Advanced materials application in biotechnologies and biomedicine

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Abstract

Materials matter: any breakthrough that changes society owes its success to the molecular building blocks used to create it. Advanced materials are essential to economic security and human well-being, with applications in industries aimed at addressing challenges in clean energy, national security, and human welfare. Therefore, speeding up the pace of development and implementation of advanced material systems is critical for achieving global competetiveness in the 21st century. In recent decades, significant progress has been evident in the processing and properties of materials intended for use in various biotechnologies, biomedicine, and dentistry. This volume specifically introduces new materials based on natural and synthetic substances with improved properties relevant to applications in biomedicine and biotechnologies.

Keywords: Antimicrobial applications; natural products; orthopedic and dental implants.

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1. MATERIALS FOR ANTIMICROBIAL APPLICATIONS

The spread of infection by pathogenic microorganisms is a real, widespread issue and an actual and global problem. Furthermore, due to the uncontrolled use of antibiotics, microorganisms have developed a growing resistance to the numerous antimicrobial agents currently available. As a result, it is critical to limit the spread of infection, particularly in healthcare settings. The demand for efficient, long-lasting, easily available, non-toxic, and reasonably priced antimicrobial agents for medical, healthcare, hygiene, and protective textile materials is rapidly increasing as their production continues to rise [1]. In this respect, microbial survival on textile materials must be reduced because germs can degrade both the fabric and the wearer's comfort. In other words, the microbial presence may have many negative impacts, including the production of offensive odor, stains, material decolorization, and a reduction in the mechanical strength of the fabric [2]. Silver and its compounds, which were previously known to be effective biocides for over 650 different microbes, have gained new interest due to the growing problem of multi-antibiotic-resistant microorganisms [3]. Without significantly influencing the color of the fabric, silver can be added to textile materials to provide the appropriate amount of antibacterial activity [4]. Additionally, a concentration of silver below the level of toxicity of 1 mg dm^{-3} is sufficient to obtain adequate antimicrobial effects [5].

2. MATERIALS FOR CONTROLLED DRUG DELIVERY

Hydrogels are highly valuable materials endowed with unique properties for the controlled delivery of various active substances. pH-responsive hydrogels, constructed from poly(methacrylic acid) (PMAA) crosslinked by poly(ethylene glycol) diacrylate (PEGDA), have emerged as compelling materials for drug delivery applications. PMAA, serving as a hydrophilic polymer, proves to be a judicious choice for the synthesis of pH-sensitive hydrogels with adjustable swelling/deswelling behavior. PEGDA, recognized for its biocompatibility and non-toxic nature and commonly employed in pharmacy and biomedicine, effectively crosslinks PMAA-based hydrogels, imparting robust mechanical properties and the possibility for loading and controlled release of ciprofloxacin and oxaprozin. The swelling behavior and

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mechanical properties exhibited by processed hydrogels based on PMAA substantiate the potential for their application in biomedicine as carriers for controlled drug delivery within the gastrointestinal tract.

3. MATERIALS BASED ON NATURAL PRODUCTS

Natural phenolics are broadly distributed in plants and are the most abundant secondary metabolites of plants. Plant polyphenols have drawn increasing attention as potential preventative measures against cancer and heart disorders [6]. It is widely acknowledged that the reactivity of the phenolic moiety causes phenolic compounds to serve as antioxidants. Biological activities of phenolic compounds include anti-inflammatory, anti-ulcer, antispasmodic, antiviral, antidiarrheal, and antitumor effects [7].

By scavenging free radicals and lowering oxidative stress, antioxidants can postpone, limit, or completely halt the oxidation of an oxidizable substrate. Antioxidants from outside sources are necessary in these circumstances to counteract the harmful effects of oxidative stress. Phenolics have been considered powerful antioxidants *in vitro* and proved to be more potent antioxidants than Vitamin C and E and carotenoids. A variety of putative pathways have been indicated as routes in which polyphenols might function as antioxidants. The most significant mechanism of their antioxidant activity is free radical scavenging, in which polyphenols can stop a free radical chain reaction, as well as suppress free radical formation by controlling the enzyme activity or chelating metal ions involved in free radical production.

4. MATERIALS FOR MEDICAL APPLICATIONS

An orthopaedic implant is a medical device used to replace a damaged or deformed bone, joint, or cartilage. The selection of materials, shape and geometry of the implants, dimensional accuracy, and adequate mechanical properties are the primary features required for the success of an orthopaedic implant. Chemical stability and toxicity, unlike other manufactured products, are of increased importance due to the need for biocompatibility over an implant's life, which could span several years while remaining sufficiently safe for use [8]. Thus, the clinical usefulness of biomaterials in orthopaedic and musculoskeletal trauma surgery is determined by the combination of mechanical and biological properties. Stainless steel, cobalt-based alloys, polymer materials (such as polyethylene), and titanium are used in the implants because they are strong and long-lasting [9]. Titanium is a common metal used in orthopaedic surgery as well as the 'gold standard' for dental implant fabrication. While titanium is a metallic element, the majority of "titanium implants" are actually alloys that are a good choice for such implants due to their appropriate mechanical properties, corrosion resistance, and biocompatibility.

We believe that the studies presented in this special issue will contribute to a better understanding of the importance of advanced materials development, inspiring future research toward different applications, not just in biotechnologies. We would like to thank all the authors for their efforts in preparing the articles or revising them in response to the reviewers' comments. We would also like to thank the reviewers for their valuable contributions. Special thanks to Prof. Dr. Bojana Obradović, Editor-in-Chief, for her guidance and support, and to the editorial staff for their assistance in producing this issue.

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Primena naprednih materijala u biotehnologijama

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Izvod

Materijali su važni: svaki napredak koji menja društvo duguje svoj uspeh molekularnim gradivnim blokovima koji se koriste za njegovo stvaranje. Napredni materijali su od suštinskog značaja za ekonomsku bezbednost i ljudsko blagostanje, sa primenom u industrijama usmerenim na rešavanje izazova u pogledu čiste energije, nacionalne bezbednosti i ljudskog blagostanja. Stoga je ubrzanje tempa razvoja i implementacije naprednih materijalnih sistema kritično za postizanje globalne konkurentnosti u 21. veku. Poslednjih decenija evidentan je značajan napredak u obradi i svojstvima materijala namenjenih upotrebi u različitim biotehnologijama, biomedicini i stomatologiji. Ova tematska sveska posebno predstavlja nove materijale zasnovane na prirodnim i sintetičkim supstancama sa poboljšanim svojstvima relevantnim za primenu u biomedicini i biotehnologiji.

Ključne reči: antimikrobne primene; prirodni proizvodi; ortopedski i zubni implantati