BIOACTIVE GLASS NANOPARTICLES CONTAINING BIOSURFACTANT: A PERSPECTIVE OF POTENTIAL BIOMEDICAL AND AGRICULTURAL APPLICATIONS

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ABSTRACT

Global population growth is driving the development of new technologies aimed at improving human and environmental health care. This demand represents a significant challenge in the emerging field of nanotechnology and biotechnology. Bioactive glasses (BG) are amorphous ceramic compounds whose structure includes network formers, intermediates, and network modifiers. Widely used in modern medicine to regenerate, repair, or replace parts of the human body, these biomaterials are biocompatible and show potential for applications in agriculture. Due to its ability to induce positive biological responses, especially when associated with biosurfactants. In this context, BG constitutes an innovative opportunity in the convergence of the needs of agriculture and biomedicine, aiming to increase the productivity, efficiency, sustainability, and economic viability of resources. Thus, this work will critically discuss the current state of the art and future trends in the synthesis of bioactive glass nanoparticles containing biosurfactants.

Keywords: Biotechnology 1. Nanotechnology 2. Nanomaterials 3. Bioactive glasses 4. Biosurfactants 5.

1 INTRODUCTION

Nanotechnology is based on the growing capacity of modern technology to manipulate atoms and particles on a nanoscale, with applications in various areas [1], from medicine to the environment and agriculture. In recent years, a new frontier at the interface between biotechnology and nanotechnology has been the target of research. This new frontier can contribute to the development of new functions and abilities of nanomaterials. Processes for synthesizing nanomaterials are being investigated and the availability of biological resources is continually being examined [2].

The ability of the BG to incorporate bioactives into their structure is of particular interest, due to their ability to release them in a controlled manner, inducing biological responses appropriate to the needs of the application [3]. BG nanoparticles, due to their small size, high surface area, and high volume-to-area ratio, are especially suitable for the controlled release of bioactive ions, as well as for the formation of composites, compared to micrometer-sized particles [4,5]. Furthermore, the morphological characteristics of nanoparticles facilitate their uniform incorporation into polymeric matrices, demonstrating their superiority for this specific purpose [6]. In this sense, biosurfactants present themselves as a promising alternative to compose the synthesis of BG nanoparticles and mesoporous materials, as they have interesting properties such as significant reduction in surface tension, high thermal and pH stability, and chemical resistance to high salt concentrations [7,8]. Furthermore, biosurfactants have non-toxic and biodegradable properties, surfactant or emulsifying molecules, synthesized by plants (saponins), microorganisms (bacteria, actinobacteria, yeast, and filamentous fungi) and higher organisms (bile salts), presenting antimicrobial, antitumor and larvicidal or insecticidal activity [8].

Therefore, this review aims to critically discuss the current state of the art and future trends in the synthesis of bioactive glass nanoparticles containing biosurfactants, highlighting potential innovation for emerging demands.

2 MATERIAL & METHODS

In May 2024, research was conducted using the Scopus and Web of Science databases, employing the keywords "nanomaterials", "bioactive glasses", "agriculture", and "biomedical". Was evaluated the number of documents per year, subject area, and document types, from 2014 to the present. Articles identified through these searches were critically evaluated and discussed within this review.

3 RESULTS & DISCUSSION

The border of nanotechnology with biotechnology can represent a great boost for the new perspective of agriculture along with other areas, pharmaceutical and biomedical, offering potential applications [9,10]. Bioactive glasses (BG) are versatile materials that can be used alone, in composites with polymeric matrices, or as coatings for metallic materials, commonly applied to tissue engineering. They can be manufactured in different formats, such as scaffolds, fibers, or nanoparticles [3]. The identification of indicators of the potential benefits of biosurfactants from the synthesis of bioactive glass nanoparticles was based on a robust literature survey, as illustrated in Figure 1.

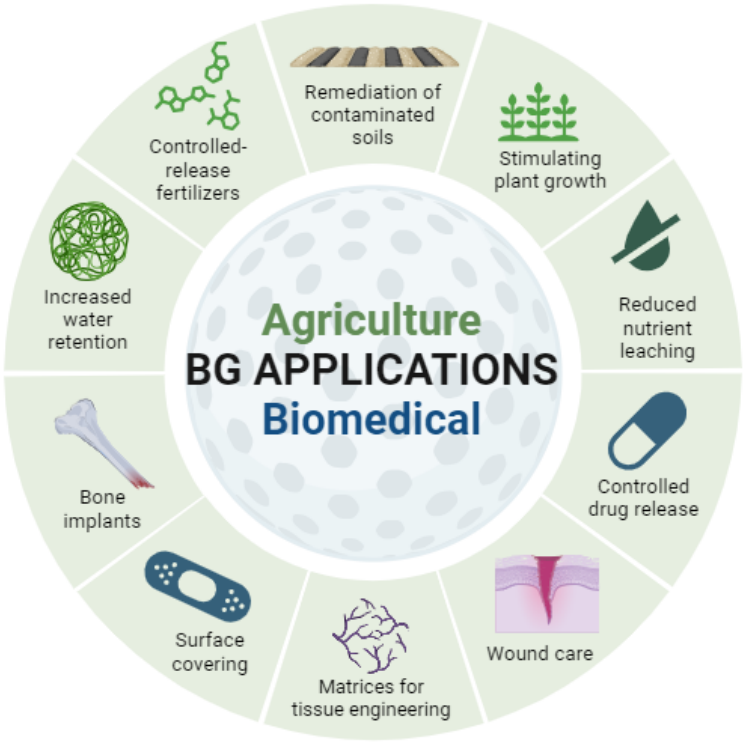

Figure 1 Frontier of BG applications in agriculture and biomedical areas

The advantages of applying biosurfactants in the synthesis of BG nanoparticles are the efficiency in reducing the surface tension of solutions at lower concentrations, thermal resistance, and pH stability, chemical resistance to high salt concentrations, and its main characteristic: biodegradability in water and soil, which can be metabolized by microorganisms to produce energy, being less likely to cause problems for humans. To improve the feasibility of applying BG nanoparticles containing biosurfactant, economic and environmental parameters can be investigated in the synthesis process, such as total or partial replacement of organic molecules, including models [11]; Specific reagents, namely toxic and/or non-commercially viable compounds; *in situ* testing and development of expansion strategies (technological implementation) [12].

4 CONCLUSION AND FUTURE TRENDS

Biosurfactants are environmentally friendly compounds with low critical micelles concentration (1–200 mg/L) and low surface tensions (25–38 mN/m). These self-aggregation structures can be applied to induce microporous and mesoporous phases. In general, in the biomedical field, BG can be used in developing advanced dressings for treating wounds. The presence of biosurfactants can help promote wound healing, reduce inflammation, and prevent infections, thus improving the effectiveness of dressings. Furthermore, BG can be functionalized with biosurfactants to create controlled drug release systems. For agricultural applications, adding biosurfactants to BG can improve its wetting capacity, which is important to ensure the even distribution of water and nutrients in the soil. Some biosurfactants have been reported to promote plant growth, possibly through mechanisms such as improving nutrient absorption or positive interaction with beneficial soil microorganisms. Therefore, the frontier of the integration of nanotechnology with biotechnology presents great potential to expand the application possibilities of glass nanoparticles, as well as make resources more productive, sustainable, and economically viable.

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