Polymer Applications In Biomedical Fields

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Abstract- Polymers are macromolecules with a wide range of structures, characteristics, and composition. They can be used in a variety of domains, including biophysics, medicine, and electronics. Biomedical polymers stand out among these polymers because of their low toxicity in vivo, ease of processing and sterilization, longer shelf life, small weight, as well as unique characteristics suitable for different appliances. This work investigates the different concentrations of biomedical polymers in the area of medicine.

Index Terms- Biopolymers; Smart polymers; Biocompatibility; Biodegradability.

I. Introduction

Sir Nicholas Harold, a British ophthalmologist, described the first synthetic polymer for medical usage, poly methyl methacrylate, in 1949, for producing intraocular lenses [1]. However, biocompatibility, biodegradation to non-toxic chemicals, small antigenicity, extreme bio-activity, processability for intricating geometries through adequate penetrability, capability for promoting cell growth and propagation, and acceptable mechanical qualities are all characteristics of a material which can be utilized on behalf of biomedical requests such as wound therapeutic, medication conveyance as well as tissue manufacturing [2].

Biopolymers are the varieties of polymers that are generated via living organisms. This may originate from a variety of plants, such as maize and soybeans, as well as other categories of trees. Biopolymers could be categorized with regarding to monomeric unit utilized in addition to the configuration of the biopolymer developed to the following categories:

1- Polynucleotides which involve DNA and RNA that are long polymers comprised of thirteen or more nucleotide monomers.
2- Polypeptides which are short polymers of amino acids.
3- Polysaccharides, which are linear, bonded polymeric carbohydrate structures [2].

Based on their origin, biopolymers may be categorized into

1- Polysaccharides (Bacterial) such as Xanthan, and Cellulose.
2- Polysaccharides (Fungal) such as Pollulan and Elsinan.
3- Polysaccharides (Plant/Algal) such as Starch, Cellulose, and Agar.
4- Polysaccharides (Animal) such as Chitin and Hyaluronic Acid.
5- Lipids/Surfactants such as Acetoglycerides, Waxes, and Emulsion.
6- Polyphenol
7- Specialty Polymers.

The United States Congress Office of Technology Assessment categorizes biopolymers into nucleic acids, proteins, polysaccharides, polyhydroxyalkanoates and polyphenols [3]. The two most significant factors to contemplate in case of selecting a polymer for biomedical usage are biostability and biodegradability. The significant biomedical polymers which are hydrolytically degradable consist of homo- and copolymers [4]. Biopolymers and smart polymers are provisions for these materials, that are mostly employed in biotechnology and medicine. Biorecognition and Biocatalysis in aqueous solutions, that entail highly quick and changeable chemical and physical changes, are two of their main uses [5].

II. MUCOADHESIVE POLYMERS

Because of their increased body area and longer residence period, they are employed for ophthalmic and buccal drug administration [6]. Bio-adhesive drug delivery systems are made of polyacrylic acid (PAAc). The structure of this drug release is of three various approaches, one is the diffusion-controlled approach where the drug is distributed via solution-diffusion beyond a polymer. The second approach is the erosion-controlled route where the drug release is triggered via suspension, degeneration, or biodegradation of the polymer. In the third approach, the drug release is performed through the level of osmotic absorption of water from the ecosystem and they are called osmotically controlled systems [7].

III. SMART POLYMERS AND BIOSEPARATION

Smart polymers have emerged as a significant class of polymers with a growing number of uses. The subject has exploded in popularity over the last two to three decades. SP have been employed in biotechnology, medicine, and engineering. These polymers can be found in three different physical forms. The first form is the linear free chains in solution. In this form, the polymer undertakes changeable collapse once an external stimulus is provided. The second form covalently cross-linked reversible gels, where the gels can expand or shrink in response to environmental change, and the third form chain adsorbed or surface-grafted form. In fact, when an external parameter is modified, the polymer expands or collapses reversibly on the surface [8].

IV. POLYMERS UTILIZED FOR VASCULAR PROSTHESES AND CARDIOPULMONARY BYPASS SURGERY

Poly (ethylene terephthalate) fibers, developed polytetrafluoroethylene foams, segmented porous polyurethanes as well as microporous silicone rubber are examples of polymers utilized for vascular prosthesis or excellent blood flow. Polymers are also employed for oxygenating blood and have to function without causing blood harm. During cardiopulmonary bypass surgery, polypropylene has been employed in both solid and microporous forms [9]. The morphology of synthetic grafts (both seeded and unseeded) retrieved after 2 weeks after implantation demonstrated a high level of polymorphonuclear leukocyte infiltration (PMNs). Shepard et al, hypothesized that complement activation would be a barrier to efficient endothelial cell seeding of prosthetic grafts since complement-activated PMNs have been shown to harm endothelial cells [10].

V. NATURAL AND SYNTHETIC BIODEGRADABLE POLYMERS AND FIBERS

Natural and synthetic polymers are utilized in medical prosthetics such as heart valves and stents. The relevance of biodegradable polymers in the area of medicine is skyrocketing these days, since nano delivery of medications to target organs is a continuing improvement. The biodegradability of materials utilized for nano delivery, both in therapy and imaging, is critical since toxicity results from the buildup of utilized components [11]. The biocompatibility of a polymer is determined based on its degradation products. The US Food and Drug Administration (FDA) has authorized poly lactic-co-glycolic acid and poly lactic acid for specific medicinal uses since their breakdown products are removed from the body in the form of CO_2 as well as H_2O.
In the future, semipermeable membrane biopolymers (cellulose) with lower antigenicity will be utilized in artificial kidneys for hemodialysis, reducing or eliminating the need for immunosuppressive medicines [11].

VI. COLLAGEN

It is found in 1838 by Payen where it is considered as the most important fundamental material of vertebrates and is the primary copious mammal protein which represents around 20-30% of the whole-body proteins. It is made from fibroblasts, which are pluripotent adventitial cells or reticulum cells that generally come from pluripotent adventitial cells or reticulum cells. Collagen is a rod-shaped protein having a length and breadth of around 3000 and 15 A, respectively, and a molecular weight of around 300 kDa [12, 13].

This type of biopolymers (i.e., collagen) can be utilized in various schemes in the field of biomedical engineering and biosciences. It can be used in tissue-based devices such as prosthetic heart valves since it can decrease mortality and morbidity for patients suffering from high-risk diseases like cardio-vascular disease (CVD). Collagen films can be utilized in the form of barrier membrane. These films can be shaped into discs where it can be used to prevent the expansion of tissue infection. Moreover, collagen forms can be used to encourage bone formation [14].

Another form of usage of this biopolymer is as executive of acute burns and as a dressing for dangerous forms of wounds. A well-known effective treatment of collagen on behalf of the monitored delivery structures is collagen-based gel like an injectable aqueous expression [14].

VII. CONCLUSIONS

Polymers have a lot of uses in the biomedical sector, and they are quite useful. These are less harmful, safer, and easier to use. The medication delivery and Bio-separation mechanisms are extremely efficient and dependable. Smart polymers are used in a variety of biological applications, including blood oxygenation and cardiopulmonary bypass operations. Their sensitivity to physical conditions and stimulus response nature makes them valuable in a variety of applications. Suture materials, tissue adhesives, and vascular grafts, as well as materials for aesthetic implants, dental composites, contact and intraocular lenses, and other applications Polymers have several applications in medicine.

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