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Green Production of Zinc Oxide Nano Particles by using Plant Extracts: A Review

Patil Vishalakshi and A. R. Shashikala*

School of Engineering, Department of Chemistry, Presidency University, Itgulpura, Bangalore – 560064, Karnataka, India; aarudirs@gmail.com

Abstract

Nano scale materials are being used extensively due to their properties and applications as they acquire large surface area to volume ratio. Green approach of nano particles has gained popularity because it is more convenient, non-toxic, and dependable than chemical synthesis methods. Researchers have intensively explored the manufacture and applications of zinc oxide nanoparticles due to their numerous applications in semiconductor devices catalysis, imaging, biosensing, cancer therapy, and drug administration. By using the bio reduction approach, the natural extracts from plant parts such as seeds, roots, stems, leaves, or flowers can be utilized to produce nano particles without the usage of chemicals. Different morphologies of the zinc oxide nanoparticle can be created. This article gives a thorough examination of the manufacture and applications of zinc oxide nano particles using a green technology approach.

Keywords: *Green Production, Nano Zinc Oxide, Nano Particles, Plant Extract*

1.0 Introduction

A nano meter is in size of one billionth of a meter (10^{-9} m or 10^{-7}cm) and it is about 10^5 times smaller than the diameter of human hair. Nano technology is a new and revolutionary field that primarily focuses on the synthesis of materials on the nano meter scale. In contrast to materials with undetermined particle sizes, nano particles are widely employed in a variety of fields such as cosmetics, medicine delivery, electronics, gene therapy, and so on due to its large surface to volume ratio. One of the most important and fundamental properties of nano particle is the optical property because of their optic characteristic, micro particles were utilized in painting prior to the fourth century AD. The most well-known example is the Lycurgus cup[1]. It is a historical example that is housed in the British Museum. This is composed of a special glass known as dichroic glass. It is made up of a little amount of gold (Au) and silver (Ag) particles in a 1:14 molar ratio because of the optical property of nano particles, when light strikes on the cup at a 90 degree angle the color change from opaque green to brilliant translucent.

2.0 Classification of Nanoparticle

Based on their morphology, size and form nano particles are categorized as follows: 1) Organic nano particles which are one of the most important types of nano particles 2) Nano particles made of inorganic materials 3) Nano ceramic particles 4) Biological Nano particles.

2.1 Organic Nano Particles

Polymeric nano particles are another name for these nano particles. Organic or polymeric nano particles in the form

*Author for correspondence

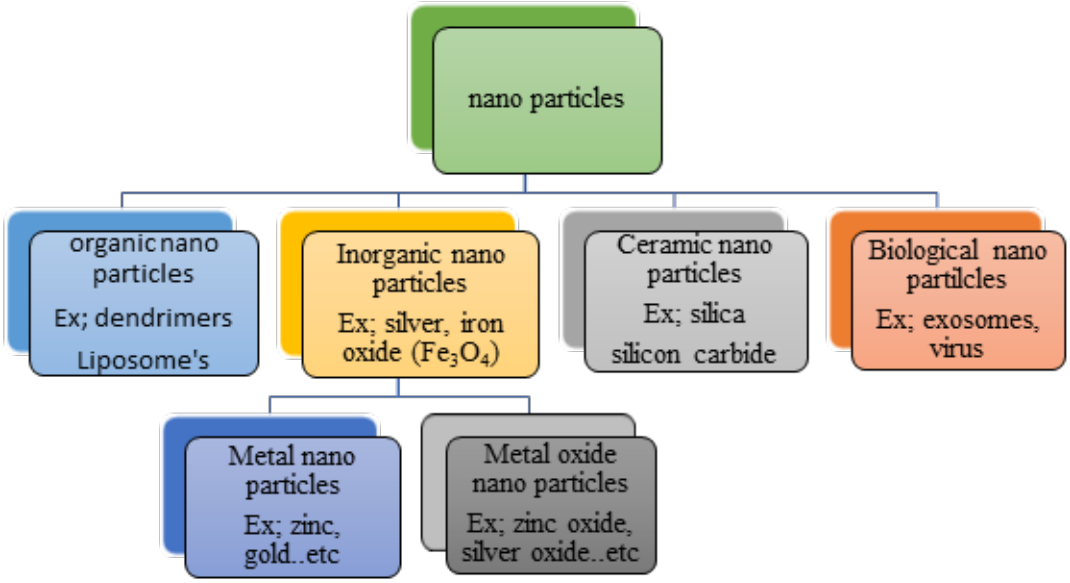

Figure 1. Classification of nano particles.

