

FLEXIBLE PACKAGING MATERIALS

Non-rigid **packaging** structures used to package and protect products. According to the **Flexible Packaging Association**, **flexible packaging** is any package or any part of a package whose shape can be readily changed. Common examples of **flexible packaging** are bags and pouches. Flexible packaging is a major group of materials that includes plastic films, papers, foil, some types of vegetable fibres and cloths that can be used to make **wrappings**, sacks and sealed or unsealed **bags**.

Synthetic or plastic packaging materials are man-made artificial materials which have a good shelf-life, strength needed to allow handling, are flexible and are of different types as given below. Various types of synthetic plastic films are available such as:

PE: beverage bottles, mouthwash bottles, boil in bag pouches

HDPE: milk jugs, trash bags, detergent bottles

PVC: cooking oil bottles, packaging around meat

LDPE: grocery bags, food wrap, bread bags

PP: yoghurt containers, shampoo bottles, straws, margarine tubs, diapers

Apart from plastics and plastic products, other flexible packages include: Paper products - Paper like webs of mixed cellulose and plastics, papers made from plastics, bonded fibre plastics, cloths and scrims, spun bonded fabrics, regenerated cellulose films, aluminium and steel foils.

A. PLASTICS

i) Low Density Polyethylene (LDPE)

Polyethylene (polythene, PE) is the material consumed in the largest quantity by the packaging industry. LDPE is the single largest polymer used in food packaging. It is a polymer of ethylene, which is a hydrocarbon gas which is a by-product of petroleum refining. LDPE is a macromolecule of ethylene with very high degree of branching. It is having density ranging from 0.916-0.925 g/cm³. LDPE is tough, translucent, has good tensile strength, impact resistance, water vapour impermeability, heat sealability, chemical inertness and low cost of production.

ii) High Density Polythene (HDPE)

You should understand that HDPE possesses a much more linear structure than LDPE. HDPE resins are produced by low-pressure process. The density of the material is around 0.95 g/cm³. It is stronger, thicker, less flexible and more brittle than low-density polythene and has lower permeability to gases and moisture. It has a higher softening temperature (121°C) and can therefore be heat sterilized. HDPE has higher tensile and bursting strengths but impact and tear strengths are lower than LDPE. High molecular weight, high-density polythene (HDPE) has very good mechanical strength; less creep and better environmental stress and crack resistance property.

iii) Linear Low Density Polythene (LLDPE)

Linear low-density polythene is low-density polythene produced by a low pressure process. The term linear is used to imply the absence of long chain branches allowing the molecules to pack closer together to give a very tough resin. It is virtually free of long chain

branches but does contain numerous short side chains. The linearity provides strength, while the branching provides toughness. Generally, the advantages of LLDPE over LDPE are improved chemical resistance and improved performance at both low and high temperatures. LLDPE shows improved puncture resistance and tear strength. The superior properties of LLDPE have led to its use in new applications for polyethylene as well as the replacement of LDPE and HDPE in some areas.

iv) Polypropylene (PP)

Polypropylene is produced by the polymerisation of propylene. It is stronger, rigid and lighter than polyethylene. Orientation can be in one direction (unbalanced) or in two directions equally (balanced). The resulting film is characterized by good low temperature durability, high stiffness and excellent moisture vapour transmission rate. One drawback of Oriented PP is its low tensile strength. Kraft paper is used for the manufacture of corrugated fibre board (CFB). Corrugated fibre board boxes are used as a shipping container for the export of frozen shrimp and the cartons should be given adequate water proofing treatment on both sides. This is done by lining with polypropylene.

v) Polyester

Polyester can be produced by reacting ethylene glycol with terephthalic acid. Polyester film's outstanding properties as a food packaging material are its great tensile strength, low gas permeability, excellent chemical resistance, lightweight, elasticity and stability over a wide range of temperature (-60° to 220°C). The latter property has led to the use of PET for boil in the bag products which are frozen before use, and as over bags where they are able to withstand cooking temperatures without decomposing. A fast growing application for polyester is oven-able trays for frozen food and prepared meals. They are preferable to foil trays for these applications because of their ability to be micro waved without the necessity for an outer board carton.

vi) Polyvinyl Chloride (PVC)

You will be surprised to know that this monomer is made by the addition of reaction between Acetylene and Hydrochloric acid. It must be plasticised to obtain the required flexibility and durability. Unplasticized PVC as a rigid sheet material is thermoformed to produce a wide range of inserts from chocolate boxes to biscuit trays. Unplasticized PVC bottles have better clarity, oil resistance and barrier properties than those made from polyethylene. They have made extensive penetration into the market for a wide range of foods including fruit juices and edible oils.

