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A REVIEW ARTICLE ON NATURAL POLYMERS USED IN PHARMACEUTICAL FORMULATIONS

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ABSTRACT

Polymers have been successfully employed in the formulation of solid, liquid and semisolid dosage forms and are specifically useful in the design of modified release drug delivery system. Both synthetic and natural polymers have been investigated extensively for this purpose, but the use of natural polymers for pharmaceutical applications is attractive because they are economical, readily available, non toxic, and capable of chemical modifications, potentially biodegradable and with few exceptions, also biocompatible. One of the most remarkable and useful features of a polymers swelling ability manifests itself when that swelling can be triggered by a change in the environment surrounding the delivery system. This review mainly put emphasis on description of various natural polymers used in drug delivery development process. 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-organism. Natural polymers are widely used in pharmaceutical and biochemical industries and their applications are growing at the fast pace as the basic knowledge of polymers helps us to know the function of drug product and also to develop new formulations or better delivery systems.

KEY WORDS : Natural polymers ,Classification ,sources ,extraction methods,manufacturing companies ,banned polymers .

INTRODUCTION

The word 'polymer' is derived from Greek words, poly which means 'many' and meros means 'parts or units of high molecular mass'. Each molecule consists of a very large number of single structural units joined together in a regular manner by covalent bonds. Polymers are the giant molecules of high molecular weight called macromolecules which are formed by linking

together a large number of small molecules, called monomers. The process by which monomers combine to form polymer is known as polymerization¹ . The polymerization is defined as a chemical reaction in which two or more substances combine together with or without evolution of water, heat or any other solvents to form a molecule

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of high molecular weight. The product obtained is called polymer and the starting material from which the polymers are made is called monomer.

Natural polymers

Semi-synthetic polymer

These polymers are obtained from natural polymers by simple chemical treatment to change the

Physical properties of natural polymers like starch, silicon.

Synthetic polymers

The fibers which are synthesized in laboratory by polymerization of simple chemical molecules are called synthetic polymers, example: Nylon, polyethylene, polystyrene, synthetic rubber, PVC, Teflon etc.

The specific application of natural polymers in pharmaceutical formulations include their use in the manufacture of solid implants, films, beads, microparticles, nanoparticles, inhalable and injectable systems as well as viscous liquid formulations²⁻⁴. Within these dosage forms, polymeric materials have fulfilled different roles such 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.

Importance of Herbal Polymers over Synthetic Polymers Biodegradable

These polymers are found in nature generally from plants and animals sources. Examples are proteins, cellulose, starch, resins.

Naturally occurring polymers produced by all living organisms. They show no adverse effects on the environment or human being. In contrary, synthetic polymers, being prepared by the help of chemicals have side effect on atmosphere as well as on the human being.

Biocompatible and non-toxic

Chemically, nearly all of these plant materials are carbohydrates in nature and composed of repeating monosaccharide units. Hence they are non-toxic as compared to synthetic polymers.

Economic

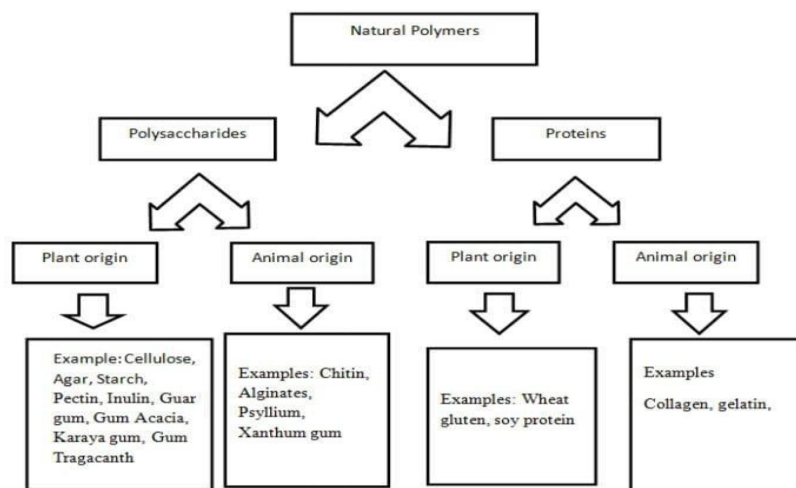
Natural polymers are cheaper and their production cost is less than synthetic material.

Safe and devoid of side effects

They are found in a natural form and hence, safe and having no side effects whereas synthetic polymers being prepared by using chemicals have side effects.

Easy availability

Natural polymers are growing in the form of herbs in many countries being economical than synthetic polymers and having no side effect and keeping in view their huge application in many industries, they are produced in large quantity hence their availability is ensured than synthetic polymers.



Classification



CELLULOSE :

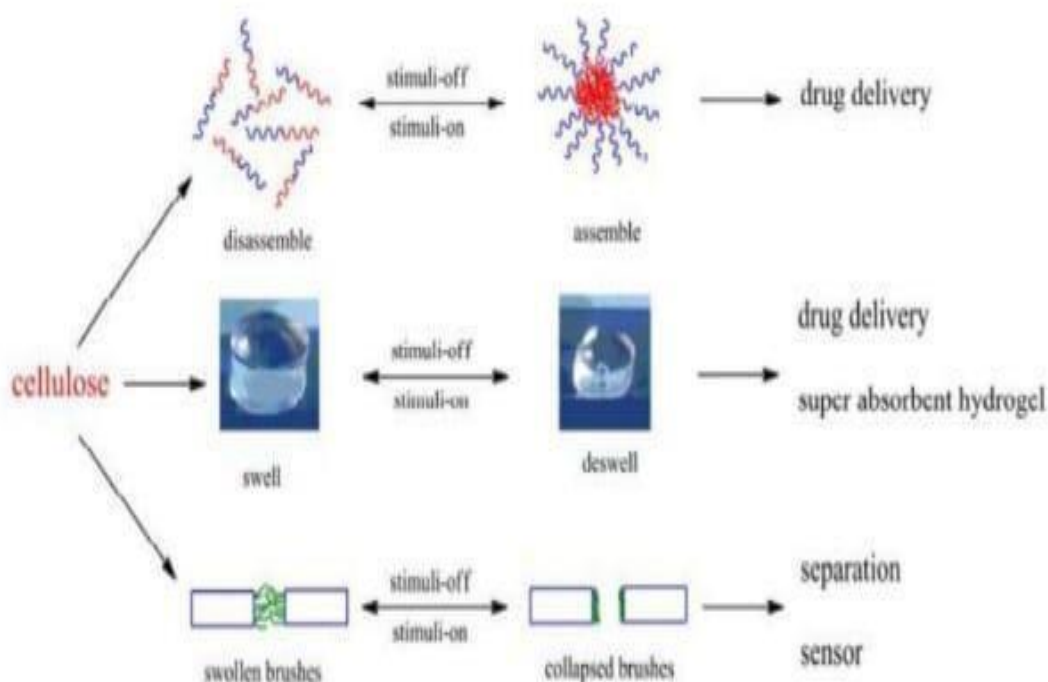
Cellulose is an organic polysaccharide located within the fibre walls of plants. This natural polymer is the most important and fascinating bio polymer.

