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A Review on Natural Polymers Used in Pharmaceutical Dosage Forms

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ABSTRACT

Polymers are macromolecules which are composed of structurally similar repeated units of monomers. Natural polymers are the ones that are obtained from natural origins like plants, animals or micro-organisms. Natural polymers are widely used in pharmaceutical and biomedical industries and their applications are growing at a fast pace as the basic knowledge of polymers helps us to know the function of drug products and also to develop new formulations or better delivery systems. Natural polymers are more advantageous than synthetic polymers as they are economical, non-toxic and abundantly available in nature. Natural polymers can be used to formulate dosage forms where the drug is designed to release a pre-deteremined rate. They can be widely used in pharmaceutical dosage forms as binders, matrix formers or drug release modifiers, film coating formers, thickeners or viscosity enhancers, stabilizers, disintegrants, solubilisers, emulsifiers, suspending agents, gelling agents and bioadhesives. In this article, source, purification, properties, pharmaceutical applications of such natural polymers have been discussed.

INTRODUCTION

Polymers are a large class of high molecular weight compounds consisting of many small molecules (called monomers) that can be linked together to form long chains. Thus, they are known as macromolecules. A typical polymer may include tens of thousands of monomers[1]. In Greek, the word poly means 'many' and meros means 'units or parts'. They consist of different functional groups[2]. Natural polymers are widely used in pharmaceutical and biomedical industries and their applications are growing at a fast pace. Basic knowledge of polymers will give us the opportunity to familiarize ourself with the function of drug products and also to develop new formulations or better delivery systems[3]. Natural polymers are used in pharmaceutical formulations in the manufacture of solid monolithic matrix systems, implants, films, beads, microparticles, nanoparticles, and injectable systems as well as viscous liquid formulations. Within these dosage forms, polymeric materials are widely used as binders, matrix formers or drug release modifiers, film coating formers, thickeners or viscosity enhancers, stabilizers, disintegrants, solubilisers, emulsifiers, suspending agents, gelling agents and bioadhesives[4].

CLASSIFICATION OF POLYMERS

Polymers can be classified as:

1. Natural polymers
2. Synthetic polymers
3. Semi-synthetic polymer

Natural polymers

The polymers obtained from nature (plants and animals) are called natural polymers. These polymers are very essential for life. They are as follows:

(a) Starch

It is a polymer of glucose and it is a food reserve of plants.

(b) Cellulose

It is also a polymer of glucose. It is a chief structural material of starch and cellulose made from from glucose of plants and is produced during photosynthesis

(c) Proteins

These are polymers of α-amino acids; they generally have 20 to 1000 α-amino acid joined together in a highly organized arrangement. These are building blocks of the animal body and constitute an essential part of our food.

(d) Nucleic acids

These are polymers of various nucleotides. For example, RNA and DNA are common nucleotides. It may be noted that polymers such as polysaccharides (starch, cellulose), proteins and nucleic acids etc. which control various life processes in plants and animals are also called biopolymers

Synthetic polymers

The polymers which are prepared in the laboratories are called synthetic polymers. These are also known as man made polymers. For example polyethene, PVC nylon, teflon, bakelite terylene, synthetic rubber etc

Semi synthetic polymers

These polymers are mainly derived from naturally occurring polymers by chemical modifications. For example, cellulose is naturally occurring polymers, cellulose on acetylation with acetic anhydride in the presence of sulphuric acid forms cellulose diacetate polymers. It is used in making thread and materials like films glasses etc. Vulcanized rubber is also an example of semi synthetic polymers used in making tyres etc. Gun cotton which is cellulose nitrate used in making explosive[5]

XANTHAN GUM

It is produced by pure culture fermentation of a carbohydrate with Xanthomonas campestris. It is also known as Corn sugar gum. It is the sodium, potassium or calcium salt of a high molecular

weight polysaccharide containing D-glucose, D-mannose, and D-glucuronic acid. It also contains no less that 1.5% of pyruvic acid. It is a cream coloured powder, soluble in hot and cold water and neutral to litmus. A 1% solution has a viscosity of about 1000 centipoises. Solutions of Xanthan gum demonstrated maximum stability at a pH value between 4 and 10. Compared with tragacanth, Xanthan gum was found to be easier to use and capable of preparing suspensions of better quality and improved consistency.

