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Sustainpack

Innovation and sustainable Development in the Fibre Based Packaging Value Chain

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D. 5.35 Report on the biodegradability of composites and cushioning materials.

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PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

REPORT ON THE BIODEGRADABILITY OF COMPOSITES AND CUSHIONING MATERIALS.

Objective: To evaluate the biodegradability of innovative materials.

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1. Introduction:

In Sub-project 5 several composites have been produced based on fibres and matrices, one of the target is to develop biodegradable innovative materials. Some selected materials produced in WP 5.1 and WP 5.2 have been tested for the biodegradability mainly in relation to compostability. The assessment of the compostability has been carried out by the application of standard methods (EN 14046-2003, ISO 14855-1999) for the determination of the complete mineralization of the material into CO_2 and water by the action of the microorganisms present in the compost inoculum.

2. Material and methods:

<u>Analysed samples:</u>

- New matrices employed for the preparation of composites: Cellulose Acetate Butyrate CAB (Eastmann), Polyester MaterBi (Novamont), Starch MaterBi (Novamont).
- Cushioning innovative material based on: potato amilopectine foam + Microfibrillated Cellulose (Starch + MFC) prepared by KTH partner.
- Chemically modified fibres (to increase water resistance): spruce sulfate pulp treated with 1 % butyl tetra carboxylic acid (BTCA fibres).

<u>Methods and experimental conditions</u>:

-***Evaluation of the ultimate aerobic biodegradability of packaging materials under controlled composting conditions***. ISO 14855-1999, EN 14046-2003.

The test measures the complete transformation (mineralization) of the organic carbon contained in the sample to CO_2 and water by the action of the compost microorganisms. The ultimate biodegradation test was conducted by mixing the sample with mature compost in a ratio equal to 1: 12. To allow the testing of small quantities of sample the composting mixture volume was enhanced by the addition of an inert material (vermiculite).

- Reactors employed: 500 ml glass vessels: 2 reactors without the sample (blank), 2 reactors with the biodegradable reference (Avicel cellulose) and 2 reactors for each sample (see Fig. 1).
- Reactor composting mixture: 36 g. vermiculite as inert support, 36 g. mature compost, the water content of the vermiculite/compost mixture was adjusted at 35%.
- Sample quantity: about 3 g each reactor.
- Reactor aeration: the reactors were equipped with inlet and outlet tubes for the aeration with compressed humidified air. The CO_2 was previously removed from the inlet air (by adsorption on soda lime).
- Temperature: the test was conducted in an incubator at 58±2°C.
- Inoculum: mature compost from a composting plant treating 70% municipal garden green waste and 30% municipal organic waste.
- CO_2 production measurement: the % of CO_2 content in the outlet reactors air was analysed by an infrared gas analyser. The measurements were performed once a day for the first 20 days and afterwards once every 2-3 days.
- The percentage of biodegradation was expressed as % of CO_2 production respects the theoretical CO_2 content of the sample (% $ThCO_2$). For each reactor, the theoretical amount of CO_2 ($ThCO_2$) that can be produced by the sample was calculated from the sample organic carbon content value and from the amount of sample added to each reactor.

3. Results and discussion.

Compost characterisation.

Dry weight = 78,22 %; Volatile solids = 36,46 %; pH = 8,2.

Sample characterisation: Total Organic Carbon Content.

CAB = 54,72
Polyester MaterBi = 63,13
Starch MaterBi = 46,38
Starch + MFC foam = 37,99
BTCA modified fibre = 42,42

Ultimate aerobic biodegradability under controlled composting conditions.

Fig. 1. Reactors for the ultimate aerobic biodegradability tests and humidification flasks.

