H&P Moulding

Injection Moulding Trials with PHA
EMPHATI PROJECT

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H&P Moulding: Brief Introduction



Injection moulding company since 1979

>20 IM machines

Processor of (almost) all thermoplastic materials

For 8 years processor of various types of bio-plastics, with focus on PHA

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H&P Moulding: Business Scope

- High Tech (verwarmingsindustrie) : Resideo, Bosch
- Med Tech : Menicon, Johnson & Johnson Vision
- Bio based : Happy Cups, Wad van Waarde



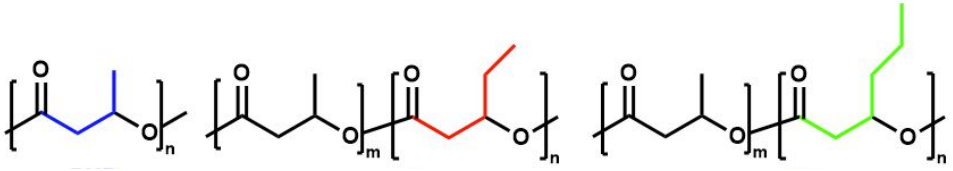


H&P Moulding: Motivation for exploring PHA

1. Streamline injection moulding processing to reduce unknowns in product development
2. Prove PHA can perform consistently in injection moulding
3. Test PHA with filler compounds to lower cost
4. Replace PP and other fossil plastics where possible
5. Test recycling of PHA to minimize wastage
6. Source PHA locally

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Twenty-one grades and compounds, seven moulds



10 unfilled PHA grades

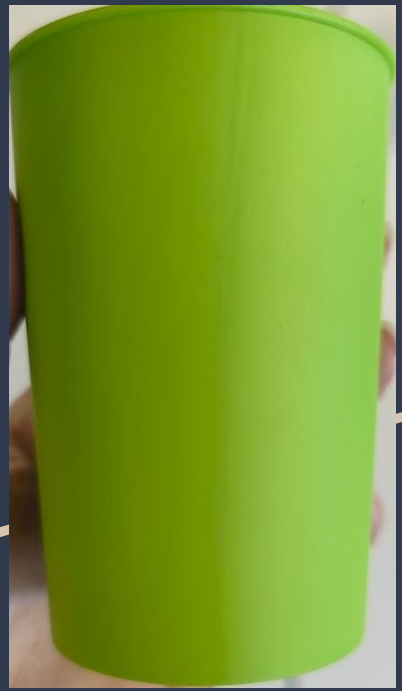
Enmat Y1000P (PHBV)
Kaneka Green Planet X331N and M304 (PHBH)
BluePHA BP330-05 (PHBH)
CJbio PHACT A1000P (P3HB4HB)
Biomer P263P and P209 (PHB)
Paques Caleyda BM 2504D and IM2 (PHBV)
PHAbuilder Phamily PB2001IM-4
Enmat Y1000P regrind

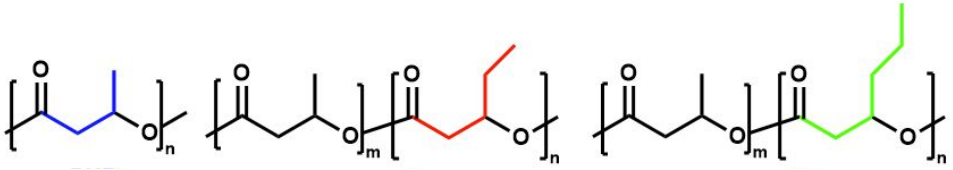
11 compounds and blends

PHA + PLA
PHBV + 30 % hemp fibre
Wittenburg Cawiton 15172C, 15172E, 15172D
Arweco Otura A5, B11, C18 — 30 % oat hull fibre
Kaneka X331N + PHBH masterbatch
Paques PHBV/PLA blend
Biomer P263P + 20 % talc

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Materials & Processing: PHBV 3%





Generally well processable, with some recurring issues in product appearance.

Degradation

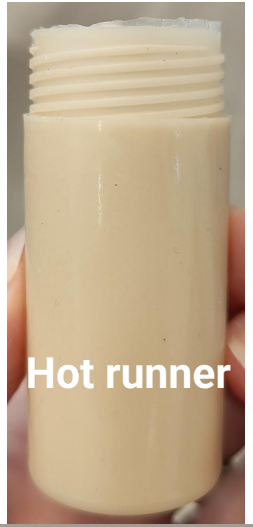
- Appears randomly, even within the **same batch**.
- Reduced by reducing **injection speed** and raising **mould temperature** from 60 °C to 70 °C.

