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PLASTICS WASTE – AN OVERVIEW

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ABSTRACT:

An overview on present status and recent developments in disposal of plastics waste is presented alongwith its prospects in building and construction industry. R & D gaps to be covered are also suggested.

Key-words: Recycling; Building & Construction Industry.

INTRODUCTION

Plastics industry has undergone tremendous growth during the last two to three decades. The world production of plastics has been predicted 8 to rise to 10 billion tonnes by the turn of this century and is expected to surpass that of iron and steel by the year 1995. In India, the current production of plastics is around 79 thousand tonnes and its demand is expected to increase to 2.5 million tonnes by the year 2000 A.D. The current per capita consumption of plastics in India is only 1.6 kg as compared to world average of 17.0 kg. Consumption per head of population in different countries[1] is shown in Fig. 1.

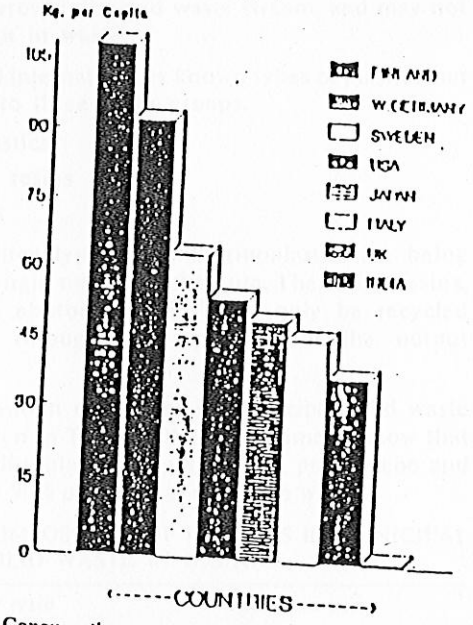

Fig. 1 – Consumption per head of population in different countries

Today, hundreds of different types of plastics are used for their various properties in thousands of different goods ranging from packaging to electronics. One of plastics major assets is its durability. Its functional life, however, is far shorter as plastic goods are disposed of as soon as they have served their purpose. Shopping bags and food packaging are disposed even within a day. This enormous amount of plastic materials in garbage and litter has become a source of concern for the environmentalists, municipal authorities and the common man. Research is being carried out all over the World in an effort to find solutions to the problem of plastics waste management. Recycling of plastics waste to solve problem of disposal is thus becoming imperative and may become mandatory.

AMOUNT AND TYPES OF PLASTICS WASTE

Currently, the amount of plastics waste in USA is approx. 25 billion pounds and that in European Economic Community is approx 20 billion pounds per year. By the year 2000 A.D., the size of the plastics waste in USA will grow to 30 billion pounds per year and a similar growth will take place in Europe. Plastics waste accounts for 5-10% of the refuse weight, but more than 25-30% of volume. Most of these plastics (approx. 70%) are packaging products thrown out within an year of production[2]. The composition of municipal solid waste in U.S.A. is given in Fig. 2.

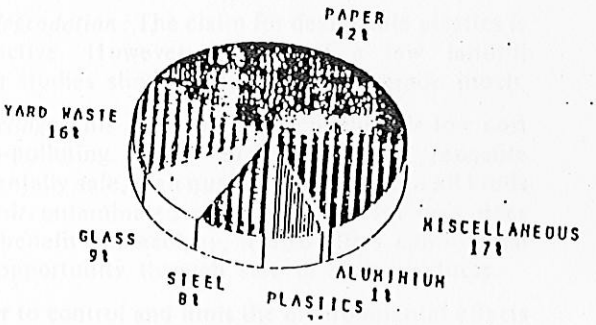

Fig. 2 – Composition of municipal solid waste in U.S.A.

In India, accordiing to a survey conducted by National Council of Applied Economic Research (N.C.A.E.R.) during 1987-88 for Indian Petro-Chemicals Ltd (I.P.C.L.), the plastics reprocessing/recycling industry comprises over 2000 units with an output of 3,23,209 tonnes. This represents 37.20% of total thermoplastics available in the country during 1987-88. This is expected to increase at the rate of 5% per year with the availability of around 2.5 million tonnes of various plastics materials and with plan for expansion and diversification of petrochemical industry by the close of this century[3].

There are three main categories of plastics wastes.

1. The waste from polymer producers and converters

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Relatively small amount of wastes from producers and converters goes to external recyclers.

2. Industrial wastes

Approximately 40% of all plastic products goes to industrial users. The largest part of this percentage belongs to LDPE packaging film which after use is slightly to moderately contaminated. The contamination level of LDPE film used often exceeds 50%.

3. Plastics waste from domestic refuse

Domestic refuse contains two types of wastes—

a) A film fraction which consists mainly of LDPE, some HDPE and PP.

b) A hard fraction which comprises several different plastics such as HDPE, PP, PVC, PS, etc.

