Mucoadhesive Drug Delivery System: A Review

Priya Mahajan, Amanpreet Kaur, Geeta Aggarwal, S.L. Harikumar
Rayat & Bahra Institute of Pharmacy, Sahauran, Kharar, District Mohali, Punjab-140104, India

Abstract
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. However, peroral route has shortcomings such as hepatic first pass metabolism and enzymatic degradation in GIT which is a hindrance to the absorption of most proteins and peptides groups of drugs. The mucosa of the oral cavity presents a formidable barrier to drug penetration, and one method of optimizing drug delivery is by the use of adhesive dosage forms and the mucosa has a rich blood supply and it is relatively permeable. The buccal mucosa is very suitable for a bioadhesion system because of a smooth and relatively immobile surface and accessibility. Mucoadhesion can be achieved by using mucoadhesive polymers. There are different types of mucoadhesive polymers are available. Laminated devices have been developed to achieve sustained drug release.

Key words:
Mucoadhesive, Oral Mucosa, Bioadhesive.

How to Cite this Paper:

Copyright © 2013 IJDDR, Amanpreet Kaur et al. This is an open access paper distributed under the copyright agreement with Serials Publication, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article History:------------------------
Date of Submission: 12-11-2012
Date of Acceptance: 20-12-2012
Conflict of Interest: NIL
Source of Support: NONE

INTRODUCTION
MUCOADHESIVE DRUG DELIVERY SYSTEM
Mucoadhesive drug delivery systems are delivery systems which utilize the property of bioadhesion of certain polymers which become adhesive on hydration and hence can be used for targeting a drug to a particular region of the body for extended periods of time.

Bioadhesion is an interfacial phenomenon in which two materials, at least one of which is biological, are held together by means of interfacial forces. The
attachment could be between an artificial material and biological substrate, such as adhesion between a polymer and a biological membrane. In the case of polymer attached to the mucin layer of a mucosal tissue, the term “mucoadhesion” is used. [1]

Mucoadhesive drug delivery systems can be delivered by various routes:-
- Buccal delivery system
- Oral delivery system
- Vaginal delivery system
- Rectal delivery system
- Nasal delivery system
- Ocular delivery system

MUCAODHESIVE ORAL DRUG DELIVERY SYSTEMS

Oral route is the most preferred route for the delivery of any drug. Drug delivery via the membranes of the oral cavity can be subdivided as:-
- Sublingual delivery: This is systemic delivery of drugs through the mucosal membranes lining the floor of the mouth.
- Buccal delivery: This is drug administration through the mucosal membranes lining the cheeks (buccal mucosa).
- Local delivery: This is drug delivery into the oral cavity.

Within the oral mucosal cavity, the buccal region offers an attractive route of administration for controlled systemic drug delivery. Buccal delivery is the administration of drugs through the mucosal membrane lining the cheeks. Although the sublingual mucosa is known to be more permeable than the buccal mucosa, the latter is the preferred route for systemic transmucosal drug delivery. This is because the buccal mucosa has an expanse of smooth muscle and relatively immobile mucosa, which makes it a more desirable region for retentive systems. Thus, the buccal mucosa is more appropriate for sustained direction of drug delivery. [2]

ADVANTAGES OF ORAL MUCAODHESIVE DRUG DELIVERY SYSTEMS:
- Prolongs the residence time of the dosage form at the site of absorption, hence increases the bioavailability.
- Excellent accessibility, rapid onset of action.
- Rapid absorption because of enormous blood supply and good blood flow rates.
- Drug is protected from degradation in the acidic environment in the gut.
- Improved patient compliance. [3]

DISADVANTAGES OF MUCAODHESIVE DRUG DELIVERY SYSTEMS:
- Occurrence of local ulcerous effects due to prolonged contact of the drug possessing ulcerogenic property.
- One of the major limitations in the development of oral mucosal delivery is the lack of a good model for in vitro screening to identify drugs suitable for such administration.
- Patient acceptability in terms to taste and irritancy.
- Eating and Drinking is prohibited. [3]

COMPONENTS / STRUCTURAL FEATURES OF ORAL CAVITY

Oral cavity is that area of mouth delineated by the lips, cheeks, hard palate, soft palate and floor of mouth. The oral cavity consists of two regions.
- Outer oral vestibule, which is bounded by cheeks, lips and gingival (gums).
- Oral cavity proper, which extends from teeth and gums back to the fauces (passage which lead to pharynx) with the roof comprising the hard and soft palate. The tongue projects from the floor of the cavity.