Cellulose is insoluble in water and most common solvents, used in a wide range of applications including composites, netting, upholstery, coatings, packing, paper, etc [3]. Many parallel cellulose molecules form crystalline microfibrils that are mechanically strong and highly resistant to enzymatic attack [4]. These are aligned with each other to provide structure to the cell wall [5, 6].

Chemical modification of

cellulose is performed to improve processability and to produce cellulose derivatives (cellulosics) as carboxymethyl cellulose (CMC), methyl cellulose (MC), hydroxyethylcellulose (HEC), etc which can be tailored for specific industrial applications

Cellulose presents many application fields as cosmetic, medical, hygiene, food and drug industry (see Figure 5). The intramolecular bonds give stiffness to the polymer chain, while the intermolecular bonds allow the linear polymers to form sheet structures [7]. Because this biopolymer is abundant in nature, biodegradable and cheap.





GENERAL PROPERTIES :

Hydroxyethyl cellulose (HEC) polymer is a hydroxyethyl ether of cellulose, obtained by treating cellulose with sodium hydroxide and reacting with ethylene oxide. HEC polymers

are largely used as water-binder and thickening agent in many industry applications, that is, personal care products, pharmaceutical formulations, building materials, adhesives, etc., and as stabilizer for liquid soaps. They are available as white free-flowing granular powders that easily dissolve in cold and hot water to give transparent solutions with varying viscosities depending on polymer concentration, type and temperature.

Natrosol™ 250 HEC (www.ashland.com) is available in 10 viscosity types, that go from low viscosity values (types L and J) ranging between 0.08 and 0.4 Pas at $c = 5$ wt.%, intermediate viscosity values (types E, G, K, M) ranging between 0.03 and 6.5 Pas at $c = 2$ wt.%, arriving

to the highest viscosity values (types MH, H, HH) ranging between 0.8 and 5 Pas at $c = 1$ wt.% (informations are given in the producer booklet Aqualon, 1999). The molecular weight and the

degree of polymerization of the Natrosol™ HEC types is directly proportional to their viscosity.

Being a nonionic polymer, Natrosol™ is less sensitive to pH changes; however, pH and temperature may slight affect the hydration and dissolution time of the polymer.

COMMERCIAL APPLICATIONS :

Cellulose for industrial use is mainly obtained from wood pulp and from cotton.[6]

Paper products:

Cellulose is the major constituent of paper, paperboard, and card stock. Electrical insulation paper: Cellulose is used in diverse forms as insulation in transformers, cables, and other electrical equipment.

Fibers:

Cellulose is the main ingredient of textiles. Cotton and synthetics (nylons) each have about 40% market by volume. Other plant fibers (jute, sisal, hemp) represent about 20% of the market. Rayon, cellophane and other "regenerated cellulose fibers" are a small portion (5%).

Consumables:

Microcrystalline cellulose (E460i) and powdered



cellulose (E460ii) are used as inactive fillers in drug tablets[60] and a wide range of soluble cellulose derivatives, E numbers E461 to E469, are used as emulsifiers, thickeners and stabilizers in processed foods. Cellulose powder is, for example, used in processed

Building material:

Hydroxyl bonding of cellulose in water produces a sprayable, moldable material as an alternative to the use of plastics and resins. The recyclable material can be made water- and fire-resistant. It provides sufficient strength for use as a building material.[62] Cellulose insulation made from recycled paper is becoming popular as an environmentally preferable material for building insulation. It can be treated with boric acid as a fire

Miscellaneous:

Cellulose can be converted into cellophane, a thin

transparent film. It is the base material for the celluloid that was used for photographic and movie films until the mid-1930s. Cellulose is used to make water-soluble adhesives and binders such as methyl cellulose and carboxymethyl cellulose which are used in wallpaper paste. Cellulose is further used to make hydrophilic and highly absorbent sponges. Cellulose is the raw material in the manufacture of nitrocellulose (cellulose nitrate).

cheese to prevent caking inside the package. Cellulose occurs naturally in some foods and is an additive in manufactured foods, contributing an indigestible component used for texture and bulk, potentially aiding in defecation.



DIFFERENT SOURCES FOR CELLULOSE:

Natural 2.synthetic

NATURAL FIBERS

natural fibers are made from plant, animal and mineral sources. Natural fibers can be classified according to their origin.

Vegetable fiber

Vegetable fibers are generally composed mainly of cellulose: examples include cotton, jute, flax, ramie, sisal, and hemp. Cellulose fibers serve in the manufacture of paper and cloth. This fiber can be further categorized into the following



Category	Description	Examples	% of cellulose
Seed fibers	Fibers collected from seeds or seed cases	Cotton , kapok	90
Leaf fibers	Fibers collected from leaves.	Sisal, fique, agave.	33
Bast fibers	Fibers are collected from the skin or bast surrounding the stem of their respective plants.	flax, jute, kenaf,	33
Skin		Hemp, ramie, rattan, and vine fibers.	
Fruit fibers	Fibers are collected from the fruit of the plant,	Coconut (coir) fiber.	30-50
Stalk fibers	Fibers are actually the stalks of the plant.	Rice, barley, wheat straws, bamboo ,grass, Tree wood	40-50

The most used vegetable fibres are - cotton ,flax and hemp ,although sisal ,jute ,cenaf ,bamboo

2 .SYNTHETIC FIBRES

synthetic or man-made fibers generally come from synthetic materials such as petrochemicals. But some types of synthetic fibers are manufactured from natural cellulose, including rayon, modal, and the more recently developed Lyocell. Cellulose-based fibers are of two types, regenerated or pure cellulose such as from the cupro-ammonium process and

modified

cellulose such as the cellulose acetates.

