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BIOLOGICAL DEGRADATION OF PVA/CH IN TERRESTRIAL AND AQUATIC CONDITIONS

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ABSTRACT

Biologically degradable plastics are coming more and more as an issue into discussions, research, development and also practical usage. They play important role in way toward environmental friendly materials/packaging and can improve environmental profile of different products and/or solve some difficult problems in fields of agriculture, medicine, packaging industry, (bio)waste management... A new material - water soluble plastic blend PVA/CH was developed in Slovakia. Study will offer results of biodegradation tests of this plastics in terrestrial as well as aquatic condition. The results proof positive influence of collagen hydrolisate on degradation but also show a relative low biological degradability of PVA in tested conditions.

Key words: biodegradable plastics, biodegradability, polyvinylalkohol/collagen plastic blend, collagen degradation

INTRODUCTION

A New water soluble plastic blend PVA/CH (Polyvinylalcohol/collagen hydrolysate) is unique mixture of synthetic and biogen materials. Its properties offer potential for a special use in practice beginning with agriculture - chemical, pesticides packaging through sieving tapes and mulching foils till the packaging of contaminated cloths in hospitals. Positive impact of the biodegradable plastics usage was described on global, regional and local level (Fritz at al., 2000). Coming out from this applications, important characteristic of material is biological degradability and toxicological impact of rests of used material in natural ecosystems, composting conditions and also water treatment systems.

Norms and standards - To make all research results at the international level, the methodology of followed standards were use for a biological degradation analyses:

1. ISO/FDIS 14852: Determination of ultimate aerobic biodegradability of plastic materials in an aqueous medium - Method by analyses of evolved carbon dioxide (2).
2. prEN 14046: Packaging - Evaluation of ultimate aerobic biodegradability of packaging materials under controlled composting conditions - Method by analyses released carbon dioxide .

MATERIALS

The blend of PVA/CH (Polyvinylalcohol/collagen hydrolysate) developed at the KPK, CHTF - STU (Slovakia) were used with different rate of collagen content - 16,8%, 12,5% and 0% (pure PVA). *PVA* is produced in Slovakia - CHZ Nováky, Collagen is obtain by improved hydrolisation technology from leather industry waste in Zlín (FT), Czech Republic. Stabilised compost was taken form Pixendorf (Austria) composting plant (local

"Biotonne" composting plant). As a reference for degradation process Cellulose (Fluka, 22181) was used.

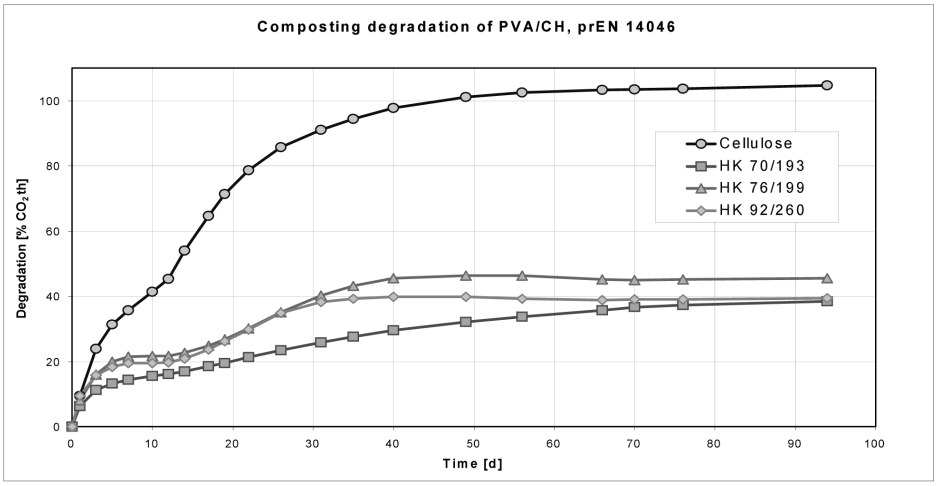
METHODS

Terrestrial analyses:
The degradation tests were performed in closed, aerated and at 58°C temperated vessels. Between 70 and 110 g (12% in mass on dry weight basis) of each one of the materials was initially mixed with 900 g of three month old stabile bio-waste compost.. The three materials were tested in parallel but due to limited amount of vessels only double determinations were done. The tests ran for 94 days until the plateau phases were reached. The biodegradation was followed by periodic measurement of the released carbon dioxide.
Aqueous analyses:
Innoculum from aqueous eluates were produced in accordance to the method DIN 38414 S4 by 24 hours overhead shaking with distilled water in a relation of 1:5 based on dry matter. The mixtures were first roughly sieved (63 µm) and finally centrifuged 4500 rpm for 20 min. The pellets from centrifuge were mixed with tap water and steering for 15 hours, supernant was used for some chemical analysis.
Aquatic - Sturm test on biodegradation: the biodegradability of a plastic material is determined using aerobic micro-organisms in aqueous system. The test mixture contains an inorganic medium, the organic test material (the sole source of carbon and energy) with concentration between 100mg/l of organic carbon, and activated sludge or, in our case - suspension of active compost pelets as the innoculum. The biodegradation was followed by periodic measurement of the released carbon dioxide.

