



# REVIEW ON MUCOADHESIVE DRUG DELIVERY SYSTEM

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**Abstract :** This comprehensive review delves into the concept of mucoadhesion in pharmaceutical technology, particularly its role in enhancing drug delivery through prolonged interaction with mucosal barriers. The analysis covers fundamental principles, bioadhesion forces, classification, and applications of mucoadhesive systems. It focuses on mucoadhesive polymers, detailing their categories, features, and importance in designing effective drug delivery forms. The review emphasizes desirable polymer qualities, discusses pros and cons of mucoadhesive systems, and highlights commercial drug applications. Various drug delivery routes are explored, showcasing the adaptability of mucoadhesive formulations. Overall, the review underscores mucoadhesion's potential to revolutionize drug administration for improved therapeutic outcomes.

**IndexTerms –Mucoadhesion,Polymers,Mucoadhesive drug delivery system,Dosage form**

## 1.INTRODUCTION

Mucoadhesion has drawn a lot of attention in pharmaceutical technology since the early 1980s<sup>[1]</sup>

Mucoadhesive systems have the potential to be used as drug carriers since they can increase contact with the epithelial barrier by extending their period of residence at the absorption site.<sup>[2]</sup>

A drug carrier system must be attached to a particular biological area in order for mucoadhesion, also known as bioadhesion, to occur. When a pressure-sensitive adhesive comes into contact with a surface (in this case, the mucus membrane), the two materials become adherent. Two Different forces that are further explicated in the mucoadhesion section hold these two surfaces together during the therapy time<sup>[3]</sup>

Bioadhesion in biological systems can be categorized into three type,

1. Adhesion between two biological stages, such as platelet aggregation and wound healing.
2. Attachment of a biological phase to an artificial substrate, such as cell adhesion to culture dishes and biofilm development on prosthetic devices and inserts.
3. Attachment of a synthetic material to a biological substrate, such as the adherence of sealants to dental enamel and synthetic hydrogels to soft tissues<sup>[4]</sup>

Pharmaceutical researchers are highly interested in mucoadhesive polymers because they improve medication administration by lengthening dose residence time and mucous membrane contact.

In the review, mucoadhesion is discussed, along with different mucoadhesive polymers and how they can be used to create drug delivery systems for gastrointestinal, nasal, ophthalmic, vaginal, and rectal routes.

The review also emphasizes already on the market mucoadhesive drug delivery methods, offering a thorough overview of their functionality and importance in pharmaceutical applications.<sup>[5]</sup>

Due to their potential to solve physiological barriers in long-term medication administration, mucoadhesives are an intriguing idea that have drawn the interest of many researchers.

It has been demonstrated that these polymers are capable of overcoming problems with regulated medication release. Scientists from all over the world have worked hard to comprehend the complexity of mucoadhesion, making it possible for us to understand more about a variety of topics in this area.

It is important to recognize that, notwithstanding the advancements to date, mucoadhesives research is still in its infancy. Further advancements in this field of research are required to fully realize their promise for use in controlled drug delivery. To improve mucoadhesive's performance in clinical settings, more study and testing will be necessary. [6]

Based on their characteristics and interactions with mucus, mucoadhesive polymers can be simply grouped into three general classes:

1. **Water-Soluble Polymers:** These polymers can bind tightly to the mucus layer because they are soluble in water. They effectively moisten the mucus thanks to their ideal polarity. The contact makes it easier for the polymer to adhere to the mucosal surface, facilitating mucoadhesion.
2. **Contrary to water-soluble polymers, water-insoluble polymers** are not soluble in water but nevertheless have the ability to cling to the mucus layer. They are joined by cross-linking agents to form a growing network. They can intersect with the mucus while retaining their integrity thanks to this structure.
3. **Swellable Networks with Cross-Linking Agents:** Polymers having both water-soluble and water-insoluble components fall under this category. [7]

### 1.1 Mucous Membrane

The wet surfaces (mucosae) lining the walls of several body compartments, such as the gastrointestinal and respiratory systems, are known as mucus membranes. They are made up of a connective tissue layer called the lamina propria, which is followed by an epithelial layer whose surface is typically kept moist by a mucus layer.

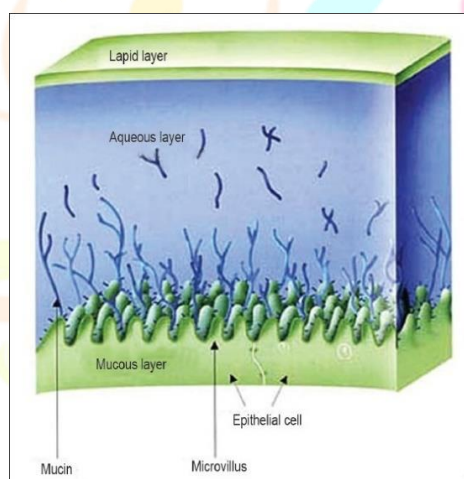


Fig.1: Mucous Membrane

The esophagus, vagina, and cornea are examples of structures with multilayered or stratified epithelia, while the stomach, small and large intestines, and bronchi have single-layered epithelia.

The latter contain, or are close to tissues containing, specialized glands such as salivary glands that produce mucus onto the epithelial surface. The former contain goblet cells, which directly secrete mucus onto the epithelial surfaces.

Either a gel layer of mucus that is adhering to the mucosal surface or a luminal soluble or suspended type of mucus is present. Mucin glycoproteins, lipids, inorganic salts, and water are the main ingredients of all mucus gels; the latter makes up more than 95% of their weight, making them a highly hydrated system. Mucus has two main purposes: lubrication and protection. [8]

### 2. MUCOADHESIVE POLYMERS

A polymer is an intriguing substance or material made up of macromolecules, very big molecules. These macromolecules are known as polymers, which are characterized by a large number of repetitive components. Polymers are essential and ubiquitous in our daily lives due to the wide range of features they contain.

Whether they are made artificially or naturally, polymers are made by a process known as polymerization in which numerous small molecules, or monomers, chemically bind together to create these large macromolecules. [9, 10]

The combining of multiple smaller molecules, known as monomers, results in polymers, which are large molecules known as macromolecules. These smaller units undergo a conversion process to create the big, intricate structures that are unique to polymers. The Greek terms "poly" (which means "many") and "meros," which means "parts or members," are the source of the English word "polymer." It alludes to massive molecules made up of recurring monomeric building blocks. Natural polymers have been present on Earth since prehistoric times and are essential to life.

