RECENT DEVELOPMENTS IN STANDARDISATION & CERTIFICATION OF OXO-DEGRADABLE PLASTICS

Do they bring more clarity?

Sam DECONINCK – Bruno DE WILDE

8th European Bioplastics Conference, December 10th & 11th, Berlin, Germany
TOPICS

• **OWS**
• Terminology & more
• Standards on oxo-degradable plastics
• Data on (bio)degradation
• Available certification systems
• Discussion & conclusions

Desk research study performed for

PlasticsEurope

Association of Plastics Manufacturers
COMPANY PROFILE

- Founded in 1988
- Consolidated sales (2011-2013): 19 million €/yr
- Export: 90%
- 70 employees

- Head office: Gent, Belgium
- Affiliates: OWS Inc., Dayton, Ohio, USA
  DRANCO N.V.
  BES GmbH, Germany
- Partner: DJK International, Tokyo, Japan
CONTRACT RESEARCH LABORATORY

• ‘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 20 years of experience
• 2500+ samples tested for 750+ clients
## REFERENCES

<table>
<thead>
<tr>
<th>Category</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Polymers</strong></td>
<td>BASF, DSM, Du Pont, FKuR, Metabolix, NatureWorks, Novamont,...</td>
</tr>
<tr>
<td><strong>Paper &amp; Board</strong></td>
<td>Ahlstrom, Huhtamaki, Int. Paper, Kuan Chun Paper, Pactiv, UPM,...</td>
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<td><strong>Packaging</strong></td>
<td>Alcan Packaging, Amcor, Mondi Packaging, Sealed Air, Tetra Pak,...</td>
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<tr>
<td><strong>Consumer Goods</strong></td>
<td>3M, Henkel, Kimberley Clark, Nestlé, P&amp;G, Sara Lee, SCA, Unilever,...</td>
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<td><strong>Inks &amp; Masterbatches</strong></td>
<td>Schulman Plastics, CIABA, Chimigraf, Flint, Sun Chemical, Wacker,...</td>
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<tr>
<td><strong>Films &amp; Bags</strong></td>
<td>Because We Care, Cortec, Sabic, Sphere, WeiMon, Wuhan Huali,...</td>
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<td><strong>Food Service Ware</strong></td>
<td>Medac, Seda, Smurfit Kappa, Solo Cup,...</td>
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<tr>
<td><strong>Other categories</strong></td>
<td>Smithers-Oasis, EuBP,...</td>
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<tr>
<td><strong>Oxo-degradable</strong></td>
<td>CIABA, Goody (ACCC), Wells Plastics, Symphony, EPI, EconVerte,...</td>
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<tr>
<td><strong>Enzyme-mediated</strong></td>
<td>Enzymoplast, ECM, Bio-Tec,...</td>
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FCBOTIGA col·labora amb el medi. Bossa 100% degradable segons normativa europea.
**TERMINOLOGY**

- CEN/TR 15351: defines processes, not materials
  - "Oxo-degradation": Degradation identified as resulting from oxidative cleavage of macromolecules

- **Term “oxo-(bio)degradable plastics”** introduced by the oxo-degradable plastics industry, **not standardized**.

- Biodegradable plastics = “hydro-degradable plastics”

- For the purpose of this study: “oxo-degradable plastics” and “biodegradable plastics”
DEFINITIONS

• Conventional polyolefins + inorganic additive
• Additive: transition metal salts based on Co, Fe, Mn, Ni, Ce
• Heavy metals: usually no issue

• Typical loading rate: 1%
• Claimed to be ‘programmable’ (concentration, formulation)

• Degradation process:
  – **Abiotic** degradation step: cleavage by oxygen, heat and/or UV light
  – **Biotic** degradation step: formation of acids, alcohols, esters,...
CLAIMS

• Role of additive claimed **not** to be initial cleavage of polymer chains, but acting as catalysator in formation of biodegradable intermediates

• UV light said to accelerate degradation, but once ‘triggered’, degradation is claimed to continue in absence of UV light

• Moisture inhibits/slow down the process (Day et al., 1997)
• OWS
• Terminology & more
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STANDARDS ON OXO-DEGRADATION

• First standards:
  • ASTM D6954 (USA, 2004)
  • XP T54-980 (France, 2007)

• Rapid growth since 2009:
  • UAE.S 5009 (United Arab Emirates, 2009)
  • SPCR 141 (Sweden, 2010)
  • BS 8472 (UK, 2011)
  • AC T51-808 (France, 2012)
  • JS 2004 (Jordan, 2012)

• 11/2013: UK (BSI) proposal for EN standard not accepted
COMPONENTS OF OXO-DEGRADATION

- Majority based on 3 ‘Tiers’

**Degradation**

**Environmental safety**

**TIER 1:**
Abiotic degradation

**TIER 2:**
Biotic degradation

**TIER 3:**
HM & Ecotoxicity
### Standards on Oxo-degradation

- No consistency in tests

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### STANDARDS ON OXO-DEGRADATION

- No consistency in criteria (pass level and/or time frame)

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✓: criteria included  ✗: no criteria included
STANDARDS ON OXO-DEGRADATION

- Only 2 standards, others are merely guidelines

1. UAE.S 5009 (United Arab Emirates, 2009)
   - \[ \text{Mw} \leq 5,000 \] within 4 weeks
   - 60% biodegradation in 6 months
   - Requires testing to be performed in triplicate and at an accredited laboratory

2. SPCR 141 (Sweden, 2010)
   - \[ \text{Mw} \leq 10,000 \] within 4 weeks (Tier 1 at 70°C)
   - 60-90% biodegradation in 24 months
MORE LEGISLATION...

