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Review Article

Application of Natural Polymers in Wound Dressings

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Abstract: A plethora of synthetic, hybrid, and biological polymers are widely being used in medical supplications. A variety of polymers are helpful in our civic activities. Their peculiar chemical, physical, and biological properties are applicable in multiple domains of life from engineering to medicine. This review specifically addresses the novel polymers and their applications in wound dressings. It has been reported by the researchers that, natural polymers are not only playing tremendous roles in micro and macro medical-industry but they are also playing a remarkable role at nano levels as nano-drug carriers and being widely used in wound dressings in pharmaceuticals. In this editorial, we will give a brief introduction of polymers and how they are widely being used in medicinal interventions, it further sheds light on the prospects of polymers with an updated version.

Keywords: Hydrogels, Natural polymers, Wound dressings.

1. INTRODUCTION

Natural polymers because of their biodegradability, biocompatibility, and closeness to the extracellular matrix are frequently used in regenerative medicine for burns and wound dressing. By triggering and stimulating the wound healing process, natural polymers aid in the restoration of damaged tissues and, as a result, skin regeneration [1]. Natural polymers have proven to be effective in a variety of biomedical applications, such as controlled administration of drugs, gene delivery, and regenerative medicine, among others. Plants, animals, and microbial are the major sources responsible for the production of natural polymers. Based on their chemistry natural polymers are divided into polysaccharide, protein, polyester, and polyamide-based polymers [2]. Because of their 3 D cross-link-based networks of polymer, immersed with water or other biological fluids, hydrogels are considered worthwhile in the Biomedical and pharmaceutical industries for wound care, burn dressing, medication administration, tissue engineering, and transplantation of organs [3].

2. NATURAL POLYMERS USED IN WOUND DRESSINGS

Here are several natural polymers which are effectively used in wound management.

2.1 Polysaccharides

There are many sources from where polysaccharides (natural polymers) can easily obtain such as gelatin, starch, cellulose, and chitosan (from vegetal source), alginate, dextran, and glucan (from microbial source) and dextran, glucan, and alginate, are all examples of animal sources. Some polysaccharides are beneficial in healing burns and wounds and are administered as hydrogels: Sulfated polysaccharides are present in different forms such as alginic acid, hyaluronic acid is acidic in nature, glucans, dextrans, and cellulose are examples of neutral sulfated polysaccharides, chitin and chitosan are basic [4]. Electrospun, dextran, cellulose, and starch are highly effective materials for producing nanofibrous composites in the regenerative medicine field (tissue engineering, wound dressing) [5]. Pullulan derivate a highly

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absorbent hydrogel (polysaccharides) was prepared via chemical cross-linking to use as an antiseptic wound dressing. Hydrogel is not cytotoxic and also has a significant water absorption capability (swelling ratio up to 4000 %), implying rapid hemostatic ability and preventing wound bed dryness and exudate accumulation. To treat open wounds and burns against bacterial biofilm encroachment, antibiotic and antimycotic drugs can be added to the hydrogel [6].

2.2 Glycolipids

Due to the rapid engagement of neutrophils and macrophages, topical applications of alpha Galactose liposomes comprising glycolipids with alpha-Gal epitopes could be effective in patients with wounds, burns, and other skin diseases [7]. Macrophages produce growth factors and cytokines that aid wound and burn healing by promoting re-epithelialization, tissue reshaping, and repairing processes. [10].

2.3 Proteoglycans

Synthetic or semisynthetic polymers have already been developed as biological, structural, and chemical proteoglycan alternatives. Proteoglycan is a kind of protein with covalently linked glycosaminoglycan chains [8]. Neo proteoglycan structures are biocompatible and biodegradable synthetic glycol conjugates made from protein, nanomaterial, or polymer base. They play an important role in cell-protein interactions [11].

