"Recent Trends in Pharma Packaging"

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ABSTRACT

Packaging is an emerging science, a developing engineering discipline, and a success contributor to pharmaceutical industries. Packaging is defined as the collection of different components which surround the pharmaceutical product from the time of production until its use. As with most other packaged goods, pharmaceuticals need reliable and speedy packaging solutions that deliver a combination of product protection, quality, tamper evidence and security needs. Constant innovations in the pharmaceuticals themselves such as, blow fill seal (BFS) vials, anti-counterfeit measures, plasma impulse chemical vapor deposition (PICVD) coating technology.New pharmaceutical packaging concept also beginning with emerging of environmental concerns without sacrificing packaging advances.

Keywords: Pharma packages, Closures and containers and Pharmaceutical packages.

1. Introduction

Packaging is an integral component supporting the pharmaceuticals market, providing advanced solutions to assist correct dosing, accurate dispensing and compliance with prescription.[1]The functionality of pharmaceutical and medical packaging is crucial in providing user-friendly packaging for both the ageing population whilst ensuring child-resistant properties, and ever-tightening and stringent regulations applied to the market drive innovations in the areas of anti-counterfeiting and tamper-proof packaging. [2] Together, these factors initiate ongoing developments in technology and innovations for the demanding market. [3] Selecting the right packaging components has a direct impact on operational efficiency, drug stability, drug safety and patient protection. [4]

1.1 Categorically differentiating pharmaceutical packaging:

a. Primary Packaging: This is the first packaging envelope which is in touch with the dosage form or equipment. E.g. Blister packages, Strip packages, etc. [5]

b. Secondary Packaging: This is consecutive covering or package which stores pharmaceuticals packages in it for their grouping. E.g. Cartons, boxes, etc. [6]

c. Tertiary packaging: This is to provide bulk handling and shipping of pharmaceuticals from one place to another. E.g. Containers, barrels, etc. [7]

Primarily two types of containers are used for packaging: [8]

1. Glass Containers
2. Plastic Containers

1.2 Functions of Pharmaceutical Packaging [9]

- **Containment** - While designing of high-quality packaging must take into consideration that both the needs of the product and of the manufacturing and distribution system. It necessitates the packaging: not to leak, nor allow diffusion and permeation of the product, to be strong enough to hold the contents when subjected to normal handling. [10]
- **Protection** - The packaging must protect the product against all adverse external influences that may affect its quality or potency, such as light, moisture, oxygen, biological contamination, mechanical damage and adulteration. [11]
- **Presentation and information** - Packaging is also an essential source of information on medicinal products. Such information is provided by labels and package inserts for patients. [12]
- **Identification** - The printed packs or its acillary printed components serves the functions of providing both identity and information. [13,14]
- **Convenience** - The convenience is associated with product use or administration e.g., a unit dose eye drop which both eliminates the need for preservative and reduces risks associated with cross infection, by administering only a single dose. [15,16]

2. Recent Trends in Pharma Packaging [17]

2.1 Blow-fill-seal technology (BFS)

Aseptic blow-fill-seal technology is the process by which plastic containers are formed, filled with sterile filtered product and sealed in a continuous sequence of operations within the controlled sterile environment of a single machine.The machines require a minimum number of operating personnel and have a relatively small space requirement. [18] This process is a robust, advanced aseptic processing technology, recognized by worldwide regulatory authorities for its inherent operational advantages over conventional aseptic production. This systems offer a unique combination of flexibility in packaging design, low operating cost and a high degree of sterility assurance. Blow-fill-seal technology has gained much market focus in recent years due to the increased focus on biologics, proteins and other complex solutions. These important products often cannot withstand exposure to high temperatures for extended periods of time without degradation of their active components. Conventional terminal sterilization, therefore, is not an acceptable method to produce a ‘sterile’ product. Bulk sterilization, sterilization by gamma irradiation or filter sterilization followed by direct packaging utilizing the blow-fill-seal process are often used successfully for these types of products. A variety of polymers may be used in the process, low and high-density polyethylene and polypropylene being the most popular. BFS technology is today's emerging drug delivery technology, most notably in the field of respiratory therapy. [19]

