Sustainable plastics based on renewable raw materials

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Karin Molenveld (Karin.Molenveld@wur.nl)

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Introduction: Sustainable plastics

Are plastics sustainable?

- Plastics were developed to replace scarce materials like ivory
- Initially plastics were based on renewable resources
- Plastics have an excellent price/performance ratio

What are current issues?

- Most plastics are produced from finite fossil feedstock and associated with climate change
- Plastics are causing pollution issues (microplastics, plastic soup,...)
- Recycling of plastics is challenging

Sustainable Plastics Technology @ WFBR

- Expertise group Sustainable Plastics Technology
- Wageningen Food & Biobased Research
- Part of Wageningen University and research
- Topics:

Biobased plastics

Plastics recycling

Biodegradation of plastics

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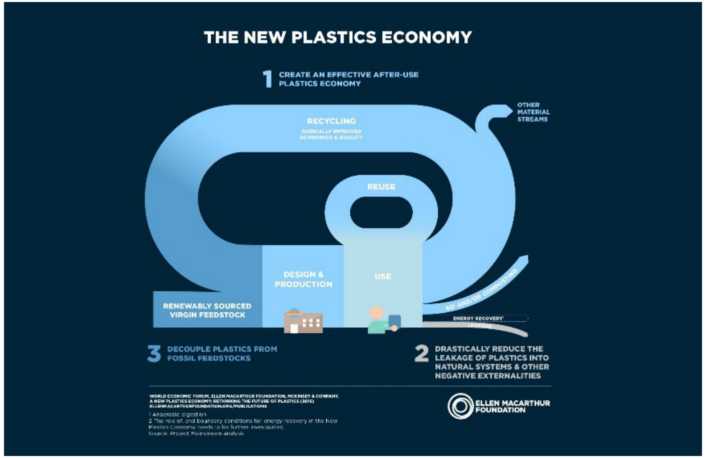
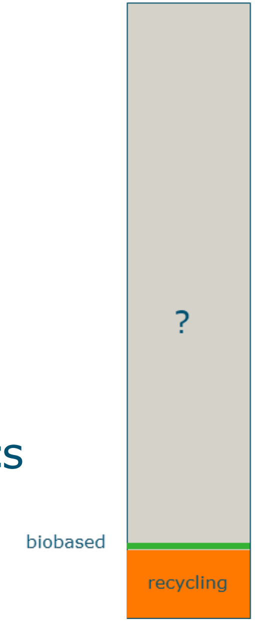
Goals vs reality



1. After use plastics economy
2. Reduce leakage into the environment
3. Decouple from fossil feedstocks

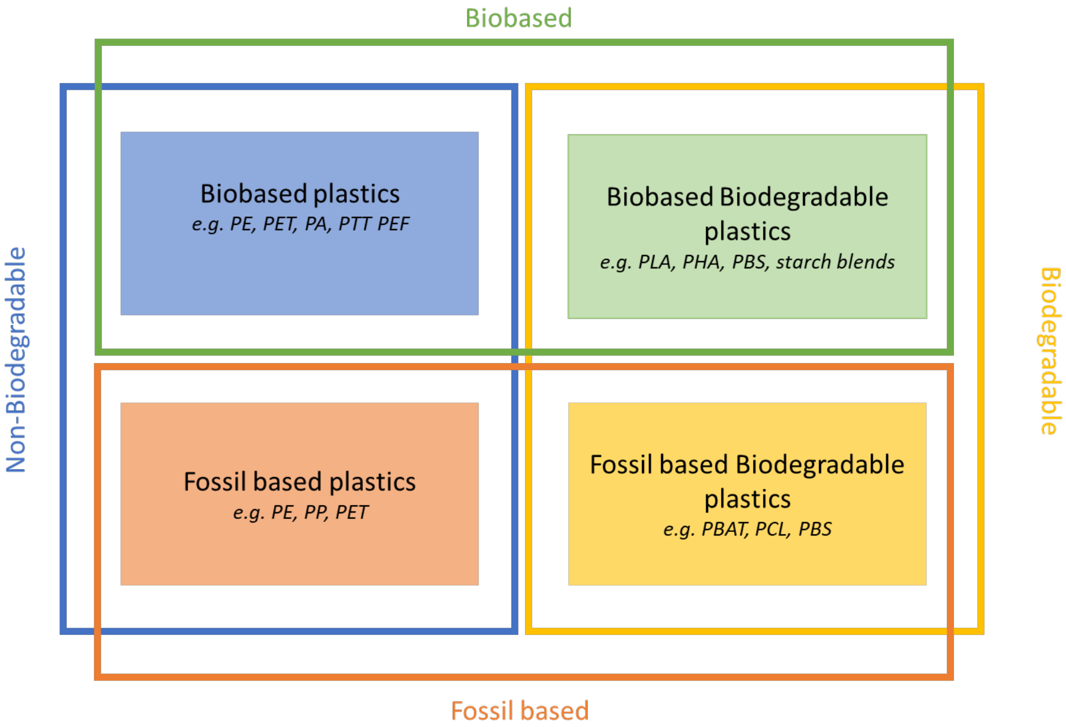
- ~ 10% recycled plastics
- ~ 1% biobased plastics
- ~90% virgin fossil plastics