Construction and demolition wastes contain plastics from electrical conduits, wiring, pipes, insulation and other building materials. Some of these are destined for disposal in narrowly directed waste stream, and may not appear as such in waste.

About 5000 internationally known types of plastics can be divided into three main groups.

1. Thermoplastics
2. Thermoset resins
3. Elastomers

Of these three types, only thermoplastics are being recycled as a virgin material substitute. Thermoset resins, together with elastomer resins, can only be recycled thermally or through decomposition of the output materials.

The composition of plastics in municipal solid waste disposal is given in Table 1. Present estimates show that three commodity plastics – polyolefins, polystyrene and PVC make up 90% of the total domestic wastes.

TABLE 1 – COMPOSITION OF PLASTICS IN MUNICIPAL SOLID WASTE IN U.S.A.

S.No.	*Polymer resin*	*Common use*
1.	High density polythylene	Rigid containers
2.	Low density polyethylene	Package films, bags.
3.	Polypropylene	Wrappers, linings boxes, crates
4.	Polystyrene	Foams, Insulation
5.	Polyvinyl chloride	Rigid containers, films
6.	Polyethylene terphthalate	Soft drink containers

EXISTING MODE OF DISPOSAL

Three basic options for plastics waste disposal are:

i) Landfill dump sites: The main disposal practice for municipal and other wastes is burial in the ground. Landfilling, the traditional method for solid waste disposal is not viable anymore. The groundwater contamination has contributed to a rapid decrease in open uncontrolled landfill sites. It is estimated that landfilling accounts for about 95% of disposal of municipal wastes in United States, 86% in England, 60-70% in European Economic Community and 30% in Japan[4].

ii) Incineration: This option creates different problems. The heat produced by this process can be used for energy generation and heating, but the costs are relatively high. Even utilising the latest incineration technology, the effect of heat being continuously introduced into the Earth's atmosphere may contribute to what has come to be known as "greenhouse effect". Moreover, plastics contribute in a significant way to toxic heavy metals on incineration.

iii) Pyrolysis: In pyrolysis, the plastics waste is heated to 350-750°C in absence of air with or without catalyst. As a result, several liquid and gaseous products are formed which are useful as fuels and chemical raw materials. This option is still in the experimental stage.

The other two options are:

iv) Biodegradation: The claim for degradable plastics is very attractive. However, results of a few landfill excavation studies show plastics do not degrade much.

v) Recycling: This is the only option which is low cost and non-polluting, and produces new reusable environmentally safe, high quality products from all kinds of unsorted/contaminated plastics waste. Not only does recycling benefit our ecology, it also offers commercial business opportunity through sale of such products.

In order to control and limit the environmental effects of plastics, certain priorities in disposal of plastics waste management schemes have been identified. The order of priorities is given in Table 2.

R&D ON RECYCLING OF PLASTICS WASTE

R&D on recycling of plastics waste can take several directions

★ To recover the original material
★ To be reconverted to another use
★ To recover the chemical constituents of the material

TABLE 2 – DISPOSAL OF PLASTICS WASTE : PRIORITY-WISE

S.No.	Method of disposal		Benefits
1.	Prevention	–	Re-usable products, less packaging
2.	Material Recycling	–	Substitution of virgin polymers,
		–	Plastics as substitute for traditional materials
3.	Pyrolysis/hydrolysis	–	Re-use of chemical structure,
		–	Thermal conversion
4.	Incineration	–	Recovery of calorific value
5.	Landfill	–	Controlled

INTERNATIONAL STATUS

SINGLE TYPE PLASTICS:

Large quantities of thermoplastics can be recovered through washing, filtering and densification methods and could be used either solely or as a percentage of feed-stock for the manufacturer of artefacts such as boxes, twine, crates, etc. However, apparent economic gains in this practice have to be balanced against deterioration in the properties of finished products compared with those prepared from virgin materials. These properties include impact strength, appearance, reproducibility of dimensions, performance, etc. The reduction in properties occurs due to contamination by foreign particles, decrease in thermal stability during processing, loss of additives and variable flow characteristics due to non-uniform particle size.

Polyolefins: Various studies on the influence of using reground materials have been attempted on polycarbonate[5], polystyrene and polyethylene[6,7]. Some of the chemical problems which arise in the recycling of plastics have been reviewed by Scott[8] and aspects of quality control and quality maintenance in reprocessing thermoplastics have been extensively studied by Hermann[9], Zoller[10] and Nightingale[11]. They pointed out that plastics differ markedly from one another in the ways in which their properties change following successive processing operations and therefore it is necessary to consider the different plastics individually. With a view to improve microstructural and subsequent mechanical properties, Williams and Bevis[12-14] have undertaken a comprehensive analysis of the effects of recycled materials, recommended pigments and its concentration and selected stabilisers on polypropylene copolymer.

