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Nano Materials: Emerging Trend in Microbiology

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Letter

During 2016–2022 the particles referred to as Nano materials market is anticipated to grow with a compound annual rate of about 20% or more. one of the key challenges for the worldwide advancement of nanomaterial's market is that the environmental sustainability of Nano manufacturing processes. Indeed, traditional top-down or bottom-up chemical and physical Nano manufacturing approaches have a greater energy-intensity compared to manufacturing processes of bulk materials. Further, they're often characterized by low process yields (using acidic/basic chemicals and organic solvents), generation of greenhouse gases, which they require specific facilities, operative conditions (e.g., from moderate to high vacuum), and high purity levels of starting materials. The principles processes to chop back or to eliminate the use and generation of hazardous substances") combined with white biotechnology ("biotechnology that uses living cells—yeasts, molds, bacteria, plants, and enzymes to synthesize products at industrial scale") can really contribute to the event of more sustainable industrial proccesses, also for nanomanufacturing. The microbial-mediated biosynthesis of nanomaterials could also be a promising biotechnological-based nanomanufacturing process that represents a 'green' alternative approach to physical and chemical strategies of nanosynthesis. The microbial-mediated biosynthesis of metallic (also as alloys), non-metallic, or metal oxides nanoparticles are reported for several microbial strains of bacteria, yeast, molds, and microalgae.

Some microorganisms have shown the potential to biosynthesize unique nanostructured materials, i.e., biomineralized nanostructures like silicified frustules, calcified coccoliths, magnetosomes, and organic nanomaterials like bacterial nanocellulose exopolysaccharide nanoparticles and bacterial nanowires. The microbial-mediated biosynthesis of nanomaterials has been extensively explored showing different advantages and features including the following: (i) synthetized nanomaterials have defined chemical composition, size and morphology, (ii) biosynthesis is performed at mild physico-chemical conditions, (iii) easily handling and cultivation of microbial cells and possibility of cell culture scale-up, (iv) possibility of in vivo tuning nanomaterial characteristics by changing key parameters of cell culture operational acknowledged or through genetically engineering tools. so on enable a broad applicability of microbial-mediated biosynthesis of nanomaterials as a real alternative to 'traditional' synthetic approaches to nanomanufacturing, many hurdles still need to be overcome: a reduction of polidispersity of nanoparticles, a more complete characterization of biocapping layer agents, effectiveness of removal procedures of bio capping layer and nanomaterial purifications, also as procedures of bio capping layer and nanomaterial purifications, standardization of microbial cell culture protocols for reproducibility of Nano synthesis processes, also as production costs and yields. Overreaching the challenge for the event of reliable ecofriendly nanotechnologies for nanomaterial synthesis is of utmost importance for future exploitations of broad-impact nanostructured-based technologies and applications, like innovative optical and electrochemical (bio) sensoristic devices and therapeutic and diagnostic applications of nanostructured materials e.g., for drug delivery, in vivo/in vitro imaging and development of antimicrobial and anti-tumoral drugs.

Despite all the advantages , microbial nanotechnology still has very limited uses. Bacteria have showed the facility to synthetize nanomaterials either by extracellular or intracellular mechanisms. These mechanisms generally produce opposite advantages and disvantages in terms of metal nanoparticles dispersity and purification. Extracellular produced nanoparticles are generally more polydispersed (i.e., with a superb variability in size) than intracellularly produced nanoparticles. against this, in extracellular nanomaterial productions less downstream extraction/purification steps (e.g., ultrasound treatment and detergent uses) are required. Thus, the extracellular mediated synthesis described for yeast and molds can greatly simplify the purification steps, besides being a plus for a possible reuse of microorganisms for more biosynthesis cycles. The characterization and identification of the enzymes responsible for Nano biosynthesis in molds remains incomplete. The photoautotrophic metabolism of microalgae and cyanobacteria is based on CO_2 (as carbon source), light (as energy source), inorganic nutrients and water. This condition generally reduce the costs of culture media (compared to culture media used for the expansion of bacteria, yeasts, and molds) and it can strongly spur the long run scaling-up from the laboratory to the economic scale, also through the design and thus the event of solar photo bioreactors for the fixation (and reduction) of atmospheric CO_2 .

One of the foremost challenges in microbial Nano biosynthesis is that the control of disparity of nanostructure materials, which heavily influence electronic and optical properties, and thus the isolation and purification of plural. Disparity, i.e., the size distribution of the nanoparticle population, could also be a key property that strongly influences the particle's behavior in fluids. Improvement and optimization of extraction and purification protocols are required, both for intracellular and extracellular biosynthesis: methods like freeze-thawing, osmotic shock and centrifugation could lead on on to changes in nanoparticle structures also as aggregation and precipitation phenomena. Through the adoption of suitable strategies, microbial biosynthesis of nanoparticles could be improved. Selection of appropriate microbial strains (in terms of rate of growth and biocatalytic activities), optimization of culturing conditions and uses of gene-splicing tools could help to beat drawbacks linked to slower producing rate and polidispersity (compared to chemical-based nanomanufacturing) Microbial biosynthetic nanoparticles are characterized by the presence of a capping layer of biomolecules adsorbed on the surface that act as stabilizing agent and biological active layer of nanoparticles. A deep knowledge of capping characteristics, a transparent identification of capping agents (mainly peptides like glutathione, metallothioneins, membrane associated proteins etc.), and possible purification of nanoparticles are fundamental for future in vivo medical applications.

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