

Mucoadhesive Means of Drug Delivery–An Appraise

Yirivinti Hayagreeva Dinakar

Creative educational society's college of pharmacy, Kurnool, India

***Corresponding Author:** *Yirivinti Hayagreeva Dinakar, Creative educational society's college of pharmacy, Kurnool, India*

Abstract: *Mucoadhesion is a novel way of improvising the performance of a drug so as to enhance the bioavailability, therapeutic efficiency and to reduce the frequency of administration etc. It was introduced to overcome certain problems in the field of controlled drug delivery. Bioadhesion is defined as the process in which a polymer which is natural or synthetic in nature adheres to a biological moiety. If the biological moiety is a mucous membrane it is called mucoadhesion. The current review focuses on mucoadhesion, a brief information on polymers used for mucoadhesion and the potential routes for this process.*

Keywords: *Mucoadhesion , Drug delivery, Polymers ,Mucus.*

1. INTRODUCTION

Controlled and sustained release systems have been developing since ages including the disadvantage of less GIT transit time. Several approaches have been suggested, one such approach is employment of bioadhesive polymers. These polymers cling to the epithelial surface. Bioadhesive polymers can be applied to both mucous and some non mucous membranes too [4].

Bioadhesion is a complex process [1].The first report of mucoadhesive systems was given by scrivener and schantz [33]. Prof. Joseph .R. Robinson is the father of mucoadhesion[43]. The process in which a polymer (natural or synthetic) attach or adhere to the biological substrate for an extended period of time is termed as bioadhesion .The aim is to deliver the drug to the specific area for prolonged period of time through interfacial forces [2,3].

Bioadhesive polymers can be applied to both mucous and some non mucous membranes too [4].Whenever the biological moiety is a mucosal layer, then the process is termed as mucoadhesion. The process is influenced by the polymeric characteristics like chain length, degree of cross linking and functional groups present in the structure of polymer [1].Mucoadhesion is a newer concept introduced in the field of controlled drug delivery systems which mainly focus on improvising the drug action. The process of mucoadhesion occurs in two steps. In the first stage an intimate contact is established between polymer and the membrane and in the second step where after the contact has been established penetration of the of mucoadhesive into the crevices of the tissue or interpenetration of the chains of mucoadhesives into mucus [8].

Advantages of mucoadhesive drug delivery systems [1, 3]

- Maintenance of effective drug concentration.
- Prevents first pass metabolism.
- Localization of drug action in case of local infections.
- Improve therapeutic performance of the drug.
- Increase in gastro intestinal transit time and bioavailability.
- Prolonged drug action.
- The after effects caused due to oral administration of drug can be avoided.
- Ease of usage in the case of unconscious patients.

- Prolongation of residence time.
- Faster rate of absorption which may be attributed to high perfusion rate due to direct contact with intestinal cells.

Disadvantages of mucoadhesive drug delivery systems [32]

- Ulcer formation due to the lengthened contact with the drug.
- Lesser patient acceptability.
- Intake of food and water is restricted.

Mucin (mol wt -200 kDa-200 mDa) [45] is a thick gel like structure secreted by the goblet cell and exocrine glands and is present in the membranes of git , eye , ear, nose , rectum and vagina. The sites have potential to mucoadhesive polymers for attachment .The network of mucin glycoproteins is called mucus which forms a continuous layer and covers the internal tracts and some tubular organs on the body.1.5 to 2 liters of mucus is approximately secreted every day[12]. One of the reason for adherence is the “mucin” which itself own certain binding properties and the polymers being the other reason [4].The mucoadhesive polymers bind firmly to the mucus membrane and release the drug at controlled rates.

The various routes of mucoadhesive drug delivery systems are as follows [1]

- Buccal route
- Ocular route
- Gastro intestinal route
- Rectal route
- Nasal route
- Vaginal route

2. MUCOADHESIVE POLYMERS

The main purpose of using mucoadhesive polymers is to localize the drug action and to improve therapeutic performance of the drug .These polymers are usually water soluble or insoluble polymers which are joined together with cross linking agents[8].The employment of mucoadhesive polymers in formulating various pharmaceuticals was started first on penicillin in 1947.Polymers used are divided into two classes –first and second generation polymers. The First generation mucoadhesives include cellulose derivatives ,chitosans, carbomers, alginates which are employed in solid and semisolid dosage forms .The first generation polymers are divided into three types