RESULTS

In spite of expectations, degradation rate did not exceed 46% in 94 days - composting test (graph 1) and 25% in 48 days Sturm - aquatic test with flat stage of degradation curves in

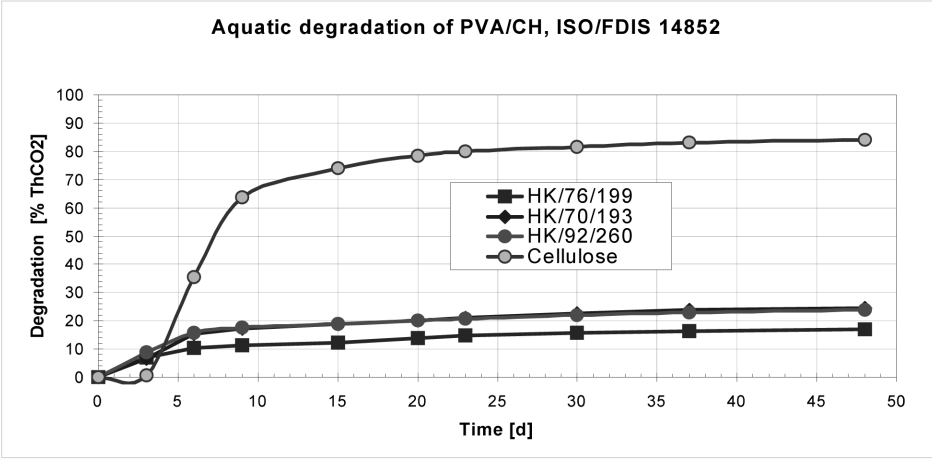
Graph 1. Biological degradation of PVA/CH in compost conditions



the end of experiments. Very interesting was finding that after composting process were pieces of material PVA/CH not water soluble any more.

Degradation values were calculated from theoretical carbon content of samples and CO_2 production during the process. As a reference, to confirm degradation potential of compost system, cellulose was used. It degraded with no problems and the value over 100% of degradation is to be seen as a result of the "priming" effect, which is well known in highly degrading processes of easy (ready) degradable substances.
Degradation rates in aquatic conditions (Sturm test), where samples were dissolved in aquatic medium, did not reach the values from terrestrial analyses. In this case the positive influence of collagen to the degradation is noticeable, where two samples with collagen hydrolysate had significantly higher degradation rate in comparison to pure PVA sample (graph 2). The same effect was detected also in anaerobic condition (Lešinský at al., 2000). As a reference was again used cellulose.

Graph 2. Biological degradation of PVA/CH in aquatic condition - Sturm test.



Validation of degradation rate in this case enable DOC (dissolved organic carbon) analyses in rest liquid after 48 days' test, which are shown in table 1.

Table 1. Carbon calculation/balance and degradation in sturm test.

name of sample (collagen content)	samples' carbon (C) content in %	weight of sample in g	start C mg/l	end C mg/l	%of degr. C	% C fixed in pellets	% C remaining in medium
HK 76/199 (0%)	51,2	1,0	1290,35	959,0	17,0	8,7	74,3
HK 92/260 (12,5%)	49,7	1,0	1252,85	775,05	23,9	14,3	61,8
HK 70/193 (16,8%)	49,3	1,0	1242,85	745,3	24,5	15,6	59,9
cellulose	42,1	1,0	1062,85	11,86	83,9	15,0	1,1

The last column "C remaining in medium" shows the content of not degraded carbon in bottles after degradation. The column "C fixed in pellets" means carbon fixed in micro-organisms cells.

During the physical/chemical analyses of composting rests was observed, as a new result, correlation between pH and colour after the degradation (lower pH - less colour). This is probably consequence of higher dissociation at higher pH-value, therefore solubility of humic acids in water is higher.

DISCUSSION

In general, the rates of biological degradation of PVA/CH were striking low.
In the composting test, it does not exceed 46%, which could be partly caused by structure of PVA (water affinity, conformation of hydroxyl groups...), degree of polymerisation (high molecular weight about 40 000),. Very interesting is also lost of solubility of the material during composting process - netting the plastics, what could be caused physically by composting condition - humidity, temperature and also chemically by reaction with humic acids.

CONCLUSION

The experiment of biological degradability showed quite radical results concerning biodegradability of investigated PVA/CH blend in different environments. There is a need for consequent analyses which will proof or refute those findings and will study degradability of (melted) PVA/CH in soil and activated sludge, so will simulate natural and practical condition. For any application in agriculture or other public use such research is essential.

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