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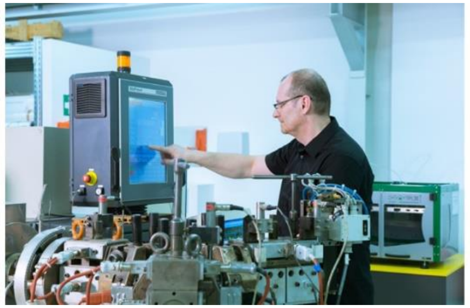

BIOBASED PLASTICS FOR A CIRCULAR ECONOMY

GHENT UNIVERSITY

NTE 7

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prezero

Pack4Food

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C-PlaNeT

CIRCULAR PLASTICS NETWORK FOR TRAINING

Overview

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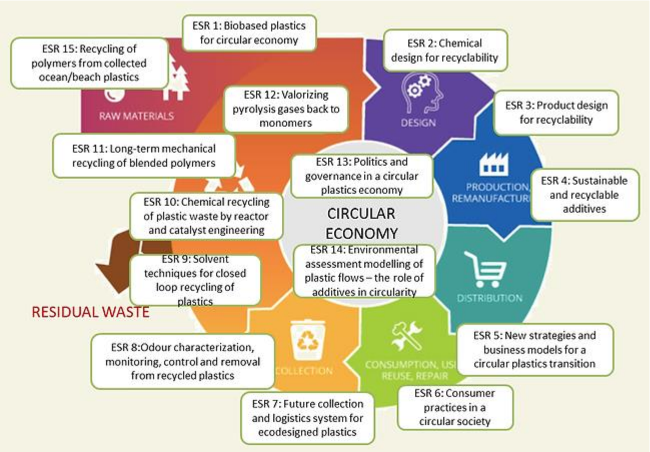
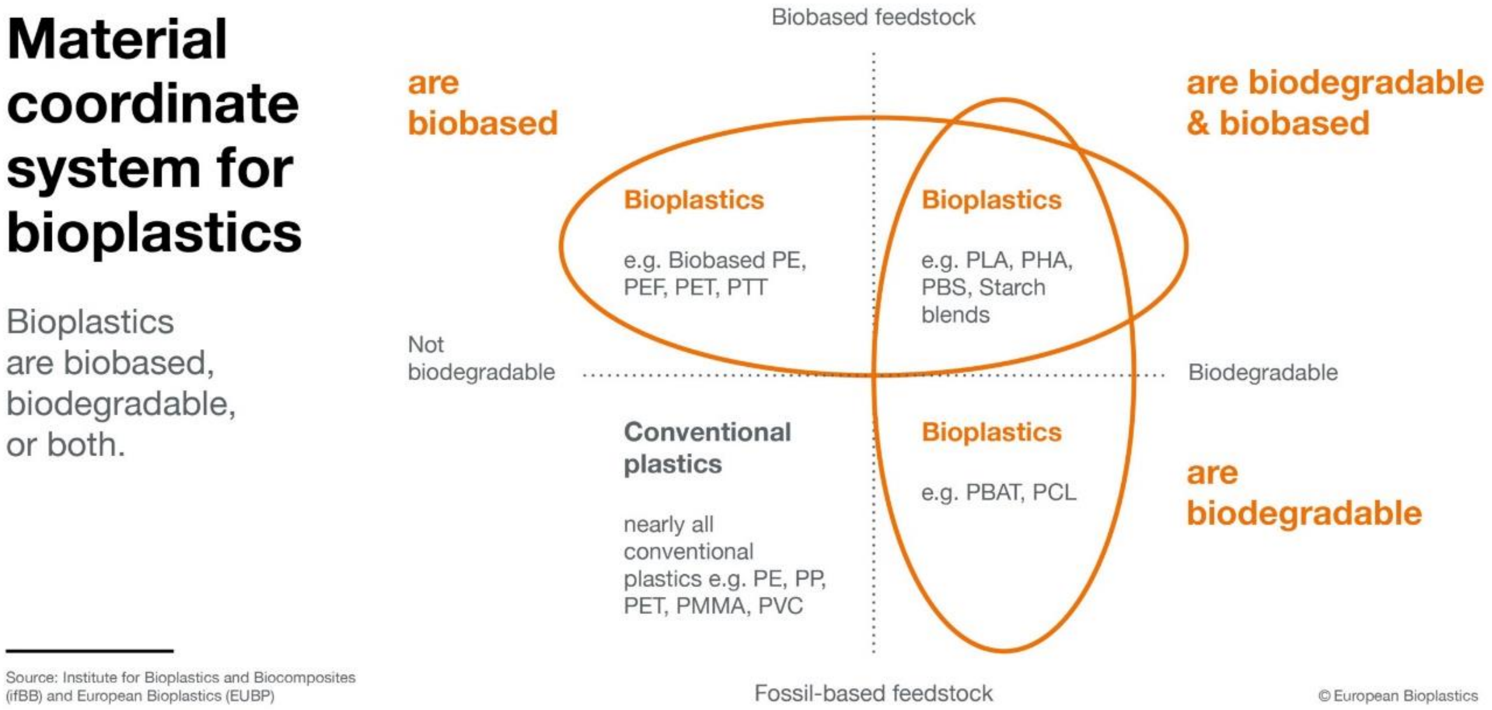
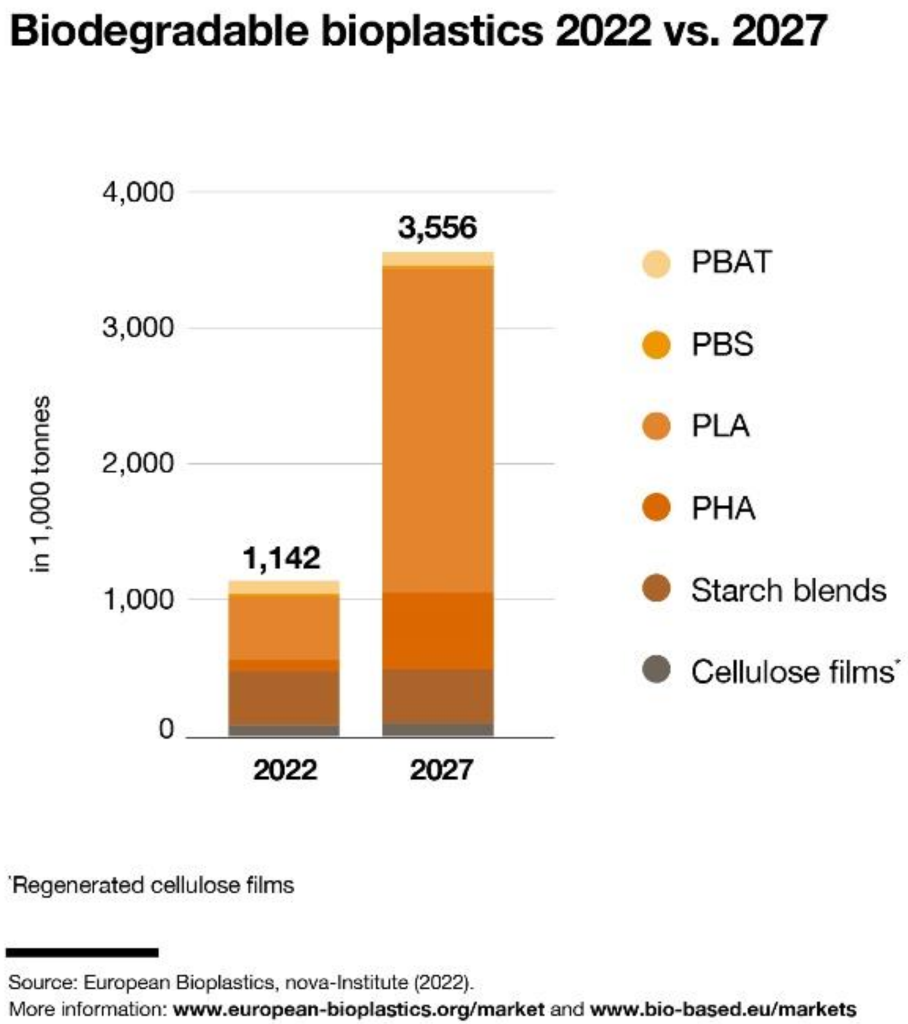