2.4 Proteins and Peptides

Vegetal Protein: Plant-derived proteins are utilized in the treatment of wounds and burns. Soy and sodium caseinate-based membrane biomaterials have potential in drug administration and wound dressing due to their biodegradability and biocompatibility. Collagen: Collagen-based dressings are manufactured from pig, bovine, or avian sources and have been authorized for partial and packed wounds with mild - to - moderate sputum. Persons with third-degree burns (skin), as well as those who are allergic or sensitive, should avoid it [9]. Gelatin: Gelatin one of the natural polymers is a collagen-based product and is derived from a variety of by-products of animals. Gelatin is used to produce biodegradable and biocompatible drug delivery solutions and dressings for the wound in the biomedical industry. Fibrin: Fibrin is a naturally occurring scaffold for the healing of wounds as well as a cell transplant transporter. Keratin: Derivatives of keratin are utilized for the dressing of chronic wounds due to their involvement with the proteolytic wound area, which promotes the process of healing. Antibiotics and growth factors were delivered in a controllable way using new wound dressings based on keratin with improved properties [10]. Silk fibroin: Because of its unique features of biocompatibility, biodegradability, flexibility, adhesion, exudate absorption, and minimum inflammatory reaction SF is considered efficient for wound dressings. SF is also used to make tendons, prosthetic ligaments, blood arteries, and skin transplants. Enzymes: Biochemical debridement of wounds is accomplished by fibrinolytic (proteolytic) enzymes, papain, and collagenase. In pectin films effective for skin wound healing, the stability of prostaglandin H production was improved [9].

2.5 Hydrogels

Hydrogels have polar/charged functional groups that give them properties including hydrophilic nature, absorption capacity, swelling in a particular medium, and enhanced stimuli reactivity. Based on their equilibrium swelling grade, they are categorized with 20–50 percent for low swelling hydrogels (SWD), 50–90 percent for intermediate swelling hydrogels (SWD), and 90–99.5 percent for high swelling hydrogels (SWD), and more than 99.5 percent for excellent absorbent hydrogels (SWD). High Swelling grade hydrogels offer excellent biocompatibility and permeability, making them ideal for medical applications. Hybrid hydrogels are heterogeneous among hydrogels, making them ideal for adhesion of cells, organizing, and cell-cell interactions in medical applications [10]. Because of their properties, chitosan-based hydrogels are regarded as a promising choice for healing wounds, particularly major injuries. Hydrogel-based PVA/HA membranes were studied for dressings application in terms of biological properties and biocompatibility. Increasing HA components in the hybrid hydrogels resulted in decreased migration and cell viability [3]. The antibacterial efficacy of a hydrogel-based on HA/

PVPA/CS designed for cutaneous wound healing was proved against *Escherichia* coli [11]. Hybrid hydrogels based on heteropolysacchorieds used in wound dressing along with producing methods and general properties are given in Table 1.

2.6 Blended Polymers with Polyvinyl Alcohol Hydrogels for Wound Dressing

Blended polymers for medical applications were formerly defined as that interact with biological systems to assess, treat, and improve body function, or to restore any organ or tissue. Due to their intrinsic biocompatibility, biodegradable hydrogel membranes are currently being used extensively in the medical sector [7]. Sodium alginate (SA) is being investigated for use in wound dressings combined with PVA polymer as either the primary or supplemental component to the dressing structure because of its strong water swelling capacity, which impacts the local wound region beyond moisture management. PVA has exceptional capabilities of forming films and is combined with natural and synthetic polymers in the past because it is water-soluble and also contains biodegradable, biocompatible, and non-carcinogenic properties. Because it is highly hydrophilic, biocompatible, and relatively inexpensive, alginate polymer is often used in biomedical applications including scaffolds, wound dressing, and surgical or dental impression materials [8].

Table 1: In the table below, a few examples of hybrid hydrogels based on heteropolysaccharides used in wound dressing are presented, along with producing methods and general properties 4.

