TECHNICAL BULLETIN: CURRENT TRENDS TO REDUCE THE ENVIRONMENTAL IMPACT OF PLASTIC

1 INTRODUCTION

Plastic products contribute to our health, safety and welfare, providing unique features such as: low cost, excellent mechanical properties-to-weight ratio and durability, reasons why it is currently are present in our daily lives, from coffee cups, pens and bags supermarket, even shoes and glasses.

Plastic bags are used in our day to day for providing ease in the transfer and storage of different products. Are bags are made mainly from derivatives of oil (PELBD, PEBD, PEAD and their mixtures), whose production must follow the practices adequate environmental conditions so as not to present a environmental threat. Additionally, the provision end and life cycle of these are factors determining factors in the environmental impact of plastic bags.

Figure 1. T-shirt type bags used for shopping in supermarkets.

Reports from some environmental foundations in Venezuela indicate that each Venezuelan uses and disposes on average 150 plastic bags a year, according to data published in 2012 (1), which it means that in the country they are thrown in the garbage 4 billion bags annually. Around the world uses 1 billion (1x1012) bags per year, of which only in China are consumed 3 million (3x106) of bags daily, according to statistics presented in 2016 by the Statistical Brain Research Institute (2).

Figure 2. Annual consumption of plastic bags per capita in Venezuela for the year 2012.

The low weight of plastic bags makes them easily carried by the winds and displayed in trees, paths, lakes, rivers and seas, generating visual pollution and affecting the fauna of the planet. For this reason, the bags plastics have become the object of criticism of various environmental organizations.

Figure 3. Improper disposal of waste plastics.

The response of several countries to this situation has been the limitation of its use through the introduction of fines, prohibitions, taxes and/or incentives for recycling and reuse. Despite some environmental defense organizations They propose a ban on plastic bags and their replacement by other types of packaging, Efforts are focused on promoting recycling and reuse alternatives, because Studies have shown that the life cycle of these substitute products such as paper or cloth, have a greater environmental impact than PEAD bags for not presenting a high rate of reuse (16).

Various alternatives are proposed in this bulletin to reduce the environmental impact of bags plastics through reuse, recycling, biodegradability and/or degradability of themselves, among others.

2 REUSE.

Reuse is simply repeating the use of an object as many times as possible before destroying it or discard it, and with this reduce the consumption of energy and the impact that manufacturing represents of said object on the environment, in all its phases.

The important thing about reusing plastic bags is extend their useful life before they are sent to the waste and thereby reduce the environmental impact from its manufacturing process and the their permanence on the planet before its degradation (approximately 1000 years) (3). That is why it is vital to make the users to take friendly measures with the environment.

An alternative to reusing bags plastics is its use in the elaboration of household items, such as rugs for the kitchen, baskets for the storage of food, bags, among others (Figure 4).

Figure 4. Products made with plastic bags reused.

In Venezuela and the world there are initiatives of reuse through art. At the national level, it stands out the work done by different artists in cities like Caracas and Maracaibo. In Caracas, specifically at Hacienda La Trinidad, held between 2015 and 2016 an exhibition of the works made by 8 Venezuelan artists using waste materials (plastic bags and other plastics). This project was looking establish relations between the plastic work of the creators and the possibilities of integrating it, from the conceptual assessment and respect for the environment natural and public art (17).

Figure 5. Works of art exhibited at Hacienda La Trinidad. Period 2015-1016.

On the other hand, Marabino designer José Jesús Araujo created in 2016 his first collection of clothing and accessories, using materials from waste among which bags were used plastic (18).

Figure 6. Piece of the designer collection Marabino José Jesús Araujo.

Regarding the artistic expressions around the world, highlights the case of the artistic

movement Tape Sculpture powered by American artist Mark Jenkins, who since 2004 creates sculptures implementing plastic bags and tape adhesive (19). His sculptures were initially exposed in the streets of the city of Washington D.C, which generated strong controversies, without however, sometime later this movement was made viral in several cities of the world (20).

Figure 7. Sculptures made by the movement Tape Sculpture.

3 RECYCLING.

Recycling is subjecting a used material to a process that allows it to be used again (4). With recycling, a raw material or a product, from a waste or a good already used, thus reducing the emission of greenhouse gases, which contribute with global warming. Also, the recycling of plastics reduces the amount of resources extracted natural resources (mainly gas and oil), thereby minimizing contamination of the water and air associated with the processes of obtaining of the raw material. More than 95% of the energy total amount required to produce one kilogram of plastic is related to the extraction and refining, so recycling results in savings energy of between 150 and 200 gallons of gasoline per ton of recycled plastic (5).

