IJBPAS, March, 2022, 11(3): 1166-1177

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

ECO-FRIENDLY NATURAL PLANT BASED POLYMERS FOR PHARMACEUTICAL FORMULATIONS - AN OVERVIEW

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Received 15th April 2021; Revised 18th May 2021; Accepted 20th June 2021; Available online 1st March 2022

https://doi.org/10.31032/IJBPAS/2022/11.3.5938

ABSTRACT

There are numerous synthetic polymers available in the field of pharmaceutical formulation, but these polymers have got several drawbacks like toxicity, environmental pollution, side effects, expensive and also found to have poor patient compliance. To overcome all these drawbacks use of natural polymers is widely accepted. These polymers being active ingredients in most of the formulations which enhances the effect of it. In the advanced pharmaceutical world, it has been used in different dosages added with existing and newly invented drugs, to attain the maximum benefit of it. It can be synthetic as well as semi synthetic. In addition to it gums and mucilage play a novel role in the preparation of dosage forms. These articles run around the natural products, that play wide role in the pharmaceutical field and these natural excipients also benefited by being biocompatible with human body, providing nutritional supplements, and cost-effective so that the overall production rate is minimized.

Keywords: Gums, Alginates, Starch, Pectin, Chitosan

INTRODUCTION

Polymers are compounds that are used as a medium in preparation of finished dosage types. In other words, it is a non-active substance that acts as a carrier or conduit for a drug or other active substance **[1]**. These acts as additives used in pharmaceutical active ingredients which convert in to pharmaceutical dosage form suitable for administration. The application of polymers in pharmaceutical formulations is growing rapidly **[2]**. Polymers have found applications in different field of biomedicine such as drug delivering systems, tissue engineering, and insertion of medical devices and artificial organs, ophthalmology, prosthesis, bone repair, dentistry and in many medical fields **[3]**.

The pharmaceutical applications of polymers range from their use as binders in tablets, to viscosity and flow control agents in liquids as well as suspensions and emulsions. They were mainly used as film coatings to mask unpleasant taste of the drug, modifies the drug release characteristic which improves drug stability, bioavailability and patient acceptability and improves overall safety and efficacy of the drug during use/storage **[4]**. We have several pharmaceutical excipients of plant origin like agar, starch, alginates, gaur gum, carrageen xanthan gum, acacia, gelatin, cellulose, tragacanth and pectin. These natural excipients are used in the pharmaceutical industry as binding agents, disintegrants, supporting agents, protective agents, colloids, thickening agents, gelling agents, suppositories bases, stabilizers and coating materials **[5]**.

The benefits of natural plant-based polymers include being of low cost, naturally safe, with minimum or no side effects, bio-acceptable and biocompatible, easily available with a renewable source and eco-friendly and also improves patient tolerance and public acceptance **[6]**.

Polymeric systems are classified based on their chemical and physico-chemical properties, as well as their function in pharmaceutical formulation and drug interactions **[7]**. To allow convenient and accurate dosing, excipients are often added go bulk formulations containing highly potent active ingredients. Different types of natural polymers **(Figure 1)** are used depending on type of formulation and route of administration. These mainly stabilizes the active ingredients, which in turn ensures that these active ingredients stays active for long period of time and stable for given time interval hence improves the shelf-life of the

product. Polymers can also be used to mask the bitter, unpleasant taste or texture, as well as ensuring that the correct amount of API reaches the right location in the body at the right time **[8, 9]**.

From animals	From vegetables	From minerals
Beeswax	Kokum butter	Bentonite
Cochineal	Pectin	Kieselghur
Gelatin	Starch	Kaolin
Honey	Peppermint	Paraffins
Lactose	Cardamom	Talc
Spermaceti	Vanilla	Calamine
Lanolin	Turmeric	Fuller's earth
Musk	Saffron	Asbestos

Figure 1: List of some Natural polymers derived from plant, animals and minerals [10]

Polysaccharides in pharmaceuticals

Natural polysaccharides including mucilage's gums and glucans are abundant in nature and available in variety of structures with broad range of physicochemical properties, majorly found in higher plants. Since these polysaccharides are hydrophilic in nature they are highly stable with less toxicity and very safe as natural excipients **[11, 12]**.

