

How to build in an environmental friendly plastic foam to the product-packaging system

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Abstract: Our daily life is pervaded with the plastic materials. Although these devices, materials and foams provide numerous benefits, they also cause a significant environmental waste problem. From this aspect, if we investigate the field of packaging, the result will be very complex and disillusionizing. In first part of this paper, I introduce those common materials, devices which we can apply when we develop a new product-packaging system. If we compare these, we can see those facts which can show very negative picture if the packaging material became waste.

In the main part, I investigate the possible ways, which can help us to solve the continuously changing environmental requirements. In this process, the Environmental Degradable Plastic (EDP) foams can be a possible solutions.

To build in a new material to system, we have to know many engineering parameter, which are necessary.

These information are essential to develop and re-think the process of systematic approached product - packaging design methods. This paper describe the complexity of this development, which would be a possible right way to use environmental plastics and keep the products in safe.

Keywords: *product-packaging system, cushioning, EDP, biodegradable*

I. INTRODUCTION

Polymers abound in nature. Wood, leaves, fruits, seeds and animal furs all contain natural polymers. Bio-based polymers have been used for food, furniture and clothing for thousands of years. The first artificial thermoplastic polymer "celluloid" was invented in the 1860s. Since then, numerous new compounds derived from renewable resources have been developed. However, many of the inventions related to bio-based polymers made in the 1930s and 1940s remained at the laboratory stage and were never used for commercial production. The main reason was the discovery of crude oil and its large-scale industrial use for synthetic polymers since the 1950s. Today, public concern about the environment, climate change and limited fossil fuel resources are important drivers for governments, companies and scientists to find alternatives to crude oil. Bio-based plastics may offer important contributions by reducing the dependence on fossil fuels and the related environmental impacts.

Nowadays, if we try to analyze a product's Life – Cycle (for example electronic product), the most of the papers in this field investigate only the product's LC. Those professionals, who works, develops or research in the packaging know that the packaging system of a product, hid very wide range of potentials which are be able to minimize and decrease the packaging waste, which mostly arises from the manufacturing and logistics processes.

Arguments which increase the packaging material demand [1]:

Demographic and life-style changes (ageing population, increased demands on health and hygiene, convenience required, - Packaging in harmony with product and brand image , individualism, etc)

Technological changes (electronic and home shopping)

Supply chain management changes (IT as a supplement to packaging communication, virtual corporations, etc)

Manufacturing changes (concentration on core business and out-sourcing, part- manufacturing, etc.)

Problems with package design methods (counting only the "household" stresses, empirically development, "over-packing", etc.)

Environmental issues (pass the more and more strictly 5R requirements)

As we re-think the above mentioned facts, we are able to recognize that these were the modifier elements which converted the packaging's classic 3P function to 5R. To pass more and more from the 5R (Reduce, Reuse, Recycle, Buy Recycled, Rot (Compost)) requirements, we have to re-think one of the most huge packaging waste indicator, the nowadays applied cushioning systems [1].

II. PLASTIC FOAMS AS THE MOST COMMON APPLIED PRODUCT DEFENDER

The packaging system is mostly set-up based on four components:

Product (with its critical elements) → consumer packaging → collector package → transportation packaging (with the fixing system).

The package-product system has to withstand the rigors of the distribution environment. The hazards of distribution are many and varied. In the most cases is usually difficult or impossible to predict, what a product-package system is going to encounter.

During distribution there is a need to be concerned dynamic forces encountered due to [3]:

- 1) dropping, throwing and other abuses caused by the manual loading, unloading and handling of packages,
- 2) the stresses applied by mechanical handling equipment,
- 3) vehicle impacts,
- 4) vehicle vibrations.

The previous four conditions result in impact and vibration to the product - package system. As a consequence of that from the viewpoint of package cushioning design the two significant factors are shock and vibration.

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Goods are protected from shock and vibration by isolation. Isolation is generally attained by placing resilient means - cushioning materials- in the package system. In concept, the package cushioning is designed to protect the packaged item of known strength from the known shock and vibration in the given environment.

