ICPE
INDIAN CENTRE FOR PLASTICS IN THE ENVIRONMENT

Envis Eco-Echoes

Management of Plastics, Polymer wastes and Biopolymers and impact of Plastics on the Eco-system

Environmental Information System

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RECYCLED PLASTICS PRODUCTS: QUALITY ASSURANCE

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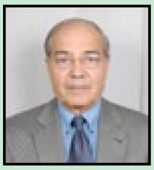
Area of Activity

Capacity Enhancement Programme on Management of Plastics, Polymer Waste and Bio-Polymers, Impact of Plastics on Eco-System



Editorial

For using any primary packaging material in direct contact with any food products, pharmaceuticals and drinking water, prior approval of the competent authority is mandatory by the packers / users for safe use of such materials. The competent authority relies on the specific approvals conferred by scientific bodies based on National and International Standards. These Standards are devised after prolonged studies and research over a period of time and after due process of deliberations in International / National forums and are adopted by the regulatory authorities in the respective countries. A list of important Indian Standards on Plastics for use in contact with Food Products, Pharmaceuticals and Drinking Water is available in ICPE website.

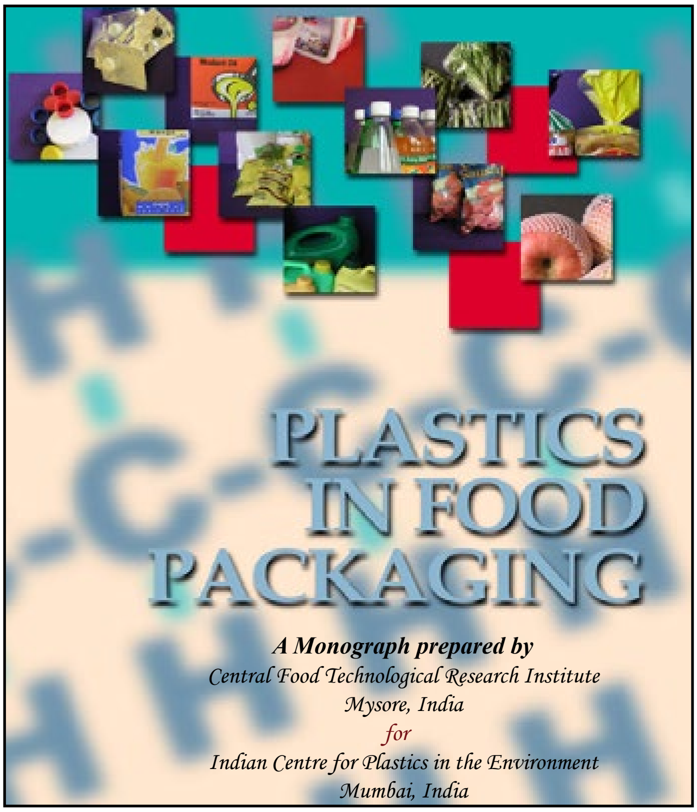
Global plastics consumption has exceeded 200 Mn MTs. India consumes more than 10 Mn MTs. Packaging is the single largest application sector of plastics. About 40% of total plastics are used for packaging applications world wide. Usage pattern in India is similar. Food industry is one of the largest users of plastics packaging, which plays a pivotal role in making food products available to the millions preserving quality. The packaging of food products makes many demands on the packaging material for preservation, shelf life, barrier properties, hygiene and a crucial requirement of minimizing the wastage during transportation and storage. In view of various transitory processes involved in handling of the very important sector – food grains, it was felt desirable to scientifically assess the merits and demerits of using plastics for packaging of common commodities compared to the alternative mode of packaging materials. ICPE thought about the above and assigned the responsibility of a study – cum – research project on the evaluation of plastics as the packaging material for wheat, paddy, sugar etc. CFTRI submitted its research report in September, 2005. The introduction part has been published in this edition. We plan to publish the important chapters of the report in this Newsletter serially.

Plastic recycling as a system is a scientific process which augments resource and hence in principle is a resource management and environment friendly activity. As plastics are recyclable, considerable quantity of used plastics waste is recycled for making usable products and thus reducing the avoidable quantum of environmental burden for manufacturing the fresh virgin material. However in India recycled plastics products are considered as cheap alternative to virgin products, whereas in many developed countries recycled plastics products are well recognized for designated application. This has been possible by making standards for processing plastics waste. Indian authority also has taken initiative in preparing such standards to control the process of recycling and thus creating interest among the potential users for recycled plastics products. A brief on the subject has been prepared for the benefit of the readers.

Chemical Resistance Data for Polyethylenes (PE) – the most used commodity plastics with guideline of suitability of using PE in contact with various chemicals has been provided in the Data Sheet. This may be used as a reference document by intended users.

Editor
Mr. T. K. Bandopadhyay

PLASTICS IN FOOD PACKAGING



PREFACE

Though we have come a long way from the pre-historic days of hunting and gathering of food, we do spend a great deal time and substantial portion of our income to get the foodstuffs that we need for our daily sustenance. Finding foodstuffs of the right quality isn't always easy - be it picking up fresh vegetables once a week from the neighborhood grocery or shopping once a month at the best supermarket chain store in town. In the former case, we often rely upon our senses - visual, tactile and even organoleptic, and occasionally, the advice of the sales assistant at the counter - to make purchase decisions. But in the self-service environments of supermarkets, it is the package which helps us in making our decisions through a host of messages that it communicates - about what it contains, what the brand is, what the ingredients are, what its special features are, when it was packed and the best-before date. Besides, through its form, colours, graphics and styling, it connects us to the promotional campaigns that we would have seen on the TV or a newspaper and acts on our subconscious to provide the last mile motivating force to buy the particular product.

We hardly realize that we are face to face with a massed display of packages and not the actual products, when we step into a supermarket store. Commodities have metamorphosed into brands identified through the packages and brands give us the assurance that we need on the products. Packages have come to be identified with products. This is especially true with fast moving consumer goods like food products. The milk sachet, the juice carton, the jam bottle, the edible oil pouch, the babyfood tin and the ubiquitous PET bottle for mineral water are some of the outstanding examples. The role of packaging in preserving food products without spoilage and contamination and giving the desired shelf life to enable country-wide and even global distribution and marketing, cannot be underestimated. From the economic point of view, packaging plays a vital role by preventing food wastages.