They are polymers in a liquid or semi-solid state. Speaking of adhesives, they too are frequently crafted from polymers to produce goeey materials that bind surfaces together. Adhesive tapes, which combine polymers and adhesives, provide a practical way to attach objects. [11]

Polymers are fascinating giant molecules with high molecular weight, known as macromolecules. They are formed through a process called polymerization, where numerous small molecules, called monomers, are intricately linked together.

The physicochemical characteristics of the polymers employed in the formulation determine how well solid dosage forms, implants, dispersion systems, transdermal patches, and particle systems work. The sales of pharmaceutical polymers make up a very modest

fraction of the total polymer market. The Food and Drug Administration closely monitors these polymers' standards to ensure that their use has no unfavorable impacts. [12, 13]

## 2.1-Categorization Of Mucoadhesive Polymers

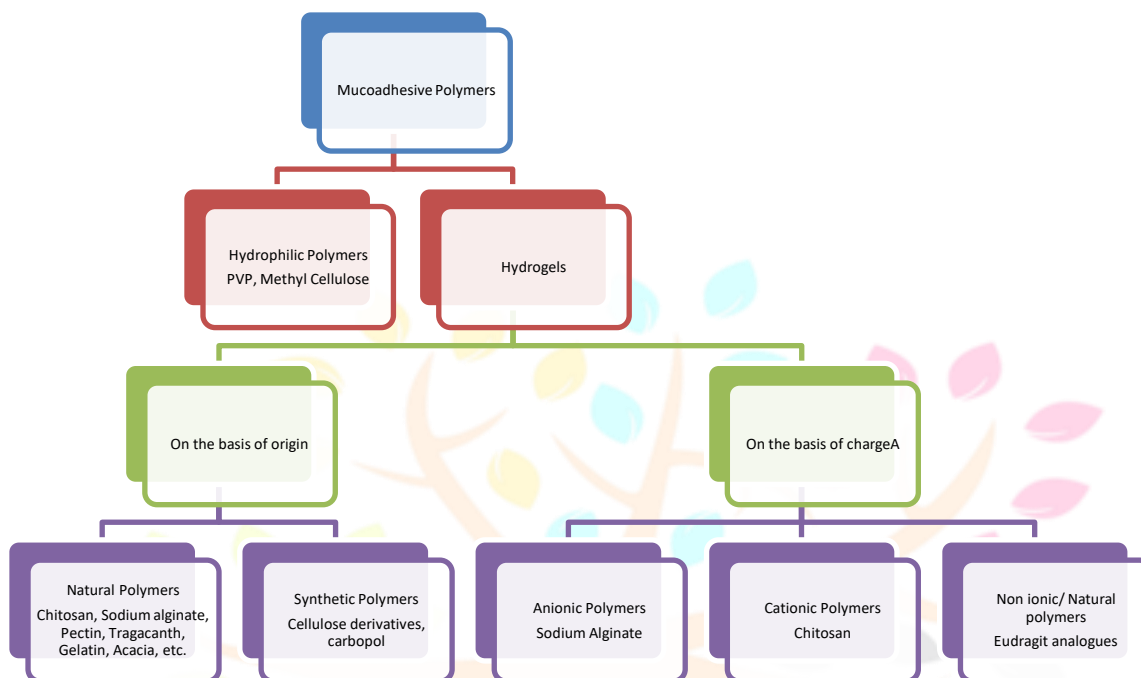


Fig 2 classification of polymers

## 2.2-IDEAL PROPERTIES OF MUCOADHESIVE POLYMERS

1. They should not be poisonous and should not be absorbed via the digestive system.
2. To ensure a product is nonirritant to the mucous membrane, it should be formulated with gentle and non-harsh ingredients that won't cause irritation when in contact with the mucous membranes.
3. For strong non-covalent bonds with mucin-epithelial cell surfaces, you might consider using materials or compounds with high affinity for mucins, such as certain polysaccharides or glycoproteins
4. It sounds like you're describing a desirable feature for a medical adhesive. Adherence to tissues and site-specificity are important characteristics for effective medical applications.
5. It shouldn't obstruct the drug's release and should enable everyday absorption.
6. Ensuring the polymer's stability during storage and throughout the shelf life of the dosage form is crucial to maintain its integrity and effectiveness.
7. Keeping the cost of polymer low is essential to maintain a competitive prepared dosage form. Lower polymer costs can help ensure that the final product remains affordable and attractive to consumers or the market.
8. The ideal drug should have a formulation that allows for daily incorporation, ensuring ease of administration and adherence for patients. This formulation should be designed to provide a steady release of the drug over time, maintaining therapeutic levels in the body without causing any hindrance to its release. [14]

## 2.3-ADVANTAGES OF MUCOADHESIVE POLYMER

1. Prolonging the residence time of a dosage form at the site of absorption is a crucial strategy to enhance the bioavailability of drugs.
2. This product offers outstanding accessibility, ensuring its use is easy and convenient for all users. Its rapid onset of action guarantees quick and efficient results, making it an ideal choice for those seeking immediate relief or effects
3. Due to a large blood supply and healthy blood flow rates, there is rapid absorption.
4. In the gastrointestinal tract (GIT), drugs are shielded from degradation thanks to their protective mechanisms in the acidic environment. The acidic conditions in the stomach can potentially break down drugs, reducing their effectiveness.
5. Improved patient compliance refers to the enhanced willingness and ability of patients to follow prescribed treatment plans and medical advice.
6. Due to the avoidance of first pass metabolism, medication bioavailability is rising.