of a nano sphere or a nano capsule because of the form of these nano particles[2], organic nano particles are widely used in drug delivery. This sort of Nano particle includes dendrimers, liposome's, micelle and ferritin.

2.2 Inorganic Nano Particles

These are non-toxic and biocompatible materials. Nano particles those are hydrophilic and carbon free. These nano particles are more stable than organic nano particles and are divided into two types: Nano particles of metal and nano particles of metal oxide.

2.3 Metal Nano Particles

Metal nano particles can be synthesized from metals using either destructive or constructive methods and all metal nano particles can be synthesized[3]. Surface attributes include surface area to volume ratio forms color and so forth[4].

2.4 Nano Metal Oxide Particles

Metal oxide nano particles have a higher reactivity and efficiency than metal nano particles[5]. Zinc oxide, copper oxide, silver oxide etc., are the few examples of metal oxide nano particles.

2.5 Ceramic Nano Particles

These are inorganic metalloid solids composed of oxides, carbides, carbonates and phosphates that are synthesized through heating or successive cooling. These nano particles might be amorphous, porous or hollow[6].

2.6 Biological Nano Particles

These are nano particles that exist naturally in the biological system. These are in the form of atoms or molecules Exosomes and viruses are two examples of nano particles.

3.0 Synthesis of Nanoparticles

3.1 Metal Oxide Nano Particles

High temperature and pressure are used in the physical production of metal oxide nano particles[7]. This method necessitates greater space for machine setup, as well as more expensive equipment. The employment of hazardous chemicals in the chemical procedure for creating metal oxide nano particles is hazardous to the surroundings and the person in charge. According to the literature, the substances utilized in physical and chemical procedures may reside in nano particles generated[8], which may have unfavorable medical uses. Another disadvantage of this

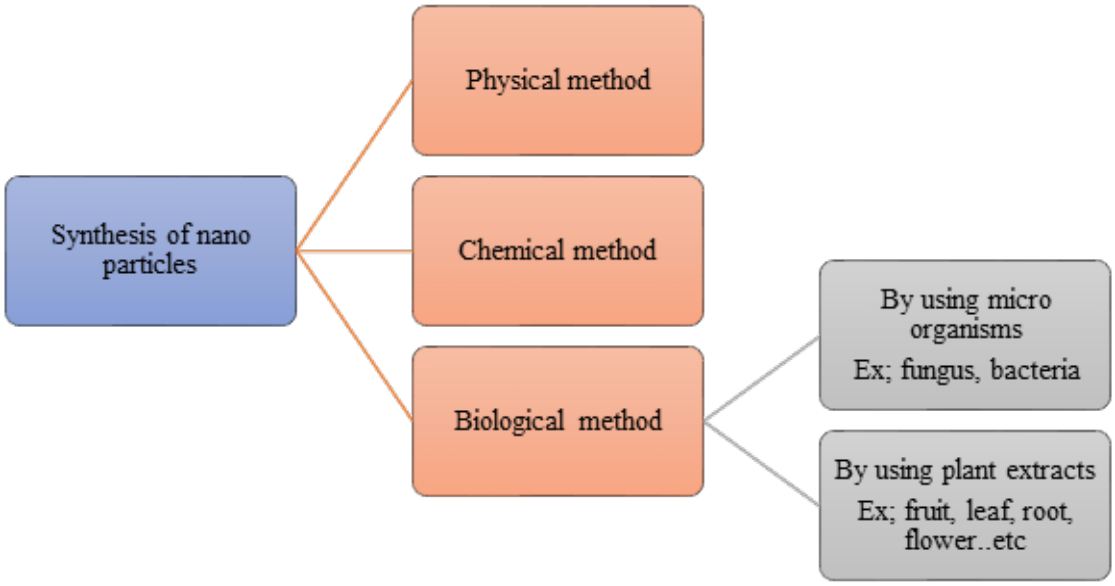

Figure 2. Methods of synthesis of nano particles.