2.2 Blow-fill-seal process

2.2.1 Container moldings

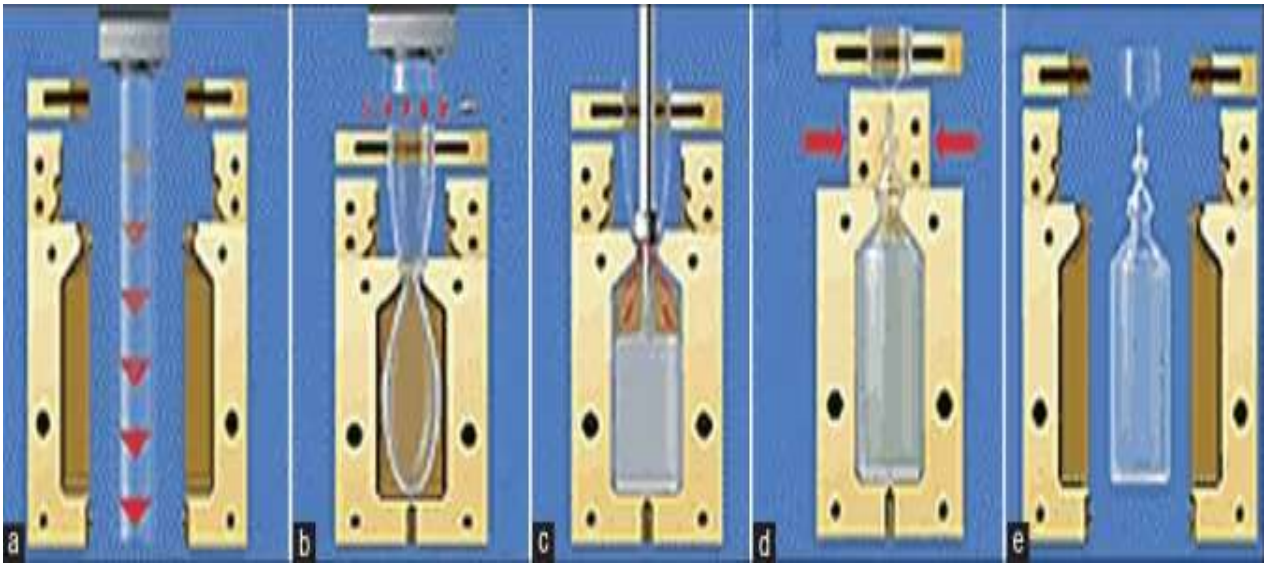
Thermoplastic is continuously extruded in a tubular shape ,when the tube reaches the correct length, the mold closes and the parison is cut. The bottom of the parison is pinched closed and the top is held in place with a set of holding jaws. The mold is then transferred to a position under the filling station. [20]

- **Container filling**

The nozzle assembly lowers into the parison until the nozzles form a seal with the neck of the mold. Container formation is completed by applying a vacuum on the mold-side of the container and blowing sterile filtered air into the interior of the container. The patented electronic fill system delivers a precise dosage of product into the container. The nozzles then retract into their original position.

- **Container sealing**

Succeeding completion of the filling process, the top of the container remains semi-molten. Separate seal molds close to form the top and hermetically seal the container. The mold opens and the container is then conveyed out of the machine. The duration of the complete cycle is between 10-18 seconds, depending on the container design and the amount of liquid to be filled. [21]



Blow-fill-seal process

2.2 Advantages

- Reduces personnel intervention making it a more robust method for the aseptic preparation of sterile pharmaceuticals.
- There is no need to purchase and stock a range of prefabricated containers and their closures.
- Cleaning and sterilization of prefabricated containers and closures is not required. A clean, sterile container is made within the BFS machine as it is required for filling.
- The cost of material transport, storage and inventory control is reduced.
- The technology allows the design of high-quality, custom-designed containers with tamper-evident closures in a variety of shapes and sizes.
- There is a large choice of neck and opening device shapes.

