# PLA recycling @ WFBR

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Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

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# PLA recycling

- **Academic perspective**
- ~1000 articles on “PLA” and “recycling”
- 6 articles report reductions in molecular mass or melt flow index after mechanical recycling, but in these cases the PLA is not dried
- Only in 1 recent (2025) paper PLA is properly dried and the reduction in molecular mass is limited
- Emergence of NIAS after mechanical recycling
- Depolymerisation

- **Industrial perspective**
- Recyclers gladly recycle PLA waste separately
- Currently, PLA waste is hardly available
- Two pathways envisioned
  - Mechanical recycling
  - Recycling via depolymerisation

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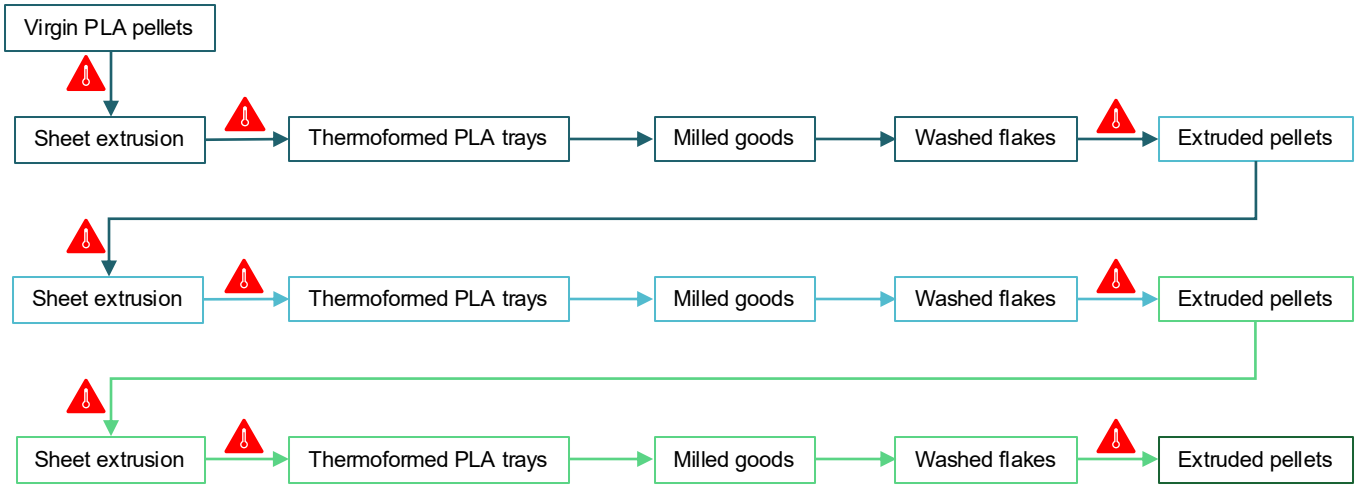
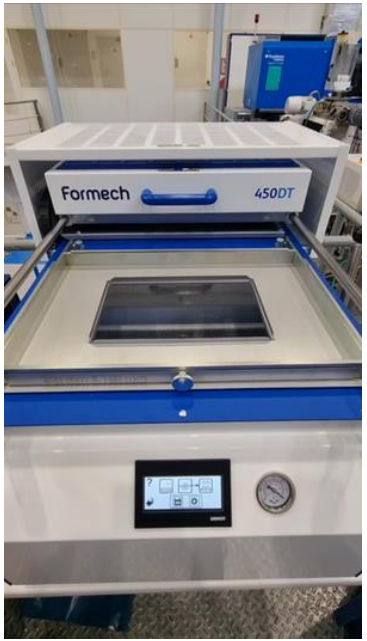
# Repetitive recycling of PLA trays

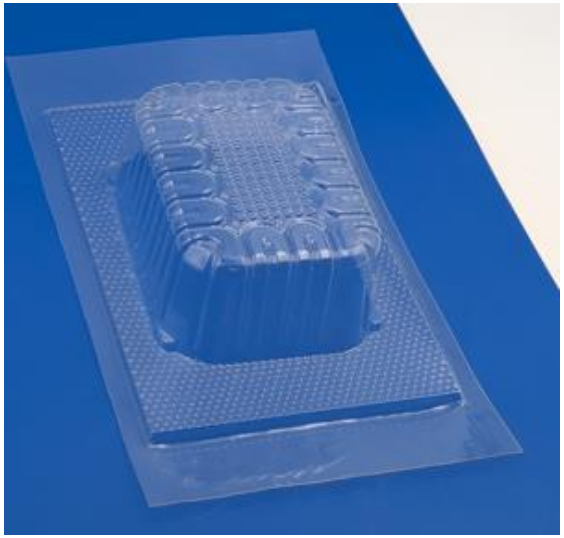



Executed with 2 different types of virgin PLA

- Renew 804 grade
- LX175 grade as reference

# Sheet extrusion and thermoforming



Film casting of ~400 µm thick films and 18 cm wide

Vacuum forming of  sheets to trays

# Milling and washing

**Mechanical grinding**

- 2 step milling (35 mm and 5 mm)

