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Review Article

Marine microbes: Invisible nanofactories

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ABSTRACT

Biological synthesis of nanoparticles has emerged as rapidly developing research area in nanotechnology across the globe with various biological entities being employed in production of nanoparticles constantly forming an impute alternative for conventional methods. Simple prokaryotes to complex eukaryotic organisms including higher plants are used for the fabrication of nanoparticles. One area of untapped potential is marine microorganism as nanofactories to fabricate nanoparticles. Marine microorganisms are known to interact with metal ions as marine ecosystems are constantly exposed to high metal salt concentration. These microorganisms may reduce the metallic ions rapidly for the formation of nanoparticles of desired shape and controlled size. The present review unearths marine microbial flora in synthesis of nanoparticles.

1. Introduction

Nanotechnology can be defined as the design, synthesis, and application of materials and devices whose size and shape have been engineered at the nanoscale.[1] It exploits unique chemical, physical, electrical, and mechanical properties that emerge when matter is structured at the nanoscale. One of the most important aspects in nanotechnology relies on the synthesis of nanoparticles with well-defined sizes, shapes and controlled monodispersity. One of the major challenges of current nanotechnology is to develop reliable and non-toxic experimental protocols for the synthesis of nanoparticles with regards to non-toxic, clean and eco-friendly.[2] Biotechnological route has emerged as a safe and alternative process in synthesis of nanoparticles by employing ambient biological resources. Perusal of studies reported by far express biological synthesis of nanoparticles from simple prokaryotic organism to multi cellular eukaryotes such as fungi and plants.[3–6] The adaptation to heavy metal rich environments is resulting in microorganisms which express activities such as biosorption, bioprecipitation, extracellular sequestration, transport mechanisms, and chelation. Such resistance mechanism forms the basis for the use of microorganisms in production of nanoparticles. The strongly interdisciplinary field of microbiology and nanotechnology has upsurge nanoparticles synthesis spanning from the microorganism which holds much promise for applications of nanoparticles related to medical and pharmaceutical sciences.[7] Microorganism isolated from array of habitats have expressed immense potential in production of nanoparticles one such habitat is marine. Marine microorganisms are known to thrive in unique niches such as tolerate high salt concentration, extreme atmospheric pressure etc. These microbes are known to have been explored with interest as source of novel bioactive factories

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synthesizing various functional metabolites displaying unique properties. However, these marine microbes are not sufficiently explored with regards to synthesis of nanoparticles few reports cited expressed the burgeoning interest among the researchers in exploiting the mechanisms of marine microbes for nanoparticle synthesis. As marine resource is one of the richest sources in the nature, marine microorganisms employed in production of nanoparticles are in infancy stage. Therefore, a possibility of exploring marine microbes as nanofactories forms a rational and reliable route in production of nanoparticles compared to the most popular conventional methods which are bound with limitations such as expensive, use of toxic elements in production protocols resulting limited applications in pharmaceutical and health sector. The present review envisions the role of marine microbes as emerging resource in synthesis of nanoparticles. The study also display so far reported marine microbial diversity in synthesis of nanoparticles, further research in this area will be promising enough to engulf the limitation of conventional methods forming a new avenue for rapid synthesis of nanoparticles with technical dimension.

2. Nanoparticles

Nanoparticles are particles with at least one dimension at nanoscale. Nanoparticles exist widely in the natural world as product of natural phenomena such as photochemical volcanic activity, ocean spray, forest-fire smoke, clouds and clay combustion and food cooking, and more recently from vehicle exhausts.[3] Owing to their unique properties nanoparticles are known to have wide range of applications the potential of nanoparticles is infinite with novel new applications constantly being explored.[4]

2.1. Synthesis of nanoparticles

Nanoparticles are synthesis by array of conventional methods which are divided into top down and bottom up processes (Fig. 1). In top down process the synthesis of nanoparticles from the bulk material is carried out by various lithographic techniques. In bottom up process is based on miniaturization at molecular level forming the nuclei and their growth into nanoparticles. These conventional methods are very popular and widely employed in synthesis of nanoparticles but are bounded with their own limitations such as expensive, use of high energy and use of hazardous toxic chemicals. Hence there is a burgeoning interest in eco-friendly process of nanoparticles production with precise control of size and desired shape.[5–8]

2.2. Biosynthesis of nanoparticles

Biosynthesis of nanoparticles is a type of bottom up process in which biological entities are employed in synthesis of nanoparticles with large number of plants and microorganism reporting in facile synthesis of nanoparticles. Use of plants has been reported to produce nanoparticles of variable size and shape.[9] But harvesting of endangered plant species can pose a risk and imbalance in the plant diversity hence research on microorganisms as ideal source in synthesis of nanoparticles has rapidly expanded with microorganism being isolated from various habitats and challenged with metal salts toward the unearthing nanoparticles production and this route has gained success with large species reporting

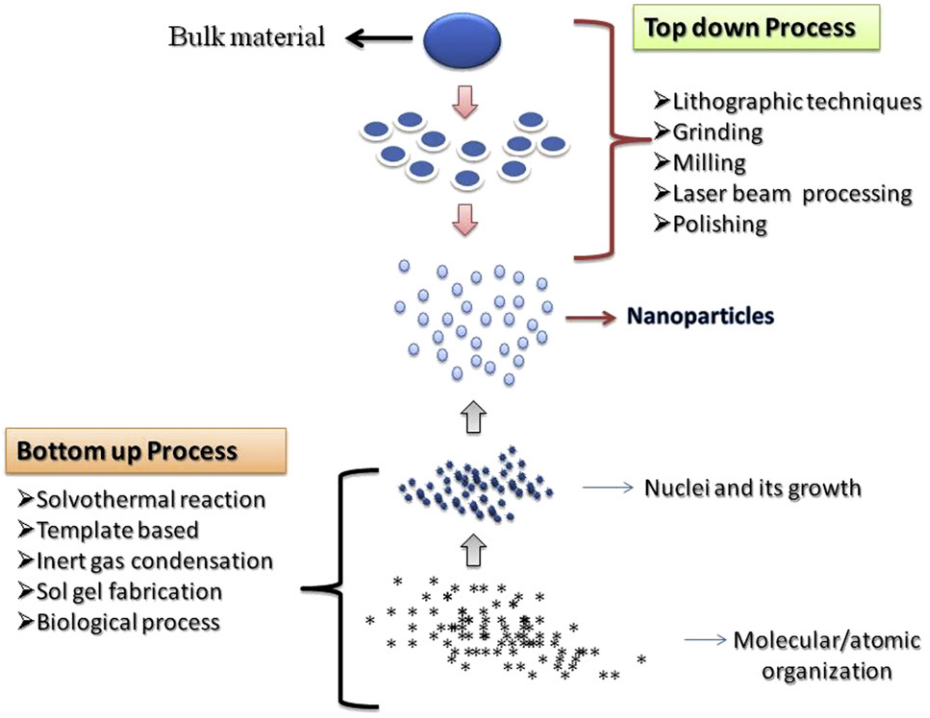

Fig. 1 – Synthesis of nanoparticles.