2.3 Blister Packs [22]

In these packaging mode has been used extensively for pharmaceutical packaging for severalgood reasons. [23] It is a packaging configuration capable of providing excellent environmental protection, coupled with an esthetically pleasing and efficacious appearance. [24]

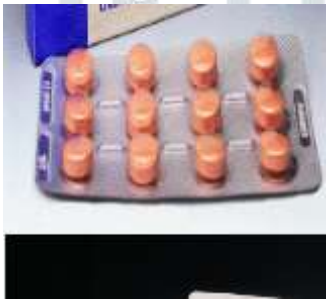
It is made up of base layer (polyvinylchloride layer) with cavities which contains pharmaceutical product. [25] It provides greater protection then strip package. It contains a lid which is made up of aluminum and paper foil. [26]

2.4 THERMOFORM BLISTERS [27]

– Plastic base web

– Blister formed with aid of heating

– Low to high barrier



Base Film – e.g. PVC, PVC-PVDC, PVC-PE-PVDC, PVC-Aclar®

Product contact materials:

For base = PVC (or PP) For lid foil = heat seal lacquer

2.5 Plasma Impulse Chemical Vapor Deposition[28]

Plasma impulse chemical vapor deposition (PICVD) was developed by Schott. It was the first CVD - based coating technology for the mass production of optical coatings on glass components. [29] The PICVD coating technologies were not capable of depositing durable functional coatings on polymethylmethacrylate (PMMA) with a sustained adhesion to the substrate. A completely new layer system on PMMA with an adapted adhesive layer has been developed for these coatings. [30]

Pharmaceutical packaging bottles coated using PICVD barrier coatings

2.6 Eco-friendly Packaging [31]

With the ever-increasing environmental concerns, drug manufacturers and packaging companies are constantly focusing on eco-friendly packaging materials, techniques, and technologies. [32] Pfizer is constantly working to reduce its carbon footprint by increasing recycling of packaging arterials and reducing the amount of virgin materials used in packaging. Example is of Eco Lips, a US-based lip care products manufacturer, which introduced its new organic lip balms in Eco friendly pharmaceutical packaging materials are the safe materials for environment which enclose pharmaceutical product in any of the dosage forms. [33] They may be derived from natural resources, like starches, proteins etc. that inflict little or nearly no harm on the environment and the environment. [34]

3. Innovation in child resistance packaging [35]

Since its introduction in the late 60s and early 70s, child-resistant packaging has led to a significant reduction in the number of children admitted to hospital for accidentally ingesting poisonous substances. However, recent statistics show accidental poisoning is still a serious problem worldwide, even in heavily regulated, developed countries. USA was the first country in the world that introduced the requirement of securing the child of chemical substances and drugs. To be able to say that the packaging is sufficiently well protected against children, at least 85% of the 200 children tested could not cope with opening the package within 5 minutes of testing. The result is positive if at least 85% of the children did not open the package (opened less than 8 for packaging unit doses of pharmaceutical products) during the first test, and if at least 80% of the children did not open the package (opened less than 8 for packaging unit doses of pharmaceutical products) during the first and second attempt. An article published in 2011 in the Journal of Pediatrics reported the number of children admitted to hospital in the US after swallowing inappropriate medication has been increasing in recent years. The most popular used packaging to protect the child is close to a 'push - turn "or " squeeze- turn ". This type of closure requires the use of two hands to open the package . Many pharmaceutical companies in the world conduct research on packaging safe for children. One example is blisters with the necessary puncture resistance and specialized peelability to meet both American standards and European testing criteria. [36]Broad range of liding structures that suit all opening mechanisms: push-through, peel-push, peel-open and tear-open. Also, one of the pharmaceutical companies introduced printed tear indicator, accompanied by text explaining how to open it as opposed to other packaging options on the market which use a notch to signify where to tear open the sachet. The level of child resistance can be further increased by incorporating Amcor's tear system with "fold first" or "squeeze first" instructions. Child resistant packaging must strike a balance between being too hard for children to open but easy enough for invalids and the elderly to access. Spray products, both cosmetic and pharmaceutical, are particularly challenging for packaging designers to protect against curious children. A spray top is much easier and more intuitive for a child's mind to grasp than a screw-top bottle. In recent years, sliding