Gums and mucilage:

Gums and mucilage are high molecular weight carbohydrate polymers derived from plants. Gums and mucilage have identical components and on hydrolysis results a mixture of sugars and uronic acids. Gums include acacia, gaur gum, and tragacanth, while mucilage can found in a variety of plant sections, including epidermal cells of senna, linseed/psyllium, seed coats, aloe barks, roots and middle lamella **[13, 14]**.

Gums are known to have mucoadhesive, bio-erosion and also biocompatible properties. They are composed of bulking units of acid and/or neutral monosaccharides, joined by glycosidic bonds **[15]**.

Merits of natural gums and mucilage in pharmaceutical products

- **Biodegradable:** All living organisms create biodegradable polymers, which are naturally available. They are completely

sustainable products which have no detrimental effects on human health or the environment **[16]**.

- **Low cost:** Natural sources are easily available and cheaper compared to that of synthetic material. The production cost is also much lower **[17]**.
- **Environmental-friendly:** Gums and mucilage from various sources can be produced in large amounts at different times of the year due to the simple manufacturing processes involved **[18]**.
- **Local availability:** Because of the wide range of applications in a number of industries, governments in developing countries promote the cultivation of plants like guar gum and tragacanth **[19]**.

Tamarind gum

Tamarind gum is obtained from the endosperm of seeds **(Figure 2)**. *Tamarindus indica,* member of 21 evergreen families. It is dispersible in hot water and insoluble in organic solvents. Tamarind gum is non Newtonian and has higher viscosity compare to the starches at equivalent concentrations. This has contributed to its use as a thickener, gelling agents, stabilizer and binder in food industry and also in pharmaceutical industry. In addition to these, in recent researches they identified other properties of tamarind seed polysaccharide (TSP) which includes non carcinogenicity, mucoadhesivity, biocompatibility, high holding capacity and thermal stability of the drug **[20-22]**.

Figure 2: Tamarind seeds and powder

Mango gum

Mango gum is a polysaccharide, dried gummy exudates obtained from the bark of *Mangifera indica*, **(Figure 3)** belongs to the family of Anacardiaceae **[23]**. Various studies on mango gum was carried out for its sustain release, binding and disintegrating properties. Tablets carrying this gum showed better appearance and improved release of drugs. Most of the mouth dissolving tablets has been prepared using this gum **[24]**.

Figure 3: Mango gum from the bark

Pectin

Pectin is non starch, natural polysaccharide extracted from the cell wall of several plants

species **(Figure 4)**. It represents both mucoadhesive and swelling properties, either used along with natural or synthetic polymers or alone in designing the different drug delivery system **(Figure 5)**. A mixture of pectin and gelatin is used in different pharmaceutical formulations as an encapsulating agent to provide sustained release characteristics **[25-27]**.

Figure 4: Pectin powder

Dosage form	Type of pectin	Application
Tablets	LM-pectin	Binding agents and delayed drug release
Gel beads	LM-pectin	Pectin beads prepared by ionotropic gelatin
Gel beads	LM-pectin (amidated)	Sustained release drug delivery using calcium pectinate gel beads
pellets	LM-pectin	Calcium petinate or calcium alginate-pectinate prepared by ionotropic gelation
Particulates	LM-pectin	Alginate-pectin-polylysine system
Microspheres	LM-pectin	Pectin-based microspheres prepared by emulsification technique
Coated pellets	LM-pectin (amidated and non-amidated)	Insoluble calcium pectinate gel coating for sustained release delivery prepared by interfacial complexation

Figure 5: Different types of dosage forms prepared by pectin [28]

Alginates

Alginates are the most flexible biopolymers isolated from the brown sea weed (Phaeophyceae) used in a wide variety of applications. Conventional use of alginate as an excipient in drugs products, typically rely on thickening, gel forming and stabilizing properties. Hydrocolloids like alginate can play a significant role in the design of a controlled release product. Alginic acid **(Figure 6)** can then be converted to an salt form which is the main form currently used **[29]**.

Alginates **(Figure 7)** have a variety of drug delivery applications including matrix style alginate gel beads, liposomes, gastrointestinal transit time, local applications and the delivery of biomolecules in tissue engineering applications **[30-32]**.

