A Review on Polymers in Pharmaceutical Drug Delivery Systems.

[1]Shubham A. Patil, [2]Prasad A. Mhaske, [3]Dr Vivek M. Satpute, [4]Mr Santosh A. Waghmare, [5]Dr Hemant V. Kamble

[1,2]Students, [3,4]Professor, [5]Principal,
Department of Pharmaceutics,
Loknete Shri Dadapatil Pharate College of Pharmacy,
Mandavgan Pharata, Shirur, Pune, Maharashtra, India
Corresponding Author: [1]Shubham A. Patil

***Abstract*- The current review article focuses on polymers in pharmaceutical drug delivery of therapeutic agents. These dosage forms include tablets, patches, tapes, films, semisolids and powders. Polymers are the backbone of a pharmaceutical drug delivery system as they control the release of the drug from the device. Polymers are being used extensively in drug delivery due to their surface and bulk properties. They are being used in drug formulations and in drug delivery devices. These drug delivery devices may be in the form of implants for controlled drug delivery. Polymers used in colloidal drug carrier systems, consisting of small particles, show great advantage in drug delivery systems because of optimized drug loading and releasing property. Polymeric nano particulate systems are available in wide variety and have established chemistry. Nontoxic biodegradable and biocompatible polymers are available.**

***Key words*- Polymeric Drug Delivery, Biocompatible Polymers, Smart Polymers, Polymeric Implants, Polymeric Drug Formulations.**

INTRODUCTION:

Polymers have become an integral part of drug delivery systems due to their improved pharmacokinetic properties. They have better circulation time than conventional small drug molecules thus target tissue more specifically. Tremendous use of polymers has been witnessed in the area of polymer therapeutics and Nano medicines. Polymers in reservoir based drug delivery systems have shown immense progress in the form of hydrogels and liposomes. Diffusion based drug delivery systems and solvent activated drug delivery systems are the other areas being explored for utilizing the polymers. In diffusion based drug delivery systems drug is dissolved in a non-swell able system or a fully swollen matrix which do not decompose during their activation time. Solvent activated systems like hydrogels swell and release the drug when exposed to aqueous environment; this mechanism is depicted. They are hydrophilic in nature. Biocompatible polymers offer a safe passage for drug delivery due to their well engineered molecular architecture according to the transitions in the underlying mechanisms of the biological process. Extensive Biodegradable polymers have been widely used in biomedical applications because of their known biocompatibility and biodegradability. In the biomedical area polymers are generally used as implants and are expected to perform long term service. These improvements contribute to make medical treatment more efficient and to minimize side effects and other types of inconveniences for patients. The pharmaceutical applications of polymers range from their use as binders in tablets to viscosity and flow controlling agents in liquids, suspensions and emulsions. Polymers can be used as film coatings to disguise/mask the unpleasant taste of a drug, to enhance drug stability and to modify drug release characteristics. Pharmaceutical polymers are widely used to achieve taste masking; controlled release (e.g. extended, pulsatile and targeted) enhanced stability and improved bioavailability. Monolithic delivery devices are systems in which a drug is dispersed within a polymer matrix and released by diffusion. The rate of the drug release from a matrix product depends on the initial drug concentration and relaxation of the polymer chains which overall displays a sustained release characteristic. Simple manipulation of the water solubility of polymers, by increasing their chain length through cross-linking or by hydrophobising or hydrophilizing them with copolymers and other groups yields a wealth of materials with a wide spectrum of possible application. The resulting materials are capable of a variety of drug-enhancing functions.

Polymers are able to:

- Prolong drug availability if medicines are formulated ashydrogels9 or microparticles.
- Favourably alter bio distribution, if formulated intodense nanoparticles.
- Enable hydrophobic drug administration if formulated as micelles.
- Transport a drug to its usually inaccessible site of action if formulated as gene medicines.
- Make drugs available in response to stimuli.

