2026 Volume: 02 Issue: 06 www.ijrpa.com ISSN 2456-9995 Review Article

International Journal Research Publication Analysis

Page: 01-20

ROLE OF POLYMERS IN CONTROLLED AND SUSTAINED RELEASE FORMULATION

M. Hemapriya*[1], Dr. V. Kalvimoorthi[2], L. Gopi[3], Dr. K. Kaveri[4]

[1]M. Pharm First Year Department of Pharmaceutics,

[2]Professor Cum Head Department of Pharmaceutics,

[3]Assistant Professor Department of Pharmaceutics,

[4]Principal. Aadhibhagawan College of Pharmacy,

Rantham, Thiruvanamalai, Tamilnadu, India.

Article Received: 01 June 2026

Article Revised: 20 June 2026

Published on: 09 July 2026

***Corresponding Author: M. Hemapriya**

M. Pharm First Year Department of Pharmaceutics, Rantham, Thiruvanamalai, Tamilnadu, India.

DOI: https://doi-doi.org/101555/ijrpa.6469

ABSTRACT

Polymers have played an integral role in the advancement of drug delivery technology by providing controlled release of therapeutic agents in constant doses over long periods, cyclic dosage, and tunable release of both hydrophilic and hydrophobic drugs. From early beginnings using off-the-shelf materials, the field has grown tremendously, driven in part by the innovations of chemical engineers. Modern advances in drug delivery are now predicated upon the rational design of polymers tailored for specific cargo and engineered to exert distinct biological functions. In this review, we highlight the fundamental drug delivery systems and their mathematical foundations and discuss the physiological barriers to drug delivery. Hierarchical progress in modern drug delivery begins with the use of polymer carriers to elicit spatiotemporal release of therapeutics in both pulsatile dose delivery products and implanted reservoir systems. Although conventional drug delivery formulations have contributed greatly to the treatment of disease, the emergence of potent and specific biological therapeutics has escalated the impetus for intelligent delivery systems. Tremendous progress has been made as a result of the exploration of diffusion-controlled and solvent-activated formulations in drug delivery. Hydrogels and other polymer-based carriers have been developed to provide safe passage for pharmaceuticals through inhospitable physiological regions. Polymers of controlled molecular architecture can be engineered to give a well-defined response to external conditions as a result of a solid understanding of the

underlying mechanisms and the nature of behavioral transitions. Polymers incorporated with therapeutics can be bioactive to provide their own therapeutic benefit or can be biodegradable to improve release kinetics and prevent carrier accumulation. Pharmaceutical agents have been conjugated to polymers to modify transport or circulation half-life characteristics as well as to allow for passive and active targeting.

KEYWORDS: Polymers, controlled molecular, biological therapeutics, Pharmaceutical agents, conventional drug delivery.

1. INTRODUCTION:

The word polymer is derived from two Greek words poly means many means unit. In basic terms, a polymer is a long-chain molecule that is composed of a large number of repeating units of identical structure. These identical structures, we understand as a unit made up of two or more molecules, join together to form a long chain. Polymers are becoming increasingly important in the field of drug delivery. 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 the unpleasant taste of a drug, to enhance drug stability and to modify drug release characteristics. The review focuses on the significance of pharmaceutical polymer for controlled drug delivery application. Sixty million patients benefit from advanced drug delivery systems today, receiving safer and more effective doses of the medicines they need to fight a variety of human ailments, including cancer.

Controlled Drug Delivery (CDD) occurs when a polymer, whether natural or synthetic, is judiciously combined with a drug or other active agent in such a way that the active agent is released from the material in a predesigned manner. The release of the active agent may be constant over a long period, it may be cyclic over a long period, or it may be triggered by the environment or other external events. In any case, the purpose behind controlling the drug delivery is to achieve more effective therapies while eliminating the potential for both under and overdosing. Polymers are playing important role in pharmaceuticals. They are used as binders in tablet, increases solubility of poorly soluble drugs, used as film coatings on drugs to disguise their taste and enhances their stability.

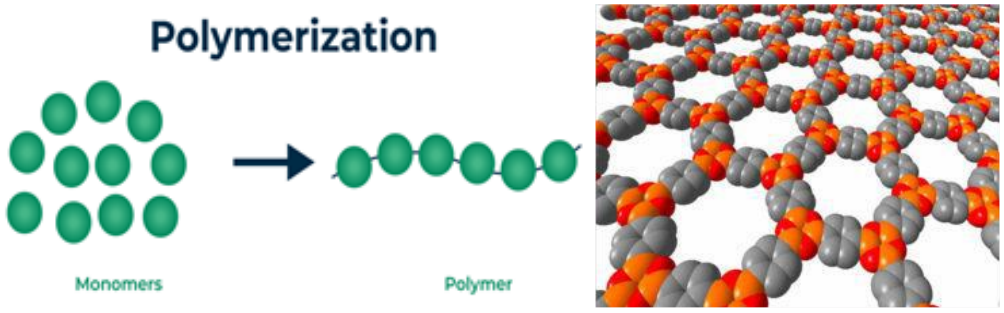

Figure 1: Process of Polymerization.

2. HISTORY

A polymer is a large molecule, or macromolecule, composed of many repeated subunits. Because of their broad range of properties, (Painter et al 1997) both synthetic and natural polymers play an essential and ubiquitous role in everyday life. Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. Their consequently large molecular mass relative to small molecule compounds produces unique physical properties, including toughness, visco elasticity, and a tendency to form glasses and semi crystalline structures rather than crystals.

The term was coined in 1833 by Jöns Jacob Berzelius, though with a definition distinct from the modern IUPAC distinction. The modern concept of polymers as covalently bonded macromolecular structures was proposed in 1920 by Hermann Staudinger, who spent the next decade finding experimental evidence for this hypothesis. Historically, products arising from the linkage of repeating units by covalent chemical bonds have been the primary focus of polymer science; emerging important areas of the science now focus on non-covalent links.