Motivation

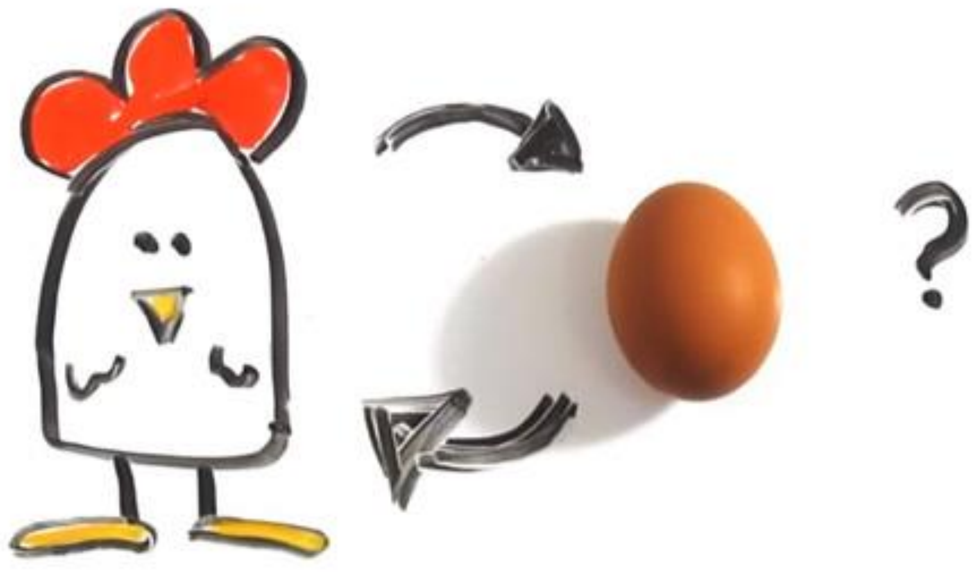
Bioplastics in Circular Economy





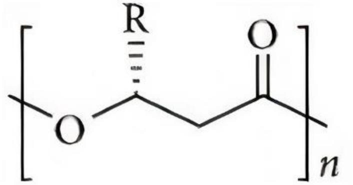
Biopolymer Recycling Overview

- To be expected: Similar behavior (and problems) to conventional thermoplastics.
- Biopolymer drop-ins are being recycled together with fossil-based counterparts.
- Cross-contamination of petrochemical polymers with biopolymers (e.g. PET with PLA) is problematic, but is only a problem of sorting technology.
- Current status: No industrial recycling streams for biodegradable biopolymers.

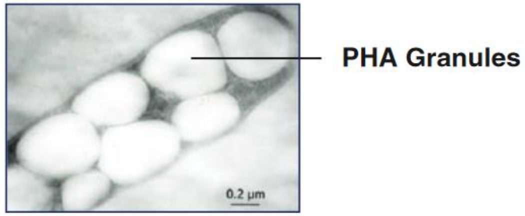


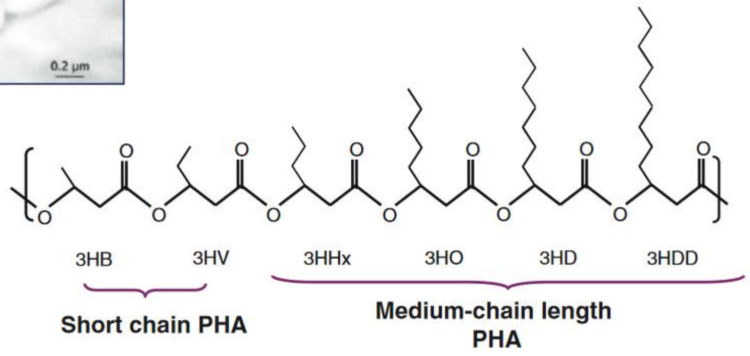
Polyhydroxybutyrate

- Polyhydroxyalkanoate (PHA)
- Accumulated within bacterial bodies



PHA has 150 monomers reported





Common PHA monomers

- Properties:
  - Biobased and biodegradable
  - Melting point-177°C
  - High crystallinity
  - Similar to PP – certain properties
  - Barrier properties- good

- Challenges
  - Narrow processability window
  - Ageing on storage

Table 1. Summary of mechanical properties of P3(HB) and petrochemical based (PP, PET, PE) and bio-based polymers (PLA).

