Chances and Limitations in the Use of New Biopolymers in Healthcare Products

Julian Lotz, BIOVOX



With the support of:



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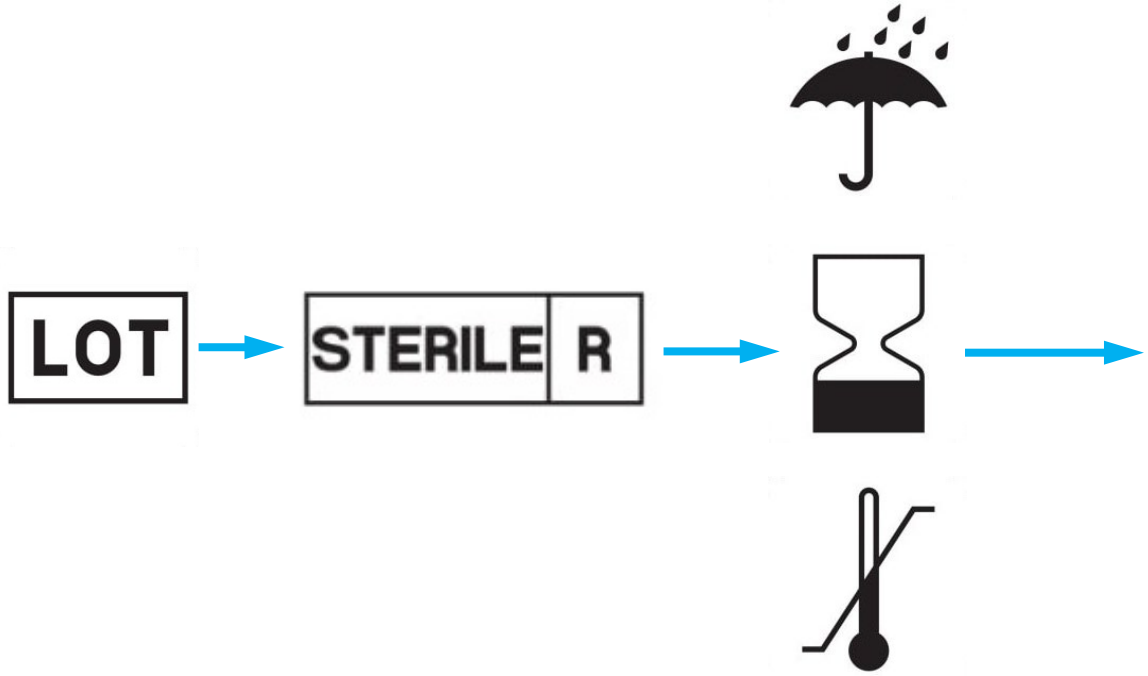
The Information Deficite

Why healthcare does not adopt new polymers quickly





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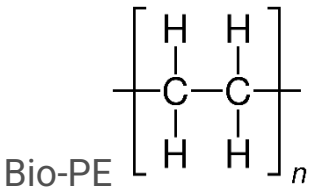
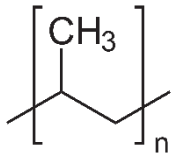
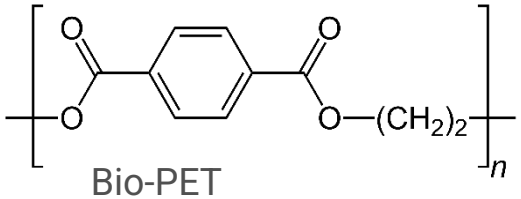
Drop-Ins



Bio-PE

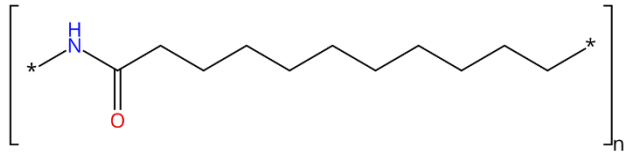


Bio-PP



Bio-PET

and other mass-balanced bioattributed polymers



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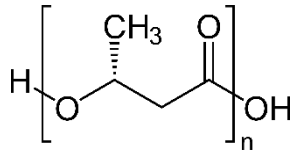
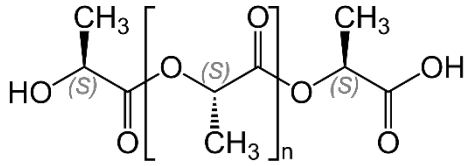
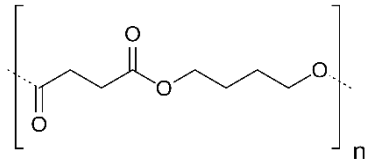
Novel Biopolymers



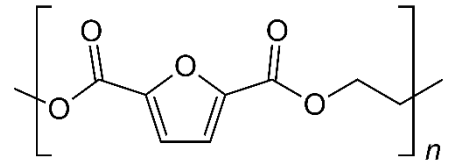
PHA family



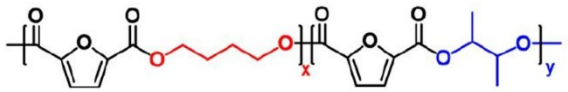
PLA



PBS



PEF



PBF

Healthcare plastics see special requirements.

And special decisionmaking.

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In a nutshell

2021 Founded
A team of 14 experts
Darmstadt, Germany

Biobased and recycled Polymers
for Devices & Packaging
in MedTech, Pharma & Lab

Medical Grade Quality
ISO 13485 Quality Management
ISO 10993 tested Biological Safety

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Bioplastics for Your Application

For injection molding, profile, tube & film extrusion

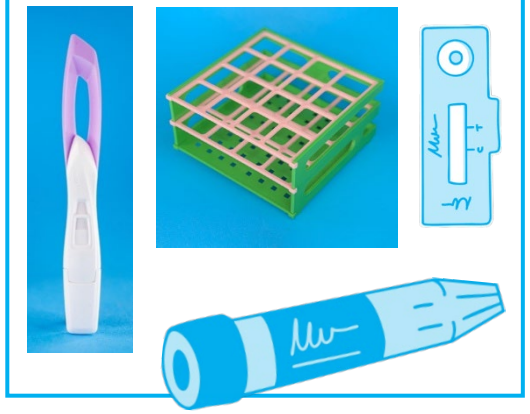
Drug Delivery



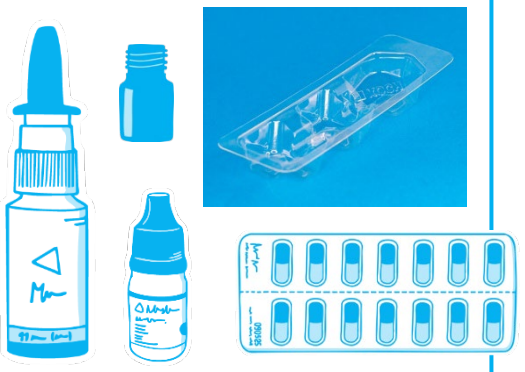
Medical Devices



IVD & Laboratory

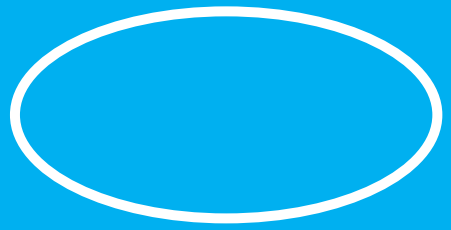


Primary Packaging



Other Applications

MedEco is available as standard or **customized to your application**. With our R&D team and a technical center in house, we can create custom compounds quickly and efficiently. Compound formulation and testing is mostly done within 24h!



Scope

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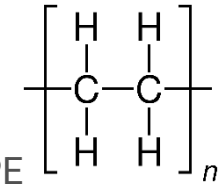
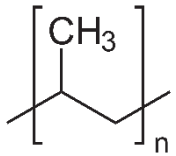
The Information Deficite

Why healthcare does not adopt new polymers quickly

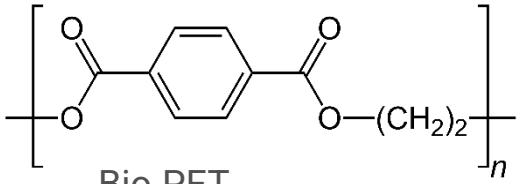
Drop-Ins



Bio-PE



Bio-PP



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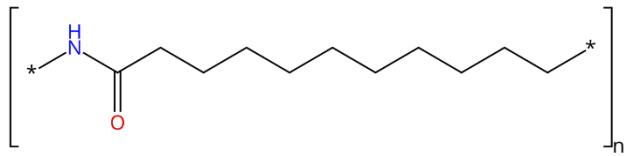
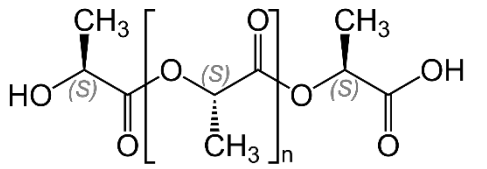


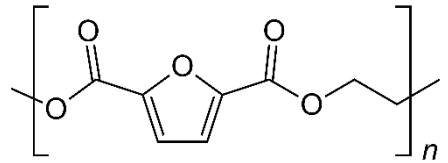
PA 11

No[illegible]rs





PLA



PEF



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Processing

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Production processes & parameters

