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Green Synthesis of ZnO Nanoparticles using *Jasminum Fluminense* Leaf Extract and its Spectral and Optical Characterization Studies

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ABSTRACT

The main objective of the present study is to deal with the green synthesis of Zinc Oxide [ZnO] nanoparticles utilizing aqueous leaf extract of *Jasminum Fluminense.*` Zinc acetate [$Zn(O_2CCH_3)_2(H_2O)_2$] and sodium hydroxide [NaOH] were used as starting materials and *Jasminum Fluminense* [Nithyamalli] leaf extract is used as precursor in the synthesis of ZnO nanoparticles. The resultant nanopowder was characterized by using Ultraviolet [UV] – Visible Spectroscopy, Fourier Transform Infrared Spectroscopy [FTIR] and Transmission Electron Microscopic [TEM] studies. Formation of ZnO nanoparticles has been confirmed by UV-visible spectroscopy and the TEM analysis spectacles that the synthesized ZnO nanoparticles are of face centered cubic (fcc) structure and the size is found to be around 20 nm. FTIR spectral analysis indicated the leaf extract acts as the reducing and capping agents on the surface of ZnO nanoparticles. This simplistic and green approach may provide a useful tool to hefty extent in the synthesis of ZnO nanoparticles. These synthesized nanostructures illustrate novel applications in many fields such as cosmetics, optoelectronics, sensors, transducers and biomedical science because it is environmentally friendly and does not involve any harmful substances.

Keywords: *Leaf extract, Nanopowder, Jasminum Fluminense and Biomedical science*

1. INTRODUCTION

In recent years the growth of hazardless free metal nanoparticles has become a great challenge. Different metal nanoparticles can be synthesized but among them Zinc Oxide (ZnO) plays a vital role in chemical industries due to its anti-corrosive and anti-bacterial activities. Metal nanoparticles can be prepared by both physical and chemical methods such as UV irradiation, microwave irradiation, chemical reduction, photochemical method, electron irradiation and sonoelectrochemical method [1]. But these methods are costly, labor intensive and hazardous to environment as well as living organisms and in order to eliminate this we need an alternative, environmentally friendly, cost-effective and safest approach [2]. So green approach of nanoparticle synthesis has gained great attention among scientists and literature review divulges that leaves are generally used for the synthesis of metal nanoparticles because they act as both reducing and stabilizing agent.

Generally nanoparticles are the cluster of atoms in nanometer range. There are two types of nanoparticles namely metal and metal oxide nanoparticles. Both of them are very important but metal oxide nanoparticle such as CuO, TiO_2 and ZnO have semiconductor properties. Now-a-days ZnO nanoparticle has gained great attention among researchers owing to its different characteristics such as catalysis, electrical conductivity and cytotoxicity [3]. The biological synthesis of ZnO nanoparticles from leaves such as *Moringa oleifera*, *Lemon grass, Coriandrum sativum* and *Catharanthus roseus* has already been reported [4-8]. In our point of view, ZnO nanoparticles from *Jasminum Fluminense* using Zinc acetate and Sodium hydroxide as starting material was reported for the first time. Commonly, ZnO is a metal oxide semiconductor belonging to II-VI group having large exciton binding energy of 60 meV and wide band gap of about 3.4 eV. It has wide application in solar cells, gas sensors, ceramics, catalysts and used as an additive in paints, cosmetics, plastics, rubber manufacturing, electronics, pharmaceuticals, agriculture and aquaculture [9]. The plant *Jasminum Fluminense* belonging to the *Olive* family called Oleaceae and it contains about 200 species native to tropical and warm temperate regions of Eurasia, Australasia and Oceania. It is a climber plant belonging to dicotyledon and angiosperm group. The main aim of the present study is to synthesize Zinc Oxide (ZnO) nanoparticles using aqueous leaf extract of *Jasminum Fluminense* and to evaluate the structure by various characterization tools such as Ultraviolet [UV] – Visible Spectroscopy, Fourier Transform Infrared Spectroscopy [FTIR] and Transmission Electron Microscopic [TEM] studies.

2. MATERIALS AND METHODS

2.1 Materials Required

Zinc acetate [Zn $(O_2CCH_3)_2(H_2O)_2$], Sodium hydroxide [NaOH] pellet and glasswares were purchased from Merck and used as received and *Jasminum Fluminense* leaves were collected from SDNB Vaishnav College Campus. The leaves and all the glasswares were thoroughly washed with double distilled water before use.

2.2 Preparation of *Jasminum Fluminense* Leaf Extract

Fresh leaves of *Jasminum Fluminense* about 10 g were collected and washed several times with tap water and then with distilled water and cut into small pieces. These leaves were boiled with 100 ml of double distilled water at 60° C for about 30 minutes. After boiling, color of the solution changes to light brown color and it was cooled at room temperature. This extract was filtered through Whatman Number-1 filter paper and stored in refrigerator for further characterization studies.