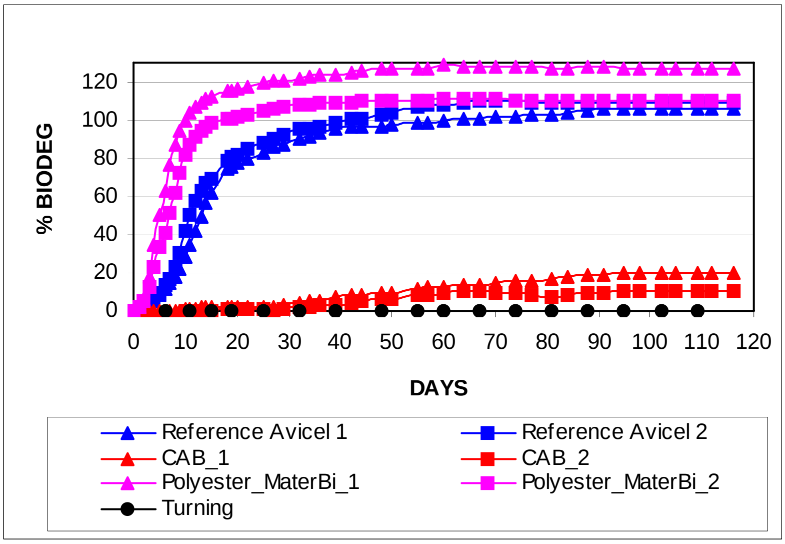

Fig. 2. Ultimate biodegradability (mineralization) of composite matrices.

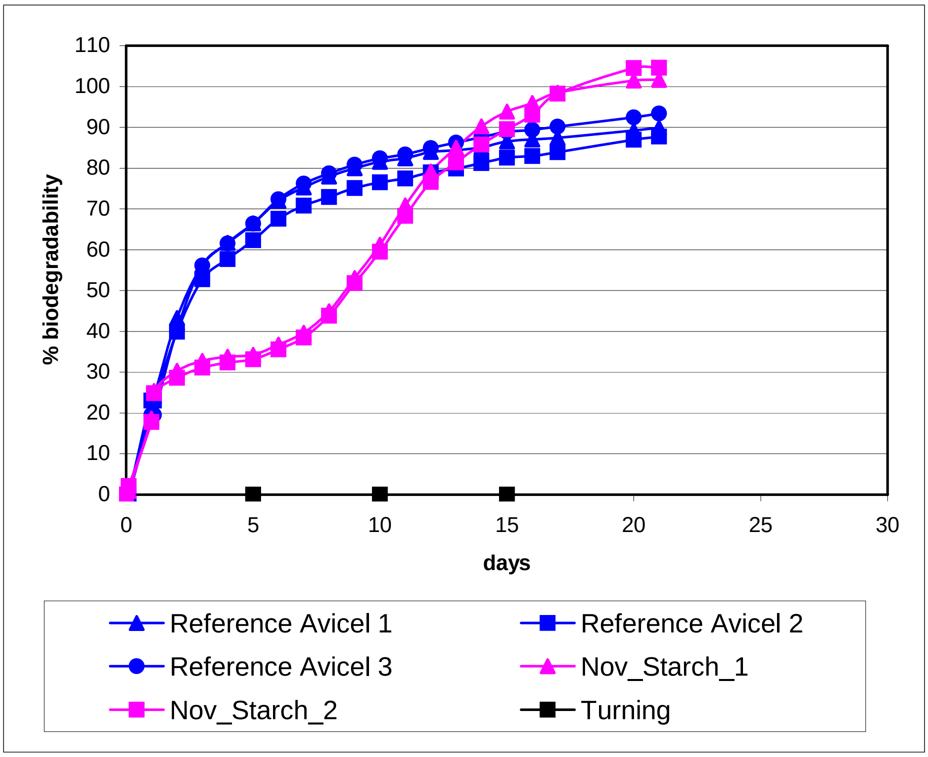

Fig. 3. Ultimate biodegradability (mineralization) of Starch Mater-Bi composite matrix.

The obtained results (Figs. 2-3) demonstrate that the Polyester Mater-Bi and Starch Mater-Bi matrices are highly biodegradable, in contrast, cellulose acetate butyrate, CAB, biodegradability is extremely low. These results give indications for the production of completely biodegradable composites based on fibres that have been already tested for their biodegradability.