Injection Molding

- Drying is very important
- Lower processing temperatures
- Standard hot runners work fine
- t/l of 200+ with PLA
- Good dimensional stability, tight tolerances
- (Almost) No forced demolding







Production processes & parameters

Film Extrusion

- PLA can be thermoformed exactly like PETG, just 20°C less temperature
- Sealing against Tyvek is possible
- PEF seems to be comparable
- Blowmolding works great with PEF

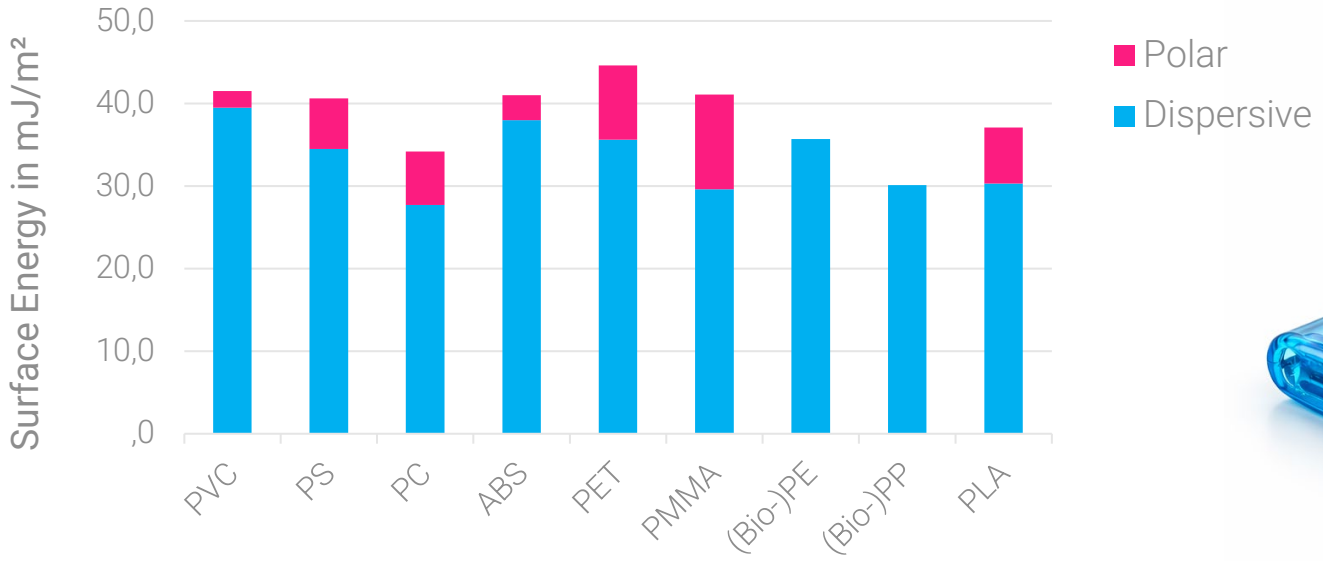




Production processes & parameters

Bonding & Welding of PLA

- Ultrasonic welding works great
- Solvent bonding: Dichlormethane, Trichlormethane
- Surface Energy: between PS and PET





Processing does not differ from conventional plastics.

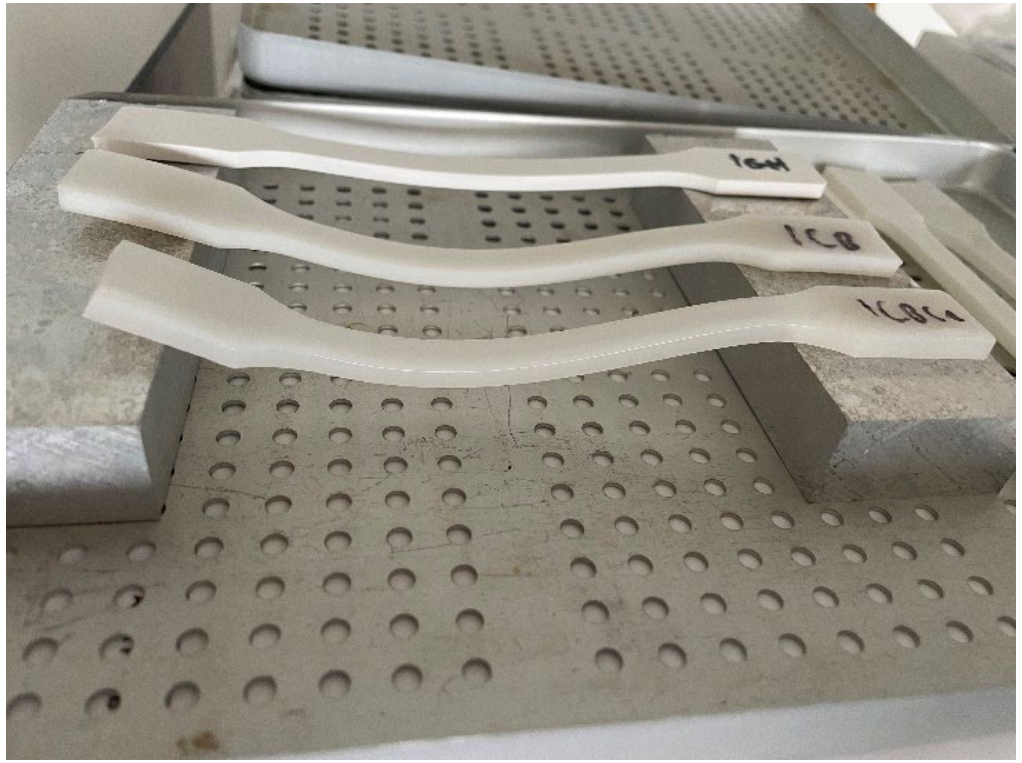


Sterilization

Sterilization

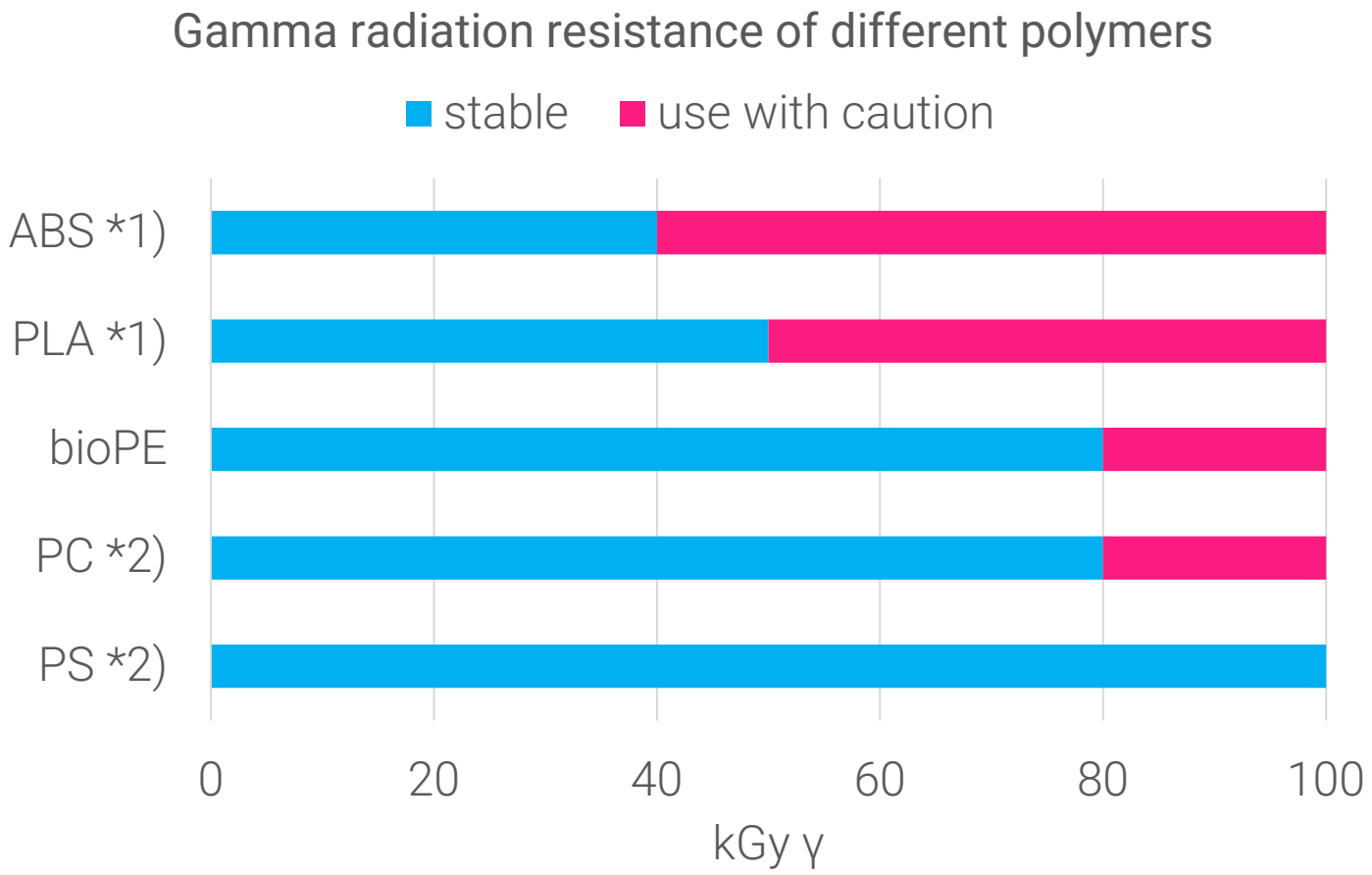
Resistance to common sterilization methods

