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Review Article

Polymers used for Fast Disintegrating Oral Films: A Review

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ABSTRACT

Current developments in the technology have presented viable dosage alternatives from oral route for pediatrics, geriatric, bedridden, nauseous or noncompliant patients. Oral thin film, a new drug delivery system for the oral delivery of the drugs, was developed based on the technology of the transdermal patch. Fast-dissolving oral thin film is a solid dosage form, which disintegrate or dissolve within 1 min when placed in the mouth without drinking of water or chewing. Oral film includes various ingredients for its formulation which includes polymers, active pharmaceutical ingredient, film stabilizing agents, sweeteners, flavours, colors, saliva stimulating agents, preservatives, surfactants etc but the first and far most a very essential ingredient which helps in film formation is a Polymer. Fast dissolving Film is prepared using hydrophilic polymers that rapidly dissolves on the tongue or buccal cavity, delivering the drug to the systemic circulation via dissolution when contact with liquid is made. Water-soluble polymers are used as film formers for fast dissolving films. The water-soluble polymers achieve rapid disintegration, good mouth feel and mechanical properties to the films. Fast-dissolving oral thin film offer fast, accurate dosing in a safe, efficacious format that is convenient and portable, without the need for water or measuring devices. In this review article the different polymers used for preparation of fast-dissolving oral thin film like Pullulan, Gelatin, Sodium Alginate, Pectin, Rosin, Starch, Chitosan are discussed together with their physicochemical properties and film forming properties.

Keywords: Fast dissolving films, Oral thin films, plasticizers, polymers.

INTRODUCTION

Recent developments in the technology have presented viable dosage alternatives from oral route for pediatrics, geriatric, bedridden, nauseous or noncompliant patients. Buccal drug delivery has lately become an important route of drug administration. Various bioadhesive mucosal dosage forms have been developed, which includes adhesive tablets, gels, ointments, patches and more recently the use of polymeric films for buccal delivery, also known as oral thin films[1,2] which is also known as, fast dissolving film, oral strip, mouth dissolving film etc. Oral thin film, a new drug delivery system for the oral delivery of the drugs, was developed based on the technology of the transdermal patch. The delivery system consists of a very thin oral strip, which is simply placed on the patient's tongue or any oral mucosal tissue, instantly wet by saliva the film rapidly hydrates and adheres onto the site of application. It then rapidly disintegrates and dissolves to release the medication for oromucosal absorption or with formula modifications, will maintain the quick-dissolving aspects allow for gastrointestinal absorption to be achieved when swallowed.[1, 3]

Pharmaceutical companies and consumers alike have embraced OTFs as a practical and accepted alternative to traditional OTC medicine forms such as liquids, tablets, and capsules. OTFs offer fast, accurate dosing in a safe, efficacious format that is convenient and portable, without the need for water or measuring devices. OTFs are typically the size of a postage stamp and disintegrate on a patient's tongue in a matter of seconds for the rapid release of one or more APIs.[3]

Fast-dissolving oral thin film is a solid dosage form, which disintegrate or dissolve within 1 min when placed in the mouth without drinking of water or chewing. After disintegrating in mouth, enhanced the clinical effect of drug through pre-gastric absorption from mouth pharynx and oesophagus as the saliva passes down into the stomach. In such cases, bioavailability of drug is significantly greater than those observed from conventional tablet dosage form. Fast dissolving films may be preferred over adhesive tablets in terms of flexibility and comfort.[4] In addition, they can circumvent the relatively short residence time of oral gels on the mucosa, which are easily washed away and removed by saliva.

Oral thin film has main four types: Flash release film, flash dispersible film, Nondisintegrating mucoadhesive film, medium disintegrating mucoadhesive film.[5] An ideal film should be flexible, elastic, and soft, yet adequately strong to withstand breakage due to stress from mouth movements. It must also possess good bioadhesive strength in order to be retained in the mouth for the desired duration of action.[6]

Oral film includes various ingredients for its formulation which includes polymers, active pharmaceutical ingredient, film stabilizing agents, sweeteners, flavours, colors, saliva stimulating agents, preservatives, surfactants etc but the first and far most a very essential ingredient which helps in film formation is a Polymer.[7] A variety of polymers are available for preparation of FDF. As the strip forming polymer (which forms the platform for the FDF) is the most essential and major component of the FDF at least 45%w/w of polymer should generally be present based on the total weight of dry film but typically 60 to 65%w/w of polymer is preferred to obtain desired properties.[8] The polymers can be used alone or in combination to obtain the desired strip properties.[9] The film obtained should be tough enough so that there won't be any damage while handling or during transportation. The robustness of the strip depends on the type of polymer and the amount in the formulation.[10, 11]

