Sys Rev Pharm 2022; 13(8): 522-526
A multifaceted review journal in the field of pharmacy
E-ISSN 0976-2779 P-ISSN 0975-8453 / DOI: 10.31858/0975-8453.13.8.522-526

Review Article

Recent Trends in Pharmaceutical Packaging

Archana Uppal Gahtori*, Priya
Department of Pharmaceutical Sciences, Shri Guru Ram Rai University, Uttarakhand, India

Article History: *Submitted: 01.07.2022* *Accepted: 25.07.2022* *Published: 01.08.2022*

ABSTRACT

As per latest reports the global pharmaceutical packaging market size is expected to reach United States Dollar (USD) 196.8 billion by 2026 from USD 99.9 billion in 2021, at a Compound Annual Growth Rate (CAGR) of 14.5% during the forecast period. This huge growth in the demand of pharmaceutical packaging is due to increase in the consumer awareness about healthcare. Market is surged with innovative packaging solutions accompanying higher patient convenience.

Packaging of pharmaceutical products is a broad multiphase process that requires more care as compared to other products. In the pharmaceutical field, these life-saving medicaments and pharmaceutical products must be packaged properly to maintain their integrity and stability until it reaches the consumer. Recent trends in pharmaceutical packaging includes Blow Fill Seal (BFS) technology, prefilled syringes, Child Resistant packaging, anti-counterfeit packaging techniques *viz.* track and trace technology, overt technology using Hologram, colour shifting security inks, sequential product numbering. Smart packaging is nowadays very popular which not only provide information on quality of product but also on its reception, storage and delivery. Intelligent packaging with QR (Quick Response) codes, Near-Field Communication (NFC) using smartphones and apps, Radio Frequency Identification (RFID), packaging built-in sensor have also entered into the market.

Packaging, by utilizing various technical approaches, is advancing constantly for providing enhanced patient compliance and better security of the product. Therefore this review article reports various recent advancements in pharmaceutical packaging.

Keywords: Smart packaging, Blow Fill Seal (BFS) technology, Packaging, patient compliance

***Correspondence:** Archana Uppal Gahtori, Department of Pharmaceutical Sciences, Shri Guru Ram Rai University, Uttarakhand, India, Email: destination1234@gmail.com

ABBREVIATIONS

USD: United States Dollar; CAGR: Compound Annual Growth Rate; BFS: Blow Fill Seal technology; QR code: Quick Response code; NFC: Near-Field Communication; RFID: Radio Frequency Identification; USFDA: United States Food and Drug Administration; FDA: Food and Drug Administration; COP: Cyclo Olefin Polymer; COC: Cyclo Olefin Copolymer; WHO: World Health Organization; API: Active Pharmaceutical Ingredient; NDC: National Drug Code; EPC: Electronic Product Code; CR: Child-Resistant; ISO: International Organization for Standardization; BS-EN: British Standards European Norm; PVC: Polyvinyl Chloride; PPM: Parts Per Million

INTRODUCTION

IThe packaging is basically a process in which individual item or several items are surrounded and placed suitably to maintain their effectiveness from the time of their packaging until their consumption or utilization (Keerthi M, *et al*., 2014; World Health Organization, 2002).

In the case of pharmaceutical products, pharmaceutical packaging is required as it is important for maintaining stability, the integrity of pharmaceutical dosage form to show its effectiveness (Singh A, *et al*., 2011).

Pharmaceutical packaging is a combination of various components that encloses pharmaceutical product or material from point of production to its use. The basic concept around which all the definitions of packaging revolve is the safety and protection of the packaged item so as to facilitate its journey until it is used by consumers (Bairagi PD, *et al*., 2020).

Types of packaging systems

Primary packaging: Primary packaging system includes packaging constituents or sub-constituents that are in direct contact with the product and having an effect on the shelf life of the product (being the first one to wrap the product). It includes ampoules and vials (used for parenteral products) prefilled syringes etc.

Secondary packaging: Secondary packaging is present exterior to the primary packaging which is used to group together the primary packages. Cartons, shipping containers, boxes are some examples of the secondary packaging system.

