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REVIEW ARTICLE

Pharmaceutical Packaging: Containers & Closures

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ABSTRACT

Pharmaceutical packaging is regarded as an integral part of the end pharmaceutical product. The primary packaging is the one which is in direct contact with the product (i.e. bottle, cap, cap liner, label etc). The functions of the primary package are to contain and to restrict any chemical, climatic or biological or occasionally mechanical hazards that may cause or lead to product deterioration. Packaging must also function as a means of drug administrations. The packaging external to the primary package is known as the secondary packaging. The secondary packaging provides the additional physical protection necessary to endure the safe warehousing and for refill packaging. Tamper–resistant packaging mainly includes film wrapper, Blister package, strip package, bubble pack and shrink package. This review article examines every significant aspect of pharmaceutical packaging in a comprehensive and readable way. It presents a detailed review of functions of packaging, factor influencing the choice of package, containers, closures and robotics. Also included is a discussion of current issues and problems in this area of packaging.

KEYWORD: Packaging, Containers, Child resistant, Robotics.

INTRODUCTION:

Pharmaceutical packaging materials comprises of different components that surround the pharmaceutical product since the time of production till its use (1). Pharmaceutical packaging may be defined as the science, art and technology of enclosing or protecting products for distribution, storage, sale and usage including printed material, employed in the finishing of a pharmaceutical product (2). It serves as means of providing identification, presentation, protection, information and convenience from the time of production until it is used or administered (3). The type of pharmaceutical packaging used depends upon its function and type of the material used. All packaging materials must finally be evaluated via testing of selected materials, sterilization, storage and stability studies (4). The external image of the package must not only compliment product confidence, but provide clear and concise product identification and other features included are:

1. Package should provide adequate information regarding the route of administration, storage conditions, batch number, expiry date, manufacturer's name & address and product license number.

2. Package should preferably have an aesthetically acceptable design.

3. Package should assist in patient compliance (1, 5).

FUNCTIONS OF PACKAGING (1, 6-8):

1. BARRIER PROTECTION: It is meant for protection against all adverse external influences that can alter the properties of the product, which may include moisture, light, oxygen and temperature variations.

2. PHYSICAL PROTECTION: It is meant for the protection of pharmaceutical dosage forms against physical damage.

3. BIOLOGICAL PROTECTION: It is meant for the protection against biological contaminants.

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4. IDENTIFICATION: The packaging should give clear identification of the product at all stages. The life of the patient may depend upon rapid and correct identification in emergencies. Packaging also serves as a mean to identify the manufacturer of the product.

5. INFORMATION COMMUNICATION: In pharmaceutical context, packaging should carry the information on the correct usage of dosage forms, their contents, their provenance, side-effects and warnings.

6. SECURITY: Pharmaceutical packaging possesses certain features to prevent it from counterfeiting. It also prevents small children from accessing the contents of formulations.

7. MARKETING: It is often used as marketing tool to differentiate a product and/or to convey a certain message or brand image to highlight the pharmaceutical aspects for consumers.

8. CONVENIENCE: Packaging must be convenient enough to increase consumer access to products and improve distribution, handling, selling and using such products.

FACTOR INFLUENCING THE CHOICE OF PACKAGE (9-12):

It is essential to have a survey about the market, the distribution system, manufacturing facilities and other considerations before selecting the packaging material.

1. THE PRODUCT:

The physical and chemical characteristics of the drug entity, the excipients, the formulation, route of deterioration of the product, type of patient must be considered while dealing with the pharmaceutical product. Apart from the properties of drug, package style to attract patient and other legal requirements should also be considered.

2. MANUFACTURING FACILITIES:

The stability of the manufacturing facilities should be considered due to new package, increased sale, improvements in Good Manufacturing Practice, revised product, new product etc.

3. THE MARKET:

The channel of sale should be considered, i.e. where, when, how and by whom it is to be used or administered (e.g. doctor, dentist, nurse, patients etc), whether for home trade and/ or export. The quantity per package and follow up sale must all be carefully considered.

4. THE DISTRIBUTION SYSTEM:

The distribution system should be carefully monitored, e.g. conventional wholesale/ retail outlet or direct or selective outlets. Less sophisticated transport systems like mules, donkeys, camels etc requires additional protection if intermediate storage facilities are nonexistent.