Ideal properties of the film forming polymers[12, 13]

- The polymer employed should be non-toxic, non-irritant and devoid of leachable impurities
- It should have good wetting and spreadability property
- The polymer should exhibit sufficient peel, shear and tensile strengths
- The polymer should be readily available and should not be very expensive
- It should have good shelf life
- It should not aid in cause secondary infections in the oral mucosa/ dental region
- It should have a good mouth feel property
- The polymers employed should have good shelf life
- It should not aid in causing secondary infections in the oral mucosa or dental regions
- It would be ideal to have a polymer that would have local enzyme inhibition action along with penetration enhancing property

Fast dissolving Film is prepared using hydrophilic polymers that rapidly dissolves on the tongue or buccal cavity, delivering the drug to the systemic circulation via dissolution when contact with liquid is made. Water-soluble polymers are used as film formers for fast dissolving films. The water-soluble polymers achieve rapid disintegration, good mouth feel and mechanical properties to the films. The disintegration rate of the polymers is decreased by increasing the molecular weight of polymer film bases.[13]

Some of the water soluble polymers used as film former are HPMC E3, E5 and E15 and K-3, Methyl cellulose A-3, A-6 and A-15, Pullulan, carboxmethylcellulose cekol 30, Polyvinylpyrollidone PVP K-90, Pectin, Gelatin, Sodium Alginate, Hdroxypropylcellulose, Polyvinyl alcohol, Maltodextrins and Eudragit RD108, 9, 10, 11, 12 Eudragit RL100. Polymerized rosin is a novel film forming polymer.[14-16]

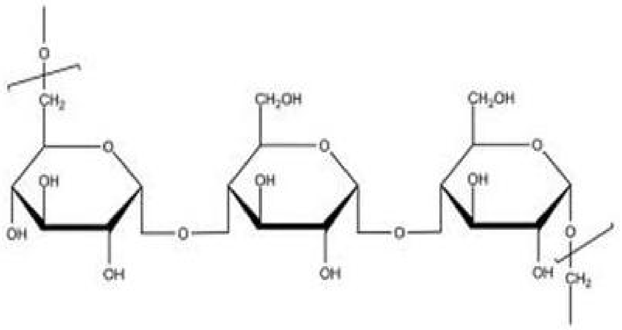
Various polymers can be employed to modulate the disintegration property of the FDF. This is especially used in case of slowly disintegrable oral bioadhesive strips or patches that need to be retained in intact form for longer duration in the oral cavity. The bioadhesive polymer used in such formulations imparts the adhesive property to the strip such that it adheres to buccal mucosa to deliver the drug for prolonged period. Bioadhesive polymer should ideally adhere quickly to the buccal mucosa and should have sufficient mechanical strength.[17, 18]

Plasticizer is a vital ingredient of the OS formulation. It helps to improve the flexibility of the strip and reduces the brittleness of the strip. Plasticizer significantly improves the strip properties by reducing the glass transition temperature of the polymer. The selection of plasticizer will depend upon its compatibility with the polymer and also the type of solvent employed in the casting of strip. The flow of polymer will get better with the use of plasticizer and enhances the strength of the polymer.[19, 20] Glycerol, Propylene glycol, low molecular weight polyethylene glycols, phthalate derivatives like dimethyl, diethyl and dibutyl phthalate, Citrate derivatives such as tributyl, triethyl, acetyl citrate, triacetin and castor oil are some of the commonly used plasticizer excipients. However inappropriate use of plasticizer may lead to film cracking, splitting and peeling of the strip. It is also reported that the use of certain plasticizers may also affect the absorption rate of the drug. The Plasticizer employed should impart the permanent flexibility to the strip and it depends on the volatile nature plasticizer and the type of interaction with the polymer. It should be noted that the properties of plasticizer are important to decrease the glass transition temperature of polymer in the range of 40.60 ˚C for non aqueous solvent system and below 75˚C for aqueous systems. Cellulosic hydrophilic polymers were easily plasticized with hydroxyl containing plasticizers like PEG, propylene glycol, glycerol and polyols. In contrast, less hydrophilic cellulosic polymers were plasticized with esters of citric acid and phthalic acid. Glycerol acts as a better plasticizer for polyvinyl alcohol while diethylene glycol can be used for both Hypromellose as well as polyvinyl alcohol films. Typically the plasticizers are used in the concentration of 0–20%w/w of dry polymer weight.[21]

Various polymers are used for preparation of fast dissolving oral films. Some of them are discussed below together with their physichochemical properties and film forming abilities.

