Engineering Journal of the University of Qatar, Vol. 12, 1999, PP. 43-54

SOME MISCONCEPTIONS ABOUT PLASTIC DEGRADATION

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ABSTRACT

In consistence with the importance of implementing best utilization of human resources towards maintaining suitable healthy environment for our next generations, concepts and fundamentals upon which most researches on degradation of plastics are based, as a solution of solid waste reduction, will be discussed. Proper understanding of plastic figures would better utilize human efforts toward useful tasks to control solid waste. Unfortunately, when plastics are made more degradable, they become less recyclable. Furthermore, care and precautions are increasingly needed in case toxic products are released upon degradation.

Key Words: Plastics Degradation, Environment, Recycling, Incineration, Energy Recovery, Misconception

INTRODUCTION

Industrial plastics have a broad range of mechanical properties. In general, they are lightweight, good thermal and electrical resistors, and easy to be fabricated in many manufacturing processes, they also have low friction factors, and high strength-to-density ratios. In comparison with metallic materials, their use is limited to relatively moderate temperatures and pressures. On the other hand, they have excellent resistance to weak mineral acids and are unaffected by inorganic salt solution- an area where metals are not entirely suitable. In addition they are better resistant to slight changes in pH, to oxygen content and impurities in solution [1].

Plastics are under continuous evolution. Hence, their database is not fully established as for other engineering materials. Their physical and chemical properties due to possible enhancement by different additives are always investigated and gaining attention. This makes plastics development play an important role in providing a more appropriate chance for industry to use appropriate and less expensive materials.

MANUFACTURING CHARACTERISTICS

The importance of plastics also increased due to the special characteristics of their manufacturing processes, namely: easy manufacturing, use of simple machines, molds and dies lasting long, less energy needed for production, less labor work, products need limited or no finishing to surfaces, less waste materials in production, easy understandable manufacturing processes by even simple people, and availability and reliability of raw materials and resources.

In general, plastics can be formed into desired shapes by the common processes in mass production like: extrusion, molding, casting and spinning. As a consequence, the world production rate of plastics has reached 150 million tons in the year 1996 and is estimated to reach 350 – 400 million tons per year within the next two decades [2].

ENVIRONMENTAL SIZE OF PLASTICS PROBLEM

To understand the size of the problem, by which plastics wastes could have effects on the environment, it is necessary to view the figures of municipal solid waste(MSW), as the main source of threat, and its corresponding constituents of plastics for some countries. This is shown in Table (1).

To determine the status of Gulf Cooperation Council (GCC) States, where this study is being conducted, figures for production rate of major polymers are given in Table (2), while the consumption rate of some polymers are given in Table (3). It is seen that the production rate of total polymers has increased by 69% whereas the consumption rate increased by 55 % during the period 1990-2000.

It has been suggested [5] that plastics typically constitute 5% of the total municipal solid wastes in USA. This figure is in the same order of magnitude as other figures given for different countries in Table (1). Therefore, we can accept the argument of Rathje and Murphy [6], that plastics waste is only small part of the total MSW problem, taking into consideration that part of this plastics has been already recycled and that most of the other part can be recycled under proper solid waste management system.

Table 1. Solid wastes by weight content of plastics and other materials for the municipal solid wastes from different countries during some selected years [3].

Country	Year	1000 m ton(total)	kg per capita	%Plastics	%Glass	%Ferro minerals	%Papers and cartons	%Others	%Organic to non org. materials
Australia	1980	10000	281	6.1	15.1	7	26.0	45.8	41.4
Austria	1988	2700	355	7	10.04	3.7	33.6	45.3	60.5
Belgium	1989	3470 I	349	7.7	7.6	3.7	28.3	52.7	47.6
Canada	1989	16000	625	4.7	6.6	6.6	36.5	45.6	74.3
Denmark	1985	2400	469	3.4	5.4	5	38.6	47.6	81.3
Finland	1989	2500	504	8	4	3	40.0	45	85
France	1989	17000	303	4.5	7.5	6.5	27.5	54	59
Germany	1987	19483	318	5.4	9.2	3.2	17.9	64.3	63.4
Greece	1989	3147	259	7	3	4	20.0	66	57
Ireland	1984	1100	311	14	7.5	3	24.5	51	56
Italy	1989	17300	301	7.2	6.2	3.1	22.3	61.2	64.4
Japan	1988	48283	394	8.3	1	1.3	45.5	43.9	77.2
Luxembourg	1990	170	466	6.4	7.2	2.6	17.2	66.6	44
Holland	1988	6900	465	7.1	7.2	3.2	24.2	58.3	88.3
New Zealand	1982	2106	670	3	2.5	7.6	33.6	53.3	37
Norway	1989	2000	473	5	3	7	30.0	55	77
Portugal	1985	2350	231	3	3	3.5	19.0	71.5	74.5
Spain	1988	12546	322	7	6	4	20.0	63	49
Sweden	1985	2650	317	10	5	6	43.0	36	89
Switzerland	1989	2850	424	13	7	6	32.0	42	70
United Kingdom	1989	18000	357	7	10	8	29.0	46	58
United States	1986	208760	864	6.7	9	8.8	34.7	40.8	37.5

