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DECOMPOSITION OF BIODEGRADABLE FILMS DEVELOPED ON THE BASIS OF POLYVINIL ALCOHOL IN THE NATURAL ENVIRONMENT

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Abstract. *The use of polymeric pack has made for many important problems. Biodegradable plastics may provide solutions to global environmental problems. The aim of this study is to examine the utilization possibilities in natural environment of biodegradable films, which was developed with polyvinyl alcohol and organic filler materials (amylum and cellulose). The films stability against the filamentous fungus was analyzed, the soil type with optimal conditions to the biodegradation of polymers was determined; the mold fungi were separated from biodegradable films and were identified to a genus.*

Key words: *polyvinyl alcohol (PVA), organic filler materials, biodegradable films (BF), sodium-carboxymethylcellulose (Na-CMC), amylum*

INTRODUCTION

The speedy increase of the world population annually causes the intensive development of the packing industry. This process results in a storage of numerous used synthetic polymer films (SPF). Therefore, SPF utilization is one of the most important problems of mankind.

Glass products are used rapidly and paper is degraded in the natural environment, but SPFs have proved very immune and resistant to different environmental factors. In view of this, polyethylene (PE), polypropylene and polyethylene terephthalate are some of the most widespread SPFs today. The high stability of SPFs is determined by such properties as strength, stretch, water-impenetrability and air-impenetrability.

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In the natural environment, the degrading of SPFs is due to the non-biological processes such as thermal oxidation, photo-oxidation, mechanical and radiation degrading etc. It brings about the break of the long molecular chains. However, the time of such a process goes on for tens or hundreds years. In order to solve the problem concerning the scores of SPFs, humans generally use landfill, incineration or recycling of synthetic polymer waste. But these approaches are not efficient since landfill and incineration have an adverse impact on the environment, contributing to the generation of CO_2 and dioxin (these molecules increase the warming of the Earth and the environmental pollution), and recycling is a very expensive and hard work.

The use of the exhaustible natural resources (petroleum, gas) for producing salable SPFs has brought about its decrease. This process is another important problem, too.

However, alternative ways to solve these problems exist. One of them is designing novel formulations of composite films with natural polymers (for example, amylum or cellulose). These biopolymers have to possess specified properties that enable faster degradation of the BF in natural conditions. After their life span BF will undergo physico-chemical and biological changes by environmental factors. Therefore, their decay products will take part in the metabolism of natural biosystems. The BF is degraded by microorganisms. The degradation is determined by the quantity and quality of organic filling materials present in the BF. These filling compounds serve as the nutrient solution for fungus (one of the numerous biodestructors).

However, what will happen with the BF in the natural environment in different types of the soil? – Still unknown. Today this approach is only in an early stage of the development at the territory of CIS.

MATERIALS AND METHODS

The following materials were used: polyvinyl alcohol (the molecular mass – 12500, degree of polymerization – 2800, degree of hydrolysis – 98.4 ± 0.4 molar %), modified amylum Tackidex (Roquete, France), sodium-carboxymethylcellulose (Na-CMC), glycerin, and citrine acid. The concentrations of the organic filler materials in the testing films were 10%, 30% and 50 %. The reference samples were shown with pure PVA films and PE films (without organic filler materials).

The testing films were prepared from the PVA solutions by the «pouring» method. The produced solution was cooled to 50-60 $^{\circ}$C. Then it was poured onto the glass or the aluminum insulating pad, left at room temperature for 24 h. and dried at 120-130 $^{\circ}$C for 2 h.

When the films were produced they were buried into two variants of the chernozem. These soil's types differ with respect to the granulometric structure and plasticity: (1) sandy loam, very slightly plastic; (2) light loamy soil, slightly plastic (the «rolling up» method by N.A. Kachinskiy was used to determine the granulometric structure and plasticity of the soil).

When the testing films were retrieved from the soil, the degree of their utilization was estimated by the analytical balance. The film's visual changes were fixed using a digital camera (Canon *Power Shot* A720IS).

RESULTS AND DISCUSSION

Our research has shown that the degradation of the pure films (developed on the basis of PVA and PE without organic filler materials) does not occur in both of the soil's variants, while the BF (PVA-films with the organic filler materials) have shown good results. The obtained findings evidence the decrease in the film's weight.

It may be noted that the best variants of the films were polymers developed on the basis of Na-CMC and amylum at 30% and 50% concentrations (Figure 1).