Poly isoprene of latex rubber and the polystyrene of Styrofoam are examples of polymeric natural/biological and synthetic polymers respectively. In biological contexts, essentially all biological macromolecules i.e., proteins (polyamides), nucleic acids (poly nucleotides), and polysaccharides are purely polymeric, or are composed in large part of polymeric components e.g., isoprenylated lipid modified glycol proteins, where small lipid molecule and oligosaccharide modifications occur on the polyamide backbone of the protein respectively. In biological contexts, essentially all biological macromolecules i.e., proteins (polyamides), nucleic acids (poly nucleotides), and polysaccharides are purely polymeric, or are composed in large part of polymeric components e.g., isoprenylated lipid modified glycol

proteins, where small lipid molecule and oligosaccharide modifications occur on the polyamide backbone of the protein.

3. CONVENTIONAL DOSAGE FORMS

Pharmaceutical products designed for oral delivery are mainly conventional drug delivery systems, which are designed for immediate release of drug for rapid/immediate absorption. Administration of the conventional dosage form by extravascular route does not maintain the drug level in blood for an extended period of time. The short duration of action is due to the inability of conventional dosage form to control temporal delivery.

The conventional dosage forms like solution, suspension, capsule, tablets and suppository etc. have some limitations such as:

- Drugs with short half-life require frequent administration, which increases chances of missing the dose of drug leading to poor patient compliance.
- A typical peak-valley plasma concentration-time profile is obtained which makes attainment of steady state condition difficult. The unavoidable fluctuations in the drug concentration may lead to under medication or over medication as the steady state concentration values fall or rise beyond the therapeutic range.
- The fluctuating drug levels may lead to precipitation of adverse effects especially of a drug with small therapeutic index, whenever overdosing occurs. In order to overcome the drawbacks of conventional drug delivery systems, several technical advancements have led to the development of controlled drug delivery system that could revolutionize method of medication and provide a number of therapeutic benefits.

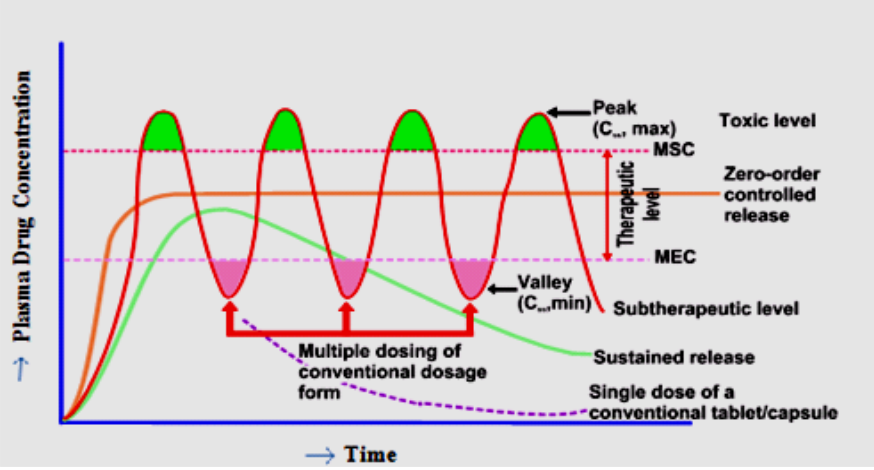

Figure 2: A hypothetical plasma concentration-time profile from conventional multiple dosing and single doses of sustained and controlled delivery formulations. (MSC = maximum safe concentration, MEC = minimum effective concentration)

3.1 EXTENDED RELEASE

USP defines the extended release (ER) dosage form as the one that allows at least a 2-fold reduction in dosing frequency or significant increase in patient compliance or therapeutic performance when compared with as conventional dosage form.

3.1.1 Controlled Drug Delivery System:

Controlled releases are drug delivery system which maintains constant level of drug in blood and tissue for extended period of time. It implies a predictability and reproducibility in drug release kinetics. In other words, the rate and duration are designed to achieve a desired concentration. Examples include Plendil ER (Felodipine), Agon SR (Felodipine), Kapanol (Morphine sulphate) and Slow-K (Potassium chloride). TIME Rx is a CR product based on agglomerated hydrophilic matrix consisting of xanthum gum and locust bean gum1-5.

Different types of controlled drug delivery systems

- Oral (through the mouth)
- Topical (skin)
- Trans- mucosal (nasal, buccal, sublingual, vaginal, ocular, rectal)
- Parenteral (injection into systemic circulation)
- Inhalation routes.

Controlled drug delivery occurs when a polymer, whether natural or synthetic, is judiciously combined with a drug or other active agent in such a way that the active agent is released from the material in a predesigned manner.

3.1.2 Sustained Release Drug Delivery System:

A sustained-release drug product is sustained release dosage forms designed to clemency a drug at a fixed rate by upholding a constant drug level for a definite period of time. Usually, the drug may be delivered in an initial therapeutic dose, followed by a slower and constant release. They have certain advantages like increase the bioavailability of drugs, ease of administration often convenient, stability of the drug, maintain uniform drug concentration in plasma, reduce the gastrointestinal irritation and side effect, toxicity to be minimize, have some demerits like release rate are affected by different aspect as food and the amount of transit through the gut, high cost, high probability of drug tolerance and dumping, high rate of first pass metabolism, and poor invitro and invivo correlation.

The difference between controlled release and sustained release, Controlled drug delivery- which delivers the drug at a pre determined rate for a specified period of time. Controlled release is perfectly zero order release that is the drug release over time irrespective of concentration.

