

# Zinc oxide Nanoparticles: Green Synthesis, Characterization, Physicochemical Performance and Anti-oxidant Properties

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## Abstract

**Background:** A growing amount of interest has been shown in the biosynthesis of metal-oxide nanoparticles by the utilization of plant extracts. Zinc oxide nanoparticles are one of the essential materials for preparing nanoscale systems.

**Objective:** The objective of the current research is to green-synthesize zinc oxide nanoparticles and study their chemical and physical properties.

**Methods:** In the study, Zinc oxide nanoparticles (ZnO-NPs) were prepared from Musa SP as one of the significant plant extracts using banana peels, and these extracts were used to produce nanoparticles for many minerals and aspects. This study clarifies ZnO-NPs physical and chemical characteristics accurately and demonstrates the significance of ZnO extract in many fields of life. The most important of which are Ag, Au, as well as oxides of some metals such as Cu, ZnO, and Fe<sub>2</sub>O<sub>3</sub>.

**Result:** These nanoparticles were diagnosed using infrared spectroscopy (FTIR) to determine the ions' positions, X-ray diffraction (XRD) to consider the crystal structure, light-emitting scanning electron microscope (SEM) to prove the shape of the surface, and finally UV-Vis spectroscopy to identify the compound ZnO.

**Conclusion:** Through these measurements, the physical and chemical properties of the material were studied found in this research that the small sized ranging from (40) to (70) nm, and the production of nanoparticles at the peak of the spectral emission of (420) nm, also this results show that ZnO-NPs had anti-oxidant properties, which were determined clearly by two procedures, DPPH and total antioxidant.

**Keywords:** Zinc oxide nanoparticles, Musa SP extract.

## 1. Introduction

In recent years, interest has been increasing in preparing nanoscale metal oxides, due to their many applications. The different properties that change dramatically at the nano scale [1]. Zinc oxide nanoparticles are the most important material for manufacturing nanoscale systems and nanoscale devices, due to their important properties such as semiconductor, electromagnetic, and piezoelectricity [2]. Zinc oxide nanoparticles can be manufactured by many methods, such as deposition, the sol-gel method, and the hydrothermal method [3]. Add to those methods, pulsed laser, chemical vapor deposition, and thermal evaporation[4], [5].

Nano zinc oxide is one of the most famous metal oxides because of its many properties. It is safe and non-toxic [6]. It is used in the manufacture of dyes, rubber, sunscreens, and cosmetics [7]. ZnO is an inorganic compound in the form of white powder. It is one of the semiconductors widely used in many fields, such as solar cells, electrical and photovoltaic devices, lighting devices, and lasers [8], [9]. It is also used in the medical field because of its distinctive and interesting physical and chemical properties [10]. It also has electrical and optical features that make it crucial in many fields [11]. Nano-technology has many applications, including cancer treatment and making home appliances, food, and environmental applications [12]. Also, environmental applications water purification and tissue engineering [13]. In this way, we were able to get nanoparticles with a large surface area. It is an attractive method for preparing nano-Zinc oxide, as it is inexpensive, it gives results on a small and homogeneous scale, with a large surface area which is a necessary requirement for the use of this oxide [14]. Recently, nanotechnology has developed greatly in bio. and environmentally friendly synthesis for the production of nanoparticles [15], [16].

Nanoparticles are classified into two categories: organic nanoparticles, which include aggregates of carbon such as graphite oxide nanoparticles, carbon nanotubes, and carbon nanoparticles [17], [18]. The second category is inorganic nanoparticles, which include magnetic particles, particles of metals, for instance, gold, silver nanoparticles, titanium, and copper. These metal particles are among the most important particles due to the increasing need for the *Musa SP* and their production in a safe and environmentally friendly manner at the lowest cost and toxicity [19]. Among these oxides is ZnO, which is the most vital material in the production of nanoscale devices due to its various properties, namely, electromagnetism [2]. ZnO is found in 1D, 2D, and 3D structure [20].

The banana plant is one of the important plants that has been used a lot in the manufacture of nanoparticles. As in the study in which the researcher prepared ZnO-NPS from banana peels, they efficiently control the growth of microbes. The researcher used them against plant pathogens that infect fungi in orchids because of the development of resistance to fungicides and the increase in the incidence of toxic effects of fungicides on non-target organisms, which causes significant losses in production [21]. Most of the researchers prepared nanoparticles from the peel of the banana plant and used them as an antibacterial, but in this study, ZnO-NPs were prepared from banana peels, and their chemical and physical properties were studied in a clear and detailed way to know and explain the importance of this nano extract in many areas of life.

