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# Mucoadhesive Drug Delivery System

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## ABSTRACT

The development of novel drug delivery systems, like the mucoadhesive system, can enhance medication effects. When designing drug delivery systems, mucoadhesion is a topic of current attention. These systems maintain tight contact with the mucous membrane, the absorption tissue, releasing the medication at the site of action, increasing its bioavailability and producing both local and systemic effects. Numerous mucoadhesive drug delivery methods have been created recently for systemic and local effects via the oral, buccal, nasal, rectal, and vaginal routes. Nowadays, six theories—mechanical, adsorption, wettability, diffusion, fracture, and electronic—are used to explain mucoadhesion. In addition to reviewing the theories and mechanisms behind mucoadhesion, this study aimed to outline the most popular techniques. Mucoadhesive drug delivery systems (MDDS) have emerged as a promising approach for targeted and sustained drug release. (1)

**KEYWORDS:** Mucoadhesive drug delivery system, Mechanism, six theories, factors affecting, Advantages, Disadvantages.

## INTRODUCTION

Drugs can be delivered to specific parts of the body for extended periods of time using mucoadhesive drug delivery systems, which utilize the property of bioadhesion of specific polymers that become sticky when hydrated, this process is called Mucoadhesive drug delivery system.

Drugs can be delivered to specific parts of the body for extended periods of time using mucoadhesive drug delivery systems, which take use of the bioadhesion of specific polymers that become sticky when hydrated. When two materials, at least one of which is biological, are held together by interfacial forces, this is known as bioadhesion. Adhesion between a polymer and a biological membrane is one example of how an artificial substance and biological substrate might attach. "Mucoadhesion" refers to a polymer that is affixed to the mucin layer of a mucosal tissue. Delivery systems that use the bioadhesion of specific polymers to become adhesive are known as mucoadhesive drug delivery systems. (19)

Mucosal drug delivary system have various types –

- Oral delivery system
  - -Sublingual delivery
  - -Buccal delivery
  - -Local delivery
- Vaginal delivery system
- Rectal delivery system
- Nasal delivery system
- Ocular delivery system (10), (19)

**• Oral delivery system:**

It is the most popular way to give any medication. Because the mucosa has a robust vascular supply and no stratum corneum epidermis, oral transmucosal absorption is typically quick. Blood concentrations grow quickly as a result of this low barrier to drug delivery. Most medications reach their peak blood levels within 10 to 15 minutes after the drug enters the bloodstream, which is significantly quicker than when the same drugs are taken orally. (14)

The following categories apply to drug distribution through the oral cavity's membranes:

**-Sublingual delivary:**
Drugs are delivered systemically through the mucosal membranes that line the floor of the mouth in a process known as sublingual delivery.

**-Buccal delivery:**

This refers to the administration of a medication via the buccal mucosa, which lines the cheeks. Numerous benefits are provided by a buccal adhesive system, including cost-effectiveness, accessibility, administration, withdrawal, and patient compliance. Nowadays, researchers are searching for innovative drug transport systems using conventional polymers. (14)

**-Local delivery:** This refers to the administration of medication into the oral cavity.

**Table1: SUITABILITY OF VARIOUS REGIONS OF THE ORAL MUCOSA FOR THE TRANSMUCOSAL DRUG DELIVERY BASED ON VARIOUS TISSUE PROPERTIES**

| | Permiability | Blood flow | Residence time |
|---|---|---|---|
| Buccal | + | ++ | + |
| Sublingual | ++ | -- | -- |
| Palatal | -- | -- | ++ |

**Note:** ++ means very suitable; -- means least suitable. Source: From de vries, M E et al., Crit. Rev.Ther. Drug carrier system., 8, 271, 1991 (8)

**• Rectal and Vaginal delivery system:**

Avoiding the stomach's acidic pH and avoiding first-pass metabolism are just two advantages of medication distribution, which is advantageous for both local and systemic effects. The vaginal mucosa has a greater blood supply and is accessible. And this are help to prevent the sexually transmitted diseases and minimise the gastrointestinal side effects regarding drug delivery (suppositories and creams). (6)
Some uses of rectal and vaginal delivery are Suppositories for pain relief, enemas for inflammatory bowel disease, mucoadhesive gels for rectal administration of hormones.

**• Nasal delivery system:**

It improve the drug resistance time with the help of mucoadhesive polymers. Avoid the first pass hepatic metabolism and target specific sites. Drugs directly access systemic circulation and potential for targeting CNS. (Nasal spray, Drops, etc). The main concerns when looking for and creating safe and efficient medication formulations for the nasal route are toxicity and absorption improvement. It is preferable to achieve sustained release over a number of hours from a pharmacokinetic perspective. However, prolonged contact with the nasal mucosa may exacerbate the excipients' toxicity. (11)

**• Ocular delivery system:**

Drug administered directly to eye are absorbed through the conjunctival and corneal epithelium. It helps to reduce systemic side effects. Many traditional and innovative drug delivery methods, including emulsion,

ointments, suspensions, aqueous gels, nanomicelles, nanoparticles, liposomes, dendrimers, implants, contact lenses, nanosuspensions, microneedles, and in situ thermosensitive gels for the aforementioned ocular diseases, have been developed to get around the obstacles to ocular drug delivery and increase ocular bioavailability.[18] The first use of soft contact lense for the effective treatment of ocular treatment is in 1965.[6]

