Chapter 14

RECYCLING OF PLASTICS IN FOOD PACKAGING

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Plastics are used world over because they are safe for packaging of foods, medicines and child care products. A few examples are - milk pouches, edible oil containers, ice-cream packs, blister packs for tablets and capsules and I.V. fluids. Blood is collected and stored in plastic bags. Plastic woven sacks made of HDPE and PP are also used for transportation, storage and distribution of grains and sugar. While plastics are safe for packaging of food and medicinal products, there are standards in each country, which specify the type of additives and pigments, which can be used safely for contact with foods. Recent developments in plastics technology have led to stronger materials so that less material is needed for particular applications. Plastics packaging achieves maximum mileage from minimum resources and is therefore an excellent means of conserving natural resources. Plastic waste is predominantly eco-neutral or inert. It does not generate toxic leachates, which contaminate the soil or ground water resources. On the contrary, those products, which biodegrade with by-products, may result in contaminating ground water resources. Plastic consumer waste is easily compactable, and occupies less space in land-fills. The fact that plastic waste is inert and does not biodegrade, makes segregation and recycling a more logical approach to waste management, for urban areas. That plastics, mostly as carry bags, form the most formidable threat to public spaces is being realized. City administrations also know the futility of banning their use. One promising solution to the problem is shredding plastic waste, mixing it with bitumen and using the polymerized mix in road construction. Therefore, it is logical to infer that plastics, as such do not create any sort of pollution to pose any threat to environment. It is only a waste management issue.

Plastics and the Environment

It is estimated that India generates 5,600 tonnes of plastic waste daily. That is bound to grow. It is reassuring that inventive minds all over India are working to turn a huge problem into an advantage — hopefully one that doesn't compromise with respect to the environmental concerns.

Plastics as a whole are being looked down upon as environment unfriendly. But this is not true. The problem with plastics is their waste disposal management. The

Ministry of Environment & Forests, Government of India, has in consultation with members of the Plastic Industry after detailed study, worked out a way to minimize the effects of plastic waste. The Plastic industry has agreed to honour the national guidelines on waste management.

Plastics make a significant contribution by reducing the weight and volume of materials that are typically thrown away. Unfortunately in India, waste is littered, instead of being disposed to facilitate collection and recycling. Plastics use less than 4% of the world's hydrocarbon resources. While about 90% is consumed for transportation, power generation and heating. In general, plastic products require less energy than products made from conventional materials, at comparable use and performance levels. Every process connected with a product, right from the time that basic raw materials are extracted from the earth to the time a product is produced, transported, used and disposed, has some impact on the environment.

Recycling of Plastics

All plastics can be recycled. More than 90% of manufacturing off-cuts and out-of-dimension products are reprocessed into primary products. Fortunately in our country, plastic re-cycling is absolutely economy driven, and does not need any subsidy. Unlike paper, textile, wood, etc., 65% of the plastics waste is recycled in our country, which is much higher in comparison to, advanced countries. It not only enables poor people to buy items made of recycled plastic at affordable prices, but also provides employment to millions of people in our country.

Recycling of plastics consists of three main steps - shredding, remelting and re-forming in moulds. The machinery used consists of a grinder, an extruder and a pelletiser, each of which could cost from Rs 1.5 – 2 lakh. After sorting according to grade, the plastic waste is put into an agglomerator that heats and shreds it into fine flakes (called the "agglu"), which are put into an extruder. Here it is heated, extruded through screens, and solidified into strands by passing it through cold water. The strands are cut into pellets, which form the raw material for moulding sheets, tarpaulins, pipes, etc. The process is energy intensive as energy costs make up two-thirds of the cost of production.

Plastics as a whole are being looked down upon as environment unfriendly. But this is not true. The problem with plastic is its waste disposal management. The Ministry of Environment and Forests, Government of India, has in consultation with members of the plastic industry after detailed study, worked out a way to minimize the effects of nuisance of plastic waste. The Plastic industry has agreed to honour the national guidelines on Waste Management. Not all plastics are recyclable. There are 5 major types of plastics which are commonly recycled:

- Polyethylene (PE) - both high density and low density PE and Linear low-density PE.
- Polypropylene (PP)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)
- Polyethylene terephthalate (PET) - others.