B. PAPER BOARD

Paper and paperboard are sheet materials made from an interlaced network of cellulose fibers derived from wood by using sulfate and sulfite. The fibers are then pulped and/or bleached and treated with chemicals such as slimicides and strengthening agents to produce the paper product. Paper and paperboards are commonly used in corrugated boxes, milk cartons, folding cartons, bags and sacks, and wrapping paper. Paper and paperboards provides mechanical strength, they are biodegradable and have good printability. Coatings such as waxes or polymeric materials can be used to improve their poor barrier properties.

Apart from their poor barrier properties to oxygen, carbon dioxide and water vapour other drawbacks include their being opaque, porous and not heat sealable.

Thicker paper is called as paper board. Paper board is heavier in weight, thicker, and more rigid than paper. Because of these properties, it is better suited to a variety of packaging products. About 70% of paper board packaging is used to protect food and other consumer goods. Paperboards are used for carton marking. Boards are made in a similar way to paper but are thicker to protect foods from mechanical damage. The main characteristics of board are thickness, stiffness, the ability to crease without cracking, the degree of whiteness, surface properties and suitability for printing. White board is suitable for contact with food and is often coated with polythene, polypropylene or wax for heat sealability. It is used for ice cream, chocolate and frozen food items. Kraft paper is used for the manufacture of corrugated fibre board (CFB). Corrugated fibre board boxes are used as a shipping container for the export of frozen shrimp. It was stressed that for the fabrication of master cartons for frozen seafoods, virgin grade kraft paper should be used and the cartons should be given adequate water proofing treatment on both sides.

C. FOILS PACKAGING

Foil is a construction of three to four plies laminated together using adhesives or extrusion coating. Each layer serves a vital purpose.

Layer – 1 : An outer layer of polyethylene, which gives material mechanical strength at a wide range of temperatures

Layer – 2 : Aluminum Foil is the barrier against water vapor transmission and aggressive greases

Layer – 3 : An inner layer of low density polyethylene making the laminate capable of being heat sealed without degradation to the outer layer of polyester.

Aluminium foil is a best example and important material in **laminates** and has wide application in food packaging. Its barrier function against the migration of moisture, oxygen and other gases, and volatile aroma, as well as against the impact of light is generally higher than any plastic **lamine** material. For this reason, **foil** is **used** extensively in food and pharmaceutical **packaging**. The use of aluminium foil in rigid, semirigid, and flexible package for in-pack thermal processing allows the selection of package geometries that ensure rapid heating and minimum heat damage during processing. On the tightness of packages, the mechanical stability and quality of sealing is of particular importance. The chemical stability of aluminium foil in contact with food depends on the composition of the food items. With present toxicological knowledge, the use of aluminium in packaging material is considered to be safe, and inner-coating of the foil is recommended in specific cases. Aluminum foil is actually made of two layers: one of aluminium and another that is coating. The surface of the aluminum layer that is in contact with atmosphere **oxidizes** and turns into aluminum oxide — hence called the **matte side**. To avoid breakage because of the thinness, the **foil** is doubled in the cold rolling mill and the rolled to the desired thickness.

D. FIBRE PACKAGING

There are many different variations of fibre-based packaging, which mostly fall into the following five categories:

1. Kraft paper (10–120 g/m²)

Kraft paper is usually manufactured using virgin wood fibre, but might have some recycled fibre content. It can be used as a barrier layer to prevent food contact with another packaging component, such as recycled fibre in the corrugated core of corrugated containerboard. The strength and barrier properties of kraft paper can be improved through the use of coatings (e.g. resins or waxes) or laminated layers (e.g. polyethylene or aluminium). Kraft paper can be either natural brown or bleached.

2. Boxboard (120–800 g/m²)

Boxboards are thick paper grades used as the base material for many packaging applications, particularly folding cartons for dry food and non-food primary packaging applications. Boxboard usually consists of four or five layers of pulp laminated together during the paper making process, with an outer coating of clay (e.g. kaolin) and varnish to provide a smooth surface suitable for printing or other finishes. Depending on the functional requirement, boxboards can have a recycled content of 0–100%.