When topical drops are administered, the ocular bioavailability is quite poor. Deeper ocular medication penetration is hampered by a number of physiological and anatomical limitations, including ocular static and dynamic barriers, reflex blinking, nasolachrymal drainage, and tear turnover. As a result, less than 5% of the dose administered topically reaches the deeper tissues of the eyes. [18]

## LITURATURE REVIEW

- **Pranshu Tangri, N. V. Satheesh Madha, 2011**

Review on "ORAL MUCOADHESIVE DRUG DELIVERY SYSTEMS"

This article focuses on defining the principles of bioadhesive delivery systems based on hydrogels to biological surfaces that are covered by mucus. An overview of the last decade's discoveries on mucoadhesion, Factors affectimg mucoadhession and applications of mucoadhesive hydrogels as drug carriers is given. Techniques that are frequently used to study the adhesion forces and physicochemical interactions between hydrogel, mucus, and the underlying mucosa are reviewed.

- **Radha Bhati and Raja K Nagrajan, 2012**

Review on "A DETAILED REVIEW ON ORAL MUCOSAL DRUG DELIVERY SYSTEM"

In this article, detailed information of penetration enhancers, design of oral mucosal drug delivery system and role of mucoadhesion and various theories of bioadhesion. Evaluation techniques and selection of animal model for in-vivo studies are also discussed.

- **Priya Mahajan, Amanpreet Kaur, Geeta Aggarwal, S.L. Harikumar, 2013**

Review on: "Mucoadhesive Drug Delivery System"

Drug actions can be improved by new drug delivery system, such as mucoadhesive system. This system remains in close contact with the absorption tissue, the mucous membrane, releasing the drug at the action site leading to improvement in both local and systemic effects. There are many routes of mucoadhesive drug delivery system, oral route is the most ancient as well as preferred by patient being convenient to take. The buccal mucosa is very suitable for a bioadhesion system because of a smooth and relatively immobile surface and accessibility. And other routes including vaginal, rectal, nasal, ocular, etc.

- **Vimal Kumar Yadav, A.B. Gupta, Raj Kumar, Jaideep S. Yadav, Brajesh Kumar, 2010**

Review on: "Mucoadhesive Polymers: Means of Improving the Mucoadhesive Properties of Drug Delivery System"

The current review provides a good insight on mucoadhesive polymers, the phenomenon of mucoadhesion and the factors which have the ability to affect the mucoadhesive properties of a polymer.

- **Bindu M. Boddupalli, Zulkar N. K. Mohammed, Ravinder Nath A., David Banji, 2010**

Review on: "Mucoadhesive drug delivery system"

This review covers the areas of mechanisms and theories of mucoadhesion, factors influencing the mucoadhesive devices and also various mucoadhesive dosage forms

## AIM

To conduct comprehensive review on mucosal drug delivery system.

## OBJECTIVES

1. Mucosal membranes can provide a direct route for drugs to enter systemic circulation, bypassing the first-pass metabolism in the liver and potentially enhancing bioavailability.
2. MDDS allows for targeted drug delivery to specific tissues or organs (e.g., targeting the lungs via nasal or pulmonary delivery), minimizing systemic exposure and reducing side effects.
3. These systems offer a non-invasive alternative to injections, making them more patient-friendly and potentially increasing patient compliance, especially in chronic conditions.
4. MDDS is ideal for localized drug delivery (e.g., in the treatment of respiratory or gastrointestinal diseases), as it delivers the drug directly to the site of action, enhancing therapeutic efficacy.
5. The mucosal route can facilitate rapid absorption of drugs, particularly those that are absorbed quickly across mucosal tissues, leading to faster therapeutic effects compared to oral administration.
6. Certain MDDS formulations are designed to provide controlled or sustained release, offering prolonged therapeutic effects and reducing the frequency of administration.
7. By targeting the drug to the site of action, MDDS can minimize systemic exposure and potentially reduce adverse effects associated with systemic drug distribution.
8. MDDS offers more convenient administration options compared to traditional methods, such as oral or injectable routes, especially for patients with difficulty swallowing or those who require frequent dosing.
9. Treatment of mucosal diseases (e.g., respiratory, gastrointestinal).
10. Prevention of infectious diseases (e.g., vaccines).
11. Management of chronic conditions (e.g., asthma, diabetes).
12. Relief from allergic reactions.
13. Treatment of inflammatory conditions.
14. Controlled release: Regulate drug release rates.
15. Sustained release: Maintain therapeutic levels over time.
16. Rapid absorption: Achieve quick absorption and onset of action.
17. Reduced variability: Minimize inter-subject variability.
18. Enhanced efficacy: Improve therapeutic outcomes.
19. Reduced toxicity: Minimize adverse effects.
20. Improved therapeutic index: Optimize safety and efficacy.

## PLAN OF WORK

- Mechanism of mucoadhesion
- Steps involve on mechanism of mucoadhesion
- Advantages and disadvantages
- Theories of mucoadhesion
- Methods to study mucoadhesion
- Components used in mucoadhesive drugs

## MECHANISM OF MUCOADHESION [10]

There are typically two phases in the mucoadhesion mechanism:

1. Contact stage
2. Consolidation stage

The mucoadhesive and mucous membrane come into contact during the first stage, which causes the formulation to expand and swell and begin making deep contact with the mucus layer.