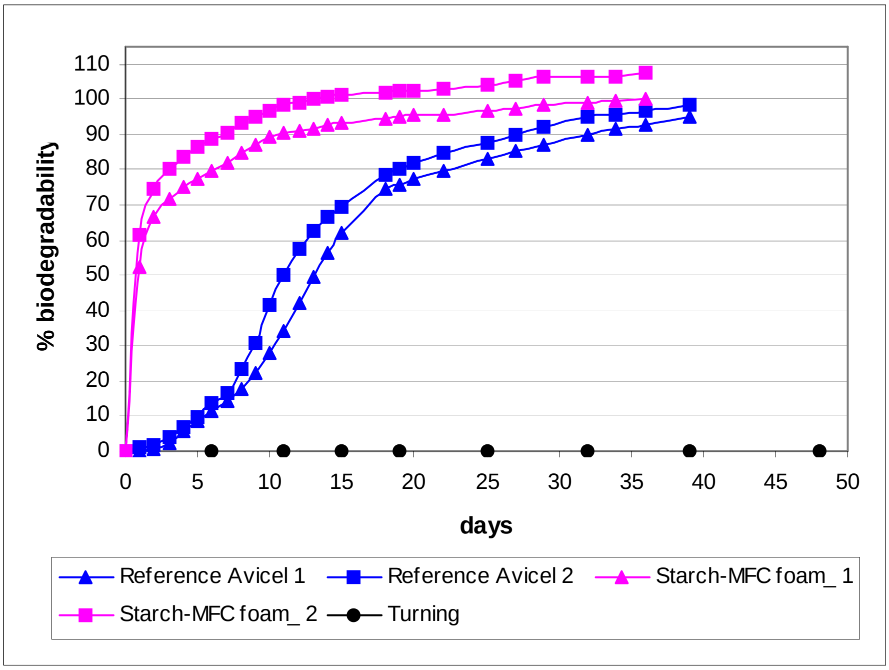

Fig. 3. Ultimate biodegradability (mineralization) of potato amilopectine foam + MFC.

The Starch-MFC foam sample produced as innovative cushioning material, is a highly biodegradable material due to its high starch content, showing a significant higher biodegradation rate respect the positive reference 100% Avicel cellulose.

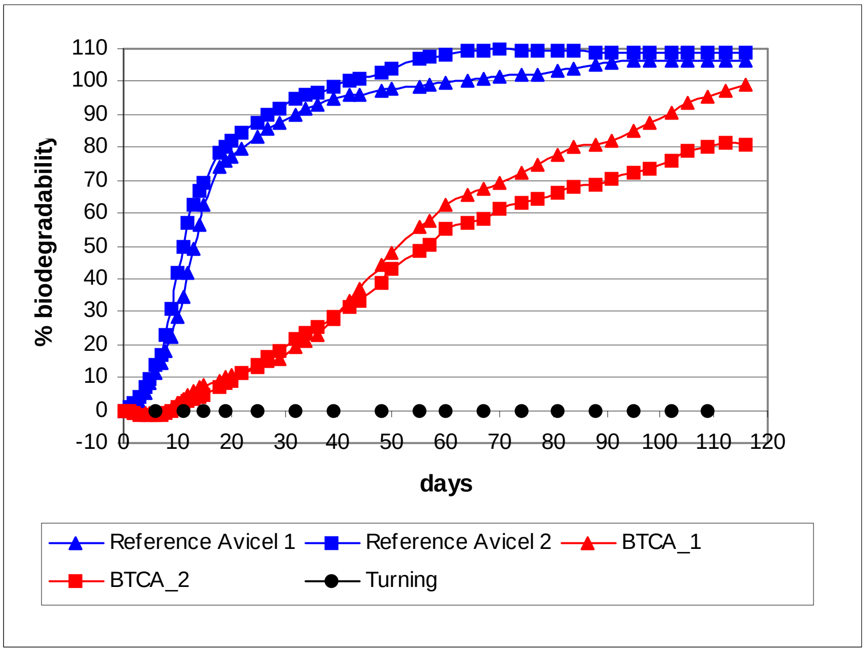

Fig. 4. Ultimate biodegradability (mineralization) of cellulose fibres chemically modified by butyl tetra carboxylic acid (BTCA fibres).

The increased water repellence of cellulose fibres together with their surface chemical modification can decrease the intrinsic biodegradability. In fact the chemical modification with BTCA decreased significantly the initial biodegradability of the fibres, but after a lag phase of 10 days the microbial attack started and an average value of 90% mineralisation was reached within 110 days of incubation. It can be concluded that BTCA modified fibres are biodegradable.

4. Conclusions.

The biodegradability tests performed on three selected matrices used for the preparation of fibre-based composites, demonstrated that Mater-Bi matrices are highly biodegradable polymers with a biodegradation kinetic rate in compost environment higher than reference Avicel cellulose. On the contrary Cellulose Acetate Butyrate (CAB) resulted to be not biodegradable. Innovative starch based foam developed in Sub Project 5 showed high biodegradation rate; while for BTCA modified cellulose fibre, the chemical modification performed to increase water resistance, mainly decreased the biodegradation kinetic rate trend, but did not compromise the intrinsic biodegradability of the fibres : in fact after three months high biodegradation values could be reached.