Over the past decades research at the level of molecular biology has unveiled the molecular basis for many diseases. New important technologies and concepts such as recombinant DNA and gene therapy have provided tools for the creation of pharmaceuticals and methods designed to specifically address such diseases. However progress towards the application of these medicines outside of the laboratory has been considerably slow principally due to the lack of effective drug delivery systems that is mechanisms that allow the release of the drug into the appropriate body compartment for the appropriate amount of time without seriously disrupting the rest of the organism functionality. The application of the polymeric materials for medical purposes is growing fast. Polymers have found applications in diverse biomedical fields such as drug delivering systems, developing scaffolds

in tissue engineering, implantation of medical devices and artificial organs, prosthesis, ophthalmology, dentistry, bone repair, and many other medical fields. Polymers have been used as a main tool to control the drug release rate from the formulations. Extensive applications of polymers in drug delivery have been realized because polymers offer unique properties which have not been attained by any other materials. Advances in polymer science have led to the development of several novel drug delivery systems.

ROLE OF POLYMERS IN DRUG DELIVERY:

Immediate drug release dosage form tablets:

Polymers including polyvinyl pyrrolidone and hydroxypropylmethylecellulose (HPMC) are found to be a good binder which increases the formation of granules that improves the flow and compaction properties of tablet formulations prior to tableting.

Capsules:

Many of the polymeric excipients used to "bulk out" capsules fills are the same as those used in intermediate release tablets. For hard and soft shell gelatin has most often used. By recent advances HPMC has been accepted as alternative material for hard and soft capsules.

Modified drug release dosage forms:

To achieve gastro retention mucoadhesive and low density, polymers have been evaluated, with little success so far their ability to extend gastric residence time by bonding to the mucus lining of the stomach and floating on top of the gastric contents respectively.

Extended release dosage forms:

Extended and sustained release dosage forms prolong the time that' systemic drug levels are within the therapeutic range and thus reduce the number of doses the patient must take to maintain a therapeutic effect there by increasing compliance. The most commonly used water insoluble polymers for extended release applications are the ammonium ethacrylate copolymers cellulose derivatives ethyl cellulose and cellulose acetate, and polyvinyl derivative, polyvinyl acetate.

Gastro retentive Dosage forms:

Gastro retentive dosage forms offer an alternative strategy for achieving extended release profile, in which the formulation will remain in the stomach for prolonged periods, releasing the drug in-situ, which will then dissolve in the liquid contents and slowly pass into the small intestine.

CLASSIFICATION OF POLYMERS:

A) Basis on interaction with water:

- Non-biodegradable hydrophobic Polymers: E.g. Polyvinyl chloride,
- Soluble Polymers: E.g. HPMC, PEG.
- Hydro gels: E.g. Polyvinyl pyrrolidine.

B) Based on polymerisation method:

- Addition Polymers: E.g. Alkane Polymers.
- Condensation polymers: E.g. Polysterene and Polyamide.

C) Based on polymerization mechanism:

- Chain Polymerization.
- Step growth Polymerization.

D) Based on chemical structure:

- Activated C-C Polymer.
- Inorganic polymers.
- Natural polymers.

E) Based on occurrence:

- Natural polymers: E.g. Proteins-collagen, keratin, albumin, cellulose.
- Synthetic polymers:- E.g. Polyesters, polyamides

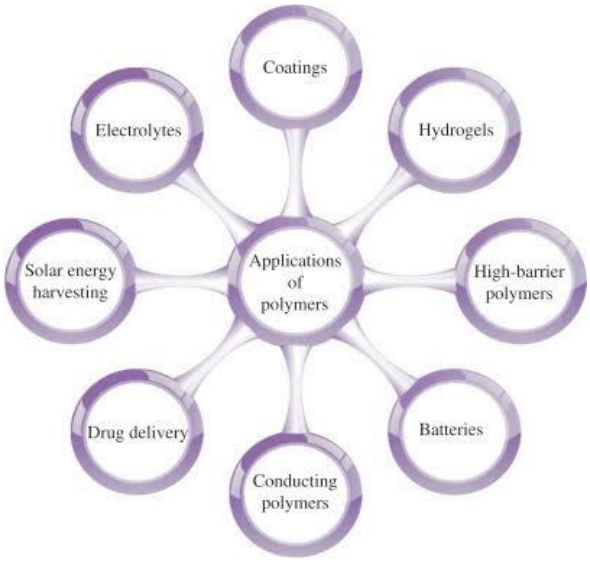
F) Based on bio-stability:

- Bio-degradable.
- Non Bio-degradable.