**Washing**

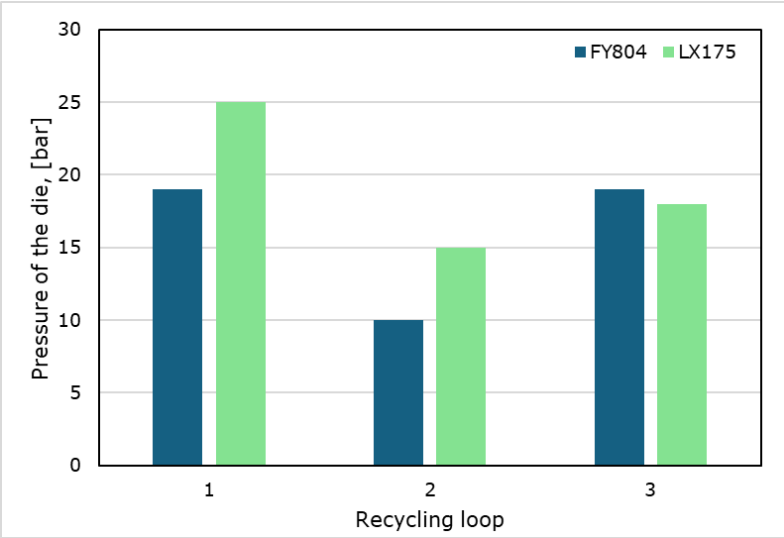
- Hot caustic wash (~80°C with 0.1M NaOH and 1.5 g/L surfactant RP38)
- Rinsing with cold water to pH neutral

**Drying**

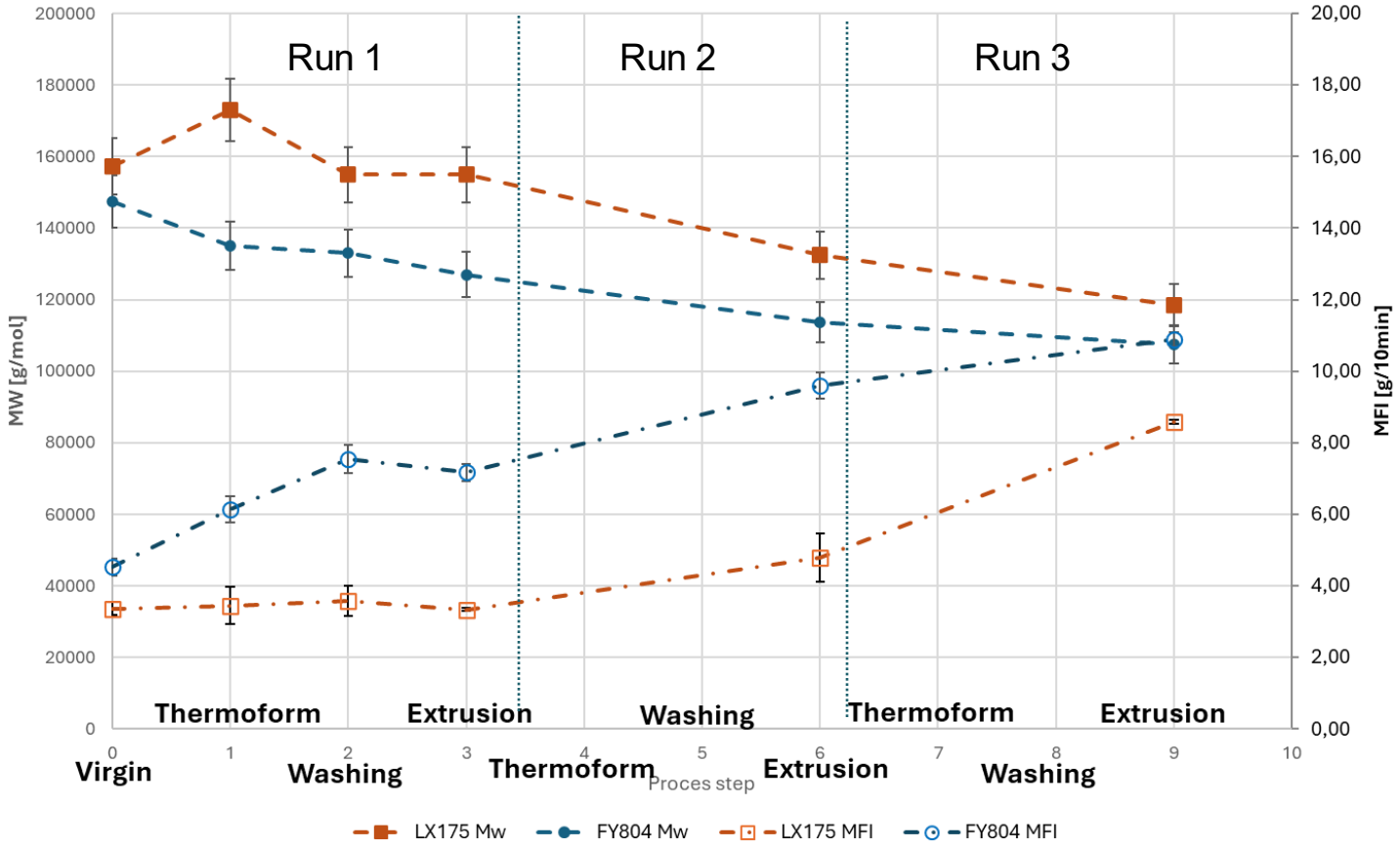
- First to air
- Then 80°C in desiccant dryer