A common problem with recycling other plastics is that plastics are often made up of more than one kind of polymer or there may be some sort of fibre added to the plastic (a composite) to give added strength. This can make recovery difficult. Of the types of plastics recycled in India, PVC (polyvinyl chloride) accounts for 45 percent, LDPE (low density polyethylene) for 25 percent, HDPE (high density polyethylene) for 20 percent, PP (polypropylene) for 7.6 percent and other polymers such as PS (polystyrene) for 2.4 percent. According to manufacturers, almost all these types of waste can be recycled up to four or five times. However, the quality of the recycled material deteriorates and additives or virgin material are added to give it strength.

Large scale recycling plants can be scientifically controlled with high standards of Research and Development and Quality Control for producing good quality compounds and recycled end products. End products like synthetic wood, benches for parks, public places, railways and airports, fencing for parks, side walks and roads, boundaries and buildings, sleepers for Railway tracks, pallets for bulk transportation, bodies of trucks, waste collection dumps, sign boards and marine transportation are some of the new markets which will have endless requirements of products developed from such plastics waste.

The economics of energy generation and cost of labour for such a waste management organization and hence the end products are favourable indicators for viability and success of this entire waste management system.

In India, success in recycling of consumer level plastics is going to be governed by the profitability of the recycling idea. There are millions of urban Indians who scour our cities for a living from waste. They play an insufficiently celebrated role in waste management.

Waste 'picking' is a well-established urban survival tactic in India's mega-cities, those metropolises that act as magnets for the poorest of the population, and recycling is a flourishing business in this informal sector. It supports up to 0.5% of the population in cities of over a million inhabitants, and saves a city 10-15% of its total waste management costs through reduction in waste volumes. Recyclable waste is attracting a few service providers only now in commercial areas. Small-scale and cottage industry recycling is still mostly illicit twilight activity, and recyclers often operate behind closed doors, avoiding registration.

Only recently has recycling won formal legitimacy in India through the Municipal Solid Waste (MSW) Rules, which direct municipalities to 'promote recycling or reuse of segregated materials' and 'ensure community participation in waste segregation'. This should improve the status and working conditions in this sector, and allow recycling technologies to be upgraded. India today presents a golden opportunity for suppliers of all types of simple, low-cost recycling processes and equipment.

Classification of Recycling

Plastics recycling technologies have been historically divided into four general types - primary, secondary, tertiary and quaternary.

i. Primary Recycling involves processing of a waste/scrap into a product. The recycling of relatively uncontaminated waste plastics, that has historically taken place in the manufacturing sector, is an example of primary recycling.

ii. Secondary Recycling involves processing of waste/scrap plastics into materials that have characteristics different from those of the original plastics products. Some manufacturing and post consumer wastes currently enter secondary recycling streams that allow higher contamination levels than primary recycling.

iii. Tertiary Recycling involves the production of basic chemicals and fuels from plastics waste/scrap as part of the municipal waste stream or as a segregated waste. Pyrolysis and hydrolysis are examples of these processes.

iv. Quaternary Recycling retrieves the energy content of waste/scrap plastics by burning/incineration.

Only primary recycling of post-consumer materials or purchased industrial plastics scrap, and secondary and tertiary plastics recycling reduce current waste disposal volumes. Quaternary recycling falls within the term 'resource recovery'. Primary recycling of scrap from in-plant operations is so commonly practised that it is excluded from standard recycling definitions.

Processing of Recycling

■ ***Initial upgrading***. Once the plastic has been collected, it will have to be cleaned and sorted. The techniques used will depend on the scale of operation and the type of waste collected, but at the simplest level, they involve hand washing and sorting of the plastic into the required groups. More sophisticated mechanical washers and solar drying can be used for larger operations. Sorting of plastics can be by polymer type (thermoset or thermoplastic for example), by product (bottles, plastic sheeting, etc.), by colour, by coating, etc.

■ ***Size reduction techniques***. Size reduction is required for several reasons: to reduce larger plastic waste to a size manageable for small machines, to make the material denser for storage and transportation, or to produce a product which is suitable for further processing. There are several techniques commonly used for size reduction of plastics:

Cutting is usually carried out for initial size reduction of large objects. It can be carried out with scissors, shears, saw, etc.

Shredding is suitable for smaller pieces. A typical shredder has a series of rotating blades driven by an electric motor, some form of grid for size grading and a collection bin. Materials are fed into the shredder via a hopper which is sited above the blade rotor. The product of shredding is a pile of coarse irregularly shaped plastic flakes which can then be further processed.