On the other hand, recycling contributes to the reduction of waste present in landfills toilets and waterways. Additionally it generates new jobs, having a positive impact on the World economy.

There are two types of recycling processes: mechanical and chemical. The first of them is also known as physical recycling, due to that the plastic is melted down and reprocessed to form a new component that may or may not be of the same type as the original part. On the other hand, Chemical recycling is a process in which the object to be recycled is returned to its components primary, as is the case of gasoline and hydrocarbons for polyolefins and monomers in polyesters and polyamides; these components can be used later as material raw material for new polymer production.

Figure 8. Mechanical recycling process.

From an industrial point of view, recycling mechanical is the most suitable due to its reliability and low cost.

In any case, it is important to raise awareness citizen about the products that can be recycled and its correct classification. In this way, the work associated with the plastic waste sorting process, which translates into monetary savings. The supermarket bags, sandwich bread, without handles or "produces bags" (the bags that regularly used to pack vegetables), dry cleaners, easy-open type and water bottle wrappers, soda, toilet

paper, among others, are candidates for recycling.
They all must be clean and dry before being deposited in containers identified for the collection of plastic bags to be recycled.

Figure 9. Plastic bag containers for recycling.

The product the bags will be converted into recycled depends mainly on the performance required for it, since the material recycled has inferior properties in comparison with virgin resin (6). There are many applications in which a bag plastic can be transformed: into new bags, in plastic wood, in hoses, etc.

Figure 10. Products made with plastic wood.

In Venezuela, several environmental foundations have taken the initiative to encourage various recycling programs, focused on the collection and sale of recyclable materials (paper, glass, cardboard and plastic) to raise environmental awareness and reduce the amount of trash going to landfills.

Likewise, around the world they are also carried out various programs that promote recycling. Specifically in countries like United States of America, this type is met of programs, which are encouraged and executed (mostly) by a variety of universities throughout the country, an example of them are: Penn State University, the Stanford University and the University of North Carolina.

For its part, Penn State University implemented in 2007 a program of recycling, which arises from the need to reduce the cost of transporting plastic waste to the nearest landfill (100 miles). East program covers the recycling of plastic bags and flexible plastic films, which are collected and transferred by the staff of maintenance to external "waiting areas", where they are later collected by the employees of the recycling plant on the routes designated.

Two years after the launch of the program (year 2009), the university managed to divert 14,515 kg of flexible plastic from the landfill, recycling this quantity instead of plastic. For the year 2012, the university collects enough flexible film to ship the container full 27.43 m twice a week at recycling plant (22).

4 DEGRADABLE ALTERNATIVES AND BIODEGRADABLE.

In addition to the reuse and recycling of plastic bags, there are other methods used in its manufacture offering less environmental impact.

4.1 Prodegrading additives

Prodegrading additives are used in virgin resin blends to promote accelerated degradation of the final product under certain conditions, such as exposure to UV rays, temperature, humidity and oxygen, among others. In presence of this type of additives, the process of degradation of the plastic bag is accelerated, reducing from approximately 1000 years to 5 years or less, depending on factors environments to which it is exposed. Prodegrading additives are used in virgin resin blends to promote accelerated degradation of the final product under certain

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These prodegradant additives are based generally in catalytic metal compounds transition such as cobalt stearate or manganese stearate. The additive is used typically at levels of 1-3% and leads to costs additional between 10-35% with respect to the value of the polyethylene (7).

Environmental companies like Nolan ITU (Australia), report concern about the implementation of metals in plastic products because these can be dispersed in the medium environment contributing to pollution same (7). However, as a counterpart, emphasize that despite the existing concern, Studies indicate that metals are present in quantities so small that they would not harm significantly the composition of the soil (8).

In addition to the above, you must It should be noted that the use of these additives can present incompatibility with the programs of reuse and recycling, since it would add materials in degradation process to the manufacture of new packaging, with the consequent decrease in properties.

- Oxo-degradants additives:

Oxo-degradable bags are made from petroleum-based polymers (usually polyethylene) and contain special additives that they degrade. These additives, known as oxo-degradants, are metal salts of acids carboxylic and dithiocarbamates.

The degradation mechanism works through the breakdown of molecular chains long, where they are catalyzed by redox reactions of transition metal salts. Radicals can then react with other chains of polymer to form carbonyl groups, being able to give rise to the chain of cleavage that produces the loss of mechanical properties, so the polymer becomes brittle and disintegrates into small fragments. In this fine way fragmented, the plastic can become invisible in the environment, but it is still present in it that these microscopic fragments can affect land and sea life when ingested by insects, birds, fish, among other animals (9).

