UDC 616-039.75

SYNTHESIS OF METAL NANOPARTICLES USING PLANTS: AN ECOFRIENDLY APPROACH

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✓ ***Resume***

Synthesis of metal nanoparticles using plants by green synthesis technology is biologically safe, environment-friendly and cost-effective. Plant contains various biomolecules such as alkaloids, phenolics, terpenoids, saponins, co-enzymes. These phytoconstituents are present in various parts of plant such as leaves, stem, roots, flower, bark. It has been found that these phytocomponents act as reducing and stabilizing agent in the production of metallic nanoparticles such as silver, gold, copper, platinum, zinc oxide etc. These plant mediated nanoparticles are used as antimicrobial, antifungal and a potential remedy for diseases like cancer, HIV, malaria, hepatitis etc.

Key words: ***Nanotechnology, MNPs, Plant extract, Drug delivery, Nanoparticle biosynthesis***

СИНТЕЗ МЕТАЛЛИЧЕСКИХ НАНОЧАСТИЦ НА РАСТЕНИЯХ: ЭКОЛОГИЧЕСКИЙ ПОДХОД

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✓ ***Резюме***

Синтез нано частиц металлов с использованием растений по технологии зеленого синтеза является биологически безопасным, экологически чистым и экономичным. Растение содержит различные биомолекулы, такие как алкалоиды, фенолы, терпеноиды, сапонины, коферменты. Эти фито составляющие присутствуют в различных частях растения, таких как листья, стебель, корни, цветы, кора. Было обнаружено, что эти фито компоненты действуют как восстанавливающий и стабилизирующий агент при производстве металлических нано частиц, таких как серебро, золото, медь, платина, оксид цинка и т.д. Эти опосредованные растениями нано частицы используются как противомикробные, противогрибковые и потенциальное средство от таких заболеваний, как рак, ВИЧ, малярия, гепатит и др.

Ключевые слова: нано технологии, МНЧ, растительный экстракт, доставка лекарств, биосинтез нано частиц.

O'SIMLIKLARDAN FOYDALANADIGAN METALL NANOZARRACHAAR SINTEZI: ECOLOGIK YONDASHUV

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✓ ***Rezyume***

Yashil sintezi texnologiyasi yordamida o'simliklardan foydalangan holda metall nanozarralarni sintezi biologik jihatdan xavfsiz, atrof muhitga zarar keltiradigan va tejamkor hisoblanadi. O'simlik tarkibida alkaloidlar, fenollar, terpenoidlar, saponinlar, kofermentlar kabi turli xil biomolekulalar mavjud. Ushbu fitokonstitentsiyalar o'simlikning barglari, poyasi, ildizlari, gullari, po'stlog'i kabi turli

qismlarida mavjud. Ushbu fitokomponentlar kumush, oltin, mis, platina, rux oksidi va boshqalar kabi metall nanozarralarni ishlab chiqarishda kamaytiruvchi va stabillashtiruvchi vosita sifatida faoliyat yuritishi aniqlandi. saraton, OIV, bezgak, gepatit va boshqa kasaliklarda ham qo'llaniladi.

Kalit so'zlar: Nanotexnologiya, MNPlar, o'simlik ekstrakti, giyohvand moddalarni etkazib berish, nanopartikullar biosintezi

Relevance

Nanotechnology is an emerging technology with wealth of applications. Recently these nanoparticles have attracted considerable attention in various fields such as sensing, imaging, biomedical devices, and pharmaceuticals. NP are atomic aggregate with dimension between 1-100nm that can drastically modify their physic-chemical properties compared to the bulk material These nanomaterials have potential applications in various areas such as treatment, development surgical nanodevices, diagnosis, drug delivery. Due to their large surface area and wider bandgap between conduction band and valence these nanomedicines, show atom like properties, which results from higher surface energy. Nanomedicine facilitates the production and application of materials to interact with the human body at a molecular level with a very high degree of specificity, this can potentially be translated into tissue-specific targeted cellular clinical applications, designed to achieve maximal therapeutic efficacy with minimal to no side effects.