Fiber classification in reinforced plastics falls into two classes:

- 1.Short fibers, also known as discontinuous fibers, with a general aspect ratio (defined as the ratio of fiber length to diameter) between 20 to 60
2. Long fibers, also known as continuous fibers, the general aspect ratio is between 200to 500.

Cellulose fibers

Cellulose fibers are a subset of man-made fibers, regenerated from natural cellulose. The



cellulose comes from various sources. Modal is made from beech trees, bamboo fiber is a cellulose fiber made from bamboo, sea cell is made from seaweed, etc. Bagasse is cellulose fiber made from sugarcane.^[12]

Extraction procedures

Extraction from palm kernel cake using liquid phase oxidation.

Hot water treatment is pretreatment step of cellulose extraction. Hot water treatment was performed in a micro-pressure reactor, which filled with 6 g of grinded PKC and 30 ml of distilled water. The reaction was heated to a temperature of 160-180°C, the reaction pressure increased rapidly up to saturated vapor pressure at the temperature. After 0.5 hour of hot water treatment, the reactor was soaked into cooling water in order to terminate the reaction. The pretreated PKC was washed

with distilled water and ethanol to remove the organic acid and saccharides, then dried and sieved to 600 Em. Liquid phase oxidation was then performed to remove the lignin from PKC and remain the pure cellulose. 2 g of pretreated PKC was mixed with 30% H₂O₂ by mixing ratio of 1-5, 1-7.5, and 1-10 of weight basis in a 100 ml flask with a tight plug. The flask with the

reaction mixture was kept for 10-24 hours at temperature of 60- 80°C.

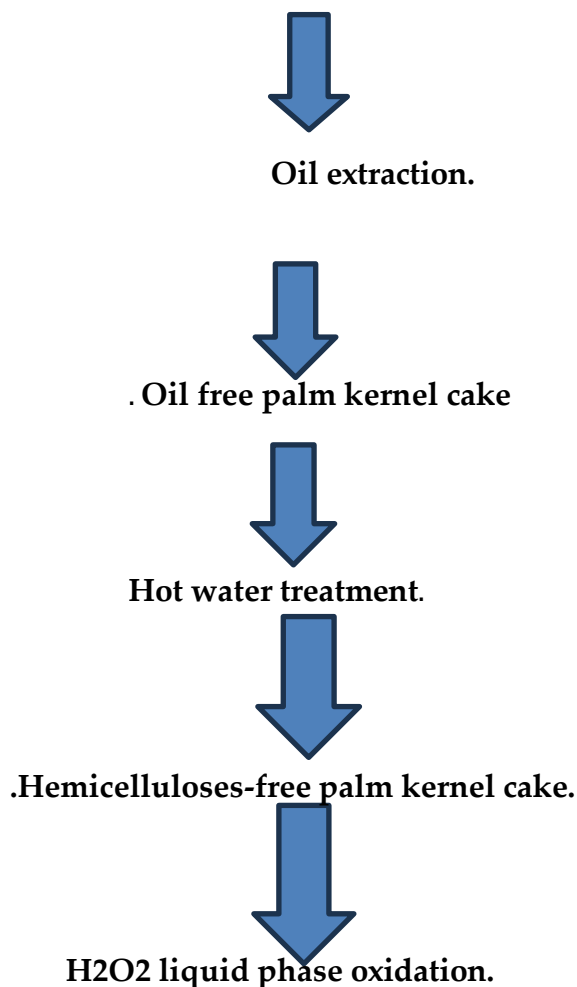
After the elapse of reaction time, an excess of cold water was added to the mixture to terminate the oxidation reaction . The mixture was then filtered in order to separate the aqueous solution of organic compounds and soild residue .

The scheme of extraction stages for cellulose from palm kernel cake is shown in Fig3.





**Dried and ground
palm kernel cake.**



Extraction agricultural waste

Dried dhaincha, corn stalks, rice straw and wheat straw

formic acid treatment conditions 90% (v/v) formic acid concentration;- 120 min reaction time at boiling temperature.

Wash fibers with fresh formic acid.

Peroxyformic acid treatment - mixing 90% formic acid with 4% H₂O₂.

Bleaching pH was adjusted to 11, by adding (NaOH).

Hydrolysis 64% w/w sulphuric acid solution for 5 h at 45 °C, with constant stirring.

The resulting mixture was washed with cold water and repeatedly centrifuged.

The residue was then dried in a vacuum oven

to constant weight for 48 hr.^[11]

CHITOSAN

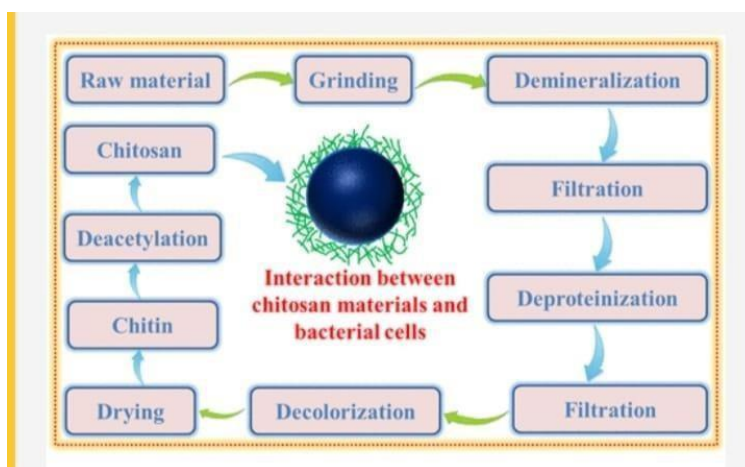
Chitosan is a polysaccharide obtained from chitin by deacetylation. This biopolymer is nontoxic and inexpensive and possesses reactive amino groups that has shown to be useful in different areas In cosmetics, as a flocculating agent in wastewater treatment and more recently as a Pharmaceutical medicines in bio medicines.