The degradation of oxo-degradable bags occurs when they are exposed to light sunlight and/or heat for a period of time dragged on. The time required for the degradation depends on environmental factors, as the intensity of solar radiation and temperature, which in turn depend on latitude and the local climate.

Figure 11. Effect of oxodegradable additive in the appearance of plastic bags.

According to the producers of prodegradant additives, the time in which degradation occurs plastic can be adjusted according to the amount of additive in the formulation. It is known that the degradation of small plastic fragments it usually takes between 2 and 5 years (9).

- Oxo-biodegradation promoter additive:

According to the European Committee for Standardization (CEN), oxo-biodegradation can be defined as the degradation resulting from oxidation and cell-mediated events simultaneously or successively". In plastic materials – and specifically in plastic bags - oxo-biodegradation occurs when adding an additive promoter of this process to the mixtures traditional polymers.

Oxo-biodegradable technology converts plastic products in biodegradable materials end of its useful life. This happens in a process of two stages; In the first one, the breaking of molecular chains polymer in the presence of oxygen. in the second stage, the smallest molecules are biodegraded by being consumed by bacteria and fungus. After biodegradation, the plastic is converted into carbon dioxide, water and biomass.

Oxo-biodegradable plastic has the same strength than ordinary plastic, but automatically converts into materials biodegradable in the presence of oxygen at the end of its useful life.

The limitation of this technology is that the product cannot be taken to landfills, since being in an oxygen-poor atmosphere (as is the case with such fillings), the anaerobic biodegradation generating gas methane. This gas produces a greenhouse effect dangerous, more powerful than carbon dioxide (CO2) (10).

- Photobiodegradation promoter additive:

Photodegradable plastics are polymers synthetic thermoplastics in which incorporated copolymers or chemical additives sensitive to light, in order to weaken the bonds of the polymer in the presence of ultraviolet radiation. Bags made with this technology are designed to be weak and brittle when exposed to sunlight for long periods prolonged. Another approach to making photodegradable plastics involves the addition of catalytic metal salts or chelates to initiate the degradation process.

These plastics degrade, in a two-step process stages, initially through the action of light UV that breaks some bonds leaving more weaker compounds with lower molecular weight which can subsequently be degraded by the application of efforts such as the action of sea waves, for example in systems photodegradable, biodegradation only occurs after an initial phase of photodegradation and subsequently the polymer is converts into carbon dioxide and water by action bacterial.

Photo-biodegradable bags can have a positive impact on both terrestrial and Marine. The effectiveness of this process depends on intensity of exposure and will vary with factors such as season, geography, etc. others (7).

4.2 Biodegradable Plastics

The term "biodegradable material" means that it is capable of developing an decomposition aerobic or anaerobic by enzymatic action of micro-organisms such as bacteria, fungi and algae, under naturally occurring conditions in the biosphere, in a reasonable time.

Biopolymers are a renewable plastic material made from biomass such as corn, wheat, sugar cane and potatoes. Although most of the Biopolymer products are not 100% free of petroleum, are biodegradable and compostable that once the biopolymer is placed in a composting environment, it breaks down into carbon dioxide and water by microorganisms, in approximately 6 months.

Biodegradable plastics are divided according to the material for its manufacture, in:

- Starch-based polymers: they are polymers thermoplastics made with at least 90% of starch from renewable resources such as corn, potato, tapioca or wheat. Examples of polymers with which starch is commonly used are:
  - Polycaprolactone (PCL)
  - Polyvinyl alcohol (PVA)
  - Polylactic acid (PLA)

- Bacterial-based polymers: are polymers manufactured by fermentation of bacteria such as polyesters aliphatic, where polyhydroxyalkanoate stands out (PHA) (11).

There are several environmental benefits that can stem from the use of biodegradable bags in compared to conventional bags based on of oil. These are: (7)

- The compost derived from the bags biodegradable increases organic content of the soil, as well as the retention of water and nutrients, while reducing inputs chemicals and suppresses diseases of the floors.
- The biodegradable bags deposited in landfills can increase the rate of degradation of organic waste present in them.

- Biodegradable landfill covers can also considerably extend the useful life of landfills.

- The energy needed to synthesize and making biodegradable bags generally much lower than needed to synthesize plastics biodegradable. The exception to this is the Polyhydroxyalkanoate (PHA) since despite of being a biopolymer, its energy consumption it is similar to that of polyethylenes in its synthesis.

