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TECHNICAL, ENVIRONMENTAL AND ECONOMIC ASPECTS OF THE USE AND RECYCLING OF PLASTICS

Since their discovery, circa 50 years ago, polymers have spread over a very wide area of applications. These materials, in technical and everyday use known as plastics, exhibit several unique properties of extreme importance. They are lightweight, mechanically strong, chemically and environmentally resistant, can also be transparent to light and show an extraordinary ability to selective transport of various chemical molecules. These properties make plastics valuable, while not expensive, materials for a wide spectrum of applications that in many cases cannot be carried out by other materials. Among such applications the most popular are food wrapping and production of household articles, while more exotic uses include many applications in the design of automobiles (starting from upholstery through many important construction parts like engine, body or brake parts) or parts of spacecrafts, aeroplanes (various parts of the body as well as internal equipment), as well as many sport articles.

In well developed industrial the countries production of plastics is an important part of the economy. In many countries it has shown systematic growth over a number of years. By the year 1996 the annual global consumption of the main thermoplastic materials (HDPE, LDPE/LLDPE, PP, PS, PVC) had reached 95.6 million metric tons. From 1994 to 1996 the consumption growth rate amounted to circa 6% a year.

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Simultaneously, employment in the plastic industry has shown systematic growth (in the USA for more than two decades the annual growth rate has been about 3%) even during periods of stagnation in other branches of industry. In Poland a growth in plastic production has been observed during at least the last decade. Data for the 1st quarter of the year 2000 show that the total production of all types of plastics is of the order 525 thousand metric tons (of which thermoplastics constitute circa 440 thousand metric tons).

However, the environmental resistance of plastics creates, however, problems as products are disposed after their useful life. A wide variety of polymeric materials and products made of such materials, as well as incompatibility or immiscibility of various types of polymers, lead to a spectrum of wastes requiring special treatment. These wastes, disposed on landfills or, even worse – in the environment, may spend many years there without any evident trace of degradation leading to a deterioration of the landscape. This appears to be one of the reasons for controversial opinions about plastics and for the hostile attitude of many “green” organisations. It is clear that such ways of disposal should be avoided, but it should also be mentioned that this hostility towards plastics is not substantiated. Several arguments can be presented to defend this point of view, indicating positive environmental aspects of the use of plastics.

1. **Production.** Polymers are manufactured mainly from crude, natural oil (petroleum). About 5% of crude oil production is consumed by the plastic industry, while the rest is used for conversion into various forms of energy. The *environmental damage*, usually coupled with all kinds of technological operations – especially in chemical industry, is *approximately the same* as the environmental impact of *automotive fuel production* from the same amount of oil.

2. **Processing.** Technological processes leading to final products made of plastics usually consume less energy and emit less harmful pollutants than the corresponding processes associated with the manufacture of similar products from other materials, like glass or steel, etc.

3. **Use.** Application of lightweight plastics as construction or packing materials leads to less heavy machines and means of transportation, resulting in much more efficient exploitation of natural resources. It is estimated, for example, that a kilogram of oil used for the production of plastics used in transportation of goods, saves several kilograms of oil which as a result is not used as a fuel for cars because of a decrease in weight of the automobile and of the load.

4. **Recycling.** There exist several technical procedures offering the possibility of recycling materials from products after their useful life. Al-

though some problems still have to be solved, the main philosophy is clear. One can distinguish several categories of processes that can be taken into consideration:

- *primary recycling* is the simplest process of returning the material back into initial processing (e.g. defective items are recycled prior to leaving the factory);
- *secondary recycling* concerning mostly post-consumer wastes that are sorted and after some cleaning are used as material for the production of goods for less demanding applications.
- both categories mentioned above belong to so called *material recycling*;
- *tertiary recycling* – consists in the chemical degradation of polymers to such a state that the resulting substances can be used for chemical synthesis of the same polymer or other materials;
- *quaternary recycling* –, which should be applied only to very contaminated plastics, is the recovery of energy through incineration of plastic waste.

It seems necessary to point out that the *incineration of plastic waste without energy recovery* **should not be** legally considered as recycling. Also, the other procedures mentioned above should be used wisely, in order to optimise the use of the value contained in particular waste. Several directives of the European Commission show clearly the attitude of the European Union with respect to recycling materials, including plastics, contained in municipal and industrial wastes. Similar regulations exist in the codes of other countries, and are being introduced to the Polish code.

The recycling of plastics is already a well developed business activity for a number of enterprises, including small and medium-sized enterprises, and quite large amounts of plastics are reprocessed in Europe, as well as the USA and Canada. In contrast, the capacity of facilities installed in Poland is very small, and evidently below requirements.

Several reasons can be considered as being responsible for the present situation in Poland. Some reasons are of a social nature (e.g. lack of knowledge and lack of willingness of citizens to participate in selective collection of wastes), other are of a legal nature (e.g. appropriate legal definitions of the processes considered as recycling, existence of fines but also financial benefits, including tax benefits for recycling companies) and of a financial nature, consisting of low availability of funds for investment, together with the difficulty of obtaining preferential credits, etc. Consequently, it can be suggested that to achieve a situation in Poland similar to the ones developed in European Union countries

although EU countries differ in this respect)the following steps should be taken:

1. education of the whole of society;
2. introducing system information and management of plastic wastes;
3. improvement of the legal system;
4. promote plastics recycling as a business (for companies, as well as financial institutions).