Pullulan

Pullulan is a natural and extracellular microbial polysaccharide produced by the fungus-like yeast, Aureobasidium pullulans. It is a neutral glucan (like amylose, dextran, cellulose), with a chemical structure somewhat depending on carbon source, producing microorganism, fermentation conditions. The basic structure is a linear α- glucan one, made from three glucose units linked α-(1,4) in maltotriose units which are linked in a α-(1,6) way.[22] The three glucose units in maltotriose are connected by an α- (1,4) glycosidic bond, whereas consecutive maltotriose units are connected to each other by an α-(1,6) glycosidic bond. The regular alternation of (1 → 4) and (1 → 6) bonds results in two distinctive properties of structural flexibility and enhanced solubility. The unique linkage pattern also endows pullulan with distinctive physical traits along with adhesive properties and its capacity to form fibers, compression moldings and strong, oxygen impermeable films. The α-(1,6) linkages that interconnect the repeated maltotriose units along the chain are responsible for the flexible conformation and the ensued amorphous character of this polysaccharide in the solid state.[23, 24]



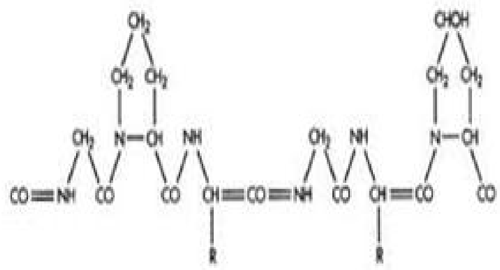
It has film-forming properties and can be used as a substitute for gelatin or other film-forming polymers in certain foods. A white to off-white tasteless, odourless powder that forms a viscous non-hygroscopic solution when dissolved in water at 5-10%. Pullulan starts to decompose at 250°C and chars at 280°C. It is moldable and spinnable, being a good adhesive and binder. It is also nontoxic, edible and biodegradable. Highly soluble in water, dilute alkali, insoluble in alcohol and other organic solvents except dimethylsulphoxide and formamide. Solubility of pullulan can be controlled or provided with reactive groups by chemical derivatization.[25] Its aqueous solutions are stable and show a relatively low viscosity as compared to other polysaccharides.10% w/w solution of PI-20 has a pH between 5.[25]

Pullulan can be made into very thin films (down to 0.01 mm) these have a high tensile strength and are stable over a range of temperatures. Pullulan can be made into films of high tensile strength and low oxygen permeability, are oil and grease resistant. Pullulan films are usually prepared by rapid evaporation of a 5-10% aqueous pullulan solution applied to a smooth surface and dried; it may also involve the use of high temperature and pressure. Pullulan can also be made into shaped bodies (This process usually involves rapid evaporation of water, compression moulding or extrusion at high temperature) commonly pullulan may be mixed with gelatin, amylose and polyvinyl alcohol. Pullulan films or shaped bodies may also contain polyhydric alcohols as plasticizers; e.g. maltitol, sorbitol, glycerol and water soluble polyvinyl alcohol.[25-27]

Due to its excellent properties, pullulan is used as a low-calorie ingredient in foods, gelling agent, coating and packaging material for food and drugs, binder for fertilizers and as an oxidation-prevention agent for tablets. Other applications include contact lenses manufacturing, biodegradable foil, plywood, water solubility enhancer and for enhanced oil recovery.[28-30] About 50 to 80 %w/w of pullulan can be replaced by starch in the production of OS without loss of required properties of Pullulan.