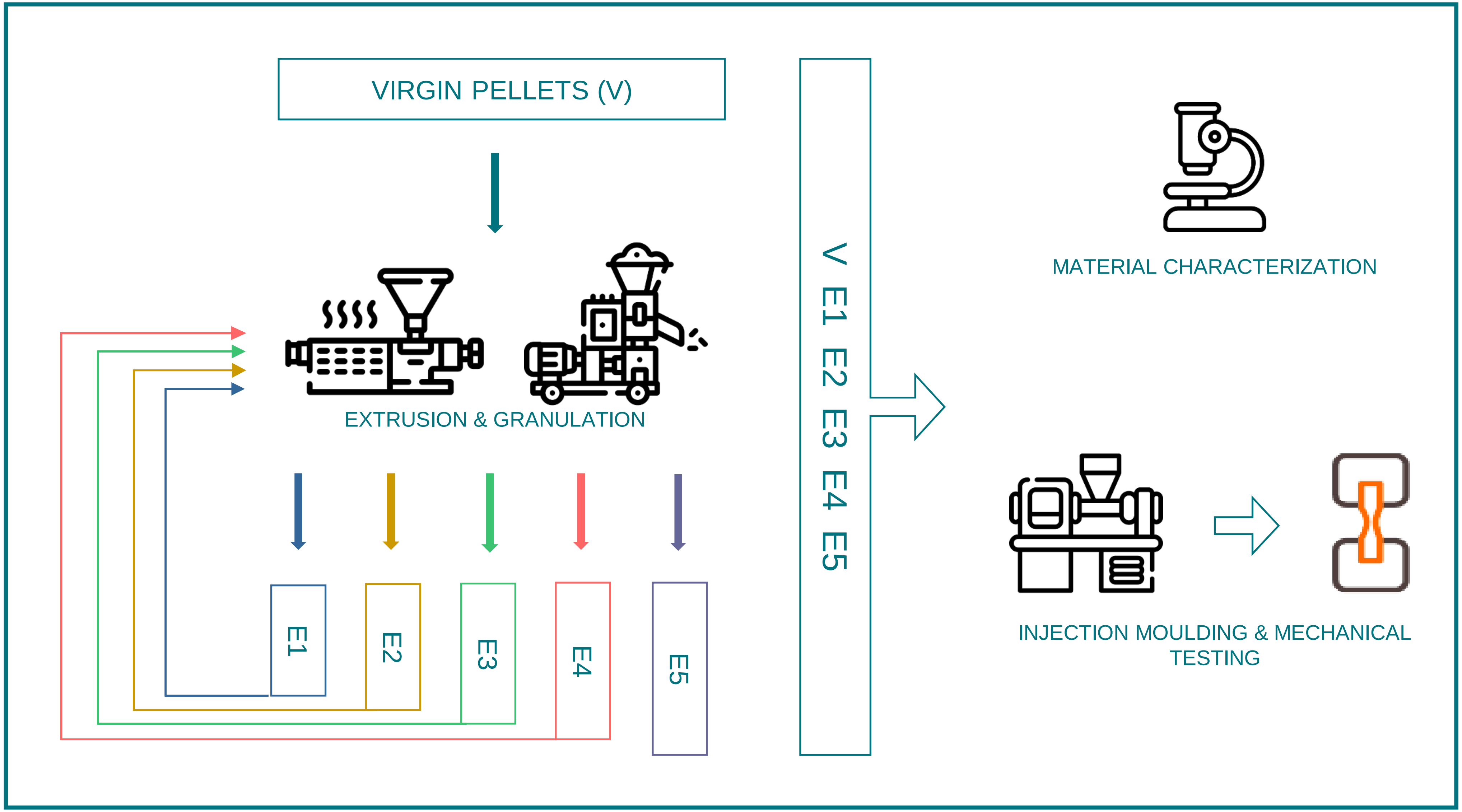
Mechanical Property	P3HB	PP	PET	LDPE	HDPE	PLLA	PDLLA
Tensile modulus (GPa)	3–3.5	1.95	9.35	0.26–0.5	0.5–1.1	2.7–4.14	1–3.45
Tensile Strength (MPa)	20–40	31–45	62	30	30–40	15.5–150	27.6–50
Elongation at break (%)	5–10	50–145	230	200–600	500–700	20–30	1.5–20
Degree of Crystallinity (%)	50–60	42.6–58.1	7.97	25–50	60–80	13.94	3.5
Melting Temperature (°C)	165–175	160–169.1	260	115	135	170–200	amorphous
Glass Transition Temperature (°C)	5–9	−20–−5	67–81	−130–100	−130–100	50–60	50–60

Source: McAdam et al.2020

- Objectives
- Further development of mechanical recycling of bioplastics (PHB).
- Improve the current bioplastic packaging products (with focus on PHAs).