## 2.4-DISADVANTAGES OF MUCOADHESIVE POLYMER

1. Due to prolonged interaction with a substance that has ulcer genic properties, localized consequences of ulcers may occur.
2. Lack of a suitable model for in vitro drug identification screening is one of the main obstacles to the development of oral mucosal administration. .ideal for such a management.
3. Patient acceptability is crucial when considering the taste and irritancy of medications or treatments. A pleasant taste can improve compliance, especially for oral medications, while minimizing irritancy helps reduce discomfort or adverse reactions.
4. Drinking and Eating are not permitted. <sup>[15]</sup>

Sr/ No.	DRUG	MUCOADHESIVE POLYMERS	APPLICATION SITE	DOSAGE FORM AND NAME
1.	Nitroglycerin	Sinchron ( Modified HPMC)	Buccal Cavity	Sustain release Tablet
2.	Triamcinolone Acetonide	Hydroxypropyl Cellulose, Carbopol 934	Buccal Cavity	Attach Tablet
3.	Beclomethasone Dipropionate	Hydroxypropyl Cellulose	Oral Cavity	Rhinocort Powder
4.	Aluminum Hydroxide	Sucrose Octasulfate	GIT Ulcer	Sucralfate
5.	Fantanyl Citrate	HPMC, Chitosan	Oral Cavity	Fantora Tablet
6.	Nitroglycerin	Carbopol, HPMC K <sub>15</sub> M, K <sub>4</sub> M	Oral Cavity	Nitrostat Tablet
7.	Miconazole	Na CMC, HEC	Oral Cavity	Loramyc
8.	Testosterone	HPMC, Chitosan, PVA	Oral Cavity	Striant SR

Table-1: commercial implementation of mucoadhesive polymers <sup>[15]</sup>

## 3.MUCOADHESIVE DRUG DELIVERY SYSTEM

The mucus layer that covers the mucosal epithelial surface of the body is intended to interact with a mucoadhesive medication delivery device. Mucin molecules, which are specific glycoproteins, are found in the mucus layer. Due to particular chemical interactions between the mucoadhesive agents and the mucin molecules, the mucoadhesive dosage form clings to the mucus layer when applied or delivered.

This adhesion increases the drug system's resident time at the absorption site by allowing it to stay in close contact with the mucosal surface. The lengthening of the stay gives the medication additional chances to cross the mucosal barrier and enter the bloodstream. This procedure can increase the effectiveness of drug administration, which may result in improved therapeutic outcomes with less frequent doses and fewer side effects.

A promising method for localized drug administration in a variety of medical applications, such as the treatment of oral, nasal, ophthalmic, or vaginal disorders, is the mucoadhesive drug system's capacity to attach to the mucosal surface and prolong residence time. <sup>[16]</sup>

A mucoadhesive drug delivery system is a specific method that improves the effects of drugs by extending the period of time in which they are in touch with the targeted mucosal surface. This system is made to stick to mucous membranes, like those in the nasal passages, over time, there has been a notable transition in pharmaceutical research focus. Previously, the main emphasis was on creating new chemical entities for drugs. However, this emphasis has shifted towards a more innovative approach known as Novel Drug Delivery System (NDDS). This new approach involves enhancing the effectiveness of existing drug molecules by developing advanced methods of delivering them into the body. The goal is to optimize their therapeutic action while ensuring patient safety and protection. This shift in research direction promises to revolutionize drug development and healthcare outcomes. <sup>[15]</sup>

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Pharmaceutical research has undergone a noticeable shift in focus over time. Prior to now, developing novel chemical entities for medications was the main focus. However, the focus now lies on a novel strategy called as Novel Drug Delivery System (NDDS). This novel strategy entails improving the potency of currently available pharmacological compounds by creating cutting-edge delivery systems. The objective is to maximize their therapeutic effect while assuring the security and protection of the patient. This change in research focus has the potential to completely transform drug development and healthcare outcomes. <sup>[17]</sup>

Mucoadhesive drug transport systems are a type of bioadhesive drug administration technology. These solutions take advantage of the particular property of specific polymers that exhibit adhesiveness during hydration. This property allows them to stick effectively to mucosal surfaces, allowing for precise drug concentration in a specific body location for extended periods of time. <sup>[18]</sup> Sustained-release dosage forms are designed to gradually release the active substance over time, but sometimes, this gradual release may not be enough to ensure a therapeutic effect. In some cases, these dosage forms can be prematurely removed from the absorption site before all the medication has been released. On the other hand, mucoadhesive dosage forms are designed to address this issue by helping to maintain a controlled release of the medication at the site of absorption. Over the years, various mucoadhesive drug

delivery methods have been developed to achieve both local and systemic effects, administered through routes such as nasal, buccal, oral, vaginal, and rectal administration [19]

#### 4. THEORIES OF MUCOADHESION:

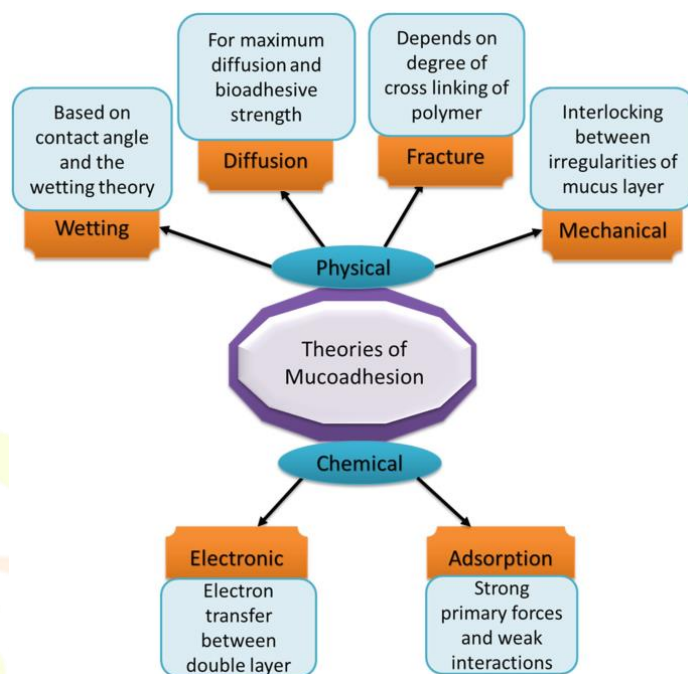


Fig3: Theories of Mucoadhesion

#### 4.1-Wettability Theory:

The "spreadability" of an active drug delivery system is defined by the wettability hypothesis as the degree to which a mucoadhesive polymer may adhere to a biological membrane. The wetting theory relates to liquid systems that have an attraction for the surface and spread over it. This affinity can be discovered via measurement techniques. Such as the contact angle. This hypothesis is applicable for organizations with low viscosity or liquid mucoadhesive properties.