- Cationic
- Anionic
- nonionic

The process of mucoadhesion in the case of cationic polymers is attributed to the electrostatic interactions between the amino groups (of the polymers) and the sialic groups (of the mucin), example- chitosan which is a semi synthetic polymer obtained by the deacetylation of the chitin .The synthetic polymers include carbomers in which the mucoadhesion occurs due to the physico-chemical properties like hydrogen bonding ,van der waal forces etc . The anionic polymers include carboxy methyl cellulose and alginates .Nonionic polymers are the class which represents weaker interactions when compared to anionic polymers and include methyl cellulose ,hydroxyl ethyl cellulose.

The second generation polymers include invasions ,lectins ,fimbrial proteins etc[13]. Lectins were first isolated from the plant cells and later their role in various biological processes of humans were identified [14]. Lectins do not bind to the mucus but bind noncovalently to the glycosilated components of the cellular membrane , hence the adhesion in the lectins termed as cytoadhesion.[13]. Lectins can be described as the potential carrier mediators for targeted drug delivery to the specific tissues due to the fact that cell surface proteins and lipids are glycosilated and these glycans represent

ligands for lectins [14].The fimbriae are the cell components .These are extracellular and long thread like protein polymers of bacteria [18] which adhere to binding moiety of the biological specific receptors [17].

The newer generation polymers include the thiolated polymers which are also called thiomers. These contain a thiol group. The main reason for the mucoadhesion to occur is the formation of covalent bonds between the thiol groups and the cysteine rich residues of the mucus [18]. These are again of two types anionic thiomers and cationic thiomers [46]. Examples of cationic thiomers include chitosan , hydroxyethyl cellulose etc and the examples of anionic thiomers include sodium carboxy methyl starch, sodium alginate cysteine conjugate etc[47]

3. CLASSIFICATION OF MUCOADHESIVE POLYMERS [1,8]

- Natural polymers

Albumin, Tragacanth, Collagen, Guar gum, Lectin, Gelatin, Chitosan, Alginates, Cyclodextrins, Hyaluronic acid etc

- Synthetic polymers:

a) Biodegradable polymers

Examples. polyadipic acid, poly lactic acid, polyaminoacids, polyphosphonates, polyphosphazenes, poly amides etc

b) Non biodegradable polymers

Examples. Poly vinyl pyrrolidone, polyvinyl alcohol, cellulose derivatives (which include methyl cellulose, sodium carboxymethyl cellulose), colloidal silica etc.

The brief description of polymers is given below

1) Albumin

Conjugation of serum albumin to PEG and then cross linked monoPEGglycolated albumin hydrogels. These are used for delivering the drug[1].

2) Hyaluronic acid [HA]

The basic structure of hyaluronic acid consists of two saccharide moieties which are D-glucuronic acid and N acetyl glucosamine .Thiolated HA is used generally. The mucoadhesion of thiolated polymers is attributed to the disulfide bonds between the sulfhydryl groups of the polymer and the cysteine rich residues present in the mucus. The thiolation of HA leads to improved mucoadhesive properties and show better stability [20].

3) Cyclodextrins (CD)

These are the oligosaccharides of the glucopyranose, which contains a central cavity (which is hydrophobic in nature) surrounded by a outer layer (hydrophilic in nature).Cyclodextrins offer several advantages like improved bioavailability ,reduces irritation ,enhanced stability, masking of taste and odour etc[21].These are been used in the mucoadhesive drug delivery systems .

4) Alginates

These are the naturally occurring polysaccharide polymers obtained from brown seaweed [22] and some bacteria too. Alginates generally consists of 1, 4 linked beta-D mannuronic acid (M) and 1, 4 alpha L guluronic acid (G) which are arranged in a homogenous or heterogeneous patterns. Sometimes alginates are chemically modified through processes like oxidation, graft co-polymerization, esterification etc, which have beneficial uses in pharmaceutical field. They are used in controlled, sustained and targeted drug delivery systems. It protects the intestinal mucosa from the gastric fluids due to its mucoadhesive properties [23].

5) Guar gum

It is obtained from Cyamopsis Tetragonolobus .The main constituent is guaran which on hydrolysis gives galactose and mannanose. In the pharmaceutical industry it is used as disintegration agent, binding agent emulsifying agent [24].

