BIO-END-OF-LIFE OF TEXTILES

Performance Days, Munich, April 27th, 2017
TOPICS

• **OWS**
  • Managed end-of-life
  • In-situ biodegradation
• DRANCO technology – UG, 1983 (pilot in 1984)
• Founded in 1988
• Consolidated sales (2012-2015): 20 million €/yr
• Export: 90%
• 75 employees
• Head office: Gent, Belgium
• Affiliates: OWS Inc., Dayton, Ohio, USA
  DRANCO N.V.
  BES GmbH, Germany
• Partner: DJK International, Tokyo, Japan
ANAEROBIC DIGESTION PLANTS
• ‘One-stop’ laboratory for biodegradability & compostability testing
• Strictly independent
• Quality control: ISO 17025

• Recognized by all certification bureaus worldwide

• Active in standardization: CEN/ASTM/ISO
• Member of several certification committees & industrial associations (EuBP, BBP,...)
• More than 25 years of experience
• 3,000+ samples tested for 800+ clients
### REFERENCES

<table>
<thead>
<tr>
<th>Category</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Polymers</td>
<td>BASF, Bio-Fed, Corbion, Du Pont, Kuraray, NatureWorks, Novamont,…</td>
</tr>
<tr>
<td>Paper &amp; Board</td>
<td>Ahlstrom, Huhtamaki, Int. Paper, Kuan Chun Paper, Pactiv, UPM,…</td>
</tr>
<tr>
<td>Packaging</td>
<td>Alcan Packaging, Amcor, Mondi Packaging, Sealed Air, Tetra Pak,…</td>
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<tr>
<td>Consumer Goods</td>
<td>Henkel, Kimberly-Clark, Lenzing, Nestlé, P&amp;G, Sara Lee, SCA, Unilever,…</td>
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<tr>
<td>Inks &amp; Masterbatches</td>
<td>PolyOne, CIBA, Chimigraf, Flint, Sun Chemical, Wacker,…</td>
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<td>Films &amp; Bags</td>
<td>Because We Care, Cortec, Sabic, Sphere, WeiMon, Wuhan Huali,…</td>
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<tr>
<td>Food Service Ware</td>
<td>Medac, Minima, Seda, Smurfit Kappa, Solo Cup,…</td>
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<tr>
<td>Other categories</td>
<td>Smithers-Oasis, EBPA, EuBP,…</td>
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<tr>
<td>Oxo-degradable</td>
<td>CIBA, Goody (ACCC), Wells Plastics, Symphony, EPI, EconVerte,…</td>
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<tr>
<td>Enzyme-mediated</td>
<td>Enzymoplast, ECM, Bio-Tec,…</td>
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</table>
MEMBERSHIPS

- Official Belgian delegate
  - TC 38/WG 30: Tests for Biodegradability

- Official Belgian delegate
- TC 261/SC 4/WG 2: Packaging – Degradability
- TC 249/WG 9: Biodegradable Plastics
- TC 411: Bio-based Products

- D 20.96: Biodegradable Plastics
- E 47.06: Chemical Fate
- D 2.N.03: Eco-evaluated Hydraulic Fluids
- D 34: Waste Management

- FNK 103.2: Bioabbaubare Kunststoffe
TOPICS

• OWS
• Managed end-of-life
  • Industrial composting
  • Home composting
  • Anaerobic digestion
• In-situ biodegradation
COMPONENTS OF COMPOSTABILITY

Environmental safety

- Chemical characteristics (Heavy metals)
- Ecotoxicity (Effect on plants)

Degradation

- Biodegradation (Degradation on a chemical level)
- Disintegration (Degradation on a physical level)
BIODEGRADATION ≠ DISINTEGRATION

Disintegration (Thickness!)