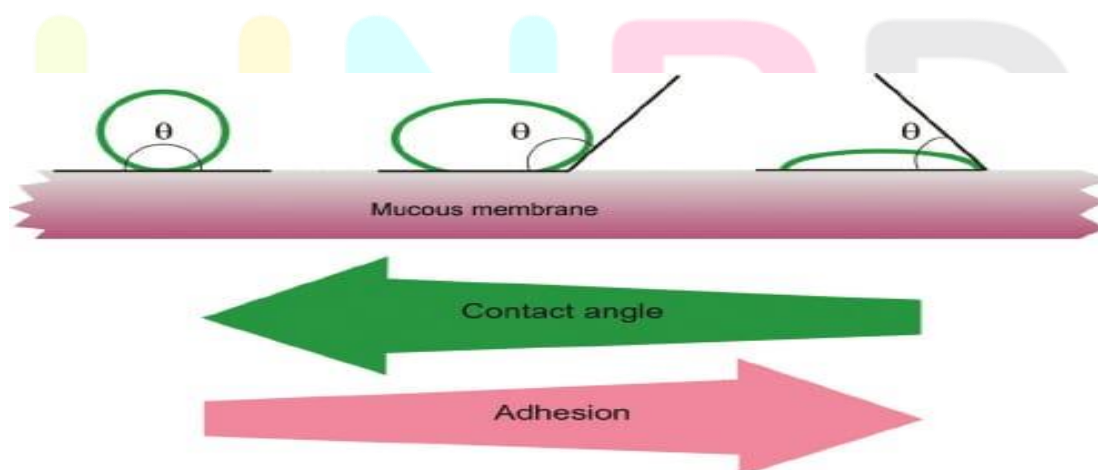


Fig 4 Wettability Theory

#### 4.2 Adsorption Theory:

Adsorption theory established van der Waals' and hydrogen bond forces for adhesive contacts. After a first contact angle between the exteriors, the mucoadhesive material adheres due to superficial forces acting between the molecules of two surfaces. Collaboration through the contact occurs as a result of compact covalent bonding, according to the chemisorption idea.

**4.3 Fracture Theory:**

The strength necessary to distinguish both surfaces from each other, according to this approach, is linked to the bonding links between the systems. This "fracture theory" conveys polymer impartiality strength from mucus to the strength of their sticky bond.

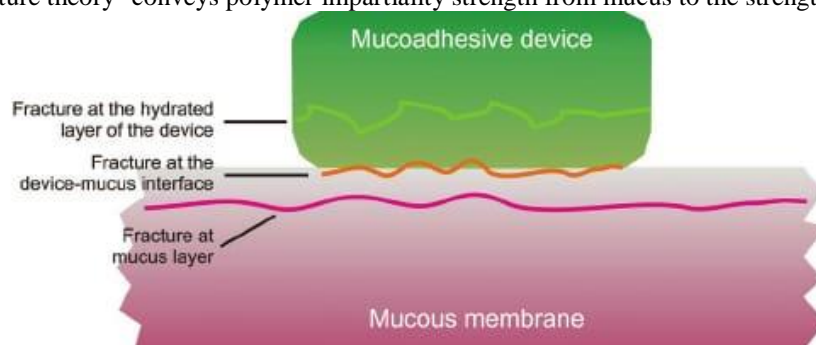


Fig 5 Fracture Theory

**4.4-Diffusion Theory:**

This theory describes the time-dependent migration of mucoadhesive polymer chains into the mucus stratum's glycoprotein chain network, as seen in. This is a two-way diffusion approach in which permeation amount is determined by the diffusion coefficients of polymers that are mutually related. While many variables are considered in such operations, the essential qualities that have a significant impact on diffusion include cross-linking density, molecular weight, chain flexibility extension capacity of both networks, and temperature.

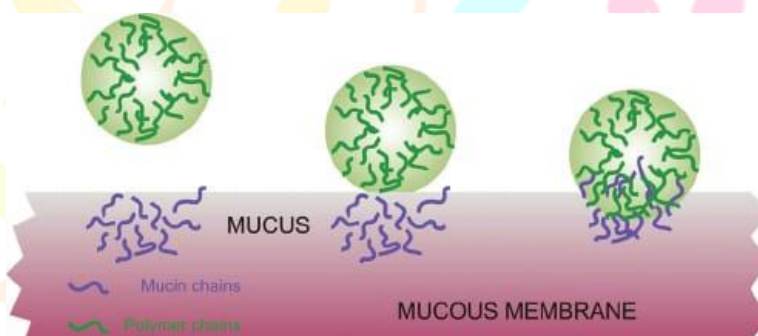


Fig 6 Diffusion Theory

**4.5-Mechanical Theory:**

According to mechanical theory, adhesion is caused by a mucoadhesive liquid filling the imperfections on a rough surface. Furthermore, roughness increases the interfacial area available to contacts, assisting in energy dissipation, and might be considered the most essential aspect of the process. The way adhesion happens isn't the same for everything. We have different ideas about how it works. These ideas help us figure out important things about how to make these systems.

**4.6-Electronic Theory:**

Every surface possesses a distinctive electrical configuration and structural characteristics. This system relies on alterations in electronic arrangements or structures. It posits that bonding arises from the exchange of electrons between the polymer arrangement and the mucous membrane epithelium, leading to the formation of a double layer characterized by electric charges at the interface of the mucoadhesive system and the mucus. This phenomenon is responsible for generating attractive forces between the two surfaces through the electronic double layer.<sup>[20][21]</sup>

