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NANOMATERIAL SYNTHESIS AND CHARACTERIZATION

Aishwarya M[1], Yazhini P[1], Daril Deehen A[1] , Suresh E[2] and Kathirvelpandian A*[2]

[1]B.Tech(Biotechnology) Student, Institute of Fisheries Biotechnology, IFPGS Campus, TamilNadu Dr.J.Jayalalitha Fisheries University, OMR Campus, Vaniyanchavadi, Chennai-603 103, TamilNadu, India
[2]Institute of Fisheries Postgraduate Studies, TamilNadu Dr.J.Jayalalitha Fisheries University, OMR Campus, Vaniyanchavadi, Chennai-603 103, TamilNadu, India

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Abstract: *Nanotechnology is fastest and developing science streams, which possess many applications in disease diagnosis, therapeutics, imaging, etc., in medical field and new revolution in the industry sector by producing Nano-wires, Solar cells, efficient bio-fuels and it could enable things to harvest energy from their environment. Food production will be immensely contributed by nanotechnology in future by producing nano composite films from proteins. The technology will help us to make our life easy with simple technological improvements. The nanomaterials could be synthesized through bottom –up and Top-down approaches. Further, synthesis is classified into physical, chemical and biological methods.*

Keywords: **Nanomaterial, Synthesis, Characterization, Plant extracts**

INTRODUCTION

Nanotechnology is a branch of engineering that deals with the things smaller than 100 nanometres. A ten times the diameter of a hydrogen atom is one billionth of a metre is a nanometre. The concept of nanotechnology is applicable in ordinary rules of physics, chemistry and biological field of research. The study of the controlling of matter on an atomic and molecular scale is involved with nanotechnology. The study and application of extremely small things which can be used across all the other science field such as chemistry, biology, physics, science materials and engineering. The National Nanotechnology Initiative definition can be distilled in three concepts such as Nanotechnology particles are very small, at the nanoscale, materials may behave in different and unexpected ways and researchers intend to harness this different and unexpected behaviorto make new technologies useful for the community. The details about nanotechnology, metals involved, synthesis and characteristics and its application in various sectors along with toxicity and efficacy assays of nanoparticles are discussed

Nanomaterials: Ultrafine particles or nanoparticles is a particle of matter which is between 1 and 100 nanometres in diameter. The material with any external dimension, internal or surface structure in the nanoscale is defined as nanomaterial. The European commission definition of a nanomaterial is incidental, natured, or manufactured material containing particles, as an aggregate or as an unbound state for 50% or more numbers of particles in its size distribution, as one or more external dimensions is in the size range as 1nm -100nm. These nano-sized particles can be created from a variety of products which exists in nature such as carbon, or minerals like silver but by its definition as nanomaterial, it must hasat least one dimension which is less than 100 nanometers.

METALS USED IN NANOTECHNOLOGY

Some of the transition metals are used in the nanotechnology such as gold, platinum, nickel, cobalt, iron, cadmium.

The nanoparticles of gold is been widely used in medical research, cancer treatment, diagnostic testing as a popular choice. The drug delivery is improved by the use of gold nanoparticles. Gold nanoparticles with phthalocyanine dye, used to locate the cancer cells in human for targeted treatment. Nanotube structures are incorporated within the platinum metals. These platinum nanoparticlesare useful as catalytic, electronic, luminescent and magnetic functionalities to nanotubes structures. Usage of nanoparticles platinum indeed reduces the amount of platinum needed. Nickel nanocrystals possess numerous catalytic functions such as conductive electrolytic layer of PEM (proton exchange membrane) fuel cells or the anode of Solid Oxide Fuel Cells (SOFC) in replacing the platinum

NANOPARTICLE SYNTHESIS

Synthesizing nanoparticles is done through physical, chemical and biological methods *(Arun et al.**2013**).* Nanoparticles can be obtained from larger molecules by using bottom-up method, top-down methods.

Bottom-up methods

It is the method of material synthesis from atomic level, this approach refers to the build-up of a material from the bottom like atom-by-atom, molecule-by-molecule. This type is used more often for preparing of the nano materials to obtain a uniform size, shape and distribution. The method plays an important role in the fabrication and processing of nanostructure and nanomaterials. It is effectively used in chemical synthesis method of synthesis.