Last quarter of the last century saw a proliferation of packaged foods in the country owing to the phenomenal growth of the food processing industries. It is true that this growth is a response to the changing market needs - especially the quest for convenience. But it became possible due to the availability of cheaper packaging alternatives based on plastics. Besides the cost factor, the advantages offered by plastics compared to other packaging materials like plant fibres, paper and paperboard, metal and glass, are numerous: their ability to be formed into unlimited range of forms and shapes and material combinations offering a much wider range of functional properties, their light weight, strength, toughness and durability. That the Indian food processing industry could reach a market size of Rs 4,60,000 crores in 2003-04, wouldn't have been possible but for the advent of plastics based packaging.

With food processing industry in India poised to grow at over 7.3 %, a growth rate that is much higher than that of the manufacturing sector in general and plastics based food packaging being a pillar of the modern food industry, it is but timely that the Indian Centre for Plastics in the Environment (ICPE) sought the assistance of Central Food Technological Research Institute (CFTRI), Mysore, to bring out the present monograph. As a review of the state-of-art of plastics based food packaging with special reference to the requirements of Indian food industry, this monograph is expected to fulfill the long felt need for such information made available from one single source. The authors, who were or are with CFTRI, the foremost resource centre on food technology and food packaging in India, have tried to present the material with a distinct orientation towards applications by combining their academic knowledge with the much valued insight gained over decades of helping food and packaging industries through sponsored research, consultancy projects and testing services. They have also drawn on many sources of published literature, which are cited under Bibliography at the end of each chapter to serve as material recommended for further reading. Though this monograph is not claimed to be comprehensive, it will hopefully give a broad perspective of the subject and help in appreciating the more or less indispensable role of plastics in food preservation and the development of food industry in India.

INTRODUCTION TO FOOD PACKAGING
An Evaluation to Plastics as preferred Packaging Material

From the pre-historic times of hunting and gathering of food through farming and storing food grains up to today's impulse buying of food products stacked across supermarket shelves, man has come a long way with regard to ways of

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finding food for survival and gastronomic pleasure. It is well recognized that globalization has now made it possible for goods produced in one corner of the globe to be available in another corner. Foods, despite their perishable nature, are no exception. However, what is not well recognized is the fact that it is the modern food preservation and packaging technologies, which are the underlying forces that make foods available thousands of kilometers away from the places of their origin and weeks, months and even years beyond the day of their harvest or production.

The safety and quality of the milk delivered at our doorstep in the humble milk sachet every morning are indeed taken for granted by all of us. We hardly realize that this would not have been possible without the development of refrigeration and pasteurization technologies, availability of cheap plastic-based packaging materials and high-speed form fill-seal liquid packaging machines and, of course, the efficient logistics of procurement, transportation, storage and distribution. Thanks to the advent of unit packaging of edible oils in functional and cost-effective multilayer plastic pouches, polyjars and PET bottles, the Indian consumer is relieved of the problems of dangerous adulteration, underweighing and uncertain quality that were associated with the earlier practice of loose vending at retail store. The ultimate convenience of off-the-shelf ready-to-eat gourmet meal with assured hygiene and taste and without the hassles of cooking in the kitchen has become affordable due to the development of heat-resistant plastics and retort sterilization technologies. Availability of safe and wholesome food in sufficient quantities to the burgeoning population is a major issue in a country like India, where nearly a third of the population lives below the poverty line and consequently, suffers either from malnutrition or under-nutrition. Though constant efforts are being made to increase food production, we have to contend with high levels of food wastages resulting from unscientific or inefficient storage practices and inadequate use of preservation and packaging technologies. Food wastage occurs through external contamination, consumption by pests and spoilage. Most of the fresh food supply is perishable because of its moderate to high water content and its nutritious nature. The storage life of juicy fruits, vegetables, fresh meat, seafoods and milk is hardly one to few days at room temperature.

Only mature dry plant tissues such as food grains, dry peas, nuts, etc., can resist spoilage for extended periods of one year or more, but they are still susceptible to attack by numerous pests. Food Preservation Deterioration and spoilage of food are caused by growth of microorganisms, which is the most common cause of spoilage of foods with moderate to high water contents, contamination with external factors like filth, dust, absorption of off-odours, normal respiration in plant tissues, loss or gain of water, autolysis as in the case of fish, chemical reactions like oxidation, physiological disorders like scald in apples, chilling injury and anaerobic respiration of plant tissues and mechanical damage. The basic aim of food preservation is to prevent undesirable changes in the wholesomeness, nutritive value, or sensory quality of food by economical methods which control growth of microorganisms, reduce chemical, physical and physiological changes of undesirable nature and obviate contamination. Chemical, biological and physical methods of food preservation exist (Fig. 1.1). Chemical preservation involves the addition of substances like sugars, salts or acids or exposure of food to chemicals,such as smoke or fumigants. Biological methods involve alcoholic or acidic fermentations as in the case of wines, beer and yoghurt.

Physical approaches to preserving food include temporary increase in the product's energy level as in the case of heat sterilization and irradiation, controlled reduction of product's temperature (chilling, freezing), and controlled reduction in the product's water content, e.g., drying, concentration. Packaging can also be classified as a physical means of food preservation though it is essentially an external method. Apart from being a stand-alone method in certain cases, packaging has to be used in combination with all other reservaion methods to maintain whatever status that has been chieved in the latter. Thus packaging becomes an essential and integral component of all food preservation methods. Food preservation and packaging perhaps went hand in hand as civilization progressed. While man learnt the use of salt

