

Recycled Polymers from Food Packaging in Relation to Environmental Protection

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Abstract

The development of production and application of plastic packages, much connected with their high resistance to the action of environmental factors, is a problem from the point of view of environmental protection. While discussing methods of reuse of plastic waste one has to consider the possibility of food packages' production from recycled polymers. When conditions which ensure the safety of a consumer of packaged food are determined, the problem should be tackled because of its ecological and economic aspects.

Keywords: recycled polymer, food packaging, health safety

Introduction

A growing load of various industrial and municipal wastes in the environment, including waste from used packages, is an increasing problem. Its scale grows successively because the amount of waste "produced" per head; for example, within the last 20 years this number has doubled and is on average 250-350 kg per person of waste per year [1-3]. In practice over 95% of waste does not undergo any sorting or processing [4-5].

Limitation of the quantity and management of used packages is a material problem. Packaging plays an indispensable role in modern society. Without packaging, many products cannot reach consumers in a sound condition. Packaging has various functions including protection of product quality, and facilitating its sale. In practice, immediately after the purchase the package becomes unnecessary and is thrown away. Considerable participation of plastic packages in the package industry is a serious issue. Used polymer packages, although they are a small part of all waste, take up about 1/3 of the volume of municipal waste because of the low density of plastics [4-6].

The world plastic industry has been developing intensively within the last few decades (Fig. 1). Total production of plastic in Poland in 1950-60 doubled on average every 3 years, in 1960-75 - every 5 years, and in the following years its growth was different but always definitely bigger than of other structural materials [7]. Share of the most important types of plastic in production and in waste is presented in Table 1 (differences between production and share in waste result from different lifetimes of plastic products in various branches of the economy).

The biggest amounts of plastics are used for packages [4, 5, 7-9] and food industry is the main client for such packages [6]. Polyethylene terephthalate is one of the most important thermoplastic polymers because of its good usage and processing properties. PET-consumption for production of bottles rises by about 15-20 percent per year. About 95 percent of the containers are used for packaging of bottles for drinks and for the rest of the field of foodstuffs. It is said that 360 thousand tons of PET for the production of bottles will be manufactured in Europe in 2002 [10]. It is also thought that PET bottles for drinks are responsible for the biggest volume of plastic waste in Poland [9].

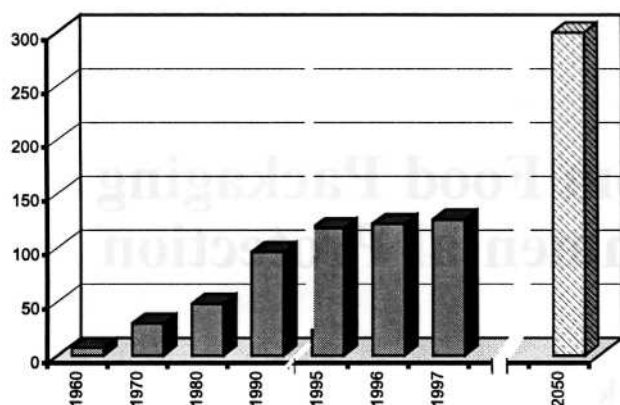


Fig. 1. The 1960-1997 and the 2050 (prognosis) productions of plastics in the world (in millions of tons) [7].

Table 1 Share of most important types of plastics in production and waste [4, 5].

Polymer	Production, %	Share in waste, %
Polyethylene	30 – 34	40 – 47
Polypropylene	12 – 15	12 – 19
Polystyrene	8 – 10	13 – 17
PET	2 – 5	5 – 12
PVC	19 – 22	10 – 11
Polyurethan	5 – 7	4 – 8
Other thermoplastics	7 – 12	8 – 9
Other plastics	7 – 20	6 – 11

Ecological Problems Related to Packages

Ecological danger from packages is related to the fact that the amount of produced and used packages grows quickly. General data show that world production of packages is on the level of about 1500 millions tons per year [6]. Usage of various kinds of package materials in Poland is shown in Table 2.

Recovery of particular types of packages differs and is estimated as [11]:

plastics	1.5%,
metals	5.3%,
glass	9.4%,
paper and cardboard	35%.

Packages are a source of environmental pollution with various substances: metals, plastics, glass, paper, cardboard and other materials. Some of these materials come from renewable natural resources; others are non-renewable. This division, important from ecological and economical points of view, makes the presentation of ecological dangers easier through a study of ecological balances.

Table 2 Packages introduced to the Polish market according to the type of material (in thousands of tons) [11].

Material	Package mass (estimation)		
	1998	1999	2000
plastics	320	335	350
steel and aluminium (cans)	160	162	165
glass	750	778	800
paper and cardboard	900	910	920

Package waste management should be based on the rules which result from Directive 94/62/EC [12]. The following types of activities are goals of environmental protection:

- Limitation of the number, cubature, material and energy consumption of packages used,
- Aiming at reuse of packaging,
- Processing of packaging waste,
- Liquidation through incineration or composting of packaging waste,
- Organised storage.

Used packaging could be divided into [13]:

- Troublesome for the environment (packaging for foods and some pharmaceuticals),
- Harmful for the environment (packaging for some chemicals and plant protection chemicals* and for some pharmaceuticals),
- Harmful and burdensome to people (packaging for some chemicals and plant protection chemicals)*.

Percentage participation of presented groups in total amount of used packaging is estimated as follows [13]:

- Used packaging not harmful to the environment but burdensome 70%
- Used packages harmful to the environment 25%
- Used packaging harmful to people 35%

Environmental nuisance is related in particular to plastic packaging. However, one should not expect a considerable limitation of usage of plastic packaging (although some countries make attempts to do so). It will be very difficult to substitute plastics with cheap and good materials and complete exclusion of polymer materials will be rather impossible. Predicted consequences of elimination of plastic packaging are presented in Fig. 2.