lock systems have become popular for many spray cans. Developed specifically for a new anesthetic spray being launched by a major US pharmaceutical company, the design's opening mechanism requires a tab to be pushed at the same time as the cap is being twisted; an action that requires the wrist and fingers to work together, something that is beyond most young children. [37]

4. Future of Pharmaceutical Packaging Technology

➢ A changing pharmaceutical industry[38]

Changes in pharmaceutical industry research and manufacturing technologies have driven significant developments in packaging and delivery systems. An increase in the number of large-molecule, biopharmaceutical drugs in development pipelines has led to an increase in the need for injectables packaging and administration systems. The old glass and elastomer closure systems may not provide the effective barrier properties needed for high-value, life saving therapies. Component manufacturers have responded with new materials and technologies that ensure extended drug-product shelf-life. [39]Many new biotechnology-derived drug therapies are unstable in liquid form and therefore are introduced as lyophilized or dry powder dosage forms. Lyophilized drugs need special stoppers for optimal performance in lyophilization chambers. The stoppers must solve the problem of the stopper sticking to the lyophilization shelf after the cycle is completed. In addition, lyophilized drugs typically are reconstituted at the point of care, thus requiring patient-friendly administration systems. [40]

➢ The increase in self-administered therapies

Decades ago, healthcare revolved around hospital care. [41] Today, healthcare often revolves around the home - a situation that has largely resulted from cost constraints and the introduction of maintenance-type drugs for treating chronic conditions such as arthritis, cancer, multiple sclerosis, and other diseases that require frequent medication. [42]Many of these maintenance therapies are delivered by injection, spurring a need for patient-friendly administration systems. These systems must ensure the potency of the drug, be tamper-evident, help deter counterfeiting, promote compliance with a dosing regimen, ensure dosing accuracy, and be as safe, easy to use and painless as possible. [43] An outgrowth of these changes is the move from the typical vial and disposable syringe to the prefillable syringe. With prefillables, dosing accuracy is ensured but they present some challenges for the industry. [44] A pharmaceutical company needs a prefillable system that protects the integrity of the packaged drug product over time and will function as represented over the full shelf life of the drug product. The response from component manufactures was to develop syringe plungers with barrier films that minimize the interaction between the packaged drug and the components. [45] At the same time, the industry has developed elastomers for molded plungers that maintain functional properties such as seal integrity, and break-loose and extrusion forces. [46] When self-administered drugs are in lyophilized or dry powder form,

manufacturers must find methods or packaging systems that help prevent accidental needle stick injuries, inaccurate dosing, and drug spray-back. Manufacturers familiar with the drug administration process must provide delivery systems that simplify drug reconstitution, especially for non-professional caregivers.

5. International standards on packaging [47]

A pharmaceutical product should meet below mentioned standards before going to a market.