The delivery system may be manually attached in certain situations, such for ocular or vaginal formulations, or it may be supplied via the nasal route, where the organ's aerodynamics encourage the deposition of the system to the membrane. The presence of moisture activates the mucoadhesive components during the consolidation process. The system becomes plasticized by moisture, which enables the mucoadhesive molecules to separate and bind together via weak van der Waals and hydrogen bonds. In mucoadhesion four forces are involve -Hydrogen bonding, Electrostatic force, Vander waals force and hydrophobic interaction. [10]

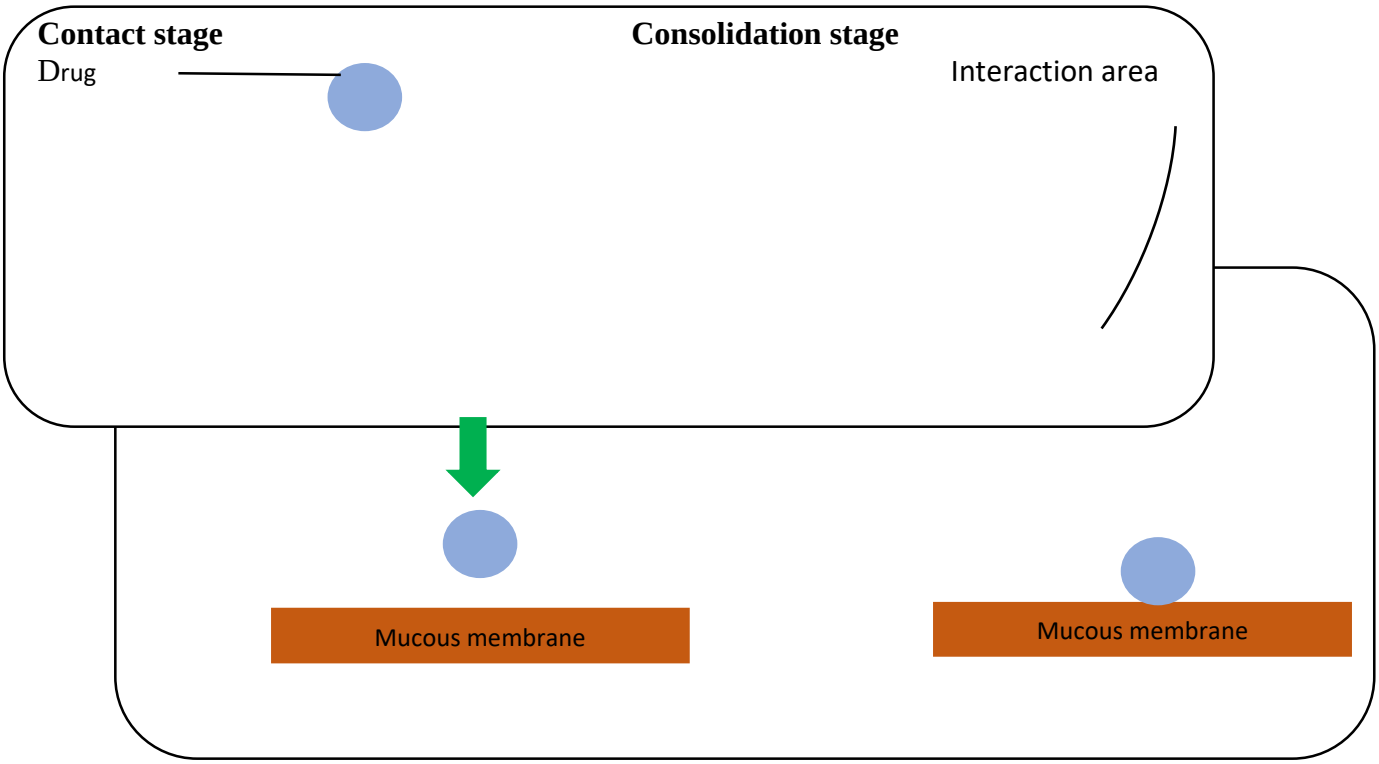



Fig.1: Two steps of Mucoadhesion

There are two theories explaining the consolidation step:

**1. The diffusion theory**

Through secondary bond formation and chain penetration, the mucoadhesive molecule and the mucus's glycoproteins interact with one another. this to take place the mucoadhesive device has features favouring both chemical and mechanical interactions. [10]

**2. The dehydration theory**

Dehydration hypothesis states that substances that easily gelify in an aqueous environment might dehydrate mucus when they come into touch with it because of the difference in osmotic pressure. [10]

