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Ethanolic extract mediated synthesis of ZnO Nanoparticles using *Aegle marmelos* leaves

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ABSTRACT

Nature and nanotechnology have not yet achieved a lucid correlation in the field of science but together they have exhibited immense potential for advancement and modification in future science and technology. Due to the unique properties of nanomaterials like nanoparticles gained considerable importance. The objective of the present work is to develop a procedure for obtaining ZnO nanoparticles via complex formation with plant extract. Aegle marmelos leaves were utilized as a template for the synthesis of ZnO nanoparticles. The ZnO nanoparticles were subjected to UV-Visible, FTIR, XRD, and SEM analysis. The presence of a phenolic group in the extract can form ZnO nanoparticles and act as stabilizing agent. The optical feature-s were typical of ZnO nanoparticles with an excitonic peak at 371nm from their absorption spectra and band gap Eg energy found to be 3.34ev. It was confirmed from the XRD pattern that the structure of ZnO nanoparticles is crystalline and the average crystal size of ZnO nanoparticles is 36.40nm. FTIR analysis proved that the particle is of biological origin. The SEM analysis displayed a fine spherical ZnO nanoparticle and a size of ZnO nanoparticle 47.82nm.

Keywords: ZnO, Nanoparticles, Green synthesis, UV-Vis, XRD, FTIR, SEM, Aegle Marmelos.

INTRODUCTION

Nanotechnology is a novel and innovative technology that deals with the designing, development, and application of devices, structures, and particles on the nanoscale. Molecules can show some unique properties in their nano size range which can be used in different fields of science including agriculture. Green nanotechnology is arising as a new branch of nanotechnology where plant-mediated synthesis of nanoparticles had already got wide attention due to its simplicity, eco-friendly nature, rapid rate of synthesis, and less cost. The chemical synthesis followed by the stabilization of synthesized zinc oxide nanoparticles causes the release of toxic by-products which are harmful to the ecosystem. Thus plant-mediated synthesis has emerged as the best alternative to chemical synthesis. There is a wide deficiency of zinc in Indian soil which is causing a considerable reduction in yield. So there is a need to supplement zinc nutrients to crop plants grown in Zn-deficient areas. If the zinc is supplemented as its nanoformulation, its bioavailability, and efficiency will be a more and it enhance productivity. So to be economic, the ZnO nanoparticles should be at an affordable rate to the farmers. Thus green synthesis of ZnO nanoparticles is getting its importance Plants are the richest sources of bio-active organic molecules which include polyphenols, flavonoids, alkaloids, terpenes, tannins, steroids, saponins, etc. These phytochemicals are non-nutritive and produced in plants as part of their defense mechanism to tolerate different kinds of stress (Tiwari *et al.* 2013).

The unique properties of nanoparticles are mainly due to their higher aspect surface area to volume ratio and quantum effects. The chemical synthesis of nanoparticles causes the release of toxic byproducts which contaminate the environment and lead to several health issues. Thus green synthesis or plant-mediated synthesis of nanoparticles has emerged as an alternate way to chemical synthesis. Green synthesis of nanoparticles is gaining importance due to their simplicity, eco-friendly nature, rapid rate of synthesis, and less cost. Zinc oxide is a potential photocatalyst instead of TiO2 due to its band gap energy and stability. Of its wide bandgap, Zinc oxide can be applied in a broad range of applications, including self-cleaning, photocatalysis, and environmental purification. To enhance the activity of ZnO in such applications in photocatalysis, the synthesis of ZnO to form nanoparticles is widely investigated (Kumar *et al.* 2013). The synthesis of metal oxide nanoparticles has attracted great interest in recent years. However, to reduce the environmental impact of material preparation, novel synthetic routes need to be found. These can vary from the swapping of precursors/reagents to the combination with natural materials to obtain the desired properties (Suligoj *et al.* 2020; 2016, Pavlovi *et al.* 2022). For a route to be considered low impact, it must satisfy at least some of the following requirements: (i) it must be made using no or low toxic precursors, (ii) it must consume an as low amount of energy as possible, and (iii) it should have high efficiency and produce as little waste as possible. Currently, plant-mediated biological synthesis of NPs is gaining importance due to its simplicity, and eco-friendliness (Janaki *et al.* 2015; Basnet *et al.* 2018). To the best of our knowledge, this is the first study using ethanolic extracts of Aegle marmelos to produce ZnO nanoparticles.