Agglomeration is the process of pre-plasticising soft plastic by heating, rapid cooling to solidify the material and finally cutting into small pieces. This is usually carried out in a single machine. The product is coarse, of irregular grain and is often called crumbs.

Further Processing Techniques

■ ***Extrusion and pelletising***. The process of extrusion is employed to homogenise the reclaimed polymer and produce a material

that is subsequently easy to work. The reclaimed polymer pieces are fed into the extruder, heated to induce plastic behaviour and then forced through a die to form a plastic spaghetti which can then be cooled in a water bath before being pelletised. The pelletisation process is used to reduce the 'spaghetti' to pellets which can then be used for the manufacture of new products.

Manufacturing Techniques

■ ***Extrusion***. The extrusion process used for manufacturing new products is similar to that outlined above for the process preceding pelletisation, except that the product is usually in the form of a continuous 'tube' of plastic such as piping or hose. The reclaimed plastic is forced along the heated tube by an archimedes screw and the plastic polymer is shaped around a die. The die is designed to give the required dimensions to the product and can be interchanged.

■ ***Injection moulding***. The first stage of this manufacturing process is identical to that of extrusion, but then the plastic polymer emerges through a nozzle into a split mould. The quantity of polymer being forced out is carefully controlled, usually by moving the screw forward in the heated barrel. A series of moulds would be used to allow continual production while cooling takes place. This type of production technique is used to produce moulded products such as plates, bowls, buckets, etc.

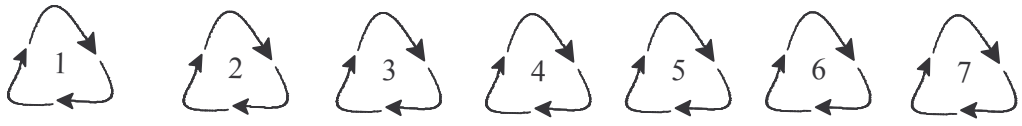
■ ***Blow moulding***. Again the spiral screw forces the plasticised polymer through a die. A short piece of tube, or 'parison' is then enclosed between a split die -which is the final shape of the product - and compressed air is used to expand the parison until it fills the mould and achieves its required shape. This manufacturing technique is used for producing closed vessels such as bottles and other containers.

■ ***Film blowing***. Film blowing is a process used to manufacture such items as garbage bags. It is a technically more complex process than the others described in this brief and requires high quality raw material input. The process involves blowing compressed air into a thin tube of polymer to expand it to the point where it becomes a thin film tube. One end can then be sealed and the bag or sack is formed. Sheet plastic can also be manufactured using a variation of the process described.

Coding for Recycling

A coding system has also been introduced in the United States to aid identification of plastics for reclamation. It is based on the 'Recycle Triangle' with a series of numbers and letters to help the identification.

While marking the symbol 7, the



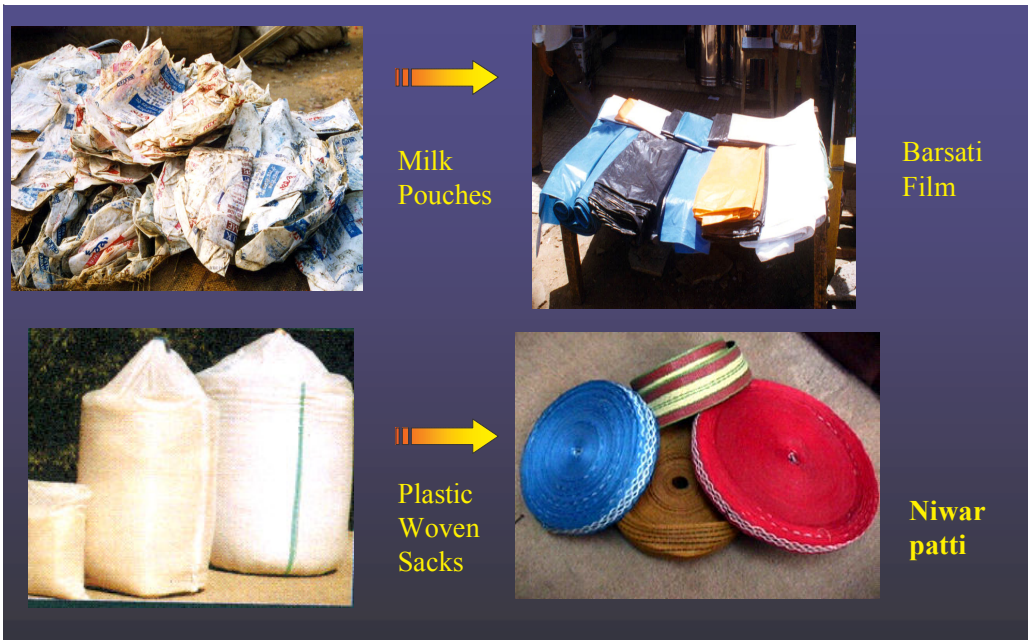


Fig. 14.1. Value added products from recycled plastics.