Gelatin

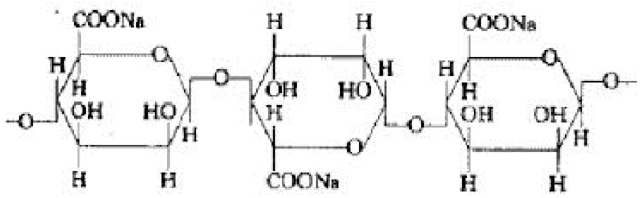
Gelatin is prepared by the thermal denaturation of collagen, isolated from animal skin, bones and fish skins. Gelatin is a generic term for a mixture of purified protein fractions obtained either by partial acid hydrolysis (type A gelatin) or by partial alkaline hydrolysis (type B gelatin) of animal collagen and/ or may also be a mixture of both.[31]



It is readily soluble in water at temperatures above 40°C, forming a viscous solution of random-coiled linear polypeptide chains. The physical properties of gelatins are related not only to the molecular weight distribution but also to the amino acid composition.[32] Mammalian gelatins commonly have better physical properties and thermostability than most fish gelatins, and this has been related mainly to their higher amino acid content. The use of mammalian gelatin in the elaboration of edible film or coatings was very well studied until the sixties, which resulted in many patents, mainly in the pharmaceutical area. The properties and film forming ability of gelatins are directly related to the molecular weight, i.e., the higher the average molecular weight, the better the quality of the film. Gelatin films were found to dissolve rapidly, excellent carriers for flavors and produce a smooth mouth feel.[33]

Sodium Alginate

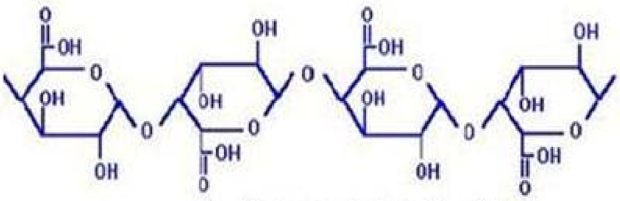
Alginate is an indigestible biomaterial produced by brown seaweeds (Phaeophyceae, mainly Laminaria) therefore it may also be viewed as a source of dietary fibre. Chiefly sodium alginate consists of sodium salt of alginic acid, which is a mixture of polyuronic acids composed of residues of D-mannuronic acid and L-guluronic acid.[34]



Alginate has a potential to form biopolymer film or coating component because of its unique colloidal properties, which include thickening, stabilizing, suspending, film forming, gel producing, and emulsion stabilizing. An attractive feature of alginate solutions is the gelling capacity in presence of Calcium. Edible films prepared from alginate form strong films and exhibit poor water resistance because of their hydrophilic nature. The water permeability and mechanical attributes can be considered as moderate compared to synthetic films. Alginate edible-films are appropriated to load additives and antibacterial compounds. A mixture of starch and alginate to form edible film improve the mechanical properties of film.[34]

Pectin

Pectin is a heterogeneous grouping of acidic structural polysaccharides, found in fruit and vegetables and mainly prepared from citrus peel and apple pomace. This complex anionicpolysaccharide is composed of β-1,4-linked d-galacturonic acid residues, wherein the uronic acidcarboxyls are either fully (HMP, high methoxy pectin) or partially (LMP, low methoxy pectin) methyl esterified.

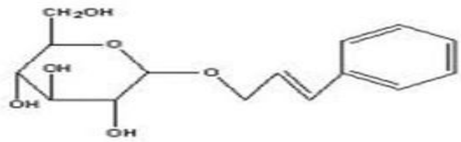


Pectin (polygalacturonic acid)

With Chitosan, HMP or LMP forms excellent films. Indeed, the cationic nature of chitosan offers the possibility to take advantage of the electrostatic interactions with anionic polyelectrolytes, such as pectin. It is also interesting to point out the application of LMP based edible coatings as a pre-treatment in osmotic dehydration for obtaining a better dehydration efficiency. Finally recently, an investigations demonstrated the prevention of crumb ageing of dietetic sucrose-free sponge cake when a pectin-containing edible film was used. This sponge cake had better preserved freshness, especially up to the fifth day of storage.[31]

Rosin

Rosin is a thermoplastic acidic product isolated from exudates of living pine trees &from freshly cut and stump wood of various species of pine. It is a hydrophobic biomaterial which is biodegradable. It is principally a resin acid and investigated as a film forming polymer and also useful as a coating material in pharmaceuticals. Free film of rosin is prepared by casting or solvent evaporation method. Rosin is also known as colophony or colophonia resina from its origin in Colophon, an ancient Ionic city.