Experiments and Results

Mechanical Recycling Pathway I - PHB and PP



Main et al. Reprocessing of PHB and PP: Material characterization- In preparation

Results-PHB and PP

Fig. 1 a)

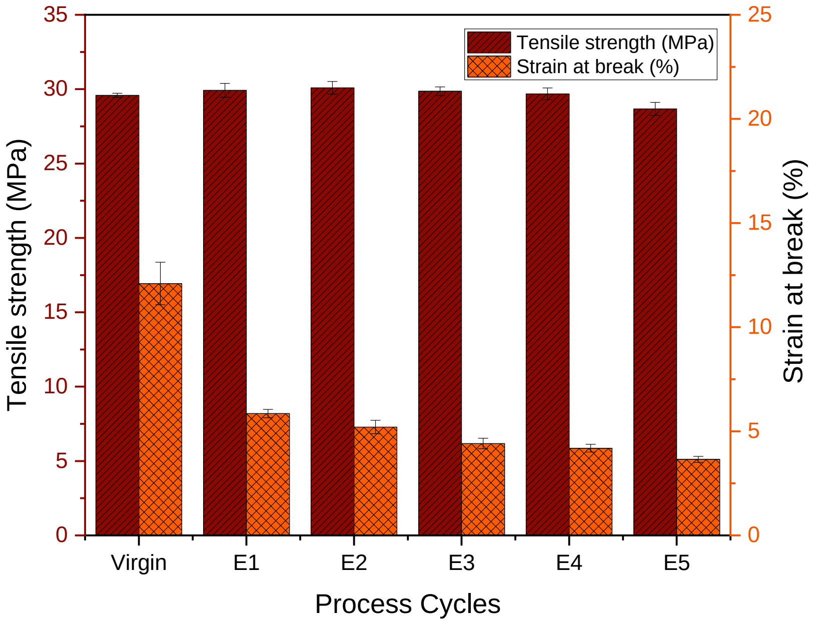
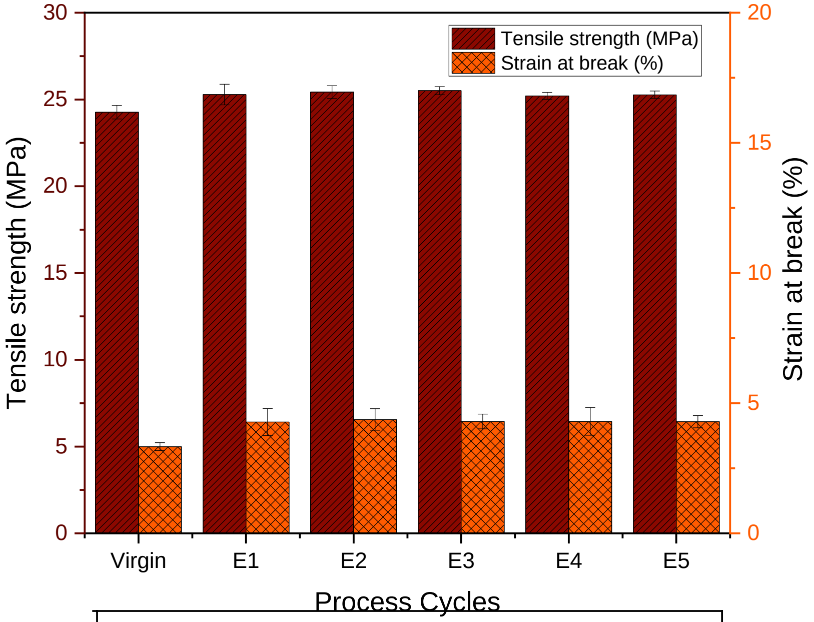


Fig. 1 b)



Tensile strength- remains constant
Strain at break- decreases
Thermal stability

Fig. 2 a)