Sustained release dosage form- is defined as the type of dosage form in which a portion i.e. (initial dose) of the drug is released immediately, in order to achieve desired therapeutic response more promptly, and the remaining (maintenance dose) is then released slowly there by achieving a therapeutic level which is prolonged, but not maintained constant. Sustained release implies slow release of the drug over a time period. It may or may not be controlled release.

Difference Between Sustained & Controlled Dosage Form

Table: 1 Difference Between Sustained & Controlled Dosage Form.

SUSTAINED RELEASE DOSAGE FORM	CONTROLLED RELEASE DOSAGE FORM
The total dose of drug and frequency of dosing is reduced by SR dosage form and therefore, it improves the patient compliance and efficacy of a treatment.	Frequency of dosing is more in conventional dosage forms as a result, total amount of drug administered is large, but efficiency of the treatment is also poor.
The plasma concentration of the drug in blood is maintained at a steady level and prolonged therapeutic action of the drug is achieved.	In multiple dosing of conventional dosage forms, the plasma concentration of the drug shows variations in blood; hence, prolonged action cannot be achieved.
By using matrix system SR tablet dose dumping can be avoided and toxicity due to overdose can be reduced.	In case of conventional dosage form, probability of dose dumping is more due to fast release of drug and multiple dosing.
The overall cost of treatment is less, because the number of dose is less, but cost of production of single unit of SR dosage form would be more due to requirement of costly processes and equipment.	The cost of production is less, but total cost of treatment would increase because of multiple dosing.
The in-vitro and in-vivo correlations are excellent.	In-vitro and in-vivo correlation may be poor.

4. TYPES OF POLYMER FOR DRUG DELIVERY SYSTEM

Polymers As For Floating Drug Delivery System: To target the delivery of a drug to a specific region of the gastrointestinal tract, such as the stomach, floating drug delivery systems typically use polymers. Various natural polymers have been investigated for their potential in stomach-specific drug delivery, including chitosan, pectin, xanthan gum, guar gum, gellan gum, karaya gum, psyllium husk, starch, and alginates.

Mucoadhesive Medication Delivery Systems Require Polymers: With benefits like increased polymer residence time, improved penetration, site-specific adhesion, and enzymatic inhibition, the next generation of mucoadhesive polymers for buccal drug delivery will surely be used for the buccal delivery of a wide range of therapeutic compounds. The delivery of medicinal macromolecules has great potential when it comes to this family of polymers. The most promising field of current research efforts targeted at the safe and efficient delivery of medications via the buccal mucosa seems to be the application of lectin and lectinomimetics.

Polymers For Medication Delivery Implants: Because of their improved biocompatibility and ability to conform to tissue without breaking during insertion or tissue reconfiguration processes, polymer microneedles are of interest for implanted drug delivery. Several polymers, including as polydimethylsiloxane (PDMS), polylactic and polyglycolic acid (PLGA), block copolymer hydrogels, SU-8 photoresist, and polyimide, have been used to manufacture these devices.

Polymers For Long-Term Effect: Utilizing a novel, very effective osteogenic chemical, biodegradable microspheres are created using the polymer utilized in the sustain release method. To attain the continuous release of 3-ethyl-4-(4-methylisoxazol-5-yl)-5-(methylthio) thiophene-2-carboxamide, a novel and powerful osteogenic agent for the management of bone disorders, microspheres containing BFB0261 were created, along with newly synthesized biodegradable polymers or copolymers, namely three poly (d, l-lactic acid) (PLA), four poly (d, l-lactic acid–co-glycolic acid) (PLGA), and eight poly (d, l-lactic acid)-block-poly(ethylene glycol) (PLAPEG) and microspheres containing BFB0261. The microspheres' release pattern was assessed.13

Polymers For Colon Targeted Drug Administration: A significant part of the colon-targeted drug delivery system is polymer. It shields the medication against deterioration or leakage into the small intestine and stomach. Moreover, it guarantees the medication's quick or regulated release in the proximal colon. Using dicarboxylic acid linkers (succinate and glutarate), McLeod et al. produced glucocorticoid-dextran conjugates by attaching dexamethasone and methylprednisolone to dextran. When there is a high bacterial count in the cecal and colonic contents, dextran conjugates quickly breakdown but resisted hydrolysis in the contents of the upper GI tract.

Polymers In Tissue Engineering: A wide range of natural–origin polymers with special focus on proteins and polysaccharides might be potentially useful as carriers systems for active biomoleculesor as cell carriers with application in the tissue engineering field targeting several biological tissues. Several polyshaccrides -based polymers in the tissue engineering such as chitosan, starch, alginate etc.

Micelles Made Of Polymers: The development of polymeric micelles (PMs) was prompted by the urgent demand for highly selective drug carriers. Hydrophobic, poorly water soluble anticancer medicines can be encapsulated in PMs made of an amphiphilic block copolymer. Significantly, key characteristics of PMs as drug carriers, such as stability, loading capacity, and drug release kinetics, enable PMs to be selectively delivered to the tumor site through a passive process known as the increased permeability and retention effect.

Polymers Utilized In Targeted Medication Delivery Micro And Nanoparticles: These polymers are biocompatible and biodegradable, and much research has been done on them lately. The pharmacokinetics of polymeric nano carriers, including poly (DL-lactide-co-glycolide), have demonstrated potential for both cellular and whole-body administration (passive targeting). The process of chemically attaching a drug to a targeting component that interacts strongly with antigens or receptors present on the target tissue is typically used to accomplish active drug targeting. This results in the drug being preferentially accumulated in the targeted organ, tissue, or cells.

Polymer Drug Conjugate: These macromolecular prodrugs consist of at least three components: a natural or synthetic, water-soluble polymeric carrier (typically of 10,000–100,000 Da), a biodegradable polymer–drug linkage (often an ester or peptidyl linkage), and a bioactive antitumor agent. Polymer–drug conjugates achieve tumour-specific targeting through the enhanced permeability and retention (EPR) effect.