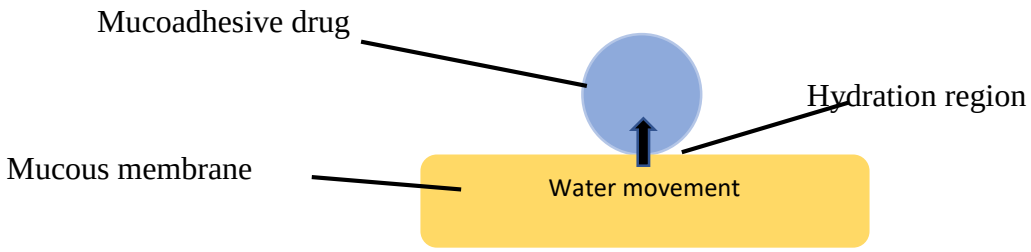



Fig.2: Dehydration theory of mucoadhesion

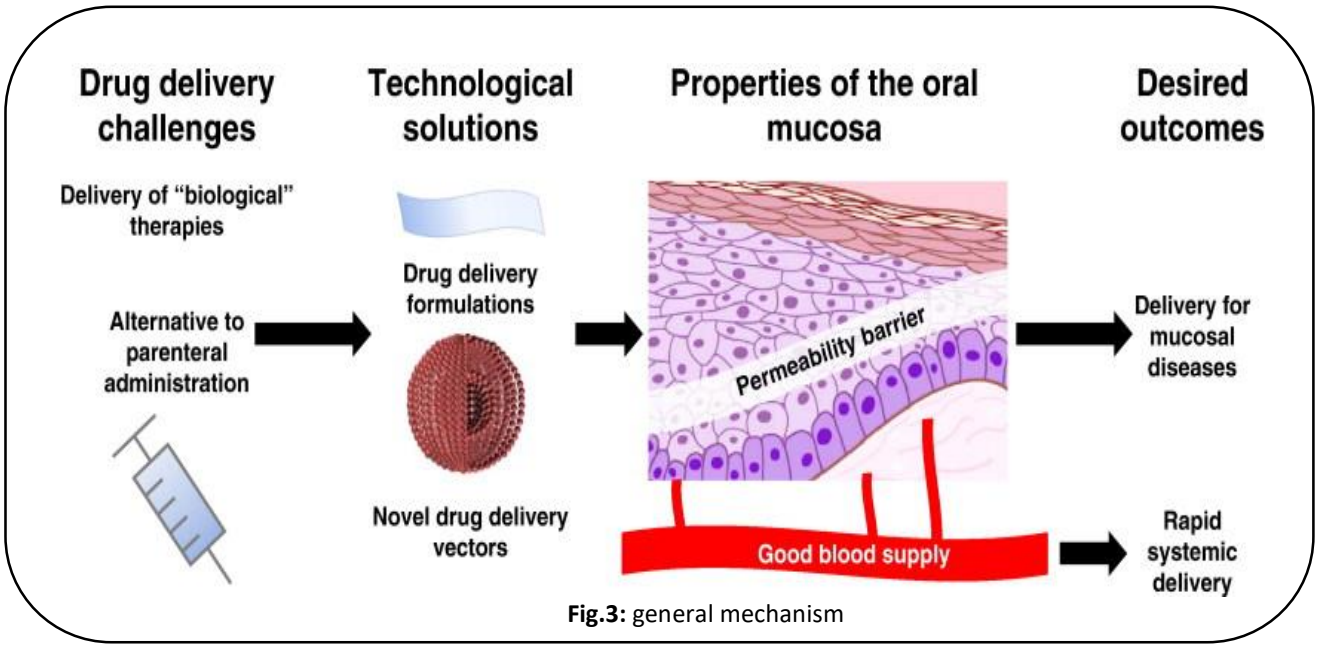
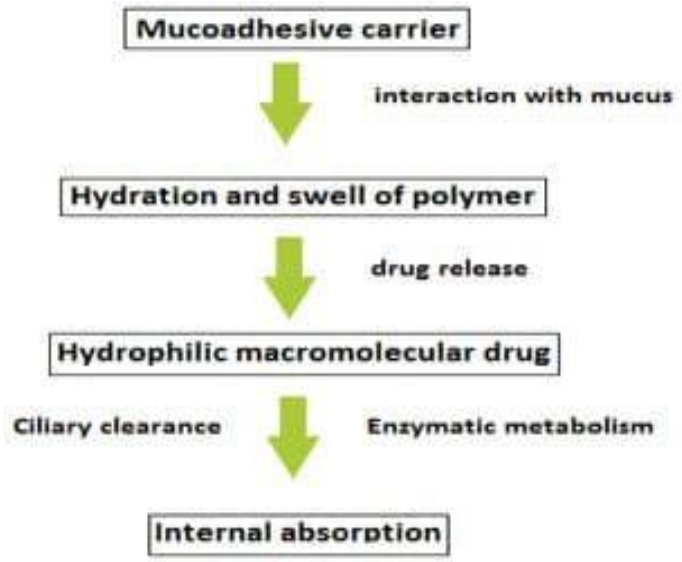



**Fig.3:** general mechanism

Fig. 4: Mucoadhesive internal drug delivery system (9)

## STEPS INVOLVE IN MECHANISM OF MUCOADHESION




1. Step I (contact stage)
2. Step II (polymer chains and mucosal membrane Interpenetration)
3. Step III (bonds creation among the entwined chains). [4]