Tertiary packaging: For bulk handling tertiary packaging system is used. It includes a barrel, edge protectors, etc., (Kulkarni S, *et al*., 2015; Nasa P, 2014; Jadhav GB, *et al*., 2014).

Initially, tablets and capsules were used for taking orally a number of medicaments (about 51%) which either packed into pharmaceutical plastic containers or cased in blisters packs (normally in Asia and Europe). However medicaments can be taken by using other popularly used means and methods which include transdermal (3%), inhalation (17%), and parenteral or intravenous (29%) (Kunal CM, *et al*., 2012).

At present various changes are taking place in the pharmaceutical industry and these changes have a significant effect on the packaging industry. The quality, safety, and time duration of usability of a product can be improved by using numerous methods related to packaging including, intelligent packaging, nanotechnology, Blow Fill Seal technology, powder application, prefilled syringes, etc. This review article summarizes the recent trends in pharmaceutical packaging (Dobrucka R and Cierpiszewski R, 2014; Pareek VI and Khunteta A, 2014).

LITERATURE REVIEW

Blow-Fill-Seal technology

According to USFDA (United States Food and Drug Administration) Blow-Fill-Seal Technology can also be termed as an advanced aseptic process. From the last 20 years, aseptic BFS technology has shown great acceptance in the production of pharmaceutical liquids by the pharmaceutical industries. Recently, BFS technology is expanding into injectable and biologics, including vaccines and monoclonal antibodies.

The BFS technology is basically a process which comprises plastic container formation by molding, followed by filling sterile product and finally sealing in one uninterrupted action to obtain sterile pharmaceutical product within seconds (Reed CH, 2002).

Ideal integration of flexibility, low operational rate, and high grade of sterility in packaging pattern is provided by BFS technology. In BFS technology small space is required for the machines and also less number of personnel is required, as the process is largely automated. In BFS technology, polyethylene and polypropylene are the most commonly used polymer for the preparation of containers, as they are estimated as inert by the FDA (Food and Drug Administration) (Sinclair CS and, Tallentire A, 1995).

The Blow-Fill-Seal technology (BFS) process includes:

Molding of the container: In this step extrusion of plastic takes place for the formation of parison which is basically an empty tube or pipe of molten plastic. Between the mold, the parison is locked and the formation of the container takes place by vacuum or by using blowing compressed sterile air. The mold is having a cavity and container takes the shape of the mold during its formation. The top of the container is kept open for its filling and container sealing step.

Filling: The next step is filling in which, from the top open part of the container, filling nozzles gets into the container, and filling is done. A definite quantity of product is transferred into the container using the electronic fill system.

Sealing: After finishing the filling step, the open top of the container which is in the semi-molten state is sealed. In the process of sealing between the head mold, the open top of the container gets compressed and as a result, sealed containers are formed.

The entire operation of container molding, filling, and sealing complete in 10-18 seconds and relies on the size of the container and quantity of product to be filled (Ingelheim B, 2003; Baban DG, 2017; Bradley A, *et al*., 1991).

Prefilled syringes

Prefilled syringes are an innovative delivery system used for the administration of parenteral medicaments. Now as an alternative to the standard syringes which need to be filled prior introduction of every dose, prefilled syringes are widely used consisting of premeasured dose and already attached needle by the manufacturer (Krayukhina E, *et al*., 2015).

Prefilled syringes as a single dose medicament system have eventually become one of the rapidly expanding systems due to numerous reasons including dosing perfection, decreased errors, security, and ease of use. A prefilled syringe brings ample benefits to both practitioner and patient (Gangane PS, *et al*., 2020; Lull ME, *et al*., 2013).

Advantages:

Convenience: In an emergency case, filling of syringe can be time-consuming and tedious with standard syringes on the other hand prefilled syringes are quick and ready to use (Glenn AT, 2006).

Accuracy: Prefilled syringe delivers the exact quantity of medication to the patients as compared to the standard syringe which has a high probability of over-loading and under-loading the barrel (Michael NE, 2008).