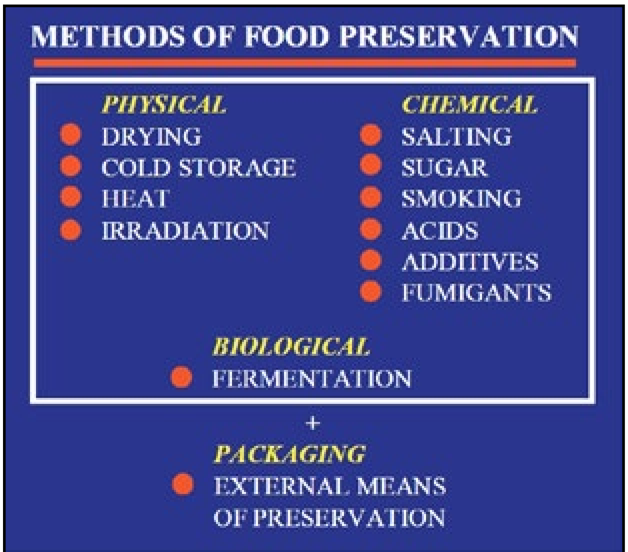

Fig. 1.1. Methods of food preservation

or spices and techniques like drying, smoking or cooling for preserving food, he also learnt by experience that packaging could help preserve food by protecting it from harmful environmental factors such as air, moisture and light. Though shells, animal skins, earthen pots, ceramic, glass, metallic vessels, woven baskets, chests, kegs, barrels and woven cloth are some of the examples of early packages, modern food packaging as it is known today has its beginnings in the early 1800's with the development of the technique of canning by the French confectioner, Nicholas Appert. He was able to extend the shelflife of many food products by packaging them into hermetically sealed glass jars and heating them in boiling water for certain time period. Metal cans instead of glass jars came into use soon afterwards. Though the technique was not scientifically understood at that time, it later became known, due to pioneering discoveries of Louis Pasteur, that heat destruction of microorganisms was responsible for the long shelf-life achieved by Appert. The development of various other modern food preservation techniques such as pasteurization, refrigeration, freezing, use of chemical additives followed. Improved packaging materials such as metal-capped glass jars, tinned steel, enameled tin cans, corrugated paperboard, coated paper and aluminium foil also gradually became available. Plastic materials came into commercial use much later in the 1950's and the decades that followed. Food Processing Industry and Packaging In industralised societies, food industry is the largest user of packaging materials. Packaging forms an integral part of food manufacture providing the link between the processor and consumer.

In fact, it plays a dominant role in the total manufacturing activity and in marketing. With packaging lines usually occupying 50% of the shop-floor area, packaging and related operations engage about 60% of the work force of 14 million in Indian food industry. The impetus to food processing industry in India came in the 1970's and 80's. It was during this period that a variety of processed food industries came into being, resulting in the proliferation of packaged foods and changing the face of the neighborhood grocery store. Commodities stocked in bulk, weighed or measured on the spot and sold started giving way to unit packs - attractively packaged and branded by the manufacturer or simply pre-packed by the grocer himself. Secondary processing came to the fore with many intermediate processed products receiving large patronage from middle income population seeking convenience. The industry was able to grow due to the introduction of plastics based packaging, especially the flexible forms, with diverse func tional characteristics and low cost. The post - liberalization period of 1990's has seen the most significant development of food industry in India, facilitated by opening up of the economy that encouraged foreign direct investment, eased import restrictions on materials and machinery, which led to setting up of state of- art packaging and processing industries. This period was also a witness to the growth of organized retailing which in turn provided increased market access to the manufacturing industry, especially the packaged foods. he supermarket culture in which products come to be identified by the packages could penetrate the Indian psyche owing to the developments in packaging technologies especially the plastics-based ones which are highly cost-effective compared to other alternatives.

The food processing sector had a market size of Rs 4,60,000 crore in 2003-04 and is expected to grow at 7.3% in the next five years. Food packaging, which is at the very heart of the modern food industry, will probably see a corresponding growth in the coming years. Packaging, despite its key role in preserving food, preventing wastages and facilitating distribution and marketing of food, is sometimes regarded as a - necessary evil, an unnecessary cost, a drain on resources and an environmental menace. Such a view, undoubtedly an uninformed one, arose since packages are ultimately disposed off while using the product and one is hardly aware of the crucial role that a package plays in delivering the product to the consumer.

The Packaging System

In order to appreciate the place of packaging in the economy, one should try to understand what it is and how it functions. Fig. 1.2 shows the life-cycle of a package from the point of its manufacture through the point of sale up to the final disposal. Based on its functions, packaging can be defined in several ways: "A coordinated system of preparing goods for transport, distribution, storage, retailing and end-use". "a means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost." "a techno-economic function aimed at minimizing costs of delivery while maximizing sales (and hence profits)".

All these definitions provided by the UK Institute of Packaging have an economic aspect that is of utmost relevance in these days of resource conservation. Packaging is also closely linked to marketing which is defined as identification, anticipation and satisfaction of customer need profitably. As the definitions show, packaging is

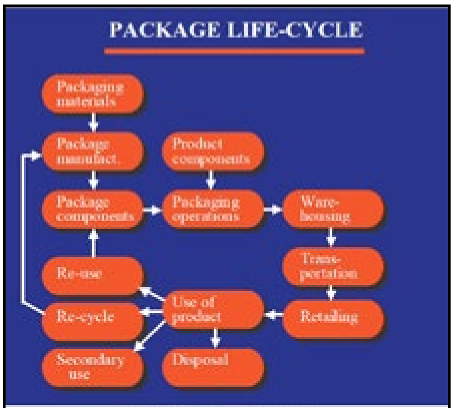

Fig. 1.2. Package life-cycle

much more than "packing" which is nothing but enclosing an article or several of them usually for shipping or delivery. Packaging functions at several levels. At the most basic level - occasionally it is most sophisticated one - is the primary package, which is in direct contact with the product. It provides the initial and usually the major protective barrier. Examples of primary packages include metal cans, glass bottles and plastic pouches. It is frequently the only primary package which the consumer sees and purchases at retail outlets and uses.

A secondary package, e.g., a corrugated fibre-board case or shipping container, contains a number of primary packages. It is the physical distribution carrier and is sometimes so designed as it can be used in retail outlets for the display of primary packages. A tertiary package is made up of a number of secondary packages, the common example being a stretch-wrapped pallet of corrugated cases. In inter-state and international trade, a quaternary package is frequently used to facilitate the handling of tertiary packages. This is generally a metal container up to 12 m in length which can hold many pallets and is intermodal in nature. That is, it can be transferred to or from ships, trains, and flatbed trucks, by giant cranes. Certain containers can also have their temperature, humidity and gas atmosphere controlled and this is necessary in particular situations such as the transportation of frozen foods or fresh fruits and vegetables.

