BIO-END-OF-LIFE OF TEXTILES

Performance Days, Munich, April 27th, 2017
TOPICS

- **OWS**
  - Managed end-of-life
  - In-situ biodegradation
COMPANY PROFILE

- 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
COMPANY STRUCTURE

OWS

- Drancotech
  - Engineering

- Lab / Consulting
  - Various Services
‘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
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>EXAMPLES</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>
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<tr>
<td>Packaging</td>
<td>Alcan Packaging, Amcor, Mondi Packaging, Sealed Air, Tetra Pak,...</td>
</tr>
<tr>
<td>Consumer Goods</td>
<td>Henkel, Kimberly-Clark, Lenzing, Nestlé, P&amp;G, Sara Lee, SCA, Unilever,...</td>
</tr>
<tr>
<td>Inks &amp; Masterbatches</td>
<td>PolyOne, CIBA, Chimigraf, Flint, Sun Chemical, Wacker,...</td>
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<tr>
<td>Films &amp; Bags</td>
<td>Because We Care, Cortec, Sabic, Sphere, WeiMon, Wuhan Huali,...</td>
</tr>
<tr>
<td>Food Service Ware</td>
<td>Medac, Minima, Seda, Smurfit Kappa, Solo Cup,...</td>
</tr>
<tr>
<td>Other categories</td>
<td>Smithers-Oasis, EBPA, EuBP,...</td>
</tr>
<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
• 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

CO₂

H₂O
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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<td></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 COATING</td>
<td></td>
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<td>ASTM D6868</td>
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</tbody>
</table>
CHEMICAL CHARACTERISTICS

- Maximum 49% of inorganic content
- Heavy metal limits: inks!

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<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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<tbody>
<tr>
<td>EU</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>USA</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>
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</tbody>
</table>
BIODEGRADATION = MINERALIZATION

- Polymers
  - Oligomers
    - Monomers
      - Biochemicals (alcohols, acids, etc.)
        - Minerals (CO$_2$, H$_2$O, CH$_4$, 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 RESULTS

Graph showing the total CO₂ production (g) over time (days) for Cellulose and Blank samples. The graph indicates the percentage of biodegradation over time.
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

• O₂ must be continuously > 10%
DISINTEGRATION RESULTS

- Importance of thickness, grammage, density,...
• Test method: 
  EN 13432 + OECD 208

• Duration: 
  2-3 weeks

• Pass level: 
  90% (germination/growth)

• Earthworms (Australia)
TOXICITY RESULTS

![Graph showing plant dry weight for Blank compost and Test compost with different percentages and pass levels.](image-url)
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

<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>
• 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
HOME COMPOSTABILITY - STANDARDS

- 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)

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

Vinçotte       AfOR (w/ Vinçotte)       DIN-CERTCO       ABA
Belgium        UK                         Germany            Australia
HOME COMPOSTABILITY - REQUIREMENTS

Requirements for industrial compostability

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

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

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

AEROBIC vs. ANAEROBIC DEGRADATION

Organic matter

Microbial population → O₂ → CO₂ + H₂O + humus + heat
→ 60-70 °C

Organic matter

Microbial population → 35 - 55 °C
CH₄ + CO₂ + humus + heat

BIOGAS
• 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
• OWS
• Managed end-of-life
• In-situ biodegradation
  • Biodegradation in soil
  • Biodegradation in fresh water
  • Biodegradation in marine conditions
PRODUCT USE/DISPOSAL

CONTROLLED

WASTEWATER

AEROBIC TREATMENT

ANAEROBIC TREATMENT

ANAEROBIC STABILISATION

SOLID WASTE

COMPOSTING

CENTRAL

HOME

USE OF COMPOST IN SOIL

BIOGASIFICATION

LANDFILL

UNCONTROLLED (LITTER or IN SITU)

OPEN WATER

SOIL

MARINE

Increased attention “Leakage” due to wearing

NO LICENCE TO LITTER!
AGGRESSIVENESS OF ENVIRONMENT

60°C > 21°C

compost > soil > fresh water > marine water > landfill

----

anaerobic digestion

[Images of compost, fresh water, and landfill]
Fungi + Bacteria + Actinomycetes

Bacteria only (Fungi inactive)

compost > soil > fresh water > marine water > landfill

anaerobic digestion
Multiple Bacteria
• 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
BIODEGRADATION IN FRESH WATER

- 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
<table>
<thead>
<tr>
<th>High T (50-60°C)</th>
<th>AEROBIC (WATER) + ANAEROBIC BACTERIA, NO FUNGI</th>
<th>AEROBIC (COMPOST &amp; SOIL) BACTERIA &amp; FUNGI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chemical pulp Starch PLA Starch/PCL PHA</td>
<td>Chemical pulp Mechanical pulp Starch PLA Starch/PCL PHA PBAT</td>
</tr>
<tr>
<td></td>
<td>THERMOPHILIC DIGESTION</td>
<td>INDUSTRIAL COMPOSTING</td>
</tr>
<tr>
<td>Low T (≤ 35 °C)</td>
<td>Chemical pulp Starch Starch/PCL PHA</td>
<td>PBAT Starch/PCL Starch Chemical pulp Mechanical pulp</td>
</tr>
<tr>
<td></td>
<td>MESOPHILIC DIGESTION WATER</td>
<td>HOME COMPOSTING</td>
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<tr>
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<td>SOIL</td>
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</tbody>
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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 O₂, 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, Mw, microbial growth, ADP/ATP,… no proof of (complete) biodegradation

- Better term: **“Thermo- or photo-fragmentable plastics”**
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