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ORIGINAL RESEARCH ARTICLE

# Green synthesis of zinc oxide nanoparticles using *parsley* extract

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**ABSTRACT**

**Objective(s):** In recent years, green synthesis of nanoparticles is under exploration due to wide medicine and biological applications and research interest in nanotechnology. Green synthesis of zinc oxide nanoparticles (ZnO NPs) is becoming increasingly importance as eco-friendly. The objectives of this study were the production of zinc oxide nanoparticles using *parsley* extract.

**Methods:** In the present study, ZnO NPs were synthesized from an extract of *parsley* at different temperatures (at room temperature and 90°C) and obtained the optimum time for preparation of ZnO NPs. The samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), Dynamic light scattering (DLS), and Diffuse Reflection Spectroscopy (DRS). The antibacterial activities of the samples were determined against *Escherichia coli (E. coli)*.

**Results:** XRD results of ZnO NPs were correctly synthesized and crystalline structure was similar to the previously reported pattern. The nanoparticle morphology was observed for ZnO nanostructured based on the SEM images. DLS analysis showed samples in the nanometer scale. The DRS absorption spectra of nanoparticles showed the Ultraviolet (UV) protective properties. The antibacterial activities against *E.coli* were observed because of the presence of ZnO NPs.

**Conclusions:** This result showed that the *parsley* extract is good candidate for the synthesis of ZnO nanoparticles with antibacterial activities against *Escherichia coli*. The result indicated that ZnO NPs can have a good potential for different applications.

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## INTRODUCTION

Today, nanotechnology has considerably enhanced and resulted to expand several technologies [1]. The nanoparticles have dimension between 1 and 100 nm and great importance due to small size and high surface area that resulted to unique properties [2]. Zinc oxide is biocompatible and safe that can be used in medical applications easily without overlays. The zinc oxide can create a variety of research fields in the future because of special properties [3-5]. Prolonged exposure to ultraviolet radiation can cause at increased risk for skin cancer and ocular damage [6,7]. The UV radiation divided to three regions UV-A in the range of 320–400 nm, UV-B from 280 to 320 nm, and UV-C from 180 to 280 nm with the potency as UV-C > UV-B > UV-A [8]. The UV-blocking property of ZnO has been interest because of the hazardous effects of UV-A, UV-B and UV-C exposure to the skin. Exposure to UV-A has been shown to decrease the immunological

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response of skin cells and produce signs of aging. Recently, the effect of morphology was reported on UV-blocking for ZnO nanoparticles [9].

The ZnO nanostructures have can be fabricated by different methods and resulted samples have good potential applications. The preparation methods can be effect on size and shape of products such as chemical precipitation [10], thermal decomposition [11], and green chemistry [12-19]. The chemical methods have several disadvantages including insolubility, dissolution of particle size, nanoparticle impurity, low efficiency, and the need for advanced equipment for production [20-23]. The researchers have come up the biological systems as simple and biocompatible methods for the production of nanoparticles with minimal environmental hazards [24]. Many living organisms have been used to synthesize nanoparticles such as bacteria [25,26], fungi [27], microalgae and macroalgae [28,29], herbs, herbal extracts and their metabolites and others [30]. But biosynthesis of nanoparticles have greatly attracted for the identification of plant systems as agent production of nanoparticles. The preparation of nanoparticle by green synthesis is done using the present of natural and biological agent in plant extracts. The synthesis of nanoparticles by natural resources leads to reduction of synthesis stages, energy use, chemical solvent, and environment damage [31,32].

Recently, the ZnO nanoparticles have been reported as antibacterial activities using chemical method and aloe vera leaves as green synthesis on the culture medium of *Staphylococcus aureus* and *Escherichia coli* as bacterial [33]. Antibacterial activities of ZnO nanoscale were quantitatively evaluated using aloe vera leaves and chemical synthesis in culture media against *Staphylococcus aureus* as Gram-positive bacteria and *Escherichia coli* as Gram-negative bacteria [34]. In this research, in order to achieve the goals of green chemistry, the synthesis of zinc oxide nanoparticles was carried out using *parsley* extract as a source of biosynthesis without using chemical agents for reducing and stabilizing to develop the multipurpose application.

## MATERIALS AND METHODS

### *Materials*

All chemicals used were analytical grade. Ultra-pure water was used for the preparation of all reagents solutions. The materials used for the synthesis of the ZnO NPs were: zinc acetate dehydrate ($Zn(O_2CCH_3)_2$) as zinc precursor purchased from Merck (Germany), and *parsley* aqueous extract as reducing agent bought from (Adonis Gol Daro,Iran).