As we connect the facts logistic systems, which means nowadays more and more material handling, re-pack, and transportation with the requirement and demands to avoid the more and more complex products, we can state that the volume of the applied cushion materials will continuously growing (Fig. 1.).



Fig. 1. The world –wide tour of a product and packaging (from the raw material till the consumer)

The statistical data also show this prognosis (Fig. 2.).

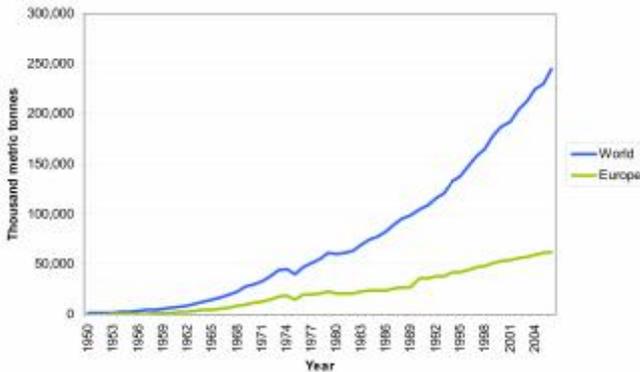


Fig. 2. World-wide and European production of plastics (in thousand metric tonnes) [2]

Plastic foams are synthetic polymers that are used widely throughout the world for various applications. One of the main industry, which use the plastic foams in huge volume is the packaging industry. In the packaging industry, we divide the produced devices for two parts:

- different kind of consumer plastic foam devices
- different kind of industrial plastic foam devices

In the following figure (Fig. 3.) summarize those plastics, which possible appear in the field of packaging industry.

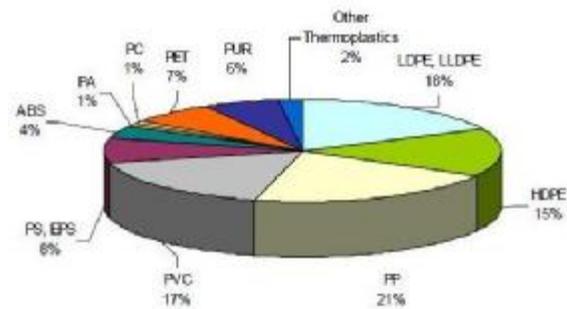


Fig. 3. World-wide thermoplastics demand by resin types [2]

As we summarize the advantages and disadvantages of the common plastic foams – as a cushioning material, we are able to make a balance. Nowadays, the balance is start to move to the direction of the disadvantages, so we have to change the package design methods and/or have to apply new materials, devices to avoid the products from the damages.

III. “GREEN” FOAM CUSHIONING?

The foams provide numerous benefits, they also cause a significant environmental litter problem. As shown earlier in Figure 3. 85% to 90% of today's total plastics are standard plastics. The Environmental Degradable Plastics [4] (EDP) can be synthesized either from petrochemical or natural resources of vegetal, aquatic, and animal origins.

Bio-based and biodegradable plastics will therefore be able to substantially reduce the chemical industry's environmental footprint only if bio-based plastics manage to conquer a meaningful share of standard plastics. Bio-based plastics have a higher product value than biofuels (e.g. ethanol) but their product value is lower than for special and fine chemicals and pharmaceuticals.

To understand the importance of these possible new materials we have to understand the differences and similarities between bio-based and biodegradable.

Bio-based plastics (Fig. 4.) are defined as man-made or man-processed organic macromolecules derived from biological resources and for plastic and fibre applications (without paper and board)

There are three principal ways to produce bio-based plastics:

- to make use of natural polymers which may be modified but remain intact to a large extent (e.g. starch plastics)
- to produce bio-based monomers by fermentation or conventional chemistry (e.g. Ci chemistry) and to polymerize these monomers in a second step (e.g. polylactic acid)
- to produce bio-based polymers directly in microorganisms or in genetically modified crops.