Metal nanoparticles (MNPs) of Gold (Au), silver (Ag), platinum (Pt), lead (Pb), copper (Cu), cadmium (Cd), iron (Fe) and other metal oxides such as titanium oxide (TiO), zinc oxide (ZnO), belong to engineered type of nanoparticles and have not only unique physical and chemical properties but also different biological activities which could be attributed to their small size and large surface area. Different chemical and biological methods are being used to synthesize these nanoparticles. Most commonly metal nanoparticles are formed by the chemical reduction of metal ions from salt solution using strong base which act as reducing agent such as sodium hydroxide or sodium borohydride followed by addition of stabilizing agent called as capping agent or stabilizer. The reagents used, as reducing agents and the solvent, which are used, are commonly toxic substances, which could be harmful for the environment and human health. This lead to the search of an alternative method for the synthesis of metal nanoparticles. One of these alternative is using biological system for the synthesis of metal nanoparticles which is based on the principle of green chemistry. Prokaryotic and eukaryotic organisms including plants, animals and microorganism are used to synthesize metal nanoparticles. Primary and secondary metabolite causes reduction of metal ion resulting in the formation of metal nanoparticles. These reducing agents or surrounding molecules form coating on the outer surface of metal nanoparticle preventing them to agglomerate. So the metal nanoparticles obtained by green synthesis are eco-friendly, easy rapid and simple to produce, biocompatible and biodegradable gives high yield in low cost.

Important aspect concerning green synthesis of MNPs by plants is the fact that each part of plant (leaves, fruit, seed, root, barks) have different phytochemical component and should be considered separately. Metal nanoparticles were synthesized using different extract from different plants and different parts using metal salts producing nanoparticles with different compositions, sizes, shapes and activities. The metal nanoparticles using plants are spheres and triangles. The size range from 15-50nm in diameter. Leaves extract is the most common choice for the synthesis of metal nanoparticles but other parts of plant such as seed, bark, flower, fruit, tuber and roots have also been reported. Most of the metabolites are present in the leaves so they are most commonly used and also because they are renewable, abundant and non-destructive.

Synthesis of nanoparticles: The use of plant materials for the synthesis of nanoparticles could be more advantageous as it is economical and it also does not require elaborate processes. The cocktail of phytochemicals which are present in plants such as phenolic acids, sugars, terpenoids, alkaloids, polyphenol, flavonoids and proteins that play vital role in this biological reduction and stabilization of metals like Au (III) salts to Au (0) or Ag (I) salts to Ag (0) to metal nanoparticles. The basic principle in the formation of these nanoparticles is that some of the phytoconstituents present in the plant extract contain these functional group (-COOH, C=O, NH_2, SH and OH) which

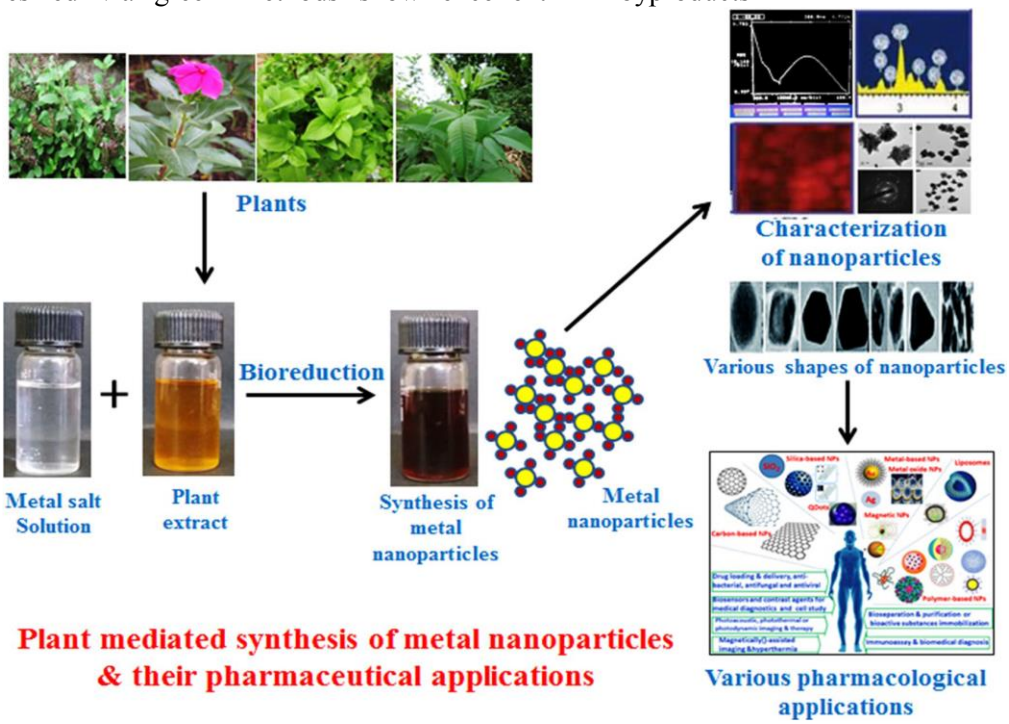
reduces the metal ion into metal atoms which are nanosized and are called nanoparticles and these nanoparticles adsorb various phytoconstituents on its surface which have various biological activities. Thus the secondary metabolites act as reducing, stabilizing and capping agent. So these metal nanoparticles with phytoconstituents adsorbed on its surface because of its large surface area and small particle size are more effective, stable and bioavailable that the pure plant extract. NPs synthesized via green methods show excellent antibacterial effects, antifungal effects, anti-cancer activity, anti-inflammatory and anti-diabetic activity.