PACKAGING MATERIALS USED IN DIFFERENT FORMULATIONS:

Pharmaceutical packaging materials can be classified in several ways (Table 2):

A. Based on their uses
B. Based on the Type of Raw Material
C. Polysaccharide
D. Based on the chemical constituent used

Type of packaging material	Examples	Properties
Multi use packaging	Glass bottles for medicines, injection syringes Plastic bottles for medicated hand wash	Refilled
Material or chemical recycling packaging	Glass, metal, paper and plastics for instance bottles	Recycled
Edible packaging	Starch, pectin, gelatin, wheat bran	Biodegradable
Single-use packaging	Paper and biodegradable plastics (PVC sheets)	Biodegradable
Packaging meant for burning i.e. energy recovery with energetic recycling	Paper, plastics, cardboard	Recycled

Table No. 1: Classification of packaging materials on basis of uses

1. PLASTICS (1, 13):

Plastic packaging constitutes 20% of all packaging. Plastic coating and packaging materials are often signaled out as they are main environmental culprits hence technological advancements are now in the growth phase to find out more innovative ways to reduce the environmental impact of packaging materials, thus making more biodegradable and hence eco friendly out of the existing one. Child-resistant plastic closures and leak-proof plastic containers for medicines and chemicals provide safety, convenience, ergonomics and ease of use. Plastics can be molded to desired shape, protect against contamination and serves as the perfect materials for shipping and storing intricate medical instruments. The flexibility of plastic is particularly suitable in the field of pharmaceutical packaging for molded packaging with sealing systems for controlled dosage. The two main types of biodegradable plastics are available in the market viz. hydro- biodegradable plastics (HBP) and oxo-biodegradable plastics (OBP). Hydro-biodegradable plastics (HBP) are made up of agricultural resources like corn, wheat, sugarcane. Some of the commonly used polymers include polyhydroxyalkanoates (PHA), polyhydroxybutyrate valerate (PHBV), polylactic acid (PLA), polycaprolactone (PCL), polyvinyl alcohol (PVA), polyethylene terephthalate (PET) etc. HBPs degrade and biodegrade somewhat more quickly to carbon dioxide, water and biomass. Oxo-biodegradable plastics (OBP) consists of a mixture of small proportion of compounds of specific transition metals (iron, manganese, cobalt and nickel) and polyolefins such as polypropylene (PP), polyethylene (PE) and polystyrene (PS). OBP has an advantage over HBP that they do not emit methane in anaerobic conditions. Plastic packaging material comes in various forms like PET, PVC, PS, polyamide, polyester, polyolefins and ethylene vinyl alcohol; which are used for various types of pharmaceutical products. It also involves preparation of flexible packaging. The main use of such containers is for bags for parenteral solutions. Hence they must be safe enough to maintain the drug properties as well as not to impose any environmental adverse effect.

2. METALS (1, 3):

Metal is the most versatile and widely used of all pharmaceutical packaging material. These have excellent barrier properties, physical protection, formability, durability, decorative potential, consumer potential and recyclability. Metals are used as containers for pharmaceutical products for non parenteral administration such as tubes, cans, aerosol and gas cylinders and packs made from foils or blisters. Different types of metals like aluminum, tinplate and steel are used in pharmaceutical packaging.

3. GLASS (2, 7, 11):

Glass accounts for 20% of the weight of all packaging. Its raw materials are present in abundant quantity in nature hence it is considered greener. It can be reused and recycled easily to make new containers which further reduce its untoward environmental impact. Glass is the only packaging material rated 'GRAS' or 'generally regarded as safe' by the U.S. Food & Drug Administration. Various grades of glasses are classified official in pharmacopoeias based on their utility and chemical characteristics. They are used as the first choice containers in cosmetics and certain pharmaceutical preparations including medicinal products for oral and local administration, for example, bottles for tablets, injections syringes for unit or multi-dose administration. Recycling of glass in the manufacture of new bottles and jars requires substantially less energy and is thus preferred from the resource conservation standpoint. Glass containers are more preferred for parenterals due to ease of sterilization and clear visibility. Although they can be processed in different forms according to the need, e.g. amber glass bottles are produced to prevent photo degradation of light sensitive drugs. Also most of the parts of analytical instruments are made of glass to increase the visibility.

4. PAPER AND PAPERBOARD (3, 9):

Paper and paperboard are made up of interlaced network of cellulose fibers, obtained from wood. Paper is always treated, coated, laminated or impregnated with materials such as waxes, resins or lacquers when used as primary packaging to improve functional and protective properties. Different types of papers used in packaging are Kraft paper, sulfite paper, grease proof paper, and glassine and parchment paper. Having all the properties combined, paperboard is thicker than paper and in multiple layers with high weight per unit area. Paperboards can be classified in to different classes like solid board, white board, chipboard and fiberboard.