### *Synthesis of ZnO nanoparticles*

For the biosynthesis ZnO nanoparticles, the amount of 5 g zinc acetate dehydrate was mixed with 50 ml of *parsley* aqueous extract at room temperature and at 90°C under constant stirring and studied the optimum time. ZnO NPs were prepared after 72 h at room temperature and after 24 h at 90°C.

### *Characterization*

The crystalline structure of nanoparticles was investigated by X-ray diffraction utilizing Cu Kα X-ray radiation with a voltage of 40 kV and a current of 30 mA by X'pert pro diffractometer (ASENWARE, AW-XBN300, China). Scanning electron microscope was employed to observe the morphology and size (KYKY, EM3200, China). Dynamic light scattering was reported the size and size distribution of nanoparticles (ZEN314, England). Diffuse Reflection Spectroscopy was investigated the UV protective properties of nanoparticles (UV2550, Shimadzu). The antibacterial activities were evaluated by disk diffusion method against *Escherichia coli* bacteria, ATCC 1399, that procured from Islamic Azad University.

## RESULTS AND DISCUSSION

### *XRD*

The XRD pattern of samples was measured in 2θ range 10-100° that used to identify the crystalline structure of ZnO NPs. Based on the results, the crystalline structure of ZnO nanoparticle was maintained at room temperature and at 90°C (Fig. 1). The peaks at 31.78, 34.44, 36.28, 47.55, 56.62, 62.83 and 67.96° attributed to (100), (002), (101), (102), (110), (103) and (112) crystal planes respectively, which correspond to wurtzite crystalline with hexagonal structure (JCPDS card No. 36-1451). There was no extra peak in the XRD pattern for ZnO NPs that confirmed the synthesized pure ZnO NPs and the absence of impurities in it. Also, due to the presence of sharp and narrow peaks in the XRD spectrum, it can be concluded that zinc oxide has a good degree of crystalline structure. The XRD pattern is according to studies of Çolak, Luque, and coworkers in 2017 [14,16].

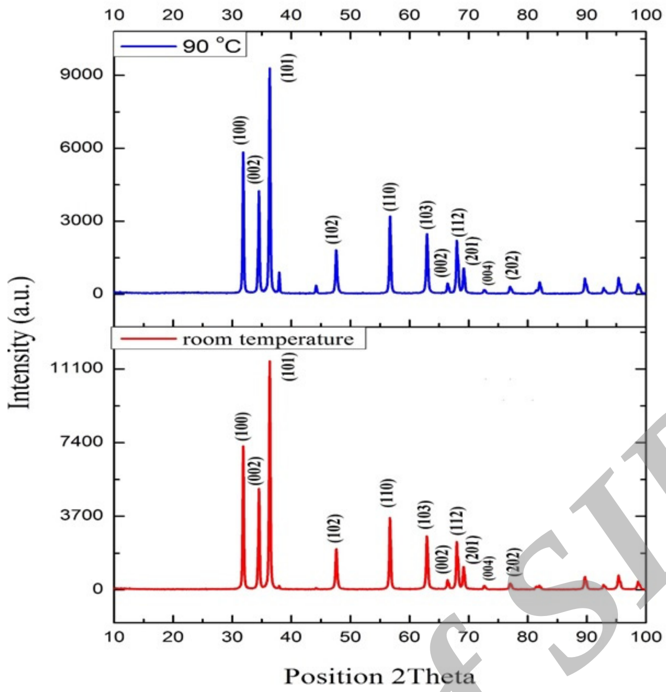

Fig. 1. XRD Pattern of ZnO NPs at room temperature and at 90°C.

*SEM*

The SEM images were shown for prepared ZnO nanoparticles with *parsley* extract at room temperature and 90 °C (Fig. 2). According to the results, zinc oxide nanoparticles had the spherical morphology and the particle size was estimated to be 50 (at room temperature) and 40 nm (at 90 °C). Therefore, it can be concluded that higher temperatures resulted to the decrease of size and uniform distribution of zinc oxide nanoparticles. Also smaller nanoparticles were synthesized at higher temperature because of necessity of shorter time. The shape is according to studies of Singha and coworkers in 2016 [13].

