Novel synthesis of zinc nanoparticle using green approach

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Abstract: In recent years, the progress of forcible green chemistry methods for synthesis of metal nanoparticles has become a major focus of researchers. They have investigated in this field in order to find a suitable method for manufacture of well-characterized nanoparticles. One of the most broad methods is production of metal nanoparticles using plants. Among these plants seem to be the most promising ones due to ease of their availability and thus they are appropriate for large-scale biosynthesis of nanoparticles. Nanoparticles synthesized by plants are more stable and the rate of synthesis is faster than in the case of microorganisms. Moreover, the nanoparticles are more varied in shape and size in comparison with those synthesized using other organisms. The preference of using plant and plant-derived materials for biosynthesis of metal nanoparticles have interested researchers to inquiry mechanisms of metal ions uptake and bio reduction by plants, and to know the practicable method of metal nanoparticle syllogism in plants.

Keywords: Nanoparticles green synthesis, plant extracts, ligands, crystalline, FT-IR, UV-Visible spectrophotometer, XRD and SEM.

I. INTRODCTION

Green synthesis of metal nanoparticle is an interesting issue of the Nano science and Nano biotechnology. There is a growing attention to biosynthesis the metal nanoparticles using organisms , plants seem to be the best candidate and they are suitable for large scale biosynthesis as plants are more stable, and the rate of synthesis is also faster moreover, the nanoparticles are more varied in their symmetries. The present investigation was carried out for green synthesis of zinc oxide nanoparticle by using the medicinal plant *Cassia articulate* (Tanners cassia). They were synthesized by mixing 1 milliliter aqueous solution of Zinc acetate with aqueous extract of *Cassia articulate* flower. The formation of nanoparticles was monitored by visualizing color changes and it was confirmed by characterization using Electron Microscope (SEM), UV-Vis spectrophotometer and Fourier Transforms Infrared (FT-IR) spectroscopy (1). In recent years, the development of efficient green chemistry methods for synthesis of metal Nanoparticles has become a major focus of researchers. They have investigated in order to find an eco-friendly technique for production of well-characterized nanoparticles.

EASE OF USE

One of the most Considered methods is production of metal nanoparticles using organisms. Among these organisms plants seem to be the best candidates and they are suitable for large-scale biosynthesis of nanoparticles. Nanoparticles produced by plants are more stable and the rate of synthesis is faster than in the case of microorganisms (2,3). Moreover, the nanoparticles are more various in shape and size in comparison with those produced by other organisms.

The advantages of using plant and plant-derived materials for biosynthesis of metal nanoparticles have interested researchers to investigate mechanisms of metal ions uptake and bio reduction by plants, and to understand the possible mechanism of metal nanoparticle formation in plants(4).

Nanotechnology is the application of science to control matter at the molecular level. Tremendous growth in nanotechnology has opened up novel fundamental and applied frontiers in materials science and engineering, such as Nano biotechnology, quantum dots, surface-enhanced Raman scattering (SERS), and applied microbiology (5).

Developments in the organization of Nano scale structures into predefined superstructures ensure that nanotechnology will play a critical role in many key technologies.

It is gaining importance in areas such as mechanics, optics, biomedical sciences, chemical industry, electronics, space industries, drug-gene delivery, energy science, catalysis, optoelectronic devices, photo electrochemical applications, and nonlinear optical devices.

For instance, nanometer-scale geranium quantum dots (less than 10 nm) could be controllably formed for novel optoelectronic device applications such as single electron transistors (SETs) and light emitters. The ability to tune the optical absorption/emission properties of quantum dots (semiconductor nanoparticles) by simple variation in nanoparticle size is particularly attractive in the facile band-gap engineering of materials and the growth of quantum dot lasers. Moreover, advances in nanotechnology are creating a novel class of magnetic resonance image contrast-enhancing agents such as small particles of iron oxide, fullerenes encapsulating Gd^{3+} ions (Gad fullerenes).

And single-walled carbon nanotube Nano capsules encapsulating Gd^{3+} ion clusters (Gad nanotubes).

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 (e.g. mechanical properties, biological and satirical properties, catalytic activity, thermal and electrical conductivity, optical absorption and melting point) compared to bulk of the same chemical composition(6). Therefore, design and production of materials with novel applications can be achieved by controlling shape and size at nanometer scale. Nanoparticles exhibit size and shape-dependent properties which are of interest for applications ranging from bio sensing and catalysts to optics, antimicrobial activity, computer transistors, electrometers, chemical sensors, and wireless electronic logic and memory schemes.

These particles also have many applications in different fields such as medical imaging, Nano composites, filters, drug delivery and hyperthermia of tumors.

PLANTS AS BIOREACTORS FOR THE SYNTHESIS OF METAL NANOPARTICLE

It has long been known that plants are able to reduce metal ions both on their surface and in various organs and tissues remote from the ion penetration site.