Rosin

Formula: $C_{15}H_{20}O_6$

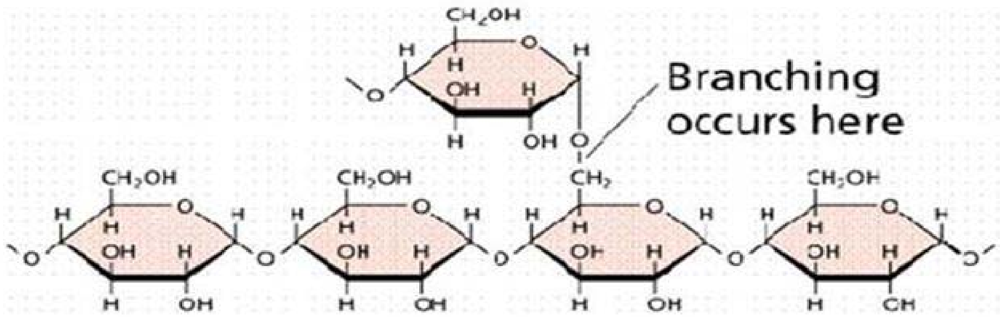
Molecular weight 296.32

Rosin is brittle and friable, with a faint piney odor. It is typically a glassy solid, though some rosin will form crystals, especially when brought into solution. The practical melting point varies with different specimens, some being semi-fluid at the temperature of boiling water, others melting at 100°C to 120°C. It is soluble in alcohol, ether, benzene and chloroform.

Films produced from the plasticizer-free solutions were smooth and transparent but brittle. Improvement in the mechanical properties was attempted by addition of plasticizers such as dibutyl sebacate (DBS). The addition of plasticizers plays a critical role in the performance of film coating, which results in decreased tensile strength, lowered Tg, and increased elongation and flexibility of the films.[35]

Starch

Starch is the major carbohydrate reserve in plant tubers and seed endosperm. Biopolymer starch is composed of glucose units and having two main constituents are, amylose and amylopectin. Amylose constituent is a linear one, having long chain of α-D glucose units linked together by α-1,4 glycoside linkages (Figure 1) and only slightly branced. The amylopectin constitutes α-1,4 linkages of glucose units, interlinked by α- 1,6 linkages and having a branched structure. The starch obtained from different sources has varying quantity of amylose and amylopectin usually 16-28% of amylose content in starch granules, whereas waxy starch solely contained amylopectin. Starch occur in nature in three main crystalline allomorphs designated as A, B and V-type. B-type crystalline is rapidly formed by amylose rich starch films and slowly by the aging of amylopectin rich starch films.[36] Amylose is responsible for the film-forming capacity of starch. The largest source of starch is corn (maize) with other commonly used sources being wheat, potato, tapioca and rice.

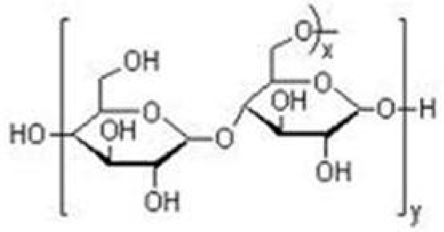


Starch is used to produce biodegradable films to partially or entirely replace plastic polymer. The films are transparent or translucent, flavourless, tasteless and colourless. However, starch film applications are limited by poor mechanical strength and its efficient barrier against low polarity compound. Many research reported that film forming conditions have an effect on crystallinity of the starch films and, therefore, their properties. Films of high-amylose corn starch or potato starch was more stable during aging, lost little of their elongation and had not or a slight increasing in tensile strength. Films from cassava starch had good flexibility and low water permeability, indicating potential application as edible films. Amylose rich starch is less sensitive to aging phenomena than amylopectin rich starch. The changes in elongation are clearly related to the changes in starch structure and B-type crystallinity.[37]

The embrittlement on aging of starch films has been explained by loss of plasticizing water by evaporation, physical aging and glass transition temperature. Starch films are known as poor water permeable. Plasticizer contents and surrounding air humidity directly affect oxygen permeability and increase with increase in plasticizer contentand high air humidity. For unplasticized films an increase in amylose content leads to a decrease in CO2 and water vapour permeability and increase in both tensile strength and elongation. For plasticized glycerol films, however the tensile strength increases with amylose content while the elongation decreases. The amylose rich starch films plasticized with sorbitol and glycerol (1:1) at 100% level were stable. Increase in air humidity, increase the crystallinity of amylopectin film and starch films. But air humidity has no effect on the crystallinity of amylose films. Plasticizer is generally required for starch-based edible films to overcome film brittleness. The most commonly used plasticizes in starch films are Glycerol, sorbitol, glucose, fructose, xylose, diacetate glycol, polyethylene glycol (PEG 200) and glycerol diacetate. Recently used, oxidized potato starch (OPS) films were transparent and flexible with interesting mechanical properties.[31.]