5. CLASSIFICATION OF POLYMERS:

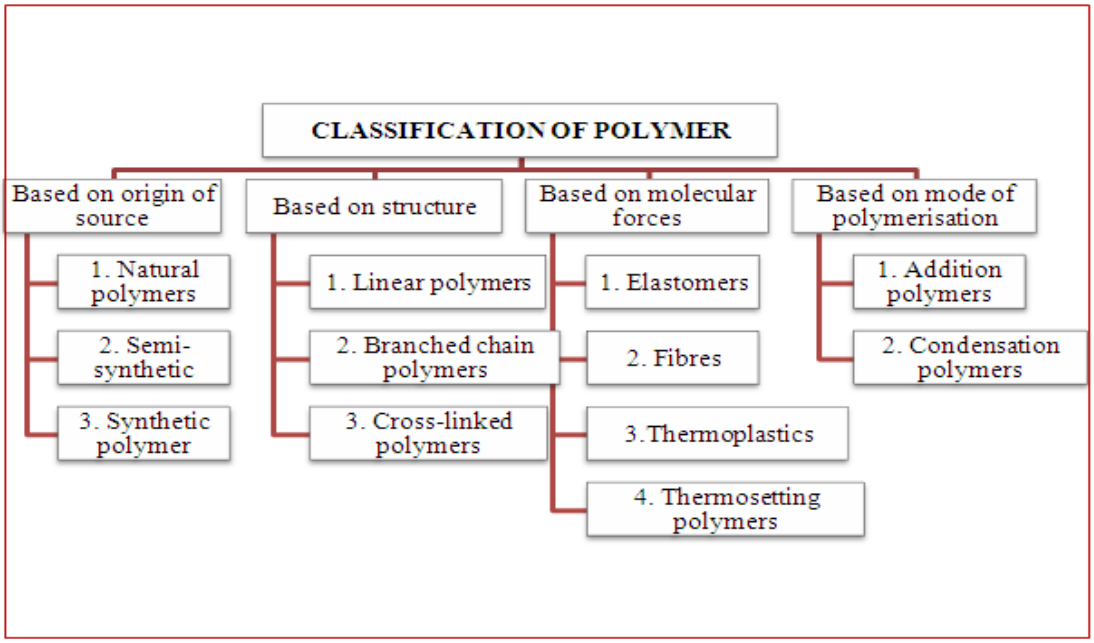

Figure 3: Classification Of Polymers.

The polymers for the drug delivery system are classified on the following characteristics:-

5.1 BASED ON SOURCE OF ORIGIN

Natural polymers: Natural polymers are polymers which occur in nature and are existing in natural sources like plants and animals. Some common examples are Proteins (which are found in humans and animals alike), Cellulose and Starch (which are found in plants) or Rubber (which we harvest from the latex of a tropical.

Synthetic polymers: Synthetic polymers are polymers which humans can artificially create/synthesize in a lab. These are commercially produced by industries for human necessities. Some commonly produced polymers which we use day to day are Polyethylene (a mass-produced plastic which we use in packaging) or Nylon Fibers (commonly used in our clothes, fishing nets etc.) For example-Polyethylene, Polypropylene, Buna-S, and Nylon-6,6.

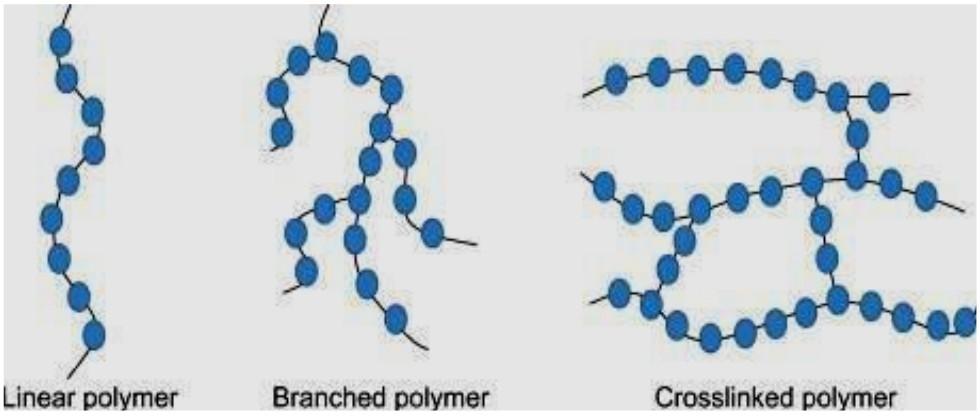

Figure 4: Linear Polymer, Branched Chain Polymer, Crossed Linked Polymer.

Semi-synthetic polymers: Semi-Synthetic polymers are polymers obtained by making modification in natural polymers artificially in a lab. These polymers formed by chemical reaction (in a controlled environment) and are of commercial importance. Example: Vulcanized Rubber (Sulphar is used in cross bonding the polymer chains found in natural rubber) Cellulose acetate (rayon).

5.2 BASED ON STRUCTURE

Linear polymers: These polymers are similar in structure to a long straight chain which identical links connected to each other. The monomers in these are linked together to form a long chain. These polymers have high melting points and are of higher density. This polymer is largely used for making electric cables and pipes. Ex: Polythene, PVC, Nylon, Polyesters, etc.

Branch chain polymers: The structure of these is like branches originating at random points from a single linear chain. Monomers join to form a long straight chain with some branched chains of different lengths. As a result of these branches, the polymers are not closely packed together. They are of low density having low melting points. Low-density polyethene (LDPE) used in plastic bags and general-purpose containers is a common example. Amylopectin and glycogen are some other examples.