5. RUBBER (2, 5):

Rubber components may be made from either natural or synthetic sources. Natural rubber has got good resealing (multi-dose injection), fragmentation and coring(description for the means by which particles are created when a needle is passed through a rubber) when compared to synthetic rubber; but is poor in respect to ageing and chances of moisture and gas permeation and the absorption of preservative systems is more.

Sterilization by multiple autoclaving is also not possible. Synthetic rubbers tend to reverse all of these properties and some formulations actually contain natural rubber in order to improve re sealability, fragmentation and coring. Most rubber formulation are relatively complex and may contain one or more of the vulcanizing agents, accelerators, fillers, activators, pigments, antioxidants, lubricants, softeners or waxes. The main types of rubber used for pharmaceutical products include natural rubber, neoprene, nitrile, butyl, chlorobutyl, bromobutyl and silicone. Of these silicone is the most expensive and although the most inert, is readily permeable to moisture, gases and absorbent to certain preservatives. Rubber components are likely to contain more additives than plastics. Hence product-package interactions should be properly tested before they are used for injectable or intravenous type products. Rubber gaskets are also sound in aerosols and metered -dose pump systems.

6. MIXED MATERIAL PACKAGING (4, 6):

It is a new type of packaging. Although each material used is recyclable yet combination of these materials makes recycling technically difficult but not impossible. Mixed material packaging are more resource and energy efficient than single material packaging. An example of this type of packaging is 'Tetra Pak' which consists of 75% paper, 20% polyethylene and 5% aluminum foil.

TAMPER RESISTANT PACKAGING (1, 5, 14, 15):

The requirement for tamper–resistant packaging is now one of the major considerations in the development of packaging for pharmaceutical products. As defined by the FDA "A tamper–resistant package is one having an indicator or barrier to entry which, if breached, can reasonably be expected to provide visible evidence to consumers that tampering has occurred tamper-resistant packaging may involve immediate-container /closure systems or secondary-container /carton systems or any combination thereof intended to provide a visual indication of package integrity when handled in a reasonable manner during manufacture, distribution and retail display". The following package configuration have been identified by the FDA as examples of packaging systems that are capable of meeting the requirements of tamper-resistant packaging as defined by FDA regulation

FILM WRAPPER:

Film wrapping has been used extensively over the years for products requiring package integrity or environmental protection. Film wrapping can be accomplished in several ways. Film wrapping machines can be generally categorized into the following types:

A. END-FOLDED WRAPPER:

The end-folder wrapper is formed by pushing the product into a sheet of over wrapping film, which forms the film around the product and folds the edges in a gift-wrap fashion. The folded areas are sealed by pressing against a heated bar. Because of the overlapping folding sequence of the seals, the film used must be heat-sealable on both surfaces. Materials commonly used for this application are cellophane and polypropylene. Cellophane, which is regenerated cellulose, is not inherently heat-sealable but requires a heat-seal coating to impart heat-sealing characteristics to the film. This is usually accomplished by coating the cellophane with either polyvinylidene chloride (PVDC) or nitrocellulose. . The PVDC provides a durable moisture barrier, PVDC coated cellophane is often used for the over wrapping of products that are sensitive to moisture. To be tamper-resistant, the over wrap must be well sealed and must be printed or uniquely decorated. If the print of the carton being over wrapped is coated with a heat-sensitive varnish, it causes the over wrap to bond permanently to the paperboard carton during the sealing of the over wrap.

B. FIN SEAL WRAPPER:

Fin seal packaging does not require the product to act as a bearing surface against which the over wrap is sealed. The seal are formed by crimping the film together and sealing together the two inside surface of the film, producing a "fin" seal since the seals are formed by compressing the material between two heater bars rather than sealing against the package. When more consistent and greater sealing pressure is applied, better seal integrity can be accomplished. For this reason, fin sealing has primarily been used when protective packaging is critical. Since the surface of the heat seal does not come in contact with the heated sealing bars on the packaging equipment, much more tenacious heat sealants such as polyethylene can be used. With good seal integrity, the over wrap can be removed or opened only by tearing the wrapper.