Applications

- Xanthan gum is used as a stabilizer, thickener and emulsifier extensively in pharmaceutical, cosmetic, and food industries.
- The pseudoplastic properties of this gum enable toothpastes and ointments both to hold their shape and to spread readily.
- For extemporaneous dispensing, a 1% solution of Xanthan gum with hydroxy benzoate, prepared in advance, was diluted to 0.5% with water when preparing the suspension.
- Xanthan gum was found to be a suitable suspending vehicle for delivering antispasmodics topically along the length of the oesophagus in patients with oesophageal spasm[6].

GUAR GUM

Guar gum comes from the endosperm of the seed of the legume plant Cyamopsis tetragonolobus. Guar gum is prepared by first drying the pods in sunlight, then manually separating from the seeds. The gum is commercially extracted from the seeds essentially by a mechanical process of roasting, differential attrition, sieving, and polishing. The seeds are broken and the germ is separated from the endosperm. Two halves of the endosperm are obtained from each seed and are known as Guar Splits. Refined guar splits are obtained when the fine layer of fibrous material, which forms the husk, is removed and separated from the endosperm halves by polishing. The refined Guar Splits are then treated and finished into powders by a variety of routes and processing techniques depending upon the end product desired.

Chemically, guar gum is a polysaccharide composed of the sugars galactose and mannose. The backbone is a linear chain of 1, 4-linked mannose residues to which galactose residues are 1, 6-linked at every second mannose, forming short side branches. Guar gum is more soluble than locust bean gum and is a better emulsifier as it has more galactose branch points. It degrades at

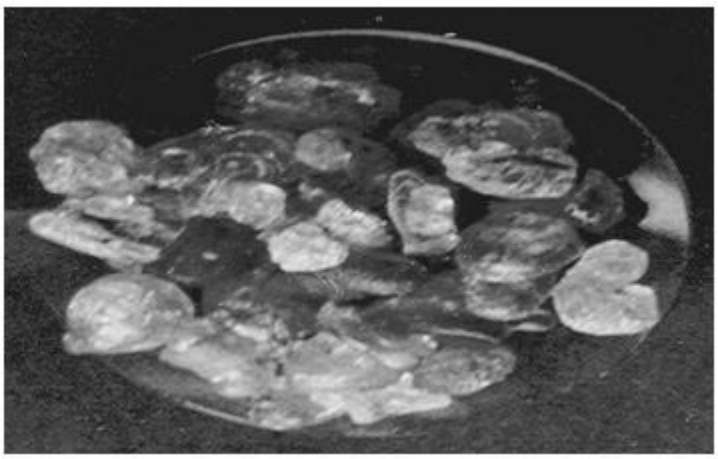
extremes of pH and temperature (e.g. pH 3 at 50°C). It remains stable in solution over pH range 5-7. Strong acids cause hydrolysis and loss of viscosity and alkalies in strong concentration also tend to reduce viscosity. It is insoluble in most hydrocarbon solvents.

Applications

- Guar gum is used as a thickener in cosmetics, sauces.
- It is used in ice creams to prevent the formation of ice crystals.
- It is used as a fat substitute that adds the "mouth feel" of fat.
- Guar gum can be used as a binder or as disintegrator in tablets.
- It can also be used in preparation of sustained release tablets[7]

ACACIA

The air dried gummy exudates from the stem and branches of Acacia senegal Wild. (Family Mimosaceae) and other species of Acacia of African origin. It is also known as Senegal gum. The tree is known in Kordofan as 'Hashab' and in Senegambia as 'Verek'. The gum, produced in Kordofan from tapped trees is considered to be good. The Senegal and Nigerian gums are also of good quality. It is soluble in water leaving only a very small residue of vegetable particles, whereas practically insoluble in alcohol and ether.



