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ORIGINAL ARTICLE

Biosynthesis, Antibacterial Activity, The Photocatalytic Performance of ZNO NPS by use of Leaf Extract of the Plant Primo Fiore

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ABSTRACT

The leaf extract of the plant Primo Fiore was used in this study to synthesize environmentally-friendly nanotechnologies. This eco-friendly method is non-toxic and does not hurt the environment. The approach is cost-effective, simple to use, and extremely efficient, with the ability to adjust the properties of the resultant compounds. For example, the ZnO compound can be controlled using the same plant extract and reaction. The impact of calcination temperature on the physical properties of ZnO NPs has been studied. X-ray diffraction (XRD) and energy dispersive spectroscopy were used to determine the structural and chemical composition of ZnO NPs (EDX). Field emission scanning electron microscopy (FESEM) and transmission electron microscopy were used to examine the morphological features of produced nanoparticles (TEM). The existence of functional groups was investigated using Fourier transform infrared spectroscopy (FTIR), according to the FESEM pictures. Most of the nanoparticles are on the nanoscale. This study demonstrated the efficacy of zinc oxide in the treatment of wastewater pollution for the degradation of colors in organic contaminants in the water medium, destroying the dye rhodamine B and its antibacterial properties. Zinc oxide nanoparticles (ZnO-NP) have been demonstrated to have a good antibacterial capability against both gram-positive and gram-negative bacteria in this study, to investigate the antibacterial activity of zinc oxide nanoparticles.

Keywords: ZnO NPs; degradation of dye Rh. B ; anti-bacterial; plant Primo Fiore

INTRODUCTION

Because of the high population density and number of factories, quality environmental monitoring and evaluation are needed to prevent the spread of this problem, One of the most important methods of monitoring is the biological technique, which involves evaluating a variety of plants, trees, fish, bacteria, and viruses as indicators in the control of environmental quality. Waste is one of the most significant pollutants that influence plants, causing changes in the environment, soil, and air that affect plant and animal life, as well as living organisms[1]. Heavy metal pollution from the most affected species, such as chromium and arsenic ions, is carcinogenic and is absorbed by the human digestive system through the skin[2]. Water pollution is currently one of the most serious issues, owing to the rise in organic and inorganic chemical pollutants used in industrial activities, such as toxic metals, dyes, organic pollutants, waste sites, and mining operations, the most dangerous of which is sewage pollution, as these pollutants change the physical properties of water and increase the number of impurities in it[3, 4]. Nanomaterials have a wide range of applications for dealing with pollutants in the environment, particularly water contamination, In the remediation of environmental contamination, nanoparticles and metal oxides are excellent adsorbents with high efficiency[5] .When alternative and new treatment methods are used to remove contaminants from non-living biomass, they have earned significant trust due to their high performance and low cost [6]. Consideration in environmentally friendly and plant systems, where this approach is low-cost and non-harmful, less contaminated and polluting the environment, and may be expanded, making it likely to be different from other chemica[5, 7, 8] .The initial phase in the production of nanoparticles from green plants is the activation of metal ions from their saline components, while the second stage is the creation of nanoparticles with the highest possible activity. ZnO crystallizes in two major forms: Hexa (wurtzite) and cubic zinc blende, and the morphology is covered by plant metabolites [9, 10]. It's one of the most important nanomaterials, and it's been studied extensively for decades. Zinc oxide nanoparticles are a semiconductor with a significant energy gap of 3.37 electron volts[11]. Many common synthetic approaches for manufacturing ZnO NPs have been documented in the literature in recent years. These methods, on the other hand, have several disadvantages, including high energy consumption, high expense, and the potential for harmful substances or dangerous physical therapies[12] . In recent years, there has been a worldwide movement toward more environmentally friendly nanocatalyst manufacturing procedures. Plant extracts, bacteria, fungi, and algae have all been employed in various ways to biosynthesize ZnO NPs. It has been claimed that various plant extracts, such as roots, flowers, leaves, stems, seeds, and fruits, are utilized to produce ZnO NPs [13]. In this paper, we show how to utilizing Using Primo Fiore leaf extract to prepare nano-zinc oxide. X-ray diffraction (XRD) and energy dispersive spectroscopy were used to determine the structural and chemical composition of ZnO NPs (EDX). Field emission scanning electron microscopy (FESEM) and transmission electron microscopy were used to examine the morphological features of produced nanoparticles (TEM). The existence of functional groups was investigated using Fourier transform infrared spectroscopy (FTIR). Treatment of Rhodamine B dye with direct solar light radiation was used to examine the photocatalytic effectiveness of produced ZnO materials, and we show an interaction between metal oxide nanoparticles with bacteria, they produce reactive oxygen species (ROS). Metal ions produced by nanoparticles have an impact on the respiratory chain and block some enzymes. Singlet oxygen, hydroxyl radical, hydrogen peroxide, superoxide anions, and other ROS are formed and accumulate as a result. Bacterial internal components, such as proteins and DNA, can be damaged by ROS.

