ANALYSIS OF BIODEGRADEABLE AGRICULTURAL FILMS AND OPPORTUNITIES OF USE

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REZUMAT. Datorita problemelor actuale de mediu exista un interes crescut de a inlocui materialele de proveniență fosilă cu materiale biodegradabile regenerabile. Acest trend este cu atât mai important și necesar în domenii ca industria alimentara, agricultura și ambalajele. Provocarea principală constă în crearea de folii agricole biodegradabile care să reziste pe o perioadă necesară și să se evite îmbătrânirea și degradarea prematură care duce la pierderea propietăților mecanice. Obiectivele acestei lucrari sunt de a identifica și de a enumera proprietățile și avantajele acestor folii biodegradabile.

Cuvinte cheie: folii agricole, biodegradabil, material din resurse regenerabile, bioplastic

ABSTRACT. Due to actual environmental problems there is an growing interest to replace materials based on finite resources (mostly fossil fuels) and to replace them with biodegradable materials from renewable resources. This trend is even more important and necessary in areas such as food industry, agriculture and packaging.. The main challenge is to create biodegradable agricultural film to withstand the required period and to avoid premature aging and degradation leading to loss of mechanical properties. The objectives of this paper are to identify environmentally substitutes that could replace the current use of petrochemically derived agricultural films

Keywords: agricultural films, biodegradable , renewable material, bioplastic

1. INTRODUCTION

Polymers started to be used in agriculture at the middle of the last century and growth ever since, especially in countries where the farmland is limited. The term plasticulture refers to the practice of using plastic materials in agricultural applications. Plasticulture insures increased yields, earlier harvests, less reliance on herbicides and pesticides, better protection of food products and more efficient water conservation, thus enabling the farmers to increase their crop production (as it doesn't depend on the climatic conditions as much as before) [1].

Despite all these advantages, the use of conventional plastics, manufactured from fossil fuels, besides consuming the finite and non-renewable resources, also contribute to the increasing problem of waste disposal, as a large portion of the plastic wastes is left on the field or burnt uncontrollably by the farmers. Aesthetic pollution and landscape degradation of regions of natural beauty represent an additional negative environmental impact. .As they are traditionally designed to resist microbial attack and biodegradation, it takes them at least 50 years to break down and the number of times they can be recycled is limited. [2] And even though they can be recycled, this practice is not a cost efficient one for the thin and dirty mulching and low-tunnel films.

Fig. 1. *NASA photo of plasticulture, Campo de Dalías, Spain*

Therefore the possibility to use materials that are biodegradable in soil seems a very good alternative to the conventional (mostly polyethylene) agricultural plastics, solving both the problem of environment protection and of cost effectiveness. At the moment, the emphasis is placed especially on developing thin biodegradable mulching films. A high performance biodegradable agricultural film must meet three critical requirements: achieving good mechanical behavior of the original films, retaining a satisfactory mechanical performance during the useful lifetime and achieving 100% biodegradation in the soil after the end of the useful lifetime, preferably before the next cultivation season [1]. Unfortunately, in several cases, biodegradability also represents a major controversial issue.

More than 20 years ago, the development of biodegradable plastics had begun. Although the first generation of products were actually a blend between traditional plastics and starch (causing a slow disintegration in nature), the second generation were products base completely on biodegradable polymers derived from synthetic or natural materials or mixes of both. The major polymers of industrial interest include PLA, the polyhydroxyalkanoates (PHAs), cellulose and starch.

2. MATERIALS AND METHODS

The mechanical properties of different biodegradable materials depends on their chemical composition and the application conditions. Several additives can be added into these biodegradable blends in order to improve their properties, which sometimes may even reach the levels of the conventional plastics. Ageing during the useful lifetime also causes great losses in the elongation.