Characteristics of an Ideal Polymer:

- It should be versatile and possess a wide range of mechanical, physical, chemical properties.
- It should be non-toxic and have good mechanical strength and should be easily administered.
- It should be inexpensive and easy to fabricate.
- It should be inert to host tissue and compatible with environment.

Applications of Polymers:



Uses of Polymers:

- Cling film/cellophane.
- Non-stick coating (Teflon).
- Tights and clothing (Nylon, Lycra).
- Windows and doors (uPVC).
- Bottles and food packaging.
- Waterproof coatings for fabrics (Goretex).
- Dental polymers.
- Wound dressings especially for burns.
- Hydrogels for use in nappies.
- Smart materials such as memory foam.

CONCLUSION:

Polymer-based pharmaceuticals are starting to be seen as key elements to treat many lethal diseases that affect a great number of individuals such as cancer or hepatitis. Although excipients have traditionally been included in formulations as inert substances to mainly make up volume and assist in the manufacturing process, they are increasingly included in dosage forms to fulfil specialized functions for improved drug delivery because many new drugs have unfavourable physicochemical and pharmacokinetic properties. The synthetic polymers can be designed or modified as per requirement of the formulation by altering polymer characteristics and on the other hand natural pharmaceutical excipients are biocompatible, non-toxic, environment friendly and economical. Several polymers have been successfully used and others are being investigated as excipients in the design of dosage forms for effective drug delivery. The delivery of drugs in a controllable pattern is an object of intensive research, whether it is academic or applied, due to its influence on healthcare. Drug release can be carried out via different routes with alterations in temperature, pH or electrical potential; however, each separate route has short-comings and the most efficient route could be the integration of all the individual routes. Continuous researches have shown that polymers, whether synthetic or natural, have a significant and important role in delivering drugs due to:

1) Drug delivery systems based on polymers could be used locally to supply the in-demand concentration for long-term, without repeated doses at different periods of time.

2) These systems have the ability to decrease drug toxicity and drug side effects, ensuring protection of the drugs till they reach the specific target, and this leads to improvement in the absorption rates of the drug. Finally, it could be stated that there is no doubt that natural and synthetic polymers may play an important role in future pharmacy, and especially in the field of drug delivery.

REFERENCES:

1. Duncan R ; The dawning era of polymer therapeutics. Nature Reviews Drug Discovery, 2003; 2:347–360.
2. Raizada A, Bandari A, Kumar B;Polymers in drug delivery : A Review. International Journal of pharma research and development, 2010; 2(8):9-20.
3. Poddar RK, Rakha P, Singh SK, Mishra DN. Bioadhesive Polymers as a Platform for Drug Delivery: Possibilities and Future Trends. Research Journal on Phamaceutical Dosage Form and Technology, 2010; 2(1): 40-54.
4. Charman WN, Chan HK, Finnin BC, Charman SA; Drug Delivery: A Key Factor in Realising the Full Therapeutic Potential of Drug. Drug Development Research 1999; 46:316-27.
5. Chandel P, Rajkumari, Kapoor A, Polymers- A Boon To Controlled Drug Delivery System, International research journal of pharmacy (IRJP), 2013; 4(4), 28 – 34.
6. Kim S, Kim JH, Jeon O, Chan I, Park KK;Engineered Polymers for Advanced Drug Delivery. European Journal of Pharmaceutics and Biopharmaceutics. 2009; 71(3): 420-430.