3. Corrugated board (250–1,500 g/m²)

Corrugated board (commonly called corrugated cardboard) is typically constructed with a high recycled content fluted core or ‘medium’ (the wavy centre), which is glued between two linerboard sheets of kraft or recycled paper, using starch. Corrugated containerboard is commonly used for secondary and tertiary packaging applications. Two and three layer corrugated boards can be bonded together to construct heavier duty packaging if required.

4. Liquid paperboard (250–500 g/m²)

Liquid paperboard (LPB) is a multi-layer composite material. It comes in two common forms: gable top LPB (e.g. fresh milk cartons) and aseptic LPB (e.g. long-life milk cartons). Gable top LPB usually has a typical structure of: printing (exterior surface), polyethylene, fibreboard, polyethylene (interior surface). Aseptic LPB usually has a layer of aluminium, with a typical structure of: printing (exterior surface), polyethylene, fibreboard, polyethylene, aluminium foil, polyethylene (interior surface). The fibreboard makes up about 75% of the weight of the packaging. Usually 100% of the fibre in LPB is from virgin sources.

5. Moulded fibreboard (>500 g/m²)

Moulded fibreboard packaging (e.g. egg cartons) is usually made with a high proportion (up to 100%) of recycled fibre. Due to the manufacturing technique and the fairly low strength requirements, moulded fibreboard packaging can use shorter fibres than is feasible with most other paper packaging applications (e.g. from newsprint). Moulded fibreboard can still be recycled at end-of-life; however less reusable fibre will be recovered.

LAMINATIONS AND CO-EXTRUSIONS

Lamination

Lamination is the technique of manufacturing a material in multiple layers, so that the composite material achieves improved strength, stability, sound insulation, appearance or

other properties from the use of differing materials. A laminate is a permanently assembled object by heat, pressure, welding, or adhesives. Laminating is the process through which two or more flexible packaging webs are joined together using a bonding agent. The substrates making up the webs may consist of films, papers, or aluminum foils.

Laminations are combination of various plies which gives material unique properties that are not given by a single material alone. In lamination process, adhesives are used. One plastic material is coated with an adhesive and subsequently adhered to another material. Laminates can be prepared by using only plastic films or plastic to paper, or aluminium foil to plastic or metalized plastic. For water based solvent based and solvent less laminating process, polyolefin films are surface treated on the laminating side although wet or molten adhesive is applied during lamination process.

Extrusion laminating

It is done using an extrusion coating machine. The molten polymer falls between the two webs being laminated almost at that instant, the two webs are pressed together. The weight of the extruded laminant adhesives is typically 10-15 g/m². The extruded laminant may also be used for properties other than just an adhesive.

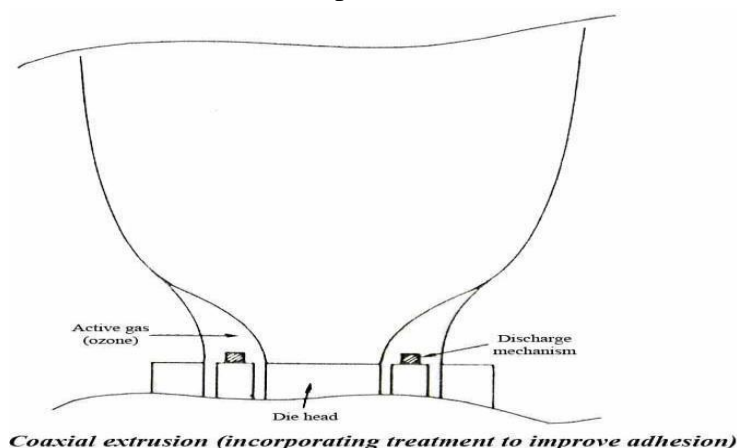
Extrusion coating

A large proportion of flexible packaging materials are extrusion coated using polyethylene with 10-50 micron thickness as the inner heat seal layer. Other ethylene polymers such as EVA, ionomer and various polymers such as PP, PET are also coated, e.g. PET is coated on paper board for making ovenable trays. Extrusion coating process somewhat similar to co-extrusion process using a flat slit die, but the main difference is that the web is being coated. Extrusion coating can be applied to paper, paper board, foil laminate, metalized plastic sheets provided they have sufficient heat stability.