In recent years, the textile industry has been seeking to develop innovative products. It is a good choice to organically combine materials with superior functional characteristics and commercial textiles to form products with excellent performance. In particular, textiles made of biological functional materials are often beneficial



to human health, which is an interesting research direction. As a biopolymer material, chitosan has the advantages of strong availability, low cost, excellent safety, outstanding performance, etc., particularly the antibacterial property, and has broad application prospects in the textile field. This review provides an overview of the latest literature and summarizes recent innovations and state-of-the-art technologies that can add value to textiles. To this end, preparation of chitosan fiber, synthesis of chitosan nanofiber, antibacterial activity of

chitosan fiber, antibacterial activity of chitosan nanofiber, etc., will be discussed. Furthermore, the challenges and prospects of chitosan-based materials used in textiles are evaluated. Importantly, this review can not only help researchers understand the development status of antibacterial textiles, but also help researchers discover and solve problems in this field through comparative reading.^[10]



PHYSICO – CHEMICAL PROPERTIES

Chitin and chitosan are composed of thousands of D-glucosamine residues linked together by β -(1–4) linkage. Depending on the degree of deacetylation of chitin, chitosan contains 15– 50% *N*-acetyl-D-glucoseamine units. Since chitin and chitosan contain amino groups and have nitrogen contents that vary from 5% to 8%, they exhibit distinct biological roles . Chitosan is an *N*-deacetylated derivative of chitin produced by changing the acetamide groups into primary amino groups. Chitosan is more water-soluble and chemically reactive compared with chitin

due to the presence of primary and secondary hydroxyl groups on each repeat unit as well as the amine group on each deacetylated unit . These reactive groups in chitosan are easily susceptible to chemical modification, changing its mechanical and physical properties and making it a desirable material for various applications. Most of the properties of chitosan emerge from their physicochemical features, including solubility, deacetylation degree, viscosity, and molecular weight.



Solubility

Chitosan is soluble in an acidic solvent but insoluble in a neutral or alkaline solvent. Although chitin is generally insoluble in solvents, deacetylating chitin results in soluble chitosan that has primary amino groups with a pK_a value of 6.5. When chitosan is dissolved in acidic solvents, the amine becomes protonated and becomes positively charged resulting in soluble chitosan. However, when the pH rises to 6 or higher, they lose their charge and become insoluble. In addition to pH, the solubility of chitosan is affected by its molecular weight degree of deacetylation, temperature, and polymer crystallinity.

Molecular Weight

Molecular weight highly affects the physicochemical and biological properties of chitosan. Chitosan's molecular weight varies depending on the source material, as well as how it is prepared and extracted. Chitosan can be classified as high, medium, or low molecular weight depending on its molecular weight range. Chitosan becomes more viscous and less soluble as the molecular weight increases, which is undesirable for a variety of industrial applications. Given its better solubility and stability, low molecular

weight chitosan is preferred for use in biological and industrial applications.

Degree of Deacetylation

The degree of deacetylation is another factor that determines the physicochemical properties of chitosan, its activity, and its application. The degree of deacetylation refers to the distribution of amino groups along the polymer chain. The cationic nature of chitosan in acidic media resulted from the amino group in the polymeric chain. Thus, the solubility and degree of viscosity are highly influenced by the degree of deacetylation. The degree of deacetylation represents the molar fraction of *N*-acetylglucosamine units in the chain and can be defined in equation (1)

below, where DD is the degree of deacetylation, $nGlcN$ is the average number of *D*-glucosamine units, and $nGlcNAc$ is the average number of *N*-acetyl glucosamine units.

The degree of deacetylation determines whether a polymer is chitin or chitosan. A deacetylation degree above 50%, often suggests the production of successful conversion of chitin into chitosan.

Viscosity

Viscosity is one of the factors that determine chitosan's



industrial applicability, and it is highly dependent on the degree of deacetylation and the molecular weight of the chitosan. Viscosity increases as the degree of deacetylation increases and molecular weight decreases

. It can be also depending on the particle size and storage time of the chitosan . Nanochitosan has lower viscosity about 30% for normal chitosan solution at the same concentration level. Storage time also affects about a 10% drop in the viscosity of normal chitosan for a storage time of 24 hours, whereas nanocolloids dropped by 17% for the same storage time . Aranaz et al. point out in their study that, viscosity is a good determinant for the stability of the polymer in solution, as a reduction is observed during polymer storage due to polymer degradation.^[9]

BIO MEDICAL APPLICATIONS :

Antimicrobial Agent

Antibiotic resistance of bacteria is a major public health problem, thus finding an alternative to antibiotics is important. Chitosan and chitosan derivatives showed antibacterial activity against a variety of microorganisms, including bacteria, filamentous fungi, and yeast . The exact mechanism of antibacterial activity is yet to be fully understood. However,

different hypotheses have been proposed, with the majority of these mechanisms relying on the polycationic characteristic of chitosan . The first proposed mechanism is that chitosan causes cellular permeability and induces intracellular component leakage as a result of its interaction with anionic components of the cell membrane, ultimately leading to cell death . Another possible mechanism is chitosan penetration through the cell membrane followed by binding to DNA, which inhibits DNA replication and eventually leads to cell death . Chitosan also seems to have a growth-inhibitory effect because it has a high ability to chelate several metal ions, such as Ni^{2+} , Zn^{2+} , Co^{2+} , Fe^{2+} , and Cu^{2+} , when the pH value exceeds its pKa value. As a result, microbial growth is inhibited . Chitosan can also inhibit the growth of microbes by forming a dense polymer film on the surface of the cell and preventing nutrient and oxygen uptake.

