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Editorial

Coatings with Natural Products—One Perspective on the Challenges Related to New Coatings' Development

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Currently, bacterial infection resulting from the prolonged use of medical devices in contact with the human body is a major problem. Approximately 60%–85% of chronic microbial infections occur because of the development of biofilm on the surfaces of medical devices and are characterized by a slow onset, symptoms of medium intensity, chronic evolution, and resistance to antibiotic treatment [1]. There are two ways to solve this problem: the use of a material suitable in the medical device and the corresponding modification of its surface to inhibit the adsorption, growth, and bacterial colonization. To avoid the narrowing of the medical device and subsequent failure due to clogging, bacterial adhesion must be prevented [2]. The simplest method of preventing bacterial adhesion is to obtain materials with anti-adhesion properties or to modify the surfaces of the medical device. Chemical modifications involve the functionalization of the surface of the material with different agents (in this case, from natural compounds) or integral modification via the addition of additives with antimicrobial action. The addition of a new layer can be beneficial, especially in the case of those with several layers, with each layer having a specific role (physico-chemical, mechanical, controlled release, antimicrobial) [3].

Research on novel bio coatings has grown in recent years, attracting interest from academic and industrial researchers worldwide—particularly in the biomedical applications of nanotechnology—driven by the outstanding benefits that their translation can offer, e.g., the enhancement of the sensitivity and efficacy and safety of existing diagnostic, treatment, and combination strategies.

Currently, both chemical synthesis and natural substances are the main ways to obtain new compounds with antimicrobial activity [4].

The use of natural products in the therapeutic management of diseases caused by microorganisms is more advantageous than the use of drugs derived from synthetic sources. This is due to the low side effects of these medicines, while their toxicological and pharmacological activity is comparable to that obtained from industrial sources. In addition to low toxicity, there is a special demand and interest in various branches of medicine for natural pharmacological products, which have effects against infectious agents.

The enormous biodiversity of microorganisms in terms of habitat, metabolism, and tolerance to extreme conditions, and the action of different agents determine their primacy in the quality of sources of substances with antibiotic effects. From this point of view, actinomycetes, mycelial fungi, and myxobacteria are leaders in the number and variety of pharmaceuticals that are obtained based on them. The natural habitats of the microorganisms were further explored to discover new bioactive compounds capable of fighting infectious diseases. Regardless of the efforts made, however, microbial communities, which populate extreme regions and oceans, remain an unexplored source of new compounds [5]. Progress in the implementation of new techniques for the screening, separation, and isolation of chemical compounds has led to the identification of over one million natural compounds, of which 50%–60% are of plant origin and over 5% of microbial origin. About 25% of these compounds have biological activity, of which 10% are derived from

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microbial sources. In numerical values among the over 22,500 biologically active microbial compounds, 45% are produced by actinomycetes, 38% by fungi, and 17% by bacteria [6–9].

The best-known sources of natural substances with healing effects are of plant origin. Plants contain a wide range of phytochemicals, which have traditionally been used for millennia in folk medicine [10–14]. Interest in natural medicines declined in the second half of the twentieth century in connection with the fact that synthetic preparations appeared during this period. These new concoctions were more efficient; it was easier to study the process of their metabolism in the body, as well as their mechanisms of action on the agents of pathogenic microorganisms, and the patenting process for such preparations was easier. However, the widespread use of synthetic preparations and the high incidence of adverse reactions generated by them revived interest in preparations of natural origin.

Plants produce a wide variety of chemical compounds with different structures and properties. Currently, the structures of over 50,000 compounds have been described, and each year, this number increases by several thousand [13–15]. A small number of these substances are typical of all organisms, being part of the primary metabolic pathways. Most are, however, secondary or phytochemical metabolites, the biosynthesis of which is limited to certain groups of plants. Bioactive plant products can be divided into several major classes depending on the chemical structure, the systematic position of the organisms from which they come, the biosynthetic pathways, and the biological properties. The most well-known and widely used classification scheme is based on the chemical structure, and the main groups are composed of phenols, alkaloids, saponins, terpenoids, limonoids, polyacetylenes and secoiridoids, etc. In recent years, phytochemicals have passed numerous in vitro and in vivo tests to establish their effectiveness as antimicrobial agents against pathogenic bacteria, fungi, and viruses, as well as their action on beneficial microflora, especially intestinal microflora. Additionally, multiple studies are needed to establish the mechanisms of action of bioactive substances from plant sources. Intense research in this area is a guarantee of the development of new preparations with antimicrobial effects extracted from plant biomass, characterized by high levels of therapeutic efficacy and minimal adverse effects on the body.

Although multicellular organisms have diverse structures and functions, they are characterized by common features in their defense and surveillance systems against pathogenic microorganisms. Previously, it was considered that plants have nonspecific systems and animal-specific systems of protection against pathogenic microorganisms. With the massive accumulation of new data, this concept has been revised, as plant-specific systems have been discovered. Protection, and in animals, nonadaptive (innate) immunity, is dependent on nonspecific inducers. Genes encoding antimicrobial peptides (MAPs) have been identified as key factors in both plant and animal protection systems. A considerable number of peptides have been discovered in recent decades, either inducible or constitutive, with activity against different types of microorganisms, characteristic of virtually all groups. These findings were preceded by the establishment of the role of thionines in plants as an example of antimicrobial peptides that protect the host from agents such as pathogenic microorganisms [13–17]. Thousands of peptide structures are currently known to possess a certain type of antimicrobial activity. Depending on the chemical structure, antimicrobial peptides of animal origin are classified into two broad groups: peptides with a linear structure and peptides with a cyclic structure. Linear peptides in turn form two distinct subgroups: (a) linear peptides with a tendency to adopt an α-helical amphipathic conformation; (b) linear peptides of unusual composition, rich in amino acids such as Pro, Arg, or (occasionally) Trp. The second group, which includes cysteine-containing peptides, can also be divided into two subgroups: (a) with a single disulfide structure and (b) with multiple disulfide structures [17]. There are currently a variety of approaches to classifying antimicrobial peptides. There are seven main criteria based on the classification of these valuable compounds: biosynthetic equipment used in their synthesis, biological source, biological functions, physicochemical properties, covalent bond pattern, 3D structure, and molecular targets [17–19].

In this Special Issue, we expect contributions from a broad community of scientists working on the application of bio-based coatings in biology/medicine and interdisciplinary teams.

In particular, the topics of interest include but are not limited to the safety of novel biocoatings intended for use on humans.

- Coatings with antimicrobial properties.
- Coatings prepared with green chemistry strategies.
- Coatings with added natural functional ingredients.
- Applications of bio-based coatings.

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