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Novel Green Synthesis of Zinc Oxide Nanoparticles & Study of Its Invitro Antimicrobial Activity

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ABSTRACT: *Green synthesis techniques make use of moderately pollutant free chemicals to synthesis nanometerials and embrace the use of benign solvents such as water, natural extracts. Green chemistry seeks to reduce pollution at source. Though physical and chemical methods are trendier for nanoparticles synthesis, the biogenic fabrication is a better choice due to eco-friendliness Nanoparticles due to their smaller size and large surface to volume ratio exhibit remarkable novel properties and methodical applications in the field of biotechnology, sensors, medical, catalysis, optical devices, DNA labeling, drug delivery and they are rewardingly treated as a bridge between bulk material and atomic and molecular structures. To Synthesize the* $Zn(OH)_2$ *precursors from various aromatic acids like 3,5 Di Nitro Benzoic Acid, 3,5 Di Nitro Salicylic Acid, Stearic Acid, Benzoyl Glycine and 2-Chloro Benzoic Acid and Spinacia oleracea leaves extract. To synthesize the ZnO nanoparticles from various precursors. To characterize the ZnO nanoparticles with the help of analytical instruments such as UV-VISIBLE, FT-IR, XRD, SEM analysis. To analyze the antibacterial activity of the ZnO nanoparticles with both gram positive and gram negative bacteria such Staphylococcus epidermis, Bacillus subtilis and Escherichia coli. To analyze the antifungal activity of the ZnO nanoparticles with fungi such, Candida albicans, Aspergillus niger and Aspergillus flavus.*

Keywords: *ZnO, UV –Visible, XRD, FT-IR and Antimicrobial activity.*

I. INTRODUCTION

Green synthesis techniques make use of moderately pollutant free chemicals to synthesis nanometerials and embrace the use of benign solvents such as water, natural extracts. Green chemistry seeks to reduce pollution at source [1-2]. It is enhanced to prevent waste than to treat or clean up waste after it is formed. This principle focuses on choosing reagents that facade the least risk and generate only benevolent by products. Though physical and chemical methods are trendier for nanoparticles synthesis, the biogenic fabrication is a better choice due to eco-friendliness [3-4]. Nanoparticles due to their smaller size and large surface to volume ratio exhibit remarkable novel properties and methodical applications in the field of biotechnology, sensors, medical, catalysis, optical devices, DNA labeling, drug delivery [5] and they are rewardingly treated as a bridge between bulk material and atomic and molecular structures. ZnO nanoparticles have found fabulous application in biomolecular detection, diagnostics, and micro electronics [6]. Green synthesis of ZnO nanoparticles were agreed out using Corriandrum Sativum leaf extract for the eco- friendly development of novel technologies. We have developed a facile and eco-friendly method for the synthesis of Zinc Oxide nanoparticles using aqueous leaf extract of Corriandrum Sativum with Zinc acetate dihydrate as precursor. ZnO have extensive applications in water purification [7] ZnO nanoparticles have been used to remove arsenic, sulphur from water even though bulk zinc oxide cannot absorb arsenic. It is because nanoparticles have much larger surface areas than bulk particles [8] The plant phytochemical with antioxidant properties is accountable for the preparation of metal and metal oxide nanoparticles. Recently nano particles synthesis was achieved with bacteria, fungi, actinomycetes [9-11] and use of plant extract such as neem, camellia sinensis, Corriandrum, nelumbo licifera, ocimum sanctum and several others which is compatible with the green chemistry principles [12-13]. Among the diverse biosynthetic approaches, the use of plant extracts has compensation such as easily available, safe to handle and possess a broad viability of metabolities. The phytochemicals responsible for the synthesis of nanoparticles are terponoids, flavonoids, carbohydrates, saponins, alkaloid and protein [14]. Coriandrum sativum also known as cilantro, Chinese parsley or dhania is an annual herb in the family Apiaceae [15]. It is a soft, hairless plant growing to 50 cm. The leaves are uneven in shape, broadly lobed at the base of the plant and slender. The flowers are borne in small umbels, white asymmetrical with the petals pointing away [16]. Genus name comes from the Greek word koris (bedbug) in reference to the purported resemblance of the smell of fresh leaves to bedbug infested linen. The therapeutic properties [17] of Coriander include being, aphrodisiac, carminative, depurative, digestive, analgesi fungicidal, revitalizing, antispasmodic, stomachic and stimulant. Coriander is constructive to refresh and awake the mind. It can be used for mental fatigue, migraine pain, tension and nervous weakness [18-25]. Approaches such as simple solution-based methods, chemical precipitation sol-gel, solvothermal [26-31] electrochemical and photochemical reduction techniques are more widely used. Chemical method leads to the presence of some toxic chemicals adsorbed on the surface that may have adverse effecte [32]. Increasing awareness towards green chemistry and biological processes has led to the development of an eco-friendly approach for the synthesis of nanoparticles. The use of environmentally benign plant leaf extract for the synthesis of zinc oxide nanoparticle offers copious profit of eco-friendliness where toxic chemicals are not used. ZnO is non toxic it can be used as photocatalytic degradation materials of environmental pollutants.