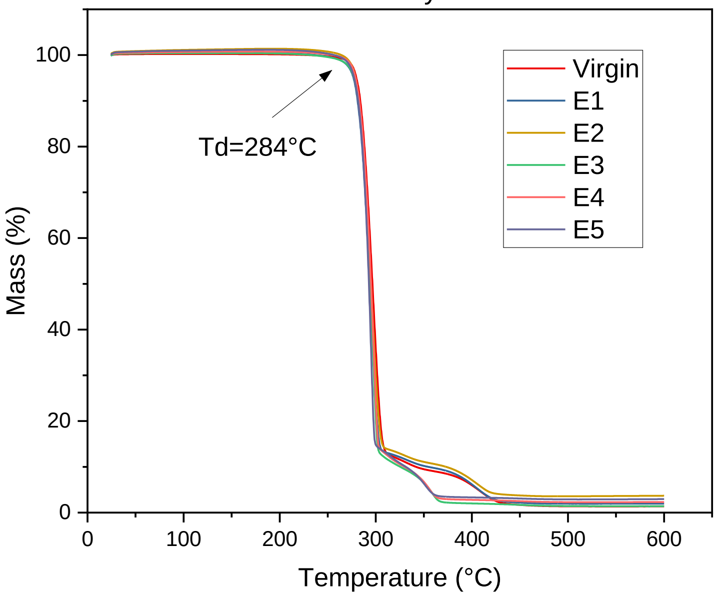


Fig. 2 b)

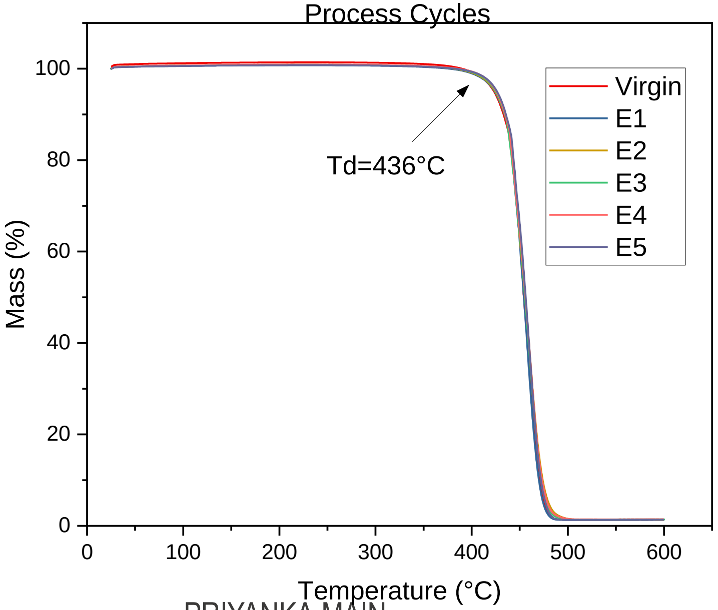


Fig. 1 Tensile Strength and strain at break a) PHB and b) PP

Fig. 2 TGA scan a) PHB b) PP

Addition of melt strength enhancer and CE- IV

E1 at 180°C of virgin PHB + MSE

- Material characterization
- Injection molding → Mechanical properties

→ Effect of MSE and **optimal composition**

E2 at same process settings without CE

E2 at increased T (200°C) with CE

- Material characterization
- Injection molding → Mechanical properties

→ Effect of CE

Results

Fig. 6 a)

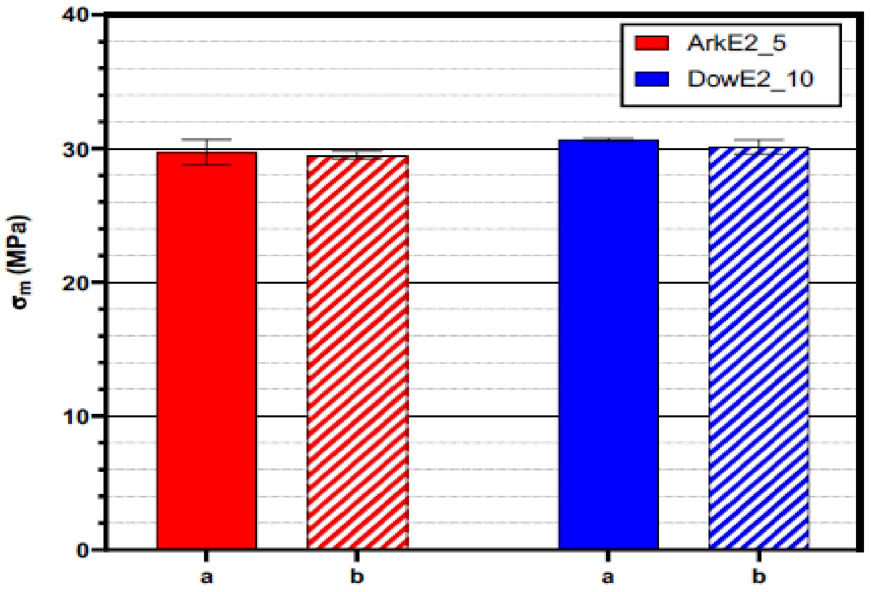


Fig. 6 b)