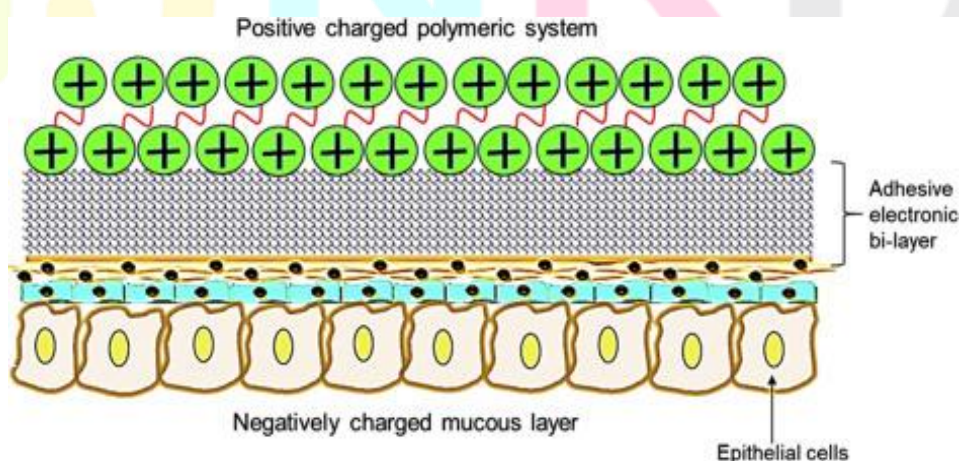


Fig 7: Electronic Theory of Mucoadhesion



## 5. Mechanism of Mucoadhesion:

An intriguing interfacial phenomenon known as mucoadhesion involves the joining of two different materials. The mucin layer found in mucosal tissues normally makes up one of these materials, whereas the other frequently consists of an artificial component like a mucoadhesive polymer. The attractive forces at the contact between these materials cause this adhesion to happen. It is just the mechanism by which these two substances adhere to one another.

Any artificial substance that has the capacity to interact with mucous membranes—the wet tissues that border the body's numerous organs, including the digestive tract, respiratory system, and others—is referred to as a "mucoadhesive." These mucoadhesive materials are made to stick to these mucous membranes, which may cause them to be kept on the surface.

**Touch stage:** During this stage, an intimate wetting happens when the mucoadhesive material between the mucoadhesive comes into touch with the mucous membrane. The mucus in the mucosal membrane wets the mucoadhesive, according to this statement.

**Consolidation stage:** The mucoadhesive substance binds to the mucous membrane through various physicochemical forces of attraction, creating a long-lasting mucoadhesion. This phase is referred to as consolidation. The mucoadhesion process is finished after these two phases. <sup>[22,23]</sup>

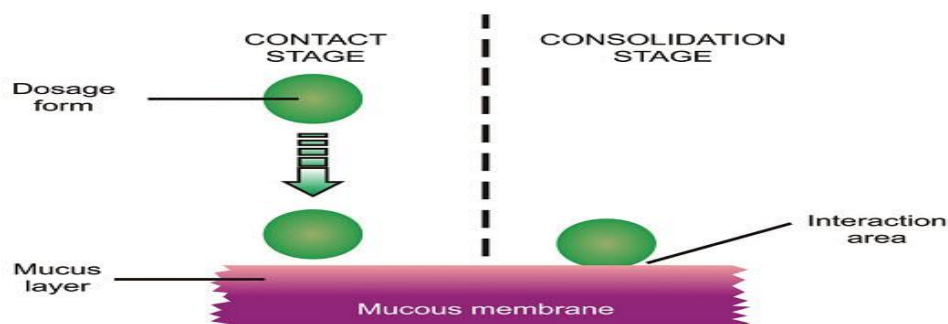


Fig.8: Influence of contact angle between device & mucomembrane on bio-adhesion

## 6. FACTORS AFFECTING MUCOADHESION:

### 6.1-MOLECULAR WEIGHT:

A polymer's capacity to adhere to mucosal surfaces gets stronger when its molecular weight rises above 100,000.

The molecular weights of polyoxyethylene polymers, which range from 200,000 to 7,000,000, strongly correlate with their mucoadhesive strength.

Higher molecular weight polymers stimulate the development of entanglements, whereas lower molecular weight polymers favor polymer molecule entwining.

Depending on the specific polymer type, different molecular weights are required to achieve the highest level of mucoadhesion.

### 6.2-FLEXIBILITY:

The diffusion of polymer chains into the interfacial region triggers the onset of mucoadhesion. For this reason, flexible polymer chains are essential to successfully entangle with the mucus and produce the desired result.

The increased chain tangling was associated with the polymer's increased flexibility with the addition of polyethylene glycol. Usually, a polymer's mobility and flexibility can be correlated with its viscosity and diffusion coefficients. This implies that a more flexible polymer can diffuse into the mucus network more successfully.

### 6.3-CROSS-LINKING DENSITY:

The average pore size, the quantity and average molecular weight of the cross-linked polymers, and the density of cross-linking are three vitally important interlinked structural elements of a polymer network.

The cross-link density has an inverse relationship with swelling intensity. Flexibility and hydration rate rise when cross-link density decreases. Mucoadhesion is also enhanced by a bigger polymer surface area.

It is advisable to utilize a polymer with fewer cross-links for significant swelling. However, excessive wetness that results in severe swelling can produce a slick mucilage that is simple to separate off the surface.

Cross-linked polymers' mucoadhesion can be improved by adding adhesion boosters, including free polymer chains, to the formulation. Grafted onto the prepared network, and polymers.

### 6.4-HYDRATION:

Hydration is required for a mucoadhesive polymer to successfully expand and produce a suitable sized macromolecular mass. This hydration also promotes chain mobility within the polymer, which helps the polymer and mucin intertwine. Polymer swelling makes it easier to attach mechanically by exposing bioadhesive sites that can interact electrostatically or by hydrogen bonding with the mucus network. The mucoadhesive polymer does, however, have a critical hydration level where the perfect balance between swelling and mucoadhesion is attained.

**6.5-CONCERNTRATION:**

The importance of this component is in creating a solid adhesive bond with the mucus. By taking into account the length of polymer chains that can enter the mucus layer, this can be made clearer. Only a few chains can penetrate each unit volume of mucus when the polymer concentration is low, leading to an unstable association. Typically, longer penetrating chains and higher adherence result from a more concentrated polymer. Each polymer does, however, have a critical concentration at which it develops a strongly coiled shape that hinders solvent access and chain penetration. As a result, high polymer concentrations may not always improve and may even make mucoadhesive characteristics worse.

