Is it necessary that misinformation on oxo-biodegradable materials continues?

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In the 1980s, the specialists in photo-ageing of polymeric materials were asked to solve the problems involved in the visual impact of plastic waste and the problems involved in the "macrotoxicity" of this waste in the marine environment. By "macrotoxicity", one understands the danger with respect to marine creatures due to the macroscopic shape of films, nets, and wire. In these years, photodegradation was considered a suitable response, reducing the impact of these harmful effects. The Laboratory of Photochemistry of the University Blaise Pascal of Clermont-Ferrand (LPPM), established in 1970, and the French National Center of Evaluation of Photoprotection (CNEP) established in 1986 were very active to promote the photo-degradation of plastic waste.

But since the year 2000, many observations of fragments of polymeric particles which accumulate in the continental and marine environments showed that photo or thermo-fragmentation due to the impact of light, heat and atmospheric oxygen under environmental conditions, was no longer a solution acceptable for non-collectable plastic waste. CNEP therefore engaged in research on oxobiodegradable polyolefinic materials (PE initially, then PP).

Today, research on these materials has advanced considerably, as well for the understanding of the fundamental mechanisms of oxo-biodegradation as for its application to industrial and commercial solutions. An agreement (not a standard) under the auspices of AFNOR (the French Standards Organisation) AC T51-808 has formalised the results of this research.

A properly formulated oxo-biodegradable polyolefin film must have the following properties of abiotic degradation as well as acquired biological breakdown:

- This film must show, under sunlight, at ambient temperature and in presence of oxygen, an accelerated photothermic oxidation whose advance must be controlled by an analytical means adapted like spectrophotometry IRTF and which must cause the film to degrade. This oxidation known as photochemical must occur over the duration of a few months (2-4 months in active season in Europe for example), this duration having to be controlled by measurements under artificial acceleration in a laboratory in which one controls simultaneously the light intensity, the spectral distribution of the light and especially the temperature to which surfaces are exposed (the SEPAP 12.24 is one of the few accelerated photo-ageing units which respect those requirements)

- The residues of film must then continue to oxidize at ambient temperature in the absence of light (for example in the surface layers of the ground).

According to AFNOR AC T51-808, thermal oxidation is to continue for 3 years. This necessary evolution is modelled in the laboratory by 300 hours thermo-oxidation at 60°C. The level of oxidation of the residues can be observed by micro-spectrophotometry IRTF (spectrophotometer IRTF

associated with a microscope IR), and must be such as to enable certification of acquired biodeterioration using “Biotest ATP”.

- “Biotest ATP” to which the deeply oxidized residues of PE or PP must be subjected, was developed in collaboration between the CNEP and SEESIB (Synthesis and Study of Systems with Biological Interest) of the Institute of Chemistry of Clermont-Ferrand (CNRS - University Blaise Pascal). The residues are introduced, as the only organic nutrient, into aqueous solutions containing mineral oligoéléments and a population of the bacteria *Rhodococcus Rhodocrous*. The activity of the bacteria is observed by a proportioning luminometric titration of the ATP, Adenosine Triphosphate, molecule which measures the activity of the bacteria. If the oxidized polymer is really a nutrient, the population of the bacteria develops and is maintained in a stable state for 6 months; in the contrary case, the population is reduced to a stable level 3 times lower than that observed in the presence of the oxidized polymer. Moreover, if the oxidized polymer contains a toxic component, the bacteria exhibit corresponding mortality.

This double protocol of experimental control of the properties of oxo-biodegradable films is performed regularly at CNEP – the Biotest ATP being commenced only when photothermic and thermal oxidation are at least equal to the thresholds defined in AFNOR AC T51-808. Many satisfactory film formulations have been developed to guarantee a successful outcome over programmed durations for PP or PE polyolefin films (of which the thickness can go up to 500 µm), dispersed accidentally or deliberately in nature and non-collectable.