method is that the synthesized nano particles are less stable at room temperature for an extended period of time. So to overcome these disadvantages with physical and chemical methods for the synthesis of nano particles, biological synthesis has attracted more attention from researchers due to it is non-toxic and environmentally friendly.

4.0 Green Approach

It is a method of synthesizing nano particles utilizing microorganisms and plant extracts with medical uses. It is an environmentally friendly, biocompatible[9], cost-effective, safe and green technique. Example; zinc oxide nano particles.

4.1 Green Synthesis of Zinc Oxide Nano Particles by using Bacteria

Aero monas hydrophilia, a Pseudo monadaceae species[10], used to synthesize spherical shaped of zinc oxide nano particles with a size of 57.72 nm as confirmed by AFM and oval-shaped zinc oxide nano particles with a size range of 42-64nm as confirmed by XRD analysis. It is also a green strategy, but it has various drawbacks such as the time required to filter microorganisms is more, the media used to grow bacteria is expensive due to a lack of regulate over the morphology and size of the nano particles.

4.2 Green Approach of Zinc Oxide Nano Particles by using Microalgae

Algae are photo synthetic organisms that range from one cellular (chlorella) to more than one cellular (brown algae). Algae has been extensively used in the manufacture of gold and silver nano particles[11]. These have a greater ability to reduce hazardous metals to less harmful ones in micro algae. Spherical and hexagonal zinc oxide nano particles are synthesized from *S. myriocystom* which belongs to the nano particle size range of 20-36nm is studied by AFM and the size of nano particles 46.6nm is analyzed by DLS technique[12].

4.3 Green Approach of Zinc Oxide Nano Particles by using Fungi

Nano particle synthesis from fungus is particularly useful since it produces more nano particles and has a higher economic viability because of the great binding capacity of metal to pile over on bacteria[13], the green approach of zinc oxide nano particles from fungus is more friendly than that of bacteria[14]. The spherical shaped zinc oxide nano particles is synthesized from *Aspergilus terreus* a member of the tri chocomaceae family[15] and the size of the nano particle is 54.8-82.5nm as determined by SEM. The majority of the zinc oxide nano particles produced by fungi are spherical in form. Table 1 provides the green

Table 1. Green approach of zinc oxide nano particles from different sources

Green approach of zinc oxide nano particles by using bacteria				
S. No	**Bacterial strain**	**Family**	**Size(nm)**	**Shape**
1	*Pseudomonas aeruginosa* bacteria	*Pseudomonadaceae*	35-81(TEM)	Spherical[16]
2	*Lactobacillus sporogeneses* bacteria	Bacillaceae	5-16 (TEM)	Hexagonal shape[17]
Green approach of zinc oxide nano particles (ZnO) by using algae				
S. No	**Algae strain**	**Family**	**Size(nm)**	**Shape**
1	*Chlamydomonas reinhardtii*	Chlamydomonaceae	55-80	nanorod, nano flower[18]
2	*Sargassum muticum*	Sargassaceae	30-57	Hexagonal[19]
Green approach of zinc oxide nano particles by using fungus				
Sl. No	**Fungal strain**	**Family**	**Size(nm)**	**Shape**
1	*Aspergillums strain*	Trichocomaceae	50-120	Spherical[20]
2	*Aspergillus fumigates*TFR-8	Trichocomaceae	1.2-6.7	spherical[21]
Green approach of zinc oxide nano particles by using protein				
Sl. No	**Protein**	**Size(nm)**	**Shape**	
1	Egg albumin	16,10-20	Spherical, hexagonal[22]	

approach of zinc oxide nano particles from different sources. Figure 3 presents the sources from which nano particles can be synthesized. Figure 4-7 depicts the schematic diagram for the green synthesis of zinc oxide nano particles by using plant extracts.