**6.6-HYDROGEN BONDING CAPACITY:**

The mucoadhesion of polymers is greatly influenced by hydrogen bonding. Polymers should have functional groups capable of establishing hydrogen bonds, such as (COOH, OH, etc.), in order to produce mucoadhesion. These groups are necessary for the polymers to form hydrogen bonds. To increase the polymer's hydrogen bonding potential, flexibility in the structure is also crucial. Examples of polymers with a high ability to form hydrogen bonds with other molecules are polyvinyl alcohol, poly (methacrylic acid), and their copolymers. <sup>[1, 19, 24, 25]</sup>

**6.7-SPATIAL CONFORMATION:**

The way polymer molecules are shaped can impact their ability to adhere to mucous membranes. This happens because certain shapes might block the functional groups that are responsible for binding to mucin. For instance, a polymer with a helical shape, like Dextran, might need a higher concentration to achieve the same level of adhesion as a more linear shape, such as polyethylene glycol<sup>[26]</sup>

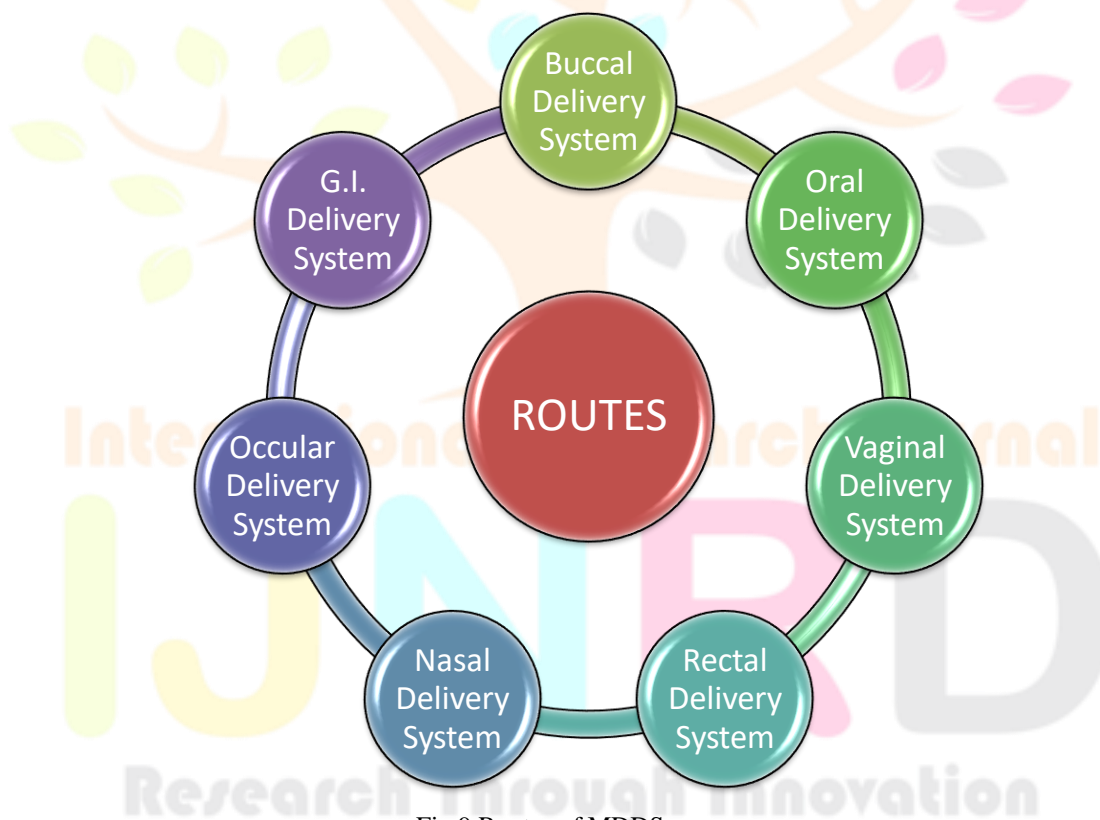
**7.ROUTE OF MUCOADHESIVE DRUG DELIVERY SYSTEM**

Fig 9 Routes of MDDS

Systems for mucoadhesive drug delivery prolong the time the dose form is left at the application site, improving absorption. For systemic and local effects via oral, buccal, nasal, rectal, and vaginal routes, various such systems have been created recently. The concept of mucoadhesion has garnered significant attention in the pharmaceutical field and is effectively employed as an administration method. Mucoadhesive drug delivery systems can be administered through various routes.



**7.1-Buccal Delivery System:**

An alternative to oral administration for medications affected by the first-pass effect is buccal drug delivery. Long regarded as an ideal location for medication administration, the stratified squamous epithelium in the buccal mucosa is supported by connective tissue lamina propria. Buccal administration has benefits including simple accessibility, epithelial resilience, flexible dose, and decreased vulnerability to enzymatic activity. As a result, oral administration systems for sticky mucosal dosage forms, including adhesive tablets, gels, and patches, have been created. The development of efficient bio adhesive buccal delivery methods, however, still faces a major issue with the absorption of hydrophilic medicines through the membrane.

**7.2-Oral Delivery System:**

The goal of a system created for oral drug administration is to provide consistent drug release as the patient's digestive system moves through it. Even while oral delivery is popular and well-liked by patients, it has challenges because of interactions with the gastrointestinal system and drug effectiveness. A lot of research has been done on lipid-based oral delivery systems, with a focus on how each system component affects delivery effectiveness and the route of lipid-based oral administration. [27]

**7.3 -Vaginal Delivery System:**

The uterus is connected to the outside of the body by the vagina, which acts as a fibrovascular conduit. Lamina propria and squamous epithelium are used to line it. There are many other dose forms that can be used for vaginal administration, including solutions, gels, suspensions, suppositories, creams, and tablets, although they usually only stay in the vagina for a short time. Bioadhesive compounds can extend the shelf life of vaginal formulations and control the rate of medication release. To treat vaginal dryness, these formulations may contain medication or even work in conjunction with moisturizers.

The potential of vaginal gels has been enhanced by recent advancements in polymer technology. A little amount of solid material is scattered inside a relatively larger volume of liquid to form these gels, which are semi-solid polymer structures. They have found use as microbicides, contraceptives, labor inducers, and other chemicals, among other things.

**7.4-Rectal Delivery System:**

A section of the colon called the rectum has a surface area of 300 cm<sup>2</sup> and a length of around 10 cm. Its main function is to remove water. Its surface area for medication absorption is considerably constrained due to the lack of villi. The rectum primarily absorbs drugs through simple diffusion over the lipid membrane. Rectal administration offers significant benefits for substances that are prone to significant first-pass metabolism, especially when administered to areas close to the anus. Additionally, it has been noted that the migration distance within the rectum is reduced by the addition of bioadhesive polymers. [24]

Rectal drug delivery refers to the administration of pharmaceuticals through the rectum to produce effects either locally or systemically throughout the body. Rectal drug distribution is one method of medication administration that makes use of mucosal adhesion. These systems have mucoadhesive characteristics, which means that a strong carrier helps the medicine attach to the mucous membrane.