Biodegradable plastics can be manufactured not only from bio-based feedstock, but also from petrochemical raw materials To start the changes in the polymer properties due to chemical, physical or biological reactions resulting in bond scissions and subsequent chemical transformations are categorized as polymer degradation [4]. Degradation reflect changes in material properties such as mechanical, optical or

electrical characteristics in crazing, cracking, erosion, discoloration and phase separation.

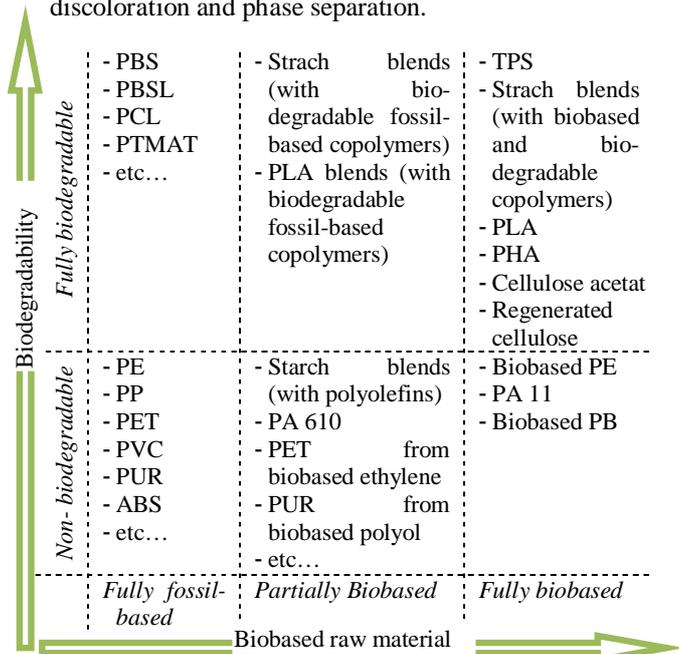


Fig. 4. Current and emerging bio-based plastics and their biodegradability [2]

In the following schematic figure, we can follow the method of a degradation process (Fig 5.).

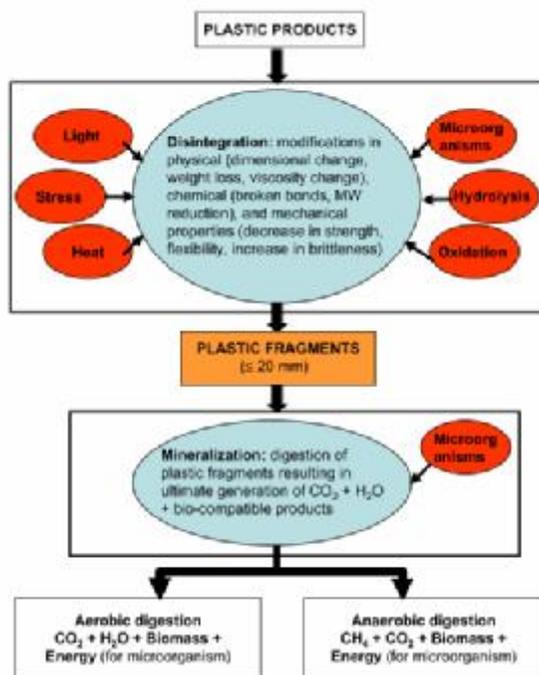


Fig 5. The schematic figure of a degradation process [4]

Degradation can be defined as a process which leads to a deterioration of any physical property of a polymer which used as a cushion in our product packaging system. In the practice, there are many parameters, which are also able to influence on the degradation of our cushion. These factors: Chemical composition, Molecular weight,

Hydrophobic character, Size of the molecules, Introduction of functionality, Additives, Chemical bonding, Methods of synthesis, Effect of substituent's, Effect of stress, Environmental conditions, etc. [5]

This list of EDP is a good representation of the potential solutions, but from the many different version we have to choose only those which can be able to pass not only on the very strictly environmental regulations, they have to pass – on that level as the well known normal plastic cushions – the very high level mechanical requirements too.