Drug Delivery

The clinical phase of drug discovery and development is typically impeded by drugs failing to reach the target site of action, resulting in various side effects rather than favorable therapeutic effects. To improve health and extend



life, various mechanisms have been developed for the targeted delivery and/or controlled release of therapeutic medications. Regarding this, the cationic polysaccharide chitosan has attracted great attention in the pharmaceutical and biomedical industries due to its wide availability and intrinsic pharmacological properties. Furthermore, biological characteristics like biocompatibility, biodegradability, non-toxicity, and low-immunogenicity lead chitosan to be involved in designing carriers for the controlled and targeted release of various drugs .

Tissue Engineering

The basis of tissue engineering is designing and developing appropriate materials that can substitute or trigger regeneration processes in damaged tissues. Chitosan, a cationic polymer, is a promising biopolymer because it has several desirable properties, such as biological activity, widespread availability, biocompatibility, and structural resemblance to extracellular matrix components. Given that, significant effort has been put into developing novel chitosan-based materials that closely resemble the structure and functionality of tissues

required for effective regeneration . Chitosan's applicability as biomaterials for advancing advancement in several tissue engineering fields , including tendon and vascular replacement , skin , and nerve regeneration, was reported by different scholars.

Bombaldi de Souza et al. developed a chitosan-based scaffolding for periosteal tissue engineering. First, chitosan was chemically modified to phosphorylated chitosan, and subsequently, a chitosan xanthan-based scaffold was developed as a periosteal substitute. The developed material was able to stimulate osteogenesis, whereas being non-toxic to adipose tissue-derived stem cells. Chitosan in tissue engineering is involved in promoting cell adhesion, cell proliferation, and cell differentiation. By incorporating a methacrylated gelatin network into a nanocomposite hydrogel made of methacrylated chitosan and polyhedral oligomeric silsesquioxane, Zhang et al. developed a biodegradable hybrid double-network hydrogel. They observed that the hydrogel could preferentially guide the mesenchymal stem cells towards osteogenic differentiation in vitro and accelerate new bone regeneration in situ using a rat



of calvarial defects .

Moreover, the polycationic nature of chitosan in a moderately acidic environment facilitates the immobilization of negatively charged enzymes, proteins, and DNA for gene delivery .

Wound Healing

Cuts, grazes, and other breaks in the skin can become infected pathogenic bacteria enter the wound and begin to multiply. The improper treatment process can lead to loss of skin, and initiation of an infection, which might

EXTRACTION OF CHITOSAN FROM SHRIMP SHELL WASTE

For extraction of chitin, the conventional chemical method was followed. Chitosan extraction was done following three major steps, i.e., demineralization, deproteination, and deacetylation. For demineralization, 10 g of sample was treated with 2N hydrochloric acid at solid to solvent ratio of 1:15 for 2 h with constant stirring at 150 rpm in incubator shaker at room temperature . Acid was slowly added to avoid frothing due to gas formation occurring because of calcium carbonate content of shell which reacts with the acid and form carbon dioxide. After demineralization, the sample

spread to other organs. Therefore, it is necessary to develop wound dressings functionalized with antimicrobial agents since it is important to appropriately treat and protect the wound to reduce the risk of infection . Since the number of novel antibiotic classes has declined and no new classes have been developed after daptomycin and linezolid in the 1980s, new commercial drugs are based on optimizations of existing molecules or combinations of multiple compounds .^[8]

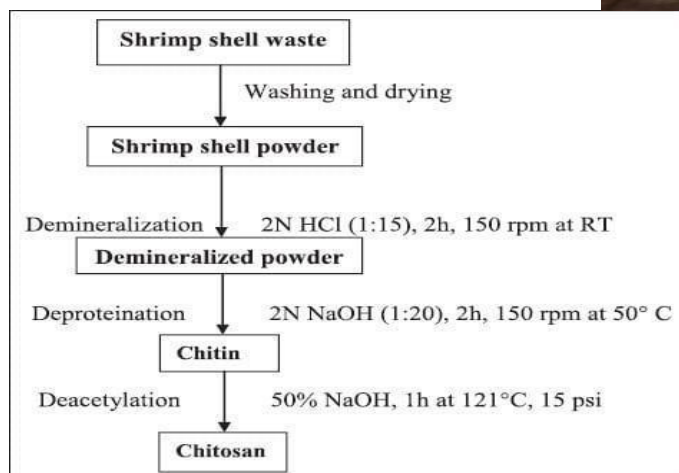
was washed with tap water till the sample reaches neutral pH. Final wash was given with hot distilled water and sample was kept for drying at 80°C overnight.

For deproteination, demineralised shrimp shell powder was treated with 2N NaOH at solid to solvent ratio 1:20 for 2 h with constant stirring at 150

rpm at 50°C in an incubator shaker followed by thorough washing and drying as mentioned above. After this step, the end product was chitin. For deacetylation, chitin was treated with strong alkali, i.e., 1 g of chitin was added to 50% NaOH for 1 h at 121°C, 15 psi followed by washing till it reaches neutral pH. After drying, the final product recovered was chitosan.^[2]

CANDELILLA WAX

Candelilla Wax (CW) is a wax obtained from the leaves of a small shrub native to northern



Mexico and the southwestern United States, *Euphorbia cerifera* and *Euphorbia antisiphilitica*, from the family Euphorbiaceae. CW is a globally recognized food additive approved by the FDA, used mainly as a glazing agent

and binder for chewing gums. It is also used in the manufacture of lip balms and lotion bars, and in the paint industry to make varnishes. Additionally, CW can be used as a substitute for carnauba wax and beeswax in different food systems. A typical composition of a micronized high purity CW used as additive by the food industry shows hentriacontane as the main component. Since CW has as its major component hentriacontane and as minor

components other n-alkanes with odd number of carbons, this creates the possibility of using CW to develop edible organogels using vegetable oils as the liquid apolar phase. This chapter discusses the information generated mainly in the laboratory of the authors of the chapter, associated with the development of CW organogels using vegetable oils as the liquid apolar phase. It also discusses the thermal,

rheological, and structural characteristics of CW organogels and organogels formed by mixtures of Tripalmitin (TP) and CW developed under static conditions or with the application of a controlled shear rate at particular stages during cooling. The chapter



reviews the results associated to the few investigations regarding the use of CW as coating barrier in food products, either as crystal-line dispersion in water or dispersed in a bio-polymer matrix.

