Bio-based and Biodegradable Plastics in Denmark
Market, Applications, Waste Management and Implications in the Open Environment
Contents

• National Plastic Center
• Introduction and objectives
• Definitions
• Feedstock and land use
• Market for bio-based and biodegradable plastics
• Applications
• Waste management
• Standards and Certifications
• Life cycle assessment as a tool
Environmental Protection Agency
Bio-based and biodegradable plastics in Denmark
National Plastic Center – Bringing together the Danish plastics efforts

- Value chain collaboration
- Guide businesses in transition to a circular plastics consumption
- Builds knowledge on plastics and communicate it to citizens and businesses
- Identify barriers for reuse and recycling of plastics in Denmark
- Develop design manuals for plastics to encourage design for reuse and recycling.
- Contribute to the development and establishment of common European design manuals
Introduction and objectives

- Considerable interest in bioplastic from consumers and industry
- Biodegradable plastics are often seen as a potential part of the solution to littering and environmental plastic pollution

Aim:
- Literature review
  - Build knowledge of bio-based and biodegradable plastics as an alternative to conventional plastics
  - Behaviour under different conditions
- Description of existing standards
- Feedstock
- Applications
- Effects in waste management
Definitions – Bio-based

- **Bio-based plastics**
  - “…a polymer composed or derived in whole or in part of biological products issued from bio-mass (including plant, animal, and marine or forestry materials)”

- **Drop-in Polymers**
  - Bio PET
  - Bio PE
  - Bio PP

- **Novel polymers**
  - PLA
  - PEF
Definitions - Biodegradable

- Biodegradable plastics
  - Biodegradation: A degradation caused by biological activity
  - Biodegradable plastic: A degradable material in which the degradation results from the action of microorganisms and converted to water, carbon dioxide and/or methane and a new cell biomass

- Both fossil and/or bio-based

<table>
<thead>
<tr>
<th>Environment</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Composting</td>
<td>High temperature (~58°C) Fungi and bacteria</td>
</tr>
<tr>
<td>Anaerobic Digestion Plant</td>
<td>Elevated temperature (20-45°C) Bacteria only</td>
</tr>
<tr>
<td>Home Composting</td>
<td>Ambient temperature (20-30°C) Fungi and bacteria</td>
</tr>
<tr>
<td>Soil</td>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Marine Water</td>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Landfill*</td>
<td>Ambient to elevated temperature</td>
</tr>
</tbody>
</table>

* landfill may be more or less aggressive throughout its life depending upon how it is managed. As it transitions from aerobic to anaerobic, material that need aerobic conditions may not biodegrade. As biodegradation takes place, the biological activity will raise the temperature.
Feedstock and land use

- Estimated 0.45 – 2.88 million hectares for current production, (feedstock dependent)
- Less than 0.1 % of total agricultural land
- Predicted annual growth in production 2 – 3 % annually
Market for bio-based and biodegradable plastics

Split of the global production capacity of bio-based or biodegradable plastics, by polymer type

- **Predicted <1 % of total plastic market**
  - Around 1.18 – 1.28 million tonnes (2016)
  - Estimated 6,500 tonnes of biodegradable products on the market within Northern Europe (including Denmark, Norway, Finland and Sweden)
Applications


- Packaging is the most common market area in Europe for bio-based and biodegradable plastics

- Most common applications of certified compostable plastics on the European market:
  - Carrier bags, biowaste bags
  - Rigid packaging, other flexible packaging
Applications

Most common applications of certified compostable plastics on the European market

<table>
<thead>
<tr>
<th>Application</th>
<th>Share of product certifications$^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier bags</td>
<td>29%</td>
</tr>
<tr>
<td>Biowaste bags</td>
<td>28%</td>
</tr>
<tr>
<td>Rigid packaging (food and non-food)</td>
<td>4%</td>
</tr>
<tr>
<td>Other flexible packaging (food and non-food, not incl. carrier or biowaste bags)</td>
<td>12%</td>
</tr>
<tr>
<td>Agricultural films</td>
<td>2%</td>
</tr>
<tr>
<td>Single use trays and plates$^1$</td>
<td>6%</td>
</tr>
<tr>
<td>Single use cups$^2$</td>
<td>4%</td>
</tr>
<tr>
<td>Single use cutlery$^3$</td>
<td>2%</td>
</tr>
<tr>
<td>Bags for loose products (vegetables and other)</td>
<td>3%</td>
</tr>
<tr>
<td>Coffee pads, filters and capsules</td>
<td>3%</td>
</tr>
</tbody>
</table>

Notes:
1. Plates will be banned across Europe under the SUP Directive Article 5
2. May be subject to national bans or restrictions under SUP Directive Article 4
3. Will be banned across Europe under the SUP Directive Article 5
Applications – Denmark

• There is a small market for biodegradable plastics in Denmark
  - Estimated 550 tonnes of compostable plastics used in Denmark annually.
  - The size of the Danish market is hard to measure due to its limited applications