C. SHRINK WRAPPER:

The shrink wrap concept involves the packaging of a product in a thermoplastic film that been stretched and oriented during its manufacture and that has the property of reverting back to its un-stretched dimension once the molecular structure is "unfrozen" by the application of heat. The shrink wrap concept has a diversity of uses in packaging, one of which is its use as an over wrap .In this

case ,the shrink film is usually used in roll form ,with the center folder in the direction of winding .As the film unwinds on the over wrapping machine ,a pocket is formed in the center fold of the sheet ,into which the product is inserted .An L-shaped sealer seals the remainder of the over wrap and trims off the excess film .The loosely wrapped product is then moved through a heated tunnel ,which shrink the over wrap into a tightly wrapped unit The material commonly used for this application are heat-shrinkable grades of polypropylene, polyethylene, and poly vinyl chloride. Since the various heat-shrinkable grades of film have different physical characteristic such as tear and tensile strength, puncture resistance, and shrinking forces, selection of the particular material used must be based upon specific product consideration so that the shrink wrap provides suitable integrity without crushing or damage the product. The major advantages of this type of wrapper are the flexibility and low cost of the packaging equipment required.

BLISTER PACKAGE:

Blister package has been used extensively for pharmaceutical packaging for several good reasons. It is a packaging configuration capable of providing excellent environmental protection, coupled with an esthetically pleasing and efficacious appearance. It also provides user functionality in terms of convenience, child resistance, and now, tampers resistance. The blister package is formed by heat-softening a sheet of thermoplastic resin and vacuum-drawing the softened sheet of plastic into a contoured mold. After cooling, the sheet is released from the mold and proceeds to the filling station of the packaging machine. The semi-rigid blister previously formed is filled with product and lidded with a heat-sealable backing material. The backing material, or lidding, can be of either a push-through or peelable type. For a push-through type of blister, the backing material is usually heat-seal-coated aluminum foil. The coating on the foil must be compatible with the blister material to ensure satisfactory sealing, both for product protection and for tamper resistance. Peelable backing materials have been used to meet the requirements of child-resistant packaging. This type of backing must have a degree of puncture resistance to prevent a child from pushing the product through the lidding and must also have sufficient tensile strength to allow the lidding to be pulled away from the blister even when the lidding is strongly adhered to it. To accomplish this, a material such as polyester or paper is used as a component of the backing lamination. Foil is generally used as a component of the backing lamination if barrier protection is a critical requirement; however, metalized polyester is replacing foil for some barrier applications. A peelable sealant compatible with the heat-seal coating on the blister is also required since the degree of difficulty of opening is a critical parameter for child-resistant packaging. The use of peelable backing materials for blister packaging must be carefully evaluated to ensure that peel strengths are sufficient to meet tamper-resistance objectives. Materials commonly used for the thermo-formable blister are poly vinyl chloride (PVC), PVC/polyethylene combinations, polystyrene, and polypropylene. For commercial reasons and because of certain machine performance characteristics, the blisters on most unit dose packages are made of polyvinyl chloride. For added moisture protection, polyvinylidene chloride (saran) or polychlorotrifluoroethylene (Aclar) films may be laminated to PVC. The moisture barrier of PVC/Aclar is superior to that of saran-coated PVC, especially under prolonged and extremely humid storage conditions.

STRIP PACKAGE:

A strip package is a form of unit dose packaging that is commonly used for the packaging of tablets and capsules. A strip package is formed by feeding two webs of a heat-sealable flexible film through either a heated crimping roller or a heated reciprocating plate. The product is dropped into the pocket formed prior to forming the final set of seals. A continuous strip of packets is formed, generally several packets wide depending on the packaging machine's limitations. The strip of packets is cut to the desired number of packets in length. The strips formed are usually collated and packaged into a folding carton. The product sealed between the two sheets of film usually has a seal around each tablet, with perforations usually separating adjacent packets. Since the sealing is usually accomplished between pressure rollers, a high degree of seal integrity is possible. The use of high-barrier materials such as foil laminations or saran-coated films, in conjunction with the excellent seal formation, makes this packaging mode appropriate for the packaging of moisture-sensitive products. Different packaging materials are used for strip packaging based on their properties. Few examples are cited below: A paper/polyethylene /foil/polyethylene lamination is commonly used. When the visibility of the product is important, heat-sealable cellophane or heat-sealable polyester can be used. In some cases the material used on either sides of the strip package varies and the choice of material used depends on both the product and the equipment.

BUBBLE PACK:

The bubble pack can be made in by sandwiching the product between a thermo formable, extensible, or heat-shrinkable plastic film and a rigid backing material. This is generally accomplished by heat-softening the plastic film and vacuum-drawing a pocket into the film in a manner similar to the formation of a blister in a blister package. The product is dropped into the pocket, which is then sealed to a rigid material such as heat-seal-coated paperboard. If a heat-shrinkable material is used, the package is passed through a heated tunnel, which shrinks the film into a bubble or skin over the product, firmly attaching it to the backing card.