Likely cause: material residence in **hotrunner**.

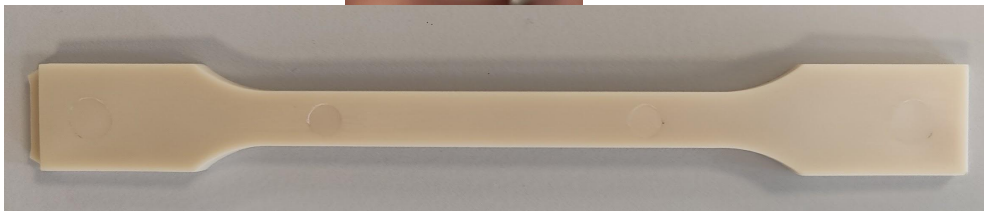
- More hotrunner tunnel openings → more visible degradation lines.
- **Degradation temperature**: ≈ 185 °C.
- Material requires ≈ 200 °C in hotrunner to flow properly.

Materials & Processing: PHBV 3%









Materials & Processing: PHBH

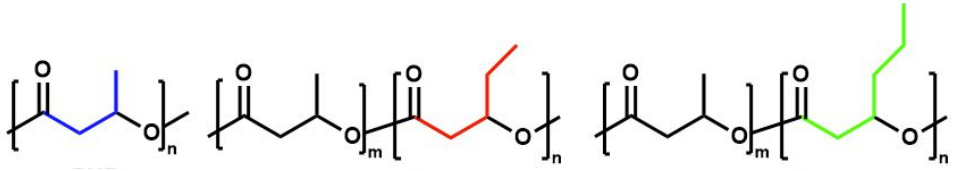










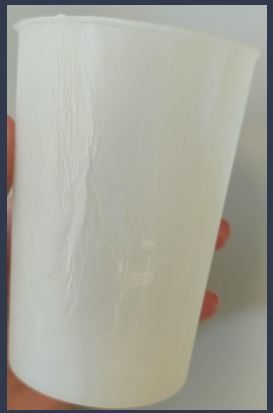


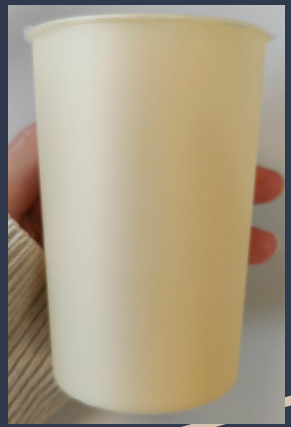
Generally well processable. Slightly more difficult to process than PHBV 3% but shows **improved material properties**.

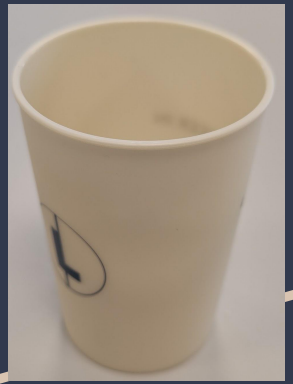
Degradation:

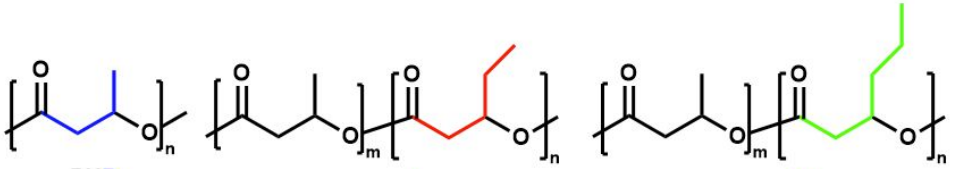
- Occurs **quickly** — prolonged residence in the cylinder rapidly lowers viscosity but no change in colour.
- **Shorter barrel lengths** are recommended.
- If material remains too long in the barrel, viscosity drops excessively and the product becomes **sticky after crystallization**.

Materials & Processing: PHBH









Same mould, same polymer, different results
This shows the importance of mould design

Different shrinkage and strength will affect demoulding behaviour and process stability.