Silver: The biochemical reaction of $AgNO_3$ with plant extract lead to AgNPs

$Ag+NO^{3-}$ + plant extract $\rightarrow Ag^{o}NPs$ + byproducts

Gold: The proposed reaction is that the Au+ is reduced to Au^{o} in presence of phytochemicals

$HAu+Cl_4.4H_2O$ +Plant extracts $\rightarrow Au^{o}NPs$ +byproducts



Characterization of Nanoparticles synthesized from plants:

Characterization is essential for determining morphological and structural properties of metal nanoparticles. The various techniques which are used for the characterization of metal nanoparticles are X-ray diffraction (XRD) for identification

Characterization is required for determination of the structural and morphological properties of metal NPs. The major techniques used for the characterization of metal NPs are X-ray diffraction (XRD) for identification of the crystalline or amorphous natures of metal NPs, scanning, and transmission electron microscopy (SEM) for evaluation of size and morphology of synthesized NPs; Fourier transform infrared (FTIR) is used for identification of functional groups used in reduction of metal salt. For each of the characterization techniques, a different method of sample preparation is required.

Factors affecting biological synthesis of metal nanoparticles: The morphological character of the prepared nanoparticles can be changed by various parameters such as ph, temperature, reaction time and reactant concentration. These factors may be taken into consideration while preparing metal nanoparticles as they play important role in optimization of metal nanoparticles.

pH: Size and shape of nanoparticles varies with the pH of solution, large size particles are produced in acidic medium. Further, the functional group easily approach for particle nucleation in the extract at pH 3 or 4 as compared to pH 2 at which only fewer functional group are available leading to particle aggregation to form larger nanoparticles. An increased number of spherical

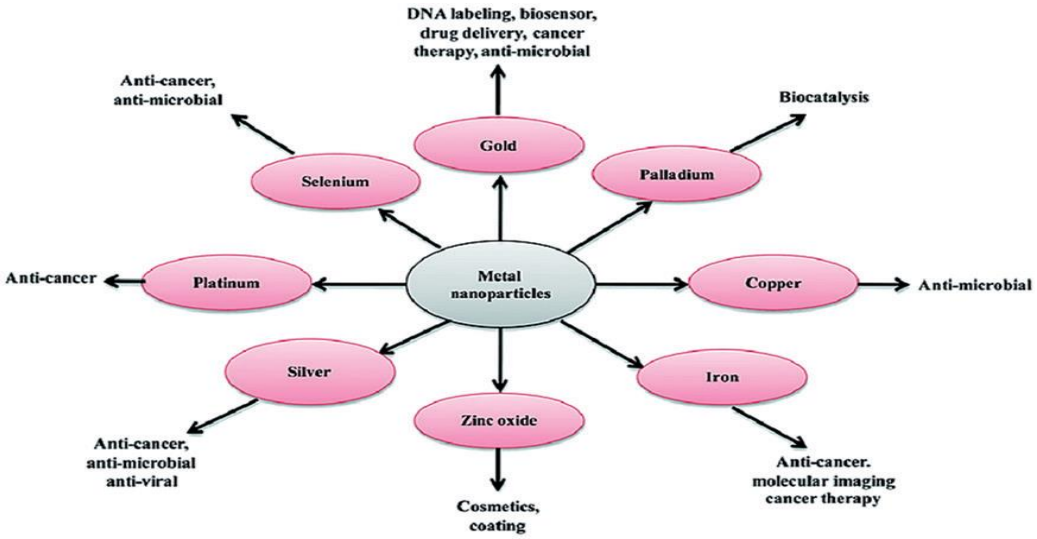
nanoparticles were synthesized using *Cinnamom zeylanicum* bark extract at pH greater than 5.