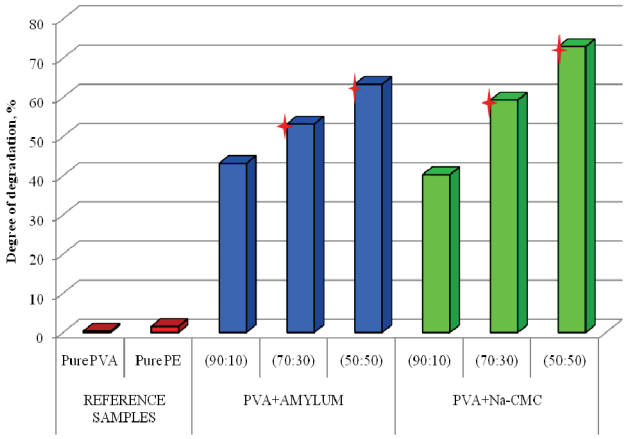


Fig. 1. The degradation of PVA films in the natural environment

The obtained data also suggest that degradation of the PVA films with amylum occurs more effectively in the sandy loam, while the films with Na-CMC show similar results for both chernozem's variants (Figure 2).

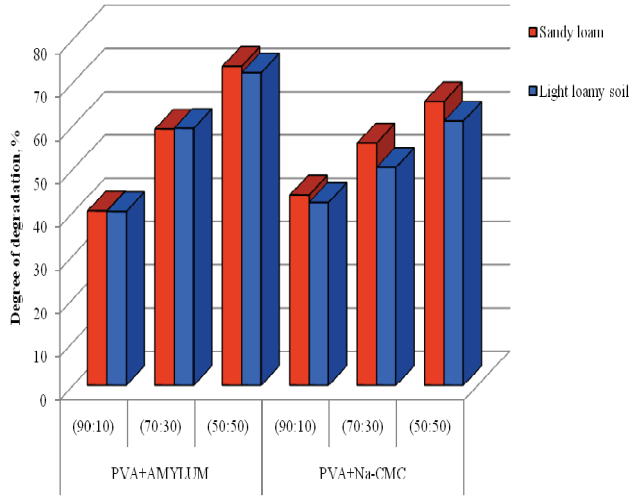


Fig. 2. The comparative estimate degree of the film's degradation against the granulometric structure and plasticity of the soil

A comparative analysis of the film's degradation has shown that films with Na-CMC (30%) are destroyed more effectively, compared to the variant with amylum. The degree of degradation is 3% in the loamy sand and 9% in the light loam. The value for the films with Na-CMC (50%) are 8% and 11%, respectively (Figure 3). The films containing Na-CMC as organic filler materials were shown to be the best variant of the BF.

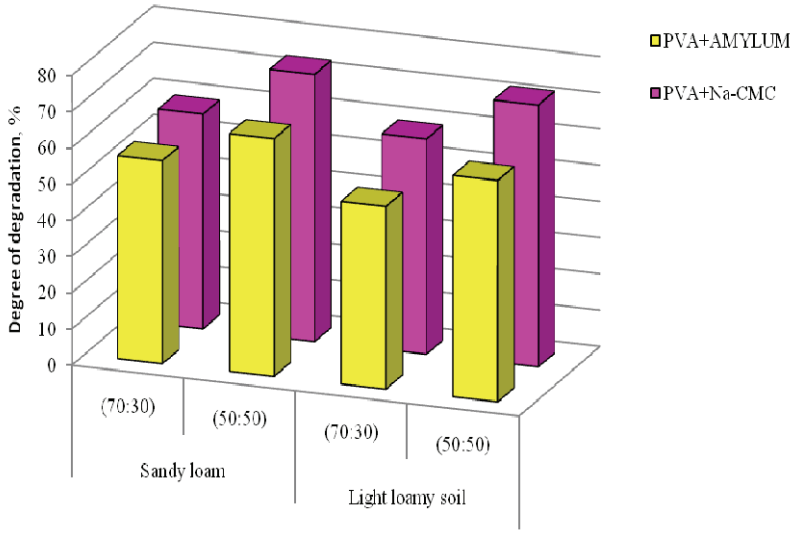


Fig. 3. The comparative estimate degree of PVA-film's degradation against the type of the filler material

The obtained findings suggest that the most effective degradation of the PVA films developed on the basis of PVA and filler materials occurs in the loamy sand. It is due to the complex of various factors including: the soil's granulometric structure, water balance, air conditions, the presence of the humus, the quantitative and qualitative micoflora's composition.

A mycological analysis of both soil's types has shown the presence of the same micoflora's representatives, which belong to two divisions, three classes, four orders, five families and eight genera: *Trichoderma, Fusarium, Aspergillus, Penicillium, Cladosporium, Mucor, Rhizopus* and *Pilobolus.*

The quantitative stock of the grown micoflora has shown that the amount of the colony forming units (CFU) was 5.9 x 10^2 fungal primordiums at 1g of dry soil in the loamy sand, while the value for the light loam is 2.6 x 10^2 CFU at 1g of dry soil (Figure 4).