PROPERTIES

Candelilla Wax functions as a thickening and hardening agent, a plasticizer, a viscosity modifier, an emollient, and a skin-protective barrier agent that helps prevent the skin from losing moisture. It contributes shine and functions as a stabilizer, an emulsifier, a fast-absorbing lubricant, and a nourishing skin conditioner. Candelilla Wax is reputed to help reduce the appearance of stretch marks as well as the signs of aging, such as wrinkles and age spots. Furthermore, it is said to hydrate parched and scaly skin for enhanced smoothness.

Candelilla Wax is known to be an effective binding agent that easily fuses ingredients. This quality makes it easy to incorporate it into most other waxes as well as resins, both natural and synthetic. This emulsifying property mainly helps water and oil constituents to bind together with a smooth uniformity, a necessary effect for products

like moisturizers, such as lotion bars, creams, and balms, to which Candelilla Wax is known to offer hydrating properties and easy spread over the skin's surface.

Its firming effect means that it can be used to set and solidify formulas for various types of makeup, such as stick foundations, eye shadow, or lip products, to which it provides an ideal "slip" without causing the products to become too hard. This firming property is also beneficial for candle formulations, as Candelilla Wax contributes hardness and smoothness to the final product.

APPLICATIONS

Candelilla Wax is insoluble in water but is highly soluble in oils and alcohols. To add Candelilla Wax to product formulations, begin by melting it before incorporating it into the chosen recipe. When adding it to formulas that require emulsification, incorporate it into their oil phases.

PRODUCT TYPE & FUNCTION

When added to this kind of formulation...

Face, Hand, or Foot Creams

L



u	r
b	e
r	e
i	n
c	s
a	S
n	a
t	l
s	v
,	e
L	s
o	,
t	O
i	i
o	n
n	t
s	m
,	e
S	n
u	t
n	s
s	,
c	B



a

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Lipsticks, Lip Balms, Lip Gloss, Mascaras

EFFECTS

Candelilla Wax functions as a(n):

Skin Protectant ,Fast-

Absorbing ,

MoisturizerNourishing ,

ConditionerHardening Agent

, Thickening Agent

,Plasticizer ,Viscosity

Modifier ,Stabilizer

**TOP MOST PROMISING POLYMER
MANUFACTURING COMPANIES****IN INDIA****1 Ravago shah polymer**

It is a cooperative undertaking between Ravago, a worldwide polymer industry leader based in Belgium, and the other i.e. Shah Polymers, based in India. With a PAN India presence, they specialise in selling plastic resins and additives. Ravago Shah Polymers is a company that creates and sells high-quality technical as well as commodity plastics. Their primary skills include exceptional distribution including the resale as well as the development of strong long-term client relationships. They have had exponential development over the last several years as a result of this initiative. They have been able to swiftly grow their supply chain on a worldwide scale with the support of a world-class global industry leader, providing a comprehensive range of goods that cater to several essential industries such as automotive , aerospace and defence .

2 .Indochem & polymers

Indochem & Polymers is a global trade and manufacturing company specialising in high-quality polymers and chemicals. Due to the excellent quality, affordable pricing, and time-lined delivery schedules of their range, they have earned a firm footing in the industry over the years. To effectively meet



the growing needs of their customers throughout India, they have partnered with a number of renowned manufacturers, including Muntajat, Lyondell Basell, Exxon, Dow, BASF, SABIC, Prime LG, Novacore, Qamar, and others, ensuring the quality of their goods. Furthermore, to prevent any damage, these items are efficiently kept in their own storage facilities under regulated circumstances. Their R&D department is always working to improve unique formulas for their chemicals company, and their world-class manufacturing facilities enable them to reliably supply high-quality goods to their clients.

3- AVH Polychem:

They were founded in 2009 and are a well-known organisation engaged in the manufacture of polymer. They have state-of-the-art infrastructure at their warehouse grounds, based in Mumbai, their main office. They've divided it into several departments to ensure that all of the procedures are carried out in a methodical manner. They deal in a wide spectrum of natural polymers. ONGC Petro Additions Limited (OPAL) has designated AVH Polychem Ltd as an authorised dealer for LLDPE, HPDE PPHP, and PPCP polymers. The company values punctuality and safety and they have developed considerably,

partnering and trading with top industries that swear by their flawless quality and exceptional service. Given the vast variety of applications for which their products are utilised, they are well-equipped to meet the unique needs of each sector. They place a priority on high-quality raw materials delivered on schedule.

4- Ashapur Polyplast:

"Ashapura Polyplast," founded in 2015, is a manufacturer of a comprehensive range of PP Granules, Plastic Granules, and other plastic granules. They manufacture these items using premium-grade raw materials sourced from reputable **polymer suppliers** in the marketplace. They provide these items at competitive prices and deliver them within the specified time range. They've put together a skilled team of professionals that stay up to date on the latest production processes and ideas. They also have a quality control unit that inspects their complete product line for predetermined factors such as design, quality, and finish. All of the units are outfitted with all of the necessary equipment, machines, and technology to produce a high-quality variety of goods.

5- Jairam Plastics:

They are another good manufacturer of polymers.



These granules are prepared utilising high- quality materials and cutting-edge technology in compliance with international quality standards. They provide these nylon granules in a variety of colours and grades to meet the specific needs of their customers. The exact conformation, robust intermolecular forces, excellent qualities, and compactness of the offered granules are all highly sought-after attributes. These facilities are staffed by their team of highly qualified individuals, allowing them to take on and finish big and urgent orders from customers in a well-organized and timely way. Their experts collaborate closely with their customers and guarantee that the items they provide are made in accordance with worldwide quality standards. In addition, their quality specialists thoroughly inspect all of the items on a variety of quality characteristics.

6- Engineered Polymers:

Engineered Polymers, as a firm has had a strong predisposition towards process and product development from its start. For three decades, they have been a recognised leader

independently operates in India's polymer sector. Their state-of-the-art factory, which employs cutting-edge technology and is run utilising current methods and time-

tested processes, allows us to provide the highest-quality polymer stock forms and machined components. Their stock forms and components are subjected to the most rigorous quality controls. To achieve the highest possible material quality, they collaborate with their clients and cooperate with the world's top resin producers and compounders. The company has a single minded devotion to ensure that they are recognized as the best polymer company brand in India and with their ever growing clientele, and rapidly expanding offerings, the company is sure to achieve the same.