- Steam sterilization: →
- EtO sterilization: ✓
- Radiation sterilization:
  reduces molecular weight – loss of elongation at break &
- PLA: no color change
- PEF: currently does yellow



Radiation Sterzilization Stability

Comparison between various polymer classes



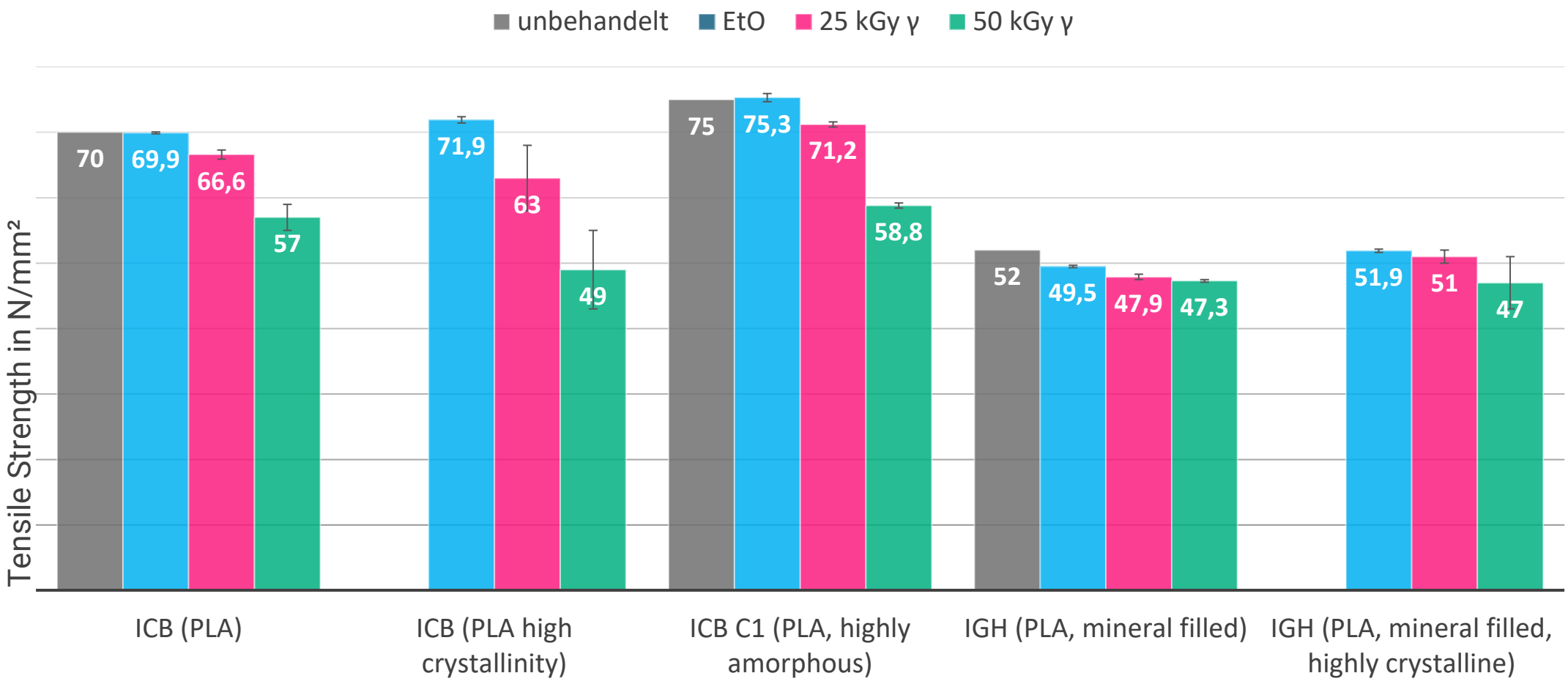
*1) Strongly dependant of the grade

*2) tends to noticeable yellowing

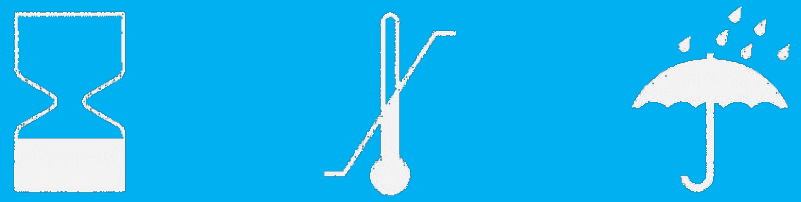
Side note: MedEco ICB hat better drop test results than PS after 45 kGy, so always have a look at the absolute values, too!

Influence of the PLA formulation

Different grades behave quite differently



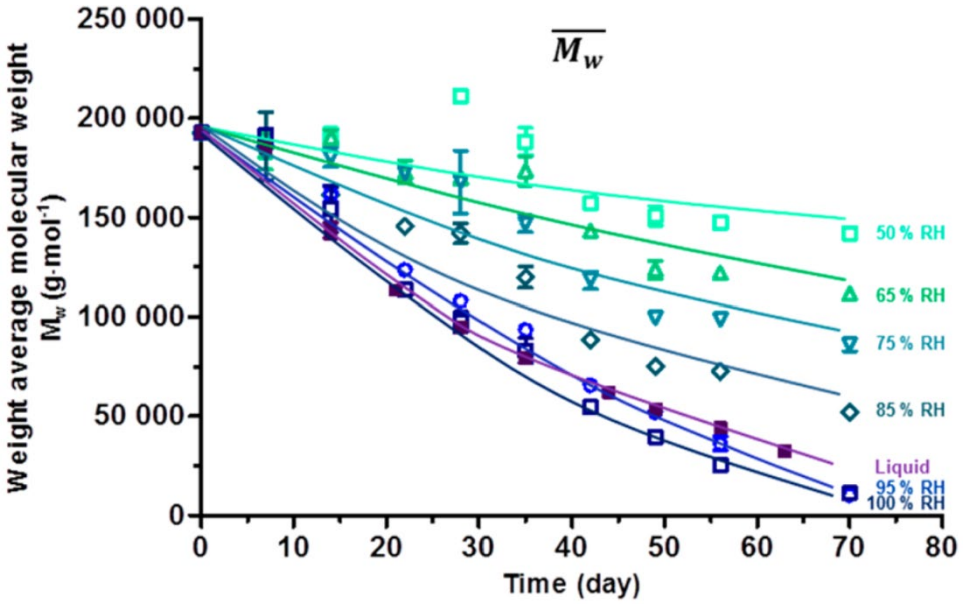
No steam, the rest is okay.



Storage: Aging

Hydrothermal Ageing

Decrease of molecular weight at 50°C at different relative humidities

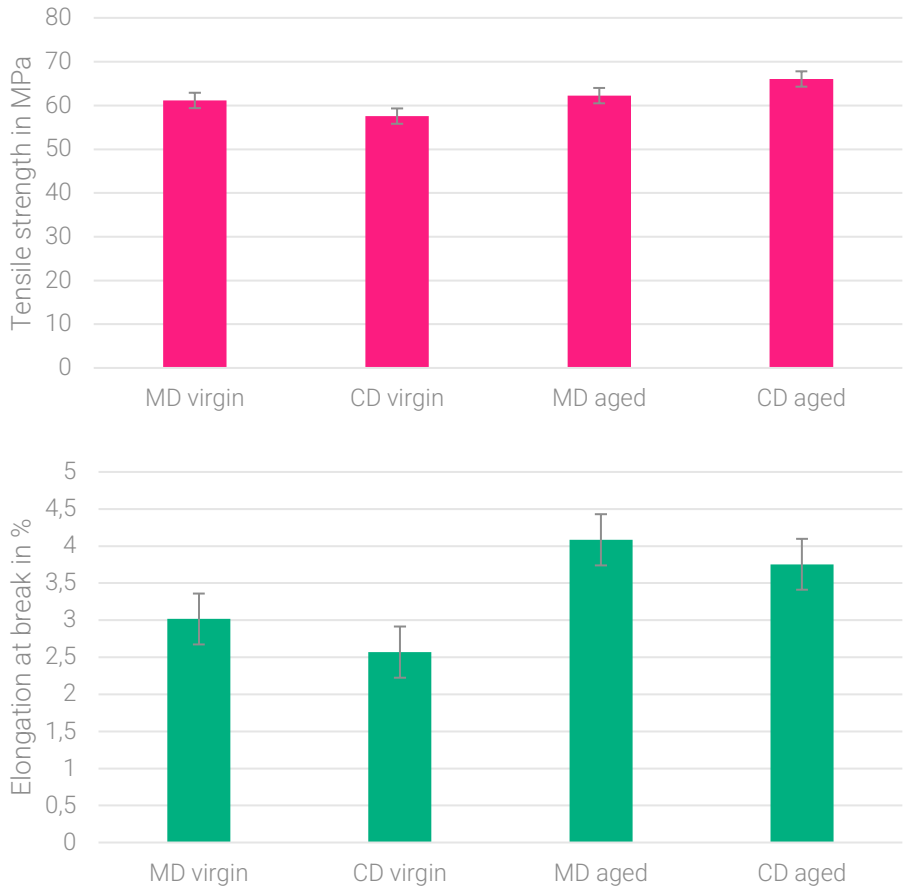


Rocca-Smith, Jeancarlo R., et al. "Beyond biodegradability of poly (lactic acid): physical and chemical stability in humid environments." *ACS Sustainable Chemistry & Engineering* 5.3 (2017): 2751-2762.
Rocca-Smith, J. R., et al. "Effect of the state of water and relative humidity on ageing of PLA films." *Food chemistry* 236 (2017): 109-119.

