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Letter to Editor

Nanobiotechnology: A promising scope of gold biotechnology

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Biotechnology defines as the "*application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods and services*", according to the Organization for Economic Cooperation and Development (OECD) (1). Remarkably, this definition covers various fields of science that could be associated to biotechnology. Consequently, it seems logical to classify the scope of research in biotechnology. However, there are some classifications of biotechnology, most notably associated with the one using color codes is most beneficial. In the year 2004, DaSilva proposed a rainbow consists of ten colors including red, yellow, blue, green, brown, dark, purple, white, gold and grey associating to different fields of biotechnology with being reduced the complexity inherent to all independent scientific-technological aspects related to biotechnology (2, 3). Drawing on this classification, one of the interesting scope of research in biotechnology, therefore, is gold biotechnology refers to nanobiotechnological field of studies (2, 3). By and large, nanobiotechnology has emerged as an intersection of nanotechnology and biotechnology in which tools from nanotechnology are developed and applied to study biological phenomena including nanodevices, nanoparticles (NPs), or other nanostructures possessing at least one dimension sized from 1 to 100 nanometers (4, 5), leading to various commercial and biomedical applications in many fields, such as electronics, catalysis, agriculture and biomedicine, etc, owing to their unique chemical, physical, electrical and magnetic properties (6-8).

Nanobiotechnology provides a promising chance to develop new materials and methods that could enhance our fundamental understanding of the interactions of nanomaterials with intracellular structures, the process, and the environment (9). Interestingly, developing NPs for pharmaceutical and biological applications is an important objective in nanobiotechnology (10-12). The majority of available research in this line has been focused on biofabrication of NPs by employing natural resources as greener and more environmentally-friendly processes in comparison to classical physico-chemical routes for NPs fabrication, owing to preventing from applying potentially toxic solvents and reagents, avoiding by-products and minimizing energy requirement (13). The extent to which natural resources can play a role in biosynthesis of NPs continues to be an issue of interest to researchers. There is considerable empirical support for this claim that many natural biomolecules, bacteria, yeast, fungi, plants, algae, photosynthetic organisms, and marine organisms could biofabricate different NPs (6). Additionally, the process of biofabrication may be catalyzed by enzymes inside the cells or on the cell surface (14, 15). Moreover, the mechanism of extracellular microbial mediated biofabrication of metallic NPs is basically due to microbial nitrate reductase responsible for reduction of metal ions into metallic NPs (16, 17). Product harvesting and recovery are exceedingly cumbersome and expensive in intracellular biosynthesis of NPs. In the contrary, extracellularly produced NPs are stabilized by the proteins as well as the reducing agents secreted by the fungus representing an advantage over intracellular process (18, 19). Interestingly, phytochemicals including proteins, flavonoids, polyphenols, alkaloids, saponins, phenols, essential oils and polyols which are present in plants extract lead to bio-reduce the metal ions converting them to metallic NPs and also capping of the phytosynthesized NPs for stabilization (20). These metallic NPs, can bind to single stranded DNA non-destructively opening up potential opportunities for medical therapeutic and diagnostic applications. Besides, hybrid polymer/protein conjugation with NPs can be produced to increase the delivery of intact DNA to cell nuclei which in turn will enhance gene expression (18). Remarkably, the strategy of utilization of enzymes secreted by the microorganisms for biofabrication of NPs opens up a rational, simple process, eco-friendly microbial enzymes based large scale bioprocess for nanoparticle synthesis (18, 20).

However, many questions remain which need to be addressed. Various reducing agents involve in the biological reduction of metal ions and converting them to nanoforms. These reducing agents may have an influence on the shape, size, and efficacy of nanomaterials (20). Consequently, there is a highly significant need to investigate the exact mechanism and the role of reducing agents involved in the biofabrication of nanomaterials for more customized fabrication and high yield. Besides, the comprehensive acute, and chronic toxicity should be explored to identify the hazards associated with the use of nanomaterials (21). The biocompatibility issues and immune response of green prepared nanomaterials should be carefully investigated in animal models as well as their pharmacokinetics and pharmacodynamics profile to reach to drug level via approval from FDA through preclinical and clinical trials.

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