SHRINK SEAL AND BANDS:

The shrink band concept makes use of the heat-shrinking characteristics of a stretch-oriented polymer. The heat-shrinkable polymer is manufactured as an extruded, oriented tube in a diameter slightly larger than the cap and neck ring of the bottle to be sealed. The heat-shrinkable material is supplied to the bottler as a printed, collapsed tube, either pre-cut to a specified length or in roll form for an automated operation. The proper length of PVC tubing is slid over the capped bottle far enough to engage both the cap and neck ring of the bottle .The bottle is then moved through a heat tunnel, which shrinks the tubing tightly around the cap and bottle, preventing the disengagement of the cap without destroying the shrink band. For ease of opening, the shrink bands can be supplied with tear perforations.

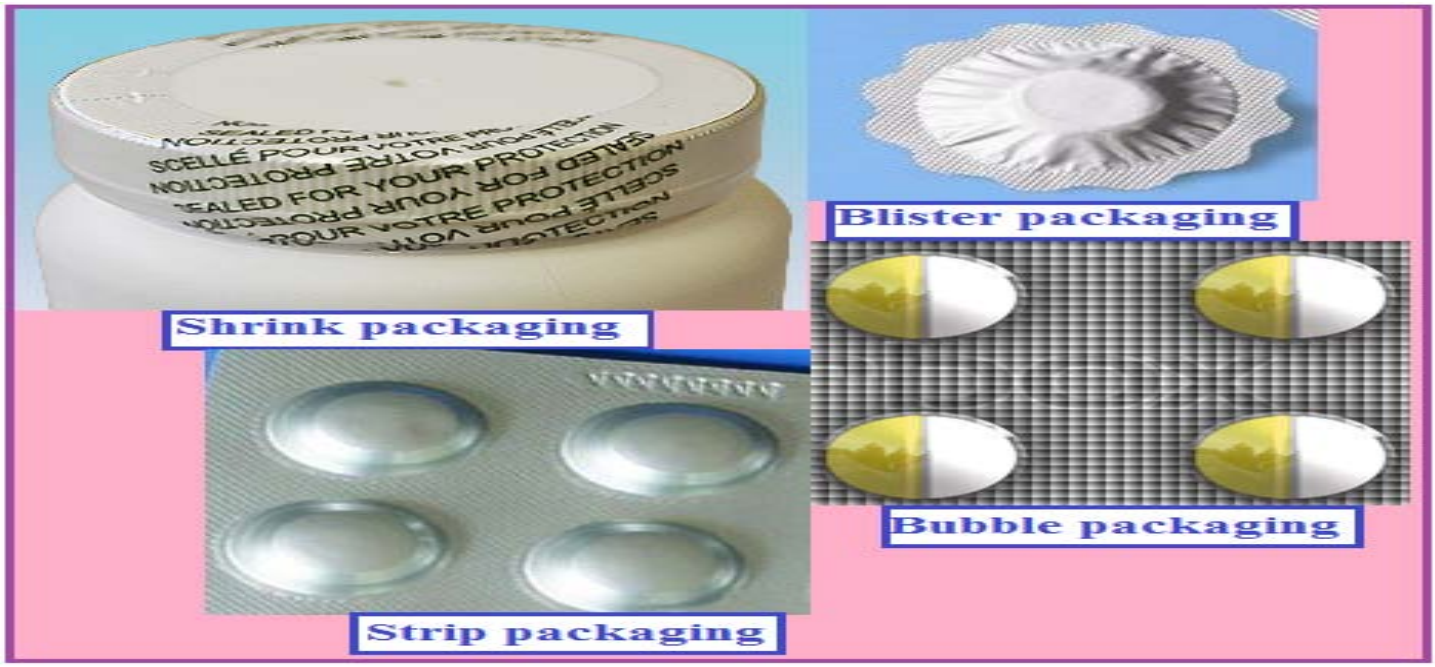

Figure No. 1: Different type of packaging

FOIL, PAPER, OR PLASTIC POUCHES:

A flexible pouch is usually formed during the product filling operation by either vertical or horizontal forming, filling, or sealing (f/f/s) equipment. In the vertical forming, filling, and sealing (f/f/s) operation, a web of film is drawn over a metal collar and around a vertical filling tube, through which the product is dropped into the formed package. The metal filling tube also acts as a mandrel, which controls the circumference of the pouch and against which the longitudinal seal is made. The formation of this seal, which can be either a fin seal or an overlap seal, converts the packaging film into a continuous tube of film. Reciprocating sealers, orthogonal to the longitudinal seal, crimp off the bottom of the tube, creating the bottom seal of the package. The product drops through the forming tube into the formed package. The reciprocation sealer moves up the film tube a distance equal to the length of the package and forms the top and final seal of the package. The top seal of the package becomes the bottom seal of the next package and the process repeats itself. Since vertical f/f/s machines are gravity-fed, they are primarily used for liquid, powder, and granular products. The horizontal forming, filling, and sealing (f/f/s) systems are generally used for products of smaller volume, which are more amenable to the flatter format of the packages. In this system, the web of film is folded upon itself rather than around a tube. As the folded film is fed horizontally through the equipment, a reciprocating platen creates pockets in the film by making vertical separation seals. The product is then placed into

each pocket and the final top seal is made. Packages formed on horizontal f/f/s equipment typically have a three-sided perimeter seal, but other variations are possible, depending on the type of equipment used. For moisture- and oxygen-sensitive products, foil is commonly used as part of the film lamination. Now a day's foil is replaced by metalized polyester which is used in the lamination for high barrier application and includes paper / polyethylene / foil / polyethylene and polyester / polyethylene / foil / polyethylene. They offer some advantages that they are of lower cost, excellent appearance, and flexural endurance.

BOTTLE SEALS:

A bottle may be made tamper-resistant by bonding an inner seal to the rim of the bottle in such a way that access to the product can only be attained by irreparably destroying the seal. Various inner seal compositions may be used, but the structures most frequently encountered are glassine and foil laminations. The inner seals are inserted into the bottle cap and held in place over the permanent cap liner by either by applying friction or by the a slight application of wax which temporarily adheres the seal to the permanent cap liner. If glue-mounted inner seals are to be used, glue is applied to the rim of the bottle prior to the capping operation. The application of the cap forces the inner seal into contact with the glued bottle rim and maintains pressure during glue curing and until the cap is removed. When the bottle cap is removed, the inner seal is left securely anchored to the bottle rim. Pressure-sensitive inner seals can also be used. The pressure-sensitive adhesive is coated on the surface of the inner seal as an encapsulated adhesive. During the capping operation, the torque pressure ruptures the encapsulated adhesive, which then bonds the inner seal to the rim of the bottle. One type of pressure-sensitive inner seal is constructed of thin-gauge styrene foam inner seal material coated on one side with a specially formulated torque-activated adhesive. The adhesive has minimal surface tack, but when applied with a properly torque cap, it provides excellent adhesion to both glass and plastic bottles. A third method of application uses a heat-sensitive adhesive that is activated by high-frequency induction. This type of application requires the use of aluminum foil as part of the inner seal composition. Once the cap is applied, the bottle is passed under an induction coil, which induces high-frequency resonation in the foil. The frictional heat that is generated activates the heat-seal coating and bonds the liner to the bottle. This type of seal can only be used with plastic caps since metal caps would interfere with the induction sealing of the inner seal. To meet the tamper-resistant criteria, the inner seals must be printed or decorated with a unique design. The seal must also be bonded sufficiently to ensure that its removal would result in destruction of the seal.

TAPE SEALS:

Tape sealing involves the application of a glued or pressure-sensitive tape or label around or over the closure of the package, which must be destroyed to gain access to the packaged product. The paper used most often is high-density lightweight papers. Labels made of self-destructing paper are available; these cannot survive any attempt at removal once they have been applied. To reduce further the possibility of removing the label intact, perforation or partial slitting of the paper can be made prior to application so that the label tears readily along those weak points if any attempt is made to remove it.

CONTAINERS:

1. GLASS CONTAINERS (1, 3, 16-18):

Glass is commonly used in pharmaceutical packaging because it possesses superior protective qualities.

ADVANTAGES OF GLASS CONTAINER:

1. Economical and easy to clean
2. Impermeability
3. Does not deteriorate with age
4. Effective closure and resolves are applicable.
5. Has FDA clearance

DISADVANTAGES OF GLASS CONTAINER:

1. Fragility
2. Heavy weight

AMPOULES:

Ampoules are thin-walled glass containers which are sealed by either tip sealing or pull sealing. The contents are withdrawn after rupture of the glass, or a single occasion only. These are great packaging for a variety of drugs. The filed – in product is in contact with glass only and the packaging is 100% tamper proof. There are wide variety of ampoule types from 0.5 to 50ml. Up to 3 color rings can be placed the stem or body for identification purpose. Printed ampoules with heavy metal free colors are available.