Zinc oxide Nano particles were created using the leaves of *Azadirachta indica* a member of the Meliaceae family. It is often known as neem and Bhuyant *et al.,*[23] were the first to synthesis zinc oxide Nano particles using azadirachta indica leaves**.** The co precipitation process was used to create zinc oxide nano particles. In this procedure, 1mL of 25% *Azadirachta indica* leaves extract was mixed with 50 mL of 2M sodium hydroxide (NaOH) and 50 mL of 2M zinc acetate dehydrate was added and constantly stirred with a magnetic stirrer for 2 hours. The precipitate was rinsed with distilled water, then ethyl alcohol. After drying overnight at 60^0 C, white powder was generated TEM, XRD patterns and UV-Visible spectroscopy have been used to characterize different properties of zinc oxide nano particles.

Fresh Nyctanthes arbor-tristis flowers are washed with water and dried for 12-14 days at ambient temperature to eliminate any moistures. 10gms of dried flower powder were cooked in 100mLof double distilled water for 13 minutes before being cooled, filtered and stored at 40degree Celsius. Then 0.01M zinc acetate is mixed with *Nyctanthes arbor-tristis* flower extract. The solution is continuously agitated for 2hours and the pH is kept at 12. The precipitate obtained was centrifuged at 15,000 rpm for 5 minutes with distilled water and the resulting white precipitate was dried overnight at 60^0 C. During drying the zinc oxide nano particles are completely converted. Different approaches were used to characterize the zinc

Figure 3. Sources for the green synthesis of nano particles.

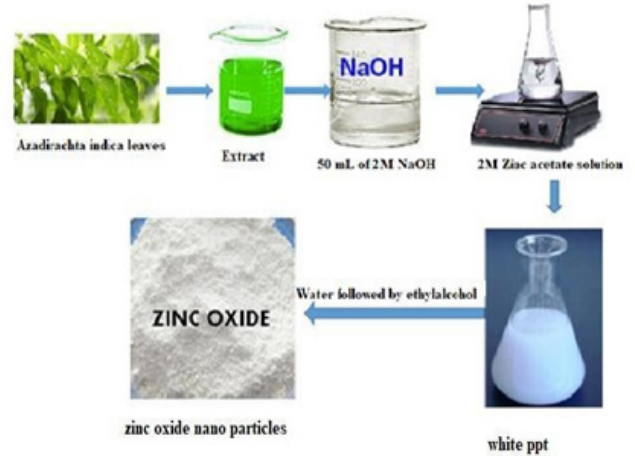

Figure 4. Zinc oxide nano particles: (Synthesis by using *Azadirachta indica* leaves).

oxide nano particles obtained including UV-Visible spectroscopy, XRD and Dynamic Light Scattering (DLS).[24]

Moringa oleifera seeds were extracted from pods and ground into powder using a mortar and pestle. 100ml of double distilled water is added to the seed powder and heated at 80^{0}C for 25minutes with constant stirring. The aqueous extract was then cooled and filtered. It is employed in the manufacture of zinc oxide nano

Figure 5. Synthesis of zinc oxide nano particles: (by using Nyctanthes arbor-tristis).

particles as a reducing and capping agent. After 2 hours, a brownish yellow color formed when 5gm of zinc nitrate hexa hydrate was combined with *Moringa oleifera* seed extract. The material was heated at 700 degrees Celsius for 6 hours to create white powder containing zinc oxide microparticles. The combination was centrifuged at 8000rpm for 15 minutes[26], and the sediment sample was kept. It was calcined for 2 hours at 4000^{0}C, and the white crystalline zinc oxide micro particles powder was stored in an amber color bottle for further investigation. The zinc oxide Nano particles have been characterized by UV-Visible Spectroscopy a XRD and FTIR analysis.