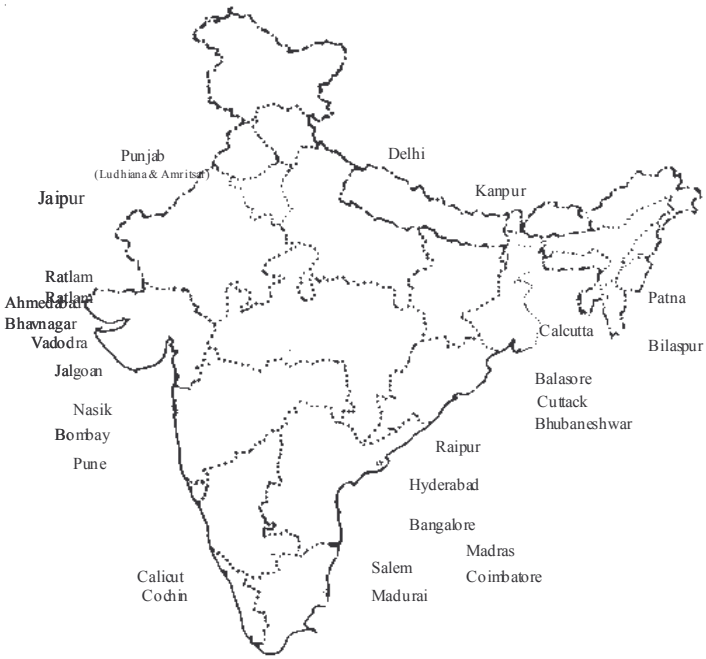


Fig. 14.2. Recycling map of India

respective basic raw materials like ABS, OPP, PC, PBT, etc, or "mixed" shall be indicated below the symbol.

In addition to the symbol indicated, the end product made out of recycled/ reprocessed plastics, wherever possible, shall be marked with "Recycled" indicating percentage of use of recycled material.

In India, the following information should also be printed bilingually, English/Hindi and local language wherever possible on the end product for the benefit of users/reprocessors: 'This product (like carry bags/shopping bags, bottles, blow-moulded containers, etc) is made of (indicate materials) and is reusable/ recyclable'.

However, carry bags/containers made out of recycled plastics shall be labeled as 'Not suitable for packing/storing/carrying food products'

"Food grade" material, like that used to make milk bags, is made from virgin plastic. Manufacturers emphasize that bags made from recycled plastic should not be used to store "unpacked" food items, as there is a chance of contamination of food with chemicals.

A CFTRI case Study on Recycled Polyethylene films

A study was conducted at CFTRI, Mysore, on recycled polyethylene materials using ICPL FS 300 virgin grade polyethylene (virgin) and extrusion waste of virgin grade (A-grade) which were obtained from an industrial organization,