**7.5-Nasal Delivery System:**

Nasal administration, commonly referred to as snorting, is a method of delivering drugs by inhaling them through the nose. Furthermore, factors such as the nasal floor, drug concentration and amount, the physical state of the dosage form, and the positioning of the head during administration all contribute to the drug absorption process. This route of administration encompasses several applications:

- 1) Utilization of nasal tablets for local drug delivery
- 2) Achieving systemic drug delivery
- 3) Transporting drugs from the nose to the brain
- 4) Delivery of nasal vaccines.

**7.6-Ocular Delivery System:**

The eye is a sophisticated organ that has unique anatomical and physiological characteristics. A unique drug delivery technique includes injecting the medication into the ODDS, also known as the conjunctival cavity of the eye. A specialized, sterile method of creating dosage forms is called ophthalmic preparation. Drugs can be administered intravenously for intraocular therapies, topically for topical treatments, or next to the eye for periocular treatments. Pharmaceutical researchers and experts deal with one of the most fascinating and difficult parts of ODDS. Usually, ocular drugs are injected directly into the eye. Drug potency, bioavailability, and clearance at the targeted location are only a few examples of the variables that affect how effectively drugs are delivered in terms of drug loading, release rate, and retention time in the eye. [27]

**7.7-Gastrointestinal Delivery System:**

The oral route is undoubtedly the most desired way of administration, but there are some serious risks with it, including hepatic first-pass metabolism, drug degradation during absorption, the presence of mucus on GI epithelia, and rapid mucus turnover. Delivery through the gastrointestinal tract (GIT) has been more well-known recently as a major administration route. Systems that use bio adhesive polymers to adhere to the epithelial surface in the GIT are called bio adhesive retentive systems. The use of bio adhesive polymers can prolong GI transit time and increase bioavailability. [24]

## 8.MUCOADHESIVE DOSAGE FORMS:

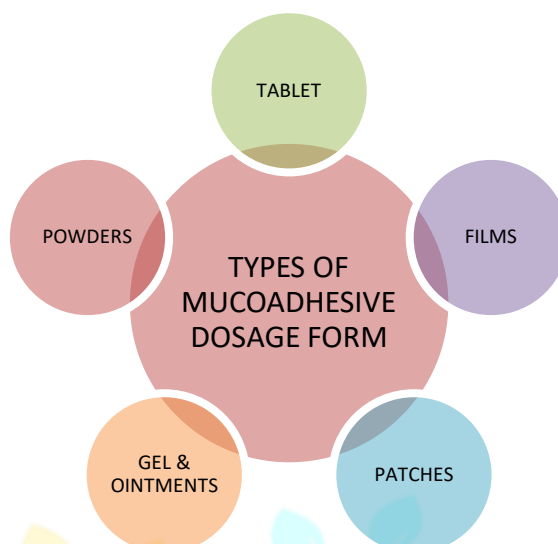


Fig 10 Dosage form of MDDS

### 8.1-Tablet

Mucoadhesive tablets are typically oval-shaped, flat, and tiny, with a diameter of 5-8 mm. These tablets allow speaking and drinking without causing undue discomfort, in contrast to conventional tablets. When they soften, they cling to the mucous membranes and stay there until they break down or release their contents. Tablets that adhere to the mucous membrane may allow for controlled medication release. Tablets having mucoadhesive qualities provide a number of advantages, including enhanced mucus layer interaction and increased drug absorption and bioavailability due to a larger surface-to-volume ratio.

Tablets that are mucoadhesive can be designed to adhere to different mucosal tissues, including those in the stomach, allowing for both targeted and more extensive controlled drug release. To achieve targeted pharmacological effects, these tablets are placed on the gastrointestinal mucosa. Due to their prolonged medication release, mucoadhesive tablets are well-liked because they reduce the need for frequent dosage and improve patient adherence. However, a noteworthy disadvantage of these pills is their lack of flexibility, which, when taken repeatedly or for a lengthy period of time, may diminish patient compliance.

### 8.2Films

Mucoadhesive films might be preferable over adhesive tablets due to their greater flexibility and comfort. They address the issue of oral gels having a short duration on mucosal surfaces since they aren't easily washed away by saliva. Additionally, when used for localized oral treatments, these films protect wounds, reducing pain and enhancing treatment effectiveness. An ideal film should be pliable, elastic, and soft while remaining sufficiently sturdy to endure the stresses of mouth movement. It's also important for the film to have strong adhesive properties to remain in the mouth for the necessary duration of action. Excessive swelling, if it does occur, should be avoided to prevent discomfort.

### 8.3Patches:

An impermeable backing, a reservoir layer containing the medication for controlled release, and a mucoadhesive surface for adhering to mucosal tissue are the layers that make up patches. Similar patch delivery technologies are employed in transdermal medicine delivery. The processes of solvent casting and direct milling are both used to make adhesive patches. The solvent casting technique involves pouring a drug and polymer solution over a backing layer, which causes the solvent(s) to evaporate, creating an intermediate sheet. The formulation's components are combined, compacted to the correct thickness, and then cut or punched into predetermined patch forms in the direct milling process. To regulate drug release direction, avoid drug loss, and maintain device integrity while in operation, an impermeable backing layer can be applied.

### 8.4Gel & Ointments:

The benefit of being simple to apply over the oral mucosa is provided by semi-solid formulations like gels and ointments. Their precise dose, however, could not be as precise as that of tablets, patches, or films. Mucoadhesive formulations are used to solve the problem of keeping gels at the application site. Some mucoadhesive polymers, like sodium carboxymethylcellulose, carbapool, hyaluronic acid, and xanthan gum, go through a phase transition from liquid to semi-solid, enhancing viscosity for prolonged and controlled drug release. Additionally promising for buccal medication delivery are hydrogels. These gels are created from water-absorbing polymers that hold medication molecules when hydrated and release them gradually through diffusion or erosion.

