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Editorial: Biosynthesis of bio-inspired nanoparticles/nanomaterials and evaluation of their therapeutic potential in the medical field

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Editorial on the Research Topic
Biosynthesis of bio-inspired nanoparticles/nanomaterials and evaluation of their therapeutic potential in the medical field

Recent advancement in nanoscience and nanotechnology has given us scope for developing biomimetic and biocompatible nanoparticles/nanomaterials using natural products. Nanoparticles/nanomaterials exhibit remarkable physicochemical and biological properties, which are entirely distinct from their bulk materials, making them ideal candidates for biological applications. The plant, microorganisms, and biopolymers-based nanoparticles/nanomaterials are highly advantageous compared to those involving chemical reductants. The biological synthesis method uses eco-friendly solvents and non-toxic chemicals and thereby helps in minimizing the release of hazardous wastes to the environment. In recent years, widespread microbial infections and mosquito-borne parasitic diseases have been a major threat to humans. In addition, dreadful diseases like cancer have become more common and bring massive mortality to human populations. Many of the currently available growth inhibitory agents and chemotherapeutics are too expensive, cause drug resistance, and have numerous side effects. In this scenario, developing novel therapeutic agents that are cost-effective, safe, and without any side effects is of utmost importance. The development of biological nanoparticles/nanomaterials either from plants, microorganisms, or biopolymers is the need of the hour. Most of the newly developed bionanoparticles/bionanomaterials are promising and have significantly contributed to preventing ailments.

This Research Topic, "*Biosynthesis of bio-inspired nanoparticles/nanomaterials and evaluation of their therapeutic potential in the medical field*", aimed to include the synthesis, physicochemical characterization, *in vitro* and *in vivo* evaluation of the antimicrobial, anti-biofilm, anti-quorum sensing, antiviral, anti-infective, and anti-cancer properties of bionanoparticles/bionanomaterials, as well as their application in the treatment and diagnosis of diseases.

Nanoparticles have interesting biomedical properties, but their long-term toxicity is of concern. In this way, the manufacture of nanoparticles began to manipulate their surface by coating them with biogenic agents and thus making them non-toxic, functionalized, monodisperse, and more stable. In addition, these capping agents alter the biological activity and surface chemistry of nanoparticles. Therefore, due to the importance of capping, Sidhu et al. reviewed and compiled biological capping agents used in the synthesis of metallic nanoparticles along with their biomedical applications. This inventive review showed the several biogenic capping agents that are being studied, such as biomolecules and biological extracts from plants and microorganisms, and their effect on the efficiency of nanoparticles in different therapeutic applications. These authors also discussed challenges and future directions in using biological capping agents for the green synthesis of important metallic nanoparticles.

Another strategy used to reduce the toxicity of silver nanoparticles without losing their antimicrobial activity is their incorporation into a polymeric matrix. For this, Artunduaga Bonilla et al. carried out the green synthesis of silver nanoparticles and their functionalization with chitosan, as well as evaluated their antifungal activity against the main species that cause sporotrichosis, *Sporothrix brasiliensis* and *Sporothrix schenckii*. These nanoparticles showed continuous release of silver by chitosan over time and showed *in vitro* antifungal activity, but without synergistic effects with itraconazole or amphotericin B. Chitosan-functionalized silver nanoparticles caused changes in *S. brasiliensis* cells, and its daily topical use was able to reduce *Sporothrix* infection and stimulate tissue repair in a murine model of subcutaneous sporotrichosis. Thus, silver nanoparticles functionalized with chitosan can be a non-toxic and efficient alternative for treating sporotrichosis.

Another point of concern in relation to nanoparticles is the conventional physical-chemical methods used for their synthesis, which can be limited and expensive, and the by-products of the reaction are potentially toxic for both human health and the environment. Thus, the biomediated synthesis of nanoparticles by microorganisms emerged as an alternative method, as it offers economic and environmental benefits. Endophytic bacteria and fungi have several metabolic pathways that give them adaptive advantages, the ability to produce bioactive compounds, provide resistance and tolerance to metals. Therefore, these microorganisms have the potential for use in the biogenic synthesis of metal-based nanoparticles with different characteristics and biological activities for biomedical applications, such as antimicrobial, antitumor, antioxidant, and anti-inflammatory. Thus, Bogas et al. highlighted the potential use of endophytic bacteria and fungi isolated from native plants or plants adapted to tropical ecosystems and tropical macroalgae as nano factories for the synthesis of nanoparticles of silver, gold, copper, iron, zinc, and other studied metals, in addition to showing its potential use in human health.