# Mechanical recycling of thermoformed PLA trays

- Extrusion (200°C, 3 kg/h throughput)
- Measuring of MFI, molecular weight and die pressure to monitor possible degradation




# Development of MFI & Mn during repetitive recycling



# Preliminary conclusions

- PLA was easy to process, extrude, sheet extrude, thermoform, mill and wash
- No problems were noted
- The process parameters didn’t change much during the multiple extrusion and film casting loops
- Both types of PLA show limited degradation via Molecular Weight and Melt Flow index measurements

- Recycling possible, but restoration of molecular weight will ultimately be required
  - Solid state post condensation can be a solution

# Solid-state post-condensation

Upcycling opportunities for PLA via SSPC

- Increase of molecular weight via condensation reactions in between $T_g$ and $T_m$
- State of the art procedure for PET recycling
- Facilities at WUR
  - Small scale: Kugelröhr, short-path vacuum distillation
  - Pilot scale: Double cone vacuum tumble dryer

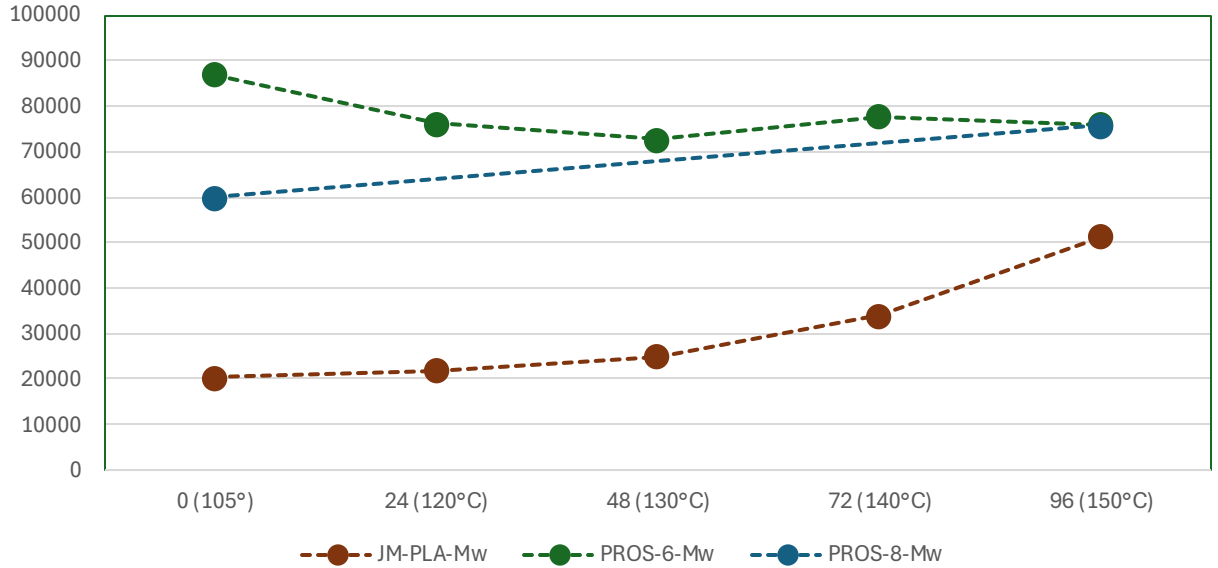
Kugelröhr

Tumble dryer

# First small scale SSPC trial

- Experiment preformed in a Kugelröhr (short-path vacuum distillation)
- Temperature was increased every 24h (from 120°C → 130°C → 140°C → 150°C)
- Pros-6
  - PLA FY804, extruded: 230°C, 3kg/h, not dried
- Pros-8
  - PLA FY804, extruded: 210°C, 1,5kg/h, not dried
- JM-PLA (In-house synthesized low MW PLA )
  - PLA from ring-opening polymerization at WFBR
  - L-lactide (monomer), stannous octanoate (catalyst)

# Small scale SSPC GPC results




| Sample | Increase in Mw |
|---|---|
| JM-PLA | +150% |
| PROS-6 | -12% |
| PROS-8 | +26% |

- Every sample measured twice with GPC (only the first and last sample from PROS-8 was measured)
- Mw increase was possible for in-house WUR sample
- No significant increase measured for partially degraded FY804 material (Pros-6)
- Difference is most likely attributed to presence or absence of active catalyst

# Conclusions mechanical recycling PLA

- PLA trays can be mechanically recycled
- Drying matters (as with any polyester)
- There is a slow decrease in molecular weight during each process step (washing and extrusion)
- Solid state post-condensation is a potential solution to restore the chain length for PLA

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# Thank you.

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