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New Generation of Green Nanoparticles: A Review

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Abstract : Medicinal plants are the “backbone” of traditional medicine, which means more than 3.3 billion people in the less developed countries utilize medicinal plants on a regular basis for therapeutic uses. The rich source of therapeutic phytochemicals leads to the development of novel drugs. The phytochemical analysis of the plants is very important commercially and has great interest in pharmaceutical companies for the production of the new drugs for curing of various diseases. Nanotechnology has proved to be a standout among the most dynamic regions of research and development in advanced medical science. Nanoparticle is the most essential part of nanotechnology which has proved to be effective in treating many diseases. Various nanoparticles have been synthesis by using plant extracts which includes silver, gold and copper oxide. Use of plant extracts fro nanoparticles synthesis is favorable over the other biological material as it removes the long process of maintenance of cell culture. The present review provides information on medicinal plants used for synthesis of nanoparticles and its applications.

Keywords : nanoparticles, green synthesis, medicinal plants, characterization, antibacterial activity.

Introduction:

Nano-technology is a rapidly growing field in which research deals with the synthesis, design, and particle structures manipulation which are ranging from 1-100 nm. Nanoparticles show various applications such as environmental, food, health care, optics, healthcare, chemical industries, etc. [1]. Another interesting branch is Nanobiotechnology- a part of nanotechnology, multidisciplinary in nature which investigates the use of nanoparticles in the biological systems. It has proved to be a cutting edge tool among the most dynamic regions of research and development in advanced medical science for treating many diseases [2]. Nanoparticles show specific characteristics as compared to large particles such as their morphology, size and distribution. Chemical and physical methods for synthesis of nanoparticles are costly and releases toxic byproducts in nature. Due to these issues, there is a requirement of an alternative for synthesis of nanoparticles [3]. Various nanoparticles have been synthesized by using plant extracts which includes silver, gold, and copper oxide. Use of plant extracts for nanoparticles synthesis is favorable over the other biological material as it removes the long

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process of maintenance of cell culture[4].The use of eco-friendly processes, for the synthesis of silver nanoparticles is known as “Green synthesis”. Green synthesis is preferred over conventional synthesis because it is eco-friendly, cost-effective, single-step method that can be easily scaled up for large scale synthesis and does not require high pressure, temperature, energy and toxic chemicals [5].

Medicinal plants:

Medicinal plants are rich assets of ingredients which are utilized for the development of drugs [6]. There are 8000 species of medicinal plants in India with known therapeutic applications [7]. It is the “backbone” of traditional medicine [8]. It has considerable significance for its attributes as a large source of therapeutic phytochemicals that may lead to the development of novel drugs due to its rich ingredients[9]. India has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal plants Indian medicinal systems like Ayurveda, Siddha and Unani employ a number of plants in the treatments of various diseases [10] with nearly about 70% of the medicinal plants in India are found in tropical forests in Eastern and Western Ghats and Himalayas [11].

Primary and Secondary Metabolites:

The term metabolite is usually restricted to small molecules with various functions, including fuel, structure, and signaling, stimulatory and inhibitory effects on enzymes, catalytic activity of their own (usually as a cofactor to an enzyme), defense, and interactions with other organisms [12].A primary metabolite is directly involved in normal "growth", development and reproduction. A secondary metabolite is not directly involved in those processes, but usually has an important ecological function[13].Secondary metabolites can be classified based on the chemical composition, chemical structure, biosynthetic pathway or their solubility in various solvents. Secondary metabolites can be divided into three large categories, namely alkaloids, terpenes and phenolics [14]. These secondary metabolites play vital roles in determining the characteristics of the drugs which are synthesized from the medicinal plants.

Phytochemicals:

Medicinal plants have bioactive compounds which are used for curing various human diseases and also play an important role in healing. Phytochemicals have two categories i.e., primary and secondary constituents. Primary constituents have chlorophyll, proteins sugar and amino acids. Secondary constituents contain terpenoids and alkaloids which exhibit vital pharmacological activities [15,16]. The phytochemical analysis of the plants is very important commercially and has great interest in pharmaceutical companies for the production of the new drugs for curing of various diseases[17].