Table 2. Production rate of major polymers in the GCC states (in 1000 tons)

Polymer	1990	2000 (projected)	Countries
Polyethylene (all types)	1290	2270	Qatar, Saudi Arabia, Kuwait, Oman, UAE
Poly (vinyl chloride)	135	135	Saudi Arabia
PVC	300	550	Saudi Arabia, Qatar
Polypropylene	200	300	Kuwait, Oman
Total	**1925**	**3255**	**GCC States**

Table 3. Consumption rate of some polymers in the GCC states (in 1000 tons), [4]

Polymer	1990	1995	2000 (Projected)
LDPE & LLDPE	110	140	170
HDPE	40	50	60
PVC	150	200	240
Polypropylene	40	50	60
Polystyrene	40	50	60
Total	**380**	**490**	**590**

PROBLEMS ASSOCIATED WITH PLASTICS DEGRADATION

Not from the explained figures but from what most people believe [7], landfills are said to contain 20 to 30 percent fast food plastics packaging, it is not surprising therefore, to have increasing attention of researchers legislators and governments to the problem of plastics effect on the environment. As a result, degradable plastics were exclaimed as a potential solution to solid waste.

Constraints due to the impact of plastics degradation on the environment, and the unsatisfactory results exhibited when degradable plastics were used as a replacement for normal plastics grounds for dispute that caused strong reactions against degradable plastics programmes [6,8].

ENVIRONMENTAL HAZARDS BY PLASTICS

Plastics are termed as relatively inert and normally present no health hazards to their makers and users; they are considered as acceptable materials for many applications. Nevertheless, it was shown recently that some monomers used in the manufacture of plastics can cause cancer [9]. It is of the present author's belief that an important line of research is to find new alternatives to such materials. It is important to note that plastics health threats are generally from producing plastics from crude petroleum rather than from plastics wastes in the environment. As reported in [10], in the year 1994 alone, the 1,834 plastics production facilities operating in the U.S.A. emitted more than 111 million pounds of toxic air, caused 507 million pounds of production- related wastes, and tens of thousands of pounds of discharges to the surface waters. In addition hundreds of thousands of pounds of other pollutants were possibly released [11]. Moreover, it has been indicated that 62-92 pounds of organic pollutants are associated with one ton of low-density polyethylene production. A total of 500 million pounds of pollutants needed to be burned, recycled or discharged in 1995 alone [12]. Such action could have caused the emission of 12 million pounds of ozone depleting chemicals. In addition, Plastic industries are usually subjected to explosions and fires, at least at oil refineries where raw materials are produced. Therefore, it may be concluded that there are serious environmental hazards and health thread from plastics, which need a great deal of work and research.

RESEARCH PROGRAMMES

If, to date, none of the developed degradable plastics has proven success in assuring necessary physical and mechanical properties, and bearing in mind that degradable plastics are not cost effective alternatives and perhaps not satisfying the conditions required for most sanitary landfills, the question to ask now is: 'how should we direct our future research programmes?''

Before putting big potential of researches in the line of environmentally degradable plastics, it is important to view the composition of solid wastes, the size of the problem in terms of energy quality, consumption and recovery, in addition to other resources.

In weight percentage, the municipal solid wastes are given in Table (4) showing that plastics contribute up to 5% by weight. The impact of that is mostly limited to the soil element of the environment, whereas the other 95% of the MSW are more important for their effects on the other two elements, namely air and water. Since air and water pollution are known to be more dangerous on human beings, it is therefore important to make the best use of our limited human resources in handling the more significant part of the environmental problems.

Table 4. Typical composition of municipal solid wastes, [5]

Component	Percent by mass (typical values)
Food wastes	14
Paper	34
Cardboard	7
Plastics	5
Textiles	2
Rubber	0.5
Leather	0.5
Garden trimmings	12
Wood	2
Misc. organic	2
Glass	8
Tin cans	6
Nonferrous metals	1
Ferrous metals	2
Dirts, ashes, brick, etc	4

Because degradable plastics cannot substitute the wide range of normal plastic materials from the viewpoints of physical and chemical properties, the packaging problem is reviewed hereafter for evaluation.

It has been reported [13] that total packaging amounts to only 30% of municipal solid wastes by weight and 50% by volume. In Germany packaging waste is reported to be 18-21 kg/capita/year during 1988-1993. Plastics constitute about 7% of total waste and plastics are only 10.4% by weight of total packaging. Also, fast food packaging is not a large-scale problem to the environment as percentage of the solid wastes; according to [6], results based on 200 samples from 11 landfills in the U.S.A., indicated that it is less than 0.5% by weight and less than 0.33% by volume.

