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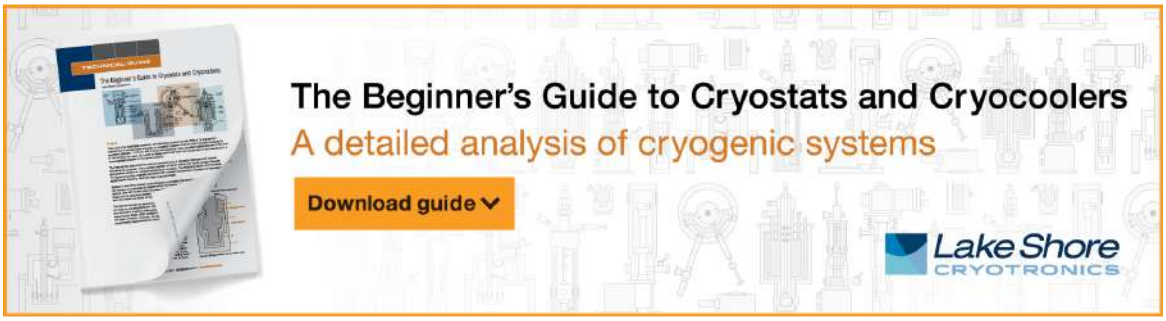

A Review On Biosynthesis Zinc Oxide Nanoparticles By Using Leaves Extract

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Abstract. A nanoparticle is a branch of nanotechnology that deals with nano-scale materials with very small particle sizes ranging from 1 to 100 nm. Metal oxide nanoparticles are more promising than the many other nanoparticles available because they have unique physical, chemical, and biological properties. Zinc oxide is one of the abundantly produced metal oxides after silicon dioxide and titanium dioxide. However, these methods of production are typically costly, labour-intensive, and can harm the environment and living organisms. Therefore, green synthesis (biosynthesis) is a good alternative where plants are used to assist nanoparticles synthesis which has eco- friendly benefits compared to chemical and physical methods. This biosynthesis method uses simple procedures, easily accessible raw materials, and a conducive environment for the synthesis process, where the precursors are safe and reduce the possibilities of harmful by-products being produced. Therefore, this review paper is focused on summaries of the biosynthesis of Zinc oxide nanoparticles from leaf extract such as *Mangifera Indica* (Mango), *Ixora Cocconea* (Jungle Geranium), *Corymbia Citridora* (Lemon-scented Gum) as a new development of green technology beneficial to the environment and to the plant itself. It also describes the progress made in the understanding of the mechanism routes reported in this review.

1. INTRODUCTION

The enormous potential of nanotechnology was just recently recognized, and it has since played a significant role in the globe. Metal oxide nanoparticles have more promise than other nanoparticles due to their unique physical, chemical, and biological features [1]. Titanium oxide (TiO_2), indium (III) oxide (InO_3), zinc oxide (ZnO), tin (IV) oxide (SnO_2), and silicon dioxide (SiO_2) are all metal oxides, with ZnO being the most prevalent after SiO_2 and TiO_2 [2]. Because of their smaller size and superior surface-dependent to volume ratio, ZnO nanoparticles have been shown to be more effective than ZnO microparticles [3]. ZnO nanoparticles are nanoscale metal oxide particles with a hexagonal crystal structure that exhibits unique features such as UV filtering, semiconducting, and photocatalytic activity [4]. Because of their widespread application, research on the manufacturing, properties, and characterisation of ZnO nanoparticles has gotten a lot of interest in the lates years [5]. Green synthesis and conventional chemical synthesis are two methods for producing ZnO [6]. Chemical synthesis is more cost-effective and yields a high yield using a minimal experimental setup [7]. These production methods, on the other hand, are typically costly, labour-intensive, and can affect the environment and living organisms [8]. As a result, there is a clear need for a more cost-effective, safe, and ecologically friendly

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technique for producing nanoparticles [8]. Many biological systems, including yeast, plants and algae, fungus, and bacteria, have been demonstrated to use the reductive capacities of their proteins and metabolites to transform inorganic metal ions into metal [8]. This review's goal was to summarise and conclude the green manufacturing of zinc oxide nanoparticles utilising leaves extract. This study will help researchers to understand the detail of leaves extract as reducing and stabilizing agent for the biosynthesis of ZnO nanoparticles.