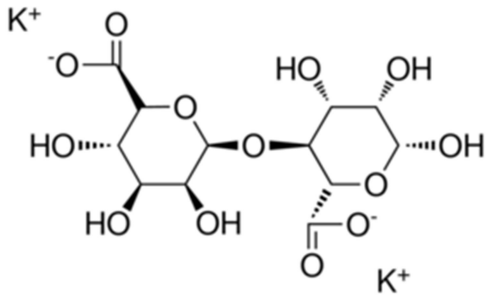

Figure 6: Structure of Alginic acid

Uses of Alginates

- Alginates have been proved that, they are beneficial for the symptoms of malignant wounds **[33]**.
- The lack of platelets and the proliferation of friable capillaries induces bleeding in malignant wounds. It is important that dressings do not adhere to or cause damage, since bleeding happens easily. Alginates are suitable because they have haemostatic properties for bleeding wounds **[34, 35]**.
- The alginates are thin, self-adhesive and fit well into the contours. This increases the freedom to carry out regular daily activities **[36, 37]**.

Figure 7: Alginates in water

Starch

Starch plays a significant role in the pharmaceutical industry used as excipients **(Figure 8)** especially in formulations of tablets. Due to their inherent physiochemical properties and their relative inertness, starch is used as binder, filler, lubricant and disintegrant in tablet formulations **[37]**. It is a polymeric carbohydrate natural polysaccharide, composed of multiple glucose units connected by glycosidic bonds. Many green plants

generate this polysaccharide as a energy storage **[38]**.

In addition, starch is the source of variety of complex derivatives. Hence by various physical, chemical and biotechnological means one can convert native starch into specialized form. This modified starch yields following advantages **[39, 40]**.

- Enhanced binding properties
- Direct compressibility
- Rapid disintegration
- Sugar free applications, and
- Parenteral use.

Figure 8: Different types of starch powders

Chitosan

Chitosan is one of the abundant and positively charged (cationic) biopolymers having multiple properties. Chitosan is an N-deacetylated chitin product consisting mainly of poly-glucosamine **[41]**. Chitosan powder **(Figure 9)** is composed of residues of glucosamine and N- acetyl glucosamine associated with (1-4) linkage and the ratio of these two is referred to as degree of deacetylation (DDA) **[42, 43]**.

Chitosan is a typical biological macromolecule derived from crustacean shells like hard outer skeleton of shellfish, including crab, lobster, and shrimp. Chitosan is one of the most valuable materials with many applications. Biomedical application is one of them **[44]**.

Application of Chitosan in pharmaceuticals

- Due to the less toxic in nature, chitosan is widely used in gene carriers and also the carriers in compressed tablets. It is used as diluent in direct tablet compression process **[45]**.
- Used as binder for wet granulation and also helps in slow drug release of drug from tablets and granules **[46]**.
- Chitosan is widely used as blood anticoagulants as well as hypocholesterolemic agents **[47]**.
- Chitosan and its derivatives are used in sustained drug release as pharmaceutical carriers due to their strong muco-adhesive properties **[48]**.
- It is also used in tissue engineering, wound healing and also to improve bioavailability of drugs and also to improve dissolution of (hydrophobic) drugs **[49]**.
- Nowadays chitosan based micro and nanoparticles based formulations play an

important role in sustained and targeted drug delivery **[50, 51]**.

Figure 9: Chitosan powder

CONCLUSION

The emphasis is now on patient compliance and, in order to achieve this goal, there is a spurt in the production of innovative drug delivery systems. In almost all formulation types, polymers play a very important role. This article highlights the various types of natural polymers with their description of unique properties and applications in pharmaceutical formulations. These may be chemically compatible with excipients in drug delivery systems, as herbal plant based polymers are biodegradable materials. In comparison to their synthetic alternatives, herbal polymers are non-toxic, readily available, and less costly. These have been used not only to maintain the release of the medications, but also to improve the gastro retentive dosage type, bio adhesive device, microcapsules etc. Therefore, there will be continued interest in the use of natural polymers in formulating novel, improved therapeutic drug delivery systems in the years to come .

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