Cross linked (or) network polymers: In this type of polymers, monomers are linked together to form a three-dimensional network. The monomers contain strong covalent bonds as they are composed of bi-functional and tri-functional in nature. These polymers are brittle and hard. Ex:- Bakelite (used in electrical insulators), Melamine, Formaldehyde resin, Vulcanized rubber, etc.

5.3 BASED ON MOLECULAR FORCE:

Elastomers: Elastomers are rubber-like solid polymers that are elastic in nature. The polymer chains are held by the weakest intermolecular forces, hence allowing the polymer to be stretched. crosslinks between the polymer chains which help it in retracting to its original position, and taking its original form. Ex: Neoprene, Vulcanized rubber.

Thermplastic polymers: Thermoplastic polymers are long-chain polymers in which inter-molecules forces (Van der Waal's forces) hold the polymer chains together. These polymers when heated are softened (thick fluid like) and hardened when they are allowed to cool down, forming a hard mass. They do not contain any cross bond and can easily be shaped by heating and using moulds. A common example is Polystyrene or PVC (which is used in making pipes).

Thermosetting polymers: Thermosetting plastics are polymers which are semi-fluid in nature with low molecular masses. When heated, they start cross-linking between polymer chains, hence becoming hard and infusible. They form a three-dimensional structure on the application of heat. This reaction is irreversible in nature. The most common example of a thermosetting polymer is that of Bakelite, which is used in making electrical insulation.

Fibres: These are a class of polymers which are a thread like in nature, and can easily be woven. They have strong inter-molecules forces between the chains giving them less elasticity and high tensile strength. The intermolecular forces may be hydrogen bonds or dipole-dipole interaction. Fibres have sharp and high melting points. A common example is that of Nylon-66, which is used in carpets and apparels. Other example such as Nylon-6 and Terylene.

5.4 BASED ON MODE OF POLYMERISATION:

Addition polymers: These type of polymers are formed by the repeated addition of monomer molecules. The polymer is formed by polymerization of monomers with double or triple bonds (unsaturated compounds). Note, in this process, there is no elimination of small molecules like water or alcohol etc (no by-product of the process). Addition polymers always have their empirical formulas same as their monomers. Example: ethene n(CH2=CH2) to polyethene -(CH2-CH2)n-. Example: Polyethylene Polystyrene

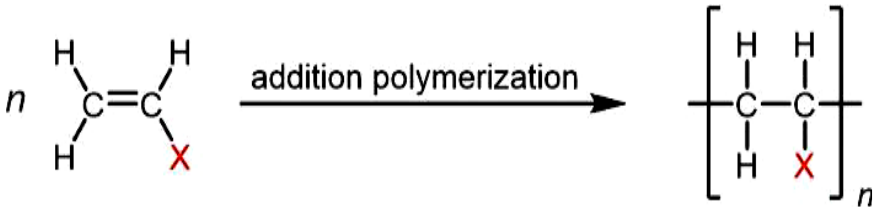

Figure 5: Addition Polymer.

Condensation polymers: These polymers are formed by the combination of monomers, with the elimination of small molecules like water, alcohol etc. The monomers in these types of condensation reactions are bi-functional or tri-functional in nature. A common example is the polymerization of Hexamethylenediamine and adipic acid. to give Nylon – 66, where molecules of water are eliminated in the process. Example: cellulose, starch.

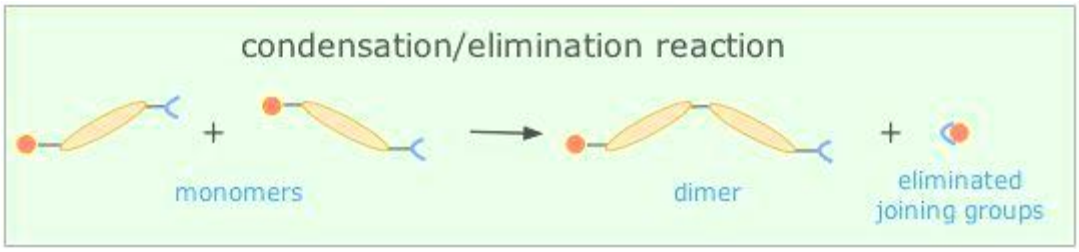

Figure 6: Condensation Polymer.

6. MECHANISM OF DRUG RELEASE FROM POLYMER:

The three primary mechanism for drug release are:

- Diffusion
- Degradation
- Swelling

Diffusion when an active ingredient, such as a medication, diffuses through the polymer that makes up the controlled-release device, it happens. The drug diffuses when it leaves the polymer matrix and enters the surrounding environment. When the delivery system is introduced into the biological environment, the combinations of polymer matrices and bioactive agents selected must enable the drug to diffuse through the pores or macromolecular structure of the polymer without causing any changes to the polymer itself.

They are of two types

A) Reservoir Diffusion System: In membrane controlled reservoir devices, the drug is contained in a core, which is surrounded by a polymer membrane, and it is released by

diffusion through the rate controlling membrane. For example, poly (N-vinyl pyrrolidone), poly (ethylene –co-vinyl acetate).

B) Matrix Diffusion System: In these devices, the drug is released either by passing through the pores or between polymer chains, and these are the processes that control the release rate. Such as polyethylene, polyvinylacetate.