- Accelerated decrease of molecular weight above 50°C and relative humidities above 50%
- Nearly no hydrolysis at 50% relative humidity at 50°C
- Accelerated decrease of molecular weight with higher acid/base content (e.g. lactic acid)
- -50% at 50°C
- -13% at 40°C

Physical Aging of PLA

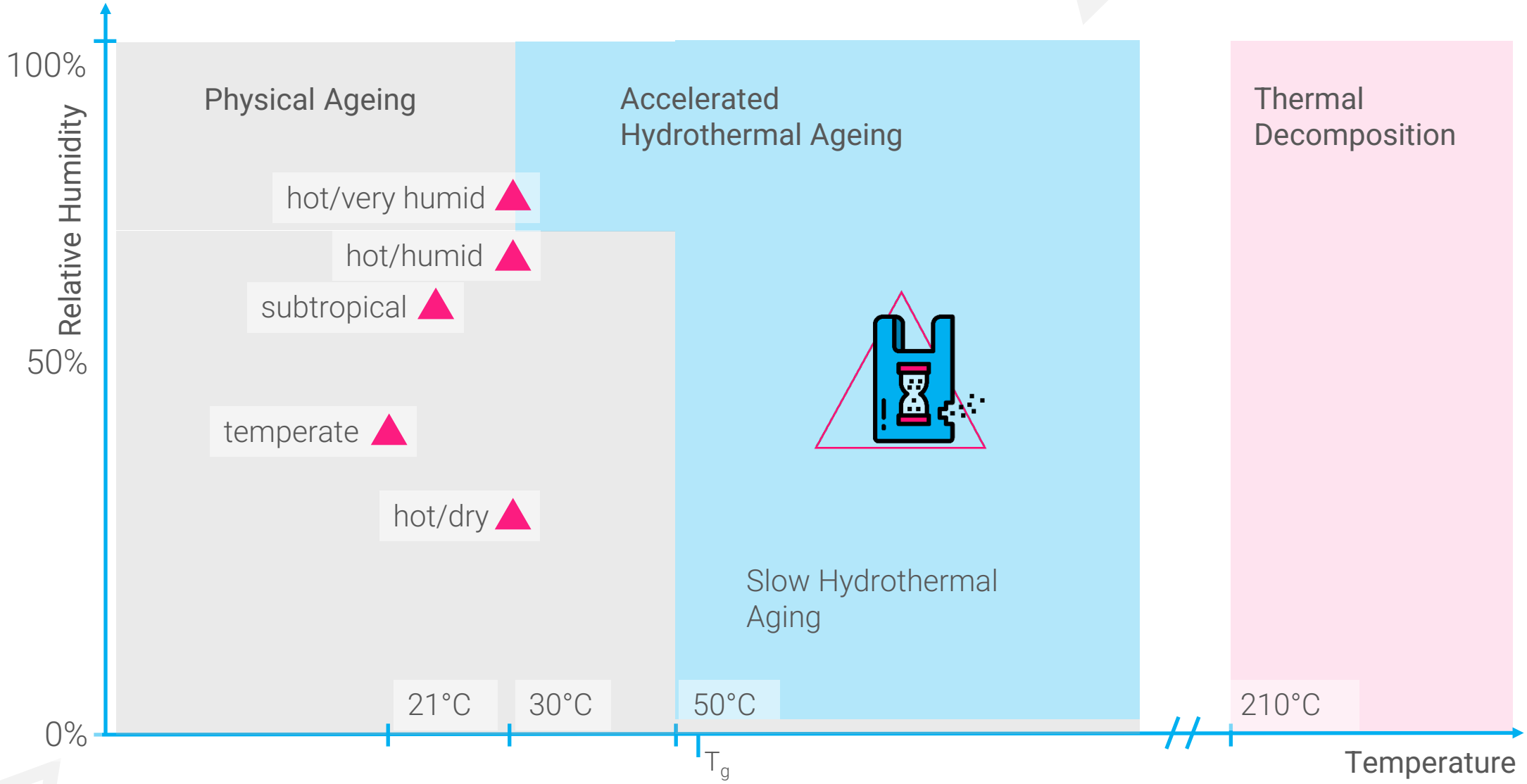
Accelerated ageing 10 years (55°C, Q_{10}=2, ASTM F1980) of MedEco XCB 500µm sheets



- Increased tensile strength and elongation at break after physical aging
- Molecular weight nearly constant
  → MedEco ICB -2%/1 year
- Alkaline inorganic filler slightly accelerate molecular weight deterioration
  → MedEco IGH C1 -13%/1 year

MD = Machine Direction
CD = Cross direction

Environmental conditions (WHO/EMA)



Stability of PLA or above works in most conditions.

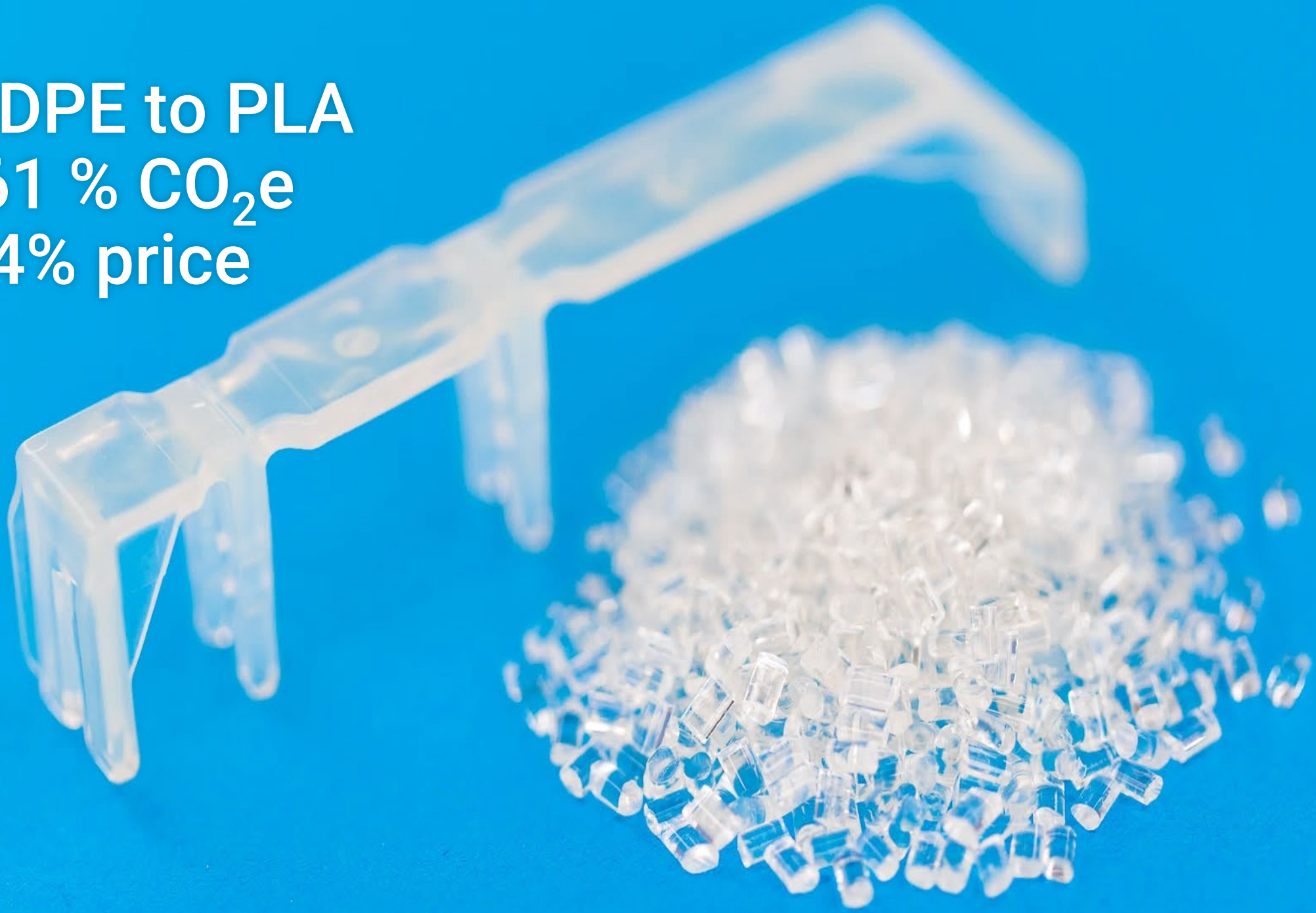
Usage

Effects on packaging

- Barrier properties of PLA: very low
- Barrier properties of PEF:
  2.5x H_2O, 10x O_2 compared to PET
- Impact resistance & elongation at break < PETG
- Robustness depends on clean cut edges
- Temperature stability (thermoformed):
  - MedEco XCB (PLA) 50°C
  - MedEco XCD (PEF) 72°C
  - MedEco XCH (High-Temp PLA) 105°C
- Transparency = PETG, XCH ~ BOPP