Co-extrusion

Co-extrusion is now an important means to make multiply films directly from the individual resins in contrast to lamination that uses films previously made films by casting or blowing or extrusion. This process is limited to only thermoplastic materials. Many combinations of coax films are possible, but most widely used ones are polyethylene, ethylene copolymers, PP and Nylon. In co-extrusion the individual molten polymer layers are extruded using separate extruders and the melts are combined either inside the die or sometimes immediately after leaving the die. In coax casting, the molten polymers are extruded separately and then fed into a combining adapter, that brings the molten polymers together but it keeps its identity and flows separately with laminar flow. The polymers in the

coax films still retain thin identity, but appear as though a monofilm, and the difference is observed only when examined under a microscope.



Coextrusion is often used in combination with extrusion coating/lamination. In coextrusion two or more layers of different polymers are extruded simultaneously through a single die. The major benefit of coextrusion is that some of the separate laminating steps required to produce a complex multilayer laminate can be combined into one step in the process. There are two main types of coextrusion dies. The most popular is the feedblock die where several melt streams fed from separate extruders join within the die and are extruded as one web. With this die type, more than two different polymers can be extruded but their viscosities must be carefully matched. With the dual slit die, two extruders feed two separate channels in the die block and the two extruded webs meet at the nip where they are pressed onto the substrates. This die type is not widely used. Coextrusion offers the possibilities of extruding a thin layer of an adhesion-promoting polymer or a tie layer, such as an ionomer or ethylene-acrylic acid copolymer, in combination with polyethylene. Tie-layers are generally used to bond two dissimilar materials (e.g. polyethylene and aluminium foil) together and to improve the adhesion. For many laminates, this may eliminate the need for chemical priming or other pre-treatments of the substrate. Another application is the coextrusion of two polyethylene layers, one at a relatively high temperature to promote oxidation and adhesion to the substrate, the second extruded at a much lower temperature to give a top coating layer with better heat sealability and an acceptable odour level.

TRANSPORT PACKAGING

IMPORTANCE OF TRANSPORT WORTHINESS OF PACKAGING MATERIAL

The best products in the world will be useless if you can't get them where they need to be. From making transportation possible to protecting your goods during transit, logistics packaging is a vital part of the delivery process. Transport packaging focuses on the packaging requirements of goods in transit, in particular for items travelling overland by road or rail (as opposed to overseas packaging). Transport packaging is very often a local affair (see export packaging for international transport) and therefore needs to be designed with local conditions and expectations in mind.

1. Protection

First and foremost, transport packaging must serve to protect goods in transit. Given the nature of road and rail infrastructure, transport packaging should be manufactured so as to absorb unintended shocks, impacts or accidents of any kind, as well as protect against the elements such as humidity, excessive temperatures or heavy weather.

2. Conveys Important Information

There can be a lot of important information that distributors need to know about the product. The transport packaging is the perfect place to display this information. A lot of different things can be printed on the boxes. It could be something simple, like which way up the packages need to go, or that the contents are fragile. It can also specify more detailed handling instructions, such as a particular temperature range to the products need to be stored at.

3. Makes Storage Possible

Transport packaging makes all kinds of products easy to store. No matter what shape, or how fragile, the right packaging allows them to be stacked, placed onto pallets, or otherwise arranged for convenience.

4. Versatility

Transport packaging must take into account the possibility of multiple stages in transit before the product reaches its final destination. This includes multiple off-loading, re-packaging, re-loading and possibly storage of the product(s). Transport packaging should thus be versatile enough to facilitate this process when necessary.

5. Customized solutions

Transport packaging should be as individual as the product itself and perfectly match the product's consistency, size and dimensions. The focus here is on packaging that is lightweight, robust, and easy to handle and that takes up as little space as possible.

IDEAL REQUIREMENTS OF GOOD PACKAGE:-

1. They should be able to hold the product without loss on account of leakage, spoilage or permeation.
 2. They should afford protect against environmental conditions like light, air and moisture during storage.
 3. They should not have any permeability for gases.
 4. They should possess sufficient strength to withstand shocks of handling, transportation etc.
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5. They should facilitate efficient safe and convenient use of contents.
6. The material must not interact with the contents.
7. The containers should afford protection from moulds, bacteria etc.
8. The cost of material should be as low as possible without compromising the quality.
9. They should facilitate easy identification.
10. They should afford protection from moulds, bacteria etc.
11. The container should not absorb or adsorb any material containing.
12. The closure should provide air tight closing to the container.
13. The closure should be compatible with the preparation.