2.3 Green Synthesis of ZnO Nanoparticles

For the synthesis of ZnO nanoparticles 1mM Zinc acetate [Zn $(O_2CCH_3)_2$ (H_2O) $_2$] was dissolved in 50 ml of distilled water and kept in stirrer for 1 hr respectively. Then 1mM of Sodium hydroxide [NaOH] Pellets was dissolved in 20 ml of distilled water and kept in stirrer for 1 hr respectively. Then 25 ml of *Jasminum Fluminense* leaf extract was added drop wise to the above mixture and continuously stirred at 50° C for another 1 hr until the colloidal solution is obtained. The colour of the resultant solution changes to light pale yellow colour which confirms the presence of ZnO nanoparticles. The precipitate was centrifuged at 10000 rpm at 50 °C for 20 min and powdered specimen was collected. This yellow coloured sample was dried using a hot air oven operating at 70 °C for 2 h and crushed using ceramic mortar and pestle to get fine Zinc Oxide (ZnO) nanoparticles and stored in air-tight bottles for further characterization studies [10].

2.4 Characterization

The optical properties of synthesized ZnO nanoparticles were investigated using UV-visible 8500 spectrophotometer in the wavelength range 250-1000 nm. The FTIR spectra were recorded using KBr pellet method by FTIR Spectrophotometer (Bruker, Tensor 27) at the wave number resolution of 1 cm^{-1} and with a total number of scans as 32 in the range 4000-650 cm^{-1} on the transmittance mode. The morphology was observed by Transmission Electron Microscopy using Hitachi Model TEM.

3. RESULTS AND DISCUSSION

3.1 UV-visible Spectroscopic Results

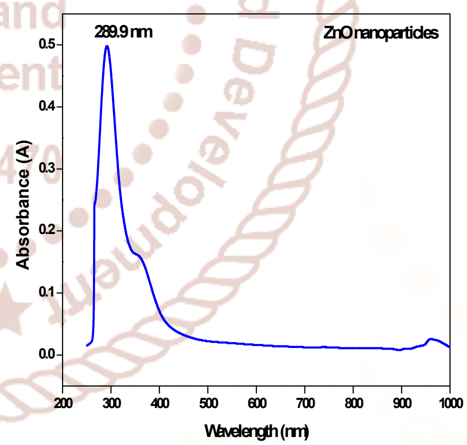

Fig. 1 UV-visible spectrum of biosynthesized ZnO nanoparticles

Figure 1 shows the UV-visible absorption spectrum obtained for the synthesized Zinc Oxide (ZnO) nanoparticles recorded between the range 250-1000 nm. It is known that the ZnO nanoparticles have free electrons due to which Surface Plasmon Resonance (SPR) absorption band appear at 289.9 nm. This absorption peak indicates the reduction of Zn^{2+} ions in the reaction medium which authenticates the formation of ZnO nanoparticles [4, 11]. No other peaks have been observed which confirms the presence of ZnO nanoparticles only. From the UV-visible graph the energy band gap is calculated using the formula

$$E_g = \frac{1240}{\lambda_{max}} eV$$

The energy band gap value is found to be 4.28 eV which is more than pure ZnO nanoparticles i.e., 3.4 eV.

3.2 FTIR Spectral Analysis of ZnO Nanoparticles

FTIR spectral analysis was carried out to find the functional groups present in ZnO nanoparticles and the FTIR spectra of ZnO nanoparticles is shown in Figure 2. The spectrum portraying band at 2924 and 2856 cm^{-1} are due to C-H stretching vibration [12]. The band at 1750 cm^{-1} corresponds to C=O stretching [9] whereas the peak at 1561 cm^{-1} is attributed to asymmetric stretching band from –COO- groups of acetate ions respectively [13]. The intense vibrational band around 1401 cm^{-1} is assigned to symmetric stretching of carbonyl side group [14] whereas the band at 922 and 858 cm^{-1} may correspond to O-H bending vibrations of carboxylic acid [15] and C-H bending vibration [10]. The vibrational band observed at 708 and 666 cm^{-1} corresponds to –C=C-H [16] and M-O stretching of ZnO [17] nanoparticles. The FTIR spectra thus demonstrates the structural changes taking place in the ZnO nanoparticles and *Jasminum Fluminense* leaf extract by the co-ordination of O-H, C-H, C=O and –COO- bonds.