Sterility: One of the important advantages of a prefilled syringe is the increased shelf life of the product. Standard syringe after its loading maintains sterility for few hours but a prefilled syringe maintains its sterility for about 2-3 years (Makwana S, *et al*., 2011).

Affordability: Prefilled syringes have appreciably reasonable prices as compared to standard syringes which are far more costly. In addition to prices, glass syringes are much more likely to break (Kale NS, *et al*., 2015).

Materials intended for the development of prefilled syringes:

Glass: Initially, glass tubing was used to form a syringe barrel which is a cylindrical tube meant for holding the product. By utilizing heat, glass tubing is shaped into a barrel. In prefilled syringes ideally, type-I or Borosilicate glass are employed as these glasses are: Sterilized easily, provide a high degree of transparency, has the least chemical reactivity. The various drawbacks associated with the use of glass in prefilled syringe includes the property of being fragile, shift in pH as some quantity of alkali ions are present in the glass (Makwana S, *et al*., 2011; Thomas S and Mathias R, 2010; Wohland A, *et al*., 2009).

Plastic: In comparison with prefilled glass syringes, plastic syringes are earning more popularity. Mostly Cyclo Olefin Polymer (COP) and Cyclo Olefin Copolymer (COC) are used for prefilled syringes. These polymers have a great advantage over the glass which includes its property of being infrangible, having great thermal resistance, excellent clarity, having effective moisture shielding properties, great flexibly, and lighter in weight.

Recent developments in the prefilled syringe: Due to increased popularity and the need for prefilled syringes in the market, manufacturers have infixed much advancement associated with materials and lubrication technology of prefilled syringes. These advancements are made so that several parenteral, diluents, vaccines, and new products can be packaged in prefilled syringes. Also, for lyophilized drugs, multi-chamber prefilled syringes have been established by the pharmaceutical company. Other improvements consist of lessened use of silicone for covering the syringe, modification in the technique to reduce tungsten residues (Boylan JC and Nail SL, 2002; Danielle L, 2010).

Anti-counterfeit packaging

The key objective of the pharmaceutical packaging system is to provide security and protection to the dosage forms but counterfeit has developed into major trouble in the security of products. In accordance with WHO (World Health Organization): A counterfeit medicinal formulation is the formulation that is intentionally and maliciously mislabelled regarding its identity and source. Counterfeiting can be exerted to each one of generic and branded medicines. The counterfeit formulation may comprise of:

- Correct or incorrect components
- Either devoid of API (Active Pharmaceutical Ingredient) or inaccurate amount of API
- False packaging (Modi S and Wadhwa S, 2009).

Counterfeit products result in morbidness, death (in extreme cases), and eventually leads to loss of trust in the healthcare system. Because of this, anti-counterfeit packaging is used to safeguard the product from such adversity (Shah RY, *et al*., 2010). Presently, a large number of anti-counterfeit packaging techniques are available in the market. Some of them are discussed below.

Track and trace technology:

Barcodes: Barcodes are the codes which are contained onto pharmaceutical product packages meant for scanning, for the identification of product during the supply chain. Barcodes also convey other details such as National Drug Code (NDC), batch number, use by date. 2D barcodes are available in linear, scripted, and 2D data matrix format (*Figure 1*) (Dhar R, 2009).

Radio Frequency Identification: RFID is a widely accepted but costly technique. It is wireless information gathering technology used for the identification of products *via* radio signals. The tags, readers, and software are the three principal elements of the RFID system. In the RFID system, goods or products get marked with tags. The tags contain a unique tracking identifier that is transmitted as a signal and only RFID readers are capable of reading these transmitted signals. Mainly these tags store information such as Electronic Product Code (EPC), customer number (Francom J, 2007). A reader recuperates data from the database regarding the ID number and accordingly takes action on it. RFID tags can also store details in its writable memory that are sent to several RFID readers present in different locations (Kwok SK, *et al*., 2008). Thus tagged item's movement can be tracked using the details. Three types of tags used are active, passive, and semi-active tags (Üstündağ A, 2005).