HDPE to PLA
-61 % CO_2e
+4% price



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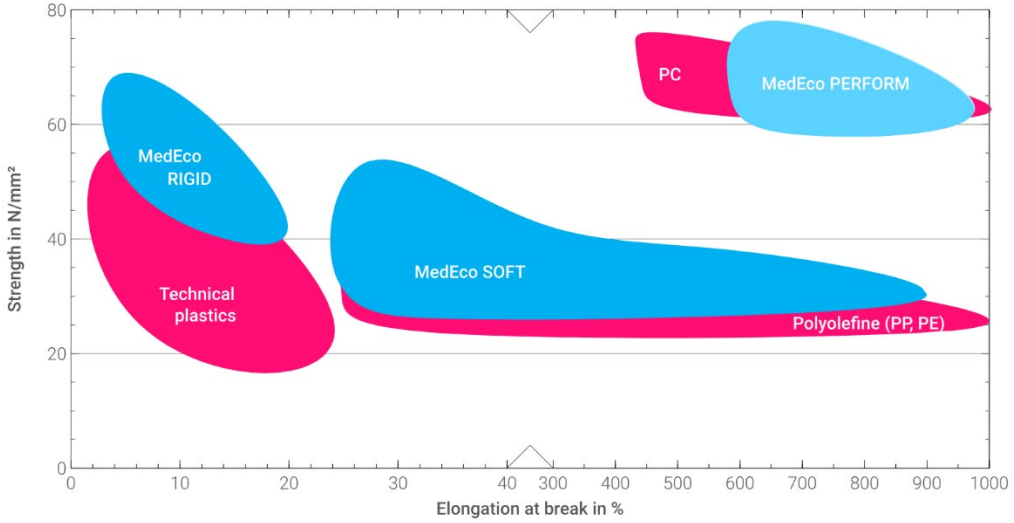
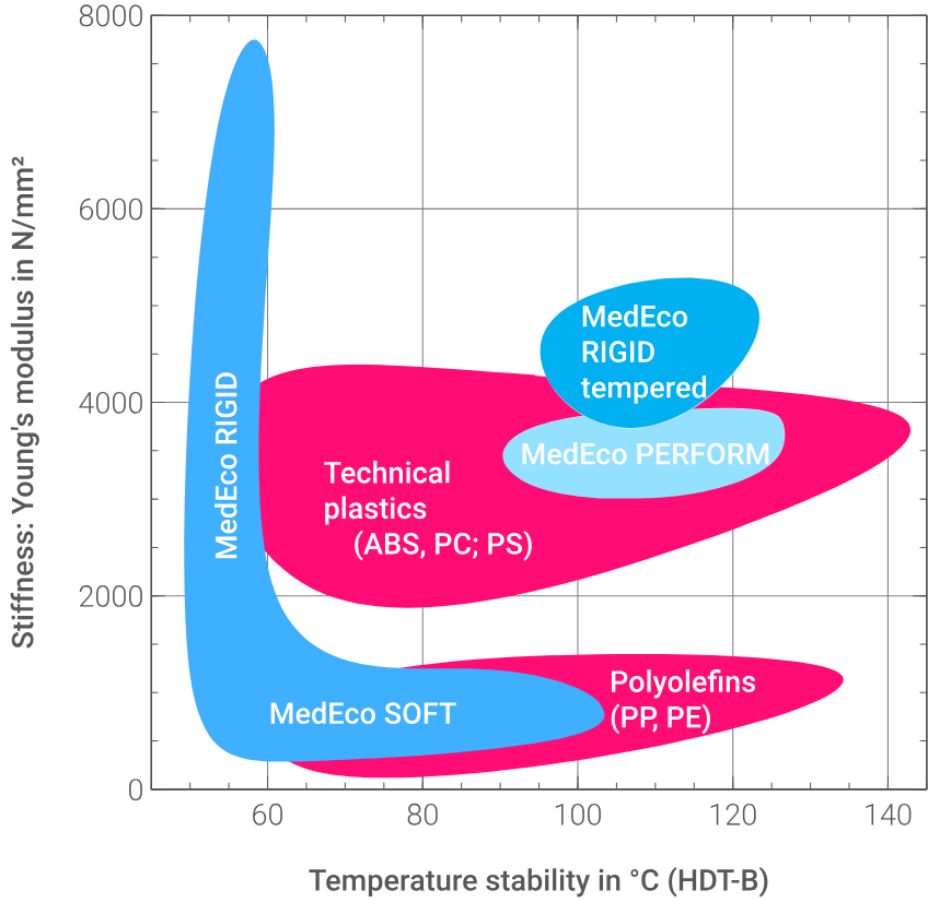
Usage

Effects on devices

- PLA allows for good substitution of ABS, PP and PC in many small to medium sized devices
- Mind the stiffness in design!





But what about PHA/PHB?

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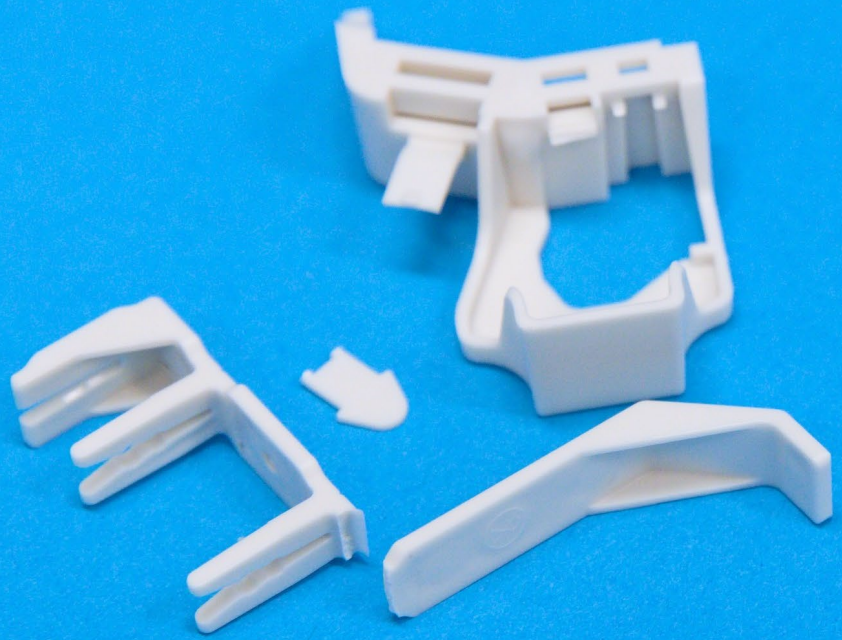



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Annex: Sustainability

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Trash Talk

How End-of-Life Drives Polymer Selection

Dr.-Ing. Julian Lotz




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Premises & Scope

- It‘s about the **phenomenons & methodology**.
- You need to collect data specifically for your applications and **lifecycle scenarios**.
- Global Warming Potential (GWP) is used for a **simplyfied assessment**; reality is more complex and **needs all impact categories** involved.
- There is **no „one fits all“ solution**.

Following slides with data from:

https://plasticseurope.lca-data.com, accessed on 11.01.2026; 20:58 h.

Leal Filho, J. Barbir, E. Carpio-Vallejo, A. Dobri, V. Voronova
Decarbonising the plastic industry: A review of carbon emissions in the lifecycle of plastics production.
in: Science of the Total Environment (999), 2025, https://doi.org/10.1016/j.scitotenv.2025.180337

Franklin Associates, Inc. for The Plastics Division of the American Chemistry Council
Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors.
in: https://www.americanchemistry.com/better-policy-regulation/plastics/resources/cradle-to-gate-life-cycle-inventory-of-nine-plastic-resins-and-four-polyurethane-precursors, accessed 11.01.2026, 20:12 h.

How do we trash our stuff?