Bionanoparticles have advantages over nanoparticles when evaluated on the coronavirus and the disease caused by it. Coronavirus is the name given to an extensive family of viruses that resemble each other, including the so-called SARS-CoVs. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is a contagious virus that, when it infects humans, causes a disease called COVID-19. Due to these issues, this virus spread rapidly worldwide, leading to a pandemic from 11 March 2020, with a high death rate. In view of this, researchers sought to develop drugs and vaccines for SARS-CoV-2 and also for COVID-19. One of the approaches followed was the use of functionalized biocompatible nanoparticulate systems with antiviral activity, where the nanocarriers were designed to design and deliver drugs and vaccines through biomaterials or bionanoparticles. Given this information, Debnath and Srivastava performed a review comparing SARS infections and their etiologic agents, as well as nanoparticles, bionanoparticles, and bioinspired nanomaterials studied for the treatment of SARS-CoV-2 and COVID-19. These authors found that some nanoparticles were recognized by biological systems as foreign particles and antigens, presenting several problems. However, some bionanoparticles, despite having disadvantages, have potential applications against SARS-CoV-2. Another point worth mentioning is the need to effectively deliver these bionanoparticles to different locations.

Nanostructures such as nanoparticles, nanofibers, and nanocomposites are used in the biomedical field, but when obtained by bionanomaterials, they have advantages. Elastin-like polypeptides are tropoelastin-derived biopolymers and exhibit interesting physicochemical characteristics at different temperatures, making them targets for designing different bionanomaterials. These can be obtained by heterologous expression in bacteria, fungi, and plants, as well as the bionanostructures synthesized from them, which have several advantages and, therefore, can be used in several applications, such as drug delivery systems, treatments for type 2 diabetes, cardiovascular disease, tissue repair, and cancer therapy. Given this, Lima et al. reviewed the major advances in elastin-based bionanomaterials, their possible forms of expression, and their importance for the field of biomedicine.

The derivatives of bisnaphthalimidopropyl (BNIP), BNIPDaoct and BNIPDanon, have antileishmanial activity but present toxicity, low aqueous solubility, and low bioavailability. To overcome these problems, Islek et al. synthesized emulsomes loaded with BNIPDaoct and BNIPDanon as lipid-based nanocarrier systems for treating *Leishmania infantum*. These authors show that the formulations were dispersed in water and achieved encapsulation of BNIPDaoct and BNIPDanon at approximately 0.31 and 0.24 mg/mL, respectively. Furthermore, delivery of these BNIP derivatives in emulsomes improved their antileishmanial activity, increased their selectivity for *L. infantum* promastigotes, and showed their macrophage toxicity compared to their free form. Thus, the promising *in vitro* antileishmanial efficacy of BNIP-loaded emulsomes highlights the potential of these systems for future *in vivo* studies.

Nanotherapeutics alter, through the properties of nanomaterials, the pharmacokinetics of drugs and therapies being transported; that is, they change their absorption, distribution, cell uptake, metabolism, and elimination. These changes may be a way to optimize pharmacokinetics in older individuals, as they may have changes in many pharmacokinetic processes that tend to impair drug efficacy and increase the risk of toxicity. In this way, Hunt et al. carried out a review to provide an overview of the broad changes in drug absorption, distribution,

cellular uptake, metabolism, action, and removal facilitated by nanomaterials and how these systems are affected by aging. These authors identified areas of overlap and advantages of nanotherapeutics in aging but also noted that toxicity should be considered along with further studies on the release and long-term safety of nanomaterials.

In summary, nanoparticles/nanomaterials have interesting biomedical properties but have disadvantages such as long-term toxicity, synthesis methods can be limited, expensive, and generate toxic by-products, and biological systems can recognize them as foreign particles and antigens causing various problems. Thus, bioinspired nanoparticles/nanomaterials emerge to circumvent these problems, and some strategies are biological capping, functionalization with polymeric matrix, and biomediated synthesis. Furthermore, these strategies can improve the physicochemical and pharmacokinetic properties of bionanoparticles/bionanomaterials and drugs and therapies transported by these bionanostructures. Therefore, bionanoparticles/bionanomaterials are being studied for antifungal, antiviral, antileishmania, and other inhibitory activities, but also in disease treatment and drug pharmacokinetics.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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