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Biopolymers : classification and properties

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Abstract: Biopolymers have gained an increasing demand in present century. They are long chain molecules. They are made of monomeric units which are covalently bonded together to form large structures. Biopolymer complexes have been reported to show higher stability to varying temperatures, pH and ionic strength. Due to their renewability, abundance, biodegradability and other unique properties such as high adsorption capabilities and ease of functionalization they have been investigated for several industrial applications. They are eco-friendly and sustainable. Biopolymers combined with other components are regularly determined to have good mechanical properties, thermal stability as well as proper physicoichemical and morphological properties. The physical properties vary for different biopolymer types and compositions. When two incompatible biopolymers are mixed, either associative and segregative phase separation occurs. Associative phase separation involves phase separation of oppositely charged polymers because of electrostatic repulsion. On the other hand segregative phase separation involves separation of similarly charged or neutral biopolymers.

Keywords: biopolymer, covalently bonded, polysaccharide, polypeptide, polynucleotide

Introduction

Biopolymers are polymeric biomolecules having a long chain of monomeric units which are covalently joined together. Contrary to synthetic polymers, biopolymers have a complex molecular assembly leading to a well-defined three dimensional structure. The word “bio” shows the biological nature of the polymer to degrade naturally. They can copy the properties of synthetic polymeric materials . Bipolymers, due to their abundance, biocompatibility and unique properties are very promising materials for highly selective and sensitive gas and vapour sensors. Biopolymer derived materials are sustainable and renewable and have excellent performance with a low carbon foot print. These exceptional attributes of biopolymers make them a favourable choice for industrial waste water treatment. Biopolymers and their derived materials are a potential sustainable replacement for petroleum-derived materials for waste water treatment .Biopolymers derived from natural sources offers great opportunities to develop novel biopolymer based composites and their functional applications in tissue engineering, medical implants, drug delivery systems and wound healing. Their usage in food packaging, wrapping and biomedical science is diverse and multiple. They are often applied in the production of colloidal dispersions such as foams or emulsions [1]. Although polymer-polymer complexes have been studied by various researchers [2-9], they still remain as one of the most challenging topics to understand [8,10]. They are preferred in the food industry due to their sustainability, non-toxicity, non-immunogenicity, biocompatibility, good chemical reactivity, relatively low cost [11-12], stability, nutritional benefits, biodegradability [13] as well as their generally –recognised-as-safe (GRAS) status. Apart from that, the replacement of synthetic stabilisers with natural biopolymers gives them 'clean' label.

Classification of biopolymers

Biopolymers can be divided into three broad groups, on the basis of the nature of repeating monomer units. These are polysaccharides, polynucleotides and polypeptides. Polysaccharides are biopolymers in which monosaccharide units are joined together with glycosidic linkage. Starch, cellulose, glycogen, chitin/chitosan, pectin and alginate are well known polysaccharides. Polysaccharide biopolymers can be further subdivided into four categories. These are sugar based biopolymer, starch based biopolymer, cellulose based biopolymer and lignin biopolymer.

Sugar based biopolymer :Starch or sucrose is used as input for manufacturing polyhydroxybutyrate. They can be produced by blowing, injection, vacuum forming and extrusion. Lactic acid polymers (poly actides) are created from milk sugar (lactose) that is extracted from potatoes, wheat and sugar beet. Polyactides are resistant to water and can be manufactured by methods like vacuum forming, blowing and injection molding [14].

Starch based biopolymer : Starch acts as a natural polymer and can be obtained from wheat, tapioca and potatoes.The material is stored in tissues of plants as one way carbohydrates. It is composed of glucose and can be obtained by melting starch. This polymer is not present in animal tissues. It can be found in vegetables like tapioca, corn, wheat and potatoes. Dextrans, produced by starch hydrolysis, which is a group of low molecular weight carbohydrates, enzymatically synthesied by immobilised Enterococcus faecalis Esawy dextrasucrase onto biopolymer carriers[15-16].