A dynamic growth of production and usage of plastic packaging, which has been noted for many years, is much related to their high resistance to action of environmental factors. This feature of plastics, convenient from the point of view of production and usage, is perceived as a disadvantage when after being used they linger for many years on landfills in a form of waste. Used packages have a big volume and are practically non-biode-

* According to the Directive on Waste only packaging for products and semi-products connected with sales and use of pesticides is regarded as dangerous waste [14, 15].

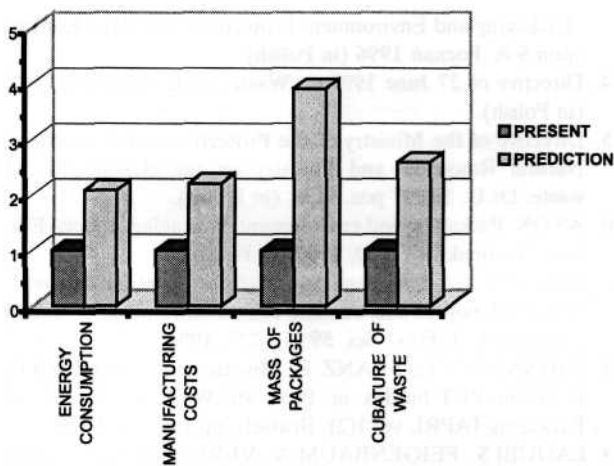


Fig. 2. Consequences (probable or possible) of plastics elimination in relation to present situation [15].

gradable, which, considering a more limited area of landfills and their growing costs, causes limitation of this method of plastic waste disposal.

The key issue in waste management is sorting of components which could be used as secondary materials; the more homogenous and less polluted they are, the more possibilities to recycle them. Because full segregation is a difficult and expensive method, it is profitable with a relatively narrow group of more precious plastics. Plastics, after being selected from a mass of waste and cleaned, may be used again after processing applying two methods:

- without changing their chemical structure (material recycling)
- with change of their chemical structure (chemical recycling).

Reuse of Plastics in Food Packaging

Because of a considerable share of plastics in food packaging (over 50% of total usage of plastics [6, 19]), there is an interest in a possibility not only to reuse packaging but also to make new food packaging from recycled materials.

One should pay attention to safety when using food packaging for the second time (multiple use) and while using recycled plastics. Problems result both from a possibility of contamination of virgin material and from contamination during previous usage of a packaging and during production processes. Contamination may be of a microbiological or a chemical nature. The packaging may have had a domestic use to which it is initially not intended, e.g. storing or conveying miscellaneous substances such as petrol, pesticides, and household products which might be toxic. The recycling processes for used plastics have not yet enabled a complete elimination of the pollutants. These substances may still be presented in the material made from reused plastics and may then migrate into the packaged goods in the next life of the

material. The residues of contamination in reusing packaging material are a potential danger for a consumer. One uses three methods to avoid migration of potential contamination:

- Packaging washing, if it is to be used in the same way as before; a precise control of effectiveness of the whole washing process, which is not always effective, is required [17-22]
- Plastic depolymerisation. The obtained monomers could be purified efficiently and then reused in a polymerisation process; then the produced polymer should be as pure as those made from conventional monomers [19]. In such a way one produces materials which are safe to the consumer, nevertheless, this is an energy-consuming and expensive process.
- Using materials which consist of a few layers; one layer, made from a recycled plastic, is separated from the product by a virgin material which is a "functional barrier"* that delays and reduces or disables the migration of the potential adventitious contaminants from the recycled plastic into the packaged food [19-20, 24, 25].

A third way with multilayer material used as packaging appears an interesting compromise both from the point of view of performance and cost [19, 24, 25].

PET bottles are an example of a primary package which is used applying the above methods: there are both PET bottles on the market which have multiple use and packaging produced using recycled polymer. However, PET recycling from used bottles is neither easy nor cheap: one has to remove all contamination from bottles (remains of drinks, labels, glue for labels, polyethylene caps) and other plastics which could be accidentally put among PET bottles during collecting. Because of high costs of production of a plastic with purity required for products which have direct contact with foods, recycled PET is used as the outer layer in multilayered containers with the inner layer (virgin material) acting as a functional barrier.

Final Remarks

Accumulation of waste in the environment stimulates studies on recycling of used packaging. It is disputable whether from ecological point of view it is more profitable to reuse packaging or to recycle it. There are many opinions on that subject, and they are not always objective and often they contradict each other.

The last few years have brought an intensive search for management methods related to constantly growing resources of plastics, also of recycled plastics, a problem which has not yet been fully solved is plastics recycling which will make it possible to obtain products which will be ready to use in determined conditions in a most rational, economic and ecological way.

There are some remarks in Polish scientific literature

* The functional barrier is any integral layer which under its normal or foreseeable conditions of use reduces all possible material transfers (permeation and migration) from any layer beyond the barrier into food to a toxicologically and organoleptically insignificant and to a technologically unavoidable level [23].

on possibilities of reusing plastics coming from recycling in food packaging [26-30]. Of course, hygienic and sanitary properties of produced packaging are the most important issue. However, one should also focus on ensuring consumer safety through the usage of multi-layer materials with a functional barrier and on evaluation of the size of possible migration of compounds from recycled plastic. It seems that one should pay more attention to usage of recycled plastics in packaging, especially when postulates related to waste management have been formed. Environmental protection and economic costs are subjects which also should be discussed.

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