Top-down methods

It is the method of reduction of the size of bulk materials and is a typical method of solid-state processing of the materials (e.g. mechanical force, laser are used). "Ball milling" is a popular method involves mechanical break apart larger materials into nanomaterial. But in top-down method some imperfection in nanomaterial synthesis will occur and may cause significant crystallographic damage to the processed patterns.

Physical method

The physical method is classified into two categories as mechanical and vapour methods. The method involves in the Top-down method which includes the mechanical pressure involves in synthesing nanomaterial from bulk materials. Metal nanoparticles are synthesized by evaporation-condensation, which may be done by using a tube furnace at atmospheric pressure. In bottom-up method, the Inert Gas Condensation (IGC) approach is used to synthesis nanostructured particles, which consists two basic steps. First step is the evaporation of the material to produce the nanomaterial and second step involves a rapid controlled condensation to produce the material. Like IGC, there are many other methods such as electrical arc discharge, RF plasma method, pulsed laser method are being used

Chemical method

In synthesis of nanomaterials using chemical method is approaching through collids, sol-gel, L-B film. The chemical synthesis is valuable because of its low time consumption for synthesis of large quantity of nanoparticles. Nanoparticles have been synthesized using three chemical techniques such as dispersion of performed polymers, polymerization of monomers and ionic gelation of hydrophilic polymers.

Biological method

Biological synthesis of nanomaterial is simple method and rapid synthesis, limited level of toxicity, nature friendly etc. They are variety of natural resources is for biological synthesis of nanoparticles, together with plant extracts, bacteria, fungi etc., This bio-synthesis falls under the bottom-up approach, the green synthesis cleaved into two parts *i.e* extracting nanomaterial from plants and microorganisms. The bio-nanomaterial is used in drug delivery, regenerative medicine etc., Synthesis of nanomaterial from plant extract is done by adding natural reducing agent in metal solution for recovering the nanomaterial.

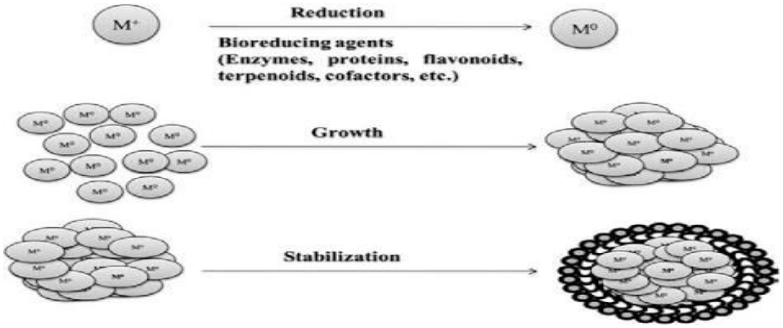

Fig -1: Biosurfactant mediated biosynthesis of selected metallic nanoparticles.https://www.mdpi.com

SYNTHESIS THROUGH PLANT EXTRACTS

The synthesis of nanomaterial is a single step biosynthesis process which makes the work much easier than other two methods of synthesis. Plant extracts are easily obtainable, toxicants free, and natural capping agents are readily supplied by plant extracts.

The production of silver, gold, platinum, nickel, iron nanoparticles are through extraction of particular plant resources by bioreduction process. The extract is simply mixed with a solution of the metal salt at a room temperature, the reaction will be get over in few minutes. Plants such as *Azadirachta indica[Shankar et al.(2004)], Aloe vera[Chandran et al.(2006)],Camellia sinensis[*Vilchis-Nestor et al.(2008)*], Catharanthus roseus[*Kannan et al. (2011)]*Lemongrass (Cymbopogon sp.,)[*Shankar et al. (2005)]*Cinnamomum camphora [*Huang et al.(2007)],*Datura metal [*Kesharwani et al.(2009)]*Geranium leaf* [Shankar et al.(2003)]are used in the biosynthesis. The nature of plant extract, concentration, concentration of the metal salt, pH, temperature and contact time are known to affect the rate of synthesis of the nanomaterials.