6) Chitosan

These are most widely used polymers. It is cationic polysaccharide which is known to be possessing mucoadhesive characteristics. It possesses disadvantages like

- Unmodified chitosan may increase residence time to lesser extent.
- Effective only at limited pH.

To overcome this problem chitosans are modified. The examples of modified chitosans include trimethyl chitosans, carboxy methyl chitosans, thiolated chitosans, chitosan-cysteine etc.

7) Poly lactic acid (PLA)

Poly lactic acid is a biodegradable polymer which is produced by the polymerization of lactic acid monomers synthetically [27]. PLA possesses properties like high mechanical strength, lesser toxicity, and good barrier properties. PLA has applications in the implants, drug delivery systems etc and is used mainly for packaging of certain products [29]. Triptorelin along with poly lactic acid is used for treatment of prostate cancer [28].

8) polyphosphonates

These are synthesized by the polycondensation of the aromatic or aliphatic diols with suitable aryl or alkyl phosphonic dihalides. It has applications in the drug delivery, osteogenesis, etc [30].

9) Methyl cellulose

It is a synthetic derivative of cellulose obtained by the heating the cellulose with a solution of sodium hydroxide and treating with methyl chloride. It is used as binder, used in the manufacture of capsules, used in the treatment of constipation etc [31].

10) Sodium carboxy methyl cellulose

It is widely used in the pharmaceutical industry as thickening and binding agents, in the manufacture of creams, ointments etc. It is also used as dental adhesives.

4. IDEAL PROPERTIES OF MUCOADHESIVE POLYMERS

- Polymers should be economical.
- They should be non irritant.
- Polymer and its degradation products should not be toxic.
- It should not decompose during its shelf life or storage.
- It should attach to tissue [1] without altering physical properties of delivery matrix [3] and must possess site specificity [1].
- It should form strong non covalent bonds with the mucous cell surface.
- Inhibit the enzymes at the active site [3].

As discussed earlier there are five routes which are potential sites for mucoadhesion. They are as follows

- Buccal route
- Ocular route
- Gastrointestinal route
- Nasal route
- Rectal route
- Vaginal route

A brief information on various routes of mucoadhesive drug delivery is as follows:

5. BUCCAL ROUTE

The buccal route allows the passage of the drug directly into the systemic circulation and avoid the first pass metabolism [34]. The drugs with short half life, sensitive to enzymatic degradation ,poor permeability are delivered by this route .The examples of polymers for this route include cellulose derivatives, chitosans, gelatin, pvp etc[38]. It is generally used for the bacterial, fungal and periodontal diseases. The various dosage forms used in buccal drug delivery include:

Films

The mucoadhesive film is known as zelactin which consists of alcoholic solution of hydroxyl propyl cellulose and three organic acids [34]. The mucoadhesive films facilitates uni and bidirectional movement of the drugs. These films are prepared by solvent casting method or hot melt extrusion methods [38]. Example –mucoadhesive film of losartan potassium [37].

Gels and Ointments

These are generally used because of their close proximity to the mucous membrane and rapid release of medicament. The mucoadhesive polymers increases the efficacy and the duration of action [38].Example- Chitosan glutamate buccal hydrogel as local anaesthetic [34].

Tablets

It consists of two layers in which one layer consists of a polymer and the other (inner core) consists cocoa butter with drug and a permeation enhancer[34].Example –buccal mucoadhesive tablets of sumatriptan succinate for the treatment of sustainable migraine[35].

The other dosage forms also include bioadhesive wafers, bioadhesive nano particles.

6. OCULAR ROUTE

Conjunctival goblet cells of the eye secrete mucin. Due to the continuous blinking of eyes and tear formation, there is removal of drug resulting in reduced bioavailability. In order to improve the drug in contact with the eye tissue [2] ,to increase the pre corneal residence time and to improve bioavailability, mucoadhesives have been employed in the ocular delivery systems[49].The example of the mucoadhesive polymers used in the ocular delivery is carbopol 934p [6] and sodium hyaluronate [4] etc.