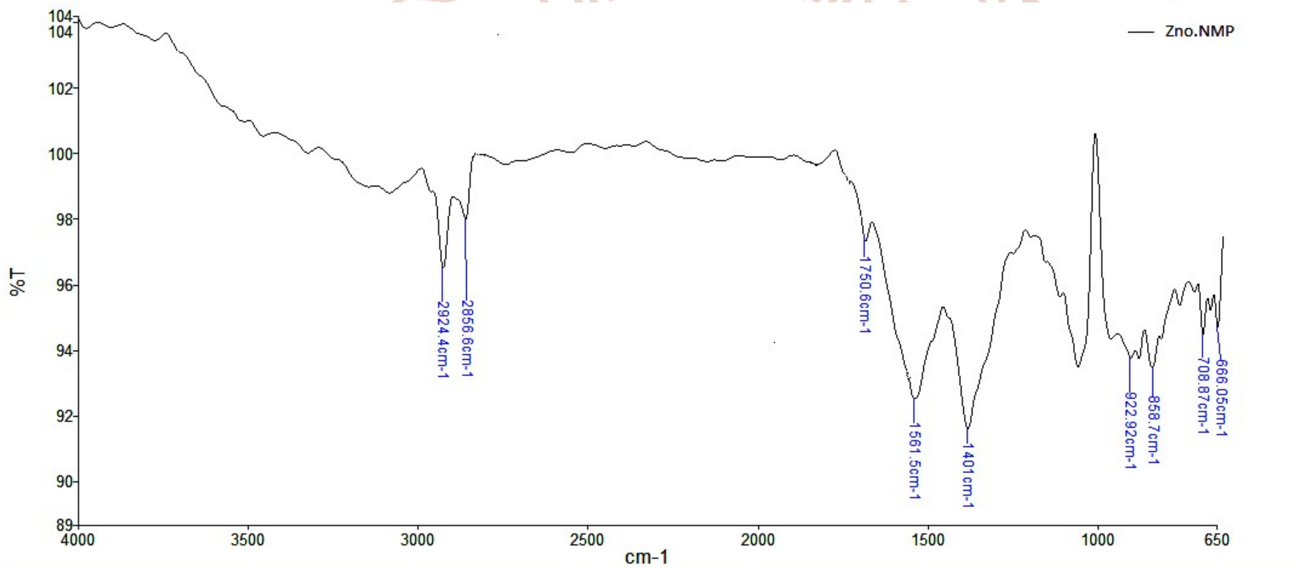

Fig. 2 FTIR spectra obtained for biosynthesized ZnO nanoparticles

3.3 TEM Results

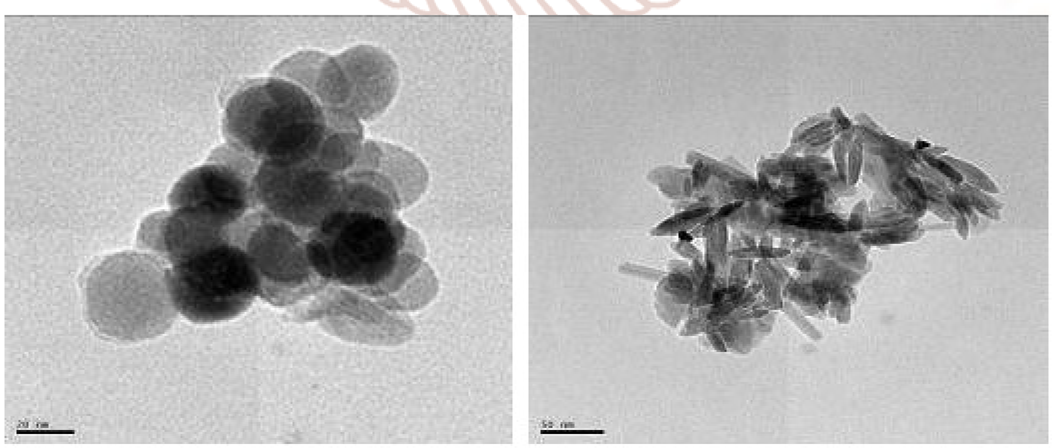

Fig. 3 TEM image of synthesized ZnO nanoparticles at different magnifications

The morphology and size of Zinc Oxide (ZnO) nanoparticles examined using Transmission Electron Microscopic (TEM) analysis as shown in Figure 3. These images depicts that the nanoparticles are hexagonal, rod shaped and some of them are spherical at different magnifications. These spherical structures indicate the presence of amorphous nature of ZnO nanoparticles [2]. The average diameter of the ZnO nanoparticle is found to be 20 nm which is correlated with the earlier reports [18].

CONCLUSIONS

In this present study eco-friendly, easy synthesis, low-cost, non-hazardous, organically effective and innovative approach of the biosynthesized ZnO nanoparticles using *Jasminum Fluminense* leaf extract have been reported. The phytochemicals present in the leaf extract acts as a biological stabilizing and reducing agent for the synthesis of metal oxide nanoparticles. The presence of ZnO nanoparticles was confirmed using UV-visible, FTIR and TEM studies. The absorption band observed at 289.9 nm with an energy band gap of 4.28 eV is confirmed by UV-visible spectroscopic studies. FTIR result confirms the presence of functional groups in ZnO nanoparticles. The particle size was found to be around 20 nm with hexagonal Wurtzite structure as evidenced from TEM results. Thus, it is exemplified that the ZnO nanoparticles synthesized in this research work acts as a promising candidate for future biological applications.

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