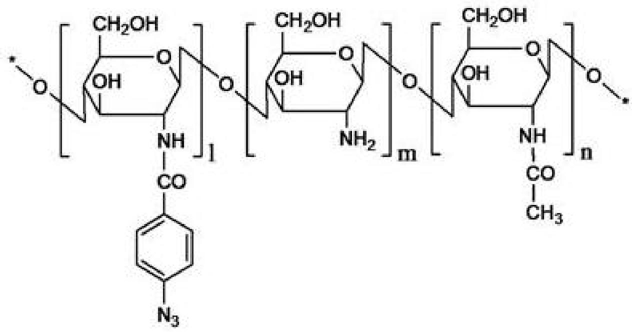
Maltodextrin

Maltodextrin is an oligosaccharide that is used as a food additive. It is produced from starch by partial hydrolysis and is usually found as a white hygroscopic spray-dried powder. Maltodextrin is easily digestible, being absorbed as rapidly as glucose, and might be either moderately sweet or almost flavorless. Maltodextrin is typically composed of a mixture of chains that vary from three to seventeen glucose units long. Maltodextrins are classified by DE (dextrose equivalent) and have a DE between 3 to 20. The higher the DE value, shorter glucose chains, higher sweetness, higher the solubility and the lower heat resistance. Well fluidity, no particular smell; Well solubility with proper mucosity; Low hydroscopicity,less agglomeration,Good carrier for sweeteners, aromatizer, stuffing. Freely soluble or readily dispersible in water, slightly soluble to insoluble in anhydrous alcohol. The maltodextrin is non-toxic, edible and is in powdered form. The maltodextrin is the film former, the polyethylene glycol 400 and the glycerine are the plasticizers. Good stableness against recrystallization.[38]



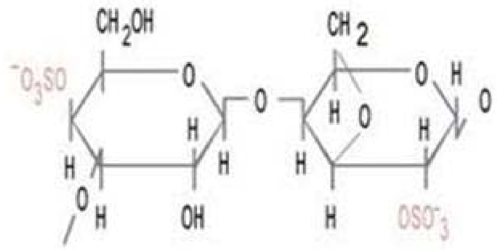
Chitosan

Chitosan (β-(1, 4)-2-amino-2-deoxy-D-glucopyranose), which is mainly made from crustacean shells, is the second most abundant natural and non-toxic polymer in nature after cellulose. However, a major drawback of chitosan is its poor solubility in neutral solutions. Chitosan products are highly viscous, resembling natural gums. Pure chitosan films are generally cohesive, compact and the film surface has a smooth contour without pores or cracks. Chitosan films such as many polysaccharide based films, tend to exhibit fat and oil resistance and selective permeability to gases but lack resistance to water transmission.[31]



Gum Carrageenan

Carrageenans are water-soluble polymers with a linear chain of partially sulphated galactans, which present high potentiality as film-forming material.



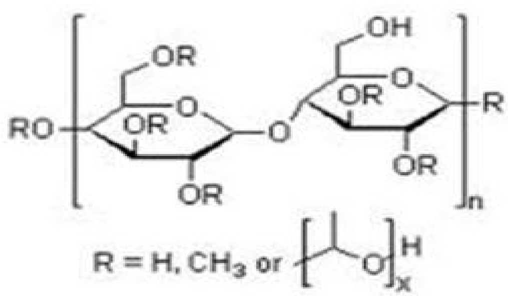
These sulphated polysaccharides are extracted from the cell walls of various red seaweeds (Rhodophyceae). Different seaweeds produce different carrageenans. Carrageenan film formation includes this gelation mechanism during moderate drying, leading to a three-dimensional network formed by polysaccharide doublehelices and to a solid film after solvent evaporation. Recently, carrageenan films were also found to be less opaque than those made of starch.[31]