ANATOMY AND NATURE OF ORAL CAVITY:
The oral cavity may be divided into two regions, the outer oral vestibule, bounded by the lips and cheeks.
and the oral cavity itself the borders being, and formed by the hardened soft palates, the floor of the mouth and tonsils.

Physical Description of Oral Cavity:
The mucosa that lines the oral cavity may be divided into three types, classified according to their function as:-

1. Masticatory mucosa: Which includes the mucosa around the teeth and on the hard palate and these regions have keratinized epithelium.
2. Lining mucosa: Which covers the lips, cheeks, base of the oral cavity, lower part of tongue, buccal mucosa and the soft palate and these regions have non keratinized epithelium.
3. Specialized mucosa: Covering the dorsum of the tongue with highly keratinization. [1]

OVERVIEW OF THE ORAL MUCOSA

Structure
The oral mucosa is comprised of squamous stratified (layered) epithelium, basement membrane, the lamina propria and submucosa. It also contains many sensory receptors including the taste receptors of the tongue. The epithelium of the buccal mucosa is about 40-50 cell layers thick, while that of the sublingual epithelium contains somewhat fewer.

Permeability
The oral mucosa in general is somewhat leaky epithelia intermediate between that of the epidermis and intestinal mucosa. It is estimated that the permeability of the buccal mucosa is 4-4000 times greater than that of the skin. In general, the permeabilities of the oral mucosae decrease in the order of sublingual greater than buccal and buccal greater than palatal. This rank order is based on the relative thickness and degree of keratinization of these tissues, with the sublingual mucosa being relatively thin and non-keratinized, the buccal thicker and non-keratinized, and the palatal intermediate in thickness but keratinized.

Environment
The cells of the oral epithelia are surrounded by an intercellular ground substance, mucus, the principle components of which are complexes made up of proteins and carbohydrates. These complexes may be free of association or some maybe attached to certain regions on the cell surfaces. This matrix may actually play a role in cell-cell adhesion, as well as acting as a lubricant, allowing cells to move relative to one another. Along the same lines, the mucus is also believed to play a role in bioadhesion of mucoadhesive drug delivery systems.

Composition of Mucus Layer:
Mucus is a translucent and viscid secretion which forms a thin, contentious gel, mean thickness of this layer varies from about 50-450 µm in humans secreted by the goblet cells lining the epithelia. It has the following general composition.

- Water -95%
- Glycoprotein and lipids – 0.5-3.00%
- Mineral salts – 1%
- Free proteins – 0.5-1.0% [1]

Functions of Mucus Layer:
1. Protective: resulting particularly from its hydrophobicity.
2. Barrier: The role of the mucus layer as a barrier in tissue absorption of the drugs and influence the bioavailability.
3. Adhesion: Mucus has strong adhesion properties.
4. Lubrication: It is to keep the mucus from the goblet cell is necessary to compensate for the removal of the mucus layer due to digestion, bacterial degradation and solubilisation of mucin molecules. [1]

Role of Saliva:
Saliva is composed of 99% water and is complex fluid containing organic and inorganic material. Secretion of saliva is highest during working hours.

1. Protective fluid for all tissues of the oral cavity.
2. Continuous mineralization / demineralization of the tooth enamel.
3. Moisten the oral cavity. [4]
THEORIES OF MUCOADHESION

There are six general theories of adhesion, which have been adapted for the investigation of mucoadhesion:

- **The electronic theory** suggests that electron transfer occurs upon contact of adhering surfaces due to differences in their electronic structure. This is proposed to result in the formation of an electrical double layer at the interface, with subsequent adhesion due to attractive forces.