MATERIAL AND METHOD

Materials

Materials used in this research consist of Zinc acetate, potassium hydroxide, ethanol, and leaves of Aegle marmelos.

Biosynthesis of zinc oxide nanoparticles

Leaves extract was prepared by stirring 5gm of leaves powder in 100 ml ethanol for one hour on a magnetic stirrer. Zinc oxide nanoparticles were synthesized by mixing 20ml zinc acetate solution and 5ml of the extract solution in an ethanol solvent stirrer for one hour using a magnetic stirrer after that addition of potassium hydroxide was dropwise stirrer for two hours resulting in a white precipitate formation. The precipitate was then filtered using a glass filter and washed repeatedly with ethanol and oven dried at 600C for two hours the obtain dried white color powder mashed using mortar and pestle and made ready for further characterization.

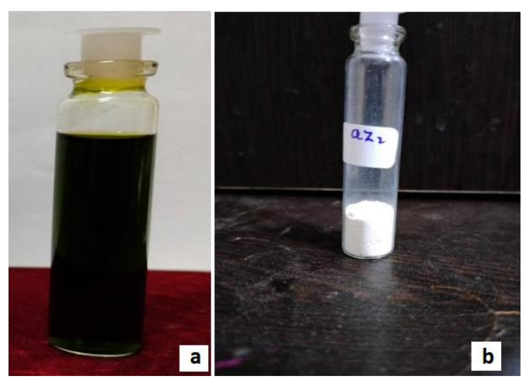

Fig.1.a) Ethanol based Aegle marmelos leaves extract, **b)** ZnO Nanoparticles

RESULTS AND DISCUSSION

a. UV -visible spectroscopy

Synthesis of Zinc oxide nanoparticles using Aegle marmelos leaf extract optical characterized by using UV visible spectrometer. The UV-visible analysis uses to confirm the nanoparticles synthesized from Aegle marmelos leaf extract is presented in Fig. 2. The spectrum showed a peak at 371nm, which is the characteristic peak value of Zinc oxide nanoparticles. The band gap energy is calculated by using the following formula. $Eg=\frac{1240}{\lambda ev}$ The band gap energy value was found to be 3.34ev.

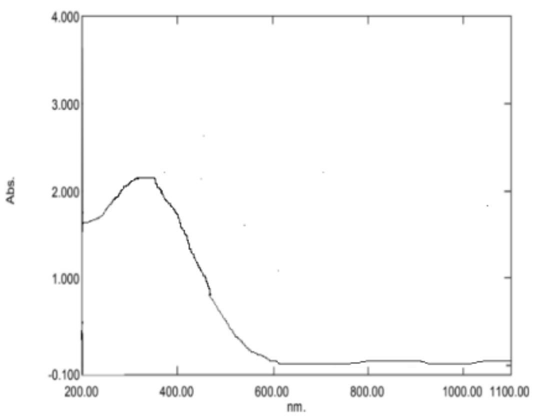

Fig.2. UV -visible spectra for Zinc oxide nanoparticles.

b. X-Ray diffraction (XRD) analysis

XRD gives the crystalline nature of ZnO nanoparticles. The graph shows main peaks corresponding to 2θ values of 30.70^0, 32.62^0, and 33.17^0 in the multiplot shown in Fig.3. The location of the peaks was compared to literature values and the presence of Zinc oxide nanoparticles was confirmed. The average size of the nanoparticles was calculated using the Debye-Scherrer equation. The average crystallite size calculated for synthesized Zinc oxide nanoparticles is 36.40nm.