## 2. Material and Working Methods

This method was followed by (Bashi 2013) [22]. With some changes, the *Musa SP* plant was used in the procedure of ZnO nanoparticles by preparing the plant extract, which involved taking the peels of the plant, then drying and grinding them thoroughly. From there, taking (100 gm) of dried plant peels powder in the shade to (100 ml) of distilled water and then heating it to a temperature of 80 C° for 20 minutes. After that, the cooling and then the plant extract are filtered. Later, prepare (50 ml) of Zinc diacetate solution and add the plant extract to it. Then, one can notice the color change of the mixture, which indicates the formation of ZnO nanoparticles of different shapes and sizes, ranging between (40–70) nm [23], [24]. This method is similar to the method of preparing iron oxide nanoparticles, using the extract of the Iraqi yellow lemon plants, in which the nanoparticles oxide was prepared from the yellow lemon plant, and the prepared particles were identified using infrared spectrometers, X-ray geodes, FESEM, and EDX, which falls within.



**Fig. 1** a) Musa SP leaf extra. b) Nano Musa SP leaf extract)

## 2.1. Characterization

The X-ray diffraction technique (Philips, X'pert, Pro-MPD, Cu-Ka 40 kV, 20mA) can be applied to estimate the purity of phases and the structural characteristics of ZnO nanoparticles created. The study was conducted using Cu-Ka radiation for scanning speed at 2°/ minute and scanning from (20° to 80°). Turned off at a 2-hour period, at an interval of 0.02°, with the X-ray tube voltage of 40 kV and a current of 30 mA. The X-ray radiation had a wavelength of approximately 1.54070 Å. The FTIR spectroscopy was used to determine the functional groups of ZnO nanoparticles between (4000 cm<sup>-1</sup> and 400 cm<sup>-1</sup>). It used scanning electron microscopy (SEM) to examine the surface morphology of the nanoparticles. Then, the UV-Vis NIR spectro-photometry (Lambda 750 UV-VIS-NIR, PerkinElmer, USA) was used to measure the UV-Vis spectra of the synthesized nanoparticles over a wavelength range between (200 –700) nm.

## 2.2. Antioxidant Assay

The antioxidant activity of *A. muricata* fruit extract and green-synthesized ZnO-NPS was estimated using two methods: DPPH and total antioxidant. In the two procedures, Gallic acid (GA) was used as a positive oversight and *A. muricata* extract was used as a monitoring.

## 2.3. DPPH Radical Scavenging Assay

Antioxidant activities of both Musa SP extract and green synthesized of ZnO-NPs were calculated using the 1,1-diphenyl-2-picryl-hydrazyl (DPPH) assay with some modifications, as conducted by Villano et al., [25]. From each concentration used (1 ml) (100-500 mg in ethanol) of Musa SP extract and green-synthesized ZnO-NPS were mixed with an equal volume of DPPH solution. The absorbance of mixtures was measured at  $\lambda_{max} = 517$  nm after being incubated in the dark at room temperature for 1 hour. The sample's capacity to scavenge DPPH radicals is determined by the formula below, Equation (1):

$$\text{DPPH scavenge effect} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (1)$$

Where **A control** is the absorbance of the control samples (DPPH solution without samples), and **A samples** is the absorbance of the sample (DPPH solution and samples).

### 3. Results and Discussion Section

#### 3.1. X-Ray Diffraction

A study of the crystal structure, the structural characterization is analyzed to obtain information about particle size, crystal structure, and surface shape [26]. Where x-ray diffraction is considered to be a successful method for determining the structure of crystallized bodies. A substance is a polycrystalline particle consisting of a large number of particles called a single crystal, which is a group of atoms stacked in a regular manner and described by crystal levels [27], [28]. In this work, the particles were subjected to X-ray diffraction, as shown in the X-ray diffraction spectrum of ZnO nanoparticles synthesized by the plant extract. It can be seen from Fig. 2 that the obtained peaks at (111), (200), (220) agree with the Bragg reflections for the angles (24.80), (37.50), (53.11). This figure and the results confirm the examined substance of ZnO and that it is a substance of high purity.