7. Harekrishna Roy, Sanjay Kumar Panda, Kirti Ranjan Parida , Asim Kumar Biswal. Formulation and In-vitro Evaluation of Matrix Controlled Lamivudine Tablets. International Journal of Pharma Research and Health Sciences 2013; 1(1): 1-7.
8. Siepmann, J.; Faham, A.; Clas, S.D.; Boyd, B.; Jannin, V.; Bernkop-Schnürch, A.; Zhao, H.; Lecommandoux, S.; Evans, J.; Allen, C.; Merkel, O. Costabile, Morgan, R.; Alexander; Ricky, D.; Wildman; Roberts, C.; Leroux, J. K. Lipids and polymers in pharmaceutical technology: Lifelong companions. Int. J. Pharm., 2019, 5(58), 128-142. http://dx.doi.org/10.1016/j.ijpharm.2018.12.080.
9. Vajra Priya, V.; Roy, H.K.; Jyothi, N.; Prasanthi, K. polymers in drug delivery technology, types of polymers and applications. Sch. Acad. J. Pharm., 2016, 5(7), 305-308.
10. Larson, N.; Ghandehari, H. Polymeric conjugates for drug delivery. Chem. Mater., 2012, 24(5), 840-853. http://dx.doi.org/10.1021/cm2031569.
11. Godwin, A.; Bolina, K.; Clochard, M.; Dinand, E.; Rankin, S.; Simic, S.; Brocchini, S. New strategies for polymer development in pharmaceutical science – a short review. JPP, 2001, 53, 1175-1184. http://dx.doi.org/10.1211/0022357011776612.
12. Ringsdorf, H. Structure and properties of pharmacologically active polymers. Polymer SCI.: Symposium., 1975, 51, pp. 135-153. http://dx.doi.org/10.1002/polc.5070510111.
13. Markovsky, E.; Baabur-Cohen, H.; Eldar-Boock, A.; Omer, L.; Tiram, G.; Ferber, S.; Ofek, P.; Polyak, D.; Scomparin, A.; SatchiFainaro, R. Administration, distribution, metabolism and elimination of polymer therapeutics. J. Control. Release, 2012, 161, 446-460.http://dx.doi.org/10.1016/j.jconrel.2011.12.021
14. Duncan, R.; Ringsdorf, H.; Satchi-Fainaro, R. Polymer therapeutics—polymers as drugs, drug and protein conjugates and gene delivery systems: Past, present and future opportunities. J. Drug Target., 2006, 14(6), 337-341. http://dx.doi.org/10.1080/10611860600833856.
15. Vicky V. Mody, Introduction to Polymeric Drug Delivery,Internet Journal of Medical Update, 5(2): 2010 July;1-2.
16. Omanathanu Pillai, Ramesh, Polymers in drug delivery, Current Opinion in chemical biology, Vol 5, issue 4, 2001, 447-451.
17. Omanathanu Pillai, Ramesh, Polymers in drug delivery, Current Opinion in chemical biology, Vol 5, issue 4, 2001, 447-451.
18. Clochard M, Dinand E, Rankin S, Simic S, Brocchini S, New strategies for polymer development in pharmaceutical science-a short review, J Pharm Pharmacol, 2001, 53(9),1175- 1184.
19. Vyas SP, Khar RK. Controlled Drug Delivery: Concepts andAdvances. I st ed. Vallabh prakashan, New Delhi,2002, 156-189.Kathryn E. Uhrich ,Scott M. Cannizzaro , Robert S. Langer, Polymeric Systems for Controlled Drug Release,Chem. Rev, 99, 1999, 3181-3198.
20. Reja M, Quadir MA, Haider SS, Comparative evaluation of plastic, hydrophobic and hydrophilic polymers as matrices for controlledrelease drug delivery, J Pharm Sci 692, 2003, 274-291.
21. Taylor and Francis, Polymers in Drug Delivery System, 2006,1-236.
22. Hoffman, A.S., Hydrogels for biomedical applications, Adv. Drug Delivery Rev.54, 2002, 3–12.
23. Park, J.H., Ye, M.L., and Park, K., Biodegradable polymersfor microencapsulation of drugs, Molecules, 10, 146–161, 2005.
24. Almeida, Biomedical application of polymer based pharmaceuticals, Biomedical Engineering – Group XII,2008.