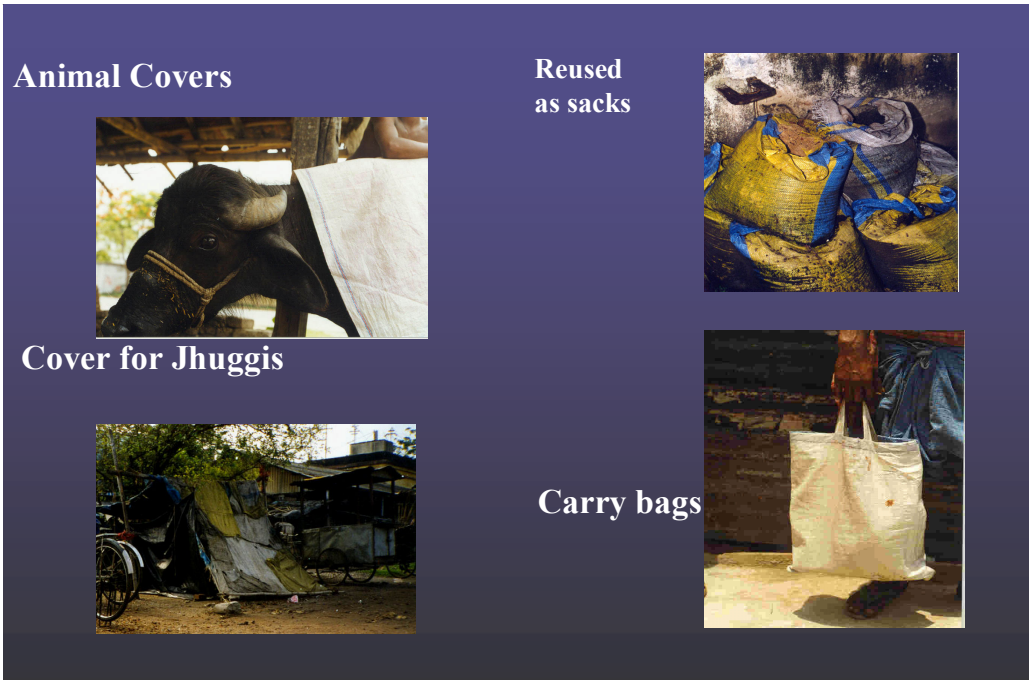


Fig. 14.3. Examples of reuse of plastic woven sacks.

reprocessed film from used milk pouches (recycled milk pouches) and waste plastics collected from different sources (B-grade). These materials were processed at a local reprocessing factory. The recycled films were evaluated for physico-chemcial properties like tensile strength, elongation at break, impact strength, grease resistance, the water vapour transmission rate (WVTR), the oxygen transmission rate, heat seal strength and drop tests. These were carried out according to specified standards. The processed films were also studied for compatibility with foods by carrying out the migration tests. In general, plastic materials coming in contact with food were assessed for the extent of migration of additives into foods by the "global migration" tests in respective food simulants. Since invariably, polyethylene forms the contact layer with fatty food, global migration was carried out using n-heptane as fat simulant. The total additives present in the materials were determined by "extraction" test with xylene and n-hexane by measuring the maximum extractible fraction of the additives.

The results revealed that there was hardly any difference between extrusion waste recycled polythene film and virgin film in all the properties. However, recycled film made form milk pouches and waste recycled films had shown significant changes in physio-chemical properties and migration tests which were not acceptable for packaging application. The compatibility results of these recycled films indicated that the migration/extraction values were nearly twice in the film extruded from milk pouch than in virgin film in n-heptane and comparatively quite higher in other solvents. The increase in migration and extraction values is probably due to degradation and improper cleaning of recycled materials.

From the studies, it could be inferred that addition of recycled low-density polyethylene will bring down the physico-chemical properties and enhance the migration and extraction values as compared to the virgin grades. Also, from the safety and strength properties point of view, it is not preferable to add recycled plastic. However, addition of extrusion waste obtained at the plant itself in certain quantity may not affect the properties significantly.

LEGISLATIONS ON RECYCLED FOOD PACKAGING MATERIALS

Different countries are coming up with polices on recycling of plastics in food packaging and to prevent environmental pollution.

EC Regulations

The European Commission has made proposals to regulate the use of recycled plastic materials and articles intended to come into contact with food. The UK Food Standards Agency has now published a consultation paper seeking views on the proposals. The Commission's proposal deals with mechanical processes for recycling food contact plastic for further use in contact with food.

Under the proposals, a system will be put in place that will allow a person or company to apply for an authorization to use a specified process to recycle food contact plastics for further use in contact

with food. The application will be examined by the European Food Safety Authority before it makes a recommendation to the European Commission. The Commission will then decide whether to grant an authorization, with the intention of ensuring that the public is protected from unsafe contaminants in the recycled plastic.

At the moment, there is no harmonized system in place across the EU for regulating the recycling of food contact plastics. Therefore, the Food Standards Agency proposes to support the intention to make harmonized rules that will apply across the EU, subject to ensuring that they provide a good framework that allows businesses to operate within a system that provides effective protection to consumers.

US-FDA

There is an emphasis throughout the United States on increasing the uses of recycled materials, including plastic. FDA is involved when industry collects used polymeric materials (usually, food containers) and proposes to recycle these materials to make new food containers. FDA's main safety concerns with the use of recycled plastic materials in food-contact articles are:

1) that contaminants from the post consumer material may appear in the final food-contact product made from the recycled material,
2) that recycled post-consumer material not regulated for food-contact use may be incorporated into food-contact packaging, and
3) that adjuvants in the recycled plastic may not comply with the regulations for food-contact use.