In this regard, plants (especially those which have very strong metal ion hyper accumulating and reductive capacity) have been used for extracting precious metals from land which would be economically unjustifiable to mine; an approach known as phytomining(7).

The metals accumulated by the plants can be recovered after harvesting via sintering and smelting methods. Interestingly, study of the metal bioaccumulation process in plants has revealed that metals are usually deposited in the form of nanoparticles. For example, *Brassica juncea* (mustard greens) and *Medic ago sativa* (alfalfa) accumulate 50 nm silver nanoparticles to a high level (13.6% of their own weight) when grown on silver nitrate as a substrate(8)

In addition, gold icosahedra of 4 nm in size were detected in *M. sativa* and semi-spherical copper particles with a size of 2 nm were observed in *Iris pseudacorus* (yellow iris) grown on substrates containing salts of the respective metals. (9)

Whole plants can obviously be used to produce metal nanoparticles. However, there exists certain limitations that should be taken into account upon industrial application of this technology. Firstly, the size and shape of nanoparticles vary depending on their localization in the plant, which may depend on differences in the content of metal ions in various tissues and the subsequent possibility of nanoparticle movement and penetration. These factors could influence the level of metal deposition around already existing nanoparticles, and also the prospect of new nucleation events (initiation of nanoparticle formation (10,11).

The heterogeneity of the size and morphology of nanoparticles produced in whole plants may hinder their use in applications where specific, finely tuned sizes and shapes are required; thus illustrating the inability to tailor the whole plant synthesized nanoparticles to market requirements. Moreover, efficient extraction, isolation and purification of nanoparticles from plant material is a difficult and problematic procedure, with a low recovery.

In this regard, *in vitro* approaches have actively been developed in recent years, in which plant extracts are used for the bio reduction of metal ions to form nanoparticles. These approaches provide a more flexible control over the size and shape of the nanoparticles (for example, by changing the medium pH and reaction temperature), as well as facilitating easy purification. Significantly, this process occurs much faster than the synthesis of nanoparticles in whole plants, because the reaction proceeds almost instantaneously, without the delay required for the uptake and diffusion of metal ions throughout the plant. This *in vitro* approach has been demonstrated using extracts from a variety of different plant species in combination with a variety of acids and salts of metals, such as copper, gold, silver, platinum, iron, and many others (12).

For example, extracts of *Pelargonium grave lens* (rose geranium) have been used to reduce gold ions into 20–40 nm decahedral icosahedral shaped nanoparticles and stabilize them, whereas gold Nano spheres and Nano triangles 0.05–18 μm in size have been synthesized in extracts from *Cymbopogon flexuous* (lemon grass).

The *Azadirachta indica* (neem, Indian lilac) extract was used to reduce tetrachloroauric acid (HAuCl4) to flat gold triangles and hexagons with a size of 50–100 nm. In that study, it was also demonstrated that the *A. indica* juice can reduce silver nitrate to polydispersed spherical nanoparticles with a size of 5–25 nm.

The leaf extract of *Aloe barbadensis* (aloe Vera) was used to produce cubic In_2O_3 particles 5–50 nm in size. It has been demonstrated using FTIR spectroscopy that plant metabolites such as sugars, terpenoids, polyphenols, alkaloids, phenolic acids, and proteins play an important role in the reduction of metal ions into nanoparticles and in supporting their subsequent stability. It has been suggested that control over the size and morphology of nanostructures may be connected to the interaction of these biomolecules with metal ions. Various plants differ in the concentration and composition of these biologically active components.

This may partly explain the morphological diversity of the described nanoparticles: triangles, hexagons, pentagons, cubes, spheres, ellipsoids, nanowires, and Nano rods.

II. REQUIREMENTS/ AND METHODS

Material Required:

Beaker, Mortar pestle, Water Bath, Watch Glass, Measuring Cylinder, Papaya Leaves (100gm), Zinc Sulphide, Zinc Chloride, Magnetic Stirrer

METHOD: Take 100gm of papaya leaves and wash it with Distill Water to remove the unwanted materials or dust particles and put it in an open sunny area to dry or to remove residual moisture and then cut the papaya leaves. Dissolve papaya leaves in 200ml Distill Water, extract till boiling for 30minute to 60minute to give a yellow solution. Add a mixture of (6gm of Zinc Chloride and 4gm of Zinc Sulphide) into yellow solution till it completes dissociation at 60 ˙C in magnetic stirrer. Heat till a deep yellow paste is obtained. Take Yellow paste in crucible and heat it to 400C till it complete dries. Then crush into a mortar pastel to gain the power.