Acacia

Applications

- Acacia is used as a suspending and emulsifying agent
- It is used as a tablet binder.
- Its demulcent properties are employed in various coughs, diarrhoea and throat preparations.
- It is used in the pharmaceutical industry as binding agent in the manufacture of cough pastilles and other medical preparations or as a coating for pills.
- The gum is also used for hair set and as a suspending agent[8]

TRAGACANTH

This polymer is obtained from the branches of Astragalus gummifer, Family Leguminosae. It contains about 60% - 70% of a water-insoluble fraction called bassorin. Tragacanthic acid is composed of D-galacturonic acid, D-xylose, L-fructose, D-galactose, and other sugars. Tragacanthin is composed of uronic acid and arabinose and dissolves in water to form a viscous colloidal solution (sol; while bassorin swells to form a thick gel[9].

Applications

It is used as a suspending agent, thickening agent and emulsifier.

SODIUM ALGINATE

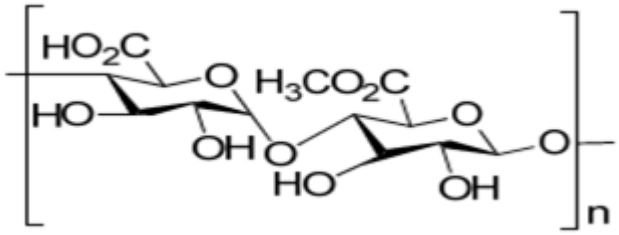
Alginates or alginic acid is an anionic polysaccharide which is a linear, and unbranched polysaccharide found in brown seaweed and marine algae such as Laminaria hyperborea, Ascophyllum nodosum, and Macrocystis pyrifera. Alginic acid can be converted into its salts, of which sodium alginate is the major form currently used. These polymers consist of two different monomers in varying proportions, namely D-mannuronic acid and L-guluronic acid linked in 1,4 glycosidic bonds as blocks of only D-mannuronic acid or L-guluronic acid in homopolymers or alternating the two in heteropolymeric blocks. Alginates have high molecular weights of 20 to 600 kDa.

Applications:

Alginates have been used and investigated as stabilizers in emulsions, suspending agents, tablet binders and tablet disintegrants[10]

PECTIN:

Pectin is the purified carbohydrate product obtained by acid hydrolysis from the inner portion of the rind of citrus peels i.e. Citrus Simon or Citrus Aurantium, (Rutaceae). The main component of pectin is a linear polysaccharide composed of ?-1,4-linked Dgalacturonic acid residues interrupted by 1,2- linked L-rhamnose residues with a few hundred to about one thousand building blocks per molecule, corresponding to an average molecular weight of about 50,000 to about 1,80,000. The galacturonic acid polysaccharides are rich in neutral sugars such as rhamnose, arabinose, galactose, xylose and glucose.



Structure of pectin

Applications

- It has high potential as a hydrophilic polymeric material for controlled release matrix drug delivery systems[11]

CHITOSAN

Chitin is the polysaccharide derivative containing amino and acetyl groups and is the most abundant organic constituent in the skeletal material of the invertebrates. It is found in mollusks, annelids, arthropods and also as a constituent of the mycelia and spores of many fungi.

Chitosan

Applications:-

Chitosan and their derivatives (N-trimethyl chitosan, mono-N-carboxymethyl chitosan) are effective and safe absorption enhancers to improve mucosal (nasal, peroral) [12]

AGAR

Agar or agar-agar is the dried gelatinous substance obtained from Gelidium amansii (Gelidaceae) and several other species of red algae like Grailaria (Gracilariaceae) and Pterocladia (Gelidaceae). Agar consists of a mixture of agarose and agaropectin. The predominant component, agarose, is a linear polymer, made up of the repeating monomeric unit of Agarobiose. Agarobiose is a disaccharide made up of D-galactose and 3,6- anhydro-L-galactopyranose. Agaropectin is a heterogeneous mixture of smaller acidic molecules that gel poorly. It's great gelling power in an aqueous environment allows it to form gels which are more resistant (stronger) than those of any other gel- forming agent, assuming the use of equal concentrations. It can be used over a wide range of pH, from 5 to 8, and in some cases beyond these limits. It withstands thermal treatments very well, even above 100°C which allows good sterilization. A 1.5% aqueous solution gels between 32°C-43°C and does not melt below 85°C. This is a unique property of agar, compared to other gelling agents. Agar gives gels without flavour and does not need the additions of cations with strong flavours (potassium or calcium) it can be used without problems to get food products with soft flavours. Its gel has an excellent

reversibility allowing it to be repeatedly gelled and melted without losing any of the original properties[13]