Nanoparticles:

Nanoparticle is about 1 to 100 nanometers in size and is the study and application of extremely small things that can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Nanoparticle research is an area of intense scientific interest due to a wide variety of potential applications in biomedical, optical and electronic fields [18].Synthesis of nanoparticles is a crucial area of research, probing for a nature-friendly manner for current science. Countless methodologies are emerged to synthesize noble metal nanoparticles of specific shape and size depending upon requirement[19].Nanoparticles can be classified into different types according to the size, morphology, physical and chemical properties. Some of them are carbon-based nanoparticles, ceramic nanoparticles, metal nanoparticles, semiconductor nanoparticles, polymeric nanoparticles and lipid-based nanoparticles. Nanoparticles possess unique electrical, optical as well as biological properties and are thus applied in catalysis, bio sensing, imaging, drug detective, Nano device fabrication and in medicine [20].

Methods of synthesis of nanoparticles:

There are various methods of synthesizing silver nano particles such as ultraviolet irradiation, aerosol technologies, lithography, laser ablation, ultrasonic fields, heating and electrochemical reduction, photochemical reduction and application of reducing chemicals like hydrazine hydrate and sodium citrate, sodium borohydride, formaldehyde, polyethylene glycol, glucose, etc[21] but these techniques are expensive

and sometimes hazardous chemicals are involved in their synthesis which is harmful to the environment also[22].

There are several methods for green synthesis of nanoparticles. They are Polysaccharide method, Tollens method, Irradiation method, Biological method, Poly oxometalates method. In this study biological method is more focused to compare with other methods [23].

Advantage of Green synthesis of nanoparticles:

Other biological systems like bacteria, fungi, yeast, cyanobacteria, actinomycetes and plants have been used. But the best one appears to be the use of plants [24]. The use of various parts of plants for the synthesis of nanoparticles is considered as a green technology as it does not involve any harmful chemicals. The synthesis of nanoparticles offer numerous benefits of eco-friendliness and compatibility for pharmaceutical and other biomedical applications [25]. Synthesizing nanoparticles via biological entities acting as biological factories offers a clean, non-toxic and environment- friendly method of synthesizing nanoparticles with the wide range of sizes, shapes, and composition and physiochemical properties [26].

Preparation of Nanoparticles:

The synthesis of silver nanoparticles by means of using aqueous extracts of medicinal plants is simple, efficient, eco friendly, inexpensive, safe and it does not require any sophisticated instrumentation[27]. Aqueous extract is prepared by boiling the plant material in distilled water for 10 to 15 minutes after which silver nitrate is added. Immediately, formation of silver nano particles begins, colour of silver nitrate changes from colourless to yellow to brown to orange indicating the synthesis silver nano particles in the aqueous solution. The time duration varies from plant to plant. Several factors affect the formation of silver nano particles, for instance, the concentration of the aqueous plant extract plays an important role in the formation of silver nano particles [28]. The concentration of AgNO₃ also influences the formation of silver nano particles but higher concentration of AgNO₃ will produce larger silver particles and vice versa [29]. The other factors that influence the shape and size of silver nano particles are pH and temperature [30]. Large particles are formed at lower pH whereas at higher pH, highly dispersed and smaller nano particles are formed.

Characterization of nanoparticles:

The synthesized silver nanoparticles are generally characterized by UV-vis spectroscopy, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), Zeta potential, Xray diffraction (XRD), etc.[31].

1. Ultraviolet – Visible (UV-VIS) spectroscopy: It is a valuable tool for structural characterization of silver nanoparticles and is a fundamental technique to ascertain the formation of stable metal nanoparticles in aqueous medium based on surface plasmon resonances (SPRs) that shift to longer wavelengths with increasing particle size. Also, it is well recognized that the absorbance of Ag NPs depends mainly upon size and shape. The appearance of SPR peaks at 446 nm provides a convenient spectroscopic signature for the formation of silver nano particles [32,33].
2. Scanning electron microscopy (SEM) studies: It can characterize the size, shape, morphology and distribution of synthesized silver nanoparticles [34].
3. Transmission electron microscopy (TEM) studies: TEM measurements are conducted in order to estimate the particle size and size distribution of the synthesized silver nano particles [35].
4. Fourier transform infrared spectroscopy (FTIR) studies: It helps to identify the possible biomolecules responsible for reduction, capping and efficient stabilization of silver nano particles [36].
5. Zeta potential: It is an essential parameter for the characterization of stability in aqueous nano suspension. A minimum of + 30 mV zeta potential value is required for indication of stable nano suspension [37]. Higher zeta potential indicates greater stability of the synthesized silver nano particles [38].
6. X- ray diffraction (XRD) studies: It has proven to be a valuable research tool to prove the formation of silver nano particles, and to determine the crystal structure of the prepared silver nano particles and to calculate the crystalline particle size[39].