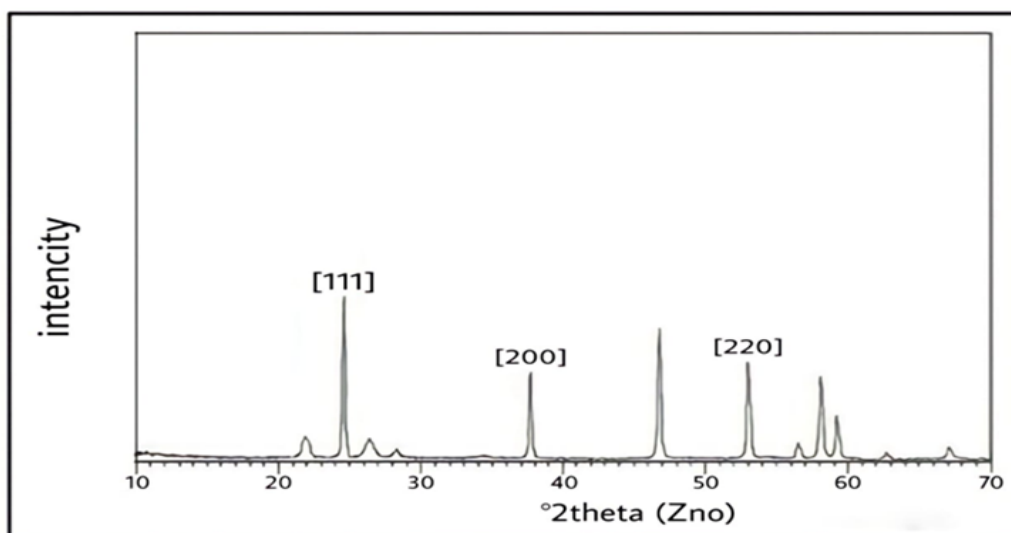


Fig. 2 The X-ray diffraction of ZnO nanoparticles

#### 3.2. Field Emission Scanning Electron Microscopy

The prepared ZnO nanoparticles were field emitting scanning microscope (FESEM). In this study, the FESEM measurement was used to verify the surface shape of the ZnO particles that were biosynthesized by the *Musa SP* plant. It can be noticed from Fig. 3 that these particles are multi-shaped and irregular, which can further the success of the study in achieving good results in reaching nanoparticles with a small size ranging from (29 - 44) nm as shown in Fig. 3 [5].

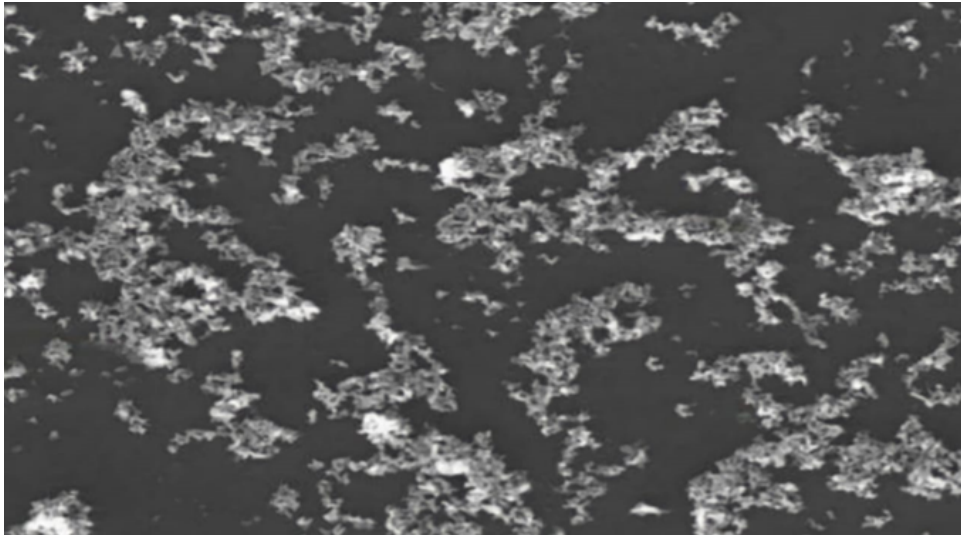


Fig. 3 FESEM images of ZnO nanoparticles

### 3.3. Fourier Transform Infrared (FTIR)

Fourier transform infrared spectroscopy, this measurement was used to analyze the aggregate pressure in the prepared material [29]. The FTIR measurement is one of the important tests, and it is crucial to obtain information about the position of ions in the crystal structure. It is used to determine the effective groups, and each compound has its own absorption. As a result, FTIR records showed the presence of the packages. The clear infrared peaks appeared at (3458.48), (3032.21), (1519.91)  $\text{cm}^{-1}$  in the intense broad band at (O-H), (C-H), (C-C) as shown in Fig. 4.