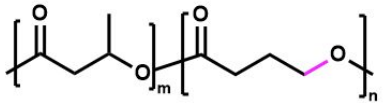
Will this knowledge, mould design can be improved

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Materials & Processing: P3HB4HB







Overview

- A **rubbery, flexible PHA** with promising elastic properties.
- Commonly used as a softening component when compounding with Enmat to reduce crystallinity and rigidity.

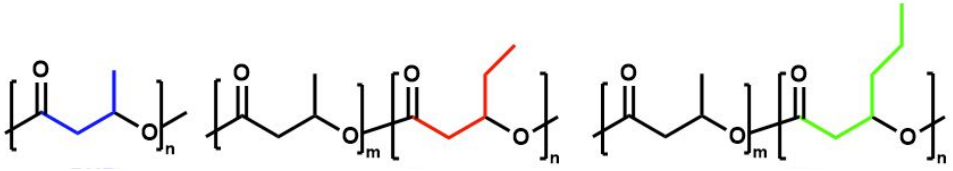
Processing Behavior

- **Not suitable for injection moulding in pure form** — highly sticky and exhibits poor flow.

Application Potential

- Shows **good flexibility and tactile durability**, though **thermal stability remains limited**.
- Explored as a **seal ring** or **rubber replacement** material.

Materials & Processing: Experimental Materials



Experimental Methodology:

Start up - finding settings that allow mould filling

Experimental settings - optimise pressure, injection speed, temp, etc.

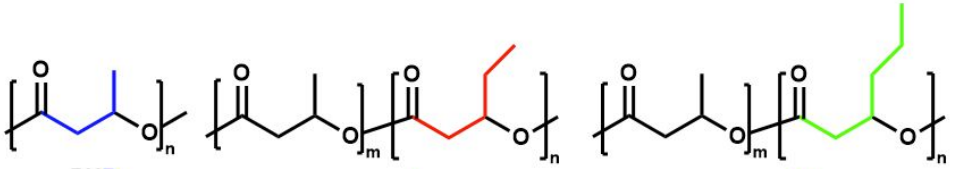
Record changes across settings

Mini-production run

Analysis



Materials & Processing: Experimental Materials











Product Development: Wadkop

Development of a 100% PHA-based coffee cup, including cup, lid, and ring.

Designed to be fully biodegradable, biobased, and environmentally safe — an alternative to conventional plastic cups.





Material Selection





Material	Type	Key Traits	Notes
Enmat Y1000P	PHBV	Hard, crystalline	Leakage, poor fit, & stiction
Kaneka X331N	PHBH	Balanced stiffness & flexibility	Stiction issue
Kaneka M304	PHBH	Softest, most like PP	Stiction issue
Cawiton C/D/E	PHBV/PHBH	Hard, crystalline	Stiction & leakage

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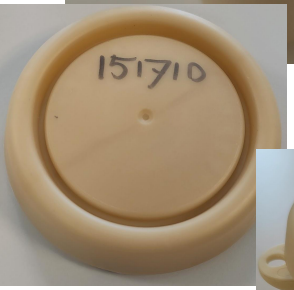
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Material Selection & Product Development







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Kaneka M304	PHBH	Softest, most like PP	Stiction issue
Cawiton C/D/E	PHBV/PHBH + slip additives	Hard, crystalline	Stiction & leakage

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References; Material or Design?

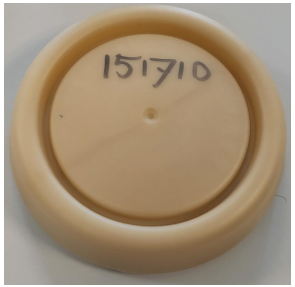
















PP to PHA transition: Lens Case

Evaluate whether a **PHA** can **replace polypropylene** (PP) in an existing mould.

Maintain the same **functionality**, **flexibility**, and **hinge performance.**





PP to PHA transition: Vial

Evaluate whether a **PHA** can **replace polypropylene** (PP) in an existing mould.



POM to PHA transition: Vial

Evaluate whether a **PHA** can **replace Polyoxymethylene** (POM) in an existing mould.



Oat Fibres
PHB/P3HB4HB

Good flexibility/hand-feel; cup does not crack.

Very low stiction → cups de-nest easily.

