FINAL REPORT

PILOT-SCALE COMPOSTING FOR QUALITATIVE EVALUATION
OF DISINTEGRATION

OF

T-SHIRT BAG FROM GOODY
(THICKNESS: 20 µm)

EN 13432 CERTIFIED BIODEGRADABLE PLASTIC BAG BIO 1
(THICKNESS: 20 µm)

EN 13432 CERTIFIED BIODEGRADABLE PLASTIC BAG BIO 2
(THICKNESS: 30 µm)

AND

PAPER BAG
(THICKNESS: 110 µm)

STUDY GS-15/2

BASF SE
G-KTS/BD - E100
67056 Ludwigshafen
GERMANY
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1. IDENTIFICATION OF TEST

**Project Number**
GS-15/2

**Conditions**
The test was performed under screening conditions.

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**Test Items**
T-shirt bag from Goody (Thickness: 20 µm)
EN 13432 certified biodegradable plastic bag Bio 1 (Thickness: 20 µm)
EN 13432 certified biodegradable plastic bag Bio 2 (Thickness: 30 µm)
Paper bag (Thickness: 110 µm)
2. PURPOSE AND PRINCIPLE OF TEST METHOD

The pilot-scale aerobic composting test simulates as closely as possible a real and complete composting process in composting bins of 200 l. The test item is mixed with the organic fraction of fresh, pretreated municipal solid waste (biowaste) and introduced in an insulated composting bin after which composting spontaneously starts. Like in full-scale composting, inoculation and temperature increase happen spontaneously. The test is considered valid only if the maximum temperature during composting is above 60°C and below 75°C, and if the daily temperature remains above 40°C during at least 4 weeks. The composting process is directed through air flow and moisture content. The temperature and exhaust gas composition are regularly monitored. The composting process is continued till fully stabilized compost is obtained (3 months). During composting, the content of the vessels is manually turned, at which time test item can be retrieved and visually evaluated. The applied test method is based on ISO 16929 (2002) “Plastics – Determination of the Degree of Disintegration of Plastics Materials under Defined Composting Conditions in a Pilot-Scale Test” and ISO 20200 (2004) “Plastics - Determination of the degree of disintegration of plastic materials under simulated composting conditions in a laboratory-scale test”. The test is only a qualitative evaluation of the disintegration by means of visual perceptions and not a quantitative determination (mass balance) of the disintegration (as is specified by ISO 16929).

3. GENERAL PROCEDURE

The fresh biowaste is derived from the organic fraction of municipal solid waste after a source-separated collection. The test item is mixed with the biowaste, which is used as carrier matrix, and composted in a pilot-scale composting unit (see Figure 1).
4. RESULTS

4.1. TEST SET-UP

The disintegration of a T-shirt bag from Goody (Thickness: 20 µm), two types of EN 13432 certified biodegradable plastic bags: Bio 1 (Thickness: 20 µm) and Bio 2 (Thickness: 30 µm) and a Paper bag (Thickness: 110 µm) was qualitatively evaluated during a 12-weeks composting process. At start of the composting process the test items were added to the biowaste as complete bags with a small amount of biowaste inside the bags. The biowaste consisted of a mixture of fresh vegetable, garden and fruit waste (VGF) and structural material. The obtained mixture was aerobically composted for 12 weeks in a 200 l composting bin.

4.2. ANALYSES BIOWASTE

The fresh biowaste was derived from the separately collected organic fraction of municipal solid waste, which was obtained from the waste treatment plant of Schendelbeke, Belgium. The characteristics of the biowaste at start are given in Table 1.

The biowaste should have a moisture content and a volatile solids content of more than 50% and a pH above 5. From Table 1 it can be seen that these requirements were fulfilled. The inoculum showed a moisture content of 70.7%, while the volatile solids (VS) content was 76.1% on total solids (TS). At start a pH of 7.2 was measured for the biowaste. After 1.6 week the pH was increased till above 8.6. The C/N ratio at start should preferably be between 20 and 30. An slightly lower C/N ratio of 19 was found back for the biowaste. The somewhat lower C/N ratio of the biowaste did not really hinder the test. A low C/N ratio results from a high level of nitrogen in the biowaste (e.g. due to many proteins). This can lead to NH₃ emission (and odor) and eventually slow or difficult nitrification towards the end of the composting cycle. It must be noted that mainly a high C/N ratio can be disadvantageous for the composting process, as this is indicative for N deficiency.