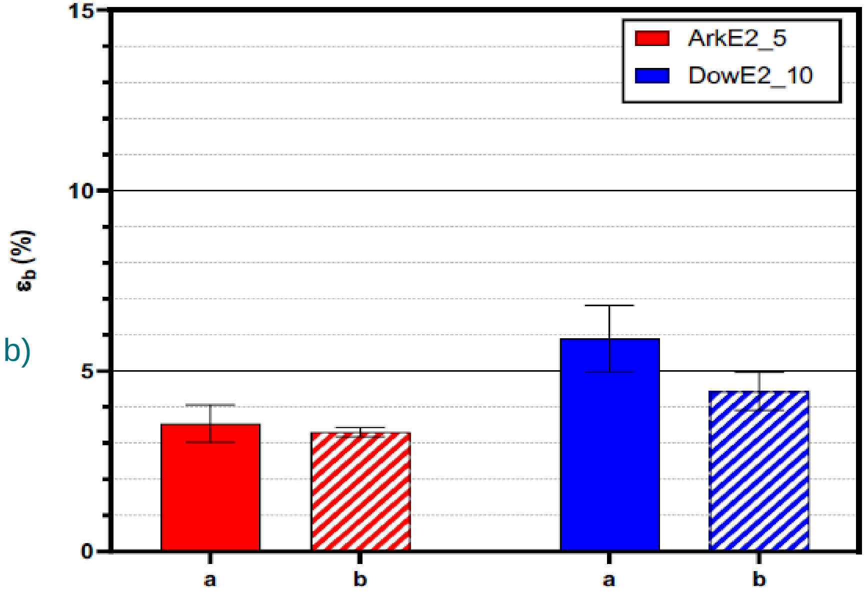
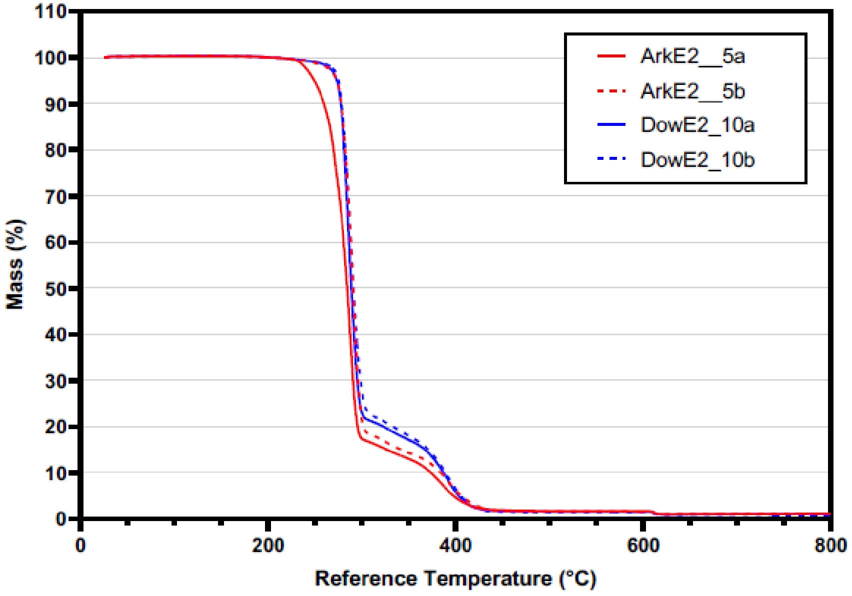


Fig. 7



MSE retains the mechanical properties in the E2.
With CE- Properties retained as well but no significant improvement due to the higher temp. nullifying the effects