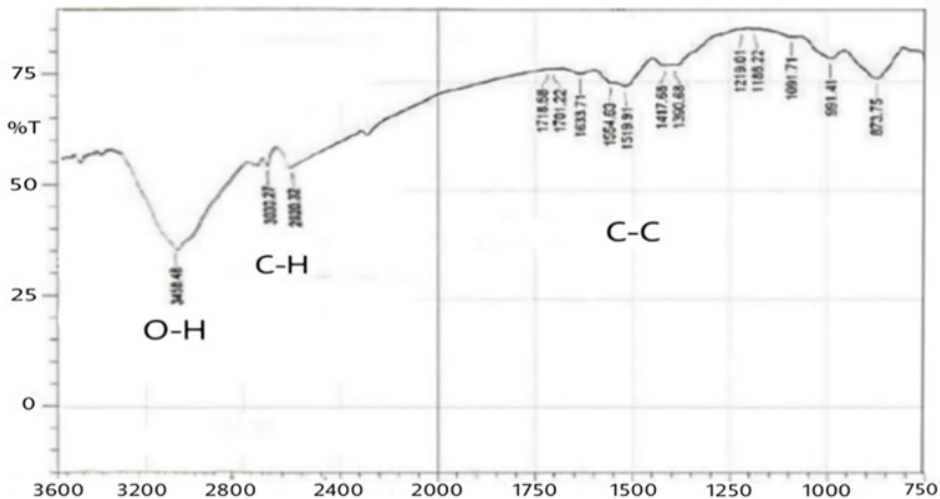
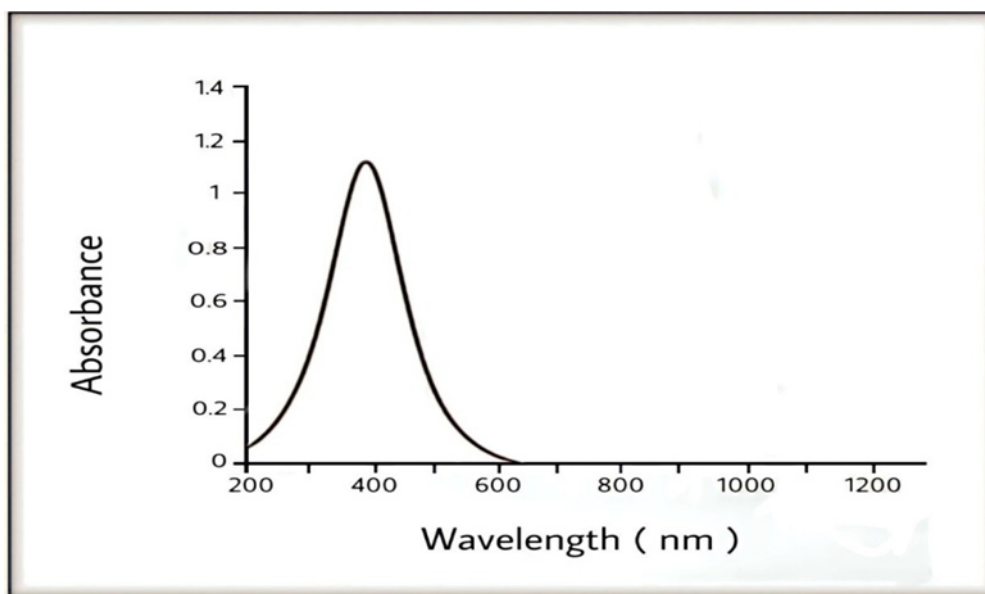


Fig. 4 FTIR spectrum of ZnO nanoparticles

### 3.4. Ultraviolet - Visible Spectroscopy

The results of the visible ray's examination of the extract of the Musa SP plant and Zinc oxide nanoparticles within the visible spectrum of the electromagnetic spectrum showed that the measurement of the UV and visible spectrum displayed the ability of the plant extract to produce Zinc oxide nanoparticles. Fig. 5 shows the production of nanoparticles at the peak of the spectral emission of (420) nm.