Table 1. Characteristics of the biowaste at start of the composting.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Biowaste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids (TS, %)</td>
<td>29.3</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>70.7</td>
</tr>
<tr>
<td>Volatile solids (VS, % on TS)</td>
<td>76.1</td>
</tr>
<tr>
<td>Ash content (% on TS)</td>
<td>23.9</td>
</tr>
<tr>
<td>pH</td>
<td>7.2</td>
</tr>
<tr>
<td>E.C. (µC/cm)</td>
<td>2190</td>
</tr>
<tr>
<td>Volatile Fatty Acids (VFA, g/l)</td>
<td>0.4</td>
</tr>
<tr>
<td>Total N (g/kg TS)</td>
<td>20.4</td>
</tr>
<tr>
<td>NOₓ⁻⁻-N (mg/l)</td>
<td>b.r.</td>
</tr>
<tr>
<td>NH₄⁺⁺-N (mg/l)</td>
<td>193</td>
</tr>
<tr>
<td>C/N</td>
<td>19</td>
</tr>
</tbody>
</table>

b.r. = below reporting limit
reporting limit: NOₓ⁻⁻-N = 5.0 mg/l
4.3. TEMPERATURE PROFILE AND ANALYSES EXHAUST AIR

Figure 2 shows the temperature evolution during the composting test. The test is considered valid if the maximum temperature during the composting is above 60°C and below 75°C. Moreover, the daily temperature should be above 60°C during 1 week and above 40°C during at least 4 consecutive weeks. As can be seen from Figure 2 these requirements were largely fulfilled. After start-up the temperature increased almost immediately till above 60°C. A maximum temperature of 78°C was reached, but immediately action was undertaken and lower temperatures were established. Furthermore, the temperature in the test bin remained above 60°C during more than 1 week. After 1.5 week of composting the test bin was placed in an incubation room at 45°C to ensure temperatures above 40°C. This resulted in a new temperature increase. The temperature stayed above 40°C during the entire test period.

Figure 3 shows the oxygen concentration in the exhaust air. The oxygen concentration remained always above 10%, which guaranteed good aerobic conditions.
Figure 3. $O_2$ concentration in the exhaust air during the composting test.
4.4. VISUAL PERCEPTIONS AND DISINTEGRATION

The mixture in the composting bin was regularly turned by hand (weekly during the first month and later on every 2 weeks), at which time the visual appearance of the different test items was carefully checked.

4.4.1. T-shirt bag from Goody (Thickness: 20 µm)

Figure 4 gives a visual presentation of a T-shirt bag from Goody in a thickness of 20 µm at start of the test.

No breakthrough in disintegration was observed for test item T-shirt bag from Goody (20 µm) during 12 weeks of composting. Figure 5 shows a visual presentation of the T-shirt bag after 1 week of composting. The test material remained completely intact. The same observation was made at the end of the test. No single hole or tear was observed in the bag. The colour of the bag had become light brown and the pink print was completely disappeared (Figure 6).

Figure 4. Visual presentation of a T-shirt bag from Goody (20 µm) at start.
Figure 5. Visual presentation of a T-shirt bag from Goody (20 µm) after 1 week of composting.

Figure 6. Visual presentation of T-shirt bag from Goody (20 µm) after 12 weeks of composting (= end of the test).
4.4.2. EN 13432 certified biodegradable plastic bag Bio 1 (Thickness: 20 µm)

Figure 7 gives a visual presentation of an EN 13432 certified biodegradable plastic bag Bio 1 in a thickness of 20 µm at start of the test.

The disintegration of the EN 13432 certified biodegradable plastic bag Bio 1 (20 µm) proceeded very well. Already after 1 week of composting tears and holes were observed in the bag and the colour of the bag had become light brown (Figure 8). From then on, the disintegration proceeded very swiftly. After 2 weeks of composting only 2 pieces of test material were retrieved in the compost. These pieces were very weak (Figure 9). The disintegration proceeded and one week later only one small piece of test material remained present. This piece had a dimension of approximately 1 × 3 cm (Figure 10). After 4 week of composting the test material seemed completely disappeared. This was confirmed at the end of the test. No single piece of test material was retrieved.

Figure 7. Visual presentation of an EN 13432 certified biodegradable plastic bag Bio 1 (20 µm) at start.
Figure 8.  Visual presentation of an EN 13432 certified biodegradable plastic bag Bio 1 (20 \(\mu\)m) after 1 week of composting.

Figure 9.  Visual presentation of the retrieved pieces of EN 13432 certified biodegradable plastic bag Bio 1 (20 \(\mu\)m) after 2 weeks of composting.
Figure 10. Visual presentation of the retrieved piece of EN 13432 certified biodegradable plastic bag Bio 1 (20 µm) after 3 weeks of composting.
4.4.3. **EN 13432 certified biodegradable plastic bag Bio 2 (Thickness: 30 µm)**

Figure 11 gives a visual presentation of an EN 13432 certified biodegradable plastic bag Bio 2 in a thickness of 30 µm at start of the test.

