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Special Column on Microbial Nanotechnology
Editorial

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The early beginnings of Nanotechnology started at an event of the American Physical Society in 1959 when Richard Feynman presented his lecture with a talk, '*There's plenty of room at the bottom*' followed by the invention of Scanning Tunneling microscope and the publication of K. Eric Drexler's *Engines of Creation: The coming era of Nanotechnology*, which led to the key developments in Nanotechnology since the latter years of the 21st century. The term *Nanotechnology* was first coined by Norio Taniguchi in 1974 to describe semiconductor processes in nanoscale at the Tokyo University of Science. Following years were a tremendous period of intensive research in Nanotechnology which extended from physical sciences to chemistry, materials science, engineering, biology and medicine and adoption of Interdisciplinary research themes. Carbon nanotubes was the hallmark discovery in 1991 at NEC Corporation in Japan, sparking widespread research in Nanomaterials and Nanosciences across the globe. A commercially available technology that used silver nanoparticles for domestic appliances as an antibacterial agent was the remarkable application of Samsung's 'Silver Nano' introduced in April 2003. Nanomaterials are of the order of 1-100 nm in one or more dimensions with size and shape-dependent properties endowing them with desirable characteristics than at their macroscopic levels. These characteristics enable functional nanomaterials suitable for a wide range of applications in dentistry, pharmaceutics, drug delivery, tissue regeneration, environment, clinical, bioimaging, agriculture, electronics, optics, chemical, metallurgy and manufacturing processes.

Nanomaterials may be synthesized by physical and chemical methods as well as by biological means. Physical methods consume high energy and costs while chemical synthesis involves toxic compounds and could produce unstable products. Biological methods produce nanoparticles using microorganisms and plant extracts and are a 'green' approach. Biosynthesis of nanoparticles by microorganisms and their commercial applications are referred as *Microbial Nanotechnology*. Several microorganisms such as bacteria, fungi, yeast, actinomycetes and algal sp. have the ability to synthesize metal and metallic compound nanoparticles during their culture growth, Nanoparticles may be produced intracellularly within the cellular compartment or extracellularly when secreted into the culture medium. Nanoparticles produced by both means have inherent advantages of size properties and have been used for a wide variety of industrial and medical applications.

Microbial Nanotechnology is an emerging science since the past two decades and still receives current attention to employ new isolates or microbes for the production of different types of nanoparticles for utilization in commercial industries with new and improved properties. By changing the cultural environment by adjusting the physico-chemical, environmental and cultural parameters, nanoparticles with unique characteristics may be obtained. This is a 'green' approach as conventional methods have to use harsh conditions to manipulate the size and shape of nanoparticles for desirable properties. Metals and metallic nanoparticles have been widely studied and antimicrobial applications of nanoparticles are of renewed interests. Bimetallic nanoparticles have been increasingly studied in recent years due to synergistic activities of both metal sp. which contribute to remarkable biological characteristics. Many different kinds of

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metallic nanoparticles have been synthesized by microbes such as Ag, Au, ZnS, CdS, U, Pd, Te, Pt, Zn, FeS, $PbCO_3$ etc. with profound applications in various industrial sectors.

Antimicrobial actions of nanoparticles have been investigated worldwide for forefront applications in medical and pharmaceutical industries. Though this sounds to be a simple approach, this is by and large required for treatment of infectious diseases, in dentistry, medical equipments of noncritical uses, orthopaedic implants, antimicrobial textiles and food packaging to control microbial growth. Antimicrobial nanoparticles should be antibacterial, antifungal and/ or antiviral. Antibacterial nanoparticles should further show broad spectrum activity towards different Gram-positive and Gram-negative bacterial sp. It has been understood that antimicrobial activity is due to reactive oxygen species causing oxidative damage. Several other researches have indicated redox potential imbalance, DNA damage, enzyme inactivation, disruption in proton motive force, ribosomal disassembly as other mechanisms of antimicrobial actions of nanoparticles.

An ideal nanoparticle should possess desirable size, shape and crystallinity properties which can be determined by a range of spectroscopic, microscopic and physico-chemical techniques. Application of these techniques to determine the nanoparticle properties is called as characterization of the nanoparticles. Each technique has its own advantages and disadvantages. Therefore, a combinatorial characterization is required for assessing nanoparticles in order to define their suitability for different kinds of applications. There is no protocol as to which technique is to be employed and any combination of techniques can be used for characterization. Dynamic light scattering, uv-visible spectroscopy, FT-IR or ATR-FTIR spectroscopy, X-ray diffraction and X-ray photoelectron spectroscopy, Scanning electron microscopy, with coupled Energy Dispersive X-ray Analyser. Transmission electron microscopy, Differential scanning calorimetry and thermogravimetry are the most widely used characterization techniques. A recent technique has been the atomic force microscopy which has replaced TEM for assessing nanoparticle size and provides two- and three-dimensional analysis of the nanoparticles. It is very important that any nanoparticle synthesized by biological or other approaches should be characterized suitably in order to evaluate its properties for any application.

An important consideration of using metallic nanoparticles is their toxicity to humans and the environment. Human health issues need safety regulations for nanoparticles used for inhalation, skin penetration and ingestion. Disposal of nanoparticles in soils, water and atmosphere can cause serious environmental concerns. Research in Microbial Nanotechnology, though not new, requires much attention for want of biological synthesis and promising industrial applications which are in arising demand for benefit of mankind.