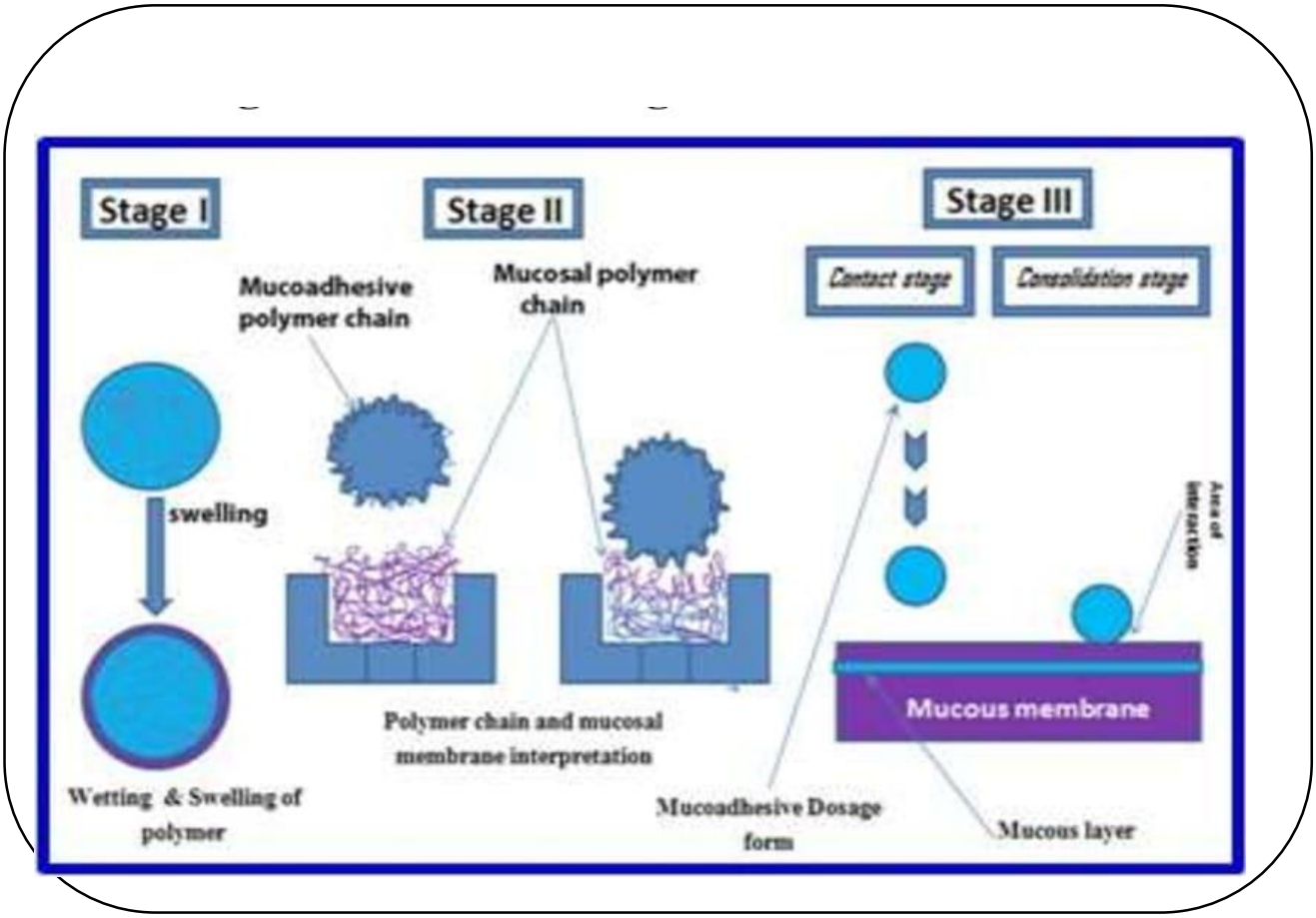



**Fig.5:** Steps involved in mechanism of mucoadhesion. [4]

## ADVANTAGES AND DISADVANTAGES

**Table 2:**

| | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| **Therapeutic** | 1. Targeted delivery<br>2. Enhanced bioavailability<br>3. Reduced systemic side effects<br>4.Improved patient compliance<br>5. Personalized medicine | 1. Limited absorption<br>2. Variable bioavailability<br>3. Local irritation<br>4. Inconsistent efficacy<br>5. Dose dumping |

| | | |
|---|---|---|
| **Pharmacokinetic** | 1. Controlled release<br>2. Increased drug residence time<br>3. Reduced peak-to-trough fluctuations<br>4. Enhanced local absorption | 1. Short residence time<br>2. Rapid clearance<br>3. Enzymatic degradation<br>4. pH-dependent absorption |
| **Biological** | 1.Biocompatible<br>2. Biodegradable<br>3. Prolong Mucoadhesion<br>4.Inhance Immunity<br>5. Non toxic | 1.Limited permeability of mucous membrane.<br>2.Immune reactions to MDDS.<br>3. Infection risk<br>4. Tissue damage. |
| **Clinical** | 1. Treatment of local diseases<br>2.systemic delivery via mucosal routes.<br>3. Reduced healthcare costs<br>4. Improved quality of life | 1. Patient variability<br>2.Altered mucosal physiology in disease states.<br>3. Drug interactions<br>4.Difficulty targeting specific diseases. |
| **Technical** | 1. Flexibility<br>2. Suitable Scalability<br>3.Drug Stability<br>4. Cost-effectiveness | 1. Formulation challenges<br>2. Manufacturing complexity<br>3. Scalability issues<br>4. Stability concerns |

## THEORIES OF MUCOADHESION

In the field of pharmaceutical sciences, theories regarding the phenomena of mucoadhesion have been thoroughly investigated and examined. The capacity of specific compounds or formulations to stick to the mucosal surfaces of biological tissues is known as mucoadhesion, and it is especially relevant to medication delivery systems. [5]