The disintegration of the EN 13432 certified biodegradable plastic bag Bio 2 (30 µm) proceeded very swiftly. Already after 1 week of composting the bag was fallen apart into big pieces, which were very fragile (Figure 12). The disintegration went on and one week later the presence of the test material in the compost was already strongly reduced. Only pieces with a maximum dimension of approximately 8 × 10 cm remained present (Figure 13). After 3 weeks of composting the test material seemed completely disappeared. This was confirmed at the end of the test. No single piece of test material was retrieved.

![Visual presentation of an EN 13432 certified biodegradable plastic bag Bio 2 (30 µm) at start (the logo is made invisible).](image-url)
Figure 12. Visual presentation of the retrieved pieces of EN 13432 certified biodegradable plastic bag Bio 2 (30 µm) after 1 week of composting.

Figure 13. Visual presentation of the retrieved pieces of EN 13432 certified biodegradable plastic bag Bio 2 (30 µm) after 2 weeks of composting.
4.4.4. Paper bag (110 µm)

Figure 14 gives a visual presentation of a Paper bag in a thickness of 110 µm at start of the test.

The disintegration of test material Paper bag (110 µm) proceeded also very well. Already after 1 week of composting big tears and holes were observed in the Paper bag. The test material had become very weak and was almost completely covered by fungal growth (Figure 15). The disintegration went on and one week later the presence of the test material was strongly reduced. Only one long piece of test material was retrieved. This piece was coming from the handles of the Paper bag (Figure 16). After 3 weeks of composting the handle of the bag was fallen apart into 2 pieces (Figure 17). These pieces were very weak and were completely covered by fungal growth. One week later the test material seemed completely disappeared. This was confirmed at the end of the test. No single piece of test material was retrieved.
Figure 15. Visual presentation of the retrieved pieces of Paper bag (110 µm) after 1 week of composting.

Figure 16. Visual presentation of the retrieved pieces of Paper bag (110 µm) after 2 weeks of composting.
Figure 17. Visual presentation of the retrieved pieces of Paper bag (110 µm) after 3 weeks of composting.
5. CONCLUSIONS

A T-shirt bag from Goody (Thickness: 20 μm), two EN 13432 certified biodegradable plastic bags Bio 1 (Thickness: 20 μm) and Bio 2 (Thickness: 30 μm) and a Paper bag (Thickness: 110 μm) were qualitatively tested for disintegration in a pilot-scale composting test. The test items were added as complete bags to a mixture of VGF and structural material and aerobically composted for 12 weeks. Regularly during the test (during the first month once a week and later on every 2 weeks) the content of the vessel was manually turned. At turning, the visual appearance of the test items was carefully checked.

The operational parameters showed that the test was valid. The temperature in the composting bin rose almost immediately till above 60°C. A maximum temperature of 78°C was reached, but immediately action was undertaken and lower temperatures were established. Furthermore the temperature remained above 60°C during more than 1 week and stayed above 40°C during the entire test period. Throughout the test, the O₂ concentration in the exhaust air remained always above 10%, which ensured good aerobic conditions.

No breakthrough in disintegration was observed for test item T-shirt bag from Goody (20 μm) during 12 weeks of composting. After 12 weeks of composting the test material still remained completely intact.

The disintegration of the EN 13432 certified biodegradable plastic bags Bio 1 (20 μm) and Bio 2 (30 μm) and the Paper bag (110 μm) proceeded very well. Already after 4 weeks of composting the different test materials seemed completely disappeared. This was confirmed at the end of the test. No single piece of these test materials could be retrieved at the end of the test.

From this qualitative disintegration test it can be concluded that the two EN 13432 certified biodegradable plastic bags Bio 1 (20 μm) and Bio 2 (30 μm), and a Paper bag (110 μm) showed a complete level of disintegration during a 12 weeks composting process. Test material T-shirt bag from Goody (20 μm) still remained completely intact at the end of the test, and therefore it can be concluded that test material T-shirt bag from Goody (20 μm) will not succeed in the quantitative disintegration test as prescribed by EN 13432 (2000) ‘Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging’, ASTM norm D 6400-04 ‘Standard Specification for Compostable Plastics’ and ISO 17088 (2008) ‘Specifications for compostable plastics’. T-shirt bag from Goody (20 μm) cannot be called compostable.

Gent, October 20, 2009

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