Poly-Vinyl Chloride: Technically, PVC is a good candidate for recycling. Because of its higher density, it can be easily separated from the other components of municipal solid waste except from PET. The main obstacle in PVC recycling technology is dehydro-chlorination and degradation during reprocessing which produces toxic emissions and leaves a brittle product.

Polystyrene: The widespread use of foamed polystyrene (FPS) in fast-food establishments, packaging and its large volume compared to its weight were responsible for some anti-plastics legislation. There have been many serious attempts to recycle polystyrene. Sebesta *et al*[15] have utilised polystyrene waste for adhesives, coatings and binders by dissolving it into solvent and stirred with some emulsifying agents. The resulting compound was treated with H_2O_2 and then solvent was distilled off at 70°C to give 40-45% latex. Other items such as polymer concrete were made from recycled styrene and polyethylene terphthalate and their properties compared with polymer concrete made from virgin materials[16]. Belz[17] has developed a modified polystyrene which can be recycled by dissolving it in alkali and reprecipitating with acid.

Thermosets: Thermoset resin based products such as glass reinforced polyester, sheet moulding compounds (SMC), dough moulding compounds, etc., provide higher stiffness, lower co-efficient of thermal expansion and cost/process advantage over engineering thermoplastics. Successful use of recycled/reground polymers as filler in SMC has been demonstrated[18]. However, the application is not cost-effective, since SMC fillers such as $CaCO_3$ are much cheaper than the cost of grinding the SMC waste.

MIXED PLASTICS

The mixed plastics are commonly obtained from two main sources—

1. Municipal Solid Waste, and
2. Automotive Shredder Ressidue.

During processing, no washing or separation is carried out and the mixed plastics are directly extruded or moulded into finished profiles for use as substitute for wood or even concrete products in construction.

The Center for Plastics Recycling Research (CPRR) at Rutgers, USA[19] has focussed a major portion of development efforts on the reclamation of commingled plastics waste through the production of linear lumber like profiles. Physical and mechanical properties obtainable from different feedstocks were thoroughly illustrated. An analysis of the results was used to project the processing of commingled plastics through inexpensive alternate technology.

CHEMICAL RECYCLING

Chemical recycling (Tertiary recycling) is relatively unexplored territory as could be seen by comparing the number of secondary to tertiary patents as shown in Table 3. It is also clear that in tertiary recycling, emphasis is on large volume polymers; much less attention has been given to non-commodity resins such as engineering thermoplastics[20].

TABLE 3 – WORLDWIDE PATENTED RECYCLING TECHNOLOGY (1981-1988)

Types of recycling	Process		Product	
	Equipment	Equipment Process	Process-product	Product
1. Primary Recycling (waste stream)	15	22	47	37
2. Secondary Recycling	152	148	307	285
3. Tertiary Recycling	11	34	108	11
4. Quaternary Recycling	7	12	12	10

In the course of researches, a few European companies hydrolysed PU flexible foam waste in the seventies. But, upto now, the knowledge could not be used in the market because of heterogeneity in recycled materials. The vast majority of tertiary recycled patents deal with recycling PU foam. Most deal with retrogradation to polyether polyols, useful for resynthesis of foam PU. The use of adequately standardised recycled polyols has already been realised in the American rigid PU foam industry. In USA, PET waste from bottles and X-ray films, which has been sorted out according to type, is being glycolysed. From this waste, approximately 27,000 tonnes of polyols are obtained every year.

Most of the patented technologies refer to processes that degrade PET to polyols by various reactions such as straight glycolysis, reaction with glycols, diacids, etc. Glycolysis may be followed by further reactions. Typically, the oligomers are claimed useful for further build-up to unsaturated polyesters or to PETG, etc. It is known that this type of technology is industrially practised to make unsaturated polyesters.

Further chemical processes for recycling are pyrolysis and hydrolysis. Both techniques are still in the developmental stage, so an assessment is not yet possible. It remains to be seen what contribution they can make to the disposal of plastics waste in the future.

NATIONAL STATUS

The focus, today, is on recycling of plastics waste all over the world and India is no exception. Plastics waste is already being reprocessed though in a very crude way. It is important that the recycled plastics waste is identified on the basis of polymer for specific end-use applications to ensure the correct usage.