We need to move to non-persistent plastics based on alternative carbon sources with improved recycling opportunities.

Biobased Plastics ≠ Biodegradable plastics

- Based on biomass or CO_2
  - Performance
  - Feedstock availability
  - Efficient production



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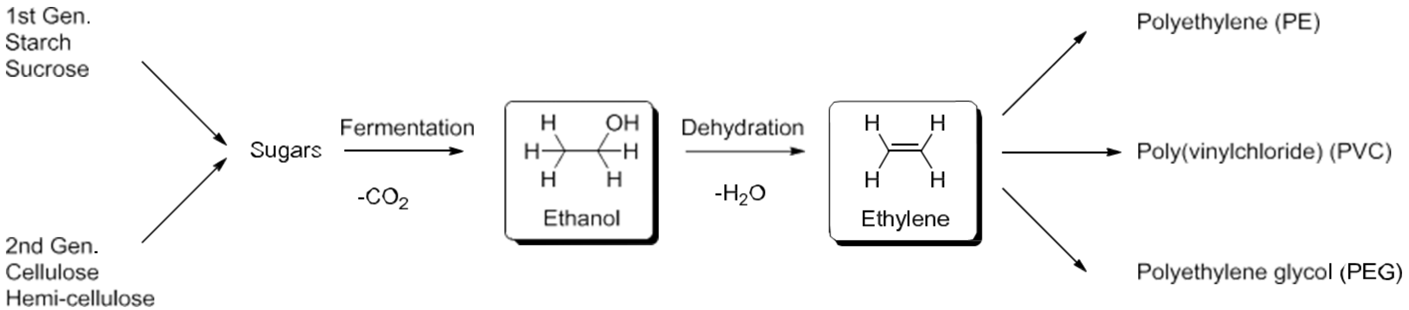
Development approaches

1. Production of drop-inn biobased plastics
    - Direct production from biomass
    - Adding biobased feedstock to the cracker
2. Production of new biobased plastics
    - Direct production of biomass

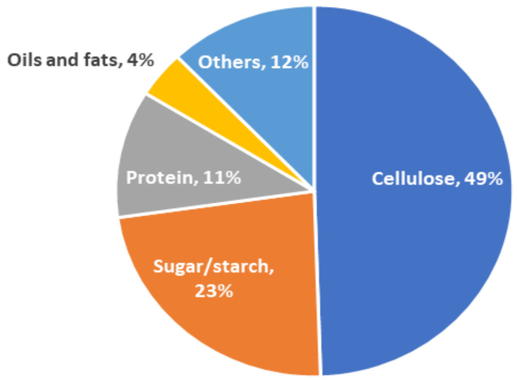
Production of biobased PE from biomass

- Braskem: PE from sugar cane, 200kton facility in Brasil
  - Performance: Identical to fossil based PE
  - Feedstock availability: Sugars are widely available and in the future lignocellulosic feedstock can be used
  - Production efficiency: 1 ton bioPE requires 3.2 ton sugar



Production of certified biobased PE

- Adding bionafta as a co-feed to current crackers
  - Performance: Identical to fossil based PE
  - Feedstock availability: Limited availability of (waste) fats and oils
  - Production efficiency: 1 ton bionafta requires 1.1 ton vegetable oil