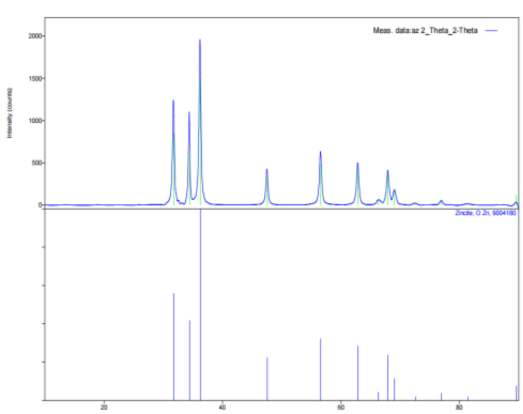

Fig.3. X-Ray diffraction spectrum of synthesized Zinc oxide nanoparticles.

c. Fourier transform infrared spectroscopy (FTIR) analysis

Fig. 4 shows the FTIR spectra of ZnO NPs taken in the range of 400-4500 cm^{-1}. The peak at 3445.08cm^{-1} is due to C=O stretching and O-H stretching of an organic compound. The peak located at 1017.86cm^{-1} and 1125.98cm^{-1} is due to the C-O stretching vibration. 897.13$cm^{-1}$and 856.38$cm^{-1}$is due to N-H bending and C-H bending, and 606.77cm^{-1} is due to C-H bending, it can be easily concluded that these phytochemicals are involved in the stabilization and reduction of the Zinc oxide nanoparticles. The peaks other than phytochemicals and two peaks that occur at 560.08cm^{-1} in the FTIR spectrum are the characteristic peaks of Zinc oxide nanoparticles.

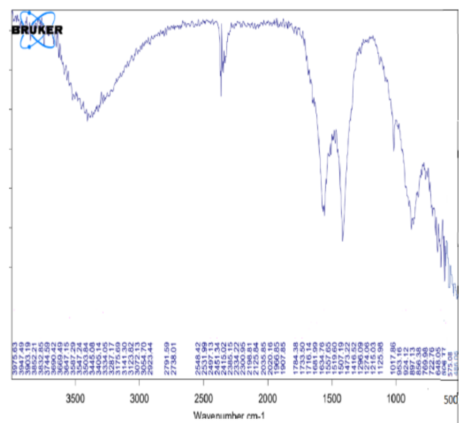

Fig.4. FTIR spectrum of zinc oxide nanoparticles

d. SEM analysis

The morphology of the synthesized NPs was examined by scanning electron microscopy. According to the results, zinc oxide nanoparticles had a spherical morphology and the result are presented in Fig.5. and the particle size is 47.82 nm.

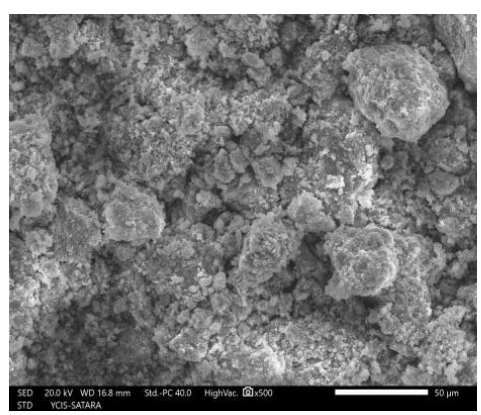

Fig.5.SEM images of ZnO NPs

CONCLUSION

The synthesis of ZnO nanoparticles via the complex formation of Zn with Aegle marmelos extract has been successfully investigated. The optical characteristic of Zinc oxide nanoparticles was studied using UV-visible analysis, XRD analysis, and FTIR analysis. The peak in the absorption spectrum confirms the formation of Zinc oxide nanoparticles, the functional groups present in the leaves extract were confirmed by FTIR analysis, and the XRD shows high purity and crystallinity of the sample. The leaves are useful in ophthalmia, inflammations, and diabetic complaints and are used for heart and brain disorders.

Conflicts of interest: The authors stated that no conflicts of interest.

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