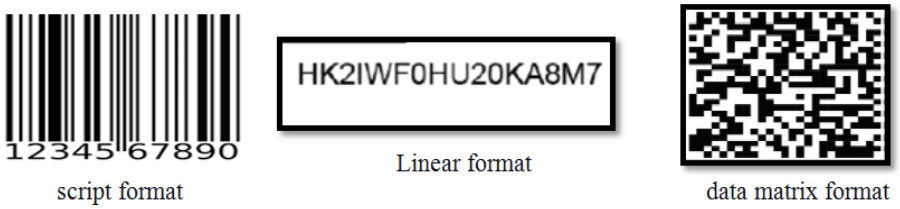

Figure 1: Different types of barcodes

Overt technologies: These are the visible features that are meant to facilitate the consumer to prove the originality of the package.

Holography: A hologram is basically an image with 3-dimensional construction. The art and method of preparing holograms is called holography (Benbasat AY, 1999). Holography is a simple method for the end-user to affirm the genuineness of the item. For first-level confirmation, readily recognizable holograms such as logos are used because at the time of inspection they provide effective authentication (Mali DK, *et al*., 2011). Additionally for second and third level confirmation hidden images and nano text can be utilized. One of the striking advantages of holograms is that by using traditional printing these highly reliable holograms cannot be manufactured or produced. Holograms can either be used separately or together with other security techniques so as to achieve efficient anti-counterfeit packaging (Chowdary Y, *et al*., 2012; Weinstein R, 2005).

Colour shifting security inks: These security inks manifest alteration in colour depending upon the angle of viewing. For affirmation of this colour shifting property, the product having color shifts are tilted and seen. To bring these visual effects, colour-shifting pigments which are perfectly powdered metallic laminates are placed in a thick opaque film. The colour shift pigment manufacturing process is highly expensive and challenging and thus produced by a finite number of suppliers.

Sequential product numbering: In the supply network, a distinctive sequential numbering of each individual packed item make identification of counterfeited product easier and results in rejection of false and non-valid numbers. The major drawbacks of these sequential product numbering include that the sequence can be vaticinated and easily replicated and thus to confirm the originality of the product, the consumer needs some method of approach to the database (Kannan S, 2011).

Covert features: Covert is the hidden features that facilitate the brand owner to detect the counterfeited product. As these features are hidden, the final consumer will not be known about its existence.

Invisible printing: In invisible printing, unique codes or marks that are imperceptible to our naked eyes are imprinted on pharmaceutical product packaging by utilizing special inks. These invisible prints can be viewed only under a specific beam of light such as UV (Ultraviolet) and IR (Infrared).

Digital watermarking: In digital watermarking, invisible information or data codes are embedded in a separate object which can be an image, hologram, etc. the object is then modified so that enclosed data or information become imperceptible to the consumer and only identified by its reader and specific software using scanners, smartphones, webcam, the hidden data can be recognized (Zadbuke N, *et al*., 2013).

Forensic markers: Forensic markers is concretely a part of covert technologies but the only dissimilarity is in confirming authenticity as forensic markers involves scientific methods including lab testing or field test equipment's.

Biological taggants: These are utilized in product development and also used in packaging constituents in an immensely small amount or lesser amount in Parts per Million (PPM). As they are present in such a small amount they are not detected by regular analytical techniques and thus for proving authenticity needs a particular lock and key reagent tool/equipment.

Micro taggant: In this coded data or information is incorporated into microscopic particles that are observed only under a microscope. As dots and strands, these micro taggants can be employed directly in packaging constituents or in adhesives. When under a microscope, these microscopic particles are examined multi-coloured fragments or layers with distinctive color pattern provides rapid authentication (Kumar AK, *et al*., 2013).

Child Resistant (CR) packaging

Child-Resistant (CR) packaging is an important form of the packaging used for mitigating the risk of children administering medications or harmful products. These Child-Resistant packages reduce gaining access to the products by making it arduous to open by the children and at the same time make sure that these packages are readily opened and closed by adults (Devi KV, *et al*., 2007). As reported by WHO approximately 3000 young children per year accidentally die because of acute poisoning mostly taking place at home. In children major reason for poisoning (non-fatal) is consuming adult medicine owned by their parents or grandparents (Schwebel DC, *et al*., 2017).