It seems that the European Commission plans to deal with the problem of plastic waste only by approaches like recycling, composting or incineration. Non collectable plastic waste is not therefore recognised by the European Commission, which envisages the total disappearance of plastic waste as from the year 2050, on the ground and in the European marine environment. They do not have and do not appear to wish to have data on the non-collectable plastic waste, which exists undoubtedly in all the continental and marine environments.

This position does not facilitate the development of biodegradable polymeric materials, which are intrinsically hydro-biodegradable or oxo-biodegradable, and the European Parliament even considered to ban oxo-biodegradables on the basis of not very expert reports and erroneous information.

The intention of this article is not to draw attention to the organizations responsible for the diffusion of erroneous information on oxo-biodegradables - organizations which will remain anonymous in this article, but with which the CNEP is in contact (critical!). This article aims to deal with the principal negative elements which usually circulate in Europe. These elements are at the base of political reactions and obstruct considerably the development of oxo-biodegradables in Europe. Fortunately this misinformation is effective only in Europe and the oxo-biodegradables experience a normal development in Turkey, in the Middle East, in Africa, in China, in South America and North America.

The negative elements which are often expressed in the case of oxo-biodegradable plastic bags are as follows:

- *Oxo-biodegradable polymers are only oxo-fragmentable.* This view is contrary to the earlier part of this article and is disseminated by several technical centres which are not specialists in this technology.

- *Oxo-biodegradable polyethylene films (thus correspondingly plastic bags) are unsuitable for recycling with polyethylene*. This opinion results from a study commissioned by the European Plastics Converters and carried out while introducing, with low relative content, 4 types of material into a recycling operation. A reading of the report shows that in 3 cases out of 4, the introduced materials were biosourced polyethylene which is not oxo-biodegradable; in the last case, the material was not certified as oxo-biodegradable - the organization not having competence to do it.

This study appeared to show a disturbance from the die from the introduction from 2% from the material. The generalization of this conclusion is unacceptable taking into account the real concentrations of the pro-oxidant elements in oxo-biodegradables. In case of future evaluations, it will be advisable to qualify well at the same time the oxo-biodegradable materials used and the results obtained.

- *The residues of oxo-biodegradable films produced after exposure to light, do not continue to oxidize at ambient temperature in the absence of light - for example in the earth*. This is contrary to what can be proven by determining the energy of activation of thermo-oxidation and by understanding the kinetics which must necessarily intervene.

- *The oxo-biodegradable polyolefins can give rise to toxicities*, either due to the organometallic prooxidant compounds, or due to organic compounds formed during the oxidizing decomposition of polyolefins. In fact, among the organometallic compounds used, only that including the cobalt cation was presented as an important toxin. However, using Biotest ATP described in AFNOR AC T51-808, we showed that the toxicity of this compound with respect to the bacterium employed appears only with contents at least 10 times higher than those used in formulations of oxo-biodegradable material. In addition, all the molecular organic compounds or oligomers formed during the photochemical degradation of the EP and PP have been identified, for at least 20 years within the Laboratory of Photochemistry Molecular and Macromolecular of the University Blaise Pascal, and none of these compounds proves to be toxic (as Biotest ATP shows).

- *It is not advisable to convert biosourced PE into oxo-biodegradable PE.* In fact, the biosourced PE is nonbiodegradable and is likely to be a visual pollutant and macrotoxic in the marine environment. It thus appears on the contrary desirable to make them acquire a biodegradable property.

Research on oxo-biodegradable materials commenced in the year 2000 must be able to continue without meeting non-scientific obstruction. In any scientific field, one can oppose to results achieved in controlled conditions only new results achieved in conditions so controlled. It is not acceptable to oppose to the achieved scientific results opinions based on little or no proven facts.

It is clear that further research efforts need to be made to consider the behaviour of non-collectable plastic waste in multiple environmental situations - and the field of the interactions between abiotic degradation and biological breakdown of polymers.

The field of oxo-biodegradation is a field with important potential for the protection of the environment especially for the marine environment in which the oxobiodegradable polymer is submitted to more favourable conditions for abiotic degradation.

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