Currently, to address these concerns, FDA considers each proposed use of recycled plastic on a case-by-case basis and issues informal advice as to whether the recycling process is expected to produce plastic suitable for food-contact applications. FDA has prepared a document entitled *Points to Consider for the Use of Recycled Plastics in Food Packaging: Chemistry Considerations* that will assist manufacturers of food packaging in evaluating processes for recycling plastic into food packaging.

If a manufacturer would like FDA to consider the use of recycled plastic for a food-contact application, the following information should be submitted:

1. A complete description of the recycling process, including a description of the source of the recyclable plastic and a description of any source controls in place intended to ensure that only plastic that initially complied with the applicable regulations is recycled. Also, a description of any steps that are taken to ensure that the recyclable plastic is not contaminated at some point, either before collection for recycling, or during the recycling process.
2. The results of any tests performed to show that the recycling process removes possible contaminants. For use of the recycled material as a substitute for plastic made from virgin materials, it would be necessary to either show that there has been no possibility of contamination with substances other than food or to demonstrate, through surrogate contaminant testing and, if appropriate, additional migration testing, that the

recycling process successfully removes possible contaminants. However, surrogate contaminant testing is no longer considered necessary to demonstrate that post-consumer recycled (PCR) polyethylene terephthalate (PET) or polyethylene naphthalate (PEN) produced by a tertiary recycling process is suitable for food-contact use. Because FDA has determined that tertiary recycling processes produce PCR-PET or PEN of suitable purity for food-contact use, the Agency no longer sees a need to evaluate tertiary recycling processes for PET or PEN or to issue individual opinion letters for them.

3. A description of the proposed conditions of use of the plastic (*e.g.*, information on intended temperature of use, type of food with which the plastic will come into contact, the duration of the contact, and whether the food-contact plastic will be for repeated or single-use applications.)

AUSTRALIA

Relatively little work has been done to determine what chemical changes occur when plastic and paper materials are recycled.

Recycling of in-house scrap materials has been practised by the packaging industry for many years. Such materials present no potential hazard because they have never been used as packaging.

However, the use of recycled packaging materials other than metals and glass, after the consumer has used them, is potentially a problem because of contamination from a variety of sources. Since there are no controls on the treatment procedures or the uses to which these materials have been put, there is no control over the type of contaminants which may be present.

The adoption of a Code of Practice by the packaging industry would be the most appropriate way to deal with the use of recycled materials in any form of packaging. This would also require research to establish the potential dangers, and provide means for their elimination.

It is inevitable that some recycled materials would not be acceptable for use in many food packaging applications.

The National Food Authority is monitoring discussions between CSIRO and parts of the packaging industry on the potential application of recycled packaging materials in the packaging of foods. The Authority, through the food regulations, has the role of determining when and how recycled materials could be used.

Consumers should be aware that recycled materials are second-hand. Products packaged in recycled packaging materials should be labelled as such. This is especially important with imported packaging materials and foods packaged in imported materials. The public should be conscious that there are potential problems especially since the European Economic Community seems to have started exporting used packaging materials to developing countries following the introduction of regulations designed to reduce land fill demand in Europe.

THE GAZETTE OF INDIA

The Central Government has notified the rules for the manufacture and use

of recycled plastics carry bags and containers:

1. **Prohibition of usage of carry bags or containers made of recycled plastics** — No vendor shall use carry bags or containers made of recycled plastics for storing, carrying, dispensing, or packaging of foodstuffs.

2. **Conditions of manufacture of carry bags and containers, made of plastics** — Subject to the provisions of rule 4, any person may manufacture carry bags or containers made of plastics if the following conditions are satisfied, namely-

   (a) Carry bags and containers made of virgin plastic shall be in natural shade or white;

   (b) Carry bags and containers made of recycled plastic and used for purposes other than storing and packaging foodstuffs shall be manufactured using pigments and colourants as per IS: 9833-1981 entitled "List of pigments and colourants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water".

3. **Recycling** — Recycling of plastics shall be undertaken strictly in accordance with the Bureau of Indian Standards specification: IS 14534: 1998 entitled "The Guidelines for Recycling of Plastics".

