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Biopolymers in Medical Implants: A Brief Review

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Abstract

Biopolymers have been established as a promising class of materials with a wide range of applications, of which medicine stands out. Characteristics such as biocompatibility, biodegradation and non-cytotoxicity make these material excellent candidates to be used in implantable materials. This review examines the main properties of biopolymers, as well as the potential of different biopolymers, including polylactic acid (PLA), silk and chitosan, for application in implantable medical devices.

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Keywords: Biopolymers; Medical implants;PLA; Silk; Chitosan.

1. Introduction

The main objective of implantable devices is to mimic a body part and are used to replace a damaged organ or structure to sustain normal body function. Some of the most used medical implants consist of heart, bones, eyes, ears, knees, breasts, hips and cardiovascular system implants [1]. Traditional materials like metals, ceramics and synthetic polymers have been applied but they present some disadvantages, like immunological rejection by the body [2–4]. Furthermore, synthetic polymers may present concerns about their biodegradation products in the body, which may lead to an unwanted immunogenic response. The degradation process occurs by hydrolysis, producing

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carbon dioxide, which lowers the local pH resulting in cell and tissue necrosis [5]. This way, biopolymers assume a major role among materials for medical implantation.

Biopolymers are polymers produced by living organisms and can be derived from microbial systems, extracted from plants, or chemically synthesized from basic biological systems. They present some advantages when compared to synthetic polymers, namely a well-defined, and more complex, structure, degradability and renewability [6–8]. Biopolymers have been developed for use as medical materials, packaging, cosmetics, food additives, clothing fabrics, water treatment chemicals, industrial plastics, absorbents, biosensors, and even data storage elements. There are three main groups of biopolymers: polysaccharides, proteins and polynucleotics and their classification is given in Table 1 [9].

Table 1. Classification of biopolymers.

Classification	Origin	Biopolymers
Polysaccharides	**Plant/algal**	Starch (amylose/amylopectin), Cellulose, Agar, Alginate, Carrageenan, Pectin, Konjac, Various gums (e.g., guar)
	Animal	Chitin/chitosan, Hyaluronic acid
	Bacterial	Xanthan, Dextran, GelIan, Levan, CurdIan, Polygalactosamine Cellulose (bacterial)
	Fungal	Pullulan, Elsinan, Yeast glucans
	Lipids/surfactants	Acetoglycerides, waxes, surfactants, Emulsan
Proteins		Silks, Collagen/gelatina, Elastin, Resilin, Adhesives, Polyamino acids, Soy, zein, wheat gluten, casein,Serum albumin
Polyesters		Polyhydroxyalkanoates, Polylactic acid
Specialty polymers		Shellac, Poly-gamma-glutamic acid, Natural rubber, Synthetic polymers from natural fats and oils, nylon from castor oil

Biopolymers, whose degradation products are not immunogenic, have a great potential to be used in the development of therapeutic devices such as temporary prostheses, three-dimensional porous structures as scaffolds for tissue engineering, and as controlled/ sustained release drug delivery vehicles and applications like suturing, fixation or adhesion [8–10]. This review will be mainly focused on the development of implantable devices made of polylactic acid (PLA), silk and chitosan.

1.1. PLA

PLA (Figure 1) is one of the most promising biodegradable polymers and it can be derived from natural feedstock such as corn starch rice, potatoes and other natural resources. The mechanical properties of PLA are similar to synthetic polymers like polypropylene, and has the advantage of higher abundance and lower cost [11]. Furthermore, PLA is bioabsorbable and this characteristic may offer some benefits when applied to implantable devices. In the case of stents, for example, after serving as an intravascular dilator it may biodegrade by the human body fluids and no foreign body will remain, avoid a second surgery for stent removal. Tamai et al. [12] developed PLA-based biodegradable stents and achieved promising results after application in human models. Another research has studied the biodegradation of PLA stents in rabbit aortas and concluded that it performed quite well [13]. Additionally, the study determined that PLA stents were as hemocompatible as stain steel stents and PLA stents allowed the measurements of luminal patency in magnetic resonance imaging, in contrast to the stain steel stents.

Chang et al. [14] prepared a novel porous PLA composite scaffold and evaluated its capacity as a carrier for the recombinant bone morphogenetic protein 2 (rhBMP2), showing a sufficient capability of carrying the protein,