

## Green Synthesis of Zinc Oxide Nanoparticles using extract of onion (*Allium cepa*) peel

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### Resumen

En el presente estudio, se sintetizaron nanopartículas de óxido de zinc mediante síntesis verde utilizando extracto de cáscara de cebolla (*Allium cepa*). El extracto se preparó calentando a 80 °C con agitación constante durante 30 minutos. Se sintetizaron muestras de nanopartículas de ZnO utilizando nitrato de zinc como precursor a temperaturas entre 70 y 80 °C hasta la formación de un coloide que fue calcinado a 200 °C por un período de 3 horas. Las nanopartículas de ZnO sintetizadas en verde se caracterizaron por difracción de rayos X utilizando el software Profex 4.3.4. Los resultados mostraron la formación de nanopartículas cristalinas de ZnO y partículas que oscilaban entre 21,4 y 38,1 nm. El alto grado de aglomeración muestra partículas en el rango micrométrico, pero el tamaño individual de las partículas se encuentra en la escala nanométrica.

Palabras clave: ZnO; Síntesis verde; Nanoestructuras

### Abstract

In the present study, zinc oxide nanoparticles were synthesized by green synthesis using extract of onion (*Allium cepa*) peel. The extract was prepared by heating at 80 C with constant stirring for 30 minutes. Samples of ZnO nanoparticles were synthesized using zinc nitrate as a precursor at temperatures between 70 and 80 °C until the formation of a colloid that was calcined at 200 °C for a period of 3 hours. The green synthesized ZnO nanoparticles were characterized by X-ray diffraction using Profex 4.3.4 software. The results showed formation of crystalline ZnO nanoparticles and the particles ranging between 21.4 and 38.1 nm. The high degree of agglomeration shows particles in the micrometer range, however, the individual size of the particles is in the nanometer-scale.

Keywords: ZnO; Green synthesis; Nanostructures

### 1. Introduction

The synthesis of nanomaterials using plants is an economic and ecological alternative. The biomolecules required for the reduction and stabilization of metal ions are already present in the plant extract. Akash et al. (2021) shows that green synthesis of nanoparticles (NPs) is a new research trend in nanotechnology. Furthermore, the green synthesized NPs are highly competent for recycling and removing heavy metals from wastewater and could solve various water quality problems around the world. Nanosorbent materials are considered the most efficient wastewater remediation methodology because it is easy to apply and there is a wide

range of adsorbents (Basheer, 2018). El-Sayed, M. E. (2020) reports that nanosorbents made from carbon tubes, polymers, zeolites, metals, and metal oxides have had an unprecedented influence on the wastewater treatment process. Likewise, nanomaterials are presented as the best feasible way to treat organic and inorganic contaminants due to their unique properties, such as a large surface area and a high adsorption capacity (Jiang et al., 2018).

Numerous studies have investigated the interaction of inorganic contaminants with nanosorbent materials. For example, Uddin and Baig (2019) used cobalt oxide nanoparticles to remove methyl orange dye; Dehghani et al. (2019) studied the removal of the pesticide diazinon from water using carbon nanotubes; Khan et al. (2016) illustrated the effect of using Fe\Cu binary oxides on the removal of hexavalent chromium from water; similarly, Cai et al. (2014) synthesized bimetallic Fe/Ni NPs embedded in kaolinite (K-Fe/Ni) for the simultaneous removal of Cu(II) and NO<sub>3</sub> with a removal efficiency of 99.7% and 40.4%, respectively. On the other hand, Alaa El Din Mahmoud et al. (2021) prepared environmentally friendly copper oxide nanoparticles (CuO NPs) by a green synthesis route without using hazardous chemicals and using extracts of mint leaves and orange peels as reductants for the removal of Pb(II), Ni(II), and Cd(II) obtaining a removal efficiency of 75% to 90%.

More environmentally friendly processes have been developed in recent years, researchers have recently focused on the so-called "green synthesis", in which compounds of microbial, animal and plant origin can be used both as economical forms of reduction of waste or as stabilizing agents in the manufacture of nanomaterials. Techniques for obtaining nanoparticles by green synthesis have been oriented towards the use of naturally occurring reagents such as vitamins, sugars, proteins, biodegradable polymers, microorganisms and plant extracts as reducing and stabilizing agents. Sugars such as glucose and fructose, water-soluble vitamins such as C and B12, contain radicals such as hydroxyls or aminos in their chemical structure that give them the characteristic of natural antioxidant agents that can effectively reduce metal ions in an aqueous solution to produce metallic nanoparticles and of metal oxides (Kharissova et al., 2013).