4. **Marking/codification** — Manufacturers of recycled plastic carry bags having printing facilities shall code/ mark carry bags and containers as per Bureau of Indian Standards Specification: IS 14534: 1998 and the end product made out of recycled plastics shall be marked as "recycled" along with the indication of the percentage of use of recycled material. Other manufacturers, who do not have printing facilities, shall comply with the condition within one year of publication of these rules. Manufacturers shall print on each packet of carry bag as to whether these are made of "recycled material" or of "virgin plastic".

5. **Thickness of carry bags** — The minimum thickness of carry bags made of virgin plastics or recycled plastics shall not be less than 20 microns.

BIBLIOGRAPHY

Baldev Raj, Vijayalakshmi NS and Ravi P (1992). Problems of plastic contamination in foods. Packaging India, 25(2): 5-14.

Bergmeyer HU, Brunt E and Lachenicht R (1974). Alkaline phosphatase in serum. In: Methods of Enzymatic Analysis Vol. 2, ed: H. V. Bergmeyer. Academic Press, New York, pp. 864-866.

Bharucha D, Meyer H, Mody A and Carman RH (1976). Hand book of Medical Laboratory Techniques. Wesley Press, Mysore, pp 53-59.

BIS (1998). IS: 9845. Methods of analysis for determination of specific and / overall migration of constituents of plastic materials and articles intended to come into contact with food stuffs. Bureau of Indian Standards, New Delhi.

CIPET (1997). Proceedings of national seminar on recycling and plastics waste management CIPET, Chennai, India.

Clesceri LS, Greenberg AE and Trussell RH (1989). Standard methods for examination of water and wastewater. 17th ed. APHA, Washington.

Code of Federal Regulations (2001) Food & Drugs. Part 21.171-199.

EEC directive 90/128/EEC (1990) relating to plastic materials intended to come into contact with food stuffs. Official Journal of European Communities No. L 75 of 21st March1990.

Kumar KR, Baldev Raj and Balasubrahmanyam N (1993). Changes in properties of recycled polyethylenes. Deutsche Lebensmittel-Rundschau, 89(12): 386-388.

Lillie RD (1965). In: Histopathological Techniques and Practical Histochemsitry. McGraw Hill. New York, pp. 176-177.

Murthy RAN, Baldev Raj, Vijayalakshmi, NS and Veerraju P (1990). Effect of volume of food simulating solvents in migration tests. Deutsche Labensmittel-Rundschau, 86:12.

Reitman S and Frankel S (1957). A colorimetric method for determination of serum glutamic oxaloacetic and gultamic pyruvic transaminases. American J Clin Pathology, 28: 56-63.

Vijayalakshmi NS, Baldev Raj, Murthy RAN and Raju PV (1992). Effect of one side and two side exposure of plain films on the amount of extractives in food simulatnts in migrtion tests. Deutsche Lebensmittel Rundschau, 88: 154-156.

Zimmerman HJ and Weinstein BS (1956). Lactate dehydrogenase activity in human serum. J Lab Clin Med, 48: 607-612.

APPENDIX

ABBREVIATIONS USED FOR PACKAGING MATERIALS

Abbreviations	Materials
PE	Polyethylene
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
MDPE	Medium density polyethylene
HDPE	High density polyethylene
HMHDPE	High molecular high density polyethylene
PET	Polyethylene terephthalate (Polyester)
KPET	PVDC coated polyester
MPET	Metallised polyester
PP	Polypropylene
CPP	Cast polypropylene
OPP	Oriented polypropylene
MOPP	Metallised oriented polypropylene
PS	Polystyrene
OPS	Orientated polystyrene
EPS	Expanded polystyrene
SAN	Styrene/acrylonitrile copolymer
ABS	Acrylonitrile/butadiene/styrene copolymer
PA	Polyamide (Nylon)
PVC	Polyvinyl chloride
UPVC	Unplastisiced polyvinyl chloride
PVDC	Polyvinylidene chloride
PVA	Polyvinyl acetate (also PVAC)
PVAL	Polyvinyl alcohol
CMC	Carboxymethyl cellulose
CA	Cellulose acetate
EVA	Ethylene/vinyl acetate
TPX	Pentene polymer
CAB	Cellulose acetate butyrate
EC	Ethylic cellulose
EVOH	Ethylene vinyl alcohol
B	Bonding agent
ION	Ionomer (Surlyn)
MXXT	Cellophane
FRP	Fibre reinforced plastics
PC	Polycarbonate
Foil	Aluminium foil