2. MATERIALS AND METHODS

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study. In this section also describes the various stages of the biosynthesis of ZnO nanoparticles processes by using plants which is specified by leaves extract generally. From the material preparation, until the characterization of ZnO nanoparticles will be discussed.

Preparation of Plant Extract

Plant materials (such as leaves) are normally carefully cleaned with deionized or distilled water before being employed in the manufacture of ZnO nanoparticles. After that, the leaves are equally chopped into little pieces and dried (either sundried or room temperature drying). Extracts are made by weighing a portion of the dried sample and heating it in deionized or distilled water (according to the desired concentration). Another alternative is to weigh a portion of the dried sample, pound it in a mortar, grind it into powder, and then boil it to the desired concentration while stirring continually. The filtrate (liquid component) is employed in the tests after filtering the solution with Whatman paper [9].

Biosynthesis of Zinc Oxide Nanoparticles

In a typical experiment to generate ZnO nanoparticles from plant extract, 2 g of a zinc precursor (such as zinc acetate or zinc nitrate) is added to 40 mL of extract solution, agitated for 15 minutes, and then placed in a water bath shaker for 3 to 6 hours at 60 to 80 °C. The solution is heated and calcined at 400 degrees Celsius. Another option is to add the same amount of zinc precursor to the extract and then boil it at the right temperature and for the right amount of time to guarantee efficient mixing. After a period of incubation, the mixture turns yellow, indicating the formation of ZnO nanoparticles [9].

Characterization Techniques of Zinc Oxide Nanoparticles

Nanostructure is characterised by a variety of methodologies and techniques. In general, two procedures are used: one to characterise and confirm the nanostructure's morphology, and the other to evaluate the nanostructure's chemical characteristics. The approaches chosen will most likely be influenced by the study's nature and intended uses. Various approaches and procedures showed diverse morphological and chemical forms of the nanostructure, each with its own set of attributes. In order to provide accurate results, the instrument class, sample pre-treatment, and experiment condition were all considered. Most nanostructure experiments used UV-Vis, XRD, TEM, FTIR, SEM, FESEM, and EDX techniques [10 - 16]. In this paper, only UV-vis, XRD and SEM results were focused.

3. RESULTS AND DISCUSSION

In this section, introduction regarding the characterization of nanoparticles of the biosynthesis of Zinc oxide nanoparticles from leaf extract for *Mangifera Indica* (Mango), *Ixora Cocconea* (Jungle Geranium) and C*orymbia Citriodora* (Lemon-scented Gum). Each of leaf extract will be characterized by SEM, XRD and UV-Vis.

Characterization of Nanoparticles for *Mangifera Indica* (Mango)

UV-vis spectrophotometric measurement was used to confirm the nanoparticles' production. The white precipitate obtained after adding plant extract to zinc nitrate hexahydrate. The appearance of white precipitates is a sign that the synthesis of ZnO nanoparticles has gone well [13]. EDX Analysis conducted determine that only distinct peaks obtained for zinc and oxide were observed. No additional peaks were observed, demonstrating the purity of the ZnO nanoparticles.

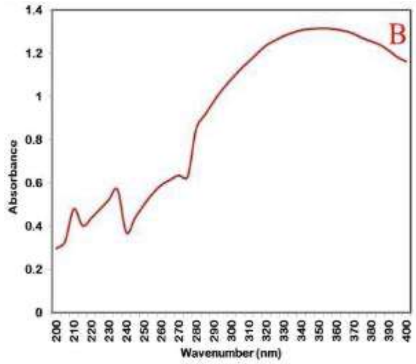

FIGURE 1: Zinc oxide nanoparticles produced with *Mangifera Indica* leaves were studied using UV-vis spectroscopy (Reprinted with permission from [13]).