After the initiation of Child-Resistant packaging, WHO and research have recorded a significant decrease in accidental poisoning of children. CR packaging has resulted in a great advantage for pharma industries and medicines are packaged in Child-Resistant packaging as per set rules and guidelines of the country (Khunt BP and Shah KV, 2012).

Types of Child Resistant (CR) packaging:

Re-closable packages: These are the packages that can be opened several times for dispensing the product contained in them and can be reclosed while maintaining the level of security required for Child-Resistant packaging. These re-closable packages should be examined to prove its adherence to (International Organization for Standardization) ISO 8317:2015

Non-reclosable packages: These are the packages that once opened cannot be reclosed properly or cannot be reconstructed again to be used as a Child-Resistant package. These non-reclosable packages must be examined to prove its accordance with BS-EN-14375 (British Standards European Norm). Blister and strip packs are the most commonly utilized non-reclosable packages (Malhotra S, *et al*., 2013).

Blister packaging: In pharmaceutical industries blister packaging is widely used as these packages can be efficiently made to comply with Child-Resistant standards. These blister packages offer appreciable protection and have a low cost. These packages are difficult to open by the children as they contain multiple layered backing made of aluminum, coldform foil, PVC (Polyvinyl Chloride), etc. but adults can simply open up the blister packaging by removing the back layer of packaging from allocated places or by pushing the medicaments including tablets or capsules across the back layers.

Child-Resistant (CR) closures and caps: Child-Resistant closures and caps because of having advanced designs, easy to use and safety components are being manufactured for a long time. These closures and caps have locking mechanisms and for opening it a special technique is required thus making

it difficult to open by children. The user has to follow 3 popular mechanisms to unlock the cap-simultaneously squeezing and turning the cap, pushing the cap while turning, turning, and then lifting the lid (Blok D, *et al*., 2016).

Smart packaging

Smart packaging is forecast to grow and expected to reach a projected value of $26.7 billion by 2024 (Schaefer D and Cheung WM, 2018). Nowadays, smart packaging technology is used for foods, pharmaceuticals, and many other types of products.

Benefits of smart packaging for patients and pharmaceutical supply chain management:

- Enhance patient compliance/adherence
- Confirm authenticity
- Support tracking
- Anti-counterfeiting
- Addiction prevention efforts
- Protect shelf life

Types of smart packaging:

Active packaging: It is packaging system used for pharmaceuticals, helps in displaying information on quality and improves safety. It has potential to sense quality of the product, the inner atmosphere of the package, or the shipping environment. It includes technologies such as oxygen scavengers, desiccants, colour changing inks, odour absorbers/emitters, microwave susceptors, etc. Examples are: Tamper freeze ink changes from clear to blue when exposed to temperatures below -10°C. Tamper Heat ink changes from grey to orange (or grey to pink) if exposed to heat greater than 65°C.

Intelligent packaging: This is more interactive and provides a way to receive, store, and/or deliver information such as QR codes, Near-Field Communication and Radio Frequency Identification, printed electronics, smartphones, smartphone apps, the Cloud, and the Internet. Some examples are:

Pharmaceutical packaging with NFC tags: NFC is a smart solution to deliver information in an interactive way on the patient's smartphones, for instance *via* video regarding the dosing.

Packaging embedded with sensor: It uses sensors of microchips as a way of recording data for accurate dosing and dose monitoring. As an example whenever a patient removes a pill out of the packaging, a built-in sensor will record this data and upload it to a cloud source. This allows physicians to monitor when pill was taken and how often they were taken. Simple metered dosing systems are added to calendar-enabled closure technologies tracking and counting pills as they are dispensed and send the data to a smartphone.

DISCUSSION AND CONCLUSION

Finally, it may be concluded from the review article that the pharmaceutical packaging industry is somehow engaged in the manufacturing process of the drug product. That's why it becomes necessary that the packaging material we use enhances the value of the product. Because of the rising demand for advanced pharmaceutical packaging in the market, huge development has occurred. The acceptance and utilization of the latest techniques are required for attaining better results.