In recent years, green nanotechnology has achieved great interest; syntheses of functional nanoparticles from iron, zinc, copper and gold have been developed without the use of dangerous toxic products. Renuga et al. (2020) synthesized copper oxide nanoparticles using *Brassica oleracea var. Italic* (broccoli), the biological components contained in the plant, such as gluconosinolates, polyphenols, flavonoids, vitamins and nutrients acted as reducing agents. With copper acetate as precursor and at a reaction temperature of 80°C, copper oxide nanoparticles with an average size of 26 nm were obtained, which were show to have excellent antifungal activity against *Aspergillus niger* and *Candida Albicans*. Similarly, Akash et al. (2021) studied copper nanoparticles (Cu NPs) synthesized in the green route and used as nanoadsorbent for the removal of Ibuprofen, Naproxen and Diclofenac from wastewater. The best removal results were obtained at the temperature 298 K, pH 4.5, 60 min and the adsorption process was endothermic. Rajeshkumar and Rinhita (2018) synthesized copper NPs using the extract of the seed of *Persea Americana* (Avocado) as a reducer for copper sulfate, obtaining smaller NPs at a pH of 11, between the range of 42 to 90 nm. . The obtained NPs showed oxidant activity and excellent antimicrobial activity against plant disease pathogens *Aspergillus niger*, *Aspergillus fumigatus*, *Fusarium oxysporum*. Madhumitha et al. (2019) characterized and evaluated the antifungal and photocatalytic activity of ZnO nanoparticles synthesized from *Pithecellobium dulce* shell, obtaining irregularly shaped and highly monodisperse nanoparticles

with excellent photodegradation efficiency with respect to methylene blue dye, an important contaminant of water released by the textile industry. Nwanya et al.(2019) successfully used the aqueous extract of dried peel of *Zea mays L.* (corn) to obtain biosynthesized copper oxide nanoparticles and confirmed the effectiveness of copper oxide nanoparticles in the photodegradation of synthetic wastewater based on methylene blue dye and wastewater from industrial textile effluents. Madrigal Muñoz (2021) synthesized ZnO semiconductor nanoparticles from *Tilia L.* (tilo)extract for application in the treatment of water with organic contaminants, verifying the photocatalytic capacity of zinc oxide nanoparticles with methylene blue with a degradation of up to 100% in 100 min in a UV light reactor. Villegas Fuentes (2021) carried out the biosynthesis from *Arnica Montana L.* as a stabilizing agent of zinc oxide semiconductor nanoparticles for the photocatalytic degradation of dyes in wastewater, using methylene blue, obtaining a degradation of 92% in a period of 210 minutes under UV light. Kumar et al. (2022) carried out a review on bioactive compounds and biomedical activities of onion peels (*Allium cepa L.*), as concentrated sources of phytochemicals, total flavonoids, total polyphenols, quercetin and its derivatives make their application feasible in the biomedical and pharmaceutical fields.

Alshameri & Owais (2022) carried out a review about the antibacterial and cytotoxic potency of plants through the synthesis of Ag and ZnO metal nanoparticles, the results showed that both nanoparticles synthesized using plant extracts have excellent antibacterial and anticancer properties due to their biocompatibility and concluded that plant extracts used to manufacture metal nanoparticles and metal oxide nanoparticles are economical, environmentally friendly and provide maximum protection of human health. Synthesis based on plant extracts allows for more exact control of the shape of the nanoparticles, making these nanoparticles more suitable for medical purposes than those produced with toxic chemicals.

The objective of the present study is to synthesize nanoparticles and/or nanostructures of zinc oxides from a green route and using an organic reducer and show that the phytochemicals found in plant extracts are crucial and play an important role in the reduction of metal ions and their stabilization as nanoparticles.

## 2. Materials and Methods

The reagent used as precursor was zinc nitrate ( $Zn(NO_3)_2 \cdot 6H_2O$ ) from the Movilab brand. The onion was collected in the markets of Lima and the peel residues were used. For the characterization, the Bruker model D8 Advance diffractometer was used.

To prepare the extract, 20 g of onion peel, previously washed and dried at 50°C in an oven for 2 hours, were used. The dried shells were added to a beaker with 100 mL of distilled water and heated for 30 minutes at a temperature of 80°C. Once the solution was cold, it was filtered through Whatman No. 4 paper and the filtrate was stored at 4°C for later use.

Zinc oxide nanoparticles were synthesized by adding 2 g of the precursor zinc nitrate to 50 mL of onion extract. The solution was stirred using a magnetic stirrer at temperatures between 70°C and 80 °C for a couple of hours. The appearance of a brown colloid demonstrates the formation of zinc oxide nanoparticles. Finally, the precipitate is dried in a muffle at 400°C for three hours obtaining a white ZnO powder (Figure 1).