7. GASTRO INTESTINAL ROUTE

This route generally prolong the gastric residence time of the drug[40]. Duration of mucoadhesion is limited due to the renewal of mucous surface[4] , ie production of fresh mucus to compensate the loss during peristalsis[48].The various dosage forms here include mucoadhesive tablets ,powders, mucoadhesive microspheres, mucoadhesive patch. Singh et al designed a oral controlled release mucoadhesive compressed hydrophobic matrices of atenolol and optimized the bioadhesion and drug release profile [39] ,the tablet of captopril with polymer carbopol 934p and steric acid has shown the sustained release of the drug for 16 hours [2].

8. NASAL ROUTE

The drug absorption in this route occurs either by transcellular transport, paracellular transport or by transcytosis [50].It is found to be beneficial for achieving systemic effect [6].The nasal mucus has good adhesive properties and helps in the transport of various particulate matter. The main advantage of this route is the prevention of first pass metabolism[12]. The example of this route is the Nasal mucoadhesive microspheres of diltiazem hydrochloride using the polymers ethyl cellulose, hydroxyl propyl methyl cellulose, carbopol [42].

9. RECTAL ROUTE

Also a potential site of drug delivery due to the easy access to absorptive membrane and prospect of using permeability enhancers [4]. Hydrogels are proved effective in this route of drug delivery [8]. Increase in the blood levels of sodium ampicillin was reported after the rectal administration with N-acetyl derivatives of collagen was shown by yata et al [4].

10. VAGINAL ROUTE

This route maintains the drug for longer duration of time and thereby reducing the frequency of administration [8]. The efficiency is influenced by biological atmosphere and the polymer properties etc [16]. It is preferred in local infections, delivery of contraceptives etc. Various dosage forms in this route include pessaries and suppositories, tablets, gels, films etc [43]. The advantages of this route include fast onset of action, reduced side effects, prolonged action etc. Gelatin, poly acrylic acid, hydroxyl propyl methyl cellulose, PVP, poly propylene glycols, etc are some of the polymers used [44,2].

11. CONCLUSION

Mucoadhesive system is substantial in the pharmaceutical industry as a way of improving therapeutic efficiency, bioavailability etc. It is a novel approach and many researches are under way in this system of drug delivery. Though certain developments have been ascertained still much more research and advancements are needed to be done in order to make it more effective and provide targeted drug delivery. In coming future this approach gains more importance as a novel and significant way of controlled, targeted, prolonged drug delivery.

REFERENCES

- [1] Saraswathi, B., Balaji, A., and Umashankar, M. S. "Polymers In Mucoadhesive Drug Delivery System- Latest Updates." 5, 8, 2013.
- [2] Yadav, V. K., Gupta, A. B., Kumar, R., Yadav, J. S., and Kumar, B... "Mucoadhesive Polymers: Means of Improving the Mucoadhesive Properties of Drug Delivery System." 16, 2010.
- [3] Roy, S., Pal, K., Anis, A., Pramanik, K., and Prabhakar, B. "Polymers in Mucoadhesive Drug-Delivery Systems: A Brief Note." *Designed Monomers and Polymers*, 12(6), 483–495, 2009.
- [4] Suresh.p.vyas., roop.k.khar., controlled drug delivery concepts and advancements, 2nd ed. vallabh prakashan, 2012, ch .7, pp 257-300.
- [5] Wagh, V., Inamdar, B., and Samanta, M. "Polymers used in ocular dosage form and drug delivery systems." *Asian Journal of Pharmaceutics*, 2(1), 12, 2008. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3255357/>
- [6] Kharenko, E. A., Larionova, N. I., and Demina, N. B., "Mucoadhesive drug delivery systems (Review)." *Pharmaceutical Chemistry Journal*, 43(4), 200–208, 2009.
- [7] Patil.S.B., Murthy R. S. R., Mahajan H.S., Wagh R.D., Gattani S.G., Mucoadhesive polymers: means of improving drug delivery, *Pharma times* .4(2), 38 (2006).
- [8] Kharenko, E. A., Larionova, N. I., and Demina, N. B., "Mucoadhesive drug delivery systems (Review)." *Pharmaceutical Chemistry Journal*, 43(4), 200–208, 2009.
- [9] Tangri, P., Khurana, S., and Madhav, N. V. S. (n.d.). "Mucoadhesive Drug Delivery: Mechanism And Methods Of Evaluation." 11, 2011.
- [10] R, S., D, S., and R, G... "Review on Mucoadhesive Drug Delivery System with Special Emphasis on Buccal Route: An Important Tool in Designing of Novel Controlled Drug Delivery System for the Effective Delivery of Pharmaceuticals." *Journal of Developing Drugs*, 06(01), 2017.
- [11] Ikechukwu ugwoke . M., verbeke . N., Kinget .R., the biopharmaceutical aspects of nasal mucoadhesive drug delivery, *j.pharmacy & pharmacology*, 53, 2000.
- [12] Carvalho, F. C., Bruschi, M. L., Evangelista, R. C., and Gremião, M. P. D. "Mucoadhesive drug delivery systems." 18, 2010.
- [13] Gavrovic-Jankulovic, M., and Prodanovic, R. "Drug Delivery: Plant Lectins as Bioadhesive Drug Delivery Systems." *Journal of Biomaterials and Nano biotechnology*, 02(05), 614–621, 2011.
- [14] Roy, S., Pal, K., A., Parmanik, K., Prabhakar, B., Polymers in mucoadhesive drug delivery system : a brief note, *Designed Monomers and Polymers*, 12(2009), 483-495. <https://www.ncbi.nlm.nih.gov/pubmed/21999572>
- [15] Tangri, P., Jawa, S., Jakhmola, V., and Mishra, R., "Highlights of Mucoadhesive Drug Delivery Systems: A Review." 14, 2017.
- [16] Sharma, D., Singh, M., Kumar, D., and Singh, G., "Novel Paradigms In Mucoadhesive Drug Delivery System." 3, 18, 2012.
- [17] muthukumar.m., dhachinamoorthi.m., Chandrasekhar. K.B., Sriram. N., A review on polymers used in mucoadhesive drug delivery system, *int. j. pharm & ind.res*, 1(2), 2011