MATERIALS AND METHODS

Chemicals: All received materials are of analytical reagent quality and used without further purification. Zinc (II) nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$, 99%), and Rhodamine B (empirical formula: $C_{28}H_31ClN_2O_3$; dye content 97%; λmax = 553 nm) were purchased from Sigma-Aldrich. Ethanol (C_2H_5OH, 99.5%), and hydrochloric acid (HCl, 37 %) were supplied by Scharlau. All solutions were prepared using deionized water (DIW).

Instruments: X-ray diffraction was used to examine the structural properties of ZnO NPs samples (XRD), On a Shimadzu-Japan XRD-6000 with CuK radiation of 1.54056, a powder XRD analysis of ZnO nanoparticles was done; the XRD pattern was recorded in the 10°–80° range. Transmission Electron Microscopy was used to investigate the size of produced materials (Philips CM200). Using a Field Emission Scanning Electron Microscope (MIRA3 TESCAN - Czech), the morphology of produced ZnO samples was studied, and elemental compositions were determined using energy-dispersive X-ray spectroscopy (EDX). The KBr pellet approach

was used to obtain FT-IR spectra for ZnO NPs using a Shimadzu FTIR 8400s in the range of 4000–500 cm-1. Solids were separated using a Hettich EBA 20 centrifuge (Germany). To break ZnO particle agglomerates and promote dispersion, a 405-power sonic, Hashing- Korea ultrasound path was used. The production of ZnO NPs was carried out using a PreeKem microwave digestion system type WX-4000 (frequency 2.45 GHz, maximum power 1000 W, China).

Preparing the plant extract: Fresh leaves of Primo Fiore are rinsed with deionized water (DIW) to eliminate dust and then processed to a very fine powder using an electric grinder under normal conditions. and submerged in 100 mL of water (DIW), To obtain the plant extract, the solution was boiled for 30 minutes at 80°C, then filtered to eliminate fine suspended particles. The clear extract was then kept at 4 °C until it could be employed in the biosynthesis of ZnO NPs.

Biosynthesis Nanoparticles of zinc oxide: A 0. 5 g Zn $(NO_3)_2.6H_2O$ was dissolved in 50 mL of aqueous Sesbania grandiflora extract, then reduced to Zn^{+2} ions by continuous magnetic stirring at 80 °C for 4 hours. To avoid photoreactions, the solution was then covered with a dense aluminium foil and kept at room temperature for 24 hours. For 20 minutes, the reaction mixture was centrifuged at 6000 rpm. The resulting brown-coloured precipitate was washed with DIW and ethanol several times to eliminate any adsorptive impurities before being dried at 80°C for four hours to yield a pale white solid. The color change from yellow to white confirmed the reduction of zinc nitrate to zinc ions. The formation of a white solid indicates the synthesis of ZnO NPs. After that, the solid was calcined for 4 hours at 500°C.