Incineration

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Incineration

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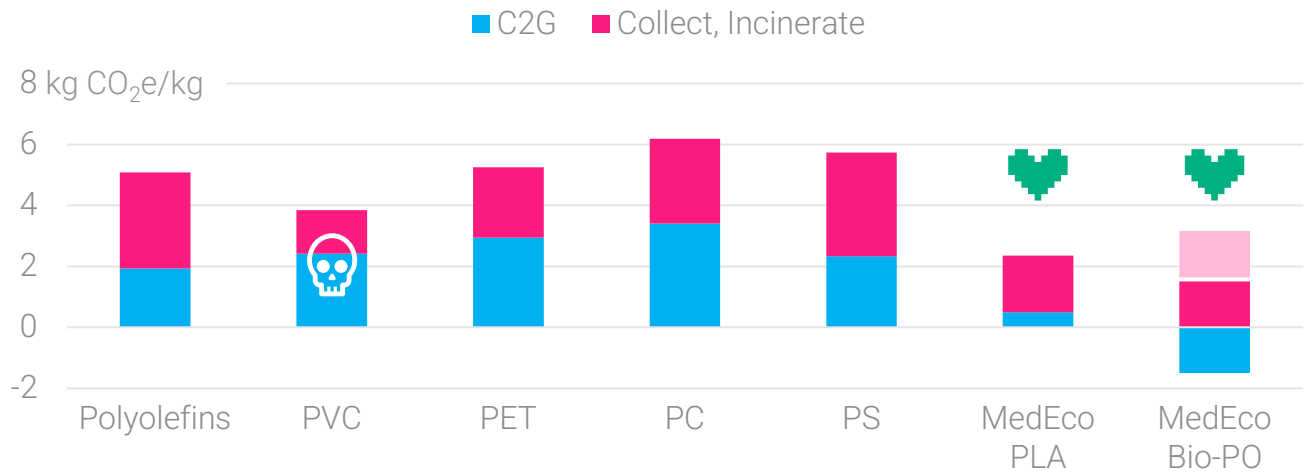

- Biobased polymers = **very low fossil carbon emissions**
- PVC is good in CO_2e, but keep **PCDD/F & HCl** in mind!
- **Net zero?** Difficult.

Then – why even burn the waste?

Landfilling

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Landfilling

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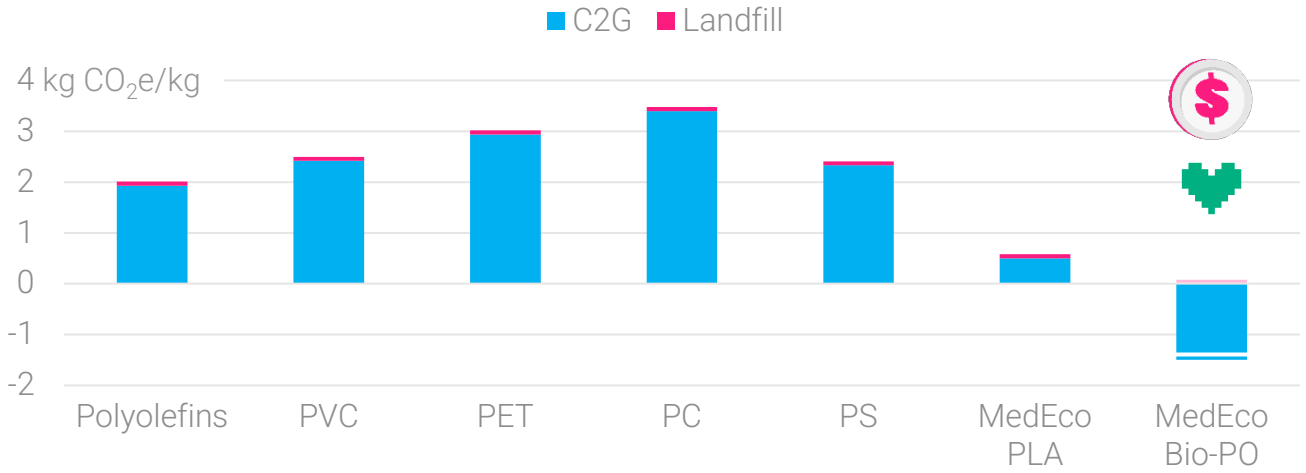
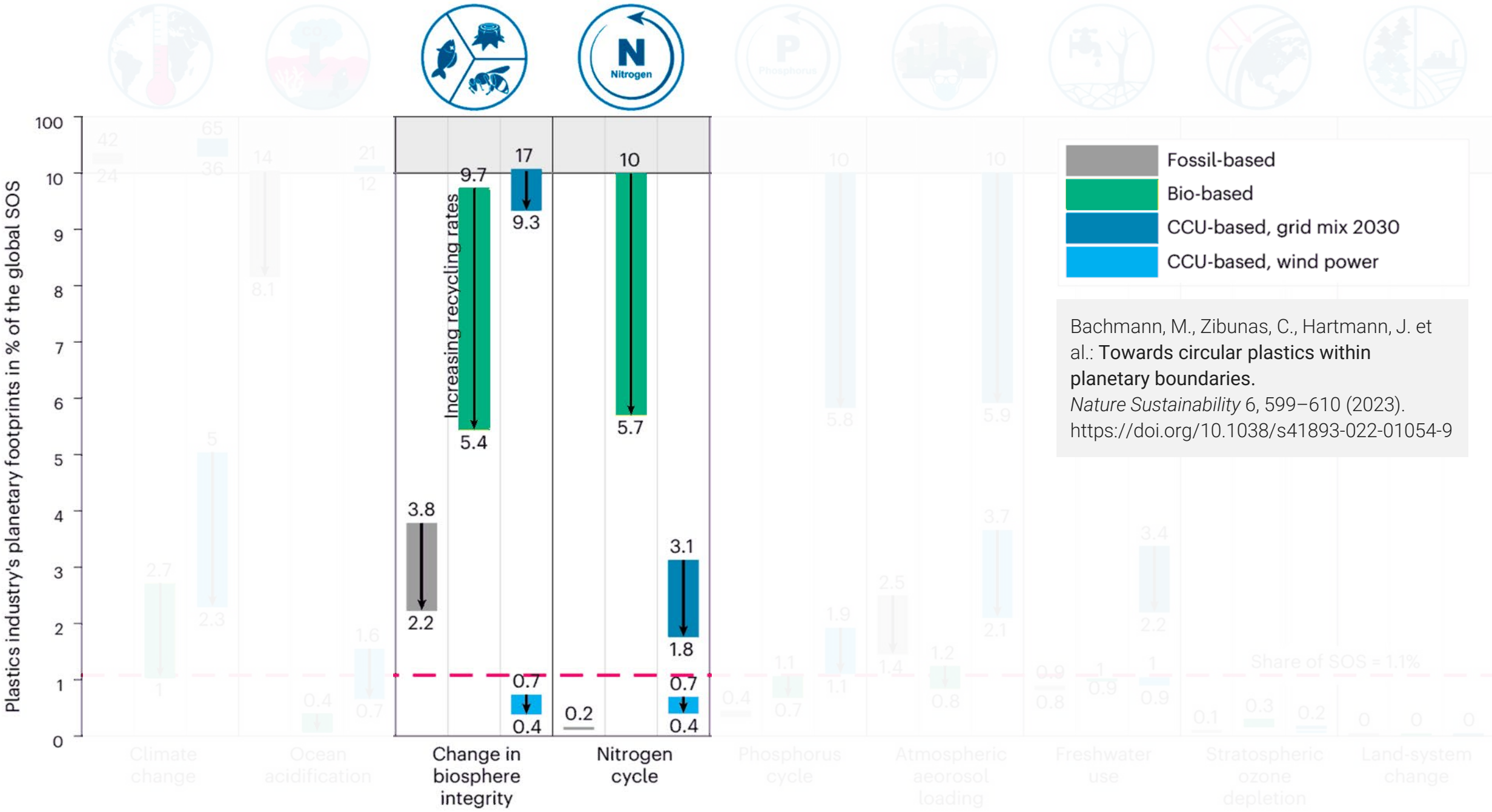


- Biobased polymers = **Carbon Capture & Storage = $$$**
- In fact, **everything is better** with landfilling?

Is landfilling of biobased plastics a great idea?



Bachmann, M., Zibunas, C., Hartmann, J. et al.: **Towards circular plastics within planetary boundaries.**
Nature Sustainability 6, 599–610 (2023).
https://doi.org/10.1038/s41893-022-01054-9

Recycling

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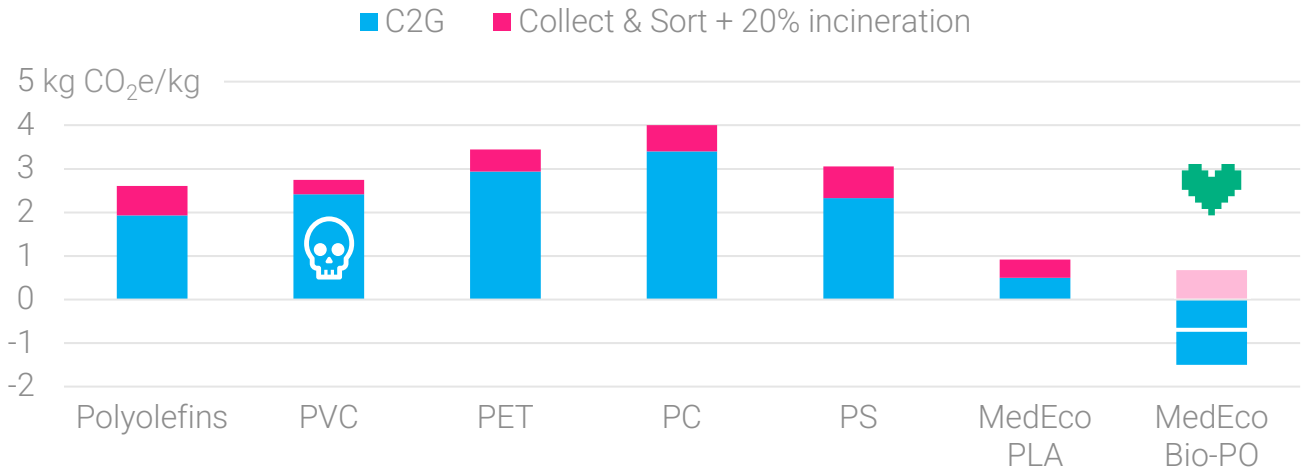
Mechanical Recycling



Scenario: Virgin material, 80%/20% recycling/incineration at EoL

- **Bio-PO** is the best?
- **Biobased + recycling is king** – much lower impact in non-GWP cat.!