7- Anshika Polysurf:

The company is the result of years of hard work that started in 1982. The company started its operation by producing chemicals for the textile industry, under the brand name "Venus". The company was able to gain significant ground and footing due to its excellent product range and quality. As the company became popular, they entered the field of polymers and produced products for sectors such as agriculture, textile, papers, personal care and medicine. The company is known for incorporating state of the art technology into its units as well as having an excellent team of professionals, picked up from all the necessary domains of



learning. One important attribute that stands Anishka Polysurf apart from the crowd is its focus on customer service and on time delivery. Client satisfaction is supreme for the owners of the company and their feedback from customers has always been glowing and positive.^[3]

ENCORE NATURAL POLYMERS PRIVATE LIMITED

"Encore Natural Polymers Private Limited", are an Indian company in the business of manufacturing different native and derivatized natural polymers for varied applications. Our company was previously known as "Indian Gum Industries Ltd." (IGI). IGI was founded in 1958 through a technical and financial collaboration with the Cesalpinia Group, Italy (acquired by Hercules Inc., in 1971), to supply Guar seed based polysaccharides. In 1987 IGI became an Indian owned company, when Hercules and Henkel decided to merge their water-soluble polymers businesses. Today, owing to the reorganization of the parent Merchant family, the Ahmedabad business division of IGI under



the name **Encore Natural Polymers Private Limited**.^[4]

OTHER COMPANIES OF NATURAL POLYMERS

COMPANY NAME	PLACE	PRODUCTS MANUFACTURED
JP polymers private limited	Mumbai	Acrylic polymers, Acrylic Resins ,Rubber Rollers ,Rubber coupling bushes etc
Jayashree polymers private limited	Maharashtra	Rubber hoses ,Damper and suspension ,molded rubber parts ,metal rubber bonded parts
Munisuvrat polymers private limited	Thane	Plastic Y cone ,plastic adapter ,plastic palin tube nd perforated tube ,plastic cups
Amar polymers and Allied private limited	Mumbai	Rubber and polymeric components
Sudesh polybag private limited	Mumbai	Basic chemicals and plastic &rubber
Jabee polymer private limited	Mumbai	Modified natural polymers in primary form
Crest polymers private limited	Maharashtra	Acrylate resins ,primary resins



WHICH ARE THE NATURAL POLYMERS IN THE SENSE OF THE SINGLE USE OF PLASTIC BAN

After relatively short negotiation period, the new rules on single use plastics to tackle marine litter work adopted and published in June 2019, in brief commonly known as the “single use plastic ban” (European parliament and Council 2019). Items that fall under this ban include single use products made of Plastics to which alternatives exists on the market, such as Cottob

bud sticks, cutlery, Plates, Straws, Stirrer sticks for balloons, as well as cups, food and beverages containers made of expanded polystyrene and all products made of oxo-degradable plastic. For the purpose of directive and its measure, a plastic is defined as a material consisting of However, in this year's amended Plastic Waste Management Rules, “MLPs were included as a category of waste that has to be collected and used in road making, as co-processing fuel in cement kilns, or processed through pyrolysis,” Pandey adds.

In February 2022, the environment ministry had also notified ‘extended producer responsibility’

(EPR) to streamline the collection and recycling of plastic waste. EPR makes producers, importers and brand owners responsible for managing products in an environmentally sound manner. Now, waste generators who manage plastic waste efficiently can earn credits that can be bought and sold.

NEW DELHI: Away from the media glare on politically sensitive money laundering cases, the ED has also begun a crackdown against syndicates involved in environmental crimes, including illegal mining of natural resources and smuggling of wildlife parts. It said it has busted cases which generated ‘proceeds of crime’ to the tune of more than Rs 2,700 crore.

PLASTIC POLLUTION

Plastic pollution is the accumulation of plastic objects and particles (e.g. plastic bottles, bags and microbeads) in the Earth's environment that adversely affects humans, wildlife and their habitat.[1][2] Plastics that act as pollutants are categorized by size into micro-, meso-, or macro debris.[3] Plastics are inexpensive and durable, making them very adaptable for different uses; as a result, manufacturers



choose to use plastic over other materials.[4] However, the chemical structure of most plastics renders them resistant to many natural processes of degradation and as a result they are slow to degrade.[5] Together, these two factors allow large volumes of plastic to enter the environment as mismanaged waste which persists in the ecosystem and travels throughout food webs.[6][7]

Plastic pollution affects seas, beaches, rivers and land (clockwise from top left):

Olive ridley sea turtle entangled in a ghost net in the Maldives

Plastic pollution of Sharm el-Naga beach, near Safaga, Egypt

Piles of plastic waste on the government-authorize "garbage island" of Thilafushi, Maldives

Canada Dry plastic bottle on hiking trail in the United States adjacent to an urban hiking trail.

A tributary of the Wouri River in Douala, Cameroon, completely clogged with plastic.

Plastic pollution can afflict land, waterways and

oceans. It is estimated that 1.1 to 8.8 million tonnes of plastic waste enters the ocean from coastal communities each year.[8] It is estimated that there is a stock of 86 million tons of plastic marine debris in the worldwide ocean as of the end of 2013, with an assumption that 1.4% of global plastics produced from 1950 to 2013 has entered the ocean and has accumulated there.[9] Some researchers suggest that by 2050 there could be more plastic than fish in the oceans by weight.[10]



Living organisms, particularly marine animals, can be harmed either by mechanical effects such as entanglement in plastic objects, problems related to ingestion of plastic waste, or through exposure to chemicals within plastics that interfere with their physiology. Degraded plastic waste can directly affect humans through direct consumption (i.e. in tap water), indirect consumption (by eating plants and animals), and disruption of various hormonal mechanisms.[13]

As of 2019, 368 million tonnes of plastic is produced each year; 51% in Asia, where China is the world's largest producer.[12] From the 1950s up to 2018, an estimated 6.3 billion tonnes of plastic has been produced worldwide, of which an estimated 9% has been recycled and another 12% has been incinerated.[13] This large amount of plastic waste enters the environment and causes problems throughout the ecosystem; for example, studies suggest that the



bodies of 90% of seabirds contain plastic debris. In some areas there have been significant efforts to reduce the prominence of free range plastic pollution, through reducing plastic consumption, litter cleanup, and promoting plastic recycling.