Photocatalytic degradation of Rh. B dye under solar radiation: A solution containing ZnO NPS and dye was magnetically agitated for 60 minutes in the dark to produce the adsorption-desorption equilibrium of dye molecules on the ZnO surface for photocatalytic degradation of Rh. B dye. The solution mixture was then moved to a Pyrex glass with a surface area of 100 mL, which was put outside the laboratory building and exposed to direct solar irradiation. Throughout the reaction, the solution was kept homogenous by constant stirring. 5 mL of reaction solutions were taken at various time intervals after each run, and the ZnO was separated by centrifugation at 6000 rpm for 20 minutes. All the experiments took place over the summer, when the average ambient temperature was 44 °C and the sun shone for 5 hours (between 10 am and 3 pm). By measuring the absorbance at 554 nm, which corresponds to Rh. B maximum absorption wavelength, the photodegradation efficiency of Rh. B was estimated. The following equation was used to compute the photocatalytic degradation efficiency (per cent) of the ZnO samples for Rh. B dye.

$$\mathrm{PDE\%} = \frac{A_0 - A}{A} \times 100 \qquad (1)$$

Where A_o is the initial dye absorbance and A is the dye absorbance at time.

RESULT AND DISCUSSION

X-ray diffraction: The existence of phases in synthesized nanomaterials was determined by XRD analysis. The X-ray pattern of ZnO NPs calcined at 400 and 500 °C is shown in Fig. 1. The resulting pattern of ZnO NPs in various diffraction angles is shown in the figure, which represents the diffraction of ZnO NPs employing Zinc (II) nitrate hexahydrate as a precursor. If no contaminants are present, XRD measurements suggest the creation of a pure hexagonal wurtzite phase. The Miller index of each XRD pattern is (100), (002), (101), (102), (110), (103), (200), (112), (201), (004). The major peak intensity in both ZnO materials is quite high, indicating good crystalline formation. 31.5383, 34. 8682, and 36. 0318 are the narrow peaks angles [14]. The crystallite size determined using Debye Scherer is shown in Table 1:

$$D = K\lambda/\beta \cos\theta \qquad (2)$$

Where D is crystal size, K is constant, **λ** is a wavelength, β is peak width (FWHM), and 2Θ is diffraction angle, the peak intensities rise with increasing annealing temperature, indicating an increase in crystallinity at higher temperatures, according to XRD patterns. With an increase in calcination temperature from 400 to 500 °C [15].

Table 1: Data of XRD pattern for the synthesized ZnO NPs.

No.	Pos. [°2Th.]	FWHM	Lattice Strain	Average Size (nm)
1	31.5383	0.2198	0.0043	
2	34. 8682	0.2532	0.0047	
3	36. 0318	0.2471	0.0033	
4	47. 7123	0.2389	0.0029	27.81
5	56.5986	0.3682	0.0044	
6	63.3018	0.3190	0.0073	
7	68.2428	0.3832	0.0053	
8	69.1091	0.1281	0.0018	
9	78.3282	0.1938	0.0003	

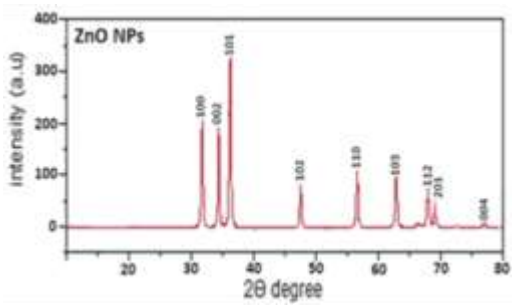

Fig 1: XRD patterns of synthesized ZnO NPs.

FESEM Analysis: The surface morphology of ZnO NPs was studied using field emission scanning electron microscopy (FESEM) under various calcination settings. Fig 2 shows FE SEM micrographs of ZnO NPs generated at 400 and 500 degrees Celsius during the calcination process. Fig 2 shows that the ZnO NPs are heterogeneous in character, with most particles having spherical to semi-sphere-shaped structures and some particles being in an aggregation state. The particles' average size is in the nanometer range, which is in line with XRD results[16] .

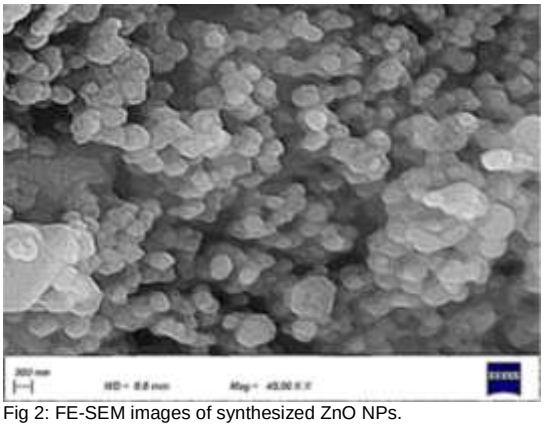

Fig 2: FE-SEM images of synthesized ZnO NPs.