Thus, recycling of plastics waste deserves to be taken as a priority project to supplement the production of virgin materials, to save on scarce foreign exchange by reduction in imports and to protect the environment. R&D work related to the disposal of plastics waste has been initiated in an *ad hoc* manner for the recovery of the basic monomers or its conversion into useful products. Bandyopadhyaya *et al*[21] have studied utilisation of polyester waste generated in fibre production plant into alkyds, polyurethane resins and also into other useful products. The method of conversion, properties and applications of the products so prepared are thoroughly described. To optimise the cost and desired properties of the end-products, Goyal and Wadhera[22] described the properties of various mixes prepared from recycled polymers (LDPE & PVC) and granules of virgin LDPE and PVC. However, it might be added that recovery of the used materials beyond second recycling could be uneconomical in view of the extent of degradation in the various mechanical properties and the consequent requirement of large quantity of fresh material to upgrade them. Potnis *et al* have attempted to prepare composite panels by mixing of wood flour with thermoplastic processing wastes. The prepared sheets may be useful in the form of panels where weight, energy savings and cost are of importance. They hope that these findings will provide a starting point for further investigations.

PROSPECTS OF RECYCLED PLASTICS IN BUILDING & CONSTRUCTION

Building industry is one of the largest consumer of plastics next only to packaging. It has been estimated that about 29% of the total World production of plastics goes into building applications and still plastics constitute only about 2% (by volume) of total building materials. The usage of plastics in India for building applications is estimated to be barely 0.2 million tonnes compared to approximately 3.92 million tonnes in U.S.A. and 2.76 million tonnes in Japan. The consumption of various plastics components for different building applications in India are given in Table 4.

As indicated in the foregoing paragraph, there is an ample demand from the building industry for recycled plastics. The major existing and new potential applications of recycled plastics to be substituted for a significant number of existing construction materials are -

★ Roof tiles
★ Floorings
★ Window components: sashes, frames, stiles and reveals
★ Demountable and fixed partitions
★ Retaining walls/Sound attenuation walls
★ Geotextiles
★ Concrete formwork
★ Landscape pavers

Pricewise, it is economical as against virgin materials and converters prefer it either because of shortage of virgin raw materials or just to manufacture cheap plastic products.

The difficulties in recycling of plastics waste into construction materials is related to several factors:

- Availability of plastics waste for recycling
- Chemical and physical technical difficulties associated with recycled polymers
- Available technologies for recycling of plastics waste

SUGGESTIONS FOR FURTHER R & D WORK

In future, recycled products can be sold on the basis of their property profile instead of generic name brands and this will open new markets for recycled plastics. R & D efforts on the recycling of plastics waste in India have been rather meagre, investment both in terms of money and men not being commensurate with the challenges looming on the horizons. It is therefore imperative to promote R & D in the following areas in a vigorous manner.

1. Investigations are needed to initiate and undertake the application oriented developmental work suggesting use of plastics waste with identified fillers and developing composites for products as substitutes for timber and concrete.

TABLE 4 – CONSUMPTION OF PLASTICS IN BUILDING & CONSTRUCTION SECTOR IN INDIA

S.No.	COMPONENT	MATERIAL	CONSUMPTION IN MT	
			1994-95	* 2,000 A.D.
1.	Pipes, Fittings and Conduits	PVC	2,01,135	4,04,554
		HDPE	36,204	72,819
2.	Overhead water tanks	LDPE/HDPE	4,578	13,970
3.	Floor Tiles & Skirting	PVC	11,867	23,868
4.	Walling materials			
	(a) Wall Paper	PVC	725	1,458
	(b) Partitions	PVC	3,821	7,685
	(c) Thermoformed false ceiling & wall panels	HIPS	140	282
5.	Sanitary appliances like:			
	(a) Flushing Cistern	PP/HIPS	1,207	2,428
	(b) Toilet Seats	PP, HIPS	905	1,820
	(c) Toilet Pots	PVC	1,408	2,511
	(d) Plumbing fixture	PVC	1,006	2,023
6.	Roof Sheets	GRP	483	971
		RMP	603	1,213
7.	Electrical Fittings	Phenolics/PP	2,715	5,461
8.	Water Proofing film	LDPE	302	607
9.	Various Profiles like handrails, step nosing, expansion joints, etc.	PVC	1,529	3,075
10.	Sound and heat insulation	PS & PUR FOAM	704	1,415
11.	Others		1,006	2,023
		Total	2,70,338	5,48,183

* Estimated

2. Utilisation of recycled polymers as substitute to virgin polymers as a new source of feed-stock should be encouraged.

3. Chemical recycling of plastics waste is in its infancy. Attempts should be made to recover the raw materials via new synthetic routes such as glycolysis, hydrolysis and methanolysis for the production of end-use products.

4. During recycling, a number of reactions detrimental to the properties of a polymer may take place. In an effort to overcome this shortcoming, upgradation of recycled plastics is essentially required.

5. Compatibility is a major problem for mixed plastics. Efforts should be made to improve the compatibility and quality of products by improving phases between the polymers and processing conditions through intensive mixing.

6. An organised effort is needed to develop good testing and evaluation facilities for recycled polymers as well as end-use products for regulation and standardisation purposes.

7. Structure – property relationship should be thoroughly studied for recycled plastics under various environmental conditions.

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