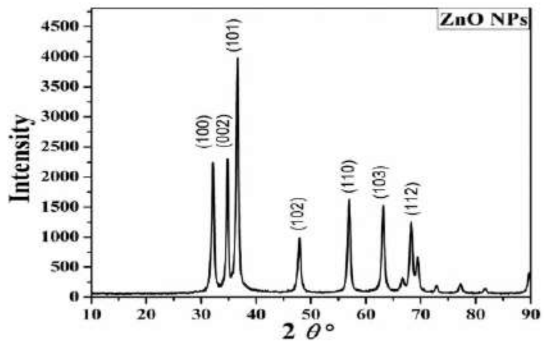

FIGURE 2: XRD analysis of zinc oxide nanoaprticles synthesized using *Mangifera Indica* leaf extract (Reprinted with permission from [13]).

Previous research has found that UV-vis spectra can be used to predict the size and form of nanoparticles. After 6 hours of incubation, UV-vis spectrophotometric spectra revealed an absorption peak at 355 nm, indicating the presence of ZnO nanoparticles (Fig. 1) [13].

The crystalline nature of the nanoparticle was determined via an XRD examination. The hexagonal wurtzite crystal structure of the nanoparticles was represented in Fig. 2 by XRD peaks obtained at two values 31.86°, 34.72°, 36.57°, 47.66°, 56.89°, 61.74°, 68.69° corresponding to lattice plane (100), (002), (101), (110), (103), (112) according to JCPDS card (NO-36-1451) [13]. Lattice planes (100), (002), and (101) indicate the presence of a pure form of nanoparticles. Nanoparticle size was calculated using Debye-Scherrer equation

$$D = \frac{K\lambda}{\beta \, Cos \, \theta} \tag{1}$$

Where, D = average particle size (nm)
K = shape factor
λ = X-ray wavelength (1.5406 A)
β = full width at half maximum (FWHM)

The average crystal size of the nanoparticles was calculated using the equation above and found to be 47.70 nm.

SEM analyses are commonly used to identify surface morphology. Figure 3 shows four SEM images of ZnO nanoparticles taken at various magnifications. The image clearly shows spherical and hexagonal shaped nanoparticles. SEM analysis estimated the average size to be 60 nm [13].

Characterization of Nanoparticles for *Ixora Coccinea* (Jungle Geranium)

The optical absorption spectra of zinc oxide nanoparticles were recorded using a UV/VIS 3000 + Double Beam UV Visible Ratio-Recording Scanning Spectrophotometer from Lab India (SKU: 174- 0020) with dimensions of (W D H)/Weight = 540 440 390 mm/36kg. The Spectrophotometer has a wavelength range of 190 to 1100 nm and a spectral bandwidth of 0.5, 1, 2, 5 nm. Figure 4 shows the UV-Vis absorption spectrum of zinc oxide nanoparticles. The absorption spectrum of the material was examined between 280 and 420 nm [8]. The absorbance peak at 340 nm, which corresponds to the characteristic band of zinc oxide nanoparticles, was visible in the spectrum [14].