EDX analysis: The elemental composition of both calcined ZnO samples was determined using an energy dispersive X-ray diffractive (EDX) study of the produced ZnO NPs nanoparticles. As shown in Fig 3, EDX spectra of both ZnO samples indicated the presence of elements Zn and O signals, and this analysis revealed the peaks that corresponded to the optical absorption of the generated ZnO NPs. In addition, the oxygen ratio in ZnO samples is 44.04, and the zinc ratio is 55.96, indicating that the generated ZnO NPs are in an appropriate pure form and agree with previous studies [17, 18].

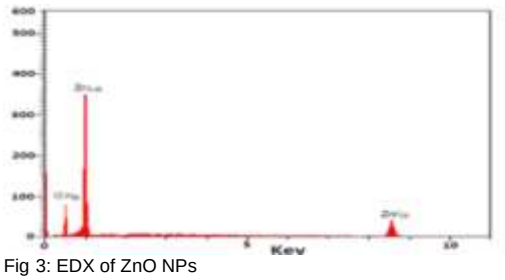

Fig 3: EDX of ZnO NPs

TEM analysis : The TEM is used to research the characteristics of nanomaterials as well as their shape. TEM pictures of produced ZnO NPs are shown in Figure4. Both samples have regular particle aggregates, as can be seen in TEM pictures. The particle size of ZnO samples calcined at 400°C is around 20–35 nm, while the size of other ZnO samples appears to be larger. This could be attributed to higher thermal heating due to aggregated particles. The nanoparticles were found to be approximately spherical in shape on TEM, and the results were identical to those obtained using SEM [19]. The extracted sizes agree well with the XRD-calculated sizes, as shown by TEM images. The average particle size and particle agglomeration appear to be increasing in both SEM and TEM data. the average particle size and particles agglomeration at high fabrication temperature[20].

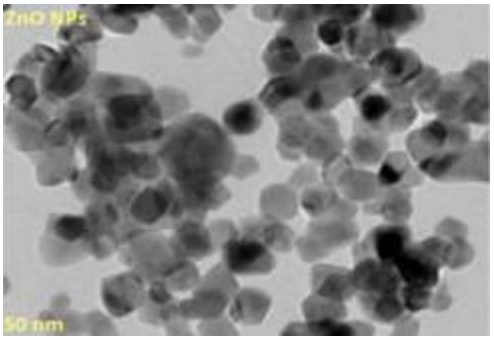

Fig 4: TEM analysis of ZnO NPs

FT-IR analysis: The quality and composition of the as-manufactured ZnO NPs nanoparticles were investigated using infrared spectroscopy. Furthermore, in the region of 500-4000 cm-1, FT-IR is a valuable technique for indicating the existence of various functional groups in synthetic samples. In general, inter-atomic vibrations cause absorption bands in ZnO and other metal oxides that are below 1000 cm-1[21]. The peak around 3300 cm-1 could be attributed to O-H stretching or OH Carboxylic, Peaks at 1658 and 675 cm-1 are Zn-O stretching and deformation vibrations, respectively. The found Zn-O frequencies for ZnO samples are consistent with previous literature [22].