III. CATALYTIC APPLICATIONS

Zinc Obtained has a catalytic activity and after oxidation it changes to Zinc Oxide (ZnO) and can be used as an effective catalyst. Urea (15 mmol, 0.90 g), Ethyl acetoacetate (13 mmol, 1.69 g), Benz aldehyde (10 mmol, 1.06 g), prepared ZnO catalyst (0.2 g), Ethanol (10 mL) were refluxed for 3 hr. Mixture was then filtered in crushed ice and crude solid product as separated by filtration and washed with water. Product was purified by recrystallization with Ethyl acetate and structure was confirmed by comparing melting point and IR data.

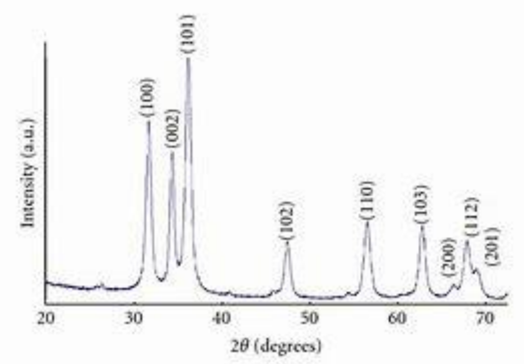
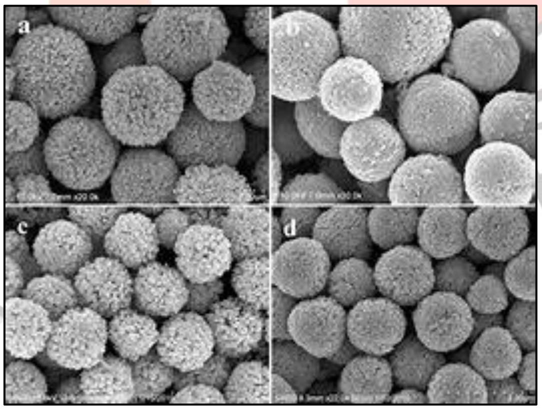


Fig.1 XRD pattern of ZnO (Prepared by Green Technique "Papaya Leaves")

The technique provides valuable information of structure, different phases and preferred crystal orientation. The pallets sintered at 400 C were finely powdered and used for XRD analysis. Inter-atomic spacing (d), lattice parameter (a), and particle size (D) were calculated for the highest intensity peak having miller indices as (hkl) for the above sample.



"Fig.2" Fig.1 f

Fig. 2 SEM images of the synthesized nanoparticles

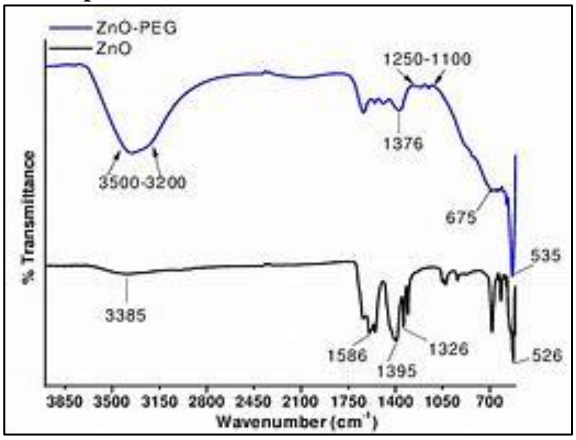


Fig.3 FT-IT PATTERN OF ZnO CATALYST PREPARED BY GREEN TECHNIQUE FROM PAPAYA LEAVES

CONCLUTION

Obviously, the synthesis of metal nanoparticles in plant extracts (plant biomasses), in spite of obvious limitations, has an effective potential and a number of substantial benefits proportional to ceremonial policy of nanoparticle synthesis. However, to compete cost-effectively with nanoparticles obtained through physical and chemical methods, it is necessary to measure these methods of nanoparticle production using plant material and to extend design for keeping their price in check during their synthesis.

When using chemical synthesis, the chief point cost of nanoparticles is mainly resolved by the cost of the metal salts and reducing agents. In the case of “green” synthesis, the bulk of the value will be determined only by the value of the metal salts, because plant wastes from the food industry can serve as reducing agents. Moreover, it is possible to moonstruck companies involved in the food industry and interested in the recycling of waste to partially pay for nanoparticle production. This fact further emphasizes the environmental advantages of “green” synthesis over traditional methods of nanoparticle production.

Equations

$n\lambda = 2d\sin\theta$: Bragg’s Law. “Eq.1”

ABBREVIATION

FT-IR: Frontier Transform Infrared Resonance , UV-VIS: Ultra Violet – Visible , XRD: X-ray Diffraction , SEM: Scanning Electron Microscope , SERS: Surface Enhanced Raman Scattering , SET: Single Electron Transistor , pH: Power of Hydrogen , 3d: 3 Dimension ,NP: Nano Particle , IR: Infrared Radiation.

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