• Desk-based research and interviews with stakeholders suggests that the single biggest use of biodegradable plastic in Denmark is in the form of compostable food waste bags

• Currently bio-based non-degradable plastics are only used in niche products
  - Key growth areas are predicted to be novel plastics with additional functionality.
Waste management – Food waste (EU scale)

**Italy**
- Widespread use of compostable plastics
  - Primarily to increase food waste capture
- Generally with a secondary composting stage to stabilize the digestate
- Minimum requirement that compost should mature for at least 90 days
  - Digestate can only be sold as a product if it has undergone this secondary composting stage

**Germany**
- Compostable plastics in Germany are not widely accepted
- Focus on biogas generation rather than digestate
  - Digestate is a “byproduct” of the process
- Fresh compost is typically applied directly to agricultural land
  - Composted for as little as 6-8 weeks
Waste management – Food waste (Denmark)

• Half of the Danish municipalities separately collect organic waste
  - Compostable plastic (34 %)
  - Fossil plastic (57 %)
  - Paper ( 3 %)

• Anaerobe digestion plants in Denmark are primarily set up to receive agricultural waste and mainly receive household waste as a ‘pulp’ after pre-treatment
  - Incompatible with compostable plastics due to the short processing duration
  - Issues with plastics becoming stuck in machinery
  - Rejects from pre-treatment are in most cases incinerated
  - Few cases of recycling from fossil bags

• Remains of any plastic is not seen as an issue due to pre-treatment
Waste management – recycling I

- “…compostable plastic mixed with recyclable plastics will reduce the mechanical properties of the recyclates”
  - Mainly for PET (less than 1% PLA acceptable)
  - Up to 10% are accepted in some 2D plastics

### Findings

<table>
<thead>
<tr>
<th>PLA Content</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3% in PET</td>
<td>0.3% PLA in PET recycling causes issues</td>
</tr>
<tr>
<td>0.1% PET</td>
<td>At 0.1% PLA can cause issues with appearance in PET bottle recycling</td>
</tr>
<tr>
<td>1-2%</td>
<td>1-2% of PLA in recycled PET yarn is acceptable</td>
</tr>
<tr>
<td>10%</td>
<td>10% of Starch based films or PLA films are acceptable in a sorted plastic film mixture, with no significant negative effect on mechanical properties</td>
</tr>
<tr>
<td>5%</td>
<td>Up to 5% of PLA or PHB does not have a negative impact on the recycling of PP film</td>
</tr>
<tr>
<td>3%</td>
<td>3% of PLA in PP (film) recycling is acceptable</td>
</tr>
</tbody>
</table>

### Notes

1. Possible higher tolerance due to textiles
Waste management – recycling II

• Positive sorting leaves non target polymers in reject stream (for incineration)
  - Potential for sorting out PLA or other polymers if there is a marked demand

• Potential for higher contamination in film fraction than in rigid plastic
  - Due to technologies used for sorting

• Little concern of contamination of plastic streams for mechanical recycling due to application in bags for organic waste
Possible applications – biodegradable plastics

Possible future applications:
• Shot gun shells
• Mulch films/agriculture films
• Blades and wires for grass trimmers
• Plant clips
• Tree protection
• Sport fishing gear
• Plastic parts in fireworks

Where items can be easily recovered or prevented from littering, the focus should be on incentivising appropriate behaviour
Standards and Certifications

- Only exist for industrial treatment (e.g. composting)

- Lack of harmonized standards
  - Bio-based content
  - Biodegradation in the open environment

- A major limitation of current standardised tests is their lack of analysis in the field or in anaerobic conditions.

- Degradation rates vary with temperature
  - mineralization rate of 30% at 15°C → 80% at 28°C within one year (soil, starch blend polymer)

- Biodegradable has little or no meaning without a clear specification of the exact environmental conditions that this process is expected to occur in, e.g.
Life cycle assessment as a tool

- Case by case evaluation (product specific)

- Origin of feedstock highly impact the results
  - Primary vs secondary raw materials

- Advantages (bio-based):
  - Reduced climate change potential
  - Reduced consumption of fossil resources

- Disadvantages (primarily from feedstock production):
  - Increased acidification
  - Eutrophication
  - Human toxicity

- Some considerations regarding agricultural intensification from feedstock production
Next step

• **Basis for further work and information**
  - Further studies on biodegradation under Danish conditions
  - Possible future applications

• **Ban on non-degradable shot wads**
• **Knowledge building on micro plastics in sludge and digestate**
• **Sector collaborations**
  - e.g. agriculture, detail or HORECA (hotel/restaurant/café)
Questions
Thank you for your attention!

Jesper Skovby Jørgensen

Environmental Protection Agency

Cirkulær Økonomi & Affald

Tolderlundsvej 5 – DK-5000 Odense C

Phone: +45 20 61 42 20

Mail: jespj@mst.dk