*DLS*

The dynamic light scattering was used to find out the size and distribution diagram of nanoparticles (Fig. 3). DLS results showed a single-peak with size of about 50 nm and a narrow distribution at room temperature and confirmed the SEM result.

The DLS results showed a single-peak with size of about 55 nm and a narrow distribution diagram at 90 °C and confirmed the SEM result (Fig. 4). The particle size distribution is according to studies of Singha and coworkers in 2016 [13].

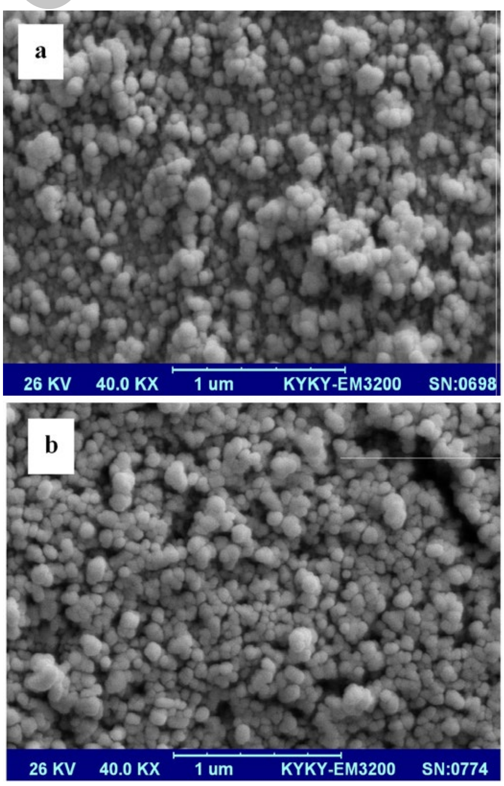

Fig. 2. SEM images of ZnO NPs at two temperatures: (a) at room temperature, (b) at 90 °C.