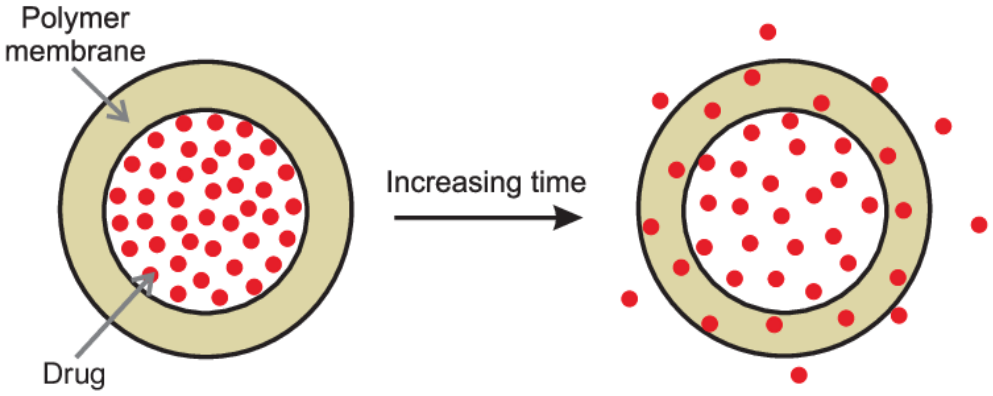

Figure 7: Reservoir Drug Delivery System.

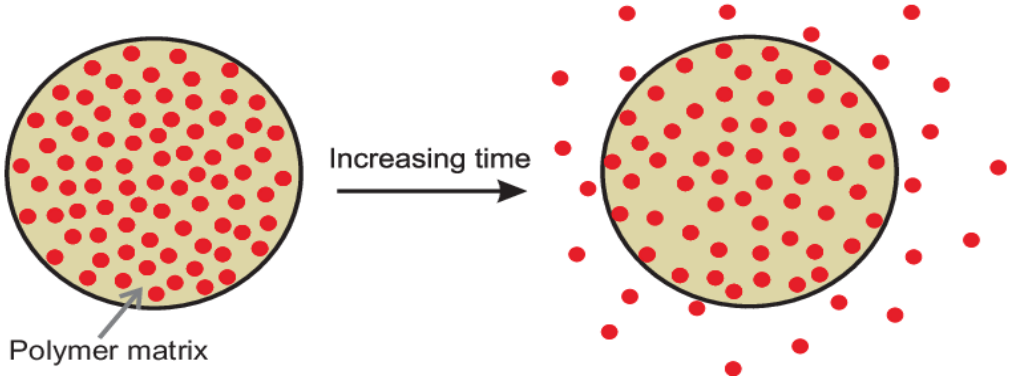

Figure 8: Matrix Drug Delivery System.

Degradation: The drug molecules, which are initially dispersed in the polymer, are released as the polymer starts eroding or degrading. The majority of biodegradable polymers are made to hydrolyze into increasingly smaller, physiologically acceptable molecules as the polymer chains break down. Certain degradable polymers, such as polyanhydrides and polyorthoesters, only degrade at their surface, causing a release rate that is proportionate to the drug delivery system's surface area.

Swelling: This type of systems are initially dry and when placed in body, absorb water or other fluids and it swells. Swelling increases aq. Solvent content within the formulation as well as the polymer mesh size, enabling the drug to diffuse through the swollen network into external environment. Eg: (N-isopropyl acrylamide), Ethylene-vinyl alcohol.

7. THE WORKING MECHANISM OF CONTROLLED AND SUSTAINED MEDICATION DELIVERY SYSTEMS BASED ON POLYMERS:

1. Drug Incorporation: The polymer matrix is first filled with the drug of interest. Several techniques, such as solvent casting, physical mixing, or drug encapsulation in the polymer, can be used to accomplish this.

2. Matrix or Reservoir Formation: A regulated drug delivery system is created by processing the drug-polymer combination. Various forms, including solid matrices, hydrogels, microspheres, nanoparticles, and coatings coated with drugs, can be employed, contingent on the intended release profile and use.

3. Diffusion or Erosion: In controlled delivery systems, medication release happens primarily through two mechanisms:

- **Diffusion-Controlled Release:** This process uses diffusion to transfer the drug molecules through the polymer matrix. Drug release is driven by the gradient in drugc oncentration between the interior and outside of the polymer. Creating barriers that regulate the pace of diffusion or employing low-permeability polymers are two ways to accomplish slow, sustained release.

- **Erosion-Controlled Release:** The polymer erodes or deteriorates progressively overtime in erosion-controlled systems. The drug is released when the polymer breaks down and exposes more drug particles or encapsulations to the outside world. By choosing polymers with certain rates of breakdown, one may regulate the erosion rate.

4. Release Profiles

- **Zero-Order, First-Order, or Alternative:** Depending on the therapeutic needs, the release kinetics can be designed to follow various patterns. For instance:

- **Zero-Order Release:** Over time, a steady rate of drug release is sustained.

- **First-Order Release:** Over time, the pace of drug release slows down.

- **Pulsatile Release:** The medication is delivered at predetermined intervals in distinct bursts.

- **Biphasic Release:** The release profile might consist of a continuous release phase after an initial burst release.

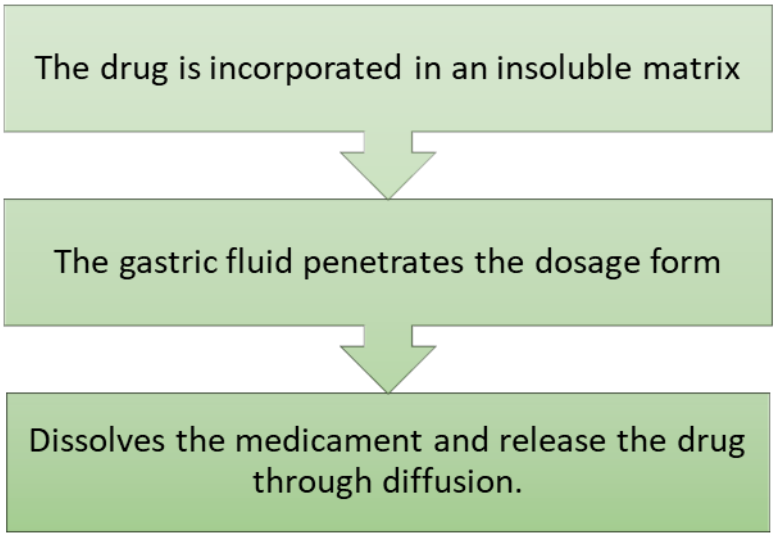

Figure 9: Release Profiles.