Biodegradation

\[ \text{CO}_2 \]

\[ \text{H}_2\text{O} \]
**STANDARDS ON INDUSTRIAL COMPOSTABILITY**

- Standards: tests and criteria

<table>
<thead>
<tr>
<th>Worldwide</th>
<th>Europe</th>
<th>US</th>
<th>Australia</th>
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<tbody>
<tr>
<td>ISO</td>
<td>EN 14995</td>
<td>ASTM D6400</td>
<td>AS 4736</td>
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<tr>
<td>PLASTICS</td>
<td>ISO 17088</td>
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<tr>
<td>PACKAGING</td>
<td>ISO 18606</td>
<td>EN 13432</td>
<td></td>
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<tr>
<td>PAPER</td>
<td></td>
<td></td>
<td>ASTM D6868</td>
</tr>
<tr>
<td>COATING</td>
<td></td>
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</table>
• Maximum 49% of inorganic content

• Heavy metal limits: inks!

<table>
<thead>
<tr>
<th></th>
<th>Zn</th>
<th>Cu</th>
<th>Ni</th>
<th>Cd</th>
<th>Pb</th>
<th>Hg</th>
<th>Cr</th>
<th>Mo</th>
<th>Se</th>
<th>As</th>
<th>F</th>
<th>Co</th>
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</thead>
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<tr>
<td><strong>EU</strong></td>
<td>150</td>
<td>50</td>
<td>25</td>
<td>0.5</td>
<td>50</td>
<td>0.5</td>
<td>50</td>
<td>1</td>
<td>0.75</td>
<td>5</td>
<td>100</td>
<td>-</td>
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<tr>
<td><strong>USA</strong></td>
<td>463</td>
<td>189</td>
<td>45</td>
<td>5</td>
<td>125</td>
<td>1</td>
<td>265</td>
<td>5</td>
<td>4</td>
<td>49</td>
<td>-</td>
<td>38</td>
</tr>
</tbody>
</table>
BIODEGRADATION = MINERALIZATION

Polymers

↓

Oligomers

↓

Monomers

↓

Biochemicals (alcohols, acids, etc.)

↓

Minerals (CO₂, H₂O, CH₄, etc.) + biomass
• Test methods: ISO 14855
  (no pretreatment allowed!)

• Duration: Maximum 6 months

• Pass level: 90% (absolute or relative to a reference)

• Exempted:
  – ‘Irrelevant’ components (≤ 1%, Σ ≤ 5%)
  – Chemically unmodified materials of natural origin
BIODEGRADATION
BIODEGRADATION RESULTS

Graph showing the total CO₂ production (g) over time (days) for Cellulose and Blank samples. The graph indicates a higher rate of biodegradation for Cellulose compared to Blank.
DISINTEGRATION

- Test method: ISO 16929 (pilot-scale)
- Duration: 12 weeks
- Pass level: 90% (≤10% may remain on 2mm sieve)

Linked to maximum thickness
• Vessels of approx. 200 liters
• Fresh biowaste + 1% product + 9% powder
• Weekly to bi-weekly turning
• Conditions: Maximum 75°C
  60°C for 1 week
  40°C for 4 weeks
• $O_2$ must be continuously > 10%
• Importance of thickness, grammage, density,...
• Test method:  
  EN 13432 + OECD 208

• Duration:  
  2-3 weeks

• Pass level:  
  90% (germination/growth)

• Earthworms (Australia)
OVERALL POSITIVE EXPERIENCE, HOWEVER

• Necessity of **by-laws**:
  – Blends of certified components
  – Multi-layer structures
  – Inks
  – Additives
  – Adhesives
  – Families of products
  – ‘Special’ products (teabags, coffee pads, …)

• OWS member of AC Seedling
  & several ISO and ASTM committees

• **End of 2016**: BPI certification committee
ACCEPTANCE OF COMPOSTABLE PRODUCTS

• Compostable products:

- Established and/or allowed/promoted
- Very limited
- Not promoted

• Belgium & California: “Biodegradable” not allowed

• Amended WFD: “Biowaste = … including waste with similar biodegradability and compostability properties”
STANDARDS vs. CERTIFICATION

- Standards
  - = theory
  - = legislative

- Certification/logos
  - = praxis
  - = control – policing system
  - = standards + certification scheme
INDUSTRIAL COMPOSTABILITY CERTIFICATION

- Seedling logo (EuBP, DE)