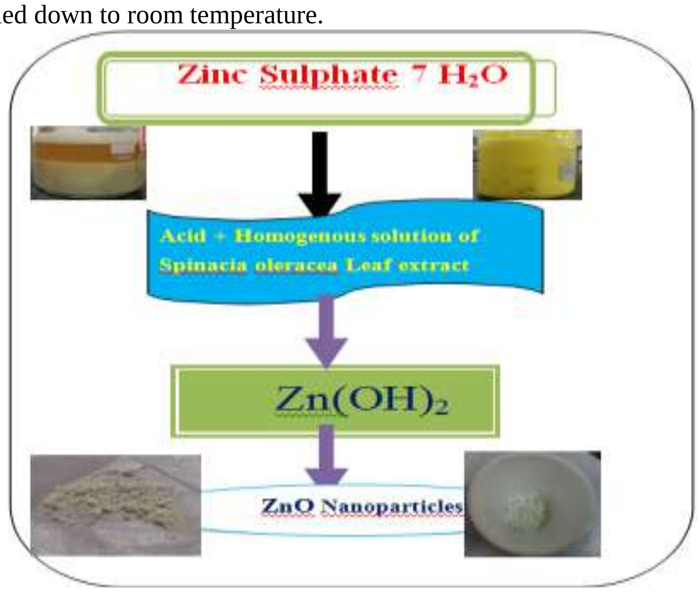
II. EXPERIMENT

2.1MATERIALS

Zinc Sulphate 7 H_2O, 3,5 Di Nitro Benzoic Acid and 3,5 Di Nitro Salicylic Acid, was used as the introductory material was supplied by Sigma-Aldrich chemicals. A fresh leaf of Spinacia oleracea were washed thoroughly with double distilled water, grinded and was filtered through Whatman filter paper was used for further studies.

2.2 Synthesis of ZnO Nanoparticles from P 1 Precursor

ZnO nanoparticle was prepared by Eco friendly synthesis method. In synthesis to 60 ml of distilled water 0.30 g aqueous Zinc sulphate was added under constant stirring. Aqueous leaf extract of Spinacia oleracea were introduced into the above solution after 10min stirring at different set (40ml). To the same 0.35g of 3,5 Di Nitro Benzoic Acid was added to resulted in a pale green aqueous solution . This was then placed in a magnetic stirrer for 2 hrs. The pale green precipitate was then taken out and washed over and over again with distilled water to get free of the impurities. Then a pale green powder of $Zn(OH)_2$ nanoparticles was obtained after drying at 80˚C in vacuum oven over night. Complete conversion of $Zn(OH)_2$ into ZnO NPs took place muffle furnace. $Zn(OH)_2$ was heated to 350 °C at a ramping rate of 10°C min^{-1} for 2hrs. The Pale green colour turned to White, which implied that ZnO nanoparticles had been produced. Nanoparticles were cooled down to room temperature.



Scheme 1. The Synthesis of ZnO nanoparticles by Green Method.

III. RESULTS AND DISCUSSION

3.1UV Visible Spectra

Probably one of the most universally utilized spectroscopy techniques, the adsorption of electromagnetic radiation in the range from ultraviolet to visible is still a versatile research tool. Just in the case of FT-IR, UV-VIS can be used to analyze certain compounds used in the functionalization of nanoparticles for dispersions and applications. Changes in the UV part of the spectrum can commonly be contributed to charge transfer bands between a surface metal cation and the functional ligand. Figure 1 shows Precursors and ZnO Nano Particles. From the spectra obtained by UV-VIS Spectrophotometer it is known that a smooth and narrow absorption bands were obtained.