- **The wetting theory** is primarily applied to liquid systems and considers surface and interfacial energies. It involves the ability of a liquid to spread spontaneously onto a surface as a prerequisite for the development of adhesion. The affinity of a liquid for a surface can be found using techniques such as contact angle goniometry to measure the contact angle of the liquid on the surface, with the general rule being that the lower the contact angle, the greater the affinity of the liquid to the solid.

- **The adsorption theory** describes the attachment of adhesives on the basis of hydrogen bonding and van der Waals' forces. It has been proposed that these forces are the main contributors to the adhesive interaction. A subsection of this, the chemisorptions theory, assumes an interaction across the interface occurs as a result of strong covalent bonding.

- **The diffusion theory** describes interdiffusion of polymers chains across an adhesive interface. This process is driven by concentration gradients and is affected by the available molecular chain lengths and their mobilities. The depth of interpenetration depends on the diffusion coefficient and the time of contact. Sufficient depth of penetration creates a semi-permanent adhesive bond.

- **The mechanical theory** assumes that adhesion arises from an interlocking of a liquid adhesive (on setting) into irregularities on a rough surface. However, rough surfaces also provide an increased surface area available for interaction along with an enhanced viscoelastic and plastic dissipation of energy during joint failure, which are thought to be more important in the adhesion process than a mechanical effect.

- **The fracture theory** differs a little from the other five in that it relates the adhesive strength to the forces required for the detachment of the two involved surfaces after adhesion.

MECHANISMS OF MUCOADHESION

The mechanism of mucoadhesion is generally divided in two steps,

1. **Contact stage**
2. **Consolidation stage**

The first stage is characterized by the contact between the mucoadhesive and the mucous membrane, with spreading and swelling of the formulation, initiating its deep contact with the mucus layer. In some cases, such as for ocular or vaginal formulations, the delivery system is mechanically attached over in other cases, the deposition is promoted by the aerodynamics of the organ to the membrane, the system is administered, such as for the nasal route.

In the consolidation step, the mucoadhesive materials are activated by the presence of moisture. Moisture plasticizes the system, allowing the mucoadhesive molecules to break free and to link up by weak van der Waals and hydrogen bonds. Essentially, there are two theories explaining the consolidation step:

1. **The diffusion theory**
2. **The dehydration theory.**
According to diffusion theory, the mucoadhesive molecules and the glycoproteins of the mucus mutually interact by means of interpenetration of their chains and the building of secondary bonds. For this to take place the mucoadhesive device has features favouring both chemical and mechanical interactions. According to dehydration theory, materials that are able to readily gelify in an aqueous environment, when placed in contact with the mucus can cause its dehydration due to the difference of osmotic pressure.

**FACTORS AFFECTING MUCOADHESION**

Based on the theories of the adhesion, it can be summarized

**Table 1: Commercial Mucoadhesive Drug Delivery System**

<table>
<thead>
<tr>
<th>DRUG</th>
<th>MUCOADHESIVE POLYMERS</th>
<th>APPLICATION SITE</th>
<th>NAME &amp; FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Triamcinolone acetonide</td>
<td>Hydroxypropyl cellulose, cabopol 934</td>
<td>Oral cavity</td>
<td>Attach tablet</td>
</tr>
<tr>
<td>2) Nitroglycerin</td>
<td>Synchron (modified HPMC)</td>
<td>Bucal</td>
<td>Susadri tablet</td>
</tr>
<tr>
<td>3) Prochlorperazine Maleate</td>
<td>Ceronia, Xanthum Gum</td>
<td>Bucal</td>
<td>Bucastem tablet</td>
</tr>
<tr>
<td>4) Beclomethasone dipropionate</td>
<td>Hydroxypropyl cellulose, Sodium CMC, pectin, and gelatin in polyethylene spread</td>
<td>Oral cavity</td>
<td>Salcoat powder spray</td>
</tr>
<tr>
<td>5) Beclomethasone dipropionate</td>
<td>Hydroxypropyl cellulose, Sodium CMC, pectin, and gelatin in polyisobutylene spread</td>
<td>Oral cavity</td>
<td>Oral base gel</td>
</tr>
<tr>
<td>6) Aluminium hydroxide</td>
<td>Polycrylic acid</td>
<td>Vaginal</td>
<td>Raplens gel</td>
</tr>
<tr>
<td>7) Fantanyl citrate</td>
<td>Succro octasulfate</td>
<td>GIT ulcers</td>
<td>Sucralfate</td>
</tr>
<tr>
<td>8) Nitroglycerine</td>
<td>Carbopol, HPMC K5M, K4M</td>
<td>Oral cavity</td>
<td>Nitrostat tablet</td>
</tr>
<tr>
<td>9) Miconazole</td>
<td>Na CMC, HEC</td>
<td>Oral cavity</td>
<td>Loramyc</td>
</tr>
<tr>
<td>10) Testosterone</td>
<td>HPMC, PVA, Chitosan PC and Eudragit R S-100 (Poly(methacrylic acid-co-methyl methacrylate))</td>
<td>Oral cavity</td>
<td>Striant SR</td>
</tr>
<tr>
<td>12) Buprenorphine</td>
<td>Gelatin and CP 934P, Polyisobutylene, and Polysoprene</td>
<td>Oral route</td>
<td>Subutex tablets</td>
</tr>
</tbody>
</table>
MUCOADHESIVE POLYMERS