Cellulose, starch, and their constituents are the two most important raw materials for the preparation of films. The characteristic of some of the most common blends are shown in Table 1. The most widespread biodegradable polymer is starch, which is also inexpensive, being readily available from agriculture. It has a range of potential applications in the markets currently dominated by petroleum-based materials, because it is abundant, renewable, safe and economic. Still, unmodified starch is unsuitable as a component of biodegradable films because it has no plastic behavior, it degrades thermally only at 260 ^{o}C and it doesn't have the adequate mechanical properties. Still, it can be chemically modified in order to overcome the issues of thermoplasticity and water sensitivity. Starch alone cannot form films with satisfactory mechanical properties (high percentage elongation and tensile and flexural strength) unless it is plasticized, blended with other materials, chemically modified, or modified with a combination of these treatments

By the modification of the abundant hydroxyl groups of native starch to form esters, the starch is transformed into a material that can be extruded, processed and shaped similar to traditional plastic products. In order to improve its procesability and tech water resistance, plasticizers like glycerol triacetate and diethyl succinate can be used, as they are completely miscible with starch esters.

Modified starch can be also used in combination with other polymers, such as polylactic acid (PLA). PLA is a thermoplastic aliphatic polyester derived from renewable resources, such as starch, tapioca products or sugarcanes. PLA films have better ultraviolet light barrier properties than low density polyethylene (LDPE).[5] It can biodegrade under certain conditions, such as the presence of oxygen, and is difficult to recycle. It is a highly transparent material of high molecular weight, exhibiting good processability and resistance to water solubility. The breakdown of its hydrophobic integrity appears only in case of prolonged exposure to moisture and the degradation occurs by hydrolysis to lactic acid, which is metabolized by micro-organisms to water and carbon monoxide.[2] Therefore, the biggest advantage of PLA is that it returns to biomass, thus reentering in the natural cycle.

Fig. 2. *Mulch Film made of PLA-Blend Bio-Flex*

A material which is used to produce biodegradable mulching, direct cover and low-tunnel films, is Mater-Bi®, produced by the Italian company Novamont. It is made from substances obtained from plants, such as corn starch, and biodegradable polymers obtained from both renewable and fossil raw materials. Mater-Bi® is suitable for blow extrusion of films with a relatively wide range of properties in terms of processability, mechanical properties and transparency, being both biodegradable and compostable. Mater-Bi® film has similar mechanical properties and usage characteristics to those of traditional films. [3]

In a research carried out in the framework of the European research project Bioplastics: 'Biodegradable plastics for environmentally friendly mulching and low tunnel cultivation' a series of experiments were developed using Mater-Bi® based thin low-tunnel and mulching films. The biodegradable films (including transparent and colored mulching films) were made of different grades of Mater-Bi® material and additives and tested both in laboratories and in four different locations in Europe under real cultivation conditions.

Table 1. *Mechanical properties of starch-cellulose blends*

Components	% Elongation	Tensile Strength (MPa)	Tensile Modulus (MPa)
100% Plasticized starch films/ 0% cellulose crystallites	110	2.6	40
90% Plasticized starch films/ 10% cellulose crystallites	85	5.7	130
80% Plasticized starch films/ 20% cellulose crystallites	73	6.5	260
70% Plasticized starch films/ 30% cellulose crystallites	47	7.7	310

The evolution of the aging of these materials was monitored with an emphasis on some of their most critical mechanical properties such as elongation at break, tensile strength and energy at break. The biodegradable films exhibit a satisfactory behavior for a period of 1 month and the degradation of the elongation at break with time is not very drastic and allows these films to function satisfactorily for the needs of the cultivation. The evolution of the tensile strength of the optimized mulching films follows closely the corresponding behavior of the conventional thicker LLDPE films

A study conducted by Dr. Anu Rangarajan and Betsy Leonard from the Department of Horticulture at Cornell University showed that the properties of Mater-Bi® mulching films are similar to the ones of black plastic. [4]

3. CONCLUSIONS

Biodegradable mulching, direct cover and low-tunnel films are made primarily from plant starches and can be tilled at the end of the season, reducing labour costs for plastic removal and disposal. They can be broken down by micro-organisms in the soil such as bacteria, fungi and algae. The successful replacement of petroleum-based materials will open new value added markets for agricultural commodities and lessen the dependence of national economy on foreign crude oil and gas.

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