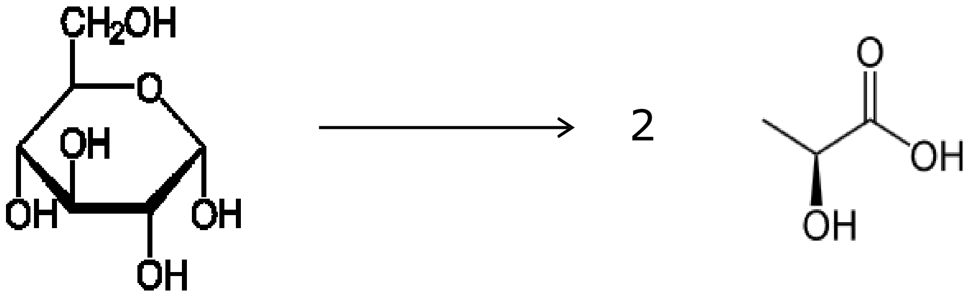


Source: Piotrowski, S et al. 2015

Feedstock	Estimated global availability in million tons
Tall oil	1.8
Waste cooking oil	5.1
Waste fats	7.5 (tallow)
Castor oil	0.74

Production of PLA (novel biobased polymer)

- Natureworks and Total Corbion: PLA from corn or sugar cane
  - Performance: Good properties but different from fossil-based
  - Feedstock availability: Sugars are widely available and in the future lignocellulosic feedstock can be used
  - Production efficiency: 1 ton PLA requires 1.4 ton sugar (90% carbon efficiency

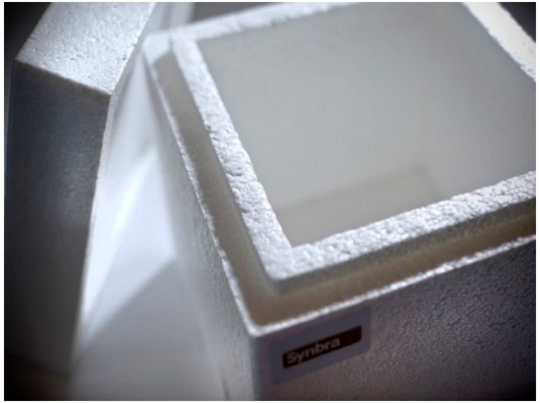


Polylactic acid (PLA)

- Most mature biobased plastic, 2 main producers ~ 300kton annually
- Various end-of-life options (chemical, mechanical, organic recycling)
- Good environmental footprint and affordable
- Properties in the range of PET and PS (stiff, transparent)
- Various grades for different production techniques