- A list is given below of the standards on packaging issued by the International Organization for Standardization (ISO), as of 10 October 1998, starting with the four main standards, after which they are listed in numerical order.
- Quality systems —model for quality assurance in design, development, production, installation and servicing. International Standard ISO 9001, 1994.
- Quality systems —model for quality assurance in production, installation and servicing. International Standard ISO 9002, 1994.
- Quality systems —model for quality assurance in final inspection and test. International Standard ISO 9003,1994.
- Quality management and quality systems elements. Part 1: Guidelines International Standard ISO 9004-1, 1994.
- Quality management and quality systems elements. Part 2: Guidelines for service. International Standard ISO 9004-2. 1994.
- Quality management and quality systems elements. Part 3: Guidelinesfor processed materials. International Standard ISO 9004-3. 1994, www.wjpps.com Vol 3, Issue 5, 2014.
- Quality management and quality systems elements. Part 4:Guidelinesfor quality improvement. International Standard ISO 9004-4. 1994.
- Reusable all-glass or metal-and-glass syringes for medical use.Part 1:Dimensions. International Standard ISO 595-1. 1986.
- Reusable all-glass or metal-and-glass syringes for medical use.Part 2:Design, performance requirements and tests. International StandardISO 595-2. 1987.
- Transfusion equipment for medical use. Part 1: Glass transfusionbottles, closures and caps. International Standard ISO 1135-1. 1987.
- Plastics collapsible containers for human blood and blood components.International Standard ISO 3826. 1993.
- Injection containers for injectables and accessories. Part 1: Injection vialsmade of glass tubing. International Standard ISO 8362-1. 1989.
- Injection containers for injectables and accessories. Part 2: Closures for injection vials. International Standard ISO 8362-2, 1988.

- Injection containers for injectables and accessories. Part 3: Aluminium caps for injection vials. International Standard ISO 8362-3, 1989.155
- Injection containers for injectables and accessories. Part 4: Injection vials made of moulded glass. International Standard ISO 8362-4. 1989.
- Injection containers for injectables and accessories. Part 5: Freeze–drying closures for injection vials. International Standard ISO8362-5.1995.
- Injection containers for injectables and accessories. Part 6: Caps madeof aluminium–plastics combinations for injection vials. InternationalStandard ISO 8362-6. 1992.
- Injection containers for injectables and accessories. Part 7: Injectioncaps made of aluminium–plastics combinations without overlappingplastics part. International Standard ISO 8362-7,1995.
- Infusion equipment for medical use. Part 4: Infusion sets for single use, gravity feed International Standard ISO 8536-4. 1998.
- Infusion equipment for medical use. Part 5: Burette-type infusion sets. International Standard ISO 8536-5.1992.
- Infusion equipment for medical use. Part 6: Freeze–drying closures for infusion bottles. International Standard ISO 8536-6. 1995.
- Infusion equipment for medical use. Part 7: Caps made of aluminium–plastics combinations for infusion bottles. International Standard ISO8536-7. 1992. www.wjpps.com Vol 3, Issue 5, 2014.
- Sterile single-use syringes, with or without needle, for insulin. Interna-tional Standard ISO 8537. 1991.
- Elastomeric parts for aqueous parenteral preparations. InternationalStandard ISO 8871. 1990.
- Aluminium caps for transfusion, infusion and injection bottles general requirements and test methods. International Standard ISO8872. 1988.
- Injection equipment for medical use. Part 1: Ampoules for injectables.International Standard ISO 9187-1. 2000.
- Injection equipment for medical use. Part 2: One-point-cut (OPC)ampoules. International Standard ISO 9187-2.1993.
- Dental cartridge syringes. International Standard ISO 9997. 1999.Caps made of aluminium– plastics combinations for infusion bottlesand injection vials requirements and test methods. InternationalStandard ISO 10985. 1999.
- Prefilled syringes. Part 1: Glass cylinders for dental local anaestheticcartridges. International Standard ISO 11040-1. 1992.156
- Prefilled syringes. Part 2: Plungers and discs for dental local anesthetic cartridges. International Standard ISO 11040-2. 1994.
- Prefilled syringes. Part 3: Aluminium caps for dental local anaestheticcartridges. International Standard ISO 11040-3. 1993.