Mucoadhesive drug delivery systems are based on the adhesion of a drug/carrier to the mucous membrane. To promote this adherence a suitable carrier is required.

Ideal Characteristics of Mucoadhesive Polymers:

A mucoadhesion promoting agent or the polymer is added to the formulation which helps to promote the adhering of the active pharmaceutical ingredient to the oral mucosa. The agent can have such additional properties like swelling so as to promote the disintegration when in contact with the saliva.

1) Polymer must have a high molecular weight up to 100.00 or more. This is necessary to promote the adhesiveness between the polymer and mucus.
2) Long chain polymers-chain length must be long enough to promote the interpenetration and it should not be too long that diffusion becomes a problem.
3) High viscosity.
4) Degree of cross linking-it influences chain mobility and resistance to dissolution. Highly cross linked polymers swell in presence of water and retain their structure. Swelling favours controlled release of the drug and increases the polymer/mucus interpenetration
5) Spatial conformation.
6) Flexibility of polymer chain this promotes the interpenetration of the polymer within the mucus network.
7) Concentration of the polymer-an optimum concentration is required to promote the mucoadhesive strength. It depends however, on the dosage form.
8) Charge and degree of ionization-the effect of polymer charge on mucoadhesion was clearly shown by Bernkop-Schnurch and Freudl. Cationic chitosan HCl showed marked adhesiveness when compared to the control. The attachment of EDTA an anionic group increased the mucoadhesive strength significantly. DTPA/chitosan system exhibited lower mucoadhesive strength than cationic chitosan and anionic EDTA chitosan complexes because of low charge. Hence the mucoadhesive strength can be attributed as anion>cation>non-ionic.
9) Optimum hydration-excessive hydration leads to decreased mucoadhesive strength due to formation of a slippery mucilage.
10) Optimum pH-mucoadhesion is optimum at low pH conditions but at higher pH values a change in the conformation occurs into a rod like structure making those more available for inter diffusion and interpenetration. At very elevated pH values, positively charged polymers like chitosan form polyelectrolyte complexes with mucus and exhibit strong mucoadhesive forces.
11) It should non toxic, economic, biocompatible preferably biodegradable.

Various mucoadhesive polymers can broadly be categorized as follow:

Synthetic polymers:
1. Cellulose derivatives (Methylcellulose, Ethyl cellulose, Hydroxyl ethyl cellulose, Hydroxyl propyl cellulose, Hydroxy propyl methylcellulose, Sodium carboxymethylcellulose).
2. Poly (Acrylic acid) polymers (Carbomers, Polycarbophil).
3. Poly hydroxyl ethyl methylacrylate.
5. Poly vinyl pyrrolidone.
6. Poly vinyl alcohol.