- [18] Griesser, J., Hetényi, G., and Bernkop-Schnürch, A., “Thiolated Hyaluronic Acid as Versatile Mucoadhesive Polymer: From the Chemistry Behind to Product Developments—What Are the Capabilities?” *Polymers*, 10(3), 243, 2018.
- [19] Tiwari, G., Tiwari, R., and Rai, A.. “Cyclodextrins in delivery systems: Applications.” *Journal of Pharmacy and Bioallied Sciences*, 2(2), 72, 2010.
- [20] Tønnesen, H. H., and Karlsen, J.). “Alginate in Drug Delivery Systems.” *Drug Development and Industrial Pharmacy*, 28(6), 621–630, 2002.
- [21] Marta szekalska., Agata pusilowska ., Emila szymanska ., Patrycja ciosek .,Katarzyna winnicka , Alginate : current uses and future perspectives in pharmaceutical and biochemical applications , int.j. Polymer science, 0(0), 2016, 1-17.
- [22] Kokate. C.K., Purohit A.P., Gokhale .S.B., *Pharmacognosy*, 4th ed . Nirali Prakashan, 2006, Ch.7, pp 138.
- [23] M. Ways, T., Lau, W., and Khutoryanskiy, V., “Chitosan and Its Derivatives for Application in Mucoadhesive Drug Delivery Systems.” *Polymers*, 10(3), 267, 2018.
- [24] Mourya, V. K., and Inamdar, N. N.,. “Trimethyl chitosan and its applications in drug delivery.” *Journal of Materials Science: Materials in Medicine*, 20(5), 1057–1079, 2009.
- [25] Prajapati, T. K., and Patel, M. K. S., “Natural and synthetic polymers used in Bioadhesive delivery system.” 11, 2017.
- [26] Hirsjärvi, S. . “Preparation and Characterization of Poly (Lactic Acid) Nanoparticles for Pharmaceutical Use.” 50 n.d..
- [27] Jamshidian, M., Tehrani, E. A., Imran, M., Jacquot, M., and Desobry, S... “Poly-Lactic Acid: Production, Applications, Nanocomposites, and Release Studies.” *Comprehensive Reviews in Food Science and Food Safety*, 9(5), 552–571, 2010.
- [28] Chaubal, M. V., Gupta, A. S., Lopina, S. T., and Bruley, D. F.. “Polyphosphates and Other Phosphorus-Containing Polymers for Drug Delivery Applications.” *Critical Reviews in Therapeutic Drug Carrier Systems*, 20(4), 295–315, 2003.
- [29] Lavanya, D., Kulkarni, P. K., Dixit, M., Raavi, P. K., and Krishna, L. N. V. (n.d.). “Sources Of Cellulose And Their Applications – A Review.” 2(6), 21.
- [30] Amanpreet kaur ., Priya mahajan., Geeta agarwal., Harikumar S.L. Mucoadhseive drug delivry systems : a review , int .j. drug dev & res,5(1) , 2013.
- [31] Yu, T., Andrews, G. P., and Jones, D. S.. “Mucoadhesion and Characterization of Mucoadhesive Properties.” *Mucosal Delivery of Biopharmaceuticals*, J. das Neves and B. Sarmiento, eds., Springer US, Boston, MA, 35–58,2014.
- [32] Khan, S., Parvez, N., Sharma, P. K., Alam, A., and Warsi, M. H... “Novel Approaches - Mucoadhesive Buccal Drug Delivery System.” 8,2016.
