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KINETICS OF DEGRADATION OF PHOTODEGRADABLE POLYETHYLENE FILMS BY THE ELONGATION AT BREAK METHOD

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Abstract

The important factor in the use of degradable films for agriculture is the rigorous control of the change in the mechanical properties. The film has to play its role before the fixed time of degradation.

This is the case of Ende plast process (low density polyethylene stabilized with iron stearates) for the agricultural film on which the mechanical tests have been performed after season aging on « chevalet » and ground.

Keywords: Ende plast - Elongation at break - Photodegradation – Chevalet – Ground - Polymer.

1. Introduction

The biological degradation of synthetic polymer must be preceded by a chemical degradation decreasing the molecular weight of the polymer. It results in a decrease of physical and mechanical properties.

A polyethylene film exposed outdoor softens and break down to small pieces. This effect is a disadvantage for some applications. In this field of particular application this degradation presents 295 to 300 nm corresponding to energy of 95 Kcal/Einstein. The UV solar rays can cause carbon chains breakdown which form the polymer [1]. A radiation of a given wave length cannot react with a molecule except if it is absorbed [2].

The Ende-plast as aliphatic hydrocarbon is transparent in th solar UV. The photosensible components added to this polymer absorb the UV from 360 nm with a maximum at 270 nm [3-4]. The change in mechanical properties of agricultural films Ende-plast after natural aging on soil and chevalet during winter and spring seasons has been followed. The method of the control of elongation at break on the normalized samples has been achieved on a stress strain machine technical interest. This concerns the season « paillage » of soil. In this case degradable films are of interest to avoid visual pollution and genes for next plants [5]. Some of these films are already commercialized such as the case of Ende-plast (low density polyethylene stabilized with iron stearate produced by AKERLUND and RAUSING Sweden) on which our work is based on. The more efficient aging factor for plastics is the solar rays have similar effects of degradation as heat. The solar spectra on soil have a wave length between. This simplified method is used by the ATO Chimie laboratory of Mont (France). The method we used for our study is:

$$\text{Loss AR} = \frac{\text{Total elongation length}}{\text{Number of specimen}} \times 2$$

We exposed the photodegradable film of low density polyethylene called Ende-plast process having a thickness of 30 µ on chevalet and soil [6]. This film has been exposed along the winter and spring periods. The irradiation time

2. Experimental work

The mechanical tests represented by the method of elongation at beak gives a good representation of the degradation behavior of Ende-plast by means of stress-strain machine made by A.T.O. Chimie laboratory of Mont (France). We measured the elongation at break (Loss AR %) of specimen as a function of the duration of solar irradiations and the site of exposure. In general, the degradation is measured by the ratio:

$$\text{Loss AR} = \frac{\text{AR initial} - \text{AR irradiated}}{\text{AR initial}} \times 100$$

has been fixed to be 20, 30, 60 and 90 days under solar UV. After the different irradiation times, film specimen have been taken 48 hours before the mechanical test (elongation at break for preparation).

The specimens have been washed and cut as normalized specimens for elongation tests 50 mm x 50 mm in the extrusion machine direction. The specimen had a rest of 24 hours in a controlled room (23° C and 60 % humidity) and elongation test have been achieved on ten (10) specimens for the same irradiation duration (same time of irradiation).

3. Results and discussion

The results of aging of Ende-plast films exposed on soil and chevalets for winter and spring periods are represented on tables 1 and 2.

The result of table 1 shows that the loss in mechanical properties is more drastic during the spring season. This difference is due essentially to the duration of solar radiation which is longer in spring than winter. Expressed in global radiation, we have respectualy 200 741 J/cm² for spring season and 38 280 J/cm² for winter season. (Station météorologique de Pau UZEIN France). The mechanical loss is drastic from the 30th day of exposure and the deviation between the two curves increases up to the end of exposure Fig. 1.

A difference in results has been noticed for the film Ende-plast exposed on soil for the periods winter- spring. This difference marked for the films exposed in « chevalets » Fig. 2 shows that the kinetics of mechanical loss is progressive effect up to the end of exposure. The comparison of natural aging of Ende-plast films exposed on soil and chevalets for the same period Fig. 3 shows a more intensive degradation for the films exposed on soil than those on chevalets. This rapid degradation is due to on one hand, the accumulation of heat under the film which accelerate the degradation and on the other hand to the mechanical action of certain climatic factors (rain, etc …) and to the development of grass under the films [7].

Ende-plast with 5 % iron stearate	0 day		20 days		30 days		60 days		90 days	
	W	*S*	*W*	*S*	*W*	*S*	*W*	*S*	*W*	*S*
Resistance to the elastic limit (N/mm²)	13.1	13.1	12	13.4	11.6	13.2	14.4	14.1	10.7	14.6
Resistance at break (N/mm²)	12.4	12.4	12.4	11.7	10.7	10.1	13	14.4	10.1	11.5
Elongation at break (AR %)	436	436	342	381	335	118	295	38	58	39

Table1: Natural aging of Ende plast films on chevalets.
(***W = Winter - S = Spring)***

Ende-plast with 5 % iron stearate	0 day		20 days		30 days		60 days		90 days	
	W	*S*	*W*	*S*	*W*	*S*	*W*	*S*	*W*	*S*
Resistance to the elastic limit (N/mm²)	13.1	13.1	14.4	12.8	14.1	13.7	13	11.7	13.9	7
Resistance at break (N/mm²)	12.4	12.4	13.1	10.4	11.4	10.3	11.4	11.7	12.7	7
Elongation at break (AR %)	436	436	410	267	280	95	93	26	36	17

Table 2: Natural aging of ende plast exposed on soil.
(***W = Winter - S = Spring)***

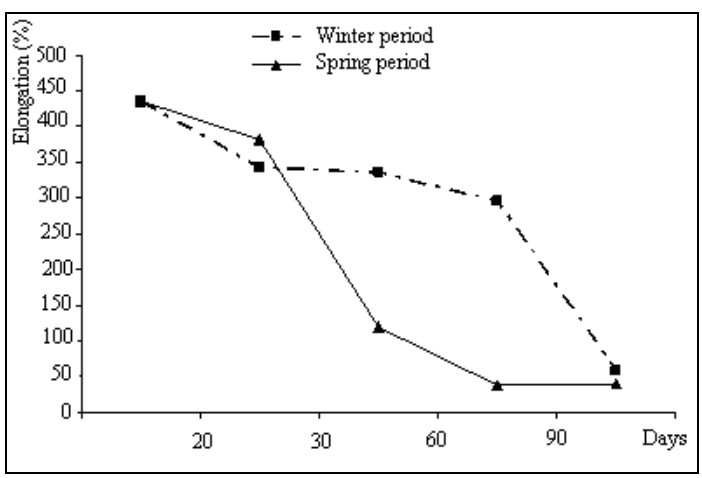

Figure 1: Natural aging exposed on chevalet.

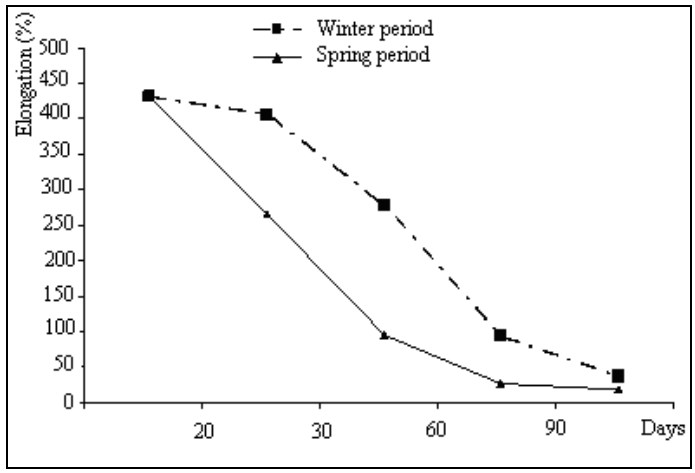

Figure 2: Natural aging exposed on soil.

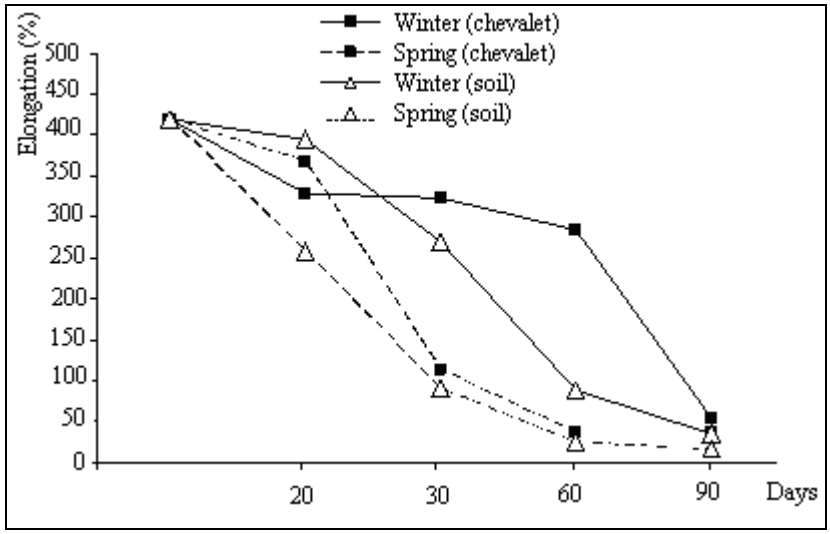

Figure 3: Natural aging kinetics of polyethylene films phodegradable (Ende-Plast) exposed on chevalet and soil for winter – spring periods

4. Conclusion

The photodegradable polyethylene agricultural films Ende-plast process exposed on soil present an accelerated degradation (aging) that those exposed on chevalets.

This mechanical degradation is more important for the spring season than that of winter because of the higher global solar radiation

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