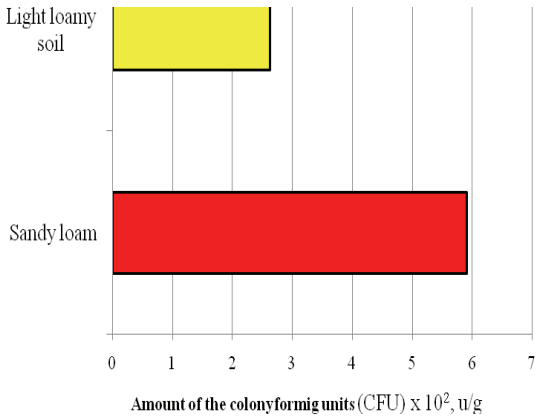
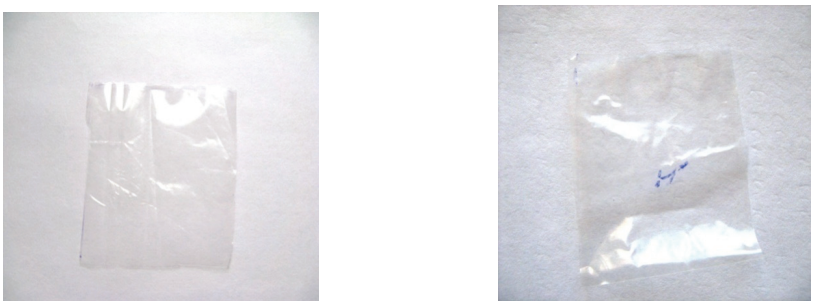


Fig. 4. The quantitative stock of the micoflora

The performed research has established that films from pure PE and pure PVA do change their initial state (they are intact), while the BF (PVA with organic materials) has taken a number of new morphological characteristics: it has become deformed, obtained a mesh structure, and changed its color (Figures 5-7).



1 2

Fig. 5. The appearance of pure films: 1-before the experiment, 2-after the experiment

1 2

Fig. 6. The appearance of the films with Na-CMC:
1-before the experiment, 2-after the experiment

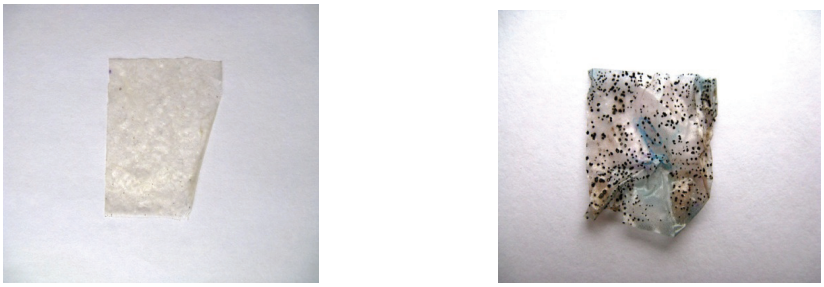


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Fig. 7. The appearance of the films with amylum:
1-before the experiment, 2-after the experiment

CONCLUSION

The performed research has proved that degradation of pure films (developed on the basis of PVA and PE without organic filler materials) does not occur in both of the soil's variants, while BF (PVA-films with the organic filler materials) has demonstrated good results. They have taken a number of new morphological characteristics. They have become deformed, obtained a mesh structure, changed their color and decreased their weight. The films with organic fillers (30% and 50%) have shown the least stability to the filamentous fungus. Therefore, amylum and Na-CMC are suitable for the fungi as a nutrient medium. The obtained findings have also shown that both soil variants are optimal for the degradation of the PVA-films with Na-CMC, but that only sandy-loam is suitable for the degradation of the PVA-films with amylum. The mycological analysis of both soil types has shown the presence of the same micoflora's representatives, which belong to two divisions, three classes, four orders, five families, and eight genera: *Trichoderma, Fusarium, Aspergillus, Penicillium, Cladosporium, Mucor, Rhizopus* and *Pilobolus.*

On the basis of the study, a large scale production of BF can be recommended so that they could be further used in field such as grocery, agricultural engineering, medicine, cosmetics and industry. The use of the composite films, which degrade in the natural environment after their life-span will help us preserve the biosphere from accumulation of various SPFs.

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BIORAZGRADNJA FILMOVA NA BAZI POLIVINIL ALKOHOLA U ZIVOTNOJ SREDINI

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Upotreba ambalaze na bazi polimernih materijala je izazvala veliki broj ozbiljnih ekoloskih problema. Biorazgradiva plastika moze da predstavlja resenje ovog globalnog problem zagadenja zivotne sredine. Istrazivanja preduzeta u ovom radu su bila usmerena ka razjasnjavanju sudbine biorazgradivih filmova (tankih slojeva), na bazi polivinil alkohola i skroba i celuloze kao organskih punilaca, u zivotnoj sredini. Utvrdena je stabilnost filmova ka dejstvu filamentnih gljivica, zatim, optimalni uslovi koji se odnose na tip zemljista gde se vrsi biorazgradnja pomenutih polimera, kao i izvrsena bioloska determinacija, do nivoa roda, gljivica koje su izolovane sa filmova u procesu razlaganja.