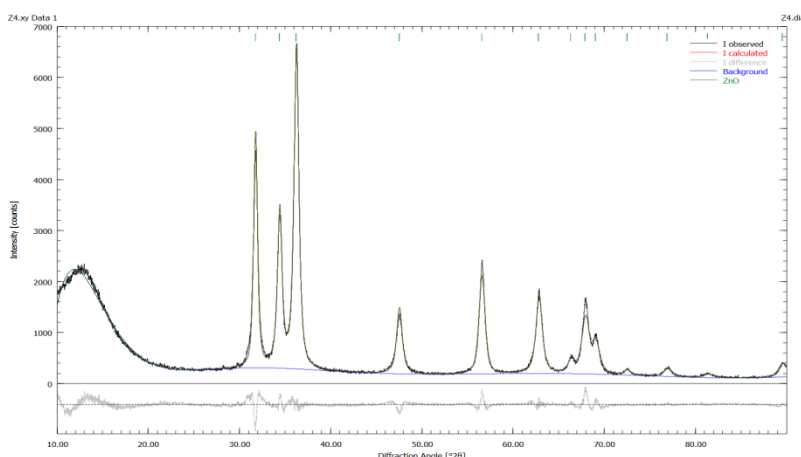
### 3. Results

In Figure 1 shows the powder obtained from the ZnO nanoparticles after calcination. Studies have highlighted the presence of phenolics, flavonoids, anthocyanins, vanillic acid and ferulic acid in onion, they have also indicated that onion peel is a more concentrated source of phytochemicals than edible pulp, being Quercetin, the main phenolic compound in onion peel (Kumar et al., 2022). The flavonoids present reduce metal ions to produce stable metal nanoparticles (Ettadili et al., 2022). The ability of flavonoids to chelate metal ions is known because of the presence of hydroxyl and carbonyl functional groups (Alshameri & Owais, 2022).



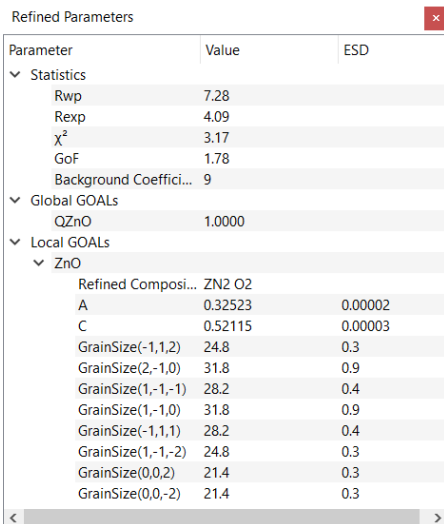
*Fig. 1. Image of the ZnO nanoparticles obtained from the green synthesis.*

For the analysis of the diffractogram obtained by XRD, the free Profex 4.3.4 software was used. The Figure 2 displays the diffractogram obtained for the sample synthesized from onion peel. The adjustment with the software shows a qualitative analysis of 100% zinc oxide. No additional diffraction peaks corresponding to impurities were detected, indicating that relatively pure ZnO was obtained. Stan et al. (2015) synthesized from onion and garlic peel extracts (*Allium sativum*, *Allium cepa*) ZnO nanoparticles with a hexagonal wurtzite structure without additional diffraction peaks and showed with FTIR spectra the biomolecules present in the plant extracts and their influence on the properties of ZnO nanoparticles.



*Fig. 2. XRD diffractogram of the ZnO nanoparticles obtained from the green synthesis.*

Likewise, the Figure 3 shows the parameters of the particle refinement where an average crystallite size between 18.5 nm and 31.8 nm can be observed.



Parameter	Value	ESD
Statistics		
Rwp	7.28	
Rexp	4.09	
$\chi^2$	3.17	
GoF	1.78	
Background Coeffici...	9	
Global GOALs		
QZnO	1.0000	
Local GOALs		
ZnO		
Refined Composi... ZN2 O2		
A	0.32523	0.00002
C	0.52115	0.00003
GrainSize(-1,1,2)	24.8	0.3
GrainSize(2,-1,0)	31.8	0.9
GrainSize(1,-1,-1)	28.2	0.4
GrainSize(1,-1,0)	31.8	0.9
GrainSize(-1,1,1)	28.2	0.4
GrainSize(1,-1,-2)	24.8	0.3
GrainSize(0,0,2)	21.4	0.3
GrainSize(0,0,-2)	21.4	0.3

Fig. 3. Refined parameters for average crystallite size..

## 4. Conclusions

The present study shows an easy and environmentally friendly procedure for obtaining zinc oxide nanoparticles using onion peel extract free of toxic compounds and rich in phytochemicals, which, through the action of a reducing agent, allow the reduction of metal ions. The XRD results confirm the purity of the ZnO nanoparticles obtained and refinement with the Profex 4.3.4 software determines an average crystallite size between 18.5 nm and 31.8 nm.

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