Mucoadhesion includes different theories –

**1) Physical theories**

a) Wetting theory

b) Diffusion theory

c) Fracture theory

d) Mechanical theory

**2) Chemical theories**

a) Electronic theory

b) Adsorption theory

**Table 3:** The list of theories of mucoadhesion with their biological reactive system and examples. [5]

| Theories | Chemical and Physical Reaction | Biological Reactive System | Result | Examples |
|---|---|---|---|---|
| Electronic theory | Electron transfer reaction | Mucus and the mucoadhesive system | Electrical double layer of charges at the mucus and mucoadhesive interface | A mucoadhesive material that is electron-rich will be more likely to donate electrons to the electrondeficient mucosal surface. |
| Adsorption theory | Hydrogen bonding reaction | Mucus and the mucoadhesive system | Adhesive interaction between the substrate surfaces | A mucoadhesive material with a positive charge will be attracted to the negatively charged mucus layer by electrostatic interactions. |
| Fracture theory | Detachment of polymer moietie | Mucus and polymer moieties | Relates the force for polymer detachment | A mucoadhesive material that is highly flexible and elastic will be more able to form microfracture bonds with the mucosal surface than a mucoadhesive material that is rigid and brittle. |

**a) Wetting theory:**

Possibly the most well-established theory of adhesion is the wetting theory. It works better with low-viscosity or liquid bioadhesives. It describes adhesion as an embedding process in which adhesive chemicals enter substrate surface imperfections and eventually solidify to form numerous sticky anchors. The adhesive must overcome any surface tension effects at the interface in order to travel freely across the substrate's surface. The contact angle and the thermodynamic work of adhesion are computed by the wetting theory. [7]

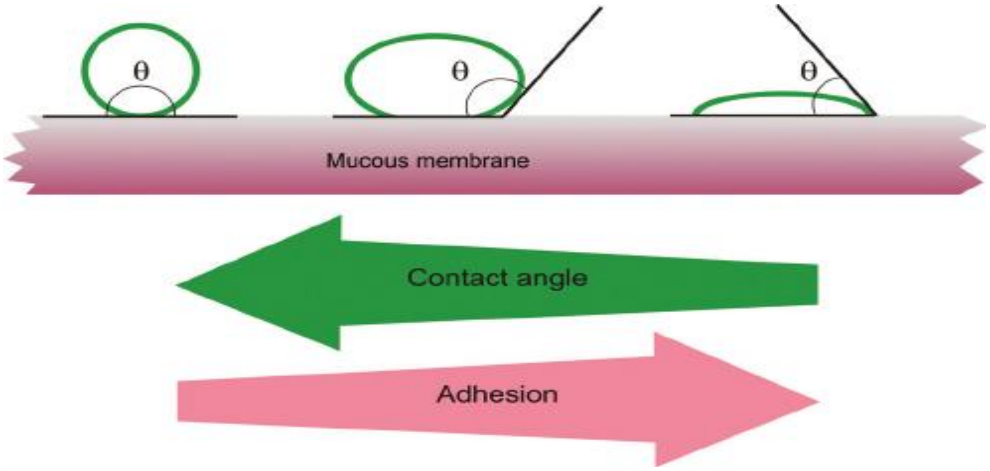



**Figure 6**: Wetting theory of mucoadhesion (1)

**b) Diffusion theory**

This theory states that mucus and the polymer chain mix deeply enough to form a semi-permanent adhesive bond. The concentration gradient that drives this process is influenced by the mobility of the available molecular chain lengths. It lowers noticeably when the cross- linking density drops and is dependent on the molecular weight between cross links. (1)

$$I = (tD_b)\ ½$$

Where,

t: time of contact

$D_b$: diffusion coefficient of the bio adhesive material in the mucus.

I: Penetration depth (3)

Interdiffusion

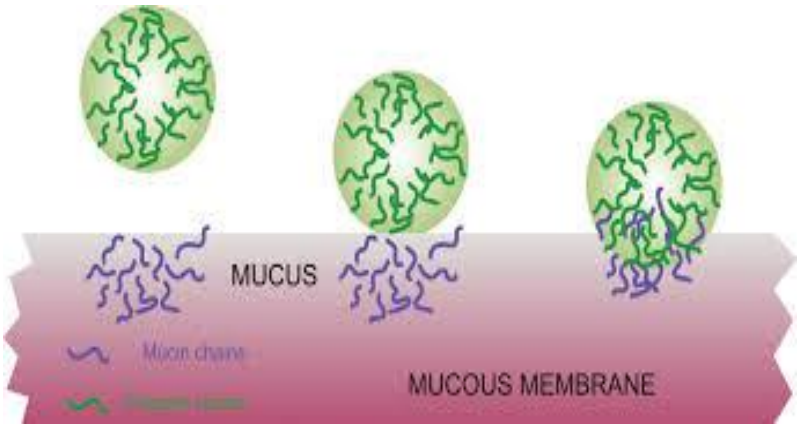



**Fig.7:** Secondary interaction between mucoadhesive device and mucus membrane.

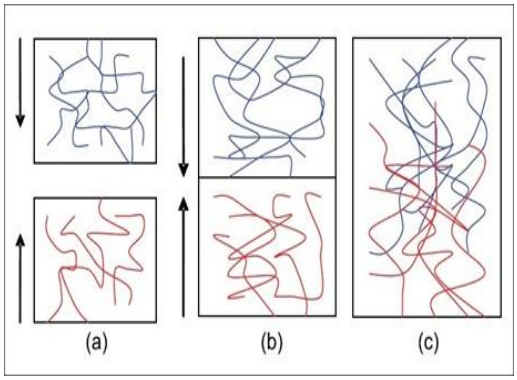



**Fig.8:** (a) Schematic representation of the diffusion theory of bioadhesion. Blue polymer layer and red mucus layer before contact; (b) Upon contact; (c) The interface becomes diffuse after contact for a period of time. [7]

### c)Fracture theory

The separation of two surfaces following adhesion is connected to the fracture hypothesis of adhesion.According to the formula, the fracture strength is equal to the adhesive strength.