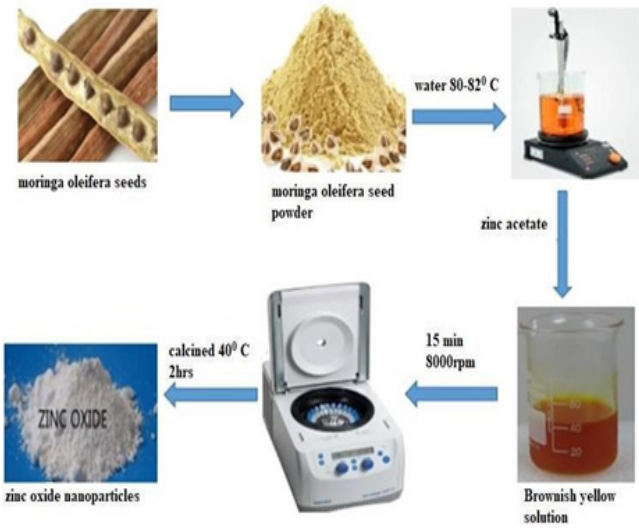

Figure 6. Green approach of zinc oxide nano particles: (by using *Moringa oleifera* seeds).

Figure 7. Synthesis of zinc oxide nano particles:(by using plantain peel extract).

The plantain peel (*Musa paradisiaca*) of the Musaceae family[26]. Take fresh plantain peels that has been cleaned several times with distilled water to remove contaminants and sliced into little pieces. Plantain peel pieces were blended with 1L of distilled water and strained through a muslin cloth to allow sedimentation.The resulting supernatant layer was filtered again using what man No. 1 paper and the extraction of Plantain Peel (PPE) was stored at low temperature for further work.[27]

A solution containing 4.6 g of zinc acetate (CH_3COOZn) in 10 mL of distilled water is added to 10 mL of plantain peel extraction and the solution's pH is maintained to 12 by adding NaOH solution. The magnetic stirrer was used to agitate the mixer for 2hours at 850^{0}C-852^{0}C after 15minutes of spinning at 5500 rpm, the supernatant solution is added to ethyl alcohol and centrifuged again under the same circumstances to remove contaminants and the pellets are obtained. These are dried in an oven for 8 hours at 900 degrees Celsius. It is calcined for 2 hours at 350^{0}C to produce zinc oxide nano particles. UV-Visible spectroscopy, XRD, and FTIR analysis are then used to characterize the samples.

Table 2. Summary of the production of ZnO nano particles from various plant sections

Sl. No	Plant (Family)	Common name	Part taken for extraction	Size (nm)	Shape
1	*Azadirachta indica* (Meliaceae)	Neem	Leaf	9.6-25.5 (TEM)	Spherical[28]
2	Cocusnucifera	Coconut	Coconut water	20-80 (TE M)	Spherical[29]
3	Gossypium (Malyaceae)	Cotton	Cellulose fiber	13 (XRD)	Spherical[30]
4	(Liliaceae) Aloe Vera	Aloe Vera	Leaves	8-20 (XRD)	Spherical[31]
5	*S. album* (Santalaceous)	Sandalwood	Leaves	100 DLS 70-140 (TEM)	Nanorods[32]
6	*S phathode* Acampanulata (Bignoniaceae)	African Tulip tree	Leaves	30-50 (TEM)	Spherical [33]
7	*Anisochilus camosus* (Liliaceae)	Kapurli	Leaf	30-40 (TEM) 20-40 (FE-SEM)	Hexagonal wurtzite, quasi-spherical[34]
8	Sapindaceae *Nephelium lappaceum* L.	Rambutan	Peel of Fruit	50.95 (XRD analysis)	Agglomerate in the shape of a needle[35]

The Table 2 provides a summary of the production of ZnO nano particles from various plant sections.

5.0 Conclusion

In the synthesis of nano particles by using plant extracts green sources like parts of plants can act as a stabilizing and reducing agent. These green sources will regulate the shape and size of nano particles, producing nano particles in an ecologically friendly manner has been a focus of research over the last decade. Plant-based nano particles have numerous applications in the food, cosmetic and pharmaceutical industries making this an important area of study.

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