Application development

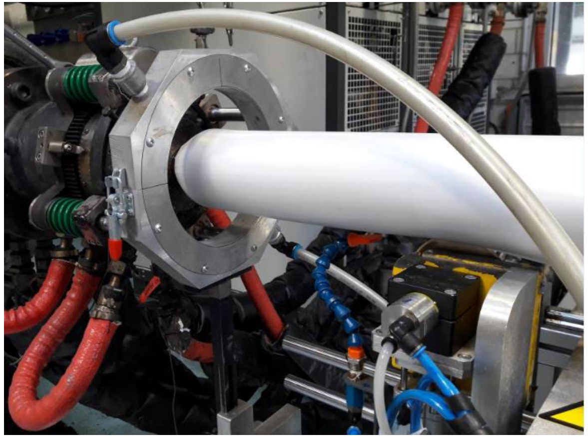
Coffee cups



Expandable bead foam

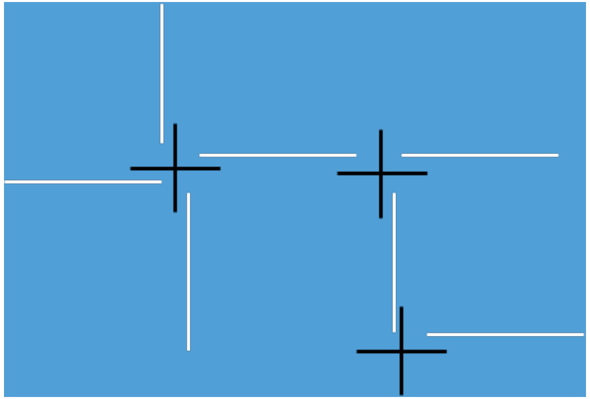
Plant pots

Example extrusion foaming

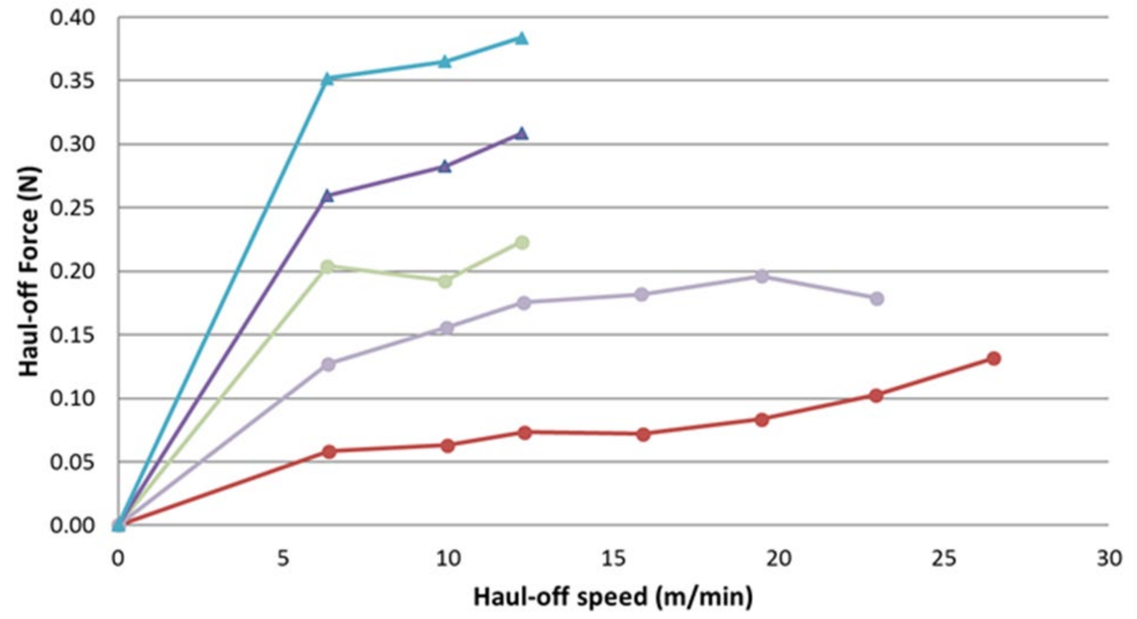


- Focus; increasing the melt strength of PLA
  - Polymer blends
  - Additives
  - Introducing crystallinity (physical crosslinks)

White: PLLA chains
Blue: Starch shaped PDLA



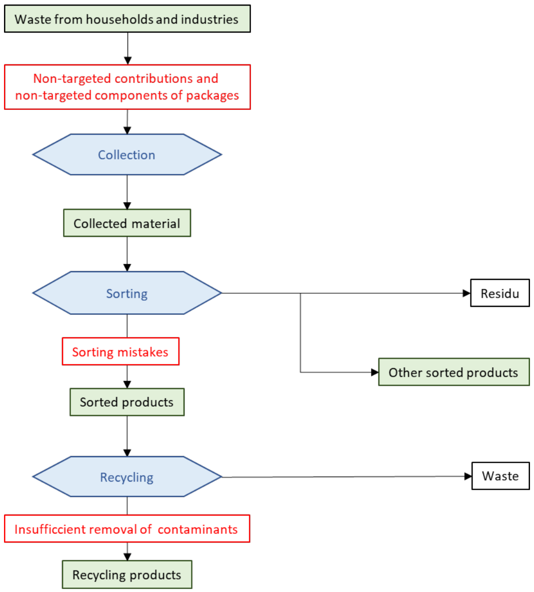
Effect on melt strength as measured via haul-off



Red line is PLA reference and addition of various 5% star shaped PDLA types

End-of-life

- In material and product development end-of-life needs to be considered
- How do materials fit in current and future waste management systems?
- Develop materials that have more opportunities at end-of-life
  - Mechanical, Chemical, Organic recycling
  - Polyesters vs Polyolefins
- Focus on biobased polyesters that offer more opportunities at EOL as compared to current fossil based plastics as this adds to their sustainability



Concluding remarks

- Developing a sustainable plastics economy is extremely challenging
- Various strategies can be envisaged and important factors are:
    - Feedstock availability and feedstock selection
    - Efficient conversion routes
    - Product development and redesign
    - Considering end-of-life is essential

Thank you

Karin.Molenveld@wur.nl