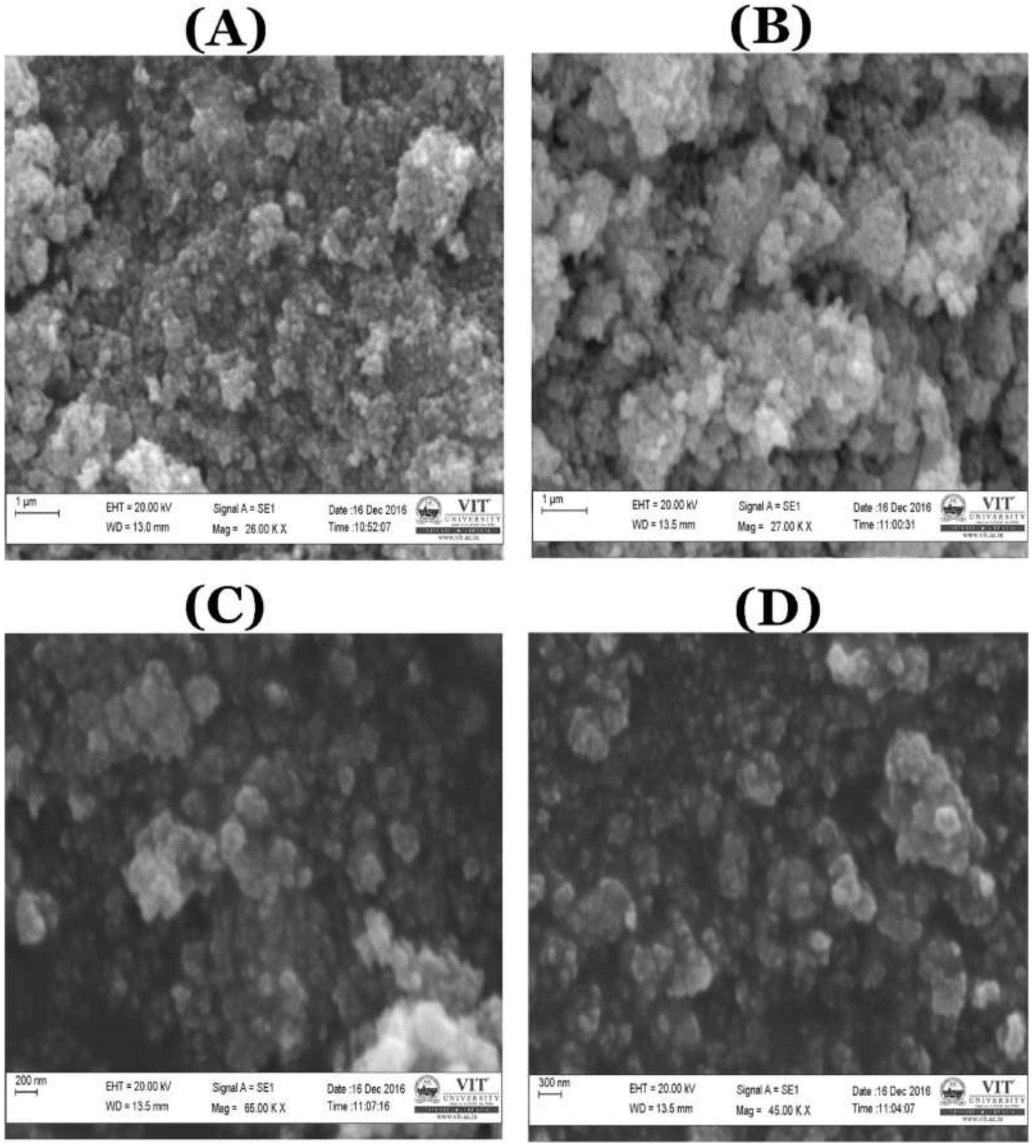

FIGURE 3: SEM analysis of synthesized zinc oxide nanoparticles in different magnification ranges (A) 26 KX (B) 27 KX (C) 65 KX (D) 45KX (Reprinted with permission from [13]).

Figure 5 shows the X-Ray diffraction (XRD) pattern of produced zinc oxide nanoparticles from *Ixora Coccinea* leaves. A normal focus diffractometer (Rigaku Miniflex, Japan) source Cu target at 30kV and 15 mA was used with scan rate of 3°min. The data was collected in the range of 5θ to 80θ and analysed with the help of the Jade 6.0 software. At 31.84°, 34.52°, 47.64°, 56.7°, 63.06°, 68.1°, and 69.18°, the X-Ray diffraction pattern reveals 2θ values: 31.84°, 34.52°, 47.64°, 56.7°, 63.06°, 68.1°, and 69.18°. Zinc oxide wurtzite structure might be attributed to all visible peaks (JCPDS Data Card No: 36-1451). Hexagonal wurtzite and cubic zincblende are the two major types of zinc oxide crytallization. The wurtzite structure is the most stable under normal conditions, hence it is the most frequent [8]. It also confirms that the produced nanopowder was impurity-free because it lacks any XRD peaks other than zinc oxide peaks [15].

