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Review of Microbial Synthesis and Recovery of Hybrid Biopolymers for Industrial Applications from Wastes

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Abstract

Since agriculture and industrial operations are expanding exponentially along with the rapid growth in global population, agro-industrial wastes are a global concern. Biopolymers are intricate molecules made by living things, but they can also be found in or formed from a variety of wastes. The main disadvantages of using polymers are the high cost of waste-to-polymer conversion procedures and the need for scale-up when producing biopolymers using microorganisms. However, using biopolymers on an industrial scale to create high added value items like food or biomedical ones can not only offset the initial expenses of producing them but also boost regional economies and environmental sustainability. Some of the most crucial elements relating to the topic are described in the current review.

Keywords: Biopolymers; Microbes; Agricultural wastes

Introduction

Organic wastes made up almost 80% of the agricultural wastes, which were predicted to be 998 million tonnes in 2009 (Obi et al., 2016). Furthermore, over the past 50 years, agricultural production has expanded by at least a factor of three, producing 23.7 million tonnes of food daily (Food and Agriculture Organization of the United Nations (FAO), 2017, Food and Agriculture Organization of the United Nations (FAO), 2019). In order to meet the projected demand for food, which is expected to rise from 8.4 billion tonnes per year to roughly 13.5 billion, the world's population will need to reach 9.7 billion people by the year 2050. (FAO, 2017). If immediate, effective steps are not made to reduce greenhouse gas emissions and the massive amount of food, agricultural, and industrial wastes that are generated globally, there could be catastrophic results [1].

The term "biopolymer" refers to a broad class of big molecules produced by cells that are made up of repeatable chemical units. These molecules are grouped into different categories based on their chemical make-up, including polyesters, polynucleotides, polypeptides, and polysaccharides. In order to reach $7,200 million USD in 2022, the biopolymer industry is anticipated to grow 17% annually. High structural and chemical diversity, bioactivity due to specially tailored regions and/or functional groups, functionality determined by stereo, region, and enantioselectivity, bio stability under similar biosynthetic environmental conditions, biodegradability, absence of toxicity, and a defined average molecular weight are the main advantages of biopolymers over chemically synthesised polymers. Aside from that, the majority of biopolymers are biocompatible [2,3].

One of the most prevalent materials in agricultural wastes is biopolymers. Given how much is produced globally, lignocellulosic residues in particular garner the most attention. However, many other biopolymers, including gelatin, gum, starch, pectin, chitin/chitosan, carrageenan, albumin, and collagen, are derived from agro-industrial wastes and can be used to create high-value commercial goods. Many biopolymers can be generated from microbial cell cultures through fermentation employing waste from the agricultural, domestic, and industrial sectors as an alternative to the purification of biopolymers from leftovers. Alginate, gellan, ß-glucans, kefiran, levan, polyhydroxyalkanoates, pullulan, and xanthan gums generated by bacteria and/or fungus are typical examples [4,5]. The ability to regulate the process and the characteristics of the produced biopolymer are the key benefits of utilising microbes to manufacture biomolecules.

Polymers produced by microorganisms

Organic waste products from domestic, industrial, and agricultural activities are intricate materials that include various sources of carbon and nitrogen in addition to microelements utilised in microbial culture. As a result, the process cost can be lower than when using traditional synthetic media by using these residues to create low-cost alternatives to culture medium for microbial growth and polymer manufacture. The most recent is discussed in the part after this. The vast chemical variety of biopolymers allows for the creation of several hybrid systems and composites in an effort to combine their properties or create new ones. A composite is a mixture of several different materials meant to improve or create new features, such as load capacity or retention, mechanical properties [6].

A straightforward method for creating functional biopolymers that perform particular functions is the synthesis of hybrid materials. New hybrid materials with various physicochemical and biological properties are created when many biopolymers are mixed with other materials. Inorganic, organic, and biological molecules are mixed with hybrid biomaterials made from biopolymers to create a wide range of structural and functional composites for several applications. The ability to anticipate hybrid biopolymer architectures, component interactions at the molecular level, and behaviour under various experimental circumstances is made possible by recent advancements in technology and material analysis [7,8]. The goal of the current review was to outline the most recent developments in biopolymers recovered from waste or manufactured from it, with a focus on the creation of hybrid biopolymeric and composite materials for use in

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medicine.It is typically thought of as a secondary alternative for agro-industrial processes to recover biopolymers found in trash. Frequently, agricultural and industrial waste is burned or burnt to create energy, fermented chemicals, composts, and/or biofuels. Though the main bond energies of each hexose monosaccharide, which is made up only of C, O, and H in a biopolymer main chain, are quite high, producing fuels from biopolymers results in significant energy losses [9].

Conclusion

Given the immense potential of -PGA, this review paper aims to provide a thorough overview of -PGA's biosynthesis, the correlation between fermentation conditions and chemical structures, the physical behaviour of -PGA with different chemistry, potential cost-optimization strategies for -PGA biosynthesis, and current and potential applications of -PGA as a sensible substitute for non-sustainable polymers. Despite the fact that recent reviews on poly-glutamic acid have been published, this paper concentrates on understanding the relationship between the genetics of microorganisms, the composition of the substrate, the conditions of fermentation, and the chemical properties of polymers from a business perspective. Comparatively, current evaluations place a greater emphasis on using genetic engineering techniques to develop high-yield -PGA producers. By reviewing this material, we intend to provide some background information for this industry's biosynthesis in practise [10].

Conflict of Interest

The authors show no conflicts of interest.

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