A total packaging system consisting of these different levels is designed based on inputs like product characteristics, availability and costs of various packaging materials and forms that can be fabricated, the nature of physical distribution environment, the needs of production line and the requirements of the consumer (Fig. 1.3). These considerations result in a

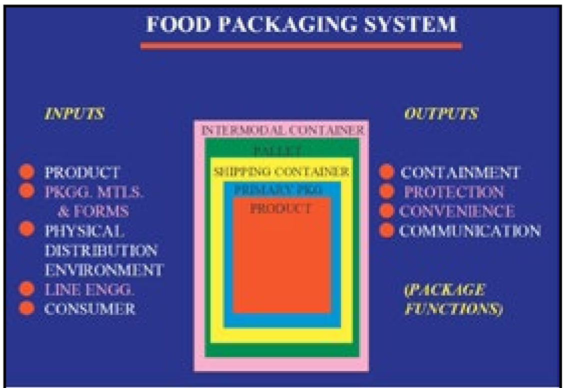

Fig. 1.3. Food packaging system

packaging system that performs the four major functions of containment, protection, convenience and communication.

Functions of Packaging

Containment, the most basic function of packaging is so obvious that it is usually overlooked. With the exception of large, discrete products, all other products - whether a litre of liquid milk or a kg of wheat flour - must be contained as a single unit before they are moved from place to place. The function of protection is often regarded as the most important since the product has to be protected from outside environmental effects, be they water, water vapour, oxygen, odours, microorganisms, dust, shocks, vibrations, stack loads, etc. In case of food products, protection afforded by the package is often a part of the preservation process. For example, aseptically packaged juice in a carton cannot retain its shelf life, if the integrity of the pack age is breached. Changing demographic trends such as urbanization, increasing incomes, more women in the workforce, nuclear families and single-person households have brought in their wake an increasing demand for convenience in consumer products ready-to-cook and ready-toeat foods and ready-to-drink beverages, foods and drinks that can be directly consumed from the packages, dispensers that facilitate use of products like sauces, etc. The convenience function designed to perform by the package allows products to be used conveniently. Another aspect of package convenience that is usually ignored is the apportionment function. The package containing the net quantity of the product reduces the output from industrial production to manageable, desirable consumer size, e.g., 1 litre of sunflower oil, 25 g portion pack of butter, etc. Put simply, the large scale production of products with its associated economies of scale could not have succeeded without the apportionment function of packaging to deliver product quantities convenient to use by the consumer. Besides convenient sizes, the relative proportions of the dimensions of the packages are designed to achieve efficiency in building into secondary and tertiary packages, such as corrugated cases and pallets and, occasionally, even the quaternary package of intermodal container. With optimal dimensions in primary and secondary packages, maximum space available on pallets and in inter modal containers, which are of standard sizes, can be used. As a consequence of this function, material handling is optimized since only a minimal number of discrete packages or loads need to be handled. Finally, packaging plays an important role in marketing products through the communication function. The modern methods of consumer marketing would fail without a package communicating various messages to he ultimate consumer. The package through its distinct form, style and surface graphics, identifies the brand, the category and the product features and even motivates the buyer in supermarket environments, which function on self-service basis without the help of a salesman to promote the product. It is no exaggeration that a package has been dubbed the "silent salesman". Besides, modern retailing extensively makes use of barcodes printed on the packages through scanning at checkout counters for efficient store operations. A knowledge of these functions of packaging and the ambient, physical and human environments in which packaging has to perform will lead to optimized packaging design and the development of real, cost-effective packaging.

Plastics as Alternatives

Development of materials for food packages occurs in response to the needs, and the needs have always been defined by the shortcomings of the materials in use at a given time. Packaging materials available prior to industrial revolution such as plant fibres, pottery and glass had the advantage of ready availability, but fell short of needs. Plant fibres were damaged by moisture and harboured pests. Pottery was heavy and brittle. Paper and paperboards which are made from plant fibres have low strength and high permeability to moisture and gases, and not ideally suited for food packaging. Glass has the advantages of transparency, imperviousness and inertness, but its fragility and high weight-to-strength ratio are limiting factors. Metal containers that came into use during 1700's for food packaging, have excellent strength besides being retortable, the main disadvantage being their shape limitations. Plant based fibres, paper and paperboard, glass and metal dominated packaging applications till the middle of the last century. Though they continue to have Significant share in present day packaging, the advent of plastics has revolutionized the whole area of food packaging especially during the last quarter of the 20th century.

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Some important developments in plastics with applications in food packaging are listed in Table 1.1. Plastics come into use in food packaging in three phases: substitution, accommodation and innovation, differentiated by the extent to which designers take advantage of the performance properties plastics offer.

"Substitution" involves direct replacement of traditional materials with virtually no change in design. Early attempts to replace glass with shatter-resistant plastics is an example. Such approaches may not result in optimum designs. When a design is made taking advantage of the performance capabilities of plastics but without going beyond the design limitations for traditional materials, the approach is termed "accommodation". For example, bottles remain bottles, but