Natural polymers:
Tragacanth, Sodium alginate, Guar gum, Xanthum gum, soluble starch, Gelatin, Chitosan

Mucoadhesive polymers can also classify into following categories:

Traditional non-specific first-generation mucoadhesive polymers
First-generation mucoadhesive polymers may be divided into three main subsets, namely:
1) Anionic polymers,
2) Cationic polymers,
3) Non-ionic polymers.
Of these, anionic and cationic polymers have been shown to exhibit the greatest mucoadhesive strength. Consequently, such charged polymeric systems will now be examined in more depth.
Anionic polymers are the most widely employed mucoadhesive polymers within pharmaceutical formulation due to their high mucoadhesive functionality and low toxicity. Typical examples include poly (acrylic acid) (PAA) and its weakly cross-linked derivatives and sodium carboxymethylcellulose (NaCMC). PAA and NaCMC possess excellent mucoadhesive characteristics due to the formation of strong hydrogen bonding interactions with mucin. Polycarbophil (Noveon) and Carbomers (Carbopol), PAA derivatives have been studied extensively as mucoadhesive platforms for drug delivery to the GI tract.

Cationic Polymers
Of the cationic polymer systems, undoubtedly chitosan is the most extensively investigated within the current scientific literature. Chitosan is a cationic polysaccharide, produced by the deacetylation of chitin, the most abundant polysaccharide in the world, next to cellulose. The intriguing properties of chitosan have been known for many years with many examples of its use in agriculture, industry and medicine. [9]

Novel second-generation mucoadhesive
The major disadvantage in using traditional non-specific mucoadhesive systems (first generation) is that adhesion may occur at sites other than those intended. Unlike first-generation non-specific platforms, certain second-generation polymer platforms are less susceptible to mucus turnover rates, with some species binding directly to mucosal surfaces; more accurately termed “Cytoadhesives”.

Lectins
The most widely investigated of such systems in this respect are lectins. Lectins belong to a group of structurally diverse proteins and glycoproteins that can bind reversibly to specific carbohydrate residues. After initial mucosal cell-binding, lectins can either remain on the cell surface or in the case of receptor-mediated adhesion possibly become internalised via a process of endocytosis.

Table 2: Various Properties and characteristics of bioadhesive polymers are discussed below:-[10]

<table>
<thead>
<tr>
<th>Bioadhesives</th>
<th>Properties</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycarbophil (polyacrylic acid crosslinked with divinylglycol)</td>
<td>Mw 2.2×10^5 η 2000–22,500 cps (1% aq. soln.) κ 15–35 mL/g in acidic media (pH 1–3) 100 mL/g in neutral and basic media</td>
<td>Synthesized by lightly crosslinking of 0.5–1% w/w divinyl glycol Swellable depending on pH and ionic strength. Swelling increases as pH increases. At pH 1–3, absorbs 15–35 mL of water per gram but absorbs 100 mL per gram at neutral and alkaline pH. Entangle the polymer with mucus on the surface of the tissue Hydrogen bonding between the nonionized carboxylic acid and mucin.</td>
</tr>
<tr>
<td>Poly (Hydroxy butyrate), Poly (ε-caprolactone) and copolymers.</td>
<td>Biodegradable Properties can be changed by chemical modification, copolymerization and blending.</td>
<td>Used as a matrix for drug delivery systems, cell microencapsulation.</td>
</tr>
<tr>
<td>Carbopol/carbomer (carboxy polymethylene) empirical formula: (C₃H₄O₂)x (C₃H₅ –Sucrose)y</td>
<td>Pharmaceutical grades: 934 P, 940 P, 971 P and 974 P. Mw 1×10⁶–4×10⁶ η 29,400–39,400 cps at 25 °C with 0.5% neutralized aqueous solution. κ 5 g/cm³ in bulk, 1.4 g/cm³ tapped. pH 2.5–3.0 ϕ water, alcohol, glycerine</td>
<td>Synthesised by cross-linker of allyl sucrose or pentaerythritol. Excellent thickening, emulsifying, suspending, gelling agent. Common component in bioadhesive dosage forms. Gel looses viscosity on exposure to sunlight. Unaffected by temp. Variations, hydrolysis, oxidation and resistant to bacterial growth. It contributes no off-taste and may mask the undesirable taste of the formulation. Incompatible with phenols, cationic polymers, high concentration of electrolytes and resorcinol.</td>
</tr>
<tr>
<td>Hydroxypropyl cellulose partially substituted polyhydroxy propylether of</td>
<td>Grades: Klucel EF, LF, JF, GF, MF and HF</td>
<td>Best pH is between 6.0 and 8.0. Solutions of HPC are susceptible to shear, heat,</td>
</tr>
</tbody>
</table>