The morphology of the produced nanoparticles was examined using scanning electron microscopy. At various magnifications, Fig. 6(a) and (b) demonstrate the surface morphology of zinc oxide nanoparticles. The majority of the nanoparticles are spherical in shape, with sizes ranging from 80 to 130 nm, according to the SEM image [8].

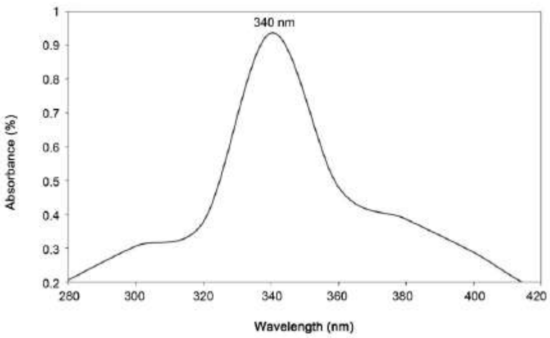

FIGURE 4: UV-Vis spectrum of synthesized zinc oxide nanoparticles [8].

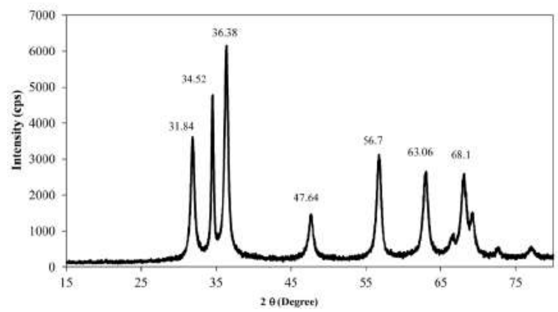

FIGURE 5: XRD pattern of synthesized zinc oxide nanoparticles of *Ixora Coccinea* leaves [8].

Characterization of Nanoparticles for Corymbia Citriodora (Lemon-scented Gum)

Figure 7 shows the UV–VIS absorption spectrum of biosynthesized ZnO nanoparticles. As a result of electron transfers from the valence band to the conduction band, the spectrum has a distinct absorption peak at 386 nm [16]. Figure 8 represents the XRD pattern of biosynthesized ZnO nanoparticles, the peaks at 32.1°, 34.6°, 36.1°, 47.7°, 56.4°, 63.1°, and 68.1° can be indexed to hexagonal wurtzite ZnO (JCPDS 36– 1451).

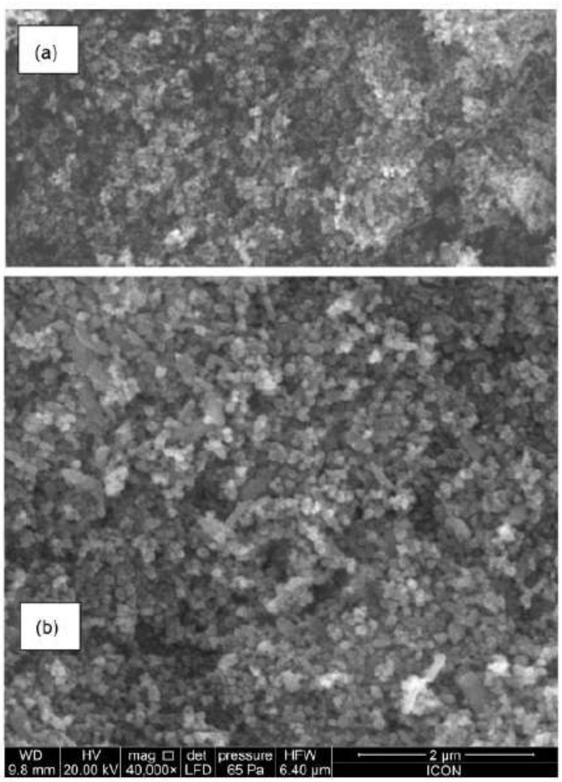

FIGURE 6: (a) and (b) SEM image of synthesized zinc oxide nanoparticles of Ixora Coccinea leaves [8].