Examples of Green Nano particle:

Plant-mediated biological synthesis of nanoparticles is gaining importance due to its simplicity and eco friendliness. Biosynthesis of gold and silver nanoparticles by plants such as *Aloe vera*, *Cinnamomum camphora*, *Emblica officianalis*, *Carica papaya*, *Parthenium hysterophorus* has been successful in the treatment of cough, coryza, hay fever, asthma, bronchial infections, bowel complaints, worm infestations, and kidney stones in traditional medicine [40]. *Catharanthus roseus* (*C. roseus*) (L.) G. Don. (Apocynaceae) is one of the important anticancer medicinal plants which is also a main source of the anti-hypertension alkaloid ajmalicine. The activity may be due to the presence of compounds such as alkaloids, terpenoids, flavonoids and esquiterpenes that were previously isolated from the plant [41]. *Cinnamomum camphora* leaf extract has been identified very recently for the production of gold as well silver nanoparticles. The polyol components and the watersoluble heterocyclic components were mainly found to be responsible for the reduction of silver ions or chloroaurate ions and the stabilization of the nanoparticles [42]. Nanoparticles from *Ocimum sanctum* has been reported to contain alkaloids, glycosides, tannins, saponins and aromatic compounds used in the treatment of headaches, coughs, diarrhea, constipation, worms and kidney malfunctions. [43].

Therapeutic Applications of Green nanoparticle:

Silver nanoparticles (AgNPs) are increasingly used in various fields, including medical, food, health care, consumer, and industrial purposes, due to their unique physical and chemical properties. These include optical, electrical, and thermal, high electrical conductivity, and biological properties [44]. Due to their peculiar properties, they have been used for several applications, including antibacterial agents, household and healthcare-related products, optical sensors, and cosmetics, in the pharmaceutical industry, the food industry, in diagnostics, orthopedics, drug delivery, as anticancer agents, and have ultimately enhanced the tumour-killing effects of anticancer drugs. AgNPs have been frequently used in many textiles, keyboards, wound dressings, and biomedical devices [45].

Antibacterial activity of silver nanoparticles:

Amidst all the therapeutic activities, antibacterial activity of silver nanoparticles is most popular and came to light earlier than other therapeutic applications. The mechanism depends on silver nitrate concentration. It is inversely proportional i.e. less metal concentration more is the activity and vice versa. This is because smaller particles have larger surface area available for interaction and will give more bactericidal effect than the larger particles [46]. The cell membrane of microorganisms is negatively charged and silver nano particles are positively charged and when these positively charged silver nano particles accumulate on negatively charged cell membrane, it brings about a substantial conformational change which leads to loss of cell permeability control and eventually death [47]. Studies have shown [48] that once silver nano particles enter the bacterial cell, they would interfere with the bacterial growth signaling pathway by modulating tyrosine phosphorylation of putative peptides substrates critical for cell viability and cell division. The nanoparticles release silver ions in the bacterial cells, which enhance their bactericidal activity [49,50].

Importance of nanoparticles:

Nanoparticles are important scientific materials that have applications in biotechnology and pharmacology. They bridge the gap between bulk materials and molecular structures. Developments in the organization of nanoscale structures into predefined superstructures ensure that nanotechnology will play a critical role in many key technologies. Nanoparticles are of great interest due to their extremely small size and large surface to volume ratio, which lead to both chemical and physical differences in their properties [51]. The synthesis and assembly of nanoparticles would benefit from the development of clean, nontoxic and environmentally acceptable "green chemistry" procedures, probably involving organisms ranging from bacteria to fungi and plants [52].

Conclusion:

Nanotechnology has proved to be a standout among the most dynamic regions of research and development in advanced medical science. The major challenge in today's world is to develop new drugs which can be used therapeutically. Nanoparticles are a gateway into the medical science, especially the ones

synthesized from green plants. The novel approach has gained popularity in the scientific arena due to its size with is the greatest advantage which has made broad spectrum of usage in the world.

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