- Prefilled syringes. Part 4: Glass barrels for injectables. International Standard ISO 11040-4. 1996.
- Containers and accessories for pharmaceutical preparations. Part 1:Drop-dispensing bottles.International Standard ISO 11418-1. 1996.
- Containers and accessories for pharmaceutical preparations. Part 2:Screw-neck bottles for syrups. International Standard ISO 11418-2.1996.
- Containers and accessories for pharmaceutical preparations. Part 3:Screw-neck bottles (vials)for solid and liquid dosage forms. International Standard ISO 11418-3. 1996.
- Containers and accessories for pharmaceutical preparations. Part 4:Tablet bottles.International Standard ISO 11418-4. 1996.
- Containers and accessories for pharmaceutical preparations. Part 5: Dropper assemblies. International Standard ISO 11418-5. 1997.
- Containers and accessories for pharmaceutical preparations. Part 7:Screw-neck vials made of glass tubing for liquid dosage forms. International Standard ISO 11418-7. 1998. www.wjpps.com Vol 3, Issue 5, 2014.
- Pen-injectors for medical use. Part 2: Needlesrequirements and testmethods. International Standard ISO 11608-2. 2000.
- Pen-injectors for medical use. Part 3: Finished cartridges requirements and test methods. International Standard ISO 11608-3.2000.
- Pen systems. Part 1: Glass cylinders for pen-injectors for medical use.International Standard ISO 13926-1. 1998.
- Pen systems. Part 2: Plungers and discs for pen-injectors for medicaluse. International Standard ISO 13926-2. 1999.
- Disposable hanging devices for transfusion and infusion bottles requirements and test methods.International Standard ISO 15010.1998. [48]

6. SUMMARY

Packaging in the pharmaceutical industry has gone through major changes in the past decade. This is undoubtedly due to the fact that they are placed high demands. The advent of new drug delivery systems and the development of new biochemical compounds have resulted in a need not only for enhanced protection against factors such as moisture, light, oxygen and mechanical forces, but also for packaging forms to play a more integral role in the drug delivery process. The protective and safety function of the product gains a special meaning here and it must be guaranteed in each type of packaging used, with no exceptions. However, the wide range of materials used in the pharmaceutical packaging industry does not impose any limitations on the manufacturers, and the dynamic development of the plastic industry leads to new opportunities and solutions related to packaging. Therefore, the innovations that are now inventions will soon be generally accessible, and they will be replaced with other novelties. Everything that is being created aims at achieving the highest product quality and thus the safety of the potential patient.

7. Conclusion

In the era of globalization, it would be a challenge for the packaging industry.It is necessary that packaging industry upgrades more in research to have a holistic approach to packaging that would go beyond functional aspect of packaging. Presently, very few pharmaceutical industries spend time and money on R and D in packaging. As packaging industry is directly or indirectly involved in the drug manufacturing process, it becomes ethically mandatory to understand and incorporate scientific methods in packaging. The pharmaceutical packaging trends are on the verge of innovative rapid growth provided the needs of the product, its security, cost and patient convenience is taken into consideration to build brand identity.

8. References

1. Dean D.A., Evans E.R., Hall I.H. Pharmaceutical Packaging Technology. Taylor & Francis e-Library, 2005: 1-6.
2. Edward JB. 1st ed. New York: Informa Healthcare; 2009. Pharmaceutical Packaging Handbook; pp. 387–92.
3. Sunil Kumar. Pharmaceutical Packaging Technology - A Review. International Journal of Research in Pharmaceutical and Biomedical Sciences; 2013, 4(4): 1413
4. Packaging: A Review. International Journal of Pharmaceutical and Chemical Sciences; 2012, 1(3): 936.
5. Manukonda Keerthi et. al., A review on packaging for different formulations. Asian J. Res. Pharm. Sci. 2014; vol. 4: Issue 3, Pg 141-151
6. Jain UK, Nayak S. 1st ed. Hyderabad: Pharma Med Press; 2008. Pharmaceutical Packaging Technology; pp. 1–273.
7. Carter SJ. Copper and Gunn's Packaging in tutorial pharmacy. 2005:133–41.
8. Trends in pharmaceutical packaging. [Last accessed on 2001 Oct 19]. Available from: http://www.ngpharma.eu.com/article/Trends-in-pharmaceutical-packaging .
9. Dean D.A., Evans E.R., Hall I.H. Pharmaceutical Packaging Technology. Taylor & Francis e-Library, 2005: 1-6.
10. Devi KV, Burande M, Deepak H, Jobanputra SB. Packaging solutions to the changing pharma market needs. Pharma Times. 2007;39:29–34.
11. James Swarbick. Encylopedia of Pharmaceutical Technology. Informa Healthcare. Third Edition. Volume-1; 2007: 378- 379.
12. Wasim Raja. et al. Innovations in PharmaceuticaL Packaging – An Update (2012) Int J of Ad Biomed & Pharm Res. 1(1): 29-39.
13. Patel R P et al., outline of pharmaceutical packaging technology. Inter Res J of Pharmacy 1 (1) 2010 105-112