Table 1.1. Important developments in plastics and their use in food packaging

Period	Developments	Contemporary food uses
1900s	Modified alkyd resin solutions Vinyl acetate polymers	Can coatings Adhesives, films
1910s	Phenol-formaldehyde resins Cellophane, casting (uncoated) Viscose	Closures (e.g., screw caps) Lamina in multilayered films Casting for processed meat
1920s	Coated "moisture-proof" cellophane Rubber hydrochloride Vinyl chloride polymers, copolymers	Pouches, dry foods Films; now in minimal use Films, blown bottles, can coating
1930s	Polystyrene Polyamide(nylon) resins Ethylcellulose Methylcellulose Polyethylene Polyvinylidene chloride (PVDC)	Trays, tubs,lids,foams Barriers in films,sheets,moldings Frozen foods, hot melt paper coating Edible films for internal moisture control in foods Films, bottles, thermoforms, heat seals Barrier films, multilayer thermoforms
1940s	Impact polystyrene Thermoforming of sheet Injection blow molding Extrusion blow molding Nylon films Styrene-butadiene latexes PVDC lacquer coating	Tubs, trays, thermoforms Trays, tubs; form-fill-seal Bottles, jars; with threaded closures Large containers, threaded Processed meat packs Paper coating, primers High barrier cellophane
1950s	Polypropylene Extrusion coating PE on paperboard Coextrusion Polycarbonates Metallized films High barrier PVDC co-extrusion resins Epoxy-phenolics	Bottles, structure layers Milk, juice and frozen food cartons Barrier containers of multilayer construction Structures, food bottles, potable water Gas & light barrier pouches Multilayer coextrusions of fims, thermoformable sheet Can coating for many foods
1960s	Polyethylene imine Styrene-butadiene resins Ionomers Ethylene copolymers Polysulphones Multilayer coextrusion & thermoforming Injection mold, reheat & blow process	Dual oven ware; composited with Polycarbonates Potable water Films, coating, heat seals Films, coating, sealant layers Dual ovenware High barrier food tubs, trays Pressurized beverage bottles
1970s	Modified polypropylene resins Ethylene-vinyl-alcohol (EVOH) Acrylonitrile resins Polyethylene terephthalate (PET) VDC-methyl acrylate copolymers Coinjection blow molding Ethylene-acrylic acid copolymers Linear low density polyolefins	Multilayer coextrusion adhesives Barrier layer in films, thermoforms Bottles, thermoforms Food bottles, jars, dual overware, paperboard trays coating High barrier multilayer films, containers Retortable barrier tubs Films, adhesives Moisture barrier films
1980s	Glycol modified PET Crystallized PET Tortuous path barrier blends Amorphous polyamide Polyarylamide resins Liquid crystal polymers Poly (ethylene 2,6 napthalene) dicarboxylate) [PEN] Ultra low density polyethylenes	Extrusion blow molded food jars Dual oven tray ware Bottles, films Barrier films, containers Barrier films & multilayers; alloys & blends High temperature, high barrier uses Monolayer barrier bottles Thin, tough films, e.g, for bag-in-box

Adapted from Brown, WE (1992).

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with new dimensions, shapes and sizes. In the third approach, viz., "innovation", form follows function, and entirely new design concepts are built around the capabilities of the new material. With large body of data related to the properties and performance capabilities of plastics presently available, efforts are increasingly directed towards this approach that takes into account both package and user functions. The use of plastics in food packaging has gone up several folds during the last two to three decades owing to the several advantages offered by them as compared to other materials. The most important advantages of plastics are their formabilities into practically unlimited range of shapes and forms and the broad range of their properties that enable design of packages with tailor-made functionalities.

Plastics being synthetic organic polymers, their properties can be adjusted, modified or enhanced by formulation, by adaptation in manufacture and by deploying such processing steps as orientation. One of plastics - largest contributions to the packaging industry is its ability to be made into very thin films and containers. In fact, packagers are increasingly substituting plastics for alternative packaging materials because they can achieve significant reductions in packaging weight, volume and cost for the same amount of product delivered. A major advantage in using plastics for packaging purpose is that most polymers possess excellent physical properties such as strength and toughness, combined with low weight and flexibility, as well as resistance to cracking. As a consequence of the diversity of packaging applications in the food industry, a wide range of polymer materials has been developed over the years. The basic material (with additives as necessary) is then converted into film, powder or sheet and moulded, or further processed into containers. e.g., trays, tubs, bags, pouches, sachets, blister packs or shrink wraps. Frequently, no one material possesses all the desirable properties required and hence, copolymers or even laminated materials consisting of two or more layers of different polymers (having different properties) cemented together, may have to be used. The stability of packages in ambient and even hostile environments is reflected in their ability to retain their properties and functionality during the life of the package. Plastics are finite barriers to permeation and this property manifests in the form of oxygen transfer, gain or loss of moisture and sorption of flavour or aroma bodies.

This property can often be used to advantage to control gas and moisture transfer as in the case of modified atmosphere packaging. Most fresh foods need to "breathe" and hence the packaging material used must allow ingress of oxygen and expiration of carbon dioxide. Where the material chosen does not permit sufficient gas transfer, the problem can often be solved by incorporation of a few holes punched onto the film. Fresh meat also requires ingress of oxygen to maintain a satisfactory surface colour. On the other hand, foods with a high fat content (dairy products, bacon, crisps, etc.) become rancid on exposure to oxygen and are often vacuum packed, or packaged in an inert atmosphere, using a material of very low permeability. Low permeability materials are also useful for the packaging of fish or coffee, where the odour must be contained strictly within the package. Foods prone to atmospheric oxidation are often protected by the addition of an antioxidant, such as BHA or BHT. Some products like cereals and crisps are delicate, and need to be loosely packed. This increases the air inside the package and coupled with the high surface area of such products, can lead to rancidity. Additional protection and longer storage life, can be obtained by addition of antioxidant to the packaging materials itself as well as to the food. This reduces the concentration of antioxidant required in the food since only the surface of the food needs protection.

Furthermore, consumers are likely to prefer addition of preservatives to the packaging materials rather than to the food itself, although migration of the antioxidant from the package to the food may still occur. The compatibility of the package with the method of preservation selected is also essential. For example, if the food is being thermally processed after packing, then the packaging must obviously be able to withstand the thermal process. Likewise, if the food is to be stored at freezer temperatures after packing, then the packaging must be able to withstand these low temperatures. The nature and composition of the specific packaging material and its potential effect on the intrinsic quality and safety of the packaged food as a consequence of the migration of components from the packaging material into the food needs to be looked into. The latter consideration, namely, the migration of potentially toxic moieties from the packaging material to food is of major concern in the selection and use of plastic packaging materials for food packaging.

Recycled Plastics Products: Quality Assurance

Recycling as a system augments resource and hence in principle it is a resource management and environment friendly activity. It is reported that natural resources of the mother Earth is depleting at a fast rate. This is an important factor which drives us towards the concept of recycling.

Due to the various advantages and due to enhanced requirements, use of plastics has been increasing all over the world at a galloping speed. Current consumption is more than 200 Mn Tons. Among the applications, there are products which are used for long term applications. However there ate many products which are used for short and medium term. Every year fresh virgin materials are required to replenish those and fresh virgin plastics are produced. However as plastics are recyclable, considerable quantity of used plastics waste is recycled for making usable products and thus reducing the load on fresh virgin material. Worldwide there is a considerable economic activity in the area of plastics recycling. India has made significant technological progress in the area of manufacturing of virgin plastics products in almost all sectors of applications. However when it comes to the recycling of plastics, the performance is insignificant in a way that this activity is mostly accomplished in an unorganised sector without the application of modern day technology. This is mainly because of the reason that recycled plastics products are considered only as a cheap alternative to the products made from the virgin plastics. While the economic aspect may be true, the environmental benefit aspect is seldom considered by a user in India. Recycling of plastics provides a scientific solution to the disposal of plastics waste and also makes positive contribution to resource management of plastics materials for a wide range of applications thus saving the environment by way of reduced consumption of energy and water and by minimizing emissions to air and water, compared to the production of virgin plastics.