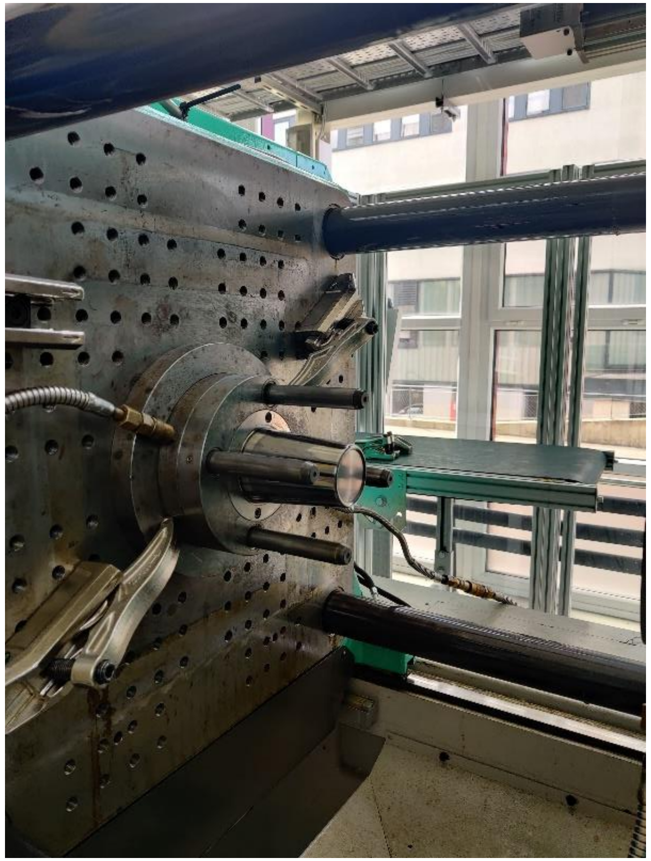
a- without chain extender (solid colour)
b- with chain extender (dotted)
Fig. 6 a) Tensile strength
Fig. 6 b) Strain at break

Fig. 7 TGA scan of the modified PHB

Food packaging

Picture 1. PHB cup

Picture 2. PP cup



Picture 3. Cup mould on injection moulding machine

Migration and oxygen ingress

Picture 6 a)

Picture 6 b)

Picture 7 MAP Packaged PHB Bag

Picture 6 a) PHB films- Virgin, E1, E2+Jon, E5 before oil migration test
Picture 6 b) After oil migration test (10 days)

Effect of PHB on rPP

Picture 8 PHB in different concentrations from 1, 2, 3, 4, 5 and 10%

+

Picture 9 Added to rPP

→

Picture 10 Mixture of PHB and rPP

→

Picture 11 Injection moulded test pieces

Conclusions and Future Work

Conclusions

- Mechanical recycling
  - Tensile strength remains even after 5 cycles
  - Good thermal stability
  - Similar to conventional polymers
  - CE which can work at the processing temp. of PHB needs to be developed
  - MSEs have a strong potential in recycling of PHB
  - PHB/rPP blends- < 5% of PHB does not affect the system (in fact PHB acts as a process aid)
- Food packaging applications
  - OTR and WVTR- improved for recycled PHB and no significant change in PP.
  - Migration from films- Simulant A and B- passed but Simulant D2- E5 showed best performance.
  - Oxygen ingress- possibility of leaks from wrinkles in the film- sealability is critical (temp. and duration of sealing).

Future Work

- Paper publication is ongoing
- Dissemination to the general public
- PPI Portugal 2023 poster contribution
- Thesis

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Prof. Ludwig Cardon (UGent)
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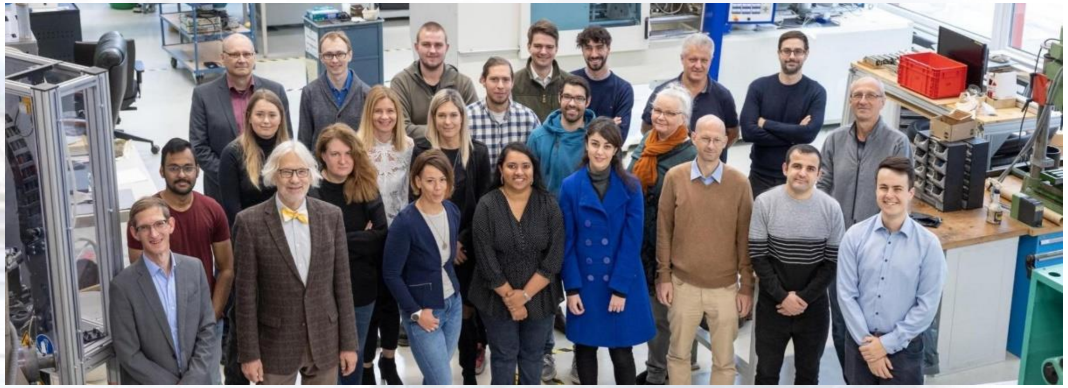

THANK YOU VERY MUCH FOR YOUR ATTENTION!

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