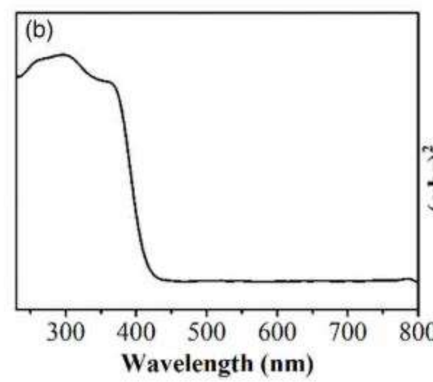

FIGURE 7: UV-Vis spectrum of the biosynthesized ZnO nanoparticles [16].

Additionally, no other peaks were seen in the sample, indicating that the biosynthesized ZnO nanoparticles are of great purity. The spectrum of sample from EDX analysis presents the only existance of O and ZN. The mean crystallographic size was determined from the XRD peaks using Scherrer's equation and found to be 21 nm [16]. During biosynthesis, the formation of ZnO nanoparticles could be seen visually. The colour of the reaction solution progressively changed from yellowish-green to pale white after many hours of combining the leaf extract with zinc nitrate. Figure 9 shows a SEM image of biosynthesized ZnO nanoparticles.

The dispersibility of ZnO nanoparticles reduced by Corymbia Citriodora leaf extract is demonstrated to be excellent. This excellent dispersibility could be attributed to the organic compounds that adsorb on the surface of ZnO nanoparticles from Corymbia Citriodora, resulting in sufficient surface charges between individual ZnO nanoparticles [16].

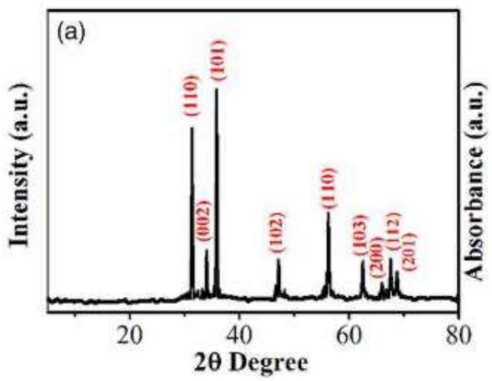

FIGURE 8: XRD pattern of biosynthesized ZnO nanoparticles of *Corymbia Citriodora* Leaf [16].

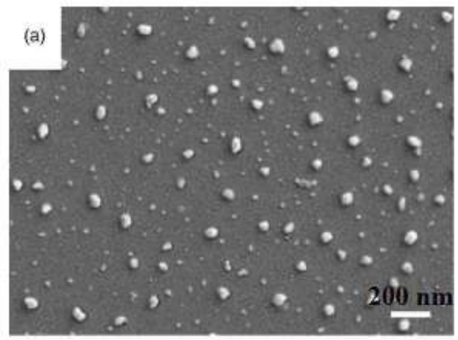

FIGURE 9: SEM image of biosynthesized ZnO nanoparticles of Corymbia Citriodora Leaf [16].

4. CONCLUSION

Biosynthesized ZnO nanoparticles are non-toxic and ecologically benign, and the cost-effective and simple synthesis processes have inspired greater research in the field of green synthesis. Despite the fact that chemically manufactured ZnO nanoparticles have great degradation efficiency of various water contaminants, biosynthesized ZnO nanoparticles are preferred since they are non-toxic and environmentally benign. As a result, more attention should be made on the production of green ZnO nanoparticles, which would assist to decrease environmental toxicity to some extent.

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