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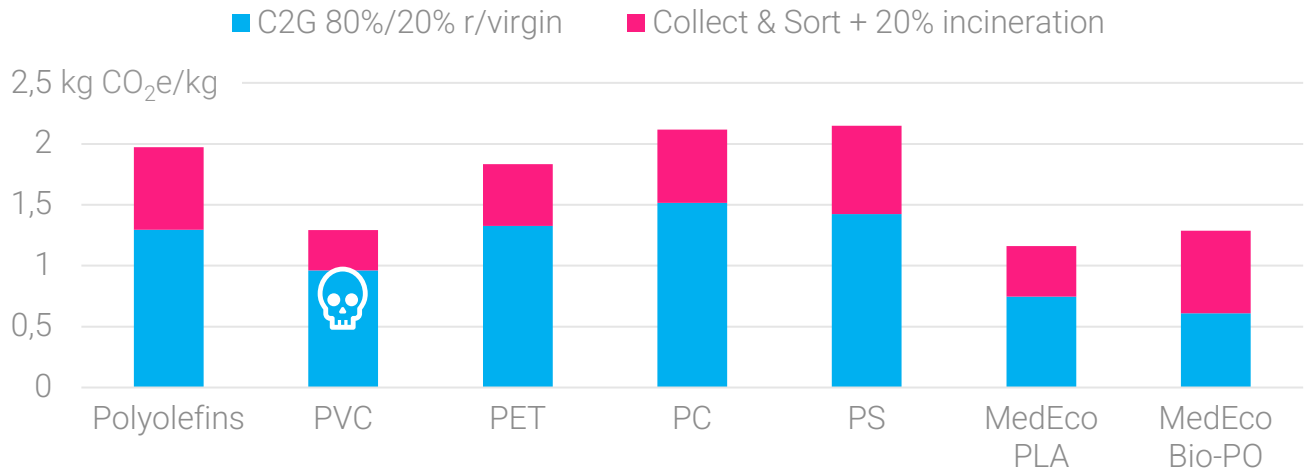
Mechanical Recycling



Scenario: 80% recycling content, 80%/20% recycling/incineration at EoL

Low impact of sterilization & contamination procedures

- Feedstock origin looses much of its significance

Let‘s just do mechanical recycling then!



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Patient Safety?

Formulation consistency?

▶ Closed loops or controlled sources

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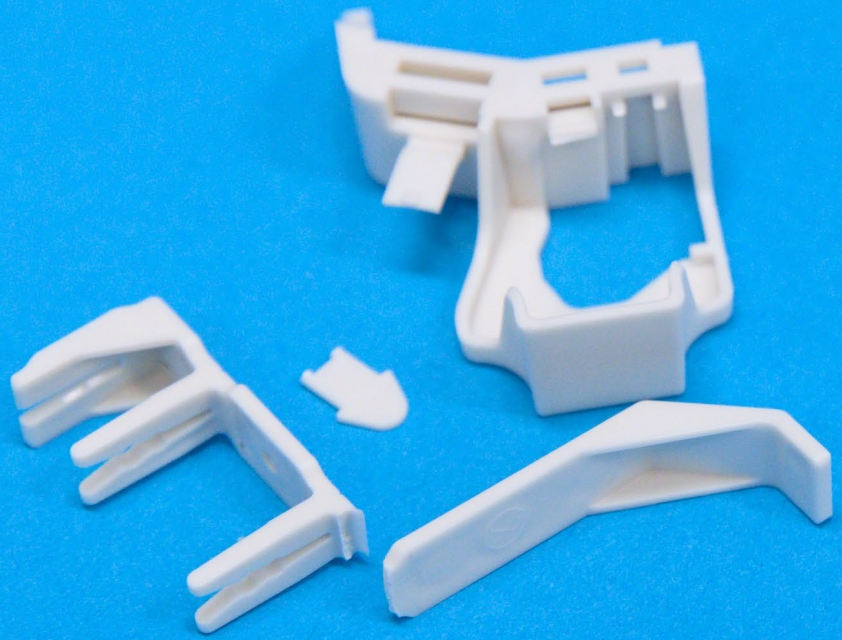



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Decontamination Recycling & sterilization lowers polymer quality.





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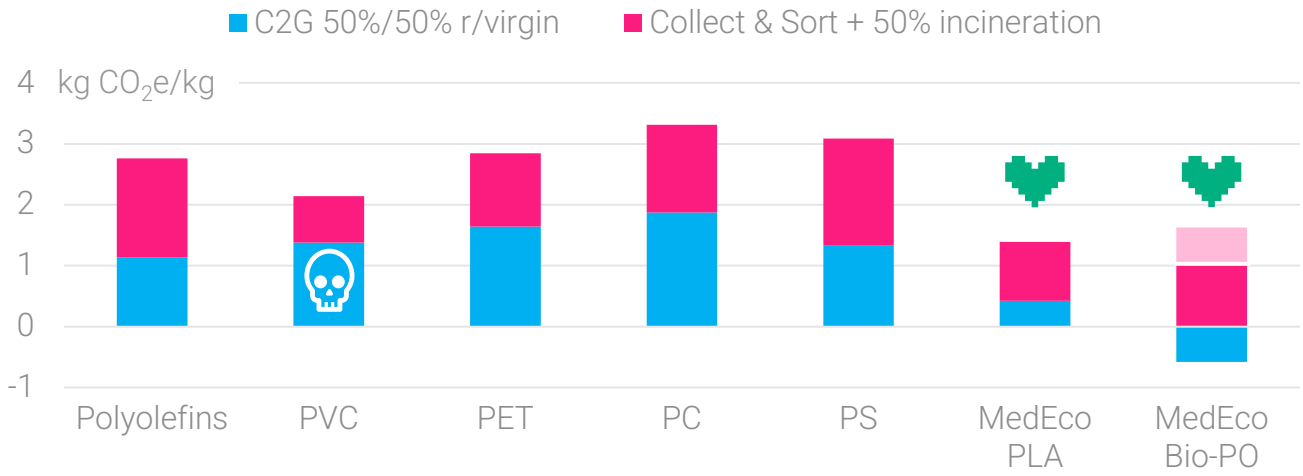
Mechanical Recycling



Scenario: 50% recycling content, 50%/50% recycling/incineration at EoL

High impact of sterilization & contamination procedures

- Back towards incineration results…

No chance for recycling in healthcare?



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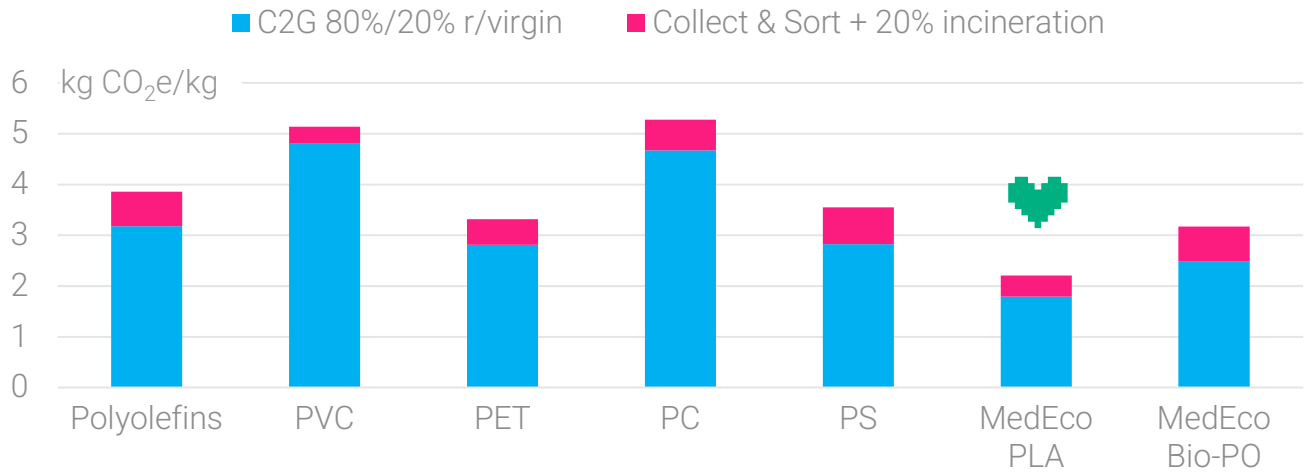
Chemical Recycling



Scenario: 80% recycling content, 80%/20% recycling/incineration at EoL

- Feedstock becomes irrelevant, efficiency in deconstruction wins.