The disadvantages of plastics biodegradable are: (7)

- Poor mechanical properties in comparison with plastic bags traditional.

- Biodegradable polymers based on starch can increase demand biological oxygen content (BOD) when introduced into waterways.

- By-products of the degradation of the plastic (dyes, plasticizers or residues of catalysts) can potentially migrate to groundwater, exposing organisms that inhabit these bodies degradation products that can be toxic.

4.3 Hydrobiodegradable Plastics

Hydrobiodegradable plastics are known by its degradation mechanism, which begins through a chemical process called hydrolysis. Subsequently, biodegradation occurs contact with microorganisms. Notably to start the degradation of these polymers, large quantities are not necessary of water, since the presence of moisture in the environment is enough.

These plastics include synthetic polymers and natural such as polyvinyl alcohol, esters and esters cellulose, acrylic acid polymers, polyacrylamides and polyethylene glycol, together with natural polymers derived from starch and some polylactides.
The degradation process of plastics hydrobiodegradable generates carbon dioxide (CO2) which is a greenhouse gas; and in anaerobic conditions (as in depths of landfills) can emit methane gas (12). Among other disadvantages, it should be noted that the products manufactured with this plastic provide weak properties compared to conventional plastic, In addition to not being compatible with the programs of recycling.

The implementation of the materials hydrobiodegradable in the manufacture of bags and of other plastic products could mean a environmentally friendly alternative, due to to the reduction of product waste petroleum derivatives in landfills. With this type of plastic can be obtained, in addition to the plastic bags, products as diverse as soft drink bottles, cooking oil bottles, containers of industrial oils, containers of detergents, packaging of various types of food, markers, pens and medical equipment disposable (13).

5 OTHER ALTERNATIVES (14)

As a complement to the use of materials degradable, in various countries around the world regulatory policies have been defined that They aim to reduce the environmental impact that have the traditional bags made with Petroleum derivatives.

Tabla 1. Main stock actions plastics in the World.

Actions	Country
Bag ban extra fine plastic (≤25microns)	China, Bangladesh, India, Australia and the United States of America (Texas and Los Angeles), India.
bag tax (User or merchant)	China, Taiwan, Wales, Northern Ireland, Scotland,

	England, Ireland, France, Germany, Columbia, United States of America (Washington D.C., Texas).
ban everyone types of bags plastic	Malaysia, Philippines, Mongolia, England, Italy, Turkey, Argentina, Chile, United States of America (Hawai).
bags promotion biodegradable	Italy
bags promotion reusable	Italy and the United States of America (Los Angeles)
recycling promotion of plastic bags	Germany and the United States of America, Canada.

These actions have positively led to the citizen awareness, greatly reducing measure per capita consumption of plastic bags in the world. Countries like China and Germany reduced consumption by 67 billion bags in 5 years and 1 billion bags in 12 years, respectively.

Additionally, it is important to note that during throughout Venezuela the following have been promoted measures: replacement of plastic bags traditional by oxodegradable bags, use of bags of different material and greater thickness, with in order to be reused, being in this way an ecological alternative and, finally, the sale to the consumer of plastic bags at the time of buy a product in establishments, such as supermarkets and pharmacies.

Figure 12. Awareness campaing citizen made by a national chain of pharmacy.

All the measures described aim to achieve the citizen awareness, since without the consumer collaboration is impossible reduce the impact produced by the bags plastic and any other plastic product. Without However, prohibitions of this type lead to the need arises to use an alternative that allows the user to transfer different types of products. These are not quite friendly anymore that studies reveal (15) that alternatives such as use of cloth bags represent an increase in gastrointestinal diseases due to the accumulation of microorganisms in its interior, so it is valid to study the feasibility of its use, because the potential health risks may not be compensated for environmental benefits.

para reducir el impacto ambiental de las bolsas plásticas a través del reúso (1), y diversas opciones que el mercado ofrece para el reciclaje de los productos plásticos.

6 CONCLUSIONS.

The use of new technologies available in the manufacture of plastic bags (such as the use of prodegrading additives), as well as the reuse and the recycling of the bags, extend their useful life and offer significant impact reduction environment of this product. The best solution of problem of the disposition of the bags and, in general, of plastic products, is the consumer awareness, without which, the problem will persist for many more years.

In order to achieve satisfactory results in terms of user awareness campaigns plastic products, work must be done in conjunction with local and national government, and with the transforming sector, in the education of the consumer to promote and carry out a proper disposal of plastic waste.

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