8. APPLICATIONS OF POLYMERS IN FORMULATION OF CONTROLLED AND SUSTAINED DRUG DELIVERY SYSTEM

The various applications of polymers in controlled and sustained delivery of drugs includes:

- Osmotic Pressure-Controlled GI Delivery System
- Gel Diffusion Controlled GI Delivery System
- Mucoadhesive GI Delivery System
- Transdermal Drug Delivery System
- Ocular Drug Delivery System
- Targeted drug delivery
- Pulmonary drug medication
- Intravaginal drug delivery
- Periodontal drug delivery
- Other Applications

8.1 Osmotic Pressure-Controlled GI Delivery System: A semi-permeable membrane is made from biocompatible polymers. E.g. cellulose acetate Examples of such type of system include Acutrim tablet which contains Phenylpropanolamine as a drug. In this device, an osmotic agent is contained within a rigid housing and is separated from an active agent compartment-b, a movable partition. One wall of the rigid housing is a semipermeable membrane so that when the pump is exposed to an aqueous environment, water will be driven osmotically across the membrane, the increased volume within the osmotic compartment will force the active agent out of the device through the delivery orifice. A major application is for gastro-intestinal drug deliveries because the delivery rate is pH-independent.

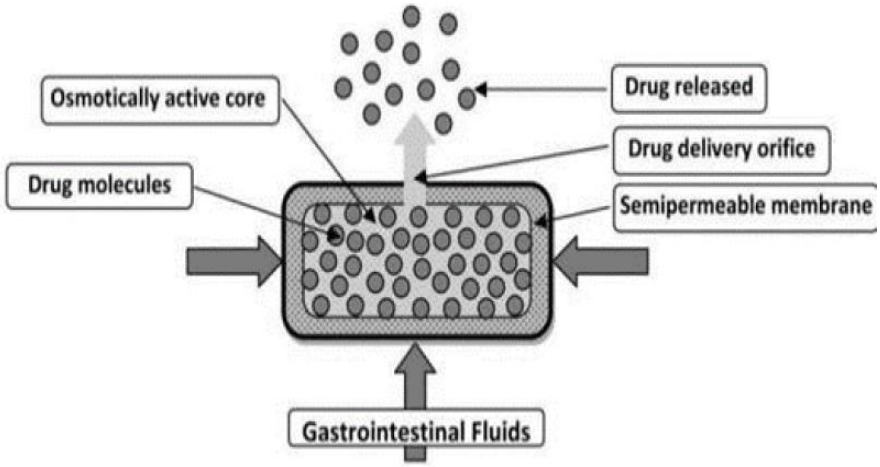

Figure 10: Osmotic Pressure Controlled GI Drug Delivery System.

8.2 Gel Diffusion Controlled GI Delivery System:

Diffusion and Dissolution-Controlled Release System:

- The drug is encased in a partially soluble membrane.
- Pores are created due to the dissolution of parts of the membrane.
- It permits entry of aqueous medium into core and drug dissolution.
- Diffusion of dissolved out of the system.

Example: Ethylcellulose and PVP mixture dissolves in water and creates pores of insoluble ethylcellulose membrane.

8.3 Mucoadhesive GI Delivery System: The new generation mucoadhesive polymers for buccal drug delivery with advantages such as; increase in the residence time of the polymer, penetration enhancement, site-specific adhesion, and enzymatic inhibition, site-specific mucoadhesive polymers will undoubtedly be utilized for the buccal delivery of a wide variety

of therapeutic compounds. The class of polymers has enormous potential for the delivery of therapeutic macromolecules.

8.4 Transdermal Drug Delivery System: TDDS is defined as, self-contained, self-discrete dosage forms, which when applied to the intact skin, deliver the drug at a controlled rate to the systemic circulation. In this, polymer matrix plays a major role. It releases the drug from the device to the skin. Advantages of Transdermal.

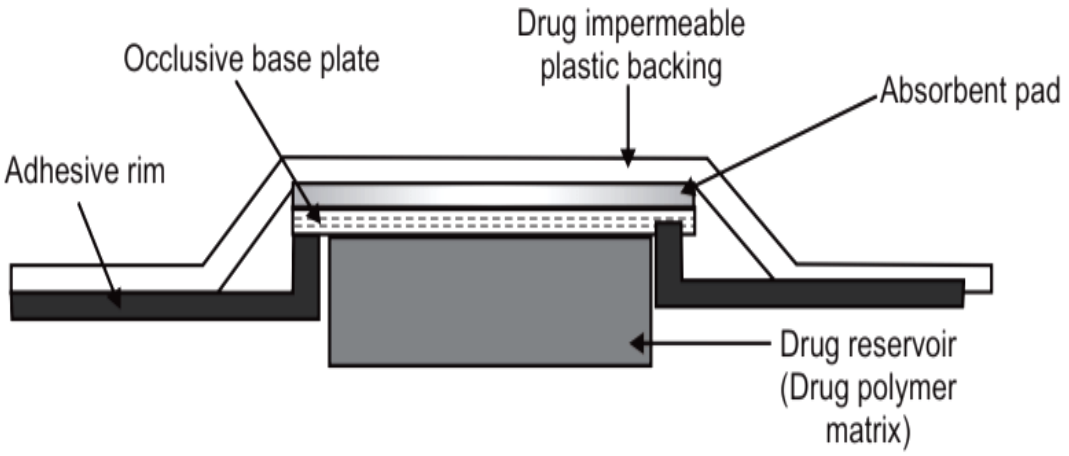

Figure 11: Transdermal drug delivery system.