$$G = (E\varepsilon. /L)\ ½$$

Where:

E: Young's Elasticity Modules
L: the critical crack length when two surfaces are separated,

ε: the fracture energy. [1]

### d)Electronic theory

The formation of ionic bonds or electrostatic attractions between the adhesive and mucosal surfaces is crucial to the electronic theory, which highlights the role of charge interactions in mucoadhesion. Adhesive materials and mucosal surfaces may carry opposite charges (positive or negative), resulting in electrostatic interactions that promote adhesion. [5] At the interface between the two surfaces, an electrical bi-layer is forming.
An effective mucoadhesion may result from the attractive force exerted by his interfacial bi-layer at the interface of two surfaces. [16]

### e) Adsorption theory

The adhesives' adhesion based on van der Waals forces and hydrogen bonds. These forces have been suggested as the primary causes of the sticky contact. The chemisorptions theory, a subset of this, postulates that strong covalent bonds cause an interaction across the contact. [10] After initial contact between two surfaces the materials adhere because of surface forces acting between the atoms in two surfaces.

### f) Mechanical theory

According to this idea, attachment emergencies result from fluid cement bonding into abnormalities on an unappealing surface. Thought to be more significant in the adhesion process than a mechanical effect, rough surfaces also increase the surface area available for interaction and improve the viscoelastic and plastic dissipation of energy during joint failure. [1] This theory mainly focus on the physical aspects of mucoadhesion or bioadhesion.

## METHODS TO STUDY MUCOADHESION [14]

- Tensile (Detachment) Method
- Rotating Disc Method
- Flow through method
- Rheological Method

## COMPONENTS USE IN MUCOADHESIVE DEUGS

- **Mucin**

Many epithelial cells manufacture mucins, a family of highly glycosylated, high molecular weight proteins. While some mucins are released into the mucosal surface or become a component of saliva, others stay membrane bound. Mucin, a viscoelastic substance that is released when the vesicles fuse with the plasma membrane, is referred to as mucus when it is coupled with other secretions. The medications coated with a mucoadhesive polymer adhere to the mucus and are therefore kept on the epithelium's surface for a long time. Over an extended period of time, the drug molecules are continuously released from the polymer. [3]

- **Chitosan**

It is created when chitin undergoes deacetylation and is a linear cationic polymer, a structural polysaccharide found in the shells of crustaceans. Because of its excellent biocompatibility, biodegradability, and nontoxic nature, chitosan is becoming more and more significant in the creation of mucoadhesive drug delivery system. Ionic connections between the amino group and salicylic acid residues allow it to adhere to the mucosa. Because it is linear, chitosan increases the flexibility of polymer chains. Onishi and Machida demonstrated how rapidly the kidneys remove chitosan and its metabolized compounds. [3]

Chitosan has been increasingly applied as pharmaceutical excipients in oral, ocular, nasal, implant, parenteral, and transdermal drug delivery because of its low cost, biodegradability, and biocompatibility. [9]

**Drugs:** Tetramethyl pyrazine, Insulin, Levonorgestrol, FD-4, Metaclopramide. (All are in liquid form)

- **Lections (16)**

Natural proteins called lectins are helpful in biological recognition between proteins and cells. A class of structurally varied proteins and glycoproteins known as lectins binds to particular carbohydrate residues in a reversible manner. Site-specific and regulated drug administration is made possible by the lectins' ability to either stay on the cell surface or enter the cell through endocytosis after binding. Despite their many benefits, lectins have the drawback of being immunogenic. [4], [3]

- **Starch**

One of the most popular mucoadhesive carriers for nasal drug delivery is starch, which has been shown to enhance the absorption of hydrophilic macromolecular medicines as well as tiny hydrophobic medications. The most popular kind of maize starch for medicinal purposes is waxy drum-dried maize starch, which is thought to be the best because of its superior bioadhesive qualities when compared to starches processed using other techniques and improve absorption of small hydrophobic and hydrophilic macromolecular drugs.

Starch is combines with other carbohydrates and form the mucoadhesive drug like- Apomorphine, Gentamicin, HGS. [9] (all are in powder form)

- **Polymers**

**Mucoadhesive polymers are categorised as – [4], [17]**

| Polymers | Examples |
|---|---|
| Synthetic polymers | 1.Cellulose derivatives (Methylcellulose, Ethyl cellulose, Hydroxyl ethyl cellulose, Hydroxyl propyl cellulose, Hydroxy propyl methylcellulose, Sodium carboxy methylcellulose).<br>2.Poly (Acrylic acid) polymers (Carbomers, Polycarbophil).<br>3. Poly hydroxyl ethyl methylacrylate.<br>4. Poly ethylene oxide.<br>5. Poly vinyl pyrrolidone.<br>6. Poly vinyl alcohol. |
| Natural polymers | Tragacanth, Sodium alginate, Guar gum, Xanthum gum, soluble starch, Gelatin, Chitosan. |
| Traditional non-specific first-generation mucoadhesive polymers-<br>1) Anionic polymers,<br>2) Cationic polymers,<br>3) Non-ionic polymers. | <br>Poly acrylic acid (PAA), sodium carboxymethylcellulose (NaCMC)<br>Chitosan, cellulose |
| Novel polymers | Tomato lectin |
| Hydrophillic polymers [3] | PYP (poly vinyl pyrrolidine),<br>MC (methyl cellulose),<br>SCMC (sodium carboxy methyl cellulose),<br>HPC (hydroxyl propyl cellulose) |

## FACTORS AFFECTING MUCOADHESIVE DRUG DELIVARY SYSTEM

- **Molecular weight:**

A polymer's mucoadhesive strength rises as its molecular weight surpasses 100,000. There is a direct relationship between polyoxyethylene polymers' mucoadhesive strength and molecular weights between 200,000 and 7,000,000. [9] For linear polymers, the finding that bioadhesiveness increases with molecular weight suggests two things:

➢ For lower molecular weight polymers to function well as bioadhesives.