Cellulose based biopolymers : These are used for packing cigarettes, CDS and confectionary. This polymer is composed of glucose and is the primary constituent of plant cellulose walls. It is obtained from natural resources like cotton, wood, wheat and corn [17]

Lignin biopolymer : Lignin comprises another important biopolymer but not of polysaccharide origin.

Polynucleotides like DNA and RNA are biopolymer of nucleotide units.

Biopolymers of amino acid monomers are linked with peptide bonds (amide linkage). Silk, collagen and keratin are examples of biopolymers of these type of polypeptides.

Biopolymers based on synthetic materials : Biopolymers based on synthetic compounds also used for making biodegradable polymers such as aliphatic aromatic copolyesters obtained from petroleum. They are compostable and bio-degradable completely though they are manufactured from synthetic components [17].

There are many more non-biodegradable bio-based biopolymers than there are biodegradable bio-based biopolymers. Two different criteria are there to define a biopolymer or sometimes called “bio plastic”. These are i) the source of raw materials and ii) polymer biodegradation.

Biopolymers made from renewable raw materials (bio-based) and biodegradable: These polymers can be produced by either biological systems i.e. by microorganisms, animals and plants or synthesised chemically from biological starting materials i.e. from sugar, corn, starch etc. One method of making a polymer biodegradable involves inserting hydrolysable ester group into it. Biodegradable bio-based biopolymers include i) synthetic polymers from renewable resources such as poly (lactic acid) PLA ii) biopolymers produced by microorganisms, such as PHAs iii) naturally occurring biopolymers, such as starch or proteins. The most used bio-based biodegradable polymers are starch and PHAs [18].

Biopolymers made from renewable raw materials (bio-based) and not biodegradable: These biopolymers can be produced from biomass or renewable resources and are non-biodegredable. Non-biodegradable bio-based biopolymers include i) renewable resource’s synthetic polymers such as specific polyamides from castor oil, specific polyesters based on biopropanediol, bio polyethylene (bio-LDPE, bio-HDPE), bio polypropylene (bio-pp) or bio poly (vinyl chloride) (bio-PVC) based on ethanol (from sugarcane) ii) naturally occurring biopolymers such as natural rubber or amber [19].

Biopolymers made from fossil fuels, and being biodegradable : These biopolymers are produced from fossil fuel, such as synthetic aliphatic polyesters made from crude oil or natural gas, and are certified biodegradable and compostable. PCL poly (butylene succinate) (PBS),and certain “aliphatic-aromatic” copolyesters are at least partly fossil-fuel based polymers, but they can be biodegraded by microorganisms [19].

Properties of biopolymers :

Biopolymers have gained special interest because they are capable of replacing many of the everyday items that are made from petroleum products. Much of the property measurements of biopolymers have variance because of several factors. These are degrees of polymerisation, type and concentration of additives and presence of reinforcement materials.

There is not much information about the properties of biopolymers, but there is still a considerable depth of investigation into their physical, mechanical and thermal properties [20].Some biopolymers possess electronic and ionic conductivity and termed as electroactive biopolymers (EABP). This has given them the potential to replace other synthetic materials. These biopolymers, which include starch, cellulose, chitosan and pectin, show a wide ranging electrical conductivity [21].saccharides. The production

Conclusion :

Polymers are known to us because of their extreme stability but their degradation cycles in the biosphere are unlimited. Use of synthetic polymers is the cause of environmental pollution. To get rid of this hazard, researchers are deeply involved in search of biodegradable natural polymers. Biopolymers are therefore defined as polymers formed under natural conditions during the growth cycles of all organisms. They are also called natural polymers. Biopolymers find immense applications in medicine, food and petroleum industries.Microrganisms can produce and excrete good amount of polysaccharides. The production is however costly.The main drawback that limits their production is the lack of efficient processes for their extraction and purification. The biocompatibility as well as biodegradabilityhowever, encourages their use.

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References:

[1] Mohan, S., Oluwafemi,OS., Kalarikkal, N., Thomas, S. and Songca, SP. 2016. Biopolymers-application in nanoscience and nanotechnology. In: Perveen FK, editor. Recent Advances in Biopolymers. Croatia: InTech., 47-72 .