Various processes of plastics recycling have been identified in ISO Standard ISO 15270: 2008. (Pictorial description has been given in the back cover). While the quality of output products of plastics waste recovery by feedstock recycling and energy recovery processes is governed by the specifications laid down in the respective end product segments, there is no such specification under Indian Standard predicting / guiding the quality of most of the recycled products produced, except in a limited cases, by mechanical recycling process – the most adopted plastics recycling process. The issue is most applicable in the cases of predicting the quality of recycled products made out of plastics waste collected from municipal solid waste stream. This leads to reduced interest among the potential users for accepting recycled products.

In many developed countries Standard Specifications have been prepared for predicting the quality of recycled plastics products. This help in attracting the attention of potential users towards products made of recycled plastics. A list of some of the International Standards for recycled plastics is given in the fig 1. Some other standards / draft standards of ISO (the International Organization for Standardization) are given in fig 2.

Fig. - 1

EUROPEAN STANDARD	EN 15342	Plastics – Recycled Plastics – Characterization of polystyrene (PS) recyclates
EUROPEAN STANDARD	EN 15343	Plastics – Recycled Plastics – Plastics Recycling Traceability and assessment of conformity and recycled content
EUROPEAN STANDARD	EN 15344	Plastics – Recycled Plastics – Characterization of Polyethylene (PE) recyclates
EUROPEAN STANDARD	EN 15345	Plastics – Recycled Plastics – Characterization of Polypropylene (PP) recyclates
EUROPEAN STANDARD	EN 15346	Plastics – Recycled Plastics – Characterization of Poly(vinyl chloride) (PVC) recyclates
EUROPEAN STANDARD	EN 15347	Plastics – Recycled Plastics – Characterization of plastics wastes
EUROPEAN STANDARD	EN 15348	Plastics – Recycled Plastics – Characterization of Poly(ethylene Terephthalate) (PET) recyclates
EUROPEAN STANDARD	CEN 15348	Plastics – Recycled Plastics – Guidelines for the development of standards for recycled plastics

In Italy, Certification Institute – IIP (Instituto Italiano Dei Plastici SRL) has Standards to certify safe use of secondary plastics materials derived from plastics waste. Some of its standards are listed in fig 3.

This type of initiative by authority imbibes the confidence on the quality of the recycled plastics products among the potential users thus encouraging the recycling activity. Indian authority, Bureau of Indian Standards (BIS), had already published the standard IS 14534:1998 - Guideline for Plastics Recycling – which has undergone first amendment in 2013. Further initiative is underway for preparing

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standards for recycled plastics products. This would help providing guidance / direction towards control of quality of inputs and the overall recycling process for predicting the intended quality of the output to a reasonable extent (recycled plastics products) thus help establishing a system to encourage recycled plastics as a material of designed choice.

Fig. - 2

ISO/DIS 18263-1	Plastics -- Mixtures of polypropylene (PP) and polyethylene (PE) recyclate derived from PP and PE used for flexible and rigid consumer packaging -- Part 1: Designation system and basis for specification
ISO/DIS 18263-2	Plastics -- Mixtures of polypropylene (PP) and polyethylene (PE) recyclate derived from PP and PE used for flexible and rigid consumer packaging -- Part 2: Preparation of test specimens and determination of properties

ISO 12418-1.	Plastics - Post-consumer poly (ethylene terephthalate) (PET) bottle recyclates. Part 1. Designation system and basis for specifications
ISO 12418-2:2012	Plastics. Post-consumer poly (ethylene terephthalate) (PET) bottle **recycled**. Preparation of test specimens and determination of properties

Benches made from Recycled Plastics - Sanjay Gandhi National Park, Mumbai

Fig. - 3

UNI 10667 – 1:1998 + A1:2000	Recycled Plastic materials – General
UNI 10667 – 7:1998 + A1:2000	Recycled Plastic materials – Polyethyleneterephthalate from post consumer for the production of fibres – Requirements and test methods
UNI 10667 – 8:1998 + A1:2000	Recycled Plastic materials – Polyethyleneterephthalate from post consumer to be used for blow moulding – Requirements and test methods
UNI 10667 – 9:1998 + A1:2000	Recycled Plastic materials – Polyethyleneterephthalate from post consumer to be used for the production of sheets and sheetings – Requirements and test methods

Jerseys made from Recycled PET Fiber

DATA SHEET

CHEMICAL RESISTANCE DATA FOR POLYETHYLENES

[R = Resistant   LR = Low Resistant   NR = Not Resistant]

Agent	LDPE / LLDPE		HDPE	
	23°C	60°C	23°C	60°C
Acetaldehyde (100%)	LR	NR	LR	NR
Acetic acid (10%)	R	R	R	R
Acetic acid (50%)	R	LR	R	LR
Acetic anhydride	NR	NR	NR	NR
Air	R	R	R	R
Alum (all kinds)	R	R	R	R
Aluminium chloride (all conc.)	R	R	R	R
Aluminium Floride (all conc.)	R	R	R	R
Aluminium sulphate (all conc.)	R	R	R	R
Ammonia (100% dry gas)	R	R	R	R
Ammonium carbonate	R	R	R	R
Ammonium chloride (sat. sol'n)	R	R	R	R
Ammonium fluoride (sat. sol'n)	R	R	R	R
Ammonium hydroxide (10%)	R	R	R	R
Ammonium nitrate (sat. sol'n)	R	R	R	R
Ammonium persulphate (sat. sol'n)	R	R	R	R
Ammonium sulphate (sat. sol'n)	R	R	R	R
Amyl acetate (100%)	NR	NR	NR	NR
Amyl acetate alcohol	R	R	R	R
Amyl chloride (100%)	NR	NR	NR	NR
Anililne (100%)	NR	NR	NR	NR
Aqua regia	NR	NR	NR	NR
Aromatic hydrocarbons	NR	NR	NR	NR
Arsenic acid (all conc.)	R	R	R	R
Ascorbic acid (10%)	R	R	R	R
Barium carbonate (sat. sol'n)	R	R	R	R
Barium chloride (sat. sol'n)	R	R	R	R
Barium hydroxide	R	R	R	R
Barium sulphate (sat. sol'n)	R	R	R	R
Barium sulphide (sat. sol'n)	R	R	R	R
Beer	R	R	R	R
Benzene	NR	NR	NR	NR
Benzoic acid (all conc.)	R	R	R	R
Bismuth carbonate (sat. sol'n)	R	R	R	R
Borax (sat'd)	R	R	R	R
Boric acid (all conc.)	R	R	R	R
Boron trifluoride	R	R	R	R
Brass plating solutions	R	R	R	R
Brine	R	R	R	R
Bromine (liquid)	NR	NR	NR	NR
Butanediol (10%)	R	R	R	R
Butanediol (100%)	R	R	R	R
Butyric acid (all conc.)	NR	NR	NR	NR
Cadmium plating solutions	R	R	R	R
Calcium disulfide	R	R	R	R