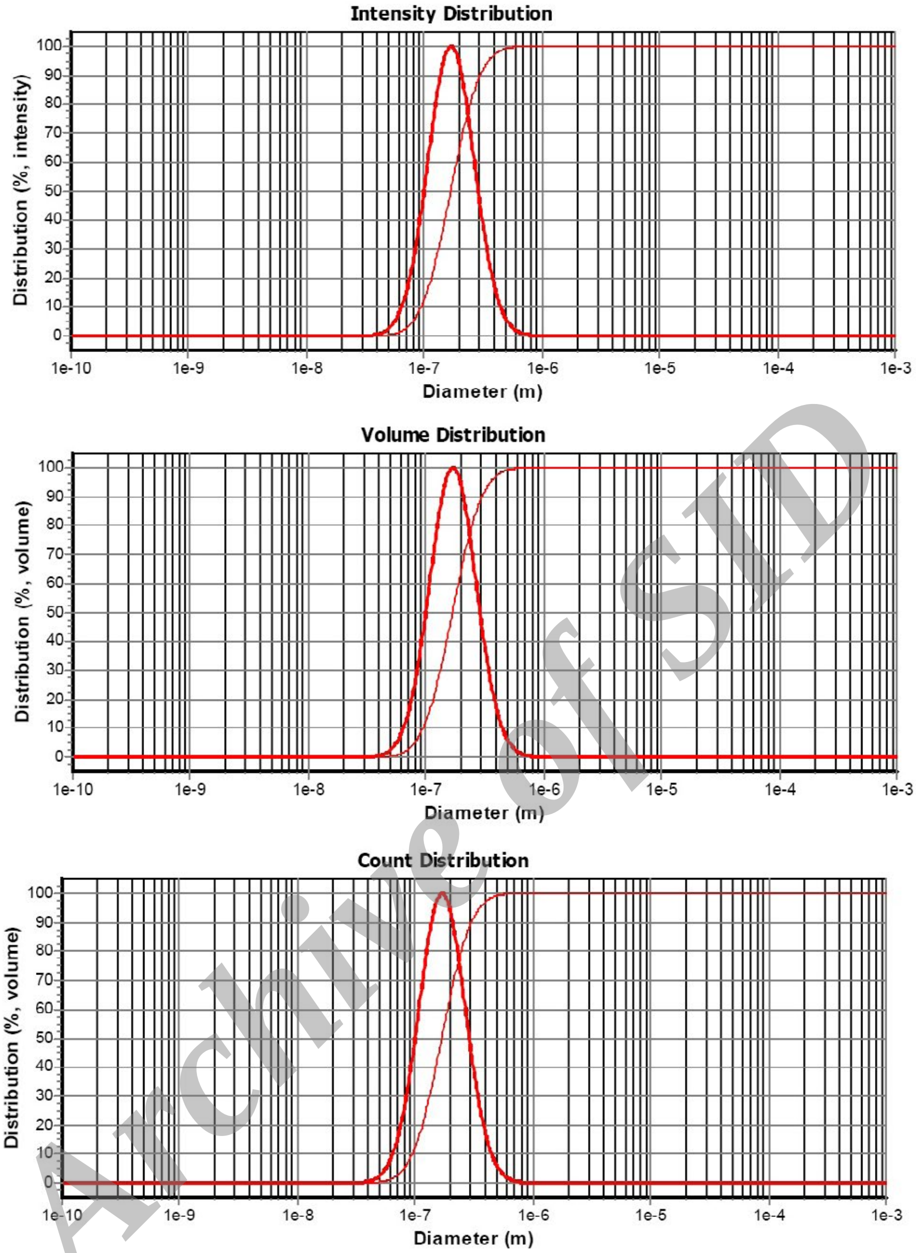

Fig. 3. DLS of ZnO NPs at room temperature.

*DRS*

The DRS absorption spectra of ZnO NPs were followed to spectrophotometer device in Fig. 5 at room temperature and 90 °C in three Ultraviolet: UV-A, UV-B, and UV-C. Absorption peak was observed in the range of 200-400 nm, which showed the protective properties of nanoparticles at this point.

The percentages of UV-A, UV-B and UV-C radiation for nanoparticles prepared in various ways are presented in Table 1. Based on the results, UV-blocking property is same for prepared ZnO NPs at two temperatures.

*Antibacterial activity*

Antibacterial activity of synthesized zinc oxide nanoparticles were investigated against *Escherichia Coli* as Gram-negative bacteria by agar diffusion method. The used concentration for determination of the antibacterial activity is 0.02 molar for