- OK Compost logo (Vinçotte, BE)
INDUSTRIAL COMPOSTABILITY CERTIFICATION

- USA: BPI – Cedar Grove
- Japan: JBPA
- Australia: ABA
- National/regional: DE, IT, KR, CA, SE, CAT
# SEEDLING vs. OK COMPOST

## Comparison Table

<table>
<thead>
<tr>
<th></th>
<th>Seedling</th>
<th>OK Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agency</strong></td>
<td>DIN CERTCO &amp; Vinçotte</td>
<td>Vinçotte</td>
</tr>
<tr>
<td><strong>Basis of certification</strong></td>
<td>EN13432, ASTM D6400 &amp; ISO 17088</td>
<td>EN13432</td>
</tr>
<tr>
<td><strong>Geographical value</strong></td>
<td>Germany, Switzerland, Netherlands, Austria</td>
<td>France, Italy, Spain, Belgium</td>
</tr>
</tbody>
</table>
TOPICS

- OWS
- Managed end-of-life
  - Industrial composting
  - **Home composting**
  - Anaerobic digestion
- In-situ biodegradation
• **Ambient** temperature

• France: Single-use shopper bags: as of July 2016  
  Fruit and vegetable bags: as of January 2017

  **Exempt:**
  • > 50 µm
  • Home compostable
  • Biobased: 30% as of 2017
    40% as of 2018
    50% as of 2020
    60% as of 2025

  As of 2020 also food service ware items

  • Europe: PPWD tasked the EC to adopt specifications for  
    home compostable plastic carrier bags
• EN 13432 + biodegradation & disintegration at ambient T

• Standards: AS 5810-2010
  AFNOR NF T 51-800 (2015) = OKCH scheme

  Europe: TC261 SC4 WG2
    Step 1: technical report
    Step 2: standard
    Timing: first meeting in June 2017
    Scope: bags first/only?

  USA: Cancelled
    + request for practice and guidance
HOME COMPOSTING

- Home composting: (situation 2011)
  - Promoted on national level
  - Promoted on regional level
  - Not promoted

- Amended WFD: MS to encourage home composting (form of waste prevention)
HOME COMPOSTABILITY - REQUIREMENTS

Requirements for industrial compostability

- Chemical analyses
- Biodegradation – higher temperatures; 6 months max
- Disintegration – higher temperatures, quantitative determination; 3 months max
- Plant ecotoxicity

Additional requirements for home compostability

- Biodegradation – ambient temperature; 12 months max
- Disintegration – ambient temperature, qualitative determination; 6 months max
TOPICS

- OWS
- Managed end-of-life
  - Industrial composting
  - Home composting
  - Anaerobic digestion
- In-situ biodegradation
CLEAR SHIFT TOWARDS AD

1990: 133,500 tpy (3 plants)
1995: 324,500 tpy (16 plants)
2000: 1,467,500 tpy (55 plants)
2005: 2,458,500 tpy (83 plants)
2010: 4,778,500 tpy (151 plants)
2015: 7,499,600 tpy (222 plants)
Future: ?

(tpy = tonnes per year; plants = number of plants)
AEROBIC vs. ANAEROBIC DEGRADATION

Organic matter

Microbial population → $O_2$ → 60-70 °C → $CO_2 + H_2O +$ humus + heat

Organic matter

Microbial population → 35 - 55 °C → $CH_4 + CO_2 +$ humus + heat

BIOGAS
AEROBIC vs. ANAEROBIC DEGRADATION

- Aerobic composting
  - Technologies & processes rather similar
  - Preferred for yard waste
  - Compost production with Energy consumption

- Anaerobic digestion
  - Different technologies & process conditions
  - Preferred for food waste, industrial byproducts and sewage solids
  - Compost production AND Energy production
TOPICS

- OWS
- Managed end-of-life
- In-situ biodegradation
  - Biodegradation in soil
  - Biodegradation in fresh water
  - Biodegradation in marine conditions
**ENVIRONMENTAL NICHES**