- [33] Fatima, S., Panda, N., Reddy, A. V., and Fatima, S. (n.d.). “Buccal Mucoadhesive Tablets of Sumatriptan Succinate.” 14.
- [34] Rajaram, D. M., and Laxman, S. D. (2016). “Buccal Mucoadhesive Films: A Review.” *Systematic Reviews in Pharmacy*, 8(1), 31–38.
- [35] Marina koland ., Charyulu.R.N ., Prabhakara Prabhu .,mucoadhseive films of losartan potttassium for buccal delivery: design and characterization , Ind .j. phrm ed & res , 44(4) , 2010.
- [36] Shinkar, D. M., Dhake, A. S., and Setty, C. M. “Drug Delivery from the Oral Cavity: A Focus on Mucoadhesive Buccal Drug Delivery Systems.” *PDA Journal of Pharmaceutical Science and Technology*, 66(5), 466–500, 2012.
- [37] Parmender Rathee., Manish jain., Arun garg ., Arun nanda., Ashima hooda.,Gastrointestinal mucoadhesive drug delivery system : A Review , J. phrm res ,4(5) , 2011.
- [38] Asija, R., Asija, S., Vyas, P., Chauhan, R. S., and Nama, N., “Gastrointestinal mucoadhesive drug delivery system: an overview.” 2(20), 6, 2014.
- [39] Dharmendra, S., and Surendra, J. K... “Mucoadhesive Drug Delivery System.” 3, 5, 2010.
- [40] Dandge, B. H., and Dehghan, M. H. G. (n.d.). “Formulation and Evaluation of Nasal Mucoadhesive Microparticles of Diltiazem Hydrochloride.” 7.
- [41] Acarturk, F. “Mucoadhesive Vaginal Drug Delivery Systems.” *Recent Patents on Drug Delivery & Formulation*, 3(3), 193–205, 2009.
- [42] Kaur, A., Kaur, R., Jaiswal, S., and Gupta, G. D., “Mucoadhesive Vaginal Drug Delivery System: An Overview.” 6(07), 8, 2016.<https://www.ncbi.nlm.nih.gov/pubmed/22259130>.
- [43] Pallavi. K., Soumya.K., Ratna kumar.K., Vaishnavi.K., Anjali.G., Suresh.D., Newer generation mucoadhesive polymers : a review inventi rapid : novel excipients , 2,2016.

- [44] Hanif, M., Zaman, M., and Qureshi, S., “Thiomers: A Blessing to Evaluating Era of Pharmaceuticals.” *International Journal of Polymer Science*, 2015, 1–9, 2015.
- [45] Ayre, A., Dand, N., and Lalitha, K. G. “Gastroretentive Floating and Mucoadhesive Drug Delivery Systems- Insights and Current Applications.” 8,2016.
- [46] Khare, A., Grover, K., Pawar, P., and Singh, I. “Mucoadhesive Polymers for Enhancing Retention in Ocular Drug Delivery: A Critical Review.” *Reviews of Adhesion and Adhesives*, 2(4), 467–502, 2014.
- [47] Ghori, M. U., Mahdi, M. H., Smith, A. M., and Conway, B. R., “Nasal Drug Delivery Systems: An Overview.” *American Journal of Pharmacological Sciences*, 10, 2015.

Citation: Dinakar, Y. (2018). *Mucoadhesive Means of Drug Delivery–An Appraise*. *ARC Journal of Pharmaceutical Sciences (AJPS)*, 4(3), pp.21-28, <http://dx.doi.org/10.20431/2455-1538.0403004>

Copyright: © 2018 Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited