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# Green Synthesis and Characterization of Zinc Oxide Nanoparticles from Neem (Azadirachta indicia)

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**Abstract:** Use of plant materials has been considered a green route and a reliable method for the synthesis of nanoparticles owing to its environmental friendly nature. Hence an attempt has been made to synthesize the Zinc oxide nanoparticle using aqueous neem (Azadirachta indica) leaf extract. The aqueous leaf extract acts as a solvent with manifold roles as promoter, stabilizer and template for the synthesis of nanoparticles. The synthesized ZnO nanoparticle was characterized using FTIR spectroscopy and SEM analysis. The results of FTIR analysis of green synthesized nanoparticle revealed the presence of biomolecules such as Polyphenols, Carboxylic acid, polysaccharide, aminoacids and proteins. The results of the SEM studies of green synthesized ZnO nanoparticle showed the formation of spindle shaped nanoparticles and Zinc oxide nanoflakes.

**Keywords:** Green Synthesis, Neem LEAF (Azadirachta indica) Extract, ZnO Nanoparticle, FTIR and SEM.

## I. INTRODUCTION

Nanotechnology is a science and engineering branch of recent well established technology referring at the nanoscale, i.e. 1 to 100 nm (Willard et al., 2014). The field of nanotechnology is one of the most active research areas in modern material science. Over last decades, nanotechnology has established as the great innovation of science and technology . In nanotechnology, a nanoparticle is defined as a small object that behaves as a whole unit in terms of its transport and properties. (Prathna et al., 2012). Metal nanoparticles are more therapeutic compared to others (Sanita Banerjee, 2012). ZnO is nontoxic and used in industrial sectors including environmental, synthetic textiles, food, packaging, medical care, healthcare, as well as construction and decoration (Barnali Ashe, 2011). The synthesis of nanoparticles by conventional physical and chemical methods has adverse effects like critical conditions of temperature and pressure, expensive and toxic chemicals, long reflux time of reaction, toxic byproducts etc. A quest for an environmentally sustainable synthesis process has lead to a few biomimetic approaches. Biomimetics is the term used to when biological principles are applied in material formation.

Green synthesis of nanoparticles has gained significant importance in recent years and has become one of the most preferred methods. Green synthesis of nanoparticle is an innovative branch of nanotechnology (Barnali Ashe, 2011). It depends on plant source and the organic compound in the crude leaf extract. Many research works had been carried out concerned with Green synthesis of nanoparticles (Vanaja et al., 2013; Awwd et al., 2013; Senthilkumar and Sivakumar, 2014 and Gnanasangeetha et al., 2014). Hence the aim of the study is to synthesize Zinc Oxide nanoparticles using neem leaf extract, Azadirachta indica and to study its Characterization using FTIR and SEM analysis.

## II. MATERIALS AND METHODS

### A. Preparation of Zinc Acetate Dihydrate Solution For Synthesis Of Zinc Oxide Nanoparticles

Zinc acetate dihydrate with 90% purity was obtained from Himedia and distilled water was used throughout the experiments for the synthesis of Zinc Oxide Nanoparticles.

### B. Selection of Plant

Fresh and healthy neem (Azadirachta indica) leaves were collected from the tree. The leaves were ensured that they were healthy and uninfected and they were thoroughly washed and rinsed with sterile distilled water and air dried.

### C. Preparation of Zinc Acetate Dihydrate Solution For Synthesis Of Zinc Oxide Nanoparticles

Preparation of Zinc Acetate Dihydrate Solution for Synthesis of Zinc Oxide Nanoparticles was carried out by following the procedure of Senthilkumar and Sivakumar (2014).

### D. Green Synthesis Of Zinc Oxide Nanoparticles Using Neem (Azadirachta Indica) Leaf Extract

- **Preparation of aqueous extract (Cold method of neem (Azadirachta indica) leaves):** Preparation of aqueous extract (Cold method of neem - Azadirachta indica leaves were carried out by following the procedure of Kanthimathi et al. (2013).

- **Preparation of aqueous decoctions (Hot method of neem (Azadirachta indica) leaves):** Preparation of aqueous decoctions (Hot method of neem (Azadirachta indica) leaves were carried out by following the procedure of Kanthimathi et al. (2013).

**E. Characterization of Zinc Oxide Nanoparticles**

- **FTIR Analysis:** The FT-IR spectra of ZnO Nanoparticles of neem (Azadirachta indica) powder were recorded in SHIMADZU-8400 spectrometer using KBr pellet method.
- **Scanning Electron Microscope:** In the present work, SEM machine was employed to study the morphology of synthesized nanoparticles. The experiment was performed at an accelerating voltage of 20 kV. The slide was coated with platinum and after the platinum coating, the SEM image was taken.

## III. RESULTS AND DISCUSSIONS

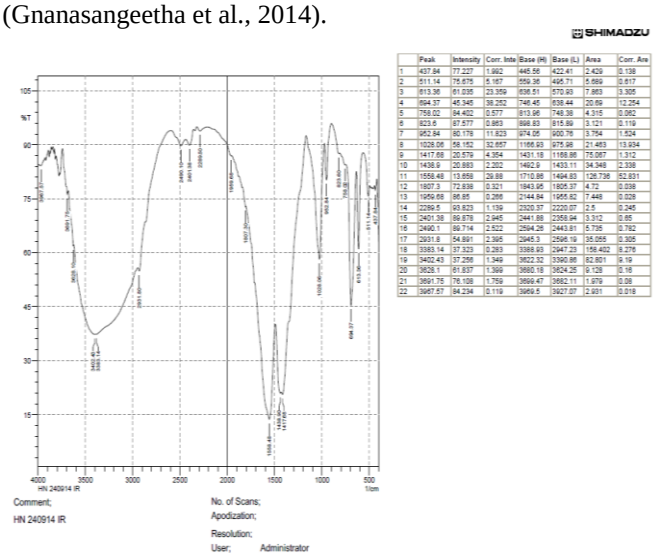
**A. Green Synthesis of Zinc Oxide Nanoparticles using Neem (Azadirachta indica)**

Zinc Oxide nanoparticles were synthesized successfully by the green synthesis method using Neem (Azadirachta indica) leaf extracts (Hot and Cold methods). During exposure to leaf extracts, reduction of zinc ions into zinc nanoparticles was observed as a result of the colour change from pale white to brown colour which occurred due to the Surface Plasmon Resonance phenomenon. The metal nanoparticles have free electrons, which helps in the formation of the Surface Plasmon Resonance absorption band, which is due to the united vibration of the electrons of metal nanoparticles in resonance with light wave (Kanthimathi et al., 2013).

**B. Characterization of Zinc Oxide Nanoparticles Using Neem (Azadirachta Indica)**

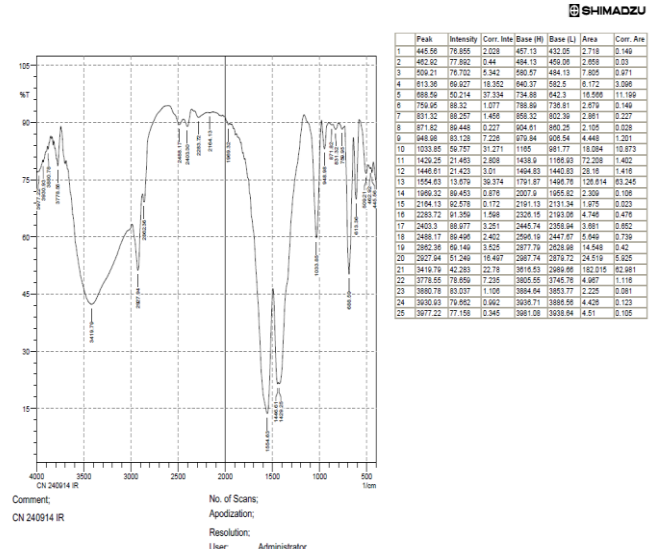
**FTIR Analysis: FTIR measurements of Zinc Oxide nanoparticles of Neem (Azadirachta indica) leaf extract:** The results of the FTIR spectrum of hot and cold methods of neem (Azadirachta indica) extracts of Zinc Oxide nanoparticles are depicted in Figs. 1and 2. The band at 437-445 cm-1 and 509-511cm-1 is attributed to ZnO nanoparticles. The broad peak at 3402-3419cm-1 correspond to O-H band and C=O indicating the compound to be aliphatic carboxylic acid. The band at 1554-1558cm-1 is attributed to the presence of aromatic ring. The band at 1028-1033cm-1 correspond to saturated primary alcohol. The band at 2927-2931cm-1 is due to doublet absorption of C-H stretching vibration of an aromatic aldehyde. These bands are indicative of terpenoid group of compounds present in aqueous neem (Azadirachta indica) extract ( Jha and prasad , 2010 and Senthilkumar and Sivakumar, 2014). From FTIR analysis, it can be inferred that alcohols, terpenoids ketones, aldehydes and carboxylic acid were surrounded by synthesized nanoparticles. Phenolic compounds flavonoids, lignans, coumarins, tannins, quercetin, alkaloids, cynogenic glycosides present in the leaves formed a strong capping on the nanoparticles(Awwd et al., 2013). The prominent doublet absorption at 2927-2931cm-1 indicates C-H stretching vibration of an aromatic aldehyde.

**SEM:** SEM studies provided further insight into the morphology and size details of the ZnO nanoparticle. The results of the SEM studies on Zinc Oxide Nanoparticles synthesized using neem (Azadirachta indica) leaves extract(Figs.3 and 4) revealed the formation of stable Zinc oxide nanoflakes and spindle shaped nanoparticles The size of the ZnO nanoparticles synthesized using neem (Azadirachta indica) leaf extracts were recorded to be 50 µm (Gnanasangeetha et al., 2014).




| | Peak | Intensity | Corr. Inte | Base (H) | Base (L) | Area | Corr. Are |
|---|---|---|---|---|---|---|---|
| 1 | 437.84 | 77.227 | 1.992 | 445.56 | 422.41 | 2.429 | 0.138 |
| 2 | 511.14 | 75.676 | 5.167 | 559.36 | 495.71 | 5.589 | 0.617 |
| 3 | 613.36 | 61.035 | 23.359 | 636.51 | 570.93 | 7.863 | 3.305 |
| 4 | 894.37 | 45.345 | 38.252 | 746.45 | 638.44 | 20.59 | 12.254 |
| 5 | 759.02 | 84.402 | 0.577 | 813.66 | 748.38 | 4.315 | 0.092 |
| 6 | 923.6 | 87.577 | 0.863 | 998.83 | 915.89 | 3.121 | 0.119 |
| 7 | 952.84 | 80.178 | 11.823 | 974.55 | 900.76 | 3.764 | 1.524 |
| 8 | 1028.06 | 58.152 | 32.657 | 1166.93 | 975.96 | 21.463 | 13.934 |
| 9 | 1417.68 | 20.579 | 4.354 | 1431.18 | 1166.88 | 76.067 | 1.312 |
| 10 | 1438.9 | 20.893 | 2.202 | 1462.9 | 1433.11 | 34.348 | 2.338 |
| 11 | 1558.46 | 13.658 | 29.88 | 1710.86 | 1494.83 | 126.736 | 52.931 |
| 12 | 1807.3 | 72.838 | 0.321 | 1843.95 | 1805.37 | 4.72 | 0.038 |
| 13 | 1959.68 | 96.85 | 0.266 | 2144.84 | 1955.82 | 7.448 | 0.028 |
| 14 | 2289.5 | 93.823 | 1.139 | 2320.37 | 2220.07 | 2.5 | 0.245 |
| 15 | 2401.36 | 89.678 | 2.945 | 2441.88 | 2358.94 | 3.312 | 0.65 |
| 16 | 2490.1 | 89.714 | 2.522 | 2594.26 | 2443.81 | 5.735 | 0.782 |
| 17 | 2931.8 | 54.891 | 2.395 | 2945.3 | 2596.19 | 35.055 | 0.305 |
| 18 | 3383.14 | 37.323 | 0.283 | 3388.93 | 2947.23 | 156.402 | 6.276 |
| 19 | 3402.43 | 37.256 | 1.349 | 3822.32 | 3390.86 | 62.801 | 9.19 |
| 20 | 3628.1 | 61.837 | 1.399 | 3660.18 | 3624.25 | 9.128 | 0.16 |
| 21 | 3691.75 | 76.108 | 1.759 | 3699.47 | 3662.11 | 1.979 | 0.08 |
| 22 | 3957.57 | 84.294 | 0.119 | 3969.5 | 3927.07 | 2.931 | 0.018 |