Some Misconception about Plastic Degradation

Moreover, a major German Research study in 1988 concluded that, the absence of plastic in packaging would increase the packaging in solid waste by four-fold by weights and two-fold by volume, in addition to doubling the energy consumption for packaging products [14]

ENERGY SPENT ON MANUFACTURING

With respect to energy related matters, a good question to ask now is whether it is justified spending high quality energy on manufacturing sustainable plastics and whether the high efficiency energy spent on the degradable plastics is redeemable energy? It was reported that 4% of US energy consumption is used in manufacturing plastics [15], and that using plastics in packaging make manufacturers save energy each year enough to power a city of 1 million home for roughly three years [16]. It is also good to know that plastics as solid waste is potential solid fuel. Plastics have a high calorific value amounting to 37,000 kJ/kg compared to 30,000 kJ/kg for coal and 16,000 kJ/kg for wood. Therefore, plastics have potential in recovering high quality energy; whether they are recycled or regenerated after use, part of the energy will be recovered.

COST COMPARISON

Here we show a comparison between biodegradable plastics manufacturing from sugar with common plastics manufacturing [17]: Sugar from Brazil is very competitive in price, it is US$ 200/ton. In biodegradable plastics, the cost of raw material represents 55% of the final cost of the plastics products. It is being reported that 3 kg of sugar is needed for each kilogram of plastics. On the average, 3.6 kJ of high qualify energy and 25 kg of steam are needed for production of one kilogram of PHB, Poly(3-Hydroxybutirate) products, whereas the normal oil/petroleum plastics price now is US$ 0.4 to 0.5 per kg and it consumes less that 1 kJ/kg of electricity. Therefore it may concluded that although the biodegradable plastics are more expensive and consume more high quality energy than normal plastics which in turn causes more carbon emission to the environment, they are also inappropriate for most product utilization due to inappropriate mechanical and chemical properties. Thus, if they solve a problem at all, they solve only a slim problem to the environment.

It should be noted that degradation in general means losses, losses of material plus energy spent on that material in mining, handling, transportation, production, pollution prevention and all other human activities; therefore degradation of that material means losses of all these energies.

POSSIBLE FRUITFUL RESEARCHES

There are doubts in gaining justified results from directing future research to find new degradable plastics as substitute to commonly used ones. However, it can be recommended to direct our activities in this field only in some special application areas such as developing film-type biodegradable covers for burns and wounds and other medical applications [18] and in seeds growing bags for agricultural utilization. Efforts to design better degradable plastics for landfills will in our view have negligible effect, if any.

RECYCLING: ENERGY SAVING RELATIVE TO INCINERATION

Table (5) gives an amount of incinerated municipal solid waste and energy recovery for the countries mentioned in Table (1).

Recycling has acted as a practical method to deal with the problem of solid waste. Plastics with no recycling potential can have potential as solid fuel. Reference [19] has indicated the relative energy saving in barrels of oil in recycling and incineration of 1 ton of different materials, as in Table (6).

It is interesting to note that the energy saving in recycling plastics is 2 to 4 times the energy saved in recycling the same weight of paper. In incinerating plastics, the energy saving is three times the energy saving in incinerating paper.

Especially for developing countries, it is also important to note that the technology for energy recovery is simple and well established. In the USA, there are 114 energy recovery plants operating in 32 States throughout the country generating enough electricity to meet the power needs of 1.2 million homes and businesses [20]. And the Environmental Protection Agency (EPA) estimates that energy recovery plants will dispose of 15.3 percent of the nation's MSW by the year 2000. Worldwide, more than two thirds of the MSW can be reduced by volume by using appropriate combustion of the MSW to generate electricity.

Table 5. Energy recovery during incineration of municipal solid wastes

Countries	Year	total incineration (1000 ton)	(1000 ton) for energy recovery
Australia	1980	200	x
Austria	1988	222	20
Belgium	1989	720	215
Canada	1989	1416	101
Denmark	1985	540	x
Finland	1989	50	50
France	1989	6970	4670
Germany	1987	5942	x
Greece	1989	1	x
Ireland	1984	x	595
Italy	1989	2749	8937
Japan	1988	32616	117
Luxembourg	1990	117	1840
Holland	1988	2555	x
New Zealand	1982	x	76
Norway	1989	400	x
Portugal	1985	604	367
Spain	1988	1400	1204
Sweden	1985	2270	1816
Turkey	1989	2500	1250
United Kingdom	1989	15000	x

Table 6. Potential of energy saving in barrels of oil for some materials (per ton recycled), [19]

Material	Recycling	Incineration
Plastics	10.2 - 11	6.8 - 7.3
Paper	2.3 - 4	2.24
Aluminum	37.2	- 0.2
Steel	2-7	- 0.06
Glass	10	- 0.06

CONCLUSIONS

It is believed that conducting more research in the field of degradable plastics would not help to get appreciable results toward the environment protection and controlling programmes.

Especially for developing countries, better utilization of the scientific human resources can be achieved if activities of people who work on plastic degradation could be rectified and directed to enhance the plastic properties to obtain long life products with lower cost. Research and development programmes are still needed and would be fruitful in adapting more established MSW recycling and incineration programmes.

Research and development programmes on degradable plastics as a solution to solid waste crisis should not be encouraged by decision makers nor by the international supporting organizations because this will mislead important sectors of our scientific human resources.

ACKNOWLEDGMENT

The Author wishes to express his gratitude to the Scientific and Applied Research Center (SARC) of the University of Qatar for supporting this work.

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