EXTENSION OF SHELF LIFE OF FOOD BY PACKAGING

"Shelf-life is the time it takes a food product to deteriorate to an unacceptable degree under specific storage, processing, and packaging conditions."

There are two important goals of packaging: reducing the rate of quality loss and increasing the shelf life of the product. Manufacturers have begun looking for new innovative ways to make packages viable for longer period. The shelf life of a food depends on the three how's: how it is packaged, how it is processed, and how it is stored. Different packaging methods generally achieve an extended shelf life for food by removing or reducing oxygen from around the surface of food. Lowering the amount of oxygen slows down and inhibits the growth of any bacteria on food. If you are planning on storing your food in a warm environment, it will only last half the time it would last in a cool place. Good shelf life is achieved by storing products at 60°F. Optimum storage temperature for shelf life is 40°F or less. It is important to find a place where the temperature remains constant. Frequent temperature changes and excess moisture can shorten storage life.

There are many benefits of extending shelf life. Highly seasonal products can be stockpiled. Product returns from retailers are reduced, and more extensive product distribution is possible. There are many different types of packaging methods to improve the shelf life of products:

1. Vacuum Packaging: Vacuum packing is a method of packaging that removes air from the package prior to sealing. This gets rid of oxygen which affects food in different ways, including: odor, color, taste & texture. This method involves placing items in a plastic film package, removing air from inside, and sealing the package. Shrink film is sometimes used to have a tight fit to the contents. The packages must have low permeability of oxygen. The table below represents how long some foods can last while using a vacuum sealer.

2. Modified Atmosphere Packaging (MAP): This is food packaging in which the composition of the air surrounding the food inside the package is changed. The main gases used in MAP are oxygen, carbon dioxide, and nitrogen. MAP can be used with fresh or processed foods, including meat, seafood, fruits and vegetables. The MAP technique is useful

for products that won't stand up to hard vacuuming or that tend to spoil in low oxygen environments.

3. Post-Pasteurization Shrink Bag Packaging: Post-Pasteurization Shrink bag packaging promotes food safety by providing a skin-tight, high- barrier packaging that withstands the rigors of a post-packaging surface pasteurization process. It increases the shelf-life for ready-to-eat deli products like: poultry, pork and beef. It can withstand high temperatures for short amounts of time. The bags allow high-speed sealing and ink adhesion, as well as clarity and skin-tight shrinking of the bag.

Packaging plays a crucial role in reducing the rate of quality loss in foods. Vacuum packaging, modified atmosphere packaging, and post-pasteurization shrink bag packaging are just a few of the many methods used to package food products.

WHAT IS AN ACCELERATED SHELF LIFE STUDY?

Shelf-life studies can come in many different forms, including accelerated studies. In these studies, accelerated conditions (i.e. elevated temperature) are applied to eligible products to predict product shelf-life at typical storage conditions. This process is performed using the Q_{10} value. The Q_{10} value of a product is the temperature quotient for a 10°C temperature difference, as expressed in the equation below:

$$Q_{10} = \frac{\text{Shelf - life at temperature } T (^{\circ}\text{C})}{\text{Shelf - life at } (T ^{\circ}\text{C} + 10^{\circ}\text{C})}$$

It is recommended that accelerated shelf-life studies be accompanied by a shelf-life study conducted under normal storage conditions in order to determine the actual Q_{10} value. This approach allows for a more specific Q_{10} value and can be used for future accelerated shelf life studies on similar products.

The most prominent spoilage concern for products eligible for accelerated shelf-life studies is rancidity. Rancidity is a chemical change in the product that occurs in a number of ways, depending on ingredients and packaging. Common forms of rancidity include:

- **Hydrolytic Rancidity** – Hydrolysis of triglycerides into fatty acids and glycerol, resulting in a distinctive –soapy flavor when the product has spoiled
- **Oxidative Rancidity** – Lipid oxidation of unsaturated fatty acids into hydroperoxides, which later form aldehydes, causing a distinctive –cardboard flavor/aroma when the product has spoiled

Accelerated shelf life studies are not recommended for all products, such as refrigerated products that spoil due to microbial growth. Each product has a specific mode of spoilage (i.e. rancidity, moisture loss/gain, organoleptic changes), so every study is tailored to the specific product.