BOTTLES, VIALS AND SYRINGES:

These are more or less thick walled containers with closures of glass or of material other than glass such as plastic materials or elastomers. The contents may be

removed in several proportions on one of or more occasions.

2. PLASTIC CONTAINER (2, 6, 19):

Plastics in packaging have proved useful due to the ease with which they can be formed, their high quality, and the freedom of design to which they lend themselves. Plastic containers are extremely resistant to breakage and thus offer safety to consumers along with reduction of breakage losses at all levels of distribution and use. Plastic containers for pharmaceutical products are primarily made from the following polymers: polyethylene, polypropylene, polyvinyl chloride, polystyrene, and to a lesser extent, polymethyl methacrylate, polyethylene terephthalate, polytrifluoroethylene, the amino formaldehydes, and polyamides. Plastic containers consist of one or more polymers together with certain additives. Those manufactured for pharmaceutical purposes must be free of substances that can be extracted in significant quantities by the product contained. Thus, the hazards of toxicity or physical and chemical instability are avoided. The amount and nature of the additives are determined by the nature of the polymer, the process used to convert the plastic into the containers, and the service expected from the container. For plastic containers in general, additives may consist of antioxidants, antistatic agents, colors, impact modifiers, lubricants, plasticizers, and stabilizers. Mold release agents are not usually used unless they are required for a specific purpose.10

ADVANTAGES OF PLASTIC CONTAINERS:

Plastic containers have a number of inherent practical advantages over other containers or dispenses. They are:

1. Light in weight and low in cost
2. Durable and unbreakable
3. Flexible facilitating product dispensing
4. Odorless and inert to most chemicals
5. Able to retain their shape throughout their use.

DISADVANTAGES OF PLASTIC CONTAINERS:

Plastics appear to have certain disadvantage like interaction, adsorption, absorption lightness and hence poor physical stability. All are permeable to some degree to moisture, oxygen, carbon dioxide etc and most exhibit electrostatic attraction, allow penetration of light rays unless pigmented, black etc. Other negative features include:

1. Stress cracking, a phenomenon related to low density polythene and certain stress cracking agents such as wetting agents, detergents and some volatile oils.
2. Paneling or cavitations, where by a container shows in ward distortion or partial collapse owing to absorption causing swelling of the plastic or dimpling following a steam autoclaving operation.
3. Crazing, a surface reticulation which can occur particularly with polystyrene and chemical substances (e.g. isopropyl myristate which first cause crazing and ultimately reaches of total embitterment and disintegration).
4. Poor key of print -certain plastics, such as the poly olefins need pre treating before ink will key. Additives that migrate to the surface of the plastic may also cause printing problem.
5. Poor impact resistance – both polystyrene and PVC have poor resistance. This can be improved by the inclusion of impact modifiers such as rubber in case of polystyrene and methyl methacrylate butadiene styrene for PVC.

3. METAL CONTAINER (1, 7, 20):

The collapsible metal tube is an attractive container that permits controlled amounts to be dispensed easily, with good re closure and adequate environmental protection to the product. The risk of contamination of the portion remaining in the tube is minimal, because the tube does not "suck back." It is light in weight and unbreakable, and it lends itself to high-speed automatic filling operations. The ductile metals used for collapsible tubes are tin (15%), aluminum (60%), and lead (25%). Tin is the more expensive than lead. Tin is the most ductile of these metals. Tin containers are preferred for foods, pharmaceuticals, or any product for which purity is an important consideration. Tin is chemically inert of all collapsible tube metals. Laminates of tin-coated lead provide better appearance and will be resistant to oxidation. They are also cheaper compared to tin alone. The tin that is used for this purpose is alloyed with about 0.5% copper for stiffening. When lead is used, about 3% antimony is added to increase hardness. Lead has the lowest cost of all tube metals and is widely used for nonfood products such as adhesives, inks, paints, and lubricants. Aluminum work hardens when it is formed into a tube, and must be annealed to give it the necessary pliability.

CLOSURES:

An effective closure must prevent the contents from escaping and allow no substance to enter the container. The adequacy of the seal depends on a number of things, such as the resiliency of the liner, the flatness of

the sealing surface on the container, and most important, the tightness or torque with which it is applied. In evaluating an effective closure system, the major considerations are the type of container, the physical and chemical properties of the product, and the stability-compatibility requirements for a given period under certain conditions (1, 3).

FUNCTION OF A CLOSURE:

1. Provide a totally hermetic seal.
2. Provide an effective seal which is acceptable to the products.
3. Provide an effective microbiological seal (11, 13, 16).