Hybrid Hydrogel	Producing Method	Properties
Nitrofurazone based PVA/SA hydrogels	Fourier Transform procedure	SA high concentration in PVA-based hydrogel films. Increase the ability of elasticity, swelling, and thermal stability of the PVA/SA hydrogel system. Increased SA concentration resulted in substantial reductions in the percentage of gel fraction and PVA/SA hydrogel mechanical characteristics. Reduced protein adsorption is associated with a low SA level, indicating good blood compatibility.
Clindamycin-loaded hydrogel film based Biodegradable PVA/SA (Polyvinyl Alcohol/ Sodium Alginate)	The FT technique is used to do physical crosslinking.	By increasing the SA concentration, the percentage of gelation (%), maximum strength, and break elongation of the hydrogel film reduces, also enhancing its swelling ability, elasticity, and thermal stability. The quantity of SA in the PVA/SA film does not influence the clindamycin release profile, although PVA/SA-clindamycin accelerates the process of wound healing in rats.
Alginate based PVA/calcium nanofiber web	Method of electrospinning	High calcium alginate concentration results in a high water vapor transmission rate, which aids in wound healing by keeping the immediate environment wet. Wound coated with PVA-based nanofiber; new epithelium appears to emerge without any adverse responses.

Hybrid Hydrogel	Producing Method	Properties
Hybrid hydrogels ontaining glucan		
PVA(glucan films)	Physical mixing and drying at 110 _C in the absence of chemical crosslinking	There was no covalent connection between PVA and glucan in the manufactured film; glucan can be discharged to heal faster. As the glucan content of the material rose, the tensile strength of the material dropped, while the breaking elongation increased. Cell mobility is hindered and wound healing time is increased when the PVA film contains a high glucan concentration.
Hydrogels made from chitosan (CS) and chitosan derivatives		
Hydrogel membranes based on PVA/CS (Polyvinyl Alcohol/ Chitosan)	Irradiation process follows the FT cycle	The swelling capacity, water evaporation, mechanical strength, and thermal stability of the material have all been enhanced. As the CS level rises, antibacterial action against Escherichia coli improves.
Glycerol addition into PVA/CS based hydrogels	FT after irradiation	In a rat model, the wound healing process is accelerated. L929 mouse fibroblast cells are harmless. After the 11th postoperative day, mature epidermal architecture emerged.
PVA/CS hydrogel films based loaded minocycline	Fourier Transform technique	Increased CS concentration reduces the fraction of gel, mechanical properties, and PVA/CS hydrogel film thermal stability. Wounds heal faster as compared to the standard sterile gauze control.
CM/ PVA /honey (Carboxymethylated chitosan/ Polyvinyl alcohol/ honey)	Fourier Transform technique	*Escherichia coli* bacteria growth is inhibited. The honey's presence promotes wound healing.
Quaternary Chitosan/ PVA Also known as Q-chitosan mats	Photo-crosslink based electrospinning technique	Gram-positive and negative bacteria are effectively inhibited from growing.

3. CONCLUSION

Polymers, a most heard word in our daily life is a macromolecule or a large molecule, which is typically a combination of a plethora of subunits. We live in an era of the industrial revolution where we cannot imagine life without polymers. They are a salient part of our personal, domestic, and commercial life from our DNA to giant spaceships. A plethora of polymers are being used in almost every domain of medical sciences. The peculiar properties of polymers such as degree of crystallization, molecular weight adjustments, cross-linking degrees, blending abilities, biocompatibility, toxicity, tensile strengths, and characterizations make them adjustable according to the situation and desired use. An excellent wound dressing begins with careful material selection. Biocompatibility, biodegradability, skin and environmental friendliness make naturally occurring polymers great wound dressing materials. A review of Various types of wound dressings were described in the local periodicals, each based on a naturally occurring. These Metals, antibiotics, proteins, and other bioactive compounds were included in the dressings to expedite the healing of wounds.

4. CONFLICT OF INTEREST

The authors declare no conflict on interest.

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