14. Khunt B. P., Dharajia H. V., Desai T. R., Shah K.V.. Innovation in Packaging: A Review. International Research Journal of Pharmaceutical and Applied Sciences; 2012, 2(2): 65-78.
15. Pharmaceutical Packaging – Needs And Advances. International Journal of Pharmaceutical Sciences Review and Research; 2012, 13(2): 141-152.
16. Elizabeth F et al.: Pharma Packaging Trends, Pharmaceutical technology.com, 2012. http://pharmaceuticaltechnology.com/features/featuresafe-simple- sustainable pharma-packaging-trends
17. Praveen Nasa, A Review On Pharmaceutical Packaging Material. World J of Pharma Res., vol 3, Issue 5, 322-368. ISSN 2277-7105.
18. Reed CH. Recent technical advancements in blow-fill-seal technology. Business Briefing: Pharmagenerics. 2002
19. Ingelheim B. Aseptic production of pharmaceuticals in boehringer ingelheim using blow-fill-seal technology. Business Briefing: Pharmatech. 2003
20. Kuhr S, Bauer U, Rothhaar D, Wolff Coatings on plastics with the PICVD technology. Thin Solid Films. 2003; 442:107–16.
21. Soroka, W. Illustrated Glossary of Packaging Terminology(Second ed.). Institute of Packaging Professionals.
22. Pilchik, R (Nov 2000), "Pharmaceutical Blister Packaging, Part 1, Rationale and Materials" (PDF), Pharmaceutical Technology: 68–77, retrieved 26 June 2017
23. Pharma CMC. "How To Minimize Blister Packaging Water Vapor Transmission Rates". Retrieved 27 September 2016
24. Stone, Brad (2008-11-14). "Packages You Won't Need a Saw to Open". Nytimes.com. Retrieved 2012-11-21.
25. Elliot, V S (22 December 2008). "Ho ho woes: Wrap rage results in lacerations and bad tempers". American Medical News. Retrieved 4 January 2010.
26. Clifford, Stephanie (2 June 2011). "Clamshell packaging is being tossed". The Bulletin. Bend, OR. New York Times News Service. Retrieved 6 June 2011.
27. Pilchik, R (Dec 2000), "Pharmaceutical Blister Packaging, Part 2, Machinery and Assembly" (PDF), Pharmaceutical Technology: 56–60, retrieved 26 June 2017
28. Plasma impulse chemical vapour deposition: A coating technique for plastic substrates. Mat World. 2003; 11:13–5.
29. Becton Dickinson promotional literature, B01/D/ENG/02/US/FL-40 Polin JB. The Ins and Outs of Prefilled Syringes. Pharm Med Packaging News. 2003.
30. Ayush Garg, Arti thakkar. Pharmaceutical packaging technology. Am. J. pharmtch Res. 2012; 2(5). ISSN: 2249-3387