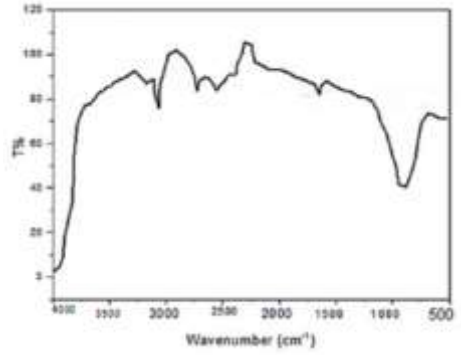

Fig 5: FT-IR analysis of ZnO NPs

Photocatalytic activity of ZnO NPs: Solar radiation has the advantages of being an endless supply of energy emitted by the sun, as well as a low-cost source with no harmful consequences on our lives. Furthermore, the ZnO photocatalyst absorbs just a small portion of total sunlight[23] . The photocatalytic degradation of Rh. B solution in the presence of ZnO would be important to explore. Experiments on photocatalytic degradation of Rh. B dye was carried out in the open air under direct sunlight. UV-Vis spectroscopy was used to determine the quantity of RB before and after irradiation. Before being exposed to solar irradiation, all suspensions were kept in the dark for 1 hour to reach adsorption-desorption equilibrium. [24]. The photodegradation of dye under sun irradiation without ZnO NPs was investigated in preliminary studies, and the photodegradation efficiency was found to be quite high, ZnO dose, and initial dye concertation were the parameters investigated. The photodegradation efficiency declines as the annealing temperature rises. The aggregation of particles and/or the creation of a new intermediate phase may cause the photocatalytic activity of ZnO samples calcined at 500 ^{0}C to decreas[25].

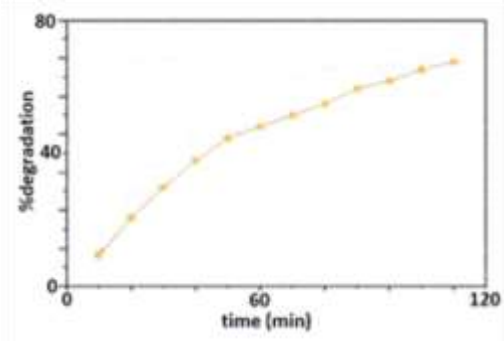

Fig 6: Photocatalytic degradation of Rh. B ZnO NPs

Antibacterial: Two varieties of bacteria were utilized to evaluate the biological activity of the produced compounds: one is (Escherichia coli), which is negative for the chromium dye, and the other is (Staphylococcus aureus), which is positive for the chromium dye. The results revealed that zinc oxide had antibacterial action against E. coli and S. aureus at two distinct doses /(0.001,0.0003g/mL) and that the results were varied, with zinc oxide showing good resistance against both bacteria by disrupting and tearing bacterial membranes. These actions are dependent on the type of nanomaterials and bacteria used. Furthermore, oxidative stress, genomic and plasmid DNA factors and degradation factors are just a few of the factors that can harm or kill bacteria [26]. The number of colonies of E. Coli bacteria is less than the number of colonies of S. aureus bacteria, according to genomic and plasmid DNA factors and degradation factors. As seen in the diagram [27] Fig 7 represents the effect of ZnO NPs on E.ColiS bacteria and bacteria S. aureus.

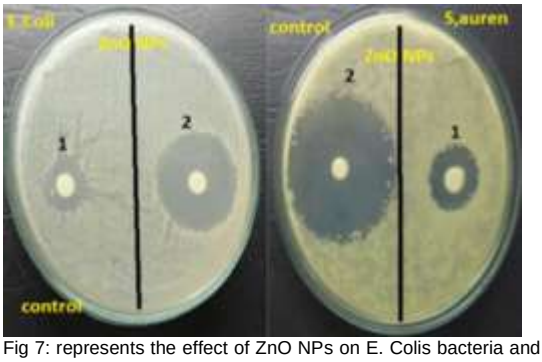

Fig 7: represents the effect of ZnO NPs on E. Colis bacteria and bacteria S. aureus

CONCLUSIONS

ZnO NPs were effectively synthesized using a simple green approach by use of leaf extract of the plant Primo Fiore. The structural, morphological, optical, elemental, topographical, and chemical features of as-synthesized nanomaterials were investigated using XRD, FE-SEM, TEM, EDX, and FT IR techniques. The photodegradation efficiency of RhB dye increased in general with extended period irradiation, higher photocatalyst loading up to 1.0 g/L, and decreased initial dye concentration. Furthermore, in the photocatalytic system, radical scavenging studies revealed that ZnO maintained good photocatalytic activity, with hydroxyl radicals and positive holes as the predominant reactive species. Photocatalysis was found to be 75 percent effective. results revealed that zinc oxide had antibacterial action against E. coli and S. aureus

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