TYPES OF CLOSURES (16, 21-23):

Closures are available in five basic designs: Threaded screw cap, lug cap, crown cap, roll-on closure and pilfer proof closure.

1. THREADED SCREW CAP:

The screw cap when applied overcome the sealing surface irregularities and provides physical and chemical protection to content being sealed. The screw cap is commonly made of metal or plastics. The metal is usually tinplate or aluminum, and in plastics, both thermoplastic and thermosetting materials are used. Metal caps are usually coated on the inside with an enamel or lacquer for resistance against corrosion. all metal crowns and closures are made from electrolytic tinplate, tin-coated steel on which the tin is applied by electrolytic deposition.

2. LUG CAP:

The lug cap is similar to the threaded screw cap. It is simply an interrupted thread on the glass finish, instead of a continuous thread. It is used to engage a lug on the cap sidewall and draw the cap down to the sealing surface of the container. Unlike the threaded closure, it requires only a quarter turn. The lug cap is used for both normal atmospheric-pressure and vacuum-pressure closing. The cap is widely used in the food industry because it offers a hermetic seal and handles well in sterilization equipment and on production lines.

3. CROWN CAP:

This style of cap is commonly used as a crimped closure for beverage bottles and has remained essentially unchanged for more than 50 years.

4. ROLL-ON CLOSURE:

The aluminum roll-on cap can be sealed securely, opened easily, and resealed effectively. It finds wide application in the packaging of food, beverages, chemicals, and pharmaceuticals. The roll-on closure requires a material that is easy to form, such as aluminum or other light-gauge metal. Re sealable, non re sealable, and pilfer proof types of the roll-on closure are available for use on glass or plastic bottles and jars. The manufacturer purchases these closures as a straight-sided thread less shell and forms the threads on the packaging line as an integral part of the filling operation. The roll-on technique allows for dimensional variation in the glass containers; each roll-on closure precisely fits a specific container.

5. PILFER PROOF CLOSURE:

The pilfer proof closure is similar to the standard roll-on closure except that it has a greater skirt length. This additional length extends below the threaded portion to form a bank, which is fastened to the basic cap by a series of narrow metal "bridges." When the pilfer proof closure is removed, the bridges break, and the bank remains in place on the neck of the container. The closure can be re sealed easily and the detached band indicates that the package has been opened. The torque is necessary to remove the cap.

Figure No. 2: Different type of closures

ROBOTICS (15, 18, 26):

The manufacturer of robots is well established providing a quality product with continuity of service, supply and software support. Economic analysis needs to be done before making the decision as to whether to automate doing robots, fixed automation, or the labor of people aided by work aids. There are two principle classes of robots. One type involves a fixed position for a central control and manipulator unit. This type of device is particularly useful where a repetitive motion is required, such as taking a package component from one position and then rapidly and accurately placing it in another position. The robot functions in an X-Y-Z axis basis. This permits the device is perform relatively crude tasks such as picking up a component, orienting it, and then moving it to the desired place and precisely positioning it in the X, Y or Z planes. The term package components can mean any part of the package itself or the product which is to be packaged. A second type, generally regarded as being more versatile than the fixed point robot is the gantry robot. This device also offers capability of the X, Y and Z directions. Programming is usually simpler for the gantry than for the fixed-position robot. The gantry robot can also use a manipulator at its pickup and discharge points. This often is as simple as a clamp or a device that has its own X-Y-Z degrees of freedom. A robot often can be economically justified when the task of doing a certain packaging operation is analyzed in detail. When the work rids is considered and their cost determined the additional cost for providing robot capability is often of a small magnitude, which justifies, it is to replace human labor. There are many examples where a single operator controls an entire production and packaging operation where robotics do all of the manual tasks. The robots are under the direction of their software. The operator is often a person who has at least an associate in science degree from a country college. Programming languages used for robots is becoming more standardized.

CONCLUTION:

Pharmaceutical packaging technology is structured to meet the needs of the global market, and assesses a wide range of current knowledge, catering for the requirements of the pharmaceutical industry as well as for pharmaceutical companies in emerging nations who are still seeking a basic grounding in the subject. Packaging should provide protection, identification, information, convenience and compliance for a product during storage, carriage, display and until such time the product is consumed. Pharmaceutical packaging should look into concerned issues like child safety, correct dosage, patient traceability, tampering and diversion of pharmaceutical products. The introduction of robotics has given a new dimension to packaging. Considerable steps have to be taken to ensure packaging traceability. Some manufacturers have affixed the use of barcodes to pharmaceutical products.

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