- interpretation is more crucial, but entanglement is crucial for greater molecular weight polymers. [19]

- **Cross-linking density:**

Three significant and connected structural characteristics of a polymer network are the density of cross-linking, the average pore size, and the quantity and average molecular weight of the cross-linked polymers. Consequently, it makes sense that as crosslinking density increases, water diffuses into the polymer network more slowly, leading to inadequate polymer swelling and a slower rate of interpenetration between the polymer and mucin. [9]

- **Charge:**

Previous generalizations on the charge of bioadhesive polymers have suggested that non- ionic polymers adhere to surfaces to a lesser extent than anionic polymers. One of the necessary properties for mucoadhesion is a strong anionic charge on the polymer. Superior mucoadhesive qualities are likely to be displayed by certain cationic polymers, particularly in a neutral or slightly alkaline medium charge. [9]

- **Permeability:**

Between the intestinal mucosa and the epidermis, the oral mucosae are generally relatively leaky epithelium. The buccal mucosa's permeability is thought to be 4–4000 times higher than the skin. There are significant variations in permeability between various oral cavity regions due to the various structures and functions of the various oral mucosae, as evidenced by the large range in this reported value. [3]

- **Concentration:**

To achieve maximum bioadhesion, a bioadhesive polymer has an ideal concentration. However, the adhesive strength drastically decreases in highly concentrated systems above the ideal level because the coiled molecules separate from the medium, limiting the number of chains that may interpenetrate. [19] Strong interactions between the chains result in an inflexible polymer coil shape that prevents active mucoadhesion participation. [18]

- **pH:**

It can affect some ionisable bioadhesive polymers and the formal charge on the mucus surface. Because the carbohydrate moiety's functional groups and the polypeptide backbone's amino acids dissociate differently depending on pH, mucus will have a varied charge density. The degree of hydration of cross-linked polyacrylic acid is dependent on the medium's pH; it continuously increases from pH 4 to pH 7 and then decreases as alkalinity and ionic strength rise. [19]

- **Initial Contact Time:**

The amount of swelling and penetration of the bioadhesive polymer chains is determined by the contact period between the mucus layer and the bioadhesive.
Furthermore, as the initial contact time grows, so does the bioadhesive strength. [19]

- **Disease state:**

Disease conditions like the common cold, gastric ulcers, ulcerative colitis, cystic fibrosis, and bacterial and fungal infections of the female reproductive system are known to alter the physiochemical characteristics of mucus. [19]

- **Functional group:**

According to adsorption theory, the development of links between the polymer and the mucus that cause mucoadhesion. Interpenetration and secondary non-covalent bonding, such as the creation of hydrogen bonds between substrates, are required for the adhesion of bioadhesive polymers to biological substrates. As a result, weakly crosslinked networks are created when these functionalized polymers engage with the mucus through secondary chemical interactions. [18]

- **Viscosity:**

High mucus viscosity leads to the strong mucoadhesive bond between mucosa layer and drug molecules.

- **Initial contact time:**

The initial contact time cannot be controlled for the mucoadhesive systems. Drug action depend on that time.

- **Presence of chemical groups, charge and ionization;**

Mucoadhesion will be facilitated by the presence of chemical groups that could help the polymer and mucus create contacts. Adhesion is increased when there are adequate amounts of chemical groups, such as hydroxyl, amine, sulfate, and carboxyl groups, that create hydrogen bonds with the mucus gel. It has also been shown that the charge density matters. Furthermore, polyanions are preferred over polycations when toxicity and bioadhesion are taken into account, and carboxyl-containing polymers are superior to sulfated ones. Mucoadhesion will be impacted because the pH influences the charge density of the mucin molecule as well as the polymer. (22)

## APPLICATION

- Improved medication bioavailability due to adhesion to particular body sites, such as the nose and oral canals. (1)
- The creation of an ideal contact with the adhesion surface, which improves the absorption of drugs. (1)
- The extension of the dosage's half-life within 10 gastrointestinal tracts. This would lessen the requirement for numerous dosage, which leads to improved patient adherence. (1)
- Numerous clinical applications, including cardiology, smoking cessation, sedative, analgesia, antiemesis, diabetes, and hormone therapy, have made use of buccal and sublingual administrations. (8)
- The mucosal membranes are highly vascularized so that the administration as well as removal of a dosage form is easy. (16)
- Vaccine delivery for treatment of different diseases including, hepatitis, pertussis, diphtheria, birth control. And the microspheres present in the vaccine delivery have a specific features like modulation of antigen release, stabilization of antigen, etc. (23)
- Targeting of delivering drug at the specific site if action.
- Imaging: various cells, cell lines, tissues and organs can be imaged using radio labelled microsphere. (23)
- Release of proteins, hormones, and peptides over extended period of time.
- Gene therapy with DNA plasmid and also delivery of insulin in the body.

## REFERANCE

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