[2] Bos, MA.and Van Vliet, T.2001. Interfacial rheological properties of adsorbed protein layers and surfactants: A review. Advances in Colloid and Interface Science, 91: 437-471.

[3] Benichou, A., Aserin, A. and Garti, N. 2002. Double emulsions stabilized by new molecular recognition hybrids of natural polymers. Polymers for Advanced Technologies, 13(1012):1019-1031.

[4] Dickinson, E. 2003. Hydrocolloids at interfaces and the inluence on the properties of dispersed systems. Food Hydrocolloids, 17: 25-39.

[5] Mackie, AR. 2004. Structure of adsorbed layers of mixtures of proteins and surfactants. Current Opinion in Colloid & Interface Science, 9:3 357-361.

[6] Sánchez, CC. and Patino, JMR.2005. Interfacial, foaming and emulsifying characteristics of sodium caseinate as inluenced by protein concentration in solution. Food Hydrocolloids,. 19(3): 407-416.

[7] McClements, DJ., Decker, EA. and Weiss J. Emulsion-based delivery systems for lipophilic bioactive components. Journal of Food Science, 72(8) :

[8] Bandyopadhyay, P., Ghosh, AK.and Ghosh, C. 2012. Recent developments on polyphenol–protein interactions: Efects on tea and cofee taste, antioxidant properties and the digestive system. Food & Function, 3(6) : 592

[9] Evans, M., Ratclife, I. and Williams, PA.2013.Emulsion stabilisation using polysaccharide-protein complexes. Current Opinion in Colloid & Interface Science, 18:272-282.

[10] Doublier, JL., Garnier, C., Renard, D. and Sanchez C. 2005. Protein-polysaccharide interactions. Current Opinion in Colloid & Interface Science, 5: 202-214.

[11] Spizzirri, UG., Parisi, OI., Iemma, F., Cirillo, G., Puoci, F., Curcio, M. et al. 2010.Antioxidantpolysaccharide conjugates for food application by eco-friendly grafting procedure. Carbohydrate Polymers, 79(2) : 333-340.

[12] Song, WL., Wang, P., Cao, L., Anderson, A., Meziani, MJ., Farr, AJ. et al. 2012. Polymer/boron nitride nanocomposite materials for superior thermal transport performance. Angewandte Chemie, International Edition, 51(26) : 6498-6501.

[13] Yin, B., Zhang, R. and Yao, P. 2015. Inluence of pea protein aggregates on the structure and stability of pea protein/soybean polysaccharide complex emulsions. Molecules, 20(3) : 5165-5183.

[14] Monzer, F. 2014. The role of colloidal systems in environmental protection. Chapter 16: 366-368.

[15] Esawy, MA., Gamal, AA., Helal, MMI., Hassan, ME., Hassanein, N.M. and Hashem, AM. 2016. Enzymatic synthesis using immobilized Enterococcus faecalis Esawy dextransucrase and some applied studies. International journal of biological macromolecules, 92 : 56-62.

[16] Hashem, A.M., Gamal, AA., Hassan, ME., Hassanein, NM. And Esawy, MA. 2016. Covalent immobilization of Enterococcus faecalis Esawy dextransucrase and dextran synthesis. International journal of biological macromolecules, 82 : 905-912.

[17] Kaurov, MS.2011. Engineering chemistry with laboratory experiments, 238-240.

[18] Nioounakis, M. 2013. Biopolymers: Reuse, recycling and disposal . Chapter 2, Section 2.5, 1st ed., Plastics Design Library , 432.

[19] Vroman, I. and Pighzert, L.2009. Biodegradable polymers. Materials, 2 : 307-344.

[20] Van de Velde, K. and Kiekens, P. 2001. Biopolymers : overview of several properties and consequences on their applications. Polym. Test., 21 (2002) : 433-442.

[21] Muthulakshmi, S. 2013. Investigations on the biopolymers papain, gum acacia, gum tragacanth and gum guar : Physical and antimicrobial properties. Ph. D dissertation , Dept. of Physics, Manonmaniam Sundaranar University, Tirunelveli.