Table – 1 UV-Visible spectral data of ZnO precursors

Precursor compound	π- π*	n- π*	ZnO Nanoparticles
P 1	**-**	**339**	**N1 349**
P 2	**213**	**340**	**N2 368**

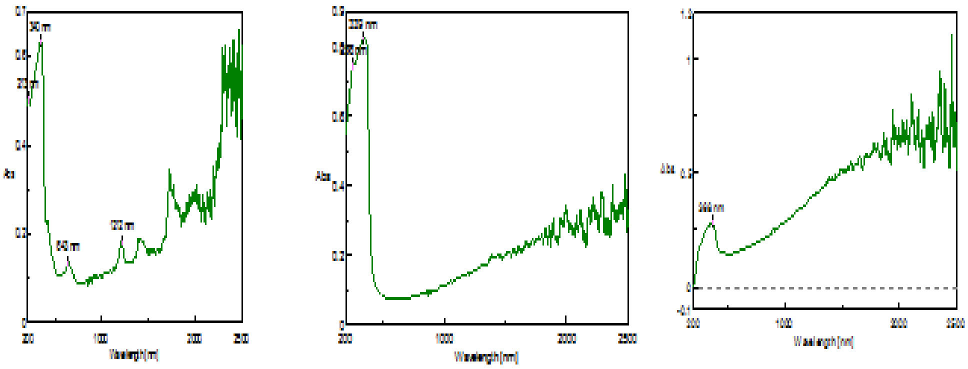


Figure.1 UV-Visible Spectra for $Zn(OH)_2$ compound P1 and (N1,N2) ZnO nanoparticles.

3.2 IR – Spectra Analysis

Various bands were observed in the FT-IR spectra. The position and number of absorption bands not only depend on crystal structure and chemical composition but also on crystal morphology. The broad band observed around 3500 cm^{-1} and 1600 cm corresponds to O-H stretching vibration due to the absorbed water on the surface of the samples [17]. The absorption around 2500 cm^{-1} is because of the presence of CO molecules in the environment. The peak around 2900 cm^{-1} is due to C-H band Band around 1600 cm^{-1} may be due to deformation vibration of H O molecule [18]. The carbonate stretches in samples are observed in samples at 1540 and 1480 cm^{-1} The intense absorption peak at ~ 500 to 600 cm^{-1} is related to the stretching vibrations of Zn–O bond [19]. The results further confirm XRD results of the spectra.

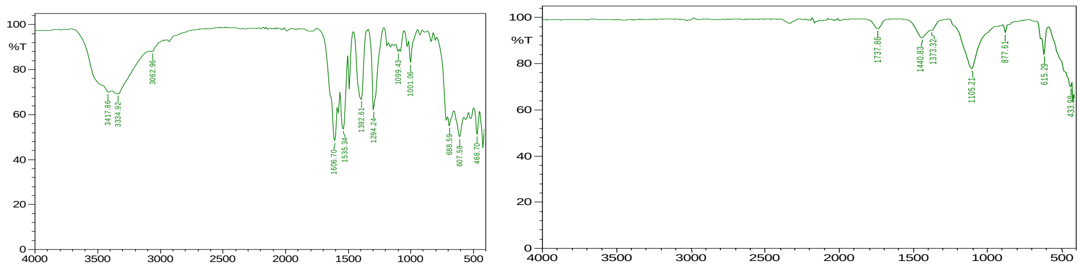


Figure. 2 FT IR Spectral graph for $Zn(OH)_2$ compound P1 & ZnO Nanoparticles N1

3.3 XRD – ANALYSIS

Figure 3 shows the XRD patterns of samples synthesized by co precipitation methods with dry temperature Td of 350°C for 2 h. The spectra are almost equal to the typical XRD spectra of ZnO nanoparticles reported from other experiments. In all our XRD patterns nine peaks are observed around 2Θ = 32.12, 34.48, 36.6, 47.76, 56.84, 63.02, 66.95, 68.23, 69.24 which correspond to (100), (002), (101), (102), (110), (103), (200), (112) and (201), respectively. For each sample, all observed peaks can be indexed as the hexagonal wurzite structure of ZnO with having space group P63mc. Moreover, a careful analysis of peak positions suggestive a small shifting in its value toward a lower 2Θ with increasing dry temperature, indicating a presence of compressive strain in the samples[14]. It is also shown that for the entire samples the reflection peaks become sharper and the full width at half maximum (FWHM) are slightly decreased with increasing dry temperature. Using the Scherrer peak broadening method, the average crystallite sizes obtained are ~ 20 nm.