Cellulose derivatives

Cellulose derivatives are polysaccharides composed of linear chains of β (1–4) glucosidic units with methyl, hydroxypropyl or carboxyl substituents. Only four cellulose derivative forms are used for edible coatings or films: Hydroxypropyl cellulose (HPC), hydroxypropyl methylcellulose (HPMC), Carboxymethylcellulose (CMC) or Methyl cellulose (MC). Cellulose derivatives exhibit thermo-gelation therefore when suspensions are heated they form a gel whereas they returns to originally consistency when cooled [34]. The films cast from aqueous solutions of MC, HPMC, HPC and CMC tend to have moderate strength, are resistant to oils and fats, and are flexible, transparent, flavourless, colourless, tasteless, water-soluble and moderate barriers to oxygen. MC is the most resistant to water and it is the lowest hydrophilic cellulose derivatives. However, cellulose derivative films are poor water vapour barriers because of the inherent hydrophilic nature of polysaccharides and they possess poor mechanical properties. A way to improve the moisture barrier would be the incorporation of hydrophobic compounds, such as fatty acids, into the cellulose ether matrix to develop a composite Edible coating made of CMC, MC, HPC, and HPMC.[31]

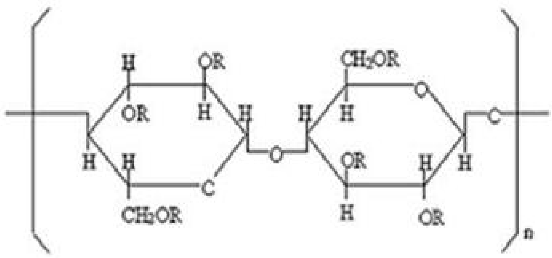
Hydroxypropyl Methyl Cellulose

Hydroxypropyl Methyl Cellulose also known as hypromellose is a partly O- methylated and O-(2-hydroxypropylated) cellulose. It is known for its good film forming properties and has excellent acceptability. HPMC forms transparent, tough and flexible films from aqueous solutions. HPMC polymer has a high glass transition temperature and is classified according to the content of substituent's and its viscosity which affects the solubility–temperature relationship. Lower grades of HPMC like Methocel E3, E5, and E15 are particularly used for film formation because of their low viscosity. HPMC films are good oxygen and moisture barriers. HPMC is also used for aqueous coating, but has poor water solubility and the film formed has poor film adhesion and poor mechanical strength.[39]



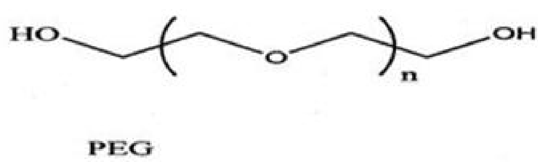
Hydroxy Propyl Cellulose

Hydroxypropyl cellulose as partially substituted poly (hydroxypropyl) ether of cellulose. Hydroxypropyl cellulose (HPC) is non-ionic water soluble thermoplastic polymer. (HPC) has excellent surface properties and forms highly flexible films. Films formed with polymers having very high glass transition temperature values are stiff. Because of relatively high glass transition temperatures (compared to other film forming polymers) of HPC, the formed films were shown to exhibit brittle fracture and were found to be stiff, with a high elastic modulus and a very low percent elongation (less than 5%). Typically slow dissolving, the films have good carrying capacity and reasonable clarity. HPC has a good film forming property. It imparts low surface and interfacial tension to its solution and thus can be used for the preparation of flexible films alone or in combination with Hypromellose.[39, 40]



Polyethylene Oxide

PEG is also known as polyethylene oxide (PEO) or polyoxyethylene (POE), depending on its molecular weight. PEG, PEO, or POE refers to an oligomer or polymer of ethylene oxide. Polyethylene glycol is produced by the interaction of ethylene oxide with water, ethylene glycol, or ethylene glycol oligomers.[39]



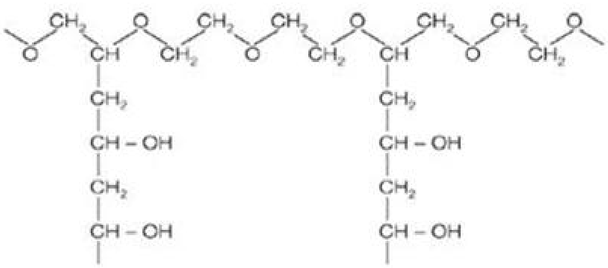
Molecular weights range from 100,000 to about 8,000,000. They exhibit many properties that are typical of other classes of water-soluble polymers – lubricity, binding, water retention, thickening, and film formation. Polyethylene Oxide water-Soluble Resins can be formed into flexible films both by thermoplastic processing and casting techniques. Such films may be made of Polyethylene Oxide water-Soluble Resins alone or blended with a wide variety of other polymers, such as polyethylene, polystyrene, polycaprolactone, ethylene vinyl acetate, nylon, etc.[41]

Kollicoat

Kollicoat a polyvinyl alcohol–polyethylene glycol graft copolymer is a pharmaceutical excipient that was especially developed as a coating polymer for instant release formulations. The polyvinyl alcohol moiety has good film-forming properties and the polyethylene glycol part acts as an internal plasticizer. The molecule is hydrophilic and thus readily soluble in water.