Visible fibre migration/segregation along the flow path.



Hemp fibres: PHBV

Able to obtain product

Issue with bridging

Importance of mould design:

- Sprue and gates must be large enough



Table 5.2.1: Mechanical properties of hemp fibre-reinforced Enmat™ Y1000P Van Noordenne, NHL Stenden (2024). Values shown as mean ± standard deviation, n = 5.

Material	E-modulus (MPa)	Elongation at break (%)	Tensile Strength (MPa)	Elongation at max strength (%)
Y1000P	4560 ± 195	1.36 ± 0.08	37.8 ± 0.1	-
Y1000P + 30% hemp (H&P molding)	8200 ± 500	1.53 ± 0.14	43.0 ± 0.1	1.53
Y1000P + 30% hemp (NHL Stenden)	8330 ± 200	1.42 ± 0.02	45.0 ± 0.1	1.42



Talc 20%
PHB

Able to obtain product

Weakness at weld line





Mould Design PHA

PHA test moulds:

- Large gate
- Sufficiently large sprue
- Sufficient venting but smaller openings

Highly crystalline materials shrinkage depends on wall thickness and flow path

Crystallization continues beyond 24 hours

Less crystalline materials shrink more uniformly even with varying wall thickness

Demoulding design is highly dependent on shrinkage -> important information for mould design.

Many conventional plastics have thin sprues/gates but PHA sprues break more easily and complicate the demoulding process.

Recycling: Enmat

Sample preparation

Regrind

Mould **virgin materia**l -> grind in grinder

Regrind of regrind

Mould **regrind** -> grind in grinder



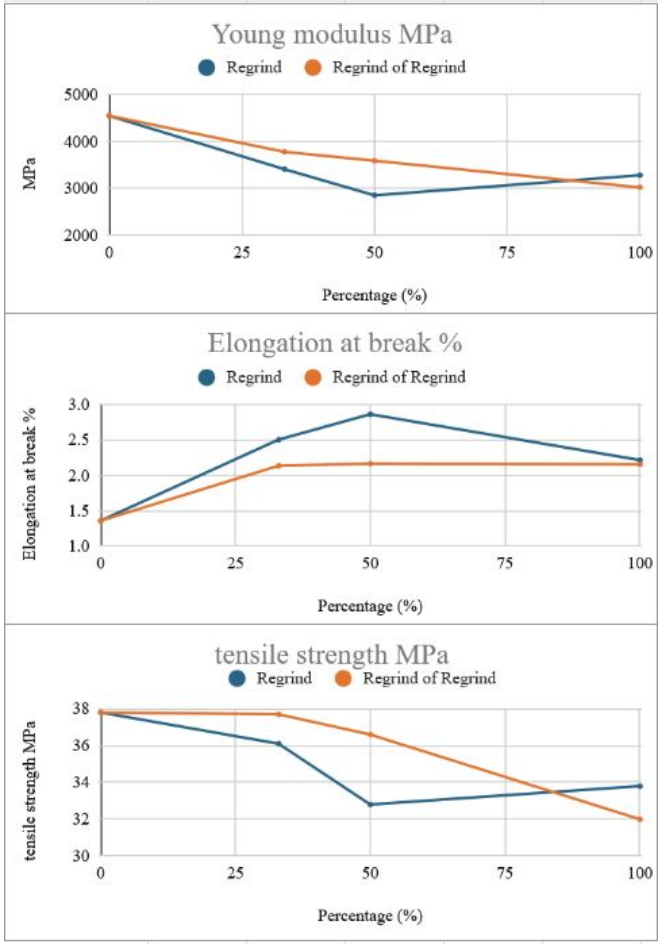
Recycling: Enmat

Overall, PHBV is recyclable with moderate loss of mechanical performance.

The second regrind retains acceptable mechanical properties but shows evidence of cumulative degradation.

This trend aligns with the known sensitivity of PHAs to thermal degradation and chain scission during melt processing.

The slight recovery in modulus for “Regrind” at 100% suggests possible recrystallization or molecular reorganization effects.



Future suggestions

Proper analysis on shrinkage across PHA grades for mould design

More research in how hot runner design can minimise degradation in PHA

Increase local sourcing of materials/help improve local materials

Discover new applications for PHA: advantages/disadvantages of the material

More research in PHA for technical applications

Thank you

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23 september 2026

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