Table - 2 The Particle size & grain size of ZnO Nanoparticles.

S. No.	Compound	Size of the particle (D) nm	Dislocation density (□)
1	**N 1**	**22.06**	**0.0153**
2	**N 2**	**18.64**	**0.0136**

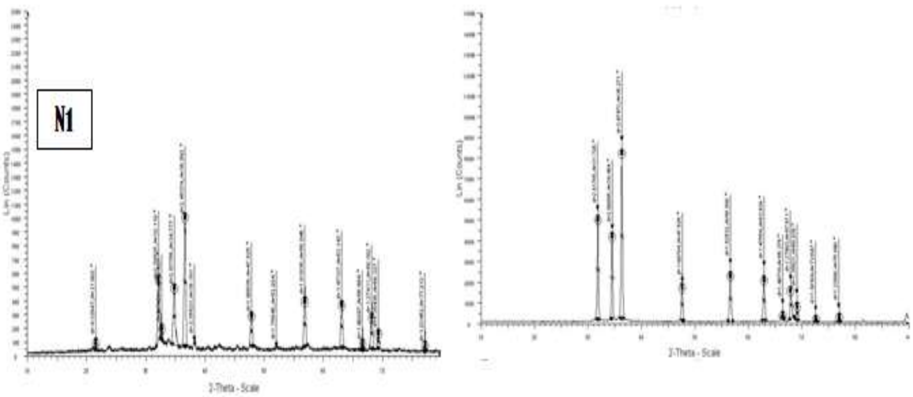


Figure.3 XRD graph for ZnO nanoparticles N1 & N2

3.4 Antibacterial activity of ZnO NPs

The antibacterial activity of ZnO NPs was studied against a gram positive (S. aureus) and a gram negative (E. coli) bacterial pathogen. The selection of the organisms was based on their roles for causing infections such as diarrhea in both children and early-weaned piglets. ZnO NPs at a concentration of 10 mg/ml showed inhibitory effect against the growth of both S. aureus and E. coli. The clear zone of inhibition around the discs was the evidence of antibacterial activity, which is presented in **Figure 4,5 and Table 5.** Results showed that ZnO NPs had good antibacterial activity against S. aurous and E. coli.

Table - 5 Antibacterial activity of ZnO Nanoparticles

S.No	Name of Microorganism	Control	NS-1	NS-2	NS -3	NS -4	NS -5	NK	D (Ciprofloxacin)
1	Staphylococcus epidermis	-	15	8	9	7	19	4	24
2	Bacillus subtilis	-	13	7	4	9	8	3	7
3	Escherichia coli	-	14	8	6	7	6	5	0

Figure.4 antibacterial activity of ZnO nanoparticles against Staphylococcus epidermis.

Table - 6 Antifunfal activity of $(ZnOH)_2$ Precursors

S.No	Name of Microorganism	C	NP-1	NP-2	NP-3	NP-4	NP-5	NK	Disc (Ketoconazole)
1	Candida albicans	-	6	7	8	10	8	-	13
2	Aspergillus niger	-	4	3	6	9	7	5	11
3	Aspergillus flavus	-	7	10	12	9	8	5	11

Figure.5 Antifungal activity of ZnO nanoparticles against Candida albicans.

IV. CONCLUSION

In this work, ZnO nanoparticles were prepared by simple Green method and characterized using UV, FT- IR, XRD and SEM with EDX. Green method has been found to be an easy, cheap, very fast and environmental friendly compared to other chemical methods. XRD shows the growth of grain size of nanoparticles and good crystallinity Size less than 30 nm after annealing. The annealed sample shows decrease in agglomeration in their morphology. UV-driven white light emission generation in luminescent lamps, flexible displays, and down-shifting of solar spectrum for enhancement of efficiency of solar cells are some of its device applications. It has been well documented that ZnO nanoparticles have good antibacterial activity. However, the open issue is that ZnO nanoparticles can easily aggregate, which greatly decreases their antibacterial and antifungal performance.

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