IV. WHAT WE HAVE TO KNOW TO USE “GREEN” CUSHION?

As well known from many papers, if we develop a new product – packaging system, it is ineluctable to clear and define the many times mentioned logistic stresses, which includes both mechanical and environmental stresses. If we can describe these stresses clearly, for example by a data logger, which be able to store the following parameters during the whole logistic link, we can start to choose the potential right EDP foam.

Parameters which ineluctable using any kind of movedamping system:

- Number and duration of the impacts [ms, m/s²]
- Vibration stresses [s, m/s²]
- Temperature and humidity inside the packaging [°C, Rh%]
- method of manipulating and handling

Additional parameters, we have to know, if we would like to use EDP foams:

- Storage times at (raw material supplier, packaging supplier, product manufacturer, distribution center, etc.)
- Degree of sunshine or light exposure

These additional information also have to be the base data of the development, because as I described in the earlier chapter, there are many type of the EDP foams, which answer differently to the described stresses. Many of the biological origin EDPs don't like the humidity. The water vapour be able to decrease their physical characteristics, and of course it is also influence the cushion characteristic. Other way, many of the synthetic origin EDPs are sensitive to the temperature and to the light exposure. These effects, if don't care about them, be able to start a disadvantageous process, which also be able to modify the characteristic of the cushion.

As we try to summarize the whole field of information we have to know, we can declare that, the development process of a new product- packaging system with a new “type” of cushion solution is a very hard task.

The following chart shows that method what we have to test, which kind of information are important, if we would like to adopt and apply a EDP in our product- packaging system.

1. Manufacturing parameters [6]
 - Effect of the processing (melt) temperature on the Expansion Ratio (ER)
 - Effect of the amount of water on the Expansion Ratio
 - Effect of PHAE on ER
 - Effect of screw speed on the expansion ratio (ER)
2. Tests to know the mechanical and technical properties
 - Cushioning curves,
 - Compressive Strength and Resiliency
 - creep characteristics and other specific information and their tests about the material
3. Tests to know the environmental characteristic of the EDP
 - geometrical size and material characteristic changes on different type of temperature and humidity variations (for example on 38°C/ 75% R.H., cycle environmental tests, etc.)
 - thermal insulation characteristic
 - Temperature hold time characteristic (possible application as a thermo box insulation), (Fig 6.)
 - water vapour adsorber characteristic



Fig. 6. Thermobox with biodegradable cushion (source: own photo 2009)

4. Investigation of the electrostatic behavior
 - protection against the ESD (Electro Static Discharge)
 - surface and volume resistance and resistivity of the packaging material
5. Analysis of the compared Life-Cycle information (normal and EDP packaging material)
 - Investigation of the emissions (e.g. CO₂, water, etc.) during the manufacturing
 - exhausted technical quantities (e.g. chemicals) during the manufacturing
 - Possible solutions and their costs about the packaging material as it became waste (reuse, recycle, degradation, etc)
- + 1 Comparison tests
 - the earlier applied common plastic foam have to be compared with the developed new cushion in the complete product – packaging system (Fig. 7.) (drop tests, vibration tests, shock tests, horizontal impact tests, stacking tests, etc.)



Fig 7. electronic product with its packaging. (source: own photo 2009) a) with common plastic foam; b)with biodegradable foam

From the above written, it is clearly, that the information about a normal product – packaging design process not enough, we have to enlarge the investigation.

VI. CONCLUSIONS

Summarizing the paper, we can clearly seen that the innovation of new type movedamping system, is a very complicated task. We have to know everything about product, about the characteristic of each cushion material (both normal and degradable), about the possible environmental and mechanical stresses, etc. These development processes additionally have to be connected with the product development, which have to be done parallel with the development of packaging system. The implementation of EDP packaging materials is a very complex and difficult task, but maybe this is the only solution to pass the more-more strictly requirements. Therefore, there is a huge potential for conducting research and large-scale biodegradation studies in this field to make valuable contribution in solving environmental and resource depletion problems of the world.

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