- United Arab Emirates
  - Since 2012: plastic carrier bags have to be oxo-degradable
  - Since 2013: extended to all disposable plastic products

- Islamabad (Pakistan)
  - Since 2013: all plastic products made from PE, PP or PS have to be oxo-degradable

- Vietnam
  - To be published soon: applicable to carrier bags only

- Philippines
  - Scheduled for 2014

- Yemen, Morocco, DR Congo,...

Countries with visual pollution
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DATA ON OXO-DEGRADABLE PLASTICS

• One source: publically available literature

• TIER 1 (abiotic degradation)
  • Majority reaches Mw ≤ 10,000, only few ≤ 5,000
  • Often at elevated T (40-75°C) & for longer periods (up to 8 weeks)

Extrapolation following Arrhenius equation:

NO proof over large T range

Source: Jackubowicz, 2003
TIER 2 (biotic degradation)

Reliability/value of test results
- Testing facility
- Peer reviewed
- Test method used (CO\(_2\), Mw, mass loss, microbial growth, ADP/ATP)
- Quality control (reference material)
- Number of replicates used
- Level of abiotic degradation

Value: High score: 91% after 733d in soil - 10d at 65°C
Source: Jackubowicz et al., 2011

Medium score: 49-63% after 600d in soil - 44d at 55°C
Source: Chiellini et al., 2003

Positive results so far not (yet) reproduced
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- **Available certification systems**
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• **EMAS (UAE)**
  - Based on UAE.S 5009 standard
  - 5 certified additive producers
  - Several certified finished products
    - Only data on Tier 1 on website
    - Testing done by additive producer/affiliate
    - *60% biodegradation within 6 months?*

• **Oxo-biodegradable Plastics Association (US)**
  - Industrial association
  - No reference to guidelines/standards
  - No certification scheme, specifications or rules
  - ‘Certification’ if product complies with definition of CEN
  - **Self certification (?)**
CERTIFICATION SYSTEMS

- **SP Technical Research Institute (SE)**
  - Based on SPCR 141 standard
  - 1 additive certified: SMC 2522 (P-Life, Japan)
  - **60% biodegradation within 24 months**

- **Biosystems America (US)**
  - Independent testing facility
  - Compliance with ASTM D6954 (only guideline)
  - 4 ‘certified’ products

- **Singapore Green Labeling Scheme (SG)**
  - Administered by Singapore Environment Council
  - Certification for wide variety of applications
  - New category for oxo-degradable plastics under development
  - Own certification scheme: **biodegradation not needed**
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DISCUSSION

• TIER 1 (abiotic degradation)
  • Unrealistic conditions
    • (Very) high temperatures: 55-70°C
    • Long(er) periods: 44-80 days
  • No guarantee of Arrhenius principle over wide range of T
    (evidence of Mw decrease at ambient T not available)
  • Extrapolation to real-life conditions not possible
DISCUSSION

- “CO₂ production is not the correct parameter”
- “Microbial growth, ADP/ATP,... also proof of biodegradation”
  - **No**, only proof of biological activity (95% PE/5% starch)

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<tr>
<th>Material</th>
<th>Biodegradation in compost</th>
<th>Biodegradation in soil</th>
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<tbody>
<tr>
<td>Wood fibers</td>
<td>71% (728d)</td>
<td>50-70% (134-664d)</td>
</tr>
<tr>
<td>Flax fibers</td>
<td>64-91% (60-225d)</td>
<td>95% (365d)</td>
</tr>
<tr>
<td>Oak leaves</td>
<td>65-76% (124-365d)</td>
<td>50-91% (220-902d)</td>
</tr>
<tr>
<td>Birch leaves</td>
<td>76% (365d)</td>
<td>56% (365d)</td>
</tr>
<tr>
<td>Pine needles</td>
<td>52% (365d)</td>
<td>62% (365d)</td>
</tr>
</tbody>
</table>

Source: European projects AIR, FAIR, BIOPAL & BIOPACK
**DISCUSSION**

- “Molecular weight decrease is proof of (bio)degradation”

- Two main questions remain:
  - Pass level of 5,000 or 10,000 Dalton low enough?
  - Does the Mw decrease continues over time?
CONCLUSIONS

1. Very few positive biodegradation results, achieved after unrealistic pretreatment and so far not repeated

2. Oxo-degradable plastics do not meet the requirements of industrial and/or home compostability

3. Better term:

   “thermo- or photo-fragmentable plastics”
THANK YOU FOR YOUR ATTENTION

Summary & report available for download:

http://ows.be/lab-consulting-services/publications/
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