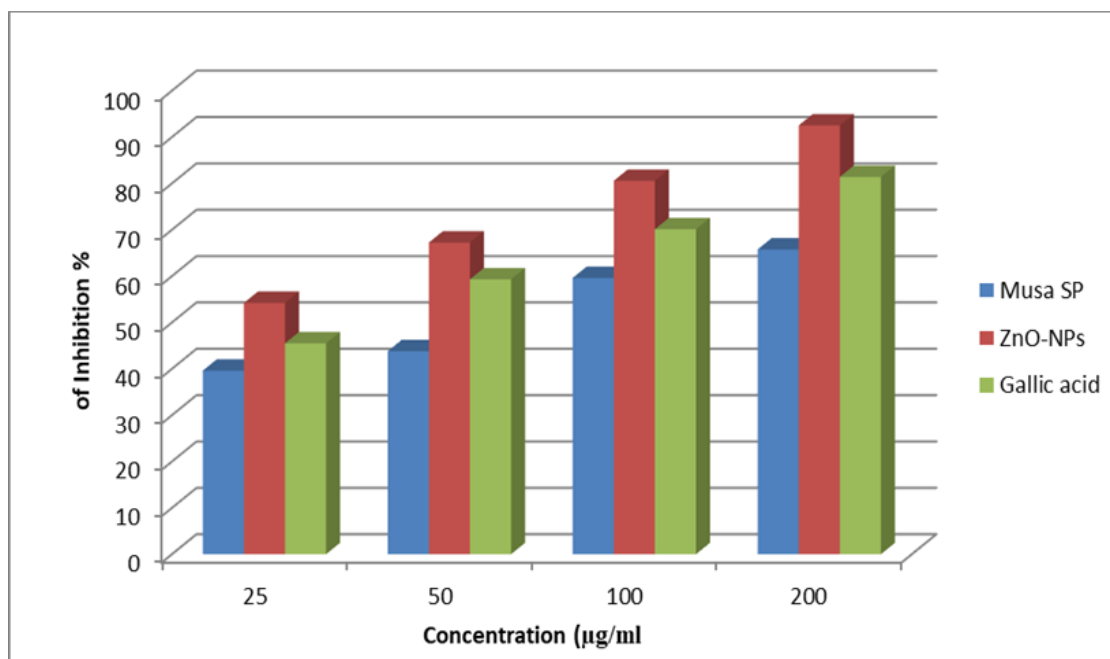


**Fig. 5** UV spectrum of ZnO nanoparticles

### 3.5. Anti-oxidant Activity of Green Synthesized ZnO-NPS

Two ways were used to measure the antioxidant activity of *Musa* spp. Extract and green-synthesized ZnO nanoparticles. This was done because there cannot be one universal way to accurately quantify the antioxidant properties of a substance. The DPPH assay is generally used to evaluate the ability of medicinal plant extracts to scavenge free radicals [26]. The DPPH assay was also used to evaluate the antioxidant activity of ZnO nanoparticles. According to the results, the DPPH solution should change colour from purple to pale yellow, which proves that the DPPH radical is being dissipated, i.e., a transfer of hydrogen atoms reduced the DPPH radical to a colourless solution as shown in Fig. 6 [30]. The antioxidant capacity of both *Musa* spp. extract, and the green synthesized ZnO nanoparticles were compared to their antioxidant capacity against gallic acid using various concentrations, as shown in Fig. 6.

Despite using gallic acid for comparison, it was demonstrated that the ZnO nanoparticles had greater free radical scavenging ability than gallic acid when compared with the *Musa* spp. extract. The greatest free radical scavenging activity, as determined by the current study, belongs to the combination of both green ZnO nanoparticles and extracts from *Musa* sp at  $(92.51 \pm 1.3\%)$ ,  $(81.44 \pm 2.1\%)$ , and  $(65.75 \pm 1.2\%)$ , respectively. The findings from this study are very much in agreement with the findings of previous studies [31], [32]. In particular, there are a number of studies that report that green synthesis increases antioxidant activity compared with the conventionally produced ZnO nanoparticles reported through conventional chemical means; these compounds, including protein, polyphenols, fatty acids, and flavonoids, are connected with ZnO nanoparticles [33].



**Fig. 6** Anti-oxidant activity of Musa SP extract and green-synthesized ZnO-NPs using DPPH assay

#### 4. Conclusion

In the conclusion, ZnO particles were prepared in an environmentally friendly way by extracting banana peels. The properties of these chemical particles were studied through the FTIR assay. In this examination, the chemical bonds that bind the nanoparticles of the extract were known. The material's physical properties were also measured by knowing the shape of the particles and their external dimensions, as well as the properties of the sample surface and the size of the particles, which was found to range from 40 – 70 nm. The prepared nanoparticles were also diagnosed using X-ray diffraction; all these measurements confirmed the presence of the nanomaterial for ZnO, with small and ideal sizes. This method is one of the easiest ways to prepare nanoparticles as it is easy, inexpensive, and valuable in many applications.

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