In the pharmaceutical packaging field, a lot of advancements have already taken place and still, there is scope for more enhancements. As compared to the conventional packaging available in the market, the latest pharmaceutical packaging techniques are focused on current issues like- child safety, cost-efficient packaging, counterfeiting of products, correct dosage, tampering of the product, or package. Therefore the latest techniques discussed in the review article appear to be optimistic in packaging pharmaceutical product.

REFERENCES

1. Keerthi M, Prasanna JL, Sharuna KS, Rao NR. A review on packaging for different formulations. Asian J Res Pharm Sci. 2014; 4(3): 141-151.
2. World Health Organization. Guidelines on packaging for pharmaceutical products. WHO Tech Rep Ser. 2002; 902(902): 120-154.
3. Singh A, Sharma PK, Malviya R. Eco Friendly Pharmaceutical Packaging Material. World Appl Sci J. 2011; 14(11): 1703-1716.
4. Bairagi PD, Darekar AB, Gondker SB, Saudagar RB. Pharmaceutical packaging materials: A brief review. World J Pharm Pharm Sci. 2020.
5. Kulkarni S, Agrawal A, Sharma SB, Jain S. Creative innovations in pharmaceutical packaging. Indian J Pharm Pharmacol. 2015; 2(4): 230-235.
6. Nasa P. A review on pharmaceutical packaging material. World J Pharm Res. 2014; 3(5): 344-368.
7. Jadhav GB, Zalte AG, Saudagar RB. Advances in pharmaceutical packaging. World J Pharm Pharm Sci. 2014; 3(5): 194-204.
8. Kunal CM, Akhilesh D, Kumar BS. Recent trends in pharmaceutical packaging: A review. Int J Pharm Chem Sci. 2012; 1(3).
9. Dobrucka R, Cierpiszewski R. Active and intelligent packaging food-Research and development: A review. Pol J Food Nut Sci. 2014; 64(1).
10. Pareek VI, Khunteta A. Pharmaceutical packaging: Current trends and future. Int J Pharm Pharm Sci. 2014; 6(6): 480-485.
11. Reed CH. Recent technical advancements in blow-fill-seal technology. Business briefing: Pharmagenerics. 2002:1-4.
12. Sinclair CS, Tallentire A. Performance of blow/fill/seal equipment under controlled airborne microbial challenges. J Pharm Sci Technol. 1995; 49(6): 294-299.
13. Ingelheim B. Aseptic production of pharmaceuticals in boehringer ingelheim using blow-fill-seal technology. Business Briefing: Pharmatech. 2003.
14. Baban DG. Advance techniques in packaging of pharmaceutical. World J Pharm Res. 2017; 6(2): 452-463.
15. Bradley A, Probert SP, Sinclair CS, Tallentire A. Airborne microbial challenges of blow/fill/seal equipment: A case study. J Pharm Sci Technol. 1991; 45(4): 187-192.
16. Krayukhina E, Tsumoto K, Uchiyama S, Fukui K. Effects of syringe material and silicone oil lubrication on the stability of pharmaceutical proteins. J Pharm Sci. 2015; 104(2): 527-535.
17. Gangane PS, Mahajan NM, Ahajan UN, Hiranwar SR. Delivering Biologics in Prefilled Syringes: An innovation in parenteral packaging. Int J Pharm Technol. 2020; 10(1): 58-66.
18. Lull ME, Piacentino JJ, Traina AN. Stability of U-500 regular insulin in prefilled syringes. J Am Pharm Assoc. 2013; 53(3): 304-306. [Pubmed]
19. Glenn AT. Prefillable syringes: Trends and growth strategies. ON Drug Delivery Ltd. 2006.
20. Michael NE. Offering a new choice in glass prefillable syringes. ON Drug Delivery Ltd. 2008.
21. Makwana S, Basu B, Makasana Y, Dharamsi A. Prefilled syringes: An innovation in parenteral packaging. Int J Pharm Investig. 2011; 1(4): 200.[Pubmed]
22. Kale NS, Kazi A, Kale SS. Drug prefilled non-reusable syringes as drug-device. World J Pharm Res. 2015; 3(10): 2095-2110.