DATA SHEET

CHEMICAL RESISTANCE DATA FOR POLYETHYLENES

Agent	LDPE / LLDPE		HDPE	
Calcium carbonate (sat. sol'n)	R	R	R	R
Calcium Chlorate (sat. sol'n)	R	R	R	R
Calcium chloride (sat son'n)	R	R	R	R
Calcium hydroxide (all conc.)	R	R	R	R
Calcium hypochlorite (bleach sol.)	R	R	R	R
Calcium nitrate (50%)	R	R	R	R
Calcium oxide (sat sol'n)	R	R	R	R
Calcium sulphate	R	R	R	R
Camphor oil	NR	NR	NR	NR
Carbon dioxide (all conc.)	R	R	R	R
Carbon disulfide	NR	NR	NR	NR
Carbon monoxide				
Carbon tetrachloride	NR	NR	NR	NR
Carbonic acid	R	R	R	R
Castor oil (all conc.)	R	R	R	R
Chemical photographic solution	R	R	R	R
Chlorine (100% dry gas)	LR	LR	LR	LR
Chlorine water (2% sat. sol'n)	R	R	R	R
Chlorobanzene	NR	NR	NR	NR
Chloroform	NR	NR	NR	NR
Chlorosulphonic acid (100%)	NR	NR	NR	NR
Cider	R	R	R	R
Citric acid (sat'd)	R	R	R	R
Coconut oil alcohol	R	R	R	R
Coffee	R	R	R	R
Cola concentrates	R	R	R	R
Copper chloride (sat.)	R	R	R	R
Copper cyanide (sat.)	R	R	R	R
Copper fluoride (2%)	R	R	R	R
Copper nitrate (sat.)	R	R	R	R
Copper plating solutions	R	R	R	R
Copper sulfate (sat.)	R	R	R	R
Corn oil	R	R	R	R
Cotton oil	R	R	R	R
Cytric acid (sat.)	R	R	R	R
Detergent synthetic	R	R	R	R
Dextrin (sat. sol'n)	R	R	R	R
Dextrose (sat.sol'n)	R	R	R	R
Diazo salts	R	R	R	R
Dibutylphtalate	LR	LR	LR	LR
Dichlorobenzene (ortho-para)	NR	NR	NR	NR
Diethyl ketone	LR	LR	LR	LR
Diethylene glycol	R	R	R	R
Diglycolic acid	R	R	R	R
Dimethylamine	NR	NR	NR	NR
Ethyl acetate (100%)	LR	LR	LR	LR
Ethyl alcohol (100%)	R	R	R	R
Ethyl alcohol (35%)	R	R	R	R
Ethyl benezene	NR	NR	NR	NR
Ethyl chloride	NR	NR	NR	NR

DATA SHEET

CHEMICAL RESISTANCE DATA FOR POLYETHYLENES

Agent	LDPE / LLDPE		HDPE	
Ethyl ether	NR	NR	NR	NR
Ethylene glycol	R	R	R	R
Ferric chloride (sat. sol'n)	R	R	R	R
Ferric nitrate (sat. sol'n)	R	R	R	R
Ferrons chloride (sat. sol'n)	R	R	R	R
Ferrons sulphate	R	R	R	R
Fluoboric acid (32%)	R	R	R	R
Fluosilicic acid (32%)	R	LR	R	LR
Formic acid (all conc.)	R	R	R	R
Fructose (sat'd)	R	R	R	R
Fruit pulp	R	R	R	R
Furfural (100%)	NR	NR	NR	NR
Futuryl alcohol (100%)	NR	NR	NR	NR
Gallic acid (sat'd)	R	R	R	R
Gasoline	NR	NR	NR	NR
Glucose	R	R	R	R
Glycerine	R	R	R	R
Glycol	R	R	R	R
Glycolic acid (30%)	R	R	R	R
Gold plating solutions	R	R	R	R
Hexachlorobenezene	R	R	R	R
Hexanol teriary	R	R	R	R
Hydrobromic acid (50%)	R	R	R	R
Hydrochloric acid (all conc.)	R	R	R	R
Hydrochloric acid (dry gas)	R	R	R	R
Hydrocyanic acid	R	R	R	R
Hydrofluoric acid (40%)	R	R	R	R
Hydrofluoric acid (60%)	R	R	R	R
Hydrogen (100%)	R	R	R	R
Hydrogen sulphide	R	R	R	R
Hydroquinone	R	R	R	R
Hypochlorous acid (conc.)	R	R	R	R
Iodine (in ki sol'n)	LR	LR	LR	LR
Lead acetate	R	R	R	R
Lead nitrate	R	R	R	R
Lead plating (sol'n)	R	R	R	R
Lead plating (sol'n)	R	R	R	R
Leaven	R	R	R	R
Liquid chloride	NR	NR	NR	NR
Lye	R	R	R	R
Magnesium carbonate (sat'd)	R	R	R	R
Magnesium chloride (sat'd)	R	R	R	R
Magnesium hydroxide (sat'd)	R	R	R	R
Magnesium nitrate (sat'd)	R	R	R	R
Magnesium sulphate (sat'd)	R	R	R	R
Mercury	R	R	R	R
Methyl alcohol (100%)	R	R	R	R
Methyl alcohol (100%)	R	R	R	R
Milk	R	R	R	R
Mineral oils	LR	LR	LR	LR