The Lifecycle Landscape

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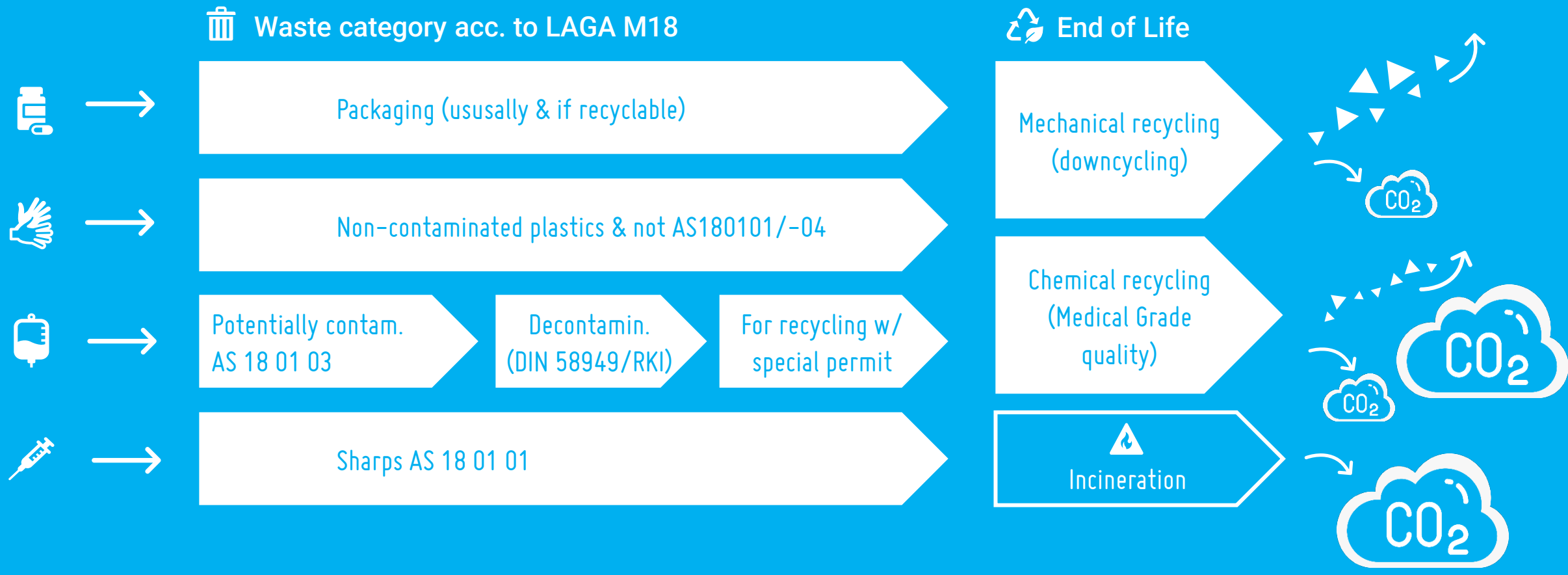
How Medical Waste is Treated (Germany)



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Choosing circular economy capable polymers

Efficiency is determined by:

- Feasibility of logistics
- Degradation due to sterilization & decontamination processes

Closed loops require:

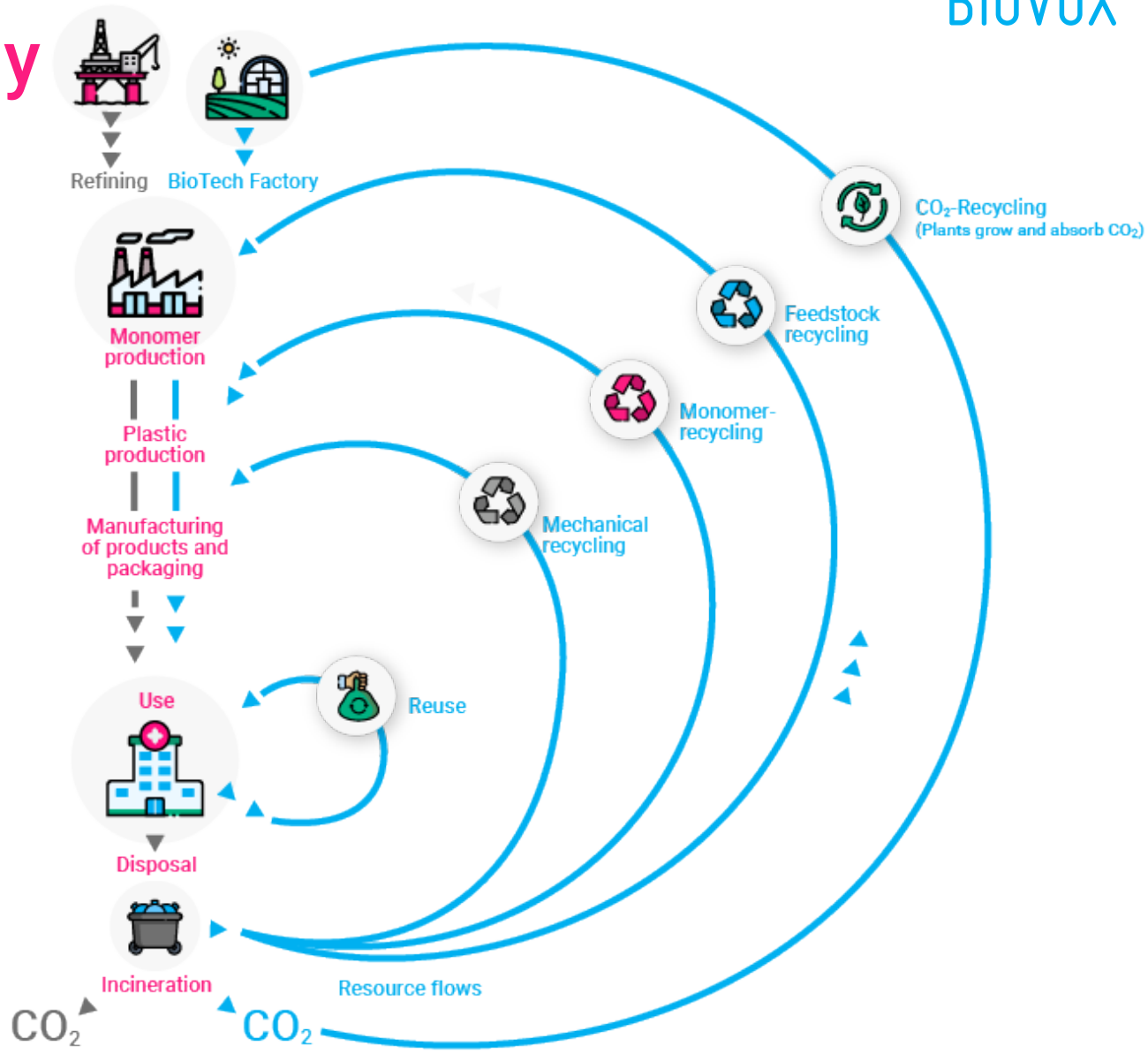
- Highly stable polymers & compounds for mechanical recycling
- De-polymerizable polymers for efficient chemical recycling

If degradation is high:

- Go for efficient chemical recycling

If you can‘t get hold of the waste stream:

- Go for maximum biobased content!



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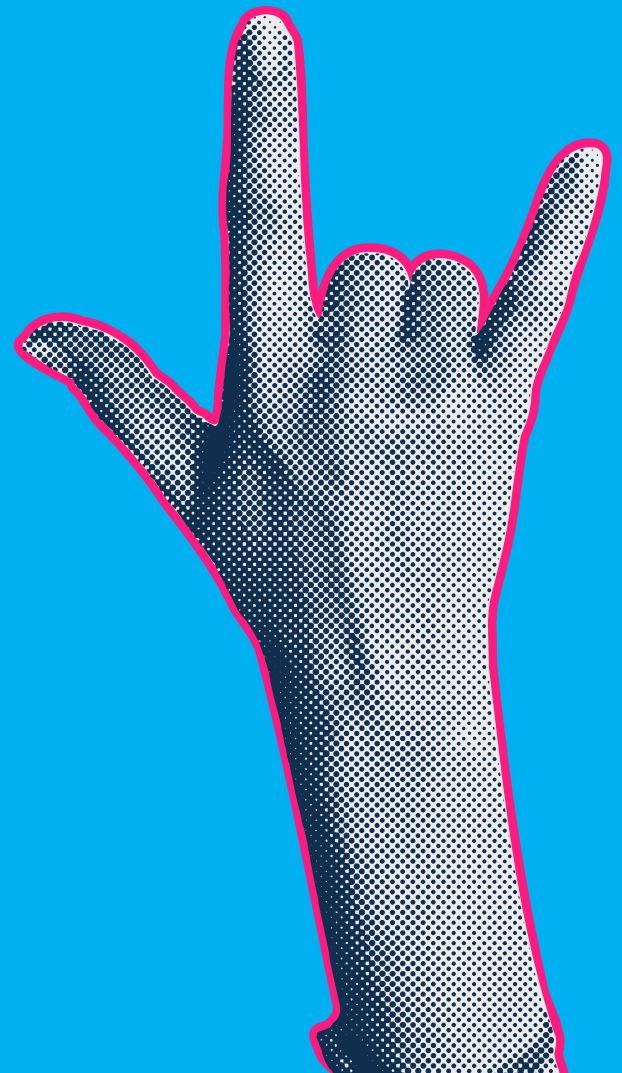
Thinking about lifecycles rocks!



Whom should I discuss further with?

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Whitepaper on Drug Delivery Devices

Sustainable Dosing Pipettes



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