23. Thomas S, Mathias R. Prefilled syringes: Why new developments are important in injectable delivery today. Irish Patents Office. 2010.
24. Wohland A, Houy S, Voldrich S, Hormes R, Lehnicke S, Witzmann A, *et al*. Encoding and reading of codes on glass containers for pharmaceutical and diagnostic products. Pharm Ind. 2009; 71(10): 1770-1774.
25. Boylan JC, Nail SL. Parenteral products. Modern Pharmaceutics 2002; 597-646.
26. Danielle L. Advanced innovations on a new generation of plastic prefilled syringes. ON Drug Delivery Ltd. 2010.
27. Modi S, Wadhwa S. Multiple strategies and technologies to combat counterfeit drugs. CSC Papers. 2009.
28. Shah RY, Prajapati PN, Agrawal YK. Anticounterfeit packaging technologies. J Adv Pharm Technol Res. 2010; 1(4): 368.
29. Dhar R. Anti-counterfeit packaging technologies: A strategic need for the Indian industry. Confederation of Indian Industry. 2009.
30. Francom J. RFID: A survey of ethical and privacy concerns. Issues in Information Systems. 2007; 3(2): 337.
31. Kwok SK, Tsang AH, Ting JS, Lee WB, Cheung BC. An intelligent RFID-based electronic anti-counterfeit system (InRECS) for the manufacturing industry. IFAC Proceedings Volumes. 2008; 41(2): 5482-5487.
32. Üstündağ A. RFID technology: A paradigm shift in business processes. 35th International Conference on Computers and Industrial Engineering. 2005; 2065-2070.
33. Benbasat AY. A survey of current optical security techniques. Massachusetts: MIT Media Lab. 1999: 1-20.
34. Mali DK, Mitkare SS, Moon RS, Kshirsagar R. Anti-counterfeit packaging in pharma industry: Review. Int J Pharm Pharm Sci. 2011; 3(3): 4-6.
35. Chowdary Y, Soumya M, Rajasekhar N, Sai S, Chowdary MS. A review on anti-counterfeit packaging and use of ICT tools to combat the issue of counterfeiting. Int J Pharm Biol Sci Arch. 2012; 3(4): 7016-7011.
36. Weinstein R. RFID: A technical overview and its application to the enterprise. IT professional. 2005; 7(3): 27-33.
37. Kannan S. Counterfeit drugs targeted by technology in India. BBC News. 2011.
38. Zadbuke N, Shahi S, Gulecha B, Padalkar A, Thube M. Recent trends and future of pharmaceutical packaging technology. J Pharm Bioallied Sci. 2013; 5(2): 98.[Pubmed]
39. Kumar AK, Gupta NV, Lalasa P, Sandhil S. A review on packaging materials with anti-counterfeit, tamper-evident features for pharmaceuticals. Int J Drug Dev Res. 2013; 5: 26-34.
40. Devi KV, Burande M, Deepak H, Jobanputra SB. Packaging solutions to the changing pharma market needs. Pharma Times. 2007; 39: 29-34.
41. Schwebel DC, Evans WD, Hoeffler SE, Marlenga BL, Nguyen SP, Jovanov E, *et al*. Unintentional child poisoning risk: A review of causal factors and prevention studies. Child Health Care. 2017; 46(2): 109-230.
42. Khunt BP, Shah KV. Innovation in Packaging: A review. Int Res J Pharm Appl Sci. 2012; 2(2): 65-78.
43. Malhotra S, Arora RK, Singh B, Gakhar U, Tonk R. Child resistant packaging: A prime concern for packaging of medicinal products. Int J Pharm Sci Ver Res. 2013; 22(2): 79-88.
44. Blok D, Ruiter I, Wever R. Operability of child-resistant caps: Review of current solutions and alternative ideas. 20th IAPRI world conference on packaging Campinas. 2016.
45. Schaefer D, Cheung WM. Smart packaging: Opportunities and challenges. Procedia CIRP. 2018; 72: 1022-1027.