**Fig.1. FTIR Analysis of Neem (Azadirachta indica) – Hot method.**




| | Peak | Intensity | Corr. Inte | Base (H) | Base (L) | Area | Corr. Are |
|---|---|---|---|---|---|---|---|
| 1 | 445.56 | 76.855 | 2.028 | 457.13 | 432.05 | 2.718 | 0.149 |
| 2 | 482.92 | 77.892 | 0.44 | 494.13 | 459.06 | 2.658 | 0.03 |
| 3 | 509.21 | 76.702 | 5.342 | 580.57 | 494.13 | 7.805 | 0.971 |
| 4 | 613.36 | 69.927 | 18.362 | 640.37 | 582.5 | 6.172 | 3.096 |
| 5 | 668.59 | 50.214 | 37.334 | 734.88 | 642.3 | 16.566 | 11.199 |
| 6 | 759.95 | 88.32 | 1.077 | 788.89 | 736.91 | 2.679 | 0.149 |
| 7 | 831.32 | 88.267 | 1.456 | 858.32 | 802.39 | 2.861 | 0.227 |
| 8 | 871.82 | 89.448 | 0.227 | 904.61 | 860.25 | 2.105 | 0.028 |
| 9 | 948.98 | 83.128 | 7.226 | 979.84 | 906.54 | 4.448 | 1.201 |
| 10 | 1033.85 | 59.757 | 31.271 | 1165 | 981.77 | 18.084 | 10.873 |
| 11 | 1429.25 | 21.463 | 2.808 | 1438.9 | 1166.93 | 72.208 | 1.402 |
| 12 | 1446.61 | 21.423 | 3.01 | 1464.83 | 1440.83 | 28.18 | 1.416 |
| 13 | 1554.63 | 13.879 | 39.374 | 1791.87 | 1496.76 | 126.614 | 63.245 |
| 14 | 1969.32 | 89.453 | 0.876 | 2007.9 | 1955.82 | 2.309 | 0.106 |
| 15 | 2164.13 | 92.578 | 0.172 | 2191.13 | 2131.34 | 1.975 | 0.023 |
| 16 | 2283.72 | 91.359 | 1.568 | 2326.15 | 2193.06 | 4.746 | 0.476 |
| 17 | 2403.3 | 88.977 | 3.251 | 2445.74 | 2358.94 | 3.881 | 0.652 |
| 18 | 2488.17 | 89.496 | 2.402 | 2596.19 | 2447.67 | 5.649 | 0.739 |
| 19 | 2862.36 | 69.149 | 3.525 | 2877.79 | 2628.98 | 14.548 | 0.42 |
| 20 | 2927.94 | 51.249 | 16.497 | 2987.74 | 2879.72 | 24.519 | 5.925 |
| 21 | 3419.79 | 42.283 | 22.78 | 3616.53 | 2989.86 | 182.015 | 62.981 |
| 22 | 3778.55 | 78.859 | 7.235 | 3805.55 | 3745.76 | 4.967 | 1.116 |
| 23 | 3880.78 | 83.037 | 1.106 | 3884.64 | 3853.77 | 2.225 | 0.081 |
| 24 | 3930.93 | 79.662 | 0.992 | 3936.71 | 3886.56 | 4.426 | 0.123 |
| 25 | 3977.22 | 77.158 | 0.345 | 3981.08 | 3938.84 | 4.51 | 0.105 |