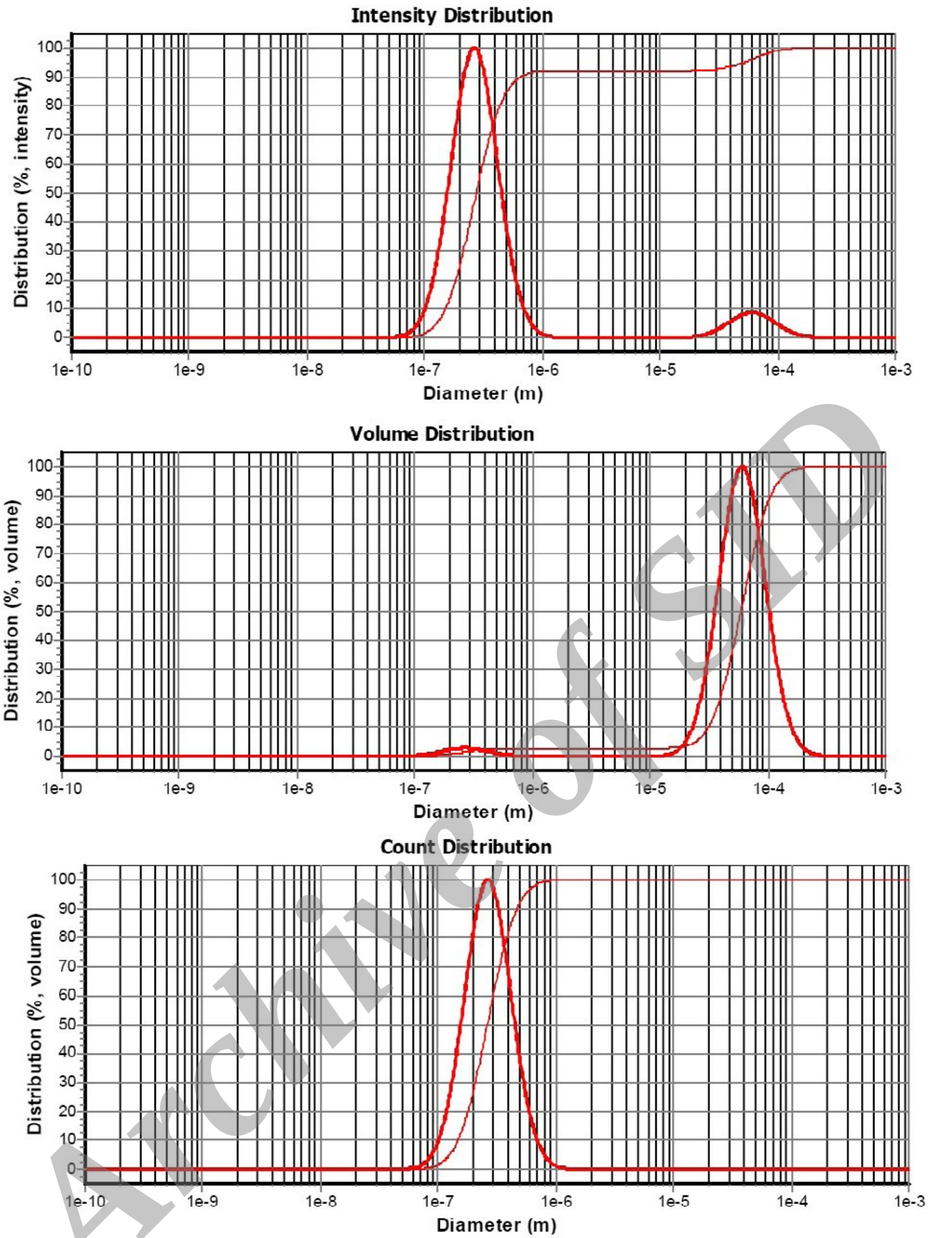


Fig. 4 . DLS of ZnO NPs at 90 °C.



samples. The zone inhibition was examined 4.8 mm at 90°C and 4.3 mm at room temperature for ZnO nanoparticles that observed higher antibacterial activity at higher temperature due to smaller size of nanoparticles. The antibacterial activity is according to studies of Das and coworkers in 2015 [17].

## CONCLUSIONS

ZnO nanoparticles prepared by green method using *parsley* extract as reducing agent. The XRD spectrum confirmed the pure ZnO crystalline structure. The DLS and SEM results showed the size in nanometer scale. Also, the SEM results showed spherical morphology and formed smaller nanoparticles at high temperatures. In this study, the reaction can be controlled to achieve the desired size with homogeneous nanoparticles by using parameters of temperature and time. The antibacterial activity observed for ZnO NPs that it was at 90°C more than at room temperature due to smaller size of nanoparticles. Future prospect

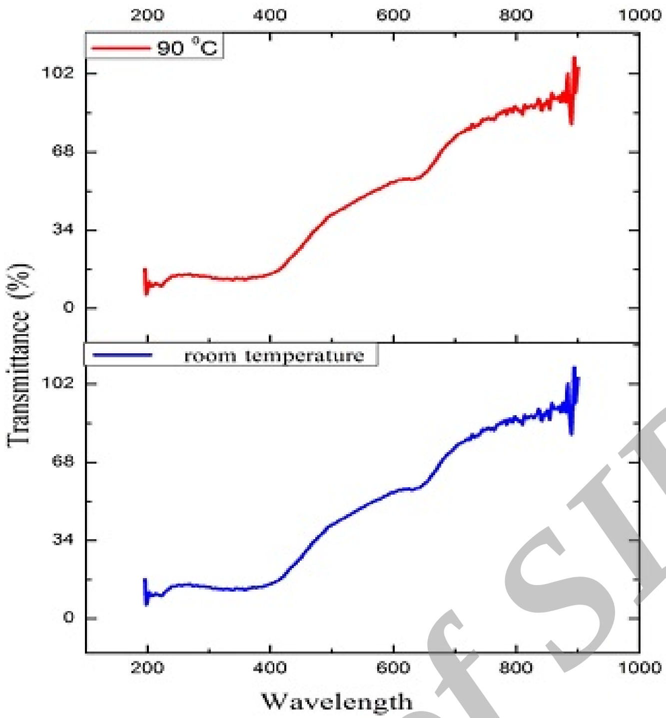


Fig. 5. DRS chart the absorption rate of ZnO NPs at room temperature and 90°C.

Table 1. The percentage of UV-A, UV-B and UV-C radiation of ZnO NPs

| Samples | UV-A(%) | UV-B(%) | UV-C(%) |
|---|---|---|---|
| Green method at room temperature | 20.00 | 51.42 | 18.75 |
| Green method at 90 ° C | 20.00 | 51.42 | 18.75 |

of green synthesis can have huge application for nanomaterial in the field of food, pharmaceutical, and cosmetic industries and thus become a major area of research.

## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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