Unit I - Topic 2

Flexible packaging materials, Plastic packaging - types of polymers in food packaging and their barrier properties

FLEXIBLE PACKAGING MATERIALS

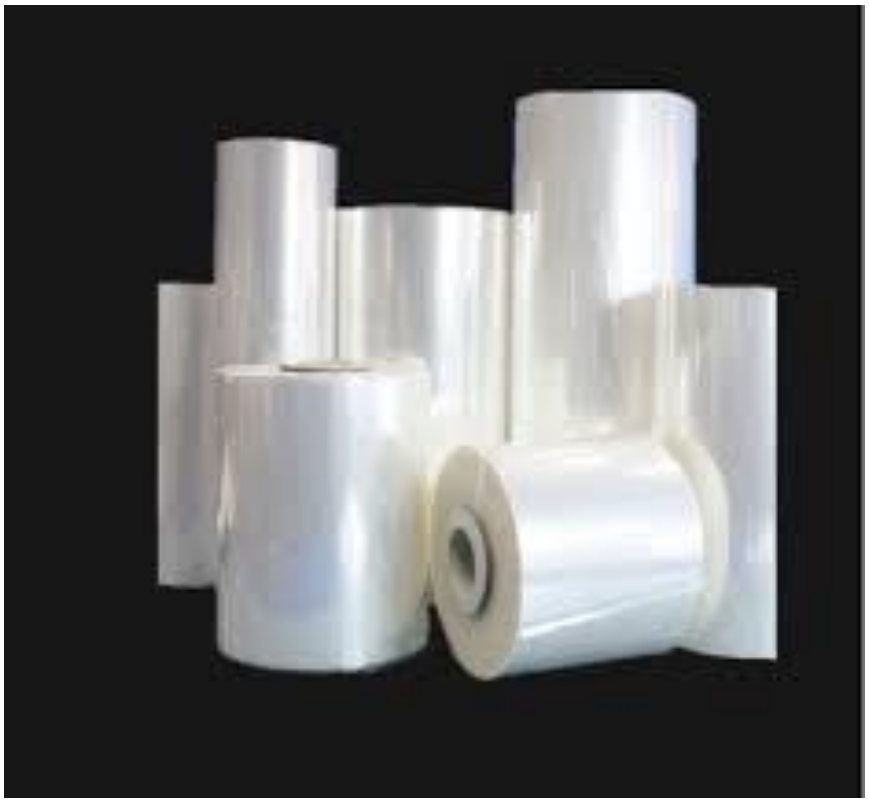
Non-rigid **packaging** structures used to package and protect products. According to the **Flexible Packaging** Association, **flexible packaging** is any package or any part of a package whose shape can be readily changed. Common examples of **flexible packaging** are bags and pouches. Flexible packaging 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 andbursting 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 onboth 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 offoods including fruit juices and edible oils.

B. PAPER BOARD

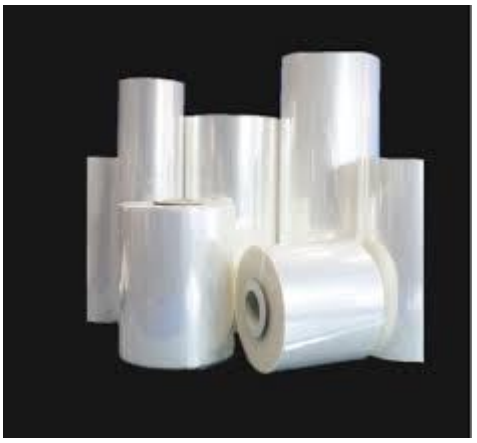
Paper and paperboard are sheet materials made from an interlaced network of cellulose fibers derived from wood by using sulfate and sulfite. The fibers are then pulped and/or bleached and treated with chemicals such as slimicides and strengthening agents to produce the paper product. Paper and paperboards 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, carbondioxide 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 **laminate** 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.

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 foilto 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