Covered in Scopus & Embase, Elsevier
Review Paper

Amanpreet kaur et al: Mucoadhesive Drug Delivery System: A Review

---

**Xantham gum**

- An anionic polysaccharide derived from the fermentation of the plant bacteria *Xanthamonas campestris*
- Empirical formula: \((C_{15}H_{28}O_{8})_n\)
- White to slightly yellowish, odorless powder.
- Soluble in water below 38°C, ethanol, propylene glycol, dioxane, methanol, isopropyl alcohol, dimethyl sulfoxide, dimethyl formamide etc.
- Insoluble in hot water.
- It is inert and showed no evidence of skin irritation or sensitization.
- It is more tolerant of electrolytes, acids and bases than most other organic gums.
- It can, nevertheless, be gelled or precipitated with certain polyvalent metal cations under specific circumstances.
- It is non-ionic and anionic water-soluble thickeners. It is strongly compatible with most water-soluble gums and resins.
- It is biocompatible and biodegradable.
- Mucoadhesive agent due to either secondary chemical bonds such as hydrogen bonds or ionic interactions between the positively charged amino groups of chitosan and the negatively charged sialic acid residues of mucus glycoproteins or mucins.
- Biocompatible and biodegradable.
- Excellent gel forming and film forming ability.
- Used also for microencapsulation.

**Hydroxypropylmethyl Cellulose HPMC**

- (cellulose 2-hydroxypropylmethyl ether)
- Empirical formula: \(\text{C}_{10}\text{H}_{18}\text{O}_{6}\text{Na}\) and \(\text{C}_{6}\text{H}_{10}\text{O}_{6}\text{Na}\) for E grades.
- Solutions are pseudoplastic with some degree of yield value. Certain ca-Iota solutions are thixotropic. Lambda is non-gelling. Kappa can produce brittle gels; Iota can produce elastic gels. All solutions show a reversible decrease in viscosity at elevated temperatures. Iota and Lambda Carrageenan have excellent electrolyte tolerance; kappa’s being somewhat less. The best solution stability occurs in the pH 6 to 10. It is compatible with most non-ionic and anionic water-soluble thickeners. It is strongly synergistic with locust bean gum and strongly inter-active with proteins.
- Excellent thermoreversible properties.

**Carrageenan**

- An anionic polysaccharide, extracted from the red seaweed *Chondrus Crispus*.
- It will dissolve in hot glycerine. Solutions are typically in the 1500 to 2500 cps range at 1%; they are pseudoplastic and especially shear-thinning.
- In the presence of small amounts of salt, solutions show good viscosity stability at elevated temperatures.
- All solutions are pseudoplastic with some degree of yield value. Certain ca-Iota solutions are thixotropic.
- Lambda is non-gelling. Kappa can produce brittle gels; Iota can produce elastic gels.
- All solutions show a reversible decrease in viscosity at elevated temperatures.
- Iota and Lambda Carrageenan have excellent electrolyte tolerance; kappa’s being somewhat less.
- The best solution stability occurs in the pH 6 to 10.
- It is biocompatible and non-ionic.
- It is strongly synergistic with locust bean gum and strongly inter-active with proteins.
- Excellent thermoreversible properties.

**Chitosan**

- A linear polysaccharide composed of randomly distributed \(-\beta-(1-4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D glucosamine (acetylated unit).\)
- Prepared from chitin of crabs and lobsters by \(N\) deacetylation with alkali.
- Dlute acids to produce a linear polyelectrolyte with a high positive charge density and forms salts with inorganic and organic acids such as glutamic acid, hydrochloric acid, lactic acid, and acetic acid.
- It is biocompatible and biodegradable.
- Excellent gel forming and film forming ability.