As of 2020, the global mass of produced plastic exceeds the biomass of all land and marine animals combined. A May 2019 amendment to the Basel Convention regulates the exportation/importation of plastic waste, largely intended to prevent the shipping of plastic waste from developed countries to developing countries. Nearly all countries have joined this agreement. On 2 March 2022 in Nairobi, 175 countries pledged to create a legally binding agreement by the end of the year 2024 with a goal to end plastic pollution.

The amount of plastic waste produced increased during the COVID-19 pandemic due to increased demand for protective equipment and packaging materials. Higher amounts of plastic ended up in the ocean, especially plastic from medical waste and masks. Several news reports point to a plastic industry trying to take advantage of the health concerns and desire for disposable masks and packaging to increase production of single use

plastic.^[5]

GLOBAL NATURAL POLYMER MARKET

Natural polymer market is anticipated to be primarily driven due to increase in demand for non-petroleum based and eco-friendly products. Further, increasing penetration of natural polymer based products in pharmaceutical industry for various applications such as for binders and fillers in drugs, excipients, wound dressing, and treatment of arthritic-affected joints, etc. Rise in demand of natural polymers from oilfield industry in hydraulic fracturing fluid is also expected to drive the natural polymer market. Another most prominent consumer of natural polymer is in packaging, with the growth in packaging industry the natural polymer market is expected to be driven.

With the increasing trend of applications towards the use of ecofriendly products many factories are focusing on research and development of natural polymers for various applications for instance development of newer drug delivering techniques using natural polymers. Further, increasing acceptance of natural polymers as substitute in medical field industry is



expected to boost the natural polymer market over the forecast period. The natural polymer market is governed through stringent environmental rules and regulations which is expected to hamper the growth of market over the forecast period. Further, increasing awareness about deforestation and protection of animals is anticipated to act as a minor

barrier for the market. Ready availability of alternatives for natural polymers, such as for cotton and natural rubber, is expected to be a restraining factor the market growth.

Increasing concern for environmental pollution and degradation over the use of non-biodegradable petroleum based substitutes along with volatile price of crude oil is expected to drive demand of natural polymer. Further, increasing investment for research and development led by the government initiatives have yielded in to various industrial application of natural polymers, in the field of agriculture, medical, pharmaceutical and packaging industry.^[14]

GLOBAL NATURAL POLYMER MARKET : REGIONAL OUTLOOK

America is expected to be

driven due to increasing application in medical, oilfield industry and packaging industry. Growing construction industry in Asia Pacific and Middle East and Africa is expected to drive the natural polymer market.

However, due lack of technological advancement and capital investment in most of the developing countries in MEA is expected to constraint the natural polymer market. Growing population, increasing industrialization along with increase in an affluent middle class in the Asia Pacific region is expected to propel the growth of natural polymer market at a significant pace.

Europe natural polymer market is anticipated to expand with a healthy growth rate primarily driven by the increase in demand for non-petroleum based and environmentally friendly product. Latin America market is expected to grow at relatively slower pace over the forecast period.

Global Natural Polymer Market: Key Participants

Examples of some of the market participants
Global Natural Polymer Market: Key Participants

Examples of some of the market participants operating in the global



natural polymer market are as follows:

Ashland Inc. Novamont S.p.A.

Archer Daniels Midland Company

Dow Chemical CompanyEconomy

Polymers & Chemicals^[6]

GENERAL GUIDELINES FOR WORKING WITH NATURAL POLYMERS

Natural polymers are biodegradable and environmentally friendly materials. Here are some general guidelines for working with natural polymers:

Material Selection:

Choose the appropriate natural polymer based on your application. Common natural polymers include cellulose, chitin, collagen, starch, and more. The choice depends on factors like mechanical properties, biocompatibility, and degradation rate.

Sourcing:

Ensure a sustainable source of the natural polymer, such as from plants, animals, or microorganisms. Consider the environmental impact of extraction and processing.

Processing and Extraction:

Develop eco-friendly extraction and processing methods to minimize environmental impact. Avoid the use of harsh chemicals

when possible.

Biodegradability:

Design products or materials that are biodegradable to reduce waste and pollution. Ensure that they degrade into non-harmful byproducts.

Reinforcement:

Natural polymers can often be reinforced with other natural or synthetic materials to enhance their mechanical properties. Consider blending with additives like fibers or nanoparticles.

Cross-Linking:

Cross-linking methods can improve the stability and mechanical properties of natural polymers. Options include physical cross-linking, chemical cross-linking, and enzymatic cross-linking.

Functionalization:

Modify the surface or chemical properties of natural polymers to tailor them for specific applications. This can include chemical grafting or introducing functional groups.

Biocompatibility:

Consider the biocompatibility of the natural polymer for applications in the medical or food industries. Ensure that the material



is safe for contact with living organisms.

Testing and Quality Control:

Establish testing and quality control procedures to assess the properties and of the performance of the natural polymer-based products.

Regulatory Compliance:

Be aware of and adhere to regulatory requirements and standards for using natural polymers, especially in sectors like healthcare and food packaging.

Life Cycle Assessment:

Conduct a life cycle assessment to understand the environmental impact of your natural polymer-based products from production to disposal.

Recycling and Waste Management:

Explore recycling options for natural polymer-based products. Promote proper waste management to reduce environmental pollution.

Collaboration:

Collaborate with experts in the field of natural polymers, as well as researchers and industries involved in sustainable materials development.

Awareness and Education:

Educate consumers and

stakeholders about the benefits of natural polymers and their role in sustainability.

Innovation:

Continuously explore new applications and innovative ways to use natural polymers to reduce the environmental footprint of various industries.

Remember that the specific guidelines may vary depending on the type of natural polymer and its intended application. Always stay updated with the latest research and developments in the field of natural polymers for sustainable materials .^[7]

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