**PRODUCT USE/DISPOSAL**

- **CONTROLLED**
  - **WASTEWATER**
    - AEROBIC TREATMENT
    - ANAEROBIC TREATMENT
    - ANAEROBIC STABILISATION
  - **SOLID WASTE**
    - COMPOSTING
      - CENTRAL
      - HOME
    - BIOGASIFICATION
    - LANDFILL
    - USE OF COMPOST IN SOIL

- **UNCONTROLLED (LITTER or IN SITU)**
  - OPEN WATER
  - SOIL
  - MARINE

*Increased attention “Leakage” due to wearing

**NO LICENCE TO LITTER!**
AGGRESSIVENESS OF ENVIRONMENT

60°C

compost > soil > fresh water > marine water > landfill

21°C

anaerobic digestion
AGGRESSIVENESS OF ENVIRONMENT

Fungi + Bacteria + Actinomycetes

Bacteria only (Fungi inactive)

compost > soil > fresh water > marine water > landfill

anaerobic digestion
Multiple Bacteria
BIODEGRADATION IN SOIL

• Legislation: **Revision of the EU Fertiliser Regulation**
  • Mulching films
  • Controlled release fertiliser coatings
  • Growth media
  • (Body bags)

  Complete biodegradation within 2 years
  *(after its functional life)*

• Standards: NF U 52-001

  Europe: Deadlock for many years
  CEN TC249 WG7 TG1: prEN17033
  *(more ecotoxicity testing!)*
• OK Biodegradable Soil (Vinçotte, BE)

• Requirements
  • Heavy metals content: same as for industrial compostability
  • Biodegradation in soil: 90% within 2 years
  • Plant toxicity: same as for industrial compostability
• Standard: EN 14987

• OK Biodegradable Water (Vinçotte, BE)

• Requirements
  • Heavy metals content: same as for industrial compostability
  • Biodegradation in fresh water: 90% within 56 days
  • Optionally: dispersibility/solubility
Ellen MacArthur: “1 tonne of plastic for every 3 tonnes of fish by 2025, and by 20540, more plastics than fish (by weight)”
BIODEGRADATION IN MARINE CONDITIONS

- Standard: ASTM D7081 (withdrawn)
- OK Biodegradable Marine (Vinçotte, BE)

Requirements
- Heavy metals content: same as for industrial compostability
- Biodegradation in seawater: 90% within 6 months
- Disintegration: 90% within 3 months
- Ecotoxicity: 1 specific aquatic toxicity test
### BIODEGRADATION vs. ENVIRONMENTAL NICHE

<table>
<thead>
<tr>
<th></th>
<th>AEROBIC (WATER) + ANAEROBIC BACTERIA, NO FUNGI</th>
<th>AEROBIC (COMPOST &amp; SOIL) BACTERIA &amp; FUNGI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High T (50-60°C)</strong></td>
<td>Chemical pulp Starch PLA Starch/PCL PHA</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>THERMOPHILIC DIGESTION</strong></td>
<td><strong>INDUSTRIAL COMPOSTING</strong></td>
</tr>
<tr>
<td><strong>Low T (≤ 35 °C)</strong></td>
<td>Chemical pulp Starch Starch/PCL PHA</td>
<td><strong>MESOPHILIC DIGESTION</strong></td>
</tr>
<tr>
<td></td>
<td><strong>WATER</strong></td>
<td><strong>SOIL</strong></td>
</tr>
</tbody>
</table>
SPECIAL CASE: OXO-DEGRADABLE PLASTICS

• “Benefits and challenges of bio- and oxo-degradable plastics: A comparative literature study” (PlasticsEurope)

• Conventional polyolefins + inorganic additives
• (Bio)degradation initiated by \( O_2 \), accelerated by UV light and/or heat
• **Not compostable, eventually biodegradable?**
  • (Very) little evidence
  • No proof of extrapolation to real-life conditions
  • Moisture inhibits/slow down oxidation process
  • Carbonyl index, \( M_w \), microbial growth, ADP/ATP,… no proof of (complete) biodegradation

• Better term: “**Thermo- or photo-fragmentable plastics**”
OWS nv
Dok Noord 5
B-9000 Gent
Belgium

Email: sam.deconinck@ows.be
Website: www.ows.be