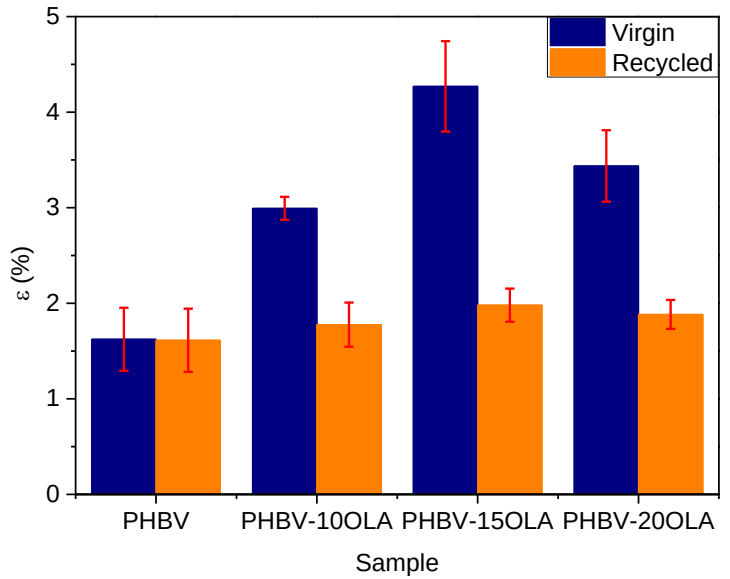




Results: Mechanical properties

- OLA has a plasticizing effect on PHBV → Lower modulus and increased elongation.
- Mechanical recycling does not significantly affect pure PHBV.
- The elimination of OLA during recycling leads to more rigid materials → Increased modulus and decreased elongation.





Conclusions

Conclusions

- OLA has a **plasticizing effect** on PHBV, although it hinders crystallization.
- Mechanical recycling has a **small effect** on intrinsic viscosity and thermal stability of **pure PHBV**.
- **OLA is eliminated during recycling**, leading to an increase of elastic modulus and a decrease of the elongation.

- **Mechanical recycling could be an interesting alternative for PHBV, although special attention should be paid to additives.**

Thank you for your attention. Questions?

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