**Fig.2. FTIR Analysis of Neem (Azadirachta indica) – Cold method.**

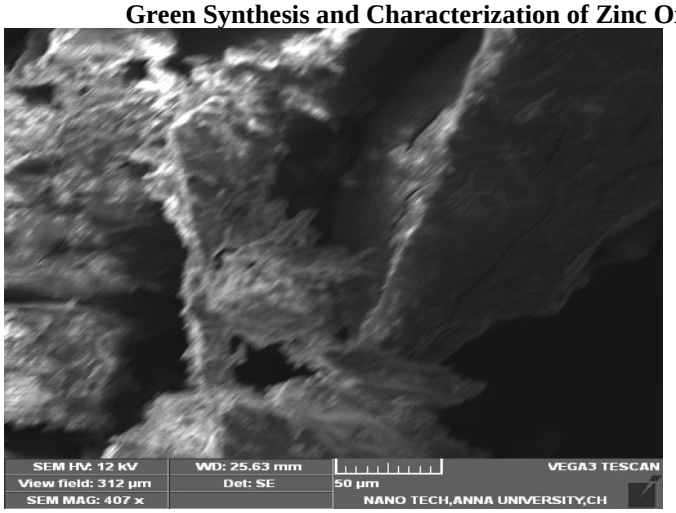



**Fig.3. SEM studies of ZnO nanoparticles – Hot method.**

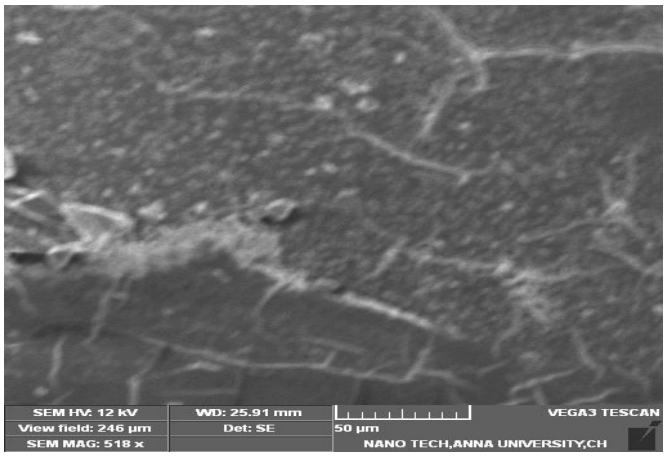



**Fig. 4. SEM studies ZnO nanoparticles – Cold method.**

## IV. CONCLUSION

Thus to conclude from the present study that zinc oxide Nanoparticles were synthesized by the neem (Azadirachta indica) leaf extract The FT-IR studies clearly indicates the reduction and capping agents ie. biomolecules present in the neem (Azadirachta indica) leaf extract. SEM studies revealed the formation of nanoflakes and spindle shaped nanoparticles and their size were 50 µm. Thus the progress of green chemistry with the use of plants in the synthesis of nanoparticles has engrossed a great attention. Owing to bountiful advantages associated with this eco-friendly nature, it has been explored as a powerful catalyst for several organic transformations. This research opens with a short course on how to synthesize Zinc oxide nanoparticle in a natural scale. Thus to pursue a healthy life and space it is imperative to develop a green synthetic approach to obtain nanomaterials targeted on different applications (Gnanasangeetha et al., 2013).

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