The use of mucoadhesive gels offers benefits like prolonged retention in the mouth, effective drug penetration, and high patient satisfaction. A significant application of these gels is in locally delivering medications for treating periodontitis, an inflammatory and infectious gum disease leading to pockets between teeth and gums, often resulting in tooth loss. Mucoadhesive polymers integrated into antimicrobial formulations can be injected into periodontal pockets using a syringe, potentially aiding periodontitis.

therapy. Furthermore, a highly viscous gel composed of carpool and hydroxypropyl cellulose was created for ointment applications, maintaining tissue contact for up to 8 hours. <sup>[1]</sup>

### 8.5 Powders:

Powder-based mucoadhesive formulations have gained significant traction in nasal drug delivery. In contrast to liquid counterparts, these formulations, which include both the medication and mucoadhesive components (often polymers), have demonstrated the ability to improve the bioavailability of drugs by extending their presence at the absorption or target site [28]. When powdered HPC and beclomethasone are sprayed onto the oral mucosa of rats, a significantly prolonged residence period is observed compared to using an oral solution. Furthermore, there is a notable 2.5% retention of beclomethasone on the buccal mucosa for a duration of up to 4 hours. <sup>[28]</sup>

## 9. NEED OF MUCOADHESIVE DRUG DELIVERY SYSTEM

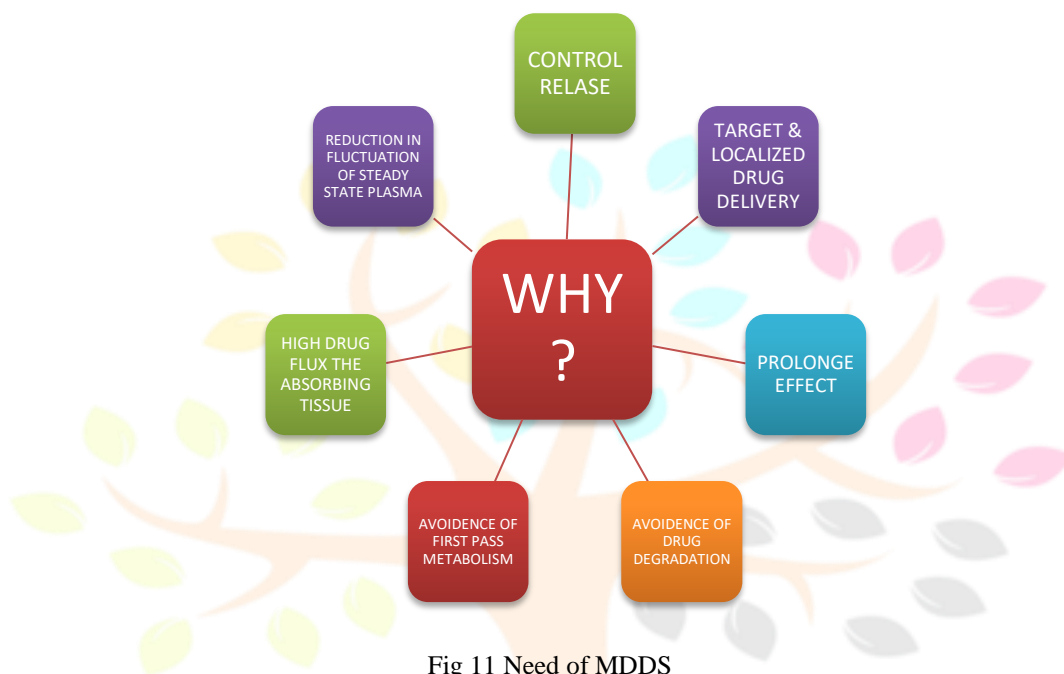


Fig 11 Need of MDDS

### 9.1 Advantages of mdds:

- Prolonged stay at the site of drug action or absorption.
- Targeted drug delivery to a specific site.
- Enhanced drug concentration gradient through close particle-mucosal contact.
- Initial interaction with intestinal cells before particle absorption.
- Simple administration.
- Simple treatment termination (excluding the gastrointestinal system).
- Enables extended drug presence in the oral cavity.
- Suitable for administering to unconscious patients (except GIT).
- Excellent method for delivering drugs with high first-pass metabolism, enhancing bioavailability.
- Decreases required dose, leading to reduced dose-related side effects.
- Suitable for drugs vulnerable to stomach acidity or enzymatic breakdown, e.g., via buccal, sublingual, or vaginal routes.
- Convenient for drugs with poor bioavailability through oral route.
- Passive drug absorption, no need for activation.
- Saliva presence aids drug dissolution, unlike rectal or transdermal methods.
- Rapid systemic absorption.
- Alternative for administering hormones, narcotics, analgesics, enzymes, etc.
- Buccal mucosa's high permeability due to rich blood supply.
- Lower dosing frequency, shorter treatment duration.
- Safer administration of potent drugs due to better plasma level control.
- Effective drug utilization, reducing overall dose.
- Improved patient compliance due to less frequent dosing.
- Steady levels minimize disease fluctuations, reducing side effects' intensity. <sup>[29]</sup>



## 9.2 Disadvantages of mdds:

- Development of ulcer genic drugs can lead to local ulcerous effects when in prolonged contact with tissue.
- A significant challenge in advancing oral mucosal delivery is the absence of a robust in vitro screening model to identify suitable drugs for this route of administration.
- Patient preference concerning taste, irritation, and mouthfeel needs to be evaluated. <sup>[30]</sup>
- The drug dissolves as a result of the consistent production of saliva (0.5-2 liters per day).
- The absence of a suitable model for in vitro screening of drugs using oral mucosal delivery is a significant drawback in this method of drug administration.
- Cost effective drug delivery system. <sup>[25]</sup>

## 10.CONCLUSION:

In conclusion, mucoadhesive systems have become a potential approach in pharmaceutical technology for improving drug delivery. These systems use specific polymers to stick to mucosal membranes, increasing medication residence duration and enhancing absorption. They come with benefits like improved bioavailability, patient compliance, and tailored distribution, but they also have drawbacks including potential side effects and in vitro testing. The commercial use of mucoadhesive polymers in diverse medication delivery methods highlights their usefulness. This novel method of drug delivery has enormous potential to revolutionize healthcare and improve treatment results.

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