**Sodium Alginate**

- Consists chiefly of the alginic acid-id, a polyuronic acid composed of \(-\beta-D-mannuronic acid resi-dues.\)
- Empirical formula: \((C_{6}H_{7}O_{6}Na)\) an anionic polysaccharide extracted principally from the giant kelp *Macrocystis Pyrifera* as alginic acid and neutralized to sodium salt.
- Purified carbohydrate product ex-tracted from brown seaweed by the use of dilute alkali.
- Occurs as a white or buff powder, which is odourless and tasteless.
- \(\text{pH} 7.2\)
- Water, forming a viscous, colloidal solution.
- Insoluble in other organic solvents and acids where the \(\text{pH}\) of the result-ing solution and acids where the \(\text{pH}\) of the...
Thiolated polymers:
The presence of free thiol groups in the polymeric skeleton helps in the formation of disulphide bonds with that of the cysteine-rich sub-domains present in mucin which can substantially improve the mucoadhesive properties of the polymers (e.g. poly (acrylic acid) and chitosan). Various thiolated polymers include chitosan–iminothiolane, poly(acrylic acid)–cysteine, poly (acrylic acid)–homocysteine, chitosan–thioglycolic acid, chitosan–thioethylamide, alginate–cysteine, poly (methacrylic acid)–cysteine and sodium carboxymethylcellulose–cysteine.

Polyox WSR
A class of high molecular weight polyethylene molecular weight polyethylene oxide homopolymers having the following properties,

<table>
<thead>
<tr>
<th>DRUG</th>
<th>DOSAGE FORMS</th>
<th>POLYMERS</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tramadol HCL</td>
<td>Microspheres</td>
<td>Carbopol, Sodium alginate</td>
<td>Gonjari et al, 2009</td>
</tr>
<tr>
<td>2. Flufenamic</td>
<td>Films</td>
<td>Chitosan</td>
<td>Mura et al, 2010</td>
</tr>
<tr>
<td>3. Ondansteron</td>
<td>Tablets</td>
<td>Carbopol, Sodium alginate, Gelatin</td>
<td>Kotagale et al, 2010</td>
</tr>
<tr>
<td>4. Domeperidone</td>
<td>Tablet</td>
<td>Taro gum</td>
<td>Arora et al, 2011</td>
</tr>
<tr>
<td>5. Glibenclamide</td>
<td>Films</td>
<td>HPMC, PVP, Carbopol</td>
<td>Indira et al, 2012</td>
</tr>
</tbody>
</table>

RECENT ADVANCES IN MUCOADHESIVE DRUG DELIVERY SYSTEM

Mucoadhesive Polymers
Diverse classes of polymers have been investigated for potential use as mucoadhesive. PAA has been considered as a good mucoadhesive. PAA is copolymerised with polyethylene glycol (PEG) or poly (vinyl pyrrolidone) (PVP) to improve these properties.

Devices
Several laminated devices have been developed to achieve sustained drug release. It can be classified as:-

- Water soluble hydrophilic nature
- Functional group for hydrogen bonding
- Biocompatible and non toxic
- High molecular weight

Novel polymers
- Tomato lectin showed that it has binding selectivity to the small intestine epithelium.
- A new class of hydrophilic pressure sensitive adhesives (PSA) have been developed by corium technologies. Complex have been prepared by non covalent hydrogen bonding crosslinking of a film forming hydrophilic polymer with a short chain plasticizer having reactive OH groups at chain ends.

Table 3: REPORTED MUCOADHESIVE / BUCCAL DOSAGE FORMS

CONCLUSION
The phenomenon of mucoadhesion can be used as a model for the controlled drug delivery approaches for
a number of drug candidates. There is no doubt that the oral route is the most favoured and probably most complex route of drug delivery. The buccal mucosa offers several advantages for controlled drug delivery for extended periods of time. The mucosa is well supplied with both vascular and lymphatic drainage and first-pass metabolism in the liver and pre-systemic elimination in the gastrointestinal tract are avoided.

REFERENCES