31. Sunisha Kulkarni et. al., creative innovations in pharmaceutical packaging. Indian J of pharmacy and pharmacology Banker G. S., Rhodes C. T. Modern Pharmaceutics oct-dec 2015:2(4):230-235.
32. Anne MM: Walmart debuts eco-friendly compliance pack. Greenpackage.com, 2012. Availablefrom:http://www.greenerpackage.com/additives/walmart_debuts_ecofriendly_compliance_pack.
33. Pharmaceutical International: Syreen Eco Syringe ReducesPharma Packaging. Pharmaceutical International'sDrug Development Correspondent, 2011. http://www.pharmaceutical-int.com/news/syreenecosyringe-reduces-pharma-ackaging.
34. Pagay SN, Bachorik RJ, II, Richard TL. Pre-filled syringe and prefilled cartridge having actuating cylinder/plunger rod combination for reducing syringing force. Patent Storm: US Patent 5411489 - Pre-filled syringe and pre-filled cartridge. 1995
35. Glenn AT. Prefillable syringes: Trends and growth strategies. Cedar cottage, Newtimber Place Lane, West Sussex, BN6 9BU, United Kingdom: ON drug delivery Ltd; 2006. Registered in England: No 05314696.
36. Burgopak health care.com :Another Award Win for the Burgopak Child Resistant Slider Pack. 2012.http://burgopakhealthcare.com/2012/04/another-award-win-for-the-burgopak-childresistant-slider-pack/ StoraEnso: Paperboard Compliance, Pharma SHR Brochure.
37. Sagar Makwana et. al., Prefilled syringes: An innovation in parenteral packaging. Inter J of pharm Investigation, vol 1 issue 4. Doi: 10.4103/2230-973X.93004
38. Trivedi U. M., Patel D., Pokar A., Modasiya M.K. A Review on Pharmaceutical Glass Packaging. IJPI's Journal of Pharmaceutics and Cosmetology; 2011, 1(4): 59-60.
39. 4.Kevin haehl., why innovative drug delivery packaging solutions are needed for today‟s patients. American pharmaceutical review- the review of American pharm.
40. Dobrucka R and Cierpiszewski R. (2014). Active and intelligent packaging food- Research and Development A review. Pol J Food Nut Sci, 64 (1):7-15.
41. Tibor H, Karim A, Ryan MA. Reducing quality risks to drug products and meeting needs of patients with enhanced components for prefilled syringe systems. Vol. 30. 48.
42. Albany Villas, Hove, East Sussex, BN3 2RW www.ijppr.humanjournals.com Citation: Mohd Sohail Aliet al. Ijppr.Human, 2017; Vol. 9 (3): 1-24.
43. United Kingdom: Frederick Furness Publishing; 2012. [Last accessed on 2005]. Smart Infusion Pumps. Available from: http://www.ondrugdelivery.com Beele Denise. Increasing Popularity of Prefilled Syringes. Packazine. 2007;1:4–5.
44. Vikas Pareek, Dr. Alok Khunteta. Pharmaceutical packaging: current trends and future. Inter J of pharmacy and pharmaceutical sci., vol 6. Issue 6, 2014 ISSN- 0975-1491
45. Ghanshyam Balkrishna Jadhav et. al., Advances in pharmaceutical packaging. World J of Pharm and Pharmaceutical sci. Vol 3, Issue 5, 194-204. ISSN 2278-4357

46. Michael NE. The American Pharmaceutical Review. Cedar cottage, Newtimber Place Lane, West Sussex, BN6 9BU, United Kingdom: ON drug delivery Ltd; 2008. Offering a new choice in glass prefillable syringes; pp. 8–12.
47. Guidelines on Packaging for Pharmaceutical Products. WHO Technical Report Series, No. 902; 2002: 154-156
48. Mehta K. C., D. Akhilesh., B. Shyam Kumar. Recent Trends in Pharmaceutical Guidelines on Packaging for Pharmaceutical Products. WHO Technical Report Series, No. 902; 2002: 154-156.