Agar

Applications

- Agar is used as a Suspending agent, emulsifying agent.
- It is used as a gelling agent in suppositories.
- It is used as a surgical lubricant.
- It is used as a tablet disintegrant.
- It acts as a medium for bacterial culture.
- It is used as a laxative.

CARRAGEENAN

Carrageenan is the hydrocolloid obtained from red seaweeds by extraction with water or aqueous alkali and recovered by alcoholic precipitation, drum drying or freezing (Class: Rhodophyceae). It consists of a mixture of the ammonium, calcium, magnesium, potassium and sodium sulphate esters of galactose and 3, 6-anhydrogalactose copolymers.

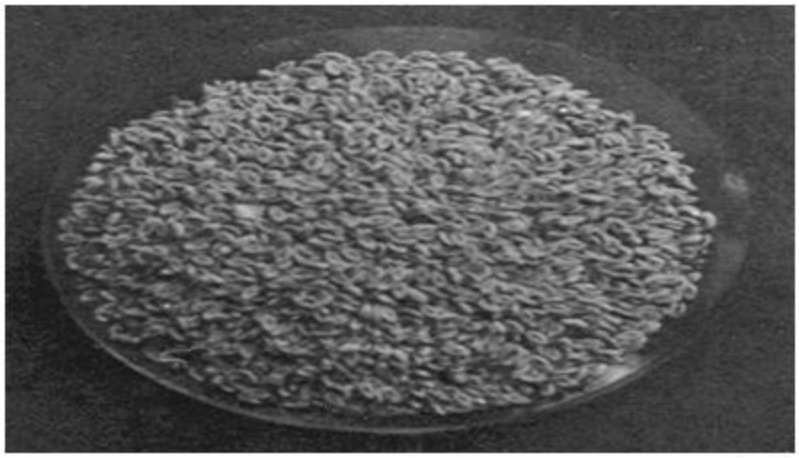
Carrageenan

Applications

- It is widely used as dissolution rate retarding polymer in the sustained release dosage form in many pharmaceutical industries.
- A solution of carrageenan (1%) was also used to induce inflammation (Paw oedema) for the screening of anti- inflammatory activity.
- Carrageenan is used in pharmacy and food industry as a suspending and gelling agent.
- Toothpaste, creams, lotions and other cosmetic products are also prepared by using carrageenan.
- In food industry, it is utilized in milk products, ice creams, chocolate, jams and gels in the concentration of 0.5-1% [14]

ISPAGHULA

Ispaghula husk consists of dried seeds of the plant Plantago ovate Forsk (Family- Plantaginaceae) commonly known as Isabgolor or Ispaghula or Spogel seeds. It contains mucilage, which is present in the epidermis of seeds. Larger doses are essential as their action is produced partly by lubricating action of mucilage and partly by the increase in bulk of intestinal contents, which mechanically stimulates the intestinal peristalsis.



Ispaghula

Applications:-

- Mucilage is used as a binding agent in the granulation of material for preparation of compressed tablets.
- It is used as a suspending and thickening agent due to its high swelling index and ability to give a uniform viscous solution.
- It is much sought in pharmaceutical industry as enteric coating material, tablet disintegrator and also used in sustained release drug formulations[15]

CONCLUSION

Polymers play a vital role in the design of various dosage forms. The natural polymers can be modified to meet the requirements of drug delivery systems. Apart from being used in conventional dosage forms, natural polymers have a wide range of applications in the design of novel drug delivery systems like gastro retentive dosage forms, bioadhesive systems, and microcapsules. There is huge scope for research on new natural polymers obtained from plants and could be further exploited in the future as a novel natural polymer for the development of different drug delivery systems in the pharma industry.

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