DATA SHEET

CHEMICAL RESISTANCE DATA FOR POLYETHYLENES

Agent	LDPE / LLDPE		HDPE	
n-Butyl acetate (100%)	LR	LR	LR	LR
n-Butylalcohol (100%)	R	R	R	R
n-Heptane	NR	NR	NR	NR
n-Octane	R	R	R	R
n-Propyl alcohol	R	R	R	R
Naphtha	LR	LR	LR	LR
Naphthalene	NR	NR	NR	NR
Niket chloride	R	R	R	R
Nicket plating solutions	R	R	R	R
Nicket sulphate	R	R	R	R
Nictine (dilluted)	R	R	R	R
Nitric acid (0.30%)	R	R	R	R
Nitric acid (30.50%)	R	R	R	R
Nitric acid (70%)	R	R	R	R
Nitric acid (95-98%)	NR	NR	NR	NR
Nitrobenezene	NR	NR	NR	NR
Oxanlic acid (sat'd)	R	R	R	R
Perchlore-ethylene	NR	NR	NR	NR
Potassium bicarbonate	R	R	R	R
Potassium bromide	R	R	R	R
Potassium carbonate	R	R	R	R
Potassium chlorate	R	R	R	R
Potassium chloride	R	R	R	R
Potassium chromate (40%)	R	R	R	R
Potassium cyanide	R	R	R	R
Potassium dichromate (40%)	R	R	R	R
Potassium terri cyanide II	R	R	R	R
Potassium terri cyanide III	R	R	R	R
Potassium fluoride	R	R	R	R
Potassium hydroxide (conc.)	R	R	R	R
Potassium nitrate	R	R	R	R
Potassium perchlorate (10%)	R	R	R	R
Potassium permanganate (20%)	R	R	R	R
Potassium persulphate	R	R	R	R
Potassium sulphate (conc.)	R	R	R	R
Potassium sulphite (conc.)	R	R	R	R
Propargyl alcohol	R	R	R	R
Propylene dichloride (100%)	NR	NR	NR	NR
Propylene glycol	R	R	R	R
Pyridine	R	R	R	R
Resorcinol	R	R	R	R
Salicylic acid (sat'd)	R	R	R	R
Sea water	R	R	R	R
Selenic acid	R	R	R	R
Silver nitrate (sol'n)	R	R	R	R
Silver plating solutions	R	R	R	R
Soap solution (all conc.)	R	R	R	R
Sodium acetate	R	R	R	R
Sodium benezoate (35%)	R	R	R	R
Sodium bicarbonate	R	R	R	R

DATA SHEET

CHEMICAL RESISTANCE DATA FOR POLYETHYLENES

Agent	LDPE / LLDPE		HDPE	
Sodium bisulphate	R	R	R	R
Sodium bisulphite	R	R	R	R
Sodium borate	R	R	R	R
Sodium bromide	R	R	R	R
Sodium carbonate	R	R	R	R
Sodium chlorate	R	R	R	R
Sodium chloride	R	R	R	R
Sodium cyanide	R	R	R	R
Sodium dichromate	R	R	R	R
Sodium ferro/terri cyanide	R	R	R	R
Sodium fluoride	R	R	R	R
Sodium hydroxide	R	R	R	R
Sodium hypochlorite	R	R	R	R
Sodium nitrate	R	R	R	R
Sodium phosphate (mono)	R	R	R	R
Sodium phosphate (tri)	R	R	R	R
Sodium sulphate	R	R	R	R
Sodium sulphide	R	R	R	R
Sodium sulpihte	R	R	R	R
Stannic chloride	R	R	R	R
Starch (sat.sol'n)	R	R	R	R
Steraric acid (100%)	R	R	R	R
Sulphuric acid (50%)	R	R	R	R
Sulphuric acid (70%)	R	LR	R	LR
Sulphuric acid (80%)	R	NR	R	NR
Sulphuric acid (96%)	LR	NR	LR	NR
Sulphuric acid (98% conc.)	LR	NR	LR	NR
Sulphuric acid (Fuming)	NR	NR	NR	NR
Sulphuous acid	R	R	R	R
Tannic acid (sat'd)	R	R	R	R
Tetrahydrofuran	NR	NR	LR	NR
Tin plating solutions	R	R	R	R
Titanium tetrachloride	NR	NR	NR	NR
Toluene	NR	NR	NR	NR
Trichloroethylene	NR	NR	NR	NR
Triethylene glycol	R	R	R	R
Turpetine	NR	NR	LR	LR
Urea (30%)	R	R	R	R
Vanila Extract	R	R	R	R
Vinegar	R	R	R	R
Water	R	R	R	R
Wetting agents	R	R	R	R
Whisky	R	R	R	R
Wines	R	R	R	R
Xylene	NR	NR	NR	NR
Zinc bromide	R	R	R	R
Zinc chloride	R	R	R	R
Zinc oxide	R	R	R	R
Zinc sterate	R	R	R	R
Zinc sulphate	R	R	R	R

Source : Product knowledge Manual on Plastics : 1997, Indian Petrochemicals corporation Ltd.


PLASTICS RECYCLING
PLASTICS ARE 100% RECYCLABLE
ISO 15270:2008
PLASTICS RECYCLING / RECOVERY OPTIONS
MATERIAL RECOVERY
MECHANICAL RECYCLING
Remoulded into Common Products for Non Critical Usage
FEEDSTOCK RECYCLING
Conversion by Changing Chemical Structure
ENERGY RECOVERY
PLASTICS WASTE
CO-PROCESSING IN CEMENT KILNS
HEAT & POWER GENERATION
Monomeric Constituents of Polymers
Reconversion into Polymers
Fuel
Rich Gas & Synthatic Natural Gas
Town Gas & Strong Gas
Synthasis Gas & Reduction Gas
Lean Gas & Water Gas
37000
KJ/Nm³
4600
Gasification
Partial Oxidation of HC in restricted supply of oxygen
½ C₂H₄ + CO₂ = 2 CO + H₂
Fe₂O₃ + 2 CO + H₂ = 2 Fe + 2CO₂ + H₂O
Reducing Agent
Production of Iron using Plastics Waste
Indian Centre for Plastics in the Environment