Table 1: Current status of fast dissolving oral films

Drug	Polymer	Plasticizer	Ref. No.
Ambroxol hydrochloride	HPMC	PEG 4000	45
Amlodipine besylate	Sodium algenate	Glycerine	46
Aripiprazole	HPMC, Maltodextrin	PEG-1000	47
Sertraline	PVA	PEG-400, PG	48
Dexamethasone	HPMC, HPC, MCC		49
Dicyclomine	HPMC, PVA	PEG-400	50
Famotidine	HPMC K15M,	PEG600	51
Piroxicam	Maltodextrin	Glycerol	52
Fentanyl	Polyvinylpyrrolidone	Triethylcitrate	53
Ketorolac	HPMC E15, Na- CMC	PG	54
Levocetrizine Hydrochloride	Sodium algenate	Glycerine	55
Cetrizine Hydrochloride	Pullulan PI-20	PEG 400)	56
Metoclopramide	HPMC E6, Na- CMC	GLYCEROL	57
Montelukast sodium	Gelatin, MCC, PVP	PEG 400	58
Ondensetron hcl	HPMC	PEG 400	59, 60
Rizatriptan	PVP, Na- CMC	Mannitol	61
Zolmitriptan	HPMC	PG	62
Rofecoxib	HPMC	Glycerine	63
Etophylline	HPMC	Ethylene glycol	64
Ropinirole	Pullulan	PEG 400	65
Tetracycline	Chitosan		66
Domperidone	HPMC E15, HPC	PEG 400	67
Nicotine	Maltodextrin	Glycerol	68
Salbutamol sulfate	HPC	Glycerine	69
Verapamil	HPMC E6, Maltodextrin	Glycerol	70
Dimenhydrinate	Modified pea starch polymer	Glycerol	71
Medicinal carbon	Na- CMC	Mannitol, sorbitol	72
Donezepil hcl	HPMC	PEG	73
Lidocaine	HPC, HPMC	PolyOx N-80	74
Tianeptine sodium	Lycoat NG73	PG	75



Film forming agent ideal for instant release formulations as well as drug delivery like drug layering and binding it is robust yet flexible the result is highly reliable, cost effective process and gives excellent appearance. Effective sealing against moisture, fast release of active ingredients from the film, it is Safe and easy to handle, re-disperse without lump organic solvent and lump, easily dispersible in water, highly flexible film through integrated plasticizer, high pigment loading capacity, easy to formulate and process.[42]

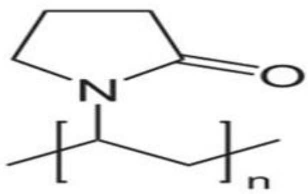
Poly Vinyl Alcohol

Polyvinyl alcohol (PVOH, PVA) is a water-soluble synthetic polymer; it has excellent film forming, emulsifying and adhesive properties. It is also resistant to oil, grease and solvents. It is odorless and nontoxic.

It has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties. The water, which acts as a plasticizer, will then reduce its tensile strength, but increase its elongation and tear strength. PVA is fully degradable and dissolves quickly. PVA has a melting point of 230°C and 180–190°C (356-374 degrees Fahrenheit) for the fully hydrolyzed and partially hydrolyzed grades, respectively.[43]

Poly Vinyl Pyrrolidone

Polyvinylpyrrolidone (PVP), also commonly called Polyvidone or Povidone, this polymer made from the monomer *N*-vinylpyrrolidone.



PVP is soluble in water and other polar solvents. When dry it is a light flaky powder, which readily absorbs up to 40% of its weight in atmospheric water. In solution, it has excellent wetting properties and readily forms films. This makes it good as a coating or an additive to coatings. PVP is a branched polymer, meaning its structure is more complicated than linear polymer, though it too lies in a two-dimensional plane.[44]

In literature it was found that various drugs are formulated as fast dissolving oral films using different polymers. Some of them are shown in Table 1.

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