Reactant concentration: The formation of metallic nanoparticles is affected by the concentration of the phytoconstituents present in the extract. The shape of silver and gold nanoparticles is affected by the amount of pytoconstituent present in the reaction medium. Exposure of chloroauric acid to increased concentration of extract resulted in synthesis of spherical nanoparticles rather than triangular. Nanoparticle size can be changed between 50nm to 350nm by using different concentration of the extract.Triangular, spherical,decahedral, hexagonal shapes of silver nanoparticles were produced by changing the concentration of Plactranthu samboinicus leaf extract.

Reaction Time: The reaction time is also very important factor in synthesizing nanoparticles. Rapid colour change was seen in 2mins when pineapple extract was used for silver nanoparticle synthesis and the shape was found to be spherical with the size of 12nm. Size of the silver nanoparticles changed ranging from 10-35nm when there was increase in reaction time from 30mins to 4 hrs using Azadirachta indica leaf extract.

Reaction temperature: Reaction temperature also plays very important role in determining the shape, size and yield of the synthesized nanoparticles by using plants. At 25℃ the peel extract of *Citrus sinesis* produced the nanoparticles with a particle size of around 35nm.And as the temperature was increased to 60 ° C the particle size of nanoparticles decreased to 10nm. The high temperature increases the rate of formation of gold nanoparticles. The spherical gold nanoparticles were formed at lower temperature whereas rod like or plate like nanoparticles are formed at high temperature. The reaction rate increases whereas the particle size saw decreases with rise in reaction temperature to 60 °.

Pharmacological applications of Metallic nanoparticles:



Nanoparticles have vast application in physicochemical and biomedical field. They are used for drug delivery, bio-imaging, biomolecular recognition and biosensing. Both gold and silver nanoparticles have been found to have broad spectrum antimicrobial activity against pathogens. Silver nanaoparticles are larvicidal against filariasis and malaria vectors. Copper and copper oxide nanoparticles have antimicrobial, antibacterial , anticancer and antioxidant activity against some pathogenic strains. Titanium dioxide and zinc oxide have antibacterial, adulticidal and larvicidal properties.

Biosynthesis of nanoparticles using plant extract:

Brassica rapa	Antifungal	Ag	*Narayanan et al., 2014*
Euphobria milii	Muscle relaxant	Au	*Islam et al. 2015*
Salix alba	Antifungal	Au	*Islam et al. 2015*
Sesbania grandiflora	Cytotoxicity	Au	*Koduru M et al 2018*
Ruta graveolens	Antimicrobial	Ni, ZnO	*Lingaraju, K. et al 2016*
Psidium guajava	Cytotoxicity	TiO	*Santhoshkumar, T et al 2014*
Galaxaura elongata	Biological activities	Au	*Abdel-Raouf, Net al 2017*
Gardenia jasminoides	Antibacterial	Fe, Pd	*Naseem, T et al 2015*
Gloriosa superba	Catalytic	CuO	*Naika, H.R et al 2015*
Punica granatum	Antidiabetic	Ag	*Rijuta et al 2018*
Lantana trifolia	Antibacterial	Ag	*Edwin Shigwenya Madivoli et al 2020*
Mansoa alliacea.	Arthritis pain	Au	*Hengyuan An et al 2019*
Ageratum conyzoides	Antimicrobial	Fe	*Edwin Shigwenya Madivoli 2019*
Rhododendron arboreum.	Antimicrobial	MgO	*Ajay Singh et al 2019*

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Entered 09.04.2021