- **Transdermal Patches:** Made of polymers, transdermal patches gradually releasepharmaceuticals via the skin. This method is easy and painless for administeringmedications such as hormone treatments, nicotine replacement therapy, andpainkillers.
- **Microneedle Arrays:** Drugs, vaccines, and biologics can be deliveredsubcutaneously under control using microneedle arrays with polymeric carriers.

8.5 Ocular Drug Delivery System: It allows prolonged contact of the drug with the corneal surface of the eye. An example of ODDS is pilocarpine in the treatment of glaucoma. In this, mucoadhesive polymers are used as barriers to control the drug release. E.g. Polyacrylic acid, Copolymers of acetate vinyl, and ethyl.

- **Contact Lens-Based Drug Delivery:** Drugs for ocular disorders, such as glaucoma and dry eye, can be released via polymers built into contact lenses, offering long-lasting comfort.
- **Ocular Implants:** By introducing biodegradable polymer implants into the eye, medication can be released gradually, minimizing the frequency of eye drops.

8.6 Targeted Drug Delivery

- **Polymer-Based Nanoparticles:** Therapeutic drugs can be incorporated into polymer-based nanoparticles, which can then be engineered for targeted drug delivery. By delivering medications only to tumor locations and reducing systemic exposure, they are utilized in cancer therapy.
- **Antibody-Linked Polymer Transporters:** Polymer carriers that have been coupled with antibodies or ligands that attach to certain receptors on target cells can improve the accuracy of medication delivery.

8.7 Pulmonary Medication Delivery

Polymeric Inhalation Formulations: To enable regulated release in the lungs, polymers are used in inhalable medication formulations for ailments such as asthmaand chronic obstructive pulmonary disease (COPD).

8.8 Intravaginal Drug Delivery

Polymeric Rings: Polymeric intravaginal rings have the ability to distribute medications over a longer period of time, including anti-virals and contraceptives.

Drug Delivery To The Central Nervous System: Biodegradable Polymer Implants and Wafers: These can be inserted into the brain or spinal cord to deliver medication locally in cases of neurological disorders.

8.9 Periodontal Drug Delivery

Polymeric Gels and Films: In periodontal drug delivery systems, polymers help torelease antimicrobial medicines under regulated conditions to treat gum disease.

8.10 Other Applications

Drug Delivery and the Treatment of Diabetes: Here the polymer will act as a barrier between the bloodstream and insulin. E.g. Polyacrylamide or N, N-Dimethyl amino ethylmetha acrylate. X

8.11 Drug Delivery Of Various Contraceptives & Hormones

It consists of a drug saturated liquid medium encapsulated in a polymeric layer which controls the concentration and release of drugs into the bloodstream. E.g.Medoxy

progesterone acetate, Progestasert, Duromine, etc. Drug Delivery of Various Contraceptive and Hormones

9. 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 full fill specialized functions for improved drug delivery because many new drugs have unfavorable 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 inthe design of dosage forms for effective drug delivery.

10. REFERENCES

1. Krushnakumar J Gandhi, et al. POLYMERS IN PHARMACEUTICAL DRUG DELIVERY SYSTEM: A REVIEW. 2012 : 58
2. Krushnakumar J Gandhi, et al. Sustained Release (SR) and Controlled Release (CR): 8
3. Punam Gaba, Controlled release drug delivery system , polymers controlled release drug delivery
4. *Kehar Singh, et al.,* A COMPREHENSIVE REVIEW: IMPORTANCE OF POLYMERS IN CONTROLLED DRUG DELIVERY SYSTEM
5. Kaur Ravinder & Kaur Sukhvir. (2014). ROLE OF POLYMERS IN DRUG DELIVERY. Journal of Drug Delivery and Therapeutics. 4. 10.22270/jddt.v4i3.826. 6.
6. Sung, Y.K., Kim, S.W. Recent advances in polymeric drug delivery systems. *Biomater Res* 24, 12 (2020). https://doi.org/10.1186/s40824-020-00190-7
7. Omanathanu Pillai, Ramesh, Polymers in drug delivery, Current Opinion in chemical biology, Vol 5, issue 4, 2001, 447-451.
8. A Godwin, K Bolina, M Clochard, E Dinand, S Rankin, S Simic, S Brocchini, New strategies for polymer development in pharmaceutical science — a short review, *Journal of Pharmacy and Pharmacology*, Volume 53, Issue 9, September 2001, Pages 1175–1184, https://doi.org/10.1211/0022357011776612

9. Patel, Vijay &Jadon, Arvind& Jain, Prateek& Khare, Basant & Thakur, Bhupendra& Khan, Rubeena& Ray, Deepshikha& Jain, Anushree. (2022). controlled drug delivery systems: an overview on advances and new technologies. 8. 85-92.
10. Nair LS, Laurencin CT. Polymers as biomaterials for tissue engineering and controlled drug delivery. AdvBiochemEngBiotechnol. 2006;102:47-90. doi: 10.1007/b137240. PMID: 17089786.
11. Tasneem K. H. Khan,et al., POLYMERS IN CONTROLLED RELEASE DRUG DELIVERY SYSTEMS: AN EXPLORATION OF PROPERTIES, AND APPLICATIONS
12. Liechty, W. B., Kryscio, D. R., Slaughter, B. v., & Peppas, N. A. (2010). Polymers for Drug Delivery Systems. *Annual Review of Chemical and Biomolecular Engineering*, *1*, 149.
13. Sung, Y. K., & Kim, S. W. (2020). Recent advances in polymeric drug delivery systems. *Biomaterials Research 2020 24:1*, *24*(1), 1–12.
14. U.Supriya et al., (2023) A Review on polymers used in controlled drug delivery system