Gold and Silver particle synthesis:

The Gold nanoparticles of size 5-100 nm are synthesised using buds of *Syzygium aromaticum*[Raghunandhan et al.(2010)]and the particles were found to be crystalline nature. In addition, flavonoids present in clove buds are found effective in reduction of gold nanoparticles. *Mentha piperitai* [Ali et al (2011)& Parashar et al.(2009)] extract was used to produce spherical shaped gold nanoparticles and exhibited antimicrobial activities against *E.coli* and *Staphylococcus aureus.* The extracts from the *Musa paradisiacal [*Bankar et al.(2010)] banana peels are also used in the synthesis of gold and silver nanoparticles. These nanoparticles exhibited antifungal activity against *E.coli, Shigella sp., Klebsiella sp., and Enterobacter aerogenes.* Silver and Gold ions can be reduced to nanoparticles using a leaf extract of *Cinnamomum camphora[.*Huang et al.(2007)]. They were most active against the yeast *Candida albicans.* The extract of *Pistacia integerrima[*Islam et al.(2015)]which act as a both stabilizing and reducing agent for the synthesis of gold particles. Nickel metal nanoparticle synthesized by using Betel leaves, *Ocimum sanctum (*tulsi) leaf extract. The gold nanoparticles with a particle size of ranging from 5 to 15 nm were produced by using *Zingiiber officinale[*Kumar KP et al.l(2011)]act as reducing and stabilizing agent. The leaf extract from *Melia azedarach[*Sukirtha et al.(2011)]is used in synthesis of silver nanoparticle and exhibited to be active against the HeLa cervical Cancer cell line. *Psidium guajava[*KhaleeBasha et al.(2010)-Raghunandhan et al.(2009)]has been reported in synthesis of gold nanoparticles using phytochemial guavanoic acid as reducing agent and capping agent, which showed antidiabetic activity.

Table 1: Nanoparticle synthesis using plant extracts.

S.No	Species	Type	Size and Shape	Reference
1.	*Aloevera*	Au,Ag	50-350nm and Spherical ,Triangular	Chandran et al.(2006)
2.	*Azadirachta indica (neem)*	Ag/Au	50-100nm	Shankar et al.(2004)
3.	*Camelia sinensis*	Ag,Au	30-40 nm	Vilchis-Nestor et al.(2008)
4.	*Catharanthus roseus*	Ag	48-67 nm	Kannan et al. (2011)
5.	*Cinnamomum camphora*	Au,Ag	55-80 nm	Huang et al.(2007)
6.	*Cymbopogon sp.(lemongrass)*	Au	200-500 nm;Spherical,triangular	Shankar et al. (2005)
7.	*Datura metal*	Ag	16-40 nm;quasilinear superstructures	Kesharwani et al.(2009)
8.	*Geranium leaf*	Au	16-40 nm	Shankar et al.(2003)
9.	*Melia azedarach*	Ag	-	Sukirtha et al.(2011)
10.	*Mentha piperita (pepper mint)*	Ag,Au	5-150 nm;Spherical	Ali et al.(2011)&Parashar et al.(2009)
11.	*Musa paradisiacal*	Ag,Au	20 nm,300nm;	Bankar et al.(2010)

12.	*Pistacia integerrima*	Ag	20-200 nm	Islam NU et al.(2015)
13.	*Psidium guajava*	Au	25-30 nm;spherical	KhaleeBasha et al.(2010)-Raghunandhan et al.(2009)
14.	*Syzygium aromaticum*	Au	5-100 nm	Raghunandhan et al.(2010))
15.	*Zingiiber officinale*	Au	5-15 nm	Kumar KP et al.l(2011)

CHARACTERIZATION OF NANOPARTICLE SYNTHESIS

The characterization of the physical and chemical properities of the nanoparticles is carried out prior to their application in the relevant field. These are characterized by their size, shape, dispersity, area, crystallinity etc.,.These are characterized for different purposes including the exposure assessment in workplaces to evaluate their health and safety hazards. There are wide range of instrumentation to measure these properties, including scanning & transmission electron microscopy and some other spectroscopy methods like Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), Atomic force microscopy (AFM), UV-Vis spectroscopy, etc., These techniques are used to resolve the diverse parameters. Additionally, the shape and size of the particle are possibly determined by TEM, SEM and AFM**.** Electron microscopy and scanning probe microscopy are the dominant methods, because of nanoparticles consist size below the diffraction limit of visible light. Electron microscopy can be paired with other spectroscopic methods for performing elemental analysis. X-ray spectroscopy are also used with nanoparticles, While the UV-Vis spectroscopy is used to determine sample formation by exhibiting the Plasmon resonance. (*Arun et al.2013, Amit kumar et al.2013)*

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